# lower ICICLE CREEK reach level assessment 2005

*produced for*

**Icicle Valley Chapter of Trout Unlimited**

*produced by*

**The Watershed Company**

# Lower Icicle Creek
# Reach Level Assessment

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**26 January 2005**

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## Executive Summary

The lower approximately 3 miles of the Icicle Creek in Leavenworth supports endangered Upper Columbia River spring-run chinook salmon, Upper Columbia River steelhead, and Columbia River bull trout. This reach has been affected by historical land use changes, as well as in-stream alterations including diversions and the construction of the Leavenworth National Fish Hatchery. Presently, habitat on the lower Icicle is considered to be functioning at unacceptable risk (The Watershed Company 2003). Several habitat restoration projects have been done in the past to correct problems or improve habitat at specific sites. However, before future restoration is proposed, it is important to look at the reach as a whole in order to ensure that the proposed habitat improvements fit with and complement the geomorphic properties of the reach, and address those processes that have been most disturbed.

This study uses a methodology developed by Rosgen (1996) to compare the lower Icicle Creek to reference reaches on the White River. A reference reach is a reach with the same classification as the reach being studied, but that is in better condition, and is more geomorphically stable, than the reach being studied.

Cross-sections on the White and on the Lower Icicle were measured and assessed. The results were condensed and tabulated to identify what Rosgen (1996) terms departures - geomorphic characteristics on the Lower Icicle that were significantly different from those on the White. The departures noted on the Icicle include a high width/depth ratio, a lack of in-stream debris, a lack of or poor quality bank and riparian vegetation, and a larger substrate.

Management recommendations derived from these departures are two-fold. First, the lower Icicle should be managed in such a way as to not make any of the noted departures worse. Any proposed habitat improvements should be examined carefully to ensure they will not have a negative effect on any of the departures. Second, active steps should be encouraged to improve those characteristics that are degraded on the lower Icicle. Habitat improvement projects that improve on a departure should be prioritized above those that have no impact on a departure.

By using the departures in this report as guidance, any future project proposed on the Lower Icicle can be assessed to determine if and how it may affect those geomorphic variables that are of most concern on the lower Icicle. In this way we can ensure that future habitat improvement project work with the geomorphological characteristics of the stream and create a local improvement that also promotes the reach-level stability of the lower Icicle.

# Icicle Creek
# Reach Level Assessment

## 1 Introduction

Icicle Creek is located east of the Cascades Mountains just south of Leavenworth, Washington (Figure 1). The creek is approximately 32 miles long and drains approximately 215 square miles (137,000 acres) of primarily steep mountainous terrain (Figure 2). It is the largest watershed tributary to the Wenatchee River, but it is second to the White River in terms of flow contribution to the Wenatchee.

The watershed has been described as “one of the most dramatic drainages on the eastside of the central Cascade Mountains” (Leavenworth Ranger District [LRD] 1995) because of its steep topography. The basin ranges from 1,100 to 9,400 feet in elevation, with some slopes exceeding 75 percent. Most of the drainage is within the Alpine Lakes Wilderness. The difference in topography between the upper and lower basins is striking (Figure 3). The average gradient of the upper 28 miles of the stream is nearly 3 percent, while the gradient in the lower approximately 4 miles is 0.17 percent.

Geologically, the basin consists of metamorphic and igneous rocks in the upper basin that have been carved by glacial and fluvial processes, with sands and gravels deposited by glacial and fluvial processes in the lower basin (Leavenworth Ranger District, 1995). During glacial retreat, a lateral moraine was deposited on the eastern flank of the lower valley, and the valley was filled with a thick layer of sand and gravel. Soils in the upper basin are thin and prone to mass wasting.

The drainage basin of the Icicle contains 14 glaciers and 102 lakes (Cappellini 2001). Rainfall ranges from nearly 130 inches per year in the upper basin to about 20 inches in the lower basin at Leavenworth. Stream flow varies from a recorded low of 44 cubic feet per second (cfs) to an estimated high of 19,800 cfs (USGS 2004). Peak flows generally occur in May and June, but exceptional floods, such as the 19,800-cfs flood in 1995, often occur in the early winter as the result of rain-on-snow events.

The earliest uses of the basin were for mining and sheep herding, beginning in the late 1800s. Other agriculture soon followed, with the lower basin being converted to orchard by 1912 (Figure 4). Timber harvest began in the 1960s, but encompasses less than 5 percent of the drainage basin (Leavenworth Ranger District, 1995). Other human activities in the basin include road building, campground development, fire suppression, residences, commercial development and recreation (Cappellini 2001). Most of the drainage basin is now part of the Alpine Lakes Wilderness, and therefore protected from timber harvest, road building and development.

Two water diversions exist on Icicle Creek. At river mile (RM) 5.7, the City of Leavenworth and the Icicle Irrigation District have a water diversion structure. At RM 4.5, a second diversion structure provides water for the Leavenworth National Fish Hatchery (LNFH) and the Cascade Irrigation Company. Together these structures remove up to 79 percent of the mean September flows (Mullan et al. 1992, in Cappellini 2001). To ensure an adequate supply of cool water, the LNFH developed a supplemental water supply system that takes water from Upper Snow Lake.

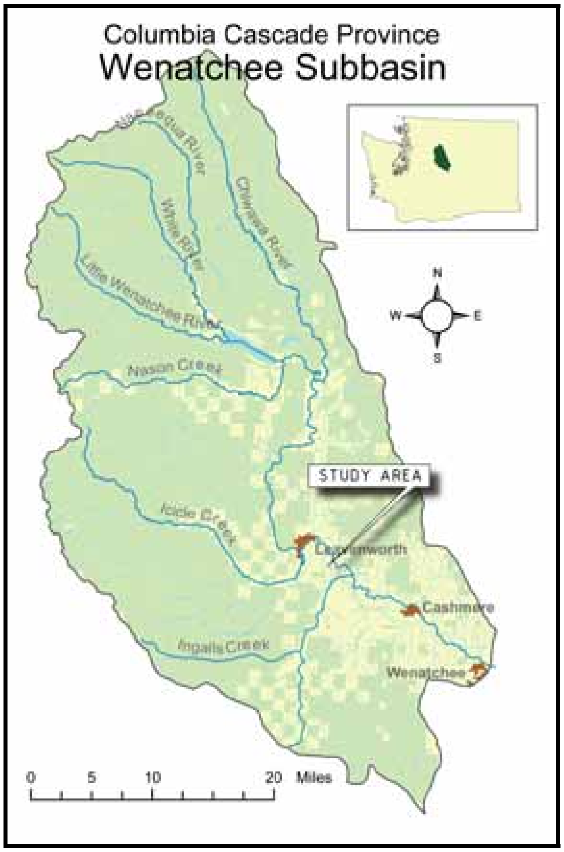


**Figure 1.** **Location of study area in Wenatchee Subbasin.**

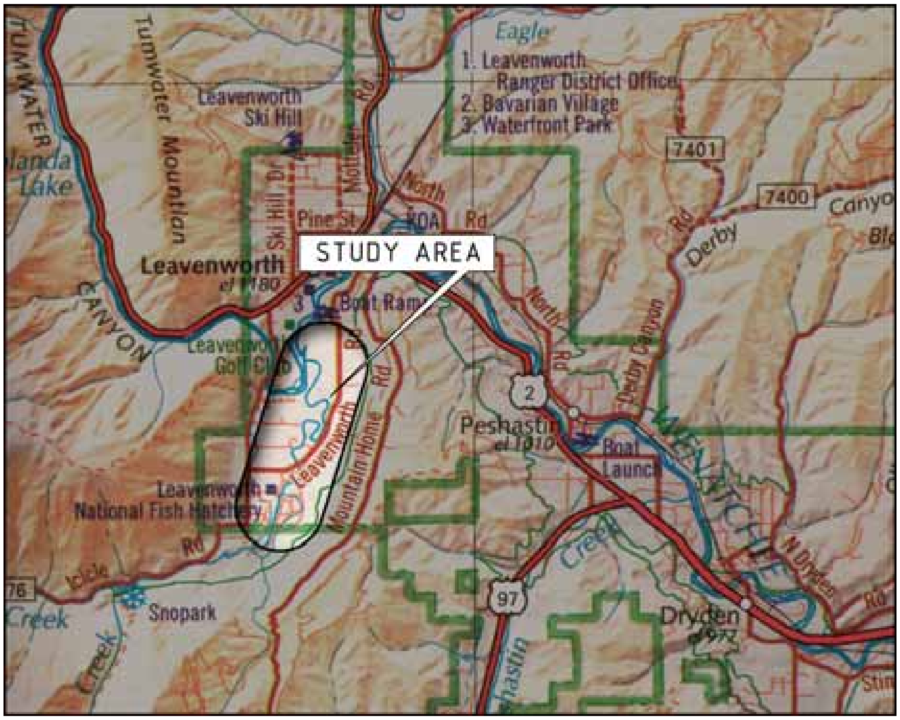


**Figure 2.** **Vicinity map.**

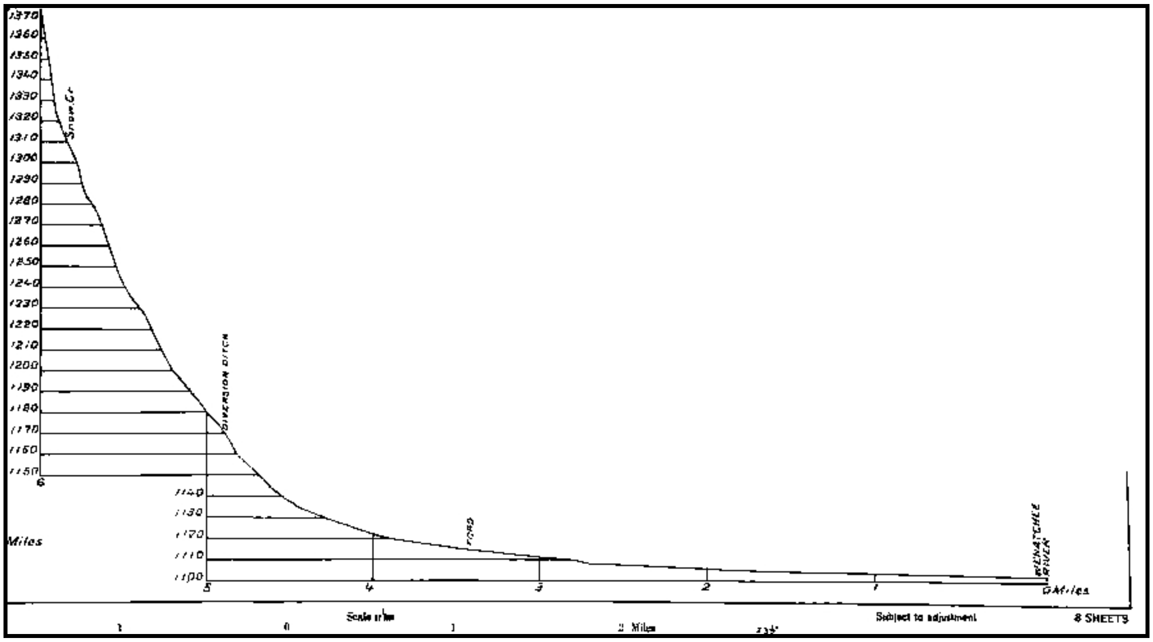


**Figure 3. Profile from 1912 USGS survey map.**

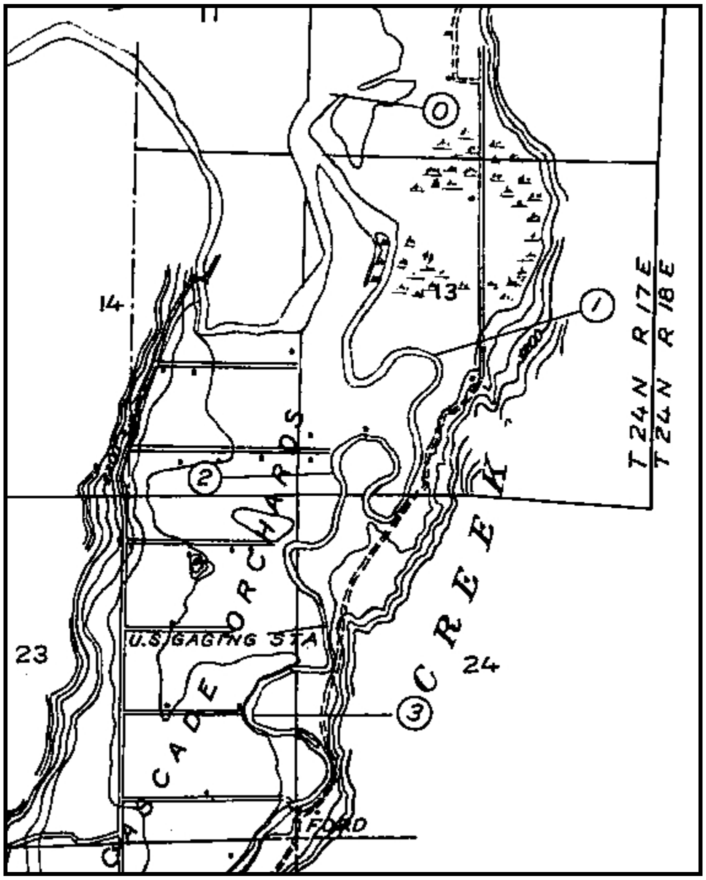


**Figure 4. 1912 survey map showing conversion to orchard.**

During the driest months, up to 50 cfs is drawn from this supply. In drought years, this additional water prevents the lower Icicle from drying out completely (Cappellini 2001).

The LNFH was built between 1939 and 1941 in an attempt to mitigate for lost habitat in the Columbia River system due to the construction of the Grand Coulee Dam. The design involved diverting the majority of the flow into a constructed canal with an energy control dam at the lower end, and building several other structures in the original channel to trap and hold migrating fish. These structures have historically blocked fish passage to the upper reaches of Icicle Creek, and have interfered with sediment flow to the lower Icicle. An estimated 36,000 cubic meters of sediment is stored by the various hatchery structures (Lorang et al. 2000).

The focus of this study is the lower approximately 3 miles of Icicle Creek, from just below the hatchery to the mouth at the Wenatchee River. As mentioned above, this portion of the creek is relatively flat, with an average gradient of 0.17 percent. Land along this reach is used for residences and for agricultural purposes, mostly hay production and/or grazing.

Historically, landowners have protected their property by installing a variety of bank protection measures, including rip-rap armoring and barbs. In 1972, a flood caused a meander to be cut off near RM 1.5. The eroded banks causing the cut-off were later repaired with rip-rap. Figure 5 shows the locations of bank protection projects.

### *SPECIES USE*

This portion of the Icicle provides valuable habitat for a number aquatic and terrestrial species, including several that are threatened or endangered (The Watershed Company, 2003). The federally listed species known to occur in the vicinity are listed in Table 1. Degradation and loss of spawning and rearing habitat is one factor that has contributed to the decline of the fish species that use the Icicle.

**Table 1. Federally listed species known to occur in Icicle Creek**

| Species | Federal Status | ESU/DPS/Region | Critical Habitat |
|---|---|---|---|
| Chinook salmon<br>Oncorhynchus tshawytscha | Endangered 1999[1] | Upper Columbia River Spring-run ESU | Withdrawn |
| Steelhead<br>*Oncorhynchus mykiss* | Endangered 1997[2] | Upper Columbia River ESU | Withdrawn |
| Bull trout<br>*Salvelinus confluentus* | Threatened 1998[3] | Columbia River DPS | Proposed |
| Bald eagle<br>*Haliaeetus leucocephalus* | Threatened[4]; 1999[5]-Proposed Delisting | Pacific Recovery Region | NO |
| Northern spotted owl<br>*Strix occidentalis caurina* | Threatened 1990[6] | NA | YES |
| Western yellow-billed cuckoo<br>*Coccyzus Americanus* | Candidate 2001[7] | NA | NO |
| Canada lynx<br>*Lynx canadensis* | Threatened 2000[8] | Contiguous U.S. DPS | NO |
| Ute ladies'-tresses<br>*Spiranthes diluvialis* | Threatened 1992[9] | NA | NO |
| Wenatchee Mountains checkermallow<br>*Sidalcea oregana* var. *calva* | Endangered 1999[10] | NA | YES |
| Showy stickseed<br>*Hackelia Venusta* | Endangered 2002[11] | NA | NO |

***Reference for Table 1 on Previous Page:***

[1] U.S. Federal Register, 24 March 1999.
[2] U.S. Federal Register, 18 August 1997.
[3] U.S. Federal Register, 10 June 1998.
[4] U.S. Federal Register, 12 July 1995.
[5] U.S. Federal Register, 6 July 1999.
[6] U.S. Federal Register, 26 June 1990.
[7] U.S. Federal Register, 25 July 2001.
[8] U.S. Federal Register, 24 March 2000.
[9] U.S. Federal Register, 17 January 1992.
[10] U.S. Federal Register, 22 December 1999.
[11] U.S. Federal Register, 6 February 2002.

### Upper Columbia River Spring-run Chinook Salmon

The Upper Columbia River (UCR) spring-run chinook ESU includes stream-type chinook salmon spawning in the Wenatchee, Entiat, and Methow Rivers and their tributaries, as well as hatchery populations from Chiwawa River, Methow River, Twisp River, Chewuch River, White River, and Nason Creek; fish from the Leavenworth National Fish Hatchery (LNFH) are not included (Myers et al. 1998; U.S. Federal Register, 24 March 1999). Adults enter the rivers from mid-April through July, and hold in deep pools with cover until spawning, which occurs from late July through September (Bugert et al. 1998).

UCR spring chinook spawning occurs in the Wenatchee River system at elevations from 500 to 1500 meters (Myers et al. 1998), including both the White River and Icicle Creek. The major spawning areas are above Tumwater Canyon in the Chiwawa River, Nason Creek, White River, Little Wenatchee River, and the mainstem of the Wenatchee River between Chiwaukum Creek and Lake Wenatchee (Chelan County P.U.D. No. 1. 1998). Spring chinook also spawn in Icicle Creek, below LNFH spillway, which blocks access to the upper watershed. It is believed that the majority of spawners below the spillway are of hatchery origin (Bugert et al. 1998). From 1958 to 1999, the number of redds in Icicle Creek below the spillway represented 7.69 percent of all redds in the Wenatchee River watershed, with redd counts from that period ranging from a high of 178 in 1975 to a low of 6 in 1999 (Andonaegui 2001). Adult spring chinook return to LNFH from May through July.

In the Wenatchee River Watershed, chinook fry emerge from the gravel in late March through early May, and generally spend their first summer in the subbasin before migrating downstream in late fall through spring. However, at least eleven different life-history strategies have been observed, ranging from spawning, rearing, and overwintering in upper-reach tributaries above Tumwater Canyon, to spawning and rearing in lower-reach tributaries and outmigrating in the fall/winter (Bugert et al. 1998). Based on data from the watershed, the majority of outmigrating spring chinook juveniles that are progeny of naturally spawned fish leave lower Icicle Creek between mid-April and mid-June, with the peak of outmigration in mid-May. Additionally, the Leavenworth National Fish Hatchery releases approximately 1.625 million spring chinook smolts in mid-April.

UCR chinook have exhibited a decreasing trend in abundance and productivity. The average recent escapement to the ESU has been less than 5,000 hatchery and wild chinook combined; all individual populations consist of less than 100 fish. Additionally, the genetic integrity of most remnant natural populations has been altered by hybridization with hatchery stocks. To date, there have been at least six known spring-chinook extinctions in this ESU (U.S. Federal Register, 24 March 1999). A dramatic increase in escapement observed in 2001 has been attributed to substantial improvement in ocean conditions resulting from natural interdecadal climate cycles in the North Pacific Ocean.

Factors influencing the overall decline of UCR chinook are hydropower development on the Columbia River, past excessive harvest, homogenization of UCR stocks due to hatchery management, changes in habitat availability and suitability resulting from water diversions, and degradation and loss of spawning and rearing habitat resulting from land-use practices. It is intended that this study will serve as a basis for the design of habitat improvements for UCR chinook and other salmond fish along lower Icicle Creek.

### Upper Columbia River Steelhead

The Upper Columbia River ESU consists of steelhead spawning in Columbia River tributary systems upstream from the Yakima River to the Canadian border, specifically the Wenatchee, Entiat, Methow, and Okanogan Rivers and their tributaries (U.S. Federal Register, 18 August 1997). In the Wenatchee River basin, this stock utilizes both the White River and Icicle Creek. The upper Columbia River steelhead are a summer run stock, with adult upstream migration passing Rocky Island and Wells Dams from July through early November (Chelan County P.U.D. No. 1. 1998). Spawning occurs the following year (March through July) (Chelan County P.U.D. No. 1. 1998). Fry emerge from the gravel in July through September, and typically remain in freshwater generally two or three years (U.S. Federal Register, 18 August 1997; Chelan County P.U.D. No. 1. 1998). Smolt outmigration past Rock Island Dam peaks in mid-May, but ranges from April to early July (Chelan County P.U.D. No. 1. 1998).

While hatchery releases to Icicle Creek by both the LNFH and the Washington Department of Fish and Wildlife (WDFW) since 1940 have been substantial, there is evidence that Icicle Creek has historically produced wild steelhead (USFWS 2001). Since the commencement of adipose-fin clipping of hatchery steelhead in 1986, the contribution of wild fish to the total number of spawners in Icicle Creek has ranged from a high of 41 percent to a low of 4 percent for years with available data (USFWS 2001). Year 2000 WDFW spawner surveys between March 3 and May 20 in lower Icicle Creek recorded 20 redds and 20 adults with an estimate of 40 to 50 total adults (USFWS 2001).

As with UCR spring chinook (above), UCR steelhead in the Wenatchee River system, exhibit a wide range of life history types. Juveniles spend two to seven years rearing in headwater streams and/or the mainstem Wenatchee, and some juveniles from any year class would be almost continually rearing or outmigrating throughout the year (Chelan County P.U.D. No. 1. 1998).

The natural production level of UCR steelhead is very low. For UCR steelhead, production has remained relatively constant in the major rivers of the ESU (Wenatchee, Methow, and Okanogan). Five-year natural escapement levels (1989-93) averaged 800 steelhead in the Wenatchee River and 450 steelhead in the Methow and Okanogan rivers combined. Natural production consistently falls below the 1:1 replacement level; up to 80% of total production is from hatcheries. Based on analyses of population size and production levels UCR steelhead are not capable of maintaining self-sustaining populations at this time (U.S. Federal Register, 18 August 1997).

Factors influencing the overall decline of steelhead are similar to UCR chinook: hydropower development on the Columbia River, past excessive harvest, homogenization of UCR stocks due to hatchery management, changes in habitat availability and suitability resulting from water diversions, and degradation and loss of spawning and rearing habitat resulting from land-use practices. Also as for UCR spring chinook, this study is intended to serve as a basis for habitat improvements along lower Icicle Creek to the benefit of UCR steelhead.

### Columbia River Bull Trout

The collective citation for the bulk of this description follows: Brown (1992), Rieman and McIntyre (1993), Sanborn et al. (1998), and U.S. Federal Register (1 November 1999); with information from other sources cited separately. The action area is within the Upper-Columbia River Recovery Unit 21 (between the Yakima River confluence and Chief Joseph Dam). Subpopulations of bull trout within the mid-Columbia DPS that are nearest to the study areas include six migratory subpopulations in the Wenatchee River and one resident subpopulation in upper Icicle Creek (U.S. Federal Register 29 November 2002). Recent evidence indicates that at least some fluvial bull trout are apparently able to negotiate a suspected passage barrier to reach the upper reaches of Icicle Creek (De La Vergne, pers. comm.).

Several life history forms occur, and all may be present within the same population. Fish exhibiting the resident life history strategy are non-migratory, spending their entire lives within their spawning stream. Migratory life history strategies include fluvial, adfluvial, and anadromous. Migratory bull trout reside as adults and subadults in larger rivers (fluvial), lakes or reservoirs (adfluvial), or marine waters (anadromous), and spawn and rear as juveniles in headwater tributaries. Bull trout exhibiting a migratory life history strategy range widely, and can be expected in tributaries that do not support spawning unless obstructed by a passage barrier. Recent tagging experiments at Rock Island, Rocky Reach, and Wells dams have detected substantial movement of tagged adults between the mainstem of the Columbia River and the Wenatchee, Entiat, Methow, and Okanogan Rivers and their tributaries (Chelan County P.U.D. No. 1. 2001)

All of the subpopulations of bull trout in the Wenatchee basin for which spawn timing is known spawn in September and October (WDFW 1998). Spawning migrations occur during the summer, but may start as early as April in some systems (Ratliff et al. 1996). Upstream movement of adult bull trout begins in May at Rocky Reach Dam (BioAnalysts, 2004). Upstream migrating bull trout are passing Tumwater Dam on the Wenatchee River from June through mid-October (Murdoch, pers. comm., 26 May 2000). Following spawning, adult bull trout move downstream quickly, remaining in deep pools in larger rivers, or in lakes for the winter. Spawned-out bull trout have been observed in November on salmon spawning grounds feeding on loose eggs (Kraemer in prep.).

Radio-telemetry studies have expanded our knowledge of local bull trout migratory behavior. Of eight bull trout that had been radio-tagged in the Columbia River and subsequently entered the Wenatchee River, five entered the Wenatchee River in late June, and the remaining fish entered between mid-July and late-September (BioAnalysts, Inc. 2002). Five of those fish remained in the Wenatchee River through the winter, and the other three left in November and early December. One of fish entered Icicle Creek in late-June and returned to the Columbia River by mid-December. Tracking studies of fish tagged at the hatchery have shown that migratory bull trout move back and forth between the hatchery and Blackbird Island on the Wenatchee River near the town of Leavenworth (De La Vergne, pers. comm.).

Bull trout are rarely found in streams with summer temperatures that exceed 15°C. Cold groundwater seeps can provide temperature refuge for bull trout in streams with summer temperatures that exceed 15°C. Temperatures in Icicle Creek can exceed 15°C during July and August (Andonaegui 2001). Juveniles disperse widely from the spawning area, and may be present even in tributaries that do not support spawning unless obstructed by a passage barrier. Juveniles that adopt a migratory life history strategy usually move downstream to a mainstem river, lake, or ocean following two or three years of rearing in headwater streams; the timing of this migration varies between and within systems, and is not confined to spring. Migration is possibly related to the need for a larger prey base that arises with the onset of piscivory. Non spawning migrations of adult and subadult bull trout may be in response to prey aggregations or attempts to locate thermal refuges.

Because of their intolerance of relatively moderate water temperatures (Selong et al. 2001) and turbidity, bull trout populations have declined in response to land-use activities throughout their range. Loss of woody debris, migration barriers, and competition and hybridization with introduced brook trout (*Salvelinus fontinalis*) have also contributed to their decline.

Adult bull trout could be expected along lower Icicle Creek from June through November during their upstream spawning migration and subsequent downstream migration. In other systems, non-spawning subadults often accompany spawners in their migrations. Bull trout are also known to overwinter in the lower Icicle/Blackbird island area from November through at least early March.

## *STUDY-RELATED HABITAT ELEMENTS OF LOWER ICICLE CREEK*

Habitat elements along lower Icicle Creek affecting its suitability for beneficial use by salmonid fish as addressed in this study include 1) the prevalence, configuration, and type of large woody debris in and along the stream channel, 2) the type, size, and density of streambank vegetation, and 3) the average size and gradation of the streambed substrate. All of these factors interact with the flow regime in the basin to affect channel morphology and function. Although the flow regime is affected by human activities throughout the basin, primarily through forest practices and flow diversions for irrigation and fish culture, but this study is not intended to provide a basis for recommending changes to or management of the flow regime of Icicle Creek.

### Woody Debris.

Large and small woody debris in streams provides a variety of habitat functions and helps define the shape of the channel. Woody structures provide hiding places and cover for fish, and their decomposition serves, partially, as the basis for a detrital food chain, feeding in turn microbes, aquatic insects, fish, and the predators of fish including birds, mammals, and even man. The turbulence that occurs around large woody objects at higher flows tends to scour out and maintain pools, which are an essential habitat type for fish and other aquatic species. Wood can help to armor and stabilize banks at specific locations, and can serve to dissipate and consume stream energy, thereby reducing bank erosion.

### Streambank Vegetation.

Dense stands of native vegetation along stream and river banks contribute to productive fish habitat in a number of ways. First, they provide the basis for the recruitment of detritus and both small and large woody debris to the stream channel, contributing to the physical structure of the channel and a detrital food chain, as mentioned above. Streambank vegetation also shades the channel and the water surface, limiting temperature increases. This effect is particularly important in areas such as lower Icicle Creek, where the hot, dry summer climate provides a source of thermal energy that would tend to raise stream temperatures to levels higher than preferred or even tolerated by salmonid fish. Dense bank vegetation also tends to stabilize those banks, reducing erosion and the rate of lateral channel migration. This reduction in streambank erosion and channel migration rates in turn tends to limit increases in the width/depth ratio of streams.

### Streambed Gravel

The supply to and type of substrate present in streams affect channel functioning and morphology, but also biological functioning and productivity. These two general types of functioning must be complementary to and compatible with each other for sustainable and beneficial functioning. (For example, placed spawning gravel which is too small to be stable and remain in place will only provide spawning habitat until it is scoured away.) A streambed gravel substrate of medium average size and which is somewhat poorly-graded (i. e. does not have excessive proportions of either fines or cobbles) generally serves as the best spawning habitat for salmonid fish, with larger fish generally able to utilize larger-sized substrate than smaller fish. This type of permeable gravel substrate is also well-suited for the production of aquatic insects, a primary food source for juvenile salmonid fish.

In recent years, local citizens and conservation groups have been working to improve fish habitat on the Icicle, and several important habitat improvement projects have been undertaken (Carpenter, pers. comm., August 2002). However, it has become clear that in order for future projects to be implemented in the most effective and efficient manner, a reach-level analysis is necessary to provide a framework for such projects. For this reason, the Icicle Valley Chapter of Trout Unlimited (TU) sought funding and commissioned this study.

## 2. Methodology

This study assessed the condition of the lower part of Icicle Creek using a procedure proposed by Rosgen (1996), which involves comparing its morphological characteristics and influences of one stream with a similarly classified stream in the same region. Streams need not be similar in size to be compared, but they should be in the same general hydrologic regime and have reaches with the same classification using Rosgen’s classification of natural rivers (Rosgen 1996).

Rosgen’s system classifies stream reaches based on six geomorphic variables, including:

1) Planform – single channel or multiple/braided channel
2) Sinuosity – defined as the stream slope divided by the valley slope
3) Slope – measured along the stream length from the top of one riffle to the top of another riffle
4) Sediment size – broken into several categories
5) Width/Depth ratio – unitless ratio of bankfull stream width to bankfull depth
6) Entrenchment ratio – unitless ratio of the width of the flood-prone area to the bankfull width

The particular combination of variables found on a given reach determines its classification. There are seven major categories of stream reach in this system, each with several subcategories, to yield a total of 94 unique stream classifications (see Figure 6). Simple letter/number combinations are assigned to each stream type.

The primary benefit of using Rosgen's classification for this study is that the measurements needed to classify each reach are all converted to unit-less numbers as part of the classification process. For example, rather than using channel width to classify a reach, Rosgen's system uses the ratio of width to depth. This use of unit-less metrics allows for the direct comparison of two streams with significantly different flow volumes.

Lower Icicle Creek appeared, based on preliminary estimates of stream classification, to be a Rosgen C4 or C5 stream. The nearest stream with a similar classification is the lower White River (Figure 7), with a likely Rosgen classification of C4c- or C5c-. Portions of the Chiwawa River were also examined for suitability, but while the same stream types can be found there, the gradient of the Chiwawa is significantly steeper than that of the Icicle.

