Monitoring of a Chop and Drop Wood Addition Project on Tributaries to the Sunday River, Maine

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Table of Contents

List of Figures

List of Appendices

Executive Summary

Geomorphic monitoring of a chop and drop project on two tributaries of the Sunday River, Maine in 2007 and 2008 has documented a weak aggradational response to the addition of wood to the channels. Cross sections and longitudinal profiles show a tendency for aggradation to occur upstream of log jams, although not all aggradation is closely associated with the wood. Ground photographs repeated in the same location both years show that small logs have moved slightly, while anecdotal evidence suggests larger trees have also moved. The repositioning of the wood should, over time, lead to the formation of larger log jams and result in a more pronounced aggradational response, increased step-pool spacing, greater pools depths, and a narrowing of the channel. Water level logging was initiated upstream and downstream of the treatment sites to determine if the presence of wood leads to an expected decrease in peak runoff and an increase in flow duration. Initial results suggest the wood may have a weak influence on runoff characteristics, but several other factors are also likely involved. Continuation of the monitoring will further document the location, magnitude, and rate of these geomorphic and hydrological adjustments, which could prove useful in planning future chop and drop projects elsewhere.

1.0 Introduction

This report describes the results of geomorphic monitoring at two chop and drop wood addition projects on tributaries of the Sunday River, ME (Figure 1). The projects were completed as part of grant funding received from the Eastern Brook Trout Joint Venture. The Eastern Brook Trout Joint Venture (EBTJV) is the nation's first pilot project under the National Fish Habitat Initiative. The long-term goals of the EBTJV are to develop a comprehensive restoration and education strategy to improve aquatic habitat, to raise education awareness, and to raise federal, state and local funds for brook trout conservation. The two chop and drop projects on the Sunday River consisted of selectively cutting streamside trees, so they fell directly into the channel. Streams with wood in the channel generally have higher fish populations (Flebbe, 1999), a greater abundance and richness of macroinvertebrates (Bond et al., 2006), and more complex physical habitat (Benke and Wallace, 2003). Wood in upper tributary channels, as added at the chop and drop projects on the Sunday River, also leads to considerable sediment storage that can reduce sediment loading downstream (Field, 2008).

Geomorphic monitoring of the chop and drop projects was conducted to document sediment storage and other morphological adjustments to the stream channel such as changes in pool depth, channel width, and step-pool spacing. Monitoring also occurred at a control site where no wood additions occurred. The two treatment sites and the control reach are steep headwater streams with frequent bedrock steps. The banks primarily consist of coarse bouldery glacial deposits, although bedrock outcrops are present. Narrow terraces, which may be occasionally overtopped by floodwaters, flank the channels in many areas, but well developed floodplains do not exist. Consequently, bank heights vary dramatically over short distances even on the same side of the channel. The monitoring consisted of four parts: topographic surveys, substrate particle size analyses (i.e., pebble counts), repeat ground photographs, and water level logging. Topographic surveys and ground photographs were conducted in 2007 and 2008 while particle size analyses and water level logging were initiated in 2008. The initial results for each of the four phases of monitoring are presented below.

2.0 TOPOGRAPHIC SURVEYS

Topographic surveying was completed with a Sokkia Set5 Electronic Total Station. A longitudinal profile, three cross sections, and a plan view map showing the position of bars and channel spanning logs were measured at each site. The survey reaches cover only a short length of the full treatment areas at the two chop and drop sites, but are representative of the sites as a whole. A comparison of cross sections between 2007 and 2008 shows changes at the treatment sites are more significant than those observed at the control reach, but do not reflect dramatic adjustments in channel width or pool depth (Figure 2). The greatest amount of erosion at any single cross section was Cross Section 2 at Treatment Site 2 where 1.0 ft of bed erosion and 1.5 feet of bank erosion occurred. Aggradation was most pronounced at Treatment Site 2 Cross Section 3 where the bed elevation increased by 1.0 ft. Although the location of aggradation is highly variable, a pattern emerges when compared with the position of channel spanning logs. For example, Cross Section 3 at Treatment Site 2, the cross section that experienced the greatest aggradation, is located just upstream of a log. Aggradation also occurred upstream of a log at Site 1 Cross Section 2. Conversely, the greatest amount of bed erosion occurred just downstream of a channel spanning log at Treatment Site 2 Cross Section 2, leading to an increase in pool depth. As smaller logs, leaves, and other organic material become packed in behind the large channel spanning logs to form more pronounced log jams, a stronger pattern of aggradation upstream and degradation downstream of channel spanning logs should emerge.

No significant channel changes occurred along the longitudinal profiles at the two treatment sites between 2007 and 2008 (Figure 3). Some minor deposition has occurred at both treatment sites with a maximum of 1.5 ft of aggradation upstream of a channel spanning log at the downstream end of Treatment Site 2. While deposition and the formation of new steps are associated with channel spanning logs at many locations, aggradation is not in all cases associated with the added wood. No areas of bed erosion are observed on the profiles. Given the difficulty in exactly reoccupying the same points along the longitudinal profile from year to year, some apparent shifts in steps and infilling of pools are present when comparing the profiles from 2007 and 2008, but these are merely artifacts of the surveying process and not true on-the-ground changes (Figure 3). In other areas, actual aggradation has resulted in the infilling of pools, but water depths could actually have increased in these areas due to the significant ponding of water behind emerging log jams. Over time, as log jams become better established, new areas of aggradation and more pronounced steps could form. Future surveys should be able to document these anticipated adjustments.

Plan view maps were created of each site showing the top of the banks, location of gravel bars, and the position of the thalweg (i.e., deepest portion of the channel) (Figure 4). The apparent increase in channel width at Treatment Site 1 between 2007 and 2008 is considered an artifact of surveying differences between different years, because of difficulties in ascertaining a clear top of bank position with varying bank heights and water surfaces. Gravel bars were mapped by surveying the water's edge around the perimeter of the exposed bar surface. The size and number of bars at Treatment Site 1 increased more significantly than at the control site or Treatment Site 2 where only minor changes occurred. The changes at Treatment Site 1 appear most dramatic upstream of channel spanning logs where sediment might be preferentially deposited in the water pooling behind the logs. While the increase in bar growth could be an artifact of different water stages at the time of the surveys, anecdotal evidence suggests water levels at the time of the 2008 surveys were higher than in 2007, which would have resulted in the mapping of smaller bars if no changes had actually occurred. With the continuation of water level logging initiated in 2008, comparisons of water levels will be possible in future survey years and changes in bar numbers and sizes better documented. Larger and more numerous bars will be expected over time, especially upstream of log jams. Continued bar growth will lead to a narrowing of the channel and an increase in water depths during low flow periods when brook trout would be under the greatest stress.

3.0 SUBSTRATE PARTICLE SIZE ANALYSES

One pebble count following the methods of Wolman (1954) was undertaken at each site to monitor changes in substrate particle size (Figure 5). Bedrock encountered during the pebble counts was considered as a large boulder in order to generate cumulative histograms of the results than can be used to monitor change over time. No comparisons of pebble count data are yet possible as the substrate particle size monitoring was only initiated in 2008. The median particle size for the treatment sites and control reach are very coarse and is expected to decrease over time at the treatment sites as fine sediment is trapped behind the channel spanning logs.

4.0 GROUND PHOTOGRAPHS

Digital ground photographs were taken throughout the length of Treatment Site 2 in 2007 (Appendix 1). GPS coordinates were used to locate the position of each photo point and a compass used to record the orientation of the camera. Given the constraints of the project budget, similar oriented photographs were not taken at the other sites. In 2008, only a few of the photo points at Treatment Site 1 were rephotographed to identify any visual changes to the position of wood, banks, and bar dimensions (Figure 6). In addition, additional photograph monitoring points were established at selected points at Treatment Site 2 and the control reach for future monitoring (Appendix 1). The matched photographs from Treatment Site 1 reveal no significant changes between 2007 and 2008, but do show minor changes in bar size and variations in the positions of small logs. The most significant change observed when comparing the photographs is the loss of leaves from the dropped trees and the accumulation of leaves and other fine organic matter behind some of the logs. Anecdotal evidence suggests much larger channel spanning logs were rotated and moved considerable distances. A large tree was observed oriented parallel to flow at Cross Section 3 of Treatment Site 1 in October 2008, although the tree was not in that position at the time of the resurvey earlier in 2008. Rephotographing the sites in future years will potentially document these more significant changes.

