Section E

Stream Channel Condition

Introduction

This report provides the results of an assessment of the stream channels of the Mendocino Redwood Company (MRC) ownership in the Willow and Freezeout Creeks watershed analysis unit (WAU). The assessment was done following a modified methodology from the Watershed Analysis Manual (Version 3.0, Washington Forest Practices Board). The stream channel analysis is based on field observations and stream channel slope class and channel confinement information developed from a digital terrain model in the company's Geographic Information System (GIS). The stream channel conditions below the MRC property were not evaluated with field observations. However, the channel conditions, particularly of Willow Creek, have been evaluated in previous studies (i.e. Trihey and Assoc., 1995, CDF&G, 1995). This information is included in the discussions of this report.

The goals of the assessment were to determine the existing channel conditions and identify the sensitivity of the channels to wood and sediment. Stream channels are defined by the transport of water and sediment. A primary structural control of a channel in a forested environment, besides large rock substrate, is from woody debris. Channel morphology and condition therefore reflect the input of sediment, wood and water relative to the ability of the channel to either transport or store these inputs (Sullivan et. al., 1987)

Stream channel conditions represent the strongest link between forest practices and fisheries resources. Changes in channel condition typically reflect changes to fish habitat. Because of this the fish habitat and stream channel assessments were done in the same reaches. The results for the fish habitat parameters are presented in Section F - Fish Habitat Assessment.

Methods

The methods of the stream channel assessment are designed to identify channel segments that are likely to respond similarly to changes in sediment or wood and group them into distinct geomorphic units. These geomorphic units enable an interpretation of habitat-forming processes dependent on similar geomorphic and channel morphology conditions. The channels are also evaluated for current channel condition to provide baseline information for the monitoring of channel conditions over the long term.

Stream Segment Delineation

The stream channel network for the Willow/Freezeout Creeks WAU was partitioned into stream segments based on three classes of channel confinement and several classes of channel gradient. These classifications were based on channel classifications prepared from digital terrain data in Mendocino Redwood Company's Geographic Information System (GIS). The slope classes used for delineation are 0-3%, 1-2%, 3-7%, 7-12%, and 12-20%. Channel confinement was classified by confined, moderately confined, and unconfined. Confined channels have a valley to channel width ratio of <2, moderately confined channels have a valley to channel width ratio of <4, and unconfined channels have a valley to channel width ratio of >4. Channel slope class or confinement information from the GIS was re-classified based on field observations.

Channel segments were delineated based on either a change in slope class or change in channel confinement. The channel segments were numbered with a two letter code, corresponding to the planning watershed the channel segment is located, followed by a unique number (*1 through n* for each planning watershed). For the Willow and Freezeout Creeks WAU data, channels for two planning watersheds are delineated. The channels for the Willow Creek planning watershed have a two-letter code of SW, the channels for the Freezeout Creek planning watershed have a two-letter code of SF. The stream segment delineations are shown on Map E-1.

Field Measurements and Observations

Selection of field sites for stream channel observations was based on gathering a representative sample of response (0-3% gradient) and transport (3-20% gradient) channels from each planning watershed of the WAU. Little attention was focused on the source reaches (>20% gradient), this was assumed to be covered in the mass wasting analysis.

For each channel segment the bankfull width, bankfull maximum depth, bankfull average depth, floodprone depth, floodprone width, and channel bankfull width to depth ratio are measured at a cross section representative of the channel segment. A peeble count of 50 randomly selected peebles is counted at the cross section to determine the D50 (median particle size) of the stream bed. Stream-bed sediment characteristics are interpreted from observations of gravel bars, channel aggradation or degradation, and particle size of the stream bed material. The segment is classified by morphology types based on Montgomery and Buffington (1993) and Rosgen (1994). The channel morphology is further interpreted by flood plain interaction for segment (continuous, discontinuos, inactive, none) and channel roughness characteristics. Large woody debris (LWD) funtioning the in channel is tallied (presented in detail in Riparian Condition section). The number and type of pools (LWD forced, bank forced, boulder forced, free formed) are observed. The field observations are summarized and defined in Table E-1.

Geomorphic Units

Channel segments were grouped into geomorphic units by similar attributes of channel condition, position in the drainage network, and gradient/confinement classes. The intent of the geomorphic units are to stratify channel segments of the WAU into units which respond similarly to the input factors of coarse and fine sediment, and LWD. These geomorphic units can then be interpreted to have similar habitat-forming processes.

Interpretations related to sediment supply, transport capacity and LWD response were the basis for development of sensitivity of geomorphic units to coarse sediment, fine sediment and LWD inputs. These interpretations were based primarily on existing conditions observed in the stream channels of the WAU. The channel sensitivity to changes to coarse sediment, fine sediment and LWD are based on how the current state of the channel is likely to respond to inputs of these variables.

Long-Term Stream Monitoring Sites

To monitor stream channel morphology conditions and stream sediment characteristics related to fish habitat, a long-term stream channel monitoring segment was established in Willow Creek. Along this segment a thalweg profile, four cross sections and streambed D50 measurements were surveyed. Stream gravel bulk samples and permeability of spawning gravels are also measured (methods and results presented in the Fish Habitat section). This long-term segment will be re-surveyed and monitored over time to provide insight into long term trends in channel morphology, sediment transport and fish habitat conditions. The long-term stream channel monitoring segment location is shown on Map E-1.

The stream monitoring segment for thalweg profile and cross section surveys on Willow Creek starts approximately 600 below the confluence with the North Fork Willow Creek and continues past the confluence approximately 130 feet. The stream monitoring segment is within 20-30 bankfull channel widths in length. Permanent bench marks (PBMs) are placed at the upstream and downstream ends of the monitoring segment. The PBMs are monumented with nails in the base of large trees along with a re-bar pin in the ground adjacent to the nail.

The thalweg profile is a survey of the deepest point of the flowing channel, excluding any detached or "dead end" scours and/or side channels. At every visually apparent change in thalweg location or depth, the distance along the channel is measured and the elevation is recorded. In the absence of visually apparent changes, thalweg measurements are taken every 15-20 feet along the channel. A profile graph of the channel's thalweg is created from the survey (see Appendix E for Thalweg profile for Willow Creek, 2000).

Along the thalweg profile, 4 channel cross sections are surveyed (locations are permanently monumented). The cross sections are located along relatively straight reaches in the monitoring segment. Cross sections are surveyed from above the floodprone depth of the channel. A graph of the cross section is created from the survey (see Appendix E for cross sections graphs for Willow Creek, 2000). At each cross section a pebble count is done, to determine the D50 of the cross section, by measuring 100 randomly selected pebbles along the cross section fall line.

