Riparian Area Existing Condition
Case Mountain

The headwaters of the Case Mountain are located in the Salt Creek and Coffeepot Canyon Drainages. Salt Creek flows in a northeasterly direction into the Kaweah River about two miles below the Sequoia National Park Boundary. Coffeepot Canyon Creek flows into the East Fork Kaweah River at the Sequoia National Park Boundary and then into the Kaweah River about a mile upstream of where Salt Creek enters the Kaweah River. The Kaweah River flows southwest into Lake Kaweah. Beneficial uses for the Kaweah drainage above Lake Kaweah include municipal water use, contact, and non-contact recreation, warm and cold-water fisheries, Preservation of rare and endangered species, spawning, wildlife, hydroelectric power generation and freshwater replenishment, (1977, Central Valley Water Quality Control Board).

Stream Type, Channel Stability, and Channel Condition

The stream surveys performed during the summer of 1999 evaluated Stream Type after Rosgen (1994) Channel Stability after Pfankuch (1978) and Channel Impact Levels after Kaplan-Henry et.al. (1994). Rosgen Stream type defines the stream channels with respect to their gradient, substrate, entrenchment, and confinement, Pfankuch evaluates upper, lower, and channel bottom parameters to determine stability. The work done by Kaplan-Henry evaluates both the riparian ecotype and the stability to assign an impact level to the channel. Impact levels are displayed on Map 1. The analysis has been further simplified following a procedure used on the Sequoia National Forest that combines the Rosgen channel types and identifies environmental indicators based on those channel types. Kaplan-Henry (1995). The riparian ecotypes range in a continuum from Naturally Stable (bedrock boulder high and medium gradient channels) to Naturally Unstable (landslide prone fine grained steep channels). Intermediate areas include stable sensitive (meadow environments) and unstable sensitive degraded Channels (gullies). Riparian ecotypes are documented on Map 2. Both Maps 1 and 2 display the Rosgen channel typing information adjacent to the stream reach. The following provides a description of the process and assumptions used in defining the four riparian ecotypes and their environmental indicators.

Riparian Ecotypes

<u>Naturally Stable</u>

This ecotype is inherently stable and comprised of bedrock, boulder and cobble controlled channels. It is not significantly influenced by land management activities. Sediment build-up can be concerns in some locally impacted areas.

<u>Stable-Sensitive</u>

This ecotype is inherently stable dominated by cobble, gravel, sand, and finer material. It is located in relatively flat riparian areas that are easily influenced by land management activities. This ecotype is comprised of streams typically associated with meadows with or without defined channels. This ecotype is stable and very susceptible to disturbances and changes in the flow, timing, and quality of water.

<u>Unstable-Sensitive-Degraded</u>

This ecotype has been degraded and represents severe alteration of another riparian ecotype. In most cases, this ecotype represents the degraded form of Stable-Sensitive ecotypes that were formerly meadows. These ecotypes are comprised of down cut meadows with lowered water tables and abandoned flood planes. Meadow functions are not operating and vegetation is comprised of species that represent dry sites; accelerated erosion is common. A less common form of this ecotype is the altered form of the Naturally-Stable ecotype resulting from extensive accelerated sediment deposition on a course substrate. These areas exhibit braided characteristics the source of which is usually associated with upstream sites and/or deposition from off-site sources of sediment (roads, trails, campgrounds etc.) that has been transmitted to the site. Recovery usually requires active restoration measures.

<u>Naturally Unstable</u>
This ecotype is typically eroded, steep, and unstable due to natural processes. It has a very high sediment load and is usually associated with debris avalanche or landslide terrain. These environments are sensitive to disturbance, and restoration is not practical due to a natural tendency for unstableness.

Environmental Indicators

Assessing the health or existing condition of these ecotypes is the next step and requires an evaluation of environmental indicators appropriate for each ecotype. Pfankuch 1978 developed a channel stability procedure to systematically measure and evaluate the resistive capacity of mountain streams. The concept of riparian ecotypes had not been developed when Pfankuch envisioned his channel condition evaluation procedure. Since this time, selection of environmental indicators appropriate for different channel types has been discussed in the literature and applied to stream surveys in the field. Five of the fifteen indicators used in Pfankuch are selected to evaluate the function of riparian ecotypes. The five indicators selected are those most affected by disturbance. These indicators are used to evaluate stream reaches that have been classified using Rosgen, 1985. Information from Rosgen, 1985; Meyers and Swanson, 1992; Forest stream inventory data from 1989 to present; and professional judgment has been used to determine which indicators are appropriate for each riparian ecotype.

The five riparian indicators used for evaluation of stream impacts and channel functions are: vegetative bank cover, stream bank cutting, channel bottom deposition, channel bottom scour and deposition, and percent stable material. The total sum of the indicators as described in Pfankuch is not employed in this system; rather the indicators are evaluated independently and then together to define a combination of processes responsible for changes in channel function.

Myers and Swanson, 1992 tested Pfankuch indicators for observer variation and the relationship between Rosgen stream type and damage to the riparian resources from ungulates. Vegetative bank protection and bottom size distribution and percent stable material were among the indicators with the least observer variation. Vegetative bank protection, cutting, and bottom size distribution and percent stable material are reported to have a high probability for varying with riparian damage as per Myers and Swanson, 1992. Deposition has a lower probability for varying with damage however it is applicable for use in Naturally-Stable and Unstable-Sensitive-Degraded riparian ecotypes. Table 1 displays probability of the five indicators to damage after Myers and Swanson, 1992. Deposition and scour & deposition are two different indicators. Because these are so closely related, they are shown together.

Table 1. Probability for variation of stream stability indicator with riparian damage after Myers and Swanson, 1992

Indicator ***Channel Type***	**Vegetative Bank Protection**	**Cutting**	**Deposition/ Scour & Deposition**	**Bottom Size Distribution and Percent Stable Material**
Naturally- Stable	Low	Low	Moderate/High	High
Stable-Sensitive	High	High	Low/Low	Moderate
Unstable-Sensitive-Degraded	High	High	Moderate/Low	High
Naturally-Unstable	High	High	Low/Low	High

Myers and Swanson, 1992, question results of detecting scour and identifying deposition, especially in fine grained channels. However based on the predominately granitic channels of the Southern Sierra Nevadas this indicator is considered appropriate for determining response to impact. Rosgen, 1994 evaluated the ability to predict response to management based on stream type. He indicates that the influence of vegetation on Naturally-Unstable riparian ecotypes is negligible. In conservations with Dr. Neil Sugahara, 1994, he states that these environments are generally occupied by invader species due to the unstable nature of the environment. Both of these views are contrary to Myers and Swanson, 1992. Therefore, based on Rosgen, Sugihara, and Forest evaluations, vegetative bank protection is not considered an appropriate indicator for Naturally-Unstable riparian ecotypes. There is agreement between Rosgen, 1994, and Myers and Swanson, 1992 as to the applicability of the other indicators in Table 1. The Forest data supports the use of these indicators to determine channel function and health. Although Myers and Swanson, 1992 do not support the use of scour and deposition, this indicator has been combined with deposition and is applicable for Sensitive-Unstable-Degraded and Stable-Sensitive riparian ecotypes. The following is a description of the five indicators identified from Pfankuch's stream stability evaluation and the riparian ecotypes they are used to evaluate.