5.0 WATER LEVEL LOGGING

Water level monitoring was implemented in 2008 with the installation of in-stream stilling wells in which HOBO water level loggers were suspended just above the bed of the channel. The HOBO loggers record the pressure of the water column above the logger as well as water temperature. An atmospheric logger was deployed at the upstream end of Treatment Site 1 to record fluctuations in barometric pressure that are required to convert pressure readings in the stilling wells into water level or stage data. Water temperature data is also required for determining water stage as the density of water, and therefore the pressure of the water column, varies with temperature. Five water level loggers and the atmospheric pressure logger were deployed. One water level logger was deployed at the control site while two loggers each were deployed at the two treatment sites: one logger upstream of the treatment area and one logger downstream. The atmospheric logger was placed at Treatment Site 1 at the top of the upstream stilling well. All loggers began recording data at 4:00 pm on July 7th, 2008. Initially the loggers were set to record a measurement every 15 minutes, however upon reviewing the preliminary data during the field calibration on August 20th, the decision was made to redeploy the loggers with a 30-minute measurement interval. Water level data was recorded throughout the remainder of the summer and fall until the loggers were removed on October 30th. The intent is to deploy these loggers in the same sites after ice-out and as soon as the weather permits in the spring of 2009.

Although comparisons with other years are not yet possible, results of the first year of water level monitoring reveal several large flow events occurred during the nearly four month recording period (Figure 7a and Appendix 2). The largest short-term stage variation of 1.7 ft was measured at the upstream logger at Treatment Site 1 on October 26th (Figure 7b). Similar but somewhat smaller peaks were recorded at the other sites. The maximum stage for both loggers at Treatment Site 2 was recorded during the August 7th runoff event (Figure 7c). A moderate flow event on July 18th displays how significant variations in stage can occur between the upstream and downstream loggers at the same treatment site. Upstream of Treatment Site 2 the July 18th event shows a stage variation of 0.9 feet, whereas the downstream logger recorded a stage variation of only half that magnitude (Figure 7d). Several reasons might explain this variation including the presence of a log in the vicinity of the upstream logger that temporarily pooled water to a greater depth than would normally be expected.

The placement of the loggers was intended to document whether the chop and drop wood additions were impacting water levels. The expectation is that the added roughness of the wood in the channel will increase the travel time of water flowing through the treated areas. This would lead to a reduction in the peak stage downstream but an increase in the duration of flow for a particular storm event relative to sites upstream. The smaller peaks around the August 7th runoff event are of nearly the same magnitude upstream and downstream of the site but the stage remains higher for a longer duration at the downstream gage, possibly reflecting an influence of the treatment area (Figure 7c). Similarly, the peak of the October 26th runoff event at Treatment Site 1 is higher upstream than downstream while the stage decreases more rapidly upstream (Figure 7b). However, the reverse is true at Treatment Site 2, indicating that the reasons for water level variations between upstream and downstream loggers are complex. Further documentation of differences in water levels between upstream and downstream loggers at the treatment sites in future years may help identify a clearer signal in response to the wood additions.

6.0 CONCLUSIONS

Geomorphic monitoring at two chop and drop wood addition projects over a two year period reveals minor channel adjustments have occurred at the treatment sites. Cross sections document a weak tendency for aggradation to occur upstream of log jams and erosion downstream, but no clear pattern has yet to emerge. The longitudinal profiles also show aggradation occurring along long lengths of the treatment areas without any significant bed erosion, providing a stronger signal that the wood additions are resulting in a depositional response in the treatment areas. Further evidence of a trend towards aggradation is the emergence of new bars and the growth of existing bars in the treatment areas. The added roughness in the channel has likely caused decreases in flow velocities and a reduced capacity to transport sediment. The additional roughness is also expected to reduce peak stages downstream while extending the duration of storm flows. Initial water level logging has not clearly documented such a response, but future monitoring may reveal such trends after additional adjustments occur within the treatment reach.

Repeat ground photographs have documented minor shifts in the position of small logs, while anecdotal evidence indicates larger trees have also moved within the treatment areas. Further movements of wood are expected to lead to the formation of large log jams that will locally enhance the aggradational response and create new steps and pools, increase pool depths, and narrow the channel. These responses should result in improved cover, resting, and spawning habitat for brook trout in the treated areas. Continuation of the surveys, ground photographs, pebble counts, and water level logging will document these changes over time and provide critical baseline information regarding the types, magnitude, and rate of channel adjustments that follow chop and drop wood additions. Such data will likely prove useful for planning similar projects on other streams throughout Maine and elsewhere.

7.0 REFERENCES

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Bond, N. R., Sabater, S., Glaister, A., Roberts S., and Vanderkruk, K., 2006, Colonisation of introduced timber by algae and invertebrates, and its potential role in aquatic ecosystem restoration: Hydrobiologia, v. 556, p. 303-316.

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Flebbe, P.A., 1999, Trout use of woody debris and habitat in Wine Spring Creek, North Carolina: Forest Ecology and Management, v. 114, p. 367-376.

Wolman, M.G., 1954, A method of sampling coarse river-bed material: Transactions of the American Geophysical Union, v. 35, p. 951–956.

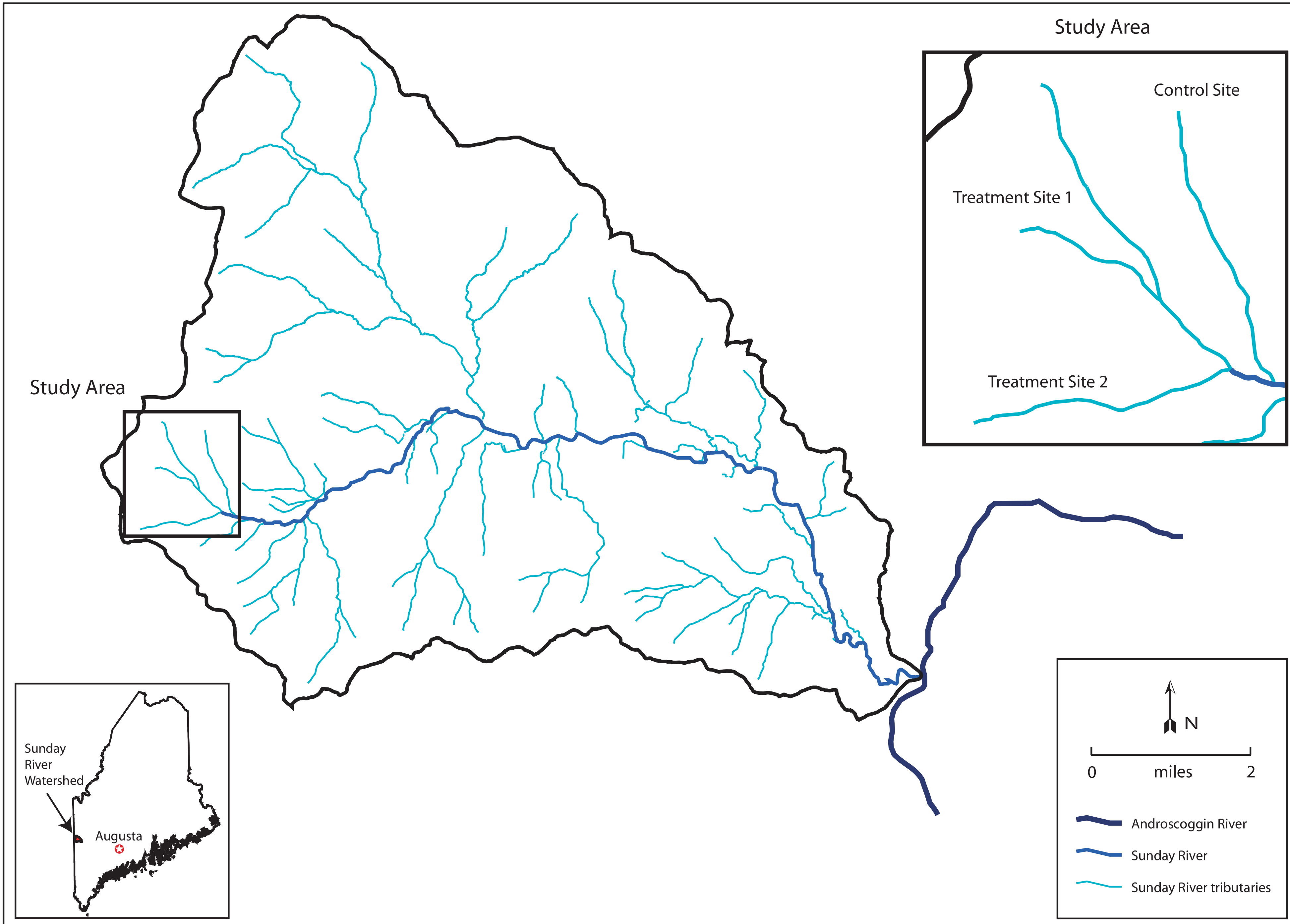

Figure 1: Watershed location map

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Sunday River Chop and Drop Monitoring Project