Results

Current Stream Channel Observations for MRC Property in Willow/Freezeout Creeks' Watersheds

Field channel surveys were done on 8 stream segments in the Willow/Freezeout WAU during the summer of 2000. Table E-1 provides a summary of the data collected (see appendix of this module for field form). Further detail specific to in-channel fish habitat relationships is found in Section F - Fish Habitat Assessment of this report.

Key to Table E-1.

Stream Channel Dimensions

Category	Description
Seg. #	the stream identification number (see Map E-1), two letter planning watershed code followed by unique number for the planning watershed.
Geomorphic Unit	number of the geomorphic unit the channel segment is in.
Surveyed Length-	length of segment surveyed.
Observed Slope	mean slope of segment as observed in field.
Maximum Bankfull Depth	maximum bankfull depth of representative cross section.
Average Bankfull Width	average bankfull width of representative cross section.
Width/Depth Ratio	bankfull channel width to depth ratio.
Floodprone depth	maximum depth during flooding, estimated by 2 times max. bankfull depth (Rosgen, 1996).
Floodprone width	width of water during flooding (Rosgen, 1996).
Entrenchment Ratio	ratio of floodprone width to bankfull channel width.

Channel Morphology

Category	Description
Montgomery/ Buffington Class	the channel type: p/r = pool/riffle, fp/r = forced pool/riffle, stp = step pool, plnbed = plane bed, cas = cascade.
Rosgen Class	Rosgen channel classification, (Rosgen, 1994).
Floodplain	description of floodplain/channel interaction.
Channel Roughness	B =boulders, C=cobbles, F=bedforms, V=live woody veg., W=large woody veg., R=bedrock, Bk=banks and roots.

Sediment/Bedform Characteristics

Category	Description
Gravel Bar Abundance	F=few, C=common, A=abundant
Gravel Bar Type	A=alternate, F=forced, P=point, M=medial
Gravel Bar Proportion Class	Proportion of stream segment in gravel bars: 0-25%, 25-50%, 50-75%, 75-100%.
Past Aggr. or Degr.	evidence of past aggregation or degradation of channel.
Current Aggr. or Degr.	current aggregation or degradation of channel.
Fine Sediment Abundance	sparse, moderate, abundant

Fine Sediment Type	type of fine sediment accumulation: P=isolated pockets, M=moderate accumulations, B=high accumulations including bars
D50	the median gravel size of the stream bed.

Pool Characteristics

Category	Description
Free	number of free formed pools in segment.
LWD Forced	number of LWD forced pools in segment.
Boulder Forced	number of boulder forced pools in segment.
Bank Forced	number of bank forced pools in segment.
Total # Pools	total number of pools in segment.
Pool Spacing	average space between pools by bankfull widths

Table E-1 (a). Stream Channel Field Observations for Willow/Freezeout Creek WAU, Channel Dimensions

Stream Name	Seg. #	Geomorphic Unit	Surveyed Length (ft)	Observed Slope (%)	Maximum Bankfull Depth (ft)	Average Bankfull Depth (ft)	Bankfull Width (ft)	Width to Depth Ratio	Floodprone Depth (ft)	Floodprone Width (ft)	Entrenchment Ratio
Willow Creek	SW1	I	729	0.5	2.8	1.95	34.0	17.4	5.6	42	1.2
Willow Creek	SW2	I	625	0.6	2.3	1.8	27.1	15.1	4.6	33.1	1.2
Willow Creek	SW2(2)	I	593	1.6	2.65	2.2	16.4	7.5	5.3	19.5	1.2
Willow Creek	SW3	II	595	1.0	1.8	1.3	24.2	18.6	3.6	26	1.1
North Fork Willow Creek	SW20	III	417	4.0	1.8	1.1	17.5	15.9	3.6	19	1.1
Unnamed Tributary	SW23	III	421	2.9	1.9	1.37	18.6	13.6	3.8	26.6	1.4
Freezeout Creek	SF1/2	IV	407	8.1	2.3	1.3	24	18.5	4.6	36	1.5
Unnamed Tributary	SF10	III	499	3.0	2.3	1.6	13	8.1	4.6	17	1.3

Table E-1 (b). Stream Channel Field Observations for Willow/Freezeout Creek WAU, Channel Morphology

Stream Name	Seg. #	Montgomery/ Buffington Class(s)	Rosgen Class(s)	Floodplain	Channel Roughness (in order influence)
Willow Creek	SW1	P/R	F4	Inactive	F-BK-LWD
Willow Creek	SW2	P/R	F4	Inactive	F-BK-LWD
Willow Creek	SW2(2)	P/R	F4	Inactive	LWD-F-BK
Willow Creek	SW3	P/R	F4	None	F-BK-LWD
North Fork Willow Creek	SW20	P/R, FP/R	F4,F4,E4,F4	Discontinuous	BK-F-LWD
Unnamed Tributary	SW23	FP/R,FP/R,P/R	B4,G4,G4	None	F-LWD-BK
Freezeout Creek	SF1/2	CAS	Aa2, Aa3	None	B-C-R
Unnamed Tributary	SF10	SP	G4,B4	None	C-LWD-BK

Table E-1 (c). Stream Channel Field Observations for Willow/Freezeout Creek WAU, Sediment and Bedforms