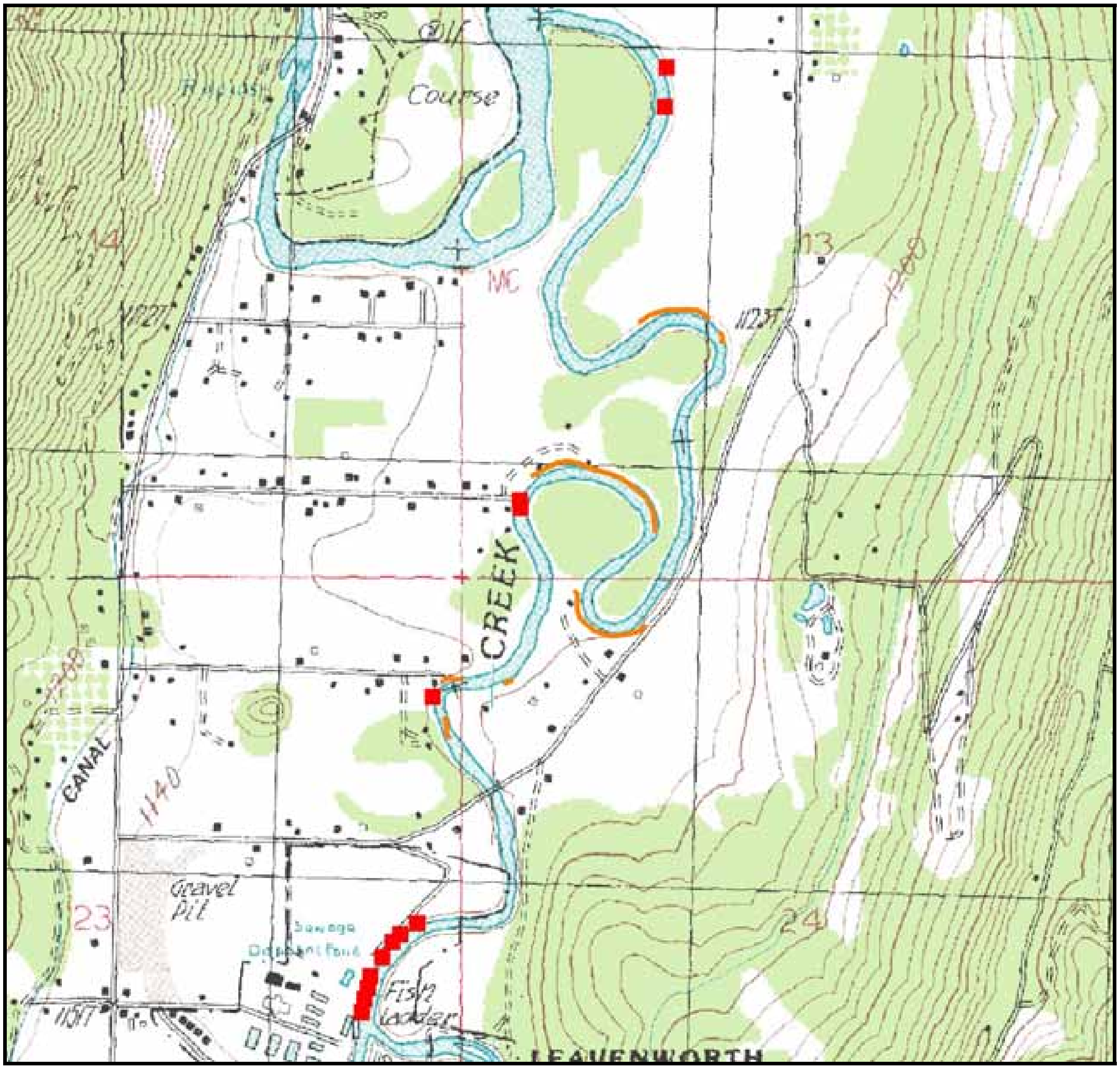


Figure 5. Shoreline modifications (after Jones & Stokes 2003).

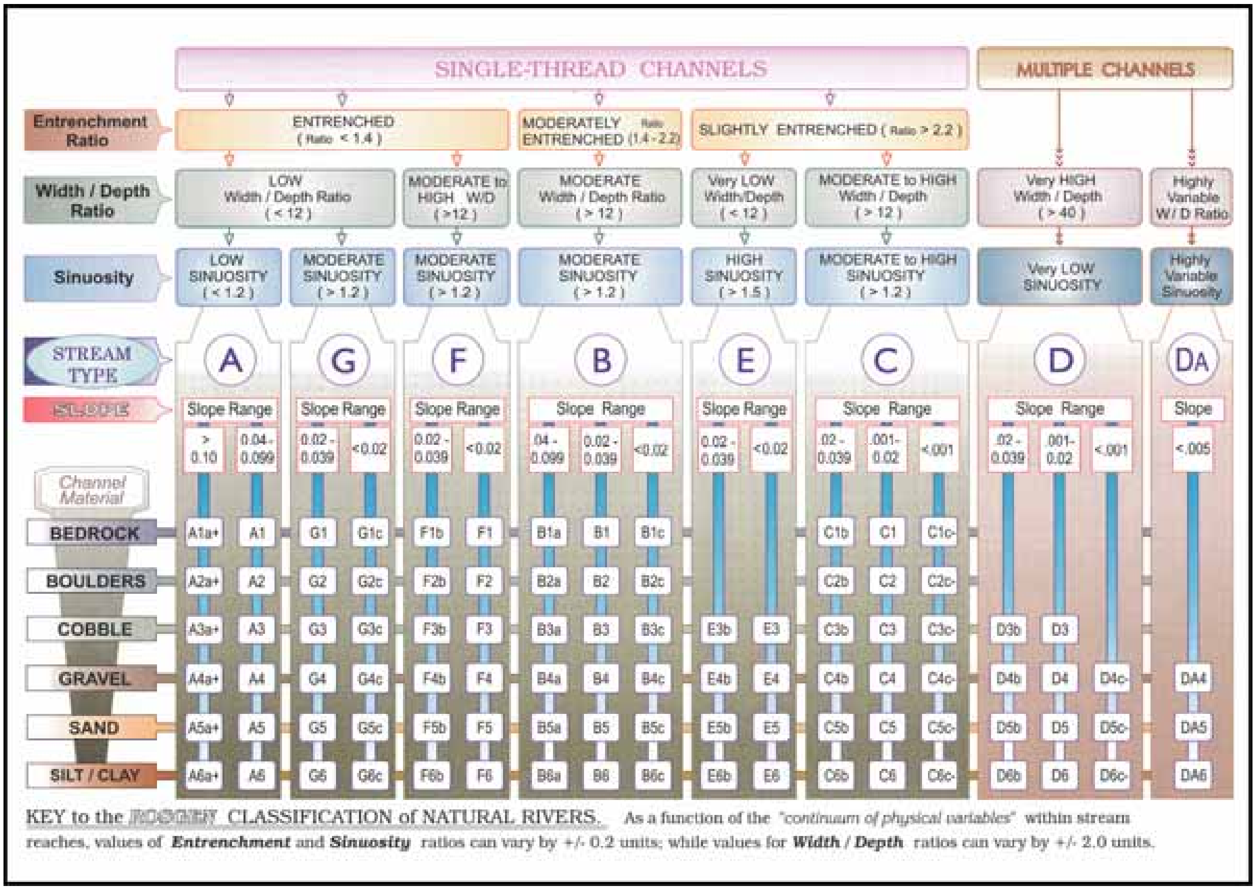


**Figure 6.** **Rosgen classification key.**

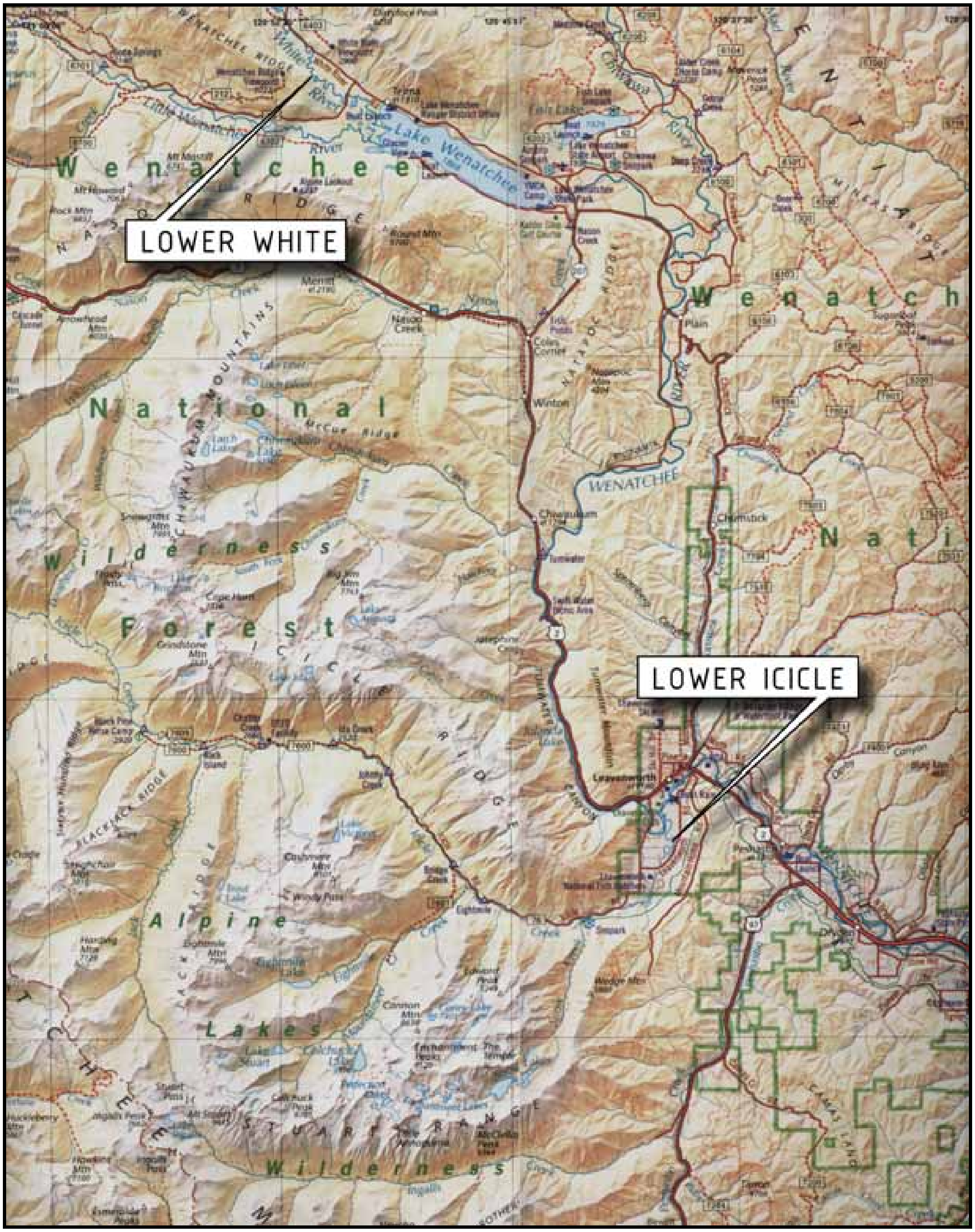


Figure 7. White River study area relative to Icicle Creek study area.

Like Icicle Creek, the White River is a tributary to the Wenatchee River. It drains an area of about 156 square miles and, while the drainage is smaller than that of the Icicle, it produces more flow to the Wenatchee than any other tributary. The upper drainage is steep and rocky, and the lower reaches, from the mouth at Lake Wenatchee to approximately RM 9, are exceptionally flat, with an average gradient of 0.04 percent. The White River Falls at RM 14.3 separates the rock-dominated upper basin from the alluvial lower basin.

The lower White River has been impacted by logging and land clearing. Cedar forest once dominated the lower basin floodplain, but now it is dominated by second-growth black cottonwood and pastureland. Some ditching has occurred to drain the lowest farmland, and some banks have been protected with rip-rap. Large woody debris is less abundant than estimated historic conditions. Overall, the river is still well connected to its floodplain (Andonaegui 2001).

Like the Icicle, the channel form of the lower White River is one of tortuous meanders. Prehistoric oxbows litter the lower floodplain, but while some channel migration has occurred during historic times, no major avulsions have been recorded or noted in the literature.

While the White River is far from pristine, it is less disturbed than the Icicle, and is commonly considered one of the less damaged watersheds in the region. Development in the lower basin is sparse compared to the Icicle, and modification to the flow or channel of the White River has been limited. Because it is similar in type, gradient and region to the Icicle, and because it is in a less disturbed condition, it can serve as a reference by which to assess the condition of the Icicle.

The first step in the comparison of Icicle Creek to the White River was to take cross-section and profile measurements of each stream. Two locations on the lower White River (Figure 8) and five locations on the lower Icicle Creek (Figure 9) were selected for cross-section measurements. Each cross-section was tied to a longitudinal profile that extended as far upstream and downstream as time and conditions allowed. At a minimum, the profile extended to the next riffle upstream or downstream to provide an accurate bed slope measurement.

At each cross-section location, the mean bankfull depth, the maximum bankfull depth, and the width of the flood-prone area were surveyed. The flood prone area is the width of the floodplain at an elevation equivalent to the channel bottom elevation plus two times the maximum channel depth. For example, if the channel bottom is at 200’ elevation, and the maximum channel depth is 6 feet, the width of the floodprone area would be the width of the floodplain at an elevation of 200’+2*6’=212’. In some instances, the bankfull width and flood-prone area were estimated where line-of-sight access was prohibitively time-consuming and the estimate could be made with enough certainty to ensure there was no adverse effect on the stream description. Channel particle size was also measured using the first-blind touch method along transects selected to reflect the relative proportion of channel bed morphology (e.g., if the channel is 30% pools and 70% riffles, transects will be selected such that 30% of the samples are taken in pools and 70% in riffles).

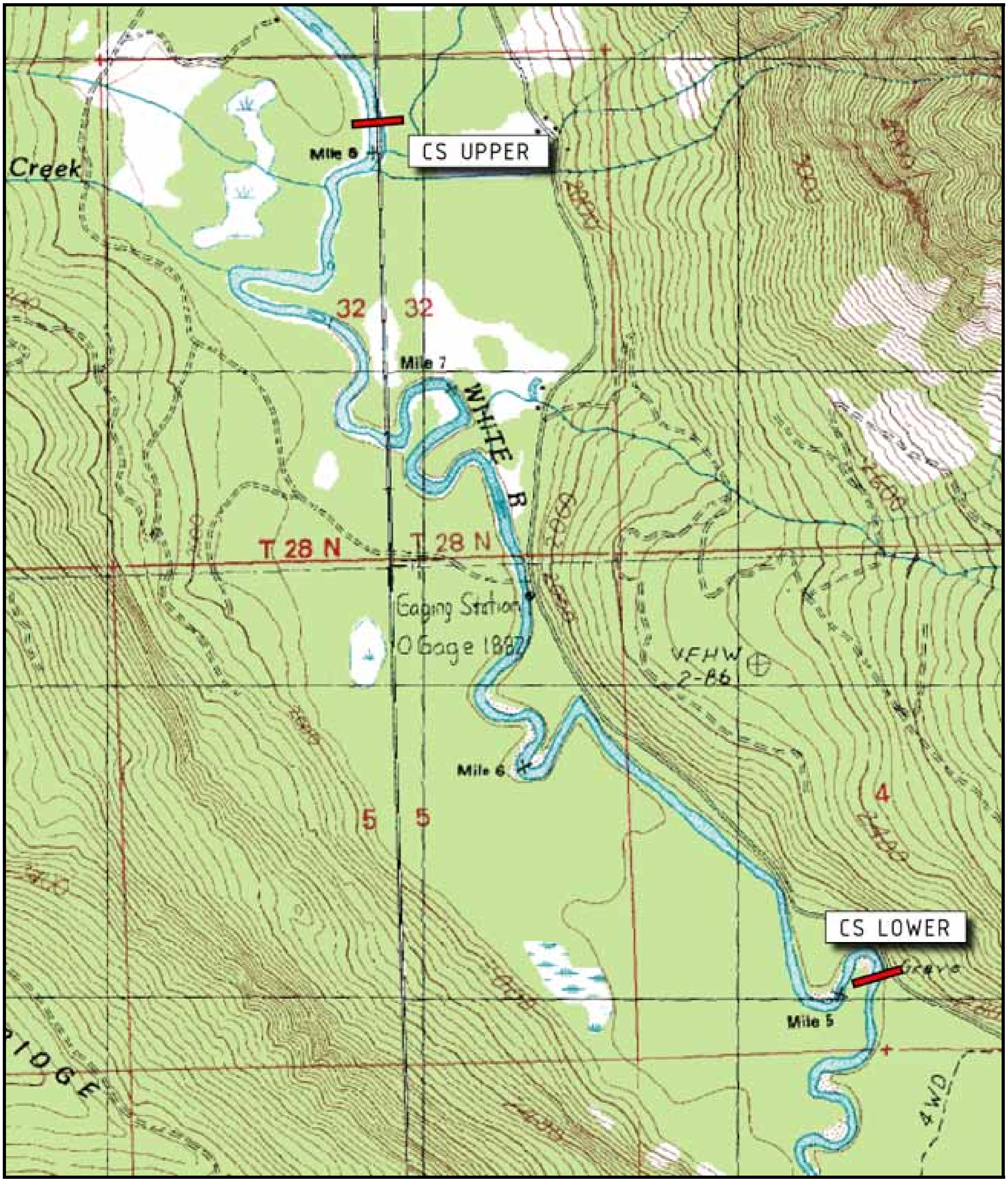


**Figure 8. White River cross-section locations.**

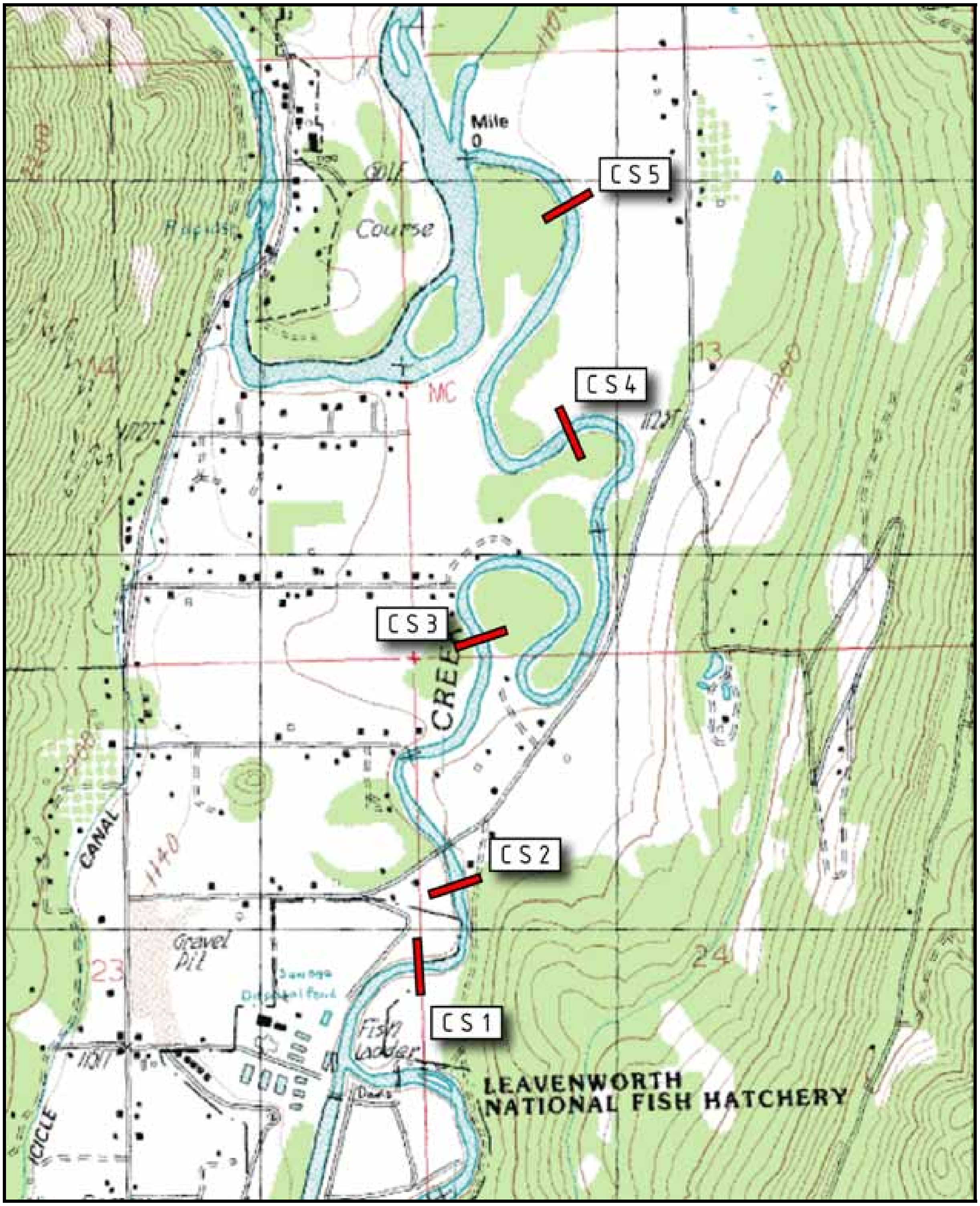


Figure 9. Icicle Creek cross-section locations.

In addition to the survey data, each cross section was examined with respect to the following channel influence variables:

1. Riparian vegetation (Table 2)
2. Streamflow regime (Table 3)
3. Stream size/order
4. Organic debris (Table 4)
5. Depositional patterns (Table 5)
6. Meander patterns (Table 6)
7. Bank Erosion Hazard Index (BEHI) (Table 7)
8. Channel stability rating (after Pfankuch 1975, and Table 8)
9. Altered channel materials/dimensions

The ratings for these variables are based on visual estimates. To maximize consistency with these estimates, the same observer assessed all channel influence variables at all sites.

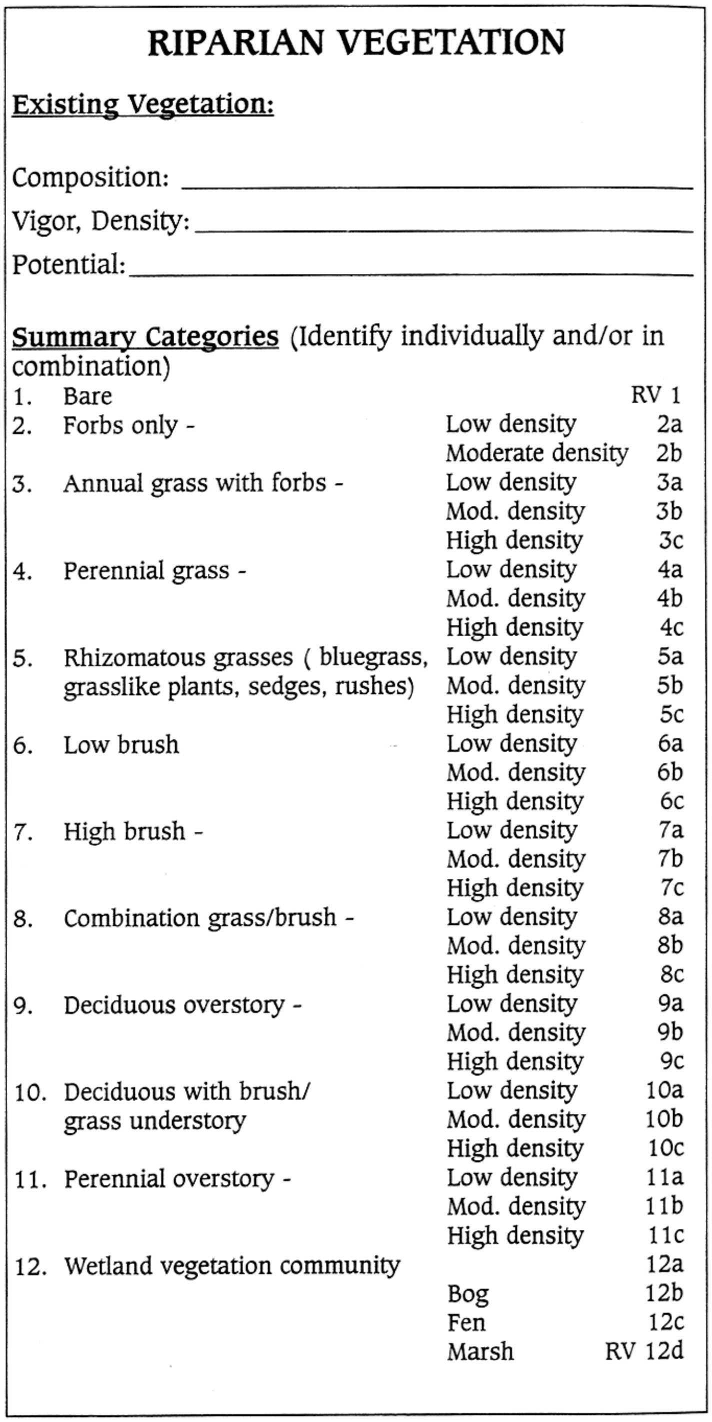
The BEHI analysis is a procedure developed by Rosgen to assess the erosion potential of stream banks on a given reach. Rosgen (2001) claims to have successfully used this methodology to accurately predict stream bank erosion rates on several rivers in the Mountain West. The methodology examines the bank heights, bankfull depths, rooting depth and density of plants on the bank, bank slope, material and layering, and bank protection, assigning a value to each variable. The values are totaled to produce an index number, which is then used in conjunction with the near bank shear stress to estimate the potential bank erosion rate in feet per year (see Figure 10).

As with the other channel influence variables, most of the parameters of the BEHI analysis are based on visual estimates, and different observers may develop significantly different conclusions. For example, estimates of rooting density have been shown to vary by as much as an order of magnitude for the same site assessed by different observers (Conley, pers. comm., September 2004). To ensure consistency, one person conducted all BEHI analyses.

The channel stability assessment used in this study is based on the Pfankuch (1975) evaluation, with additional information provide by Rosgen (1996) for each stream type. The Pfankuch evaluation uses 15 categories to examine the upper banks, the lower banks, and the channel bottom. Points are assigned to each category based on its evaluated condition, which can be assessed as excellent, good, fair, or poor. The numbers are totaled to produce a single value. In general, the higher the value, the more prone the stream is to instability. Rosgen (1996) modified the stability rating based on his stream classification. Some stream types are more prone to instability and more susceptible to disturbance than others. Therefore, one channel type may be significantly less stable than another type with the exact same Pfankuch evaluation score.

The analysis used in this study allows the development of a quantitative basis for comparing similar reaches on two streams. From that comparison, the actual condition of the reference reach is assumed to be the potential condition of the study reach. In this study, Icicle Creek is the study stream, and the White River is the reference stream. The comparison allows for the determination of how far and in what ways the Icicle has departed from its potential stability

**Table 2. Riparian Vegetation Classification (Rosgen 1996).**



## RIPARIAN VEGETATION

**Existing Vegetation:**

Composition: ____________________

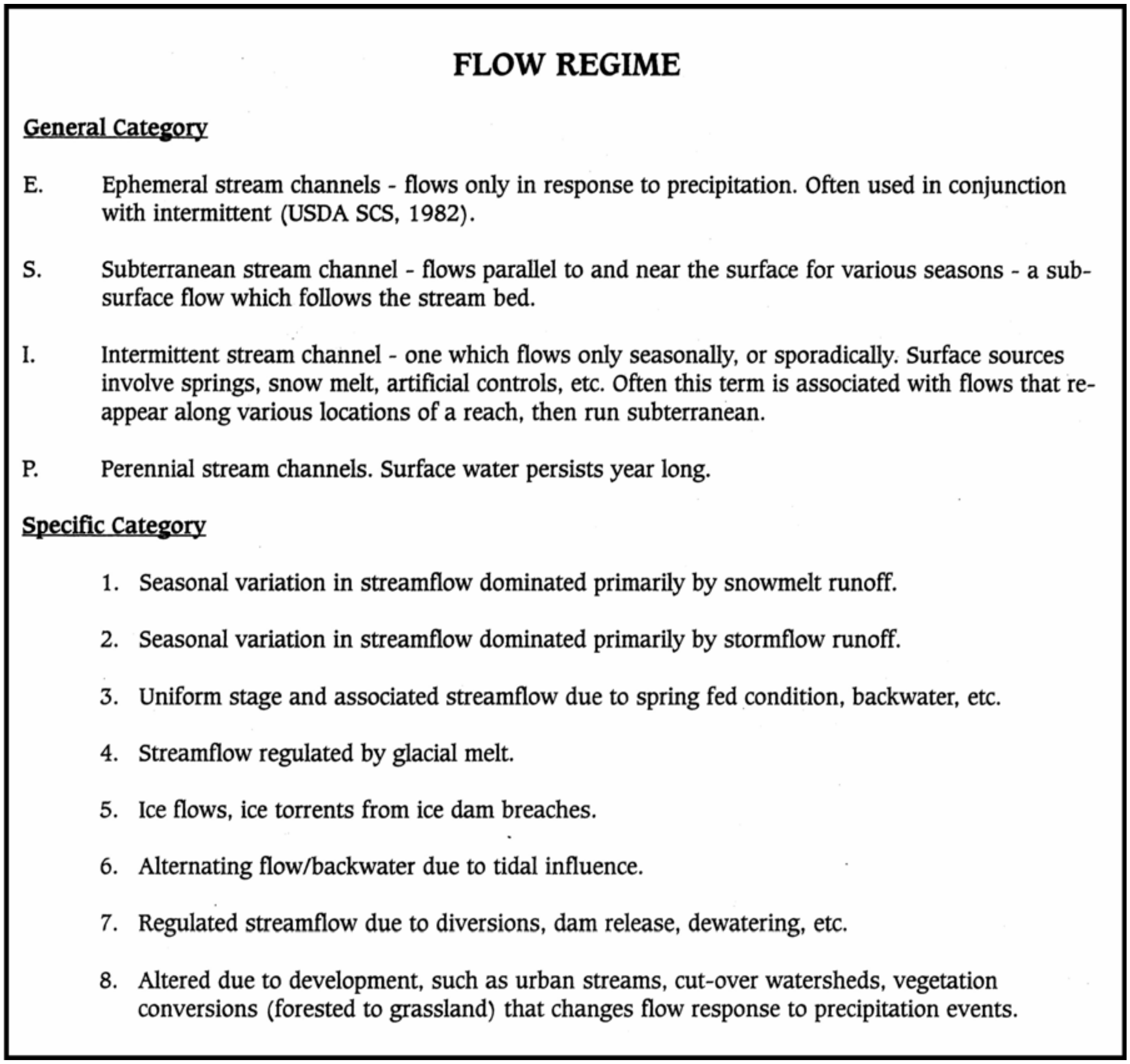
Vigor, Density: ____________________

Potential: ____________________

**Summary Categories** (Identify individually and/or in combination)

| | | | |
|---|---|---|---|
| 1. | Bare | | RV 1 |
| 2. | Forbs only - | Low density | 2a |
| | | Moderate density | 2b |
| 3. | Annual grass with forbs - | Low density | 3a |
| | | Mod. density | 3b |
| | | High density | 3c |
| 4. | Perennial grass - | Low density | 4a |
| | | Mod. density | 4b |
| | | High density | 4c |
| 5. | Rhizomatous grasses ( bluegrass, grasslike plants, sedges, rushes) | Low density | 5a |
| | | Mod. density | 5b |
| | | High density | 5c |
| 6. | Low brush | Low density | 6a |
| | | Mod. density | 6b |
| | | High density | 6c |
| 7. | High brush - | Low density | 7a |
| | | Mod. density | 7b |
| | | High density | 7c |
| 8. | Combination grass/brush - | Low density | 8a |
| | | Mod. density | 8b |
| | | High density | 8c |
| 9. | Deciduous overstory - | Low density | 9a |
| | | Mod. density | 9b |
| | | High density | 9c |
| 10. | Deciduous with brush/ grass understory | Low density | 10a |
| | | Mod. density | 10b |
| | | High density | 10c |
| 11. | Perennial overstory - | Low density | 11a |
| | | Mod. density | 11b |
| | | High density | 11c |
| 12. | Wetland vegetation community | | 12a |
| | | Bog | 12b |
| | | Fen | 12c |
| | | Marsh | RV 12d |

**Table 3. Flow Regime Classification (Rosgen 1996).**



## FLOW REGIME

**General Category**

E. Ephemeral stream channels - flows only in response to precipitation. Often used in conjunction with intermittent (USDA SCS, 1982).

