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EA Engineering, Science, and Technology

Preliminary Draft

COMPREHENSIVE ANALYSIS FOR WATER RIGHTS CLAIMS IN THE UPPER KLAMATH RIVER BASIN, OREGON

LIMITING FACTOR ANALYSIS

Prepared for

The Bureau of Indian Affairs

Prepared by

EA Engineering, Science, and Technology

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1. INTRODUCTION

As part of the comprehensive study to develop water rights claims for the Klamath Tribe treaty area, EA Engineering, Science, and Technology (EA) initiated an investigation focused on the development of instream flow recommendations for the protection of important fishery resources in streams within the historic tribal boundaries. Included in that study are determinations of flows necessary to maintain channel morphology (channel maintenance flows) and important riparian habitats.

For the study, EA is using the U.S. Fish and Wildlife Service (USFWS) Instream Flow Incremental Methodology (IFIM) and the associated software - Physical Habitat Simulation (PHABSIM). Application of the IFIM - PHABSIM procedure requires the field measurement (collected at two or three different discharges) of various physical (substrate) and hydraulic (discharge, water velocity, water depth) parameters at cross-channel transects representing important fish habitats (e.g., riffles, pools, runs, etc.) within each study stream. The hydraulic (IFG4) and habitat models of PHABSIM are used to develop habitat-flow relationships for selected fish species and their lifestages. These relationships are then used to derive monthly flow recommendations for each stream on the basis of its fish population composition and the timing of life history functions.

Recognizing that fish populations are influenced by both flow-related and non-flow-related factors, EA completed an evaluation of potential major limiting factors that may be operating on over 40 study stream segments within the treaty area. Because the IFIM-PHABSIM analysis will adequately assess the limitations of physical habitat in relationship to flow, the limiting factor analysis focused on conditions (e.g., channel stability, sedimentation, potential fish barriers) and other parameters (e.g., water temperature, water quality) which may be influencing existing, or the development of potential, fisheries in the study streams.

With respect to channel stability, because the flow recommendations derived via the IFIM process are theoretically specific to the set of channel characteristics present during the field measurements, the relative stability of the channels should be evaluated as part of the recommendation process. The dynamic nature of fluvial systems will necessarily result in some changes in channel morphology: streams are continually adjusting to local climatological and geologic conditions. Such streams are considered to be in a state of dynamic equilibrium if their adjustments, through time, maintain channel forms which are stable (i.e., in equilibrium) or fluctuate about some average shape (Richards 1982). However, streams that encounter different bank materials, are subjected to a new discharge regime (Richards 1982), or are impacted by certain land use activities (e.g., channelization) may exhibit a temporal and spatial disruption in this steady-state condition. A determination as to whether such conditions exist in streams within the treaty area is important to the ultimate derivation of sound, scientifically defensible instream flow recommendations. Bovee (1982) has suggested that an important early step in the planning of any instream flow study is the determination of the state of dynamic equilibrium for prospective study streams.

Today, the majority of perennial streams within the historic reservation boundaries exhibit conditions reflecting decades of irrigation use (water diversions, channelization) imposed on these systems. Consequently, many of the potential limiting factors noted above occur in these streams, and warrant an overall assessment.

This report summarizes the results of EA's evaluation of potential limiting factors present in the study streams designated for detailed IFIM measurement. In addition to being used in the flow recommendation process, the results can be used to identify potential fisheries enhancement opportunities within each study stream.

The rest of this report consists of five sections and an appendix:

- 2. STUDY AREA, which briefly describes the study area and study streams evaluated as part of the limiting factor analysis
- 3. METHODS, which describes the field and interpretive methods used during the study
- 4. RESULTS, which presents the results of the limiting factor investigation
- 5. DISCUSSION/CONCLUSIONS, which analyzes the results as they pertain to the development of instream flow recommendations for the project

There is also a list of the references cited in the report and an appendix containing tables and figures of the SRI/CSE rating data for each study site.

2. STUDY AREA

The upper Klamath River drainage basin, located in south central Oregon (Figure 2-1), may be broken down into eight major subbasins that encompass the former Reservation boundary of the Klamath Indian Tribe (in which the Tribe maintains its right to hunt, fish, and gather).

2.1 SUBBASIN DESCRIPTIONS

As shown in Figure 2-1, subbasin 1 (Williamson River above Klamath Marsh) is in the northeastern portion of the study area and contains the source of the Williamson River—the major river in the project area. Subbasin 2 (Williamson River above Spring Creek) includes Klamath Marsh, where the Williamson River turns south; the Kirk geologic blockage of the river; and the area south of the blockage to just above the confluence with Spring Creek. Subbasin 3 (Williamson River below Spring Creek) includes Spring Creek, which, along with the Sprague River confluence, is a major water source for the Williamson River, the largest tributary to Upper Klamath Lake. Subbasin 4 (Sprague River below Sycan River) includes the southern part of the drainage basin from the confluence of the Sycan River on the east to the confluence of the Williamson on the west. Subbasin 5 (Sprague River above Sycan River) includes the easterly portion of the Sprague River, including both North and South Fork tributaries. Subbasin 6 (Sprague River - Sycan River Basin) comprises all of the Sycan River, including Sycan Marsh and its spring source. Subbasin 7 contains the drainage into upper Klamath Lake along its northwestern side formed by the eastern slope of the Cascade Range, and Subbasin 8 includes Upper Klamath Lake's southwestern drainage.

2.2 STREAM SYSTEM DESCRIPTIONS

Upper Klamath Lake, with the largest surface area of all natural lakes in Oregon, is fed by surface water entering from the north and west and by large springs and seeps located in the lake bed. Upper Klamath Lake receives its major surface inflow from the Williamson River and from Agency Lake at the mouth of Wood River (see Figure 2-1).

The Williamson River arises from large springs along the toe of Booth Ridge in the northeasterly portion of the study area. It flows northward for some distance before turning west and entering Klamath Marsh, an extensive and important wetlands fed by springs and numerous small tributaries. From Klamath Marsh the river flows southerly into Upper Klamath Lake just above the city of Klamath Falls, Oregon. Between Klamath Marsh and Upper Klamath Lake the Williamson has two major tributaries. The first, Spring Creek, which enters the Williamson above the town of Chiloquin, exhibits an almost constant spring-fed flow of about 300 cfs; the second, the Sprague River, joins the Williamson just south of Chiloquin.

The Sprague River's headwaters are on the western slopes of Coleman Rim and Gearhart Mountain near the eastern boundaries of the study area. It is joined by a major tributary, the

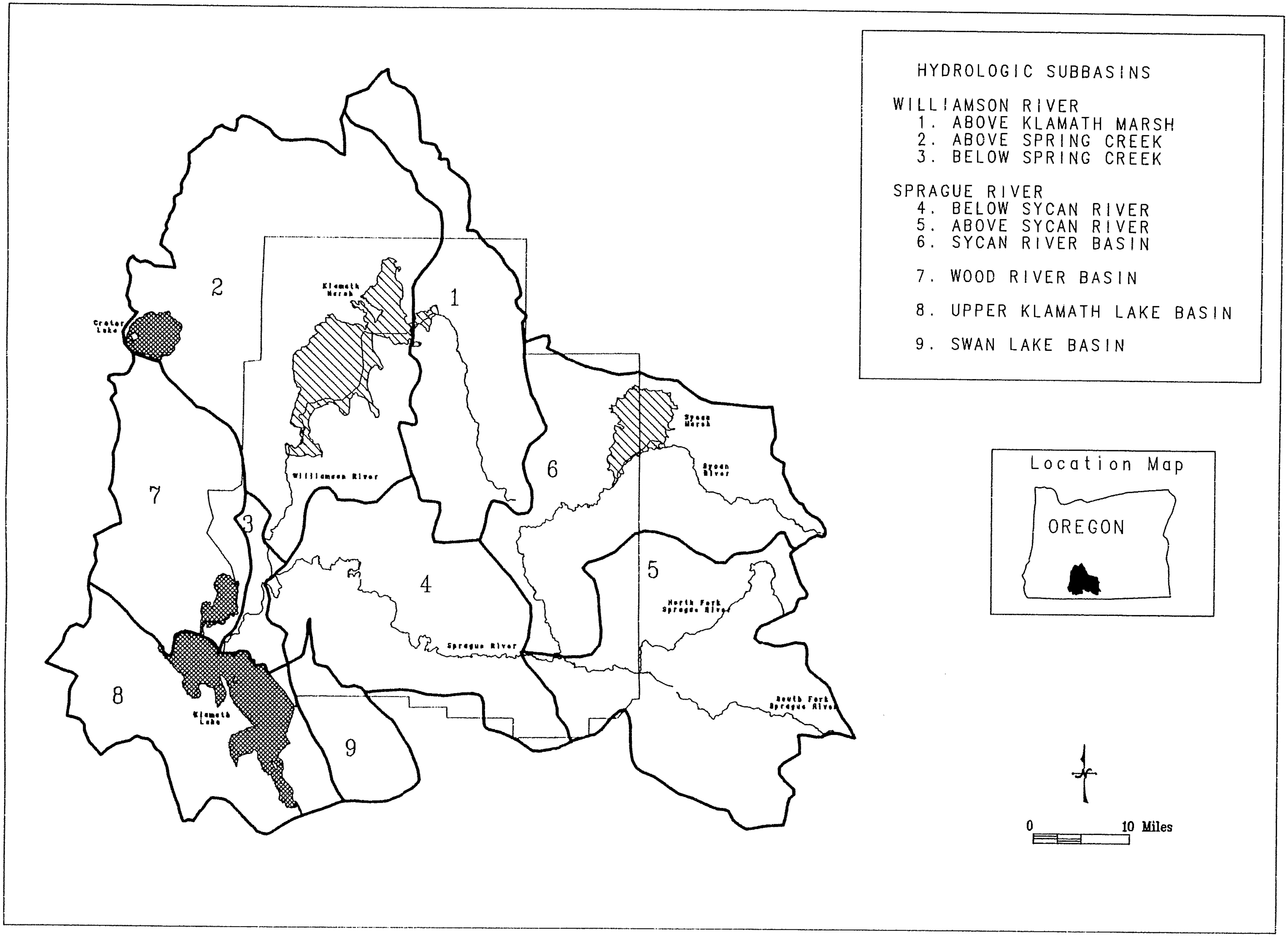

Figure 2-1. Major hydrologic subbasins of the Upper Klamath River Drainage Basin.

Sycan River, in the central portion of the Sprague River Valley. The headwaters of the Sycan are on Winter Ridge near the extreme eastern boundary of the study area. The river flows in a northwesterly direction until it enters Sycan Marsh; there it flows in a southwesterly direction to its confluence with the Sprague River. Below the confluence with the Sycan River, the Sprague flows in a generally westerly direction until it merges with the Williamson River near the town of Chiloquin.

Wood River rises from Wood River Springs—located about 17 miles due north of Agency Lake. Wood River receives input from several small creeks and eventually drains into Agency Lake, the shallow, marshy, northerly arm of Upper Klamath Lake.

2.3 STUDY SITE LOCATIONS

Table 2-1 lists the Upper Klamath Basin instream flow study sampling reaches where detailed field sampling was done. The reach number, name, site description, USGS quad where site is located, and habitats sampled are shown in the table. These sites represent the locations where specific flow recommendations will be formulated and water right claims made. They represent stream reaches with unique ecological characteristics which support significant fishery resources of interest to the Klamath Tribe.

TABLE 2-1 UPPER KLAMATH BASIN INSTREAM FLOW STUDY SAMPLING REACHES

Reach #	Reach	Site Description	Quad S-T-R
WM-1	Williamson River (Hwy 97 to Upper Klamath Lake)	Site begins at Waterwheel Campground. Site length = 4,517'	Agency Lake S20-T35S-R7E SE1/4 SE1/4 NE1/4
WM-2	Williamson River (Sprague River to Hwy 97)	Site begins 3 miles upstream from Hwy 97. Site length = 4,325'	Agency Lake S4-T35S-R7E NE1/4 SE1/4 SE1/4
WM-3	Williamson River (Spring Creek to Sprague River)	Site begins at mouth of Spring Cr. at Collier State Park. Site length = 4,070'	Fort Klamath S9-T34S-R7E SW1/4 SE1/4 NE1/4
WM-4	Williamson River (Lower end of Kirk Canyon to Spring Creek)	Site beings immediately downstream from bridge just past Williamson River campground. Site length = 1,672'	Soloman Butte S35-T33S-R7E SE1/4 SW1/4 SE1/4
WM-5	Williamson River (Kirk to Lower end of Kirk Canyon)	Site begins immediately downstream from bridge crossing Williamson River on Kirk Rd. Site Length = 860'	Soloman Butte S1-T33S-R7E NE1/4 NW1/4 SW1/4
WM-6	Williamson River (Klamath Marsh to Kirk)	Site begins immediately upstream from R.R. trestle crossing Williamson River. Site length = 1,818'	Fuego S36-T32S-R7E SE1/4 NE1/4 NW1/4
WM-7	Williamson River (Deep Creek to Klamath Marsh)	Site begins immediately upstream from end of F.S. Rd. 070. Site length = 1,010'	Gordon Lake S12-T31S-R10E SE1/4 SE1/4 NE1/4
WM-8	Williamson River (Wickiup Spring to Deep Creek)	F.S. Rd. 490 to Williamson River Site begins immediately upstream from private land F.S. boundary. Site length = 1,235'	The Bull Pasture S31-T31S-R11E NE1/4 NW1/4 SW1/4
WM-9	Williamson River (Campground Springs to Wickiup Spring)	No access.	
WM-10	Larkin Creek	Hwy 97 N to Collier Park Camping sign. Pull into parking area where road first comes adjacent to creek. Site starts upstream of 2nd backwater slough. Site length = 305'	Soloman Butte S2-T34S-R7E SE1/4 SE1/4 SW1/4
WM-11	Sand Creek	Located off F.S. on 2300. When you cross over the bridge, move downstream approx. 100' to lower end of site. Site length = 369'	Sun Pass S29-T31S-R7E SW1/4 SE1/4 NE1/4

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Reach #	Reach	Site Description	Quad S-T-R
WM-1	Williamson River (Hwy 97 to Upper Klamath Lake)	Site begins at Waterwheel Campground. Site length = 4,517'	Agency Lake S20-T35S-R7E SE1/4 SE1/4 NE1/4
WM-12	Scott Creek	2.5 miles past Sand Creek; park at the junction heading for 97N. Site starts 200 m downstream of road crossing. Site length = 192'	Pothole Butte S16-T31S-R7E NE1/4 NE1/4 SW1/4
WM-13	Cottonwood Creek	Located 4.1 mi in on FS Road 1370, off Hwy 138. Site length = 100'	Miller Lake S25/36-T28S-R6E
WM-14	Jackson Creek	97 N to Silver Lake Hwy to 49. Drive through Jackson Creek USFS campground. The 1st time you see the creek approx. 10' from road site begins. Site length = 282'	Gordon Lake S8-T30S-R11E NE1/4 SW1/4 NW1/4
WM-15	Irving Creek	Site begins approx. 25' upstream from where F.S. Rd 49 crosses Irving Creek Site length = 98'	Gordon Lake S19-T30S-R11E NE1/4 SE1/4 SW1/4
WM-16	Deep Creek	Site is within mosaic cattle guard approx. 125 m. upstream of 1st fenceline beyond cattle guard. Site length = 172'	The Bull Pasture S28-T31S-R11E NE1/4 NW1/4 NW1/4
WD-1	Wood River (Fort Creek to Agency Lake)	Combined with WD-2	
WD-2	Wood River (near Ft. Klamath) (Annie Creek to Fort Creek)	Located 2,000' downstream of Wood River picnic area. Site length = 1,130'	Fort Klamath S15-T33S-R7.5E SE1/4 SW1/4 SW1/4
WD-3	Crooked Creek	Located 160' downstream of Hwy 62 crossing. Site Length = 632'	Fort Klamath S12-T34S-R7.5E SW1/4 NW1/4 NE1/4
WD-4	Fort Creek	No access.	
SP-1	Sprague River (Chiloquin Dam to Williamson River)	Site beings approx. 1/4 mile below Chiloquin Dam. Site length = 2,930	Chiloquin S3-T35S-R7E SE1/4 SW1/4 NE1/4
SP-2	Sprague River (Braymil to Chiloquin Dam)	Just upstream of powerline intertie 1.2 miles out of Chiloquin on the Sprague River Hwy. Site length = 3,040'	Chiloquin S35-T34S-R7E SE1/4 NE1/4 NE1/4

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WM-1	Williamson River (Hwy 97 to Upper Klamath Lake)	Site begins at Waterwheel Campground. Site length = 4,517'	Agency Lake S20-T35S-R7E SE1/4 SE1/4 NE1/4
SP-3	Sprague River (S'Ocholis Canyon to Braymil)	On highway, turn left at mile marker 13 into camping area. Site starts approx. 700' downstream. Site length = 2,617.5'	S'Ocholis Canyon S9-T35S-R9E NW1/4 NE1/4 NE1/4
SP-4	Sprague River (Trout Creek to Upper end of S'Ocholis Canyon)	Site begins 1/4 to 1/2 mile downstream of 5850 Bridge. Site length = 2,047.5'	S'Ocholis Canyon S10-T35S-R9E NW1/4 SE1/4 NE1/4
SP-5	Sprague River (Sycan River to Trout Creek)	Just before the Sprague River train tracks (just west of Beatty), turn right and follow road to locked fence. Site starts there. Site length = 2,920'	Sprague River West S8-T36S-R10E NW1/4 NE1/4 NE1/4
SP-6	Sprague River (1.5 miles upstream of Beatty)	None found in field notes. Site length = 2,462.5'	
SP-7	Sprague River (NF/SF Sprague River to Kirk Spring)	No access.	
SP-8	Trout Creek	Located 2,500' downstream of Middle/South Forks confluence off F.S. Rd. 5850 on F.S. land. Site length = 196'	Sprague River West S35-T35S-R9E NW1/4 SW1/4 SE1/4
SP-9	Whisky Creek	No sample site established.	
SP-10	NF Sprague River (Balley Flats to NF/SF)	Located on Rocking AC Ranch, 600' downstream of Ranch Road Bridge. Site length = 500'	Bly S6-T36S-R14E SE1/4 NW1/4 NE1/4
SP-11	NF Sprague River (Boulder Creek to Balley Flats)	Located 0.2 mi upstream of FS boundary at Upper FS boundary. Site length = 500'	Bly S35-T35S-R14E SW1/4 SW1/4 NE1/4
SP-12	Fivemile Creek (Lower Forest Service boundary to NF Sprague River)	Located 1.5 mi upstream of confluence w/NF Sprague River, 1/4 mi downstream of Ranch Road crossing. Site length = 250'	Bly S1-T36S-R13E SW1/4 SE1/4 NE1/4
SP-13	Fivemile Creek (Headwaters to lower Forest Service boundary)	Located at Northern F.S. boundary, just upstream of Swamp Creek. Site length = 451'	Rodeo Butte S1-T35S-R13E SW1/4 SE1/4 SE1/4

TABLE 2-1 UPPER KLAMATH BASIN INSTREAM FLOW STUDY SAMPLING REACHES

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WM-1	Williamson River (Hwy 97 to Upper Klamath Lake)	Site begins at Waterwheel Campground. Site length = 4,517'	Agency Lake S20-T35S-R7E SE1/4 SE1/4 NE1/4
SP-14	SF Sprague River (Fishhole Creek to NF/SF)	No access.	
SP-15	SF Sprague River (Ish Tish Creek to Fishhole Creek)	Out of Bly, 1st left on 4350, then a right on Highway 34. Cross 2 bridges. Site is just upstream of 2nd bridge. Site length = 627'	Campbell Reservoir S31-T36S-R15E SW1/4 SE1/4 SW1/4
SP-16	SF Sprague River (Brownswoth Creek to Ish Tish Creek)	Out of Bly approximately 8 miles on Highway 140, turn at mile marker 62 left up gravel road (1st left) after (015) Picnic Area. Turn left on 037 (14), pass 1 gate right up Creek Bed Road until trail, hike 400 m down to site. Site length = 815'	Campbell Res. S3-T37S-R15E SE1/4 NW1/4 NE1/4
SP-17	Deming Creek	Located 4.5 miles up F.S. Road 018. Site length = 200'	Campbell Reservoir S11-T36S-R15E SW1/4 NW1/4 SW1/4
SY-1	Sycan River Upstream of Snake Creek (Blue Creek to Snake Creek)	Drive up Sycan S River Ranch Rd marked private. Go through 5 gates to locked gate. Turn left and wind your way to the stream. Site length = 1,170'	Spodue Mountain S16-T35S-R12E NE1/4 NW1/4 SW1/4
SY-2	Sycan River in canyon (Teddy Powers Meadow to Blue Creek)	Take 130 to river, then continue downstream approx. 0.4 miles. Site starts where road heads up hill. Site length = 1,245'	Spodue Mountain S24-T34S-R11E NE1/4 SE1/4 NE1/4
SY-3	Sycan River (Torrent Springs to Teddy Powers Meadow)	Located 1/2 mile upstream of Sycan Ford. Site length = 486'	Silver Dollar Flat S27-T33S-R12E NE1/4 SW1/4 SW1/4
SY-4	Sycan River above Torrent Springs (Merrit Creek to Torrent Springs)	Located 1.5 miles upstream of Torrent Springs on F.S. Rd. 4672. Site length = 1,150'	Riverbed Butte Spring S25-T33S-R12E SE1/4 SW1/4 NW1/4
SY-5	Sycan River below Marsh (Guard Station to Merrit Creek)	Located 100' upstream of F.S. Road 3207 crossing. Site length = 1,000'	Riverbed Butte Spring S16-T33S-R13E NW1/4 SE1/4 NW1/4

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WM-1	Williamson River (Hwy 97 to Upper Klamath Lake)	Site begins at Waterwheel Campground. Site length = 4,517'	Agency Lake S20-T35S-R7E SE1/4 SE1/4 NE1/4
SY-6	Sycan River above ZX Ranch (Long Creek to Guard Station)	Located at high voltage transmission line crossing approximately 1 mi upstream from FS boundary. Site length = 625'	Sycan Marsh East S22-T32S-R14E NE1/4 NE1/4 SE1/4
SY-7	Sycan River (Paradise Creek to Long Creek)	Located 1,000' downstream from main FS road crossing; near Pines Crossing. Site length = 555'	Shake Butte S22-T33S-R15E NW1/4 NE1/4 NW1/4
SY-8	Long Creek	Williamson Hwy, left on 46, left on 27 on main gravel road, come to where road crosses stream. Site is downstream approx. 200 m. Site length = 460'	Sycan Marsh West S4-T32S-R13E NW1/4 SW1/4 NE1/4
SY-9	Calahan Creek	East on Sprague River Hwy, left on Williamson River Road to Long Creek, left at Long Creek Bridge Cinder Rd. 7 mi to Campground. 300' downstream of Campground. Site length = 205'	Hamelton Butte S26-T31S-R12E NW1/4 SE1/4 NW1/4
SY-10	Coyote Creek	Site begins just upstream of road crossing the Creek. Site length = 162'	Sycan Marsh West S27-T31S-R13E SE1/4 SW1/4 NE1/4
SPWNG #1	Williamson River	@ Ken's Place. 5 transects (partials) placed over spawning areas.	
SPWNG #2	Williamson River	@ Wagon Wheel Campground; riffle immediately downstream of Hwy 97 Bridge. Two transects placed over spawning area.	Agency Lake S21-T35S-R7E NW1/4 SW1/4 NE1/4

3. METHODS

The limiting factors for streams within and adjacent to the historic Klamath Tribe treaty area were assessed from both field data and the literature.

3.1 LITERATURE REVIEW AND AGENCY CONTACTS

Literature and data relevant to the development of instream flow recommendations for the Upper Klamath Basin were obtained from a variety of sources. Initially, EA contacted the Klamath tribal and BIA representatives who were most familiar with the historical and present fishery resources within the study area, including the fisheries in Upper Klamath and Agency lakes and the historical distribution of anadromous fish. The U.S. Forest Service (USFS) and the U.S. Fish and Wildlife Service (USFWS) were also contacted for information. Other data and reports were obtained and reviewed as part of the overall literature review task conducted in conjunction with the IFIM analysis.

The limiting factor analysis was completed in the context of the habitat requirements for the designated species of interest, as determined from the above literature review and agency contacts. The analysis considered the needs of all major life history components for each species, including those related to reproduction (spawning and egg incubation) and growth (juvenile and adult).

3.2 FIELD SURVEYS AND DATA ANALYSIS

Field surveys included an initial field reconnaissance of all major streams within the study area, completed in May 1990, followed by detailed field sampling (which included IFIM measurements) of specific study sites (completed during September 1990).

3.2.1 Stream Reach Inventory and Channel Stability Evaluation

During the September 1990 field survey, each of the study streams and reaches was evaluated using a modification of the USFS Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE) methodology (Pfankuch 1978). This predominantly visual technique was designed primarily to assess the physical aspects of channel and streambank stability, but it has been shown to be sensitive to fishery habitat quality (Eifert and Wesche 1982). In its present form, the SRI/CSE is applied in a scorecard-rating format wherein 15 variables related to the upper and lower banks and the stream channel bottom are evaluated. Figure 3-1 is an example of a completed form.

The 15 variables used in the numerical rating include (1) landform slope, (2) mass wasting potential, (3) debris jam potential, (4) vegetative bank cover, (5) channel capacity, (6) bank rock content, (7) flow obstructions, (8) bank cutting, (9) deposition, (10) rock angularity (11) bed material brightness, (12) bed material consolidation, (13) particle size distribution,

(14) scour and deposition patterns, and (15) abundance of aquatic vegetation. The variable-specific ratings were summed to generate an overall stream stability rating for each site. Where sites were combined into reaches, a weighted average SRI/CSE rating was computed and assigned to the reach (Pfankuch 1978). The weighting of a site was computed by multiplying its individual SRI/CSE rating by the length that it represented. This was done for each individual site to be included in the reach, and the sum of those products was then computed. This reach sum was then divided by the reach length (the sum of the lengths of stream represented by all the sites). The resulting stream or reach SRI/CSE ratings were classified into one of four categories as follows: Poor (115+), Fair (77–114), Good (39–76), or Excellent (less than 39). A brief description of each variable and its significance for fish habitat is provided below.

- UPPER BANKS: Variables 1-4 reflect conditions above the normal high water mark of the stream—the portion of the topographic cross section extending from the break in general slope of the surrounding land (e.g., where a mountain slope begins to rise above the valley bottom) to the normal high water line.

  - **Landform Slope (Variable 1):** the slope of the land adjacent to the stream channel. This variable determines the extent to which banks can erode; in general, the steeper the banks, the greater potential for materials to erode and slough into a stream. If streams flows are insufficient to periodically transport (flush) the fine sediment fraction (sands and silts) of these materials, excessive sediment accumulation can occur, which can decrease suitability of the stream for reproduction and its food production capacity.

  - **Mass Wasting Potential (Variable 2):** the degree to which the upper banks show signs of sloughing. Bank slope, bank material size and shape, slope moisture content, and vegetative development all serve to determine to potential for mass wasting of the upper banks. As with landform slope, the greater the potential for mass wasting, the greater the potential for fine sediments to enter a stream and negatively impact important fish habitats (spawning, food production, adult and juvenile rearing).

  - **Debris Jam Potential (Variable 3):** the potential for objects in the stream or on the banks to become lodged in constricted areas (by floating or rolling), creating debris jams and possible barriers to fish movement. Debris jams can be both beneficial (provide fish cover, create pool habitats) to fish populations and detrimental (preclude or deter fish passage within a given stream reach; accelerate bank scour through flow deflection), and they should not be indiscriminately removed without carefully evaluating their functional role within a given system.

- **Vegetative Bank Protection (Variable 4):** an index of the extent of vegetative cover on the upper banks. Because bank soils are mainly held in place by plant roots, the more vegetation associated with a bank the greater its stability. Plant roots and stalks also contribute to the "roughness" coefficient of the floodplain, which helps to reduce water velocities associated with flood flows (out-of-bank flows), thereby reducing their erosion potential. In general, a slope with less than 50 percent ground cover and no or few trees is considered to have "poor" vegetative bank protection. Such slopes have a greater potential for mass wasting.

- LOWER BANKS: Variables 5–9 are associated with the lower banks, those contained between the intermittently submerged portion of the channel cross section, from the normal high water line to the water's edge during low flow conditions.

  - **Channel Capacity (Variable 5):** The quantity of water that can be effectively transported through a channel, determined by characteristics such as channel width, depth, gradient, and roughness. Channels without an adequate width-to-depth ratio (e.g., 15:1—15 feet wide to 1 foot deep) may flood during extremely high flows. Although some overbank flooding is necessary for valley and channel maintenance (Whiting et al. 1991), too much can destabilize vegetative communities and subsequently the banks.

  - **Bank Rock Content (Variable 6):** the size and quantity of materials constituting the lower channel banks. In general, the larger and more angular the rock, the more resistive the bank is to erosion and detachment when exposed to high flows, and the lower the sediment recruitment potential to the stream.

  - **Obstructions and Flow Deflectors (Variable 7):** objects, debris, etc., large enough to deflect or alter the natural flow patterns in a stream channel. As with debris jams, the presence of flow deflectors can have both negative effects (scouring and increased erosion) and positive effects (creation of pools and rearing habitats) on instream fish habitats.

  - **Cutting (Variable 8):** a rating of the scouring or uprooting of aquatic vegetation. Channel and bank cutting can result from a variety of conditions: increased bank slope; loss of bank stability through cattle grazing, logging, etc.; channelization; and high flow conditions. In streams where bank cutting is prevalent, the substrates are generally heavily embedded with fine sediments.

  - **Deposition (Variable 9):** the deposition of material (substrates, sediments) in a stream channel. When sediment recruitment exceeds transport, increased sediment deposition can occur, resulting in the formation of new, or the expansion of existing point or channel bars. Areas prone to sediment deposition include low-gradient sections (pools), inside sections of meander bends, and low-velocity areas behind debris and instream object cover (e.g., boulders, log jams). Extensive deposition of fine sediments within salmonid spawning areas (pool:riffle interchanges) can cause reductions in egg survival and fry emergence.