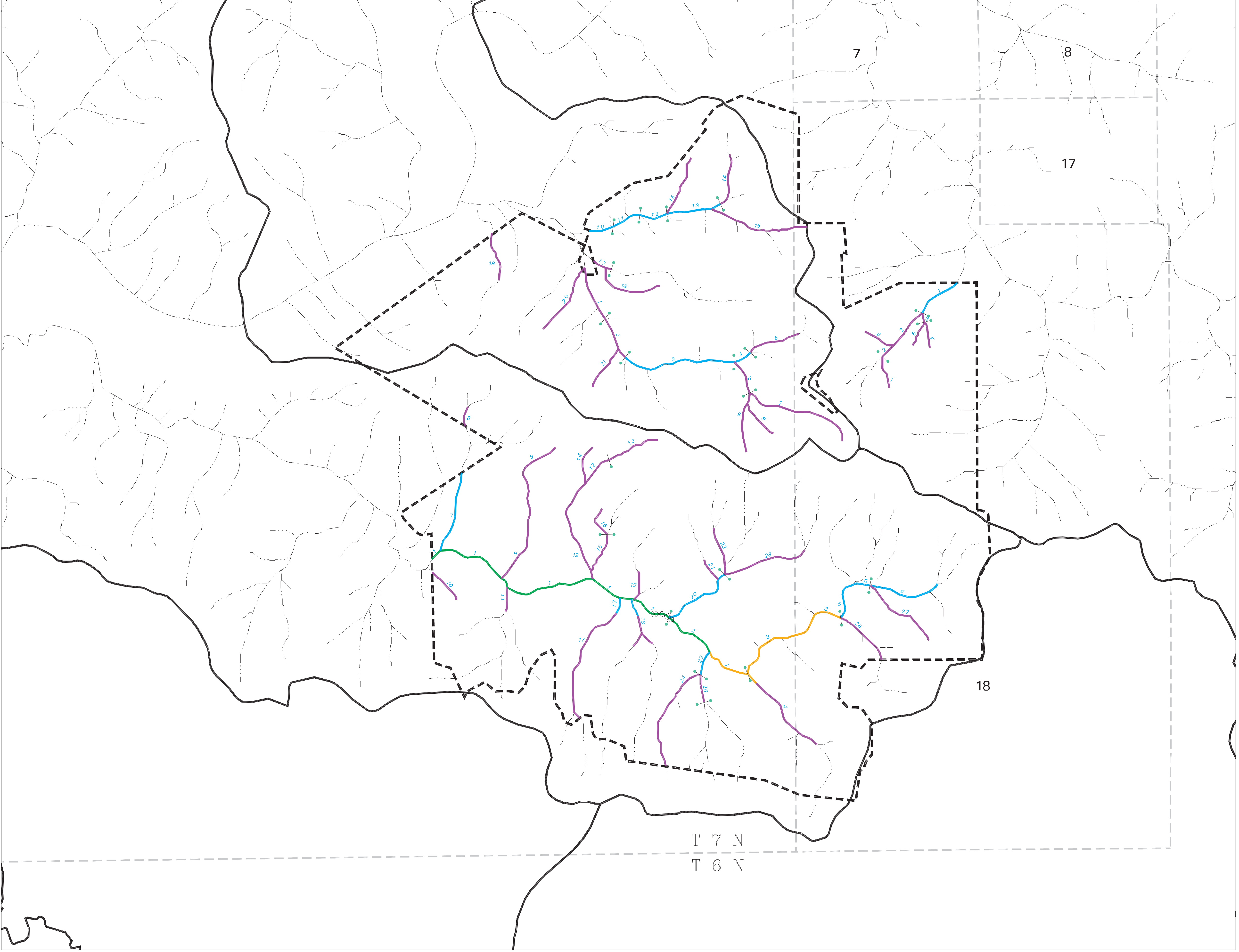
Stream Name	Seg. #	Gravel Bar Abundance	Gravel Bar Type(s)	Gravel Bar Proportion	Past Agg.or Degr.	Current Agg.or Degr.	Fine Sed. Abundance	Fine Sed. Type	D50 (mm)
Willow Creek	SW1	C	P-A	50-75%	DEGR	AGG	Moderate	B	52
Willow Creek	SW2	C	P	50-75%	DEGR	AGG	Abundant	B	34
Willow Creek	SW2(2)	C	P	50-75%	DEGR	AGG	Abundant	B	36
Willow Creek	SW3	C	P	25-50%	AGG & DEGR	AGG	Abundant	B	35
North Fork Willow Creek	SW20	C	P	25-50%	NONE	NONE	Moderate	M	31
Unnamed Tributary	SW23	C	F,P	25-50%	NONE	AGG	Sparse	P	51
Freezeout Creek	SF1/2	C	F	25-50%	NONE	NONE	Sparse	P	106
Unnamed Tributary	SF10	n/a	n/a	n/a	NONE	NONE	Moderate	M	79

Table E-1 (d). Stream Channel Field Observations for Willow/Freezeout Creek WAU, Pools

Stream Name	Seg. #	Free	LWD Forced	Boulder Forced	Bank Forced	Total # Pools	Pool Spacing (bkfull widths)	Mean Residual Pool Depth (ft.)
Willow Creek	SW1	0	10	0	3	13	1.6	1.6
Willow Creek	SW2	2	8	0	2	12	1.9	1.5
Willow Creek	SW2(2)	0	10	1	1	12	3.0	1.4
Willow Creek	SW3	0	3	0	1	4	6.1	1.2
North Fork Willow Creek	SW20	0	5	0	4	9	2.6	0.9
Unnamed Tributary	SW23	0	6	0	4	10	2.3	1.3
Freezeout Creek	SF1/2	NA	NA	NA	NA	NA	NA	n/a
Unnamed Tributary	SF10	2	3	3	0	8	4.8	0.8

Willow Creek / Freezeout Creek Watershed Analysis Unit

Map E-1
Stream Channel Geomorphic Units and Segments



Depositional Channels Entrenched in Streamside Terraces

Highly Confined Depositional Channels within Steep Canyon Walls

Moderate Gradient (2-8%) Transport Segments of Willow and Freezeout Creeks

High Gradient (8-20%) Transport Segments of Willow and Freezeout Creeks

Long Term Monitoring Sites

Flow Class

Class I

Class II

Class III

MRC Ownership

Planning Watershed Boundary

0 1/2 1 Mile

February 16, 2001

Stream Geomorphic Units

Stream geomorphic units were developed for the stream network on the MRC property in the Willow/Freezeout Creeks watersheds. These units are general representations of stream channels with similar sensitivities to coarse sediment, fine sediment and large woody debris inputs. Four stream geomorphic units were developed for interpretation of stream channel response to forest management interactions. The four stream geomorphic units are described below.

Geomorphic Unit I. Depositional Channels Entrenched in Streamside Terraces.

Includes Segments: Field verified – SW1, SW2(lower)

General Description:
Stream channel segments in this unit flow in an entrenched channel within streamside terraces varying from 5 to 8 feet deep. These channels are highly confined within terraces with no floodplain and little channel migration capability. The terrace deposits adjacent to the channel are composed primarily of consolidated sand, silt and clay sized particles. Cohesion of the terrace substrate is high and moderately susceptible to bank erosion. Channel gradients are low (<1 percent), but sediment transport capacity is relatively high during high flows due to the highly confined channel keeping water energy directed with the entrenched channel. The channel bed is composed primarily of gravel sized particles.

Associated Channel Types:
This unit primarily exhibits pool/riffle morphology. The Rosgen (Rosgen, 1994) classification for channels is this unit is F4.

Fish Habitat Associations:
Sediment supply in this unit is high but despite the lower gradient transport of sediment through this unit can be adequate because of the entrenched channel helping to focus the power of winter flows. Large woody debris is in high demand to aid in sorting of sediment, promote pool scour, and to offer salmonids refuge from high winter flows in this confined channel. The addition of wood into this unit could greatly improve the habitat for all life stages of anadromous salmonids.

Conditions and Response Potential

Coarse Sediment: Moderate Response Potential
Coarse gravel accumulations are primarily in point and alternating point gravel bars. Gravel bars are common within this unit and currently store a high amount of coarse sediment. Currently the channel does show evidence of aggradation. The highly confined water flow of this unit creates high coarse sediment transport capacity. However, based on evidence of current aggradation, if the coarse sediment supply is high the bed will aggrade reducing channel complexity and habitat.