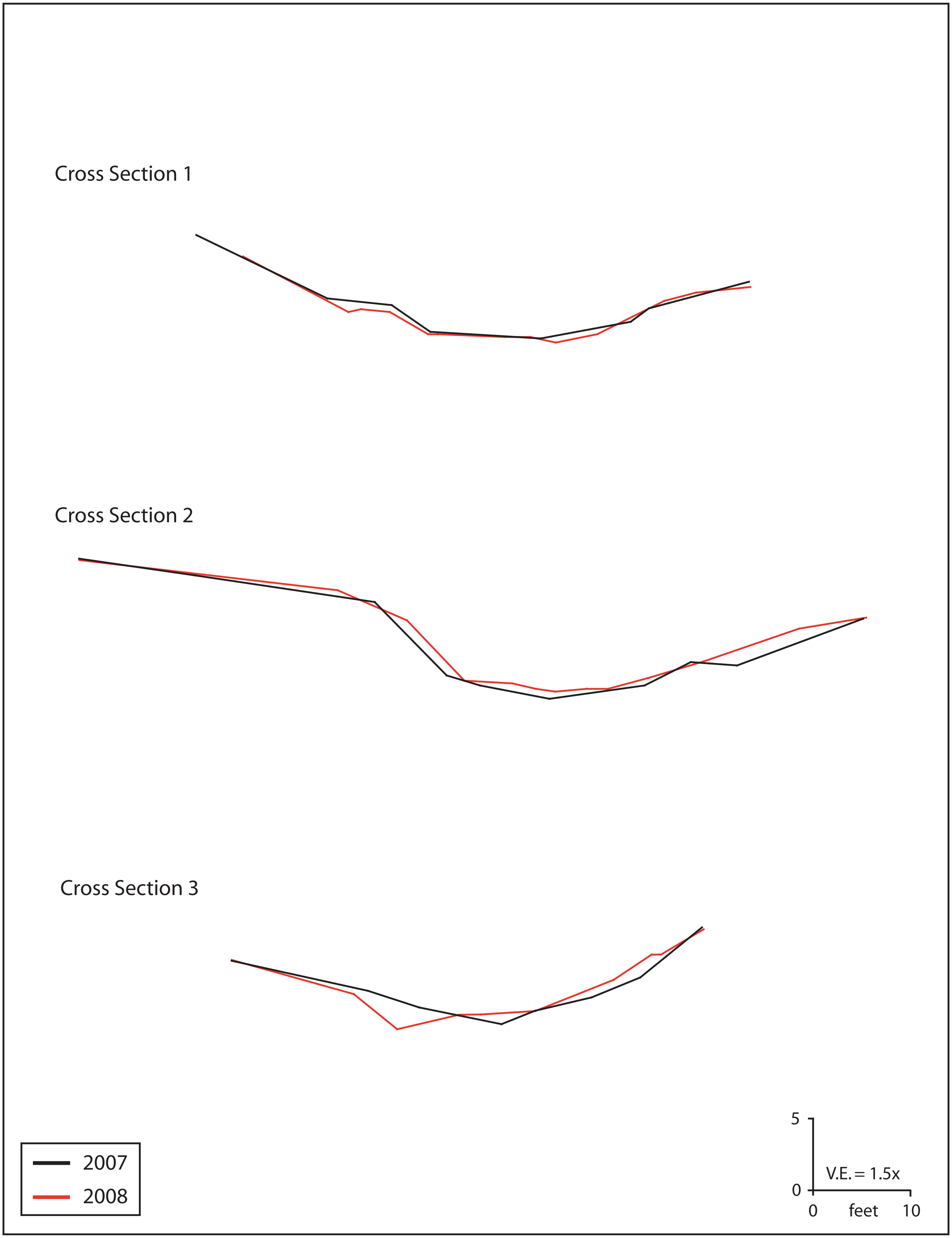

Figure 2a: Treatment site 1 cross sections

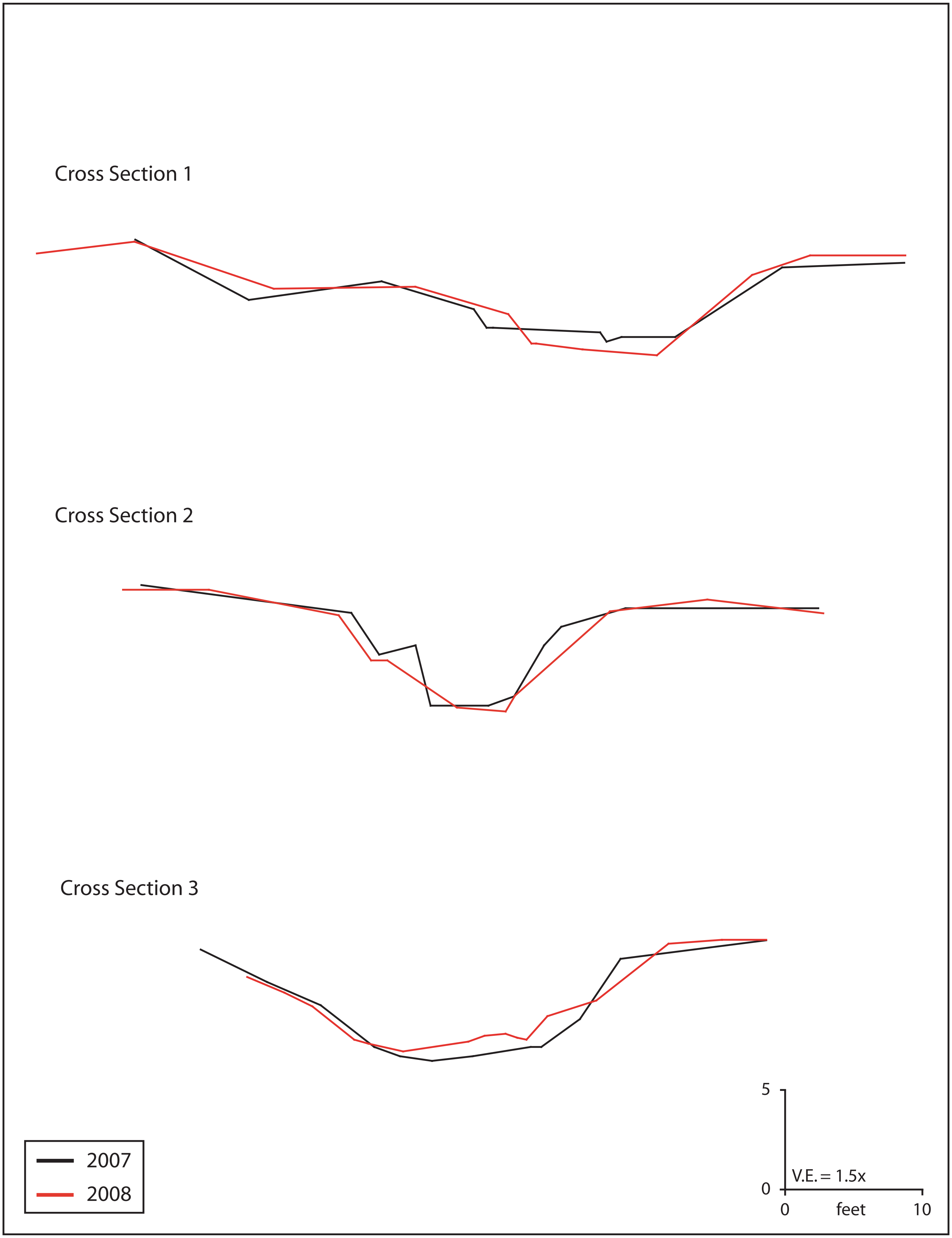

Figure 2b: Treatment site 2 cross sections