- CHANNEL BOTTOM: Variables 10–15 define the characteristics associated with the bottom portion of the channel, which is generally submerged.

  - **Angularity (Variable 10):** a measure of the shape and structure of the bottom substrates, and an indirect indicator of how much bedload movement is occurring in a given stream channel. In general, the greater the angularity of the rock, the more stable the stream bottom, and the less bedload movement there is.

  - **Brightness (Variable 11):** an index of the percentage of the stream substrates that are "bright" and clean of all algae and sediment deposits (vs. dull, darkened, and stained). A stable stream bottom is generally dull and dark, and will have less than 5 percent of its materials polished by the effects of frequent tumbling of particles.

  - **Consolidation (Particle Packing) (Variable 12):** an assessment of the size gradation and packing of substrate materials within the stream bed. Under stable conditions, substrate particles will be interwoven and voids filled, rendering the material resistant to extreme flow forces.

  - **Bottom Size Distribution and Percent Stable Materials (Variable 13):** an index of the percentage of substrate consisting of stable sized materials. The size of the bottom material is generally indicative of the historical flow patterns that have shaped the channel to its existing shape. Knowledge of the bottom composition of a stream permits comparisons to be made at a later time, to determine if changes are occurring.

  - **Scouring and/or Deposition (Variable 14):** an estimate of the percentage of the stream bottom affected by scour or deposition. A stable channel has less than 5 percent of its bottom affected by scouring and deposition. Some scouring can result in the creation of fish habitat; e.g., scour pools created just downstream of log weirs or debris jams. However, excessive scouring can dislodge fish eggs from egg nests (redds), remove invertebrate food organisms through catastrophic drift, and erode stream banks resulting in increased inputs of sediment and allochthonous materials.

- **Aquatic Vegetation (Variable 15):** a qualitative estimate of the extent and abundance of aquatic vegetation occurring within the substrate. In general, as substrate stability increases, the bottom materials can more readily accommodate plant growth and the development of invertebrate communities. A stream channel containing thick mats of moss and/or algae has an excellent stability ranking. Although this aquatic vegetation can provide cover for fish, and also serve as a medium for aquatic invertebrate production, excessive algae production can indicate nutrient loading, and may result in increased biochemical oxygen demand (BOD) and temporary reductions in dissolved oxygen.

The SRI/CSE was applied to the streams and study reaches selected for the detailed IFIM - PHABSIM analysis. The evaluation was made during low-flow conditions at each site, which provided the best opportunity to evaluate bank, channel, and stream bottom conditions thoroughly. The field assessment consisted of evaluation an 1,800-ft reach at each site, extending about 900 feet upstream and 900 feet downstream of a particular IFIM site. In addition to making comparisons of overall ratings between sites, which provided an overall ranking, the individual scores for each variable at each site were evaluated, identifying the factors most likely to be limiting for that site. All SRI/CSE scores were recorded in waterproof field notebooks. Copies of all data are on file in EA's Lafayette, California, office.

3.3 LIMITING FACTOR ANALYSIS

The assessment of potential limiting factors for each site integrated information obtained from agency contacts, literature and reports, the initial field reconnaissance, the SRI/CSE assessment, and field observations made during the IFIM surveys. The analysis identifies and describes the major factors likely (under present conditions) to be limiting fish production at each site. The SRI/CSE evaluation also provided information relevant to assessing steady-state conditions at each site and the validity of applying IFIM flow recommendations on a long-term basis.

4. RESULTS

This section presents the results of the limiting factor analysis, organized on a reach and stream basis. General descriptive information as well as the specific SRI/CSE ratings is provided for each site. Tables of the site-specific ratings for the 15 variables, along with the detailed weighing terms, and figures showing the value for each variable are presented in Appendix A. The assessment of fish habitat quality has been evaluated in relation to the fish species present in the stream or reach. Habitat needs considered include the survival, reproduction, and passage of present fish species.

4.1 LOWER WILLIAMSON RIVER (DOWNSTREAM OF KLAMATH MARSH)

The reach of the Williamson River from its mouth (where it enters Upper Klamath Lake) to the south end of Klamath Marsh will be referred to as the lower Williamson River. The river through this reach is fairly straight and flows through coniferous forests of various densities, at its upper end, then through open pastureland and grassy areas near its mouth, where it has been subjected to severe channelization. The Sprague River merges with the Williamson River just below the town of Chiloquin. Six sites were selected and sampled along the lower Williamson River.

Instream habitat in the lower Williamson River was divided into three sections. The first section begins just below Klamath Marsh and ends at the geological dike at Kirk, and its dominant habitat can be classified as low-gradient pool. The site sampled (WM-6) had no obvious cover, and the substrate consisted entirely of silt and sand combinations. Riparian growth was observed to consist of grass, brush, and a heavily wooded area (containing small willows and pines) which began close to the stream. The water at the sampled site was heavily stained (with humics) and slow-moving. Kirk Reef, a geologically distinct landscape feature at the downstream end of this section, acts as a hydraulic control as well as a potential barrier to fish passage that is flow-dependent. Flow through this section is subsurface flow except when the water level exceeds this control (i.e., spring runoff or wet winter years).

The second section, extending from Kirk Reef to Spring Creek, consists of medium-gradient to high-gradient riffle and run habitats. Two sites (WM-4 and WM-5) were sampled in this section. The dominant substrate types were rubble and boulder, and it was noted that the substrate in WM-5 was highly fragmented and extremely difficult to walk on. Site WM-4 had largely overhanging brush and woody debris cover and some velocity cover behind boulders; cover at WM-5 consisted mainly of boulders. Riparian growth consisted mostly of willows, brush, shrubs, and grass in an abundance of rocks. The water at these sites also was heavily stained.

The third section runs from Spring Creek to Upper Klamath Lake and consists almost entirely of low-gradient deep run habitat. Three sites (WM-1, WM-2, and WM-3) were sampled in this section. The larger substrate types consisted of bedrock and rubble while sand, gravel (fine and coarse), and aquatic vegetation were the most common embedded substrate types. Cover consisted mainly of brush near the river banks. Riparian growth consisted mostly of grass and brush, but willows, aspens, and pines were also found at some of the sites sampled.

The weighted SRI/CSE rating for the lower Williamson River was 66, indicating overall "good" bank and channel stability. At this location and below, the river course has been channelized and the bank and channel stability reflect the man-induced effects of stream alterations. Historically this section was characterized by large meanders and surrounding wetlands. Significant amounts of highly productive rearing habitat in the adjoining wetlands has been lost as a result of this channelization. All of the sites sampled were given a rating of "good" except WM-1, which was rated "fair." The rating for rock angularity was the lowest individual rating of all the indexes among all the sample sites. Bank rock content was also rated "poor" at sites WM-1 and WM-6. Nevertheless, the banks were visually noted to be of high stability throughout the sites sampled in the entire reach.

Dissolved oxygen (DO) and water temperature data were collected over a 31-year period (1959–1990) on the lower section of the lower Williamson River (near Upper Klamath Lake). Other water quality data were available but were not collected recently enough to be useful. Water temperature averaged about 10.6 C, with a minimum of 0 C and a maximum of about 22 C. The optimum ranges of water temperature for most of the target species fall within this range, although the highest temperatures are unsuitable for salmonid species. DO averaged 9.3 mg/L, and dissolved oxygen percentage (DO%) averaged 97 percent. Although these average values are adequate for fish survival, the lowest DO recorded during this period was 0 mg/L. Some water quality data collected in the mid-1970s at the Williamson River Kirk Gage shows a lower mean and minimum DO% (62.3 percent and 11.0 percent) and higher maximum and mean water temperature (24.4 and 11.8) than the 31-year data. Average pH during the 31 year recording period was 7.7 with a range of 6.1–8.9.

4.1.1 Limiting Factors

The lower two sections of the lower Williamson River were rated as having good bank and channel stability, some substrate types for spawning, and acceptable but variable water quality for all target species, depending upon the location and time of year (e.g., during low-flow conditions near the mouth, temperature and DO may become stressful for salmonids). The section above Kirk, bounded by Klamath Marsh upstream and Kirk Reef downstream, has several limitations. The substrate in this section (silt and sand) is inadequate for spawning, and it would appear to have dissolved oxygen deficiencies and higher temperatures that could limit the production and survival of fish. The stained water observed (also observed in the section below Kirk Reef) results from the extraction of pigments from vegetation (Bell 1986) as the water passes through Klamath Marsh. During periods of low flow, fish passage into and out of this section is limited by Kirk Reef.

4.2 TRIBUTARIES ENTERING THE LOWER WILLIAMSON RIVER

4.2.1 Larkin Creek

Larkin Creek is a spring-fed creek that flows north until it enters the lower Williamson River just downstream of the Williamson River recreation site. It is a relatively straight and low-gradient stream that flows through coniferous forest. Approximately the same flow was recorded during both the fall and spring sampling efforts, and it appears that the hydrology of Larkin Creek is primarily characterized by consistent flow, because it is spring-fed, with intermittent high flows depending on storm events. Snowmelt is generally not a factor for this stream. Larkin Creek has undergone some stream restoration activity. The instream habitats consisted mainly of runs with intermittently spaced falls created by small weirs and of small pool and riffle areas. The dominant substrate within the channel consisted of silt interspersed with aquatic vegetation. The stream is mostly shaded, with woody debris as overhead cover.

The overall SRI/CSE rating for Larkin Creek was 59, which indicates "good" channel stability, and only bank rock content ("poor") and vegetative bank cover ("fair") were given individual ratings lower than "good." The dominance of "excellent" and "good" ratings for this sampled reach indicate that the banks and channel are fairly stable overall. Riparian growth consisted of mostly grasses, with some occasional shrubs, and there were many fallen trees across the stream. No water quality data were available for Larkin Creek.

4.2.2 Limiting Factors

Fish passage could potentially be limited by the presence of weirs and fallen trees within the channel of Larkin Creek. Inadequate substrate types for spawning could limit fish production of the trout species within this stream.

4.3 TRIBUTARIES ENTERING KLAMATH MARSH

4.3.1 Sand Creek

Sand Creek originates in the Anderson Bluffs, east of Crater Lake, and flows east before entering Klamath Marsh. The reach sampled was mostly shaded, had a medium gradient, and flowed through a fairly flat deciduous forest. At one sampled site it was observed that a section of right bank looked as though it had been part of a trout rehabilitation project: the bank was reinforced with logs and appeared to provide some overhead cover. The dominant instream habitat within the sampled reach was run, with a few areas of riffle and pool. Fine gravel and silt combined for approximately 75 percent of the dominant substrate types. Overhead cover was mainly in the form of overhanging brush. Riparian growth consisted of thick alders, cottonwoods and lodgepole pine.

Sand Creek was given an overall SRI/CSE rating of 67, indicating "good" channel stability. Despite this overall rating, bank rock content, rock angularity, bed material brightness, and abundance of aquatic vegetation were each given a rating that fell within the "poor" range. It was observed that water clarity was low, an indication of possible bedload movement. Although bank rock content was rated "poor," thick root mats were observed, and these could provide good bank stability where the vegetative type was trees and/or large brush. No recent water quality data were available for Sand Creek, but summertime data collected in 1975-1976 indicated that water temperature, dissolved oxygen and pH were well within optimal range for salmonid populations.

4.3.2 Scott Creek

Scott Creek is a small creek that originates on Mount Scott and flows east before entering Klamath Marsh. The reach sampled had a low gradient and flowed through coniferous forest. Riparian vegetation consisted of lodgepole pine, willows, grass, and brush. Instream habitat consisted of over 90 percent run, with small amounts of pool and riffle habitats. Substrate consisted of mixtures of silt, sand, and fine gravel. The only cover was sparse overhanging brush. The stream is almost entirely shaded by surrounding forest and riparian brush. According to a neighboring landowner, the presence upstream of a series of ponds causes this creek to run dry nearly every year.

A SRI/CSE rating of 83 ("fair") was assigned to Scott Creek. Indices that received "fair" and "poor" ratings included bank cutting, bank rock content, debris jam potential, and flow obstructions. No recent water quality data were available for Scott Creek, but summertime data collected in 1975-1976 indicated that water temperature, dissolved oxygen, and pH were well within optimal ranges for salmonid species.

4.3.3 Cottonwood Creek

Cottonwood Creek originates east of Mount Theilsen and flows southeast before entering Klamath Marsh. The sampled reach flowed through mostly coniferous forest with luxuriant undergrowth, was heavily entrenched, and was surrounded by heavy underbrush and fallen timber. Riparian vegetation consisted mainly of brush, shrubs, and fallen trees. The instream habitat consisted almost entirely of low-gradient run. The dominant substrate was fine gravel and some coarse gravel, but these were often embedded with sand and silt.

A "fair" rating (83 on the SRI/CSE scale) was assigned to Cottonwood Creek. Debris jam potential was the only index that was rated "poor;" this is primarily due to the predominance of fallen timber and heavy underbrush. No recent water quality data were available for Cottonwood Creek.

4.3.4 Limiting Factors (Sand, Scott, and Cottonwood Creeks)

The "poor" rating assigned to rock angularity, bed material brightness, aquatic vegetation and the visual clarity of the water in Sand Creek suggests the potential for bedload movement within the channel. Conversely, "poor" ratings for bank rock content and bank cutting, and small-diameter substrate types (silt to fine gravel) in Scott Creek and embeddedness of silt and sand within the substrate in Cottonwood Creek indicate a high level of sedimentation. Both bedload movement (dislodging of eggs before they hatch) and sedimentation (covering spawning gravels) could limit spawning in these tributaries. Flow obstruction and debris jam potential may be a problem on Scott Creek and Cottonwood Creek. Scouring, sedimentation, and blockage of fish passage can result from debris jams. The absence of a year-round flow in Scott Creek, due to diversions, places limitations on any fish production.

4.4 UPPER WILLIAMSON RIVER (UPSTREAM OF KLAMATH MARSH)

The reach from the headwaters of the Williamson River to where it enters Klamath Marsh will be referred to as the upper Williamson River. This reach is more sinuous than the Lower Williamson River, many tributaries merge into it, and many irrigation divisions remove water from it. The lower section of the upper Williamson River flows through mostly open meadows with groves of pines. The upper section of the reach runs through land forested mostly with pines, with some grassy areas. The instream habitat of the upper Williamson River is almost entirely low-gradient run. The substrate was predominantly silt and sand, with some aquatic vegetation. Grass was dominant within the riparian zone, and in most places bank cover was the only cover present. Two sites (WM-7 and WM-8) were sampled in this reach.

The weighted SRI/CSE rating for the upper Williamson River was 68, which indicates "good" overall bank and channel stability, although bank rock content, rock angularity, and bed material consolidation were rated "poor" at both of the sites. There was evidence of bank instability (slumping and sloughing) at site WM-7, and the channel substrate was observed as being unstable at both sites. No recent water quality data are available for the upper Williamson River, but summertime data collected at Royce Ranch (WM-7) from 1975–1977 indicated that maximum water temperatures can exceed the optimal range for salmonids (22 C) during low-flow periods.

4.4.1 Limiting Factors

The poor rock angularity and bed material consolidation suggest that bedload movement could be a limiting factor in the upper Williamson River, and the dominance of silt substrate would limit possible spawning habitat. Fish passage from the upper Williamson reach to the lower Williamson reach is blocked by Klamath Marsh. Occurence of high water temperatures, related to diversion, could limit salmonid populations in these reaches during low-flow conditions.

4.5 TRIBUTARIES ENTERING THE UPPER WILLIAMSON RIVER

4.5.1 Jackson Creek

Jackson Creek originates north of Yamsay Mountain, flowing north and then west through mostly coniferous forest before entering the upper Williamson River just above Klamath Marsh. The stream passes through the Jackson Creek Recreation Site, and further downstream it becomes braided as it passes through Hoyt Ranch. The reach sampled was mostly shaded, with much undergrowth. Flows observed in fall and spring were both quite low. Instream habitat consisted of approximately 80 percent cascade/pocket water, with a few small areas of run and pool habitat. The riparian zone was made up of Douglas fir and ponderosa pine. The dominant substrate types were rubble and boulder, with sand to coarse gravel embedded. A thick coating of algae and moss was present on the substrate. Cover consisted of overhanging woody debris, and some velocity cover could be found behind boulders.

The SRI/CSE rating assigned Jackson Creek was 50 ("good"). This score was the lowest of the Williamson River drainage sites. The score indicates very stable bank and channel characteristics, and although bank rock content was given a "poor" rating, the banks overall were quite stable. No recent water quality data were available for Jackson Creek; summertime data collected in 1975–1976 indicated that water temperature, dissolved oxygen, and pH were well within optimal ranges for salmonid species.

4.5.2 Irving Creek

Irving Creek is a relatively short stream that flows in a northwest direction through Royce Ranch before entering the upper Williamson River. It is medium-gradient to low-gradient and flows through coniferous forest with large, old trees and very little undergrowth. The main instream habitat consisted of run with some small pools and short riffles. The dominant substrate type was sand, which was often embedded with silt, fine gravel, and aquatic vegetation. The riparian zone consisted of large mature trees, grass, shrubs, brush, and woody debris. There was some bank cover, and also overhanging woody debris cover.

The SRI/CSE rating for Irving Creek was 57, which indicates "good" bank and channel stability, and no individual index received a lower rating than "fair." Banks were observed as being generally stable. No recent water quality data were available for Irving Creek, but summertime data collected in 1975–1976 indicated that water temperature, dissolved oxygen, and pH were well within optimal ranges for salmonid species.

4.5.3 Deep Creek

Deep Creek originates south of Yamsay Mountain, flowing south and then southwest through sparsely forested areas and open, flat, grassy flood plains. The downstream section flows through the Deep Creek Ranch before entering the Upper Williamson River. The riparian zone consisted mainly of grass with a few shrubs, sparse willows and lodgepole pine, and many fallen trees and woody debris. The stream is almost entirely medium-gradient to low-gradient run habitat, with some small areas of riffle, pool, and pocket water. Substrate is mostly sand with silt and fine gravel embedded. Cover is mainly in the form of overhanging and instream woody debris.

A SRI/CSE rating of 89 ("fair") was assigned to Deep Creek. This was the highest rating given any individual site in the Williamson drainage basin. Bank rock content, flow obstructions, rock angularity, and bed material consolidation were all rated "poor." Raw cut banks were observed as well as poorly developed root systems within the banks. Although no recent water quality data are available for Deep Creek, summertime data collected in 1975–1976 indicated that water temperature, dissolved oxygen, and pH were within optimal ranges for salmonid species.

4.5.4 Limiting Factors (Jackson, Irving, Deep Creeks)

The lack of flow in Jackson Creek could greatly limit its fish production, and the cascade/pocket water habitat could also limit fish passage. Each of the three tributaries has a different characteristic that could limit spawning. The large substrate types (rubble and boulder) limit spawning habitat for trout species in Jackson Creek, the lack of adequate gravel substrate types and the presence of embedded silt limit Irving Creek, and bedload movement, along with sedimentation, in Deep Creek comprise factors that would limit production of trout species. Poor rock angularity and bed material consolidation in Deep Creek suggest that there is much bedload movement and instability within the channel. Low bank rock content and poorly developed root systems in the banks of Deep Creek could potentially make the banks unstable, so that during periods of high flow bank erosion could deposit material into the stream. Fish production may be limited in Deep Creek by the combination of small substrate sizes and lack of consolidation within the substrate. It is quite possible, given the substrate, that even if fish could spawn, eggs could be dislodged due to potential movement of substrate material. A road crossing culvert on Irving Creek may cause passage limitations at lower flows. The site sampled on Irving Creek was just above this culvert, and at all flows the stream was small and could not support a large fishery.

4.6 LOWER SPRAGUE RIVER (DOWNSTREAM OF S'OCHOLIS CANYON)

The lower reach of the Sprague River begins at the downstream end of S'Ocholis canyon and flows north and west until it merges with the Williamson River. It flows through areas of generally flat coniferous forest and also areas of open grass and sagebrush. The Chiloquin Dam is located close to the mouth of the Sprague River, near the town of Chiloquin, and there are several ranches located along the sinuous middle section between Chiloquin and S'Ocholis Canyon. Instream habitat types ranged from low-gradient run directly downstream of the canyon to medium/low-gradient run and riffle upstream of Chiloquin Dam and medium-gradient fast run and riffle downstream of Chiloquin Dam. Substrate types consisted of bedrock, rubble, boulder, and silt. Moderate-to-high substrate embeddedness was observed at some of the sites. The stream channel from the base of Chiloquin Dam to approximately 600 feet downstream seems to have been dredged: the substrate is large and very angular on both sides of the dredged area. Riparian vegetation was dominated by willows and grass, which provided good bank stability in some areas. There was not much cover observed at the sites sampled, except for some velocity cover provided by boulders, isolated woody debris, and occasional overhanging brush. It was noted during the spring visits that the water was quite murky. Three sites were sampled in this reach, two near the town of Chiloquin (SP-1, SP-2) and one near S'Ocholis canyon (SP-3). The weighted SRI/CSE rating for this reach was 52, which indicates "good" bank and channel stability. Only vegetative bank cover ("fair") for SP-2 was rated lower than "good."

No recent water quality data were available for the lower Sprague River, but summertime data collected in 1975–1977 below the dam, near Chiloquin, and by the K600 turnout indicate that water temperatures can reach levels that are lethal to salmonids (24–25 C).

4.6.1 Limiting Factors

The dam at Chiloquin limits upstream spawning and downstream fry passage. Although there is a fish ladder at the dam, it has been observed that few fish actually use it. Silt, as either a dominant or an embedded substrate, may adversely affect fish production by limiting spawning habitat. Temperature is a potential limiting factor in this reach—maximum temperatures that are lethal to salmonid species have been observed during the summer. Agricultural diversions within the upstream portion of this reach could exacerbate this problem.

4.7 UPPER SPRAGUE RIVER (UPSTREAM OF S'OCHOLIS CANYON)

This reach of the Sprague River begins at the merging of the North and South forks of the Sprague River and flows west and north to just upstream of S'Ocholis canyon. This reach is also quite sinuous, as it flows through mostly flat meadow and pasturelands. Instream habitat was classified as run, and it was noted that the stream surface was about 4–6 feet below the level of meadow and pastureland. The dominant substrate at sample sites was silt, and cover was practically nonexistent. The riparian vegetation, where present, was almost all grass with a few small patches of willows. The water was turbid in both the fall and spring. Areas surrounding some of the three sites that were sampled showed signs of heavy cattle grazing.

The weighted SRI/CSE rating for this reach was 82, which is "fair" in terms of bank and channel stability. Bank rock content and rock angularity were rated "poor" at all three sites, and bank cutting was rated "poor" at two of the sites and "fair" at the other. Sloughing and slumping of banks observed at river bends is evidence of bank instability that could be directly related to cattle grazing. Limited water quality data was collected on the upper Sprague River from 1973 to 1990. Average water temperature was 12 C, with maximum temperatures of 22 C; average DO and DO% were 10.3 mg/L and 93.9 percent, respectively. In 1975-1977 summertime maximum temperatures of 26 C were observed in the Sprague River near Love Pine Bridge. These data indicate that summer water temperatures can become stressful and, at the maximum, lethal to salmonids in sections of this reach.

4.7.1 Limiting Factors

The evidence of heavy cattle grazing suggests that several factors could contribute to limiting fish production along this stretch of the Sprague River. Bank instability is most likely, because of the lack of significant riparian vegetation, the poor bank rock content, bank cutting, and trampling by cattle. This instability could lead to sloughing and bank failure, resulting in sediments entering river. The high percentage of silt substrate suggests that this is indeed a severe problem throughout this reach. Cattle waste runoff into the river can cause water quality problems that could also affect fish growth and survival. Summertime water temperature, in excess of 25 C related to or exacerbated by irrigation withdrawals is also a limiting factor.

4.8 TRIBUTARIES ENTERING THE UPPER SPRAGUE RIVER

4.8.1 Trout Creek

The main stem of Trout Creek is formed by the North and South forks of Trout Creek and flows northeast before entering the upper Sprague River. Trout Creek is of medium gradient and flows through spacious coniferous forest with essentially no undergrowth. The site sampled on Trout Creek was located in a small V-shaped canyon on the main stem. The riparian zone consisted mostly of grass, with some willow/alder brush and other trees. The instream habitat was approximately 75 percent run and 25 percent riffle, with some small sections of cascade. The dominant substrate types within the run habitat were silt, fine gravel, and rubble, with the rubble highly embedded with finer particles (sand and fine gravel). The riffle habitat had coarse gravel and rubble as dominant substrate types, and embeddedness with finer particles was not as prevalent as in the run. Algae was observed to be growing on the stream bottom. Cover consisted mainly of overhanging brush and some isolated velocity cover behind boulders.

The SRI/CSE rating was 71, which falls in the "good" range for bank and channel stability. Landform slope and particle size distribution (both "fair") were the only individual indexes not receiving a rating greater than or equal to "good." No recent water quality data were available for Trout Creek, but summertime data collected in 1975-1977 indicated that maximum temperatures in the South Fork could reach 27 C, a temperature lethal to salmonids. The North Fork during the same period exhibited temperatures well within the optimum for salmonids.

4.8.2 Whiskey Creek

Whiskey Creek originates east of Bly Mountain Pass, flows north into and out of a small portion of the Fremont National Forest and through private land, and then enters the upper Sprague River. In the fall it appeared that the water in the lower section of the stream (where it flows through private land) was diverted, and the stream was essentially dry. The upper section, at the Forest Service boundary, was also dry, suggesting that this is an ephemeral stream with water only during snowmelt run-off. The riparian zone consisted entirely of grass, as this stream is basically a drainage ditch flowing through a meadow. No fish habitat was observed anywhere in this stream. No water quality data were available for Whiskey Creek.

4.8.3 Limiting Factors (Trout and Whiskey Creek

Because of the location of the stream in a V-shaped canyon and the "fair" rating given landform slope and particle size distribution, it is possible that there is an erosion problem for Trout Creek, especially at high flows. The occurrence of fine particles in the substrate of slow-moving run habitat also seems to support the conclusion that sediment build-up in this habitat would limit spawning. High summertime water temperature is a likely limiting factor in the South Fork of Trout Creek. A dry stream from diversion or natural lack of flow limits any fish production in Whiskey Creek.

4.9 NORTH FORK SPRAGUE RIVER

The North Fork Sprague River begins east of the Gearhart Mountain Wilderness, flowing north around the perimeter of the Wilderness and then flowing southwest until it merges with the South Fork Sprague River to form the main stem of the upper Sprague River. The river looks fairly straight in its upper, mountainous reach and becomes more sinuous in the lower, flat valley area, where it flows through pastureland and areas of sagebrush. Two sites were sampled on the North Fork Sprague, one in each reach. The weighted SRI/CSE rating for the North Fork Sprague was 87 which is "fair" on the rating scale. The two sites individually were rated very differently; one "poor" and one "good."

The lower site (SP-10) was given a rating of 117, which is "poor" and was the highest rating among all sites sampled in the entire upper Klamath Basin. It received "poor" ratings for bank rock content, deposition, rock angularity, bed material brightness, bed material consolidation, particle size distribution, and scour and/or deposition patterns. The banks were visibly unstable, with widespread evidence of sloughing. Instream habitat was mostly low-gradient run, and the dominant substrate consisted of a combination of sand and silt with some aquatic vegetation. Cover was non-existent, as the stream surface was only about

6 feet below the level of the pastureland. Riparian vegetation consisted mostly of grass, but there was some willow and alder brush also. The characteristics of this reach are much like those of the upper Sprague River.

The upper site (SP-11) was given an individual SRI/CSE rating of 59, which indicates "good" bank and channel stability. Landform slope was the only index that received a "poor" rating. The site, located in a deep canyon, had instream habitat consisting of alternating pools and cascades. Substrate was dominated by rubble and boulder, with some coarse gravel embedded. Riparian growth consisted mostly of willow and alder brush, and overhanging brush provided bank cover.

Water temperatures collected in 1990 by the USFS in the North Fork (at Road # 3411) from mid-May to mid-October ranged from 2 to 27 C, averaged about 13 C, and fluctuated over a range of 5–15 C during the day. Water temperatures collected in 1991 by the USFS (near Dead Horse Rim), during about the same period, ranged from 2 to 18 C, averaged about 10 C, and only fluctuated by about 5 C during any given day.

4.9.1 Limiting Factors

The lower reach of the North Fork Sprague River has the same limitations on fish production as the upper Sprague River. It has problems with sedimentation and possible water quality deficiencies that are due to the presence of cattle. The only possible limiting factor in the upper reach is that bank erosion may occur during high flows, dumping sediment into the river. Although from the site sampled this does not seem to be a problem, it may be contributing to the sedimentation seen in the lower reach. Water temperature collected by the USFS in the North Fork approached or exceeded upper lethal levels for trout species. Rainbow trout can survive such temperatures as those of 1990, but they need to be gradually acclimated to higher temperatures, and the water must be saturated with oxygen (Moyle 1976). The large daily fluctuation in water temperature could be stressing fish as they attempt to acclimate themselves. The water temperatures measured in 1991 would seem to be much more favorable to fish production. It is unknown how agricultural diversions are related to or exacerbate these temperature effects, but diversions of this reach during low-flow conditions could limit salmonid populations.

4.10 TRIBUTARIES ENTERING THE NORTH FORK SPRAGUE RIVER

4.10.1 Fivemile Creek

Fivemile Creek flows south through areas consisting mostly of meadow and pastureland before entering the North Fork Sprague River. It is a fairly straight stream, ranging in gradient from low to medium. Two sites were selected and sampled, one on an upper reach (SP-13) and one on a lower one (SP-12). The lower reach showed evidence of heavy cattle grazing. Because reach lengths were not available, an overall weighted SRI/CSE rating could not be computed for Fivemile Creek. The two individual ratings (95 and 105), however, were very similar and fell in the "fair" range for bank and channel stability. Both sites rated "fair" or "poor" for indexes that dealt with sedimentation, and there was visual evidence of bank sloughing and slumping at both sites.

The lower reach of Fivemile Creek was characterized by run habitat, and its substrate was dominantly unembedded silt. Riparian vegetation was mostly grass and thick willow/alder brush, the latter providing overhanging cover for most of stream.