S. Subterranean stream channel - flows parallel to and near the surface for various seasons - a sub-surface flow which follows the stream bed.

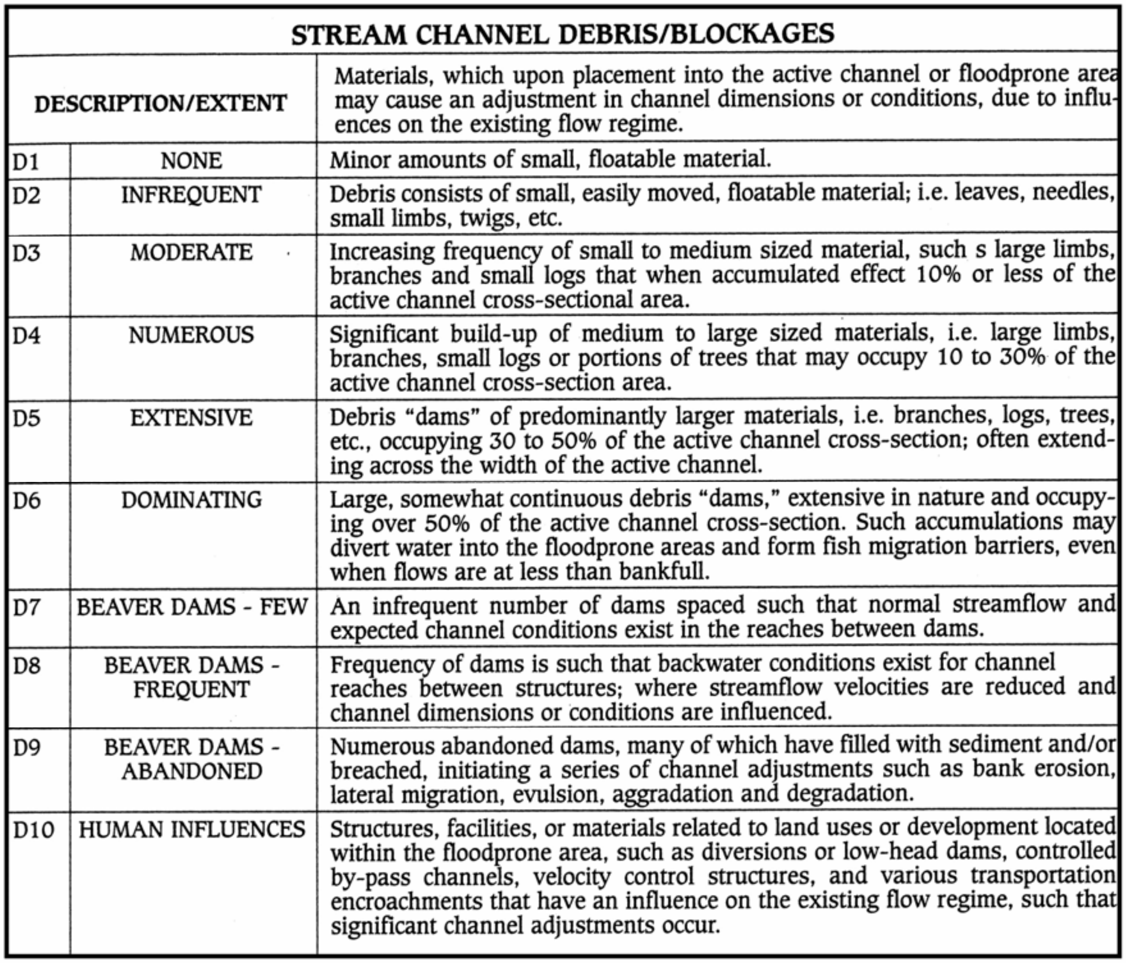
I. Intermittent stream channel - one which flows only seasonally, or sporadically. Surface sources involve springs, snow melt, artificial controls, etc. Often this term is associated with flows that re-appear along various locations of a reach, then run subterranean.

P. Perennial stream channels. Surface water persists year long.

**Specific Category**

1. Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2. Seasonal variation in streamflow dominated primarily by stormflow runoff.
3. Uniform stage and associated streamflow due to spring fed condition, backwater, etc.
4. Streamflow regulated by glacial melt.
5. Ice flows, ice torrents from ice dam breaches.
6. Alternating flow/backwater due to tidal influence.
7. Regulated streamflow due to diversions, dam release, dewatering, etc.
8. Altered due to development, such as urban streams, cut-over watersheds, vegetation conversions (forested to grassland) that changes flow response to precipitation events.

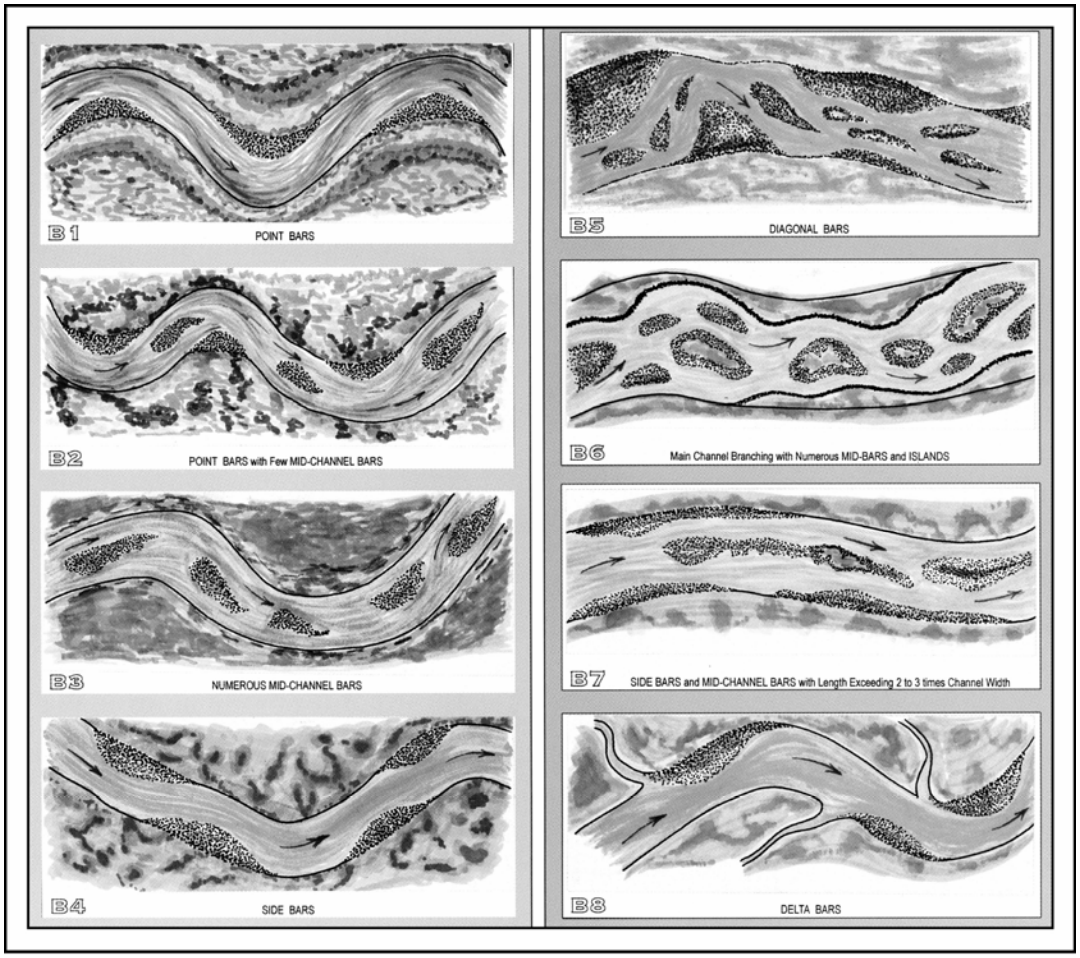
**Table 4. Debris Classification (Rosgen 1996).**

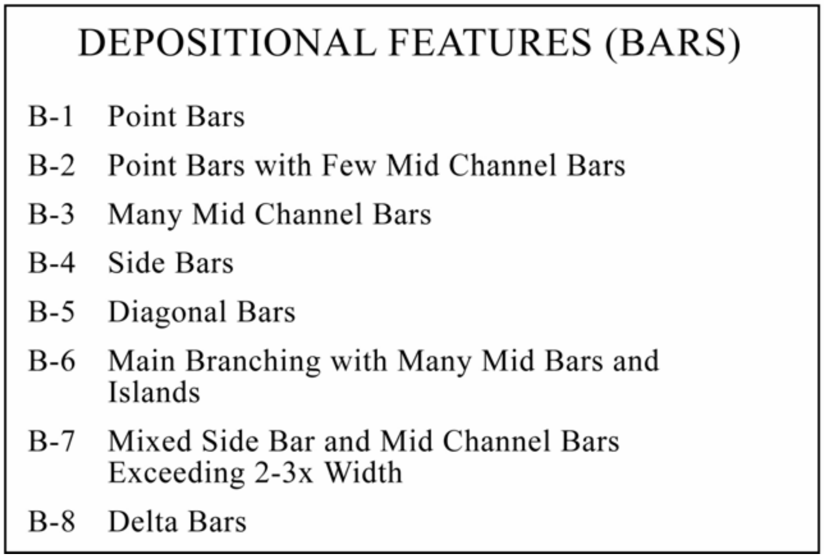


**STREAM CHANNEL DEBRIS/BLOCKAGES**

| DESCRIPTION/EXTENT | | Materials, which upon placement into the active channel or floodprone area may cause an adjustment in channel dimensions or conditions, due to influences on the existing flow regime. |
|---|---|---|
| D1 | NONE | Minor amounts of small, floatable material. |
| D2 | INFREQUENT | Debris consists of small, easily moved, floatable material; i.e. leaves, needles, small limbs, twigs, etc. |
| D3 | MODERATE | Increasing frequency of small to medium sized material, such s large limbs, branches and small logs that when accumulated effect 10% or less of the active channel cross-sectional area. |
| D4 | NUMEROUS | Significant build-up of medium to large sized materials, i.e. large limbs, branches, small logs or portions of trees that may occupy 10 to 30% of the active channel cross-section area. |
| D5 | EXTENSIVE | Debris "dams" of predominantly larger materials, i.e. branches, logs, trees, etc., occupying 30 to 50% of the active channel cross-section; often extending across the width of the active channel. |
| D6 | DOMINATING | Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section. Such accumulations may divert water into the floodprone areas and form fish migration barriers, even when flows are at less than bankfull. |
| D7 | BEAVER DAMS - FEW | An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams. |
| D8 | BEAVER DAMS - FREQUENT | Frequency of dams is such that backwater conditions exist for channel reaches between structures; where streamflow velocities are reduced and channel dimensions or conditions are influenced. |
| D9 | BEAVER DAMS - ABANDONED | Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments such as bank erosion, lateral migration, evulsion, aggradation and degradation. |
| D10 | HUMAN INFLUENCES | Structures, facilities, or materials related to land uses or development located within the floodprone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures, and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur. |

**Table 5. Depositional Pattern Classification (Rosgen 1996).**

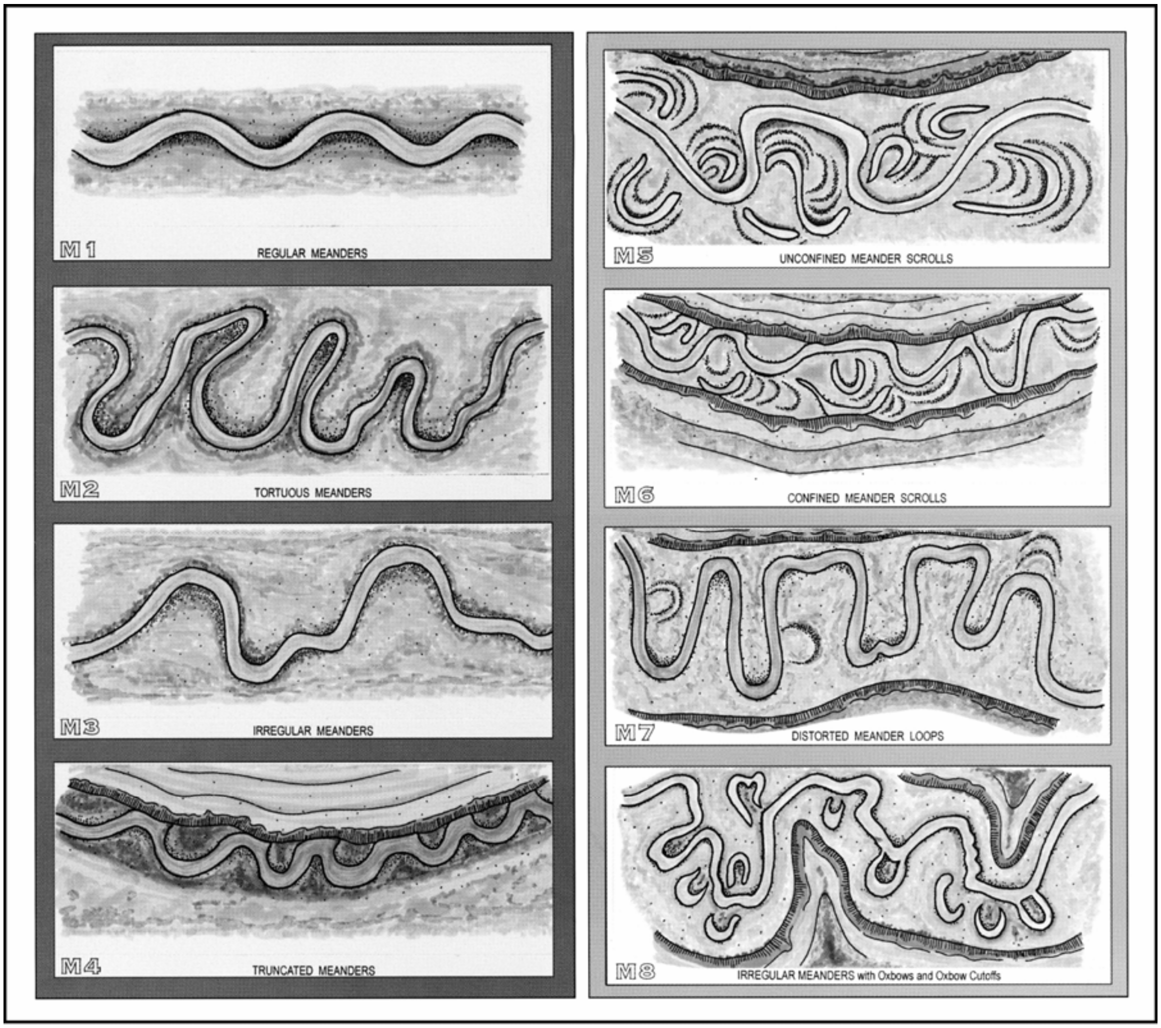


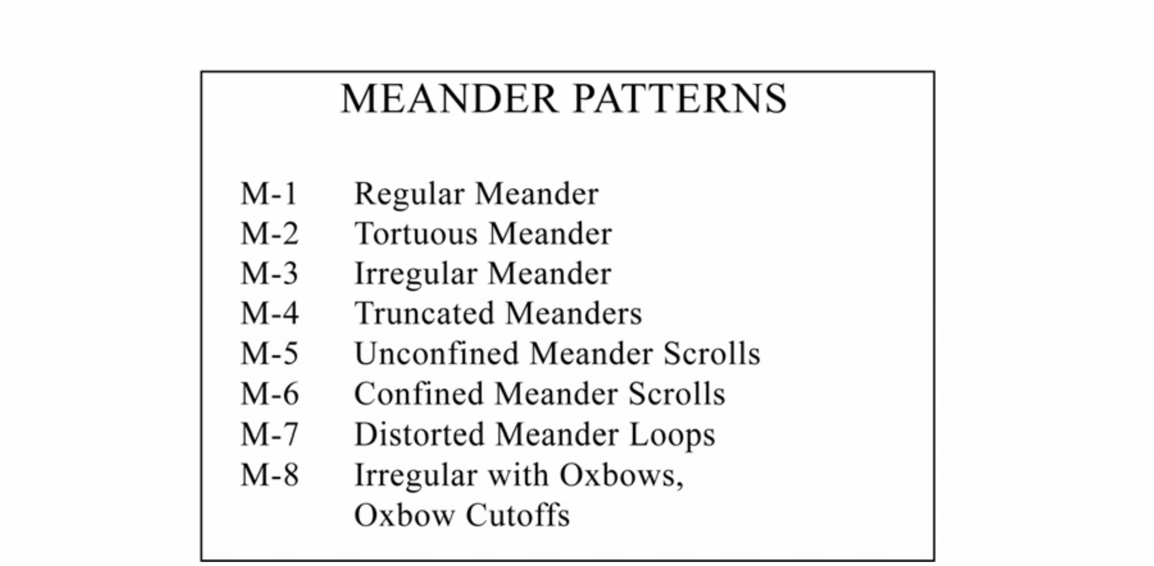


DEPOSITIONAL FEATURES (BARS)

| | |
|---|---|
| B-1 | Point Bars |
| B-2 | Point Bars with Few Mid Channel Bars |
| B-3 | Many Mid Channel Bars |
| B-4 | Side Bars |
| B-5 | Diagonal Bars |
| B-6 | Main Branching with Many Mid Bars and Islands |
| B-7 | Mixed Side Bar and Mid Channel Bars Exceeding 2-3x Width |
| B-8 | Delta Bars |

**Table 6. Meander Pattern Classification (Rosgen 1996).**

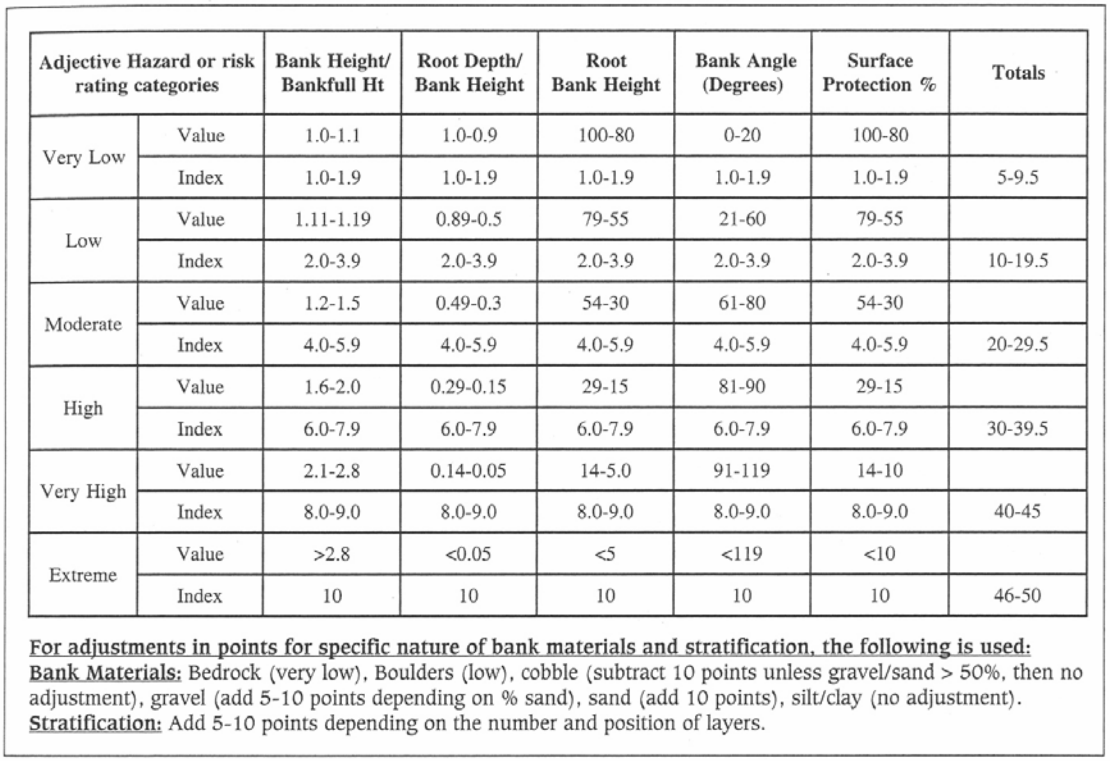




MEANDER PATTERNS

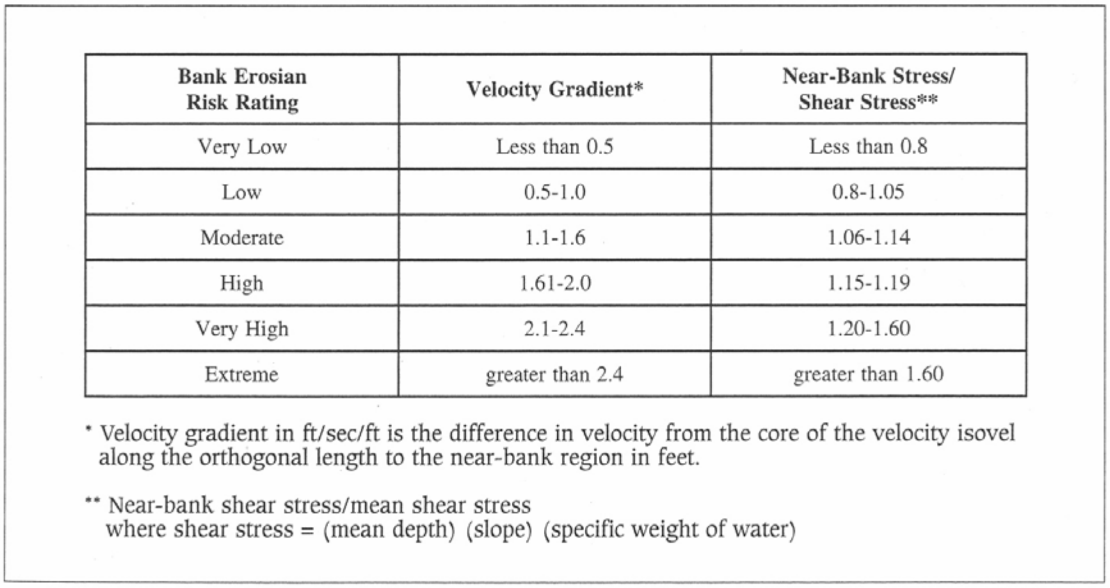
| | |
|---|---|
| M-1 | Regular Meander |
| M-2 | Tortuous Meander |
| M-3 | Irregular Meander |
| M-4 | Truncated Meanders |
| M-5 | Unconfined Meander Scrolls |
| M-6 | Confined Meander Scrolls |
| M-7 | Distorted Meander Loops |
| M-8 | Irregular with Oxbows, Oxbow Cutoffs |

**Table 7. BEHI Analysis Factors (Rosgen 1996).**



| Adjective Hazard or risk rating categories | | Bank Height/ Bankfull Ht | Root Depth/ Bank Height | Root Bank Height | Bank Angle (Degrees) | Surface Protection % | Totals |
|---|---|---|---|---|---|---|---|
| Very Low | Value | 1.0-1.1 | 1.0-0.9 | 100-80 | 0-20 | 100-80 | |
| | Index | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 | 1.0-1.9 | 5-9.5 |
| Low | Value | 1.11-1.19 | 0.89-0.5 | 79-55 | 21-60 | 79-55 | |
| | Index | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 | 2.0-3.9 | 10-19.5 |
| Moderate | Value | 1.2-1.5 | 0.49-0.3 | 54-30 | 61-80 | 54-30 | |
| | Index | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 | 4.0-5.9 | 20-29.5 |
| High | Value | 1.6-2.0 | 0.29-0.15 | 29-15 | 81-90 | 29-15 | |
| | Index | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 | 6.0-7.9 | 30-39.5 |
| Very High | Value | 2.1-2.8 | 0.14-0.05 | 14-5.0 | 91-119 | 14-10 | |
| | Index | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 | 8.0-9.0 | 40-45 |
| Extreme | Value | >2.8 | <0.05 | <5 | <119 | <10 | |
| | Index | 10 | 10 | 10 | 10 | 10 | 46-50 |

**For adjustments in points for specific nature of bank materials and stratification, the following is used:**
**Bank Materials:** Bedrock (very low), Boulders (low), cobble (subtract 10 points unless gravel/sand > 50%, then no adjustment), gravel (add 5-10 points depending on % sand), sand (add 10 points), silt/clay (no adjustment).
**Stratification:** Add 5-10 points depending on the number and position of layers.

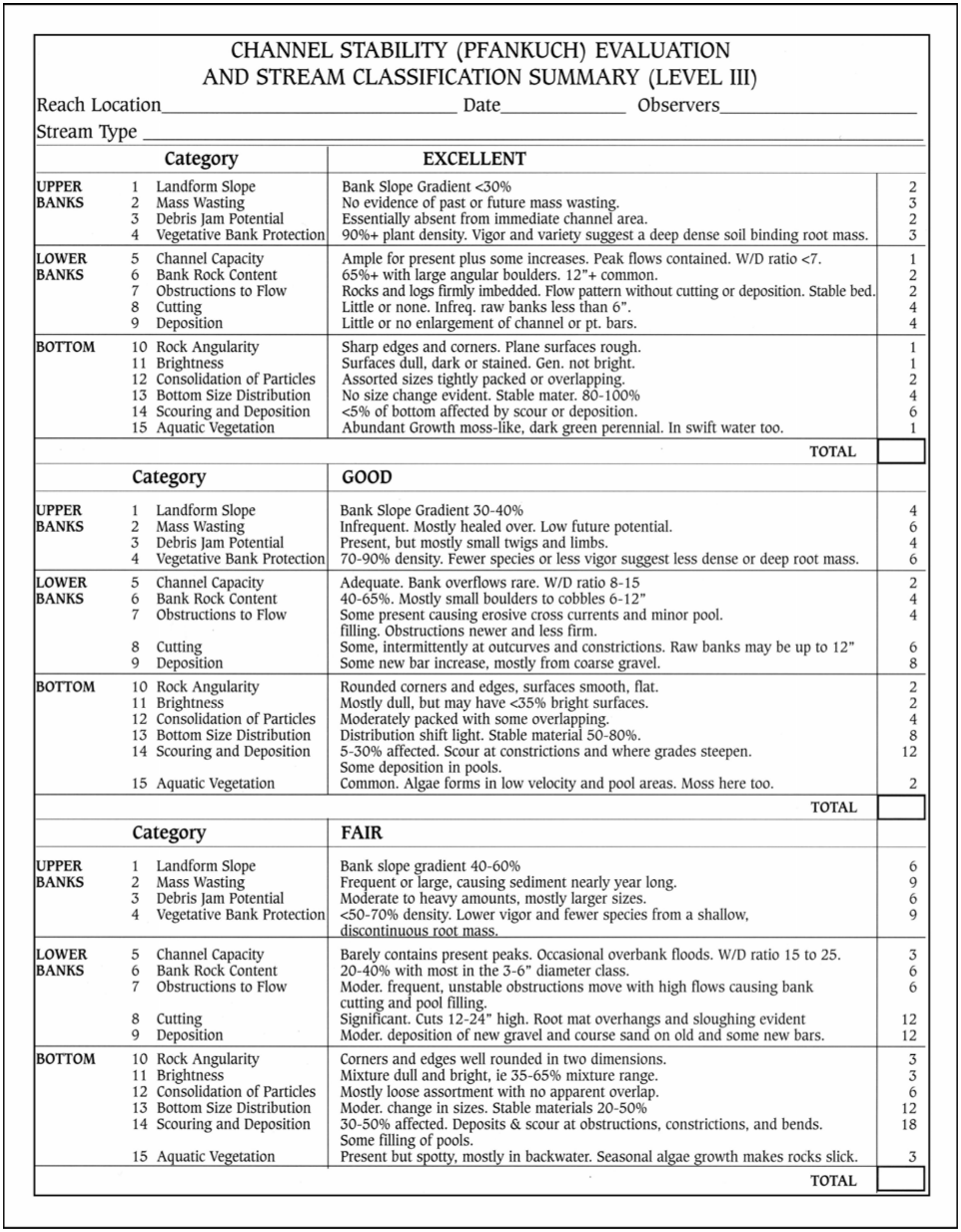


| Bank Erosian Risk Rating | Velocity Gradient* | Near-Bank Stress/ Shear Stress** |
|---|---|---|
| Very Low | Less than 0.5 | Less than 0.8 |
| Low | 0.5-1.0 | 0.8-1.05 |
| Moderate | 1.1-1.6 | 1.06-1.14 |
| High | 1.61-2.0 | 1.15-1.19 |
| Very High | 2.1-2.4 | 1.20-1.60 |
| Extreme | greater than 2.4 | greater than 1.60 |

* Velocity gradient in ft/sec/ft is the difference in velocity from the core of the velocity isovel along the orthogonal length to the near-bank region in feet.