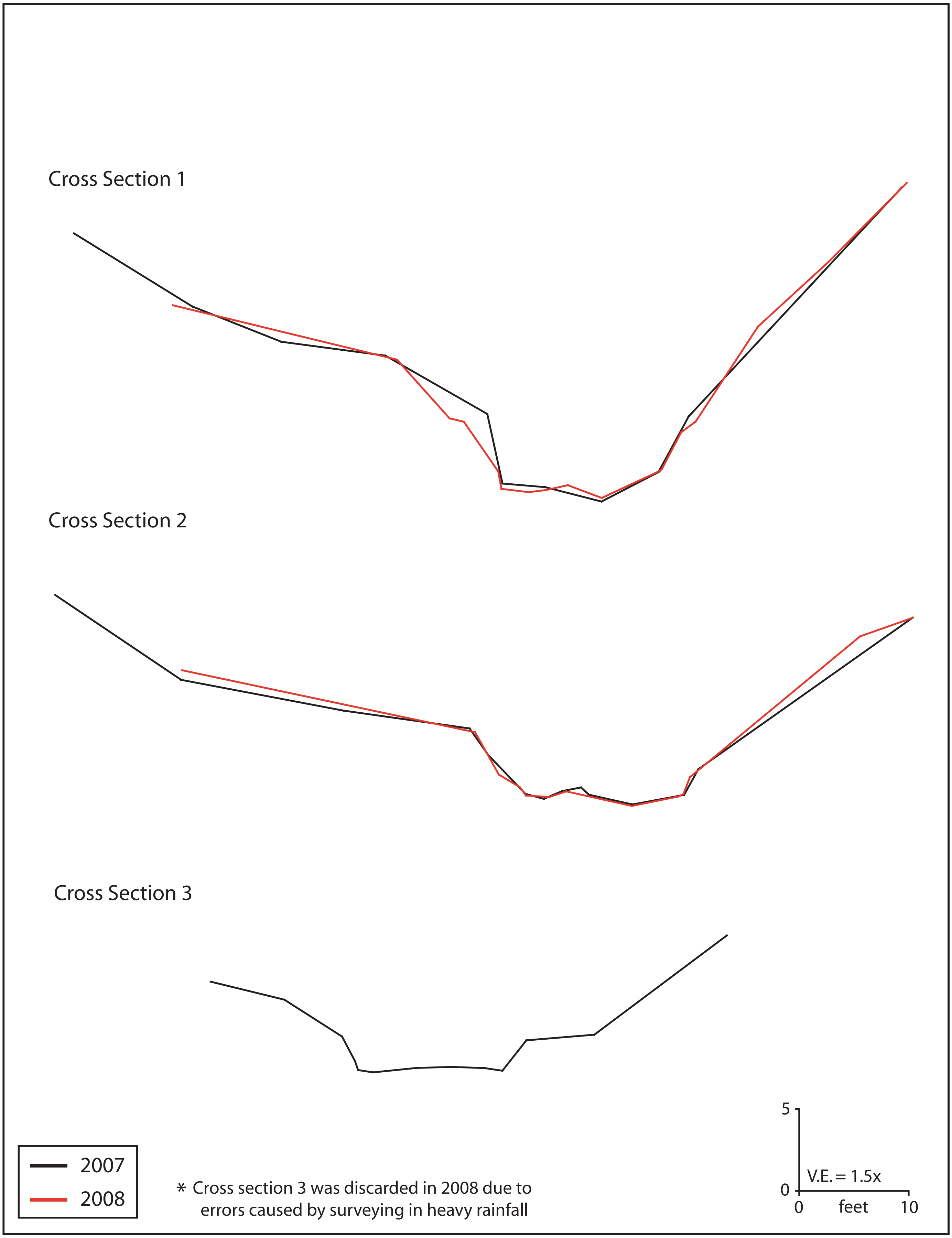

Figure 2c: Control site cross sections

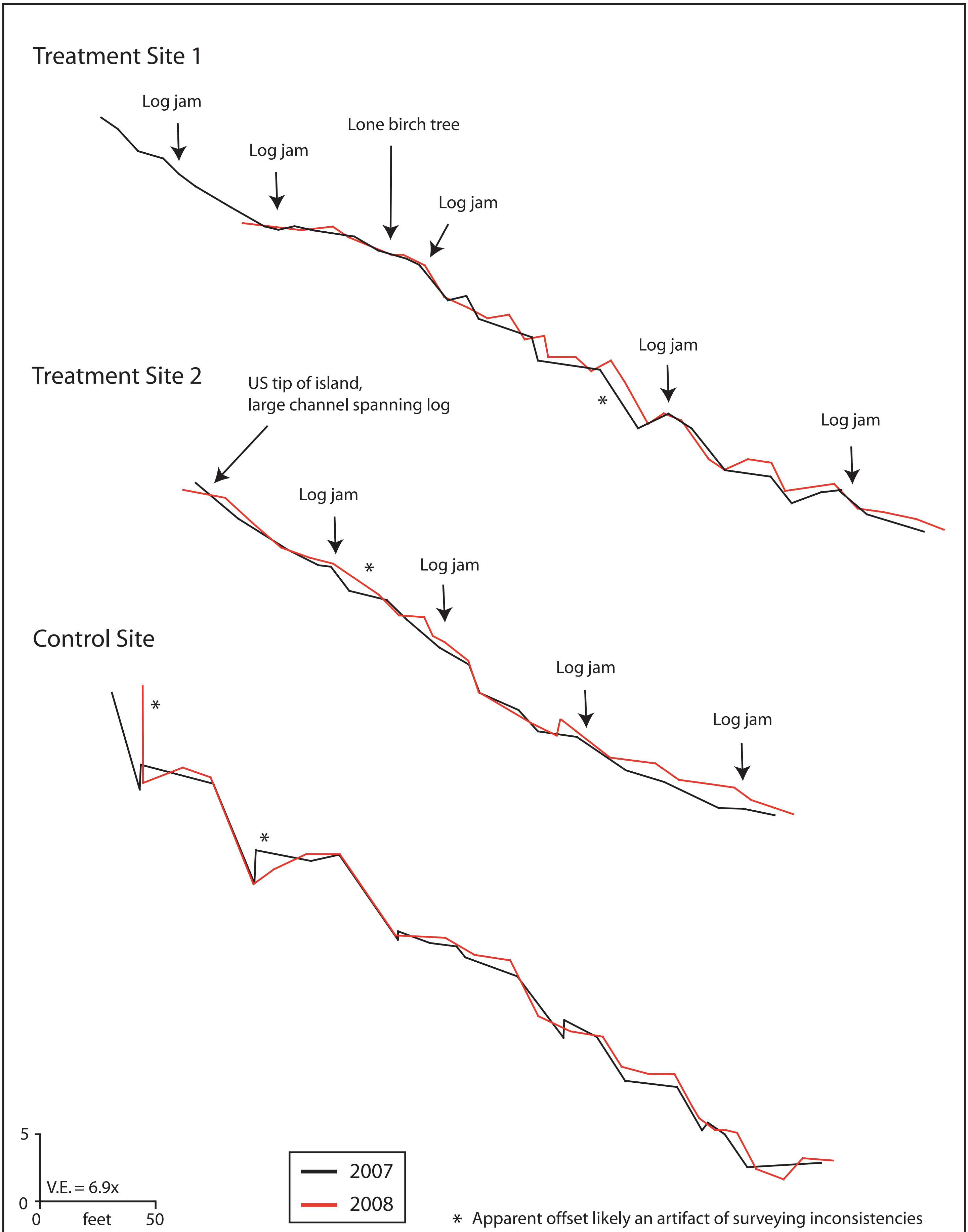

Figure 3: Longitudinal profiles of monitoring sites

