Long Term Trend Monitoring Project
For The
South Fork Trinity River Watershed

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I. Purpose, Objectives and Goals

The South Fork Trinity River is the largest undammed wild and scenic river in California (Figure 1). It once supported a thriving anadromous fishery that provided recreational opportunities and livelihood to local residents and surrounding communities. During the 1964 flood, widespread erosion and landsliding resulted in extensive sedimentation of fish habitat within the mainstem and its tributaries. Since then, anadromous fish stocks have plummeted from historic levels.

There is keen interest among local residents as well as land management and regulatory agencies to understand the current conditions and trends within the watershed as they pertain to channel conditions and fish habitat (Pacific Watershed Associates, 1994; Berol, 1995; Lower South Fork Trinity River Watershed Analysis, 1998). Some studies have been conducted to assess the current condition of the South Fork Trinity River and key tributaries, but actual instream conditions and trends directly affecting fish habitat and recovery of anadromous stocks are still not well documented or understood.

The combination of Trinity River Restoration Grant funding and the application of the Total Maximum Daily Load (TMDL) process to the South Fork Trinity River provides a unique opportunity for collaboration among interested parties to initiate a long-term trend monitoring program in this watershed. Its purpose would be to evaluate and track the condition of the South Fork Trinity River watershed on the hillslopes and in the mainstem. The monitoring will address the questions and concerns expressed by local residents regarding recovery in the mainstem, and also will meet the goals of the South Fork Trinity River TMDL. This watershed is well suited for such a project because of the baseline data that have been acquired in previous studies.

The purpose of this trend monitoring project is to track changes in sediment loading and storage in the South Fork Trinity River, as well as trends in sediment input from hillslopes over a long period of time. The long-term goal is to measure the extent to which overall watershed conditions have improved, regardless of changes in anadromous fish populations. The monitoring will focus on conditions that would indicate long-term recovery from the impacts associated with the 1964 flood and land management disturbances. The monitoring plan is designed to track changes in upslope management conditions as well as physical instream conditions. Although a rigorous cause-and-effect relationship cannot be established between hillslope trends and instream sediment loads, the combined monitoring is expected to provide crucial insights about overall watershed condition. For example, a storm event may trigger few landslides, but mainstem sediment storage in the monitoring reaches may still increase. This would indicate that hillslope conditions are on a general recovery trend while the mainstem is lagging behind

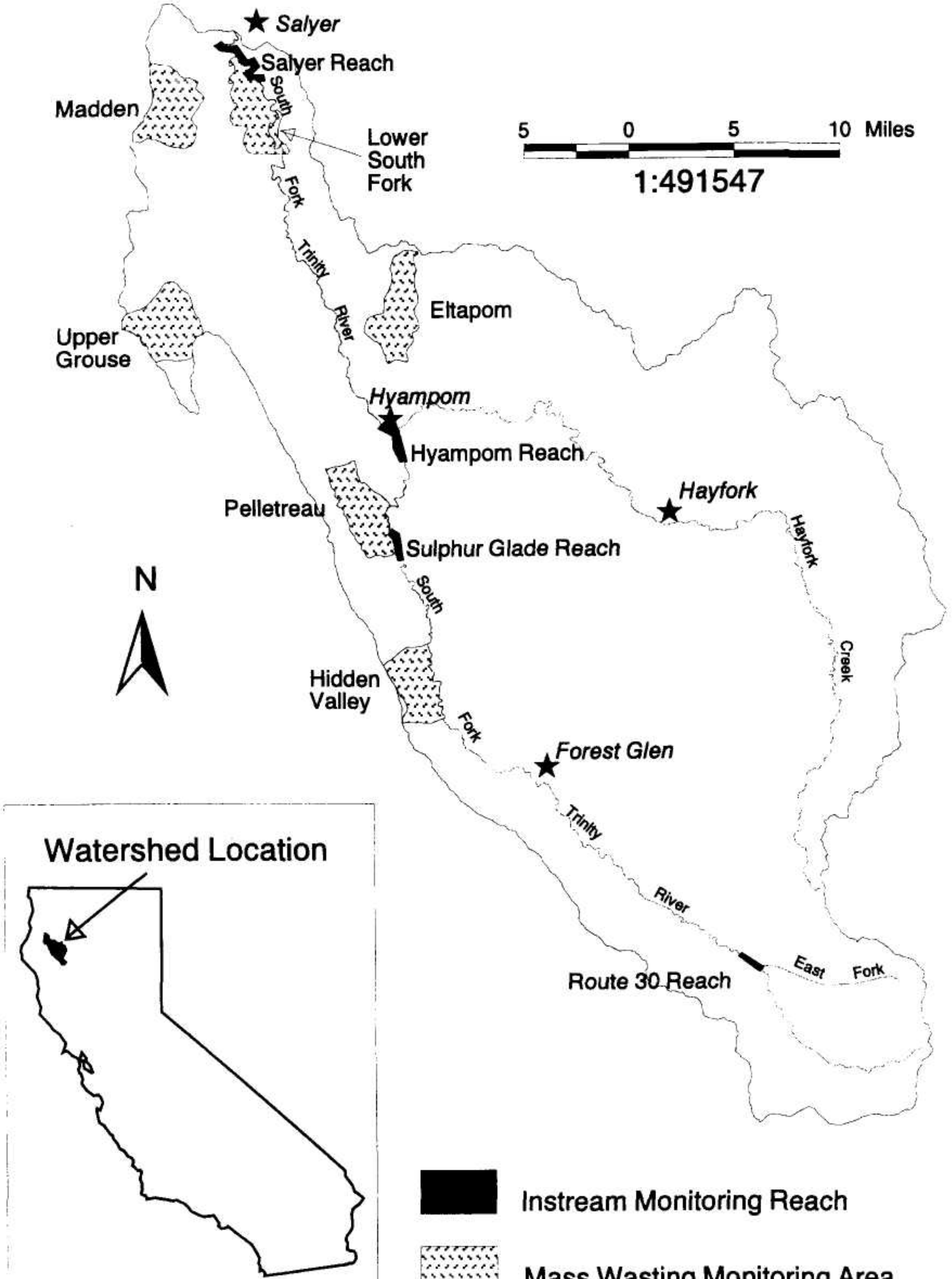


Figure 1. Location of South Fork Trinity Watershed and Monitoring Sites

and still routing sediment. Without a combined hillslope and instream monitoring effort, the overall trends within the watershed would remain unknown.

The remainder of this document presents the rationale, protocol, methodologies, analysis tools and results from the first two years of channel surveys.

II. Background

The South Fork Trinity River drains approximately 970 square miles of rugged mountains and deeply incised stream valleys in northwestern California. The watershed is dominated by coniferous forest with some grassland near Hayfork and Hyampom. The western part of the watershed is underlain by more erodible and unstable South Fork Mountain schist, Galice metasediments and Franciscan terrane, while the eastern part is underlain by more competent Rattlesnake Creek and Hayfork terranes.

The region was settled in the late 19th century and the local economy has been dominated historically by logging. By 1977, 52 percent of the watershed had been logged and 3,400 miles of road had been built (Pacific Watershed Associates 1994).

In the middle 20th century, anadromous fish were abundant, particularly winter and summer steelhead, spring and fall Chinook salmon, and coho salmon. The flood of December 1964 had a discharge of 95,400 cfs at Salyer (USGS Gage No. 11529000). This rain-on-snow event caused extensive and predominantly natural landsliding, particularly in the weaker west-side geologic terranes. Management-related landslides were locally significant, but overall delivered only about one-third as much sediment as natural landslides (Raines, 1990). The resulting sediment production caused widespread channel aggradation, decreased channel complexity, and decreased pool depth. Since 1964, a substantial decline in fish populations has been observed (Borok and Jong, 1997).

Historic data regarding instream conditions within the South Fork Trinity River are insufficient to illustrate changes in watershed condition. Evidence that the South Fork Trinity River is recovering from the 1964 event is largely anecdotal. Fish populations have not returned to historic levels, and the condition of fish habitat is unclear.

Some historic cross sections exist, primarily at three mainstem gauging stations established by the USGS. Two of the gages showed little aggradation in response to the 1964 flood, probably because they are located in confined transport reaches. The gage near Salyer showed about 20 feet of aggradation after the 1964 flood, but the stream has since downcut to pre-flood levels. Whether these changes represent overall watershed response or just local hydraulics is unclear. A few other cross sections were established and measured, primarily in headwater tributaries to monitor effects of the 1987 fires. Thirty-four stream reaches were surveyed by Shasta-Trinity National Forest personnel in 1989, but these surveys do not have the longevity to reveal trends.

Several hillslope sediment source investigations have been completed in the South Fork Trinity watershed by the California Department of Water Resources and the U.S. Forest Service (CDWR 1979, CDWR 1992, SRNF 1998). Earlier studies were generally descriptive in terms of relative erodibility and susceptibility to landslide processes throughout the watershed. However, the information has not been suitable for establishing trends. Later studies have been more quantitative in terms of estimating volumes of sediment delivery due to both mass wasting and surface erosion associated with managed and unmanaged areas. The latest and most comprehensive study of the watershed was completed in 1998 (Raines, 1999). This study identified landslides as the major source of sediment, followed by streambank erosion, road surface erosion, and hillslope surface erosion. The sediment source investigation revealed that hillslope sediment inputs between 1944 and 1998 had declined dramatically, indicating that hillslope conditions are generally recovering. However, it will be important to observe hillslope trends into the future to generate an overall picture of watershed health.

A sediment storage analysis performed by Six Rivers National Forest in 1997 estimated total sediment storage for the South Fork Trinity watershed to be 63,000,000 tons or 65,000 tons per square mile (Llanos et al. 2000). This study identified tributaries with high sediment storage, but did not address changes in sediment storage over time. However, it did describe proportions of sediment stored in active, semi-active, and inactive deposits, and these proportions may reflect the relative mobility of stored sediment. Despite this and other investigations, very little data exist on long-term sediment storage trends.

Fish habitat inventories have been performed on the mainstem and many tributaries of the South Fork. These data include information on pool depth and frequency, as well as temperature. A study by Six Rivers National Forest (1990) found temperature to be limiting in the lower section of the mainstem. Gilroy et al. (1992) found that fine sediment levels may be limiting for fish, and it is thought that pools are too shallow now for temperature stratification (Pacific Watershed Associates, 1994).

We hypothesize that the South Fork Trinity River is continuing to recover from the effects of the 1964 flood and that this recovery is demonstrated by:

- downcutting of the mainstem channel,

- increasing pool depths,

- increasing proportion of channel occupied by pools,

- decreasing proportion of fine sediment on the channel bed, and

- decreasing incidence of landslide enlargement and initiation of new landslides as compared to historic levels.

III. Instream Sediment Monitoring

A. Reach Selection Criteria

The main criterion we used to select stream reaches for monitoring was sensitivity to changes in sediment input and storage. The South Fork Trinity River has many miles of steep, confined bedrock gorge. We think that annual flows through these sections are sufficient to transport large volumes of sediment and leave the channel unchanged (i.e., transport capacity exceeds sediment supply). For this reason, we did not re-measure cross sections at USGS gauging stations, except the one near Salyer that showed changes from the 1964 flood. Because we wanted the response reaches to be representative of the watershed, reaches were selected away from localized sediment sources as much as possible. However, this was not completely possible, particularly in the lower South Fork where large landslides are very common.

Four reaches of the South Fork Trinity River are lower gradient, more alluvial, and considered most suitable for instream sediment trend monitoring (Figure 1).

Reach 1 at Route 30 (river mile 72.75 to73.75) extends approximately one mile downstream from the Forest Service bridge (Figures 2a and 2b). It is somewhat less sensitive than the other reaches and represents less watershed area. This reach responds to effects in the headwaters and could indicate amounts of sediment being routed to the lower watershed. Because it is closer to the headwaters, it is more sensitive to local events like the 1987 fires and should reflect changes in land use activity more quickly than reaches lower in the watershed.

The **Route 30 Reach** is confined (average bankfull width is 80 feet), but it has well-developed alternate bar morphology. Overall channel slope is 0.6 percent. Stream terraces are not a dominant feature within this reach. Bankfull width is generally from valley wall to valley wall.

Reach 2 at Sulphur Glade (river mile 36.5 to 38.5) extends from below French Ranch downstream to Hitchcock Creek and has the lowest gradient and highest storage of any reach above Hyampom Valley (Figures 3a and 3b). The sediment storage analysis indicated that this reach had relatively high storage for the South Fork Trinity River (Llanos et al. 2000). Because of its low gradient, it is sensitive to changes in sediment supply. This reach has similar gradient, size and form to the **Salyer Reach** and may provide validation for observed trends within the mainstem channel. Also, monitoring this reach allows us to track sediment movement through the watershed and to isolate the condition of the upper watershed.

This reach is upstream of most large sediment inputs, based on the 1998 Sediment Source Investigation. The majority of landslides and high sediment-producing tributaries (including Pelletreau, Cold Springs and Hitchcock Creeks) are downstream. The **Sulphur Glade Reach** is somewhat confined but does contain some large stream terraces

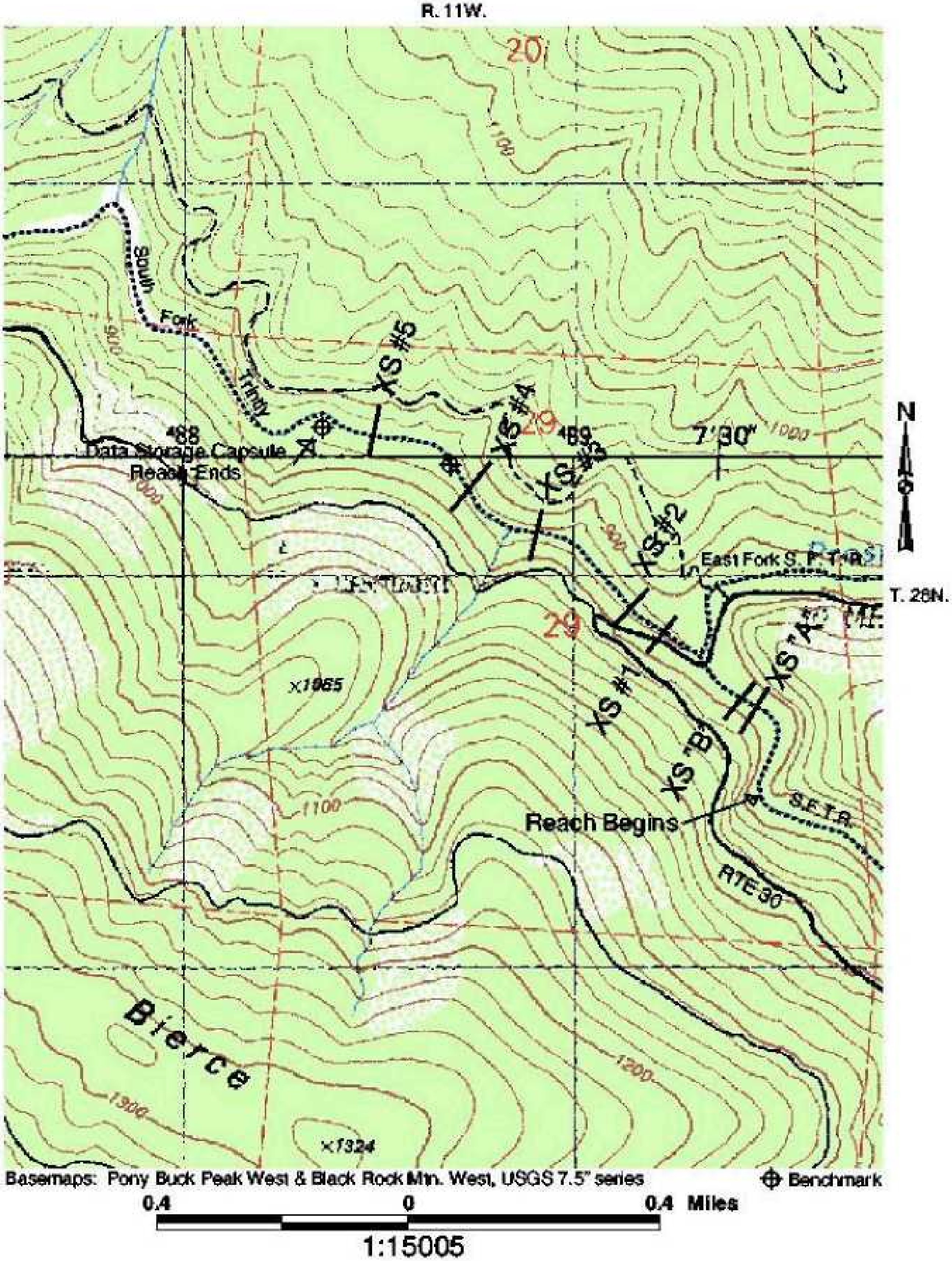
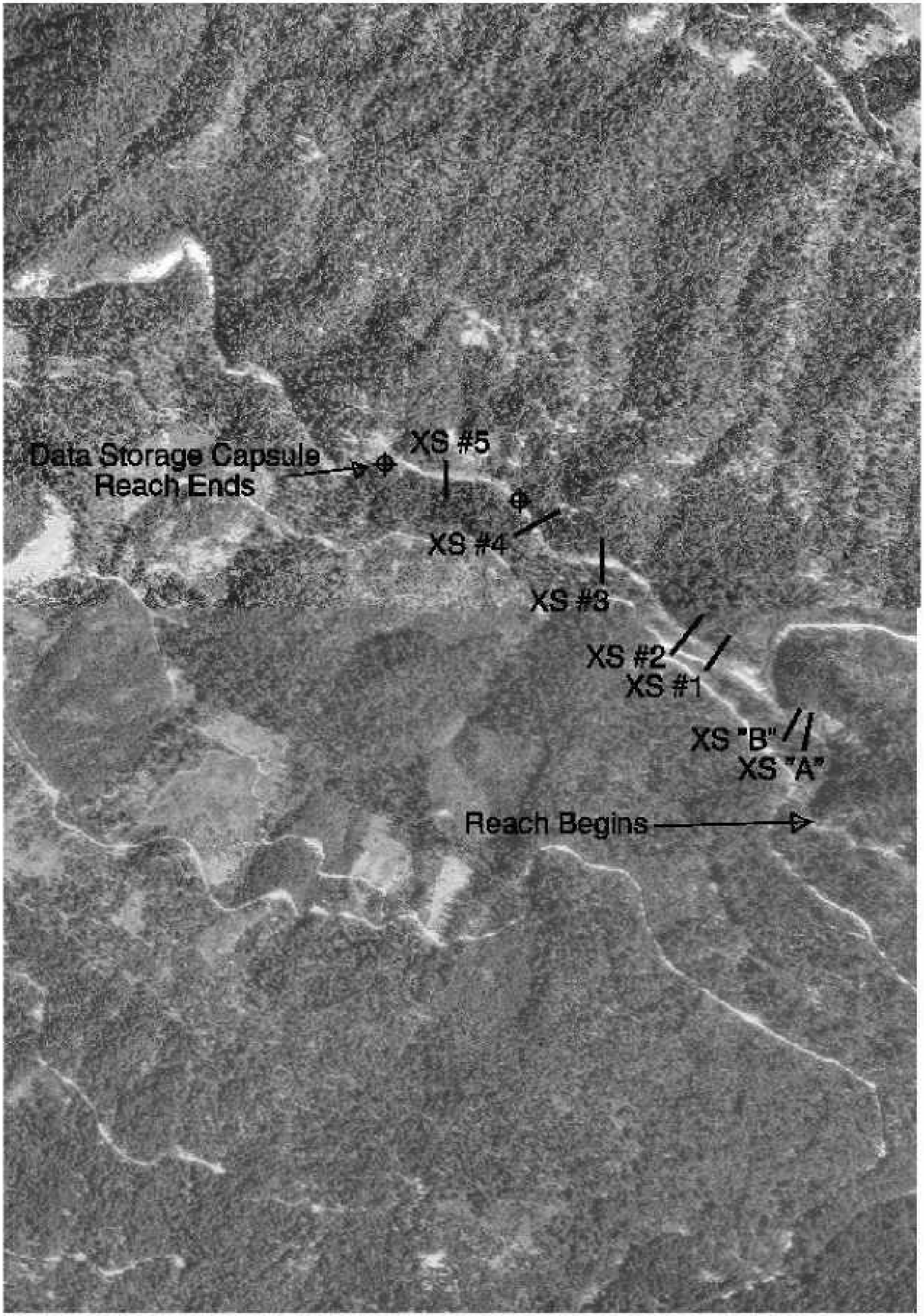
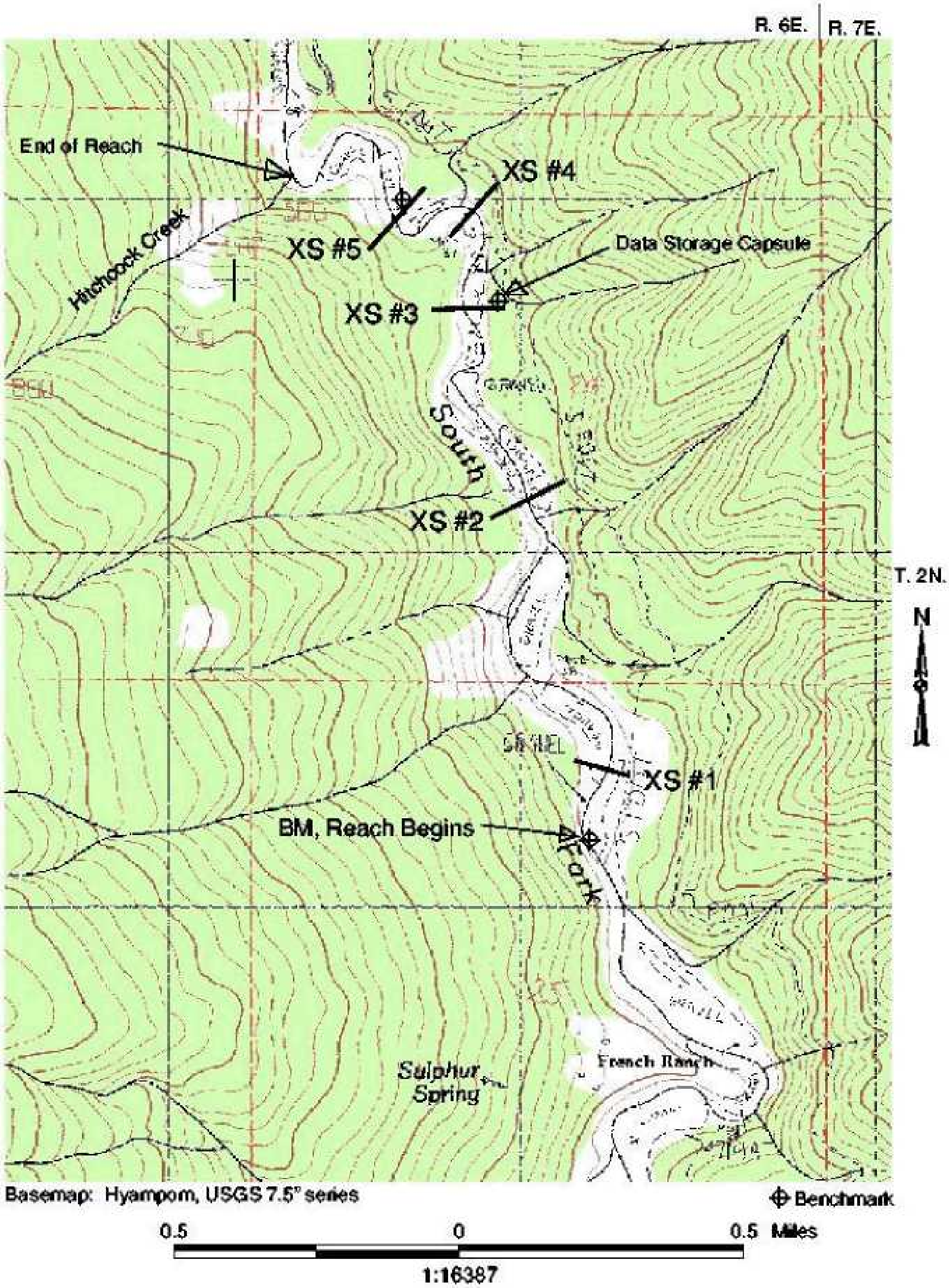


Figure 2a. Route 30 Reach



⌖ Benchmark

Figure 2b. Aerial View of Route 30 Reach



Basemap: Hyampom, USGS 7.5" series

Figure 3a. Sulphur Glade Reach

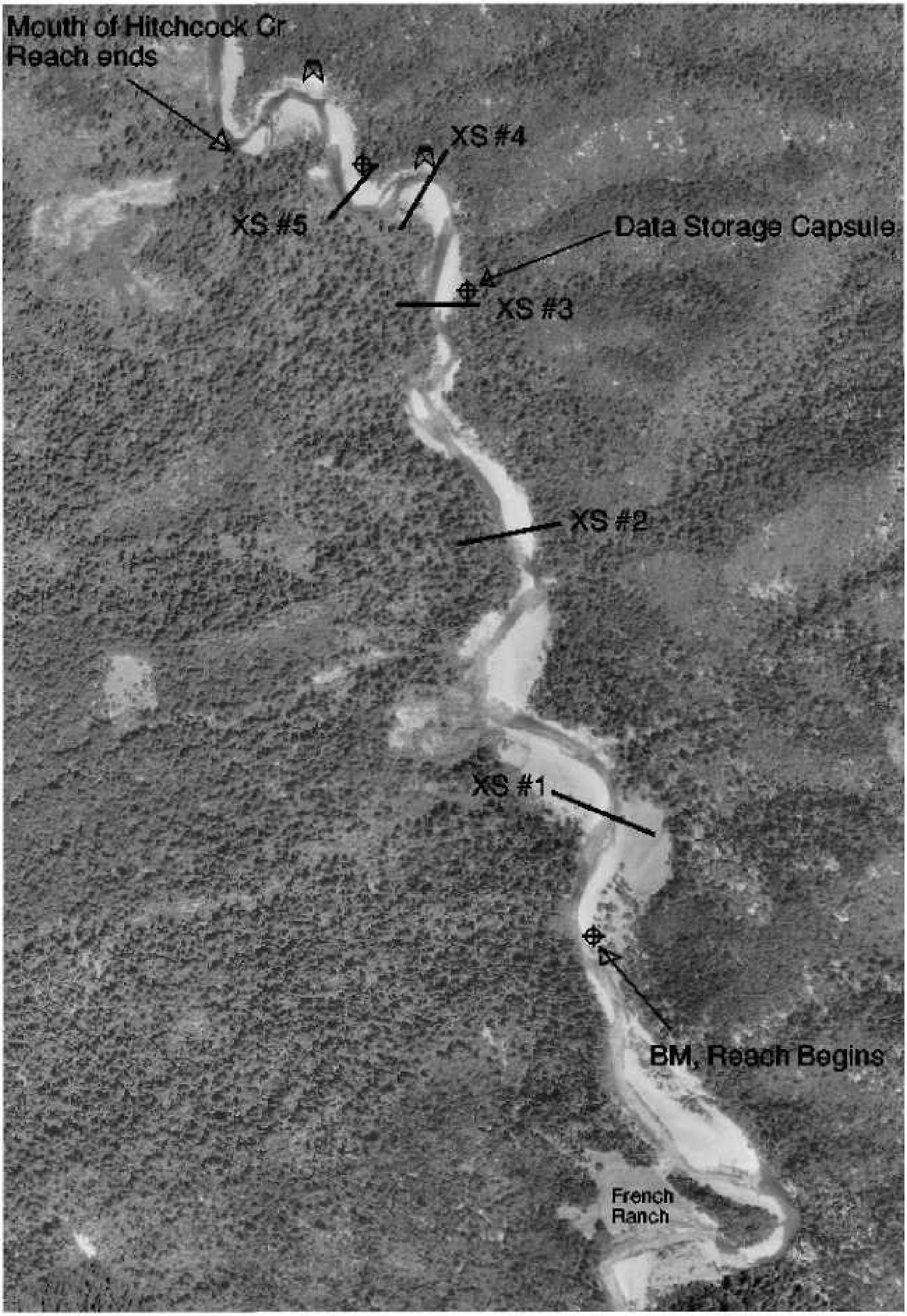
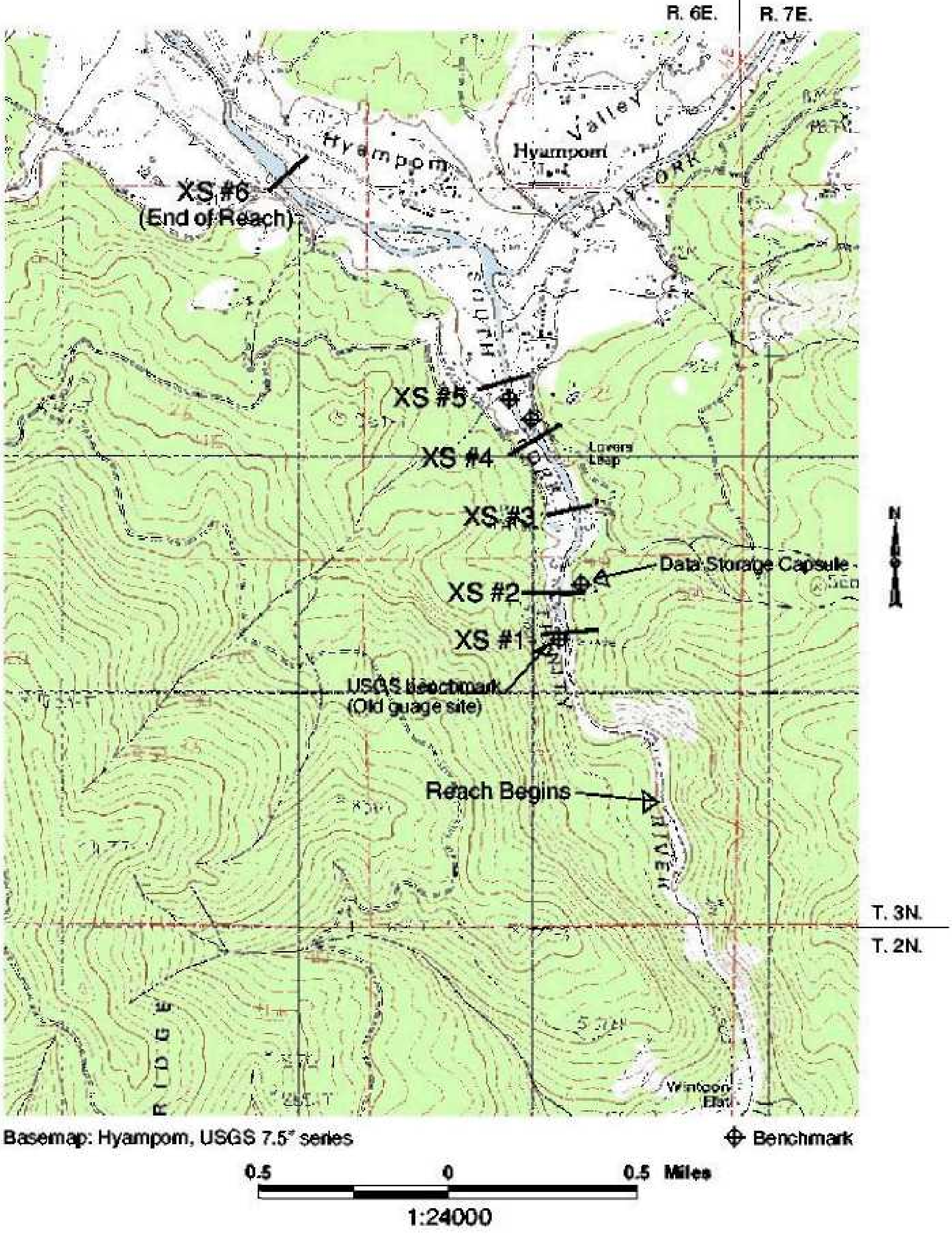