The upper reach contained both riffle and run instream habitat types, with highly embedded substrates ranging from silt to fine gravel and some aquatic vegetation. Riparian vegetation consisted almost entirely of grass as the stream was only 1-2 feet below the level of the pastureland, so these small banks provided the only cover.

Water temperature data collected from mid-May to mid-October 1990 ranged from 10 to 22 C and averaged about 16 C. The daily fluctuation in water temperature averaged about 5 C during the spring and fall and about 10 C during the summer.

4.10.2 Limiting Factors

The lower reach of Fivemile Creek, which is subject to cattle grazing, would seem to have the same limiting factors as the North Fork Sprague and upper Sprague River. Bank instability, sediment deposition, and water quality problems which characterize streams subject to cattle grazing could be severely limiting fish production. A complete lack of gravel substrates make this reach highly unsuitable for spawning. The upper reach of Fivemile Creek had a better SRI/CSE rating, but it also suffers many of the same bank and channel instability and sedimentation problems as the lower reach. Water temperature in Fivemile Creek may be too warm for brook trout but is acceptable for brown and rainbow trout, although the higher temperature approaches the upper tolerance for these species.

4.11 SOUTH FORK SPRAGUE RIVER

The South Fork Sprague River originates along the south border of the Gearhart Mountain Wilderness, flowing southwest, then south, then west, and finally northwest to where it merges with the North Fork Sprague River, forming the main stem of the upper Sprague River. It is slightly sinuous and, like the North Fork Sprague River, changes from a medium-gradient coniferous forest in its upper reach to low-gradient pastureland and sagebrush in its lower reach. One site was selected and sampled in each of these reaches. The weighted SRI/CSE rating for South Fork Sprague River was 77 ("fair"). The individual ratings were quite different; one "poor" and one "good."

The lower reach had a SRI/CSE rating of 90, which falls in the middle of the "fair" range. Bank rock content, bank cutting, deposition, and bed material consolidation were rated "poor," as the banks showed abundant evidence of erosion. This was another of those stream sections where the water surface was about 6 feet below the level of the pastureland. The instream habitat type was run, and the dominant substrates were silt, embedded with gravel, and rubble, embedded with sod. The riparian zone consisted of grass and sagebrush; except for the bank, there was no obvious cover.

The upper reach, on the other hand, had an SRI/CSE rating of 49, which classified it as "good," and no individual index was scored lower than "good." Instream habitat was classified as pocket water, with the dominant substrate identified as boulder highly embedded with gravel and rubble. The riparian vegetation consisted of moderately thick alder and willow brush which provided overhead bank cover.

Water temperature collected in 1991 by the USFS (below confluence with Buckboard Creek) decreased from late June to late October. In June it ranged from 12 to 20 C; by October it ranged from 5 to 10 C.

4.11.1 Limiting Factors

The lower reach of the South Fork Sprague River is much like the lower reach of the North Fork Sprague River, Fivemile Creek, and the Upper Sprague River. Bank instability and sedimentation, possibly as a result of cattle grazing pressure, make this reach of the South Fork Sprague River limited in its fish production capacity. The upper reach seems to be more stable in its bank and channel characteristics. Existing data suggest that water temperature does not seem to be limiting, although it may be too warm for optimal brook trout production.

4.12 TRIBUTARIES ENTERING THE SOUTH FORK SPRAGUE RIVER

4.12.1 Demming Creek

Demming Creek originates in the southwest corner of the Gearhart Mountain Wilderness and flows southwest until it enters the South Fork Sprague River. It is a fairly straight stream that flows from forested areas in its upper reach down into open meadow and pastureland in its lower reach. The site sampled was located in the upper reach, on the valley bottom of a wide canyon. The hillsides were loosely forested with conifers, interspersed with open grassy and rocky areas. Instream habitat consisted mostly of medium-gradient run, with some areas of pool, riffle, and cascade. The substrate was dominantly rubble or coarse gravel, both embedded with sand and fine gravel particles. The riparian vegetation was lush and extensive willow/alder brush which provided overhead cover near the banks. The SRI/CSE rating for Demming Creek was 65, which falls in the "good" range. Landform slope, debris jam potential, and scour and/or deposition patterns each were rated "fair" and were the only individual indexes that were rated lower than "good."

Water temperatures measured by the USFS in Demming Creek from late June to late October in 1991 ranged from 1 to 17 C. Water temperatures were cooler and more variable in the late summer and early fall period than in late spring and early summer.

4.12.2 Limiting Factors

The rich willow/alder riparian zone, along with woody debris observed in the channel, could lead to potential debris jams, which in turn could cause scouring. And, the "fair" rating, given the landform slope, indicates that erosion may occur during periods of high flow. The presence of sand and fine gravel embedded within the substrate suggests that this may be a problem. Existing data indicate that water temperature would not limit trout production in Demming Creek.

4.13 LOWER SYCAN RIVER (DOWNSTREAM OF SYCAN MARSH)

This lower reach of the Sycan River begins at the south end of Sycan Marsh and flows southwest through Teddy Power Meadows and then south until it joins the Sprague River. Five sites were sampled along this lower reach of the Sycan River. The upper four sites flowed through mostly coniferous forest; the lower site (nearest the confluence of the Sycan and Sprague River) through flat pastureland. The weighted SRI/CSE rating for the lower Sycan River was 85 ("fair"). In each of the individual sites overall ratings ranged from nearly "poor" to "good."

Site SY-1 (located farthest downstream) was given a rating of 109, which is on the upper end of the "fair" scale, bordering on "poor." Vegetative bank cover, bank rock potential, bank cutting, deposition, rock angularity, and scour and/or deposition patterns were all rated "poor" at this site. The banks were 10 feet high, raw cut, and generally unstable throughout the reach. The instream habitat was identified as low-gradient run and was surrounded by a heavily grazed floodplain. There was sparse riparian zone vegetation except for some grass and a few small shrubs. The substrate was dominated by silt, which was embedded with sand and gravels.

The second site (SY-2, moving upstream) was located in a canyon of lodgepole and ponderosa pine. The instream habitat consisted mainly of low-gradient run, with some small, shallow riffles. It was given a SRI/CSE rating of 54, which indicates that its banks and channels exhibited "good" stability. The substrate showed a heavy silt content, along with some boulder substrate embedded with sand and gravel types. This, together with a "fair" landform slope, suggest that some erosion and sediment deposition may occur during periods of high flow. Riparian growth was mostly grass and shrubs, with some willows and pines.

The section containing site SY-3 was given a SRI/CSE rating of 80, or "fair." It consisted mostly of very low-gradient run, with some riffle. It did not receive any "poor" ratings, but landform slope, bed cutting, and bed material deposition were rated "fair." One bank had more evidence of sloughing, erosion, and bank cutting than the other. All substrate types were present, in different combinations. The riparian vegetation consisted of grass and trees, with some sand and rock.

The upper two sites (SY-4 and SY-5) had no measurable flow during the fall sampling period. Both consisted of alternating low-gradient run-pool and riffle habitats. The downstream site (SY-4) was located in a deep, narrow canyon and was given a SRI/CSE rating of 69 ("good"). It was dominated by well-consolidated larger substrate types (coarse gravel to boulder), with little or no silt evident. The banks were visually stable and the riparian zone consisted mostly of rock, with some grass. Site SY-5, located just below Sycan Marsh, was in a forested region with some open areas containing grass and rocks. It received a SRI/CSE rating of 97, which is in the middle of the "fair" range. Its banks were relatively stable, but it got low ratings on indexes that dealt with sedimentation. Silt was common in the run habitat, along with combinations of gravels, rubble, and boulders. Aquatic vegetation was predominant in the riffle habitat, resulting in the flow obstruction index rating of "poor."

Water temperature data was collected at two locations on the lower Sycan River from late July to early October 1990. The water temperature ranged from 10 to 21 C during much of this period, but 26 C was recorded in midsummer.

4.13.1 Limiting Factors

Habitat in the lowermost reach of the Sycan River is severely limited, primarily by heavy cattle grazing. Lack of vegetation and/or rocks have made the banks very unstable, which in turn is most likely responsible for the heavy sedimentation within the stream. The upper three sections of the reach did not have nearly the sedimentation load observed in the lowermost section. However, the upper two sites had no measurable flow during the fall, and had fairly stable bank and channels. What appears to be good fish habitat, without adequate flow, is limited. The water temperature seems to be adequate for rainbow trout, brown trout, and Klamath largescale sucker, except when it exceeds 24 C. Water temperature data collected in the mid-1970s included a maximum water temperature of 35 C. Trout can survive temperatures in the mid-20s if they become acclimated and there are saturation levels of oxygen (Moyle 1976), but these higher temperatures would be lethal, especially to brown trout and suckers.

4.14 TRIBUTARIES ENTERING SYCAN MARSH

4.14.1 Long Creek

Long Creek begins near Antler Springs and flows south and then east to Sycan Marsh. It is low-gradient and highly sinuous, and the reach that was sampled flowed through a flat, wide meadow of grass and lodgepole forest. The water level in the stream was approximately 4 feet below the surrounding grassland.

The instream habitat was evenly divided among pool, riffle, and run types. The substrate for all three habitat types contained sand and gravel that was highly embedded with silt. The amount of silt decreased from pool to run to riffle, probably in relation to the velocity. There was no real riparian zone except for grass, and banks were the only source of cover.

The SRI/CSE rating for Long Creek was 86, which indicates "fair" bank and channel stability. No individual index received a score lower than "fair," but among those that received this rating were bank cutting, deposition, and bed material consolidation. The banks appeared unstable, and sloughing was evident, especially at bends in the stream.

No adequate water quality data were available for Long Creek.

4.14.2 Calahan Creek

Calahan Creek begins near Blue Buck Springs and flows south through Calahan Meadow before joining Long Creek. The area is moderately forested with conifers and there are some open grassy areas. It is a small, meandering, relatively low-gradient stream.

Calahan Creek scored 89, which is "fair" on the SRI/CSE rating scale. It rated "fair" in most of the sedimentation-related indexes, and it was observed that the run habitat substrate was heavily dominated by silt. An abundance of fallen woody debris in the high-water floodplain led to a "fair" assessment of debris jam potential. It was also noted that the area had the appearance of being moderately grazed.

The riparian zone consisted mostly of grass areas, but it did contain some moderately forested areas. Instream habitat was mostly run, with some riffle, and the substrate was dominated by silt and gravels. Cover was present in the form of undercut banks, logs, and brush.

No water quality data were available for Calahan Creek.

4.14.3 Coyote Creek

Coyote Creek begins near Round Butte and flows southeast into Sycan Marsh. It is a small, meandering stream and it flows through mostly open, flat meadows grazed by cattle, along with some areas partially forested with coniferous trees. The stream flows through a culvert just downstream of the sample site.

It received an overall SRI/CSE rating of 88 ("fair") and was rated "poor" for the individual indexes of vegetative bank cover, channel capacity, bank rock content, and rock angularity.

Many raw cut banks were observed, along with some occurrences of sloughing. The stream consists almost entirely of run habitat, with some occasional areas of riffle. The substrate is heavily dominated by silt embedded with gravels. There is no riparian growth except for the grassy meadows.

4.14.4 Limiting Factors (Long, Calahan, and Coyote Creeks)

Sedimentation is the major factor limiting fish production in these tributaries. Although there appeared to be a good variety of fish habitats within Long Creek, the large amounts of silt present indicates that spawning in this stream would be limited. Debris jam potential on Calahan Creek, especially at high flows, could limit fish passage, create flow problems, and lead to bank scouring. There were some small areas of fine and coarse gravel that were not embedded with silt. Bank instability very likely promotes the deposit of sediments into Coyote Creek. The buildup of this sediment, evident in the substrate, limits fish production, as it is not suitable for spawning. Effects of cattle grazing (erosion, water quality) on Calahan Creek also have potential limiting effects. It is unknown what fish passage restrictions might be caused by the culvert on Coyote Creek, but it could be a limitation, especially at low flows.

4.15 UPPER SYCAN RIVER (UPSTREAM OF SYCAN MARSH)

The upper reach of the Sycan River begins at its headwaters and ends at its entrance into Sycan Marsh. The upper section of this reach flows through coniferous forest containing some open, grassy areas, whereas the lower section flows through a high, flat "tableland" area consisting mostly of grass and rocks with an occasional grove of coniferous trees. One site in each section was selected and sampled.

The weighted SRI/CSE rating for the upper Sycan River reach was 77 ("good"), which is more indicative of the upper section than the lower. The upper section (SY-7) was rated 68 ("good") on the SRI/CSE scale, and visually the banks were quite stable. The lower section (SY-6) was given a SRI/CSE rating of 95, which put it in the middle of the "fair" range. Most individual indexes received scores of "good" or "fair," with only channel capacity receiving a "poor" rating.

Instream habitat in the upper section was almost entirely medium-gradient to low-gradient run, with some areas of riffle. The substrate was dominated by gravel, rubble, and boulder combinations. In the lower section, the instream habitat consisted of low-gradient run, and the substrate was dominated by fine and coarse gravel, with no evidence of silt or sand sedimentation.

The riparian zone in the upper section consisted of a small margin of grass along with some areas of thick forest, which occurred near the stream edge, while the riparian zone in the lower section consisted mostly of rock and grass, and only bank cover was present.

Water temperatures collected by the USFS during 3-month periods (July–September) in 1980 and 1991 show a warming trend near Sycan Marsh and a definite cooling from summer to fall. Water temperatures recorded during the second half of July were quite warm (24–26 C), and would not be suitable for trout.

4.15.1 Limiting Factors

Despite a "fair" rating on the lower section, the upper Sycan River appears to have some good fish production potential. The sedimentation load characteristic of the reach below Sycan Marsh and much of the Sprague River basin are not evident here. Water temperature (during summer months) and in adequate flow constitute limiting factors in this section of the Sycan River.

4.16 WOOD RIVER AND CROOKED CREEK

Wood River and Crooked Creek are both spring-fed and flow south through mostly flat pastureland before entering Agency Lake. The water was very clear at the sites sampled, evidence of their spring-fed sources. The surfaces of both Wood River and Crooked Creek were 2–3 feet below the adjacent pastureland.

Wood River was given a SRI/CSE rating of 93; Crooked Creek, a rating of 110, which puts them into the "fair" range of bank and channel stability. Banks were noted to be generally stable, although some sloughing and sagging was evident, especially along the outside banks of bends on the Wood River. Individual scores for bed material brightness and consolidation suggest instability within the channel as well. It was visually noted that much of the substrate at both sites was in motion. Crooked Creek received various other low scores that suggest further problems; flow obstructions (causing a rating of "poor") were evident, hindering flow in the channel.

Wood River had both run and riffle instream habitat. Crooked Creek was predominantly run habitat. Sampled substrates consisted of combinations of silt, sand, and fine gravel. The riparian zone of the two sites was almost entirely grass, although Wood River riparian vegetation included some sparse willows and alders.

4.16.1 Limiting Factors

Moderate bank and channel instability make both Wood River and Crooked Creek potentially limiting in terms of fish production. The available substrates may not be suitable for spawning fish, and substrate movement could dislodge eggs.

5. DISCUSSION/CONCLUSIONS

The overall results of the survey have identified several factors which may limit fish production in the streams of the Klamath Tribe treaty area. A general, brief discussion of these limiting factors is presented below.

<u>Irrigation Diversions</u> - Irrigation withdrawals have resulted in the periodic flow reduction or dewatering of many of the streams and river reaches within the study area, precluding the development of productive, or even viable, fish populations. For most of the streams, flows are marginal for fish production during drought years; with diversions, conditions of low or no flow prevail. There is also potential for stranding mortality of fish, since diversion flows result in channel dewatering.

Most streams and rivers within the study area are diverted for irrigation; natural flow regimes have been altered. This has resulted in the disruption of the balance between flow rates and sedimentation levels within the channels. The physical manifestation of this phenomenon is changed channel morphology and substrate material composition. Wesche et al. (1989) studied the physical response of low-gradient channels to water diversion and concluded that within a 50-year time frame channels tended to become narrower and shallower, which ultimately reduced their sediment conveyance capacity.

Diversions can also affect the quality of salmonid spawning gravels by altering the quantity and timing of stream flows, thereby influencing sediment transport and deposition. If high flows are continually diverted above a given reach of stream, stream competency (ability to transport fine sediments) is reduced, resulting in sediment deposition. Increased sediments can reduce gravel permeability and intragravel flow (important for transporting oxygen to and removing metabolic wastes from incubating eggs) or entomb fry within the gravel matrix (Kondolf et al. 1987). Spawning habitat of good quality was generally lacking in the streams surveyed in the study area.

<u>Agriculture/Grazing</u> - Cattle grazing and other agricultural practices have impacted the riparian zones of many of the streams, resulting in bank sloughing, erosion, and increased sediment recruitment. From the perspective of fisheries habitat, streamside vegetation has five important functions (Wesche et al. 1987): (1) regulation of stream temperatures, (2) provision of stream bank stability, (3) input of nutrients by allochthonous material, (4) direct input of invertebrates as fish food, and (5) provision of cover for fish. Reduction of streamside vegetation in the Upper Klamath River drainage has therefore affected all of these valuable fish production components and created conditions that can limit fish productivity.

<u>Sediment</u> - Almost all stream reaches observed had significant quantities of fine sediment deposited in the streambed. Sediment can impact fish populations in many ways, including (1) embedding of gravel and rubble substrates, causing loss of habitat for certain species/

lifestages; (2) filling of pools; and (3) loss of macroinvertebrates as a food base. The unique geology that typifies this region inherently produces a relatively high amount of fine particles which can be recruited into stream systems. In addition, extensive and intensive logging in the upper areas of the watershed and the poor bank/channel conditions in the valley reaches due to farming and ranching have caused considerable habitat degradation within the basin.

Temperature - Temperature data has been collected at numerous points within the watershed. Data indicate that in the Sprague and Sycan rivers, during the warmest portion of the summer, daytime water temperatures may exceed the tolerance limits of many of the species of concern. Present-day water temperatures in all three of the primary drainages in the basin (Williamson River, Sprague River, and Sycan River) would exceed the historical natural water temperatures. This is due to a combination of several factors: (1) there is less water in the channels during the summer because of irrigation, (2) return flow waters are heated considerably before re-entering stream channels, (3) present-day channels tend to be shallower than natural channels, and (4) in some areas considerable streamside vegetation has been lost, which provided shade. All four of these causes are directly or indirectly linked to irrigation withdrawals or other agricultural use of the land. If a significant amount of water were to be left in the channel during the summer months and riparian zones allowed to recuperate, summer water temperatures would in all likelihood be reduced.

Passage - With the construction of the Chiloquin Dam on the lower Sprague River, passage upstream for most species has been virtually eliminated. While the dam does have a fish ladder, reportedly very few fish use it. This has resulted in the loss of access to large amounts of available habitat for spawning runs of Upper Klamath Lake sucker populations. Even if the suckers were able to access the upstream areas, success of downstream passage by fry would still be in question.

Channelization - Stream channels have been straightened on agricultural lands and for road and railroad development. Channelization tends to reduce stream length, habitat diversity, and riparian zone integrity and thus to promote bank instability and erosion.

Water Quality - Although we have no information on the use of herbicides and pesticides on the agricultural lands along the river corridors, the residuals and byproducts of those that are used certainly would be carried into the stream channels with irrigation return flows and could have deleterious effects on aquatic organisms. The presence of cattle grazing along river corridors will also affect water quality as cattle waste runs off into the streams.

Food - A reduction in the number and diversity of food organisms (aquatic macroinvertebrates) may have resulted from sedimentation, habitat loss, or changes in water quality.

Harvest - Although fishing for two suckers species has been terminated, fishing for other species could have localized effects on target populations.

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APPENDIX A

Tables and Figures

TABLES

TABLE A-1 SRI/CSE RATINGS FOR KLAMATH IFIM SITES (UNADJUSTED)

Site	Rating Criteria															Total Score	Quality Rating
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
WD-1																0	
WD-2	2	3	2	4	2	8	6	8	12	4	3	8	10	18	3	93	Fair
WD-3	2	3	2	6	3	8	8	12	12	3	4	6	16	24	1	110	Fair
SY-1	2	3	2	12	2	8	2	16	16	4	2	6	12	20	2	109	Fair
SY-2	5	6	2	8	1	4	4	4	4	2	1	2	4	6	1	54	Good
SY-3	5	5	2	6	3	6	4	12	6	2	1	6	8	12	2	80	Fair
SY-4	2	6	4	3	3	6	4	8	8	2	2	2	4	12	3	69	Good
SY-5	2	6	2	3	3	8	8	8	12	3	3	6	12	18	3	97	Fair
SY-6	6	9	2	6	4	5	4	12	10	3	2	6	10	14	2	95	Fair
SY-7	4	3	4	6	2	4	4	4	8	2	1	4	8	12	2	68	Good
SY-8	2	3	2	8	2	6	4	12	12	3	2	5	12	12	1	86	Fair
SY-9	2	3	6	8	2	6	6	8	10	4	2	5	10	15	2	89	Fair
SY-10	2	3	2	12	4	8	3	12	12	4	2	4	10	8	2	88	Fair
SP-1	3	3	4	5	2	4	3	4	4	2	2	4	5	7	2	54	Good
SP-2	2	3	4	7	2	5	2	4	4	2	1	2	4	6	1	49	Good
SP-3	4	6	4	6	1	2	2	6	6	2	1	4	4	6	1	55	Good
SP-4	2	4	4	7	1	8	4	16	16	4	1	6	14	10	2	99	Fair
SP-5	2	3	2	9	2	8	6	16	8	4	2	2	4	6	2	76	Good
SP-6	2	3	2	9	2	8	6	12	12	4	3	6	12	18	2	101	Fair
SP-7																	
SP-8	6	3	3	3	2	4	2	8	6	2	2	4	12	12	2	71	Good
SP-9																	
SP-10	2	3	5	6	1	8	5	12	16	4	4	8	16	24	3	117	Poor
SP-11	8	6	2	6	1	2	2	4	4	2	1	2	4	12	3	59	Good
SP-12	2	3	2	6	1	8	4	4	16	4	4	8	16	24	3	105	Fair
SP-13	2	3	2	6	3	8	2	12	12	3	3	8	12	16	3	95	Fair
SP-14																	
SP-15	2	3	2	9	2	8	2	14	16	3	2	8	12	6	1	90	Fair
SP-16	3	5	4	3	2	2	3	4	4	2	1	2	6	6	2	49	Good
SP-17	6	3	6	4	2	2	4	4	4	2	2	3	4	18	1	65	Good
WM-1	4	3	4	3	1	8	3	8	8	4	2	6	10	12	2	78	Fair
WM-2	2	3	3	6	2	4	2	8	5	3	2	6	8	10	2	66	Good
WM-3	2	3	5	4	2	6	4	5	4	3	2	6	4	6	2	58	Good
WM-4	5	3	4	3	1	2	2	5	8	3	3	4	8	7	3	61	Good
WM-5	6	6	4	6	1	2	4	4	8	1	1	4	6	9	2	64	Good
WM-6	3	3	4	3	1	8	2	4	5	4	1	6	12	7	2	65	Good
WM-7	2	3	6	5	2	8	3	6	5	4	2	7	8	6	2	69	Good
WM-8	2	3	6	6	3	8	2	4	5	4	2	8	4	8	2	67	Good
WM-9																	
WM-10	2	4	4	8	2	8	4	4	4	2	1	4	5	6	1	59	Good
WM-11	2	3	4	5	2	8	3	6	5	4	4	2	5	10	4	67	Good
WM-12	2	3	6	6	2	8	8	12	4	2	2	8	12	6	2	83	Fair
WM-13	4	3	7	9	1	6	6	8	8	2	2	6	8	12	1	83	Fair
WM-14	2	3	2	7	1	8	2	4	4	2	1	2	5	6	1	50	Good
WM-15	2	3	4	3	3	6	2	4	4	3	3	5	6	6	3	57	Good
WM-16	2	3	2	6	2	8	8	12	10	4	2	8	10	10	2	89	Fair

LEGEND

Index Number	Low	High
1 Landform slope	2	8
2 Mass wasting potential	3	12
3 Debris jam potential	2	8
4 Vegetative bank cover	3	12
5 Channel capacity	1	4
6 Bank rock content	2	8
7 Flow obstructions	2	8
8 Bank cutting	4	16
9 Deposition	4	16
10 Rock angularity	1	4
11 Bed material brightness	1	4
12 Bed material consolidation	2	8
13 Particle size distribution	4	16
14 Scour and deposition patterns	6	24
15 Abundance of aquatic vegetation	1	4
	38	152

TABLE A-2 ADJUSTED RIVER SRI/CSE RATINGS BASED ON DISTANCE WEIGHTED SAMPLE REACHES

Site	Downstream Node	Distance (miles)	Upstream Node	Distance (miles)	Length (miles)	SRI/CSE Value	SRI/CSE Rating	Weighted Value
Sycan River								
SY-1	3.00	0.000	3.01	10.887	10.887	109	FAIR	1,186.68 *
SY-2	3.01	10.887	3.02	19.315	8.428	54	GOOD	455.11
SY-3	3.02	19.315	3.03	26.389	7.074	80	FAIR	565.92
SY-4	3.03	26.389	3.04	28.479	2.090	69	GOOD	144.21
SY-5	3.05	30.904	3.06	36.307	5.403	97	FAIR	524.09
Total					33.882	85 **	FAIR	2,876.02
SY-6	3.07	46.279	3.08	49.960	3.681	95	FAIR	349.70
SY-7	3.08	49.960	3.09	57.386	7.426	68	GOOD	504.97
Total					11.107	77	GOOD	854.66
Sprague River								
SP-1	2.00	0.000	2.01	0.704	0.704	54	GOOD	38.02
SP-2	2.03	5.146	2.04	7.974	2.828	49	GOOD	138.57
SP-3	2.06	28.268	2.07	31.249	2.981	55	GOOD	163.96
Total					6.513	52	GOOD	340.54
SP-4	2.07	31.249	2.08	33.698	2.449	99	FAIR	242.45
SP-5	2.10	50.337	2.11	66.338	16.001	76	GOOD	1,216.08
SP-6	2.11	66.338	2.12	69.380	3.042	101	FAIR	307.24
Total					21.492	82	FAIR	1,765.77
North Fork Sprague								
SP-10	4.00	0.000	4.01	4.433	4.433	117	POOR	518.66
SP-11	4.02	10.007	4.03	14.862	4.855	59	GOOD	286.45
Total					9.288	87	FAIR	805.11
South Fork Sprague								
SP-15	5.01	4.346	5.02	10.628	6.282	90	FAIR	565.38
SP-16	5.03	11.469	5.04	14.282	2.813	49	GOOD	137.84
Total					9.095	77	FAIR	703.22
Williamson River								
WM-1	1.00	0.000	1.01	6.924	6.924	78	FAIR	540.07
WM-2	1.01	6.924	1.02	10.901	3.977	66	GOOD	262.48
WM-3	1.02	10.901	1.03	16.235	5.334	58	GOOD	309.37
WM-4	1.03	16.235	1.04	22.212	5.977	61	GOOD	364.60
WM-5	1.04	22.212	1.05	27.149	4.937	64	GOOD	315.97
WM-6	1.05	27.149	1.06	28.445	1.296	65	GOOD	84.24
Total					28.445	66	GOOD	1,876.73
WM-7	1.07	60.965	1.08	73.291	12.326	69	GOOD	850.49
WM-8	1.08	73.291	1.09	80.116	6.825	67	GOOD	457.28
Total					19.151	68	GOOD	1,307.77

