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FINAL REPORT

Dead River Recovery Post-Event Additional Environmental Assessment: Survey of Morphological Stream Parameters Using Rosgen Method

Marquette County, Michigan

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Part 2 of 3

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Under Contract to:

Upper Peninsula Power Company

UPPCO

Appendix 1

Post-Event Environmental Assessment (October 2003)

Post-Event Environmental Assessment

Dead River, Michigan

October 22, 2003

Prepared by
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Under Contract to
Upper Peninsula Power Company

Executive Summary

Background

On May 14, 2003, a breach of the fuse plug occurred on the Silver Lake Basin, located on the Dead River in the Upper Peninsula of Michigan. In the area of the fuse plug, the force of the water created a new outlet stream channel, connecting to the original channel approximately 4,100 feet downstream of the former lake outlet. The released water caused erosion of the fuse plug, fuse plug foundation material, and spillway channel. In addition, erosion and deposition of eroded sediments occurred in selected downstream areas in the Dead River system.

Environmental Assessment and Recovery Project Underway

Upper Peninsula Power Company (UPPCo) began a multi-phase Post-Event Environmental Assessment (EA) and Recovery Project. This effort is being performed by UPPCo with assistance from CH2M HILL. Planning, EA, and recovery activities began in May, shortly after the event, and resulted in submittal of the *Agency Draft Work Plan* on June 23 and the *Final Work Plan* on September 22, 2003. This EA Report documents the results of the first phase of EA work conducted under this project.

Scope

The multi-phase project approach was formulated with input from Michigan Department of Environmental Quality, Michigan Department of Natural Resources, the U.S. Fish and Wildlife, and the Keeweenaw Bay Indian Community. With agency concurrence, the first phase of the EA began in June. This effort consisted primarily of a system-wide approach to qualitatively assessing the impact of the event on the river channel, its banks, and its habitat. The purpose of this work was to document and evaluate the post-event conditions of the Dead River system, using qualitative and quantitative observations and measurements, and to identify specific reaches, sub-reaches, and sites that would be investigated in detail at a later time.

The primary focus of the initial EA is on the river channel, the habitat within the channel, the reservoirs, water quality, and, to a lesser extent, the fisheries potentially affected by the release. To facilitate system evaluation, the channel and reservoirs were divided into 11 reaches. Habitat and channel stability scores were generated for roughly 20 miles of river, and further divided for the purpose of adequate characterization into 34 sub-reaches. Physical conditions at four open water bodies (the Dead River Storage Basin, McClure Basin, Forestville Basin, and the Harbor/Lake Superior area) were also documented.

While UPPCo has conducted an EA on roughly 20 miles of river, it is not assuming responsibility for this event or the subsequent damage. The data collected under this EA will be shared with interested government agencies.

Results

In general, the stream reaches immediately downstream of Silver Lake Basin (Reach 2) and Tourist Park Basin (Reaches 9 and 10) scored lower than those in the middle reaches of the system (Reaches 4, 6, and 8). About 95 to 100 percent of Reaches 2, 9, and 10 exhibit Poor or Marginal habitat and Unstable to Moderately Unstable geomorphological conditions, with significant sedimentation on the channel bed and adjacent banks. In addition, Reach 2 has steep and sometimes high unstable river banks that are potential sources of new sediment loadings to the river system. Reaches 4, 6, and 8 appear to be in relatively good condition with high percentages of Excellent and Good habitat scores and channel stability ratings of Stable to Moderately Unstable.

Based on measured turbidity and total suspended solids measurements, water quality is improving over time. In addition, fish were observed at numerous places throughout the watershed.

Conclusions

This EA has generated considerable data regarding the post-event Dead River channel conditions within the study area. Some of the post-event stream reaches of the river system (~40-45 percent) are in relatively good condition (Reaches 4, 6, and 8), while other reaches (~30-35 percent), most notably those immediately downstream of Silver Lake (Reach 2) and at or downstream of Tourist Park (Reaches 9 and 10), are not. The unstable portion of the river and its banks negatively influences upstream and downstream channel stability, sediment transport, and habitat quality.

Although the river and its functions have been impacted, portions of the river are currently stable and provide aquatic habitat and others show some evidence of natural recovery.

Two of the four reservoirs/areas inspected appear to be potentially impacted by post-event deposition, namely the upper portion of the Dead River Storage Basin and the Harbor/Lake Superior area. Detailed pre-event bathymetric (and to an even greater extent substrate) data are unavailable for much of the relevant water body areas, complicating the assessment process.

As a result of this assessment, three sites within Reach 2 were identified that merited immediate action consisting of further investigation and/or interim measures to address the conditions observed. These are the post-event outlet of Silver Lake (with the potential for additional headcutting), the steep river bank upstream of Mulligan Creek, and the blockage of Mulligan Creek at its confluence with the Dead River. As a result of further analysis conducted in September 2003, additional interim measures are not warranted at the Silver Lake Outlet.

The results of this EA are qualitative and preliminary. They are of value for planning supplemental EA work anticipated for the spring of 2004.

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Acronyms

BEHI	Bank Erosion Hazard Index
cfs	Cubic feet per second
DO	Dissolved oxygen
EA	Environmental Assessment
FERC	Federal Energy Regulatory Commission
GPS	Global positioning system
KBIC	Keeweenaw Bay Indian Community
MDEQ	Michigan Department of Environmental Quality
TSS	Total suspended solids
UPPCo	Upper Peninsula Power Company
USFWS	U.S. Fish and Wildlife Service
WPSC	Wisconsin Public Service Company
YOY	Young-of-the-year

1 Introduction

1.1 Background

On May 14, 2003, a breach of the fuse plug occurred on the Silver Lake Basin, located on the Dead River in the Upper Peninsula of Michigan. In the area of the fuse plug, the force of the water created a new outlet stream channel, connecting to the original channel approximately 4,100 feet downstream of the former lake outlet. The released water caused erosion directly below the fuse plug, fuse plug foundation material, and spillway channel. In addition, erosion and deposition of eroded sediments occurred in selected downstream areas in the Dead River system.

Upper Peninsula Power Company (UPPCo) began conducting a Post-Event Environmental Assessment (EA) and implementing measures (as needed) for recovery of critical functionality lost as a result of the event. UPPCo's plans are documented in the *EA Work Plan* (submitted in draft form on June 23, 2003; revised with agency input in July; and finalized on September 22, 2003). The Work Plan was developed with input from the Michigan Department of Environmental Quality (MDEQ), the Michigan Department of Natural Resources, the U.S. Fish and Wildlife Service (USFWS), and the Keeweenaw Bay Indian Community (KBIC).

The study area consists of the Dead River system (riverine and reservoir habitats and floodplain areas) from the Silver Lake Basin downstream to and including the sediment deposition area within Lake Superior. This area and its general location in the study area within the State of Michigan are presented in Figure 1-1.

1.2 Environmental Assessment Purpose and Goal

CH2M HILL was contracted by UPPCo to implement elements of the EA. The goal of the EA is to provide a technical and credible basis for documenting and evaluating the post-event conditions on the Dead River system for use in developing and implementing a recovery plan. The recovery plan will focus on critical functionality lost as a result of the event. System functions under initial consideration during the EA process are as follows:

- Channel stability
- Aquatic habitat
- Fisheries
- Terrestrial biology
- Water quality
- Navigation
- Recreation

UPPCo has embarked on a multi-phased project. The overall approach is illustrated in Figure 1-2. The first phase of the EA is primarily a qualitative analysis focusing on the system as a whole and identifying reaches, sub-reaches, or sites that could be potentially addressed and/or characterized in greater detail during the next phase of the assessment.

1.3 Environmental Assessment Work Completed to Date

The first phase EA work completed through September 2003 consists of the following work elements:

- Task 1. Qualitative Assessment
  - 1.1. Pre-event information collection and preliminary review
  - 1.2. Field Survey
    - a. Instream Habitat Evaluation
    - b. Stream Channel Assessment (using Rosgen Level III Part I)
    - c. Visible Reservoir Review
- Task 2. Timely Quantitative Assessment
  - 2.1. Water Quality Monitoring

This report describes the EA work conducted to date and presents the key findings and conclusions of this effort. The results of this work will be used to develop a Supplemental Work Plan covering the next phase of the EA effort.

1.4 Report Organization

The report is divided into three remaining sections: the first describing the work scope of this EA, the second presenting the results and key findings, and the third providing a summary and conclusion. Supporting documentation is provided as Appendixes.

2 Environmental Assessment Scope of Work

2.1 Qualitative Assessment

This assessment consisted of a preliminary review of pre-event information and a field survey of the Dead River system. The scopes of these efforts are briefly described below.

2.1.1 Review of Pre-Event Information

Pre-event information about the watershed was collected by UPPCo and provided to CH2M HILL for preliminary review before and after the field survey was conducted. The information reviewed is provided in Appendix A.

2.1.2 Field Survey

The field survey consisted of the habitat evaluation, stream channel assessment, and reservoir/lake review. The methods and protocols used for this assessment are described below. (Additional details are provided in Appendix B.) The habitat evaluation, in conjunction with the existing pre-event information review, provides a basis from which biological sampling locations can be generated and detailed plans developed. The Rosgen-based channel assessment serves to identify areas of erosion, sedimentation, and departure, if any, from equilibrium for planning immediate and longer-term recovery actions. The reservoir/lake review provides an understanding of the current sedimentation conditions, particularly those that are critical inputs for scoping surveying if needed at a future time.

For the purposes of evaluation, the Dead River watershed has been divided into 11 separate reaches. The reaches are illustrated in Figures 2-1a and 2-1b and summarized in Table 2-1.

TABLE 2-1
Description of River Reaches Established in the EA Work Plan

Reach	Reach Length (miles)	Reach Type	Reach Description
Reach 0	1.9	River	Dead River upstream of Silver Lake (Reference Reach)
Reach 1	3.5	Reservoir	Silver Lake Basin
Reach 2	6.7	River	Silver Lake to Dead River Storage Basin
Reach 3	10.2	Reservoir	Dead River Storage Basin
Reach 4	1.4	River	*Dead River Storage Basin to McClure Basin*
Reach 5	1.5	Reservoir	McClure Basin
Reach 6	6.6	River	McClure Basin to Forestville Basin
Reach 7	1.0	Reservoir	Forestville Basin
Reach 8	1.7	River	Forestville Basin to Tourist Park Basin
Reach 9	1.3	River	Tourist Park Basin
Reach 10	0.7	River	Tourist Park Basin to the mouth of the river
Reach 11	1.3	Harbor & Lake	Lake Superior at the mouth of the river

Reach 0 is being used for Habitat and Channel characterization and not as a reference for Biological Studies. A separate biological reference reach (Reach 12) will be established in the future.
Reach 2 includes both the former Silver Lake Basin outlet channel and the newly formed outlet channel.

During this field reconnaissance, the Dead River system was surveyed, from above Silver Lake into Lake Superior. Reach boundaries were adjusted slightly to take into account backwater and other effects observed in the field. In addition, the stream was further divided into sub-reaches, based on similar stream type or habitat characteristics. In situations where conditions inappropriate for application of the EA methods were observed (e.g., the predominance of bedrock waterfalls), additional evaluation and scoring were not performed. For example, Reach 6 (downstream of McClure Basin dam) was subdivided into 10 sub-reaches and 96 percent was scored. Each sub-reach was labeled with the reach and sub-reach numbers, chronologically from downstream to upstream. The reservoirs were not broken into sub-areas. The habitat and stream condition assessment at the sub-reach level provides the basis for determining where and what actions, if any, are needed. A total of 34 sub-reaches were identified and evaluated.

2.1.2.1 Habitat Evaluation

A qualitative habitat evaluation was performed to gain an initial understanding of the habitat in each river reach within the study area that could be used as the basis for planning future biological (fisheries and macroinvertebrate) sampling. By performing this in conjunction with the stream channel stability assessment effort, future recovery efforts can be focused on critically impacted reaches. In addition to in-stream, bank, and riparian physical conditions, habitat features examined during the field reconnaissance survey included water quality, spawning areas, refugia, and feeding areas. These features are important as they affect fish abundance and health as well as community composition.

Habitat Evaluation Methodology. The EA used the habitat evaluation methodology described in the MDEQ guidance document *Qualitative Biological and Habitat Survey Protocols for Wadeable Streams and Rivers* (revised May 2002). For the purpose of this initial EA, only the habitat evaluation component of the MDEQ method was used.

The Michigan habitat method is only intended for wadeable portions of perennial and intermittent streams that flow between well-defined stream banks. As a result, it was used for the river reaches and the portions of Reach 1 (Silver Lake Basin) and Reach 9 (Tourist Park Basin), where wadeable stream habitat was created as a result of the event. The portions of these former basins that were not wadeable and the reservoirs themselves were not evaluated using this methodology.

The methodology used assigns numeric scores to ten of the habitat metrics to arrive at an overall habitat characterization score (Table 2-2).

TABLE 2-2
MDEQ Qualitative Habitat Scoring System for Wadeable Stream and Rivers

Habitat Characterization	Overall Score
Excellent	>154
Good	105 – 154
Marginal	56 – 104
Poor	<56

Additional information regarding the habitat evaluation is provided in Appendix B.

2.1.2.2 Stream Channel Assessment Using Rosgen Level III Assessment Part I

A stream channel assessment was performed for all of the stream reaches along the entire Dead River system from Silver Lake to Lake Superior to identify and evaluate post-event conditions. The assessment is based on a visual survey of current geomorphological conditions within the stream corridor and in the adjacent flood-prone area.

Stream channel assessment was performed on a sub-reach level where each new sub-reach is defined based on changes in channel geomorphology (i.e., channel stream type, valley type, degree of channel incision, channel bed material, channel bank, vegetation, etc.) (see Appendix B). For geomorphological purposes, each sub-reach was classified based on the following parameters:

- Stream type
- Flow regime
- Stream size/stream order
- Meander patterns
- Depositional features
- Stream channel debris/blockages
- Riparian vegetation
- Revised Pfankuch channel stability evaluation procedure
- Bank erosion hazard index/near bank stress calculation for bank erosion prediction
- Stream type succession

The field survey provides ratings of channel stability and a channel index number, which were created from the numbers documented on the field survey worksheets. The index value provides a relative scaling of stability based upon the factors observed in the field. When compared to other sub-reach index value scores, a relative ranking can be obtained to prioritize follow-up detailed analysis and recovery planning.

Portions of the former Silver Lake Basin and former Tourist Park Basin (reservoirs) were analyzed using the stream assessment and habitat procedures. These reservoirs may or may not be reconstructed. The stream assessment approach only quantifies the current stream-like state and does not quantify the change in reservoir function.

Additional information regarding the stream stability assessment is provided in Appendix B.

2.1.2.3 Visible Reservoir Review

The upper end of the Dead River Storage Basin, the McClure Basin, the Forestville Basin, and the Harbor/Lake Superior area were visited in August during the field survey. These open water areas were reviewed to gain a preliminary understanding of conditions potentially caused by the event and to identify appropriate approaches for acquiring more comprehensive bathymetric and substrate information, where warranted. The following information was collected:

- Location, composition, and extent of visible sediment deposition.
- Reservoir areas less than 1 meter deep (where bathymetric surveying, if performed, would be performed manually).

Additional information regarding the reservoir/open water areas survey is provided in Appendix B.

In addition, on October 16, 2003, the Harbor/Lake Superior area was revisited by UPPCo, the MDNR, the MDEQ, the USFWS, and the KBIC. The purpose was to conduct underwater videotaping of known lake trout (*Salvelinus Namaycush*) spawning areas.