Figure 3b. Aerial View of Sulphur Glade Reach

⊕ Benchmark
⩓ Photo Point



Basemap: Hyampom, USGS 7.5' series

Figure 4a. Hyampom Reach

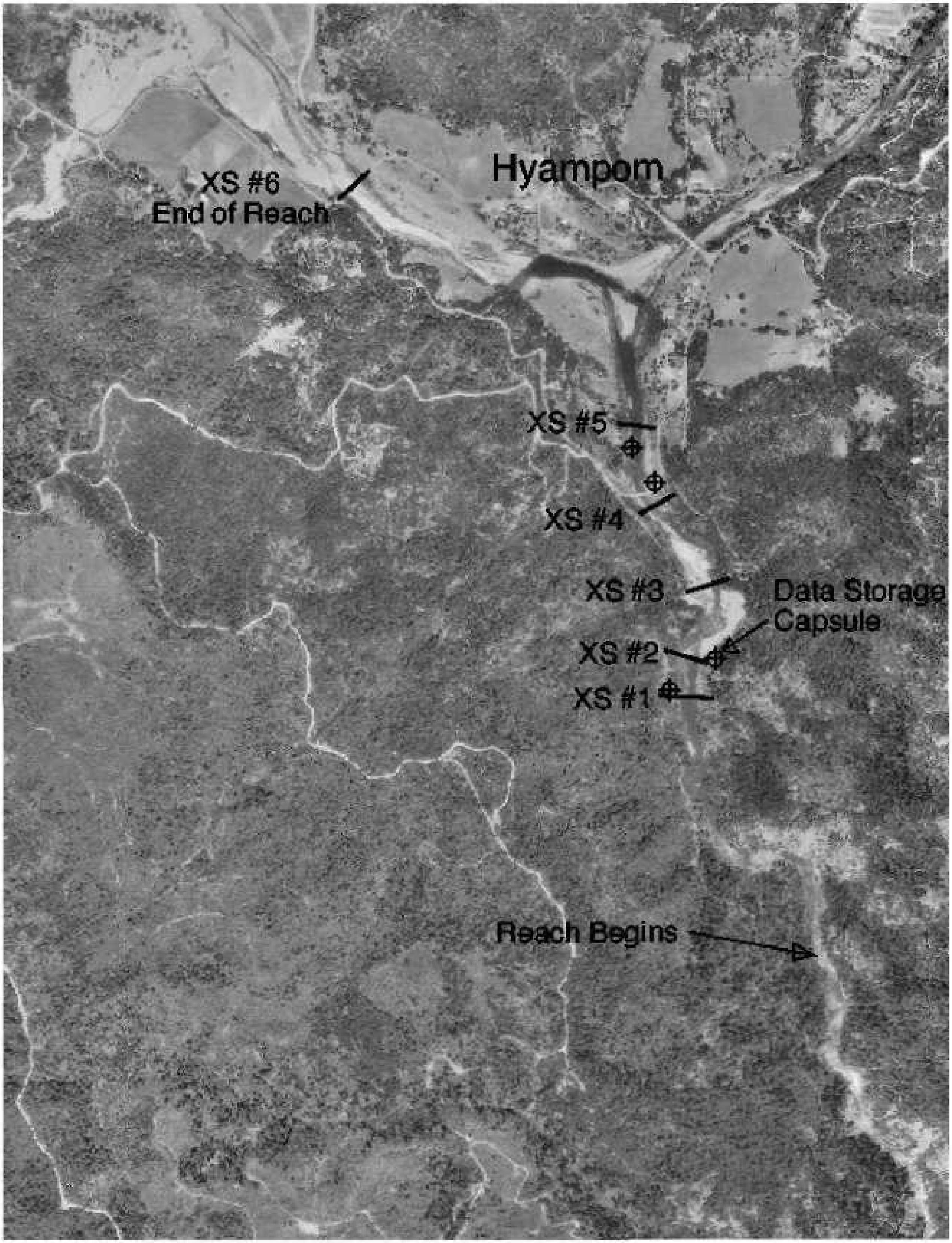
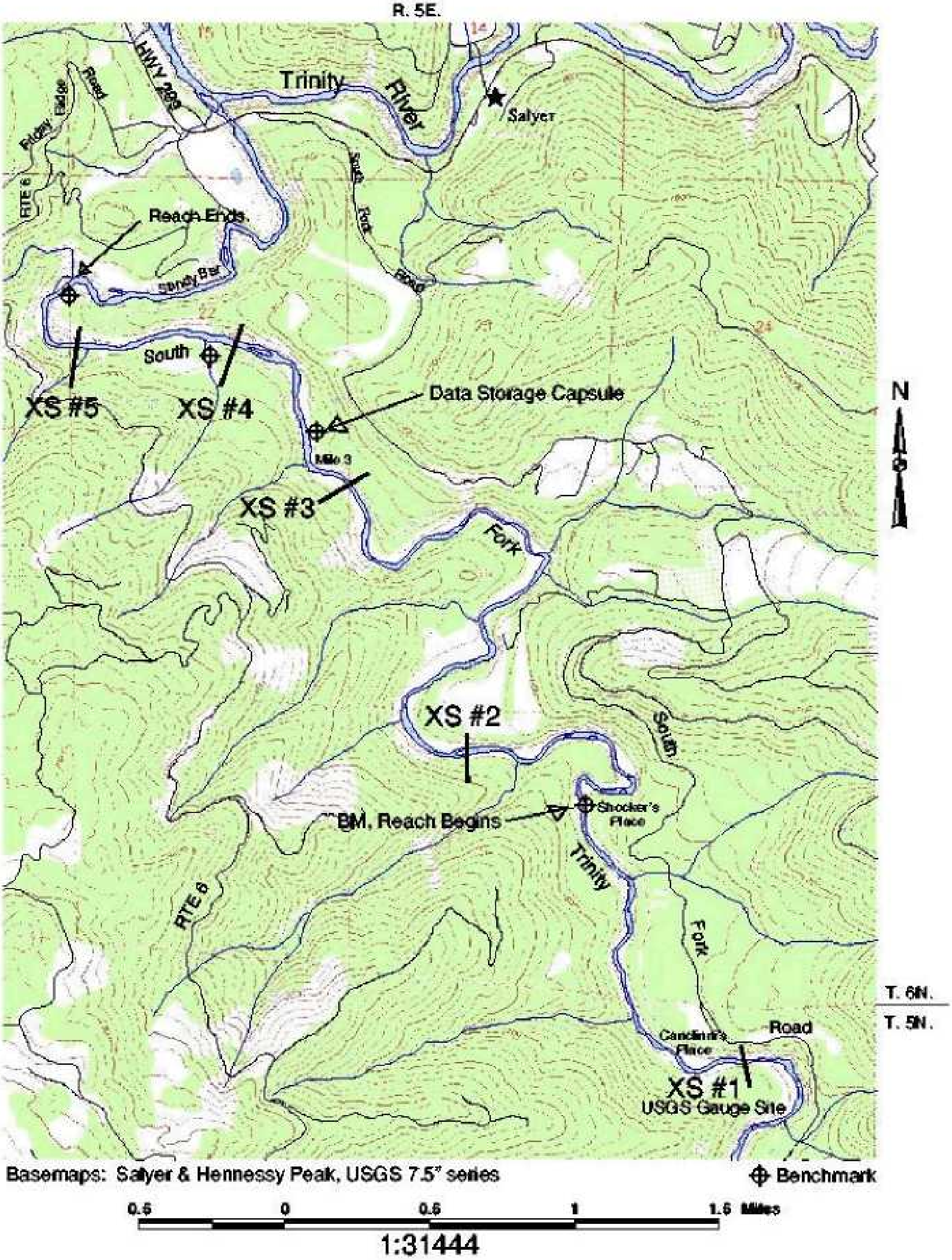
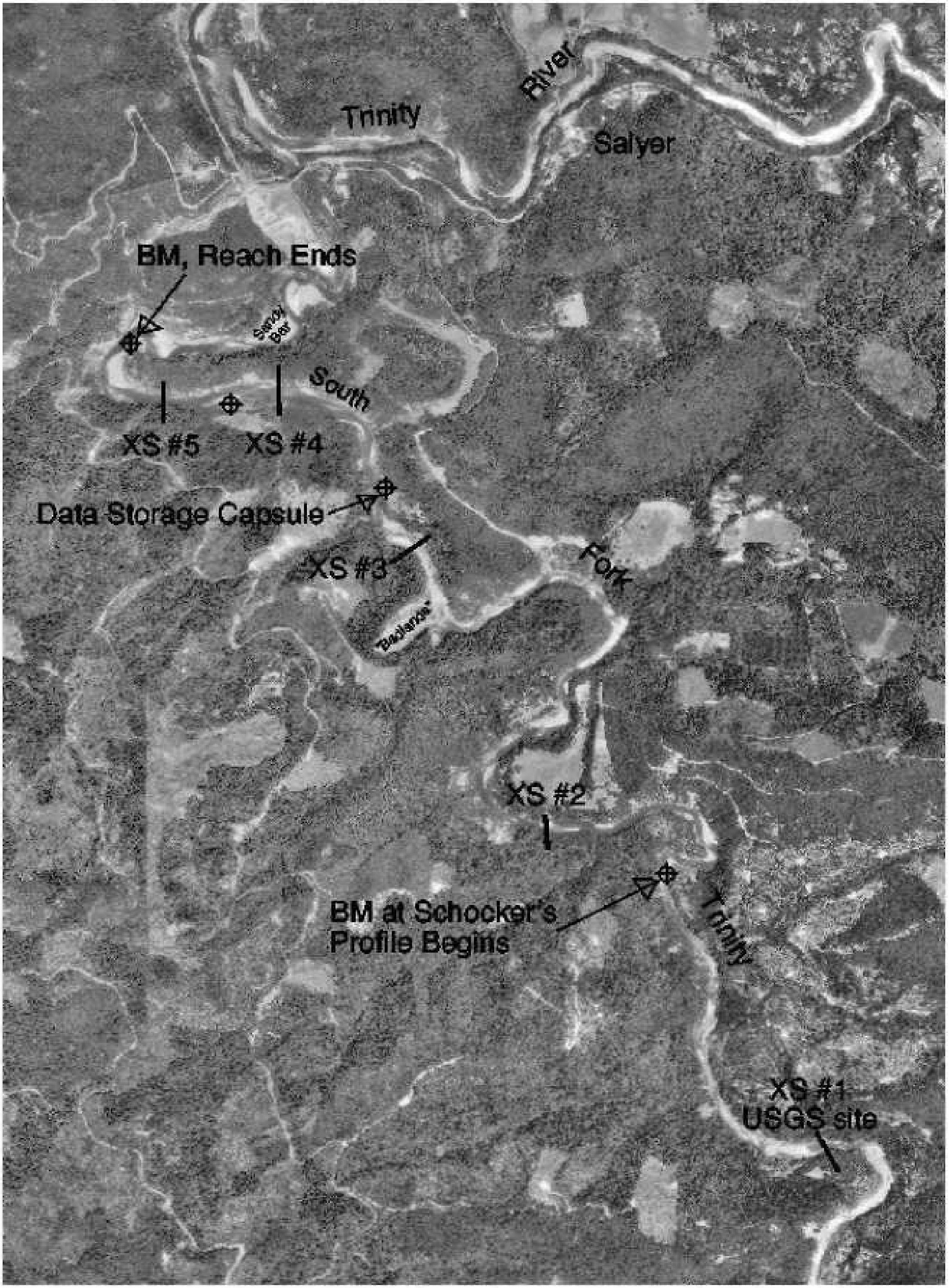


Figure 4b. Aerial View of Hyampom Reach



Basemaps: Salyer & Hennessy Peak, USGS 7.5" series

Figure 5a. Salyer Reach



⊕ Benchmark

Figure 5b. Aerial View of Salyer Reach

which represent significant long-term sediment storage. Average bankfull width is 200 feet. Average slope for this reach is 0.4 percent.

Reach 3 at Hyampom (river mile 29.5 to 31.6) contains the largest sediment storage area in the entire South Fork Trinity watershed (Figures 4a and 4b). Although the valley probably always contained large amounts of sediment, there is evidence that the channel may be higher than before the 1964 flood. The old bridge across Pelletreau Creek, which was 20 feet above the channel, has only recently become exposed again after being buried by 1964 flood deposits. While other reaches of the South Fork Trinity River may have flushed out 1964 sediment, it appears that Hyampom Valley is still adjusting. The gradient within this reach is lower than upstream (0.3 percent) and the channel is unconfined. Therefore, this reach is relatively sensitive to sediment delivered from upstream sources. Because the channel geometry is wide and shallow, stream power is relatively low. Consequently, this section may respond more slowly than other reaches and would represent very long-term conditions.

This reach contains sections that are completely unconfined. In some places, bankfull width is over 700 feet and the channel migrates frequently from valley wall to valley wall.

Reach 4 at Salyer (river mile 1.5 to 6.2) is the most downstream monitoring reach, extending from river mile 6.2, just downstream of the USGS gage near Salyer, to Sandy Bar (Figures 5a and 5b). This reach should reflect changes in the entire watershed. In addition, it has a lower gradient (0.2 percent) and contains more stored sediment than any other reach below Hyampom Valley. Thus, it is the most sensitive reach of mainstem channel in the lower watershed. Some historic cross section data associated with the USGS gage near the Canclinni property show 20 feet of aggradation after the 1964 flood and subsequent degradation to near 1955 levels. It is possible that the lower mainstem has already flushed through sediments from the 1964 flood. More comprehensive monitoring of the **Salyer Reach** may reveal if the changes at the USGS gage are anomalous or actually represent lower mainstem conditions.

Little data presently exist regarding the condition of pools in the **Salyer Reach** although anecdotal reports from long-time local residents suggest that pools were much deeper before the 1964 flood (Berol, 1995). Because this reach is used by nearly all anadromous fish in one way or another, it is an important place to monitor.

The channel in the **Salyer Reach** is quite confined, often by bedrock walls. Average bankfull width is 290 feet. Streamside landslides are common in this reach, including several large features. Although landslides may cause local data anomalies, large active landslides are common throughout the lower South Fork Trinity River.

B. Rationale for Selecting Monitoring Indicators

Before deciding which parameters were most appropriate for long-term trend monitoring, previous research on the South Fork Trinity River was reviewed to determine if earlier measurements could be used to extend this monitoring project into the past. Although many McNeil samples, pebble counts, pool surveys, fish population studies and temperature studies were found, none of those sites were worth re-occupying. This exercise provided good reconnaissance of the watershed, but all previously collected data were rejected as being unrepeatable, insensitive to long-term trends, and/or outside the study reaches.

Indicators that will be used for this sediment trend monitoring include (1) cross-section surveys, (2) longitudinal profile surveys, (3) pebble counts, and (4) photo points.

1. Cross section Surveys

Repeated cross section surveys are the simplest way to quantify changes in stream channel geometry. The protocol is well established, cost is relatively low, and results are easy to evaluate.

The repeated surveying of established cross sections is a primary tool for long-term trend monitoring. The data provided can be used to calculate mean bed elevation, bankfull width, mean depth at bankfull, and the width-to-depth ratio. All these parameters can be tracked over time to illustrate changes in stream morphology. The bankfull channel is used for these calculations because well-defined relationships exist between the bankfull channel and hydrologic variables such as discharge of water and sediment. The elevation of bankfull discharge is determined in the field at the time of survey.

Bankfull width is simply the width of the water surface at bankfull discharge. In alluvial channels, bankfull width would be expected to increase when the sediment supply exceeds transport capacity. Because the South Fork Trinity River is typically confined within narrow valley walls, bankfull width is not expected to change much.

Mean water depth is calculated by taking the area under the bankfull water surface and dividing by the bankfull width. Mean bed elevation is the elevation of the bankfull water surface minus the mean water depth. By definition, the mean bed elevation determines whether the streambed is aggrading or degrading, and is a clear representation of trends in sediment storage. The cross section at the USGS gage near Salyer (11529000) is an example of how repeated surveys can show channel filling and the subsequent erosion and return of the streambed to pre-flood levels.

The width-to-depth ratio is the width of the bankfull water surface divided by the mean water depth at bankfull discharge. Streams are predicted to get wider and shallower as they become overwhelmed by sediment supply in excess of transport capacity (the width-to-depth ratio will increase).

Cross sections were surveyed at five or more representative riffles in each of the four reaches. Cross sections may be surveyed with a tape, level and stadia rod, or laser level. Cross sections targeted riffles which are more sensitive to sediment supply than pools (Lisle, personnel communication) and were located away from the influence of wood or other temporary structures affecting channel geometry.

Cross sections have some limitations. They only represent one place in the channel, although multiple cross sections help to define a longer reach. Also, cross sections represent one moment in time and do not show changes that may have occurred during high flow events such as scour and fill. Finally, changes in cross sections are not easily related to fish abundance or survival.

2. Longitudinal Profile

Although cross sections provide valuable data for quantifying changes in channel morphology, the main tool for illustrating changes in slope and pool depths is the longitudinal profile survey. Analysis of the longitudinal profile can tell us the pool/riffle ratio, maximum residual pool depth, mean riffle length, mean residual water depth, channel slope and R^2 from a least-squares regression. A program called Winlongpro is available from Milestone Software that will perform some of these calculations.

Pools provide rearing and hiding habitat, as well as cold water refugia. Large influxes of sediment generally decrease the number and volume of pools, resulting in diminished pool habitat. The Channel Assessment Procedure Field Guidebook (Province of British Columbia, 1996) suggests that channel disturbance resulting in aggradation will lead to more extensive riffles, smaller and shallower pools, and finer bed texture. Repeated longitudinal profiles should reveal the degree to which pools are impacted by sediment.

Pool definition has been a common problem with previous channel profile analyses. For this study, pools were defined objectively using the survey points and the residual water depth. The residual water depth is the depth of water that would remain in the channel if the discharge were reduced to zero. Depth at riffle crests would be zero. Additionally, we set a minimum pool depth to reflect the biological significance of larger pools. For example, on the Route 30 Reach, we set minimum pool depth at one foot; if a pool were less than one foot deep at it deepest point, it would not be counted as a pool. Using this criterion does not change residual depth, only the number of pools.

The pool/riffle ratio provides a revealing measure of a section of channel. It is the total length of all the pools divided by the total length of all the riffles. This ratio is generally expected to be lower as sediment supply overwhelms transport capacity because pools will fill and the proportion of the reach classified as riffles will increase. The pool/riffle ratio also reflects how much of the reach is pool habitat.

A similar indicator of sediment loading is mean riffle length. It is predicted that when sediment supply exceeds transport capacity, the riffles will enlarge and take up more of the channel. This would cause an increase in mean riffle length.

Maximum pool depth is another indicator of sediment loading. As sediment supply surpasses transport capacity, it is expected that pools will fill in and maximum (residual) pool depth will decrease. It is likely that the deepest pool on each reach will be the same pool each year. It may be useful to record the maximum depth of several of the deepest pools in each reach. This would be a rapid and efficient way to collect useful long-term trend data without surveying the longitudinal profile.

Mean residual water depth is another indicator of sediment loading. Standardized data are used and the mathematical average of all the depths is calculated (depth over riffles = 0). This index incorporates both the amount of riffles (more riffles → more zero values) and the pool depths, so it is somewhat more sensitive to changes in sediment supply than the pool/riffle ratio or maximum pool depth alone.

Finally, useful information can be gleaned from fitting the long profile with a smooth line based on a least-squares regression. This provides objective slope data as well as a measure of the channel variability. It is predicted that as sediment supply surpasses transport capacity, channel slope will decrease and the value of R^2 will increase, indicating homogeneity of the bed.

Many pool inventory techniques have problems due to high operator variability, lack of replicability and discharge dependency. By using residual pool depth and surveying the channel, operator subjectivity will be minimized. However, this survey method will not account for changes in pool volume caused by sediment deposits along the sides of pools. It also tells us little about pool complexity and how fish respond to changes.

3. Pebble Counts

Pebble counts are the cheapest, easiest way to monitor gross changes in size distribution of streambed sediment. The protocol for pebble counts is well established and has been used extensively since Wolman introduced the technique in 1954. Substrate monitoring is required for the TMDL process, and pebble counts are the best way to meet that goal.

Generally, pebble count data are displayed as percent finer than a given size. Particle sizes are assigned a percentage based on their rank. For example, D35 is the size in millimeters at which 35 percent of the sampled particles are smaller. Changes in the size of a given percentile can show if the streambed is getting coarser or finer over time. It also can be used to monitor the amount of sediment finer than a given size.

Pebble counts are inexpensive but they cannot completely characterize the size distribution of streambed sediment. The principal shortcoming of pebble counts is that they tend to under-represent the finer particle sizes. This is particularly true for sizes less than about 5 mm, which is in the range of fine sediment than can affect fish survival. Secondly, pebble counts are not performed within spawning redds because the size distribution of the streambed is changed by the spawning fish. Therefore, sampling outside of redds may not reflect the actual condition of spawning gravels in the study reaches. Furthermore, size distribution of the streambed has not been well correlated with fish abundance or survival. Finally, pebble counts are somewhat imprecise and the data resolution may be insufficient to document subtle changes.

4. Photo Points

At each cross section, four photo points were established as follows: from left bank looking to right bank; from right bank looking to left bank; from above the cross section looking downstream; and from below the cross section looking upstream. Additional photo points were established at other appropriate locations where the channel could be observed.

Photographs will be stored digitally so they can be compared to photos taken in future years. Photographs provide excellent semi-quantitative data and help to show changes in the channel that are not easily captured by other survey techniques. Care must be taken that photographs and negatives are not lost or damaged.

C. Sampling Time Frame

There are two factors to consider when deciding how frequently to sample. After baseline data have been established, future sampling efforts should be frequent enough to ensure that channel changes are being detected. On the other hand, sampling is probably not needed every year, particularly in low-flow years when channel changes have been minor.

We propose a variable sampling scheme based on antecedent flow and channel conditions rather than a fixed time interval. After the first year (1998), sampling was repeated two years later (2000) even though peak flows were small. This will reveal sampling variability and the sensitivity of reaches to change, and it can guide future sampling frequencies (e.g., after 5, 10, 15 year recurrence interval flows). Sampling frequency should be adaptive. When significant channel changes are observed, it may be prudent to re-survey the following year regardless of flow magnitude. It must be recognized that re-surveying will be driven in part by budget constraints. Nevertheless, this study was designed to enable Forest Service personnel to re-survey at a minimum after a 10- to 15-year peak flow. Furthermore, a variable sampling scheme should allow monitoring when changes occur and avoid sampling when no change has occurred.

After the storm effects have been measured, the sampling interval should again be reduced to monitor channel changes as long as they remain significant. If funding is limited, we recommend re-occupying as many cross sections as possible at the expense of the profile. This is because cross section surveys are easily repeatable, utilize readily available equipment and can be completed in a short period of time. Changes in the cross sections also could be used to indicate whether a survey of the longitudinal profile is justified. Sufficient benchmarks and reference points were established to enable the profiles to be shortened if necessary. However, profile surveys must be long enough to represent characteristics of the reach as a whole and not be affected by local anomalies.

An alternative to profile surveys is to measure the maximum residual pool depths of several large pools in each reach. A very minimum level of monitoring could be accomplished even in the leanest budget year by reoccupying all the photo points.

D. Field Methods

1. Channel Surveys

Although survey technology continues to advance, we tried to keep the survey protocol simple so that future surveys could be done with a tape and level. However, time and budget constraints may preclude using a tape in the future, particularly for the longitudinal profile. Moreover, the South Fork Trinity River is so large that stringing a tape down either the thalweg or the center of the channel is nearly impossible. A tape and level should be used for surveying the cross sections. We used a standard Topcon auto-level and fiberglass tape to survey the cross-sections and a Nikon DTM-520 total station to survey the profile.

The total station shoots to a prism and measures angles, bearings and distances which are converted to x, y, and z coordinates. Make sure your prism is either completely sealed, so it doesn't get water in it, or very leaky so you can rinse out the vapor.

To measure pool depths, we mounted the prism on the end of a standard 16-foot telescoping range pole. Thus, the rod length (usually fixed in a laser survey) was variable up to 16 feet and allowed us to get to the bottom of deep pools or elevate the target above brush. Rod height was fixed at intervals (i.e., rod collapsed, one section deployed, two sections deployed, etc.). Failure to keep track of changes in target height can be a significant source of error.

We surveyed as a two-person crew, one person on the instrument and one on the rod. The instrument person was in charge of data management and all field notes. The rod person waded or swam down the thalweg. We did not employ any flotation devices for the rod person other than a life jacket or PFD. Others have used a “belly-boat" (inner tube with a seat - usually used by fishermen) and swim fins with success. We found it was difficult to stay in position in a boat, and time was needed to get in and out frequently. The rod person often used a facemask to see the channel bottom and determine the thalweg. Swimming the pools was refreshing in August and a cold prospect in October. If working past August, you will need a dry-suit, preferably Gore-Tex. On the Salyer Reach, a canoe was used to transport the instrument.

Stations were typically 600 feet apart with two turning points used for each turn. There was a substantial learning curve, but eventually we were spending about 45 minutes per station, or about 800 feet per hour or 7 hours per mile.

The thalweg was surveyed continuously downstream at every slope break and often more frequently. Few shots were more than 50 feet apart no matter how uniform the bed. We tried to use a minimum of three points to determine a line.

In addition to the thalweg, the water surface was surveyed, but much less intensively. Generally, water surface was surveyed at the downstream end of the pool, just above the riffle crest. Surveying the water surface is useful to validate the data and identify anomalous points.

Cross sections are monumented with 3/8-inch rebar fitted with aluminum caps. We decided to use four rebar “pins" at each cross section. Two were placed near the edge of the active channel where they are easy to find and use for stringing a tape, etc. Because it is likely that these pins will be exposed to water and debris at high flows, few are expected to last the duration of this monitoring project. Future surveyors should plan to replace some of these lower pins from time to time as needed. Due to the instability of the lower pins, two more were added upslope on stable ground. These may be hard to find, generally being 100 feet upslope, but they should be more permanent.

Cross-section pins were numbered 1-4 beginning on the left bank (facing downstream). That is, the upslope pin on the left bank is Pin #1, the pin at the edge of the channel on the left bank is Pin #2, the pin at the edge of the channel on the right bank is Pin #3, and the upslope pin on the right bank is Pin #4.

An important element of cross section data analysis is the identification of bankfull flood elevation in the field. Because many areas of the South Fork Trinity River have little or no floodplain, bankfull must be determined from other indicators such as vegetation, soil type, or breaks in slope. For assistance identifying bankfull in the field, see Leopold (1994), Dunne & Leopold (1978), Harrelson et al. (1994), and a video produced by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Stream Systems Technology Center, entitled *A Guide to Field Identification of Bankfull Stage in the Western United States*.

Error Discussion

This year’s survey was done with an Auto-level and a total station, two highly accurate instruments. This allowed for comparison between surveys done this year as well as previous surveys. As expected, both the level and total station surveys are extremely close. This makes the errors associated with the Criterion 400 survey laser used in 1998 stand out. As discussed in Cook et al. (1999), the Criterion 400 was accurate, but not precise. Values from the 1998 longitudinal profile survey are probably reliable.

Unfortunately, some of the cross-section surveys done in 1998 with the Criterion 400 now look like they need to be thrown out (e.g., Sulphur Glade XS#2).

Additionally, the Criterion 400 surveys were found to have a systematic distance error, which caused the cross-sections to appear wider than they really are. Many cross-sections were adjusted by about 96% to compensate and bring the 1998 surveys in line with the laser and total station surveys. This suggests that the Criterion 400 may not have been in proper calibration at the time surveying was done in 1998. None of the 1998 profile surveys were adjusted.

The use of the total station for the profiles made data analysis generally very easy. The exception was the Salyer reach. Inexperience combined with equipment problems and time constraints caused the Salyer reach to be surveyed in a most haphazard and unconventional way. The reach from “Schocker’s Cap” to XS#3 is pretty good. Below that, sometimes the seldom taken water surface shot was the only thing available for elevation control. While the total station surveys of the other reaches can be considered fairly definitive, the Salyer reach values are still uncertain.

2. Pebble Counts

Pebble counts were performed underneath the cross section tape. Distance across the active channel (usually between pin #2 and pin #3) was divided by 100 to determine the sampling interval. In a few cases, the sampling interval was deemed too small (i.e., it was likely the same particle could be sampled twice). In these cases the active channel width was divided by 50 to determine the sampling interval and a second transect located a few feet downstream. Pebbles were selected randomly along the tape transect. The intermediate diameter of each pebble was recorded in millimeters.

3. Photo Points

Photos were taken at each cross section and selected viewpoints. Each cross section was photographed while the tape was strung out. Photos were taken (1) from the left bank looking at the right bank, (2) from the right bank looking at the left bank, (3) from upstream looking downstream, and (4) from downstream looking upstream. In larger channels, multiple photos were needed sometimes to show upstream or downstream views, and left and right bank photos were taken from the center of the channel to show more definition of the bank. Reach-specific photo points will be described in **Appendix A: Location and Access**.

IV. Hillslope Sediment Source Trend Monitoring

The relationships between hillslope conditions and in-channel conditions are well known *in theory* but difficult to evaluate in specific detail. In other words, it is generally impractical to monitor actual cause-and-effect relationships between hillslopes and channels except in "spectacular" cases such as Devastation Slide. This is mostly a result of the relatively long and highly variable *delayed response* of stream channels to dispersed upslope disturbances. Nevertheless, tracking hillslope conditions can help to characterize the overall "recovery" of a watershed.

A. Methods

The principal emphasis of hillslope monitoring should be sediment production and its delivery downslope and ultimately downstream. The primary monitoring objective will be to relate points or areas of sediment production to management activities (usually on a subjective basis), rather than to track actual sediment movement to points of impact in the aquatic system. Existing information clearly indicates the higher contribution of mass wasting to the overall sediment budget of the South Fork Trinity River (Raines, 1999). However, sediment production *attributable to management* may be more evenly balanced between mass wasting and chronic surface erosion processes in managed landscapes (i.e., cutover areas and roads). Therefore, the data collection strategy will address both sediment production regimes.

1. Mass Wasting Regime

Significant landsliding tends to be associated with major storm/flood events. There have been six such events in this region since about 1930 (in 1955, 1964, 1975, 1986, 1995 & 1997), so comparable triggering events are expected to recur on average every 10-15 years. Mass wasting in heavily managed terrain could result from somewhat less extreme storm events than in undisturbed terrain. Due to the stochastic nature of landslide processes, data collection will be flexible in response to triggering events.

Landslides occur more frequently on sensitive geomorphic terrains that can be mapped across the landscape. These include inner gorge areas, toe zones of older landslide deposits, and steep headwall areas. Subsequent impacts to aquatic resources are also much more likely to result from landslides that occur on certain parts of that landscape. These include relatively steeper slopes in middle or lower slope positions and particularly in the vicinity of major road/stream crossings.

Hillslope monitoring will test the hypothesis that sediment production from mass wasting associated with recent harvesting and road building has been significantly reduced compared to historic levels because of (1) more benign forest practices adopted under the Northwest Forest Plan, (2) reduced management levels, and/or (3) more effective mitigation on the sensitive terrains and high potential delivery sites noted above.

A representative suite of sampling areas has been established in the most sensitive parts of the South Fork Trinity watershed in terms of past observed landslide frequency (Figures 1 and 7 through 12) which include the Grouse, Old Campbell, Hyampom, Lower South Fork, Eltapom and Hidden Valley subwatersheds. Although effects of individual storms are usually distributed unevenly across a region, the monitoring areas will be fixed so that temporal comparisons will be valid.

All of these monitoring areas contain substantial management disturbance, except for the Old Campbell subwatershed which will serve as a "control" area. The combined monitoring area comprises about 10-15 percent of the relatively unstable lands in the western part of the watershed, or roughly 25,000 ac. These areas will be inventoried primarily by examining aerial photos following a major, landslide-producing storm/flood event. Assuming an average coverage of 600 acres per photo, there will be about 40-50 aerial photo effective areas to inventory. The photos may either have been recently acquired on the normal 5-year cycle or specially flown. Some level of field verification of aerial photo observations will also be done, depending on the scale and extent of observed storm impacts. Therefore, the aerial photos will be acquired in the first or second year following the triggering event.

An intensive aerial photo inventory of the six monitoring areas will be performed to delineate landslides and note characteristics according to the 1995 Landslide Study protocol (i.e., type, size, management-related or natural, slope position, runout to stream, and trend since previous photos) which is presented in Appendix E.

The resulting tabulated data will be used to identify a sample of landslide sites for field verification. These will be predominantly ones associated with management and representative of the various recorded factors above. The field sample will probably range from 30-50 percent of inventoried, management-related features, with the smaller fraction for larger magnitude storms when presumably more landslides would occur. In some cases, a full census of management-related features may be appropriate.

Storms of sufficient magnitude to warrant a trend monitoring effort in the South Fork Trinity watershed may also generate a number of storm-damage sites on the road system. Most of these sites will automatically receive a comprehensive geotechnical review prior to repair under ERFO (Emergency Relief for Federal Roads), and the assessments would complement data collection for this mass-wasting trend monitoring. Additional field data collection associated with ERFO reviews would include all road/stream crossing failures, culvert diversions, road prism failures, and instances of substantial sediment delivery to streams. Observations of relevant BMP implementation or effectiveness at observed sites would also be recorded. Finally, a complete photographic record of observed impacts would be maintained. (See Appendix F for detailed protocol.)

Data tables will then be revised on the basis of field data collection. Final monitoring results will be compiled and interpreted. Key conclusions are likely to address: comparative numbers, types and sizes of slides; relative frequencies of management-related and natural landslides; and frequency trends relative to sensitive geologic or geomorphic terranes.

The estimated cost of this landslide monitoring is about $9500, including $4000 for aerial photos, $1800 for aerial photo analysis, $2700 for field checking, and $1000 for data management. Since the active landslide GIS layer for the Six Rivers National Forest will likely be updated following major storms, much of the data for this trend monitoring in the Lower South Fork, Old Campbell and Grouse Creek subwatersheds would be acquired anyway. However, there may be cases where monitoring would be initiated in the South Fork Trinity watershed without taking on a Forest-wide inventory for the Six Rivers.