<u>Vegetative Bank Cover</u>

This indicator evaluates stream bank vegetation and root mat strength for bank stabilization and reduction of flood flow velocity. In addition, stem density, growth, and reproduction are estimated as important factors. Variety of plants and plant vigor is also considered. Vegetative bank cover is not applicable in Naturally-Stable ecotypes because boulder and bedrock controlled drainages are stable with or without vegetation. Nor is this indicator applicable in Naturally Unstable ecotypes because vegetation is more a function of elevation and available water; furthermore, invader species are most common in these constantly changing unstable environments, (Sugihara, 1994, personal comm.).

Vegetative bank protection in Stable-Sensitive ecotypes is an excellent indicator to evaluate the condition of riparian areas and is sensitive to morphological changes that occur in meadows. All Stable-Sensitive ecotypes have the potential to achieve excellent or good conditions if left to heal in the absence of impacts. A Stable-Sensitive riparian ecotype in excellent vegetative condition would be expected to have 80-90% ground cover. Vegetation in lesser amounts has the potential to result in degradation to the less stable Unstable-Sensitive Degraded riparian ecotype.

Bank Vegetation for Unstable-Sensitive-Degraded ecotypes is generally composed of invader species along channel banks. The abandoned floodplain that generally exists at a higher elevation above these environments can be very well vegetated or could be devoid of riparian vegetation dependent on the availability and direction of subsurface water flow. These are usually sites of old meadows or existing meadows with terraces that have been down-cut with the active channel working to re-establish a new floodplain and new equilibrium. Unstable Sensitive Degraded riparian ecotypes, because of their often degraded condition are expected have "good" condition after Pfankuch, 1978 with 70% or greater ground cover with continuous stable root mass.

Bank Cutting

This indicator evaluates loss of aquatic vegetation by scour or uprooting. Where plants are naturally absent steepness of the channel bank is evaluated. Where roots bind upper bank soil surface horizon, undercutting is assessed as is overhanging sod and bank slump into the channel. Stream bank stability due to the loss of aquatic vegetation by high stream flows and bank cutting are inter-related. Bank cutting is not applicable in Naturally-Stable ecotypes because they are by definition rock controlled environments and very resistant. Bank cutting in ever changing, always eroding Naturally Unstable ecotypes is not a good indicator of channel condition.

Bank cutting is an excellent indicator to evaluate changes in Stable-Sensitive ecotypes. A clear trend can be seen as channel types shift from E to C states along with an increase in width-to-depth ratios associated with bank cutting. Stable-Sensitive ecotype in excellent condition has less than 20% of the banks affected by cuts greater than 1' high.

A Stable-Sensitive riparian ecotype undergoing a continued trend of cutting will result in Unstable-Sensitive-Degraded ecotype more commonly known as a gully. This trend can be reversed in Stable-Sensitive riparian ecotypes by removal of the disturbance Unstable-Sensitive-Degraded riparian ecotypes in fair condition should not have more than 30% of the reach comprised of cut banks of 1' or higher. It is common for channels in this ecotype to have near vertical raw banks that exceed two feet high and root mat overhangs.

Channel Bottom Deposition, and Scour & Deposition

Deposition, and scour and deposition are based on the amount of sand and gravel bar development in areas where they did not previously exist. Increases in sediment accompany increases in width-to-depth ratios, increased surface water slope, increase velocity, decrease of channel sinuosity and an increased channel bar and bench formation.

Channel bottom deposition and scour & deposition would generaly not be applicable indicators for Naturally Unstable ecotypes because their channel bottoms are always in a state of deposition and flux. The channel is also usually so steep and void of pools in this ecotype that that there is no place for sediment to deposit and because there is so much loose debris it would be impossible to quantify changes in response to disturbance. However, because there is a noticable difference among Naturally-Unstable ecotypes (Rosgen channel types A3, A4, A5, A6) with regard to the amount of deposition and scour and deposition that occurs in these environments this element is used to document this variabliity. These ecotypes are rated differently because they are considered inherently unstable. Therefore if either of these indicators are present rating begins at high and moves to extremely impacted if both indicators are above thir boundary conditions.

Deposition and scour and deposition are the only indicators applicable to Naturally-Stable riparian ecotypes. The presence of deposition and sediment movement in this ecotype is an indication of transport from upstream or off-site sources. Management actions that have the potential to affect this indicator are reduction in sediment from off-site sources. In watersheds void of Naturally-Unstable and Unstable–Sensitive-Degraded riparian ecotypes, this indicator would evaluate the effectiveness of water quality and soil conservation measures. Naturally Stable ecotypes in good condition have a low frequency of mid channel bars, good pool to riffle ratios and no more than 5-30% of the bottom affected by sand and gravel bar deposition.

Scour and deposition is not appropriate in Stable-Sensitive ecotypes due to the ever-changing depositional nature of these environments; however scour and deposition is not to be confused with deposition, which is an excellent indicator in these meadow environments. Deposition in Stable-Sensitive channel types show trends similar to other indicators in this environment. As deposition increase in Stable-Sensitive ecotypes channel types can be seen to trend toward a more unstable state. Once the boundary conditions or threshold for sediment deposition is exceeded these ecotypes will trend toward the Unstable-Sensitive-Degraded riparian ecotypes. Stable-Sensitive ecotypes in excellent condition have little or no sand bar development with less than 5% of the bottom affected by deposition of sand and gravel bars.

Unstable-Sensitive-Degraded ecotypes show a shift toward enlarging mid-channel sand and gravel bars, filled pools, and fish habitat comprised predominately of riffles with little pool development. The indicators of deposition and scour and deposition, like in Naturally-Stable ecotypes, are evaluated together and evaluate the amount of sand and gravel that accumulates in sand bars, behind logs, and narrow stream reaches. Unstable-Sensitive-Degraded riparian ecotypes in good condition have between 5-30% of the channel affected by bar development from deposition.

<u>Bottom Size Distribution and Percent Stable Material</u>
Bottom size distribution and percent stable material is based on the normal distribution of stable material (rock) of a given channel type. As pools become filled with sediment an increase of fine material becomes the predominate size class and stable material becomes less abundant.

This indicator is not applicable for Naturally-Stable riparian ecotypes because on-site impacts do not alter the natural stability of these systems, as they are comprised of stable material by definition. If sedimentation increases to the point where a shift in size classification is significant these ecotypes have probably become braided systems and shift into the Unstable-Sensitive-Degraded riparian ecotype. This indicator is also not applicable for Stable-Sensitive riparian ecotypes because these are predominately depositional fine-grained systems and would not show a "distribution shift." This indicator is also very hard to evaluate in Naturally-Unstable ecotypes because of the random distribution of landslide and debris avalanche deposits.

This indicator is appropriate for evaluation of Unstable-Sensitive-Degraded riparian ecotypes. Based on observed forest conditions most of these ecotypes have a moderate shift from stable material. An Unstable-Sensitive-Degraded riparian ecotype in good condition would have a slight distribution shift where stable material would comprise between 50 to 80% of the existing substrate.

Environmental indicators are important for the evaluation of the condition of riparian ecotypes and play an important part in monitoring to determine if changes are occurring within the hydrologic zone of influence. As discussed above, not all indicators are appropriate for all ecotypes. Table 2 displays those environmental indicators that are associated with the riparian ecotypes. With the exception of Stable-Sensitive riparian ecotypes, indicators specific to an ecotype have a description of the conditions that Pfankuch, 1978, uses in describing a channel in "good" condition in the column below the appropriate indicator. Stable-Sensitive riparian ecotypes have ratings of excellent.