* Weighted value = length x SRI/CSE value

** Adjusted SRI/CSE value = total weighted SRI/CSE value divided by total reach length

FIGURES

Fig. A-1 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Wood River Site 2

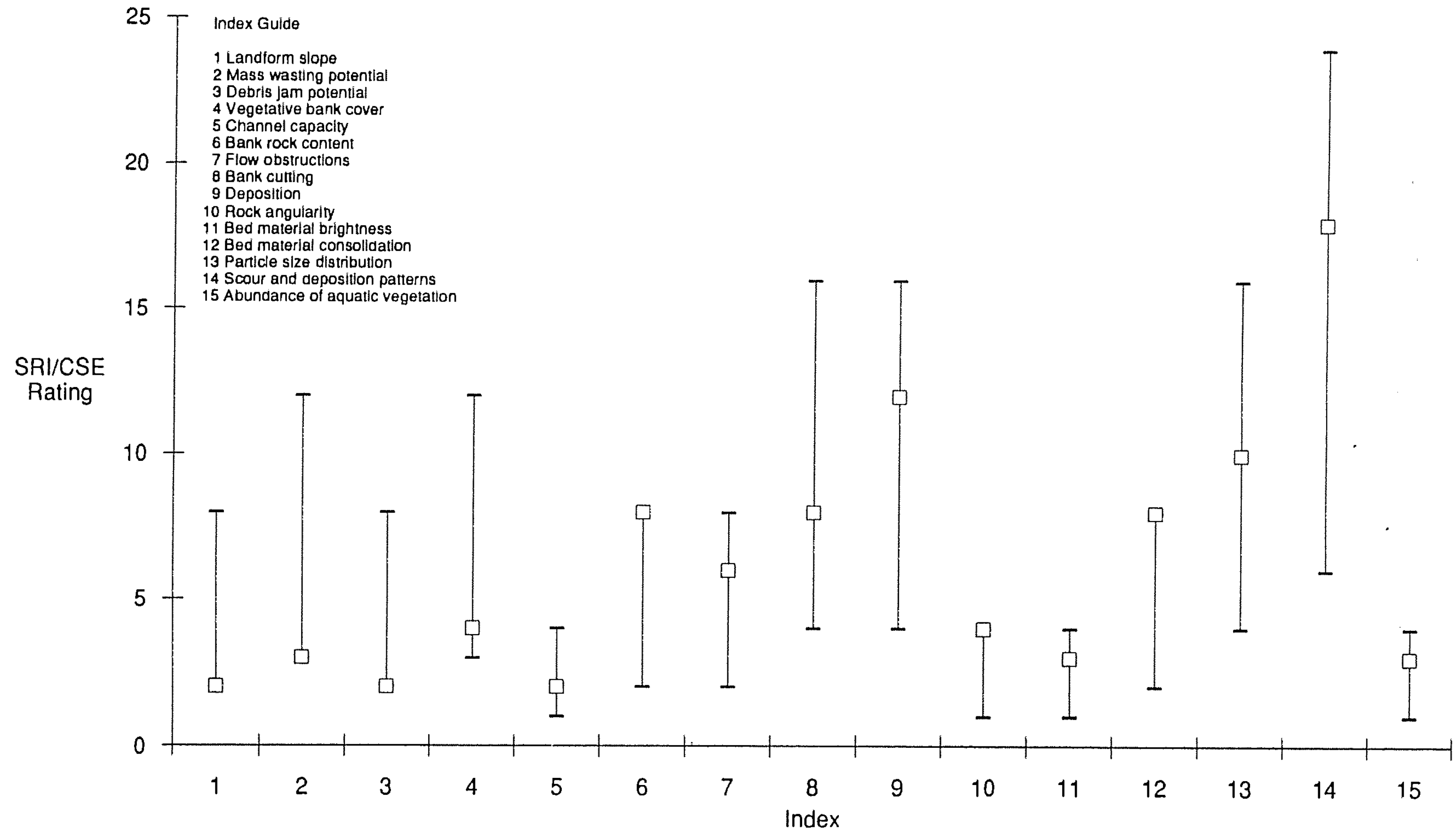

Fig A-2 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Wood River Site 3

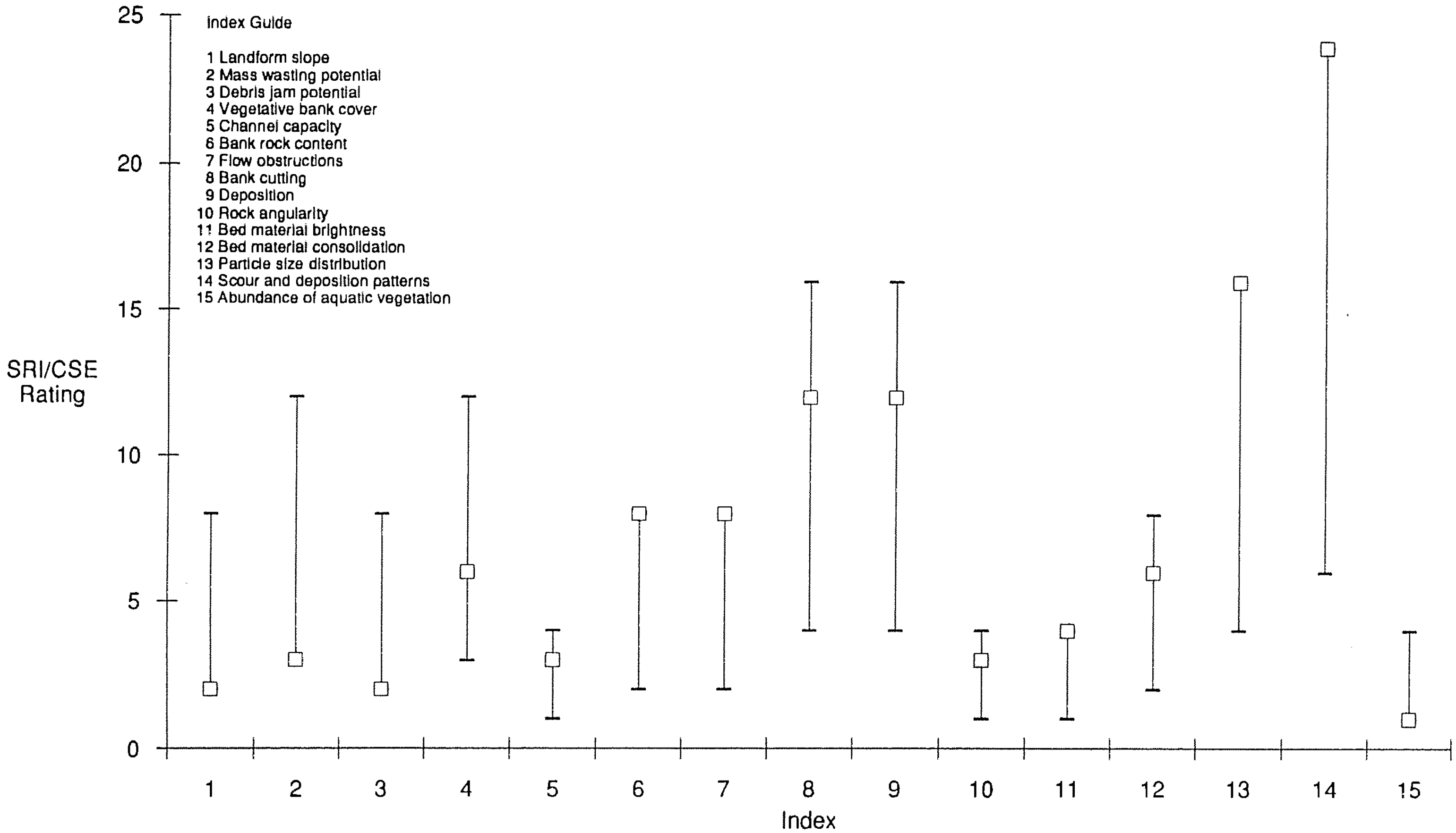

Fig A-3 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 1

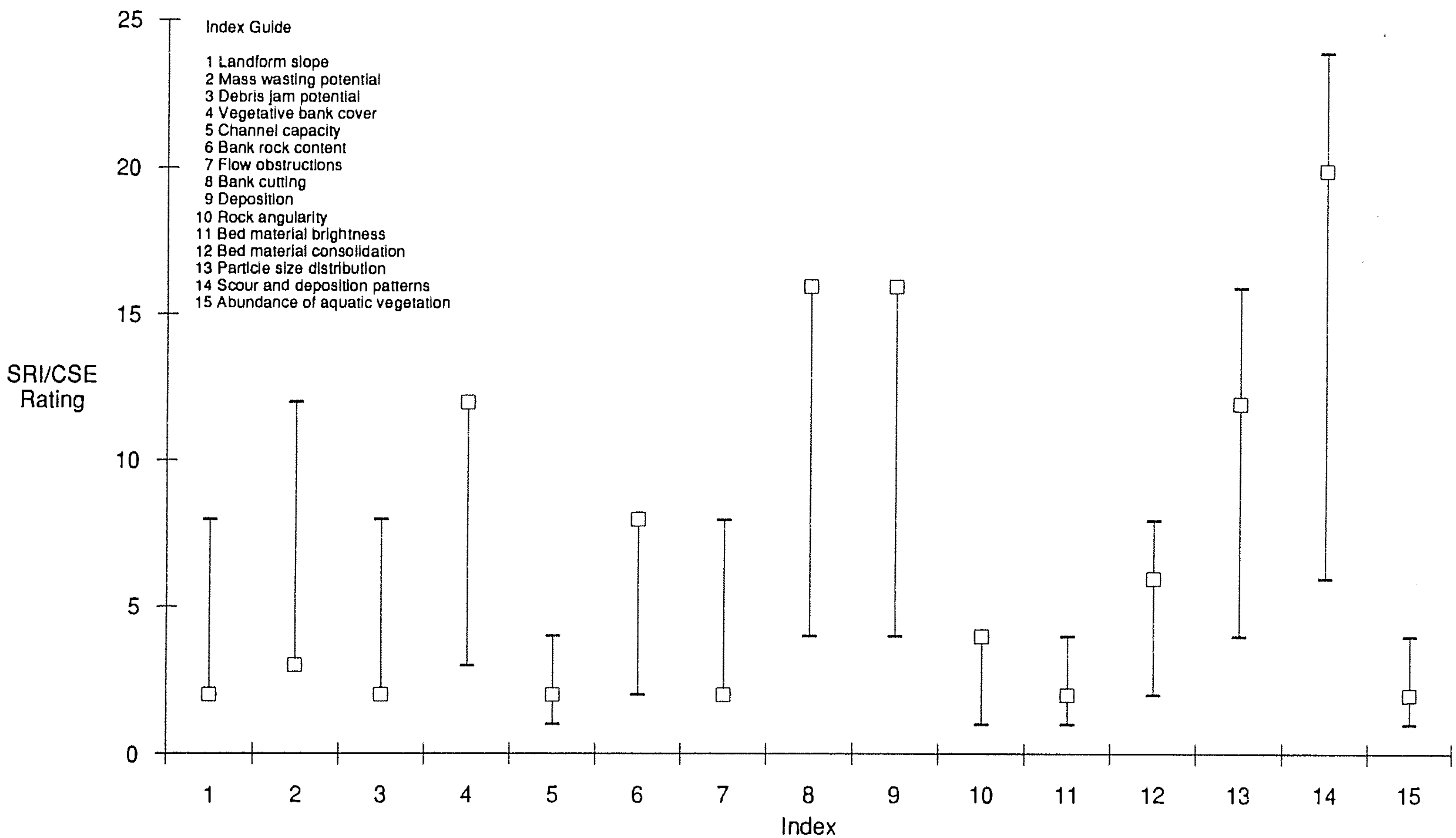

Fig A-4 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 2

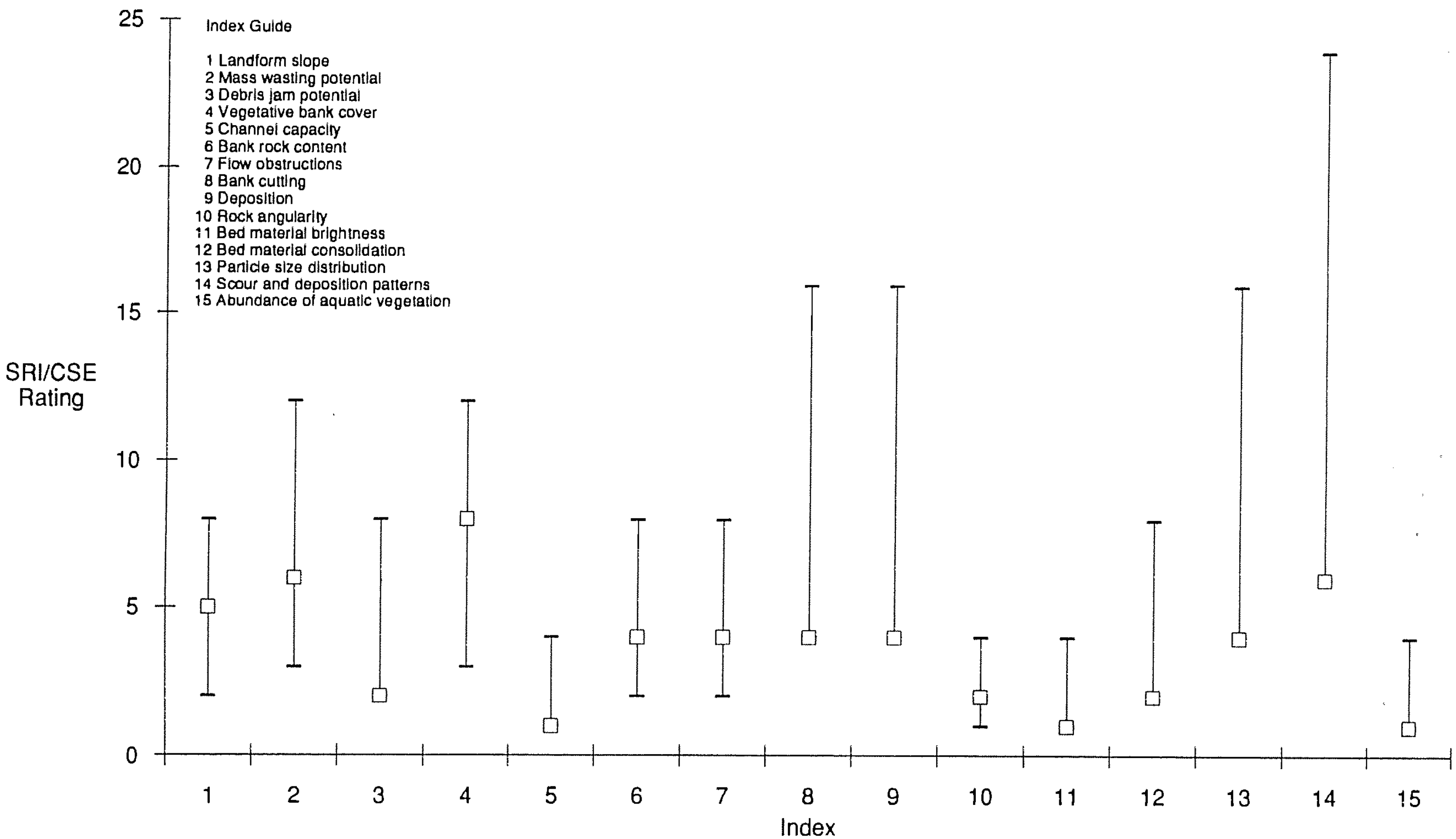

Fig A-5 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 3

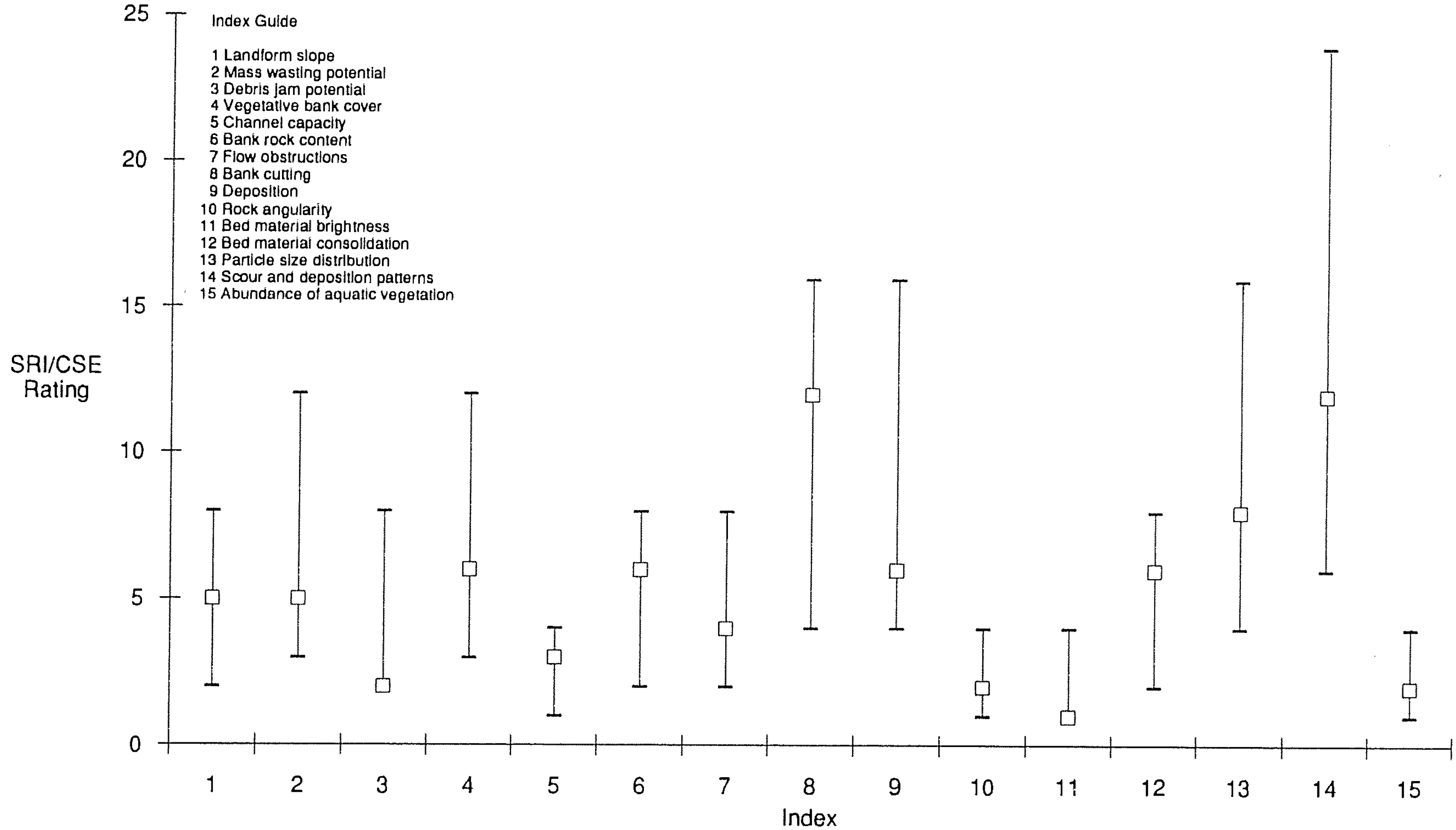

Fig A-6 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 4

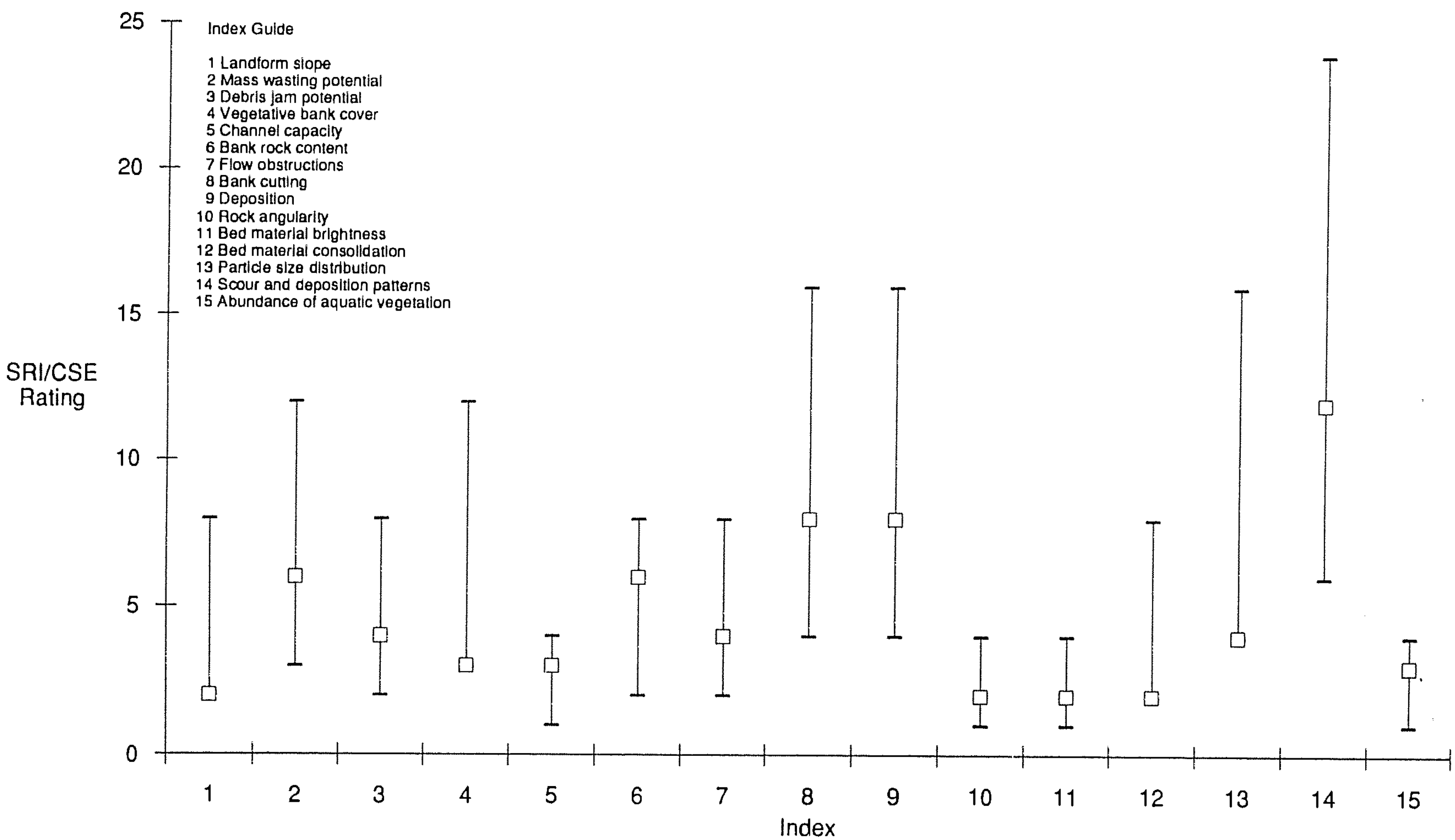

Fig A-7 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 5

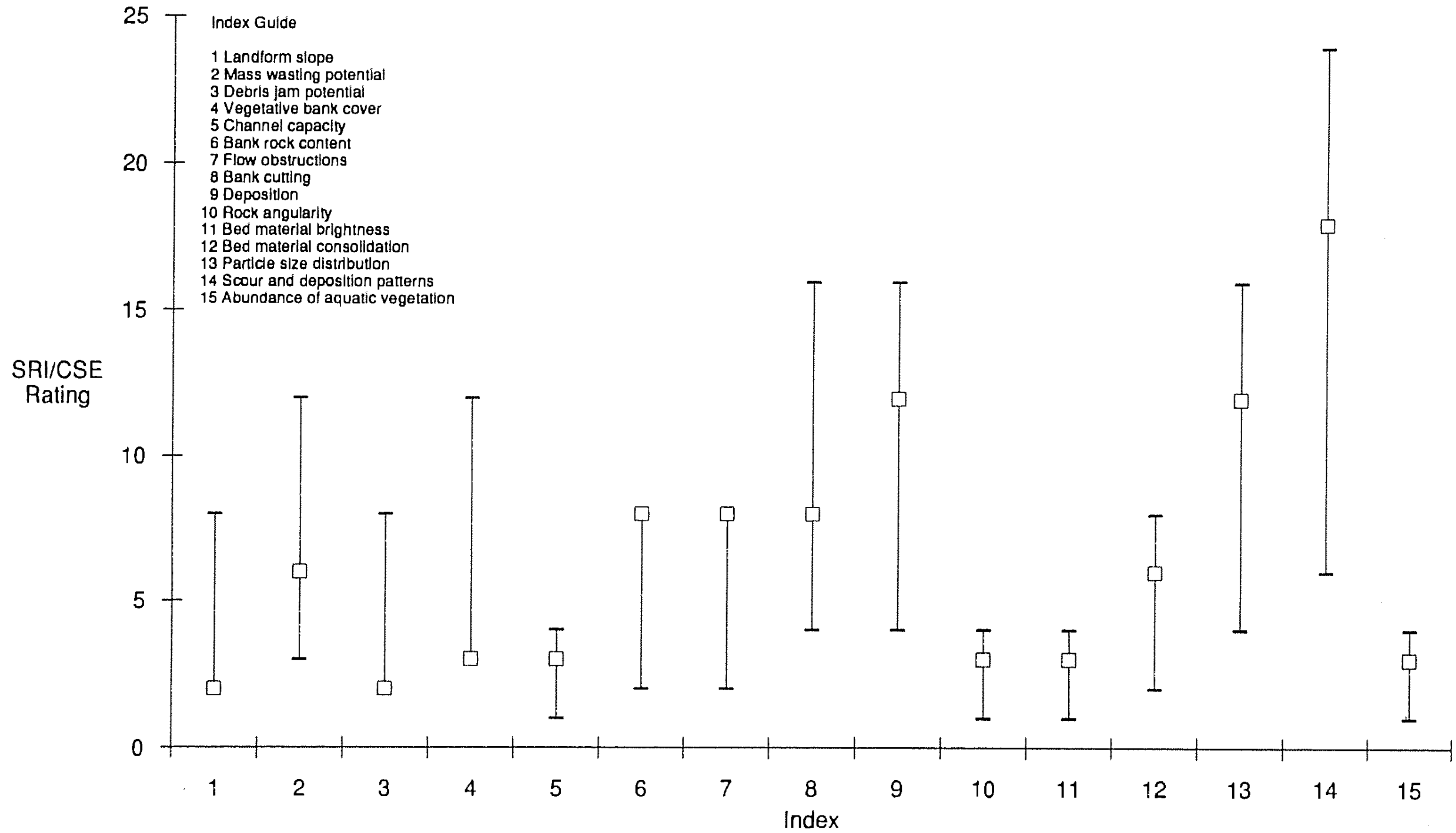

Fig A-8 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 6

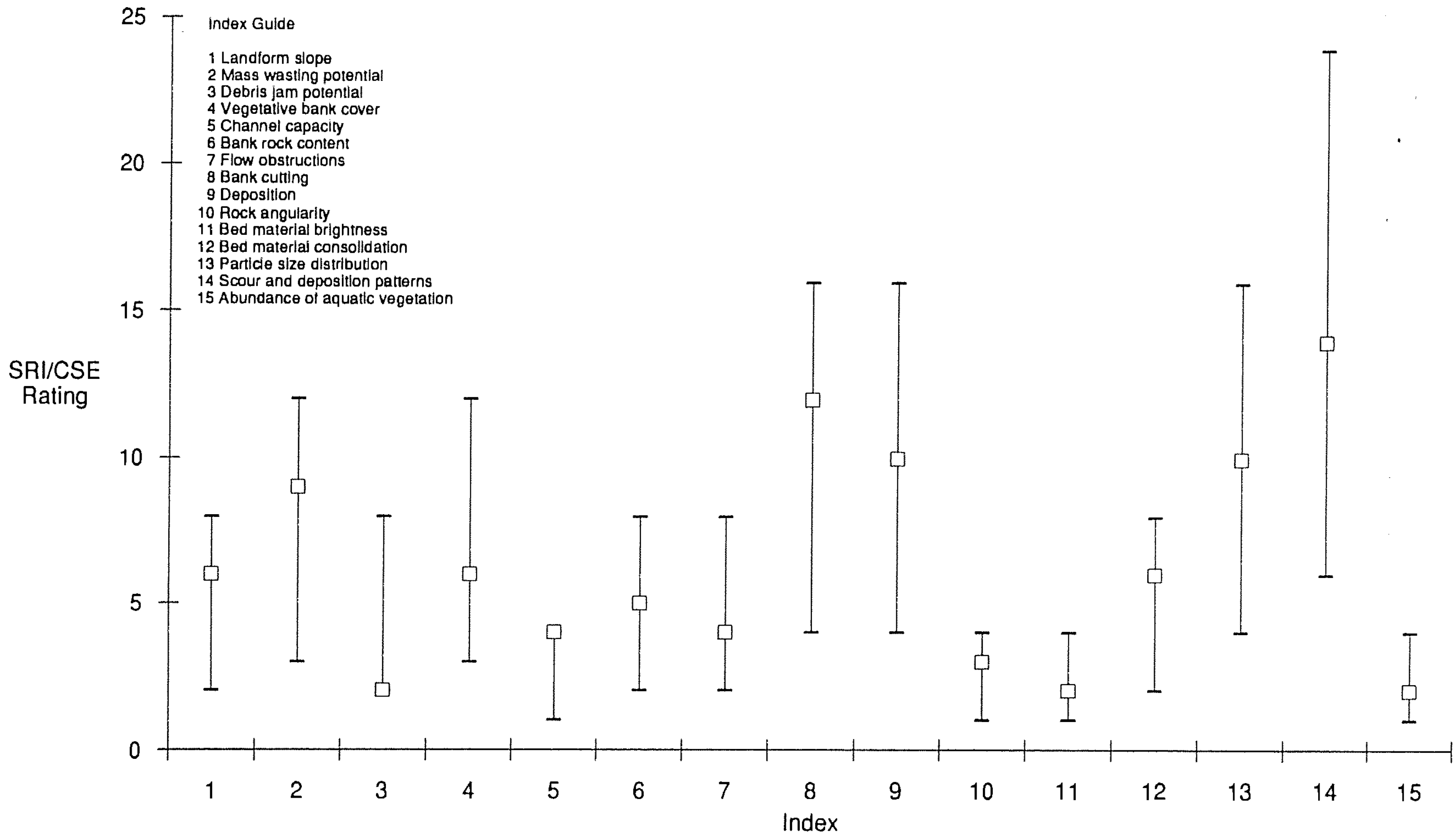

Fig A-9 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 7

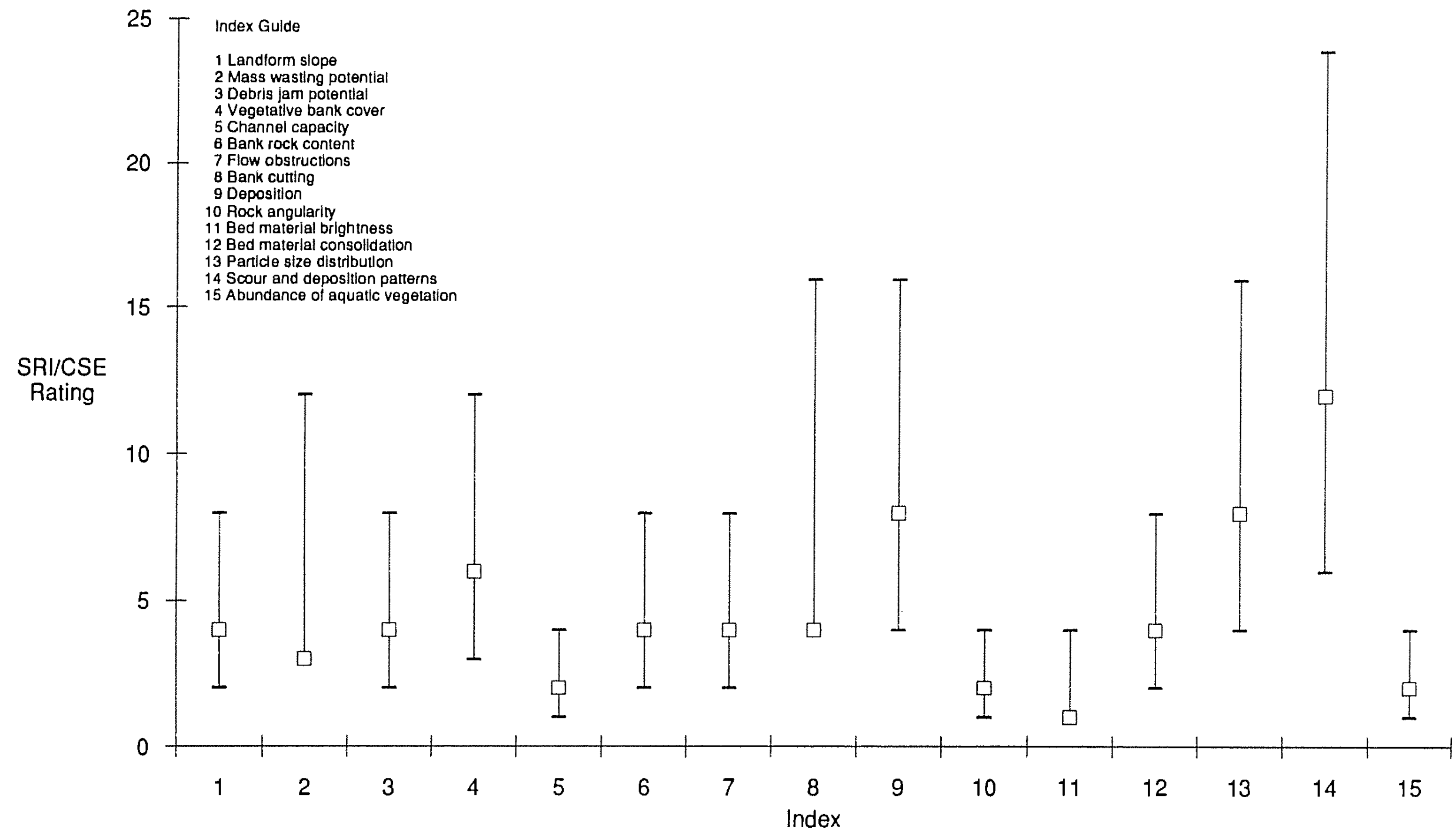

Fig A-10 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 8

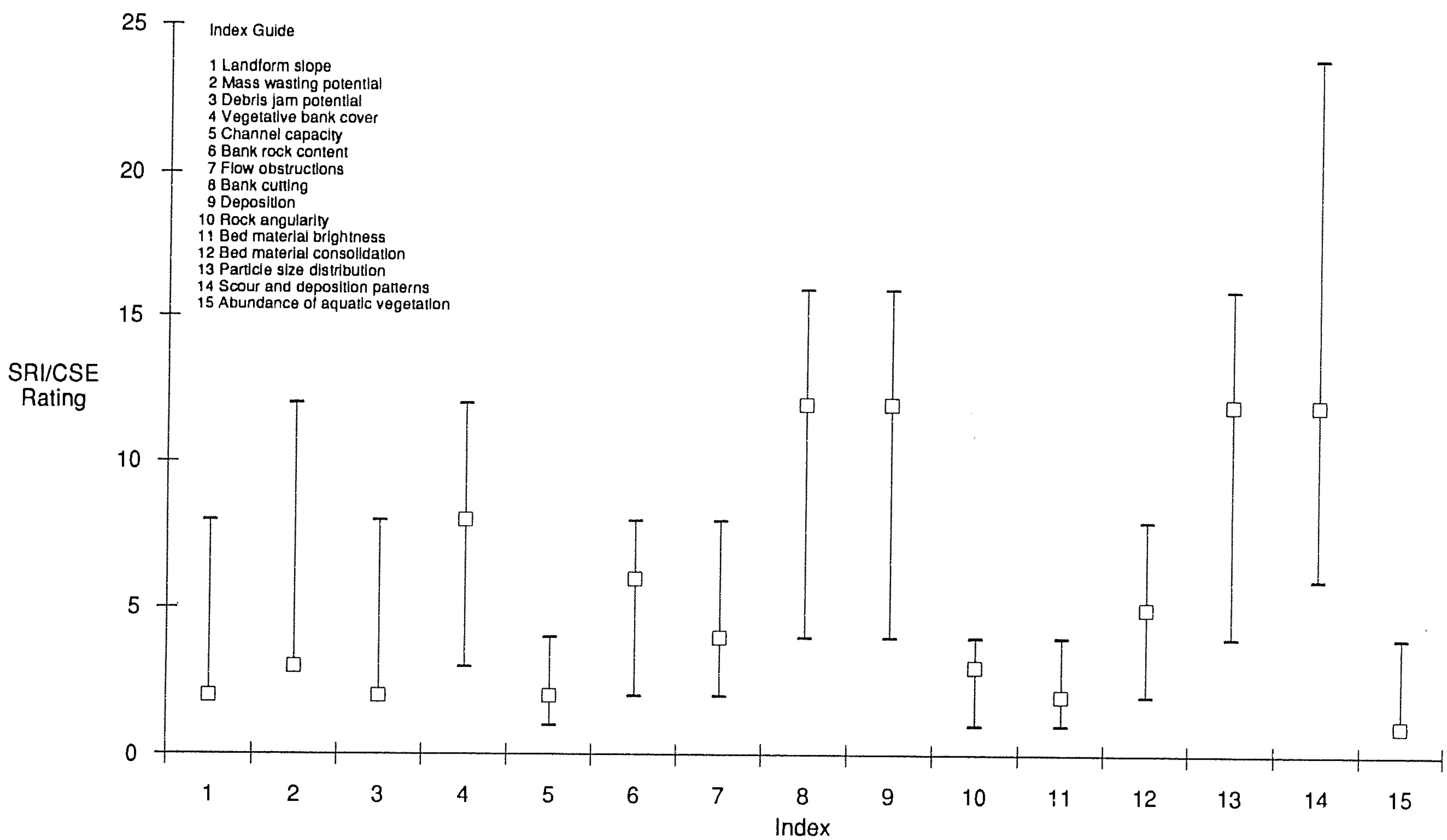

Fig A-11 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 9

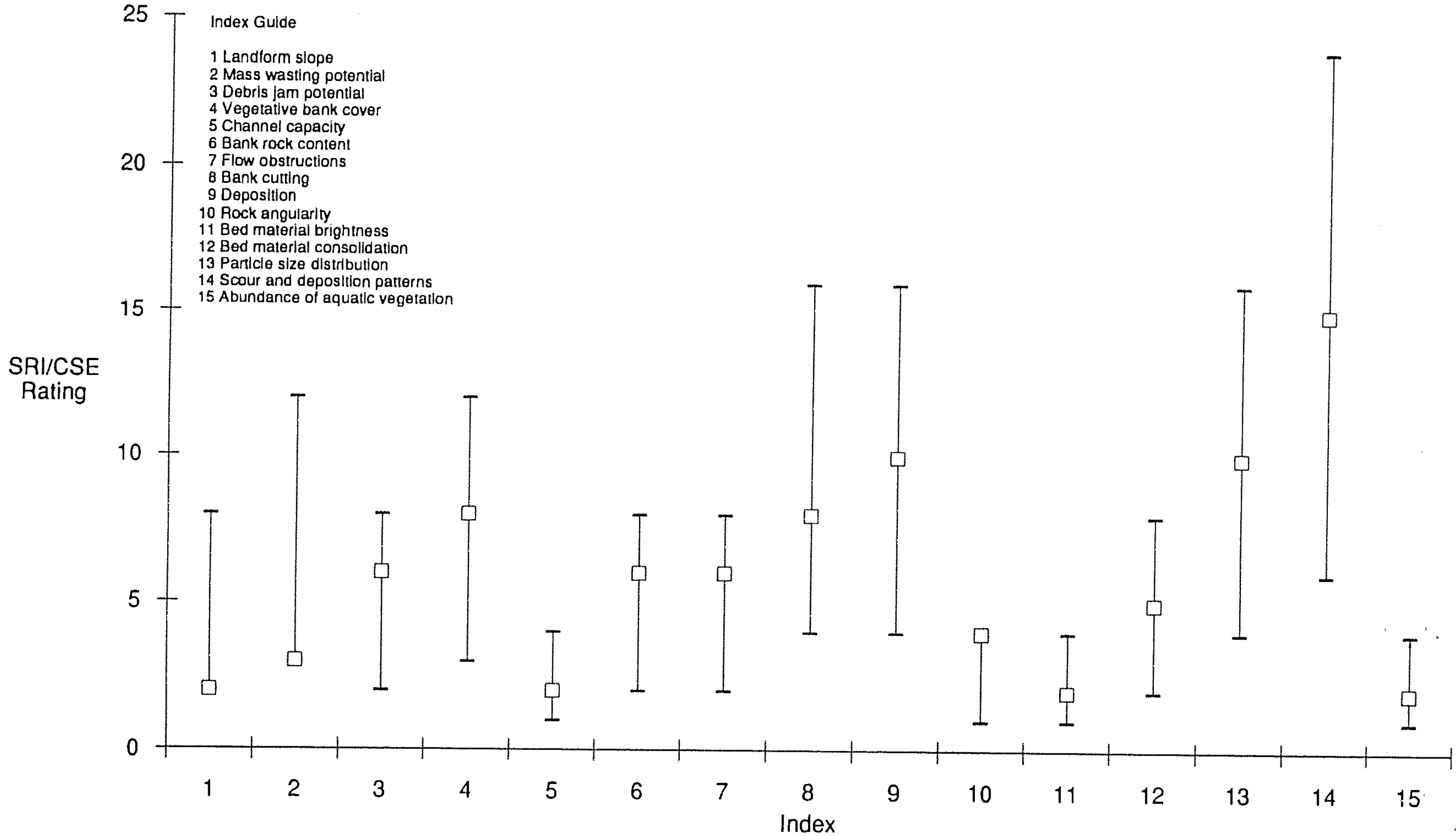

Fig A-12 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sycan River Site 10