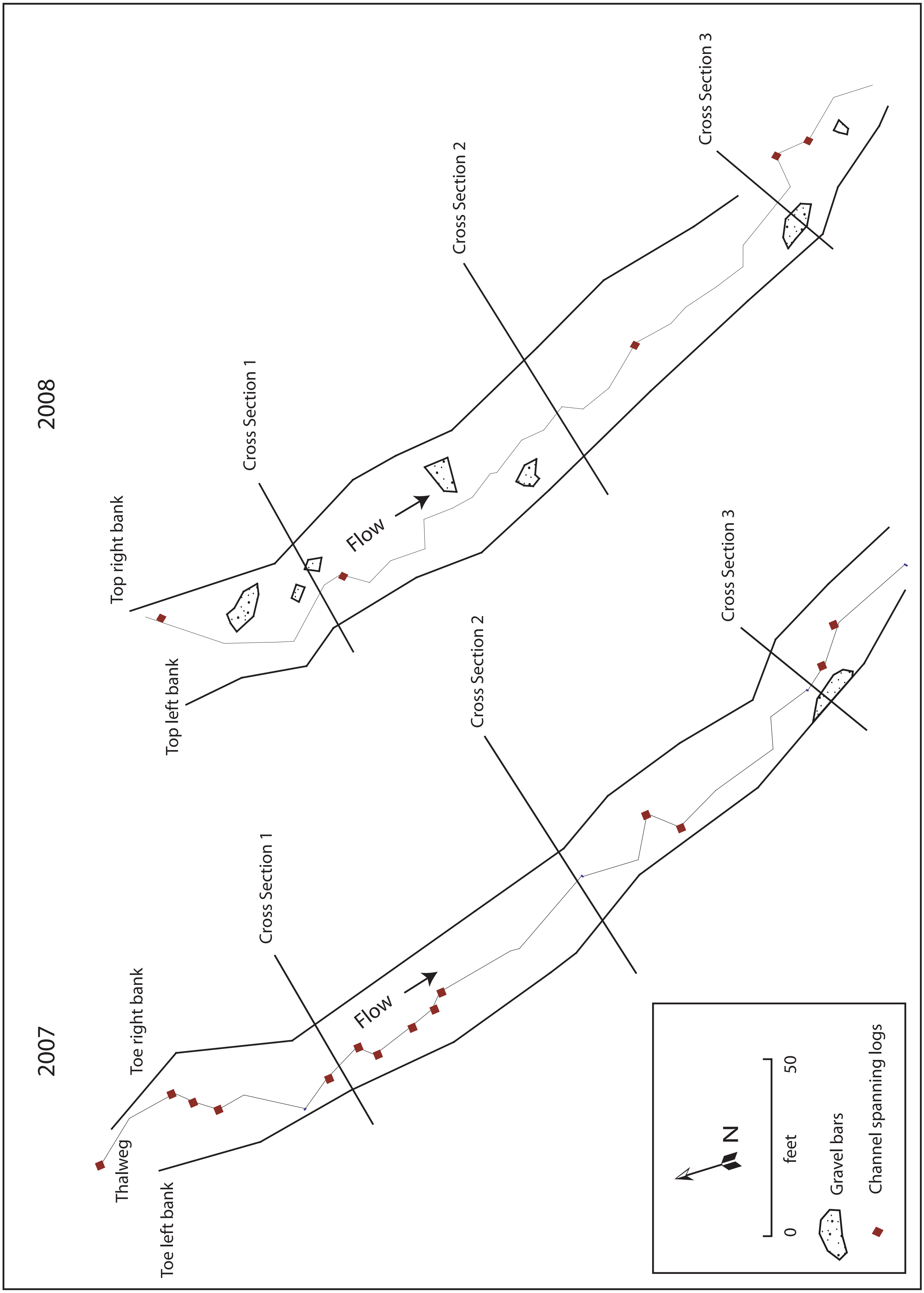

Figure 4a: Treatment site 1 planview map

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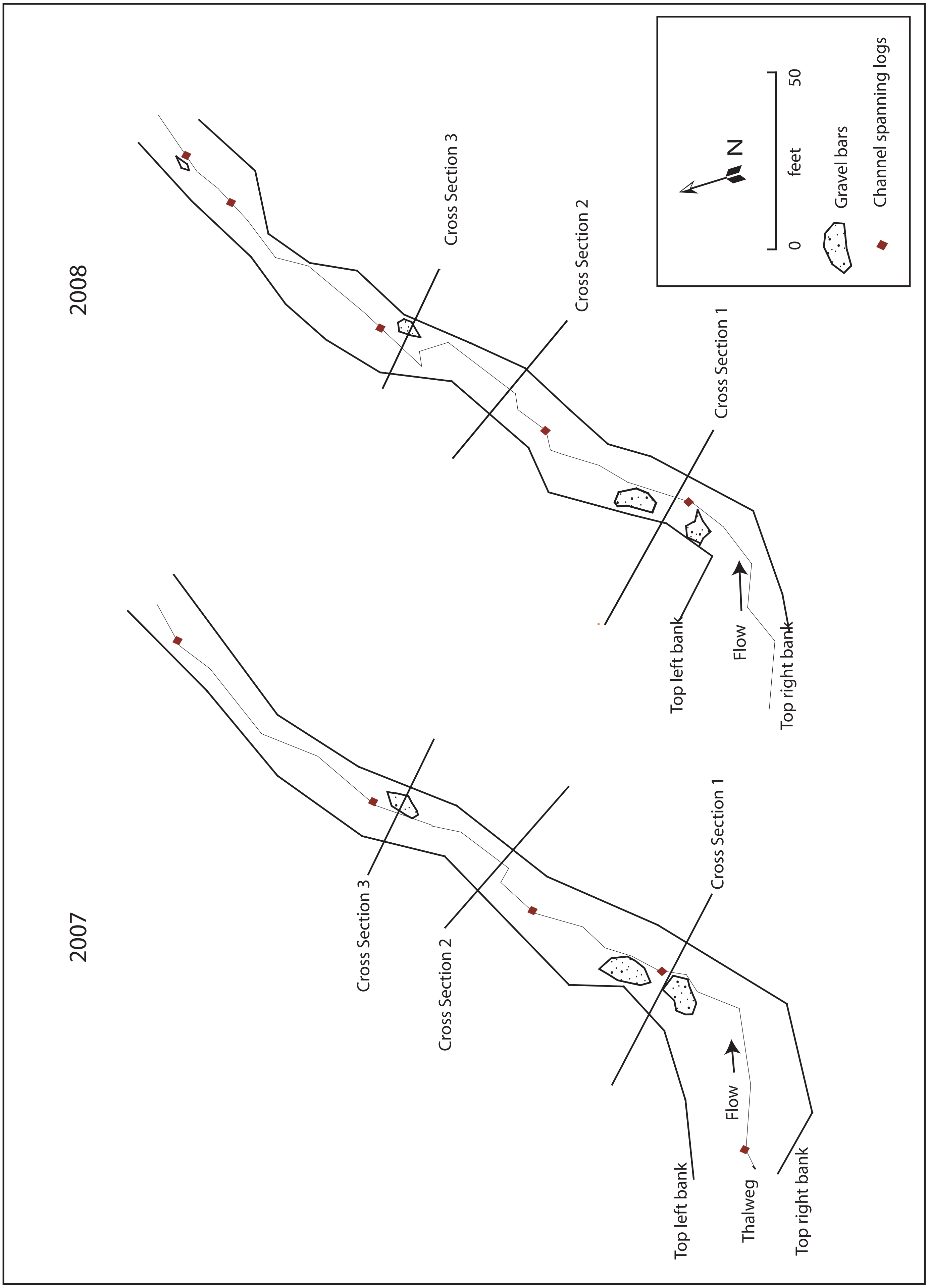