Fine Sediment: High Response Potential
Moderate to high accumulations of fine sediment is observed in this unit. Fine sediment deposition is on the top of gravel bars, accumulated in the bed of pool tail-outs, along pool margins, and in some pools. The channels of this unit have high fine sediment transport capacity due to high flow capacity of the channel. However, when there is a high fine sediment supply in transport, accumulations of fine sediment occur in this unit.

Large Woody Debris: High Response Potential
Large woody debris loading is currently below targeted conditions in this unit. The LWD that is present is providing stream habitat development, cover and sediment storage. Additional LWD would continue to improve habitat conditions. The high flows that are confined in the channel of this unit require LWD pieces to be braced in the channel or debris jams to keep the LWD in place. Ample LWD needs to be recruited to this unit over time to sustain levels of LWD.

Geomorphic Unit II. Highly Confined Depositional Channels within Steep Canyon Walls.

Includes Segments: Field verified – SW2(upper), SW3, SW4(lower)

General Description:
Stream channel segments in this unit are confined within steep canyon walls. These channels are highly confined within the canyon with little floodplain development or channel migration capability. Currently young terrace deposits (<40 years) are developed adjacent to the channel. These terrace deposits are composed primarily of unconsolidated gravel sized particles, hypothesized to be from severe channel aggradation in the 1960's to 1970's. The current channel is entrenched, intermittently within these terrace deposits. Cohesion of the terrace substrate is low and highly susceptible to bank erosion. Channel gradients are low to moderate (1-2 percent). Sediment transport capacity is relatively high during high flows due to the highly confined channel keeping water energy directed within the confined channel. The channel bed is composed primarily of gravel sized particles, but lacks complexity or diverse aquatic habitat due to the high flux of sediment aggradation and degradation.

Associated Channel Types:
This unit primarily exhibits pool/riffle morphology. The Rosgen (Rosgen, 1996) classification for channels is this unit is F4.

Fish Habitat Associations:
Sediment supply in this unit is high but despite the lower gradient transport of sediment through this unit can be adequate because of the entrenched channel helping to focus the power of winter flows. Large woody debris is in high demand to aid in sorting of sediment, promote pool scour, and to offer salmonids refuge from high winter flows in this confined channel. The addition of wood into this unit could greatly improve the habitat for all life stages of anadromous salmonids.

Conditions and Response Potential

Coarse Sediment: High Response Potential
Coarse gravel is stored in streamside terraces and in the active channel in point and alternating point gravel bars. Gravel bars are common within this unit and currently store a high amount of coarse sediment. Channel segments in this unit have had severe aggradation in the past when the sediment supply is high. Currently the channel has degraded through the past aggradation and is intermittently entrenched in unconsolidated gravel deposits. These gravel deposits are a source of sediment delivery over time. The current channel lacks complexity due to the high flux of coarse sediment aggradation and degradation.

Fine Sediment: High Response Potential

Moderate to high accumulations of fine sediment is observed in this unit. Fine sediment deposition is on the top of gravel bars, accumulated in the bed of pool tail-outs, along pool margins, and in some pools. The channels of this unit have high fine sediment transport capacity due to high flow capacity and moderate gradients of the channel. A lot of sand size particles were observed in this unit, presumably from erosion of the banks of the young terraces in the unit. When there is a high fine sediment supply in transport, accumulations of fine sediment occur in this unit.

Large Woody Debris: High Response Potential

Large woody debris loading is currently below targeted conditions in this unit. The LWD that is present is providing stream habitat development, cover and sediment storage. Additional LWD would continue to improve habitat conditions. Due to the high amount of sediment in the channels of this unit LWD would greatly improve sediment storage and sorting, improving aquatic habitat conditions.

Geomorphic Unit III. Moderate Gradient (2-8%) Transport Segments of Willow and Freezeout Creeks.

Includes Segments: Field verified - SW20, SW23, SF10
Extrapolated – SW5, SW6, SW7, SW17(lower), SW18(lower), SF3, SF4, SF11, SF12, SF13

General Description:
Stream channel segments in this unit are confined within canyons with steep side slopes. Typically entrenchment ratios (flood prone to bankfull width ratio) are between 1.1 and 1.5. This high degree of confinement does not allow much terrace formation or channel meandering. The channel segments in this unit are predominantly transport reaches, but isolated areas of depositional reaches occur in this unit depending on channel gradient. These channels typically have active fans forming at the outlet of these channels. Due to the moderate gradient (2-8 percent) the channels are responsive to aggradation and degradation from changes in the stream sediment supply. The substrate of the channels in this unit varies from gravel to boulder sized particles. The fans or terraces in this unit appear to be created from large episodic sediment loads. The moderate gradient of the stream allows channels to down-cut through the terrace deposits.

Associated Channel Types:
This unit primarily exhibits forced pool/riffle and step pool morphology, with some isolated areas of pool/riffle morphology. The Rosgen (Rosgen, 1996) classification for these channels varies between F4 and G4 depending primarily on channel slope. However, some areas of E4 and B4 channel types are observed in this unit.

Fish Habitat Associations:
This unit is characterized by larger substrate that provides a roughness element to the stream. Larger sized cobbles and small boulders break up the flow of water creating velocity breaks promoting resting spots for salmonids. This unit has low amounts of large woody debris, however due to the high entrenchment wood recruitment would be beneficial in increasing complexity of cover and help to improve habitat for all life stages of salmonids.

Conditions and Response Potential

Coarse Sediment: High Response Potential
Accumulations of coarse sediment are found in point and LWD forced gravel bars. The gravel bar abundance is common with some abundant accumulations. Currently the channels show evidence of down-cutting and occasional evidence of aggradation in response to coarse sediment fluctuations. There is evidence of past aggradation and degradation of the channels in this unit as well.

Fine Sediment: Moderate Response Potential

Accumulations of fine sediment were observed in this unit. Fine sediment accumulations varied from sparse to moderate primarily on the top of gravel bars, but also in isolated pockets in pools. The discontinuous floodplain and moderate slope gradient promotes high fine sediment transport due to concentrated stream power within confined channels.

Large Woody Debris: High Response Potential

LWD in this unit was observed to force storage of coarse sediments and create scour and pool formation. The areas of down-cut channels in this unit would likely benefit and stabilize with increased large woody debris loading do to increased sediment storage capacity raising the elevation of the stream bed.

Geomorphic Unit IV. High Gradient (8-20%) Transport Segments of Willow and Freezeout Creeks.

Includes Segments: Field observed – SF1, SF2
Extrapolated – SW4, SW9, SW10, SW11, SW12, SW13,SW14, SW15, SW16, SW17(upper), SW18(upper), SW19, SW21, SW22, SW24, SW25, SW26, SW27, SW28, SF5, SF6, SF7, SF8, SF9, SF14, SF15, SF16, SF17, SF18, SF19, SF20, SF21

General Description: to do
Channel segments in this unit are high gradient transport reaches from 8-20% with high sediment transport capacity. The channel segments in this unit typically flow through tightly confined, steep-sided canyons. These are typically zones of scour during high flows or debris flows. Stream substrate is typically from cobble to large boulders.