** Near-bank shear stress/mean shear stress
where shear stress = (mean depth) (slope) (specific weight of water)

**Table 8. Pfankuch Stability Rating Part 1 (Rosgen 1996).**



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

Reach Location______________________________ Date_____________ Observers____________________

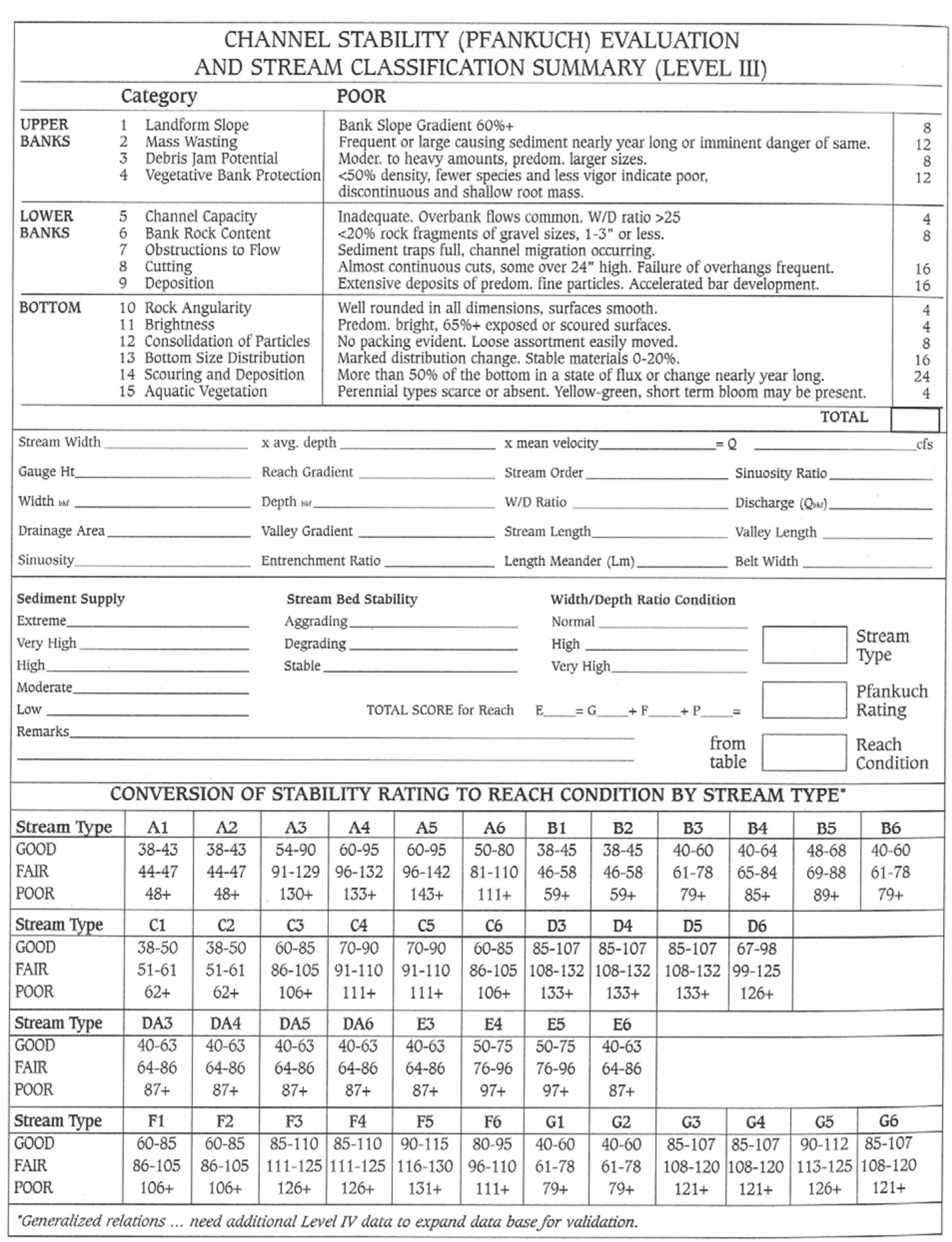
Stream Type ________________________________________________________________

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | 3 |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | 2 |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | 1 |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | 2 |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | ☐ |

| | | Category | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | 6 |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | 8 |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | 2 |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | 2 |
| | | | TOTAL | ☐ |

| | | Category | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | 12 |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | 3 |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | 6 |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | 12 |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | 3 |
| | | | TOTAL | ☐ |

**Table 9. Pfankuch Stability Rating Part 2 (Rosgen 1996).**



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | 8 |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | **TOTAL** | |

Stream Width ________ x avg. depth ________ x mean velocity ________ = Q ________ cfs

Gauge Ht ________ Reach Gradient ________ Stream Order ________ Sinuosity Ratio ________

Width $_{bkf}$ ________ Depth $_{bkf}$ ________ W/D Ratio ________ Discharge ($Q_{bkf}$) ________

Drainage Area ________ Valley Gradient ________ Stream Length ________ Valley Length ________

Sinuosity ________ Entrenchment Ratio ________ Length Meander (Lm) ________ Belt Width ________

**Sediment Supply**
Extreme ________
Very High ________
High ________
Moderate ________
Low ________

**Stream Bed Stability**
Aggrading ________
Degrading ________
Stable ________

**Width/Depth Ratio Condition**
Normal ________
High ________
Very High ________

☐ Stream Type

TOTAL SCORE for Reach E____= G____+ F____+ P____= ☐ Pfankuch Rating

from table ☐ Reach Condition

Remarks ________________________________________

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |
| **Stream Type** | **C1** | **C2** | **C3** | **C4** | **C5** | **C6** | **D3** | **D4** | **D5** | **D6** | | |
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 | | |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 | | |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ | | |
| **Stream Type** | **DA3** | **DA4** | **DA5** | **DA6** | **E3** | **E4** | **E5** | **E6** | | | | |
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | | | | |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | | | | |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | | | | |
| **Stream Type** | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **G1** | **G2** | **G3** | **G4** | **G5** | **G6** |
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

**Generalized relations ... need additional Level IV data to expand data base for validation.*

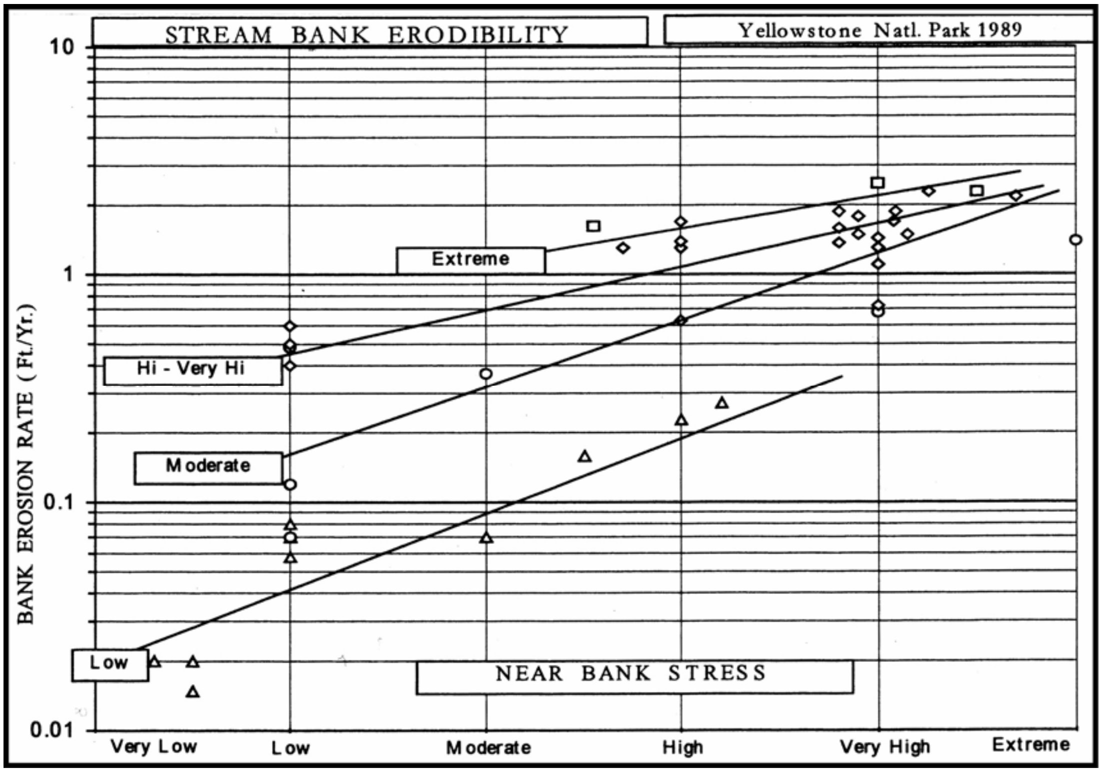


**Figure 10. BEHI Erosion Rate Determination.**

condition, i.e. the White River. In this context, the term “stability” refers to a state of dynamic equilibrium, in which the streambed and banks may fluctuate, but over time, the dimensions, pattern, profile and channel features are maintained, and the stream neither aggrades nor degrades.

# 3. Results

As expected, most of the cross-section measurements indicated the streams were of the C-type classification. However, two cross-sections, the White Lower and Icicle CS4, resulted in entrenchment ratios sufficiently small to support a classification of F-type. Table 10 lists all the cross-sections, their classifications, and the corresponding channel influence variables.

### *ICICLE CS1*

Icicle CS1, CS2, CS3, and CS5 were compared to the White Upper cross-section, since they all shared the C-type designation from Rosgen’s classification. Icicle CS1 is located immediately downstream of the Leavenworth National Fish Hatchery, at a boat launch area. The width/depth ratio of CS1 is somewhat less than that of the White Upper. Particle size is larger at Icicle CS1, but woody debris is less prevalent. Riparian vegetation at Icicle CS1 is less mature and less dense than at the White Upper cross-section. The deposition pattern at Icicle CS1 is somewhat different than at the White Upper, but this difference is minor. The White Upper cross-section is characterized by point bars with some side bars, while Icicle CS1 is characterized by point bars

**Table 10. Summary of Rosgen Analysis.**

| Segment | Class | W/D | Ent. Ratio | D50 | Riparian Vegetation | Flow Regime | Debris | Deposition Pattern | Meander Pattern | Bank Stability Score/Rating | BEHI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| F-Type Cross-sections | | | | | | | | | | | |
| White Lower | F5 | 30.6 | 1.2 | 0.3 | 11b | P1 | D4 | B1/B4 | M3 | 92/Good | 35.3 |
| Icicle CS4 | F4 | 64 | 1.2 | 48 | 6B/4B | P1 | D1 | B2 | M3 | 101/Good | 31 |
| C-Type Cross-sections | | | | | | | | | | | |
| White Upper | C4 | 38 | 2.2 | 16 | 9b | P4 | D4 | B1/B4 | M3 | 93/Fair | 27.6 |
| Icicle CS1 | C4c- | 30 | 2.2 | 32 | 6a/6c | P1 | D2 | B2 | M3 | 86/Good | 56.3 |
| Icicle CS2 | C3 | 30 | 2.2 | 96 | 7b | P1 | D2 | B2 | M3 | 67/Good | 24.3 |
| Icicle CS3 | C4c- | 103 | 2.2 | 24 | 5B/6B | P1 | D2 | B2 | M3 | 85/Good | 21.9 |
| Icicle CS5 | C4c- | 38 | 2.2 | 16 | 9B/4a | P1 | D2 | B4 | M3 | 104/Fair | 27.9 |

with some mid-channel bars. In other words, the only difference in deposition pattern relates to how well the side- or mid-channel bars connect to the banks, which is a matter of degree. Both patterns generally indicate excess sediment. Bank stability at CS1 was rated higher than at the reference reach, indicating more stable banks at CS1 than at White Upper. However, the BEHI results were somewhat contradictory, indicating the erosion hazard at CS1 is higher than at White Upper. Figures 11 and 12 are photographs of Icicle CS1 and White Upper cross-sections.

### *ICICLE CS2*

This site is just above the Icicle Road bridge, at a location where a bedrock slope on the right bank and the bridge abutment on both banks appears likely to constrict the channel during high flow events. The gradient at this reach is 0.12%, which is significantly higher than the gradient at Icicle CS1 (0.04%) but about the same as the White Upper reference reach (0.14%). Width/depth ratio is lower than at the reference reach, and sediment size is significantly larger, consistent with the higher gradient and potential high flow constriction. Riparian vegetation at Icicle CS2 is again generally less mature and less dense. Though some of the hillslope on the right bank is forested with mature conifers, grasses and shrubs dominate the remainder of the riparian area. Debris is largely absent in this reach, and the deposition pattern is the same as at Icicle CS1, similar to the reference reach. Bank stability at Icicle CS2 was rated much higher than at the reference reach, and the erosion hazard index of Icicle CS2 and the reference reach were similar. Figures 13 and 14 are photographs of the Icicle CS2 cross-section.

### *ICICLE CS3*

Icicle CS3 is located in a residential area of the creek, with broad floodplain flats on either bank. The width/depth ratio at this reach was exceptionally high, nearly three times that of the reference reach. Bed material was somewhat larger than the reference reach, and debris in the channel was very sparse. Riparian vegetation in this reach was much less mature and dense than on the reference reach, dominated by grass lawns and pasture with few woody species with deep-penetrating roots. Bank stability was rated comparable to, and slightly better than the reference reach, and the erosion hazard index was somewhat lower than on the reference reach. Figure 15 is a photograph of the Icicle CS3 cross-section.

**Figure 11.** **White Upper, looking downstream.**

**Figure 12.** **Icicle CS1 looking upstream towards the Hatchery**

**Figure 13.** **Composite of Icicle CS2 looking upstream. Note hill on right bank (left side of photo).**

**Figure 14.** **Looking downstream of Icicle CS2 towards Icicle CS3. Note broad floodplain on both banks.**

**Figure 15.** **Icicle CS3, looking downstream.**

### ICICLE CS5

Icicle CS5 is located near the confluence with the Wenatchee. Both banks are formed in floodplain deposits. The width/depth ratio of this reach is the same as that of the reference reach, as is the bed material size. The riparian vegetation on this reach is comparable to that of the reference reach on the left bank, dominated by mature deciduous trees, but is immature and sparse on the right bank, dominated by pasture grasses. The deposition pattern of this reach is comparable to the reference reach. Bank stability was rated lower on this reach than the reference reach, but the erosion hazard for the two reaches was nearly identical. Figures 16 and 17 are photograph of the Icicle CS5 cross-section.

### ICICLE CS4

Because CS4 was determined to be an F-type stream under Rosgen's classification, it was compared to the F-type classification on the White River, which is the White Lower cross-section. The width/depth ratio on Icicle CS4 is more than twice that of the White Lower. Sediment size is significantly larger at Icicle CS4 than on the White Lower. Perennial trees dominate riparian vegetation on the White Lower, while grasses and shrubs dominate that of Icicle CS4. Significantly less debris exists at Icicle CS4 than at the White Lower, and the bank stability rating indicates that the banks at Icicle CS4 are somewhat less stable. Differences in deposition pattern were also observed, but are considered minor. Point bars dominate both reaches, but the White Lower also has side bars, while Icicle CS4 has mid-channel bars. Mid-channel bars and side bars differ in how well connected they are to the stream bank, which is a matter of degree. Both patterns generally indicate excess sediment. BEHI and bank stability ratings on the two streams are similar.

At the C-type cross-sections, a similar pattern of departures is noted. One Icicle cross-section is significantly higher in width/depth ratio, sediment size on the Icicle tends to be larger, riparian vegetation is less well developed, and debris is less common. Bank stability and BEHI ratings vary, but no meaningful difference between the two streams can be drawn. As with the F-type reaches, the actual differences in the deposition pattern ratings is not significant.

Figures 18 and 19 are photographs of White Lower and Icicle CS4 cross-sections.

## 4. Discussion

The Rosgen methodology used in this study provides a framework for gathering useful data about a stream, and a method of quantification that allows one to draw comparisons between one stream and another. While there is disagreement about the utility of this methodology, it is nevertheless scientifically defensible and widely used. This study has attempted to eliminate some of the more controversial aspects of Rosgen's methodology, which pertain to comparing streams from one region to those of another region and the potential lack of reproducibility between different observers. This study also examined other information, including historic aerial photos and maps, GIS data, and several other reports on the Icicle, the White, and the region surrounding them. Hence, while the Rosgen analysis was central to this study, the recommendations and conclusions that follow are not derived exclusively from the Rosgen analysis, and are consistent with earlier reports and data.

**Figure 16. Icicle CS5, looking downstream.**

**Figure 17. Icicle CS5 looking downstream. Note erosion on right bank (right side of picture). Rip-rap in channel indicates a previous toe of bank.**

**Figure 18.** **Lower White, vegetation on left (looking downstream) bank.**

**Figure 19.** **Icicle CS4 looking upstream. Note large bar developed on left bank (right side of photo).**

The White River is used as the reference stream in this analysis. As mentioned earlier, the White is not an undisturbed system. The lower basin has been subject to extensive land clearing, replacing ancient cedar forests with grazing and hay production, interspersed with areas of deciduous forest. The width/depth ratios for the White are higher than typical for a C- or F-type stream. One source (Cappellini 2001) indicates that a "slug" of sediment is currently progressing down the White, causing excess deposition and bank erosion. It is unclear how or why this slug of sediment originated, but it is causing disturbances on the White.

Because the White River is not pristine, using it as a reference reach can be somewhat misleading. This analysis works by comparing the physical characteristics of the stream in question with those of a better-functioning reach. If both streams are disturbed in a similar manner, problems common to both streams will be difficult to detect. Even though the White River is somewhat disturbed, and therefore not the perfect reference reach, it is the best candidate available. It is close to the Icicle, shares similar basin characteristics, has a similar flow pattern and stream type, is similar in gradient, and has similar flow volumes.

The most significant differences, or departures, as Rosgen terms them, between the White and the Icicle, are width/depth ratio, bank vegetation, bed material, and debris. Two of the five Icicle cross-sections had higher width/depth ratios than the White. The Icicle had less vegetation, or less established vegetation, at all cross-sections, and had less debris as well. Bed material was generally coarser on the Icicle.

All of these departures are consistent with the disturbances known to have taken place on the Icicle based on historical evidence and other research on the reach. Historically, the floodplain of the Lower Icicle was converted from native forest to orchard. Over time, the orchard was converted to a combination of pasture and residential land. These land use changes removed much of the root structure that once helped to stabilize the banks of the Icicle. The loss of native forest also limited the potential for woody debris recruitment. Such land use changes are cited as a primary cause of the reduction and loss of habitat that has led to the decline of fish populations on the Icicle (The Watershed Company 2003).

Bed-material differences are consistent with the slightly higher overall gradient of the Icicle. However, another reason for the larger particle size in the Icicle may be the dams that divert water to the irrigation systems and hatchery. These impediments to sediment transport may have lead to a winnowing effect, where the finer particles are eroded from the channel but not replaced by new incoming sediment.

Several factors have combined to reduce the amount of debris in the Icicle. First, debris was removed from the channel via human effort to improve navigation. Second, the dams that control water flow into the various diversions may trap debris that would otherwise lodge in the lower Icicle. Finally, the lack of native forest has resulted in fewer trees to be recruited into the lower Icicle from its banks.

The increased width/depth ratio is consistent with the other variables. The conversion of the riparian vegetation to pasture or residential property, with frequently mowed lawns, generally results in a significant reduction in bank stability. As the less-stable banks erode, the stream grows wider and shallower, increasing the width/depth ratio. This is likely the case on both the

White and the Icicle, since all reaches had width/depth ratios that would normally be considered high.

Bank erosion on the Icicle has been a problem for some time. Figure 5 indicates where bank erosion problems have been sufficiently detrimental that projects were undertaken to protect the banks. Presently there are some large areas of bank erosion that are still problematic, or where the bank protection has failed, likely increasing the volume of fine sediment in the Icicle and downstream receiving waters.

## 5. Recommendations

The goal of this study is to determine what factors influencing the Icicle are out of balance, and how best to correct those factors. This analysis indicates that the most problematic factors, or the most significant departures, on the Icicle are the width/depth ratio, the lack of adequate riparian vegetation, the lack of woody debris in the channel, and the sediment size. Therefore the first step in developing a restoration strategy for the Icicle should be to avoid exacerbating any of these conditions. Bank vegetation should be maintained. Woody debris should not be removed, though it may be feasible to move it from one location to a more beneficial location. The channel should not be widened (except possibly at the Icicle Road bridge, where the abutment may be artificially constricting the channel).

Along with the strategy of not exacerbating the problems, steps should be taken to begin correcting the problems. Future restoration projects should be designed to accomplish one or a combination of the following goals:

1. Reduce, or prevent increase in, width/depth ratio.
   The width depth ratio is a critical component of stream morphology. According to Rosgen (1996) “The width/depth ratio is key to understanding the distribution of available energy within the channel, and the ability of various discharges occurring within the channel to move sediment.” A deep, narrow channel is more capable of moving sediment than a shallow, wide channel. As a channel widens, it looses its capacity to carry sediment, which leads to sediment deposition in the channel. As sediment is deposited, the channel becomes shallower, and continues to loose competence to carry sediment. This shifts the balance of hydraulic stress away from the bed and towards the banks, increasing bank erosion and causing the stream to widen in a negative feedback cycle.

2. Increase in-channel debris.
   Woody debris in streams provides a variety of habitat functions and helps define the shape of the channel. The turbulence that is created around large woody objects tends to scour and maintain pools, which reduce stream energy. Wood can also help armor and stabilize banks at specific locations by serving as a barrier to stream flow. Finally, debris produces hydraulic roughness, or resistance to flow, which reduces stream energy and helps prevent excess erosion.

3. Improve bank vegetation.
   Bank and riparian vegetation plays a crucial role in stream functioning. Deep complex roots from trees and large shrub provide resistance to erosion and help maintain bank stability. Bank vegetation also serves to produce hydraulic roughness, slowing water

velocity and removing stream energy, preventing erosion. During flood events, riparian vegetation prevents scour of the riparian area, and slows water velocity. As bank erosion occurs, trees on the banks and in the riparian area will be recruited into the channel, and help to limit the amount of erosion to a more natural rate, while providing excellent habitat.

4. Improve substrate/sediment transport.
   The material that makes up the channel influences the cross-sectional form of the channel, the plan view, and the longitudinal profile. It also provides roughness and resistance to hydraulic stress. Disturbances to the sediment transport regime can have dramatic impacts on overall stream stability.

In many cases, it will be possible for future restoration projects to address more than one geomorphic departure. For example, projects that acquire and revegetate banks and riparian areas could and should be highly encouraged because they not only provide improved bank and riparian vegetation, but also promote bank stability, which helps maintain the width/depth ratio, and provides a source for future woody debris recruitment. Since some measure of bank erosion is both inevitable and desirable, conifers should be especially encouraged as potential recruitment sources of large woody debris. Conifers provide excellent habitat and last longer as woody debris in the stream than most hardwood species.

In addition to slowing the rate of bank erosion, projects at areas such as Icicle CS3 and CS4, where the width/depth ratio is exceptionally high, should encourage channel narrowing. This can be done by rebuilding the banks in a narrower configuration, or by installing structures along the banks designed to trap sediment and allow the stream to re-establish a more stable width/depth ratio. Ideally, a structure to reduce the width/depth ratio would be made from large trees with rootwads attached, to serve as large woody debris. In conjunctions with bank and riparian revegetation, such a project would address all of the departures. The structure itself would address the width/depth ratio, and the reduced woody debris, while providing a more stable bank on which to re-establish vegetation. The associated revegetation would improve bank and riparian vegetation and promote bank stability, which would in turn help maintain the width/depth ratio. Finally, the restoration of a smaller width/depth ratio would also restore a more natural sediment transport regime, since sediment transport is directly related to the depth of flow.

An earlier study (Jones & Stokes 2003) identified the erosion hazard areas of the lower Icicle (Figure 20). These areas should be targeted for bank preservation and restoration. Revegetation in these areas can help slow the erosion rate in the long term and also provide woody debris for future stream stability and habitat. It will often be helpful in these areas to combine revegetation with temporary or deformable bank protection in order to stabilize the banks long enough for the vegetation to grow sufficiently to be effective. Complex large woody debris structures should be particularly encouraged in association with bank revegetation.

The best way to address the sediment issue would be to reconnect the sediment transport process from the upper watershed to the lower watershed. Lorang et al. (2000) indicated that all the structures at the hatchery could be removed and the accumulated sediment released, without

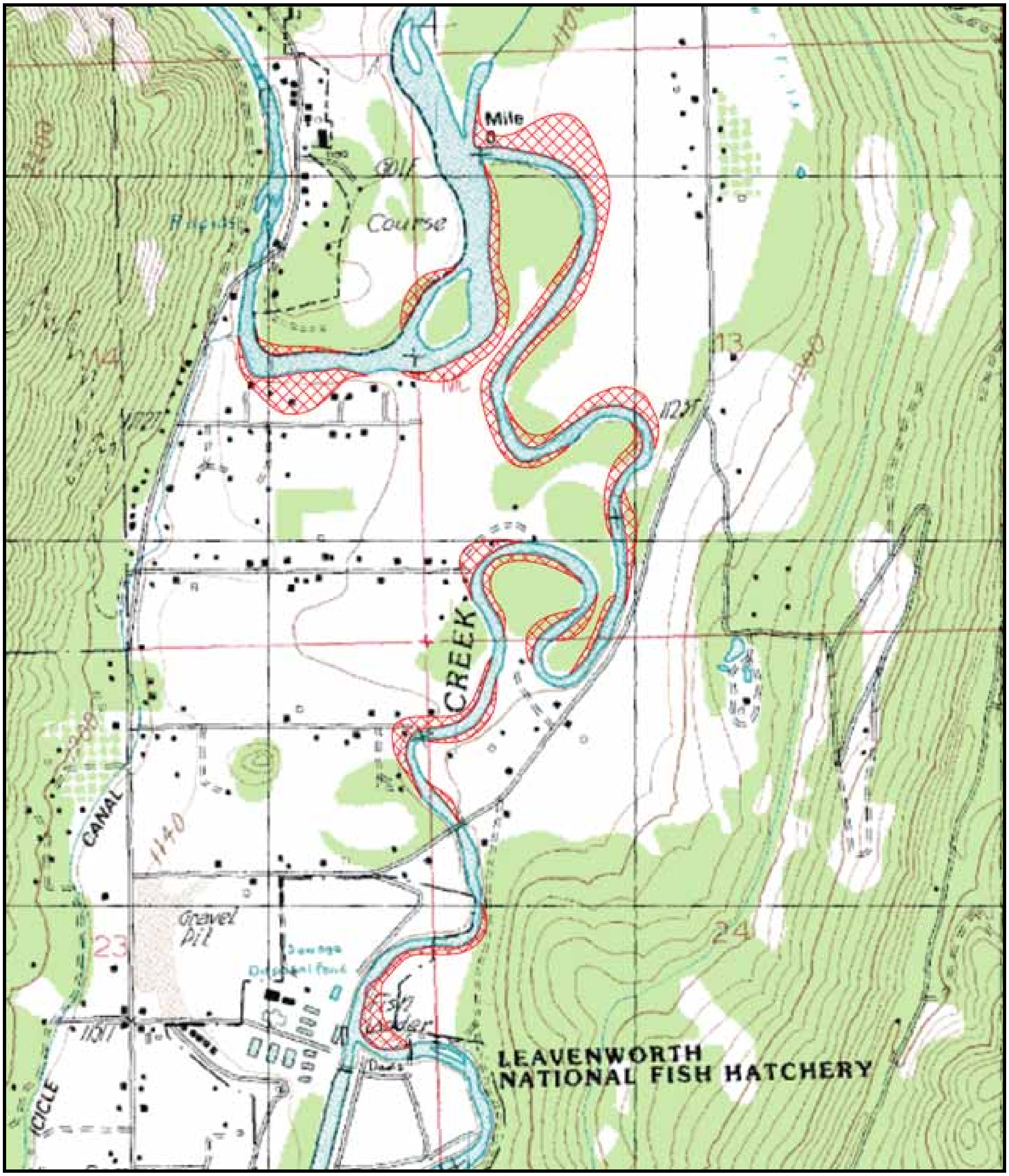


**Figure 20.** **Erosion areas on Icicle Creek (Jones & Stokes 2003).**

causing significant damage.  Failing that, other methods of moving bedload through the upper Icicle and into the lower Icicle should be explored and encouraged.

These recommendations are meant to serve as general guidance.  Individual proposals for habitat improvement projects should be examined carefully determine their impact, both short term and long term, on the geomorphic departures.  From that examination, habitat improvement projects should be categorized into the following three groups:

1. Project that positively address a geomorphic departure
2. Projects that have no effect on a geomorphic departure
3. Projects that negatively effect a geomorphic departure

Habitat improvement projects in Group 1, which aim to improve habitat and improve the geomorphology of the lower Icicle, should be preferred over those in Group 2 that only aim to improve habitat.  Projects in Group 3 should be redesigned, if possible, to achieve a neutral or positive effect on geomorphology.  If such a re-design proves to be impossible, then the project should not be allowed.  Allowing project that exacerbate existing geomorphological problems would not only limit the success of the habitat restoration project being proposed, but may lead to habitat destruction elsewhere on the lower Icicle.

Following these guidelines will ensure that future habitat improvement projects work with the geomorphological characteristics of the lower Icicle.  It will also help to ensure the long-term success of the habitat improvement projects, and produce long-term improvements in the functioning of the lower Icicle.

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# APPENDIX A

## FIELD DATA

# White BEHI data analysis

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Completed by | | MI | | | | | | | | Page | 1 |
| Date | | 9/9/2004 | | | | | | | | | |
| **Field Data** | | | | | | | | | | | |
| Sta. Or Location | Rosgen Type | Bank Height Feet | BF Depth L. Feet | BF Depth Mid Feet | BF Depth R. Feet | BFW Feet | Root depth | Root Density* value | Bank Slope L Degrees | Protected Percent | Bank Material Jse 1 line per laye |
| UP-LB | C4 | 1 | 1.3 | 4.3 | 5.6 | 146 | 1 | 5 | 2 | 0 | sand/silt |
| UP-RB | C4 | 7 | 1.3 | 4.3 | 5.6 | 146 | 1.5 | 5 | 67 | 25 | sand/silt |
| LOW-LB | F5 | 11 | 4.6 | 4.2 | 1.25 | 110 | 2.5 | 5 | 40 | 0 | sand/silt |
| LOW-RB | F5 | 7 | 4.6 | 4.2 | 1.25 | 110 | 2.5 | 5 | 26 | 0 | sand/silt |
| **Analysis** | | | | | | | | | | | |
| Reach | Bank Height / Bankful Height | Root Dept / Bank Height** | Root Density | Angle Left | Protected | | Bank Material | | | Shear Stress Ratio | |
| UP-LB | 0.18 | 1 | 5 | 2 | 0 | | 5 | | | 0.77 | |
| UP-RB | 1.25 | 0.214285714 | 5 | 67 | 25 | | 5 | | | 1.25 | |
| LOW-LB | 2.39 | 0.227272727 | 5 | 40 | 0 | | 5 | | | 8.80 | |
| LOW-RB | 1.52 | 0.357142857 | 5 | 26 | 0 | | 5 | | | 5.60 | |
| **Index Adjective** | | | | | | | | | | | |
| UP-LB | Very Low | Very Low | Moderate | Very Low | Extreme | | Moderate | | | | |
| UP-RB | Moderate | High | Moderate | Moderate | High | | Moderate | | | | |
| LOW-LB | Very High | High | Moderate | Low | Extreme | | Moderate | | | | |
| LOW-RB | High | Moderate | Moderate | Low | Extreme | | Moderate | | | | |
| **Points - Assigned as middle of range given by Rosgen for each Index adjective.** | | | | | | | | **Total** | **Composite Index** | Shear Stress Ratio | |
| UP-LB | 1.5 | 1.5 | 5 | 0.75 | 10 | | 5 | **23.75** | **Moderate** | Very Low | |
| UP-RB | 5 | 7 | 5 | 2.5 | 7 | | 5 | **31.5** | **High** | Very High | |
| LOW-LB | 8.5 | 7 | 5 | 1.5 | 10 | | 5 | **37** | **High** | Extreme | |
| LOW-RB | 7 | 5 | 5 | 1.5 | 10 | | 5 | **33.5** | **High** | Extreme | |

# White Upper Cross-section field data form

| | |
|---|---|
| Stream Name | **White Upper** |
| Observors | **MI, BM, FK** |
| Location | **Grey property** |

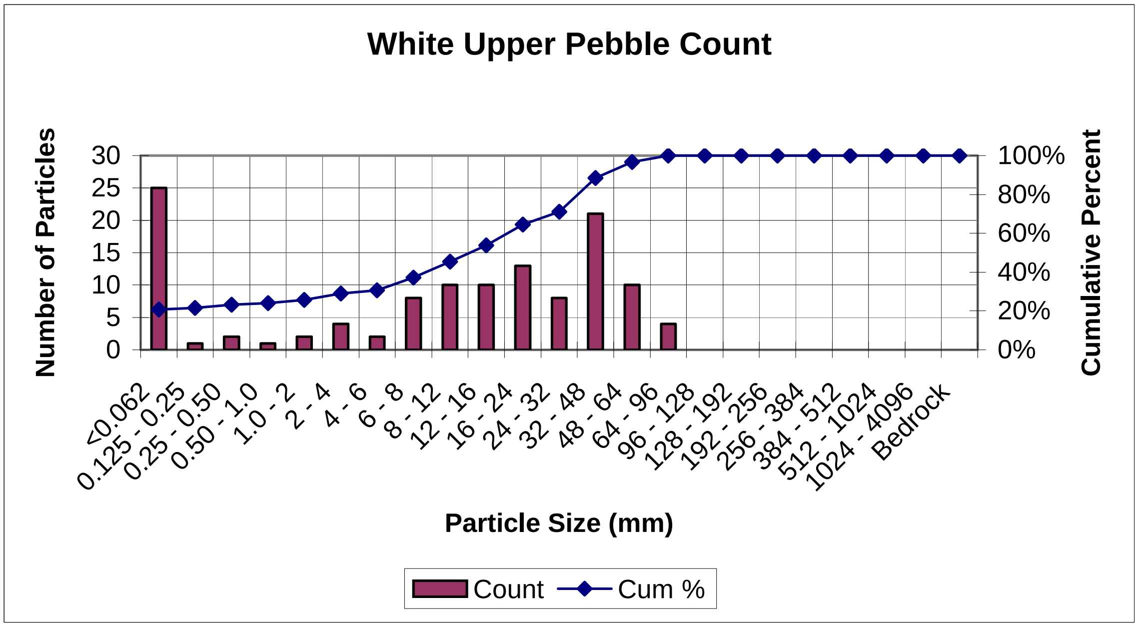
| | | | | | |
|---|---|---|---|---|---|
| Bankfull width | **146** | Bankfull max depth | **7.2** | Channel Slope | **0.0013** |
| Bankfull mean depth | **3.8** | Flood-prone area width | **>300** | Valley slope | **NA** |
| Width/Depth ratio | **38** | Entrench. Ratio | **>2.2** | Sinuosity | **1.3** |