Table 2. Conditions for the various indicators appropriate for specific riparian ecotypes and their boundary conditions for a condition rating of "Good" after Pfankuch 1976.

Environmental Indicator → ***Riparian Ecotype* ↓**	**Vegetative Bank Protection**	**Bank Cutting**	**Bottom Deposition and Scour& Deposition**	**Bottom Size Distribution and % Stable Material**
Naturally Stable **Rosgen Channel Type:** **A1, A2, B1, B2, B3, C1, C2, F1, F2, G1, G2** ***Restoration Not Required***	NA	NA	**Low frequency of mid-channel bars and good pool to riffle ratio**	NA
Stable Sensitive **Rosgen Channel Type:** **B4, B5, B6, C3, C4, C5, C6, E3, E4, E5, E6** ***Recover with Passive Restoration***	**80 to 90 % ground cover with stable continuous root mass**	**Less than or equal to 1 foot of exposed bank cuts affecting less than or equal to 20% of the channel**	**Little or no sand bar development with 0 to 5% of the bottom affected by bar deposition**	NA
Unstable Sensitive Degraded **Rosgen Channel Type:** **G2, G3, G4, G5, G6, F3, F4, F5, F6, and those D3, D4, D5, D6 in unexpected geomorphic settings.** ***Recover with Active Restoration***	**Greater than or equal to 70 % ground cover with stable continuous root mass**	**Less than or equal to 1 foot of exposed bank cuts affecting less than or equal to 30% of the channel**	**Low frequency of mid channel bar development, Improved pool to riffle ratio, with 5 to 30% deposition behind obstructions**	**Slight size distribution shift between 50-80% stable material**
Naturally Unstable **Rosgen Channel Type:** **A3, A4, A5, A6** **(Landslide and Debris slide Terrain)** ***Impractical to Restore***	NA	NA	NA	NA

Application of Environmental Indicators to Determine Channel Condition

Channels that have been channel typed after Rosgen, 1985, and evaluated for channel stability after Pfankuch, 1978 have the field data necessary for determination of condition, health, level of impact, or any other term that suggests evaluation of function. Initially the channels need to be grouped into their appropriate riparian ecotype. Environmental indicators appropriate for the riparian ecotype then need to be assessed to determine the Pfankuch condition rating. In most cases, the division between a rating of fair and good is the boundary condition or threshold used to assess health or condition. This boundary condition is stricter for all indicators in meadow (Stable-Sensitive ecotypes) due to the significant role vegetation plays in these environments. The division between good and excellent is used as the boundary condition for all environmental indicators in Stable-Sensitive riparian ecotypes.

The condition of a riparian ecotype is based on how many environmental indicators exceed the boundary condition or threshold for the indicators applicable to the ecotype. Table 3 displays the relationship between the assigned level of impact or condition rating and the number of environmental indicators exceeding threshold or boundary conditions appropriate for a functioning ecotype. Ecotypes with fewer environmental indicators will not reach impact levels greater than the rating assigned to the number of available environmental indicators.

Number of Environmental Indicators Exceeding Boundary Conditions or Threshold	Level of Impact or Condition Rating
0	Minimal
1	Low
2	Moderate
3	Moderate-High
4	High*
5	Extreme*

Table 3. Number of environmental indicators and condition rating for riparian ecotypes
*Naturally-Unstable riparian ecotypes are ranked using the assumption that they are inherently unstable and therefore if one element is above a threshold the ranking is high and if two elements are over threshold the impact ranting is extreme.

Riparian ecotypes such as Stable-Sensitive and Naturally-Stable contain three or one environmental indicator(s) and therefore cannot exceed an impact level of moderate-high or low, respectively. Given the tendency for Stable-Sensitive environments to change to Unstable-Sensitive-Degraded environments if vegetation, cutting, and deposition occur, it is intuitive that meadow environments cannot exceed moderate high impact levels and still function as a meadow. Conversely, unless a Naturally-Stable environment has a tremendous amount of sediment deposited and shifts in character to a naturally unstable degraded braided system, it will maintain it's stable nature and will recover once the source of sediment is stabilized or restored.

Case Mountain Stream Channels

Ten channels were surveyed in the Case Mountain area. The following information provides a description of the riparian ecotype and the level of impact observed in the field. A database summarizes this data in Appendix A. Appendix A also contains water conductivity information collected for the USGS study. Photographs of each reach, detailed cross section and substrate information along, and channel stability evaluation forms are provided for each reach evaluated. This information is grouped by stream and further subdivided by channel reach. Names have been assigned to the surveyed channels and can be found on Maps 1 and 2.

The first channel that is encountered upon entering the Case Mountain area is the "Entrance" Creek. The Entrance Creek has one major tributary, which is named Entrance 1 on Maps one and 2. The other drainages are accessed using roads east and west of this main drainage. To the east lay Grove 3A and it's tributary Grove 3B, Coffeepot, Grove 5, Grove 6B and Grove 6A. These drainages and the Entrance drainage are all tributary to Coffeepot Canyon. Coffeepot Canyon is tributary to East Fork Kaweah River. To the west of Entrance Creek lay Grove 1C and it's tributary Grove 1D, Grove 1B and Grove 1A. All of the drainages on the west side of Case Mountain are tributaries of Salt Creek. For simplicity, these drainages will be discussed as if their names were Grove 1A Creek and so on.

Grove 6A

Grove 6A is the easternmost drainage in the Case Mountain area. The reach that comprises Grove 6A is 1900 feet in length with a vegetative component that is predominately shrubs and brush with minor grass and forbs beneath the cover that the brush provides. The drainage is comprised predominately of sand size material and has a channel gradient of roughly 25%. This channel would be classified as an A5a+ channel type using the Rosgen 94 channel classification. This places the channel in the naturally unstable riparian ecotype.

The level of impact exhibited in Grove 6A is High. This impact rating is based on the scour and deposition characteristics of the channel. Scour and deposition appears to be consistently in a state of flux supporting the naturally unstable nature of the channel.

Grove 6B

Grove 6B is comprised of two reaches. The uppermost reach, reach 1 (R1) is very similar in character to Grove 6A; steep naturally unstable and comprised of a high percentage of sand-sized material. This reach is roughly 635 feet long and is classified as a Rosgen A5a+ channel. Reach 2 (R2) is immediately downstream of reach 1 and in contrast is naturally stable. Reach 2 is roughly 2,320 feet long, comprised of bedrock, which continues downstream to its confluence with Grove 5 creek, and is a Rosgen A1a+ channel. Reach 2 has small inclusions of sandy material where gradients are lower than the average 19-17% gradient that is present throughout both reaches.

The overstory of is composed of conifers with an understory of shrubs, brush, and a small amount of willow. Grasses forbs and litter provide soil protection. Channel impacts in both reaches are rated as minimal.

Grove 5

Grove 5 contains five reaches four of the five reaches are mapped as naturally unstable ecotypes with the remaining reach mapped as a stable sensitive ecotype. The naturally unstable ecotypes begin at the confluence with Grove 6B drainage and extend upward to the headwaters of the drainage. Below Coffeepot road, the drainage is inaccessible where it extends down through the burned area. Reach 4 is mapped just between the two upper roads. Within this reach, the channel is less entrenched, contains a somewhat developed floodplain, and is characteristic of a stable sensitive riparian ecotype. Grove 5 transitions between entrenched and less entrenched sections of creek with stream gradients that range between 6 and 25%. Substrate size ranges from sand to cobble. Above the burned section of the channel, the vegetation is predominately conifer with subordinate alder overstory with brush, grass, and litter on the ground. Brush and willows is present in small amounts through out the channel.