Figure 4b: Treatment site 2 planview map

Sunday River Chop and Drop Monitoring Project

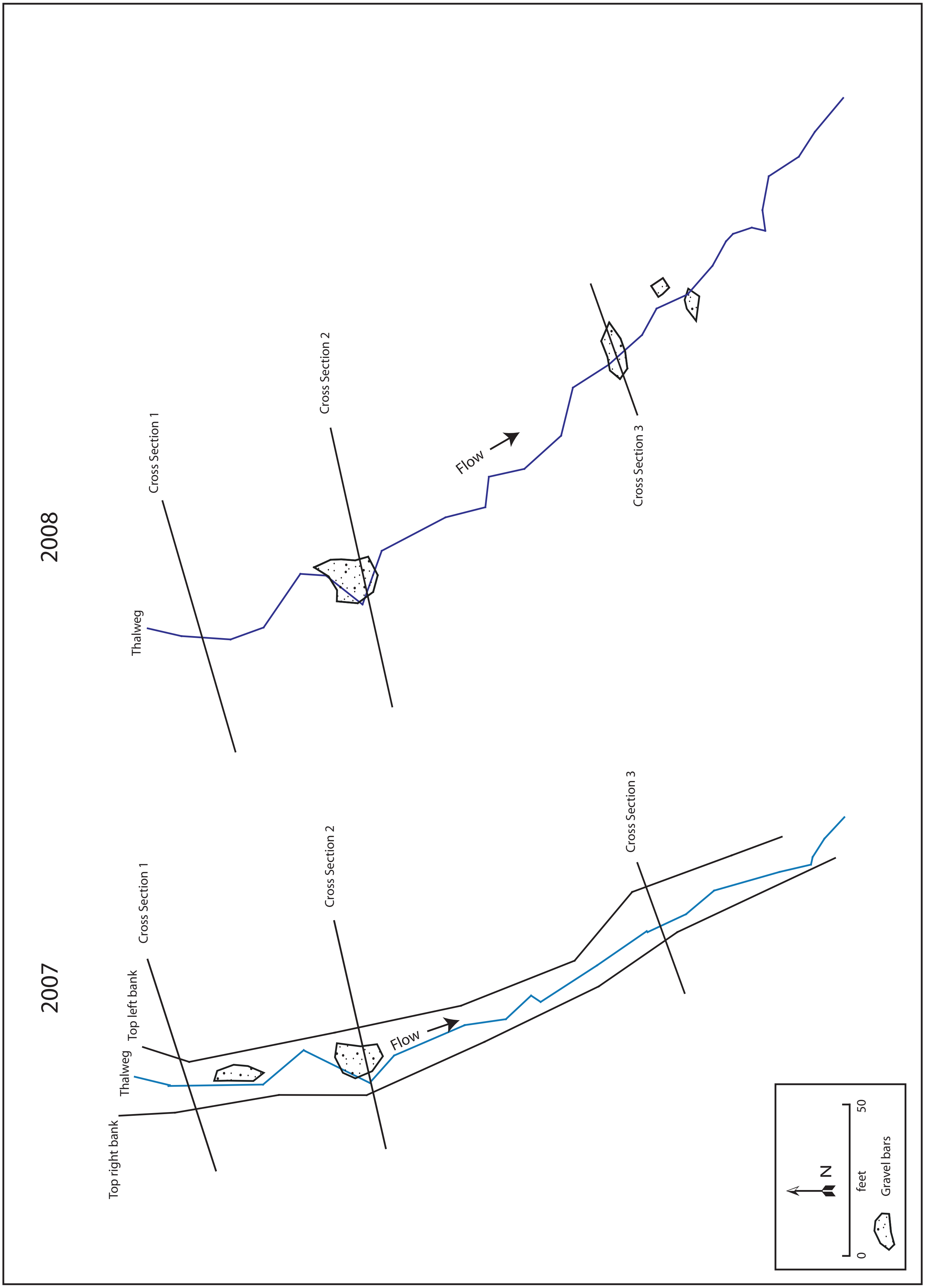

Figure 4c: Control site planview map

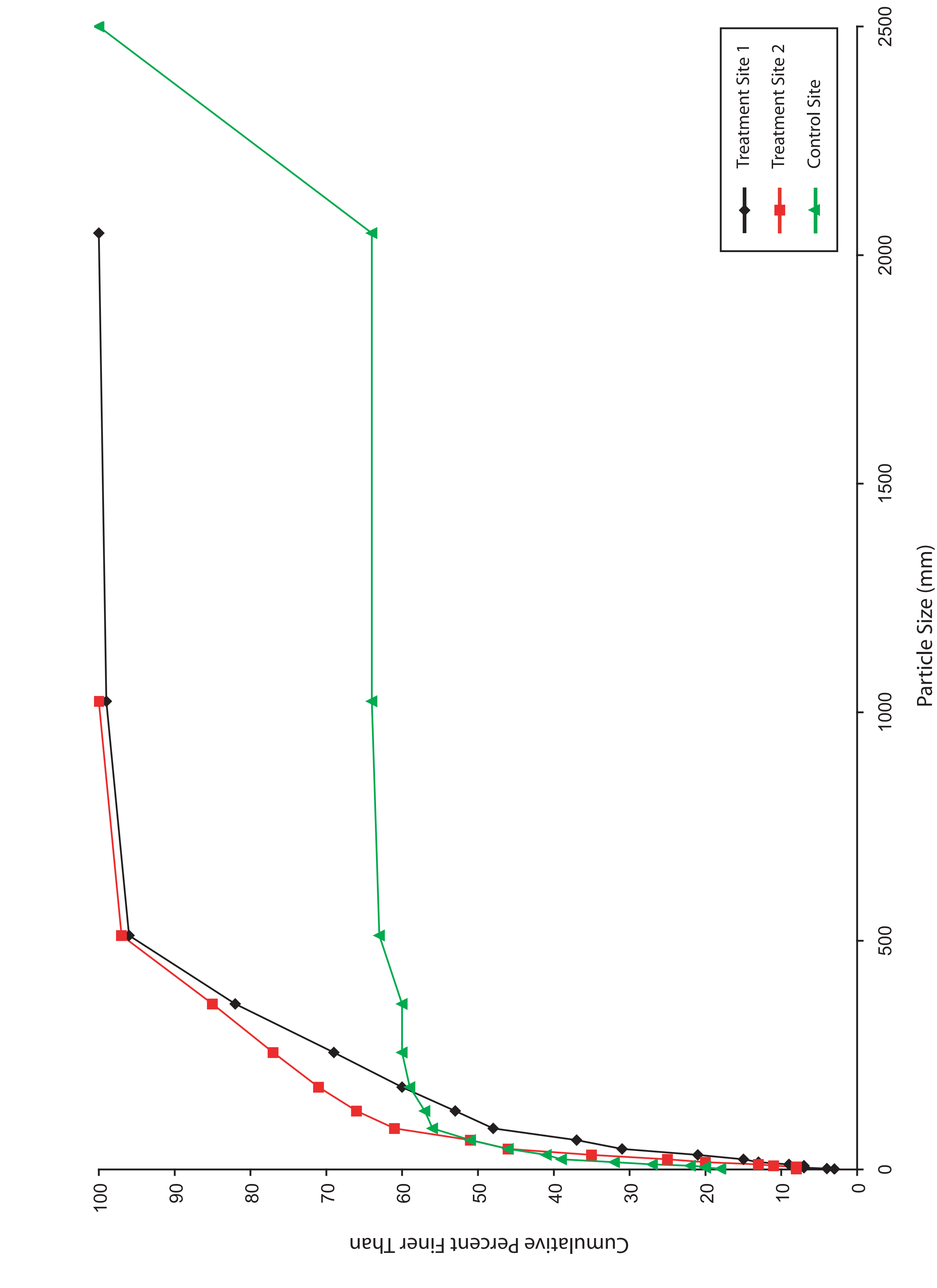

Figure 5: Pebble count data

Sunday River Chop and Drop Monitoring Project

2007 GPS WP 35, N80E

Photo #44; view DS from lower end of island

2008 GPS WP 35, N80E

Photo #1, note movement of notched log (lower left of photo)

2007 GPS WP 34, N90E

Photo #45; view DS from US end of reach, gravel bar DS of island

2008 GPS WP 34, N90E

Photo #2

Figure 6a: Treatment site 2 matched photos

2007 GPS WP 34, N70W

Photo #46; US view of island

2008 GPS WP 34, N70W

Photo #3

2007 GPS WP 38, N71W

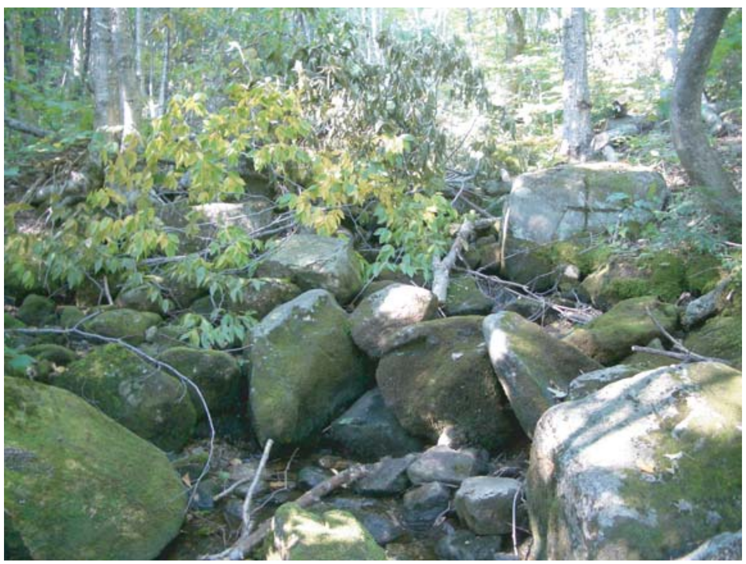

Photo #40; US view at cross section 2, channel-spanning log and step

2008 GPS WP 38, N71W

Photo #4; LWD jam collecting organics and debris

Figure 6b: Treatment site 2 matched photos

2007 GPS WP 38; N23E

Photo #39; DS view of channel-spanning log

2008 GPS WP 38; N23E

Photo #5; LWD collecting debris

2007 GPS WP 39; N85E

Photo #38; DS view of small RB gravel bar

2008 GPS WP 39; N85E

Photo #6; Fines accumulating above and below water surface

Figure 6c: Treatment site 2 matched photos

2007 GPS WP 42; S30E

Photo #34; US view from LB at DS end of reach

2008 GPS WP 42; S30E

Photo #7; Log at lower right of photo has rolled into stream

2007 GPS WP 42; S32W

Photo #35; US view of channel-spanning log at DS end of reach

2008 GPS WP 42; S32W

Photo #8; Log has been moved out of the center of the stream

Figure 6d: Treatment site 2 matched photos

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2007 GPS WP 42; S73E

Photo #33; DS view of channel-spanning log near DS end of survey reach

2008 GPS WP 42; S73E

Photo #9; channel-spanning log has shifted and settled lower in the stream

Figure 6e: Treatment site 2 matched photos

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Hydrographs for the Entire Study Period (July 7 - October 30, 2008)