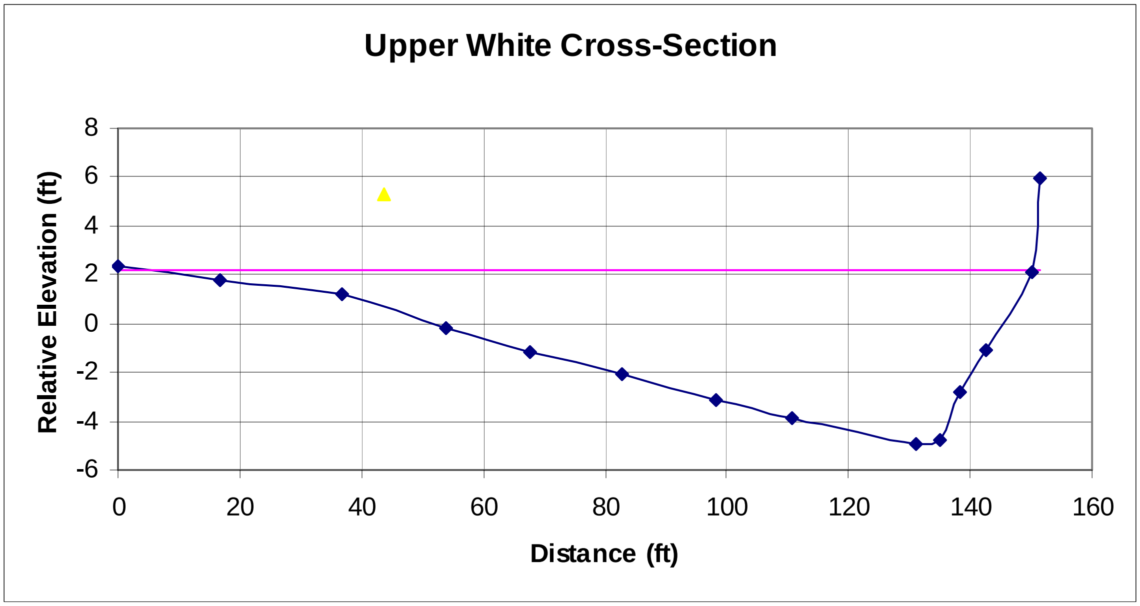
Pebble Count:

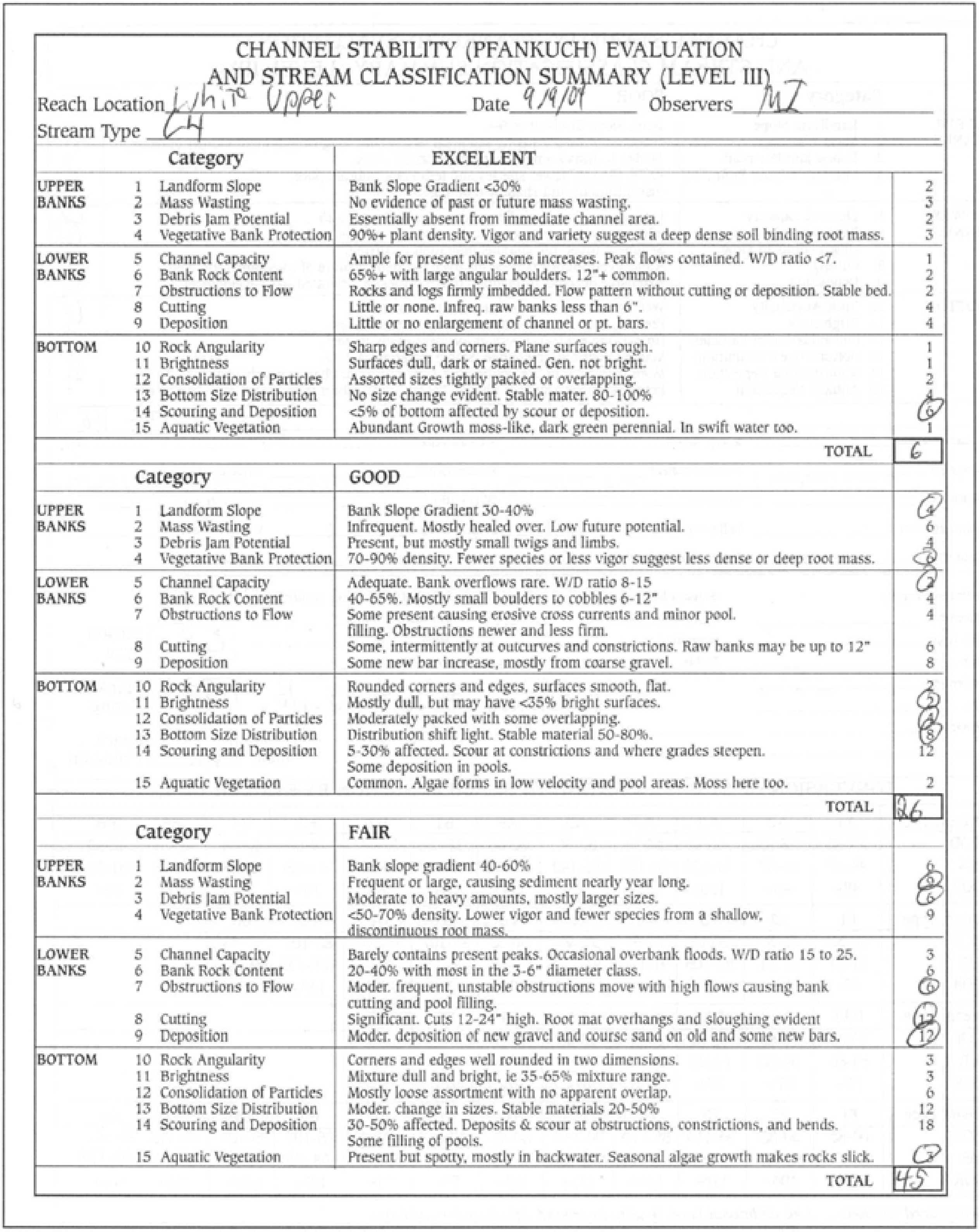
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **25** | **0.207** | **0.207** |
| | Fine | 0.125 - 0.25 | | **1** | **0.008** | **0.215** |
| | Medium | 0.25 - 0.50 | | **2** | **0.017** | **0.231** |
| | Coarse | 0.50 - 1.0 | | **1** | **0.008** | **0.240** |
| .04 - 0.08 | Very Coarse | 1.0 - 2 | | **2** | **0.017** | **0.256** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **4** | **0.033** | **0.289** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **2** | **0.017** | **0.306** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **8** | **0.066** | **0.372** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **10** | **0.083** | **0.455** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **10** | **0.083** | **0.537** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **13** | **0.107** | **0.645** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **8** | **0.066** | **0.711** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **21** | **0.174** | **0.884** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **10** | **0.083** | **0.967** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **4** | **0.033** | **1.000** |
| 3.8 - 5 | Small | 96 - 128 | | **0** | **0.000** | **1.000** |
| 5.0 - 7.6 | Large | 128 - 192 | | **0** | **0.000** | **1.000** |
| 7.6 - 10.0 | Large | 192 - 256 | | **0** | **0.000** | **1.000** |
| 10 - 15 | Small | 256 - 384 | Boulder | **0** | **0.000** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | Bedrock | | **0** | **0.000** | **1.000** |
| Total number sampled | | | | **121** | | |
| D50 | | | | **12-16 mm** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **9b** | Depositional patterns (see 6-4, fig 6-10) | **B1/B4** |
| Streamflow regime (see 6-2) | **P1/P4** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI l/r) | **23.75/31.5** |
| Debris/Blockages (see 6-6) | **D4** | Channel stability rating (Pfankuch) | **93** |




Upper White Cross-Section
Relative Elevation (ft)
8
6
4
2
0
-2
-4
-6
0
20
40
60
80
100
120
140
160
Distance (ft)



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

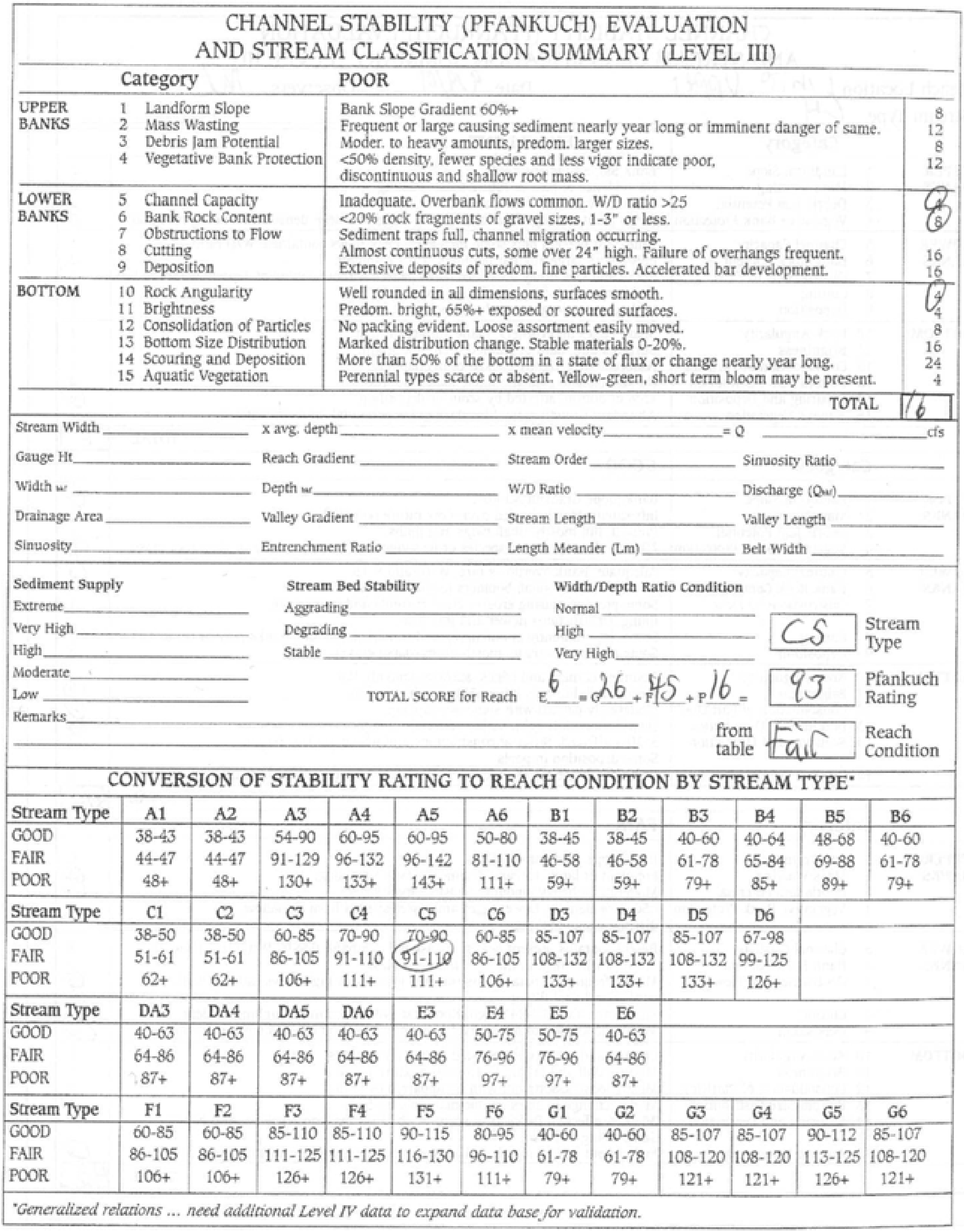
Reach Location White Upper Date 9/9/09 Observers MJ

Stream Type C4

| | Category | EXCELLENT | |
|---|---|---|---|
| UPPER BANKS | 1 Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 Mass Wasting | No evidence of past or future mass wasting. | 3 |
| | 3 Debris Jam Potential | Essentially absent from immediate channel area. | 2 |
| | 4 Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | 1 |
| | 6 Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | 2 |
| | 8 Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| BOTTOM | 10 Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 Scouring and Deposition | <5% of bottom affected by scour or deposition. | [✓ 6] |
| | 15 Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | TOTAL | 6 |

| | Category | GOOD | |
|---|---|---|---|
| UPPER BANKS | 1 Landform Slope | Bank Slope Gradient 30-40% | [✓ 4] |
| | 2 Mass Wasting | Infrequent. Mostly healed over. Low future potential. | 6 |
| | 3 Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] |
| LOWER BANKS | 5 Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | [✓ 2] |
| | 6 Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 Deposition | Some new bar increase, mostly from coarse gravel. | 8 |
| BOTTOM | 10 Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 Brightness | Mostly dull, but may have <35% bright surfaces. | [✓ 2] |
| | 12 Consolidation of Particles | Moderately packed with some overlapping. | [✓ 4] |
| | 13 Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | [✓ 8] |
| | 14 Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | 2 |
| | | TOTAL | 26 |

| | Category | FAIR | |
|---|---|---|---|
| UPPER BANKS | 1 Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 Mass Wasting | Frequent or large, causing sediment nearly year long. | [✓ 8] |
| | 3 Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | [✓ 6] |
| | 4 Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | [✓ 6] |
| | 8 Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | [✓ 12] |
| | 9 Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | [✓ 12] |
| BOTTOM | 10 Rock Angularity | Corners and edges well rounded in two dimensions. | 3 |
| | 11 Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 Consolidation of Particles | Mostly loose assortment with no apparent overlap. | 6 |
| | 13 Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | 12 |
| | 14 Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 2] |
| | | TOTAL | 45 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | [✓ 4] |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | [✓ 8] |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | [✓ 4] |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | 16 |

Stream Width ________ x avg. depth ________ x mean velocity ________ = Q ________ cfs

Gauge Ht ________ Reach Gradient ________ Stream Order ________ Sinuosity Ratio ________

Width bkf ________ Depth bkf ________ W/D Ratio ________ Discharge (Qbkf) ________

Drainage Area ________ Valley Gradient ________ Stream Length ________ Valley Length ________

Sinuosity ________ Entrenchment Ratio ________ Length Meander (Lm) ________ Belt Width ________

**Sediment Supply**
Extreme ________
Very High ________
High ________
Moderate ________
Low ________

**Stream Bed Stability**
Aggrading ________
Degrading ________
Stable ________

**Width/Depth Ratio Condition**
Normal ________
High ________
Very High ________

Stream Type: C5

TOTAL SCORE for Reach E 6 = G 26 + F 45 + P 16 =

Pfankuch Rating: 93

from table — Reach Condition: Fair

Remarks ________

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |
| **Stream Type** | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 | | |
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 | | |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | [✓ 91-110] | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 | | |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ | | |
| **Stream Type** | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 | | | | |
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 | | | | |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 | | | | |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ | | | | |
| **Stream Type** | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

*Generalized relations ... need additional Level IV data to expand data base for validation.*

# White Lower Cross-section field data form

| | |
|---|---|
| Stream Name | **White Lower** |
| Observors | **MI, FK, BM** |
| Location | **RM14.75, below Sears Creek Road bridge** |

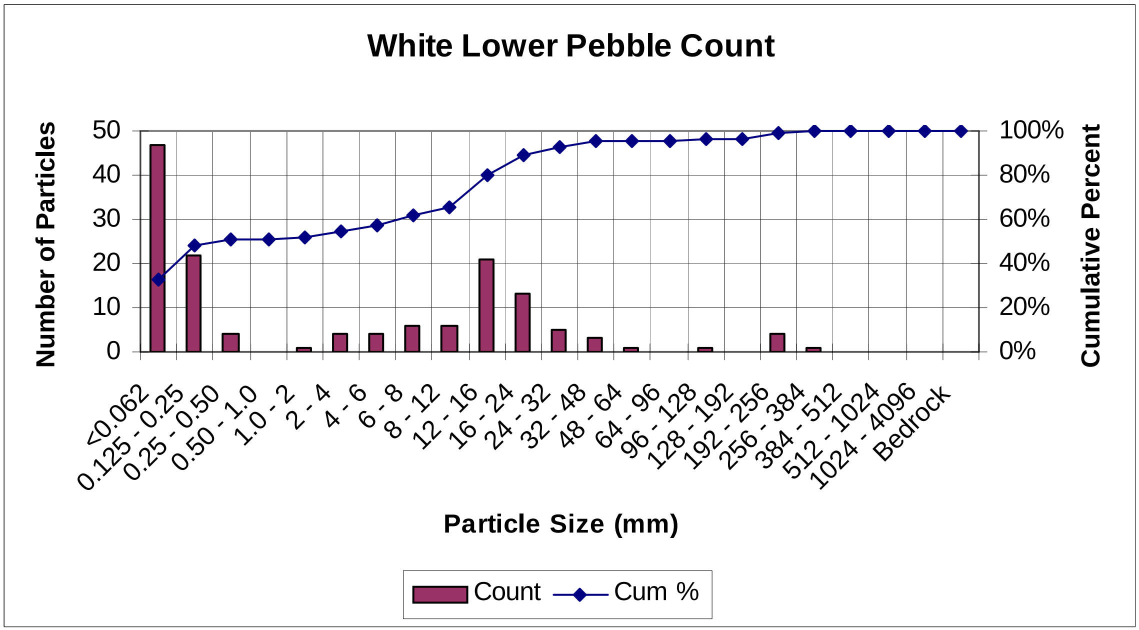
| | | | | | |
|---|---|---|---|---|---|
| Bankfull width | **110** | Bankfull max depth | **5.6** | Channel Slope | **0.013** |
| Bankfull mean depth | **3.6** | Flood-prone area width | **130** | Valley slope | **NA** |
| Width/Depth ratio | **30.6** | Entrench. Ratio | **1.2** | Sinuosity | **2.3** |

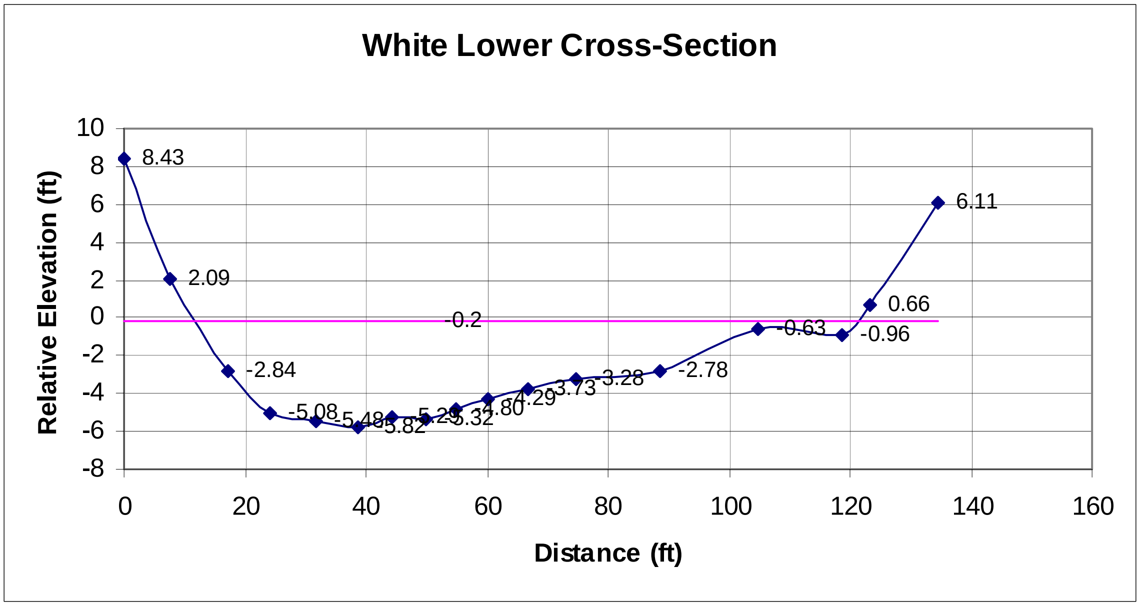
Pebble Count:

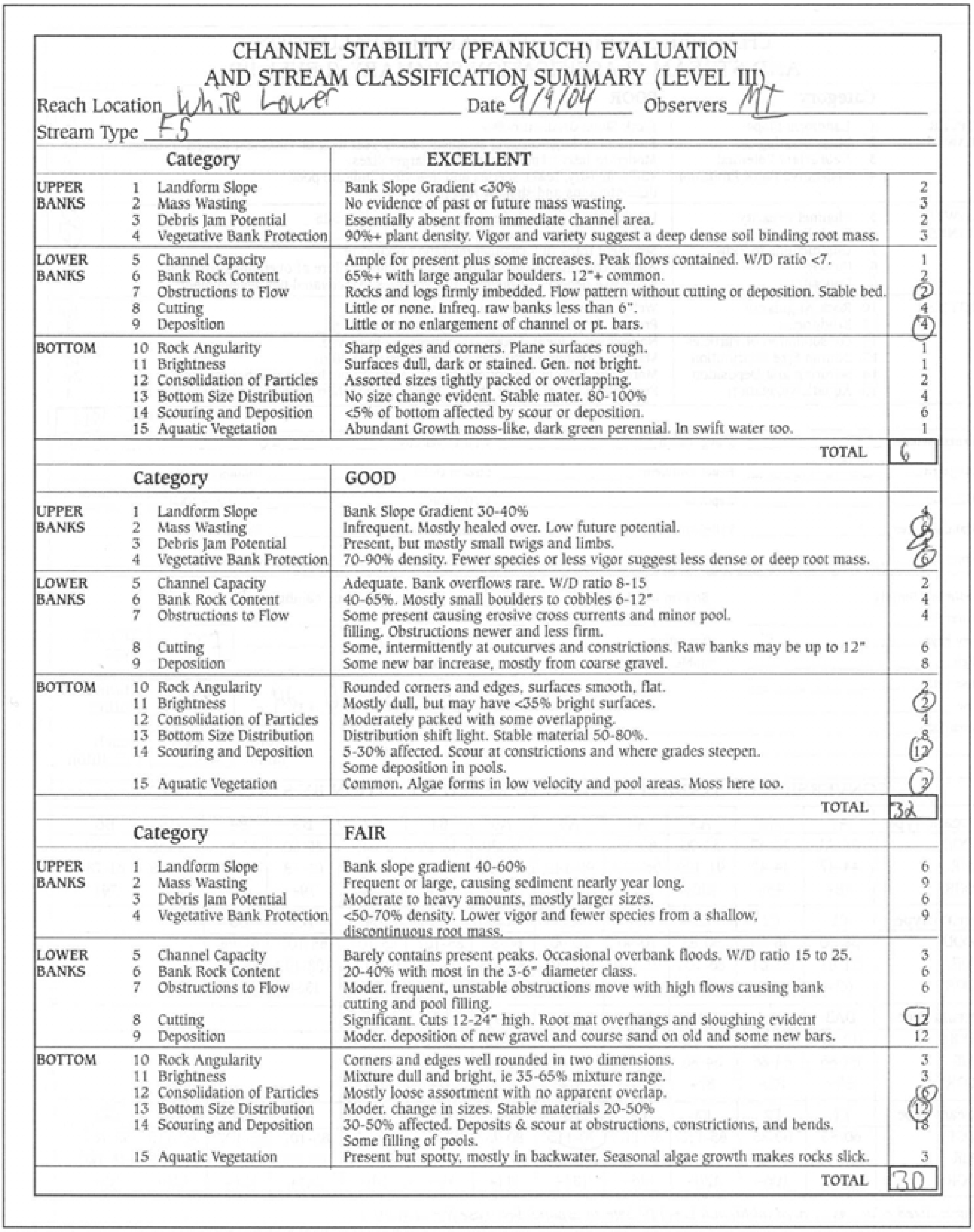
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **47** | **0.329** | **0.329** |
| | Fine | 0.125 - 0.25 | | **22** | **0.154** | **0.483** |
| | Medium | 0.25 - 0.50 | | **4** | **0.028** | **0.510** |
| | Coarse | 0.50 - 1.0 | | **0** | **0.000** | **0.510** |
| .04 - 0.08 | Very Coarse | 1.0 - 2 | | **1** | **0.007** | **0.517** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **4** | **0.028** | **0.545** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **4** | **0.028** | **0.573** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **6** | **0.042** | **0.615** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **6** | **0.042** | **0.657** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **21** | **0.147** | **0.804** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **13** | **0.091** | **0.895** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **5** | **0.035** | **0.930** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **3** | **0.021** | **0.951** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **1** | **0.007** | **0.958** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **0** | **0.000** | **0.958** |
| 3.8 - 5 | Small | 96 - 128 | | **1** | **0.007** | **0.965** |
| 5.0 - 7.6 | Large | 128 - 192 | | **0** | **0.000** | **0.965** |
| 7.6 - 10.0 | Large | 192 - 256 | | **4** | **0.028** | **0.993** |
| 10 - 15 | Small | 256 - 384 | Boulder | **1** | **0.007** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | Bedrock | | **0** | **0.000** | **1.000** |
| Total number sampled | | | | **143** | | |
| D50 | | | | **.25-.5** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **11b** | Depositional patterns (see 6-4, fig 6-10) | **B1/B4** |
| Streamflow regime (see 6-2) | **P1/P4** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **33.5/37** |
| Debris/Blockages (see 6-6) | **D4** | Channel stability rating (Pfankuch) | **92** |




White Lower Cross-Section
Relative Elevation (ft)
10
8
6
4
2
0
-2
-4
-6
-8
0
20
40
60
80
100
120
140
160
Distance (ft)
8.43
2.09
-2.84
-5.08
-5.48
-5.82
-5.29
-5.32
-4.80
-4.29
-3.73
-3.28
-2.78
-0.2
-0.63
-0.96
0.66
6.11



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

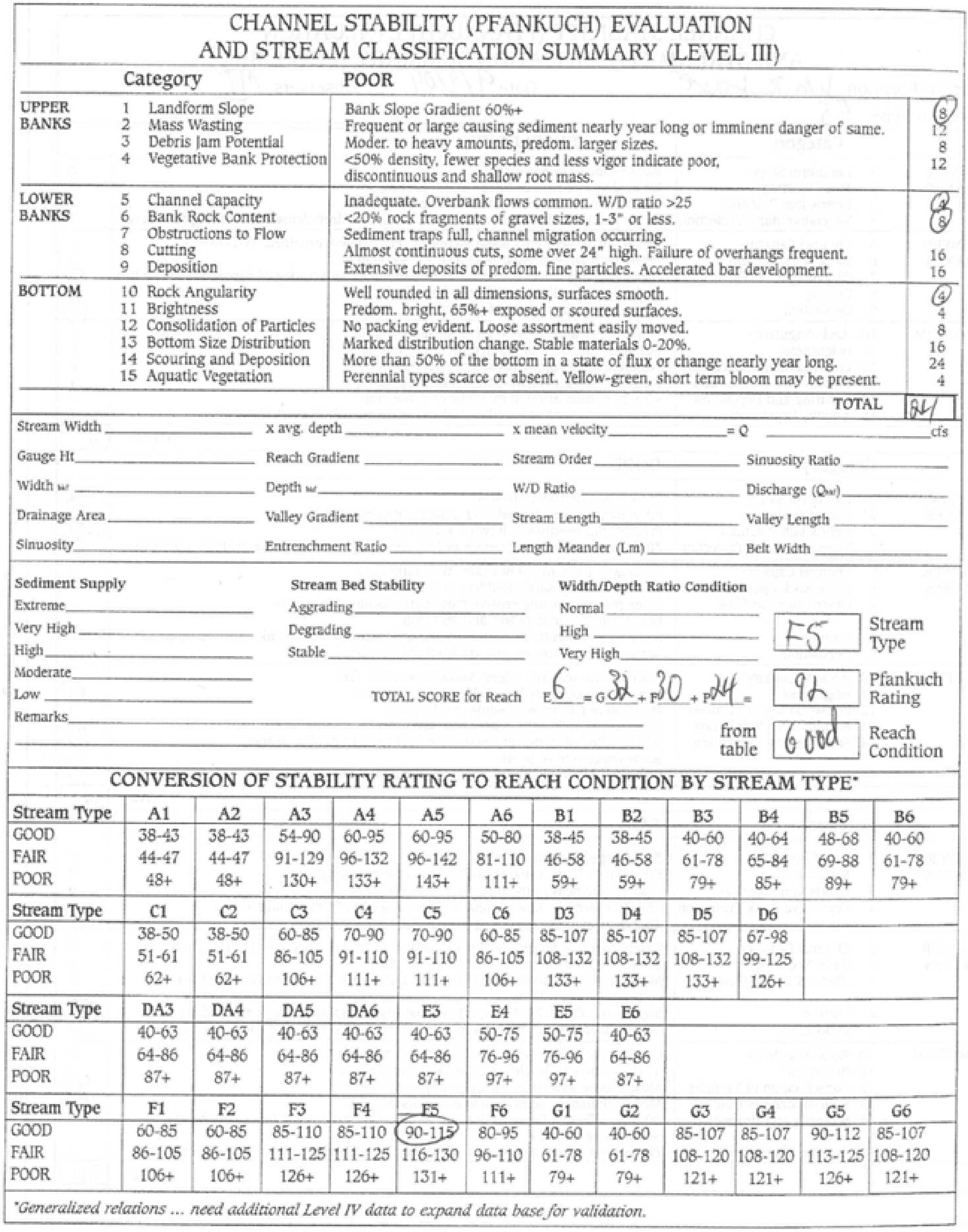
Reach Location White Lower Date 9/9/04 Observers MT

Stream Type F5

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | 3 |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | 2 |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | 1 |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | [✓ 2] |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | [✓ 4] |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 6 |

| | | Category | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | [✓ 6] |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | [✓ 4] |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | 8 |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | [✓ 2] |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | [✓ 2] |
| | | | TOTAL | 32 |

| | | Category | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | [✓ 12] |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | 3 |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | [✓ 6] |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | [✓ 12] |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | 3 |
| | | | TOTAL | 30 |



# CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | [✓ 8] |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | [✓ 4] |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | [✓ 8] |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | [✓ 4] |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | 84 |

Stream Width ________ x avg. depth ________ x mean velocity ________ = Q ________ cfs

Gauge Ht ________ Reach Gradient ________ Stream Order ________ Sinuosity Ratio ________

Width ________ Depth ________ W/D Ratio ________ Discharge (Q) ________

Drainage Area ________ Valley Gradient ________ Stream Length ________ Valley Length ________

Sinuosity ________ Entrenchment Ratio ________ Length Meander (Lm) ________ Belt Width ________

**Sediment Supply**

Extreme ________

Very High ________

High ________

Moderate ________

Low ________

Remarks ________

**Stream Bed Stability**

Aggrading ________

Degrading ________

Stable ________

**Width/Depth Ratio Condition**

Normal ________

High ________

Very High ________

Stream Type: F5

TOTAL SCORE for Reach E 6 = G 32 + F 30 + P 24 = 92 Pfankuch Rating

from table: Good Reach Condition

## CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | [✓ 90-115] | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

*Generalized relations ... need additional Level IV data to expand data base for validation.*

# Icicle BEHI data analysis

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Completed by | | MI | | | | | | | | Page | 1 |
| Date(s) | | 9/27/2005 | and | 9/29/2005 | | | | | | | |