Impact level in Reach 1 (2,590 feet) is high and results from high levels of scour and deposition. Reaches 2 (420 feet), 3 (1580 feet), and 5(260 feet) have impact levels of extreme, which result from elevated deposition and scour and deposition. Reach 4 (260 feet) is the stable sensitive ecotype in Grove 5 and has an impact rating of moderate-high. Reach 4 is beginning to develop multiple channels and is transitioning to an unstable-sensitive-degraded riparian ecotype. Vegetative bank protection is diminished, cutting is present at elevated levels, deposition is high with mid channel bars forming; the reach is extensively trampled and is beginning to develop a deposition of fine material.

Coffeepot

Coffeepot drainage is comprised of two reaches that are naturally unstable riparian ecotypes. The two reaches range in gradient from 17 to 18 % and are predominately comprised of small cobbles. These reaches would be classified as a Rosgen A3a+ channel. These reaches have inclusions of finer grained sections that would be classified as A4a+ Rosgen channel types. These reaches are roughly 1740 and 1530 feel in length and are very similar in character. Vegetation is comprised of a conifer overstory, understory of shrubs and brush and grass and forbs providing vegetative ground cover. Impact levels are minimal in this drainage and the channel reflects this in the overlack of deposition or scour and deposition.

Grove 3A/B

Grove 3A/B drainage confluences with Coffeepot drainage just below the surveyed section. Grove 3A confluences with Grove 3B approximately 2/3 of the way upstream. The channel and its tributary are subdivided into six reaches. With the exception of Grove 3A, Reach 4, the entire channel and its tributary is classified as a naturally-unstable ecotype with all but one reach being extremely impacted. This is due to accumulated deposition and scour & deposition in the channel bottom. The remaining naturally-unstable ecotype in Grove 3A, Reach 3 has an impact rating of low resulting from high levels of scour & deposition. The substrate in Grove 3A reaches is composed of coarse sands and gravels with gradient ranges from 5 to 15 %. Tributary to Grove 3A, Grove 3B has only one reach which has a predominately sand substrate. There is a dense conifer overstory and an understory comprised of dense shrubs and brush in the channel. Some of the reaches do not have the conifer overstory and in these areas, the brush comprises the dominant vegetation. Grasses and forbs provide ground cover vegetation.

The remaining reach in Grove 3A is Reach 4. Reach 4 is a naturally-stable reach comprised of 100 % bedrock. Conifers and heavy Alder provide the overstory. The impact level in this section is minimal with little to no sedimentation. This is most likely a function of the steepness of the reach as the gradient is roughly 18%.

Entrance/Entrance 1

The drainage at the entrance to the Case Mountain area is the most complex and extensive channel in the area. The channel was named Entrance by the survey crews and has one main tributary called Entrance1. Entrance has four reaches and Entrance 1 has three reaches. All of the reaches identified have heavy conifer overstory and Alder that is only sometimes present. Riparian ecotypes and impact levels are variable.

The first reach of Entrance is classified as an “F4” channel type using the Rosgen classification. It is considered an unstable-sensitive-degraded riparian ecotype and represents an altered form of a more stable channel type. It is currently trending toward a stable-sensitive ecotype (a Rosgen C4 channel type) as it has developed a floodplain with point bars and meanders within this downcut reach. Lateral erosion is the process that is currently occurring and vertical erosion is subsided in this reach. Once vegetation becomes established the channel will gain in stability and its moderate level of impact will be reduced. Cattle damage is pervasive through this reach. Cattle impacts combined with road runoff are responsible for impacts to the channel. This reach is 1,240 feel in length and substrate material is comprised of all materials with the dominant particle size being gravel.

The second reach of Entrance is at the confluence of Entrance 1. Reach 2 is a stable sensitive reach classified as Rosgen B5c channel. This reach has a sinuosity 1.4 times the length of the channel and occupies a floodplain about 14 feet wide. Cattle impacts are evident and impact level of moderate-high supports the impact from grazing. As road crossing are present upstream part of the impacts would be expected to from increased discharge from road drainage as well. Specific characteristics of the channel include low vegetative bank protection and high levels of cutting and deposition.

This reach runs the risk of transitioning to an unstable-sensitive-degraded riparian ecotype if management is not improved. The trend would be to gully resulting in vertical erosion and then once stabilized lateral erosion similar to Entrance reach 1 above. The risk in lateral erosion is the risk it causes to the stability of large conifers and water quality/soils resources. This reach is 620 feet long and has a gradient of 2% and a substrate of sand size material. This area may once have been a meadow prior to the growth of conifers in the area.

Reach 3 of Entrance is an unstable-sensitive-degraded riparian ecotype and exhibits gully characteristic. It has an impact rating of high with low vegetative protection, high amounts of cutting, deposition, accumulated fine material and scour & deposition. The reach is 930 feet long and the predominate substrate material is fine gravel. Average stream gradient is 4%.

Reach 4 is a naturally-unstable riparian ecotype and is minimally impacted. The substrate material is comprised of coarse gravel and has a stream gradient of 22%. Vegetative bank protection is good and deposition, cutting, and fine material low. This section of channel is functioning well. This reach is 2,480 feet long. The upper 200 feet of reach 4 contains numerous seeps that don’t really form a channel as they terminate at the road in a large pool that is roughly 10’ by 30’. The whole area is trampled and ground cover is absent.

Entrance 1 reaches follow trends similar to Entrance reaches. Reach 1 that begins at the confluence of the two drainages has similar characteristics to Entrance reach 2. It is a transitional stable-sensitive reach with sinuosity and is almost void of riparian vegetation. Deposition appears to be high although not to the extent to affect the impact rating of low.

Entrance 1 reach 2 is naturally-unstable and has high levels of scour & deposition. The impacts of roads upstream could be responsible for the observed impact level. Entrance 1 reach 3 is naturally-stable and is minimally impacted.

Grove 1C/ Grove 1D

Grove 1D is tributary to Grove 1C. This drainage flows into Salt Creek. Four reaches form the stream system. The lowermost reach 3 is naturally-stable and minimally impacted. Bedrock provides the stability for this reach and a gradient of 20% maintains the pool depths. Confers and hardwoods make up the overstory and alder is present in an understory along with shrubs and brush.

The remaining reaches in Grove 1C and its tributary Grove 1D are naturally-unstable with an impact rating of extreme. Reach 1 has a substrate composed of fine sand, reach 2 gravel, and reach 1 of Grove 1D sand. Deposition and scour & deposition are high in these reaches.

Grove 1B

Grove 1B is comprised of four reaches. Reach 1 is located in the headwaters of the drainage. This reach is a stable-sensitive ecotype that has meadow characteristics. The area is badly trampled and channel characteristics were impossible to distinguish due to the trampling. The area has a bimodal distribution of sands and cobbles. The area is at risk of losing riparian character and is trending towards an unstable-sensitive-degraded ecotype due to the degradation occurring from grazing. This reach is 800 feet long and transitions into reach 2, which is 475, feel long. Reach 2 is immediately downstream from this reach and is very steep, 15% gradient. This area is actively cutting upstream into the meadow like environment of reach 1.