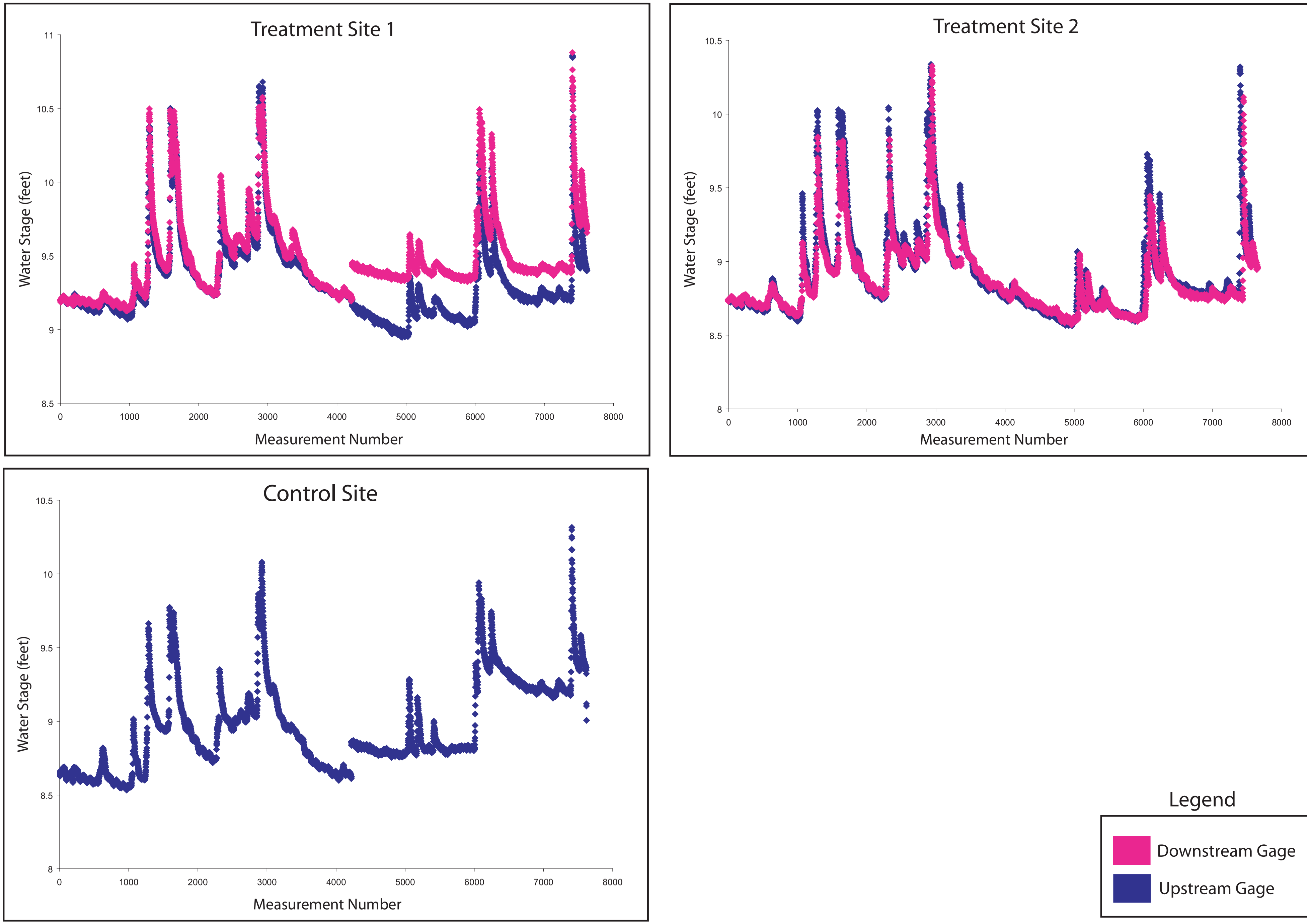

Figure 7a: Hydrographs for the overall study period

Storm Hydrographs from October 23 - 30 (30-minute measurement interval)

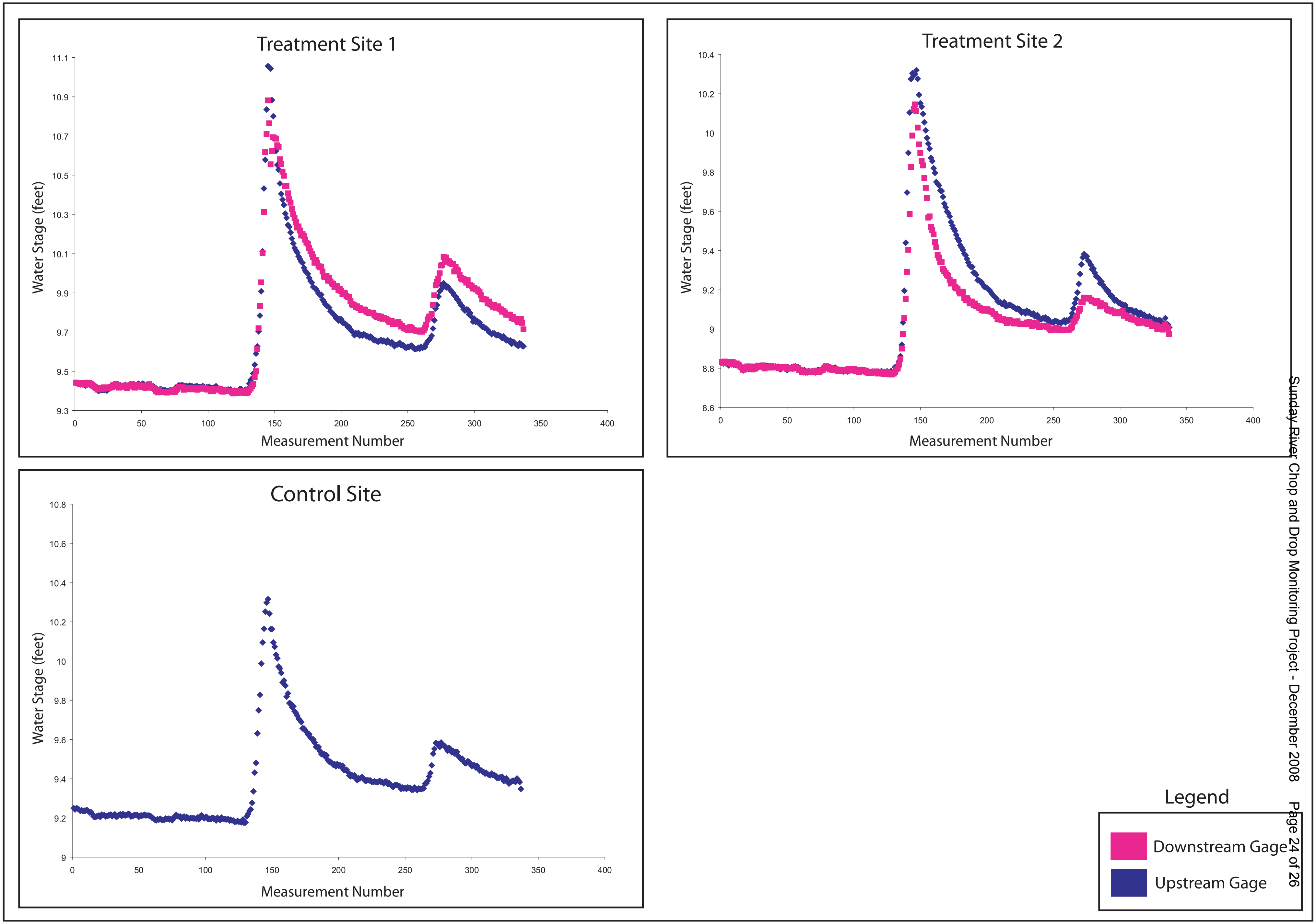

Figure 7b: October 26th event hydrographs

Storm Hydrographs from August 1 - 14 (15-minute measurement interval)