2.1.3 Quantitative Evaluation

Quantitative evaluation plans were made, recognizing that certain aspects of the work may be modified, depending upon field survey data. UPPCo has committed to performing water quality monitoring, biological studies, and other studies to support potential expedited action. Of these, the water quality monitoring began in June and is ongoing. Other activities are anticipated in the spring of 2004.

2.1.3.1 Water Quality Monitoring

The water quality monitoring that is being performed follows the Water Quality Monitoring Plan provided in Appendix C of the EA Work Plan.

Eleven monitoring stations (river and basin stations) have been established along the Dead River from Silver Lake to Lake Superior (Table 2-3).

TABLE 2-3
Water Quality Monitoring Stations

River Reach	Monitoring Stations
Silver Lake to Dead River Storage Basin	DR-1
Dead River Storage Basin	DRB-1, DRB-2, DRB-3, DRB-4
Dead River Storage Basin to McClure Basin	DR-2
McClure Basin	MCB-1
Forestville Basin	FVB-1
Forestville to Tourist Park Basin	DR-3
Tourist Park Basin to Lake Superior	DR-4
Lake Superior at the mouth of the river	SM-1

River and Basin Stations (excluding DRB-2 through DRB-4). For all monitoring stations, the coordinates for each station are being recorded using a differential global positioning system (GPS) unit. For all basin stations, samples and readings are being obtained via small watercraft. Water chemistry parameters are being measured with a portable, multi-parameter water quality meter or other appropriate portable meters. All monitoring equipment is being calibrated for the various parameters according to the manufacture's instructions at the beginning of each field day. Measurements are being recorded at mid-channel and mid-depth at each river monitoring station. Water quality parameters measured in the field include dissolved oxygen (DO), temperature, pH, specific conductivity, and turbidity. Water samples are also being collected for laboratory analysis of total suspended solids (TSS) at all monitoring stations. Secchi disk depth measurements are also being recorded at each monitoring station to measure water clarity, and weather conditions are being noted in the field log book at the same time (i.e., cloud cover, wind, and wave conditions).

Basin Stations DRB-2 through DRB-4. At basin monitoring stations DRB-2, DRB-3, and DRB-4, the coordinates for each station are being recorded using a differential GPS unit, and turbidity is being measured using a calibrated, multi-parameter water quality meter at mid-depth. Secchi disk depth measurements are also being recorded at each monitoring station to measure water clarity, and weather conditions are being noted in the field log book at the same time (i.e., cloud cover, wind, and wave conditions). In addition to the field measurements described above, water samples are being collected for laboratory analysis of TSS at each monitoring station.

Water samples are being collected at mid-depth to avoid surface and bottom effects upon the samples.

2.1.4 Reporting and Planning Supplemental Environmental Assessment Work

This document presents the results of the Phase I EA actions. A supplemental work plan for follow-on EA actions will be developed considering the results of the field assessment. The supplemental EA work plan will be developed in consultation with the agencies and will be submitted at a future date.

3 Environmental Assessment Results

This section presents the results of the EA work completed during the summer of 2003.

3.1 Review of Pre-Event Information

A preliminary review of information assembled by WPSC was conducted by CH2M HILL for the system as a whole, focusing primarily upon stream conditions, reservoirs, and fisheries. A list of information made available for review is included in Appendix A. A brief summary of information found through the review of these data sources is provided below.

3.1.1 Stream Geomorphology

While some historical information (previous flood routing studies) was available for the Dead River, limited stream geomorphical data was available. Available information included aerial photography (1998 and May 2003), post-event 2-foot interval topography from the Hoist Dam downstream to Lake Superior, U.S. Geological Survey topography quadrangle maps (1959), information from a May 2003 fly-over, and limited channel cross sections of Reach 6 associated from a fisheries study, *Channel Morphology, Fish Community, and Temperature Conditions of the Dead River Bypassed Channel Prior to Flow Augmentation* (MDEQ June 2001). Reach 6 flows between the McClure and Forestville reservoirs and is referred to as the "bypass channel." (The cross section markers from the 2001 MDEQ study were observed during the field survey.) General geomorphological characteristics were gleaned from the available information, including gross channel profile slope (including bedrock dominated segments), bank slopes, valley type (confined or unconfined), general stream type, and channel pattern (sinuosity, belt width, meander wavelength, abandoned ox-bow channels, and single or braided channel).

The 1994 Federal Energy Regulatory Commission (FERC) UPPCo Dead River Hydroelectric Project application documentation discusses geologic-scale morphology influences, within the context of glaciation and historic cultural resources. Consequently, the FERC documentation does not provide detailed information on channel geomorphology for pre-event conditions. Detailed geomorphic information, such as channel type (including bed material size distribution), riffle and pool cross sections, detailed channel profile slope, post-event topography upstream of the Hoist Dam, and stream assessment stability metrics, was unavailable for a stream stability analysis of the river system. While the available information provided a basis for gross-scale characterization of the Dead River, it was not sufficient to make detailed pre- and post-event geomorphological comparisons at specific locations.

3.1.2 Reservoirs and Harbor/Lake Superior Area

Substrate types, emergent and aquatic vegetation communities, and physical features (cover) were surveyed in the Dead River, McClure, and Silver Lake basins in 1992 for the FERC application process (Stone & Webster 1994). Results from these surveys for the upper Dead River Storage Basin and McClure Basin are shown in the figures provided in

Appendix C. These figures also depict 5-foot contour intervals of the basin bathymetry measured during the 1992 surveys.

Excerpts from the FERC application reference document (Stone & Webster 1994) describing the 1992 habitat inventory, mapping, and evaluation are included here for background information relevant to the visual reservoir review conducted in August 2003. A description of the Silver Lake Basin is not included since it was essentially dewatered during the breach and not included in the visual reservoir review.

> <u>Dead River Storage Basin:</u> *The major substrate found in the Dead River Storage Basin is a thick layer of silt, organic debris, and sand. The deeper portions of the reservoir, which occupy the former river channel, contain a thick silt/organic ooze substrate. Sand/gravel bars, silt/organic debris backwater areas, cobble/rubble substrate zones, and bedrock substrate areas are all found in the impoundment. Sand/gravel bars and silt/organic debris backwater areas are more abundant in the upper portion of the impoundment (upstream of the Little Dead River inlet). Cobble/rubble and bedrock-dominated substrates are more frequently encountered in the downstream portion of the impoundment (downstream of the Little Dead River inlet).*
>
> *Aquatic vegetation is restricted almost entirely to the littoral zone in water depths to about 2 meters. The most prevalent aquatic plant communities are dominated by pondweeds. Associated rooted, submerged species include other pondweeds, bur-reed, and water smartweed. Near-shore areas are commonly highly dominated by the bulrush, wool-grass (Scirpus cyperinus), which is often accompanied by a small rush (Juncus filiformis). Cattails occur in only a few very small stands.*
>
> *Physical habitat features for resident fish species are diverse. Standing snags, submerged stumps, fallen timber, and other wood debris are scattered throughout the reservoir. The inlet of the Dead River contains large amounts of fallen timber and submerged stumps.*
>
> <u>McClure Basin:</u> *McClure Basin has a relatively thick layer of silt/organic ooze as its primary substrate. Sand, gravel bars, silt/organic areas, cobble/rubble zones, and bedrock-dominated substrates are found in the impoundment.*
>
> *The main body of McClure Basin support only a modest aquatic plant community manifested by scattered, sparse beds of pondweeds. In the shallow upstream end of the reservoir, aquatic vegetation is more diverse and includes other pondweeds and bur-reed.*
>
> *Physical habitat features are primarily limited to woody materials. Submerged stumps, fallen timber, and a few standing snages provide cover opportunities for resident fish.*

As described in the final EA associated with the FERC license application process, the Forestville Basin is a small, moderately deep impoundment with an average depth of about 20 feet and maximum depth of about 60 feet near the dam (FERC 2002). Unlike the Dead River and McClure basins, neither substrate nor bathymetry data were included in the FERC license application documents for Forestville Basin. Therefore, no bathymetry or physical substrate data were available for review prior to the field effort.

Forestville Basin is similar to McClure Basin in surface area and storage capacity. The surface area of Forestville Basin is about 110 acres compared to about 96 acres for McClure. Maximum storage capacities are about 2,900 acre-feet and 1,870 acre-feet for Forestville and

McClure basins, respectively. Water levels typically fluctuate less than 1 foot in McClure and up to 2 feet in Forestville (FERC 2002).

Limited information was available for review prior to the field review of the Presque Isle Harbor in Lake Superior, which is where the mouth of the Dead River is located. A report describing a 1968 water quality survey of Lake Superior near Marquette was reviewed. This report described the bottom sediments near the Dead River mouth as consisting of "sand, small stones, red clay, iron ore pellets and a small amount of organic detritus" (MWRC 1968). Bedrock was reported at one sampling station about 1,400 feet east of the Dead River mouth. Bathymetric data were not provided in the report.

The U.S. Corps of Engineers conducted bathymetric surveys of Presque Island Harbor. This work was performed in July 2002 and May 2003. The area surveyed by the Corps covers some but not all of the area of interest for this assessment.

3.1.3 Fisheries

Pre-event fisheries data are available for the impoundments on the Dead River (Table 3-1), but are generally limited for the riverine portions of the Dead River system. Pre-event knowledge of the status of the fishery in the Dead River between Silver Lake and the Dead River Storage Basin is lacking. However, good numbers of naturally reproducing brook trout have been documented in Mulligan Creek, a major tributary to the upper Dead River (MDNR 1995).

Although no information on the recreational fishery was found for the Dead River, it is known that the system was managed entirely for trout until the early 1980s when northern pike invaded the system from the Little Dead River (personal communication, George Madison/MDNR). The resulting effect on the brook trout population is unknown, but it is likely that the invasion of pike had a detrimental effect on the overall trout population in the Dead River system.

A limited amount of pre-event fisheries data is available for the riverine sections of the Dead River below the Dead River Storage Basin. The MDEQ conducted a survey of the fishery at three reaches between McClure Storage Basin and Forestville Basin. This survey documented that although brook trout were the most abundant fish species in all three survey reaches, the standing population of brook trout was much smaller than those in other northern Michigan rivers. The MDEQ survey provides a limited amount of pre-event information on the characteristics of the fish community in this stretch of the Dead River.

Additional but dated information (late 1960s and early 1970s) is available regarding the macroinvertebrate and game fish communities in the lower Dead River. The known pre-event fisheries data for the Dead River system are summarized in Table 3-1.

3.2 Field Survey Results

Survey results are first presented for the stream reach portion of the watershed and then for the reservoir/harbor portion of the watershed.

TABLE 3-1
Summary of Pre-Event Aquatic Biological Data

Stream Reach	Description	Fisheries / Macroinvertebrate Findings	Source
Reach 1	Silver Lake Basin	Mixed fishery dominated by warmwater species (smallmouth bass, yellow perch, and white sucker). Other species include: cisco, splake, lake trout, brook trout, pumpkinseed, creek chub, common shiner, and golden shiner. Splake (a non-reproducing hybrid trout species) and brook trout were actively stocked to supplement the recreational fishery. No macroinvertebrate information was found.	MDNR 2003 Stone and Webster 1994
Reach 2	Silver Lake to Dead River Storage Basin	No recreational fishing or creel survey information was found; however, the Dead River was managed entirely for trout until the early 1980s when pike invaded the system from the upper Little Dead River. *Abundant brook trout reported in a Mulligan Creek tributary entering this reach though it is actively stocked.* Likely that Reach 2 held a population of brook trout pre-event. No macroinvertebrate information was found.	Personal communication George Madison/MDNR MDNR 1995
Reach 3	Dead River Storage Basin	Warmwater fish community dominated by northern pike, walleye, yellow perch, and smallmouth bass. Historical *shift from coldwater, trout-based fishery to warmwater species fishery.* Heavy predation by northern pike and walleye has led to steady decline in the yellow perch population. Other species present include white sucker, golden shiner, pumpkinseed, and black bullhead. No macroinvertebrate information was found.	MDNR 2003 Stone and Webster 1994
Reach 4	Dead River Storage Basin to McClure Basin	No fisheries information was found. A penstock burst in 1997 caused extensive erosion that filled channel below powerhouse with sand causing loss of macroinvertebrate community. Restoration efforts included removing sediments with heavy equipment and efforts to accelerate invertebrate recolonization. Monitoring in 1998 showed macroinvertebrate population on the incline (species composition data available, but not densities). Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	*Adam Kowalski* 1999 Phillips 1971
Reach 5	McClure Basin	Similar fish community as the Dead River Storage Basin: northern pike, smallmouth bass, and walleye are the dominant species. Yellow perch and pumpkinseed are the principle prey species. Brown trout are actively stocked to supplement the recreational fishery. Limited spawning habitat for northern pike (shallow, vegetated areas). Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	Stone and Webster 1994 Phillips 1971

TABLE 3-1
Summary of Pre-Event Aquatic Biological Data

Stream Reach	Description	Fisheries / Macroinvertebrate Findings	Source
Reach 6	McClure Basin to Forestville Basin	Reach supported a good population of young-of-the-year (YOY) brook trout. Lack of habitat diversity and adequate pool habitat limits population of adult trout. Reach A – extremely shallow riffle areas dominate, making foraging difficult from an energetics standpoint, flow limiting factor, but excellent nursery habitat for young trout. Most abundant species: brook trout (5,214 per hectare; 77% YOY) and mottled sculpin (3,772 per hectare). Reach B – more deep pool habitat than Reach A, but slower velocity and sand substrate. Most abundant species: brook trout (1,582 per hectare; 39% YOY), bluntnose minnow (598 per hectare), and mottled sculpin (3,772 per hectare). Reach C – more narrow and shallow than Reach B, sand and organic substrate, best habitat for adult trout (more riffles and pools, higher velocity). Only three species captured: brook trout (3,898 per hectare; 73% YOY), brook stickleback (17 per hectare), and mottled sculpin (732 per hectare). Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	MDEQ 2000 Phillips 1971
Reach 7	Forestville Basin	Warmwater fish community dominated by walleye, yellow perch, and smallmouth bass. Other species include: white sucker, longnose sucker, sculpins, and sticklebacks. Brown trout are also actively stocked to supplement the recreational fishery. Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	MDNR 2003 Phillips 1971
Reach 8	Forestville Basin to Tourist Park Basin	Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	Phillips 1971
Reach 9	Tourist Park Basin	Contained a warmwater fish community dominated by smallmouth bass and yellow perch. Other species included bluegill, pumpkinseed, northern pike, and northern hog sucker. Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	MDNR 2003 Phillips 1971

TABLE 3-1
Summary of Pre-Event Aquatic Biological Data

Stream Reach	Description	Fisheries / Macroinvertebrate Findings	Source
Reach 10	Tourist Park Basin to the mouth of the river	Coho and chinook salmon and rainbow trout comprised recreational fishery in this reach during winter and early spring (historical information, 1984-1987).	MDNR 1992
		Historical (1968) qualitative biological samples collected from this reach indicated substrate consisted of silty sand and organic matter. A well-balanced clean-water benthic community, including mayflies and caddisflies, was found at each station. Limited use, considering age of data.	Michigan Water Resources Commission 1968
		Qualitative data on aquatic insect nymphs and larvae are available from 1971, but of limited use, given the age of the data.	Phillips 1971
Reach 11	Lake Superior at the mouth of the river	Two natural rock reefs (one 2,500 feet east and another 4,000 feet southeast of the mouth of the Dead River) support lake trout spawning. Adults are present in the harbor from early September to December and spawn in mid-October to early November.	USFWS 8/28/03
		Historical (1968) qualitative biological samples indicated dominant organisms were oligochaetes, midges, and amphipods.	Michigan Water Resources Commission 1968
		Qualitative data on aquatic insect nymphs and larvae available from 1971, but of limited use, given the age of the data.	Phillips 1971

3.2.1 Habitat and Stream Channel Assessment Results

3.2.1.1 Overview of Stream Reach Geomorphologic Characteristics

The upper part of the Dead River watershed consists of Reaches 0 through 3 (Figure 2-1a). The lower part of the Dead River Storage Basin consists of Reaches 4 through 10 (Figure 2-1b). Most of the reaches contain riffle and pool sequences at some point along their channel. Glide and run sequences occur in several reaches, Reach 6 in particular. Channel sinuosity (channel length divided by valley length) ranges from 1.0 (straight in Reach 4) to over 2.0 (tortuous meanders in Reach 6). Most of the reaches are within confined valleys, and therefore do not regularly form winding, sinuous patterns. Reach 6 and the new channels within the Silver Lake Basin (Reach 1) and Tourist Park Basin (Reach 9) are exceptions to this generalization, as these reaches have unconfined valleys. Reaches 2 and 6 comprise over half of the total Dead River stream length. General characteristics of the stream reaches are summarized in Table 3-2. Detailed descriptions of the reach conditions observed during field reconnaissance survey are included in Appendix B and photographs are provided in Appendix D.