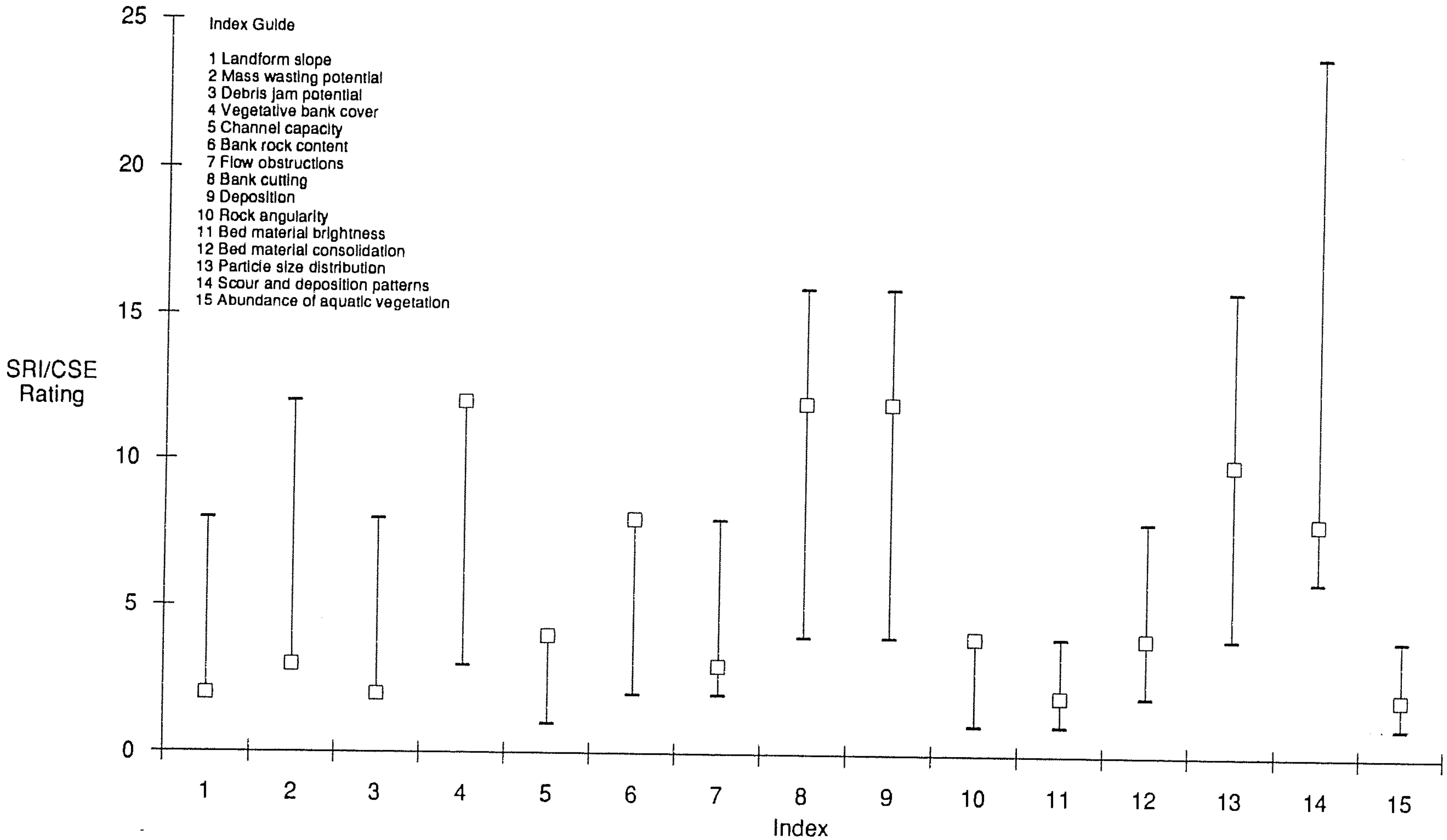

Fig A-13 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 1

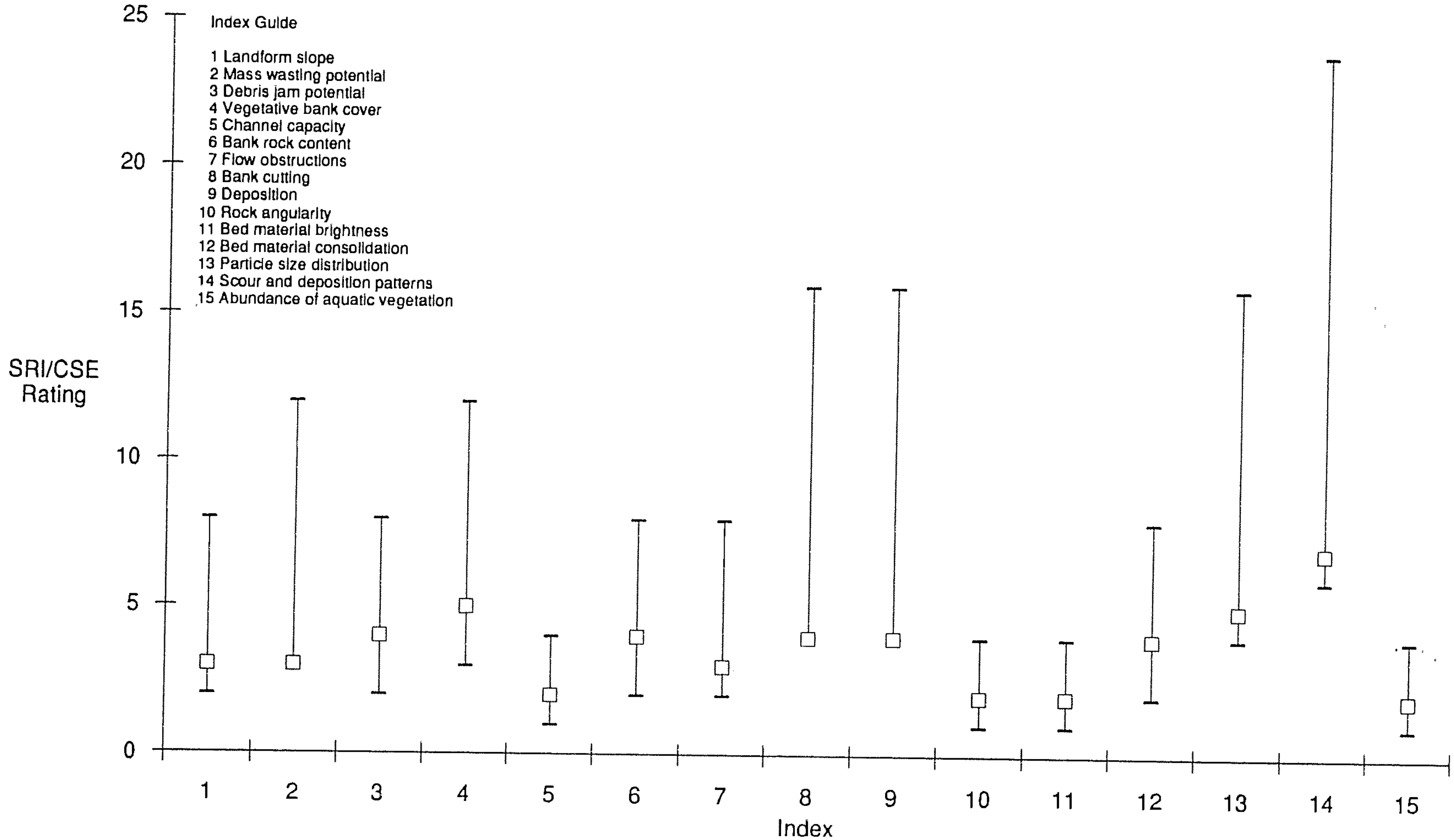

Fig A-14 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 2

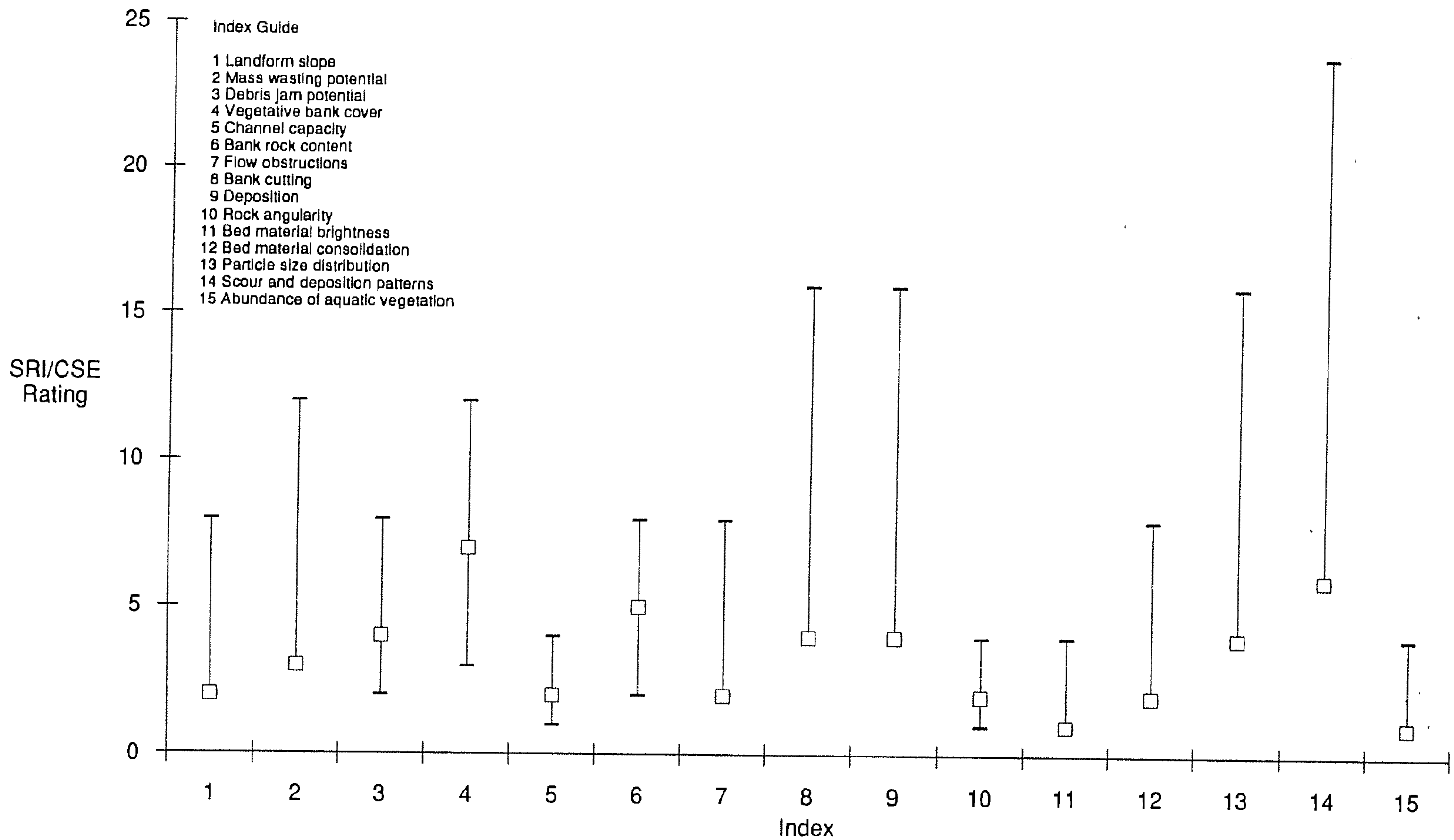

Fig A-15 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 3

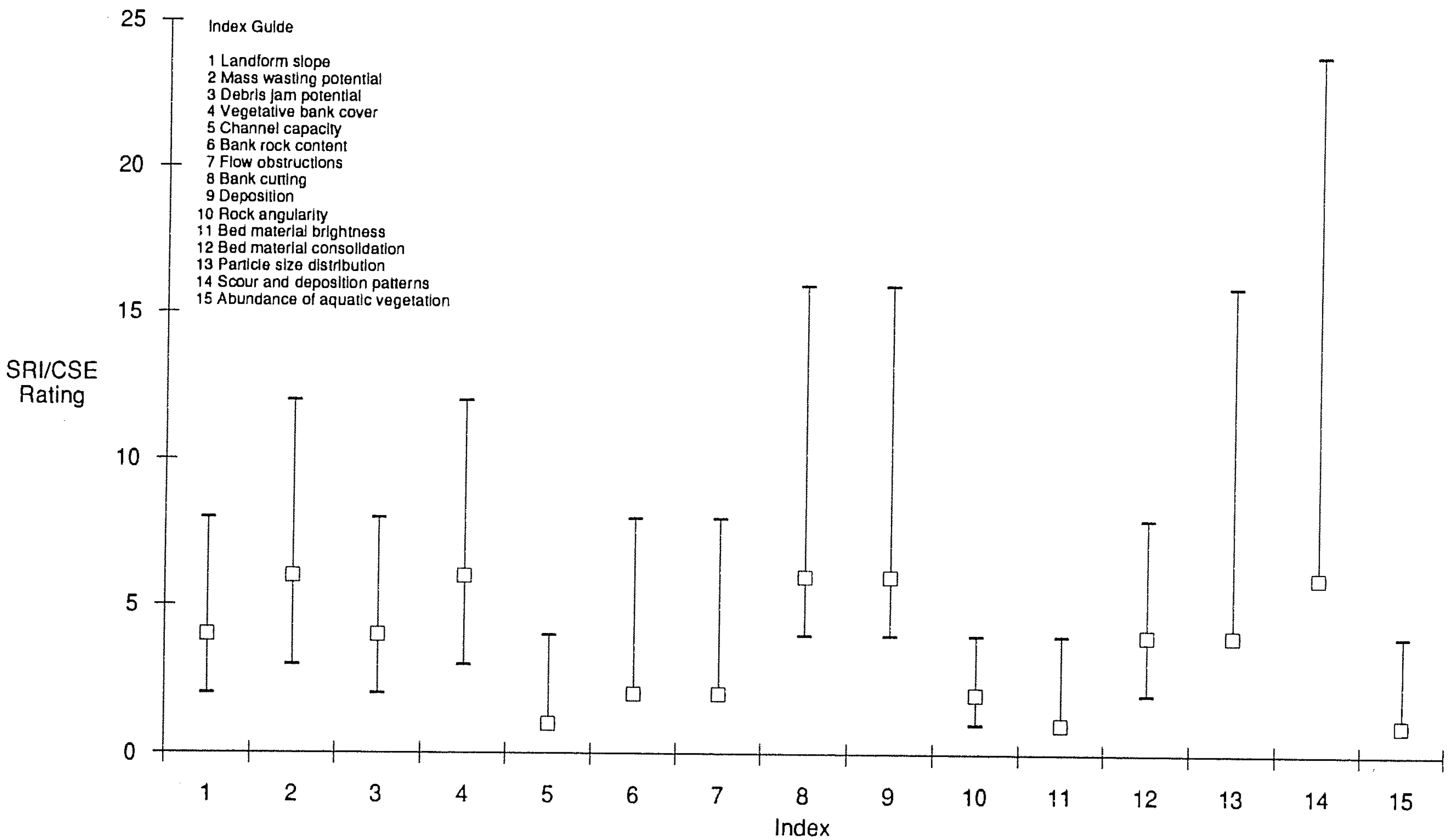

Fig A-16 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 4

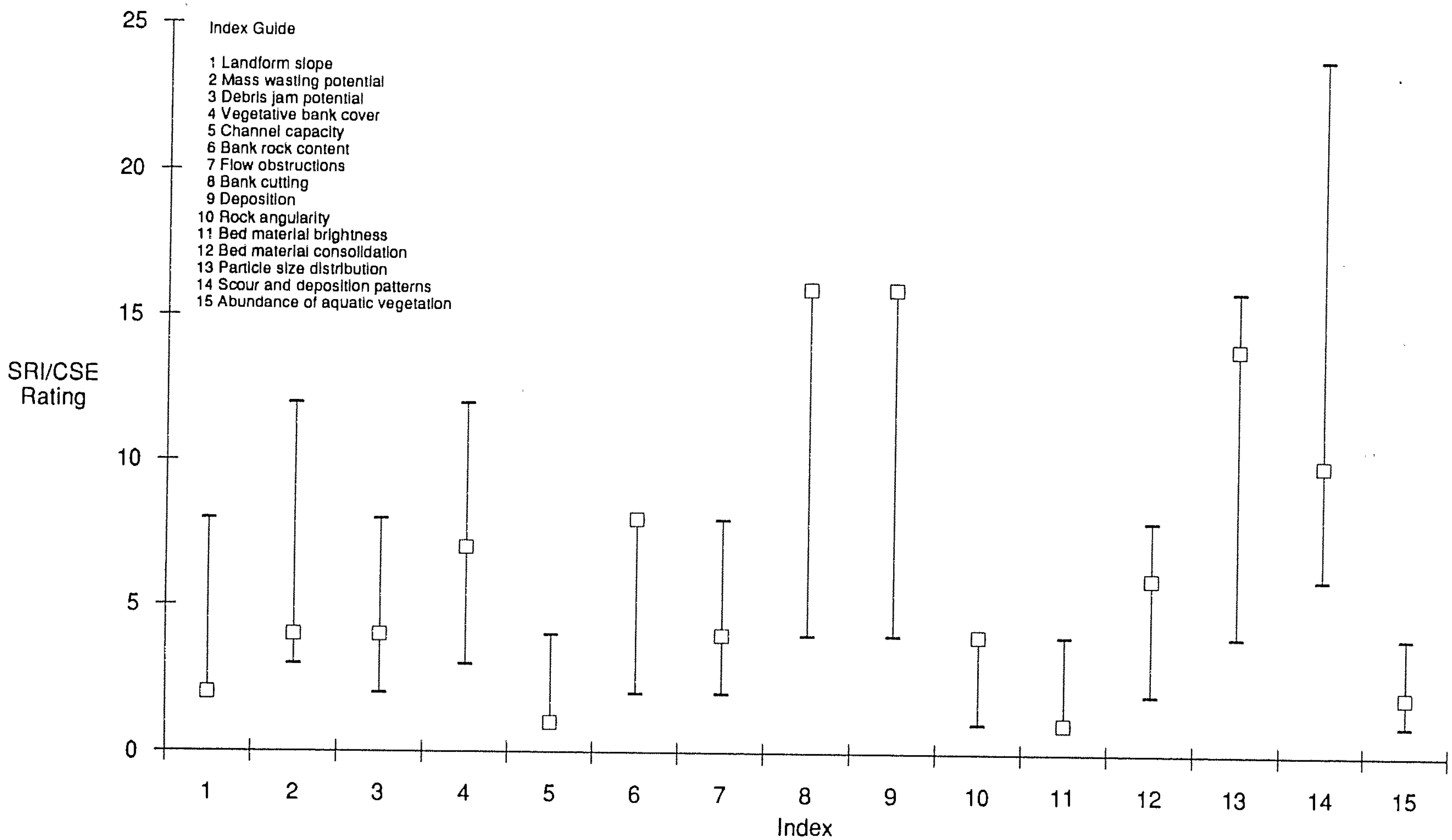

Fig A-17 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 5

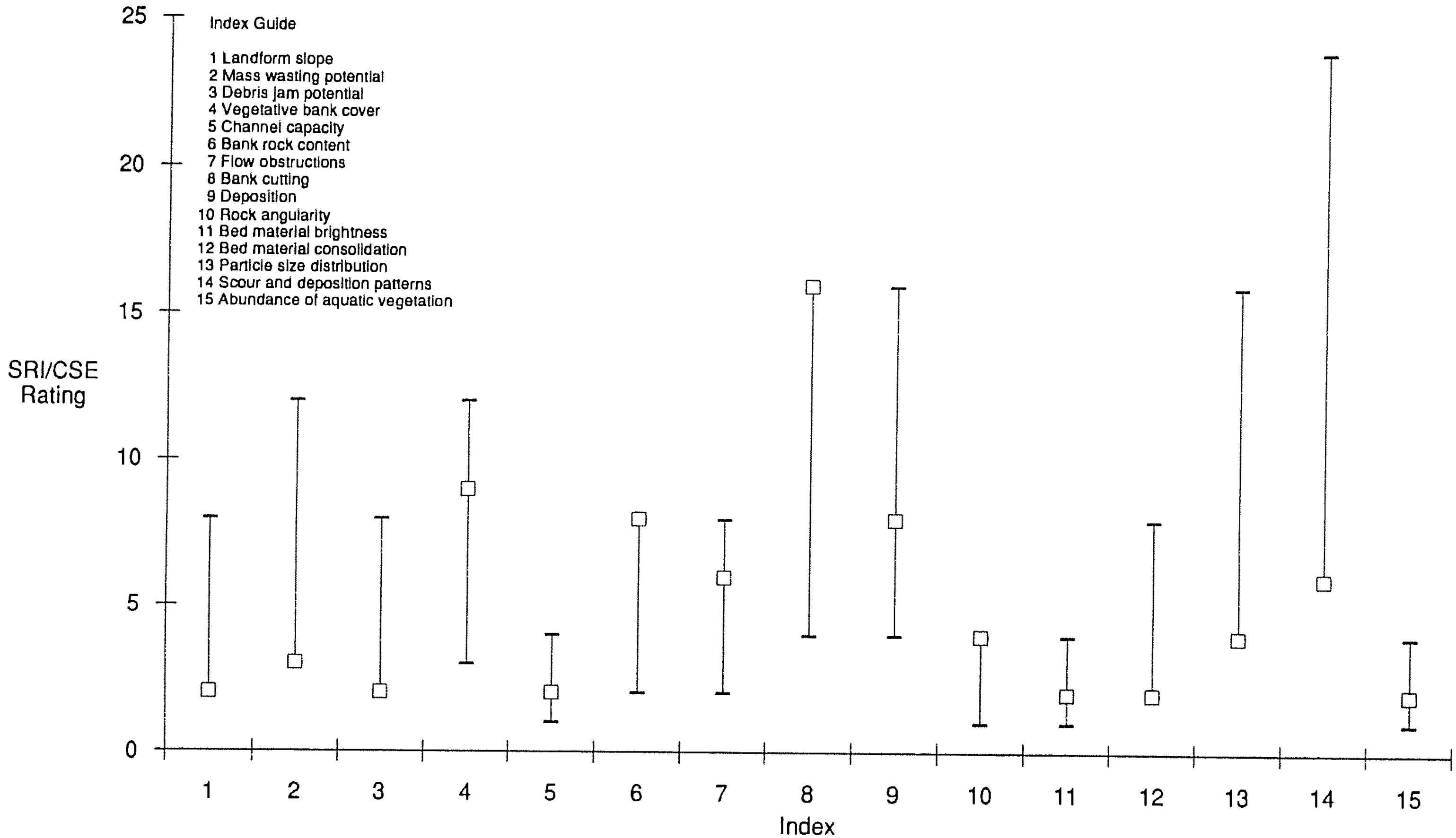

Fig A-18 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 6

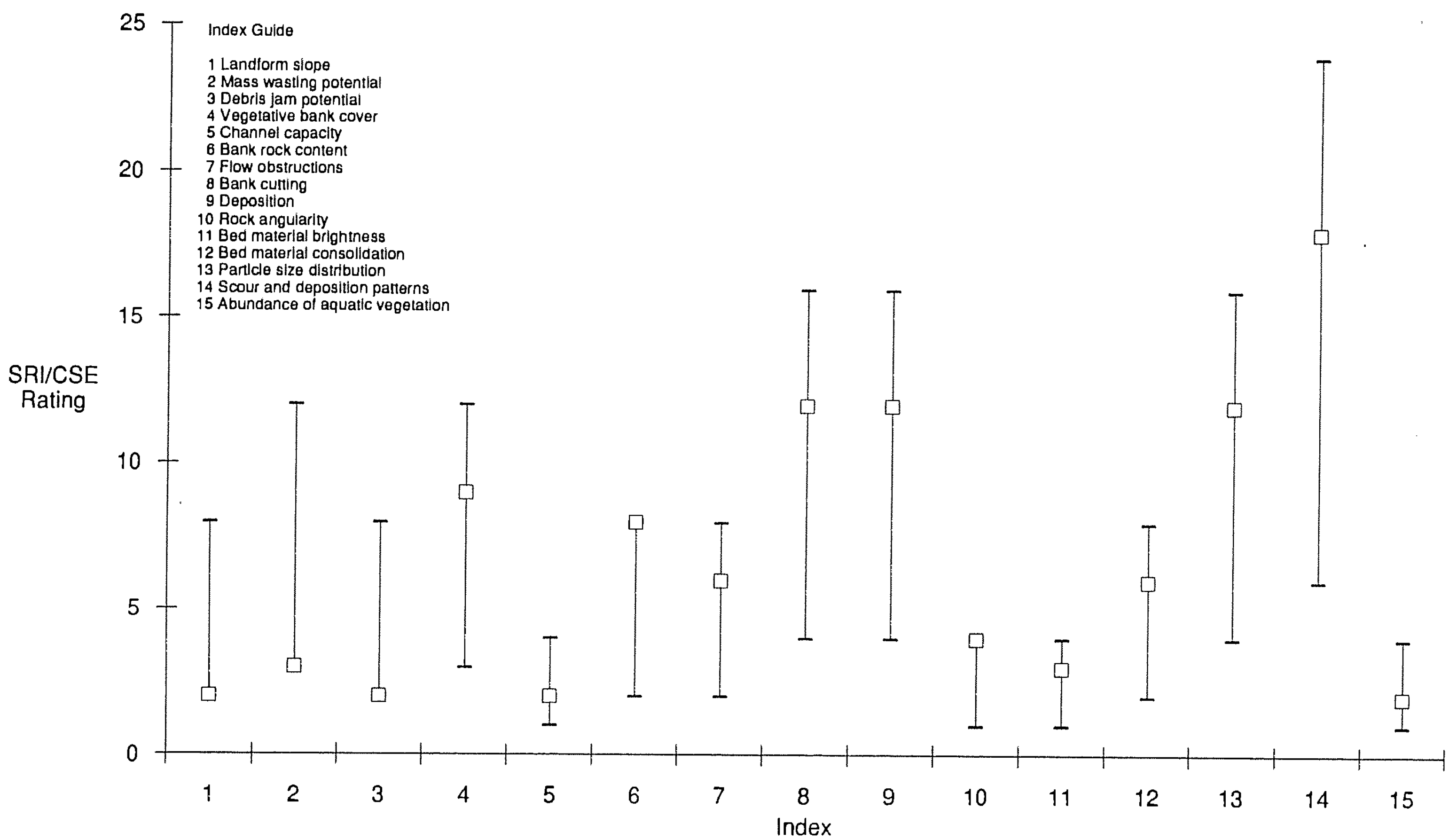

Fig A-19 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 8