**Field Data**

| Sta. Or Location | Rosgen Type | Bank Height Feet | BF Depth L. Feet | BF Depth Mid Feet | BF Depth R. Feet | BFW Feet | Root depth | Root Density* value | Bank Slope L Degrees | Protected Percent | Bank Material Jse 1 line per laye |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CS1-LB | C4c- | 8 | 4.2 | 4.7 | 2.6 | 126 | 2 | 2 | 12 | 0 | silt |
| CS1-RB | C4c- | 5.6 | 4.2 | 4.7 | 2.6 | 126 | 1.5 | 5 | 25 | 0 | silt |
| CS2-LB | C3 | 8 | 4.03 | 4.9 | 3.8 | 126 | 2 | 8 | 13 | 0 | silt |
| CS2-RB | C3 | 6 | 4.03 | 4.9 | 3.8 | 126 | 2 | 8 | 13 | 50 | silt |
| CS3-LB | C4c- | 7 | 1.12 | 0.2 | 2.02 | 126 | 1 | 5 | 16 | 50 | silt |
| CS3-RB | C4c- | 2 | 1.12 | 0.2 | 2.02 | 126 | 2 | 8 | 26 | 25 | silt |
| CS4-LB | F4 | 9 | 1.9 | 2.8 | 2.3 | 148 | 0.5 | 2 | 18 | 50 | silt |
| CS4-RB | F4 | 7 | 1.9 | 2.8 | 2.3 | 148 | 2 | 8 | 18 | 0 | silt |
| CS5-LB | C4c- | 4.4 | 2.9 | 4.4 | 3.3 | 138 | 1 | 8 | 7 | 0 | silt |
| CS5-RB | C4c- | 9 | 2.9 | 4.4 | 3.3 | 138 | 0.5 | 5 | 32 | 10 | silt |

**Analysis**

| Reach | Bank Height / Bankful Height | Root Dept / Bank Height** | Root Density | Angle Left | Protected | | Bank Material | | | Shear Stress Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| CS1-LB | 1.90 | 0.25 | 8 | 12 | 0 | | 0 | | | 1.90 |
| CS1-RB | 2.15 | 0.267857143 | 5 | 25 | 0 | | 0 | | | 2.15 |
| CS2-LB | 1.99 | 0.25 | 2 | 13 | 0 | | 0 | | | 2.11 |
| CS2-RB | 1.58 | 0.333333333 | 2 | 13 | 50 | | 0 | | | 1.58 |
| CS3-LB | 3.47 | 0.142857143 | 5 | 16 | 50 | | 0 | | | 3.47 |
| CS3-RB | 0.99 | 1 | 2 | 26 | 25 | | 0 | | | 0.99 |
| CS4-LB | 3.21 | 0.055555556 | 8 | 18 | 50 | | 0 | | | 3.91 |
| CS4-RB | 2.50 | 0.285714286 | 2 | 18 | 0 | | 0 | | | 3.04 |
| CS5-LB | 1.00 | 0.227272727 | 2 | 7 | 0 | | 0 | | | 1.33 |
| CS5-RB | 2.05 | 0.055555556 | 5 | 32 | 10 | | 0 | | | 2.73 |

**Index Adjective**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CS1-LB | High | High | Very High | Very Low | Extreme | | Very Low |
| CS1-RB | Very High | High | Moderate | Low | Extreme | | Very Low |
| CS2-LB | High | High | Low | Very Low | Extreme | | Very Low |
| CS2-RB | High | Moderate | Low | Very Low | Moderate | | Very Low |
| CS3-LB | Extreme | Very High | Moderate | Very Low | Moderate | | Very Low |
| CS3-RB | Very Low | Very Low | Low | Low | High | | Very Low |
| CS4-LB | Extreme | Very High | Very High | Very Low | Moderate | | Very Low |
| CS4-RB | Very High | High | Low | Very Low | Extreme | | Very Low |
| CS5-LB | Very Low | High | Low | Very Low | Extreme | | Very Low |
| CS5-RB | Very High | Very High | Moderate | Low | Extreme | | Very Low |

**Points - Assigned as middle of range given by Rosgen for each Index adjective.**

| | | | | | | | | Total | Composite Index | Shear Stress Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| CS1-LB | 7 | 7 | 8.5 | 0.75 | 10 | | 0 | **33.25** | **High** | Extreme |
| CS1-RB | 8.5 | 7 | 5 | 1.5 | 10 | | 0 | **32** | **High** | Extreme |
| CS2-LB | 7 | 7 | 3 | 0.75 | 10 | | 0 | **27.75** | **Moderate** | Extreme |
| CS2-RB | 7 | 5 | 3 | 0.75 | 5 | | 0 | **20.75** | **Moderate** | Very High |
| CS3-LB | 10 | 8.5 | 5 | 0.75 | 5 | | 0 | **29.25** | **Moderate** | Extreme |
| CS3-RB | 1.5 | 1.5 | 3 | 1.5 | 7 | | 0 | **14.5** | **Low** | Low |
| CS4-LB | 10 | 8.5 | 8.5 | 0.75 | 5 | | 0 | **32.75** | **High** | Extreme |
| CS4-RB | 8.5 | 7 | 3 | 0.75 | 10 | | 0 | **29.25** | **Moderate** | Extreme |
| CS5-LB | 1.5 | 7 | 3 | 0.75 | 10 | | 0 | **22.25** | **Moderate** | Very High |
| CS5-RB | 8.5 | 8.5 | 5 | 1.5 | 10 | | 0 | **33.5** | **High** | Extreme |

# Icicle 1 Cross-section field data form

| | |
|---|---|
| Stream Name | **Icicle CS1** |
| Observors | **MI, JC, DO, TT** |
| Location | **Boat Launch** |

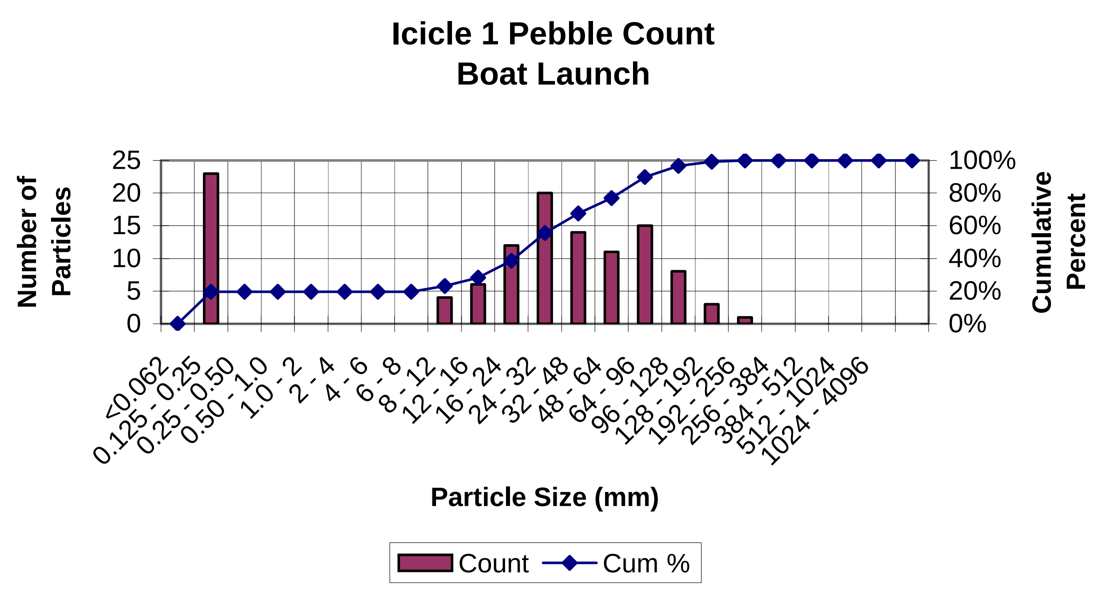
| | | | | | |
|---|---|---|---|---|---|
| Bankfull width | **126** | Mankfull max depth | **5.32** | Channel Slope | **0.0008** |
| Bankfull mean depth | **4.2** | Flood-prone area width | | Valley slope | **NA** |
| Width/Depth ratio | **30** | Entrench. Ratio | **>2.2** | Sinuosity | **1.3** |

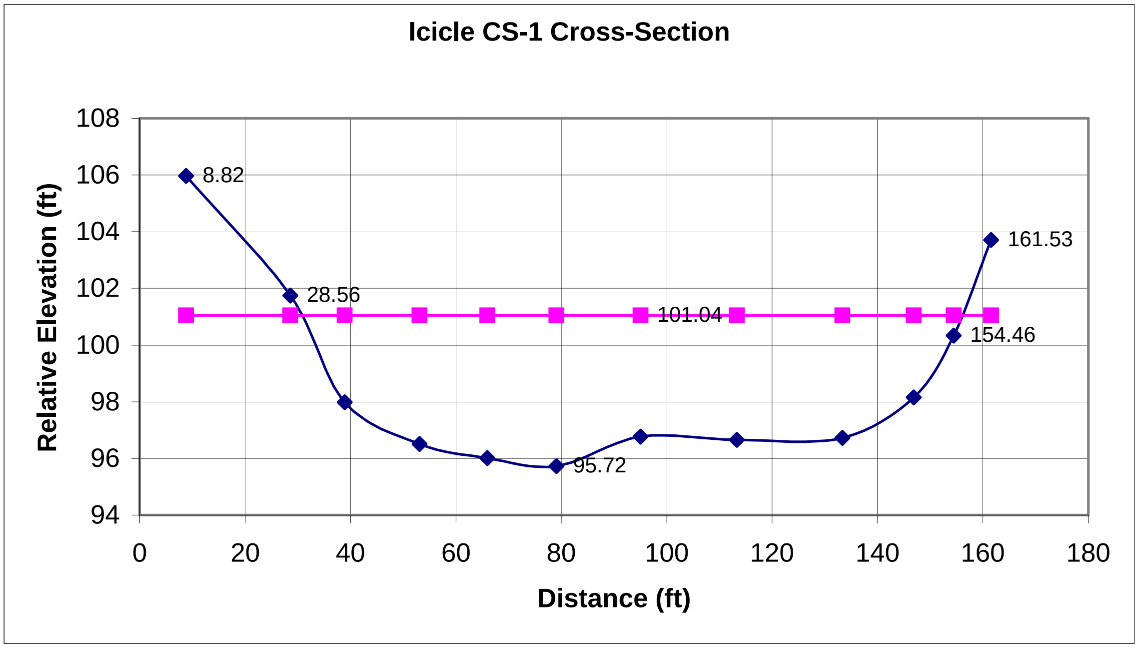
## Icicle 1 Pebble Count:

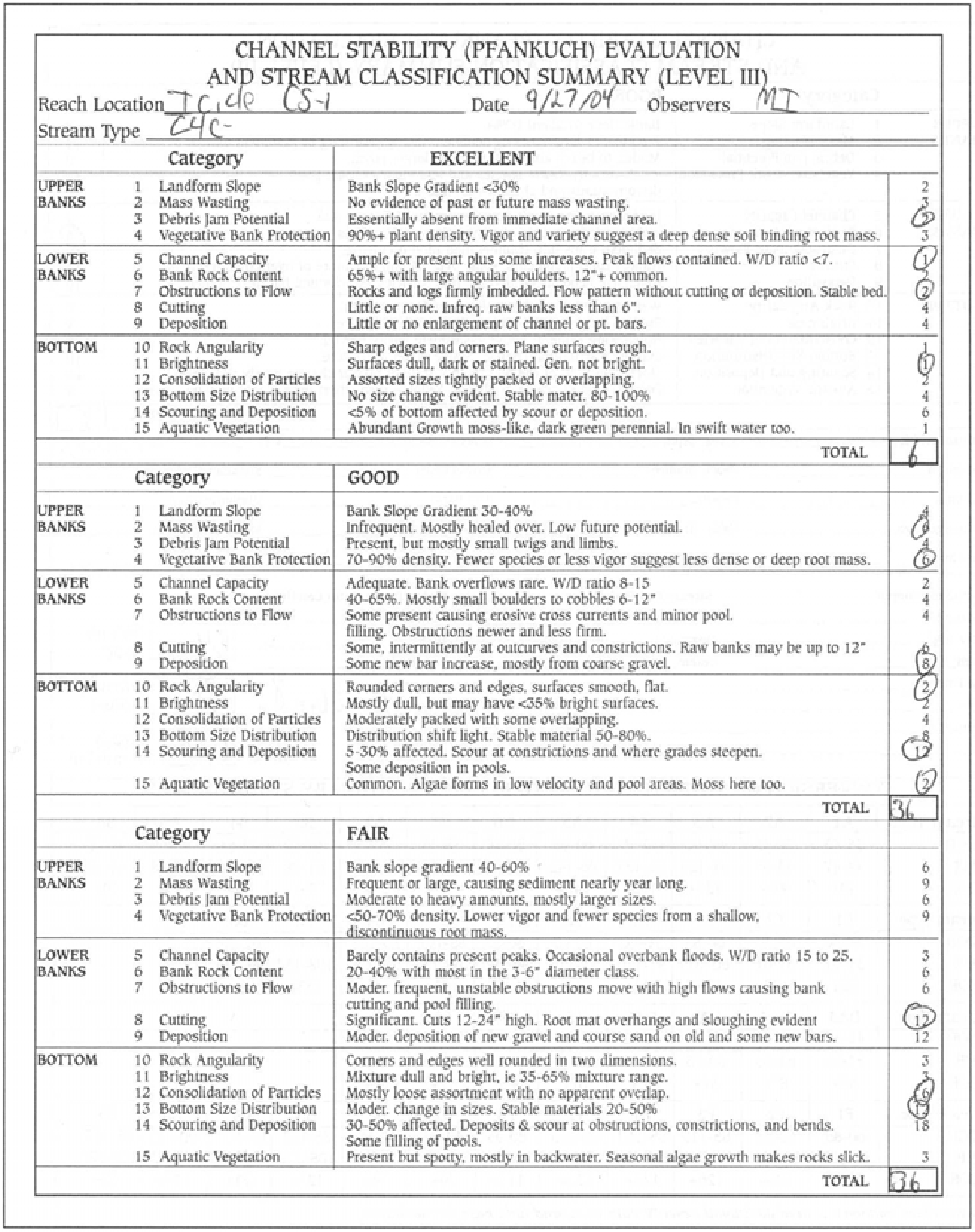
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **0** | **0.000** | **0.000** |
| | Fine | 0.125 - 0.25 | | **23** | **0.197** | **0.197** |
| | Medium | 0.25 - 0.50 | | **0** | **0.000** | **0.197** |
| | Coarse | 0.50 - 1.0 | | **0** | **0.000** | **0.197** |
| .04 - 0.08 | Very Coarse | 1.0 - 2 | | **0** | **0.000** | **0.197** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **0** | **0.000** | **0.197** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **0** | **0.000** | **0.197** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **0** | **0.000** | **0.197** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **4** | **0.034** | **0.231** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **6** | **0.051** | **0.282** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **12** | **0.103** | **0.385** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **20** | **0.171** | **0.556** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **14** | **0.120** | **0.675** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **11** | **0.094** | **0.769** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **15** | **0.128** | **0.897** |
| 3.8 - 5 | Small | 96 - 128 | | **8** | **0.068** | **0.966** |
| 5.0 - 7.6 | Large | 128 - 192 | | **3** | **0.026** | **0.991** |
| 7.6 - 10.0 | Large | 192 - 256 | | **1** | **0.009** | **1.000** |
| 10 - 15 | Small | 256 - 384 | Boulder | **0** | **0.000** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | | | **0** | **0.000** | **1.000** |
| Total | | | | **117** | | |
| D50 | | | | **24-32** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **6a/6c** | Depositional patterns (see 6-4, fig 6-10) | **B2** |
| Streamflow regime (see 6-2) | **P1** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **29.75/26.5** |
| Debris/Blockages (see 6-6) | **D2** | Channel stability rating (Pfankuch) | **86** |




Icicle CS-1 Cross-Section
Relative Elevation (ft)
108
106
104
102
100
98
96
94
Distance (ft)
0
20
40
60
80
100
120
140
160
180
8.82
28.56
101.04
161.53
154.46
95.72



## CHANNEL STABILITY (PFANKUCH) EVALUATION
## AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

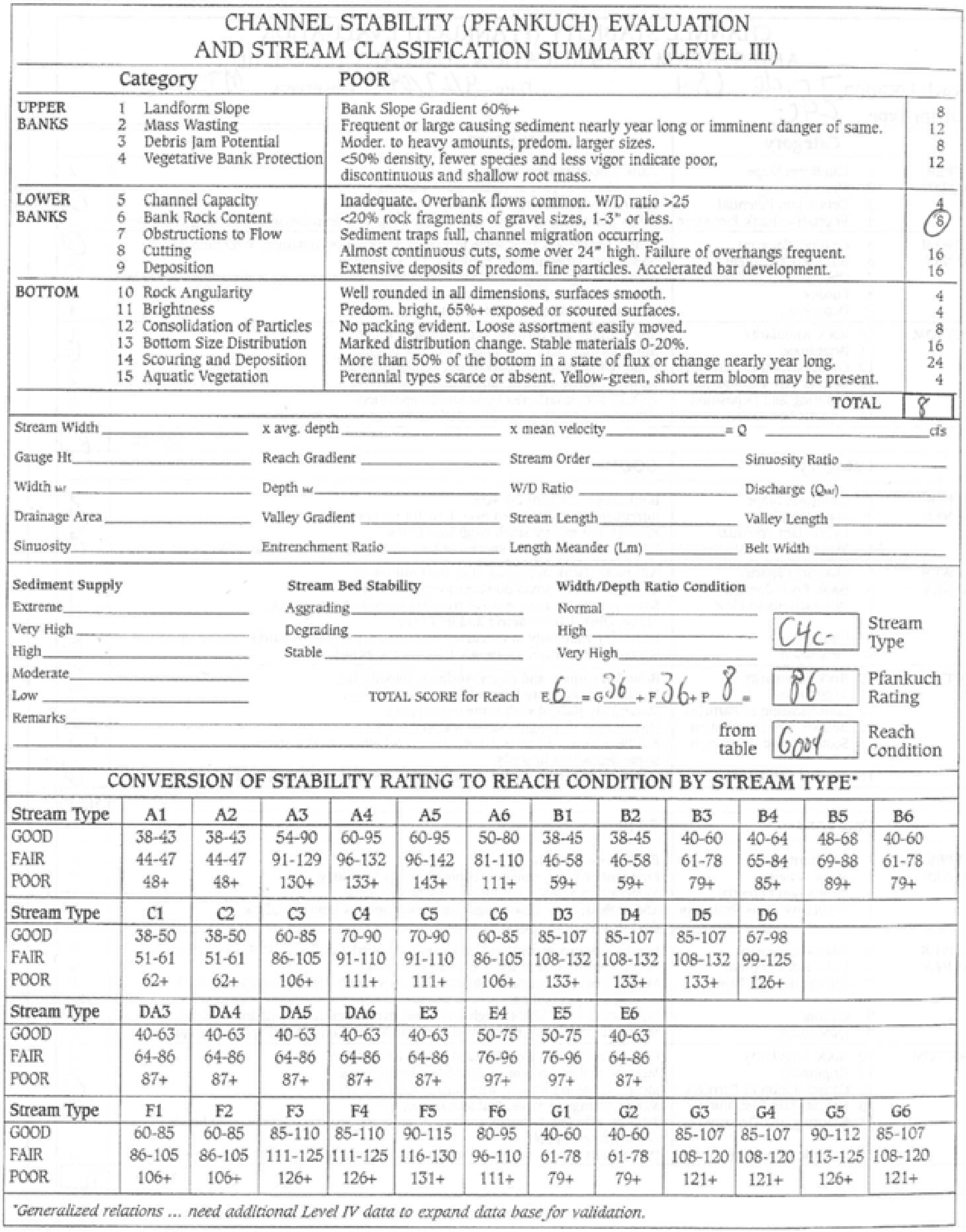
Reach Location Icicle CS-1 Date 9/27/04 Observers MI

Stream Type C4c-

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | 3 |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | [✓ 2] |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | [✓ 1] |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | [✓ 2] |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | [✓ 1] |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 6 |

| | | Category | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | [✓ 6] |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | [✓ 8] |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | [✓ 2] |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | 2 |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | [✓ 12] |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | [✓ 2] |
| | | | TOTAL | 36 |

| | | Category | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | [✓ 12] |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | 3 |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | [✓ 6] |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | [✓ 12] |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | 3 |
| | | | TOTAL | 36 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | [✓ 8] |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | 8 |

Stream Width ______ x avg. depth ______ x mean velocity ______ = Q ______ cfs

Gauge Ht ______ Reach Gradient ______ Stream Order ______ Sinuosity Ratio ______

Width bkf ______ Depth bkf ______ W/D Ratio ______ Discharge (Qbkf) ______

Drainage Area ______ Valley Gradient ______ Stream Length ______ Valley Length ______

Sinuosity ______ Entrenchment Ratio ______ Length Meander (Lm) ______ Belt Width ______

**Sediment Supply**
Extreme ______
Very High ______
High ______
Moderate ______
Low ______

**Stream Bed Stability**
Aggrading ______
Degrading ______
Stable ______

**Width/Depth Ratio Condition**
Normal ______
High ______
Very High ______

Stream Type: C4c-

TOTAL SCORE for Reach E 6 = G 36 + F 36 + P 8 = 86 Pfankuch Rating

from table: Good Reach Condition

Remarks ______

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

**Generalized relations ... need additional Level IV data to expand data base for validation.*

# Icicle 2 Cross-section field data form

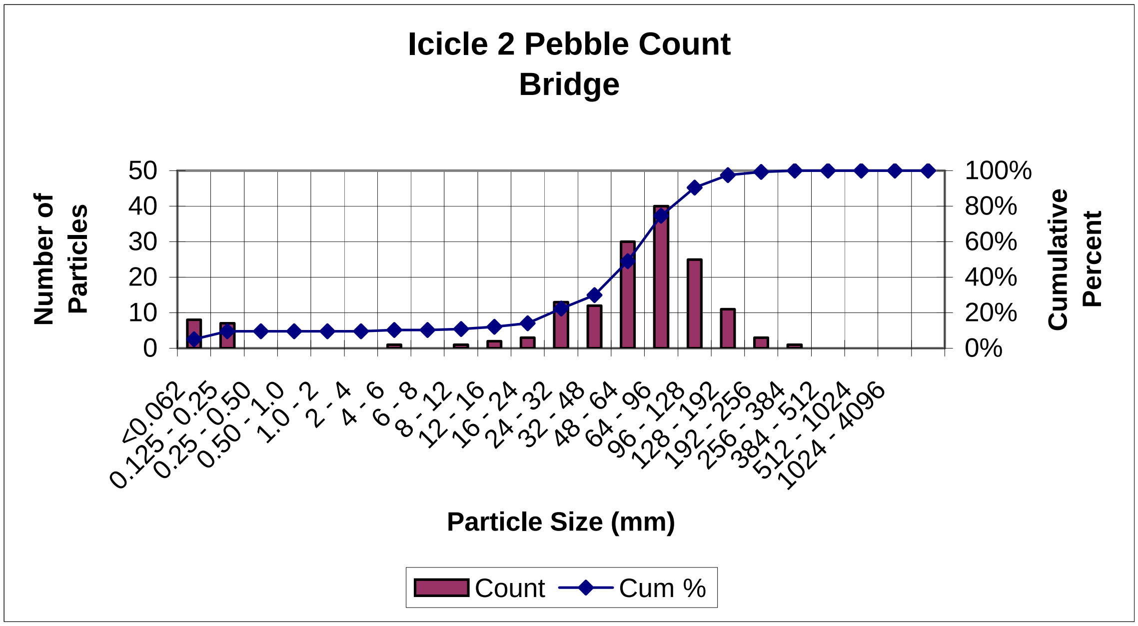
| | | | | | |
|---|---|---|---|---|---|
| Stream Name | **CS2** | | | | |
| Observors | **MI, JC, DO, TT** | | | | |
| Location | **Bridge** | | | | |
| Bankfull width | **126** | Mankfull max depth | **5.1** | Channel Slope | **0.0012** |
| Bankfull mean depth | **4.2** | Flood-prone area width | | Valley slope | **NA** |
| Width/Depth ratio | **30** | Entrench. Ratio | **>2.2** | Sinuosity | **1.3** |

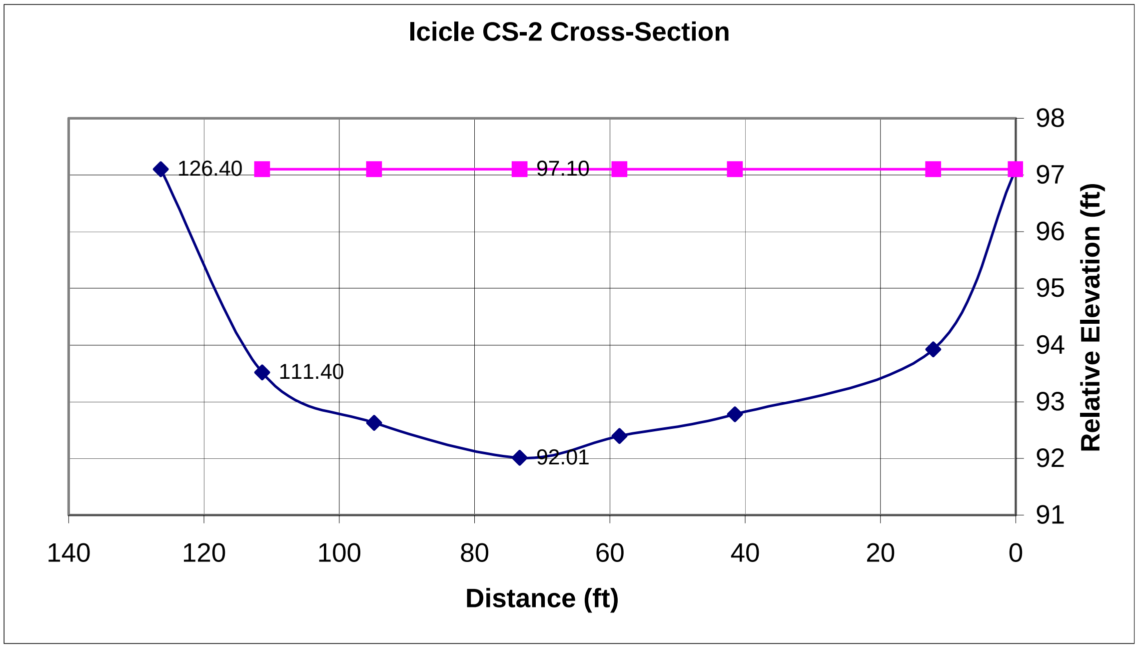
Pebble Count:

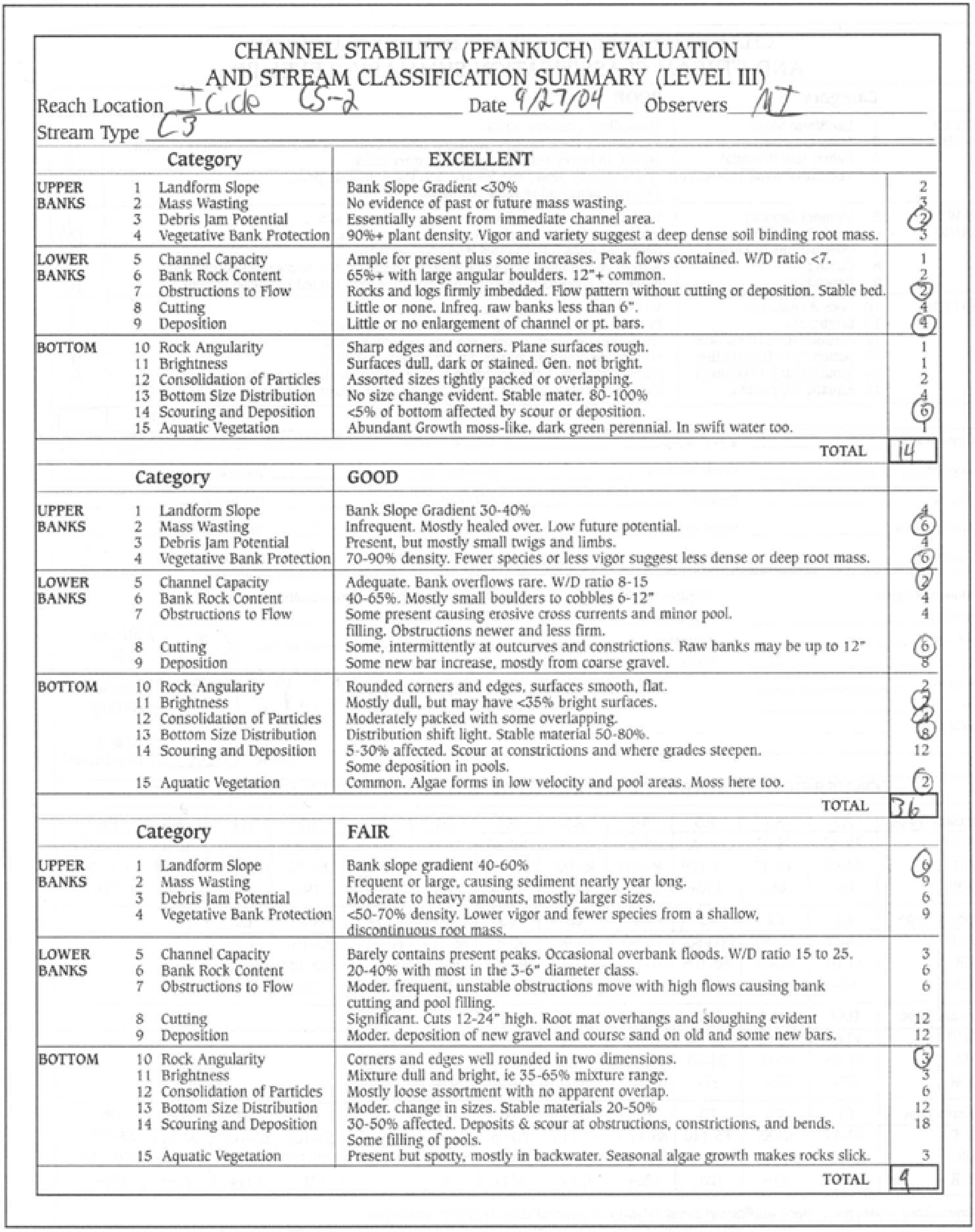
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **8** | **0.051** | **0.051** |
| | Fine | 0.125 - 0.25 | | **7** | **0.045** | **0.096** |
| | Medium | 0.25 - 0.50 | | **0** | **0.000** | **0.096** |
| | Coarse | 0.50 - 1.0 | | **0** | **0.000** | **0.096** |
| 0.04 - 0.08 | Very Coarse | 1.0 - 2 | | **0** | **0.000** | **0.096** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **0** | **0.000** | **0.096** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **1** | **0.006** | **0.102** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **0** | **0.000** | **0.102** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **1** | **0.006** | **0.108** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **2** | **0.013** | **0.121** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **3** | **0.019** | **0.140** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **13** | **0.083** | **0.223** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **12** | **0.076** | **0.299** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **30** | **0.191** | **0.490** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **40** | **0.255** | **0.745** |
| 3.8 - 5 | Small | 96 - 128 | | **25** | **0.159** | **0.904** |
| 5.0 - 7.6 | Large | 128 - 192 | | **11** | **0.070** | **0.975** |
| 7.6 - 10.0 | Large | 192 - 256 | | **3** | **0.019** | **0.994** |
| 10 - 15 | Small | 256 - 384 | Boulder | **1** | **0.006** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | | | **0** | **0.000** | **1.000** |
| Total | | | | **157** | | |
| D50 | | | | **64-96** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **7b** | Depositional patterns (see 6-4, fig 6-10) | **B2** |
| Streamflow regime (see 6-2) | **P1** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **27.8/20.8** |
| Debris/Blockages (see 6-6) | **D2** | Channel stability rating (Pfankuch) | **67** |




Icicle CS-2 Cross-Section
126.40
111.40
97.10
92.01
98
97
96
95
94
93
92
91
Relative Elevation (ft)
140
120
100
80
60
40
20
0
Distance (ft)