TABLE 3-2
Stream Reach Characteristics Overview

Reach	Stream Type(s)	Flow Sequence	Typical Sinuosity	Valley Characteristic	Length (mile)	Length (percent)
Reach 0	E and B	Riffle/Pool	1.30 to 1.57	Confined	0.23	1.2%
Reach 1	F	Riffle/Pool	1.37	Unconfined	3.45	17.2%
Reach 2	*F*	*Riffle/Pool and Glide/Run*	*1.22*	*Confined*	5.68	28.4%
Reach 4	B and F	Riffle/Pool	1.00	Confined	0.55	2.7%
Reach 6	C	Riffle/Pool and Glide/Run	2.04	Confined and Unconfined	6.31	31.9%
Reach 8	F and B	Riffle/Pool	1.04	Confined	1.48	7.4%
Reach 9	C	Riffle/Pool and Glide/Run	1.21	Unconfined	1.25	6.2%
Reach 10	F	Glide/Run	1.12	Unconfined	1.08	5.4%
				Total Miles	**20.03**	**100%**

Some stream segments were not assessed because the stability protocol was inappropriate. See Appendix B for definitions of stream types.

3.2.1.2 Habitat and Channel Stability Scoring Results

Table 3-3 summarizes the habitat and stability scores for each sub-reach, which are graphically illustrated in Figures 3-1a, 3-1b, 3-2a, and 3-2b. The stability scores fall into qualitative description categories based upon the stream type. With the stream assessment approach, the stream types could only be estimated since a definitive determination of stream type required additional detailed cross section survey and bed material characterization (pebble count). Therefore, qualitative description categories (e.g., stable, unstable) were assigned based on the estimated stream type. For stream reaches that could potentially fall into different qualitative categories based upon the numerical score, a hyphenated qualitative description was used (e.g., moderately unstable).

TABLE 3-3
Stream Sub-Reach Habitat and Stability Score Summary

Reach, Sub-Reach	Habitat Score[a] (larger score = better habitat)	Habitat Qualitative Description	Stability Score (smaller score = better stability)	Stability Qualitative Description[b]
R00-01	160	Excellent	62	Stable
R01-01	25	Poor	132	Unstable
R01-02	62	Marginal	110	Stable - Mod. Unstable
R01-03	118	Good	83	Stable
R02-01	71	Marginal	137	Unstable
R02-02	43	Poor	123	Mod. Unstable – Unstable
R02-03	39	Poor	141	Unstable
R02-04	68	Marginal	131	Unstable
R02-05	39	Poor	131	Unstable
R02-06	54	Poor	132	Unstable
R02-07	99	Marginal	91	Mod. Unstable – Unstable
R02-08	51	Poor	134	Unstable
R02-09	61	Marginal	126	Mod. Unstable – Unstable
R02-10	74	Marginal	120	Mod. Unstable
R02-11	33	Poor	134	Unstable
R02-12	108	Good	69	Stable – Mod. Unstable
R04-01	130	Good	75	Stable
R06-01	118	Good	86	Stable – Mod. Unstable
R06-02	176	Excellent	58	Stable
R06-03[c]	NA	NA	NA	NA
R06-04	163	Excellent	71	Stable
R06-05	156	Excellent	81	Stable - Mod. Unstable
R06-06	150	Good	93	Mod. Unstable
R06-06-DEQ-C[c]	154	Good	82	Stable - Mod. Unstable
R06-07-DEQ-B[c]	159	Excellent	84	Stable
R06-08	151	Good	64	Stable
R06-09-DEQ-A[c]	137	Good	69	Stable - Mod. Unstable
R08-01	140	Good	77	Stable - Mod. Unstable
R08-02	134	Good	65	Stable
R08-03[d]	NA	NA	NA	NA
R08-04[e]	NA	NA	NA	NA
R08-05	137	Good	55	Stable
R09-01	47	Poor	131	Unstable
R10-02	53	Poor	125	Unstable

[a] Greater than 154 = Excellent, 105-154 = Good, 56-104 = Marginal, Less Than 56 = Poor

[b] Qualitative score descriptions depend on the stream type. Exact stream type could not be determined with the level of effort specified for this preliminary Post-Event EA. Therefore, combined qualitative descriptions were used for scores that could fall in two categories contingent on the stream type.

[c] Sub-reaches R06-06, R06-07, and R06-09 contain stream segments that were published by the MDEQ for fish populations and channel shape *Channel Morphology, Fish Community, and Temperature Conditions of the Dead River Bypassed Channel Prior to Flow Augmentation* (2001).

[d] Bedrock waterfall dominated sub-reach, habitat and stability assessments are inappropriate.

[e] Sub-reach is impounded due to remnant of old dam (Dam No. 1), habitat and stability assessments are inappropriate.

NA = not applicable

One sub-reach was assessed upstream of Silver Lake Basin (Reach 0) as a reference for stability and general habitat conditions. Reach 0 scored 160 out of 200 ("Excellent") for habitat and 62 ("Stable" for a B4 stream type) for stability.

The general trend between the habitat and stability scores was an inversely proportional linear relationship (Figure 3-3). Increased stability in a stream system typically encourages improved habitat conditions for aquatic life. In turn, unstable stream conditions typically disturb good habitat conditions, and therefore stress aquatic life.

The relative condition of the reaches is further illustrated in Tables 3-4 and 3-5, which summarize habitat ratings and stability ranking, respectively.

TABLE 3-4
Stream Reach Habitat Rating Summary

	Miles of Stream					
Reach	**Excellent**	**Good**	**Marginal**	**Poor**	**Unassessed** [a]	**Total**
Reach 0	0.23	0	0	0	0	**0.23**
Reach 1	0	0.45	2.64	0.36	0	**3.45**
Reach 2	0	0.32	2.55	2.81	0	**5.68**
Reach 4	0	0.29	0	0	0.26	**0.55**
Reach 6	3.26	1.99	0	0	1.06	**6.31**
Reach 8	0	0.80	0	0	0.68	**1.48**
Reach 9	0	0	0	1.25	0	**1.25**
Reach 10	0	0	0	0.52	0.56	**1.08**
Total Miles	**3.49**	**3.85**	**5.20**	**4.95**	**2.56**	**20.03**
Percent [a]	**17.4%**	**19.2%**	**25.9%**	**24.7%**	**12.8%**	**100%**
Percent [b]	**20.0%**	**22.0%**	**29.7%**	**28.3%**	**—**	**100%**

[a] Some stream segments were not assessed because the habitat protocol was inappropriate. Percent based on total miles within reach including unassessed miles.
[b] Percent based on total assessed miles within the reach, not including unassessed miles within each reach.

Reach 2 accounts for roughly 57 percent of the Poor habitat stream miles and Reach 9 accounts for roughly 25 percent of the Poor habitat stream miles. Reaches 1 and 10 account for the remaining 18 percent. All of the assessable miles in Reach 6 were assigned either an Excellent or Good rating.

TABLE 3-5
Stream Reach Stability Rating Summary

	Miles of Stream						
Reach	Stable	Stable – Moderately Unstable	Moderately Unstable	Moderately Unstable – Unstable	Unstable	Unassessed [a]	Total
Reach 0	0.23	0	0	0	0	0	0.23
Reach 1	0.45	2.64	0	0	0.36	0	3.45
Reach 2	0.32	0	0.48	1.23	3.66	0	5.68
Reach 4	0	0.29	0	0	0	0.26	0.55
Reach 6	2.49	2.55	0.21	0	0	1.06	6.31
Reach 8	0.42	0.38	0	0	0	0.68	1.48
Reach 9	0	0	0	0	1.25	0	1.25
Reach 10	0	0	0	0	0.52	0.56	1.08
Total Miles	3.90	5.87	0.69	1.23	5.79	2.56	20.03
Percent [a]	19.4%	29.3%	3.4%	6.2%	28.9%	12.8%	100%
Percent [b]	22.3%	33.6%	3.9%	7.0%	33.1%	—	100%

[a] Some stream segments were not assessed because the stability protocol was inappropriate. These miles included in the first set of percents calculated.
[b] Percent not including unassessed miles.

Reach 2 accounts for 70 percent and Reach 9 accounts for 18 percent of the Moderately Unstable and Unstable miles in the watershed. Reaches 1 and 10 account for the remaining 12 percent of these stream miles.

Key Findings. The sub-reaches from the Silver Lake Basin to the Dead River Storage Basin (Reaches 1 and 2) tended to have lower habitat scores (tending toward poor habitat) and the higher stability scores (tending toward instability) than those downstream of Dead River Storage Basin (Figures 3-1a, 3-2a, and 3-3). Notable exceptions were the reaches in and downstream of the drained Tourist Park Basin (Reaches 9 and 10), which also had low habitat and high stability (unstable) scores. The scores support visual observations that these reaches were the most affected per this assessment methodology.

In general, sub-reaches downstream of the Dead River Storage Basin and upstream of Tourist Park Basin had higher habitat scores (tending toward good habitat) and lower stability scores (tending toward stability) (Figures 3-1b, 3-2b, and 3-3). There were notable amounts of woody debris in the reaches below the Hoist Dam, which are now providing additional habitat for fish and macroinvertebrates. The stability and habitat scores indicated that the Dead River Storage Basin absorbed the bulk of the damaging hydraulic forces that resulted from the event. The lack of extensive erosion, sedimentation, and departure from channel equilibrium in these reaches can also be attributed to the established riparian corridor vegetation and channel bed material. There are numerous oxbow wet backwater areas along Reach 6 in particular (downstream of McClure Dam) that appear to provide functional aquatic habitat.

3.2.1.3 Bank Erosion Hazard Index

The Bank Erosion Hazard Index (BEHI) is a methodology that rates the susceptibility of stream banks to potential erosion. The BEHI methodology focuses on the stream banks only, whereas the stability analysis described in the previous section includes the channel as a whole. The BEHI methodology considers bank height (relative to bankfull height), slope, vegetative cover and root density, and materials (including stratification of materials). Each factor was given a score and the total score was used to assign a qualitative descriptor of the potential bank erosion hazard (Extreme, Very High, High, Moderate, Low, Very Low). Additional information on the BEHI rating method is provided in Appendix B.

Several segments of sub-reaches were scored using the BEHI methodology. In general, BEHI scores were recorded for banks that appeared unstable. However, for reference purposes, several banks that appeared stable were also scored to illustrate the range of stability states throughout the Dead River system. The BEHI scores and associated bank erosion potential for each segment are summarized in Table 3-6 and also shown in Figures 3-4a and 3-4b. In general, the results show higher (less stable) BEHI scores are more prevalent in Reaches 1, 2, 9, and 10. There are BEHI scores for other reaches, but they generally indicate lower (more stable) BEHI scores, are more isolated, and also are typically shorter in length.

The Extreme, Very High, and High BEHI ratings for reaches are summarized in Table 3-7.

Key Findings. All but two of the 33 BEHI segments with Extreme or Very High erosion potential were in Reaches 1, 2, and 9. Reaches 2 and 9 had notable percentages of their total bank length (twice the reach length, each bank was assessed individually) rated with an Extreme or Very High erosion potential. These were the same reaches with predominately Unstable and Moderately Unstable stability scores and Poor and Marginal habitat scores for their sub-reaches. The banks in Reaches 1, 6, and 10 were quite stable and had no Extreme, Very High, or High BEHI ratings.

3.2.2 Physical Reservoir Review Results

The primary objective of the reservoir review was to look for visible signs of deposition, scour, bank erosion, or changes in physical features (such as an influx of woody debris) potentially resulting from the event. In addition, water depth measurements were recorded using a sonar device for comparison to pre-event bathymetry data and for use in planning future EA activities. These data are for making a first-cut assessment of findings related to the event, as well as providing valuable information on target areas and depths for additional bathymetric mapping or sediment sampling if needed.

In addition to the pre-event bathymetry data, the local channel or reservoir morphology provided a basis for assessing the likelihood of deposition or scour that may have occurred during the event. For example, where a riverine reach expands into a wide reservoir channel, velocity as well as sediment transport capacity would be expected to decrease. Such areas were investigated with sonar to assess whether or not the expected depths (relative to pre-event bathymetry or surrounding depths) were encountered.