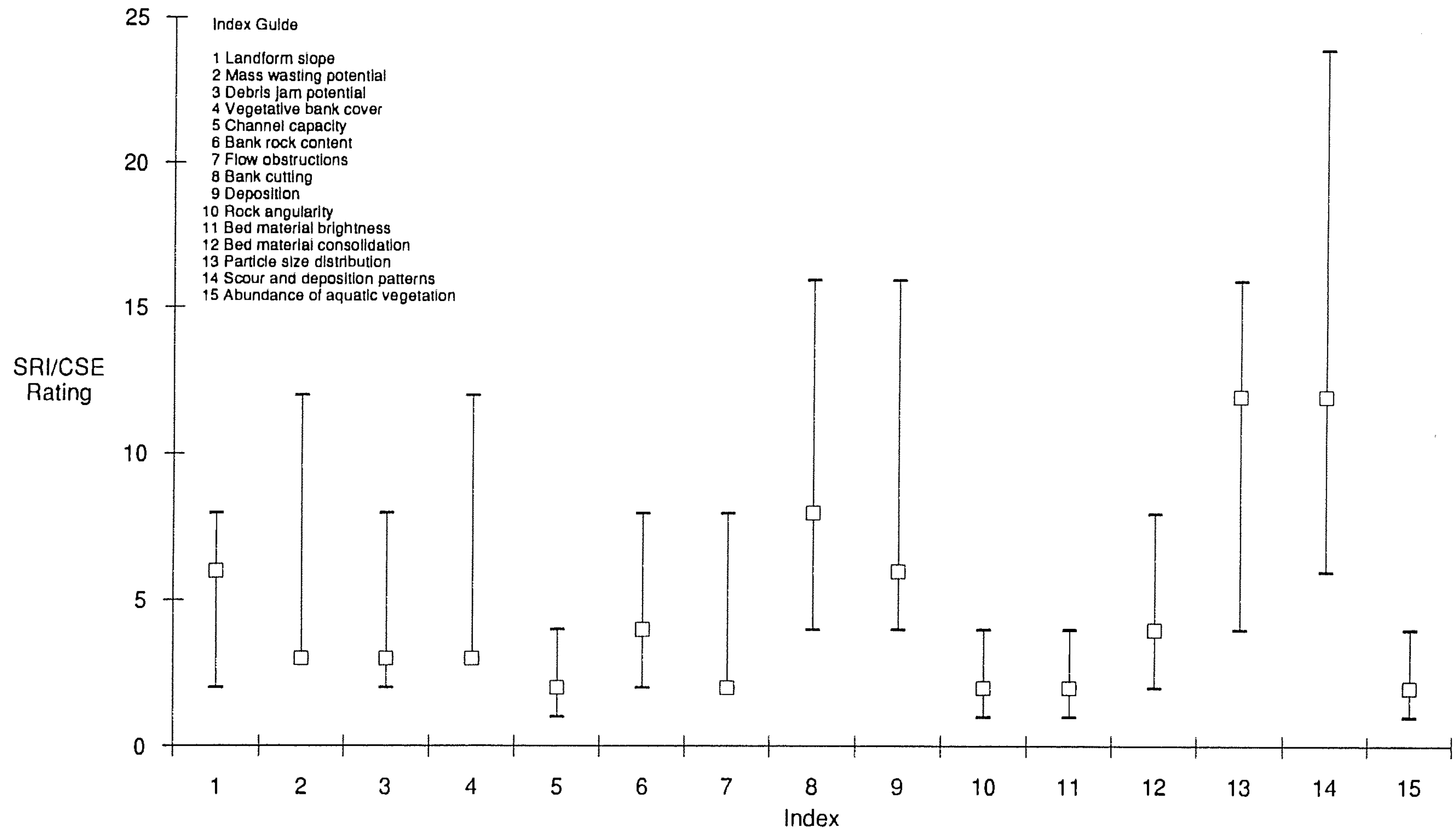

Fig A-20 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 10

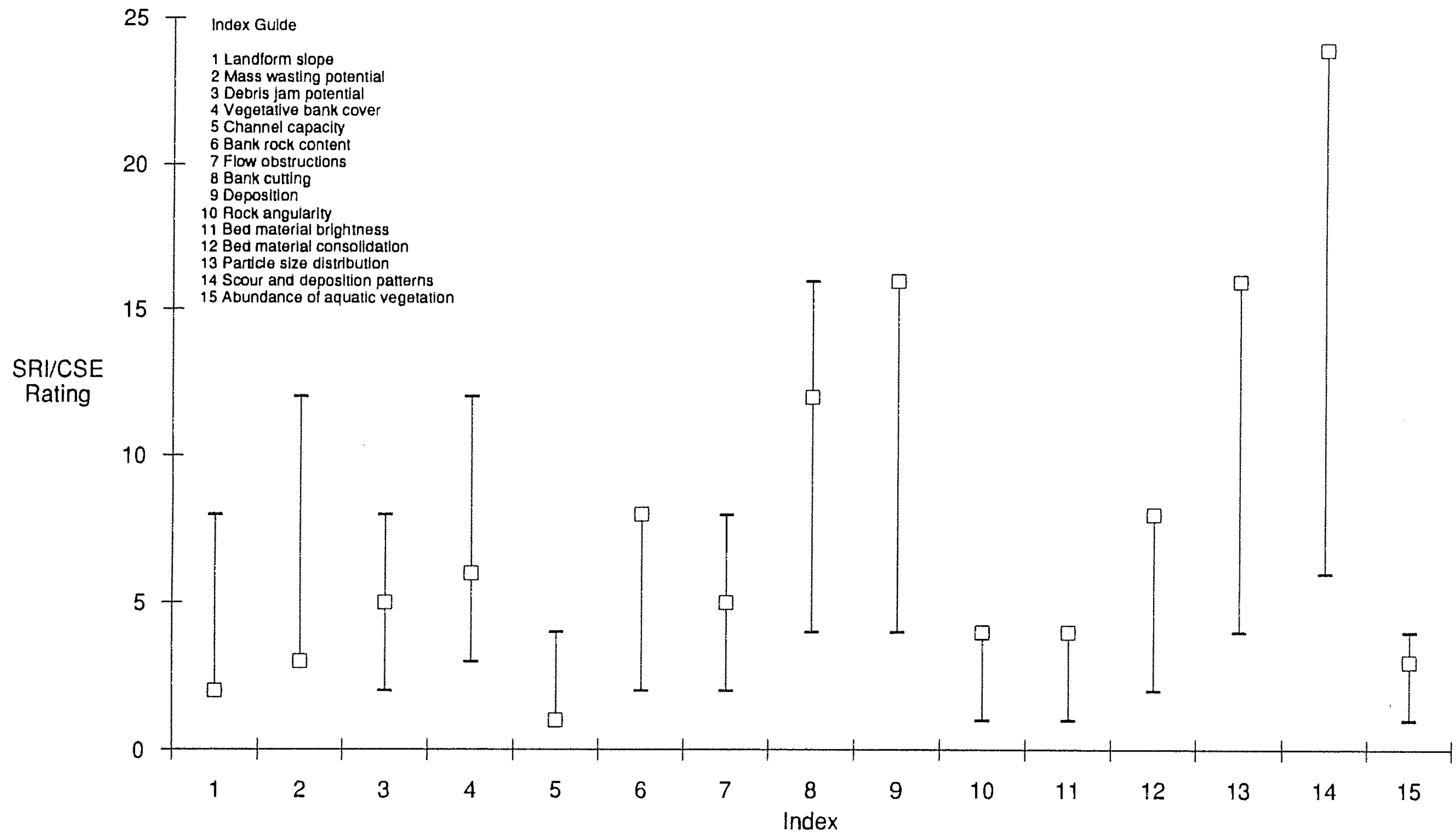

Fig A-21 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 11

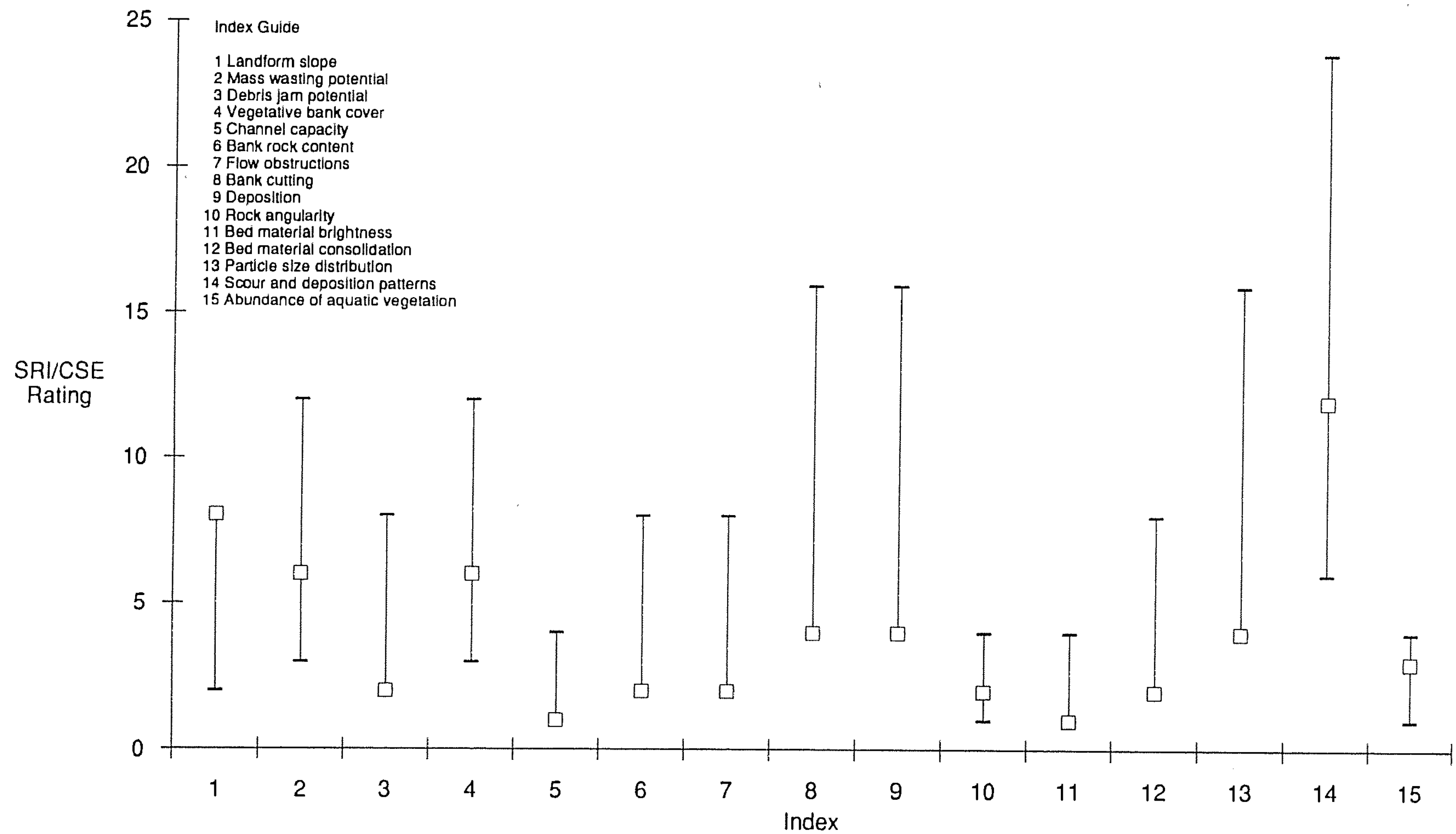

Fig A-22 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 12

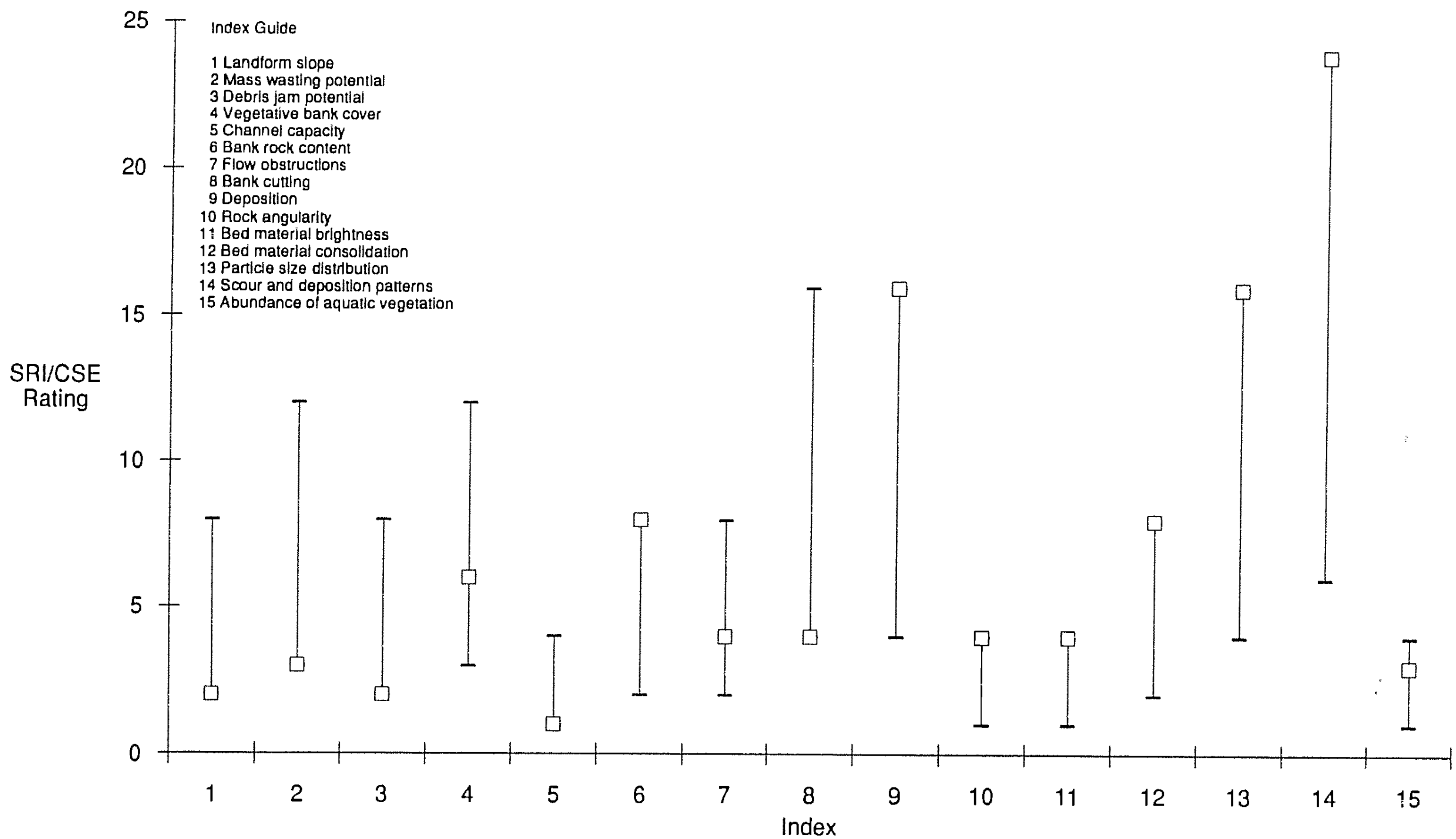

Fig A-23 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 13

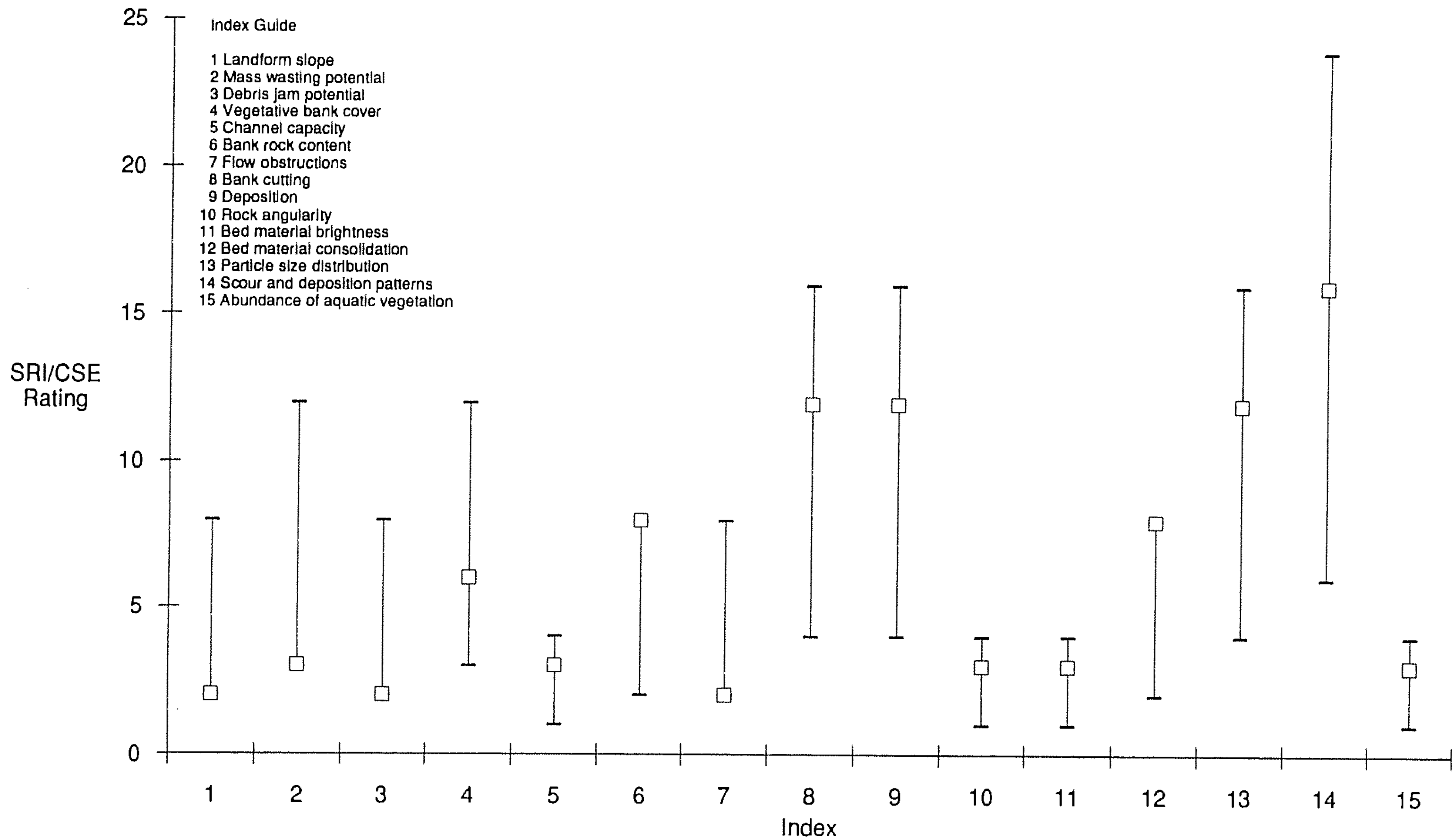

Fig A-24 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 15

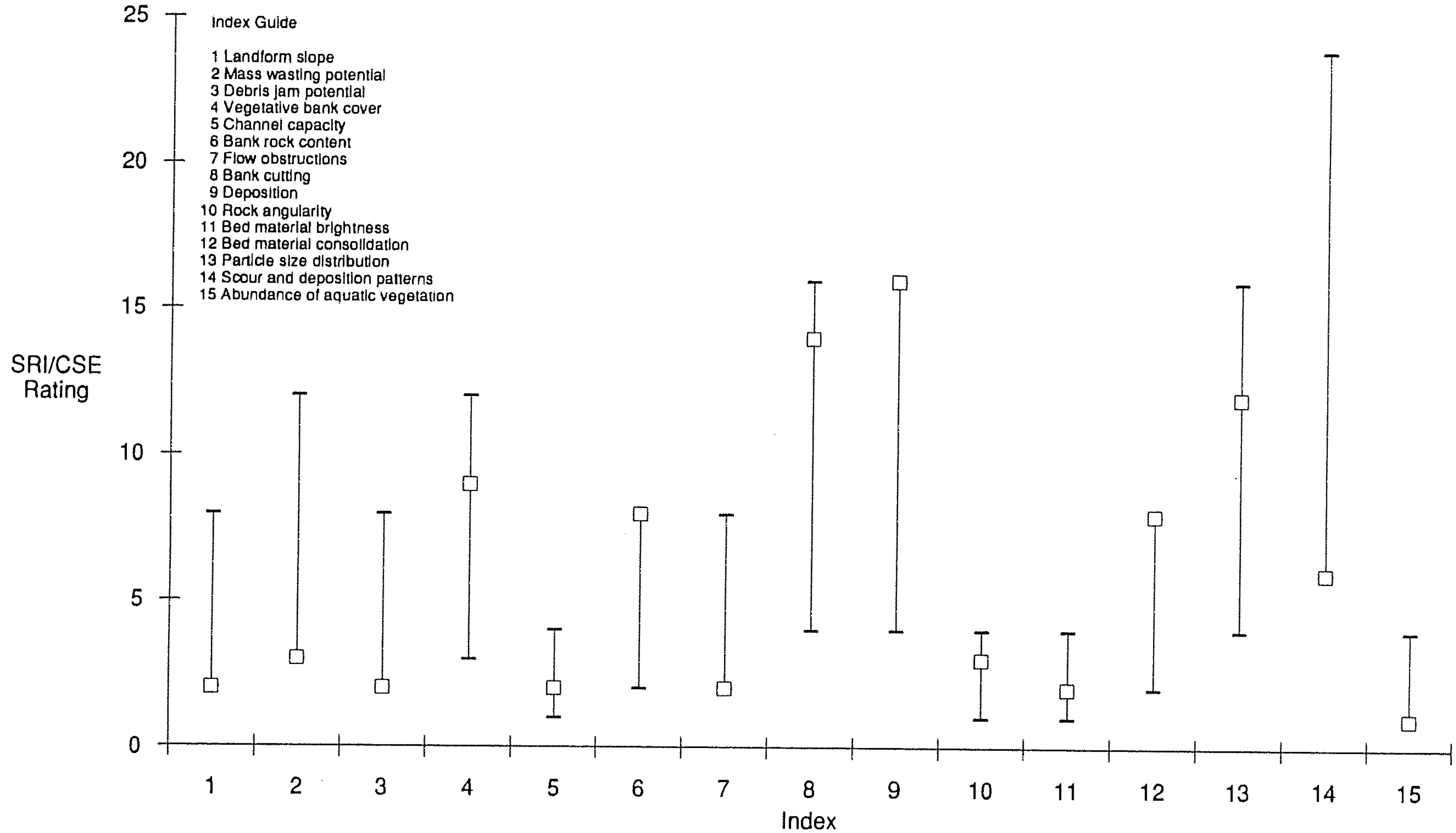

Fig A-25 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 16

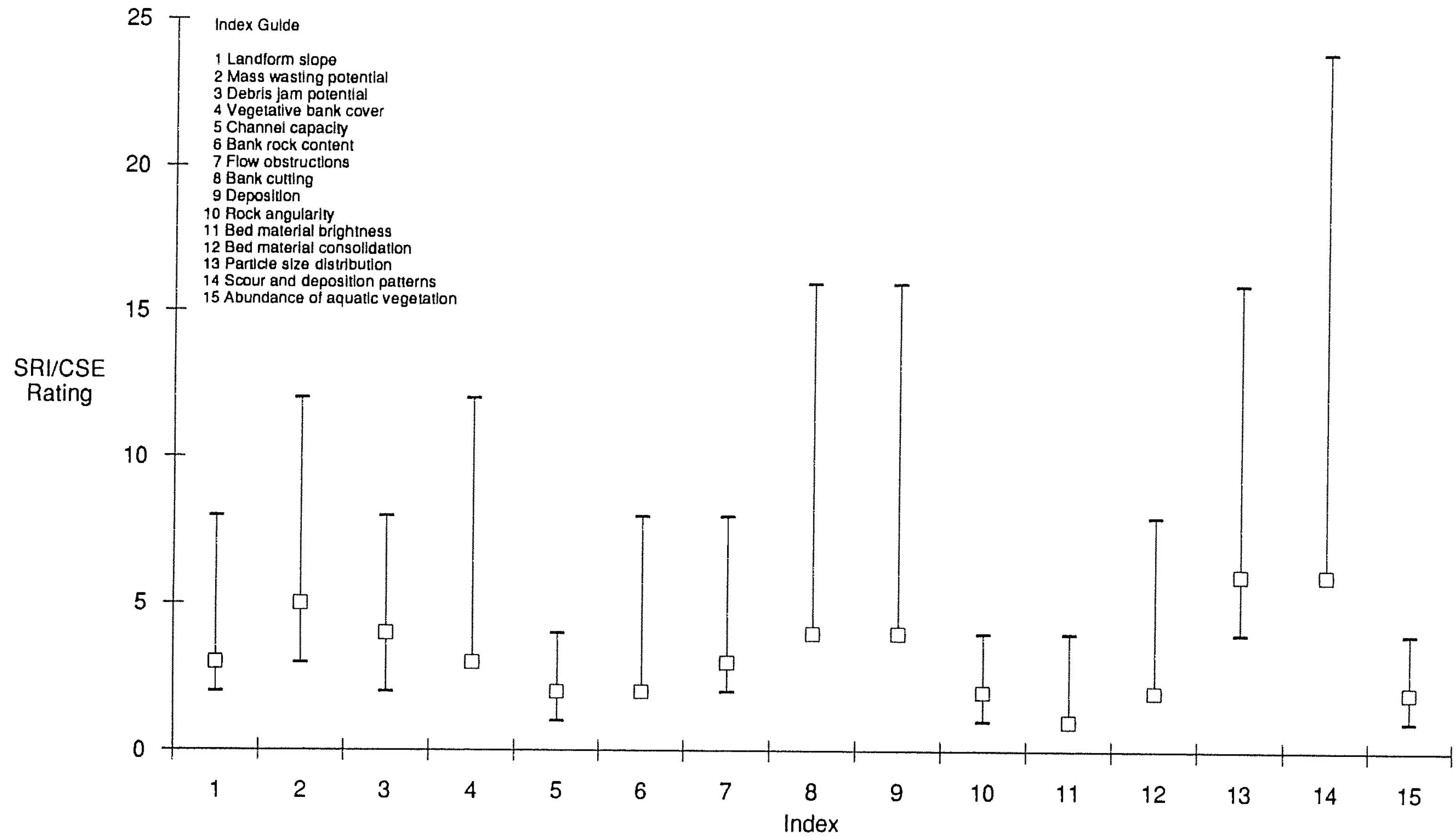

Fig A-26 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Sprague River Site 17