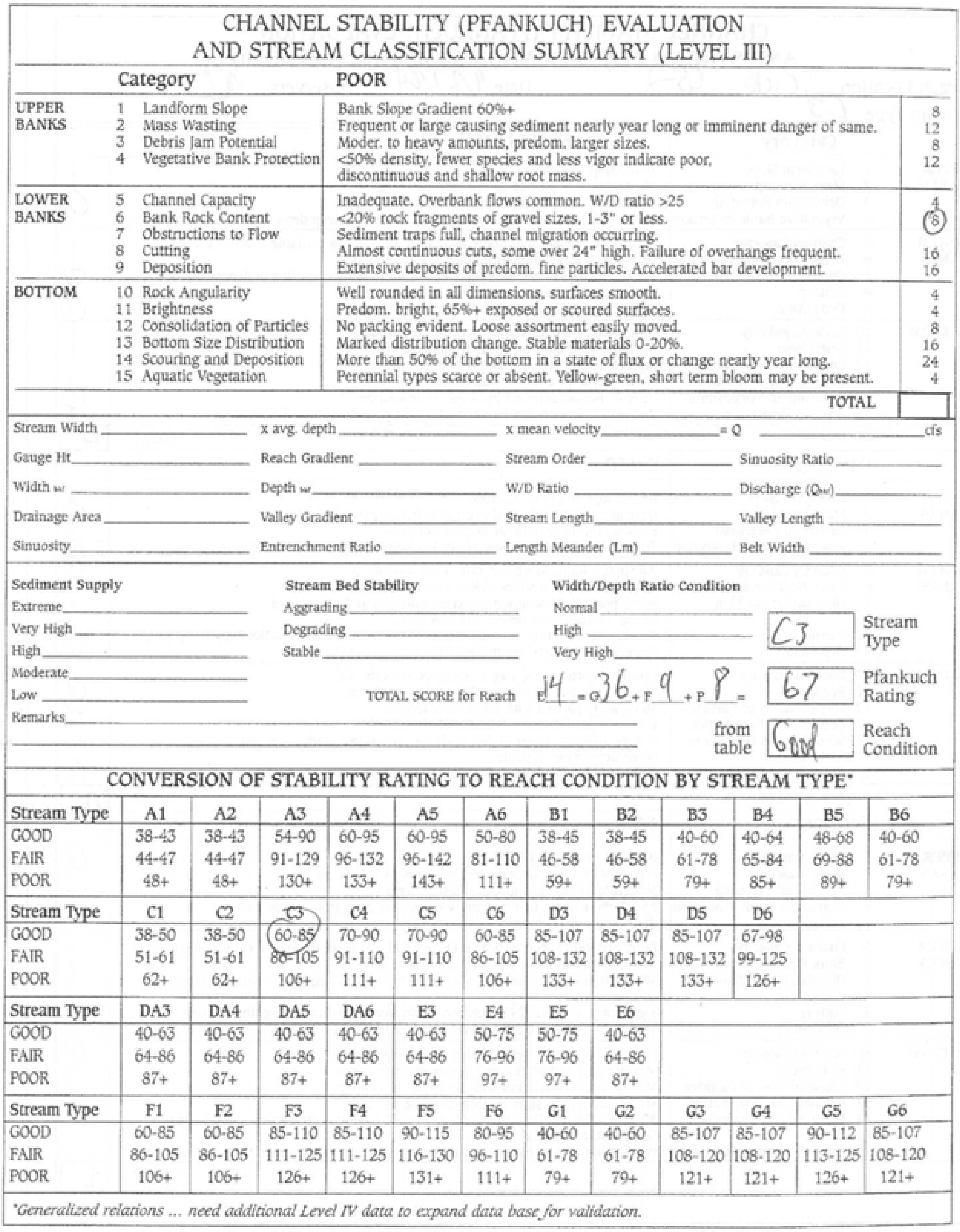
## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

Reach Location Icicle CS-2 Date 9/27/04 Observers NT
Stream Type C3

| Category | | | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | 3 |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | [✓ 2] |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | 1 |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | [✓ 2] |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | [✓ 4] |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | [✓ 6] |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 14 |

| Category | | | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | [✓ 6] |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 6] |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | [✓ 2] |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | [✓ 6] |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | 8 |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | [✓ 2] |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | [✓ 4] |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | [✓ 8] |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | [✓ 2] |
| | | | TOTAL | 36 |

| Category | | | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | [✓ 6] |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | 12 |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | [✓ 3] |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | 6 |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | 12 |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | 3 |
| | | | TOTAL | 4 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | ⑧ |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | |

Stream Width ______ x avg. depth ______ x mean velocity ______ = Q ______ cfs

Gauge Ht ______ Reach Gradient ______ Stream Order ______ Sinuosity Ratio ______

Width bkf ______ Depth bkf ______ W/D Ratio ______ Discharge (Qbkf) ______

Drainage Area ______ Valley Gradient ______ Stream Length ______ Valley Length ______

Sinuosity ______ Entrenchment Ratio ______ Length Meander (Lm) ______ Belt Width ______

**Sediment Supply**

Extreme ______
Very High ______
High ______
Moderate ______
Low ______

**Stream Bed Stability**

Aggrading ______
Degrading ______
Stable ______

**Width/Depth Ratio Condition**

Normal ______
High ______
Very High ______

Stream Type: C3

TOTAL SCORE for Reach E 14 = G 36 + F 9 + P 8 = 67 Pfankuch Rating

from table: Good Reach Condition

Remarks ______

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

**Generalized relations ... need additional Level IV data to expand data base for validation.*

## Icicle 3 Cross-section field data form

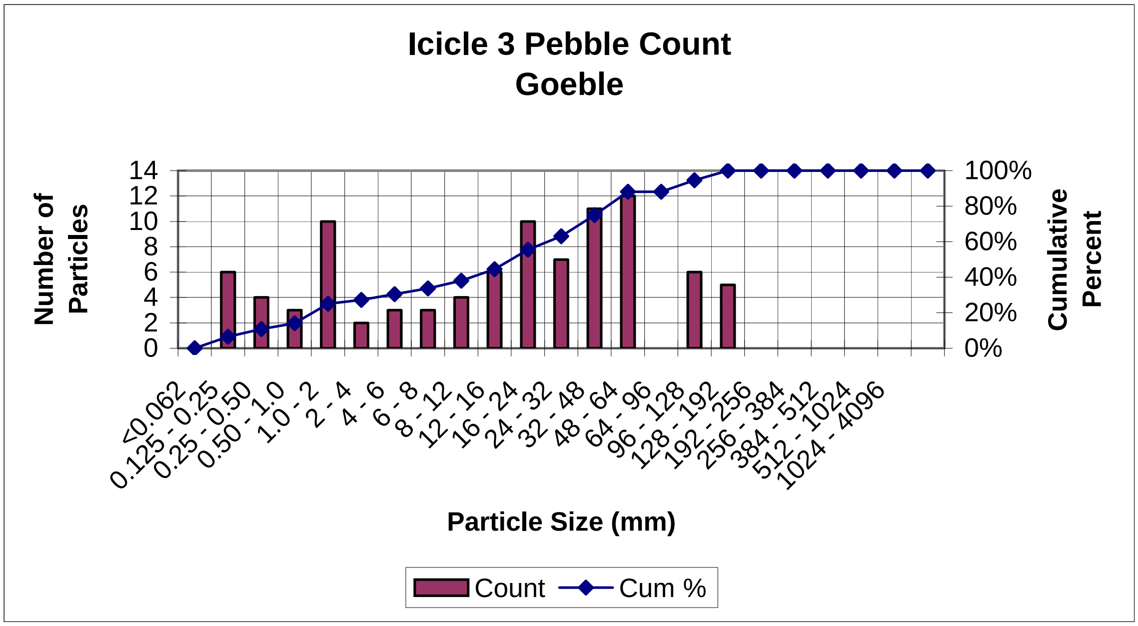
| | | | | | |
|---|---|---|---|---|---|
| Stream Name | **CS3** | | | | |
| Observors | **MI, DO, TT** | | | | |
| Location | **Goebel Property** | | | | |
| Bankfull width | **126** | Mankfull max depth | **2.32** | Channel Slope | **0.0039** |
| Bankfull mean depth | **1.22** | Flood-prone area width | | Valley slope | **NA** |
| Width/Depth ratio | **103** | Entrench. Ratio | **>2.2** | Sinuosity | **2.7** |

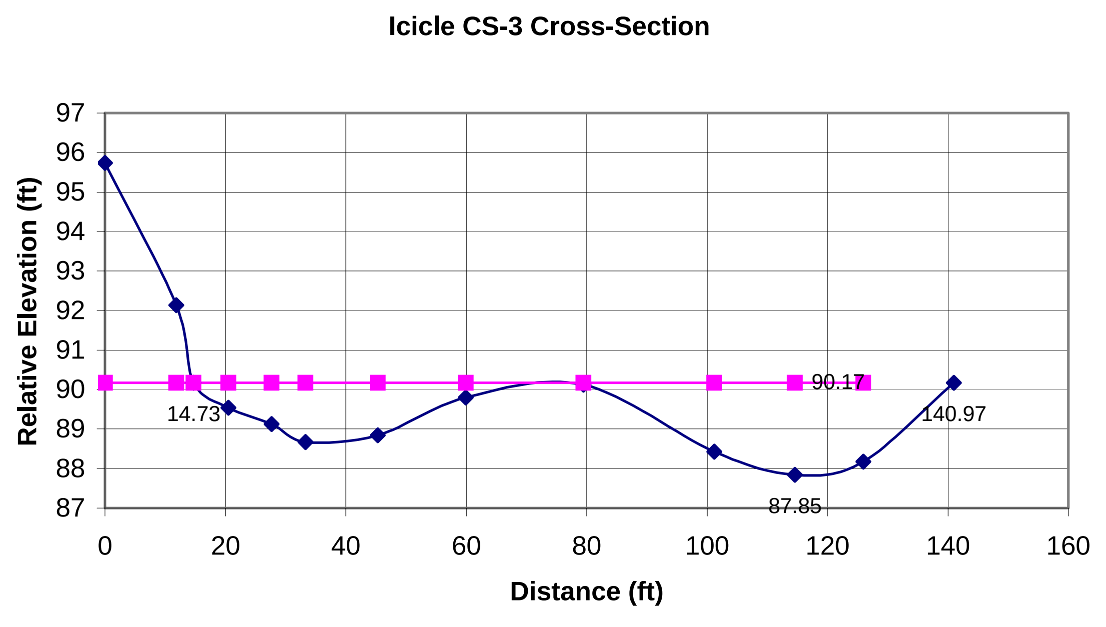
Pebble Count:

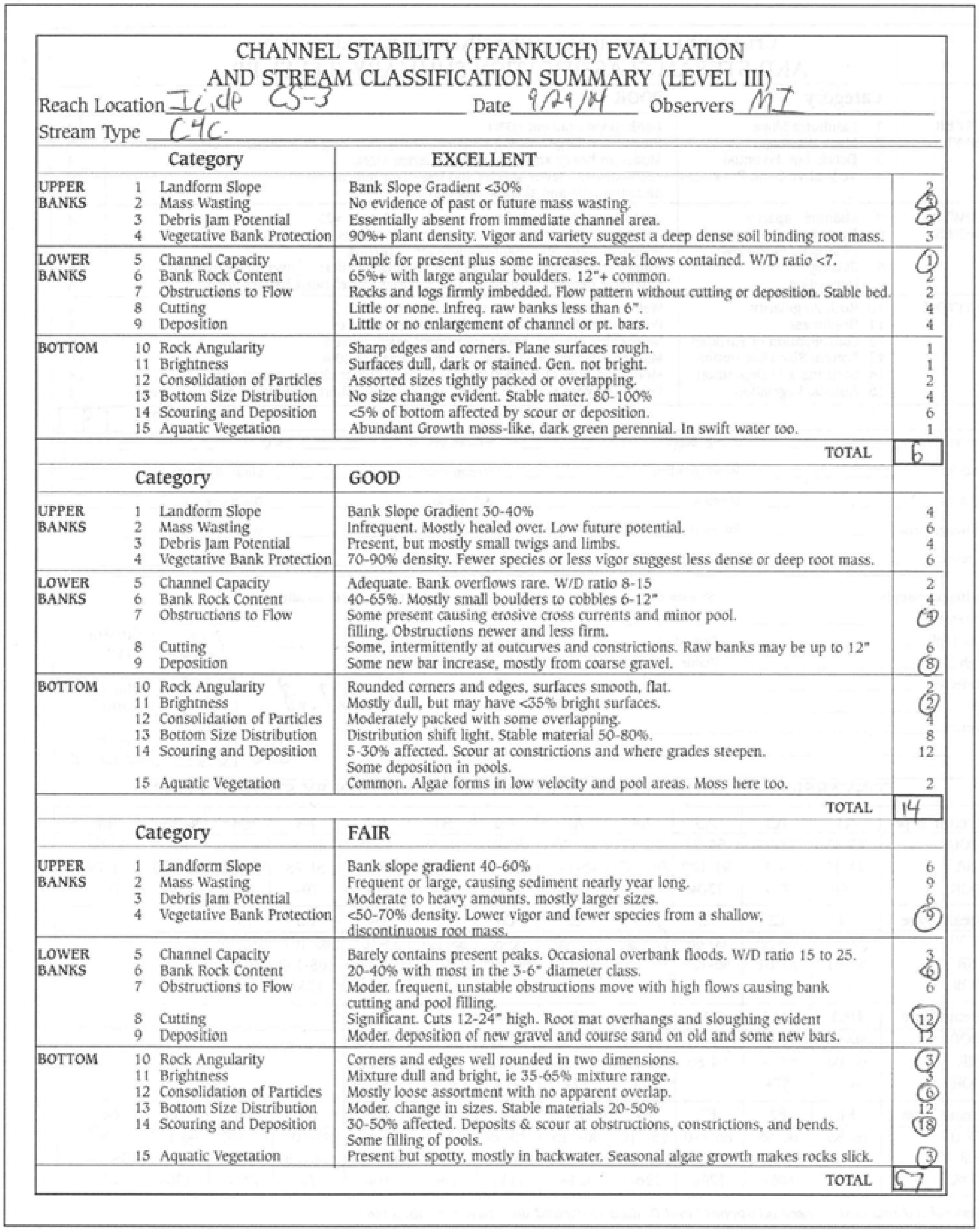
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **0** | **0.000** | **0.000** |
| | Fine | 0.125 - 0.25 | | **6** | **0.065** | **0.065** |
| | Medium | 0.25 - 0.50 | | **4** | **0.043** | **0.109** |
| | Coarse | 0.50 - 1.0 | | **3** | **0.033** | **0.141** |
| 0.04 - 0.08 | Very Coarse | 1.0 - 2 | | **10** | **0.109** | **0.250** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **2** | **0.022** | **0.272** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **3** | **0.033** | **0.304** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **3** | **0.033** | **0.337** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **4** | **0.043** | **0.380** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **6** | **0.065** | **0.446** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **10** | **0.109** | **0.554** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **7** | **0.076** | **0.630** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **11** | **0.120** | **0.750** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **12** | **0.130** | **0.880** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **0** | **0.000** | **0.880** |
| 3.8 - 5 | Small | 96 - 128 | | **6** | **0.065** | **0.946** |
| 5.0 - 7.6 | Large | 128 - 192 | | **5** | **0.054** | **1.000** |
| 7.6 - 10.0 | Large | 192 - 256 | | **0** | **0.000** | **1.000** |
| 10 - 15 | Small | 256 - 384 | Boulder | **0** | **0.000** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | | | **0** | **0.000** | **1.000** |
| Total | | | | **92** | | |
| D50 | | | | **16-24** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **5b/6b** | Depositional patterns (see 6-4, fig 6-10) | **B2** |
| Streamflow regime (see 6-2) | **P1** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **29.25/14.5** |
| Debris/Blockages (see 6-6) | **D2** | Channel stability rating (Pfankuch) | **85** |




Icicle CS-3 Cross-Section
Relative Elevation (ft)
97
96
95
94
93
92
91
90
89
88
87
0
20
40
60
80
100
120
140
160
Distance (ft)
14.73
90.17
140.97
87.85



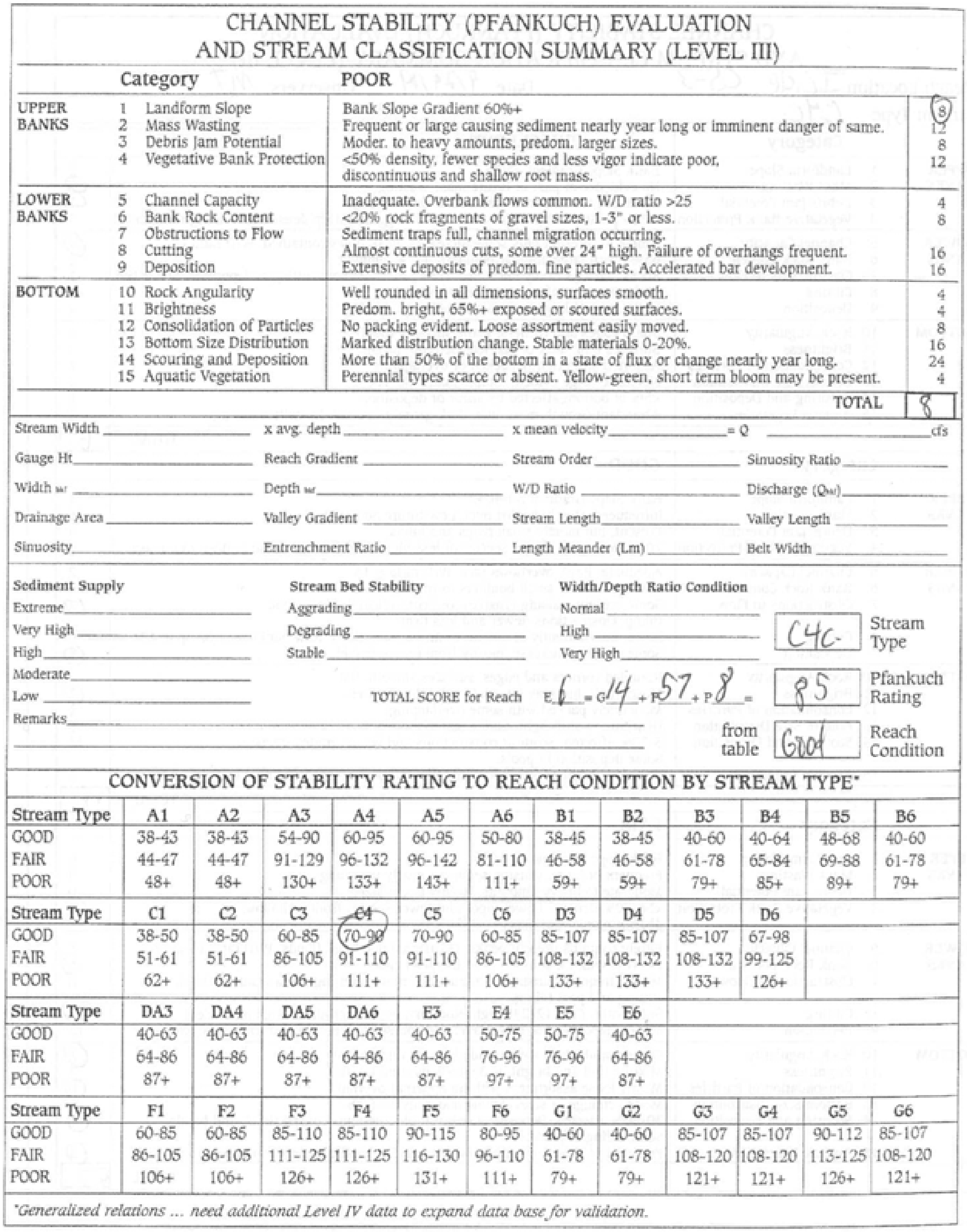
## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

Reach Location Icicle CS-3 Date 9/29/14 Observers MI
Stream Type C4C.

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | [✓ 3] |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | [✓ 2] |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | [✓ 1] |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | 2 |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 6 |

| | | Category | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | 6 |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | [✓ 4] |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | [✓ 8] |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | [✓ 2] |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | 2 |
| | | | TOTAL | 14 |

| | | Category | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | [✓ 9] |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | [✓ 6] |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | [✓ 12] |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | [✓ 3] |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | 3 |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | [✓ 6] |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | 12 |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | [✓ 18] |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] |
| | | | TOTAL | 57 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| UPPER BANKS | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| LOWER BANKS | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | 8 |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| BOTTOM | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | 8 |

Stream Width ______ x avg. depth ______ x mean velocity ______ = Q ______ cfs

Gauge Ht ______ Reach Gradient ______ Stream Order ______ Sinuosity Ratio ______

Width bkf ______ Depth bkf ______ W/D Ratio ______ Discharge (Qbkf) ______

Drainage Area ______ Valley Gradient ______ Stream Length ______ Valley Length ______

Sinuosity ______ Entrenchment Ratio ______ Length Meander (Lm) ______ Belt Width ______

**Sediment Supply**
Extreme ______
Very High ______
High ______
Moderate ______
Low ______

**Stream Bed Stability**
Aggrading ______
Degrading ______
Stable ______

**Width/Depth Ratio Condition**
Normal ______
High ______
Very High ______

Stream Type: C4c

TOTAL SCORE for Reach E 6 = G 14 + F 57 + P 8 =

Pfankuch Rating: 85

from table — Reach Condition: Good

Remarks ______

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

**Generalized relations ... need additional Level IV data to expand data base for validation.*

# Icicle 4 Cross-section field data form

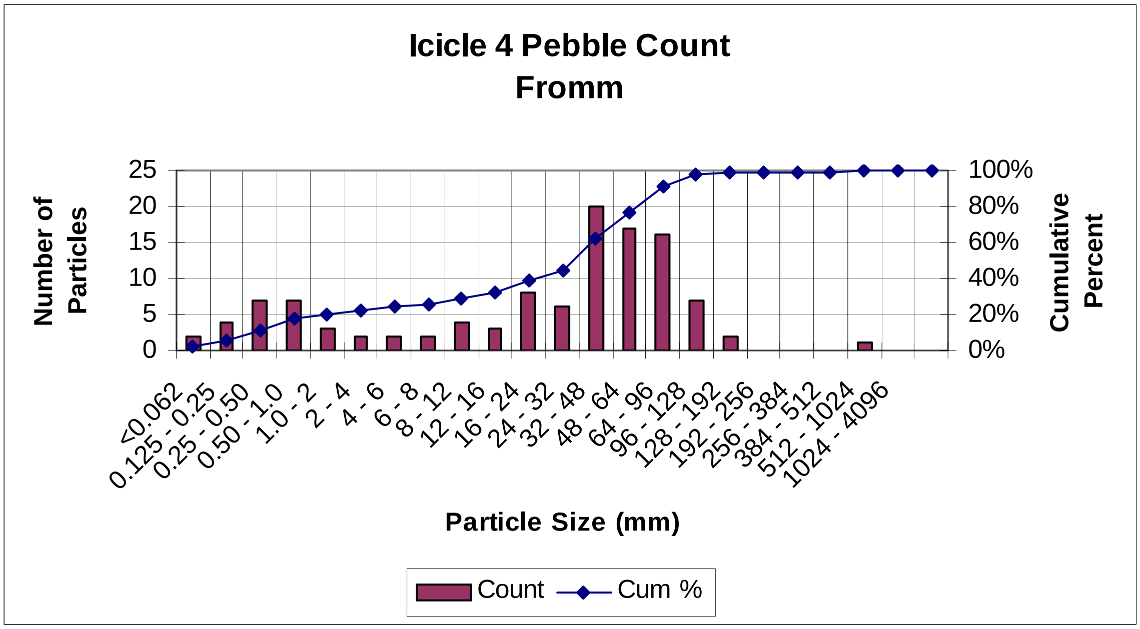
| | | | | | |
|---|---|---|---|---|---|
| Stream Name | **CS4** | | | | |
| Observors | **MI, DO, TT** | | | | |
| Location | **Fromm** | | | | |
| Bankfull width | **148** | Mankfull max depth | **3.1** | Channel Slope | **0.0064** |
| Bankfull mean depth | **2.3** | Flood-prone area width | **175** | Valley slope | **NA** |
| Width/Depth ratio | **64** | Entrench. Ratio | **1.2** | Sinuosity | **2.7** |

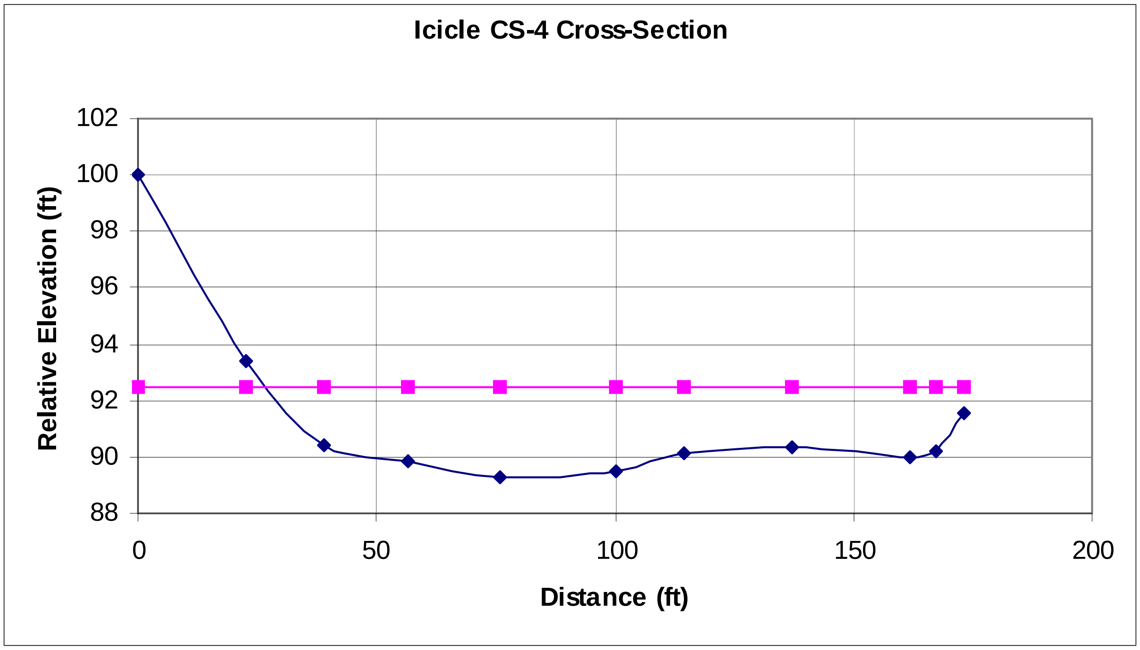
Pebble Count:

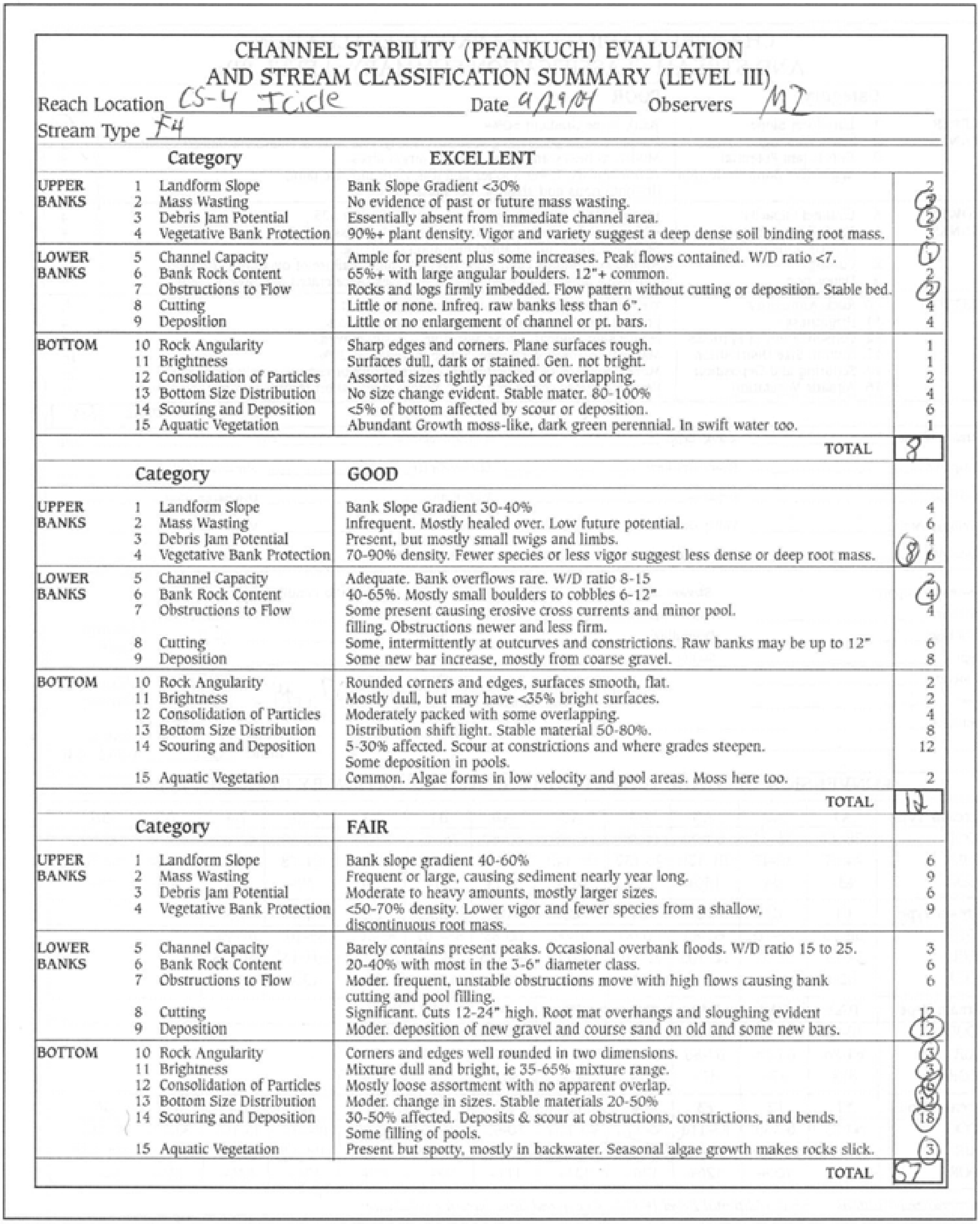
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **2** | **0.018** | **0.018** |
| | Fine | 0.125 - 0.25 | | **4** | **0.035** | **0.053** |
| | Medium | 0.25 - 0.50 | | **7** | **0.062** | **0.115** |
| | Coarse | 0.50 - 1.0 | | **7** | **0.062** | **0.177** |
| .04 - 0.08 | Very Coarse | 1.0 - 2 | | **3** | **0.027** | **0.204** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **2** | **0.018** | **0.221** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **2** | **0.018** | **0.239** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **2** | **0.018** | **0.257** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **4** | **0.035** | **0.292** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **3** | **0.027** | **0.319** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **8** | **0.071** | **0.389** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **6** | **0.053** | **0.442** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **20** | **0.177** | **0.619** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **17** | **0.150** | **0.770** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **16** | **0.142** | **0.912** |
| 3.8 - 5 | Small | 96 - 128 | | **7** | **0.062** | **0.973** |
| 5.0 - 7.6 | Large | 128 - 192 | | **2** | **0.018** | **0.991** |
| 7.6 - 10.0 | Large | 192 - 256 | | **0** | **0.000** | **0.991** |
| 10 - 15 | Small | 256 - 384 | Boulder | **0** | **0.000** | **0.991** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **0.991** |
| 20 - 40 | Medium | 512 - 1024 | | **1** | **0.009** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | | | **0** | **0.000** | **1.000** |
| Total | | | | **113** | | |
| D50 | | | | **32-48** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **6b/4b** | Depositional patterns (see 6-4, fig 6-10) | **B2** |
| Streamflow regime (see 6-2) | **P1** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **32.75/29.25** |
| Debris/Blockages (see 6-6) | **D1** | Channel stability rating (Pfankuch) | **101** |