Reach 1 has an impact rating of moderate-high and reach 2 high. There is potential for headward erosion to move upstream and degrade the riparian values in reach 1. This would probably have a negative affect on resource values, as riparian ecotypes of this nature are very sparse in the Case Mountain area.

Moving downstream to reach 3 the stream gradient flattens out and the fine material eroded from upstream becomes deposited in this reach. This reach has a gradient of 9% and has a substrate of very fine sand. This reach is 530 feet in length and is extremely impact from sedimentation generated upstream. Conifers provide the main overstory with a small component of alder.

Reach 4 is the lowermost reach in Grove 1B. This reach is naturally-stable due to substrate, which is composed of cobbles. It does have a slight bimodal distribution due to the sedimentation upstream and has a fine sand component. Another factor associated with the fine material in the channel is the blown out culvert at the road crossing near this reach. The sedimentation affects the impact rating of the channel, which is rated as low. Conifers and alder make up overstory and woody brush comprises the majority of the understory. This reach is roughly 1,700 feet long and has a large woody component, which adds stability.

Grove 1A Channel

Grove 1A is the westernmost drainage in the study area and is 2220 feet in length. This channel has only one reach and is very steep with moss on lower banks. Forbs and brush are abundant and woody debris is common. Where the channel widens and gradient decreases there are signs of trampling. The average creek gradient is 25%. About 100 to 150 feet above Salt Creek road is very stable bedrock controlled drainage with a gradient of 30+%. The channel is bimodal and substrate is composed of over 70% fine sand and 30% gravel. This suggests that the channel is being impacted by sand deposition. Impact level for this reach is extreme.

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Channel Geometry Relationships
Section 2

Understanding the relationships of the channel morphology and the water that flows through the channel provides a reference point and a foundation for assessing the current condition of the existing stream channel and provides an objective description of the future potential of the stream channel. The characteristics of the channel are related to the amount of sediment and water that flows through the channel balanced against the material that makes up the channel bed and banks. This geomorphic approach documents the physical characteristics of Case Mountain and identifies patterns common to the Kaweah River and the Southern Sierra Nevada Region. These patterns are the basis behind the concept of "bankfull discharge." This discharge is responsible for doing the work in moving sediment through the system and creating the pattern, dimension, and profile characteristics seen in the river today.

Bankfull Stage

A river is at the bankfull stage when the water level is at the incipient point of the floodplain, that is, water is just beginning to overflow from the channel onto the floodplain. The floodplain of a river is defined as the relatively flat area adjacent to the river channel, which is constructed by the river in the present climate and frequently receives overflow (Leopold, 1994). Flood frequency analysis has revealed that on average, the bankfull flow has a recurrence interval of 1.5 years, meaning that the floodplain is at least partially inundated on average 2 years out of 3 (Dunne and Leopold 1978).

Bankfull discharge is significant because it "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels" (Dunne and Leopold 1978). E. D. Andrews has named the river stage that carries the most sediment over time the effective discharge; others have referred to this as the channel forming discharge (Andrews 1980, Leopold, 1994). Andrews has shown that bankfull discharge and effective discharge have a very close relationship (Andrews 1980, Leopold, 1994). A river sizes itself to a capacity near the bankfull discharge rather than that of the largest floods because over time most work is performed a discharges at or near the bankfull discharge.

It is important to consider the phase "over time" when discussing the discharge that carries the greatest amount of sediment. It is intuitive to most people that the river moves a greater amount of sediment at higher flows, however lower flows are much more common in occurrence and therefore over time transport a higher quantity of sediment (Wolman and Miller 1960, Leopold, 1994, and Rosgen 1996). Discharges near the bankfull stage occur with such a frequency that over time those discharges carry the greatest amount of sediment. Field measurements have verified that the erosion rate, the sediment transport rate, and the bar building by deposition are most active when the discharge is near bankfull (Leopold, 1994).

Importance of Regional Curves

Many researchers have demonstrated the high correlation between the average values of bankfull width, depth, cross sectional area, and discharge for streams with the drainage area in a region (Dunne and Leopold 1978, Leopold 1994, and Rosgen 1996). The plots of bankfull channel dimensions and bankfull discharge against drainage area are commonly referred to as "regional curves." Regional curves are created from data collected at river gauging stations.

Regional curves, once they are created, are useful when determining bankfull stage at an un-gauged station. Drainage area can easily be obtained from a map of the basin. Once drainage area is known, the regional curve provides a tool in which acquire an estimate of the channel dimensions and bankfull discharge, with the proper understanding of the variability in the regional curve (Dunne and Leopold 1978).

The regional curves tend to help field researchers key in on bankfull when working at un-gauged stations, aid in the proper use of stream classification systems, and provide a channel dimensions database for a region. When identifying bankfull in the field however, it is important to first identify the geomorphic feature of the floodplain and use the regional curve to verify that the bankfull stage identified falls within the acceptable variance of the regional curve.

Development of Regional Curves

Following the protocol outlined in the "Step-Wise Procedure for Calibrating Bankfull Discharge at USGS Stream gauging Stations" (Rosgen, 1996), regional curves were developed to integrate bankfull channel dimensions and bankfull discharge with drainage area for the Southern Sierra Nevada region. Adding data points to these curves is an ongoing effort of the Sequoia National Forest.

Bankfull stage was determined in the field at the following USGS gaging stations (USGS gage number): South Fork Tule River (11204500), Tule River near Springville (11203200), Little Kern River (1185400), Monache Meadows (11188299), and the North Fork of the Kern River (11185350). Forest Service personnel performed data collection in the Tule River and the Kern River drainage data was collected under a Forest Service contract by URS Greiner Woodward Clyde.

Bankfull stage was determined through the observation of bankfull indicators along the river near the gauging stations. Useful indicators include (Harrelson et. al., 1994):

- "The height of deposition features (especially the top of a point bar, which defines the lowest possible level for bankfull stage);
- a change in vegetation (especially the lower limit of perennial species;
- slope or topographic breaks along the bank;
- a change in the particle size of bank material, such as the boundary between coarse cobble or gravel with fine-grained sand or silt;
- undercuts in the bank, which usually reach an interior elevation slightly below bankfull stage; and
- stain lines or the lower extent of lichens on boulders.

The elevation of the bankfull stage identified in the field was related to the staff gage at each gaging station. Once the staff height at bankfull stage was known, the bankfull discharge was determined using the discharge-rating curve compiled from the USGS flow record. The drainage area at each station was also determined using USGS records.

Channel cross-section surveys were performed to determine the bankfull channel dimensions of width, depth, and cross-sectional area. Table 1 provides a summary of the information compiled in order to create the regional curves.

Regional curve data listed in Table 4 was used to plot figures 1 through 4. Figures 5 through 7 are plots of the field data collected by seasonal crews together with the information collected at the USGS gauging stations. This field data is contained in Appendix B and in field reconnaissance forms contained in each creek file. The plots give the equation of the trend line and the R^2 value of each data set. The R^2 value ranges from 0.66 for bankfull width to 0.94 for bankfull depth in relation to drainage area for the gauge station plots and from 0.71 for bankfull depth to 0.92 for bankfull cross-sectional area for the survey data plotted together with the gauge station plots. The plots provide a means to estimate bankfull channel dimensions and discharge based on drainage area, with the understanding of the variability in the regional curves.