Associated Channel Types:
This unit varies it morphology from step pool to cascades with some occasional waterfalls. The cascades and waterfalls occur in the steepest segments of this unit. The Rosgen (Rosgen, 1996) classification for these channels varies between A2, A3, and Aa2, Aa3 depending on channel gradient and substrate composition.

Fish Habitat Associations:
The high gradient channels of this unit pose potential barriers to coho salmon although they may be accessible to steelhead up to about 12% at 20% it is highly unlikely any salmonids will be present. Much of these segments that could be accessible to steelhead are subject to subsurface flow in summer months.

Conditions and Response Potential

Coarse Sediment: Moderate Response Potential
Accumulations of coarse sediment are found primarily in LWD forced gravel bars. The gravel bar abundance is common but mainly associated with the LWD distribution in the channels. Currently the channels show evidence of down-cutting. However, the high gradient of the channels produces high stream power that creates high coarse sediment transport capacity. Coarse sediment deposited in these channels typically does not stay stationary for long, with the exception of the largest most competent particles.

Fine Sediment: Low Response Potential

Accumulations of fine sediment were not frequently observed in this unit. Fine sediment accumulations varied from sparse to moderate primarily on the top of gravel bars. The entrenched and high gradient channel promotes high fine sediment transport and little fine sediment deposition due to concentrated stream power within confined channels.

Large Woody Debris: High Response Potential

LWD in this unit was observed to force storage of coarse sediments. The areas of down-cut channels in this unit would likely benefit and stabilize with increased large woody debris loading do to increased sediment storage capacity raising the elevation of the stream bed.

Stream Conditions and Response for Stream Channels below Mendocino Redwood Company Ownership in the Willow and Freezeout Creek Watersheds

The primary focus of the stream channel analysis is the condition and response of stream channels to forest management on the MRC ownership of Willow and Freezeout Creeks. However, MRC does not own the property around the lowest most stream channels in the watersheds. In Freezeout Creek approximately 1 mile of low gradient fish bearing stream is below the MRC ownership prior to entering the Russian River. In Willow Creek approximately 3 miles of low gradient stream channel receives inputs from the stream channel network of the MRC ownership.

Freezeout Creek

In Freezeout Creek the bottom most 1 mile of stream, below the MRC ownership, is low gradient with stream gradient less than 1 percent. The channel appears entrenched within streamside terraces with some interaction with a floodplain. Anadromous salmonids use this low gradient reach for spawning and rearing habitat as no known barriers exist on lower Freezeout Creek. The end of anadromous fish on Freezeout Creek is at or near the MRC property line. The end of anadromous fish usage corresponds with a significant change in stream gradient just as Freezeout Creek leaves the MRC ownership (segment SF1). The stream gradient of Freezeout Creek is so steep at this location (greater than 30 percent gradient) that fish passage is impossible. An unnamed tributary to Freezeout Creek (SF10) has anadromous fish use for approximately 800-900 feet until the gradient steepens significantly with a series of rock and LWD created waterfalls making fish migration impossible.

The lower 1 mile of Freezeout Creek, due to its low gradient, is a depositional reach for sediment and LWD. The boulder cascade channels coming out of the MRC ownership will not likely provide delivery of LWD. LWD is important in these high gradient reaches for its sediment storage capability but the boulders in the channel coupled with a narrow canyon will likely trap mobile LWD making downstream transport of LWD unlikely. Sediment (fine and coarse) will be transported out of the MRC ownership where it can deposit in lower Freezeout Creek. Consideration of the inputs of coarse and fine sediment within the Freezeout Creek watershed is important so to not adversely impact the lower 1 mile of low gradient stream habitat on Freezeout Creek.

Willow Creek

Approximately 3 miles of low gradient (less than 1 percent gradient) stream channel of Willow Creek is below the MRC property in the Willow Creek watershed. A high amount of stream aggradation is occurring in the lower Willow Creek channels with the source of the high sediment coming primarily from what is now the MRC ownership. A combination of high sediment inputs from past management practices in the watershed and poor channel conditions to transport that sediment has resulted in significant stream channel aggradation between the 2nd and 3rd bridges along the County Road on lower Willow Creek (Trihey and Assoc., 1995). The aggradation is significant enough to limit fish migration above the aggraded reach. Indeed, fish migration is probably only likely in certain favorable streamflow conditions.

Trihey and Associates (1995) stated that high sediment delivery from the upper watershed is expected to continue. Our observations support this conclusion. A high amount of sediment is stored in streamside terraces, particularly in stream geomorphic unit II along Willow Creek. This sediment is going to be eroded out of these upper reaches over time contributing sediments downstream. Considerable channel down-cutting was observed in tributary channels of Willow Creek. The bank erosion and down-cutting of tributary channels (Trihey and Associates referred to this as forested gullies) is a fairly high source of sediment in the upper Willow Creek watershed (Trihey and Assoc., 1995). The majority of the Willow Creek watershed is composed of Franciscan melange geology. This type of geology has high erosion and sediment rates associated with it. The naturally high geologic erosion rate from the Franciscan melange will likely contribute sediments affecting the lower channel reaches.

The aggradation of the lower channel of Willow Creek has created conditions such that high flows that in the past would stay confined in a channel transporting stream sediments now spread out onto the floodplain, reducing the ability to scour sediments from the aggraded channel. Streamflow has been observed to be almost completely diverted out of the channel during high flows between the 2nd and 3rd bridges (Trihey and Assoc., 1995).

The aggradation of the lower channel also creates conditions that increase the frequency of high water flows accessing the floodplain. This increase in flooding will likely continue until a channel can form or be restored that will route both the sediment and water loads from Willow Creek.

The combination of high sediment inputs and low sediment transport capacity has lead to the conclusion that the lower Willow Creek channel will likely continue to aggrade (Trihey and Assoc., 1995). The solution that seems to have the best merit for restoration of the Willow Creek is a combined approach of reducing sediment inputs from the upper watershed and restoring the sediment transport capacity of the lower channel. Without both parts being accomplished the likelihood of Willow Creek to be restored for anadromous fish spawning and rearing is unlikely. This will be extremely challenging given that cost effective solutions may not be easily found.

Long Term Stream Monitoring

During the Summer of 2000 a long term channel monitoring segment was surveyed for thalweg profiles, cross sections, stream gravel permeability and stream gravel composition along Willow Creek. This was the first year that this data was collected, so there is no temporal or comparative analysis that can be done. This represents the base line condition for future monitoring. The plots of the surveys are included in the appendix of this module (Appendix E) for display. The results of the stream gravel bulk samples and permeability are presented in section F - Fish Habitat Assessment of this report.