TABLE 3-6
Sub-Reach Bank Erosion Hazard Index (BEHI) Summary

Sub-Reach-BEHI ID	Est. BEHI Segment Length (ft)	Low Bank Height (ft)	Field Est. Max Bankfull Height (ft) [a]	Root Depth (ft)	Root Density (%)	Bank Angle (degrees)	Surface Protection %)	Dominant Bank Material[b]	Material Stratification[c]	Total Index Score	Bank Erosion Potential[d]
R01-01-B01	600	6	0.4	0	0	90	0	10	0	57.9	Extreme
R01-03-B01	250	5	0.5	0.16	5	90	5	10	6	63.9	Extreme
R01-03-B02	150	80	0.5	2	20	90	20	7	5	57.1	Extreme
R01-03-B03	100	4	0.5	0.33	10	90	30	10	0	52.5	Extreme
R02-01-B01	40	6	1.5	2	15	90	0	10	0	52.5	Extreme
R02-01-B02	25	10	1.5	2	20	90	0	10	0	55.1	Extreme
R02-01-B03	300	6	1.5	1.5	25	90	30	10	0	49.2	Extreme
R02-01-B04	50	3	1.5	0.5	5	90	5	10	0	53.4	Extreme
R02-01-B05	100	8	1.5	0.66	10	90	20	10	0	53.8	Extreme
R02-01-B06	100	8	1.5	2	40	90	90	10	0	44.3	Very High
R02-02-B01	1,000	3	1.5	0.5	10	80	10	10	0	48.4	Extreme
R02-02-B02	100	3	1.5	6	10	80	10	10	0	41.0	Very High
R02-03-B01	2,300	7	1.5	0	0	90	10	10	0	56.9	Extreme
R02-03-B02	1,900	3	1.5	1	5	80	15	10	0	47.3	Extreme
R02-03-B03	600	12	2	2	10	90	10	10	0	54.5	Extreme
R02-04-B01	1,000	85	1.5	0.66	1	85	5	10	5	61.8	Extreme
R02-04-B02	150	30	1.5	1.5	1	70	5	10	5	58.9	Extreme
R02-04-B03	600	4	1	0	0	80	10	10	0	54.9	Extreme
R02-04-B04	500	60	1	1	1	80	5	10	0	55.9	Extreme
R02-04-B05	500	60	1	1	1	80	5	10	0	55.9	Extreme
R02-05-B01	50	25	1	1	5	60	5	7	5	55.9	Extreme
R02-05-B02	100	40	1	1	10	70	20	5	8	55.1	Extreme
R02-05-B03	1,700	6	1	0	0	80	5	10	0	55.9	Extreme
R02-07-B01	150	40	1	0.5	1	90	10	10	0	56.9	Extreme
R02-07-B02	3,450	23	0.5	0.8	5	85	15	5	0	49.7	Extreme

TABLE 3-6
Sub-Reach Bank Erosion Hazard Index (BEHI) Summary

Sub-Reach-BEHI ID	Est. BEHI Segment Length (ft)	Low Bank Height (ft)	Field Est. Max Bankfull Height (ft) [a]	Root Depth (ft)	Root Density (%)	Bank Angle (degrees)	Surface Protection %)	Dominant Bank Material[b]	Material Stratification[c]	Total Index Score	Bank Erosion Potential[d]
R02-07-B03	400	20	1	1	5	85	20	10	0	53.1	Extreme
R02-08-B01	1,000	12	1	2	15	85	20	7	5	53.7	Extreme
R02-08-B02	300	15	0.5	3	10	90	15	8	0	51.0	Extreme
R02-08-B03	450	3	0.5	0	0	85	0	10	0	56.8	Extreme
R02-09-B01	400	15	0.5	2	5	90	30	10	0	44.8	Very High
R02-09-B02	800	4	0.5	0	0	80	0	10	0	55.9	Extreme
R02-09-B03	800	30	0.5	1	5	90	5	10	0	57.9	Extreme
R02-10-B01	300	10	1	0	15	80	5	10	0	55.9	Extreme
R02-11-B01	400	3	5	0	0	60	0	10	7	51.9	Extreme
R04-01-B01	150	10	3	3	40	60	20	5	0	40.2	Very High
R06-01-B01	150	5	5	2	50	19	80	7	0	23.9	Moderate
R06-02-B01	300	4	4	3	40	45	70	-5	0	10.5	Low
R06-07-B01	2,240	6	2	4	40	19	70	3	0	26.9	Moderate
R06-08-B01	750	7	4	3	60	30	75	0	0	22.5	Moderate
R08-01-B01	1,500	5	5	2	25	45	15	10	3	38.4	High
R08-01-B02	450	30	5	3	25	50	5	7	3	50.3	Extreme
R08-02-B01	1,500	6	3	3	50	30	75	0	0	23.1	Moderate
R08-05-B01	300	2	2	2	80	15	95	0	0	6.6	Very Low
R09-01-B01	11,400	7	3	0	0	45	0	10	7	58.5	Extreme

[a] Actual bankfull not determined because regional curves are unavailable.
[b] Bedrock = 0 pts, boulders = 0 pts, cobble = subtract 10 pts unless sand/gravel > 50%, gravel = add 5-10 pts, more for sand mix, sand = add 10 pts, silt = 0, peat = 0
[c] Added 5-10 pts depending on position of unstable layers in relation to bankfull stage, low position = higher points
[d] In general, BEHI scores were recorded for banks that appeared unstable. However, for reference several banks that appeared stable were also scored to illustrate that there were a range of stability states throughout the Dead River system.

TABLE 3-7
Stream Reach Bank Erosion Hazard Index Summary[a]

Stream Reach	BEHI Rating for Reach Total Bank Length [b]		
	Extreme	Very High	High
Reach 0	0.0%	0.0%	0.0%
Reach 1	3.0%	0.0%	0.0%
Reach 2	31.6%	1.0%	0.0%
Reach 4	0.0%	2.6%	0.0%
Reach 6	0.0%	0.0%	0.0%
Reach 8	2.9%	0.0%	9.6%
Reach 9	86.4%	0.0%	0.0%
Reach 10	0.0%	0.0%	0.0%

[a] Typically banks were only assessed for their BEHI if they looked unstable.
[b] Each bank is assessed separately; therefore, the reach total bank length is twice the reach length.

Selected observations, by reservoir or open water body, are provided below and/or summarized in Table 3-8. Key findings are presented thereafter. Additional information is provided in Appendix B.

3.2.2.1 Dead River Storage Basin (Reach 3)

The review of the Dead River Storage Basin focused on the upstream end of the reservoir (Figures 3-5a and 3-5b) where the greatest potential impacts of the event were anticipated. The western, or upstream, end of this reach was a relatively narrow, shallow backwater environment. Evidence of scouring and what appeared to be recent deposit was noted. Submerged stumps, macrophytes (submerged, floating leaf, and emergent), and large woody debris were common. In general, most of the visible sediment deposition observed during the review was located upstream, or west of the boat ramp toward the center or south shore of the reservoir (Figure 3-5a). It is probable that some fine sediment (i.e., silts and clays) deposited downstream of this upper area; however, it was not significant enough to reveal a difference between the water depths measured during the visible reservoir review compared to the 1992 bathymetric data.

3.2.2.2 McClure Basin (Reach 5)

Survey results for the McClure Basin are illustrated in Figure 3-5c. A longitudinal mid-channel sand bar associated with some stumps and large woody debris was observed near the boat ramp (which is about 600 feet upstream of County Road 510). Based on pre-event aerial photographs, this bar feature existed before the event. No other sediment formations were observed in the water body. There were a few thin overbank deposits of sand veneers in the upper channel, but they were very limited in occurrence. Due to elevated turbidity, visibility through the water column was limited to a few inches.

TABLE 3-8
Summary of Pertinent Pre- and Post-Event Information for the Surveyed Reservoirs/Open Water Bodies

	Dead River Storage Basin (Reach 3) (Hoist Dam)	McClure Basin (Reach 5) (McClure Dam)	Forestville Basin (Reach 7) (Forestville Dam)	Harbor/Lake Superior Area (Reach 11)
Surface Area (acres)	3,202 (Roughly 800 surveyed)	96	110	NA (Roughly 100 surveyed)
Pre-Event Bathymetry	See Appendix C (5-foot contour interval)	See Appendix C (5-foot interval)	No information contained within the references reviewed.	U.S. Corps of Engineers July 2002 and May 2003, primarily in navigation channel.
Pre-Event Habitat Description	Thick layer of silt, organic debris, and sand. Deeper portions of former river channel contain thick silt/organic ooze. Sand/gravel bars, silt/organic debris in backwaters. Cobble/ruble substrate zones and bedrock areas more frequent in downstream portion of impoundment. Standing snags, submerged stumps, fallen timber, and other wood debris are scattered throughout the reservoir. The inlet of the Dead River contains large amounts of fallen timber and submerged stumps. (Stone and Webster 1994)	Thick layer of silt/organic ooze as primary substrate. Sand, gravel bars, silt/organic areas, cobble/rubble zones, and bedrock-dominated substrates are found in the impoundment. Physical habitat features include: submerged stumps, fallen timber, and a few standing snags. (Stone and Webster 1994)	No substrate information contained within the references reviewed.	Sand, small stones, red clay, iron ore pellets, and a small amount of organic detritus (MWRC 1968).
Post-Event Survey Observations	Upstream third of reservoir: submerged stumps, large woody debris common. A sand deposit was observed, with up to about 4 feet (visual estimate) of sand extended above the water surface. Stream channel inflow to reservoir appears to have scoured with maximum water depth of 30 feet; 1992 habitat survey indicated a water depth of 2 feet in this area. Substrate visual appears to be sand, organic material, fine sediments. No visible impact at mouth of Silver, Clark, or Barnhardt Creeks. See Figures 3-5a and 3-5b.	Sand bar mid-channel with stumps and large woody debris near boat ramp. Pre-event aerials indicate bar feature existed. Bar size change was not quantifiable during the review. Visibility through the water column was limited to a few inches. No sediment in-reservoir formations other than the mid-channel bar were observed. See Figure 3-5c.	Visibility through the water column was limited to a few inches. No new sediment in reservoir formations were observed. Although some sand deposits were observed on the downstream side of the small mid-channel islands and peninsula between the bridge and the open reservoir, these were apparent at roughly the same size in the pre-event aerial photographs. See Figure 3-5d.	Sediment deposition observed near structures, areas of overland flow, or increased roughness, sediment deposition was observed. (upstream of Lake Shore Drive bridge). Sand visible throughout much of the lower reach (upstream of Lake Shore Drive bridge). Submerged delta present at the mouth of the Dead River. Visual observation showed dominant grain size appeared to be sand, with some organic debris (broken sticks and wood fragments). Video evidence indicates that known lake trout spawning areas are intact with interstitial spaces free of fine sediments. See Figure 3-5e.
Additional information	1992 thalweg was about 7 feet deep at pool elevation of 1,342. August 2003 depths of 1 to 3 feet at pool elevation of 1,340.	A few overbank deposits of sand veneers in the reservoir's upper channel were observed.	Not applicable.	August 2003 channel thalweg depth adjacent to barrier wall south of the power plant ranged from 2.5 to 13 feet.

3.2.2.3 Forestville Basin (Reach 7)

Survey results for the Forestville Basin are illustrated in Figure 3-5d. Although turbidity limited visibility, there was no visible evidence of significant sediment deposition in this reservoir. There were some sand deposits on the downstream side of the small mid-channel islands and peninsula between the Forestville Road bridge and the open reservoir. These features were apparent on the pre-event aerial photographs as well. Based on the visible review of the reservoir, it was not possible to determine if these features had changed; however, comparing the observations in the field to the pre-event aerial photographs, it does not appear that these deposits have increased in area.

3.2.2.4 Harbor/Lake Superior Area (Reach 11)

Survey results for this open water area are illustrated in Figure 3-5e. Near structures, areas of overland flow, or other zones of increased roughness, sediment deposition was observed. Sand was visible throughout much of this reach, particularly just upstream and southwest of the powerplant where the river widens. The channel thalweg, ranging from 2.5 to 13 feet deep, was located adjacent to the barrier wall south of the powerplant.

A delta was present at the mouth of the Dead River in Lake Superior. Based on visual observation, the dominant grain size appeared to be sand, with some organic debris (primarily broken sticks and wood fragments) intermixed. The delta surface appeared to be very flat with very little topographic variation. Water depths of 3.5 to 6 feet were recorded using a portable depth finder.

The underwater videotaping effort (conducted by UPPCo) indicated that natural and previously constructed lake trout spawning areas in the Harbor/Lake Superior area are still intact.

3.2.2.5 Key Findings

Two areas of sediment deposition that appear to be associated with the event were observed during the reservoir review. These areas are within the upper (western) portion of the Dead River Storage Basin and the most downstream portion of the Dead River near the mouth and extending into Lake Superior.

Based on field observations and a comparison of water depths measured during the reservoir review versus pre-event bathymetry, there is no significant evidence of sediment deposition or scour in McClure Basin. Although no pre-event bathymetry data was available for Forestville Basin, there was no significant evidence of sediment deposition or scour at that location either (based primarily on channel/reservoir morphology).

The known lake trout spawning areas in the Harbor/Lake Superior area appear to be intact with interstitial spaces clear of fine sediment. (A DVD containing the resulting video-record is enclosed with this EA Report).

3.3 Other Findings and Observations

3.3.1 Water Quality Results

Water quality monitoring was performed by UPPCo. The initial water quality monitoring report for the Dead River (UPPCo June 2003) showed that turbidity and TSS decreased with increasing distance downstream of Silver Lake. In June, the plume of increased turbidity appeared to have moved half-way through the Dead River Storage Basin. Additional sampling performed by UPPCo (UPPCo August 2003) attached in Appendix A shows a trend of improved water quality as measured by turbidity and TSS.

Turbidity in the lower portion of the Dead River Storage Basin was still observed during the August field survey, with increased clarity observed in the upper basin and in the river upstream of the Dead River Storage Basin. Visual observations confirmed that visual turbidity differences are still present in the impoundments downstream of the Dead River Storage Basin and in Reach 4. However, only moderate turbidity was observed in many portions of Reach 6, with good clarity observed downstream of the confluence of Midway Creek and the Dead River, and Brickyard Creek and the Dead River. These tributaries provide clear, cold water to the Dead River, which is aiding in dissipating the turbidity caused by the event.

Increased turbidity was observed in the lower portion of Reach 8 during hydropower releases from the Forestville Powerhouse; however, during non-release periods, a marked increase in water clarity was observed. This difference may be due to turbidity still present in the Forestville Basin in contrast to the clearer water in the bypassed channel, which provides baseflow to the lower portion of Reach 8 during non-release periods. Low turbidity was observed throughout the riverine section of upper Reach 8.

3.3.2 Fisheries and Macroinvertebrates

Based on the initial field observations and habitat evaluations, the greatest impact to the fish and macroinvertebrate communities in the riverine portions of the Dead River system appears to be limited to two distinct areas: the stretch between Silver Lake and the Dead River Storage Basin and the stretch between the former Tourist Park Basin and Lake Superior. The stretch between the Dead River Storage Basin and the former Tourist Park Basin appears to have been minimally affected by the flood event, with abundant small fish observed and dense macroinvertebrate communities observed in riffle/run reaches of this stretch. The overall impacts to the fish community are unknown, but are likely temporary in nature in this segment of the river. The long-term effects of the flood event may be beneficial to the fish community in this stretch of the river, because abundant woody debris has been deposited, which will likely provide increased cover and substrate for macroinvertebrate colonization.

The two distinct river sections mentioned, Reach 2 (the reach between Silver Lake and the Dead River Storage Basin) and Reach 10 (the reach between the former Tourist Park Basin and Lake Superior), have been altered by sand deposition throughout both stretches and there has been a loss of riparian vegetation to provide shade and stability. The long-term effects on the fish and macroinvertebrate communities are unknown, but based on the field observations, there have been immediate effects to both communities in these sections.

The effect of the event on the fish communities in the impoundments is unknown; many fish were identified by sonar by the reservoir review team. Therefore, there was no whole-scale loss of fish communities in the reservoirs due to the increased turbidity. Long-term effects on the reservoir fish communities are unknown; however, any effects are likely to be temporary in nature, at least in the McClure and Forestville Basins, where little to no sand deposition was observed. The effects of sand deposition in the upper Dead River Storage Basin and in the Harbor/Lake Superior are unknown.

3.3.3 Flow Considerations

Flow in Reaches 8, 9, and 10 is influenced by releases from the City of Marquette's Forestville Basin penstock. According to a conversation with Kirby Juntila of Marquette Board of Light and Power, about 440 cubic feet per second (cfs) (high flow conditions) are released from the Forestville Basin Penstock for about 5 hours during the mid-day and the stream's baseflow is about 5 cfs (low flow conditions) during the remainder of the day. Reach 8 experiences high flow conditions at other times in the day as well. Sub-reaches R08-01, R09-01, and R10-02 were ultimately assessed at low flow conditions, as these are the limited conditions for the aquatic life. Sub-reaches R08-02 through R08-05 are constantly subject to the lower baseflow (5 cfs) because they are upstream of the Forestville Basin penstock release.

UPPCo operates a penstock that directs water from the McClure Basin dam downstream to the top of the Forestville Basin (downstream end of sub-reach R06-01). The original stream channel is called the "bypass channel" and currently has a baseflow of about 5 cfs. This baseflow is expected to increase to 20 cfs based on a new FERC license for the McClure Dam. UPPCo plans to complete construction of a siphon to increase the baseflow to 20 cfs by the end of the 2004 construction season. This increase in baseflow is expected to improve the habitat scores in Reach 6, because low flow was a key determining factor for some of the lower habitat scores in portions of this reach.