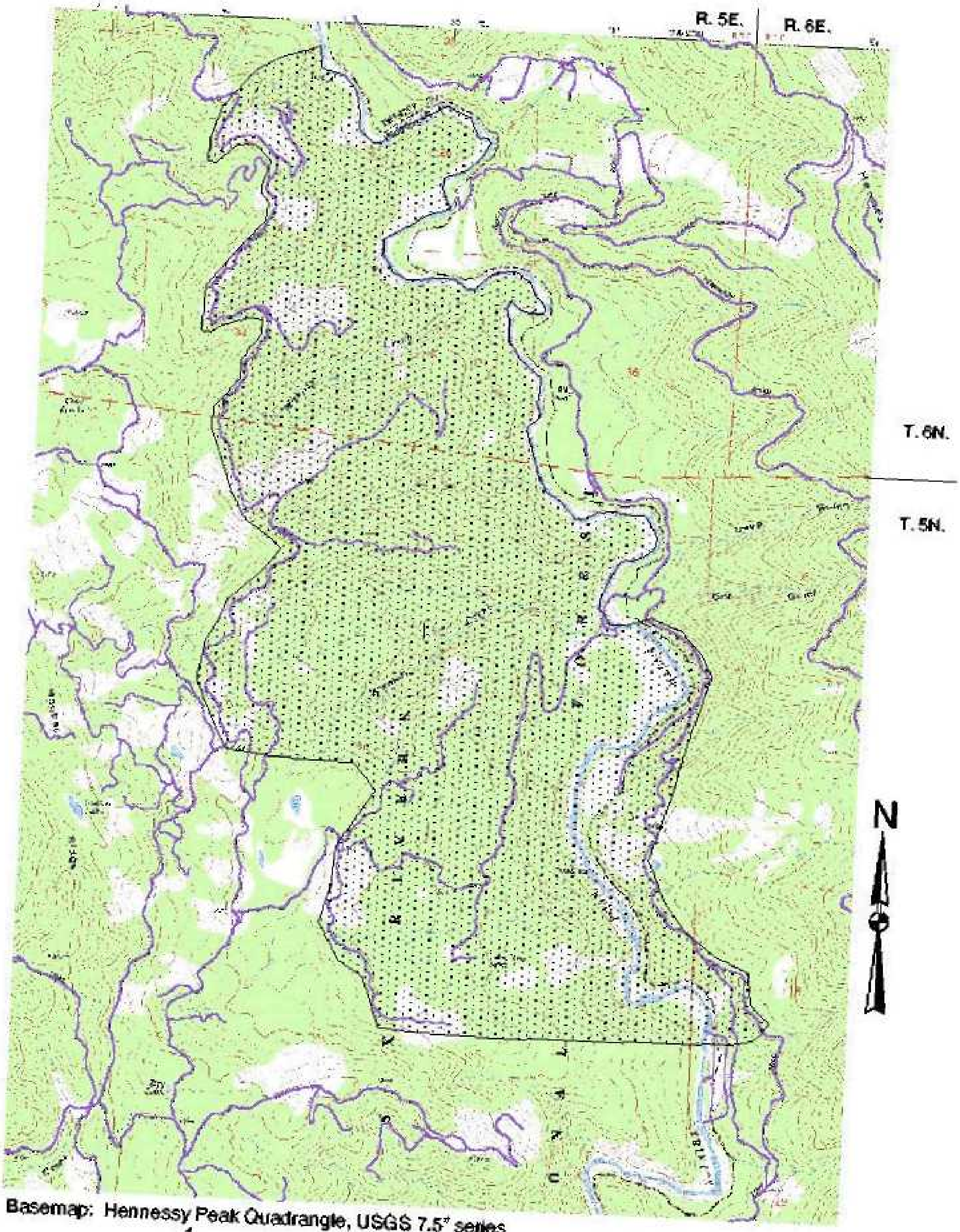
2. Chronic Accelerated Erosion

Erosion potential varies substantially across the whole watershed. Important factors are geologic and soil units, slope, road geometry and grade, and existing vegetation. Virtually all erosion problems attributable to management are likely to be associated with road prisms (cut slope, tread and fill slope) rather than harvested areas, since intensive tractor logging has been curtailed or eliminated in this watershed. Accelerated erosion will also tend to occur on barren landslide scars (i.e., new features or older ones that are not re-vegetating), some of which may be associated with past management.

Estimating surface erosion associated with the road system will require field sampling, which could be in conjunction with Best Management Practices (BMP) assessments focused on road construction and maintenance practices. Erosion monitoring will need to be more frequent than for the mass wasting regime to provide meaningful data, probably on the order of every third year. We propose to use the screening protocol being developed for ATM Planning to identify parts of the road system most susceptible to erosion. Then a representative sample will be selected across geographic sub-areas defined in the Sediment Source Analysis (Raines, 1998). The sample will be stratified according to: (1) geologic/soils types (principally on South Fork Mtn. schist, Franciscan sedimentary, Galice metasedimentary and decomposed granitics which have the higher erosion rates); (2) hillslope position and gradient (with emphasis on steeper middle and lower slopes); and (3) road geometry and surface type (with emphasis on the larger native and aggregate-surfaced roads). The assessment method for periodic road erosion will involve visually estimating soil volumes mobilized and delivered to channels. Indicators would include fresh cutslope sloughs, blockage of inboard ditches, rilling/gullying of road tread, rilling/gullying of fill slopes, sediment plumes on slopes, and residual coarse lag material in ditches.

In addition, any major road failure sites (such as landslides and washouts) identified under ERFO or storm monitoring will be assessed in terms of secondary erosional effects such as diversions, continuing gullies, etc (see Appendix F for detailed protocol).

Over the longer term, this hillslope monitoring information will be related spatially to in-channel monitoring information to provide a more accurate, qualitative picture of sediment mobilization and movement through the fluvial system than we have at present. Spatial patterns may emerge from this analysis that would highlight the most important "hot spots" of sediment production from landsliding and chronic surface erosion. For example, there could be important contrasts in sediment deposition between response reaches downstream of areas with mostly "natural" sediment production from mass wasting, compared to areas with predominantly management-related sediment production from both mass wasting and accelerated surface erosion. In other words, tributary channels may respond differently to "natural" versus “management-dominated” sediment production regimes. There may also be observable differences in timing of instream responses between the two types of areas.



Basemap: Hennessy Peak Quadrangle, USGS 7.5" series

Figure 7a. Lower South Fork Mass Wasting Monitoring Area

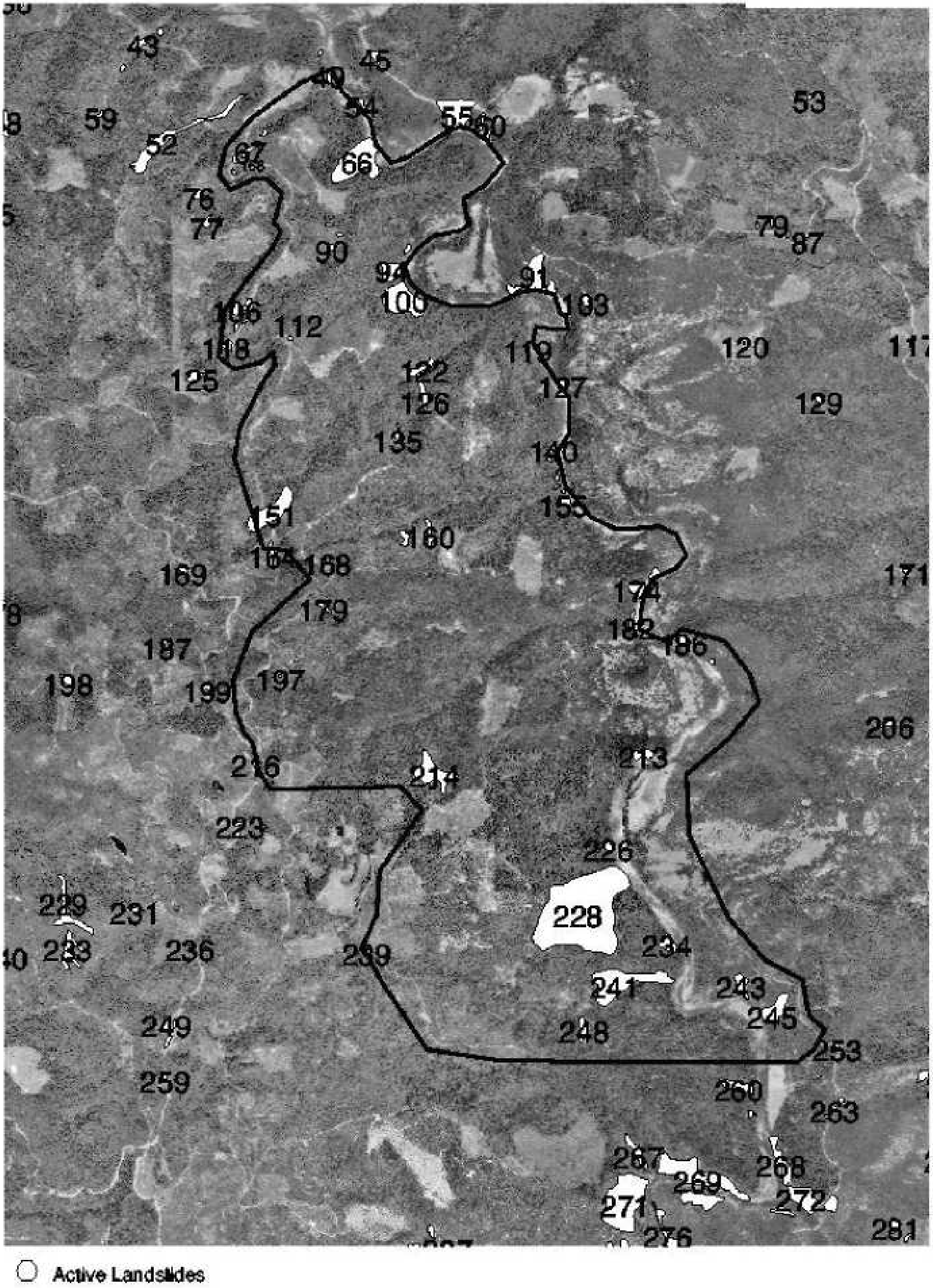


Figure 7b. Lower South Fork Mass Wasting Monitoring Area

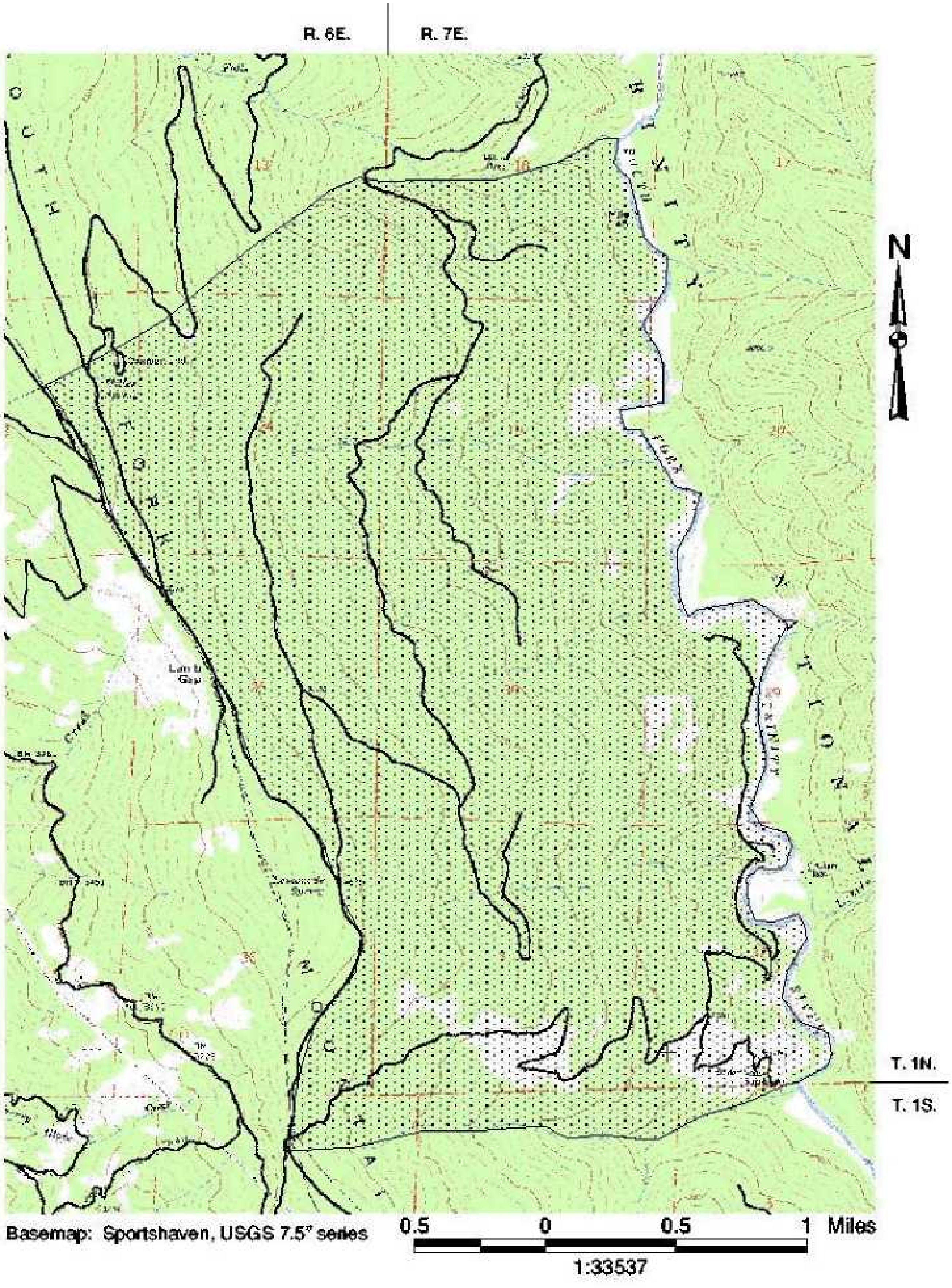
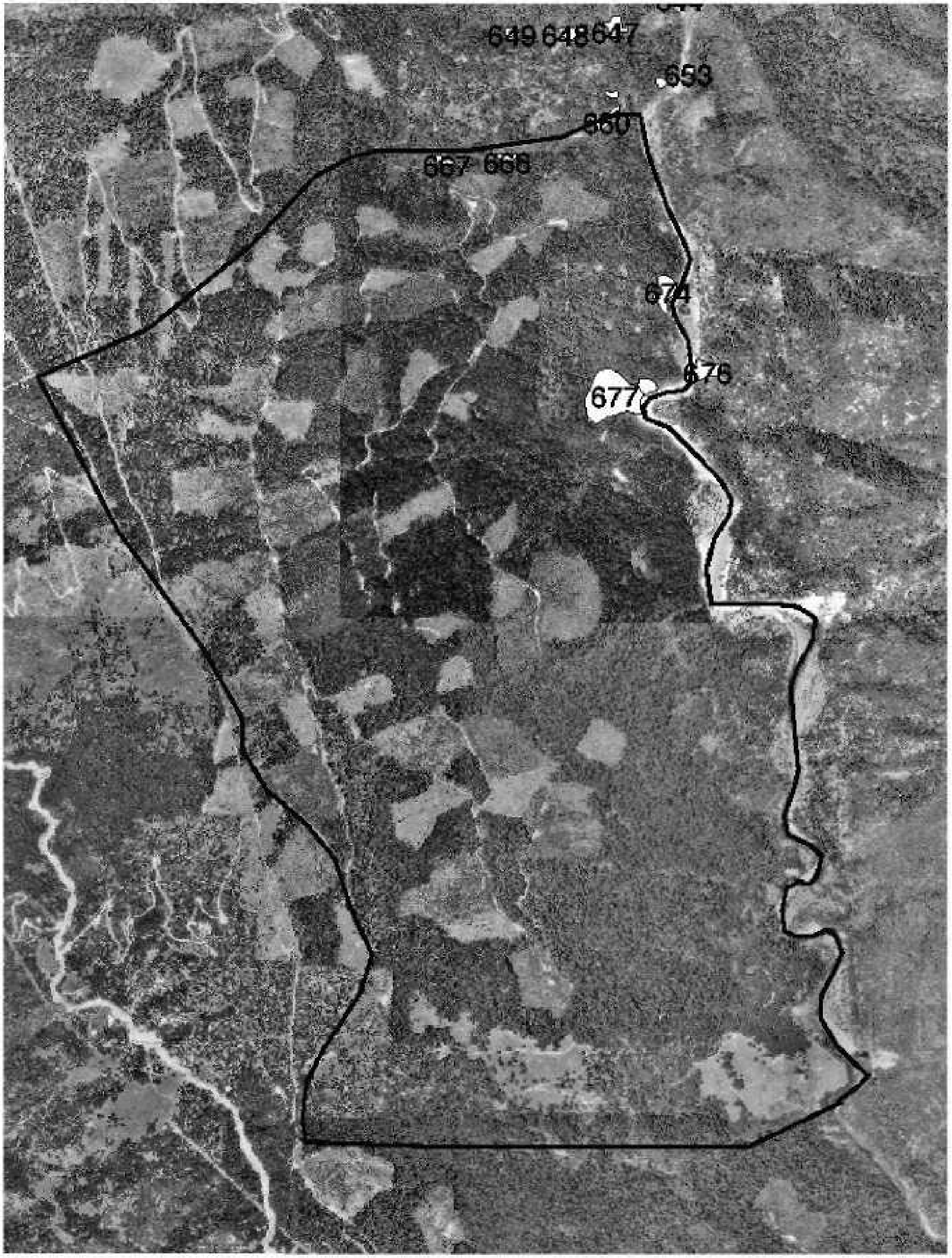
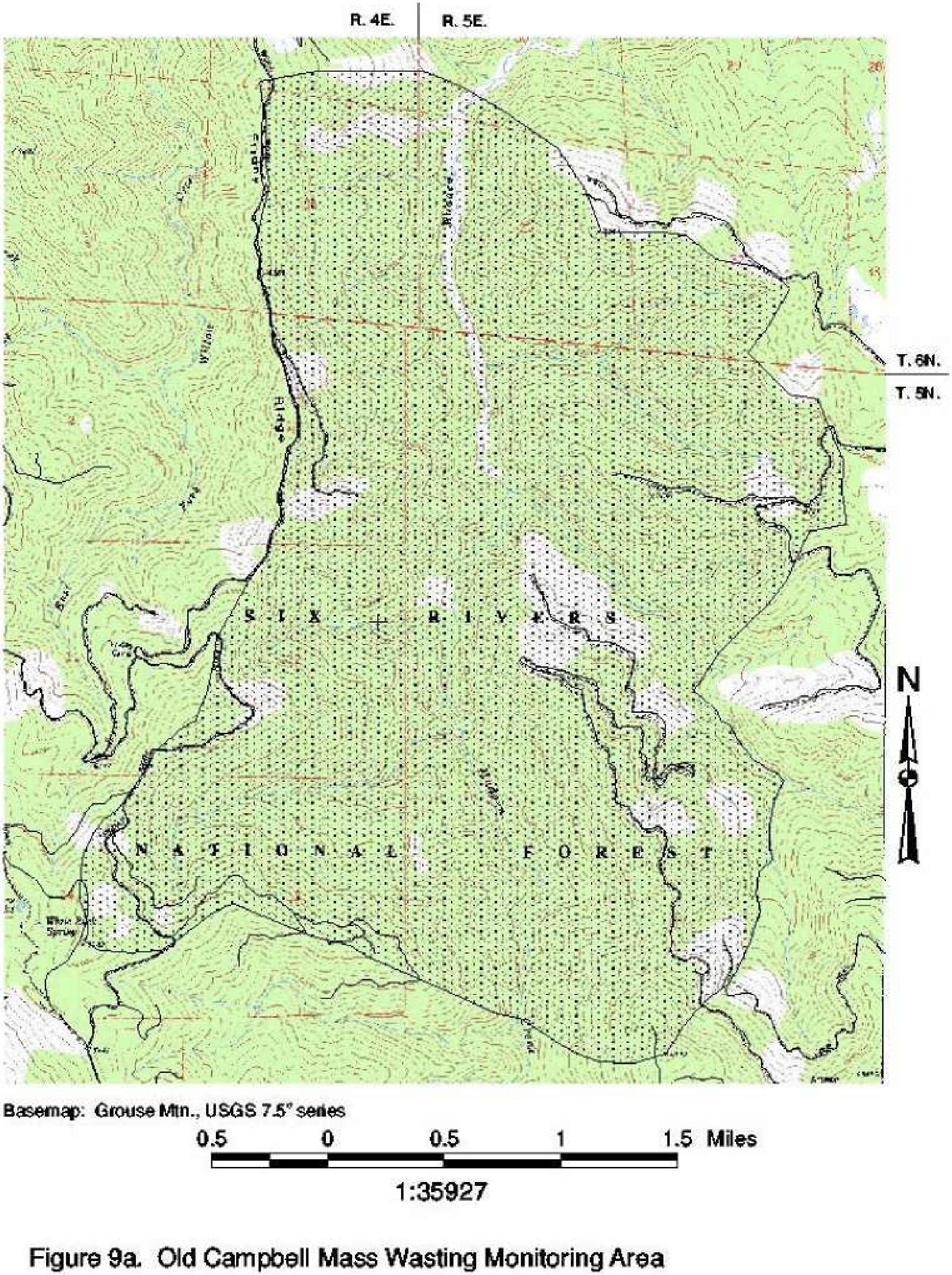


Figure 8a. Hidden Valley Mass Wasting Monitoring Area



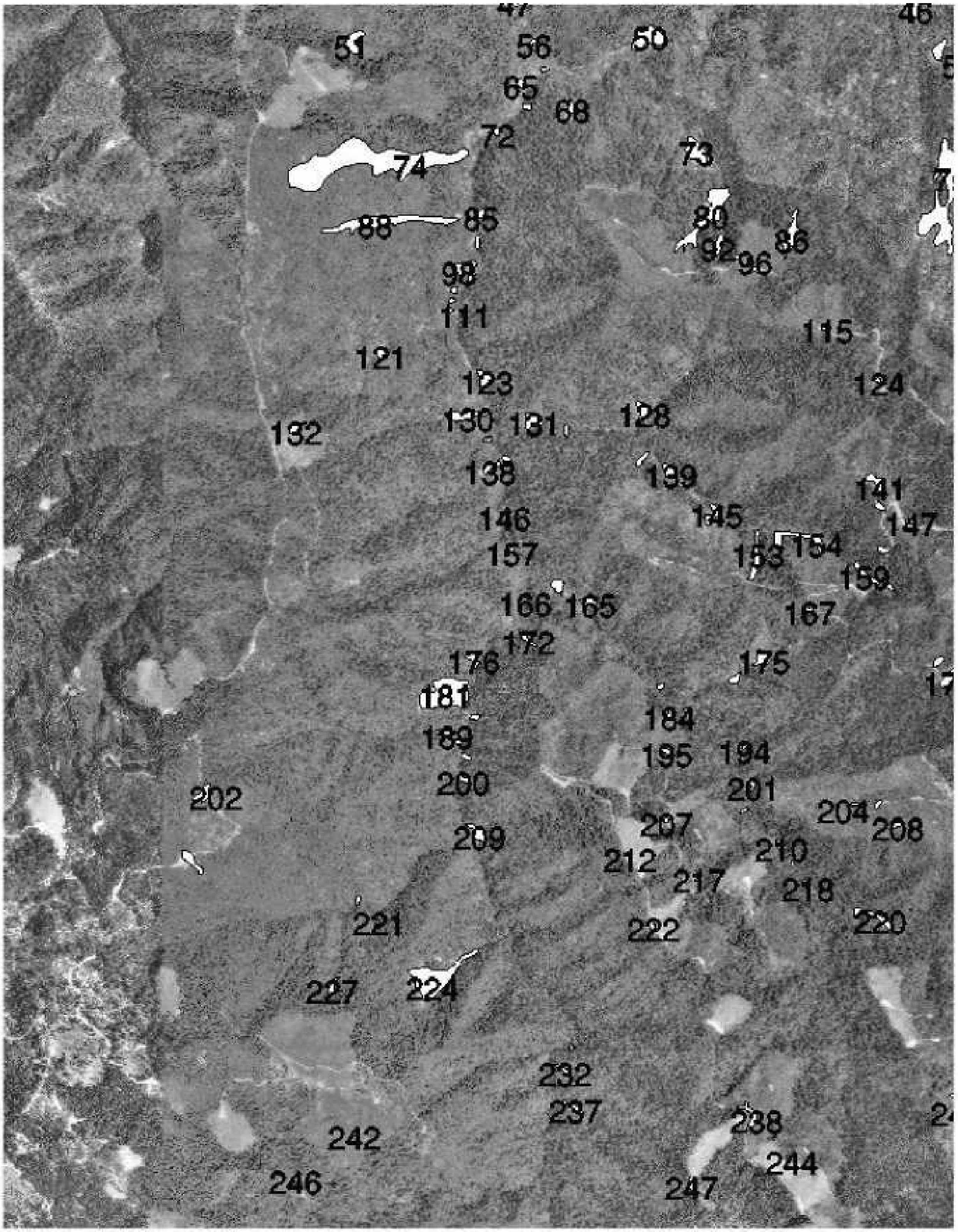
○ Active Landslides

Figure 8b. Hidden Vally Mass Wasting Monitoring Area



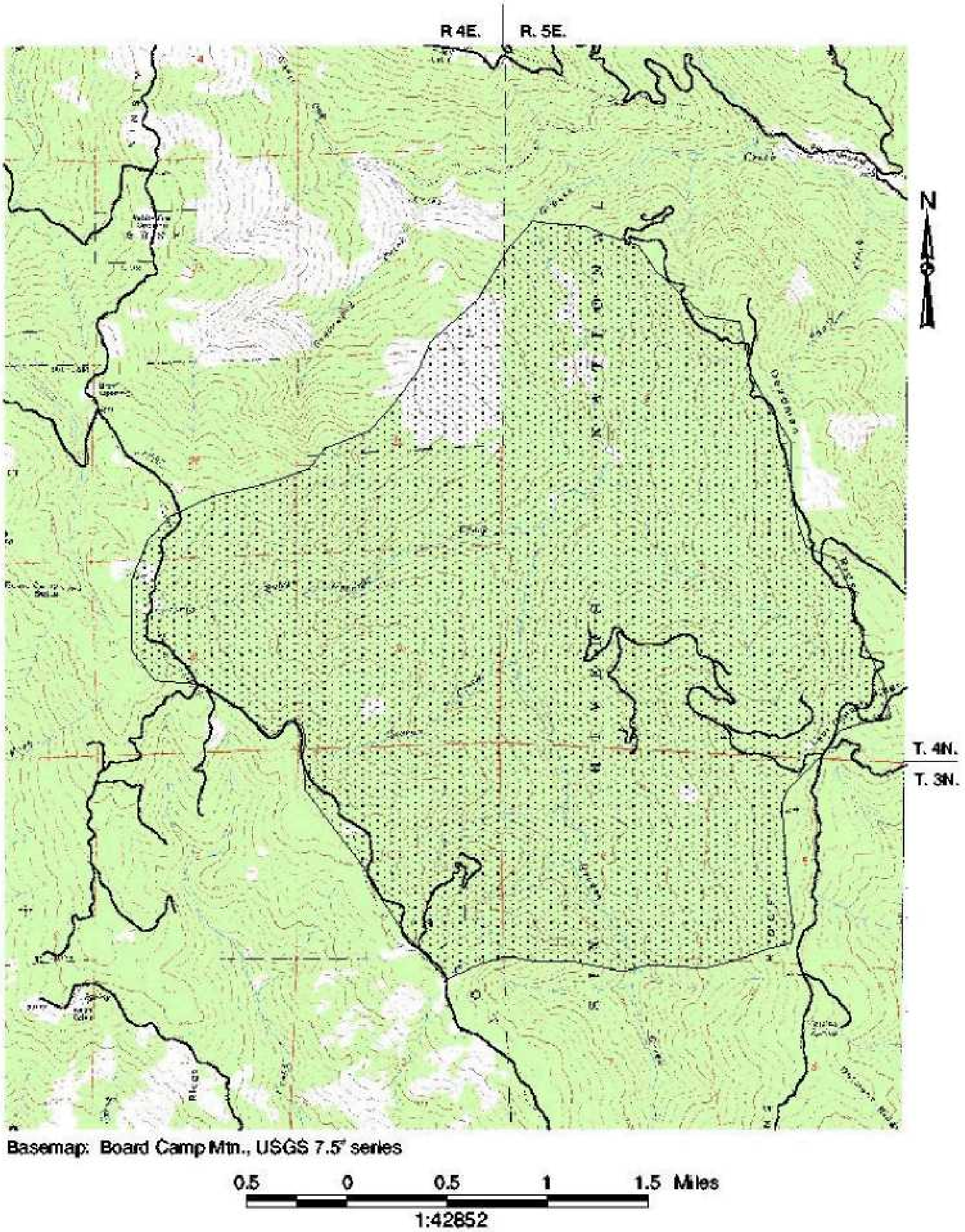
Basemap: Grouse Mtn., USGS 7.5" series

Figure 9a. Old Campbell Mass Wasting Monitoring Area



○ Active Landslides

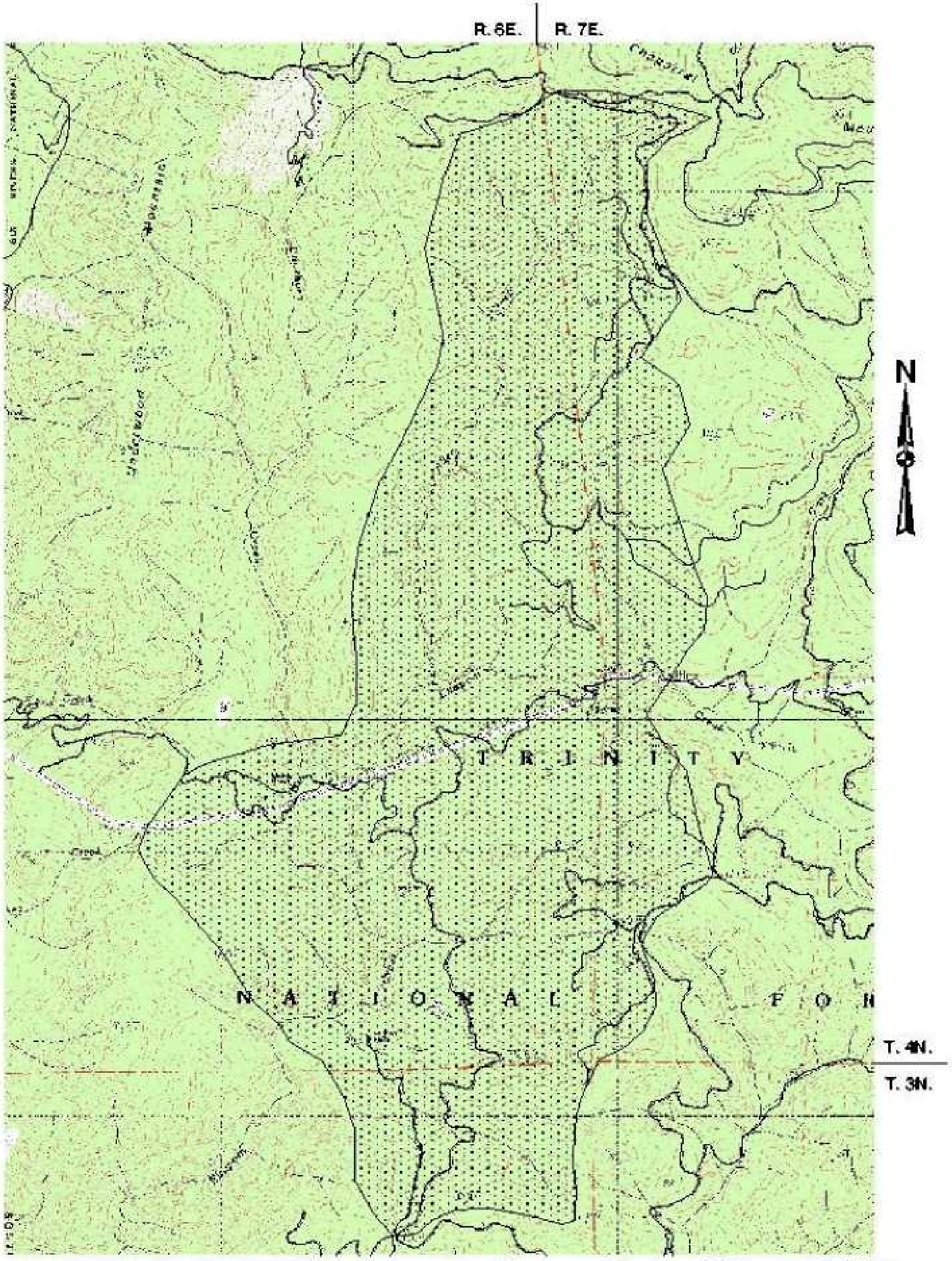
Figure 9b. Old Campbell Mass Wasting Monitoring Area