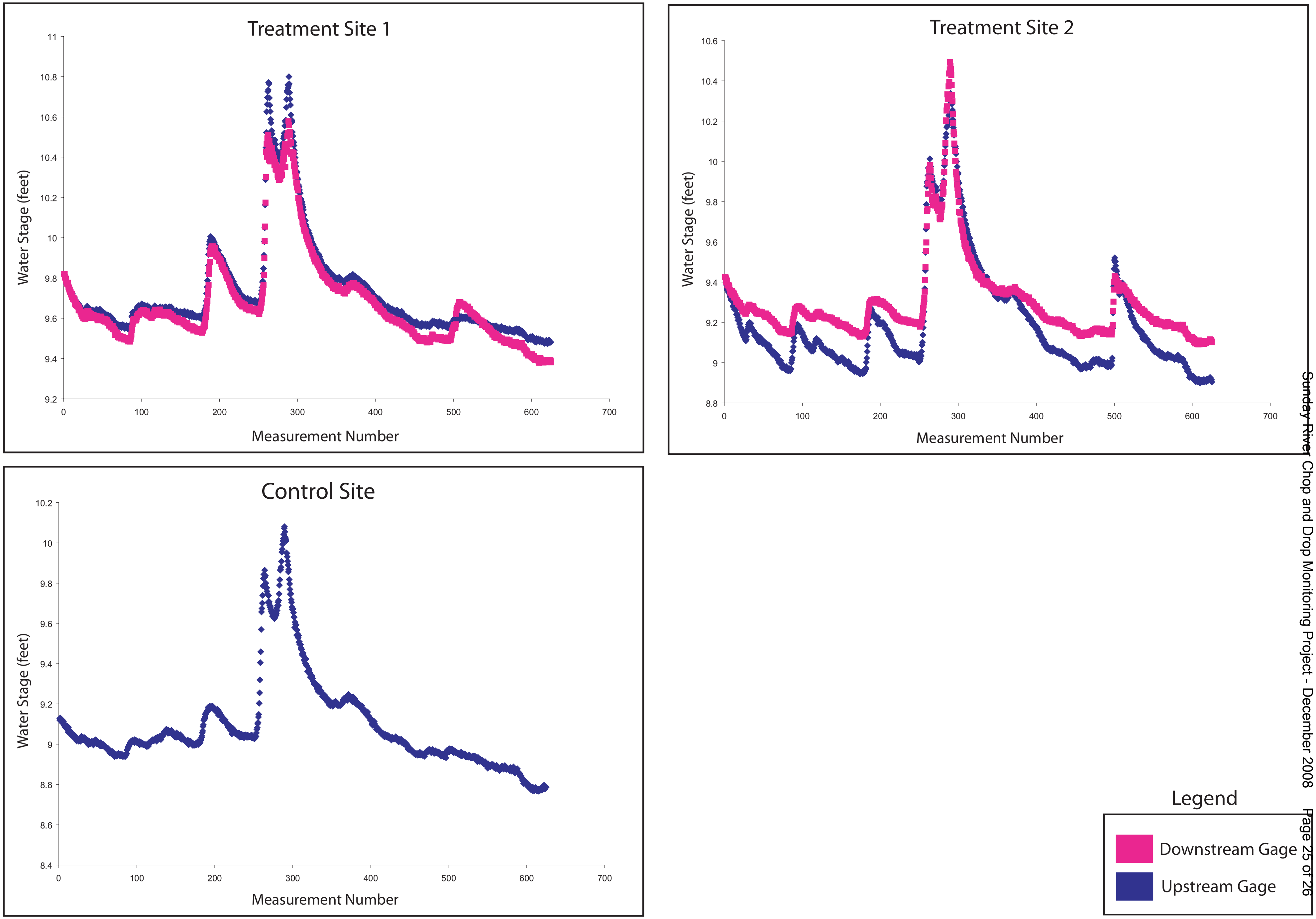

Figure 7c: August 7th event hydrographs

Storm Hydrographs from July 7 - 20 (15-minute measurement interval)

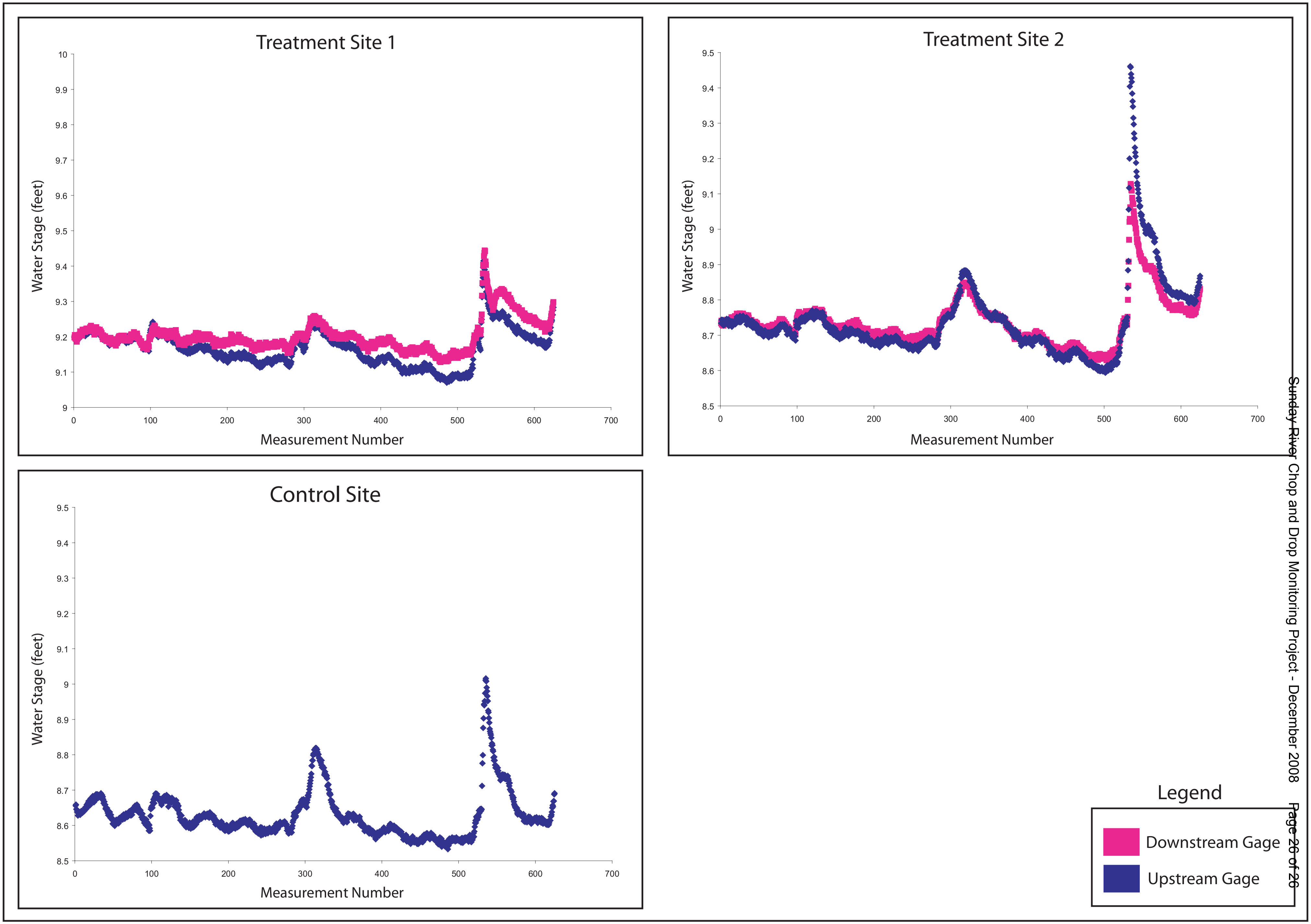

Figure 7d: July 18th event hydrographs