Literature Cited

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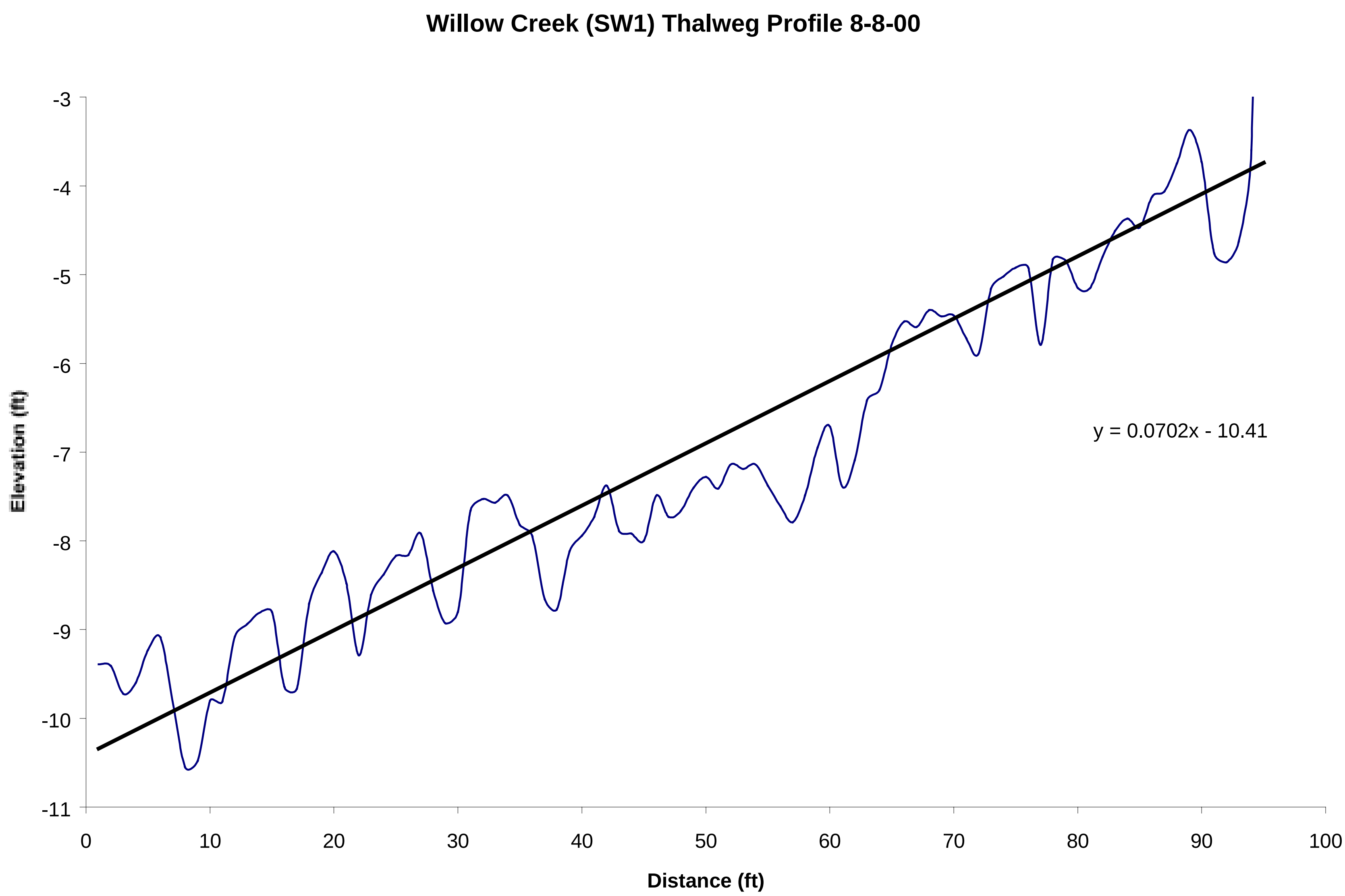