Basemap: Board Camp Mtn., USGS 7.5' series

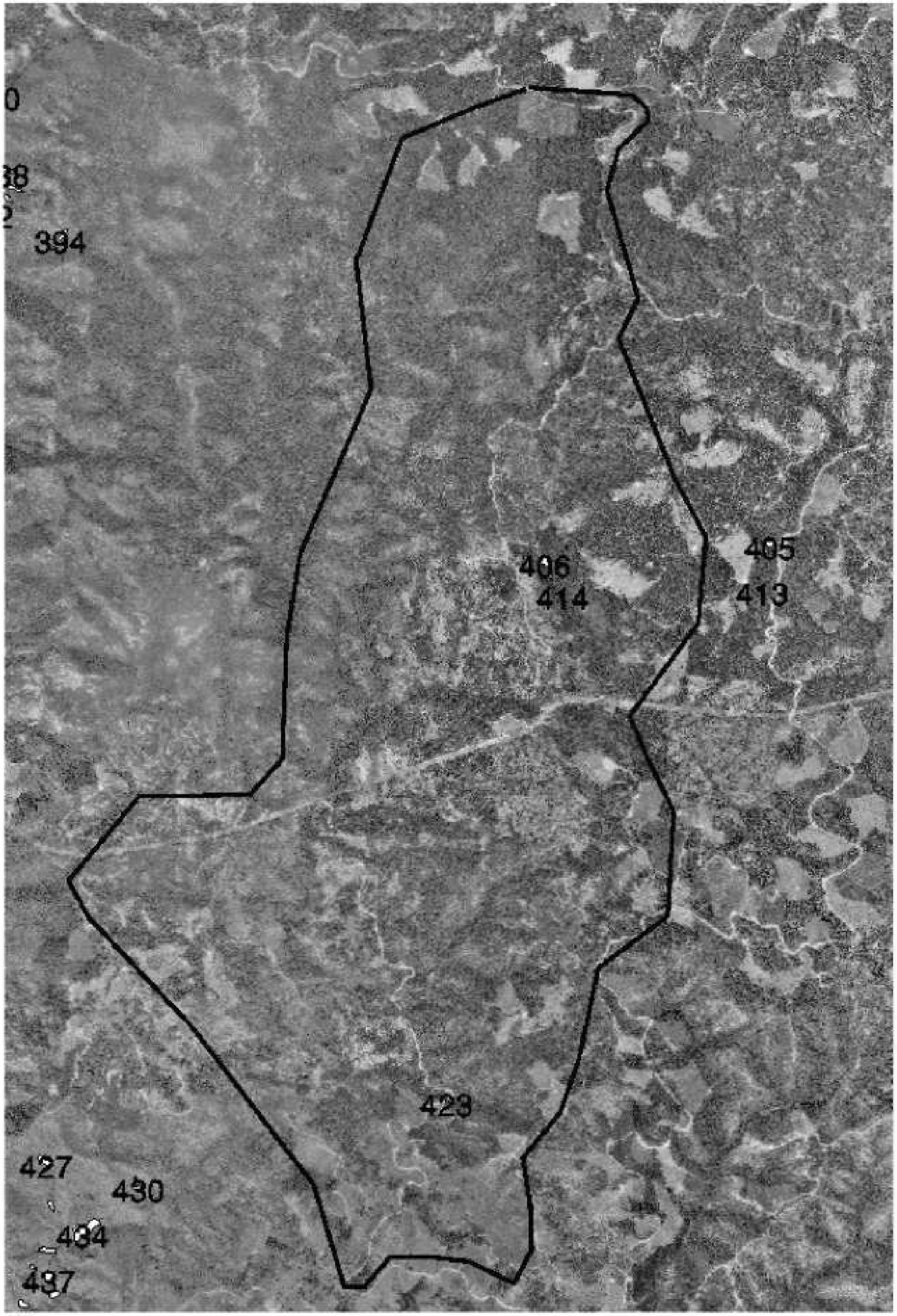
Figure 10a. Upper Grouse Mass Wasting Monitoring Area

Figure 10b. Upper Grouse Mass Wasting Area



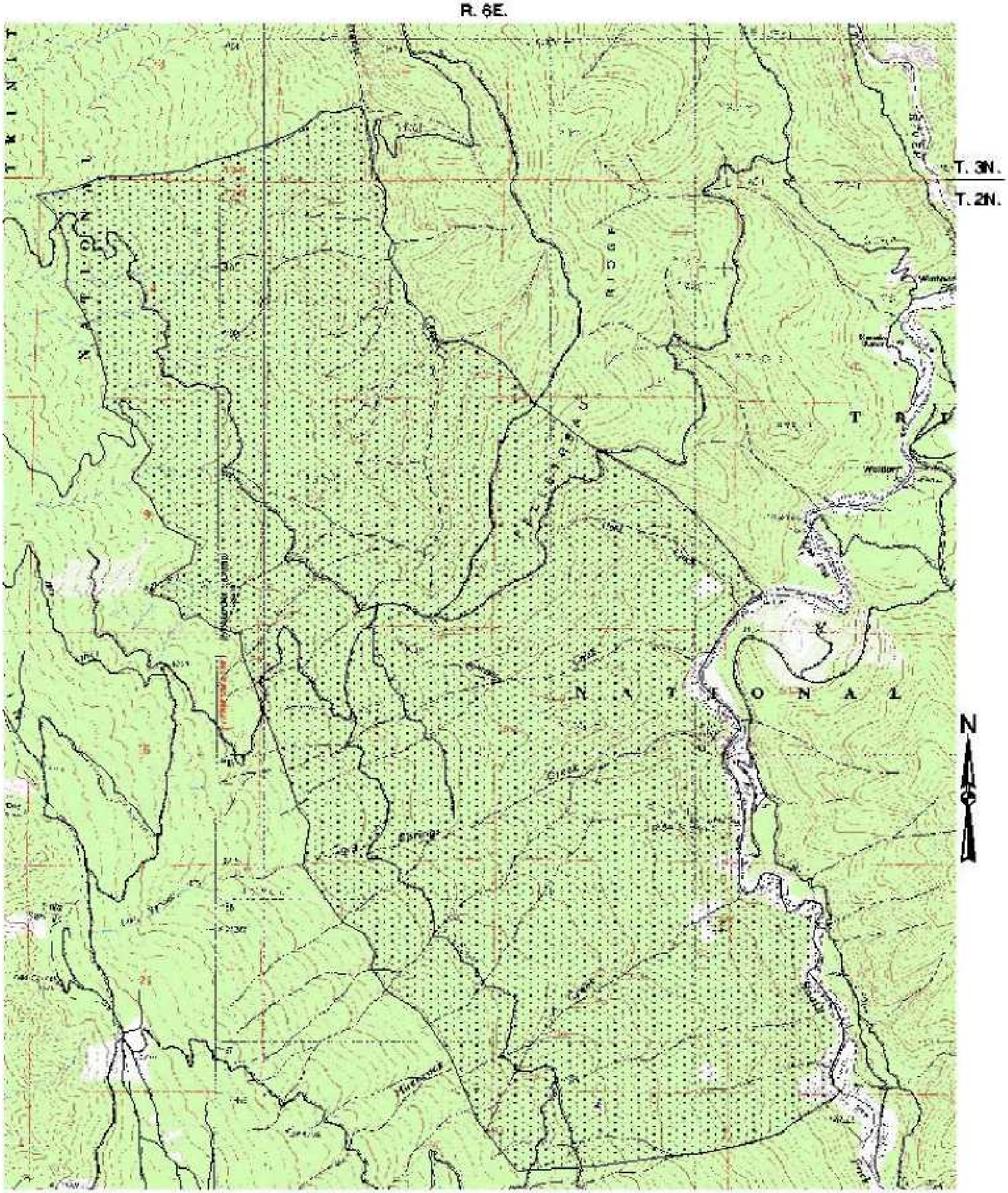
Basemap: Hyampom Mtn., USGS 7.5' series

Figure 11a. Eltapom Mass Wasting Monitoring Area



○ Active Landslides

Figure 11b. Eltapom Mass WastingMonitoring Area



Basemaps: Hyampom and Blake Mtn., USGS 7.5" series

Figure 12a. Pelletreau Mass Wasting Monitoring Area

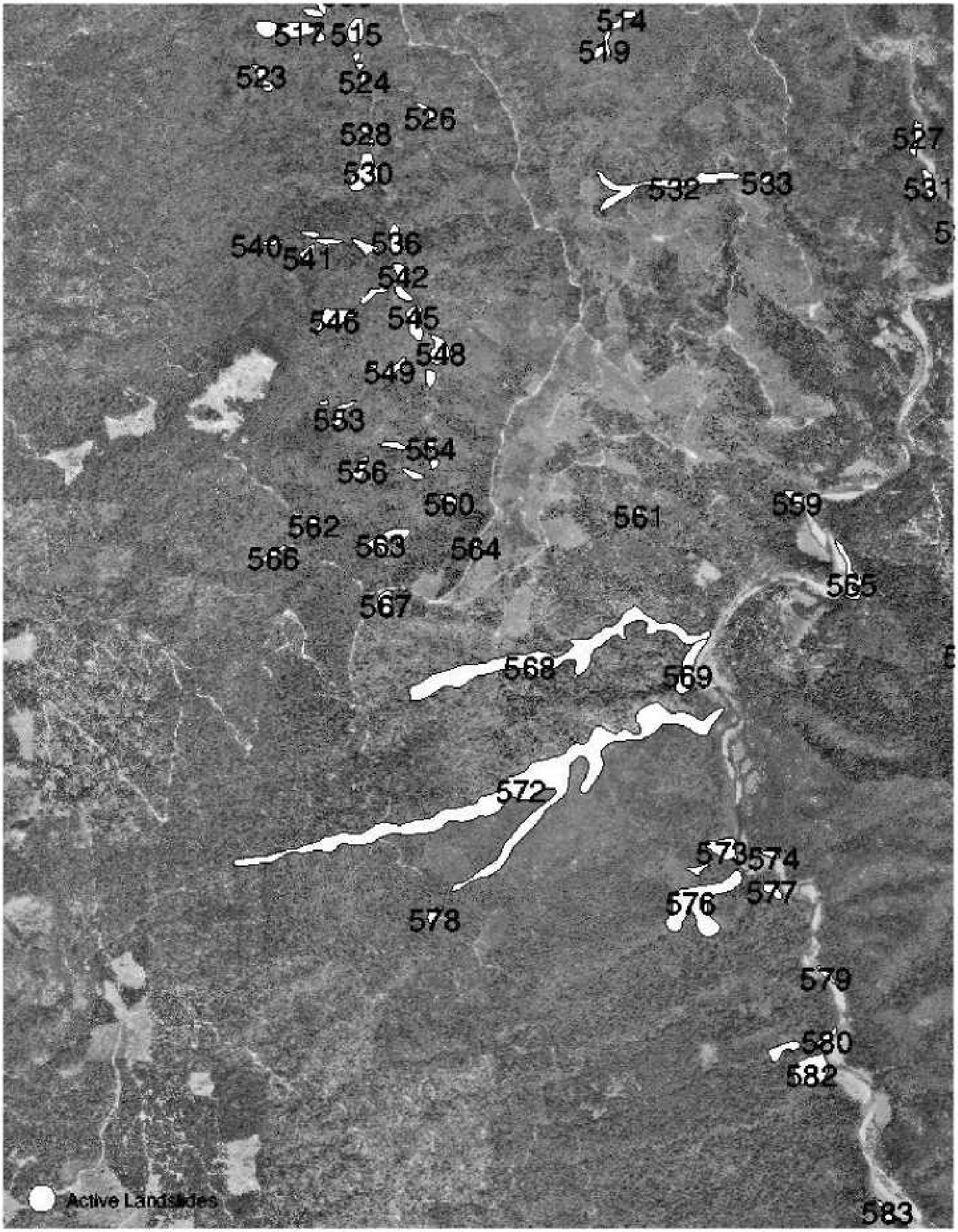


Figure 12b. Pelletreau Mass Wasting Monitoring Area

V. Results

A. Cross Section Survey Interpretation

Comparing the 2000 survey with 1998 it appears that most cross sections downcut less than half a foot (Table 1, and Figure 13). Only three of 20 cross sections aggraded, two of them in Salyer. This suggests that moderate flood flows are winnowing away at the sediment stored in the channel.

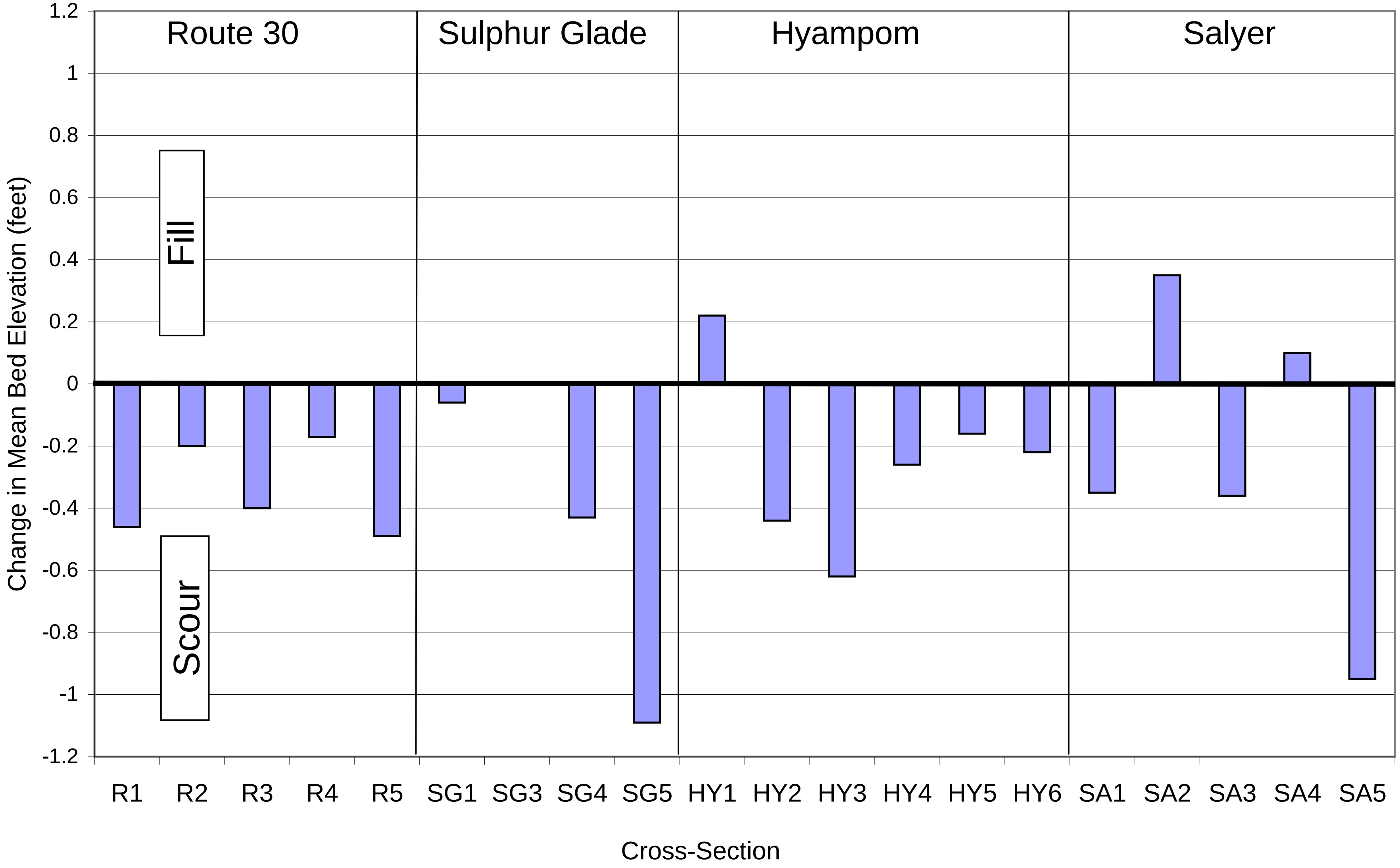
Table 1. Summary of Changes in Cross-Section Parameters

	Wetted Width Change (ft)	Mean Depth Change (ft)	Change in W:D Ratio	Change in Thalweg Elevation (ft)	Change in Mean Bed Elevation (ft)
Route 30, XS#1	-0.7	0.5	-1.4	-0.5	-0.46
Route 30, XS#2	0.8	0.2	-1.2	-0.1	-0.2
Route 30, XS#3	-4.9	0.6	-1.8	-0.4	-0.4
Route 30, XS#4	-3.0	0.2	-4.8	-0.1	-0.17
Route 30, XS#5	5.5	0.5	-4.5	-0.7	-0.49
Sulphur Glade, XS#1	-4.7	0.1	-1.7	0.1	-0.06
Sulphur Glade, XS#3	-1.8	0.0	-0.4	-0.2	0
Sulphur Glade, XS#4	2.1	0.4	-2.2	-0.1	-0.43
Sulphur Glade, XS#5	-2.2	1.1	-6.3	-3.3	-1.09
Hyampom, XS#1	-1.9	-0.2	1.4	0.3	0.22
Hyampom, XS#2	-0.5	0.4	-13.3	-0.5	-0.44
Hyampom, XS#3	0.3	0.6	-2.9	-0.4	-0.62
Hyampom, XS#4	-3.0	0.3	-3.7	-0.3	-0.26
Hyampom, XS#5	3.8	0.2	-1.0	-0.2	-0.16
Hyampom, XS#6	0.6	0.2	-1.3	0.8	-0.22
Salyer, XS#1	22.7	0.4	1.6	-1.3	-0.35
Salyer, XS#2	-2.7	-0.4	0.3	-0.8	0.35
Salyer, XS#3	2.1	0.4	-0.5	0.3	-0.36
Salyer, XS#4	7.4	-0.1	0.8	0.1	0.1
Salyer, XS#5	-3.0	0.9	-2.3	-1.0	-0.95

Between 1998 and 2000 most cross sections showed a minor decrease in their width to depth ratio (all but three cross sections got relatively narrower and deeper) (Figure 14). The pattern is similar to the change in mean bed elevation because the South Fork Trinity is generally confined, therefore width changed very little.

A similar index is the change in cross sectional area. This is the area under the bankfull water surface, the elevation of which is assumed constant. Again, most cross sections showed scour and an increase in the area of the bankfull channel (Figure 15).

Figure 13. Change in Mean Bed Elevation, 1998-2000



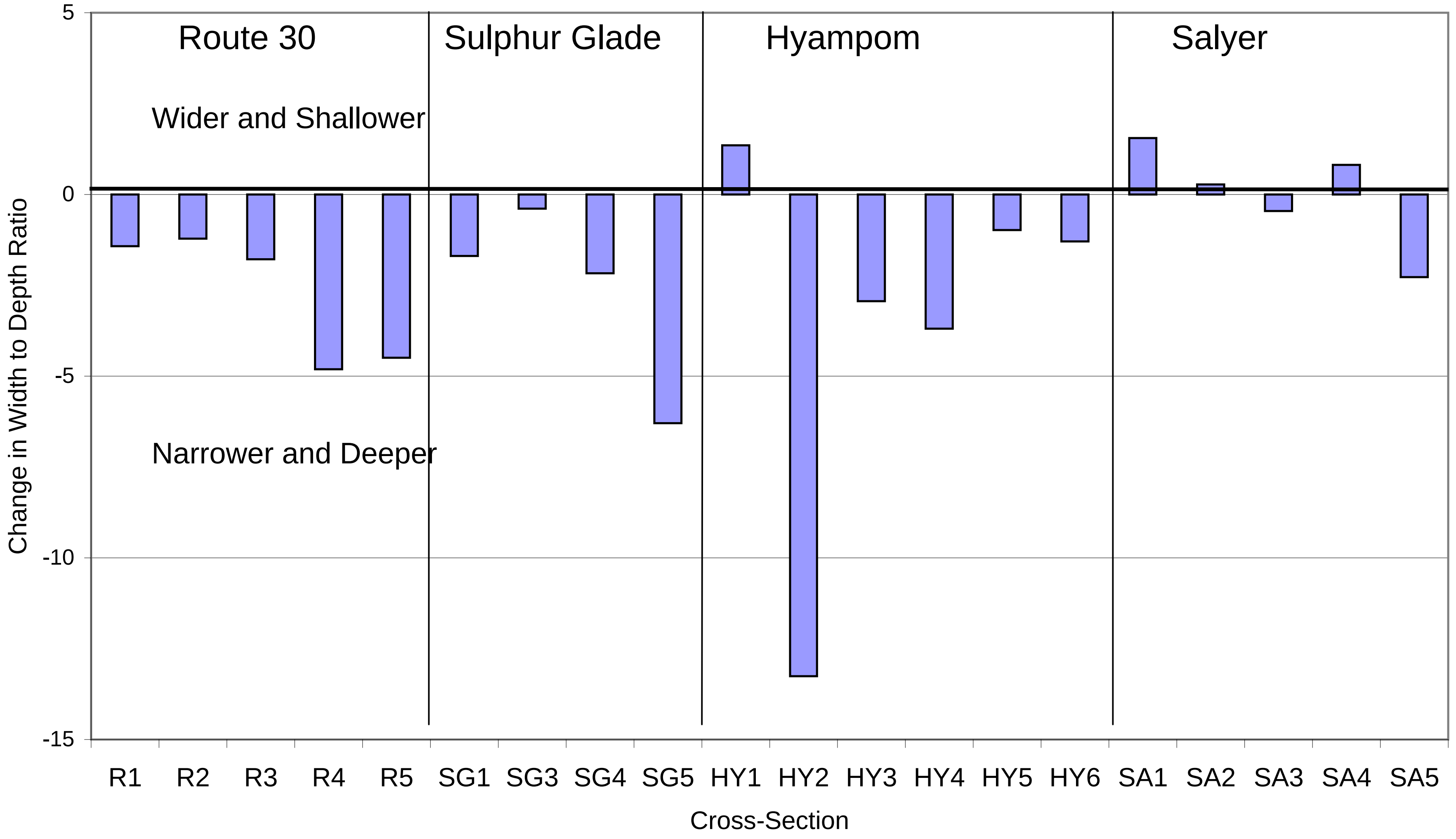
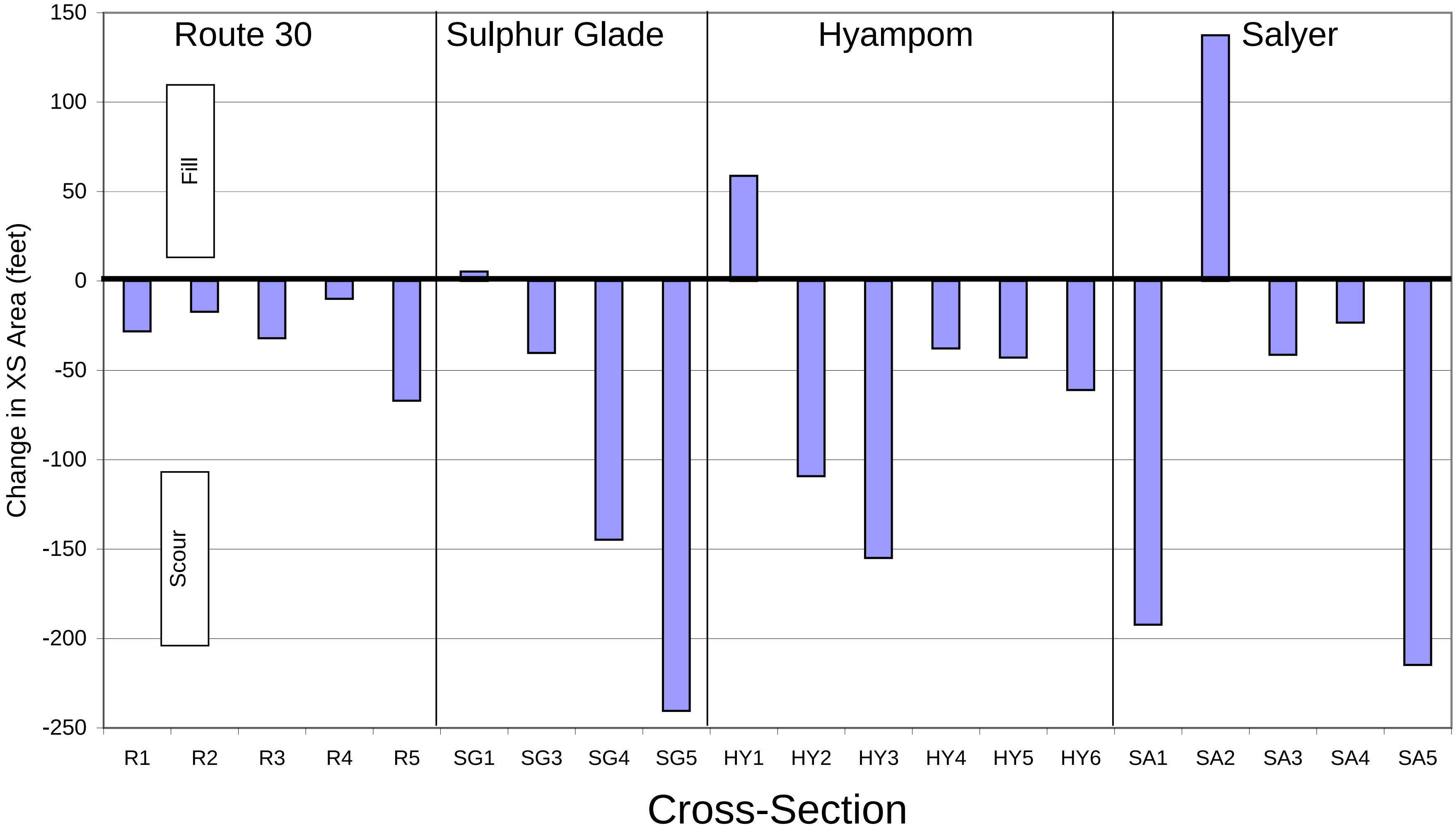


Figure 14. Change in Width to Depth Ratio
1998-2000

Figure 15. Change in Cross-Sectional Area
1998-2000



These three indices clearly indicate that the South Fork Trinity River is degrading, although the magnitude of the change is relatively small.

B. Longitudinal Profile Interpretation

Data from the profile surveys show the opposite trend of the cross section data. The pool/riffle ratio decreased, riffle length increased, number of pools decreased, R2 indicated less complexity of the channel bed, and although maximum pool depth went up, mean residual water depth went down (Table 2, Figure 16). These all are believed to indicate signs of aggradation.

Table 2. Summary of Changes in Longitudinal Profile Parameters.

	RTE 30	S.G.	Hyampom	Salyer
Length	-11	-837	-68	-1153
Number of Pools	-2	-11	-7	1
Maximum Pool Depth	2.6	0.8	-0.7	2.1
Mean Pool Depth	-0.1	1.12	0.04	-0.25
Mean Residual Water Depth	-0.28	-0.11	-0.37	-0.03
Percent of Reach in Pools	-9.0	-13.9	-10.7	-2.5
Percent of Reach in Riffles	9.0	13.9	10.7	2.5
Pool/Riffle Ratio	-0.76	-3.01	-0.86	-0.82
Mean Riffle Length	39.4	100.8	70.4	11.8
Slope (%)	-0.0001	-0.0005	0.0003	0.0001
R-Squared value	0.0083	0.0059	-0.0174	-0.0268
Mean Bedform Elev. Difference	0.19	0.37	0.33	0.36

C. Pebble Count Interpretation

The repeated sampling of streambed gravels should illustrate trends in sediment size and whether the channel is impacted by fine sediments. If the South Fork Trinity is recovering from sedimentation associated with the 1964 flood, we would expect an increase in the size of the D50, and a decrease in the proportion of sediment finer than 2 mm.

Changes in the pebble count were highly variable with no consistent trend (Table 3). About half the cross sections got coarser and half got finer. The most consistent trend was the reduction in the portion of bed material finer than 2 mm. Reduction in the proportion of fines was observed on 15 of 18 cross sections (83%).

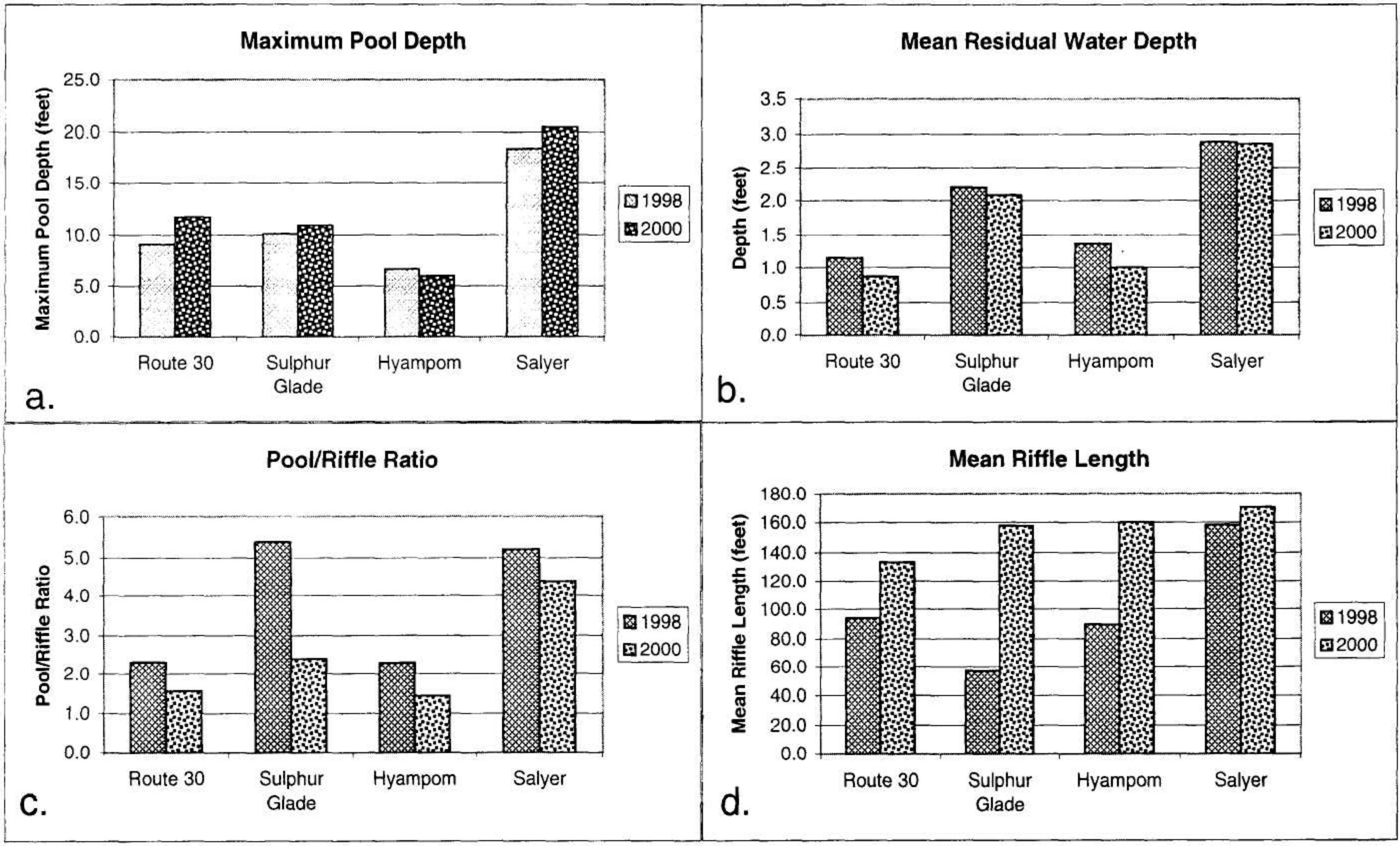


Figure 16a-d. Changes in Longitudinal Profile Characteristics.

Table 3. Changes in Particle Size Distribution Parameters.

	Change Percent Less Than 2 mm	Change D50 (mm)	Change Dmean (mm)	Change D84 (mm)
Route 30, XS#2	-7.6	-0.9	-51.0	-16.6
Route 30, XS#3	-10.0	20.5	-46.8	62.0
Route 30, XS#4	-6.6	-2.4	-41.0	-7.1
Route 30, XS#5	9.8	-65.2	-48.3	-63.6
Sulphur Glade, XS#1	0.4	6.2	-1.9	-30.5
Sulphur Glade, XS#2	-11.2	12.7	-104.3	-3.8
Sulphur Glade, XS#3	-4.0	-6.5	-13.1	-17.3
Sulphur Glade, XS#4	-12.2	21.3	6.7	3.2
Sulphur Glade, XS#5	-1.0	7.2	30.0	67.1
Hyampom, XS#1	-37.5	10.6	-21.3	2.1
Hyampom, XS#2	-8.6	0.4	0.5	-9.1
Hyampom, XS#3	-1.1	2.5	4.2	5.4
Hyampom, XS#4	-1.2	-10.3	10.0	22.2
Hyampom, XS#5	8.4	-1.4	23.3	11.0
Hyampom, XS#6	-5.8	6.9	4.7	2.6
Salyer, XS#2	-9.5	-64.3	19.1	-10.6
Salyer, XS#4	-6.7	-15.9	-6.6	-25.3
Salyer, XS#5	-15.8	3.7	5.5	7.0

V. Discussion

Route 30 Reach

The Route 30 Reach showed consistent but minor degradation of the cross sections. Mean bed elevation, thalweg elevation and width to depth ratio all decreased. Mean depth increased. Change was most pronounced at Cross Section #5 where a large conifer had fallen across the cross section in late 1998. The woody debris in the active channel has been effectively removed, but scour associated with the log remaining on the left bar has created 2-foot deep scour hole on the cross section.

Maximum pool depth increased (the confluence pool at the mouth of the East Fork). Scour may have been increased by flow constrictions caused by collapse of a large riparian maple tree into the center of the pool. Mean pool depth and mean residual water depth for the reach as a whole decreased slightly. Mean riffle length and percent of reach in riffles increased. These are usually signs of aggradation.