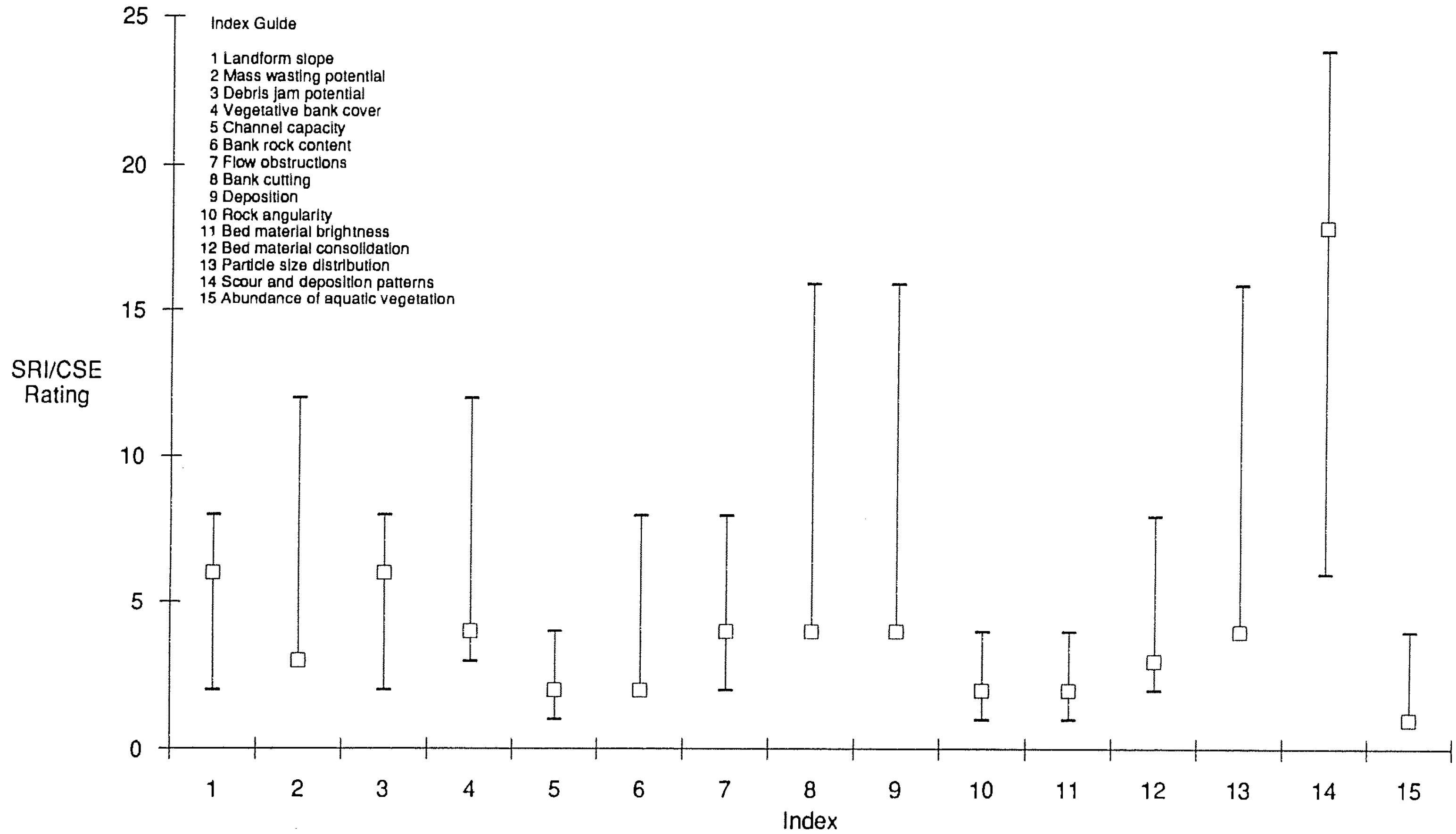

Fig A-27 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 1

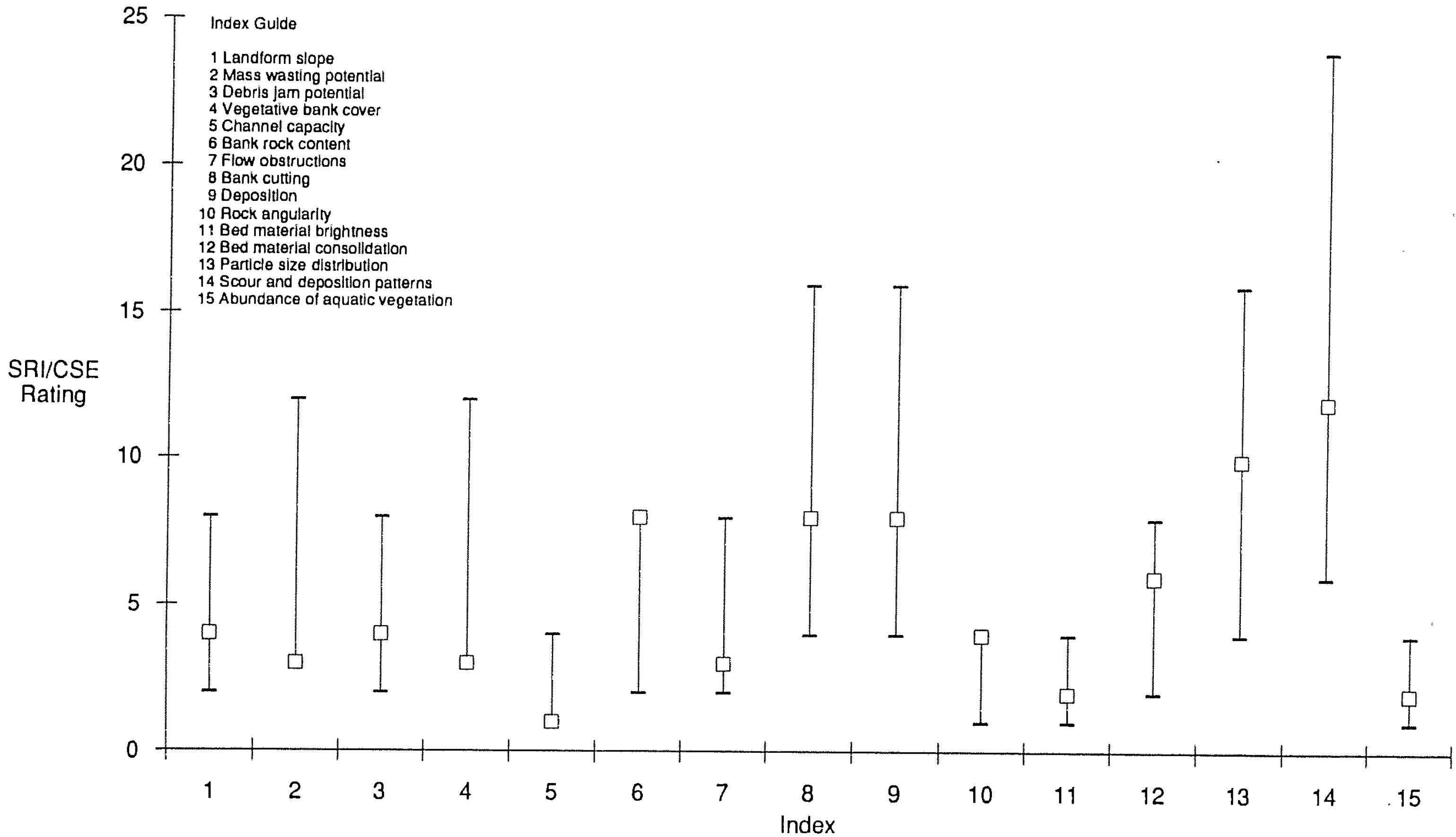

Fig A-28 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 2

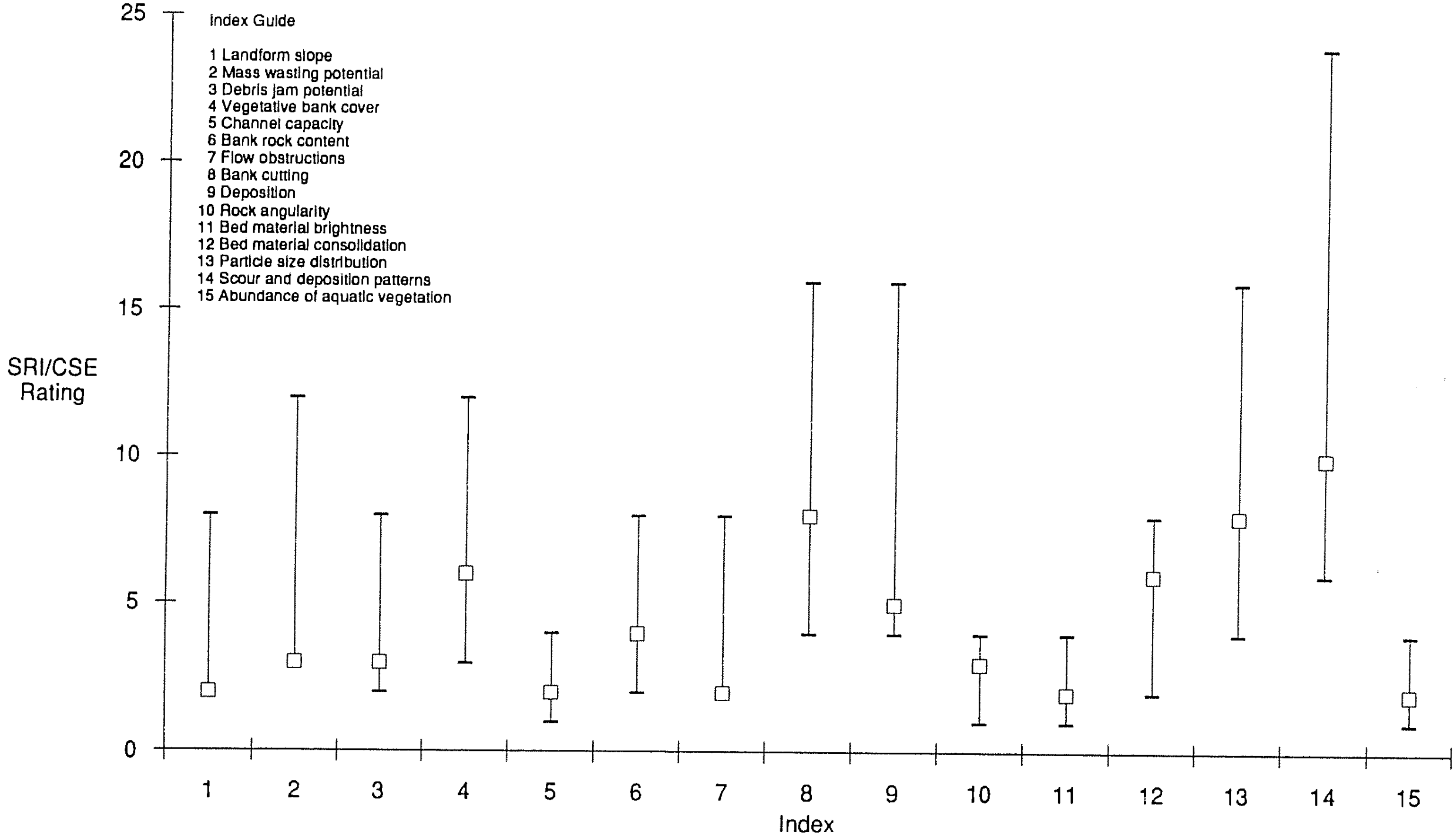

Fig A-29 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 3

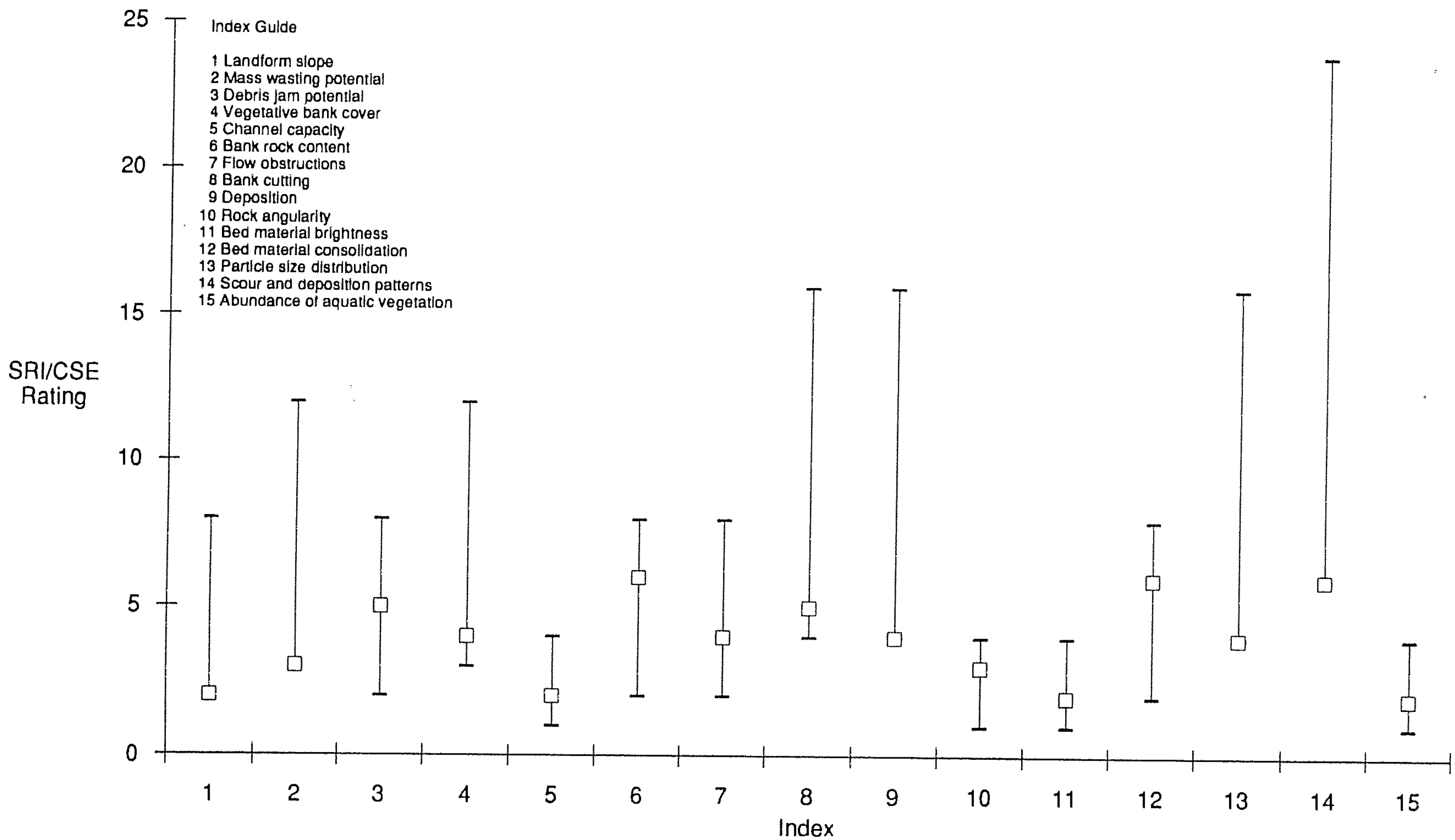

Fig A-30 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 4

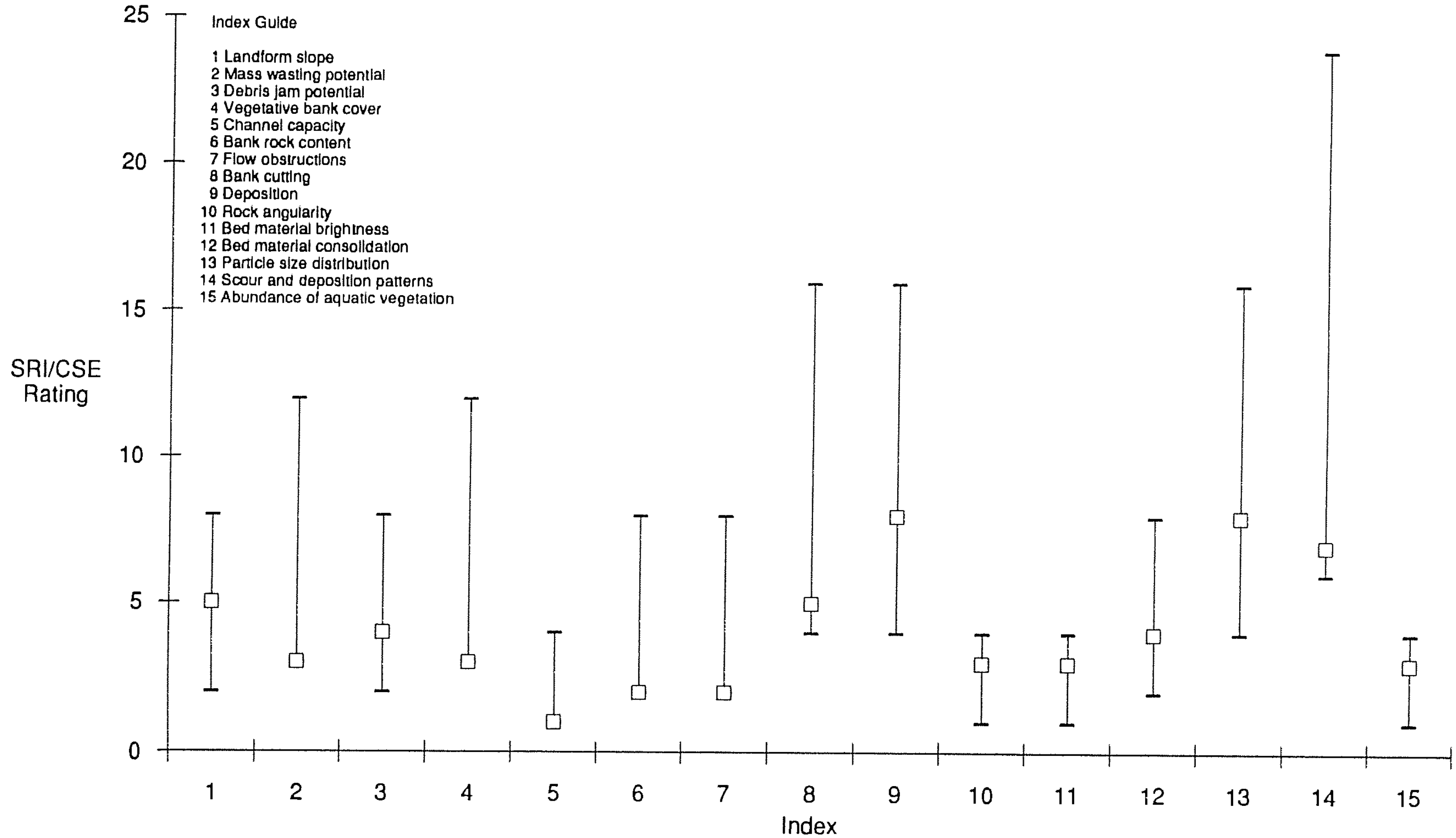

Fig A-31 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 5

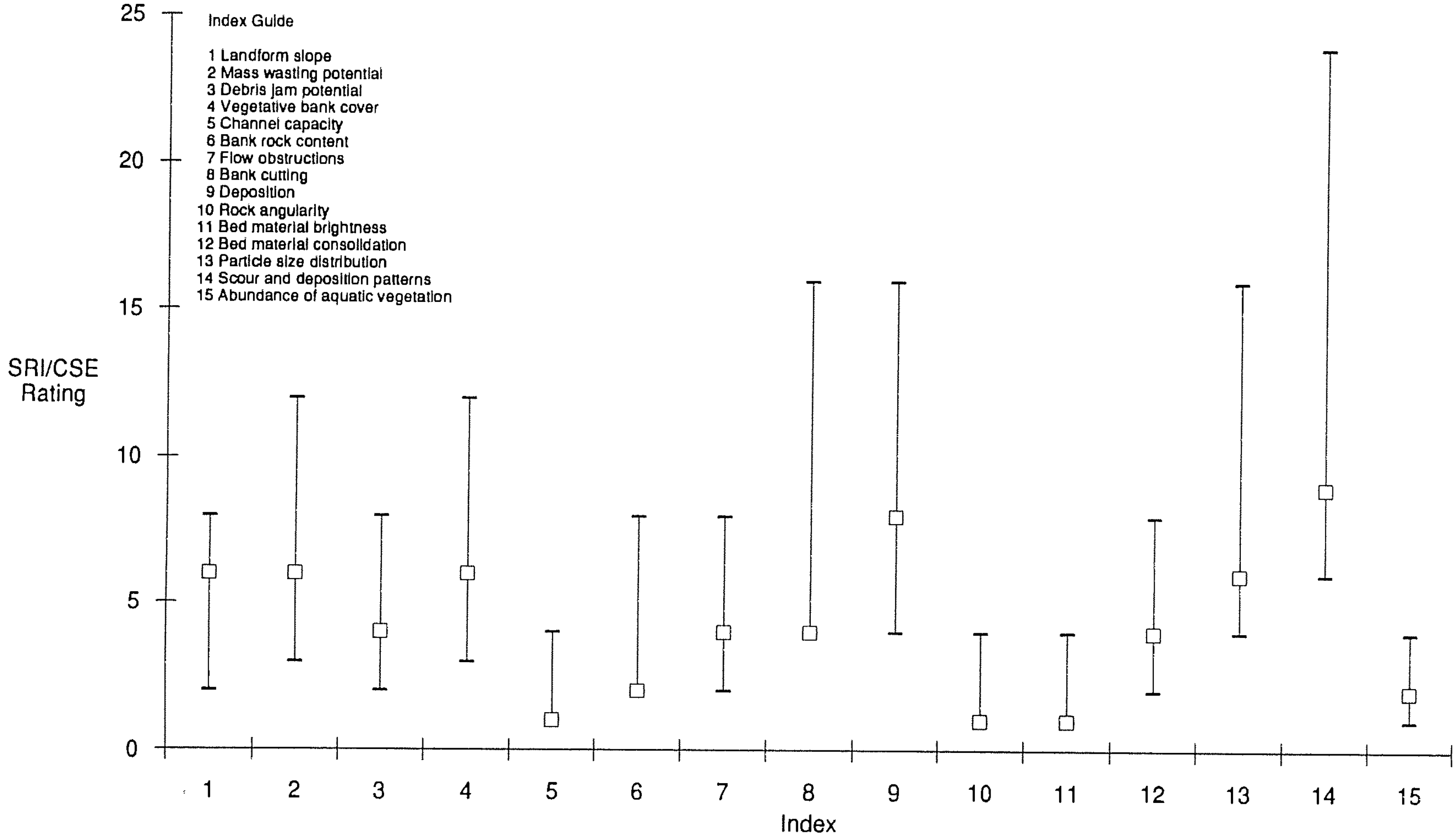

Fig A-32 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 6

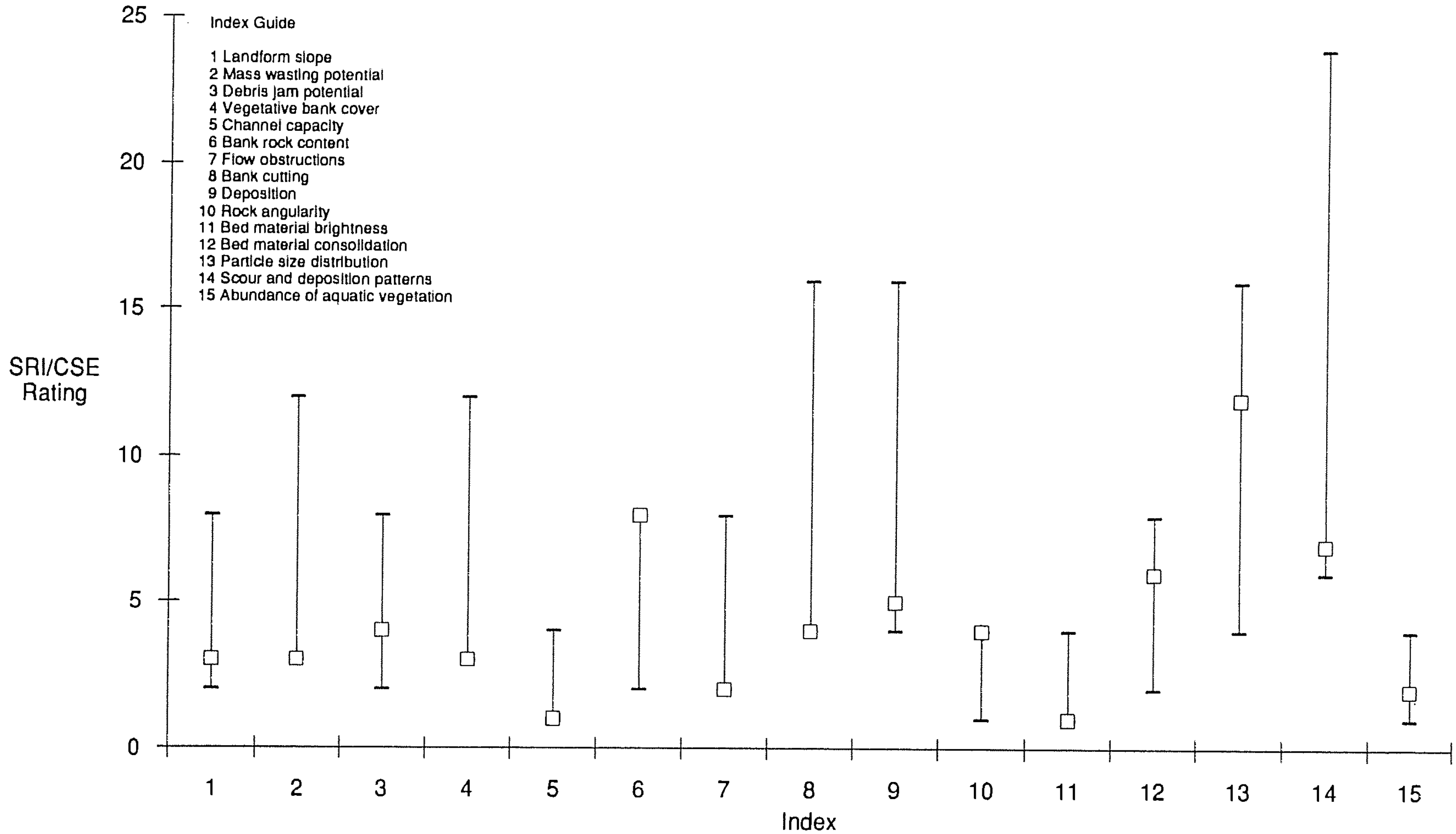

Fig A-33 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 7

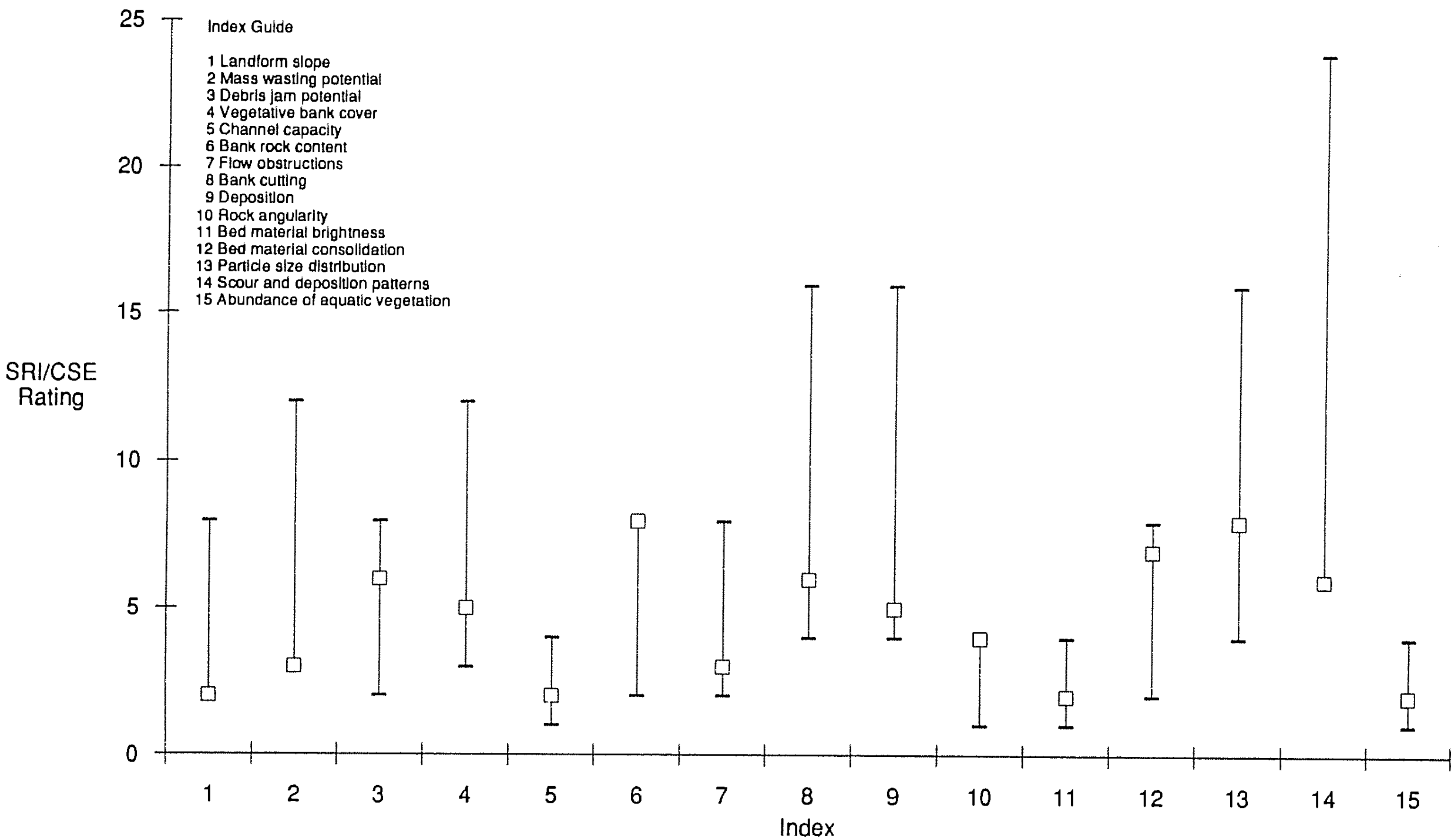

Fig A-34 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 8