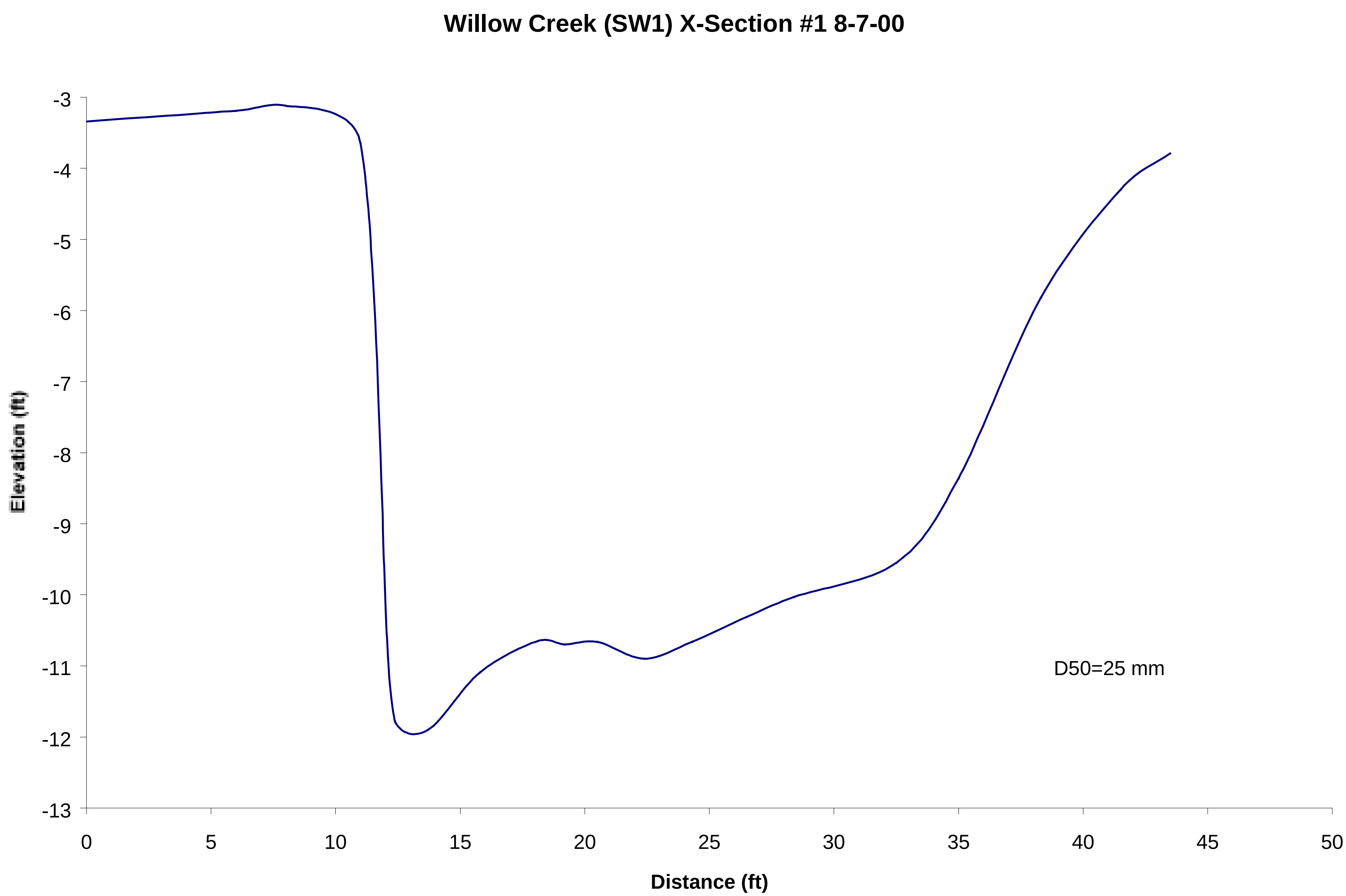
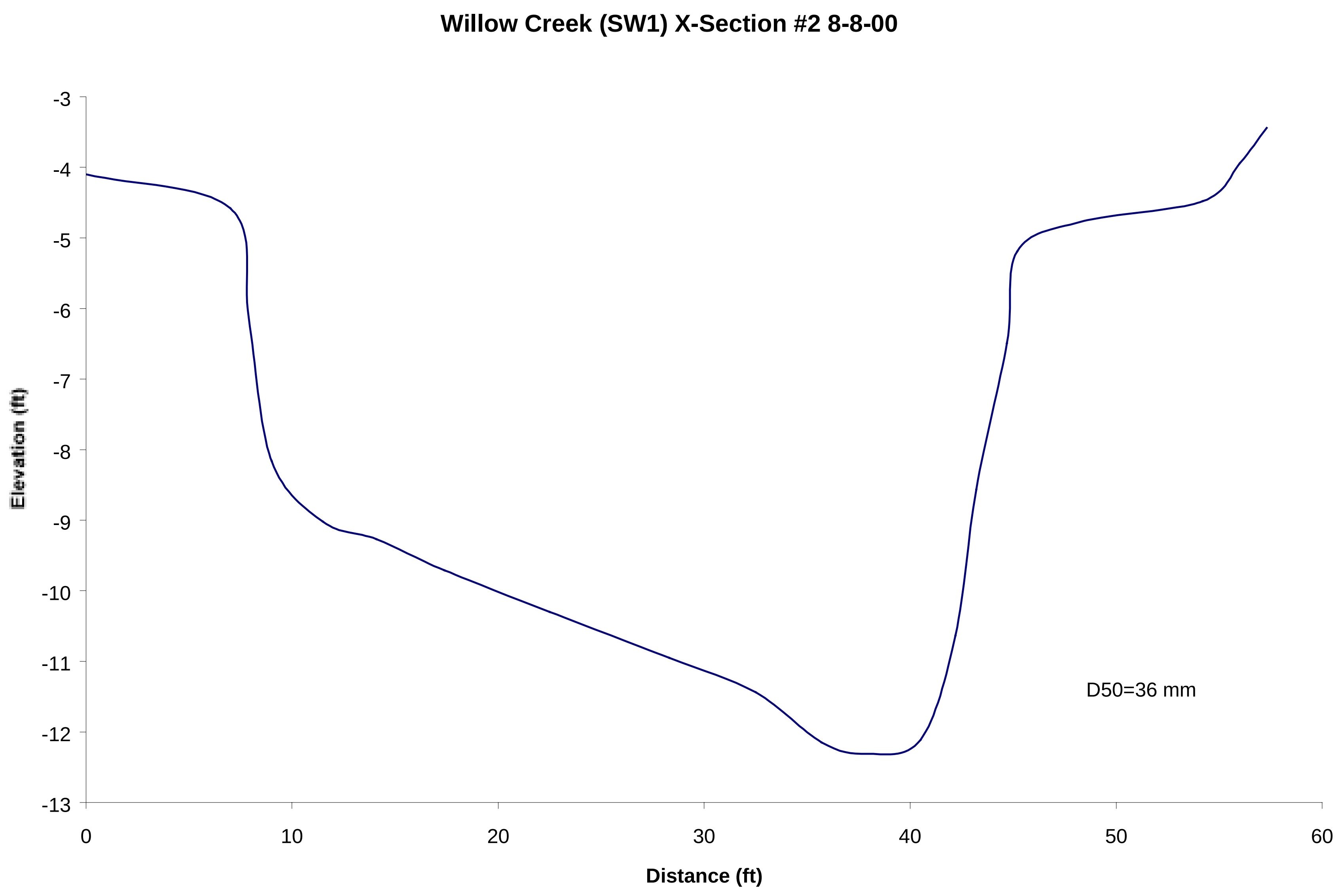
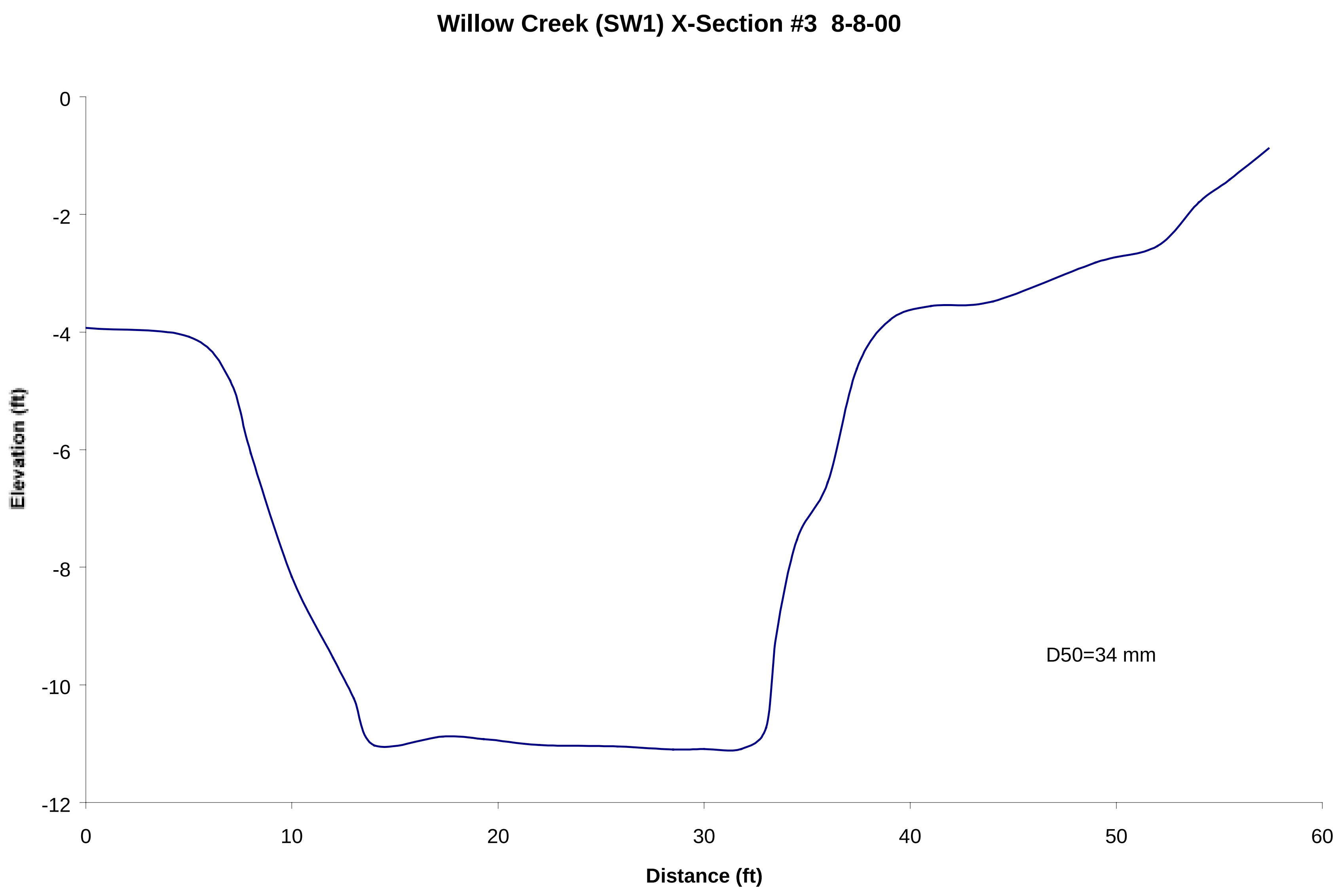
Appendix E