Sulphur Glade Reach

All cross sections in the Sulphur Glade Reach showed a decrease in mean bed elevation, thalweg elevation and width to depth ratio. Although Cross Section #1 had a slight decrease in cross sectional area, the other cross sections showed increased channel capacity consistent with degradation. The 1998 survey of Cross Section #2 is seen to be in error and unusable. The 1998 survey of Cross Section #5 is presented here, although the data is highly suspect. In the future, data from 2000 should be used to detect changes in cross section #2 and #5.

Although the number of pools decreased dramatically, both maximum pool depth and mean pool depth increased. Consistent with fewer pools, mean riffle length and percent of reach in riffles increased. Mean residual water depth decreased, indicating aggradation.

Hyampom Reach

In the Hyampom Reach, Cross Section #1 showed some aggradation while all other cross sections showed degradation. Cross Section #1 is placed at the head of Hyampom Valley and is expected to be the most sensitive and first to respond to sediment pulses from upstream. It is somewhat surprising that the aggradation at Cross Section #1 was not observed at Cross Section #2, which is only 300 feet downstream. Cross Section #2 showed lowering of the right side of the mid-channel bar as well as erosion (probably from upstream migration) of the transverse riffle crest along the left bank. The other noticeable change in the Hyampom reach was the removal of the lateral bar near the right bank of Cross Section #6.

In contrast to the cross section data, profile analysis indicates fewer pools, reduction of maximum pool depth as well as mean residual water depth, and an increase in mean riffle length and percent of reach in riffles. Mean pool depth increased, but only slightly.

Salyer Reach

The Salyer reach had the most inconsistent results of the four reaches. Two of the cross sections showed an increase in mean bed elevation while three cross sections showed a decrease in mean bed elevation. Only two cross sections showed a decrease in the width to depth ratio. This suggests that some areas of the channel are aggrading and some areas are scouring out.

Profile data for the Salyer reach shows more consistent evidence of aggradation (fewer pools, reduced mean residual water depth, longer riffles, etc.), although the magnitude of these changes is the smallest of any of the reaches. This is surprising because the Salyer Reach is much larger and changes would be expected to be larger. The fact that changes are proportionally much smaller than the other reaches suggests channel change has been minimal.

There is one explanation for disagreement between the cross section and longitudinal profile results. The cross-section data are derived from a fixed elevation. That is, downcutting is not relative but absolute. The channel is so many feet lower than a fixed point. The profile data on the other hand is totally relative. Pool definition and water depth are all determined from the relative elevation of the channel bed to the downstream riffle crest. Thus, if you could magically remove exactly one foot from every part of the streambed, the cross-sections would show an erosion of one foot but the profile characteristics would be unchanged.

One hypothesis is that something like this occurred between 1998 and 2000, only instead of no change in profile characteristics, some decreased proportion of sediment is being stored on the riffles and causing a subsequent decrease in mean water depths. The most likely cause of this is the lack of high flood flows necessary to scour the pools and increase channel complexity. There was a small flood in 1997, which may have increased channel complexity, the results of which we surveyed in 1998. Since that time, only moderate flows (up to bankfull) have occurred. Perhaps these flows have only enough power to winnow away some of the smaller particles and not enough to scour out the pools. That would explain the observed data with the bed going down and the water depth also decreasing, and would be consistent with the reduction in the proportion of fine sediment observed.

It is possible that the changes observed in the South Fork Trinity River are just not great enough to conclusively determine if the channel is downcutting. The cross-section data show a lowering of the bed, but the fact that mean residual water depth also declined suggest that channel response is complex and dynamic. Future surveys should determine whether there is a trend of increasing riffles and decreasing water depth or whether this set of data is anomalous. One hypothesis is that cross sections will continue to downcut and that after the next moderate flood flow, water depth and riffle length will return to 1998 levels.

Hillslope Sediment Source Trend Monitoring

No hillslope sediment source trend monitoring has occurred to date because this monitoring is triggered by landslide producing storm events. No significant events have occurred since the baseline hillslope sediment source inventory protocol was established in 1998.

References

Berol, E., 1995. “A River History: Conversations with Long-Term Residents of the Lower South Fork Trinity River”. Report prepared for Patrick Truman and Associates and South Fork Coordinated Resource Management Planning Group.

Borok, S.L. and H.W. Jong, 1997. “Evaluation of Salmon and Steelhead Spawning Habitat Quality in the South Fork Trinity River Basin, 1997”. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 97-8

California Department of Water Resources, 1979. “South Fork Trinity River Watershed Erosion Investigation”. California Department of Water Resources, Northern District, Red Bluff, CA.

California Department of Water Resources, 1992. “South Fork Trinity River Sediment Investigation”. California Department of Water Resources, Northern District, Red Bluff, CA.

Dean, M., 1994. “Life History, Distribution, Run Size, and Harvest of Spring Chinook Salmon in the South Fork Trinity River Basin”. Chapter VII. Job VII. P.193-227. In: K.Urquhart and R.M. Kano (eds.). “Annual Report, Trinity River Basin Salmon and Steelhead Monitoring Project, 1991-1992 Season”. California Department of Fish and Game, Inland Fisheries Division, Sacramento, CA. 235 p.

Gilroy, M.M., M.K. Arey and G. Tanaka, 1992. “Trinity River Basin Restoration Program, South Fork of the Trinity River Habitat Typing Report 1991”. Prepared for USDI Bureau of Reclamation, Interagency Agreement No. 9-AA-20-08530, USDA Forest Service, Shasta-Trinity National Forest, Hayfork, CA.

Harrelson, C.C., C.L. Rawlins and J.P. Potyondy, 1994. “Stream Channel Reference Sites: an illustrated guide to field technique”. General Technical Report RM-245. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Haskins, D.M., and R.A. Irizarry, 1988. “A Holistic Appraisal of Cumulative Watershed Effects on Watershed Condition and Fisheries, South Fork Trinity River, Northwestern California”. USDA Forest Service, Shasta-Trinity National Forest, Redding, CA.

Leopold, L.B. 1994. *A View of the River*. Harvard University Press, Cambridge, MA. 298 p.

Llanos, A., Cook, C., and A. Dresser. 2001. Measurement of Sediment Storage and Streambank Erosion in the South Fork Trinity Watershed, Northwestern California. USDA, Forest Service, Six Rivers National Forest, Eureka, CA.

Madej, M.A., 1999. Spatial and Temporal Changes in Thalweg Profiles. Earth Surface Processes and Landforms.

Montgomery, D.R., and J.M. Buffington, 1993. "Channel classification, prediction of channel response, and assessment of channel conditions", TFW-SH10-93-002, Timber, Fish, and Wildlife Agreement, Department of Natural Resources, Olympia, Washington. 84 p.

Pacific Watershed Associates. 1994. Action Plan for Restoration of the South Fork Trinity River Watershed and its Fisheries. Prepared for U.S. Bureau of Reclamation and the Trinity River Task Force

Province of British Columbia, 1996. Forest Practices Code of British Columbia Channel Assessment Procedure Field Guidebook. 95 p.

Raines, M., 1999. "South Fork Trinity River Sediment Source Analysis". Final report prepared for Tetra Tech, Inc.

Shasta-Trinity National Forest, 1989. "South Fork Trinity River Watershed and Fisheries Monitoring Plan".

Shasta-Trinity National Forest, 1990. "Annual Progress Report for South Fork Trinity River Watershed and Fisheries Monitoring Program".

Shasta-Trinity National Forest, 1989. "Annual Progress Report for South Fork Trinity River Watershed and Fisheries Monitoring Program".

Six Rivers National Forest, 1998. "Lower South Fork Trinity Watershed Analysis".

Wolman, M.G., 1954. "A Method of Sampling Coarse Gravels". Transactions, American Geophysical Union 35:951-95

Appendix A: Location And Access

Reach 1 - Route 30

The Route 30 reach is so named because Forest Service Route 30 (the “wild-mad road" which runs roughly from the town of Wildwood to the town of Ruth) crosses the South Fork Trinity River here. The reach begins at a big pool approximately 500 ft upstream of the bridge and extends downstream approximately 3000 ft downstream of the bridge.

The upstream section of the reach, above the confluence with the East Fork of the South Fork, was originally surveyed in 1989 by the Shasta-Trinity National Forest as part of their watershed monitoring after the 1987 fires. Surveys were conducted again in 1990 and then abandoned. They monumented six cross sections, only two of which could be found in 1998. We surveyed those two cross sections in addition to our usual 5, which are all downstream of the confluence.

To get to the Route 30 bridge from Eureka, take Highway 36 east to Mad River, turn south on the Ruth Rd., go past Ruth and pick up Route 30 at Barry Creek. Follow Route 30 up over South Fork Mountain at Cedar Gap and down to the South Fork. Total drive time from Eureka is about 3 hours. From the North or East, pick up Route 30 on Highway 36 about 2 miles west of Wildwood and follow it south to the South Fork Trinity. Be aware that from the north the first bridge will be over the East Fork. The South Fork is another few miles. From the north the bridge is about 1 hour from Highway 36 at Wildwood.

On the bridge itself, on the northwest corner, there is a carriage bolt sunk into the concrete of the bridge. This is the benchmark for the upper part of the reach. Two other benchmarks exist on the Route 30 reach. One is a brass cap that we set on top of a giant (15-foot diameter) boulder that sits mid-channel about halfway down the reach. The other is a piece of rebar set in the concrete we poured around the data storage capsule (sometimes called a “nipple") at the end of the reach. This benchmark is located about 100 feet upslope on the left bank above a big bedrock outcrop. Photos of all benchmarks were taken to help locate them and the benchmarks were all GPS'ed.

Besides photos of the cross sections, only one photo point exists for this reach. Photos were taken from the bridge, looking upstream and looking downstream.

Although a trail runs along the right bank, and an old road runs along the left bank, the fastest access to all parts of the reach is down the channel.

Reach 2 - Sulphur Glade

We named this reach the Sulphur Glade reach because originally it was intended to stretch from the mouth of Sulphur Glade Creek to the mouth of Hitchcock Creek. Actually, the reach begins downstream of French Ranch, but we still call it the Sulphur Glade reach. Immediately downstream from French Ranch there is a huge bar/terrace along the right bank and then the valley walls close in. Right where the valley begins to open up again is the start of the reach. It ends at the mouth of Hitchcock Creek.

To get to the Sulphur Glade reach, take the St. Johns Road (County 316) from Hyampom to the end of the road (approximately 45 minutes from Hyampom). The road ends at a little parking area at the trailhead for the South Fork Trinity River Scenic Trail. This trail is the only access to the reach without crossing private property. Follow the trail south until it comes down to the river (about a 20-minute hike). This is near cross section #3, approximately in the middle of the reach.

The data storage capsule is here, east of the trail about 100 feet, in a copse of small oaks. Look for a small boulder embedded in the trail, then turn your head to the left and look for reflectors mounted on bearing trees around the data storage capsule. A rebar here also serves as a benchmark for the middle part of the reach.

We installed a brass cap at the upper end of the reach on a 15-foot diameter boulder imbedded in the right bank at about bankfull level. This is the benchmark for the upper part of the reach. We installed another benchmark near the bottom of the reach. This is a rebar set in concrete in the middle of the big meanders, very close to cross section #5. It should be noted that the last time we were there someone had vandalized the site. They didn't have much luck mauling the rebar or cement, but they ripped out all our flagging and reflectors and attempted to cover the benchmark with debris. Be prepared to look around - it's there somewhere. Also, Pin#3 had been damaged but Pin#4 was in good condition.

Sulphur Glade has some nice photo points. On the right bank of the two prominent meanders are two prominent landslides. There is a good view down on the channel from here and both were used as photo points, looking both upstream and downstream. The trail passes very close to one of the slides; the other one may take a little deduction to figure out. Upstream from cross section #3 a HUGE boulder (60-foot diameter) is visible on the left bank. It is possible, with aide from a small alder on the downstream side, for an agile hydrologist to get up there and it provides an excellent view of the channel. The top of this rock was also used for photo monitoring..

The brass cap, data storage capsule, and cross sections #1, #3, #4, and #5 were GPS'ed. For the lower benchmark, find cross section #5 pin#3 (GPS'ed) and look about 50 feet downstream.

Hiking up to the trail from cross section #5 will save time.

Hyampom Reach

This reach begins in the gorge above Hyampom Valley and runs down past the confluence with Hayfork Creek to the old bridge site near Gene Rickstrew's driveway. The fastest way to get there from Eureka is to take Highway 299 to Forest Service route 60, which runs from Burnt Ranch to Hyampom. Allow one hour to get to Route 60 and another hour to get to Hyampom.

The upper part of the reach requires belly-deep wading. Access to the very top of the reach can be made by taking the trail along the left bank and dropping down a little ridge. The lower section is generally shallow.

There are three brass cap benchmarks on this reach. The most upstream one is a brass cap set by the USGS to reference their gauging station. The gauging station is gone but the cap remains, on the left bank about halfway down the straightaway from the gorge. Cross section #1 is about 5 feet upstream of the cap. The second benchmark is a brass cap near the northeast corner of the bridge. The third, visible from the bridge, is about 400 feet downstream of the bridge, on a 15 foot diameter boulder in the channel near the left bank. Although no cap was set at the bottom of the reach, we surveyed the old bridge footing on the left bank down by Gene Rickstrew's place intending that to be a benchmark for the lower part of the reach.

The data storage capsule is near the old USGS gauging station - right by their old cableway. Part of the cable still protrudes from the rock, about 5 feet downstream of the data storage capsule. This is a large rock outcrop on the right bank, a few hundred feet from the gorge.

Cross Sections #1 and #2 are near the old USGS gauging station. Cross section #3 is underneath the powerlines by Lover's Leap. Cross Section #4 is just upstream of the bridge. Cross Section #5 is approximately 500 feet downstream from the bridge. Cross section #6 is at the old bridge site near Rickstrew's place.

The only photo points established for the Hyampom reach are from the bridge, looking upstream and downstream.

Salyer Reach

Although closest to Eureka, the Salyer reach is the most difficult to survey. It begins at John Shocker's place, approximately river mile 6, and runs to the mouth of Old Campbell (previous to 1997 known as Madden) Creek, approximately river mile 1.5. Both these places are access points (use Sandy Bar for access to Old Campbell Creek). The only other access is at mile 3. The owner of ``the mansion", Mr. McCoy, may be willing to permit access on his property given enough notice. John Schocker has been extremely kind and helpful; allowing us access with short notice and letting us camp on his property.

The biggest problem with access to this reach is that the channel is confined and the water is deep. Swimming or boating is required. The survey equipment we used was not waterproof so we used a canoe to transport it from station to station. This required extra time for shuttling vehicles, and because this reach can generally only be traveled in one direction (downstream).

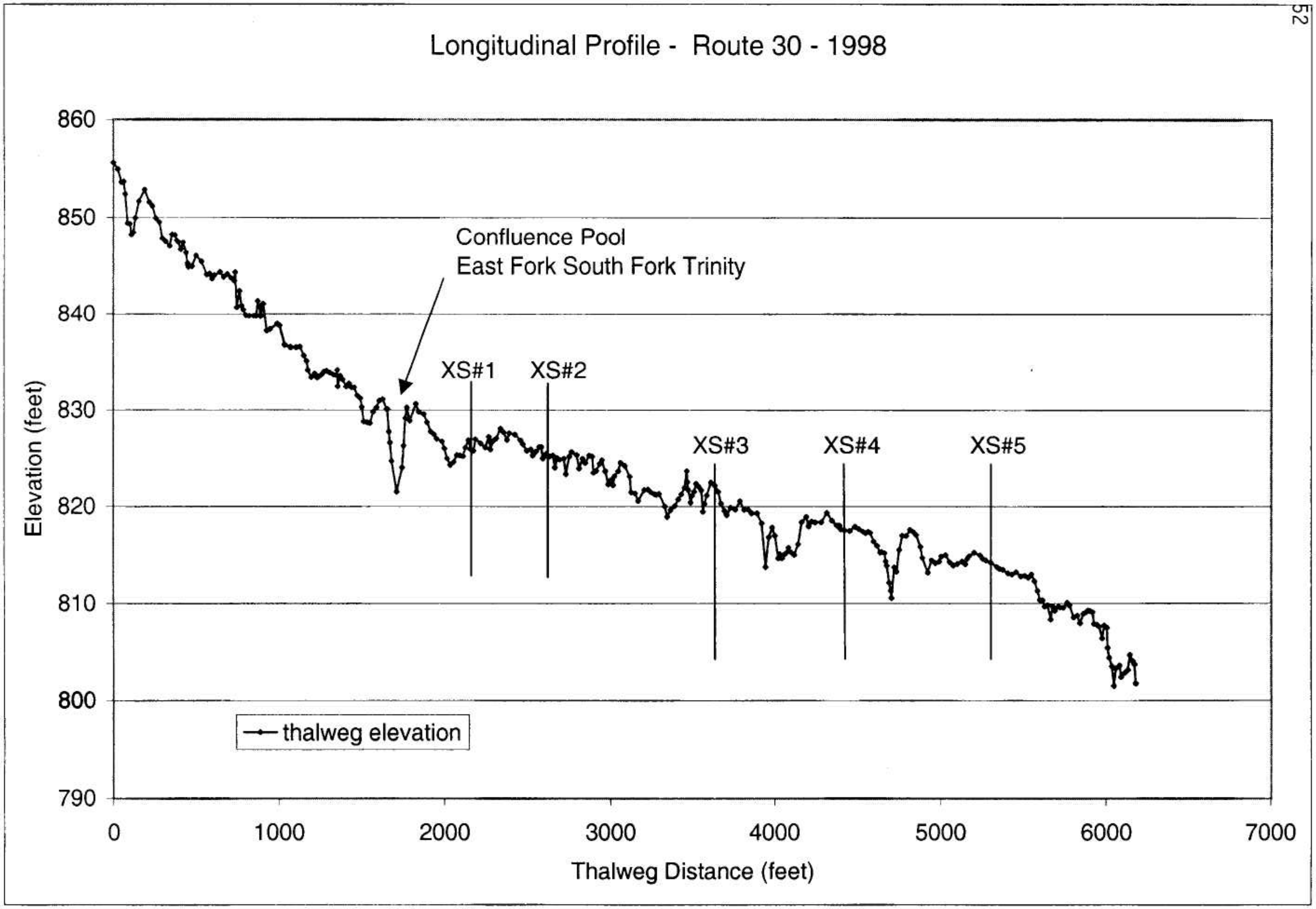
There are four benchmarks. The reach starts at an old property corner on John Shocker’s land (the property boundary has been moved but the marker remains). It looks like a fat piece of rebar with a stout cap and sits right next to the cliff on the right bank. The reach starts here. The second monument is a brass cap set by Forest Service surveyors. It is on the terrace at mile 3, sort of on the northwest end of the terrace, in what used to be the road (no longer driveable). Several bearing trees are there to help you. We set the data storage capsule here about 5 feet from the cap. The third benchmark is a property corner (aluminum cap on pipe) up the hillside on the left bank about mile 2.3 (south section 22). The fourth benchmark is a brass cap we installed in a crack in the rock on the right bank across from the mouth of Old Campbell Creek. The rock outcrop there is in two pieces. The cap is on the north end of the south piece (i.e., hike up the rock from the south side).

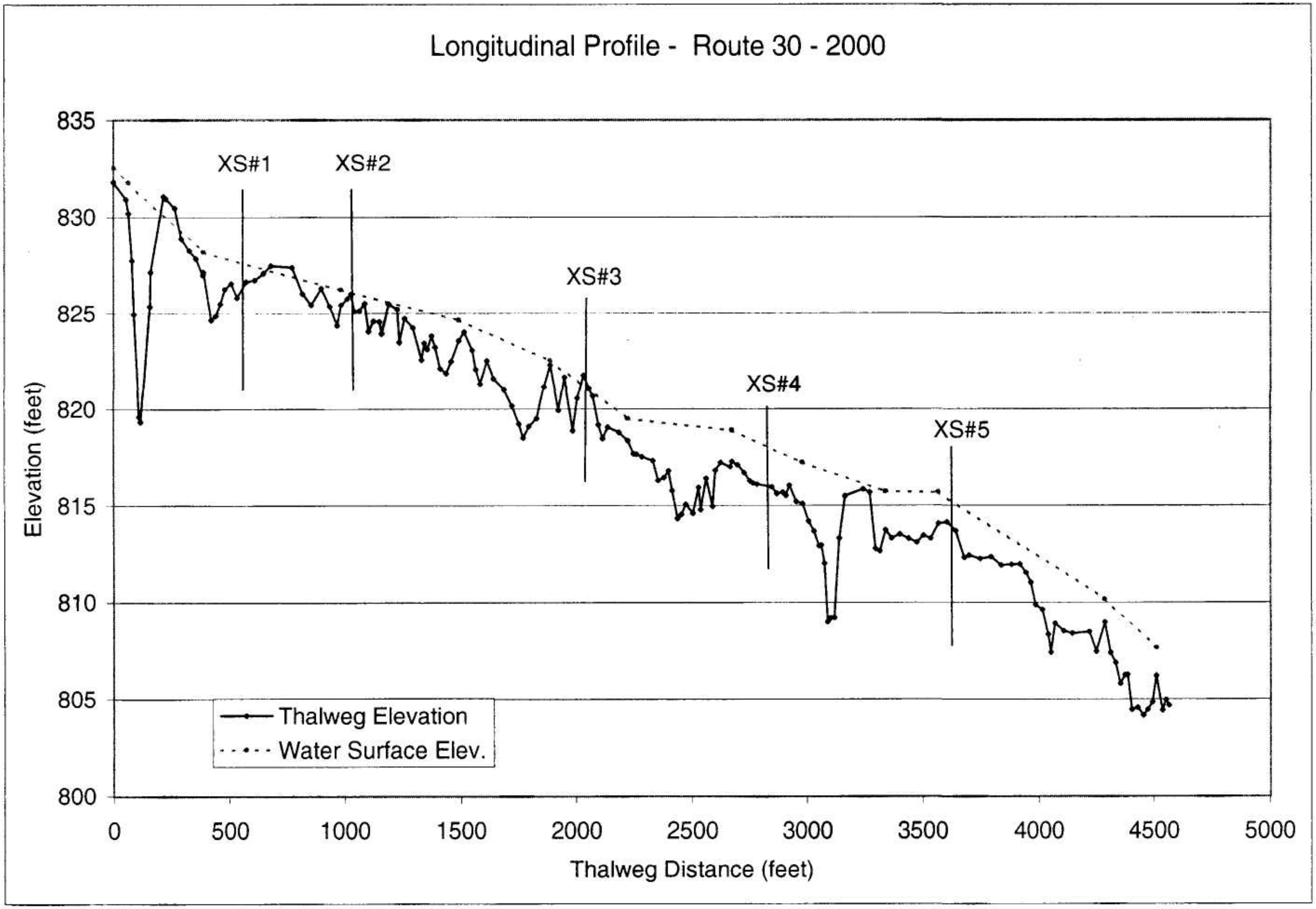
Cross Section #1 is the USGS Salyer gauge site (although it is outside of the section where the profile was surveyed). Cross Section #2 is just downstream from Mahala Creek. Cross section #3 is just upstream of mile 3. Cross Sections #4 and #5 are in section 22, Cross Section #5 being right about mile 2.

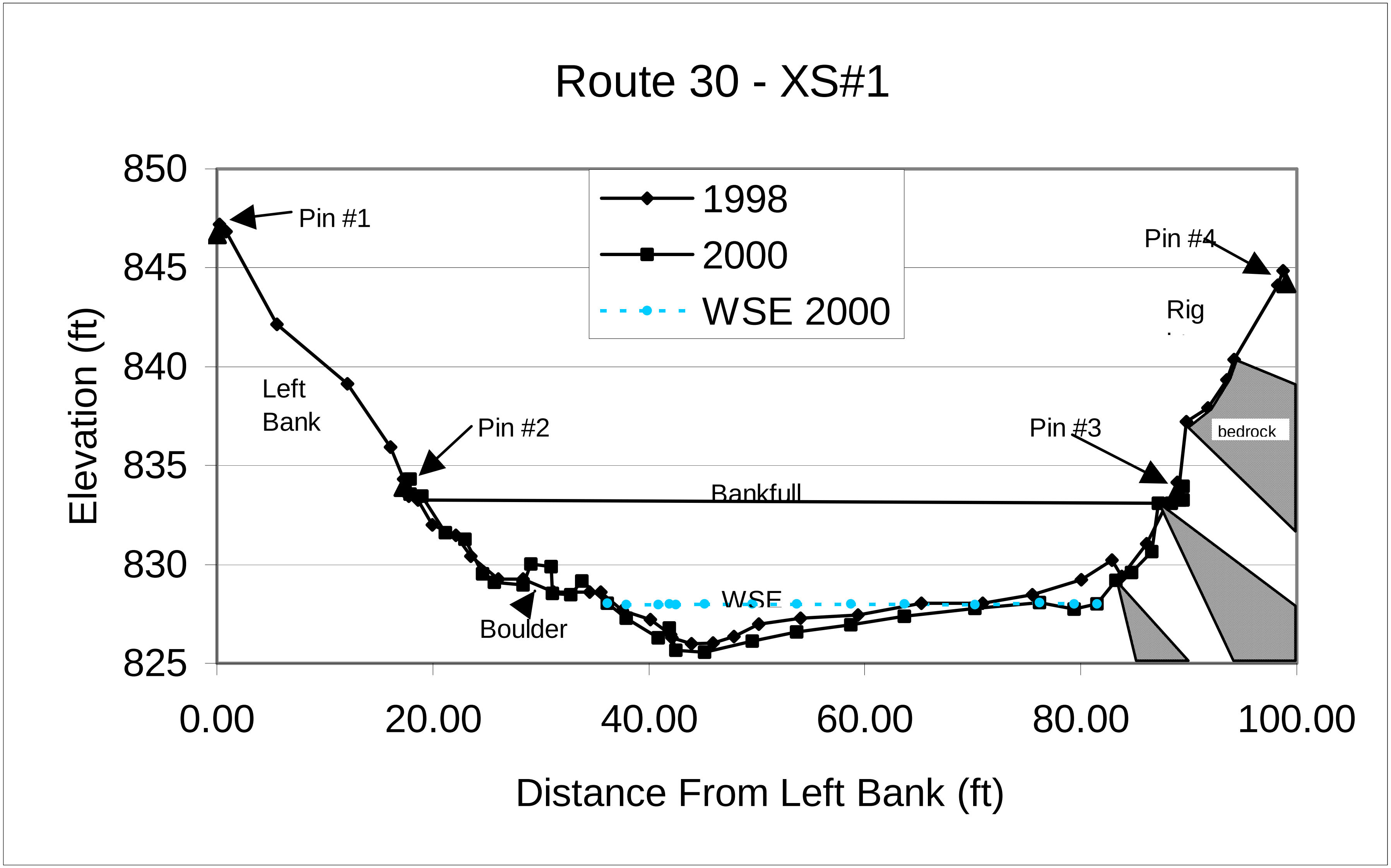
Other than photos of the cross sections, no photo points were established for this reach. The top of the slide that comes down the left bank from FS Route 6 just upstream of Old Campbell Creek would be a good one.

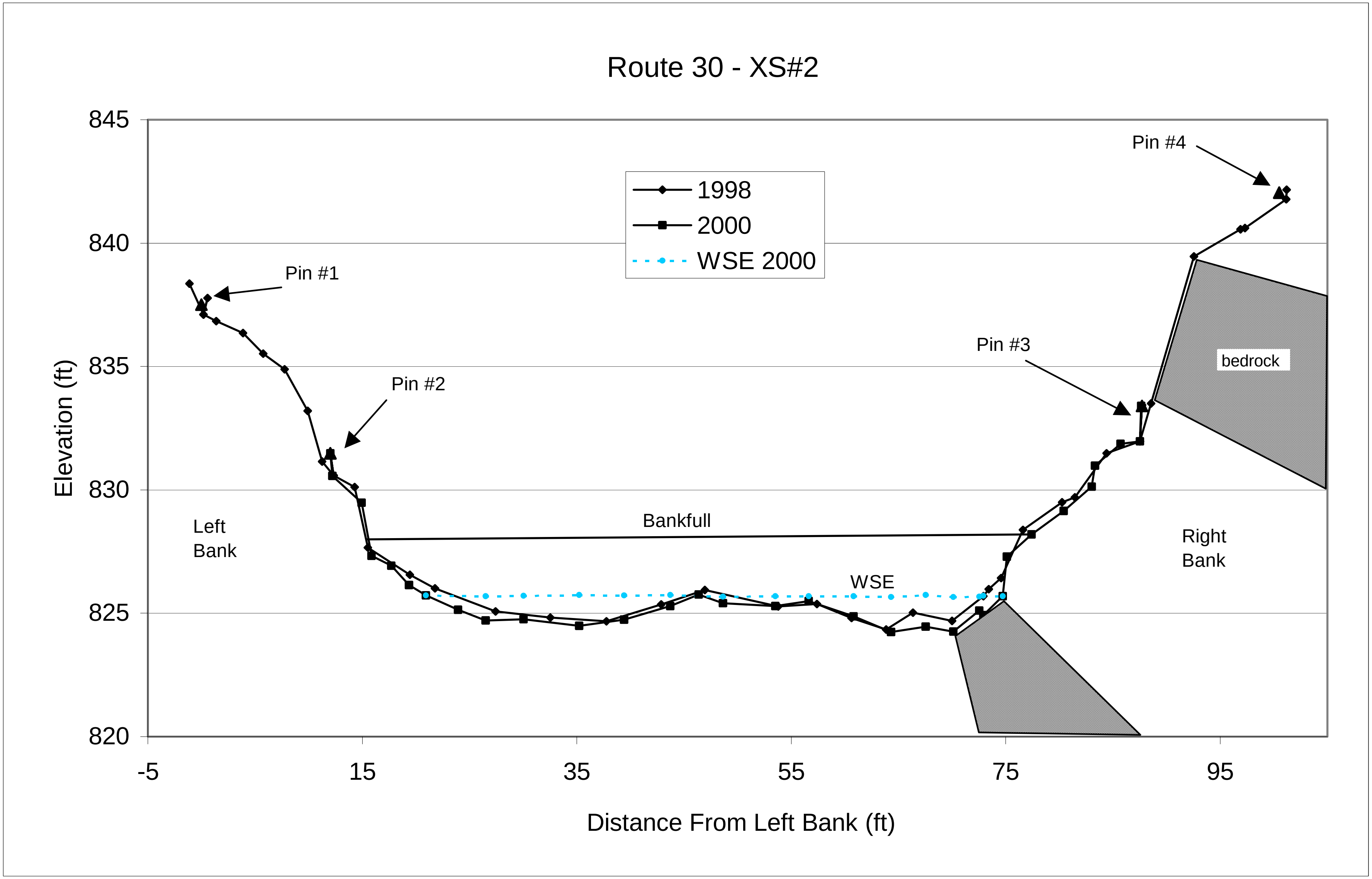
Historical footnote: We always wondered why the USGS called their gauge “near Salyer’’ when the town is miles away and not even on the South Fork of the Trinity. Well, it turns out the historic Salyer ranch site was on the big terrace at mile 3.