3.3.4 Wetlands

During the course of conducting the field survey, a few areas were observed that may be considered wetlands (pursuant to U.S. Army Corps of Engineers jurisdiction under the Clean Water Act Section 404 and MDEQ Regulations Part 303) that may have been affected by the event. Two such sites were found: one near the confluence of the new channel and the existing channel, and one near the AAO bridge. Other sites with high potential for this occurrence are along the former Silver Lake and Tourist Park banks and in stretches of the river's floodplain where the channel has migrated away from its former location. Similarly, there are sites that were newly inundated that have the potential to become new wetlands. These sites were observed in the vicinity of the Mulligan Creek confluence, in the vicinity of Connors Creek confluence, and within the Dead River channel where wet sites are no longer directly connected to the primary post-event river channel.

3.3.5 Impact of the Future Tourist Park and Silver Lake Basin Use on Ratings

If Tourist Park is re-established as a reservoir and Silver Lake Basin's former elevation and outlet are re-established, the ratings and general picture presented above would change significantly. Tourist Park (Reach 9), which accounts for roughly 25 percent of the Poor habitat stream miles and roughly 20 percent of the Moderately Unstable to Unstable channel ratings, would be converted to a different form of habitat and the resource would need to be handled in a different manner. Silver Lake, though much less of an issue from a wadeable stream habitat and channel stability perspective, contributes to a Low rating that could be eliminated as a result of reservoir redevelopment.

4 Summary and Conclusions

4.1 Summary

Key information regarding habitat and stability ratings are summarized by reach in Table 4-1.

TABLE 4-1
Stream Reach Habitat and Stability Rating Summary

Reach	Habitat Rating (Percent of Reach) [a,b]	Stability Rating (Percent of Reach) [a,b]
Reach 0	Excellent (100%)	Stable (100%)
Reach 1	Good (13.0%) Marginal (76.5%) Poor (10.5%)	Stable (13.0%) Stable – Moderately Unstable (76.5%) Unstable (10.5%)
Reach 2	Good (5.6%) Marginal (44.9%) Poor (49.5%)	Stable (5.6%) Moderately Unstable (8.5%) Moderately Unstable – Unstable (21.6%) Unstable (64.3%)
Reach 4	Good (100%)	Stable – Moderately Unstable (100%)
Reach 6	Excellent (60.1%) Good (37.9%)	Stable (47.4%) Stable – Moderately Unstable (48.6%) Moderately Unstable (4.0%)
Reach 8	Good (100%)	Stable (52.5) Stable – Moderately Unstable (47.5%)
Reach 9	Poor (100%)	Unstable (100%)
Reach 10	Poor (100%)	Unstable (100%)
All Reaches	Excellent (20.0%) Good (22.0%) Marginal (29.7%) Poor (28.3%)	Stable (22.3%) Stable – Moderately Unstable (33.6%) Moderately Unstable (3.9%) Moderately Unstable – Unstable (7.0%) Unstable (33.1%)

[a] Some reaches were not scored because the habitat and stability protocol were inappropriate for the stream type. 47.3% of Reach 4, 16.8% of Reach 6, 45.9% of Reach 8, 51.9% of Reach 10 and 12.8% of all reaches.
[b] Percentage expressed based percent of total assessed miles.

In general, the reaches immediately downstream of Silver Lake Basin (Reach 1) and Tourist Park Basin (Reaches 9 and 10) are in worse condition than those downstream of the Dead River Storage Basin (Reaches 4, 6, and 8).

Reach 0, the reference reach for geomorphic and habitat conditions, was Stable and had Excellent habitat. The "channel" within the former Silver Lake Basin (Reach 1) was somewhat impacted according to this approach to system assessment, but appeared to be stabilizing with new vegetation. Reach 2 is in Poor condition, with about 95 percent of the reach exhibiting Poor or Marginal habitat and Unstable to Moderately Unstable conditions, and significant sedimentation on the channel bed and banks.

Downstream of the Dead River Storage Basin, Reach 4 was impacted immediately downstream of the Hoist Dam spillway, yet the downstream channel had Good habitat and was Stable to Moderately Unstable. Reaches 6 through 8 appear to be in relatively good condition with high percentages of Excellent and Good habitat and Stable to Moderately Unstable conditions.

Reaches 9 and 10 appear to be impacted by the breach of the Tourist Park Basin dam. During this assessment, they were assigned Poor habitat scores, and Unstable channel stability ratings. Sedimentation (Reach 10) was observed on the channel bed and banks.

In summary, roughly 42 percent of the reaches assessed constitute Good to Excellent habitat, 30 percent were Marginal, and 28 percent were Poor. Similarly, roughly 56 percent are in the two most stable categories, 11 percent in the next two stability categories, and 33 percent are Unstable.

Shallow depths to bottom and sediment deposition were observed in the upper end of the Dead River Storage Basin and in the Harbor/Lake Superior area. Available data suggests that some habitats may have existed in these areas. The amount of deposition associated with this event and the quality of the habitat in these areas are not known.

Water quality as indicated by turbidity and TSS has been improving since June, when UPPCo began monitoring. Fish were observed in numerous sub-reaches and reservoirs within the system, indicating that all habitat and fish in the river were not lost, but rather that portions of the river continue to provide a variety of habitat as reflected in the habitat scores.

4.2 Conclusions

This EA has generated considerable data regarding the Dead River channel conditions within the study area. Some of the post-event stream reaches of the river system (~40-45 percent) are in relatively good condition (Reaches 4, 6, and 8), while other reaches (~30-35 percent), most notably those immediately downstream of Silver Lake (Reach 2) and at or downstream of Tourist Park (Reaches 9 and 10), are not. Ninety-five to 100 percent of Reaches 2, 9, and 10 scored poorly relative to both habitat and stability metrics. All of the Extreme BEHI scores were found in Reaches 2 and 9. The unstable reaches of the river and associated channel banks negatively influence upstream and downstream channel stability, sediment transport, and habitat quality.

Two of the four reservoirs/areas inspected (McClure Basin and Forestville Basin) appear to be relatively unaffected by the event, while the other two reservoirs (Dead River Storage Basin and Harbor/Lake Superior area) appear to be potentially impacted by post-event deposition. Detailed pre-event bathymetric (and to an even greater extent substrate) data are unavailable for much of these water body areas, complicating the assessment process. Nonetheless, the underwater videotaping of the Harbor/Lake Superior area indicates the known lake trout spawning areas are intact.

Although the river and its functions have been impacted, portions of the river are currently stable and providing aquatic habitat and others show some evidence of natural recovery.

As a result of the EA, three sites within Reach 2 were identified that merited immediate action consisting of further investigation and/or interim measures to address the conditions observed. These are the post-event outlet of Silver Lake (with the potential for additional headcutting), the steep river bank upstream of Mulligan Creek, and the blockage of Mulligan Creek at its confluence with the Dead River (see Appendix F). As a result of further analysis conducted in September 2003, additional interim measures are not warranted at the Silver Lake Outlet.

The results of this EA are qualitative and preliminary. They are of value for planning supplemental EA work anticipated for the spring of 2004.

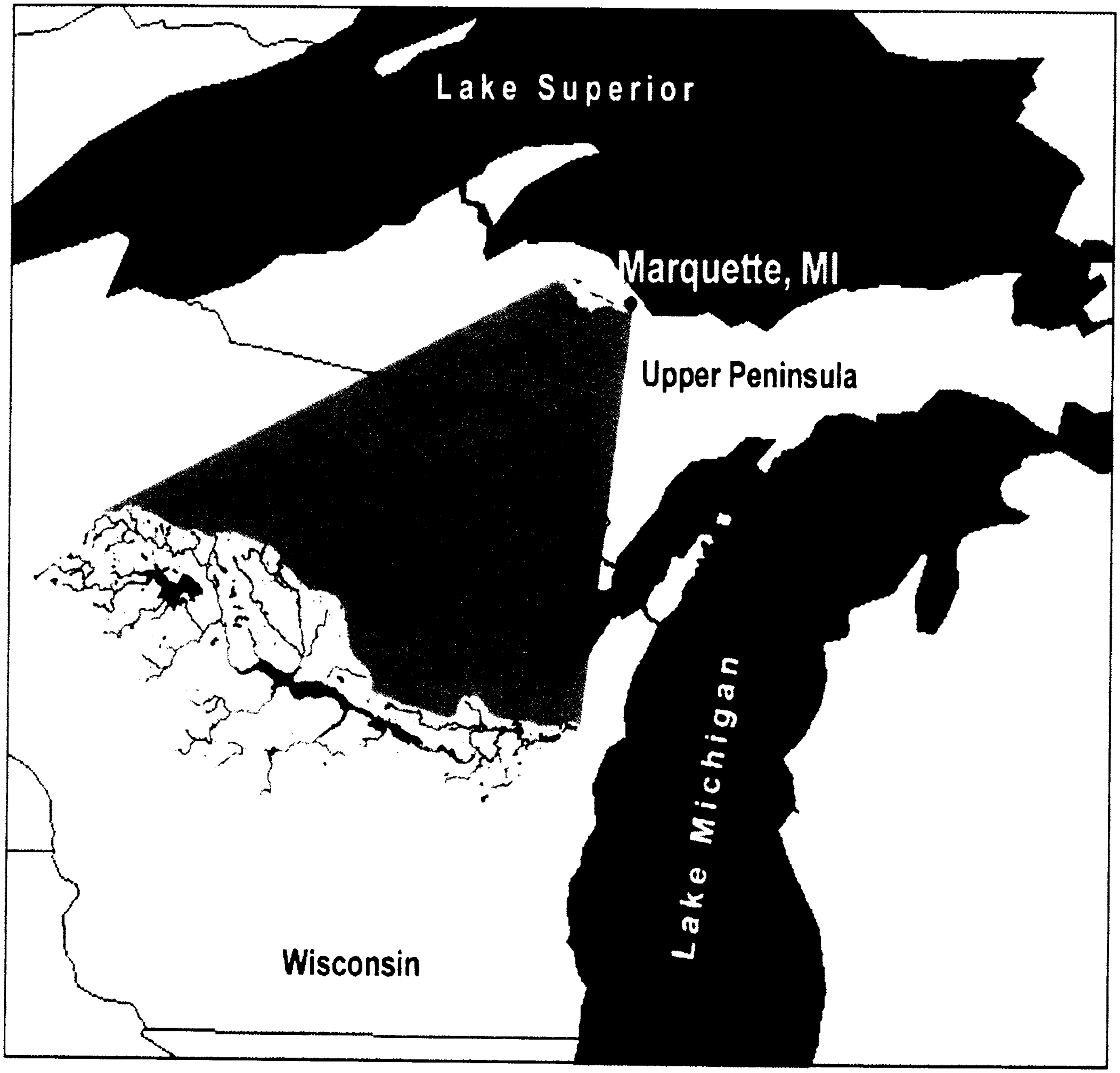

FIGURE 1-1
Study Area
Dead River, Michigan
Upper Penninsula Power Company

W062003001 MKE 182055 P1 AP Figure 1 1 10 13 03 mjl

CH2MHILL

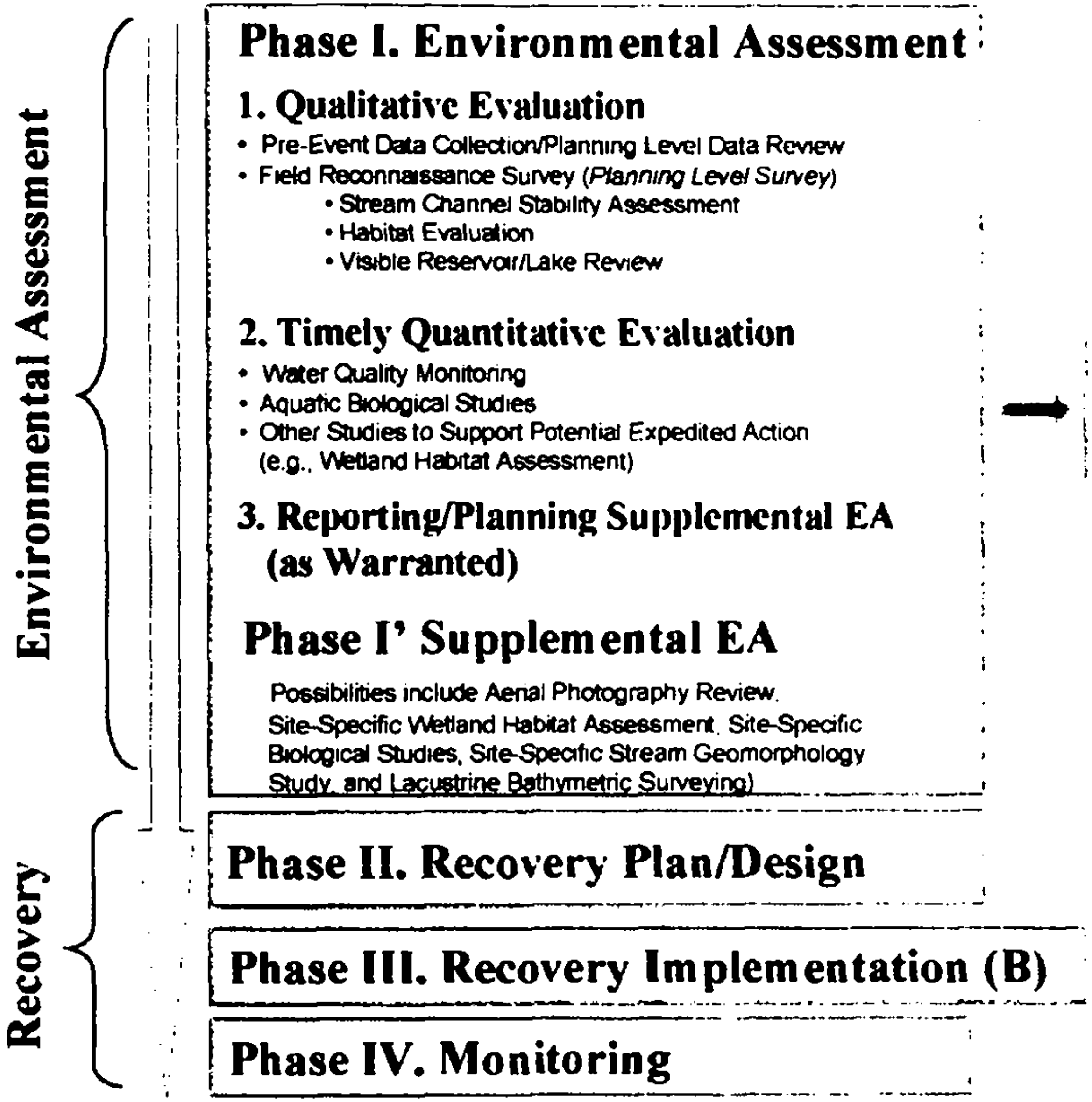

FIGURE 1-2
Environmental Assessment and Recovery Approach
Dead River, Michigan
Upper Penninsula Power Company
CH2MHILL

WO62003001 MKE 182065 P1 AP Figure 1-2 10-13-03 my

LARGE-FORMAT IMAGES

One or more large-format images (over 8½" X 11") go here. These images are available in E-Library at:

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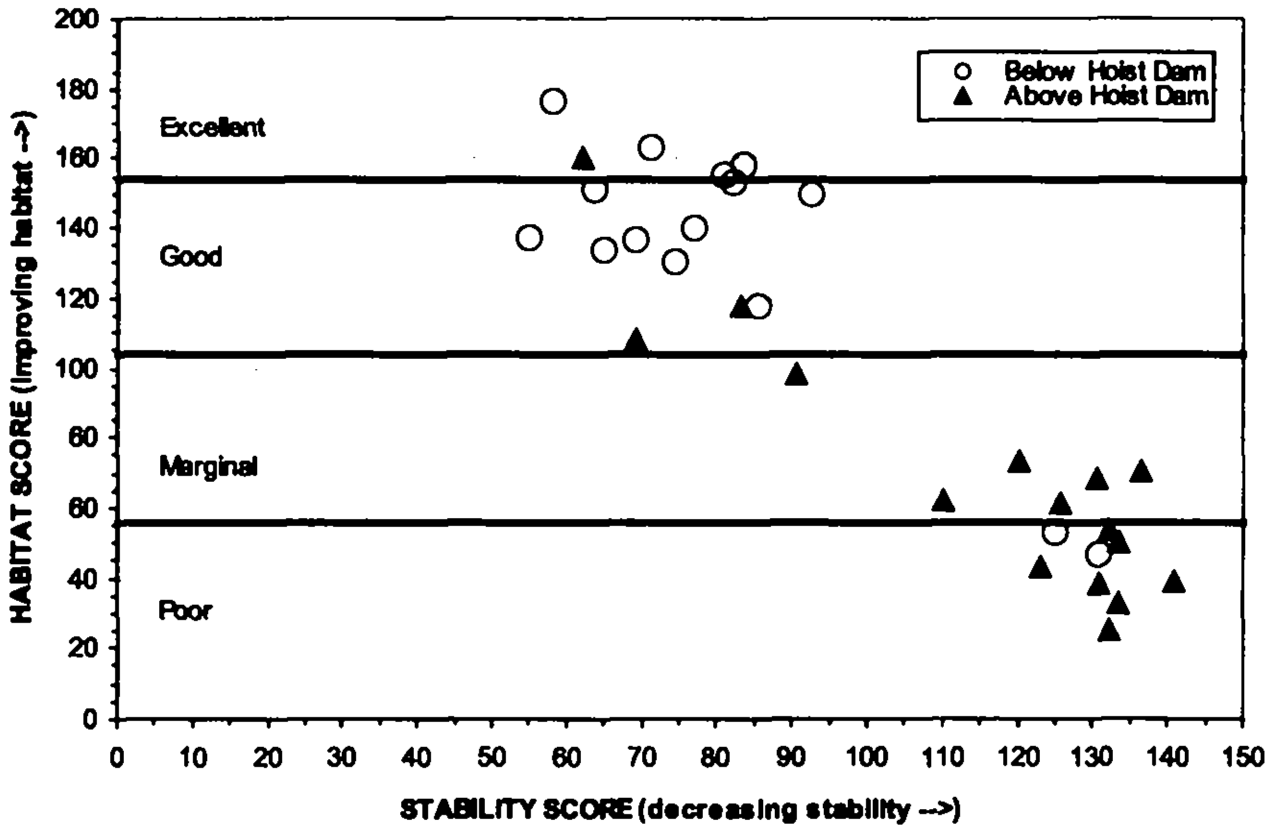

FIGURE 3-3
Total Stream Habitat Versus Stability Scores
Post Event Environmental Assessment
Dead River, Michigan
Upper Penninsula Power Company

WOS2003001 MKE 182034.P1.AP Figure 3-3 10-13-03 sgj
CH2MHILL

Appendix A
References/Source Information

APPENDIX A

References/Source Information

TABLE A-1
References for Dead River Environmental Assessment and Recovery Project

CH File No.	Code	Author	Date	Title
100—Pre-Event				
101	R	Stone & Webster Michigan, Inc.	1994 (April)	Dead River Hydroelectric Project (FERC Permits 10855 and 10857), Vol II, Exhibit E
102	R	Stone & Webster Michigan, Inc.	1994 (April)	Dead River Hydroelectric Project (FERC Permits 10855 and 10857), Vol III, Exhibit E
103	R	Stone & Webster Michigan, Inc.	1994 (April)	Dead River Hydroelectric Project (FERC Permits 10855 and 10857), Vol IV, Exhibit E
104	R	Stone & Webster Michigan, Inc.	1994 (April)	Dead River Hydroelectric Project (FERC Permits 10855 and 10857), Vol V, Exhibit E
105	R	Stone & Webster Michigan, Inc.	1994 (April)	Dead River Hydroelectric Project (FERC Permits 10855 and 10857), Vol VI, Exhibit E
106	R	Federal Energy Regulatory Commission	2002 (July)	Final Environmental Assessment
107	D	Federal Energy Regulatory Commission	2002 (October)	Order Issuing New License
108	D	Federal Energy Regulatory Commission	2002 (October)	Order Issuing Original License
109	D	Upper Peninsula Power Company	2003 (January)	Water Quality Monitoring Plan, Dead River Hydroelectric Project
110	D	Federal Energy Regulatory Commission	2003 (April)	Order Modifying and Approving Water Quality Monitoring Plan Under Article 408
111	R	Dept. of Environmental Quality	2000 (August)	Channel Morphology Fish Community and Temp Conditions of the Dead River Bypass Channel Prior to Flow Augmentation
112	D	MDNR	1995 (September)	Water Survey-Mulligan Creek Stocking Evaluation-Evaluate Brook Trout Stocking
113	D	MDNR	1985 (July)	Age Frequency by Species/Silver Lake Basin - Stocking Evaluation
114	D	MDNR	1982 (September)	Number, Weight, and Length by Species/Sundstrom Lake
115	D	MDNR	1989 (October)	Age Frequency by Species/Forestville Basin-Evaluate Brown Trout Plants
116	D	MDNR	1982 (July)	Age Frequency by Species/Tourist Park Basin-Evaluate Fish Population Prior to Development of a Fisheries Management Plan
117	R	Dept. of Environmental Quality	2000 (August)	Channel Morphology, Fish Community, and Temperature Conditions of the Dead River Bypassed Channel Prior to Flow Augmentation
118	R	Mead & Hunt	1999 (July)	Exhibit F, Supporting Design Report, Marquette Hydroelectric Project No. 2589

TABLE A-1
References for Dead River Environmental Assessment and Recovery Project

CH File No.	Code	Author	Date	Title
119	R	Marquette Board of Light and Power	1999 (July)	Application for a New License for a Major Water Power Project 5 Megawatts or Less, Volume 1 of 3, Marquette Hydroelectric Project FERC Project No. 2589
120	R	Marquette Board of Light and Power	1999 (July)	Application for a New License for a Major Water Power Project 5 Megawatts or Less, Volume 2 of 3, Marquette Hydroelectric Project FERC Project No. 2589
121	R	Marquette Board of Light and Power	1999 (July)	Application for a New License for a Major Water Power Project 5 Megawatts or Less, Volume 3 of 3, Marquette Hydroelectric Project FERC Project No. 2589
122	DW	U.S. Dept. of the Interior	1975 (October)	National Wetlands Inventory, Wetland Legend, Negaunee NE, Michigan
123	R	The Office of Research & Development	1971	An Ecological Survey of Dead River
124	R	James Peck	1992 (April)	The Sport Fishery and Contribution of Hatchery Trout and Salmon in Lake Superior and Tributaries at Marquette, Michigan, 1984-87
125	DW		2002 (July)	Lake Superior, Condition of Channel (4 copies)
126	P	Aero-Metric Engineering, Inc.	1994 (May)	1994 Aerial Photography - Dead River Basin Site
127	R	Harza Engineering Company	2001 (February)	Cool Season Probable Maximum Flood for Dead River Projects (Silver Lake, Hoist & McClure Sub-Basins
128	R	Harza Engineering Company	2001 (January)	Warm Season Probable Maximum Flood for Dead River Projects Silver Lake, Hoist & McClure Sub-Basins
129	DW			Index to Map Sheets, Marquette County, Michigan
130	R	Adam Kowalski	1999 (April)	Recolonization of Invertebrates in the Dead River
131	R	Dept. of Environmental Quality	1968 (August)	Michigan Water Resources Commission-Water Quality Survey of Lake Superior in the Marquette Vicinity
132	R	Harza Engineering Co.	2001 (March)	Flood Routing of Probable Maximum Floods (PMF) in Dead River Basin (Silver Lake, Hoist & McClure) (and 3 disks)
133	DW	Stone & Webster Michigan, Inc.		Dead River Storage Basin Habitat Map Substrate
135	P	U.S. Geologic Survey	1959	Marquette County Quadrangle Map
300—Post-Event				
303	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (1 of 10)
304	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Cross Sections Existing Conditions (2 of 10)
305	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Cross Sections Existing Conditions (3 of 10)
306	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (4 of 10)
307	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (5 of 10)
308	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (6 of 10)
309	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (7 of 10)

TABLE A-1
References for Dead River Environmental Assessment and Recovery Project

CH File No.	Code	Author	Date	Title
310	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (8 of 10)
311	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (9 of 10)
312	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (10 of 10)
313	F	STS Consultants	2003 (May)	Silver Lake Breach Site-Site Plan-Existing Conditions (1 of 10, full size)
314	F	Central Lake Superior Watershed Partnership	2003 (June)	Dead River Inventory CLSWP CD/Dead River Watershed Field Inventory Sections 1-5
315	D	MDNR	2003 (June)	Michigan Dept. of Natural Resources - Stocking History - 3 pgs.
317	DW	Wisconsin Public Service Corporation	2003 (June)	Phase 1 Site Work Silver Lake Breach Drawings 1-8
318	D	Jessica Mistak	2003 (June)	Email on Information for the Dead River Creel
319	D, DW	D. Bandrowski	2003 (May)	Bid Schedule, Construction Specifications, Quality Assurance Plan, Silver Lake Basin Temporary Seeding and Hoist Dam Access Road Drawings
320	R	Upper Peninsula Power Company	2003 (June)	Dead River Basin Initial Water Quality Monitoring Report
321	R	Central Lake Superior Watershed Partnership	2003 (May)	Dead River Watershed Field Inventory, Sections: 1-5
322	R	Marquette County Conservation District	2003 (June)	Lower Dead River Watershed Management Plan Draft
323	D	United States Department of Agriculture	2003 (June)	Aerial Photography Field Office, Internet Data Information
325	D	Department of Transportation	2003 (June)	Preliminary 2004-2006 State Transportation Improvement Program (STIP) Projects
332	P			Dead River Inaccessible Property Cover Layer

R=Report; D=Data; DW=Drawings F=Figure; P=Photo or Digital Imagery

Appendix B

Field Methods and Supplemental Documentation

APPENDIX B

Field Methods

The field survey was conducted in accordance with the Draft Work Plan (June 23, 2003). Additional information on the methods used are provided at the end of this appendix.

The survey was conducted through the use of three field teams. The survey team was comprised of Stream Teams 1 and 2 and the Reservoir Team. Stream Team 1 assessed the Dead River upstream of the Dead River Storage Basin, Team 2 assessed the Dead River downstream of the Dead River Storage Basin, and the Reservoir Team assessed the Dead River Storage Basin, McClure Basin, Forestville Basin, and Lake Superior/Harbor area. Each stream team contained an engineer and biologist experienced with stream and habitat assessments. The assessment teams are summarized in Table B-1.

TABLE B-1
Stream and Reservoir Assessment Teams

Team	Name	Affiliation	Background	Experience
1	Emily Holtzclaw, P.E.	CH2M HILL	Engineer	Rosgen Level III Training Stream Assessments Restoration Design Hydraulics and Hydrology
	John Burgess	CH2M HILL	Biologist	Fish and Macroinvertebrate Sampling Fisheries and Aquatic Biology Stream Assessments
2	Brent Brown	CH2M HILL	Engineer	Stream Assessments Stream Restoration Design Stream Restoration Research Hydraulics and Hydrology
	Rob Price	CH2M HILL	Biologist	Rosgen Level I Training Stream Assessments Aquatic Biology
Reservoir	Steve Miller	CH2M HILL	Engineer	Reservoir/Lake Assessments Reservoir/Lake Restoration Bathymetric Surveys Stream Assessments Stream Restoration Design Hydraulics and Hydrology Sediment Transport and Sampling Aquatic Biological Sampling
	Mike Mettler	Normandeau	Biologist	Reservoir/Lake Assessments Bathymetric Surveys Aquatic Biological Sampling
	Dale LaFernier	UPPCo	Hydropower	Dead River System Transportation and Boat Captain

The final reach divisions are illustrated Figures 2-1a and 2-1b of the EA Report and are listed in Table B-2.

TABLE B-2
Description of River Reaches Established during the Field Survey

Reach	Reach Length (miles)*	Reach Type	Reach Description
Reach 0	0.23	River	Dead River upstream of Silver Lake (Reference Reach)
Reach 1	3.5	Reservoir	Silver Lake Basin
Reach 2	5.7	River	Silver Lake to Dead River Basin
Reach 3	10.2	Reservoir	Dead River Basin
Reach 4	0.55	River	Dead River Basin to McClure Basin
Reach 5	1.5	Reservoir	McClure Basin
Reach 6	6.3	River	McClure Basin to Forestville Basin
Reach 7	1.0	Reservoir	Forestville Basin
Reach 8	1.5	River	Forestville Basin to Tourist Park Basin
Reach 9	1.3	River	Tourist Park Basin
Reach 10	0.7	River	Tourist Park Basin to the mouth of the river
Reach 11	1.1	Harbor & Lake	Lake Superior at the mouth of the river

Reach 0 will be used for Habitat and Channel characterization and not as a reference for Biological Studies.
Reach 2 includes both the former Silver Lake Basin outlet channel and the newly formed outlet channel.
*Total reach lengths adjusted downward to reflect actual lengths scored (after eliminating portions of reaches where use of the selected scoring methodology would have been inappropriate).

As the stream assessment teams progressed upstream in a particular reach, they subdivided the reach into sub-reaches based on changes in either the stream type or habitat conditions. For example, Reach 6 (downstream of McClure Basin dam) was subdivided into 10 sub-reaches. Each sub-reach was labeled with the reach number and sub-reach number, chronologically from downstream to upstream. For example, the fifth sub-reach in Reach 6 was labeled R06-05. The reservoirs were not broken into sub-areas.

The stream assessment and reservoir teams conducted the assessments over a 6-day time table. Due to the length of the reaches, the size of the reservoirs, and the coordination required between the stream and reservoir teams to ensure complete assessment coverage, some stream reaches and reservoirs required multiple days to assess. Table B-3 summarizes the dates each reach was assessed and who conducted the assessments.

TABLE B-3
Stream and Reservoir Assessment Dates

		Assessment Dates					
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Reach #	Team	18-Aug-03	19-Aug-03	20-Aug-03	21-Aug-03	22-Aug-03	23-Aug-03
0	Team 1						
	Team 2					Note 2	
1	Team 1						
	Team 2					Note 2	
2	Team 1						
	Team 2			Note 1	Note 2		
3	Reservoir				Note 3		
4	Team 1						
5	Reservoir						
6	Team 1						
7	Reservoir						
8	Team 1						
	Team 2						
9	Team 1						
10	Team 1						
	Reservoir						
11	Reservoir				Note 3		

Notes:
1. Team 2 included Shawn Puzen/WPSC and Jessica Mistak/MDNR.
2. Team 2 included Shawn Puzen/WPSC and Mitch Koetje/MDEQ.
3. Mike Mettler was not present on the Reservoir Team on Thursday, August 21, 2003.