Table 4. Summary of data collected in order to create the Southern Sierra Nevada regional curves.

USGS Gaging Station	**Drainage Area (mi^2)**	**Bankfull Discharge (cfs)**	**Bankfull Width (ft)**	**Bankfull Depth (ft)**	**X-Sectional Area (ft^2)**
South Fork Tule River 11204500	109	77	34.3	1.84	61
Tule River near Springville 11203200	247	668	77.8	2.4	152
Little Kern River near Quaking Aspen 11185400	132	435	42	1.8	74
Kern River Near Quaking Aspen 11185350	530	1866	74.6	4.11	230
South Fork of the Kern River near Monache Meadows 11188200	146	205	27.8	2.2	50

Figure 1. Bankfull discharge as a function of drainage area, gauging stations.

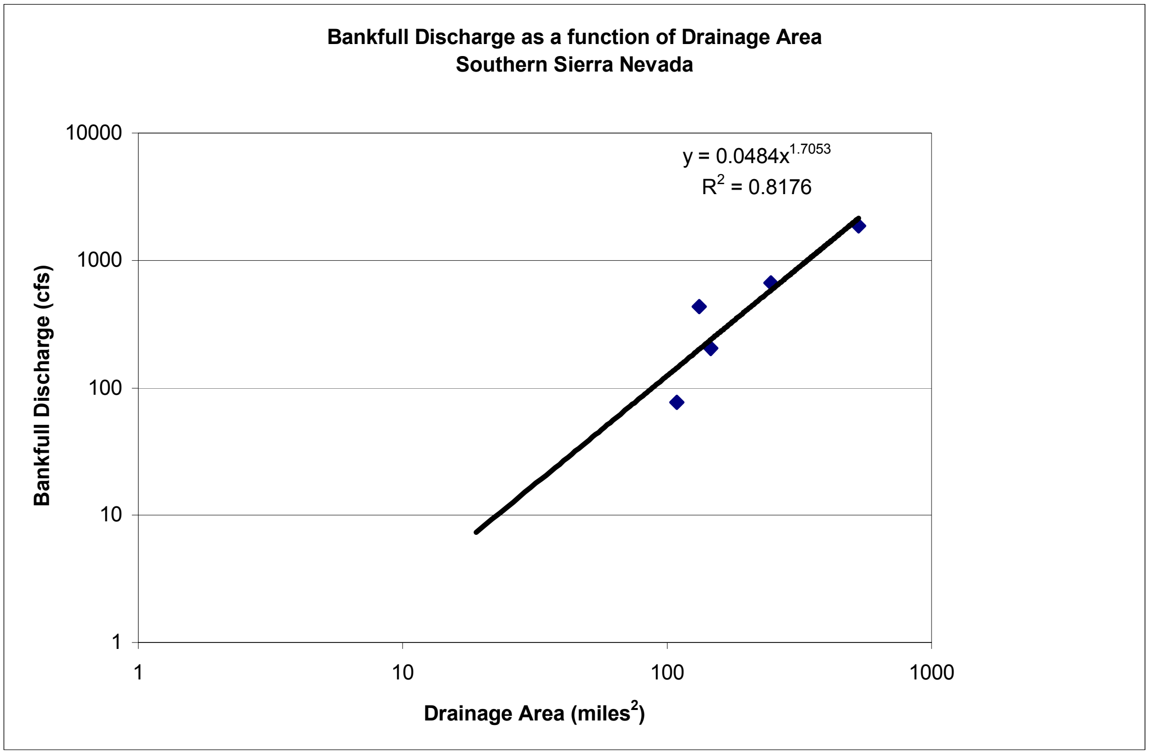


Figure 2. Bankfull width as a function of drainage area, gauging stations.

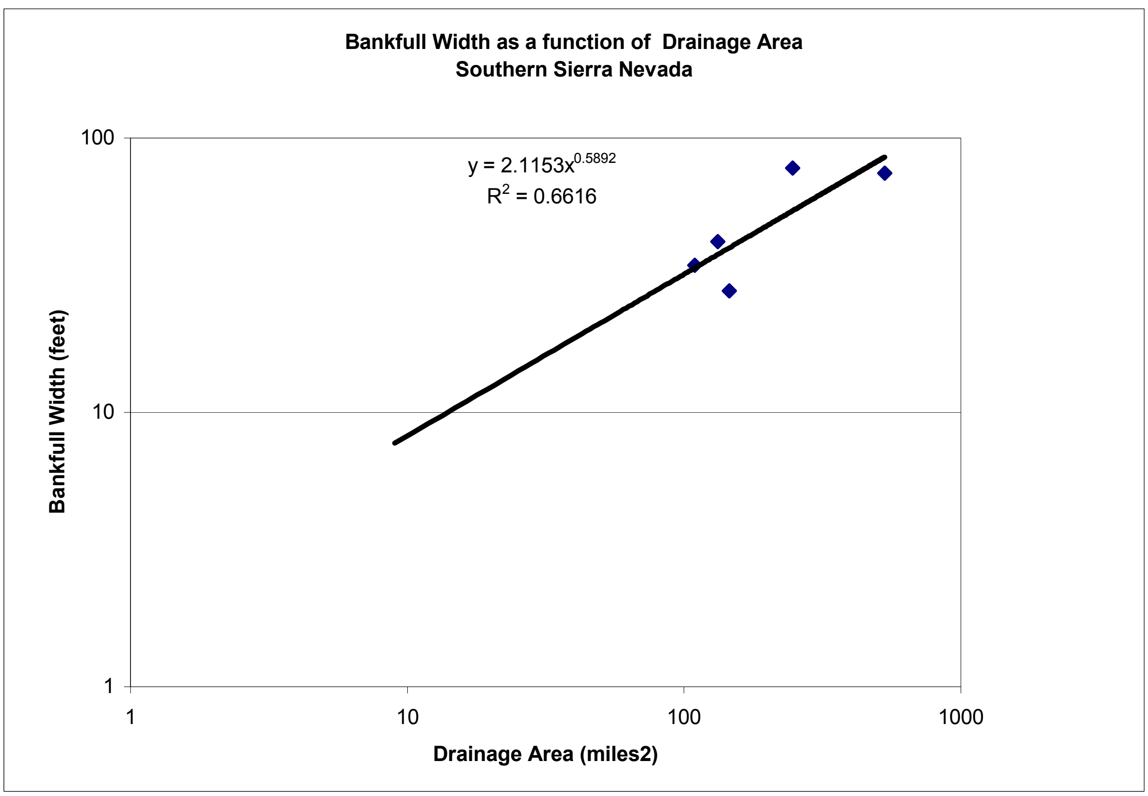


Figure 3. Bankfull depth as a function of drainage area, gauging stations.