Appendix B : Plots

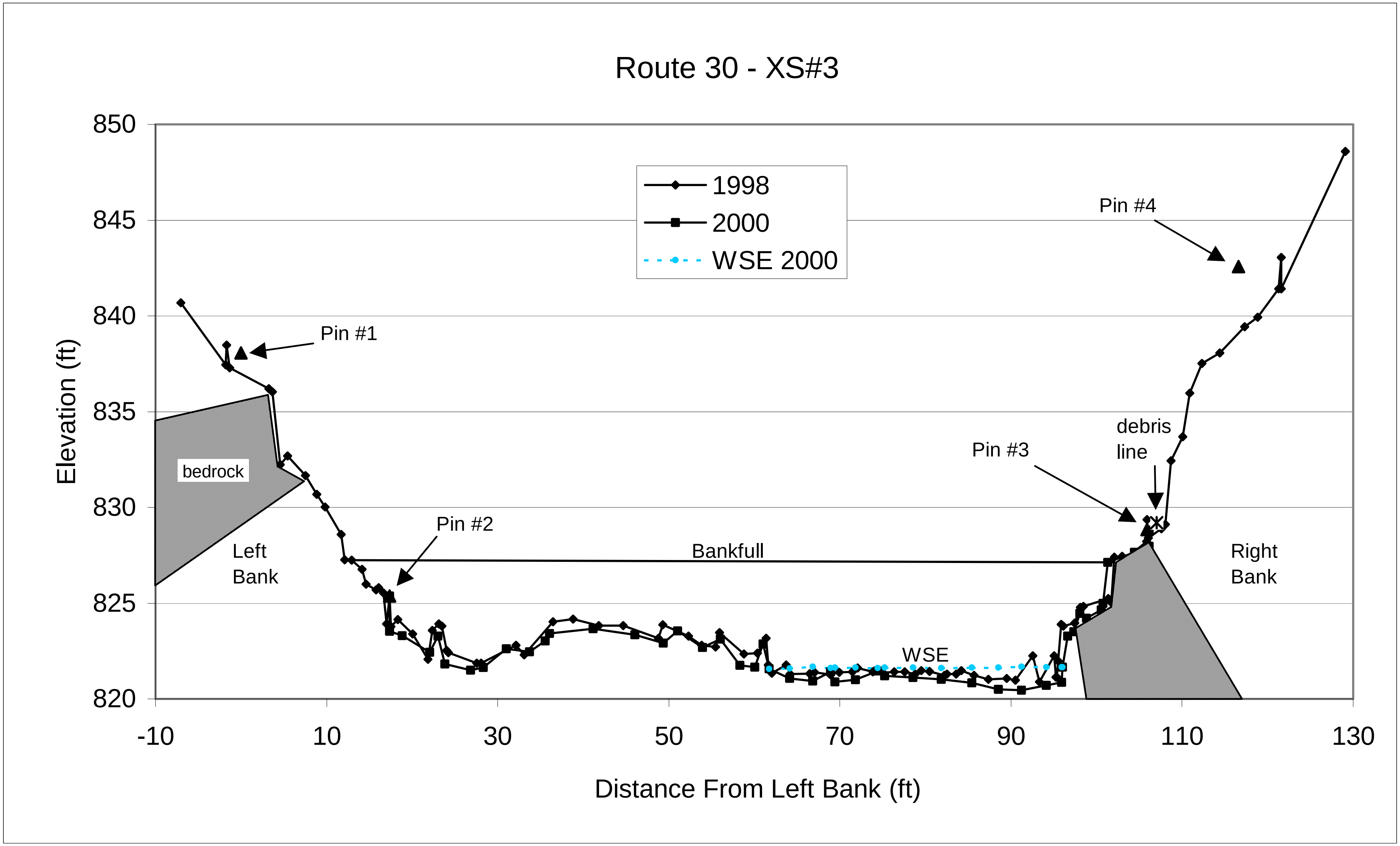

Longitudinal Profile - Route 30 - 1998

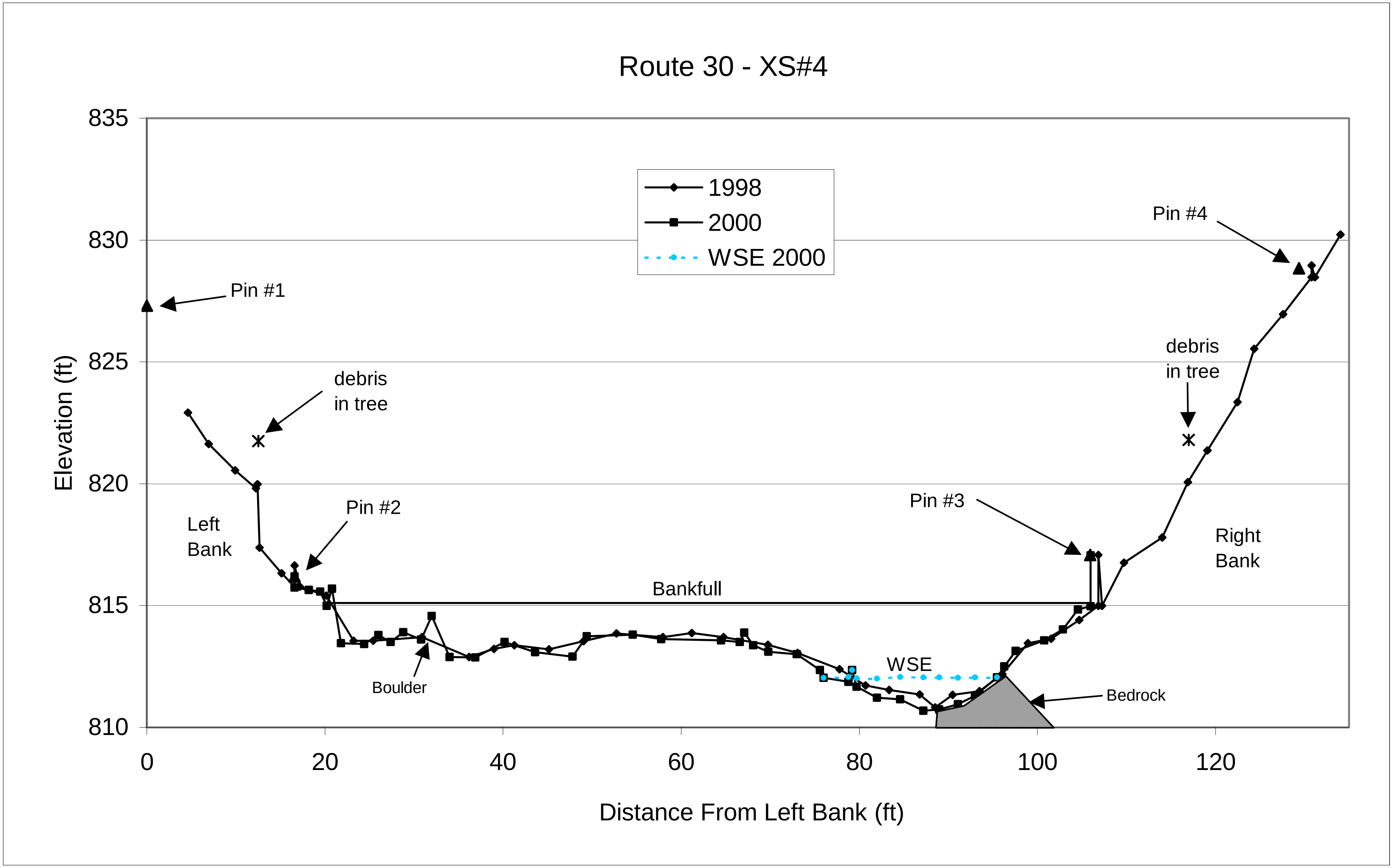

Longitudinal Profile - Route 30 - 2000
Elevation (feet)
835
830
825
820
815
810
805
800
Thalweg Distance (feet)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
XS#1
XS#2
XS#3
XS#4
XS#5
Thalweg Elevation
Water Surface Elev.

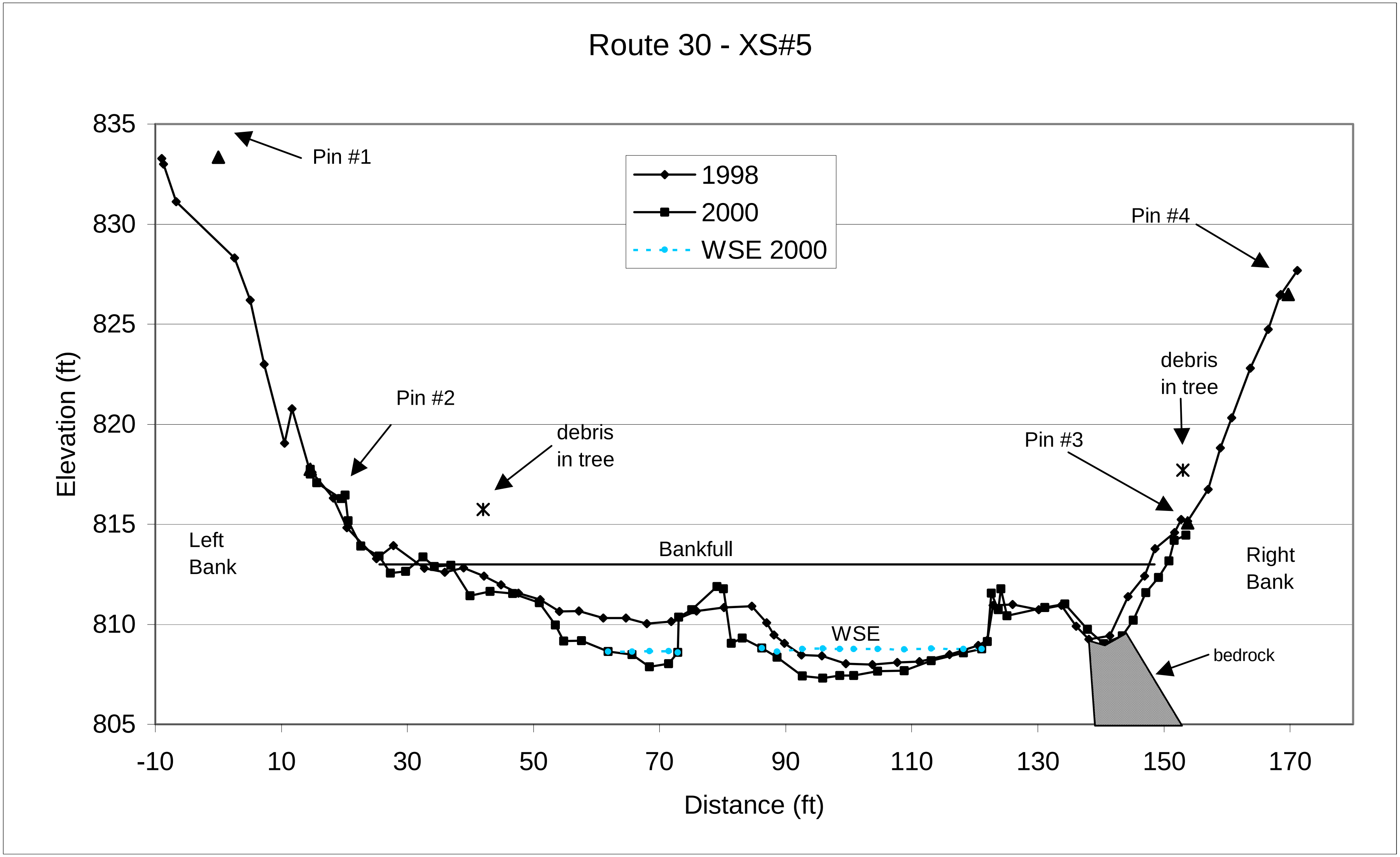

Route 30 - XS#1
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
Left
Bank
Rig
bedrock
Bankfull
WSE
Boulder
Elevation (ft)
850
845
840
835
830
825
0.00
20.00
40.00
60.00
80.00
100.00
Distance From Left Bank (ft)



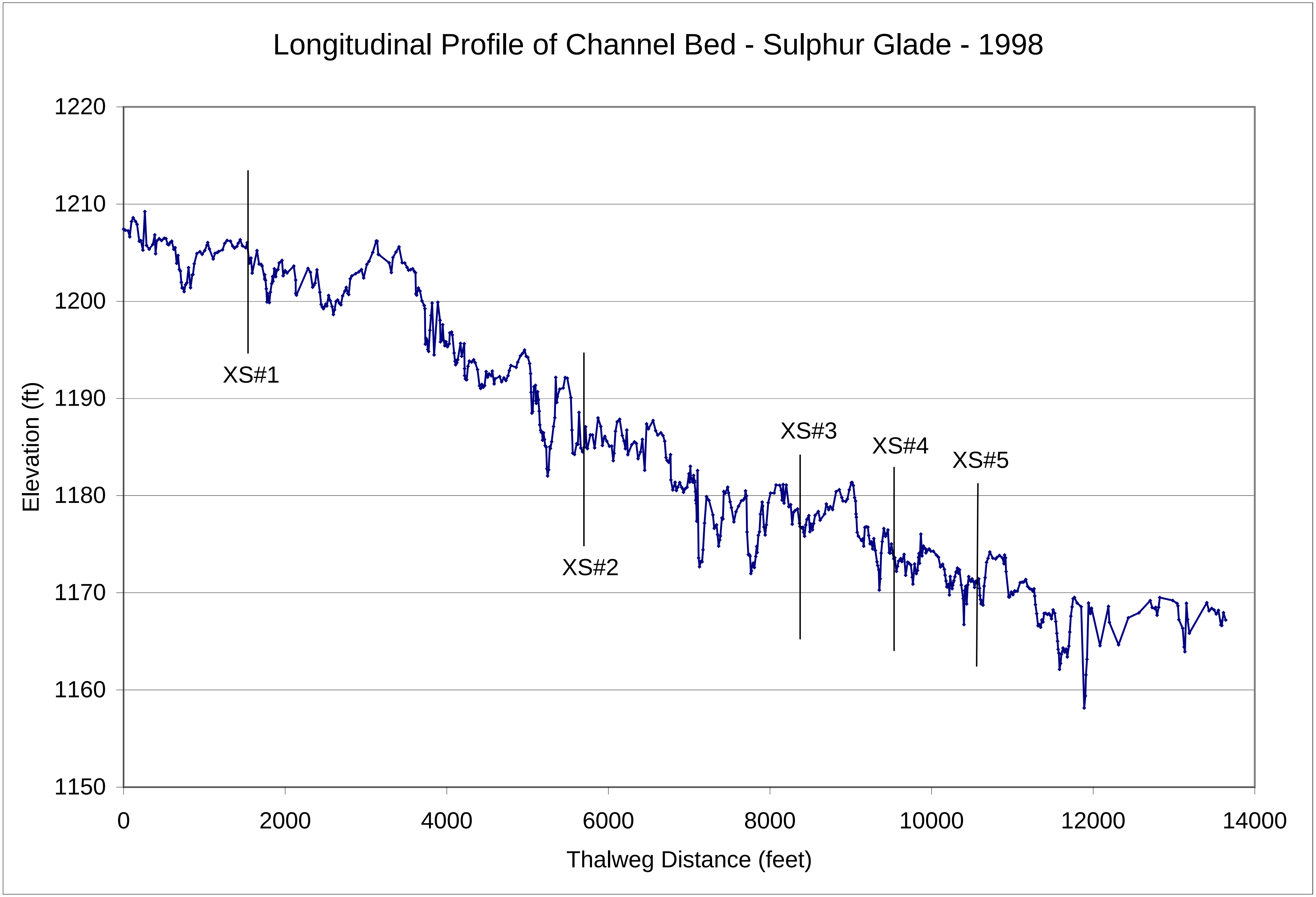
Route 30 - XS#2
845
840
835
830
825
820
-5
15
35
55
75
95
Elevation (ft)
Distance From Left Bank (ft)
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
bedrock
Left
Bank
Right
Bank
Bankfull
WSE


Route 30 - XS#3
1998
2000
WSE 2000
Elevation (ft)
850
845
840
835
830
825
820
-10
10
30
50
70
90
110
130
Distance From Left Bank (ft)
Pin #1
Pin #2
Pin #3
Pin #4
debris line
bedrock
Left Bank
Right Bank
Bankfull
WSE

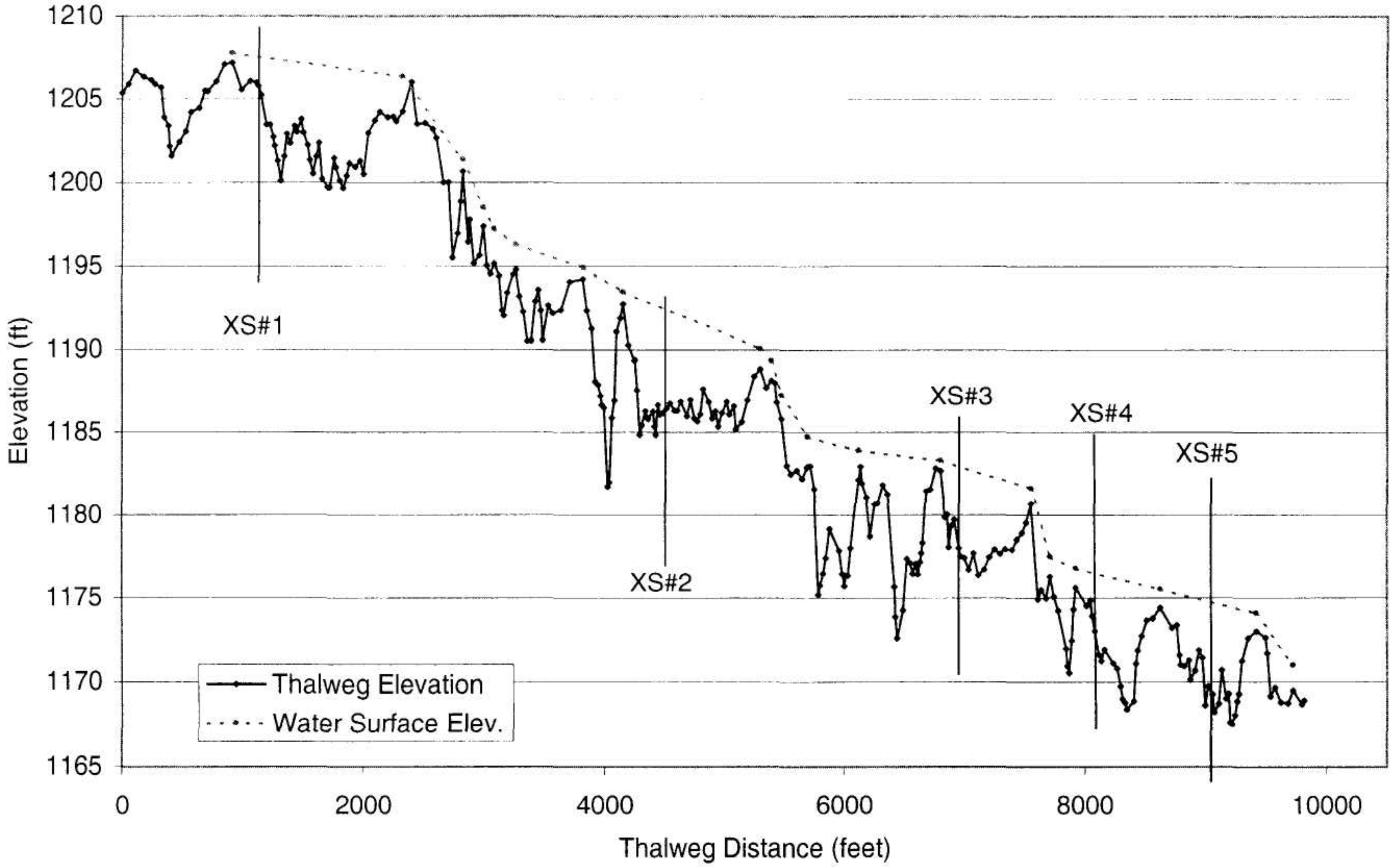

Route 30 - XS#4
1998
2000
WSE 2000
Elevation (ft)
835
830
825
820
815
810
0
20
40
60
80
100
120
Distance From Left Bank (ft)
Pin #1
debris
in tree
Left
Bank
Pin #2
Bankfull
Boulder
WSE
Bedrock
Pin #3
Pin #4
debris
in tree
Right
Bank

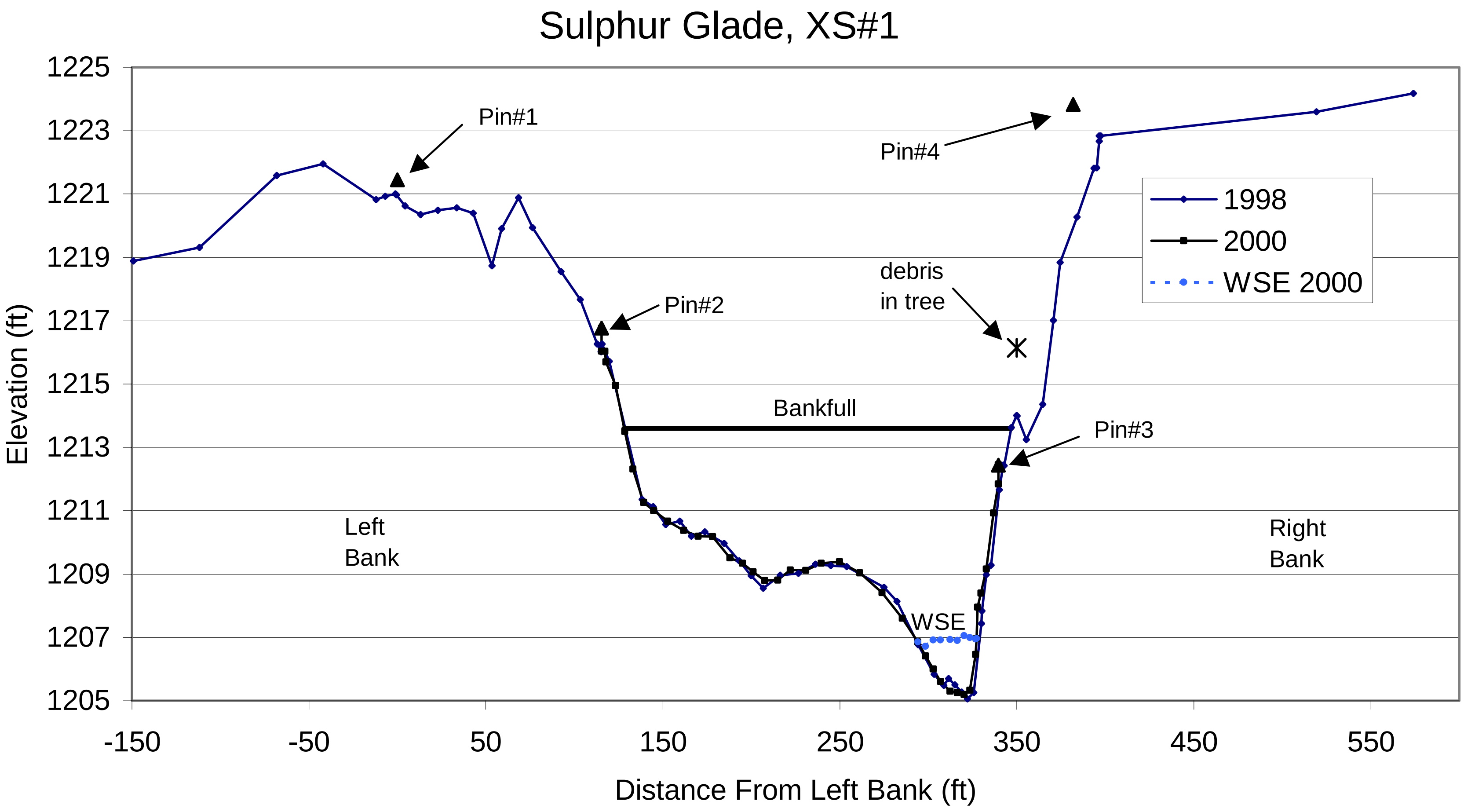


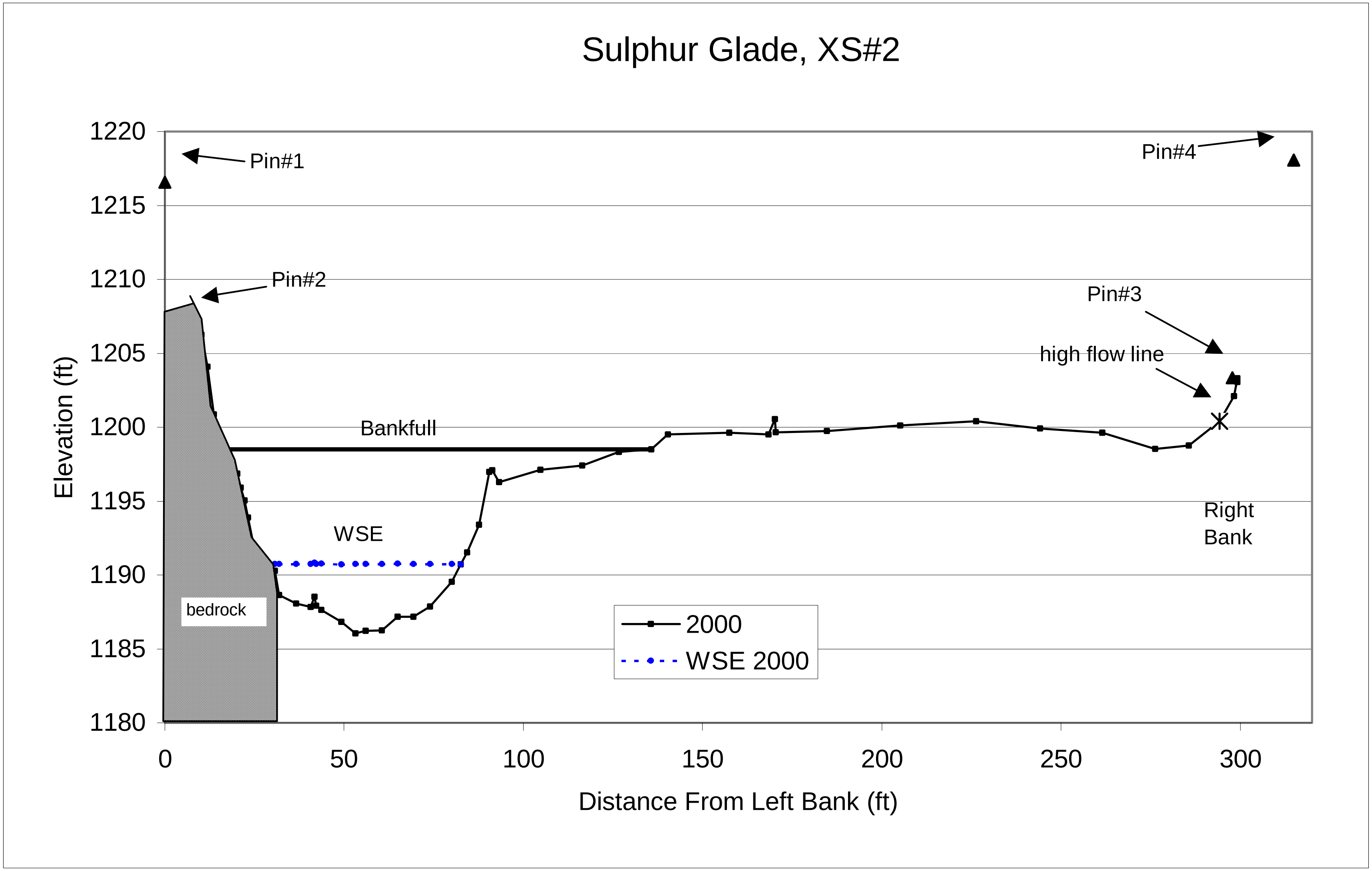
Route 30 - XS#5
Elevation (ft)
Distance (ft)
835
830
825
820
815
810
805
-10
10
30
50
70
90
110
130
150
170
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
debris in tree
debris in tree
Left Bank
Right Bank
Bankfull
WSE
bedrock

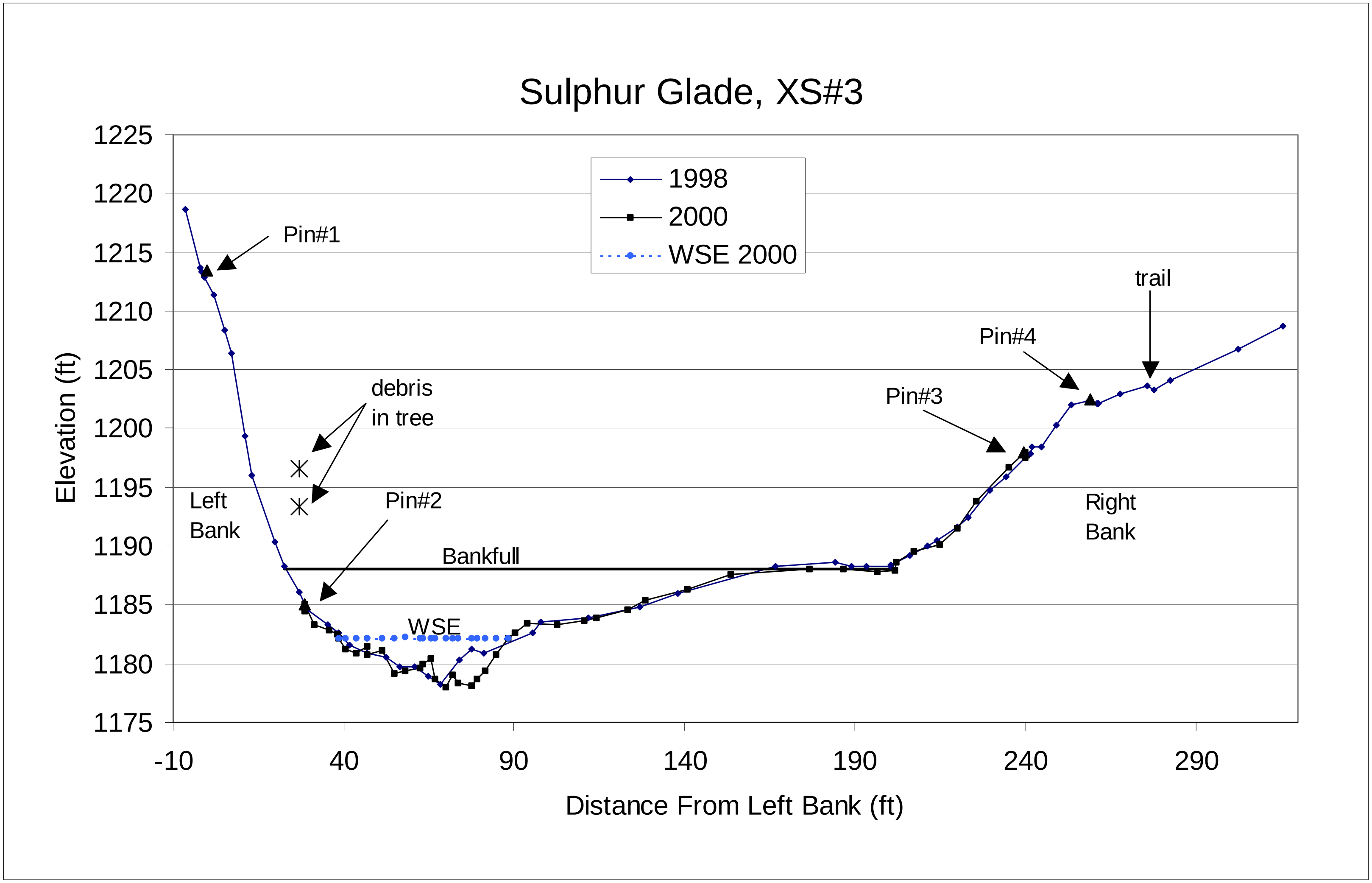


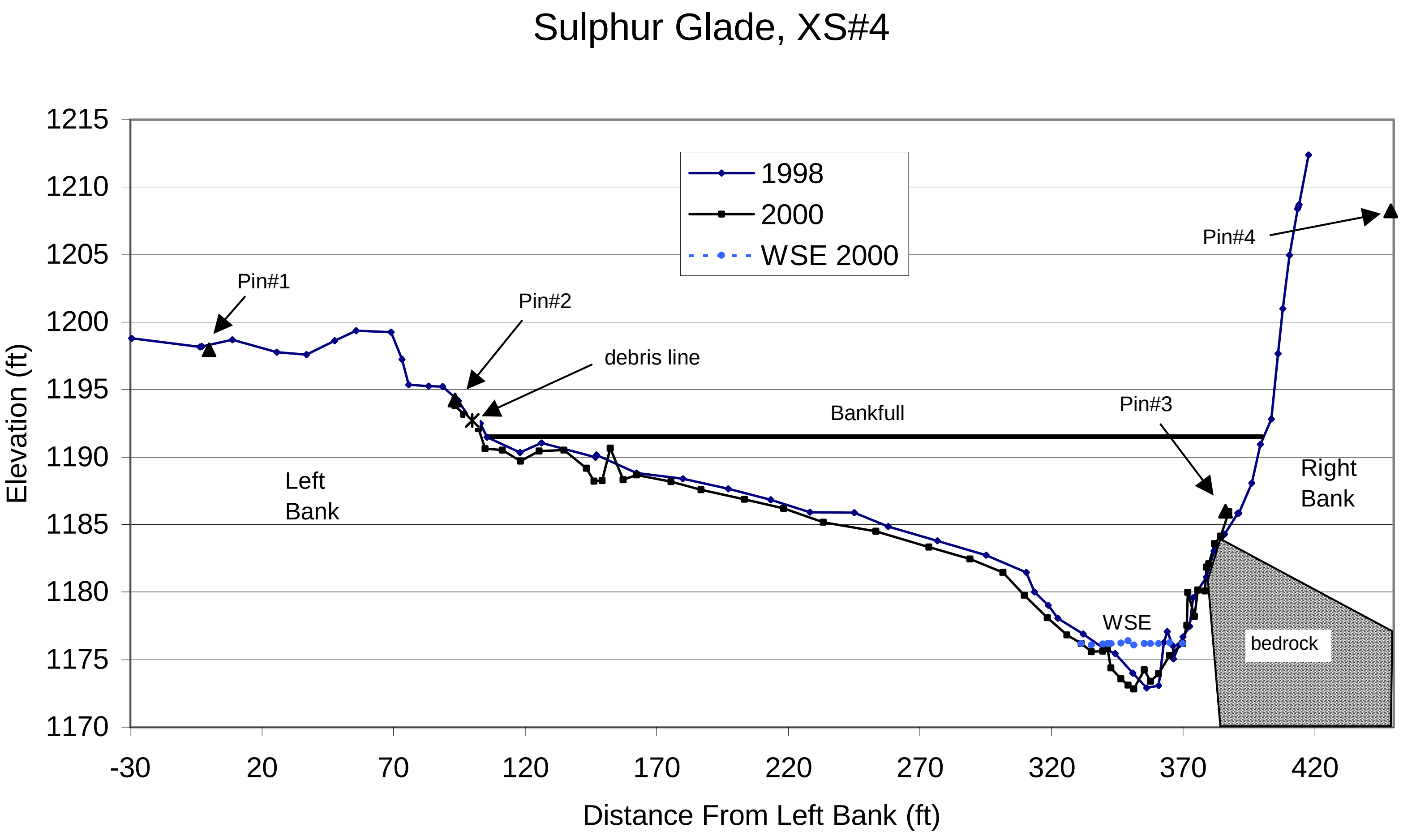
Longitudinal Profile of Channel Bed - Sulphur Glade - 2000