The Michigan Department of Environmental Quality (MDEQ) Habitat Scoring System for Wadeable Streams and Rivers was used to score the habitat conditions in each stream sub-reach. In addition, the Stream Reach Inventory and Channel Stability Evaluation (U.S. Department of Agriculture) (also known as the Revised Pfankuch Channel Stability Evaluation Procedure) was used to assess the overall channel stability of each sub-reach. Each field team member determined their own score for each metric independently and the total score was an average of the team members' scores for that sub-reach. As mentioned above, additional information regarding the stream and habitat assessment methodology is provided at the end of this Appendix. The results of the assessment are presented in the main body of the EA Report.

Reservoir Assessment Methodology

The reservoir assessment was conducted at a cursory level documenting field observations on field maps and in log books. The assessment team used a small boat, existing bathymetric data, a fish/depth finder, and a handheld GPS unit to measure the reservoir depths. The results of the reservoir review are depicted in figures of this report (Figures 3-5a through 3-5e). These figures show water depths measured from a boat using a portable fishfinder and hand-held GPS unit. The portable fishfinder used during the review was a Hummingbird Piranha™ 1 with 24-degree sonar coverage and 200-kHz operating frequency. The handheld GPS unit was a Garmin® Etrex Legend (typical accuracy during the field work ranged from 10 to 20 feet on the reservoirs and 20 to 40 feet on Lake Superior).

Overview – General Reach Descriptions

Following the methodology discussed above, field observations made during the reconnaissance efforts for each of the reaches (Reach 0-11) are summarized below.

Reach 0 (Upstream of Silver Lake)

Reach 0 of the Dead River is upstream of the confluence with the pre-event Silver Lake Basin (Figure 2-1a). Reach 0 has a "V" shaped valley and extends 1,190 linear feet upstream of Silver Lake Basin. This reach is generally a well-defined riffle-pool system (with several deep pools, greater than 3 feet deep) and with moderate sinuosity (sinuosity = 1.30). The river upstream of Reach 0 was more sinuous (sinuosity = 1.57) with a lower gradient; however, this segment was not evaluated in detail as part of this study. Macroinvertebrates and trout were observed throughout Reach 0. Substrate materials include gravel and cobble, with some boulders and sand. Overhanging shrubs, fallen trees, undercut banks, exposed roots, and boulders provide diverse and functional habitat throughout the entire reach.

The right and left banks are well vegetated throughout the entire reach, with the exception of two small areas. These two erosional areas are on the right bank (looking downstream): one at a mid-reach location and one just upstream of the mouth of the pre-event Silver Lake Basin. The riparian buffers along the left bank are well forested with old-growth trees and a mixture of shrubs and high canopy trees. The right bank riparian zone includes a forested buffer within 30-50 feet with clear-cut logging extending beyond 50 feet.

Reach 1 (Silver Lake)

Reach 1 includes the pre-event Silver Lake Basin (Figure 2-1a) downstream of Reach 0. The Dead River now flows into and out of a pool smaller than the pre-event Silver Lake. The Dead River upstream of Silver Lake is a moderately sinuous channel (sinuosity = 1.37) with a low gradient, and most likely follows the original channel alignment of the Dead River before Silver Lake Basin was created. Downstream of the pre-event Silver Lake is a 1,920-linear-foot section of the Dead River that flows from Silver Lake into Reach 2, reconnecting with the pre-event Dead River channel.

Reach 1 includes banks that range between 1 and 6 feet high, where the majority of the bank heights are around 1 foot high with little to moderate vegetative protection. The bed material is clean sand and well-defined riffles and pools are not present. Immediately downstream of the remaining ponded water in Silver Lake and within the old Silver Lake boundary, the bed material includes soft sand and peat-like lake bottom material. This pocket of bed material extends for about 200 feet from the edge of the remaining ponded water in Silver Lake until the bed material returns to the clean sand seen in the upper sections of Reach 1. The 200 feet of old lake bottom bed material appeared to include the headcut that occurred after the Silver Lake Basin drained.

The former Dead River channel between the Silver Lake Basin dam and the location where the Dead River now flows into the remaining ponded water in Silver Lake was not assessed because it is no longer an active stream.

The majority of Reach 1 has a shallow and flat floodplain. The riparian buffer includes grasses and some bare areas where vegetation was not able to establish.

Reach 2 (Silver Lake to Dead River Storage Basin)

Reach 2 extends from the edge of the pre-event Silver Lake Basin (former fuse plug location) downstream to the Dead River Storage Basin (Figure 2-1a). Reach 2 is a highly variable reach ranging from areas with wide floodplains and low bank heights, to areas with narrow valleys and bank heights over 100 feet. Bank material variations range between sand, gravel, clay, and bedrock, and some banks have several material classifications present. Large areas of sand, gravel, cobble, and boulder deposits are present throughout the reach. The bed material consists of mostly sand, with some areas of cobble and gravel riffles. In two areas along Reach 2, the dominant bed and bank material is exposed bedrock.

At the upstream end of Reach 2, the newly formed Dead River has formed a confluence with the original Dead River, downstream of the Silver Lake Basin dam. At this confluence, the outer banks of the Dead River range between 30 and 50 feet high, with vertical sand, gravel, and overhanging trees that appeared on the verge of falling into the River. The Dead River flows along this outer bank area for about 1,000 linear feet.

Two major tributaries enter the Dead River in Reach 2: Connors Creek and Mulligan Creek. After Silver Lake Basin drained, the confluence with both tributaries was affected. The Connors Creek confluence received sand deposits that have caused the creek to braid and pool water upstream of the braids. However, Connors Creek is still able to drain and is hydraulically connected to the Dead River. It appeared that fish and other aquatic life are able to move in and out of Connors Creek.

Mulligan Creek enters the Dead River about 7,000 linear feet downstream of Connors Creek. The Mulligan Creek confluence has been cut off from the Dead River by a sand and gravel deposit that has caused Mulligan Creek to back-up and not freely discharge to the Dead River. As a result, it appeared that Mulligan Creek is discharging through sub-surface flow in the highly porous sand deposits. Under the current conditions, aquatic life is not able to migrate into or out-of Mulligan Creek. Mulligan Creek is discussed further in Section 3.

Between Mulligan Creek and Connors Creek, the Dead River separates into two well defined channels for 1,400 linear feet. One of the channels runs along a sand and gravel bank with one small pocket of clay. This is generally known as the "high banks" or "clay banks" area. The banks in this area range between 50 and 100+ feet in height and are nearly vertical for this entire segment. This area is discussed in more detail in Section 3.

Downstream of the Mulligan Creek confluence with the Dead River, the County Road AAO bridge deck was washed out due to the event. Immediately upstream and downstream of this crossing, trees were removed along the banks and riparian zones. The current banks and buffer areas consist mostly of sand. Isolated pockets of organic soil are present along the western side of the AAO bridge. In a 300-linear-foot reach just upstream of the AAO bridge, the County has placed riprap along the outer bank of a 90-degree bend to prevent erosion and channel migration.

Downstream of the AAO bridge, lake sub-reach 2E and the downstream end of lake sub-reach 2D were assessed with a boat during the visible reservoir review. Reach 2E is a transition zone from a riverine environment to a lacustrine environment. It is a low velocity, meandering channel with frequent side channels and adjacent backwater areas. Wet areas are prevalent throughout the lower reach along both sides of the channel.

Evidence of the high discharge event was noticeable in the upper portions of these river/reservoir transition reaches, primarily in the form of organic litter perched in overbank vegetation; or shrubs or small trees leaning in a downstream direction where the overbank flows were concentrated. Other than some localized areas where the hydraulics were favorable to deposition, there was little evidence of significant sediment deposition on the overbanks (as viewed from the boat).

Some of the channel banks in the upstream portion of these river/reservoir transition reaches are eroded; however, for the most part this reach appeared to be quite stable due to an active floodplain and dense vegetation along the channel and overbanks. In limited areas where bank sloughing occurred, it was common to see new vegetation re-establishing.

Reach 3 (Dead River Storage Basin)

Unlike the review of other reservoirs, the review of the Dead River Storage Basin focused on the upstream end of the reservoir (Figures 3-5a and 3-5b). The very western, or upstream, end of this reach is a relatively narrow, shallow backwater environment. Submerged stumps, macrophytes (submerged, floating leaf, and emergent), and large woody debris are common.

A sand deposit was observed in the upper end of the reservoir (Figure 3-5a). On the day of the reservoir review (water surface elevation on August 17, 2003, was 1,340.34 feet [WPSC personal communication]), up to about 4 feet (visual estimate) of sand extended above the water surface in the center of the channel. The grain sizes appeared to be predominantly medium to coarse sand.

Upstream of the large sand deposit, the river channel passes through almost two 90-degree bends as it approaches the reservoir through a narrow land gap. The channel banks through this reach are either rock or densely vegetated; therefore, the channel did not widen through this constriction during the event. However, based on water depth, the river bottom appeared to have significantly scoured. A maximum water depth of 30 feet was measured in this short reach. The majority of the channel cross section is over 20 feet deep —even a short distance off shore in many areas. The 1992 habitat survey indicated a water depth in this reach of only 2 feet.

Based on visual observations (no substrate samples were collected), the reservoir substrate in the proximity of the large sand deposit appeared to be dominated by organic material and fine sediments. For the most part, the thalweg in the upper end of this reach parallels the south shore with more shallow water depths and a higher density of stumps and large woody debris to the north. It was evident that some large trees were deposited in this upstream reach as a result of the event.

In comparison to the 1992 bathymetry data, it appeared that portions of the thalweg along the south shore of the upper reservoir (west of the boat ramp) have become more shallow as a result of sediment deposition. The thalweg was measured in 1992 at about 7 feet deep at a pool elevation of 1,342 feet above mean sea level. Water depths as shallow as 1 to 3 feet were measured in the thalweg at the same location during the reservoir review (pool elevation of 1,340 feet). At full pool, these depths would equate to 3 to 5 feet, so some deposition has occurred. The channel thalweg is used in this portion of the reservoir for navigating small boats to and from private property along the south shore.

The reservoir review extended downstream to where the reservoir narrows just east of the mouths of the Clark and Barnhardt Creeks. The wet areas along the south shore across from Silver Creek were not walked; however, as observed from the boat while traveling through this reach, the perimeter appeared to be physically intact and well vegetated. There was no visible impact of the Silver Lake Basin flood at the mouths of the Silver, Clark, or Barnhardt Creeks.

In general, most of all the visible sediment deposition observed during the review was located upstream, or west of the boat ramp toward the center or south shore of the reservoir (Figure 3-5a). It is probable that some fine sediment (i.e., silts and clays) deposited downstream of this upper area; however, it was not significant enough to reveal a difference between the limited water depths measured during the visible reservoir review compared to the 1992 bathymetry data.

Reach 4 (Hoist Dam to McClure Basin)

Reach 4 extends from the Hoist Dam downstream to the tailwater of the McClure Basin (Figure 2-1b). This reach consists of two distinct channel segments: upstream and downstream of the Dead River Basin penstock release. Downstream of the penstock, the channel is generally straight (sinuosity = 1.00) and the bank heights range from about 6 to 8 feet high. The valley is a confined, "V" shape with steep, well vegetated banks, and a well established buffer (mixture of trees and underbrush). Some of the banks are undercut, but there is no evidence of mass wasting. The substrate is dominated by compacted cobble and gravel. Tailwater from the McClure Basin extends to a point about 1,500 linear feet downstream of the penstock release.

An 800-linear-foot segment upstream of the penstock release point shows signs of high flows. This segment is dominated by cobble to boulder sized rock debris, much of which appeared to be mobilized from the bedrock immediately downstream of the Hoist Dam. There is minimal flow in the channel, and what flow there is appeared to be from a tributary source and seepage in the vicinity of Hoist Dam. The primary purpose of this segment is to pass large overflows from over the top of the Hoist Dam to the Reach 4 segment downstream of the penstock.

Reach 5 (McClure Basin)

The visible reservoir review for this reservoir extended from the dam, through the main body of water, and upstream of County Road 510 about 6,000 linear feet (Figure 3-5c). The public boat ramp is located about 600 feet upstream of County Road 510 where the upper reservoir channel is relatively narrow. Upstream of the boat ramp, the channel width averages about 60 feet. Near the boat ramp, there is a longitudinal mid-channel sand bar associated with some stumps and large woody debris. The bar is located far enough offshore that access to and from the ramp using the 16-foot aluminum V-hull johnboat is not affected. Based on pre-event aerial photographs, this bar feature existed before the Silver Lake spillway breach. It may or may not have grown in size, but this was not quantifiable during the review.

Due to elevated turbidity, visibility through the water column was limited to a few inches. Other than the mid-channel bar mentioned above, no sediment formations were observed in the water body. There are a few thin overbank deposits of sand veneers in the upper channel, but they are very limited in occurrence.

Reach 6 (McClure Dam to Forestville Basin)

Reach 6 varies considerably as it extends between the McClure Dam and the upstream end of the Forestville Basin (Figure 2-1b). Reach 6 starts at the tailwater of the Forestville Basin (at the confluence with the McClure Basin penstock release channel) with a sand dominated bed and flat gradient glide-pool system. The left bank (looking downstream) has a flat bench and then becomes very steep (10:1), extending about 40 feet high, while the right bank is relatively flat with 3- to 8-foot-high banks. The banks and buffer are well vegetated with a mixture of trees and underbrush.

Progressing upstream, Reach 6 changes as the valley becomes confined on both sides, cobble and gravel riffles begin to appear, and bedrock is present on portions of the bed and bank outcrops. Cobble and gravel dominate the substrate, which is densely populated with macroinvertebrate larvae. Upstream of McClure powerhouse, the valley becomes very confined with bedrock banks and a series of several waterfalls dropped over 100 feet in elevation over about 2,000 linear feet of channel.

Upstream of the waterfalls, the valley widens to allow the channel to meander extensively (sinuosity = 2.04). The channel gradient flattens to a glide-pool system with sand and gravel dominate substrate material. The 3- to 8-foot-high banks are well vegetated with a mixture of trees and underbrush, as is the near buffer zone. The left riparian buffer has been clearcut; however, at least a 100-foot buffer adjacent to the stream remains undisturbed. Proceeding upstream of the power cut that crosses Reach 6 north to south, the valley gradually begins to constrict; however, a low floodplain is maintained to allow the channel to continue to meander as a glide-pool system, and oxbows create frequent backwater wet areas. Channel banks range from 3-8 feet high and are well vegetated with trees and underbrush. The channel buffer is several hundred feet wide and is well established with trees and underbrush.

Reach 6 loses much of its meander as the valley constricts into a bedrock dominated, cascading waterfall gorge as it approaches the McClure dam. This constriction begins about 5,700 linear feet downstream of the dam (about 2,000 linear feet downstream of railroad trestle). This cobble-boulder-bedrock dominated channel continues with 80- to 100-foot-high banks.

Reach 7 (Forestville Basin)

This survey covered the basin as a whole, starting from the boat ramp located about 600 feet upstream of the Forestville Road bridge crossing. The review extended about 2,100 linear feet upstream of the boat ramp through the highly sinuous and narrow (about 60 feet wide) backwater channel. The reservoir width increases from about 300 to 600 feet about 1,900 feet downstream of the bridge. About 1,200 feet upstream of the dam, the reservoir narrows again from about 1,250 to 450 feet wide in the upper forebay. Findings are illustrated in Figure 3-5d.

As with McClure Basin, turbidity limited visibility; however, there was no visible evidence of significant sediment deposition in the reservoir. There were some sand deposits on the downstream side of the small mid-channel islands and peninsula between the bridge and the open reservoir; however, these features were apparent on the pre-event aerial photographs as well. Based on the visible review of the reservoir, it was not possible to determine if these features had changed; however, comparing the observations in the field to the pre-event aerial photographs, it does not appear that these deposits have increased in area.