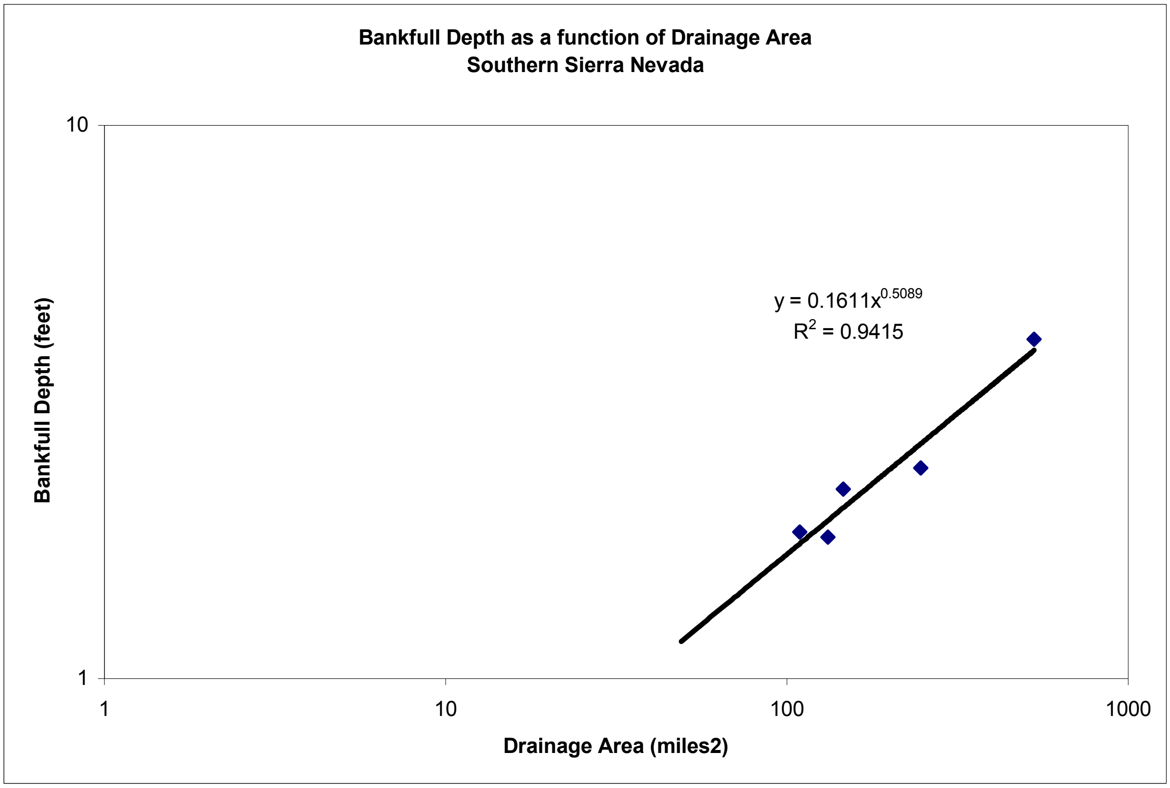


Figure 4. Bankfull cross sectional area as a function of drainage area, gauging stations.