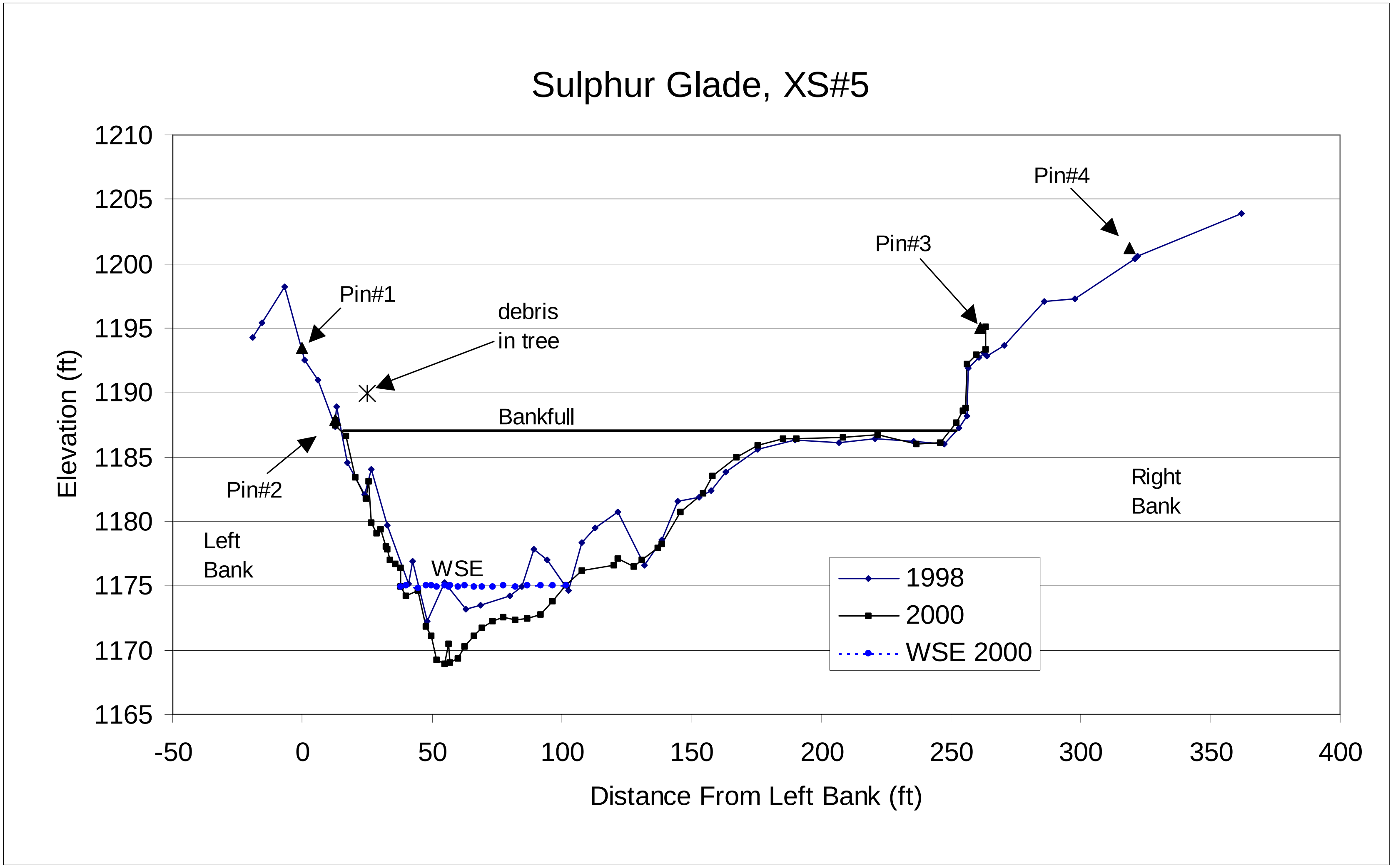


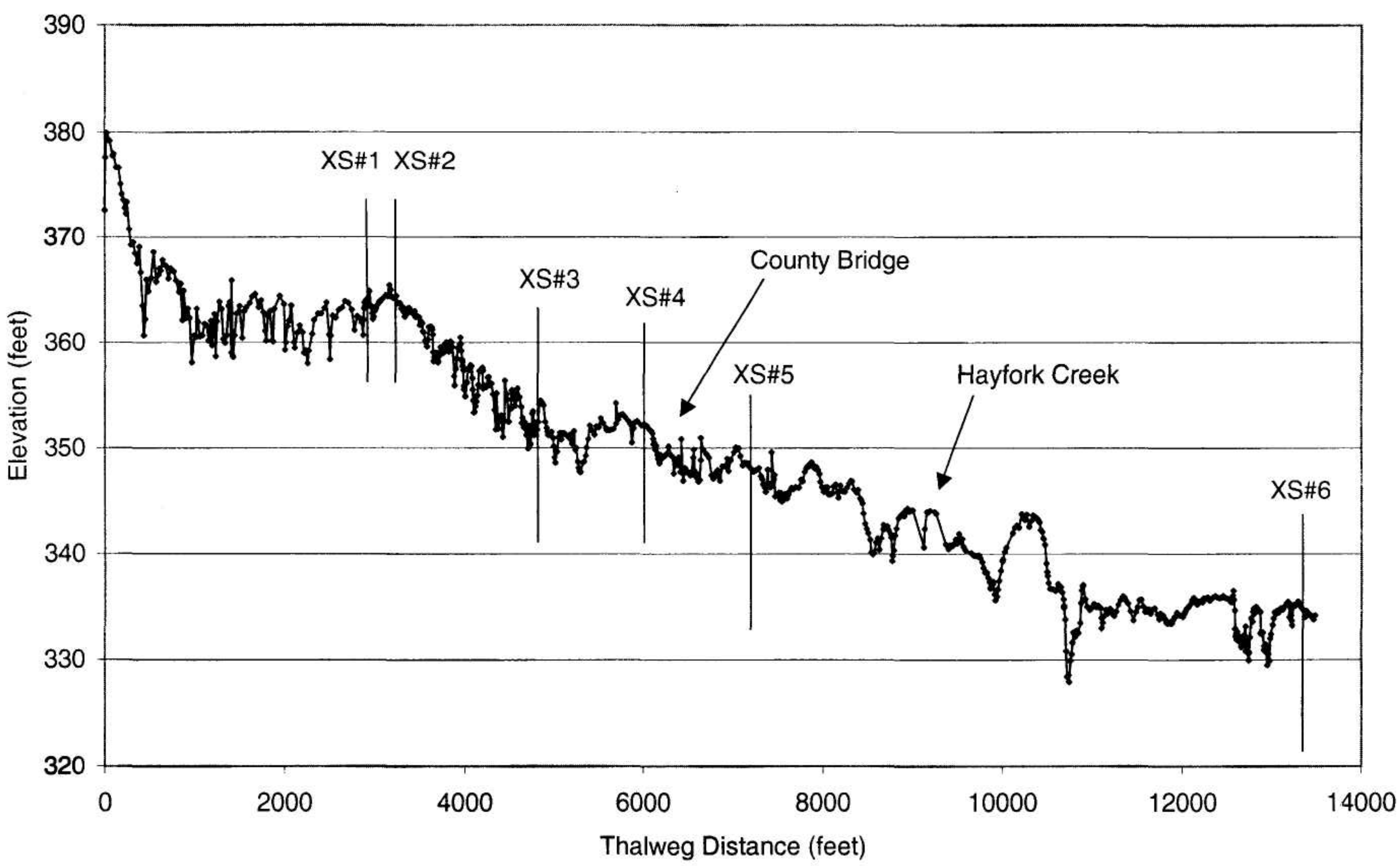

Sulphur Glade, XS#1
Elevation (ft)
1225
1223
1221
1219
1217
1215
1213
1211
1209
1207
1205
-150
-50
50
150
250
350
450
550
Distance From Left Bank (ft)
1998
2000
WSE 2000
Pin#1
Pin#2
Pin#3
Pin#4
debris
in tree
Bankfull
WSE
Left
Bank
Right
Bank


Sulphur Glade, XS#2
Elevation (ft)
1220
1215
1210
1205
1200
1195
1190
1185
1180
0
50
100
150
200
250
300
Distance From Left Bank (ft)
Pin#1
Pin#2
Pin#3
Pin#4
high flow line
Bankfull
WSE
Right Bank
bedrock
2000
WSE 2000

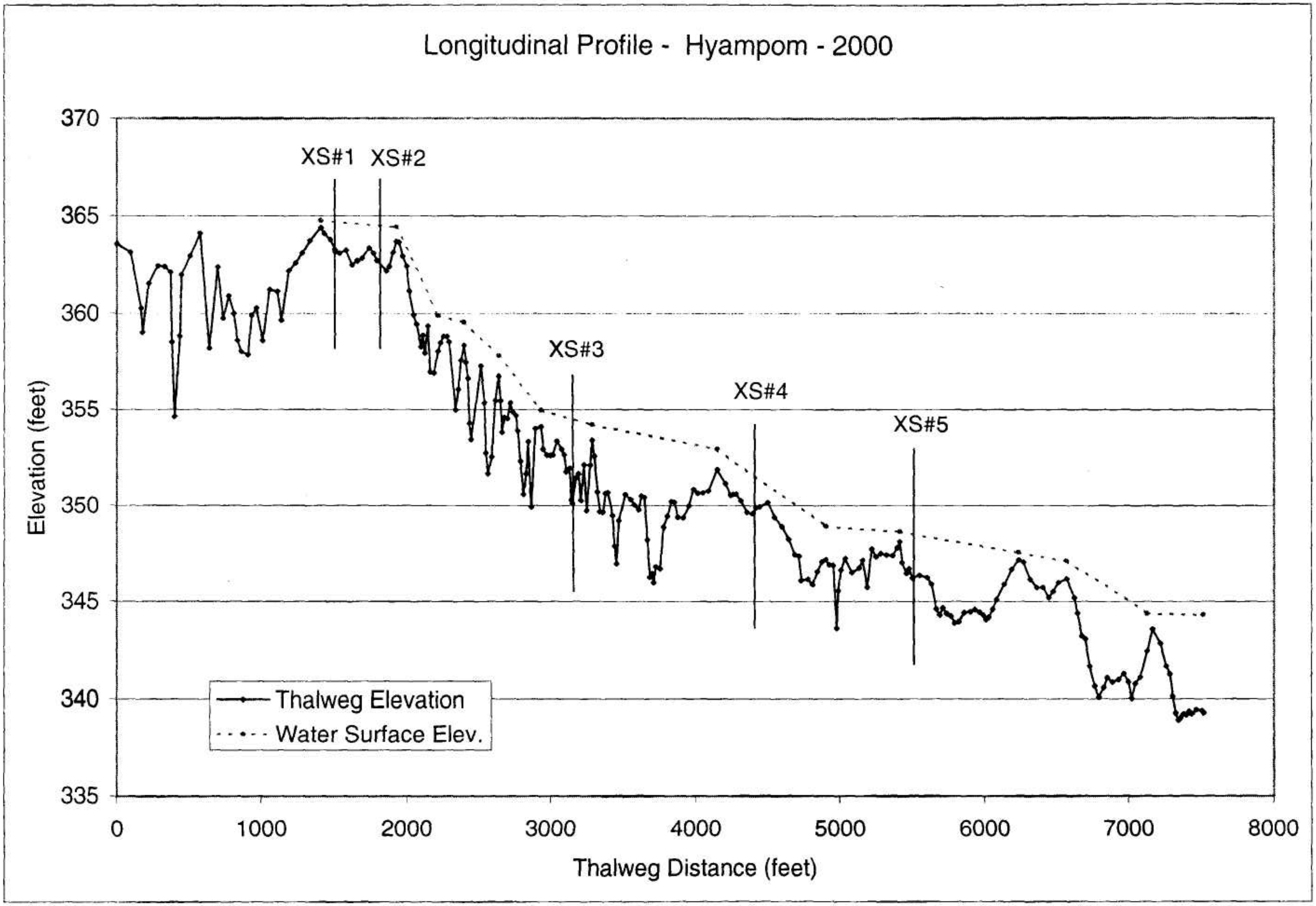

Sulphur Glade, XS#3
1998
2000
WSE 2000
Elevation (ft)
1225
1220
1215
1210
1205
1200
1195
1190
1185
1180
1175
Distance From Left Bank (ft)
-10
40
90
140
190
240
290
Pin#1
debris
in tree
Left
Bank
Pin#2
Bankfull
WSE
Pin#3
Pin#4
trail
Right
Bank

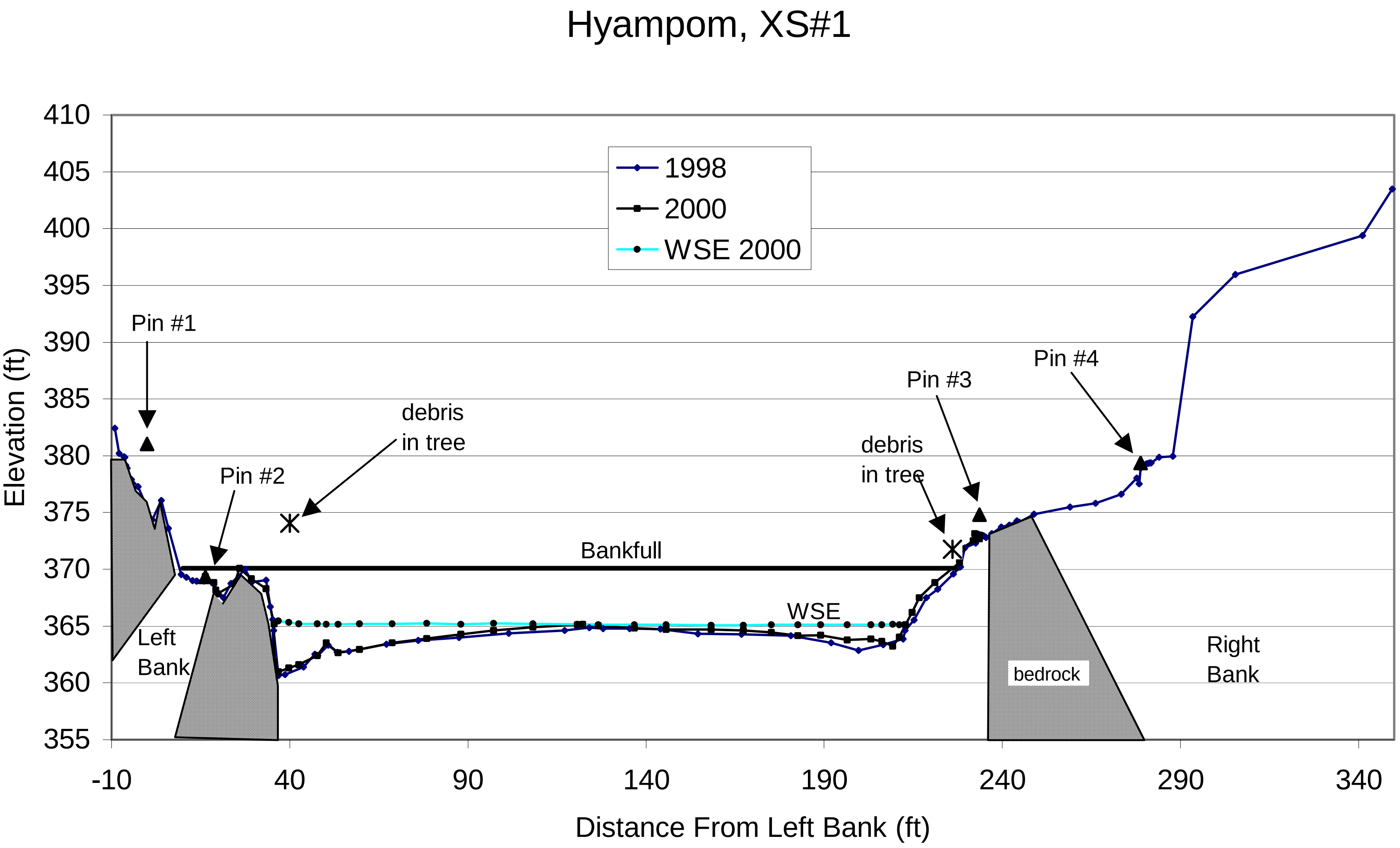

Sulphur Glade, XS#4
1998
2000
WSE 2000
Pin#1
Pin#2
debris line
Bankfull
Pin#3
Pin#4
Left Bank
Right Bank
WSE
bedrock
Elevation (ft)
1215
1210
1205
1200
1195
1190
1185
1180
1175
1170
-30
20
70
120
170
220
270
320
370
420
Distance From Left Bank (ft)

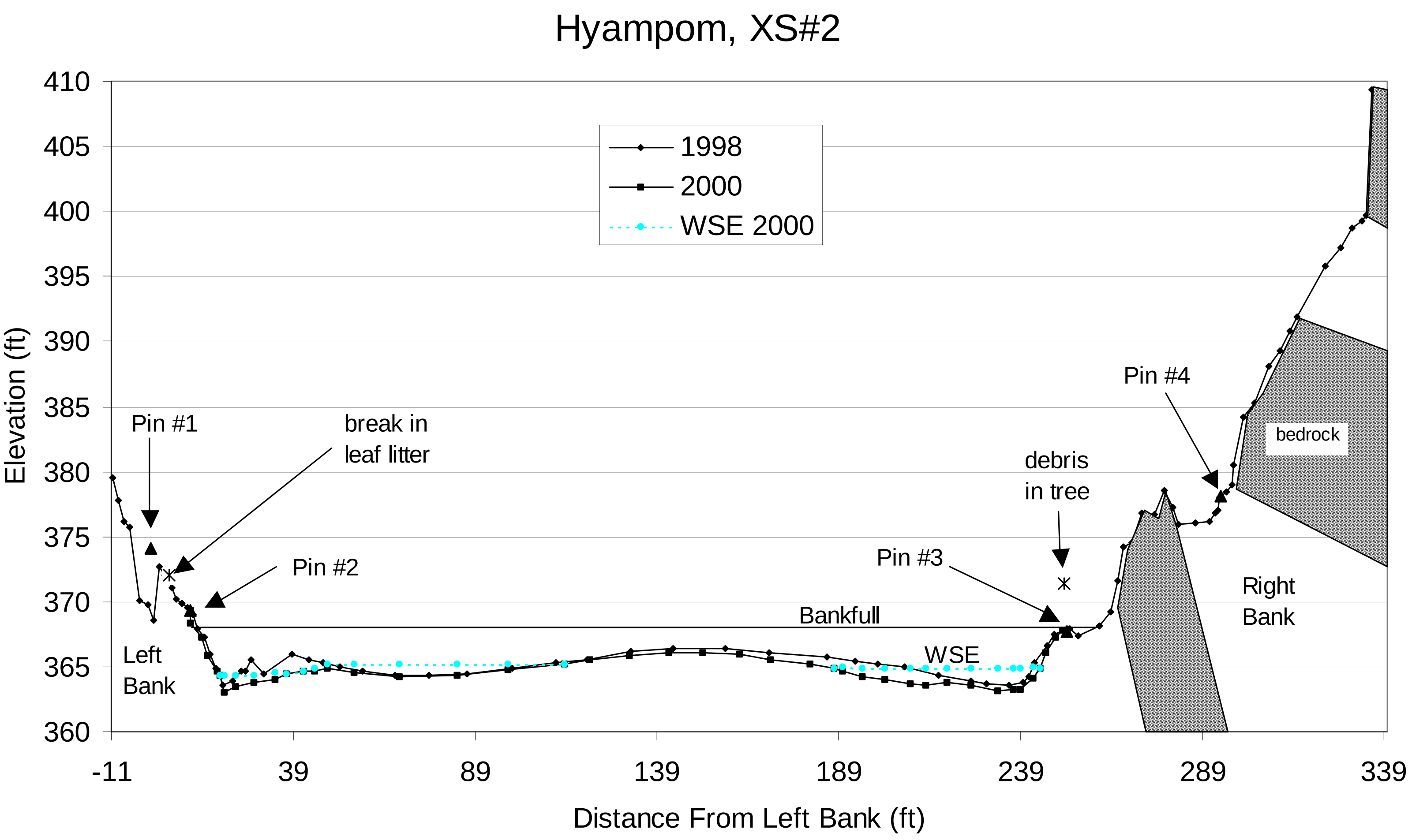

Sulphur Glade, XS#5
Elevation (ft)
1210
1205
1200
1195
1190
1185
1180
1175
1170
1165
Distance From Left Bank (ft)
-50
0
50
100
150
200
250
300
350
400
Pin#1
Pin#2
Pin#3
Pin#4
debris
in tree
Bankfull
WSE
Left
Bank
Right
Bank
1998
2000
WSE 2000

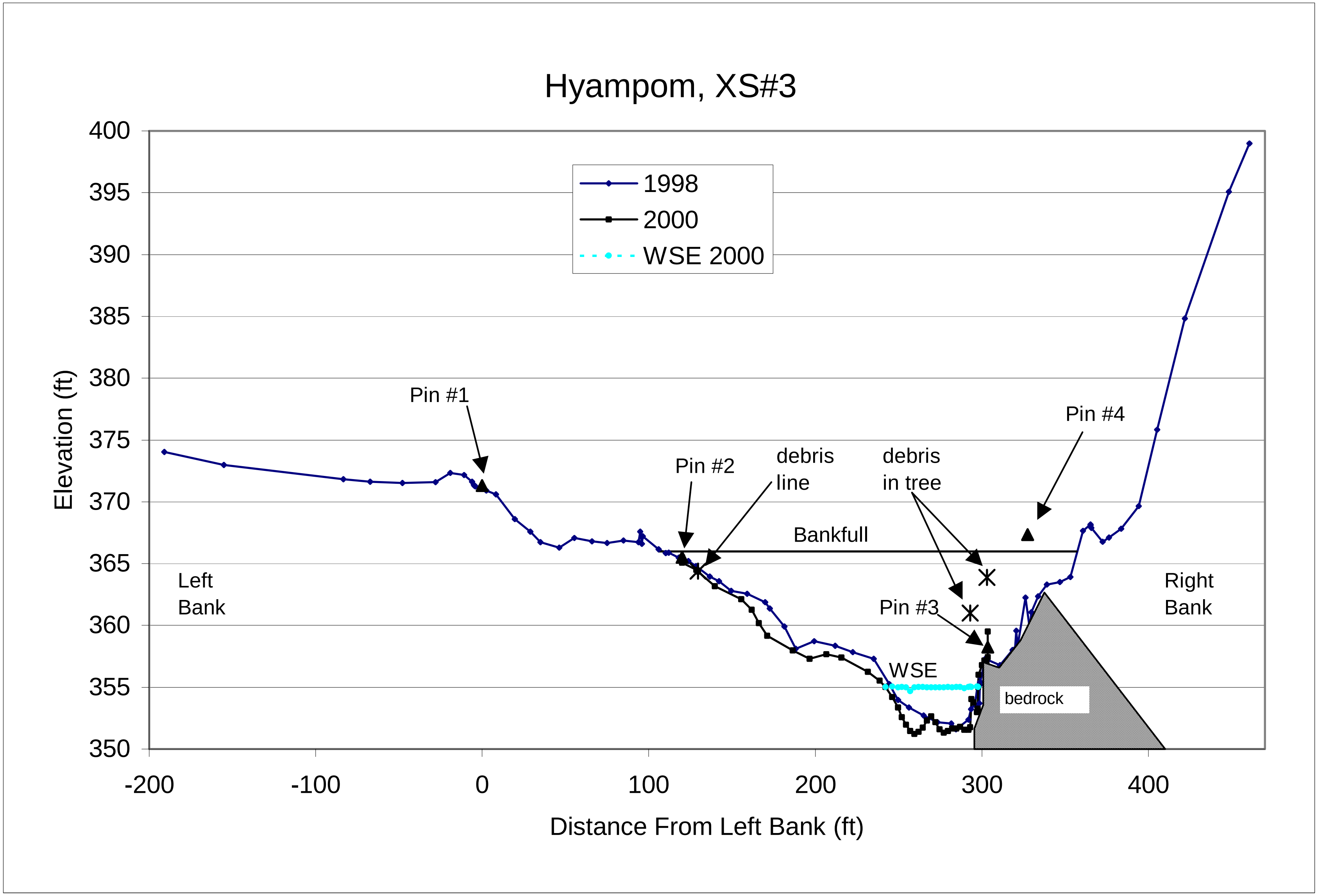


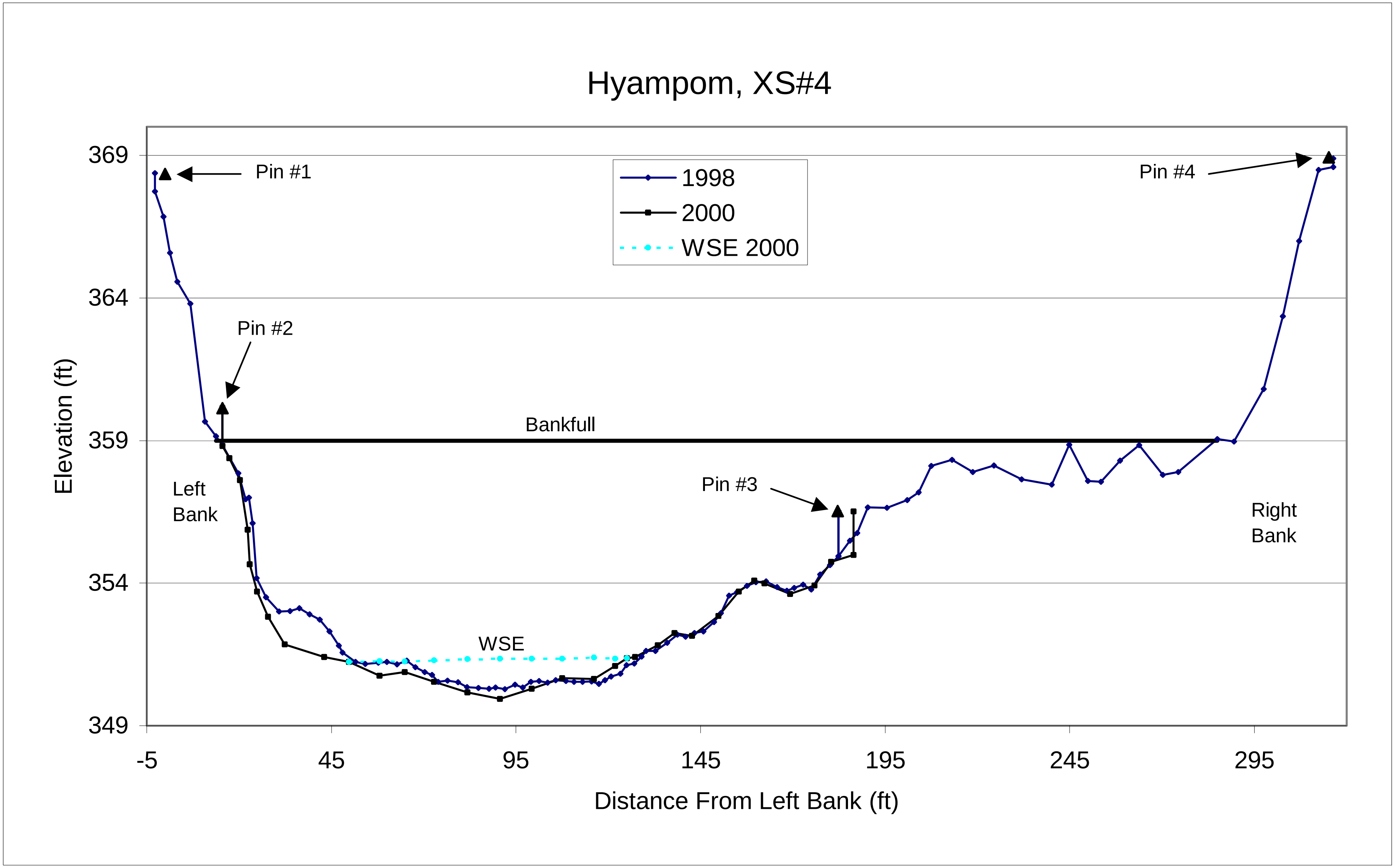
Longitudinal Profile - Hyampom - 1998

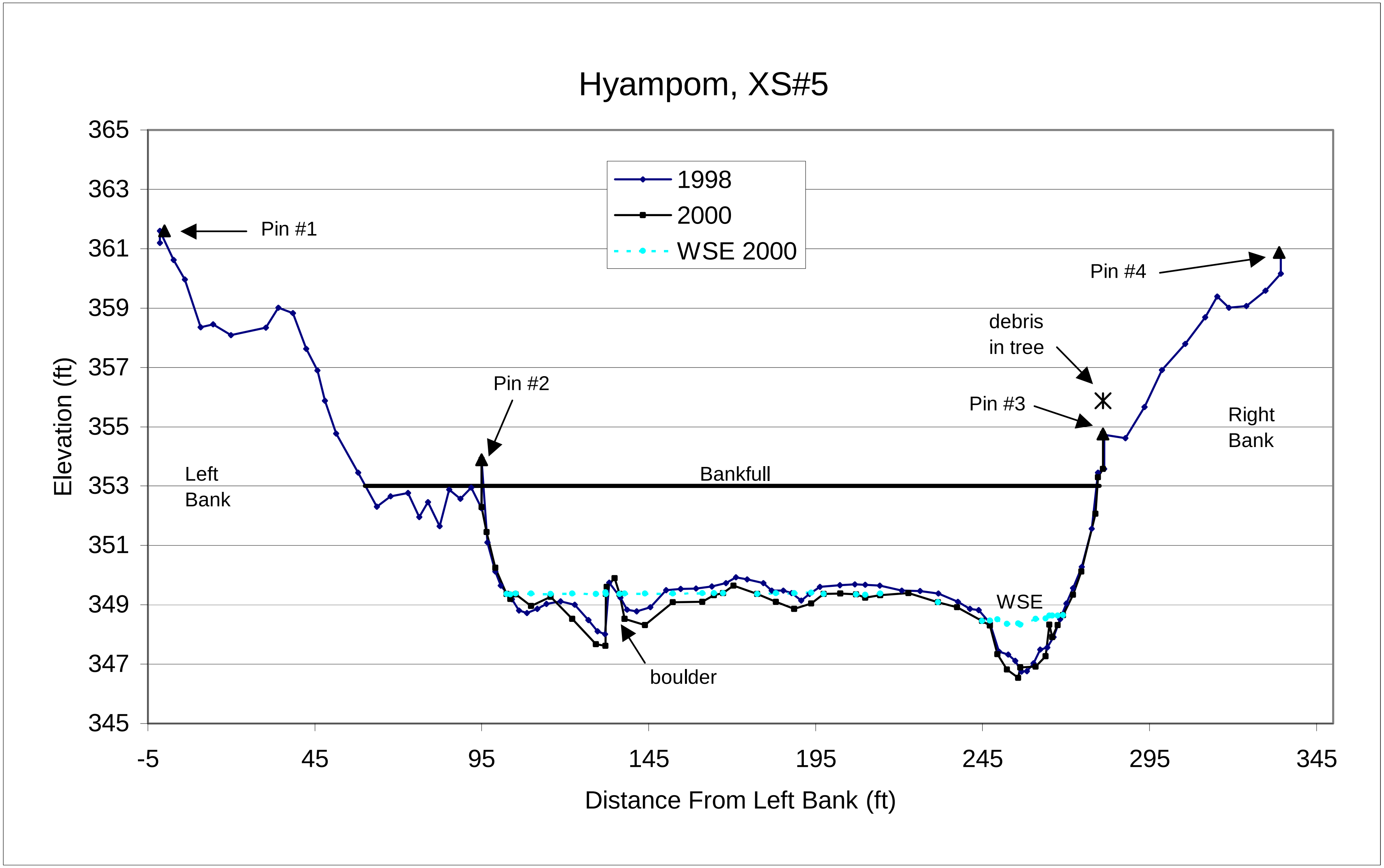

Longitudinal Profile - Hyampom - 2000
370
365
360
355
350
345
340
335
Elevation (feet)
XS#1
XS#2
XS#3
XS#4
XS#5
Thalweg Elevation
Water Surface Elev.
0
1000
2000
3000
4000
5000
6000
7000
8000
Thalweg Distance (feet)