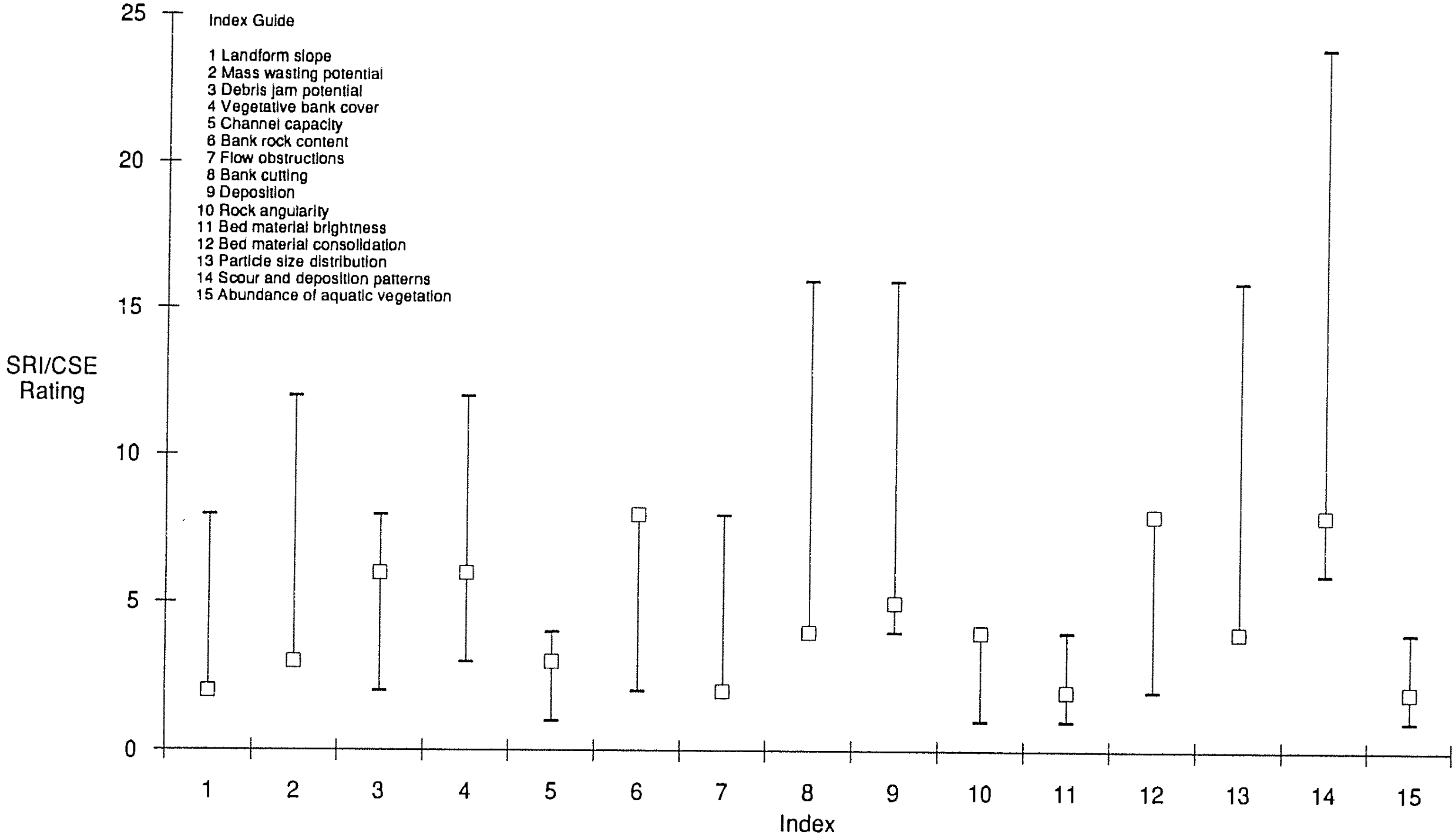

Fig A-35 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 10

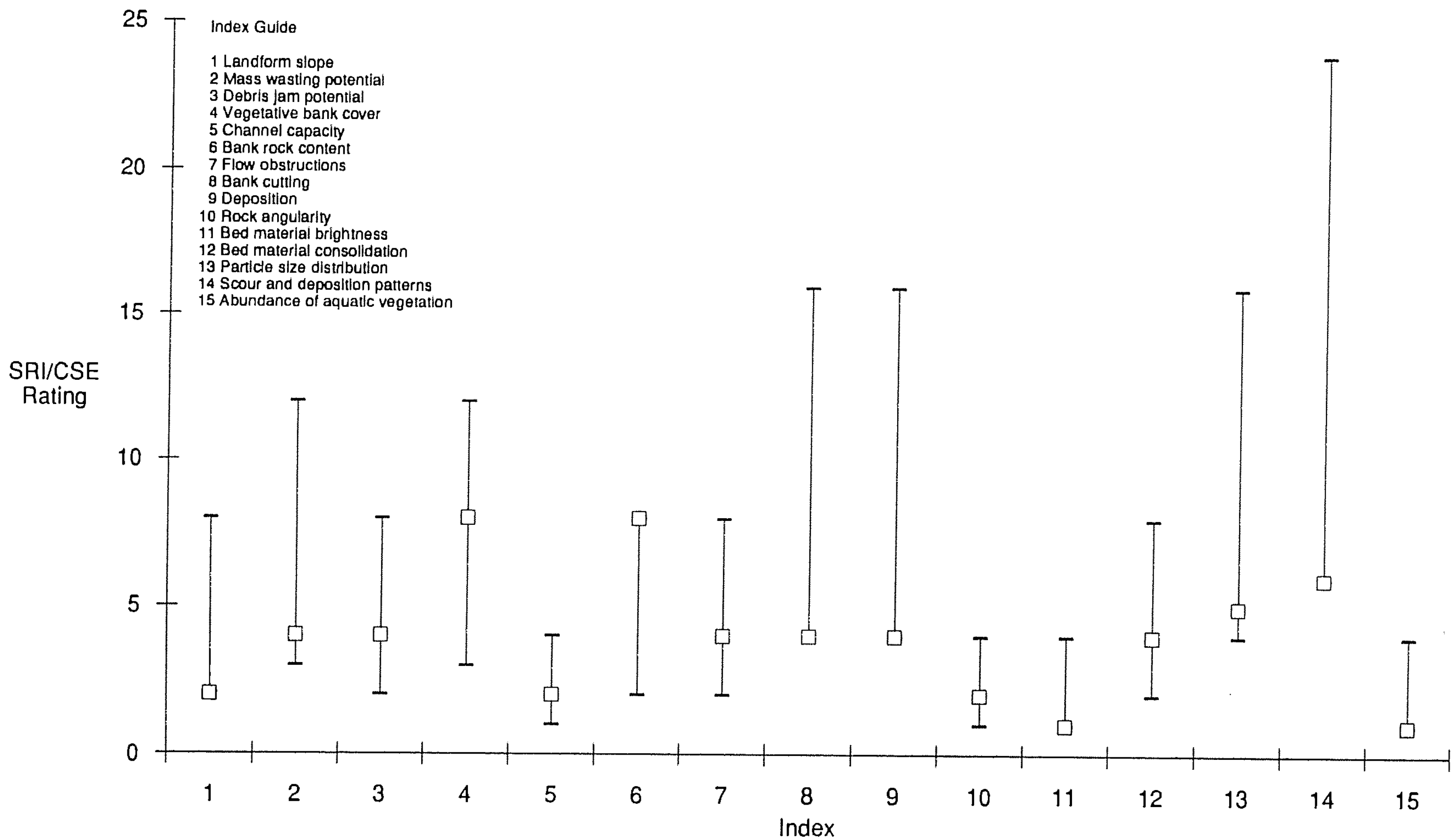

Fig A-36 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 11

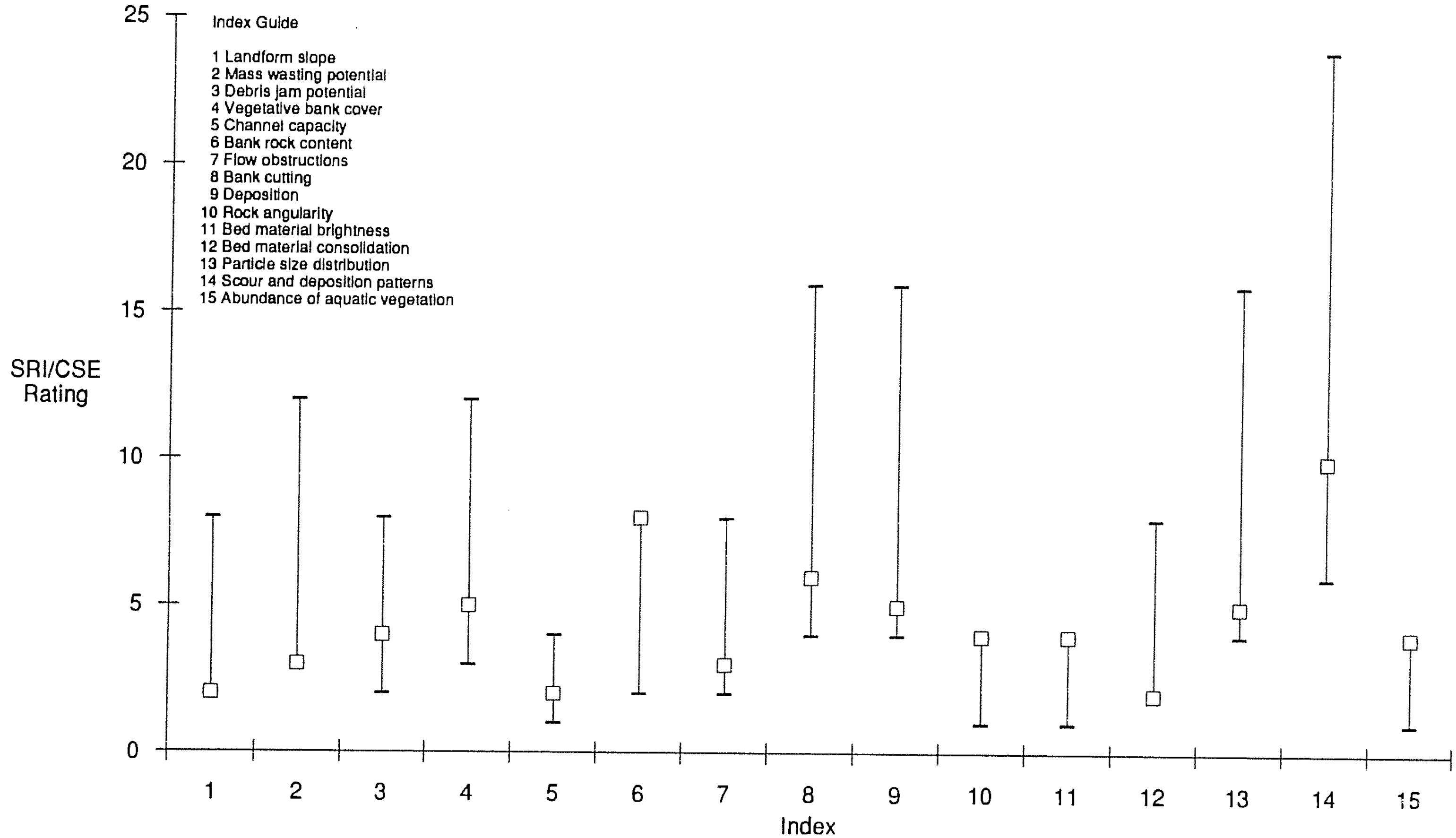

Fig A-37 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 12

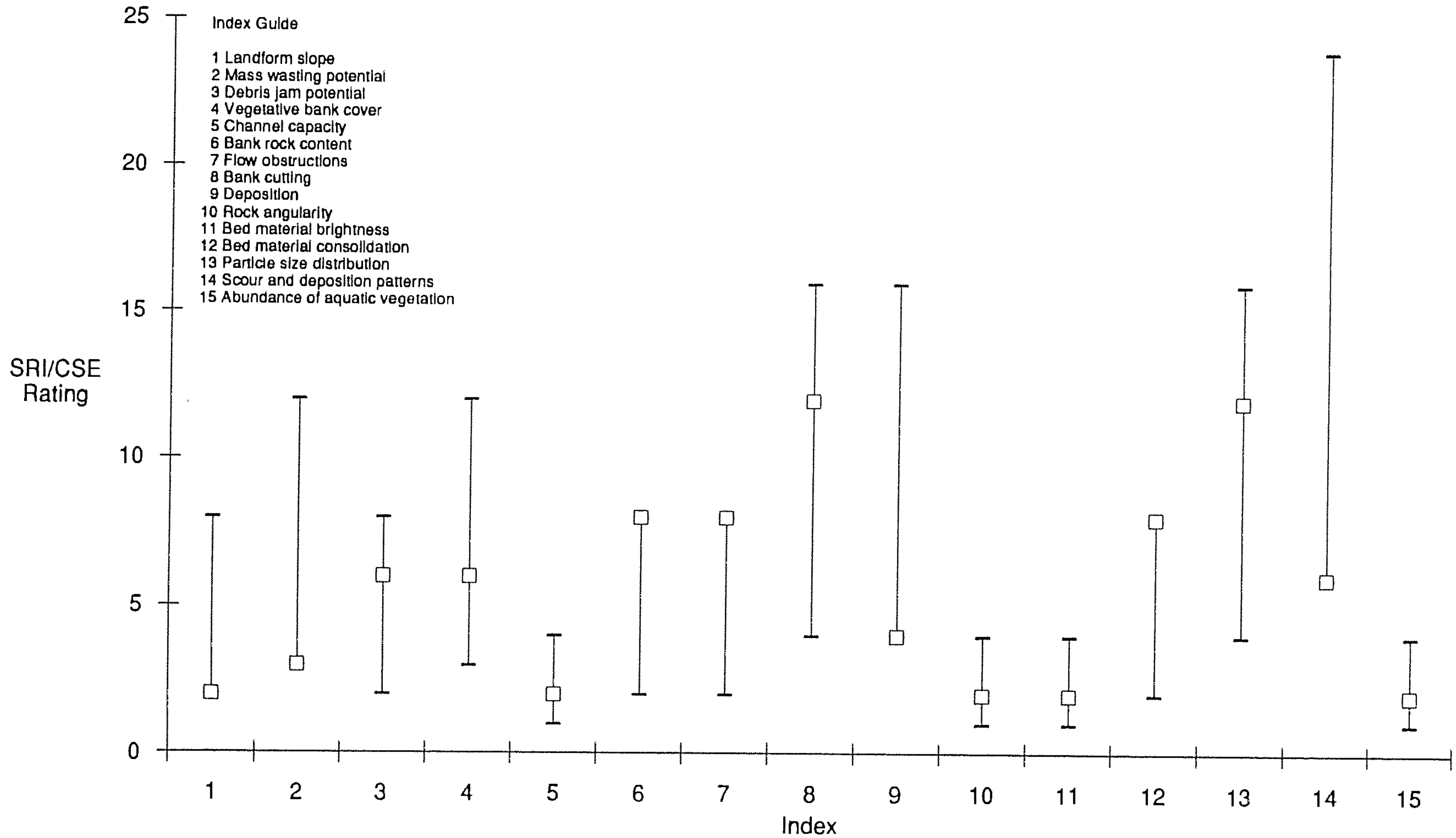

Fig A-38 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 13

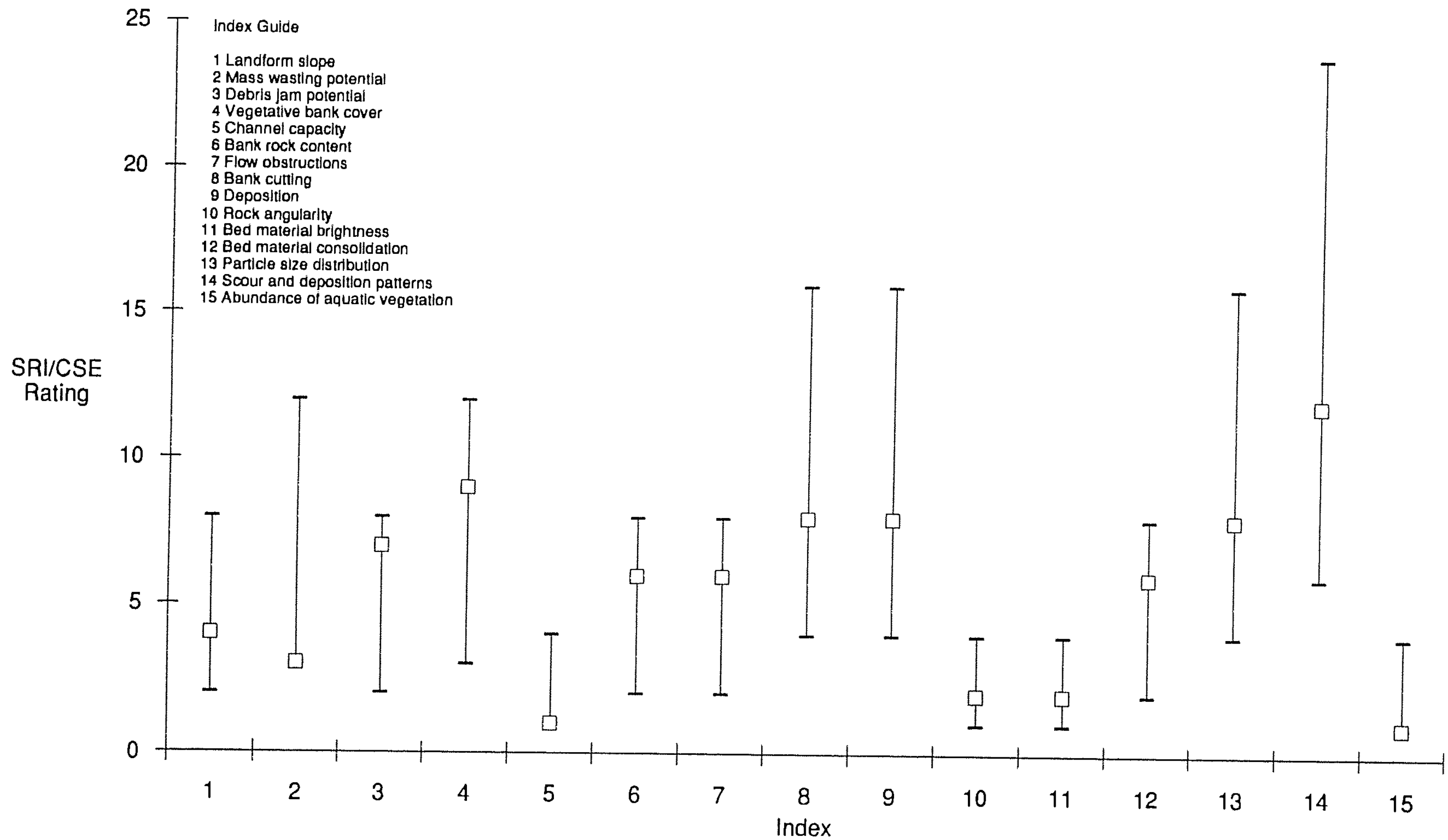

Fig A-39 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 14

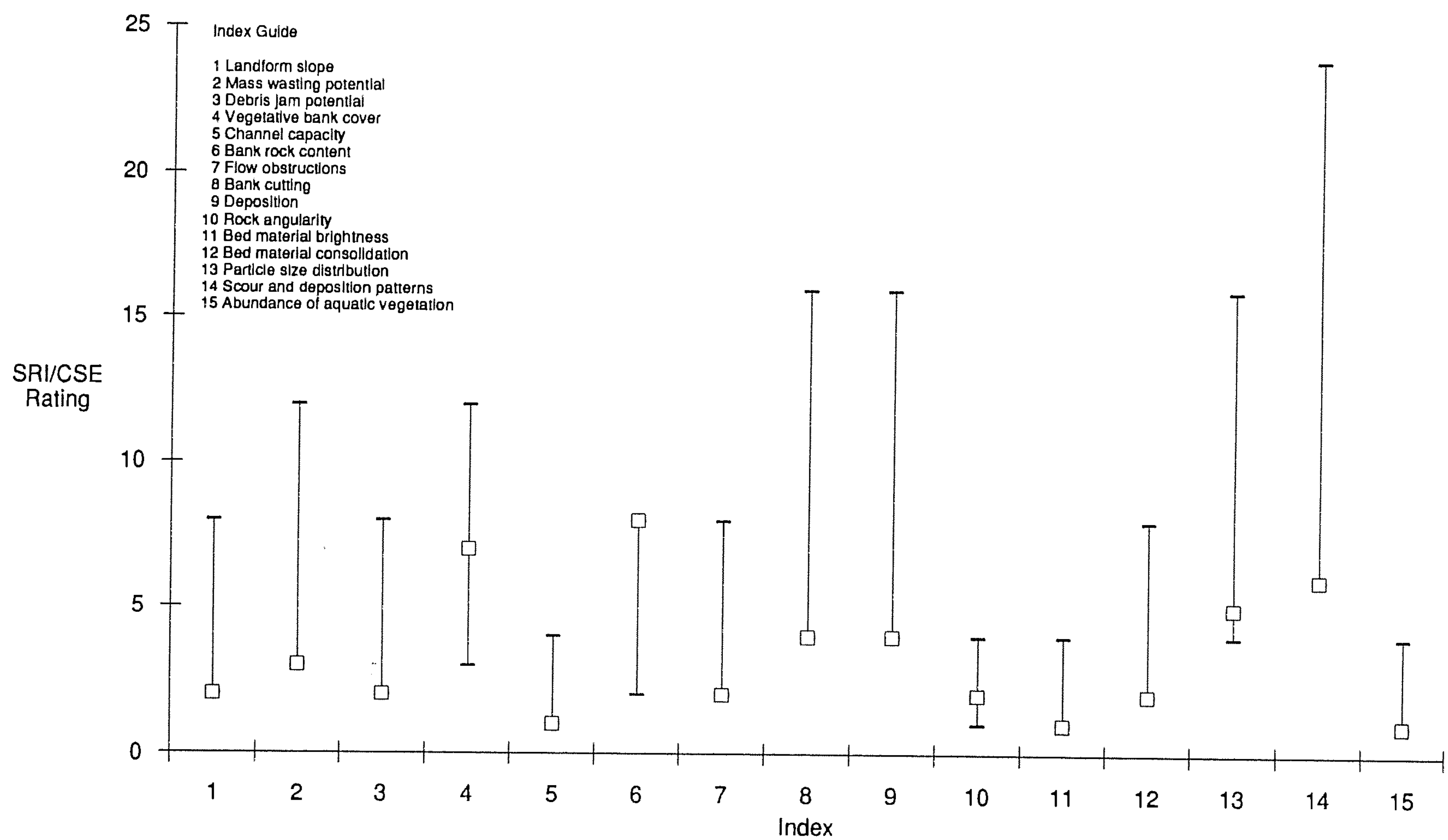

Fig A-40 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 15

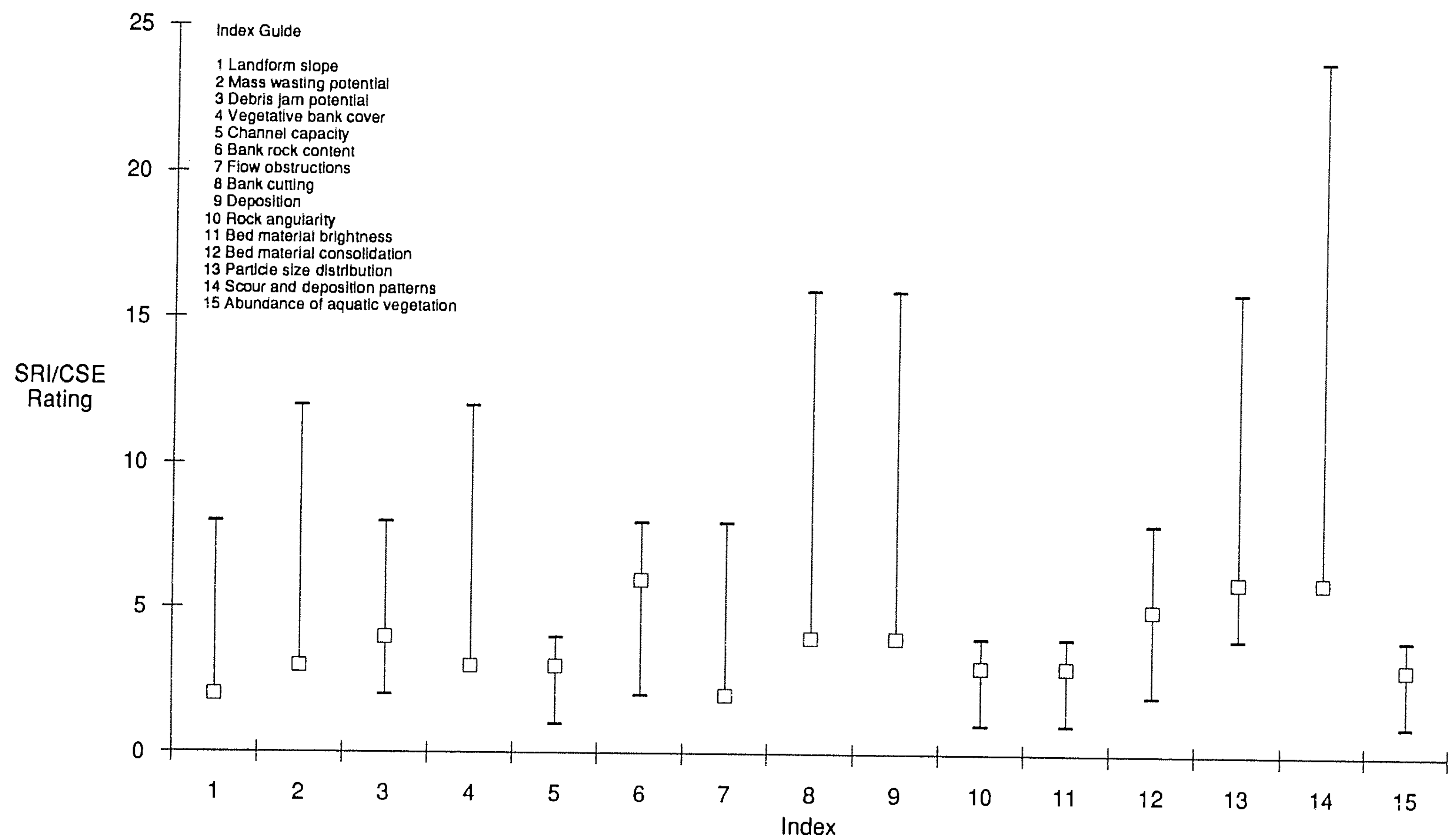

Fig A-41 Stream Reach Inventory and Channel Stability Evaluation (SRI/CSE)
Upper Klamath Basin
Williamson River Site 16