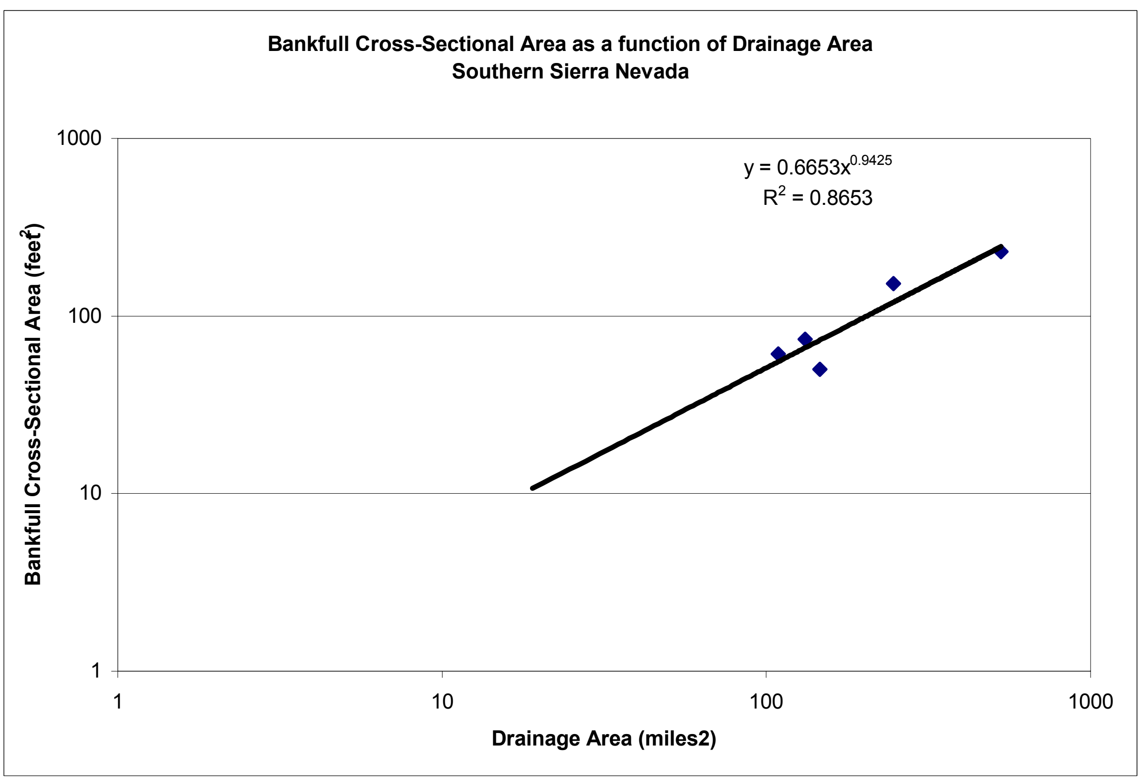


Figure 5. Bankfull depth as a function of drainage area, survey reaches

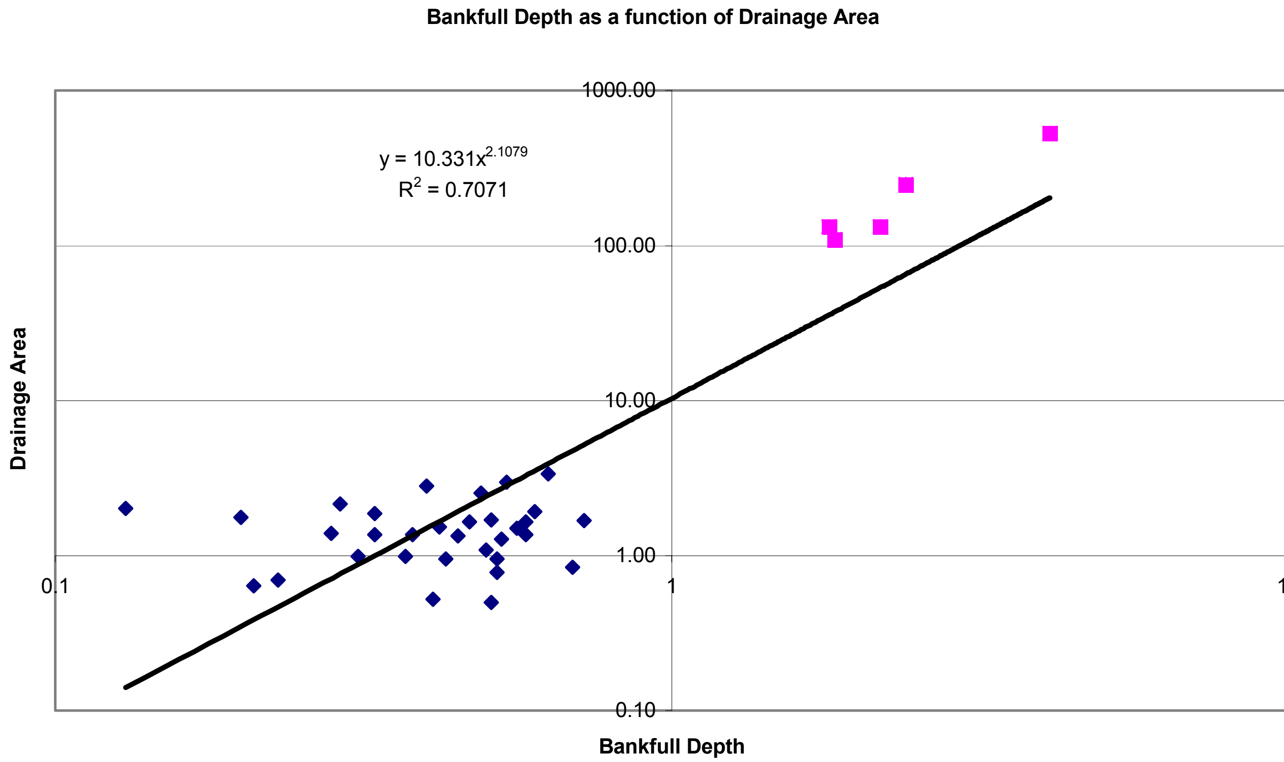


Figure 6. Bankfull width as a function of drainage area, survey reaches

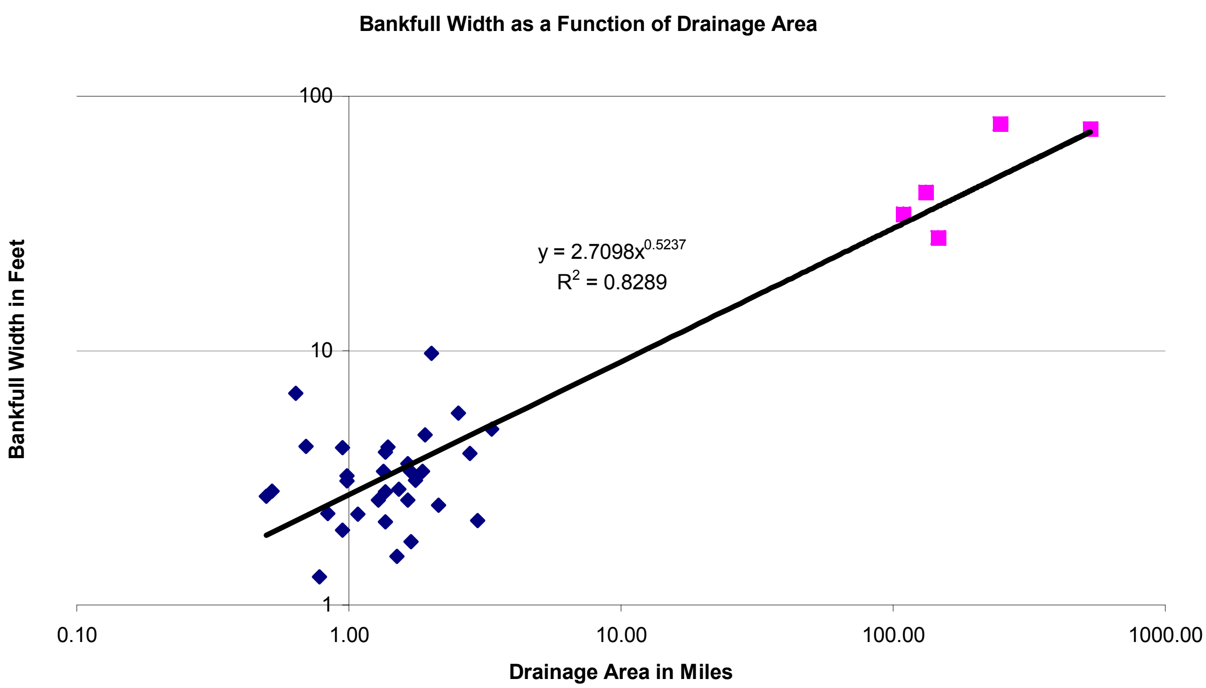
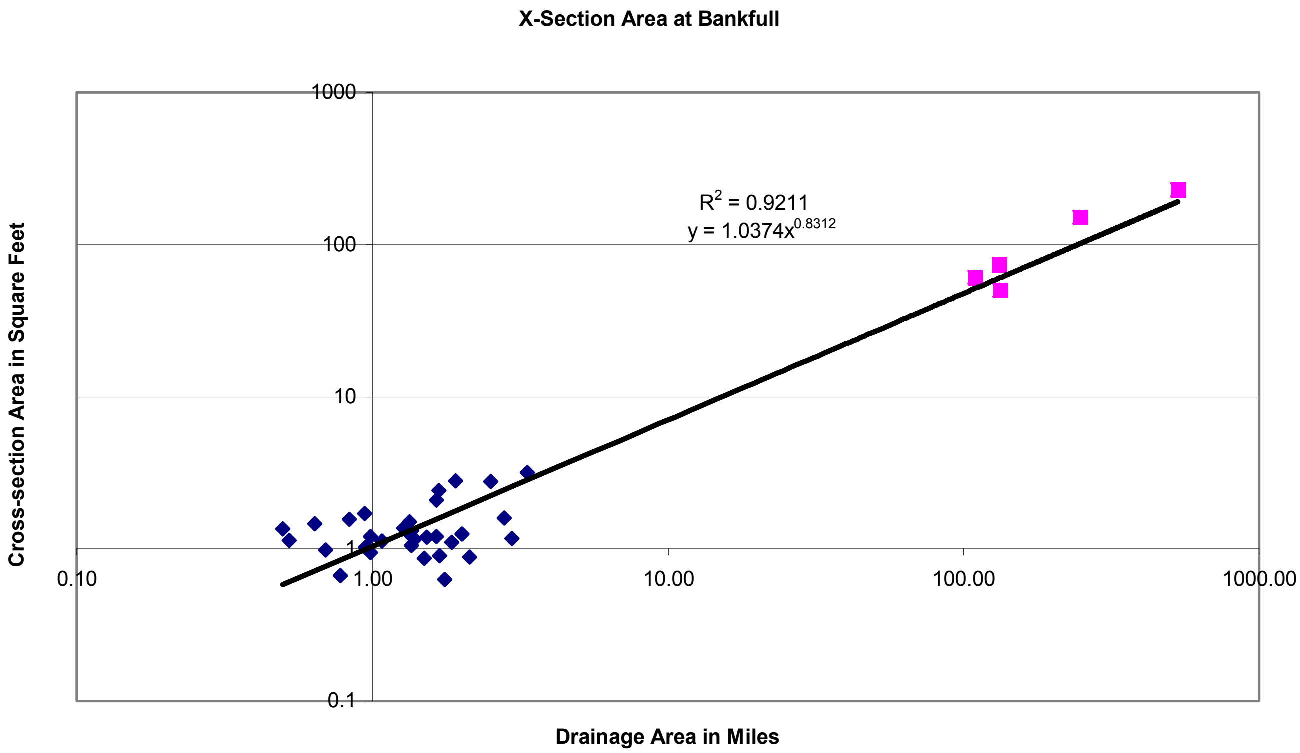


Figure 7. Bankfull cross sectional area as a function of drainage area, survey reaches.



Section 2
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Appendix A

Case Mountain Field Data Summary

Appendix B

Case Mountain Channel Geometry Data

Gage Site Date for Various Locations on the Sequoia National Forest