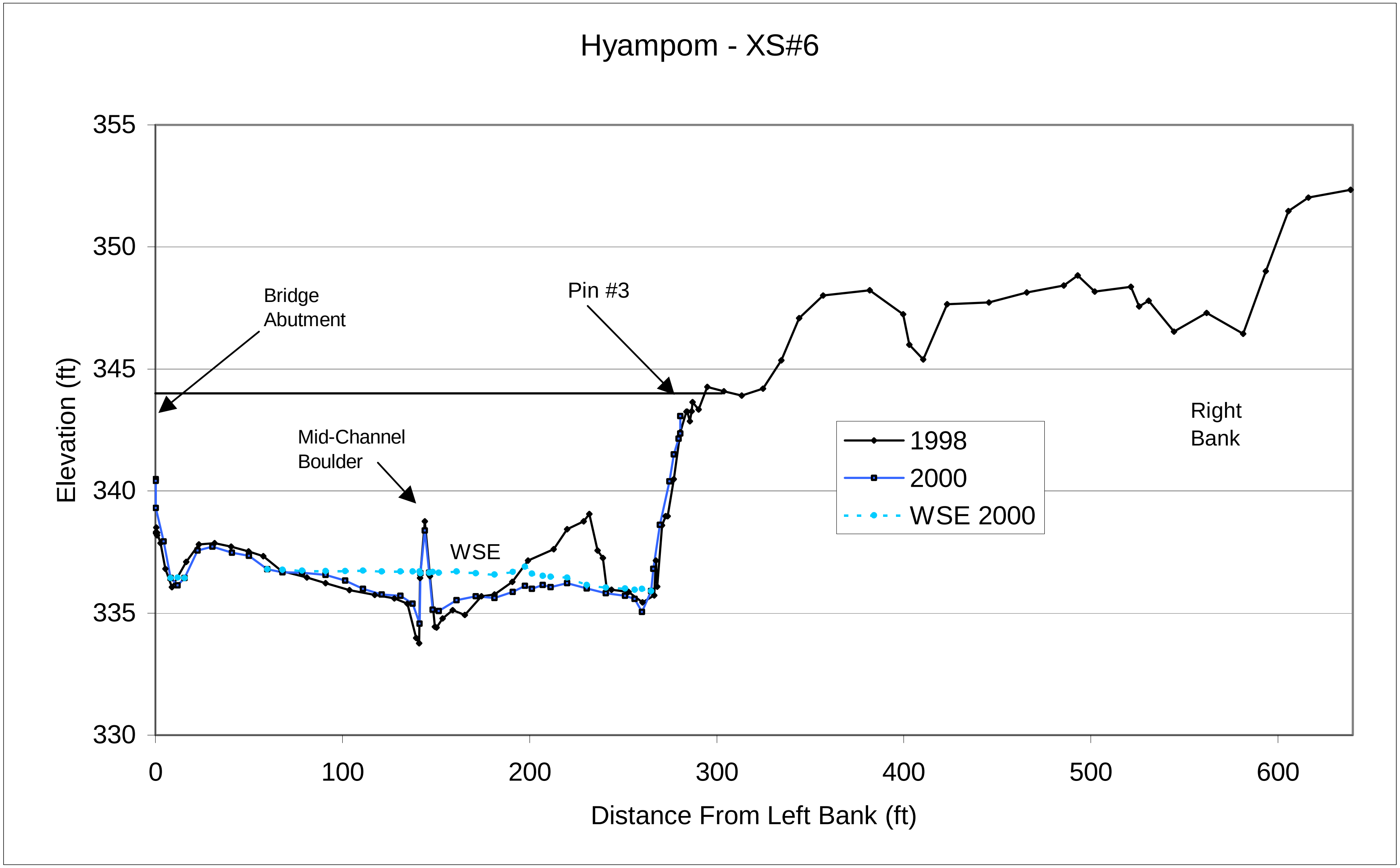

Hyampom, XS#1
Elevation (ft)
Distance From Left Bank (ft)
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
debris in tree
debris in tree
Bankfull
WSE
Left Bank
Right Bank
bedrock
410
405
400
395
390
385
380
375
370
365
360
355
-10
40
90
140
190
240
290
340

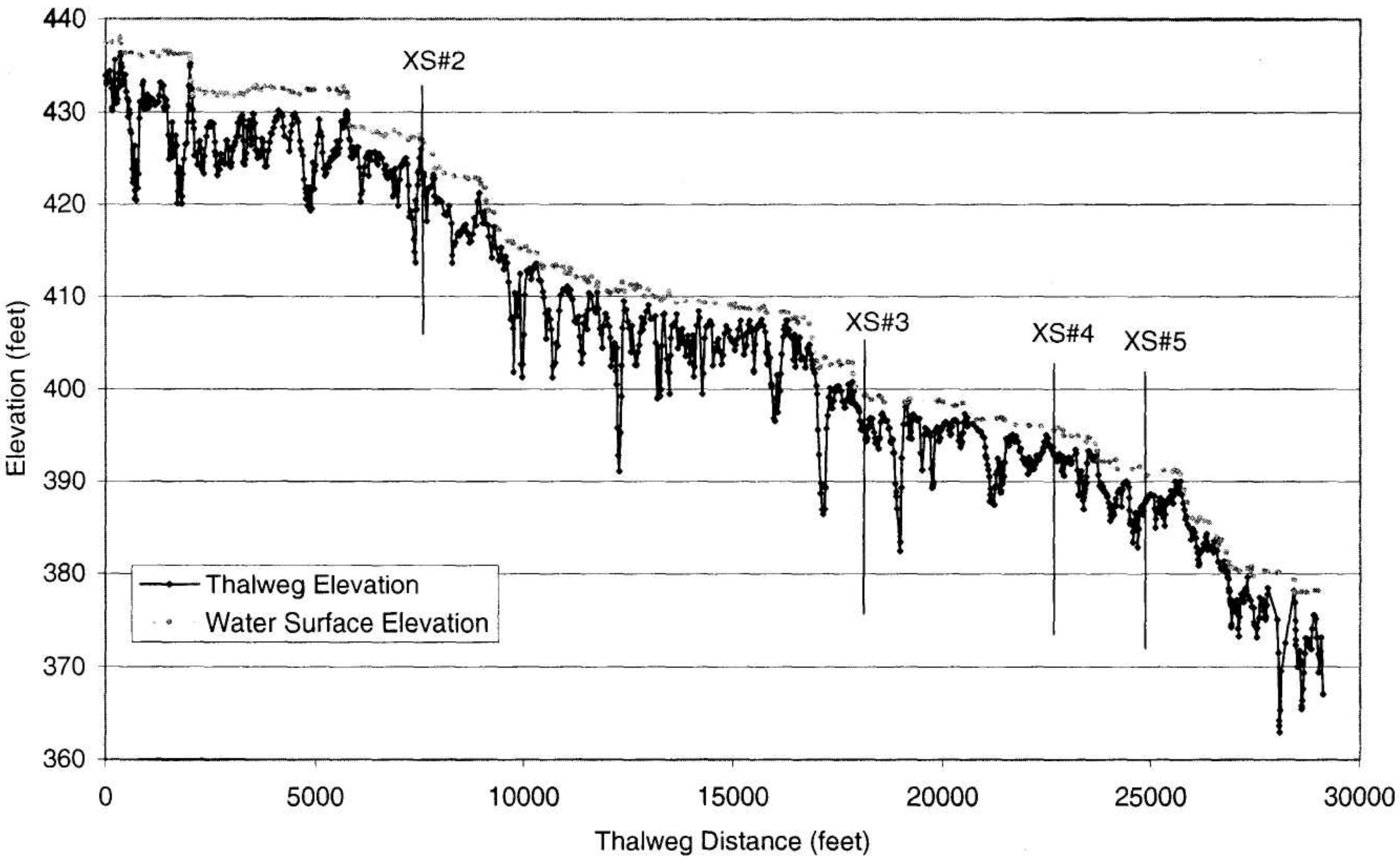

Hyampom, XS#2
410
405
400
395
390
385
380
375
370
365
360
Elevation (ft)
-11
39
89
139
189
239
289
339
Distance From Left Bank (ft)
1998
2000
WSE 2000
Pin #1
break in
leaf litter
Pin #2
Left
Bank
Bankfull
WSE
Pin #3
debris
in tree
Pin #4
bedrock
Right
Bank


Hyampom, XS#3
1998
2000
WSE 2000
400
395
390
385
380
375
370
365
360
355
350
Elevation (ft)
-200
-100
0
100
200
300
400
Distance From Left Bank (ft)
Pin #1
Pin #2
debris
line
debris
in tree
Pin #4
Bankfull
Left
Bank
Right
Bank
Pin #3
WSE
bedrock

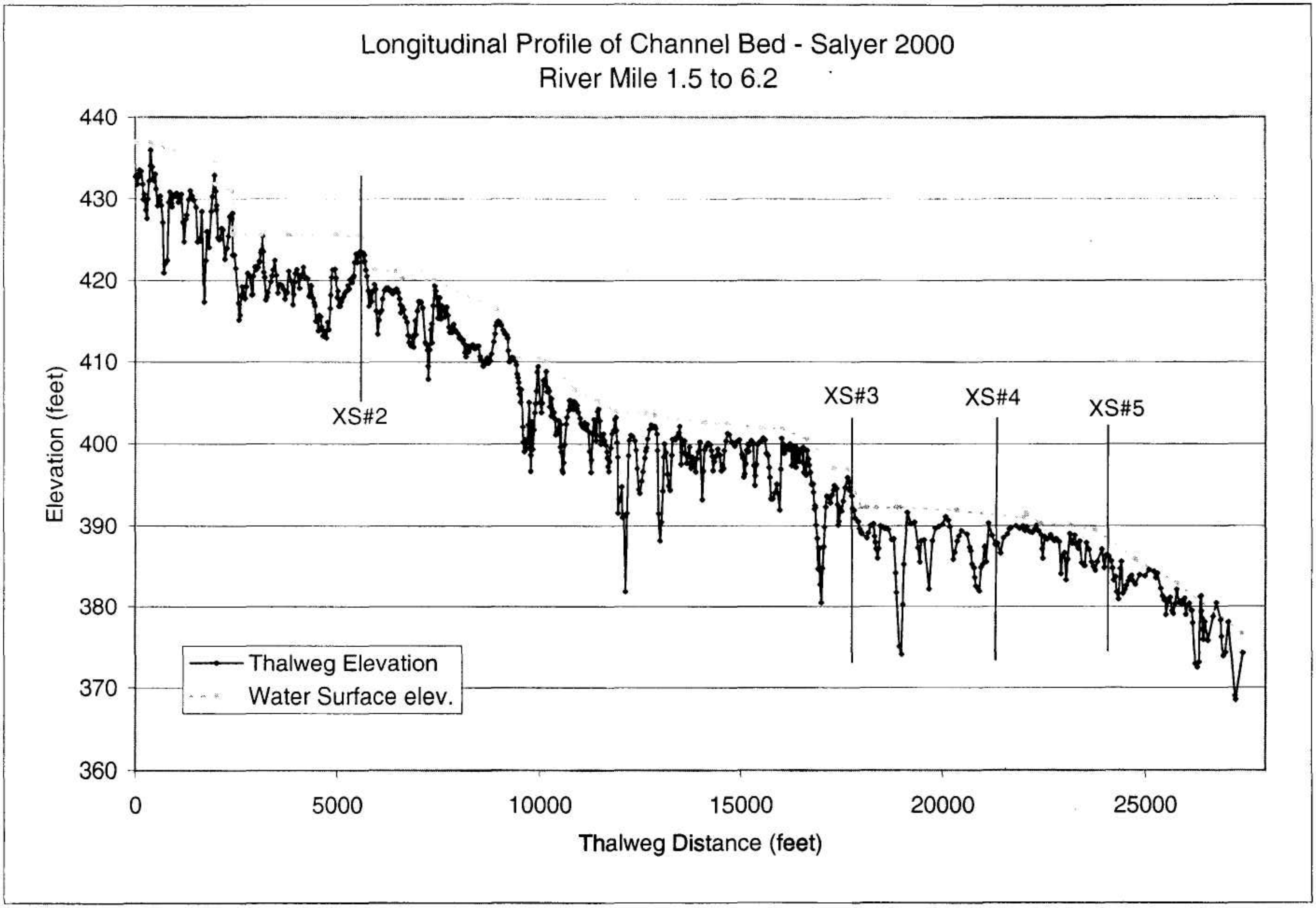

Hyampom, XS#4
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
Bankfull
WSE
Left Bank
Right Bank
Elevation (ft)
369
364
359
354
349
Distance From Left Bank (ft)
-5
45
95
145
195
245
295

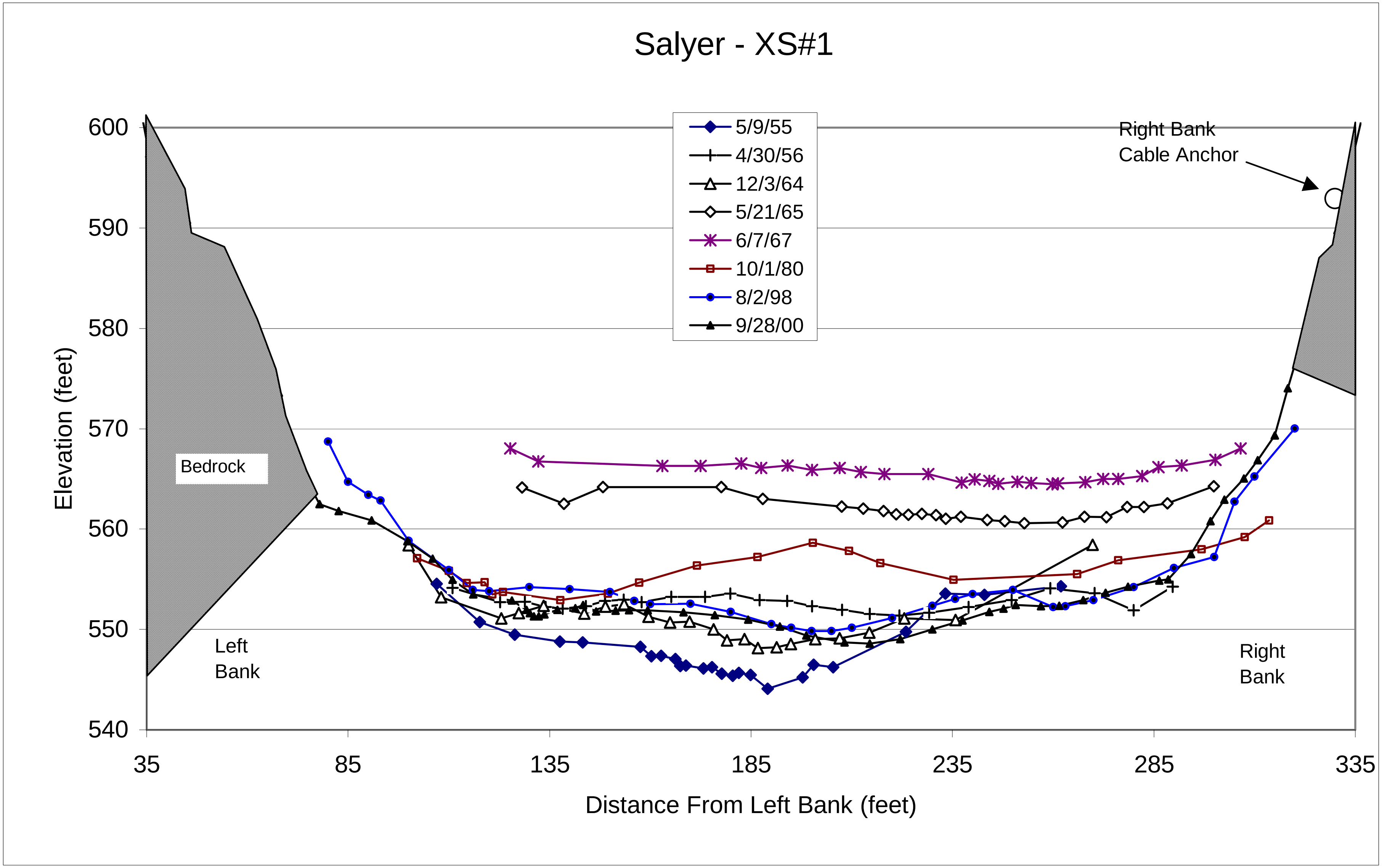

Hyampom, XS#5
1998
2000
WSE 2000
Pin #1
Pin #2
Pin #3
Pin #4
debris
in tree
Left
Bank
Right
Bank
Bankfull
WSE
boulder
Elevation (ft)
365
363
361
359
357
355
353
351
349
347
345
-5
45
95
145
195
245
295
345
Distance From Left Bank (ft)

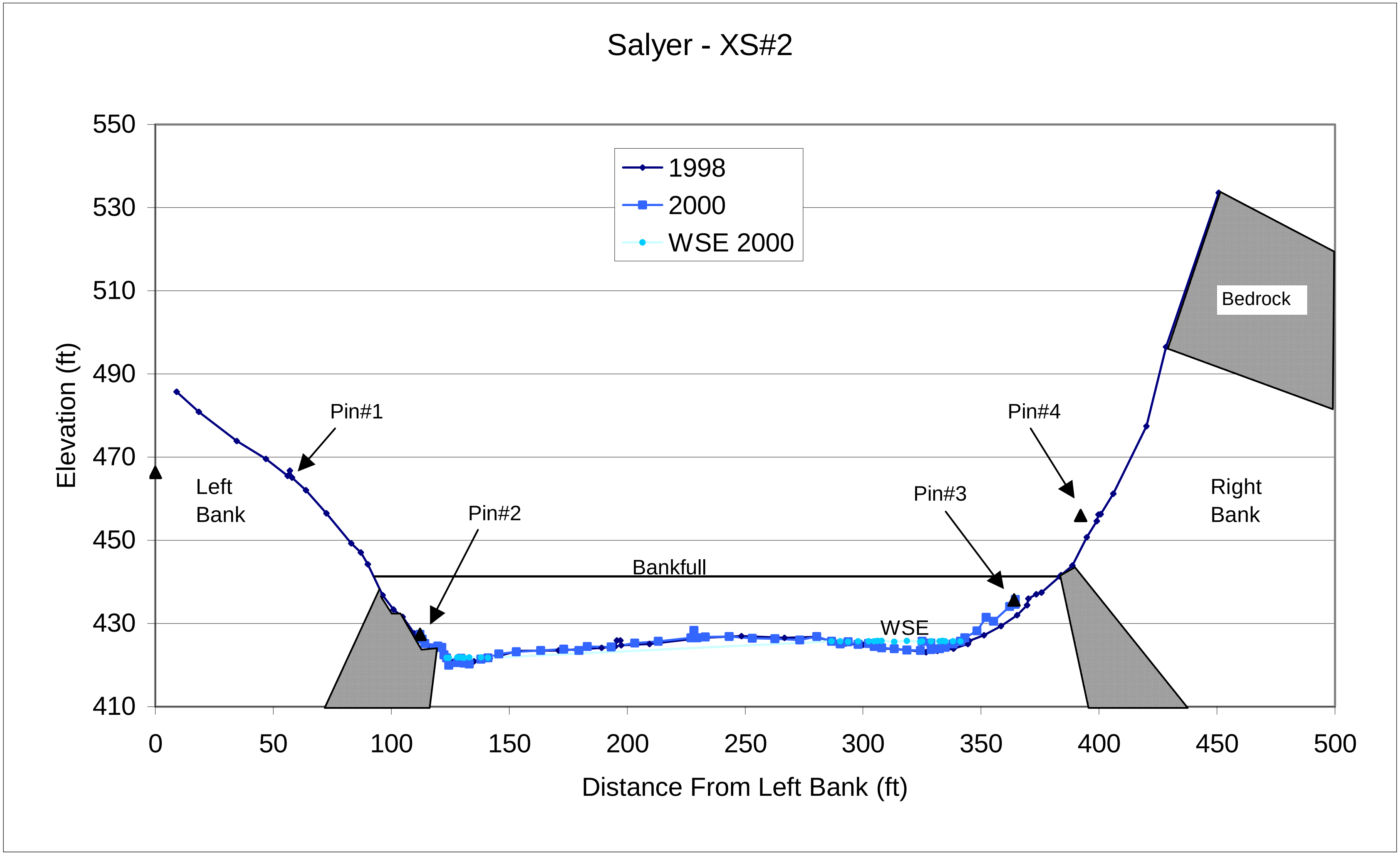

Hyampom - XS#6
Elevation (ft)
355
350
345
340
335
330
0
100
200
300
400
500
600
Distance From Left Bank (ft)
Bridge
Abutment
Pin #3
Mid-Channel
Boulder
WSE
Right
Bank
1998
2000
WSE 2000

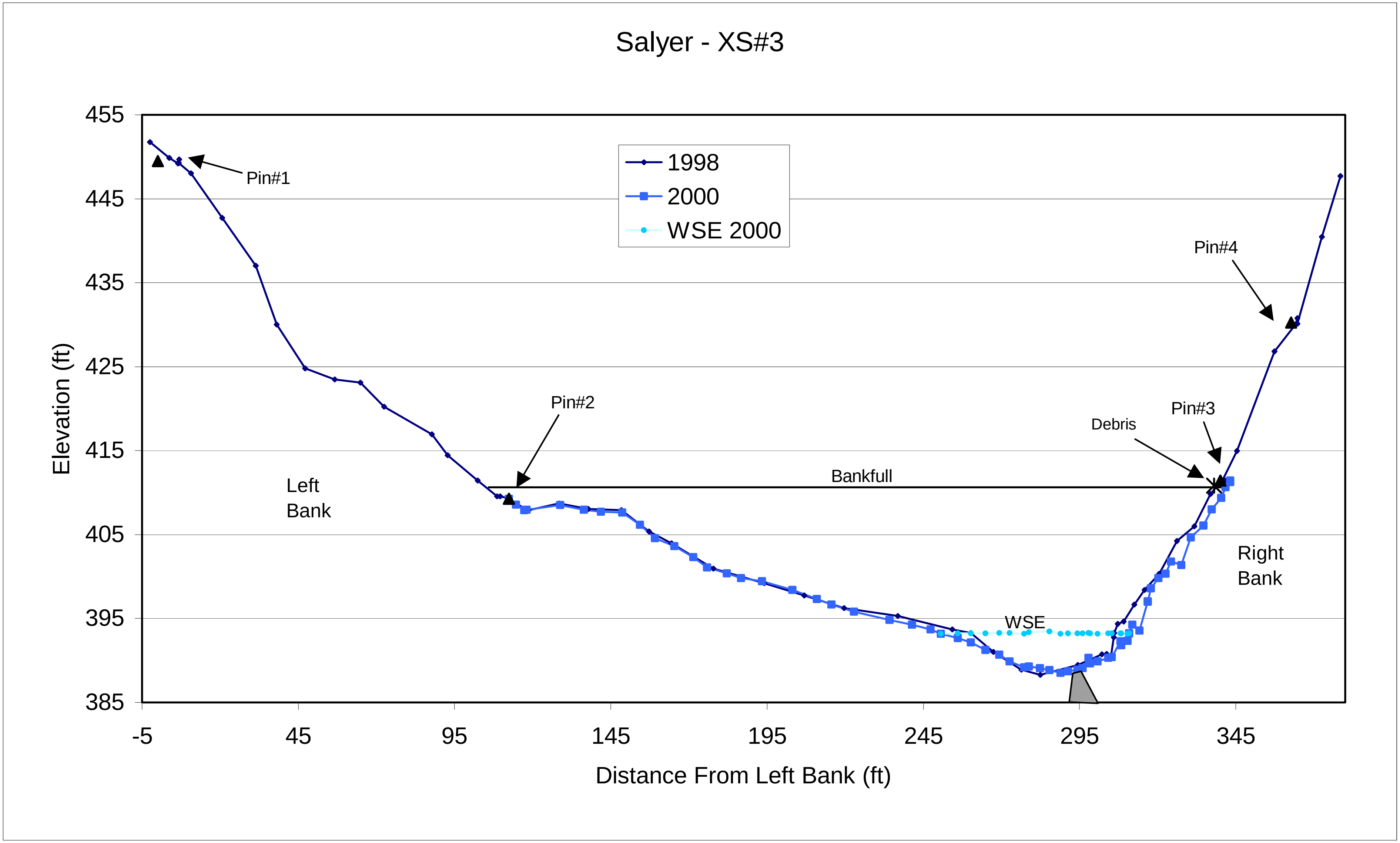


Longitudinal Profile of Channel Bed - Salyer 1998
River Mile 1.5 to 6.2

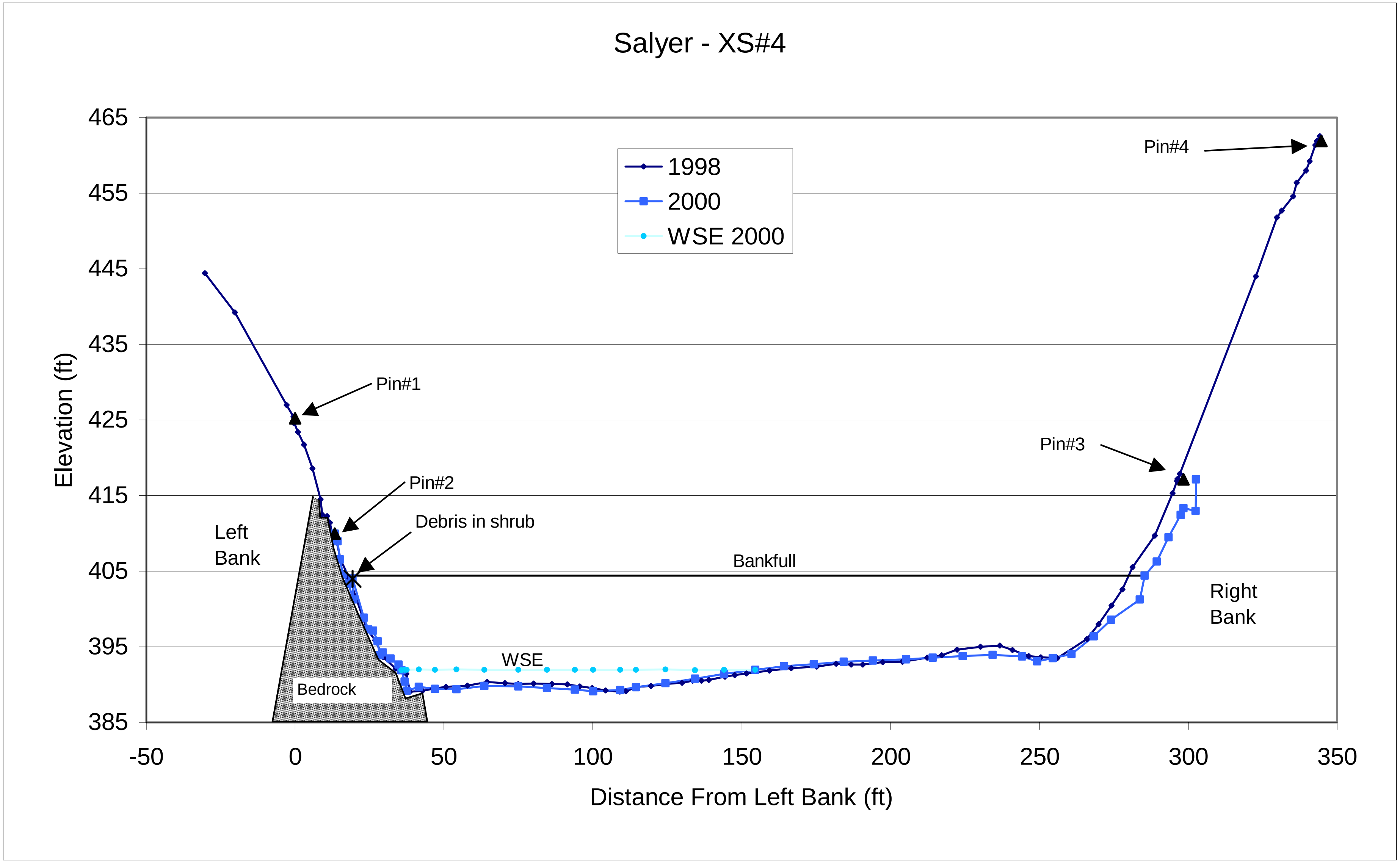

Longitudinal Profile of Channel Bed - Salyer 2000
River Mile 1.5 to 6.2
Elevation (feet)
440
430
420
410
400
390
380
370
360
Thalweg Distance (feet)
0
5000
10000
15000
20000
25000
XS#2
XS#3
XS#4
XS#5
Thalweg Elevation
Water Surface elev.

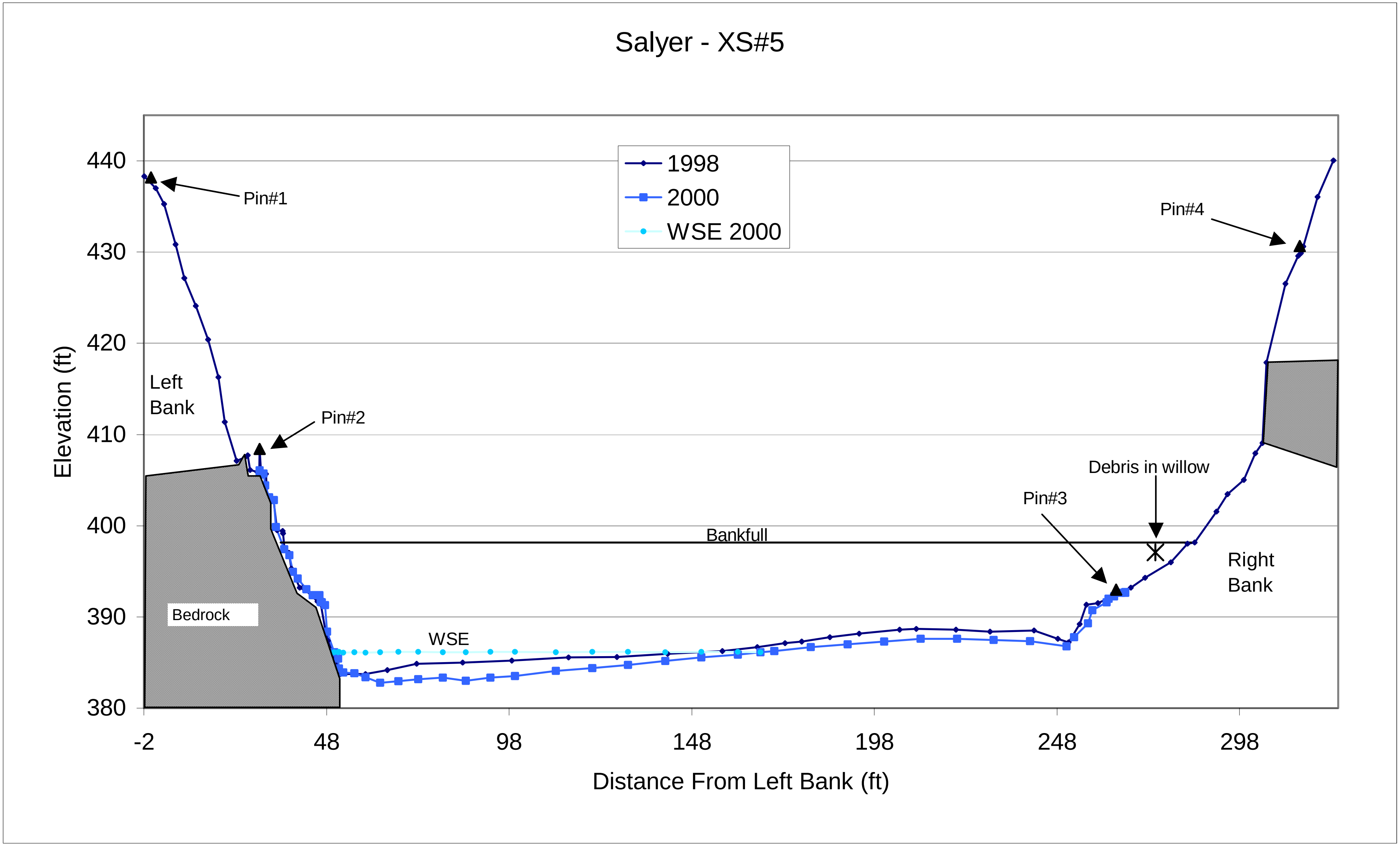

Salyer - XS#1
Elevation (feet)
600
590
580
570
560
550
540
Distance From Left Bank (feet)
35
85
135
185
235
285
335
5/9/55
4/30/56
12/3/64
5/21/65
6/7/67
10/1/80
8/2/98
9/28/00
Right Bank
Cable Anchor
Bedrock
Left
Bank
Right
Bank


Salyer - XS#2
550
530
510
490
470
450
430
410
Elevation (ft)
0
50
100
150
200
250
300
350
400
450
500
Distance From Left Bank (ft)
1998
2000
WSE 2000
Bedrock
Pin#1
Pin#2
Pin#3
Pin#4
Left
Bank
Right
Bank
Bankfull
WSE



Salyer - XS#3
1998
2000
WSE 2000
Pin#1
Pin#2
Pin#3
Pin#4
Debris
Bankfull
Left Bank
Right Bank
WSE
Elevation (ft)
455
445
435
425
415
405
395
385
-5
45
95
145
195
245
295
345
Distance From Left Bank (ft)


Salyer - XS#4
1998
2000
WSE 2000
Elevation (ft)
465
455
445
435
425
415
405
395
385
-50
0
50
100
150
200
250
300
350
Distance From Left Bank (ft)
Pin#1
Pin#2
Debris in shrub
Pin#3
Pin#4
Left
Bank
Right
Bank
Bankfull
WSE
Bedrock


Salyer - XS#5
1998
2000
WSE 2000
Elevation (ft)
440
430
420
410
400
390
380
-2
48
98
148
198
248
298
Distance From Left Bank (ft)
Pin#1
Pin#2
Pin#3
Pin#4
Left Bank
Right Bank
Bedrock
WSE
Bankfull
Debris in willow

None of the rest of the appendices are included in this edition of this document.