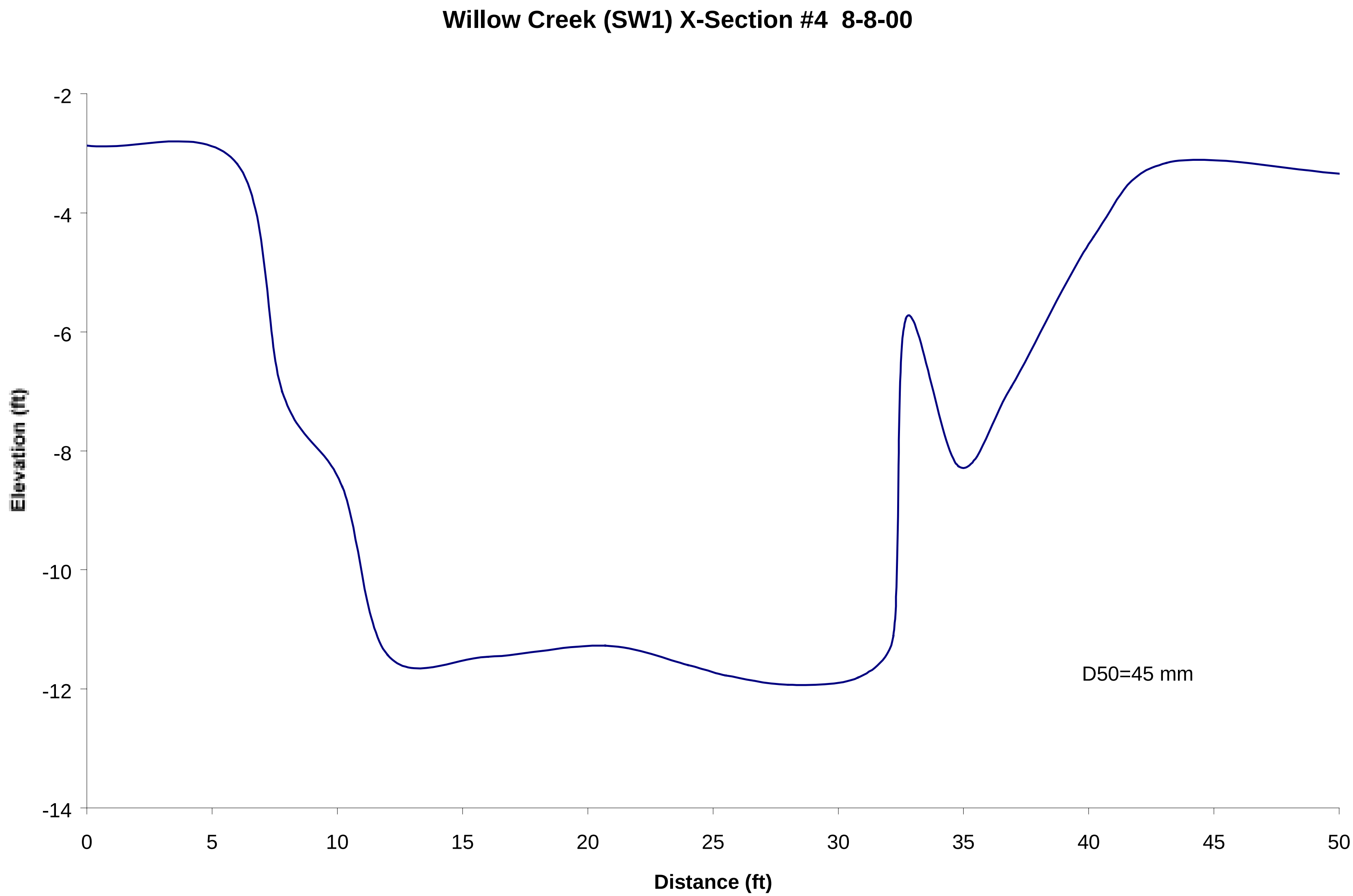
Stream Channel Condition Module


Willow Creek (SW1) Thalweg Profile 8-8-00
Elevation (ft)
-3
-4
-5
-6
-7
-8
-9
-10
-11
0
10
20
30
40
50
60
70
80
90
100
Distance (ft)
y = 0.0702x - 10.41


Willow Creek (SW1) X-Section #1 8-7-00
Elevation (ft)
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
5
10
15
20
25
30
35
40
45
50
Distance (ft)
D50=25 mm


Willow Creek (SW1) X-Section #2 8-8-00
Elevation (ft)
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
10
20
30
40
50
60
Distance (ft)
D50=36 mm


Willow Creek (SW1) X-Section #3 8-8-00
0
-2
-4
-6
-8
-10
-12
Elevation (ft)
0
10
20
30
40
50
60
Distance (ft)
D50=34 mm


Willow Creek (SW1) X-Section #4 8-8-00
Elevation (ft)
-2
-4
-6
-8
-10
-12
-14
0
5
10
15
20
25
30
35
40
45
50
Distance (ft)
D50=45 mm