Icicle CS-4 Cross-Section
Relative Elevation (ft)
102
100
98
96
94
92
90
88
0
50
100
150
200
Distance (ft)



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

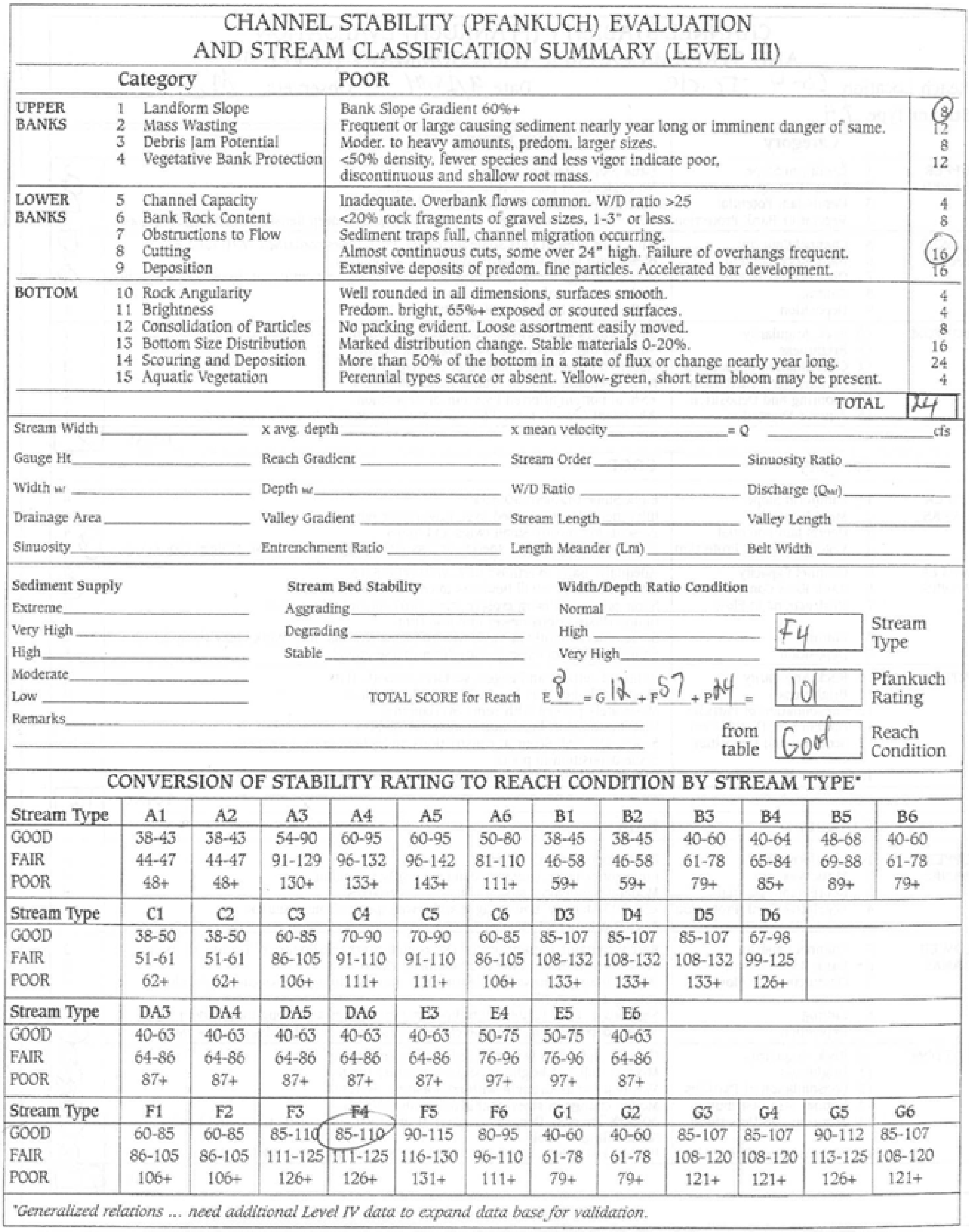
Reach Location CS-4 Icicle Date 4/29/04 Observers MJ

Stream Type F4

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | [✓ 3] |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | [✓ 2] |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| LOWER BANKS | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | [✓ 1] |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | [✓ 2] |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| BOTTOM | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 8 |

| | | Category | GOOD | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 30-40% | 4 |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | 6 |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | 4 |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | [✓ 8] 6 |
| LOWER BANKS | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | [✓ 4] |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | 6 |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | 8 |
| BOTTOM | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | 2 |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | 2 |
| | | | TOTAL | 12 |

| | | Category | FAIR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| LOWER BANKS | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | 12 |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | [✓ 12] |
| BOTTOM | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | [✓ 3] |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | [✓ 3] |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | [✓ 6] |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | [✓ 12] |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | [✓ 18] |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] |
| | | | TOTAL | 57 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | | POOR | |
|---|---|---|---|---|
| UPPER BANKS | 1 | Landform Slope | Bank Slope Gradient 60%+ | [✓ 8] |
| | 2 | Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 | Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 | Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| LOWER BANKS | 5 | Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 | Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | 8 |
| | 7 | Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 | Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | [✓ 16] |
| | 9 | Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| BOTTOM | 10 | Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 | Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 | Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 | Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 | Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 | Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | | TOTAL | 24 |

Stream Width ______ x avg. depth ______ x mean velocity ______ = Q ______ cfs

Gauge Ht ______ Reach Gradient ______ Stream Order ______ Sinuosity Ratio ______

Width bkf ______ Depth bkf ______ W/D Ratio ______ Discharge (Qbkf) ______

Drainage Area ______ Valley Gradient ______ Stream Length ______ Valley Length ______

Sinuosity ______ Entrenchment Ratio ______ Length Meander (Lm) ______ Belt Width ______

**Sediment Supply**
Extreme ______
Very High ______
High ______
Moderate ______
Low ______

**Stream Bed Stability**
Aggrading ______
Degrading ______
Stable ______

**Width/Depth Ratio Condition**
Normal ______
High ______
Very High ______

Stream Type: F4

TOTAL SCORE for Reach E 8 = G 12 + F 57 + P 24 = Pfankuch Rating: 101

from table — Reach Condition: Good

Remarks ______

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | [✓ 85-110] | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

*Generalized relations ... need additional Level IV data to expand data base for validation.*

# Icicle 5 Cross-section field data form

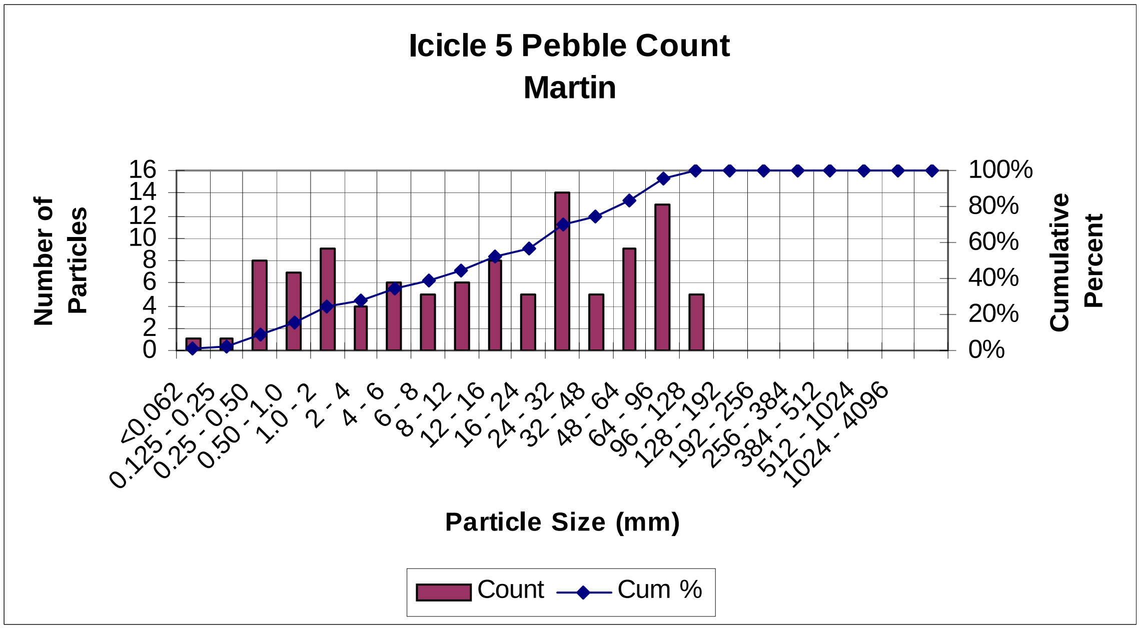
| | | | | | |
|---|---|---|---|---|---|
| Stream Name | **CS5** | | | | |
| Observors | **MI, DO, TT** | | | | |
| Location | **Martin Property** | | | | |
| Bankfull width | **138** | Mankfull max depth | **5** | Channel Slope | **0.0005** |
| Bankfull mean depth | **3.6** | Flood-prone area width | | Valley slope | **NA** |
| Width/Depth ratio | **38** | Entrench. Ratio | **>2.2** | Sinuosity | **1.5** |

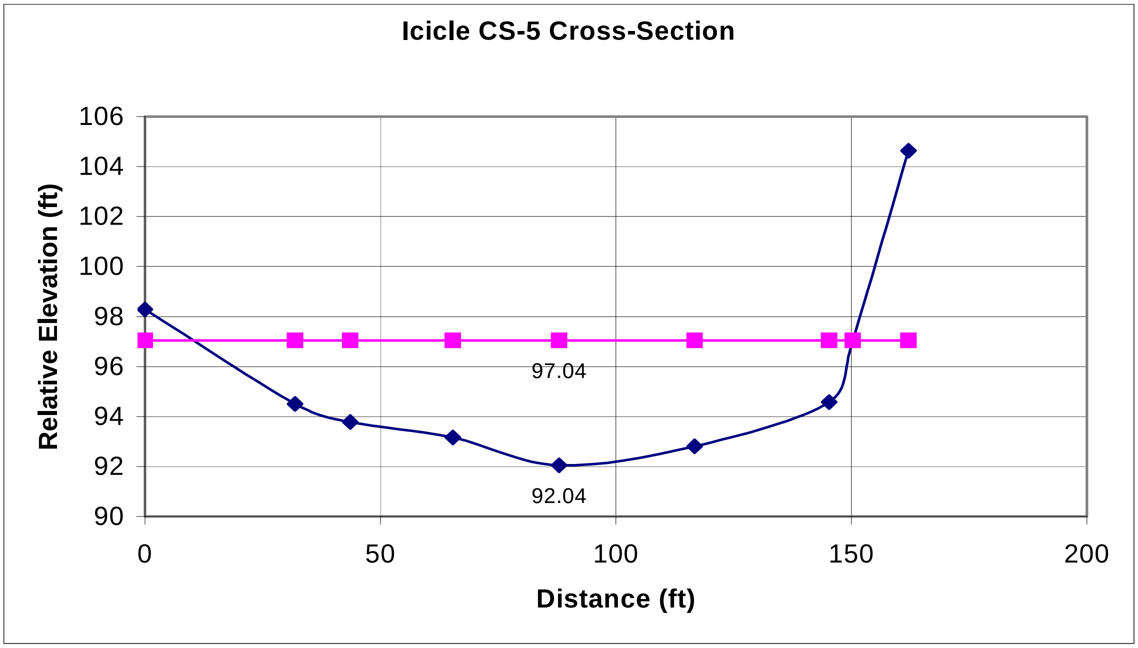
Pebble Count:

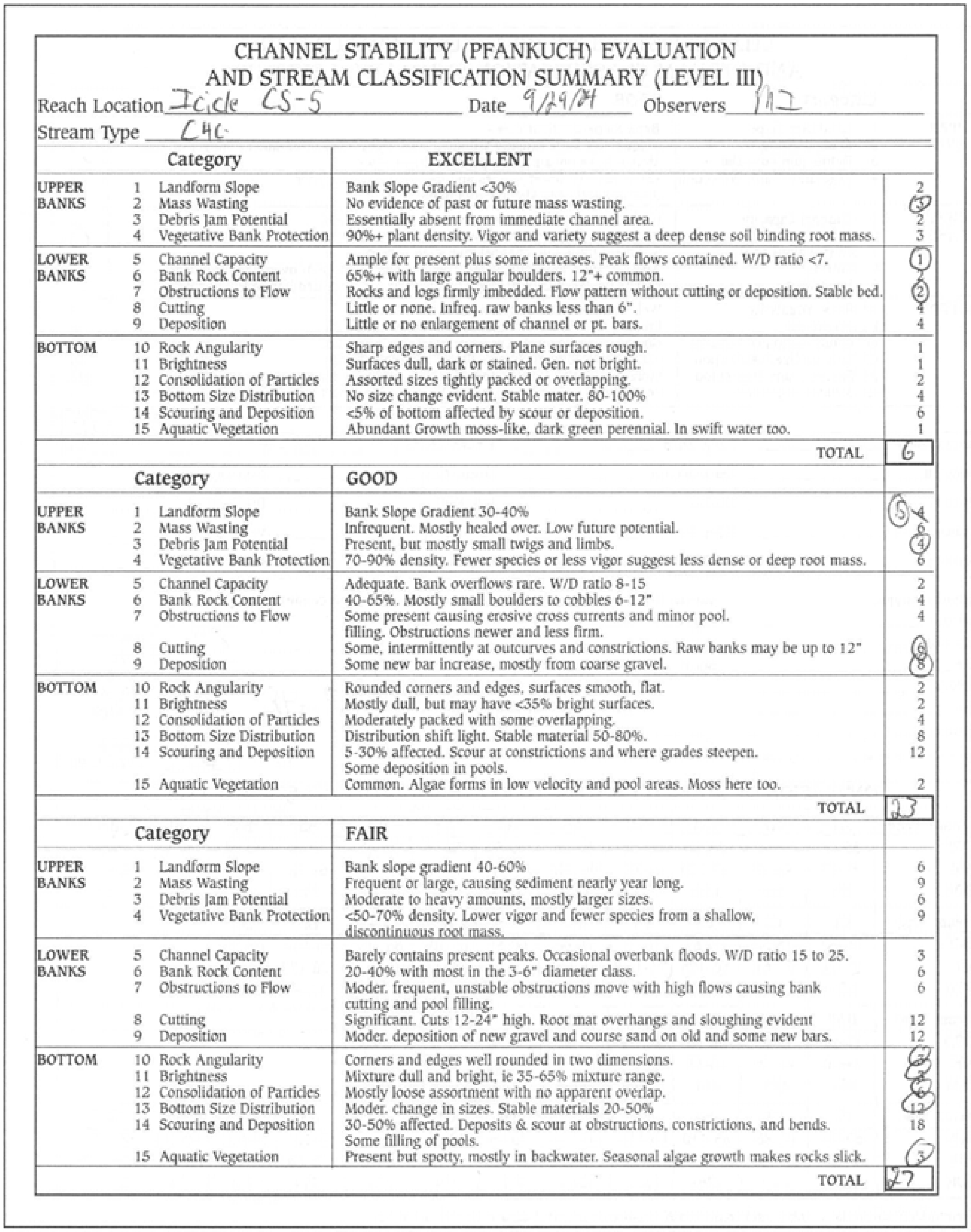
Observors

| Inches | Particle | Millimeter | | Count | % | Cum % |
|---|---|---|---|---|---|---|
| | Silt/Clay | <0.062 | Sand | **1** | **0.009** | **0.009** |
| | Fine | 0.125 - 0.25 | | **1** | **0.009** | **0.019** |
| | Medium | 0.25 - 0.50 | | **8** | **0.075** | **0.094** |
| | Coarse | 0.50 - 1.0 | | **7** | **0.066** | **0.160** |
| .04 - 0.08 | Very Coarse | 1.0 - 2 | | **9** | **0.085** | **0.245** |
| 0.08 - 0.16 | Very Fine | 2 - 4 | Gravel | **4** | **0.038** | **0.283** |
| 0.16 - 0.24 | Fine | 4 - 6 | | **6** | **0.057** | **0.340** |
| 0.24 - 0.31 | Fine | 6 - 8 | | **5** | **0.047** | **0.387** |
| 0.31 - 0.47 | Medium | 8 - 12 | | **6** | **0.057** | **0.443** |
| 0.47 - 0.63 | Medium | 12 - 16 | | **8** | **0.075** | **0.519** |
| 0.63 - 0.94 | Coarse | 16 - 24 | | **5** | **0.047** | **0.566** |
| 0.94 - 1.26 | Coarse | 24 - 32 | | **14** | **0.132** | **0.698** |
| 1.26 - 1.9 | Very Coarse | 32 - 48 | | **5** | **0.047** | **0.745** |
| 1.9 - 2.5 | Very Coarse | 48 - 64 | | **9** | **0.085** | **0.830** |
| 2.5 - 3.8 | Small | 64 - 96 | Cobble | **13** | **0.123** | **0.953** |
| 3.8 - 5 | Small | 96 - 128 | | **5** | **0.047** | **1.000** |
| 5.0 - 7.6 | Large | 128 - 192 | | **0** | **0.000** | **1.000** |
| 7.6 - 10.0 | Large | 192 - 256 | | **0** | **0.000** | **1.000** |
| 10 - 15 | Small | 256 - 384 | Boulder | **0** | **0.000** | **1.000** |
| 15 - 20 | Small | 384 - 512 | | **0** | **0.000** | **1.000** |
| 20 - 40 | Medium | 512 - 1024 | | **0** | **0.000** | **1.000** |
| 40 - 160 | Large - Very Large | 1024 - 4096 | | **0** | **0.000** | **1.000** |
| Bedrock | | | | **0** | **0.000** | **1.000** |
| Total | | | | **106** | | |
| D50 | | | | **12-16** | | |

| | | | |
|---|---|---|---|
| Riparian vegetation (see 6-1) | **9b/4a** | Depositional patterns (see 6-4, fig 6-10) | **B4** |
| Streamflow regime (see 6-2) | **P1** | Meander patterns (see 6-5, fig 6-12) | **M3** |
| Stream size/order (see 6-3) | **S8** | Stream bank erosion potential (BEHI) | **22.25/33.5** |
| Debris/Blockages (see 6-6) | **D2** | Channel stability rating (Pfankuch) | **104** |




Icicle CS-5 Cross-Section
Relative Elevation (ft)
106
104
102
100
98
96
94
92
90
97.04
92.04
0
50
100
150
200
Distance (ft)



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

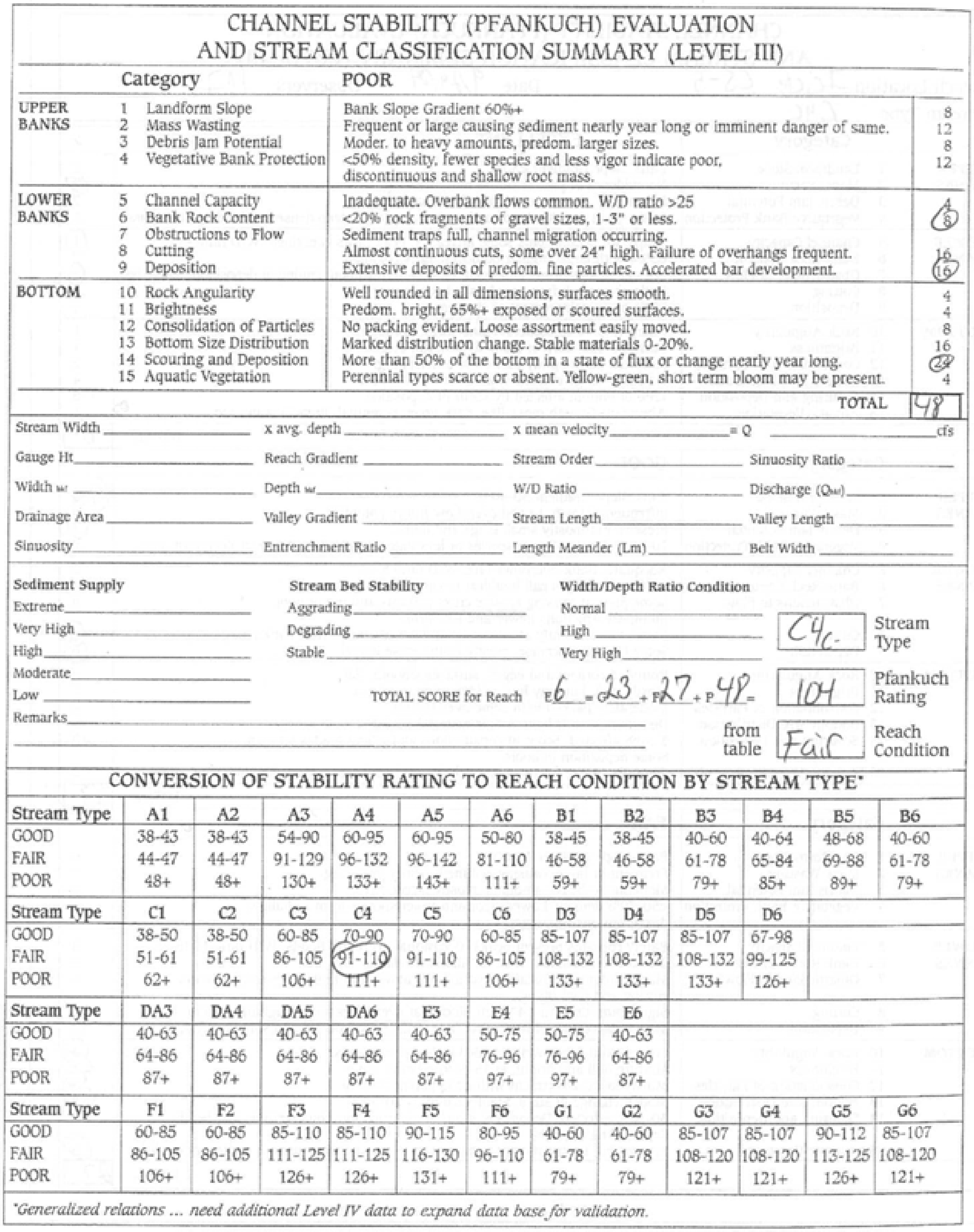
Reach Location Icicle CS-5 Date 9/29/04 Observers MJ

Stream Type C4c

| | | Category | EXCELLENT | |
|---|---|---|---|---|
| **UPPER BANKS** | 1 | Landform Slope | Bank Slope Gradient <30% | 2 |
| | 2 | Mass Wasting | No evidence of past or future mass wasting. | [✓ 3] |
| | 3 | Debris Jam Potential | Essentially absent from immediate channel area. | 2 |
| | 4 | Vegetative Bank Protection | 90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass. | 3 |
| **LOWER BANKS** | 5 | Channel Capacity | Ample for present plus some increases. Peak flows contained. W/D ratio <7. | [✓ 1] |
| | 6 | Bank Rock Content | 65%+ with large angular boulders. 12"+ common. | 2 |
| | 7 | Obstructions to Flow | Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed. | [✓ 2] |
| | 8 | Cutting | Little or none. Infreq. raw banks less than 6". | 4 |
| | 9 | Deposition | Little or no enlargement of channel or pt. bars. | 4 |
| **BOTTOM** | 10 | Rock Angularity | Sharp edges and corners. Plane surfaces rough. | 1 |
| | 11 | Brightness | Surfaces dull, dark or stained. Gen. not bright. | 1 |
| | 12 | Consolidation of Particles | Assorted sizes tightly packed or overlapping. | 2 |
| | 13 | Bottom Size Distribution | No size change evident. Stable mater. 80-100% | 4 |
| | 14 | Scouring and Deposition | <5% of bottom affected by scour or deposition. | 6 |
| | 15 | Aquatic Vegetation | Abundant Growth moss-like, dark green perennial. In swift water too. | 1 |
| | | | TOTAL | 6 |

| | | Category | GOOD | |
|---|---|---|---|---|
| **UPPER BANKS** | 1 | Landform Slope | Bank Slope Gradient 30-40% | [✓ 5] ~~4~~ |
| | 2 | Mass Wasting | Infrequent. Mostly healed over. Low future potential. | 6 |
| | 3 | Debris Jam Potential | Present, but mostly small twigs and limbs. | [✓ 4] |
| | 4 | Vegetative Bank Protection | 70-90% density. Fewer species or less vigor suggest less dense or deep root mass. | 6 |
| **LOWER BANKS** | 5 | Channel Capacity | Adequate. Bank overflows rare. W/D ratio 8-15 | 2 |
| | 6 | Bank Rock Content | 40-65%. Mostly small boulders to cobbles 6-12" | 4 |
| | 7 | Obstructions to Flow | Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm. | 4 |
| | 8 | Cutting | Some, intermittently at outcurves and constrictions. Raw banks may be up to 12" | [✓ 6] |
| | 9 | Deposition | Some new bar increase, mostly from coarse gravel. | [✓ 8] |
| **BOTTOM** | 10 | Rock Angularity | Rounded corners and edges, surfaces smooth, flat. | 2 |
| | 11 | Brightness | Mostly dull, but may have <35% bright surfaces. | 2 |
| | 12 | Consolidation of Particles | Moderately packed with some overlapping. | 4 |
| | 13 | Bottom Size Distribution | Distribution shift light. Stable material 50-80%. | 8 |
| | 14 | Scouring and Deposition | 5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. | 12 |
| | 15 | Aquatic Vegetation | Common. Algae forms in low velocity and pool areas. Moss here too. | 2 |
| | | | TOTAL | 23 |

| | | Category | FAIR | |
|---|---|---|---|---|
| **UPPER BANKS** | 1 | Landform Slope | Bank slope gradient 40-60% | 6 |
| | 2 | Mass Wasting | Frequent or large, causing sediment nearly year long. | 9 |
| | 3 | Debris Jam Potential | Moderate to heavy amounts, mostly larger sizes. | 6 |
| | 4 | Vegetative Bank Protection | <50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass. | 9 |
| **LOWER BANKS** | 5 | Channel Capacity | Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25. | 3 |
| | 6 | Bank Rock Content | 20-40% with most in the 3-6" diameter class. | 6 |
| | 7 | Obstructions to Flow | Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling. | 6 |
| | 8 | Cutting | Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident | 12 |
| | 9 | Deposition | Moder. deposition of new gravel and course sand on old and some new bars. | 12 |
| **BOTTOM** | 10 | Rock Angularity | Corners and edges well rounded in two dimensions. | [✓ 3] |
| | 11 | Brightness | Mixture dull and bright, ie 35-65% mixture range. | [✓ 3] |
| | 12 | Consolidation of Particles | Mostly loose assortment with no apparent overlap. | [✓ 6] |
| | 13 | Bottom Size Distribution | Moder. change in sizes. Stable materials 20-50% | [✓ 12] |
| | 14 | Scouring and Deposition | 30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools. | 18 |
| | 15 | Aquatic Vegetation | Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. | [✓ 3] |
| | | | TOTAL | 27 |



## CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

| | Category | POOR | |
|---|---|---|---|
| **UPPER BANKS** | 1 Landform Slope | Bank Slope Gradient 60%+ | 8 |
| | 2 Mass Wasting | Frequent or large causing sediment nearly year long or imminent danger of same. | 12 |
| | 3 Debris Jam Potential | Moder. to heavy amounts, predom. larger sizes. | 8 |
| | 4 Vegetative Bank Protection | <50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass. | 12 |
| **LOWER BANKS** | 5 Channel Capacity | Inadequate. Overbank flows common. W/D ratio >25 | 4 |
| | 6 Bank Rock Content | <20% rock fragments of gravel sizes, 1-3" or less. | 8 |
| | 7 Obstructions to Flow | Sediment traps full, channel migration occurring. | |
| | 8 Cutting | Almost continuous cuts, some over 24" high. Failure of overhangs frequent. | 16 |
| | 9 Deposition | Extensive deposits of predom. fine particles. Accelerated bar development. | 16 |
| **BOTTOM** | 10 Rock Angularity | Well rounded in all dimensions, surfaces smooth. | 4 |
| | 11 Brightness | Predom. bright, 65%+ exposed or scoured surfaces. | 4 |
| | 12 Consolidation of Particles | No packing evident. Loose assortment easily moved. | 8 |
| | 13 Bottom Size Distribution | Marked distribution change. Stable materials 0-20%. | 16 |
| | 14 Scouring and Deposition | More than 50% of the bottom in a state of flux or change nearly year long. | 24 |
| | 15 Aquatic Vegetation | Perennial types scarce or absent. Yellow-green, short term bloom may be present. | 4 |
| | | TOTAL | 48 |

Stream Width ________ x avg. depth ________ x mean velocity ________ = Q ________ cfs

Gauge Ht ________ Reach Gradient ________ Stream Order ________ Sinuosity Ratio ________

Width bkf ________ Depth bkf ________ W/D Ratio ________ Discharge ($Q_{bkf}$) ________

Drainage Area ________ Valley Gradient ________ Stream Length ________ Valley Length ________

Sinuosity ________ Entrenchment Ratio ________ Length Meander (Lm) ________ Belt Width ________

**Sediment Supply**
Extreme ________
Very High ________
High ________
Moderate ________
Low ________
Remarks ________

**Stream Bed Stability**
Aggrading ________
Degrading ________
Stable ________

**Width/Depth Ratio Condition**
Normal ________
High ________
Very High ________

Stream Type: C4c-

TOTAL SCORE for Reach E 6 = G 23 + F 27 + P 48 =

Pfankuch Rating: 104

from table — Reach Condition: Fair

### CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

| Stream Type | A1 | A2 | A3 | A4 | A5 | A6 | B1 | B2 | B3 | B4 | B5 | B6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-43 | 38-43 | 54-90 | 60-95 | 60-95 | 50-80 | 38-45 | 38-45 | 40-60 | 40-64 | 48-68 | 40-60 |
| FAIR | 44-47 | 44-47 | 91-129 | 96-132 | 96-142 | 81-110 | 46-58 | 46-58 | 61-78 | 65-84 | 69-88 | 61-78 |
| POOR | 48+ | 48+ | 130+ | 133+ | 143+ | 111+ | 59+ | 59+ | 79+ | 85+ | 89+ | 79+ |

| Stream Type | C1 | C2 | C3 | C4 | C5 | C6 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 38-50 | 38-50 | 60-85 | 70-90 | 70-90 | 60-85 | 85-107 | 85-107 | 85-107 | 67-98 |
| FAIR | 51-61 | 51-61 | 86-105 | 91-110 | 91-110 | 86-105 | 108-132 | 108-132 | 108-132 | 99-125 |
| POOR | 62+ | 62+ | 106+ | 111+ | 111+ | 106+ | 133+ | 133+ | 133+ | 126+ |

| Stream Type | DA3 | DA4 | DA5 | DA6 | E3 | E4 | E5 | E6 |
|---|---|---|---|---|---|---|---|---|
| GOOD | 40-63 | 40-63 | 40-63 | 40-63 | 40-63 | 50-75 | 50-75 | 40-63 |
| FAIR | 64-86 | 64-86 | 64-86 | 64-86 | 64-86 | 76-96 | 76-96 | 64-86 |
| POOR | 87+ | 87+ | 87+ | 87+ | 87+ | 97+ | 97+ | 87+ |

| Stream Type | F1 | F2 | F3 | F4 | F5 | F6 | G1 | G2 | G3 | G4 | G5 | G6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOOD | 60-85 | 60-85 | 85-110 | 85-110 | 90-115 | 80-95 | 40-60 | 40-60 | 85-107 | 85-107 | 90-112 | 85-107 |
| FAIR | 86-105 | 86-105 | 111-125 | 111-125 | 116-130 | 96-110 | 61-78 | 61-78 | 108-120 | 108-120 | 113-125 | 108-120 |
| POOR | 106+ | 106+ | 126+ | 126+ | 131+ | 111+ | 79+ | 79+ | 121+ | 121+ | 126+ | 121+ |

**Generalized relations ... need additional Level IV data to expand data base for validation.*