Reach 8 (Forestville Dam to Former Tourist Park Basin)

Reach 8 consists of two distinct segments: upstream and downstream of the Forestville Basin penstock release. The flow varied throughout the day based on releases from the penstock. Downstream of the penstock, the channel is essentially straight (sinuosity = 1.04), about 60-75 feet wide, and has bank heights ranging from 3-8 feet on the left bank up to about 40 feet on the right bank. The bed is dominated by cobble and gravel, with exposed bars when the penstock is not releasing flow. The left bank is generally well vegetated with some undercut banks, while the higher and steeper right bank has sections of mass wasting. The buffer on both sides of the channel is well vegetated with trees and underbrush.

Downstream of the Forestville penstock release, the right bank (looking downstream) is about 40 feet high and predominately composed of sand. A 1,000-linear-foot segment is actively eroding into the stream channel. Several trees have fallen and more are in danger of falling into the channel as the bank continues to collapse. The steep bank slope, sandy material, and lack of stable vegetation on the bank surface will allow this erosion to continue.

Proceeding upstream of penstock release, the stream baseflow is much lower (occupies about one-third of channel) and the valley begins to constrict with bedrock outcrops and boulders. The bed is still dominated by cobble and gravel; however, moving upstream toward Dam No. 1 (historic dam), the channel becomes increasingly dominated by bedrock and boulders. Dam No. 1 impounds a pool that extends about 2,300 linear feet upstream where it meets a 1,000-linear-foot free flowing segment immediately downstream of the Forestville Dam that has stable, well vegetated banks and a cobble dominated bed.

Reach 9 (Tourist Park Basin)

The Tourist Park Basin consisted of an approximately 95-acre impoundment, which was drained due to the failure of the Tourist Park dam. Stream flow through the basin is now limited to the historic channel (about 75-100 feet wide, sinuosity = 1.21) in the bed of the former reservoir. The majority of the former reservoir bed (now channel overbanks and riparian area) has been seeded and is covered with grass. Two areas have had bank slopes stabilized with riprap: near the breached dam and along one property on the upper end of the reservoir. There are numerous tree stumps present on the former reservoir bed, and along the historic channel (bank heights ranged from 2-4 feet).

The Reach 9 channel is influenced by the fluctuating base flows caused by releases from the Forestville penstock. The channel bed has a gradual slope, creating a shallow (less than 1 foot of water at low flow) glide pool system. The shallow base flow meanders through the wide channel (no deep pools were observed), through woody debris and occasional braided gravel bars. The bed is dominated by sandy material, and the bank material is dominated by sand that is not stabilized with vegetation and is consequently a potential source of additional sediment. There are several oxbow backwater wet areas along the channel and at low flow the channel braids around small sand and gravel islands. Woody debris is present in the channel and along the banks. There is a bedrock waterfall downstream of the outlet from the basin that cascades about 14 feet vertically over about 100 feet.

Reach 10 (Tourist Park Basin Dam to Lake Superior)

Reach 10 is located downstream of the former Tourist Park basin (downstream of Sugarloaf Avenue). The channel is dominated by extensive sand deposition, with some gravel and cobble bars immediately downstream of the old pedestrian bridge east of Sugarloaf Avenue. There is also deposition and scour around the abutment of the two bridges. The bed is dominated by sand (potential source of sediment), which shifts with daily high flows from the Forestville penstock. The 100-foot-wide channel has bank heights ranging from about 4-8 feet. The bank vegetation has been scoured somewhat; however, the stable buffer vegetation is comprised of a mixture of trees and underbrush. Upper bank slopes are approximately 3:1 (H:V) and bank slopes are 1:1 or steeper.

Reach 11 (Lake Superior Harbor)

The most downstream end of the Dead River, from about 750 feet below the Hawley Road bridge into Lake Superior, was accessed and reviewed from a boat. Only those observations from the most downstream reach (near the powerhouse and into Lake Superior) are presented here, because the upstream portion overlaps with Reach 10 described above.

The lower 2,000 feet of the Dead River is relatively wide and shallow. The river morphology has been altered in this reach due to the presence of numerous structures such as the Lake Shore Drive bridge at the river mouth, the washed-out railroad bridge, remnant wood pilings across the channel width and perpendicular to flow, and steel sheet pilings extending into the river along the south side of the powerplant. Near structures, areas of overland flow, or increased roughness, sediment deposition was observed.

Sand was visible throughout much of this lower reach, particularly just upstream and southwest of the powerplant where the river widens. The channel thalweg, ranging from 2.5 to 13 feet deep, is adjacent to the barrier wall south of the powerplant.

A delta is present at the mouth of the Dead River in Lake Superior. Based on visual observation, the dominant grain size appeared to be sand, with some organic debris (primarily broken sticks and wood fragments) intermixed. The delta surface appeared to be very flat with very little topographic variation.

During the review, the field team attempted to roughly delineate the outer fringe of the delta using a hand-held GPS unit and portable depth finder. Observed depths are illustrated in Figure 3-5e. The water depths measured at the seven locations shown ranged from 3.5 to

6 feet. (Horizontal accuracy ranged from 20 to 40 feet as indicated by the GPS. This accuracy was influenced primarily by boat drift in the wind.)

Stream and Habitat Assessment Methodology

The stream and habitat assessment forms and references are provided.

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BANK EROSION HAZARD INDEX (BEHI) AND NEAR BANK SHEAR (NBS) STRESS SUMMARY TABLE

Team Name ____________________ Date ____________________ Stream: Dead River

This form covers Reach ________ to Reach __________ Location: ______________

Reach-BEHI ID	Segment Length (ft)	Low Bank Height (ft) *A*	Field Est. Max Bankful Height (ft) *B* [a]	Root Depth (ft) *C*	Root Density (%) *D*	Bank Angle (degrees)	Surface Protection (%)	Dominant Bank Material and points[b]	Material Stratification[c] (Y/N and pts)	NBS Est. Mean Bankful Height[a] (ft)
									Y / N /	
									Y / N /	
									Y / N /	
									Y / N /	
									Y / N /	
									Y / N /	
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									Y / N /	
									Y / N /	

[a] actual bankful to be verified through Regional Curve development during subsequent phases of Project

[b] Bedrock = 1, Boulders = 2, Cobble = 3 (subtract 10pts unless sand/gravel > 50%), Gravel = 4 (Add 5-10 pts, more for more sand), Sand = 5 (Add 10 pts), Silt = 6, Peat = 7

[c] Add 5-10 pts depending on position of unstable layers in relation to bankfull stage, low position=higher points

HABITAT AND PFANKUCH SUMMARY TABLE

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Team Name ______________________ ______________________

Date ____________

This form covers Reach ________ to Reach ___________

Stream: Dead River

Location: ______________________________

	Instream Habitat												Pfankuch Channel Stability														
													Upper Banks				Lower Banks					Bottom					
Reach ID	Riffle/Run or Glide/Pool?	1. Epifaunal Substrate	2. Embeddedness/Pool Substrate	3. Velocity/Depth Regime/Pool Variability	4. Sediment Deposition	5a. Channel Flow Status-Flow Volume	5b. Channel Flow Status-Flashiness	6. Channel Alteration	7. Frequency of Riffles/Channel Sinuosity	8. Bank Stability (LB/RB)	9. Vegetative Protection (LB/RB)	10. Riparian Veg. Zone Width (LB/RB)	1. Landform Slope	2. Mass Wasting	3. Debris Jam	4. Vegetative Bank Protection	5. Channel Capacity	6. Bank Rock Content	7. Obstructions to Flow	8. Cutting	9. Deposition	10. Rock Angularity	11. Brightness	12. Consolidation of Particles	13. Bottom Size Distribution	14. Scouring and Deposition	15. Aquatic Vegetation
	RR GP									/	/	/															
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PHOTO LOG

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Watershed: ______ Date: ______

Stream(s): Dead River Investigators: ______

Camera ID:

Reach #-Photo # R01-01-P01	Direction NN, NE, EE, SE, SS, SW, WW, NW	Notes

Reach __________ Typical Cross Section Sketch (looking downstream) Date: ________ Initials: ____________

___ bench height
___ top/bottom width
___ floodprone width
___ bank slopes
___ overbank/valley type
___ major features
(select all that apply)

Dominant Bed Material:	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Peat

Stream Type:	Flow Regime: E S I P 1 2 3 4 5 6 7 8 9
Stream Size: (est. bankfull width, ft)	Stream Order: (determine from map)

Meander Pattern:	M1	M2	M3	M4	M5	M6	M7	M8		
Depositional Patterns:			B1	B2	B3	B4	B5	B6	B7	B8
Debris and Blockage:	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Riparian Vegetation: (Code and percent coverage)	Left Bank (looking downstream)	Right Bank (looking downstream)

Existing Successional State:	Potential Successional State(s):

Reach __________ Typical Cross Section Sketch (looking downstream) Date: ________ Initials: ____________

___ bench height
___ top/bottom width
___ floodprone width
___ bank slopes
___ overbank/valley type
___ major features
(select all that apply)

Dominant Bed Material:	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Peat

Stream Type:	Flow Regime: E S I P 1 2 3 4 5 6 7 8 9
Stream Size: (est. bankfull width, ft)	Stream Order: (determine from map)

Meander Pattern:	M1	M2	M3	M4	M5	M6	M7	M8		
Depositional Patterns:			B1	B2	B3	B4	B5	B6	B7	B8
Debris and Blockage:	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10

Riparian Vegetation: (Code and percent coverage)	Left Bank (looking downstream)	Right Bank (looking downstream)

Existing Successional State:	Potential Successional State(s):

Stream: ______________________ Reach: ______________ Date: ______ Observers: __________ Comments: ______________________________

Location	Key	Category	Excellent Description	Rating	Good Description	Rating	Fair Description	Rating	Poor Description	Rating
Upper Banks	1	Landform Slope	Bank slope gradient <30%.	2	Bank slope gradient 30-40%.	4	Bank slope gradient 40-60%.	6	Bank slope gradient 60%+.	8
	2	Mass Wasting	No evidence of past or future mass wasting.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly year long.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris Jam Potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative Bank Protection	90%+ plant density. Vigor and variety suggest a deep, dense soil binding root mass.	3	70-90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species & less vigor indicating poor, discontinuous, and shallow root mass.	12
Lower Banks	5	Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	1	Adequate. Bank overflows are rare. W/D ratio = 8-15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio = 15-25.	3	Inadequate. Overbank flows common. W/D ratio > 25.	4
	6	Bank Rock Content	65%+ w/ large angular boulders. 12"+ common.	2	40-65%. Mostly boulders and small cobbles 6-12".	4	20-40%. With most in the 3-6" diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	8
	7	Obstructions to Flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock Angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges, surfaces smooth, flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, ie 35-65% mixture range.	3	Predominantly bright, 65%+, exposed or scoured surfaces.	4
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom Size Distribution	No size change evident. Stable material 80-100%.	4	Distribution shift light. Stable material 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.	12	Marked distribution change. Stable materials 0-20%.	16
	14	Scouring and Deposition	<5% of bottom affected by scour or deposition.	6	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic Vegetation	Abundant growth moss-like, dark green perennial. In swift water, too.	1	Common. Algae forms in low velocity and pool areas. Moss here, too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
			Excellent Total =		Good Total =		Fair Total =		Poor Total =	

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream Type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand Total =

Stream Type =

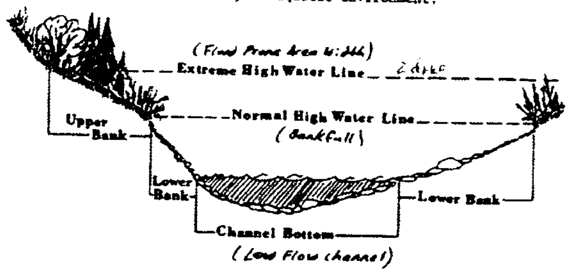
Modified Channel Stability Rating =

DEFINITION OF TERMS AND ILLUSTRATIONS

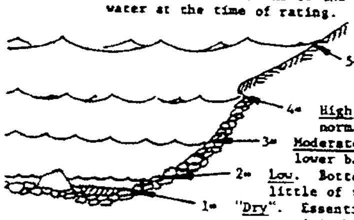
Upper Bank - That portion of the topographic cross section from the break in the general slope of the surrounding land to the normal high water line. Terrestrial plants and animals normally inhabit this area.

Lower Banks - The intermittently submerged portion of the channel cross section from the normal high water line to the water's edge during the summer low flow period.

Channel Bottom - The submerged portion of the channel cross section which is totally an aquatic environment.



Stream Stage - The height of water in the channel at the time of rating is recorded, using numbers 1 through 5. These numbers, as shown below, relate to the surface water elevation relative to the normal high water line. A decimal division should be used to more precisely define conditions, i.e., 3.5 means 3/4ths of the channel banks are under water at the time of rating.



5= Flooding. The flood plain is completely covered.
4= High. Channel full to the normal high water line.
3= Moderate. Bottom and 1/2 of lower banks wetted.
2= Low. Bottom covered but very little of the lower banks wet.
1= "Dry". Essentially no flow. Water may stand in bottom depressions.

Amplification of the Stream Channel Evaluation Items

General

Space on the field form permits only the very briefest description of the various components. This field booklet provides, in the text which follows, some of the basic rationale in support of these brief "kernels" or core thoughts. These explanations are arranged in the same order as they appear on the field form.

The channel cross section is subdivided into three components, to focus your attention on the various indicators to be subjectively evaluated. Once again, you are cautioned not to "key in" on any one item or group of items. All that have been included are interrelated and all must be used in an unbiased way to achieve consistent evaluations of the current situation.

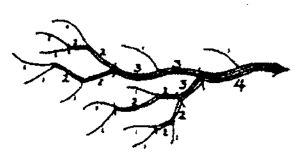
Stream channel ratings should not be attempted without the preparation provided by this Field Guide. The language of the text has been kept rather general to avoid limiting its use as a management tool to a small geographic area. These general descriptions, coupled with your local experience, will stimulate mental images of indicator conditions which, when shared with fellow workers, will lead to consistent, reproducible ratings.

Illustrations in the text should be considered general in nature and not specific for all situations. It is suggested that local conditions be photographed and the pictures added to this Field Guide to achieve local uniformity.

A word of additional caution: Keep the scale of the reach being evaluated in context with the scale of dimensions given in the text and on the inventory form. Rating items were taylored for and best fit the 2nd to 4th order stream reaches. Very small, unbranched, first order segments will require a scaling down of sizes while the larger stream and river reaches will require some mental enlargement of the criteria given to fit the situation.

STREAM ORDER CLASSIFICATION

First order streams are unbranched reaches found usually but not exclusively at the head of drainage basins. Second order reaches are formed when two or more first order reaches come together and so on as illustrated below.



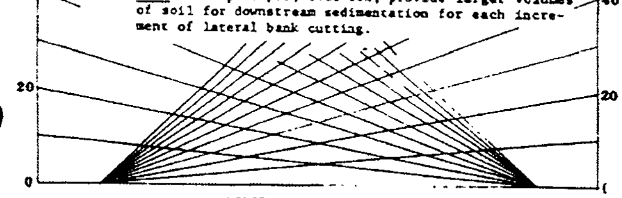
I. Upper Channel Banks

The land area immediately adjacent to the stream channel is normally and typically a terrestrial environment. Landforms vary from wide, flat, alluvial flood plains to the narrow, steep termini of mountain slopes. Intermittently this dry land flood plain becomes a part of the water course. Forces of velocity and turbulence tear at the vegetation and land. These hydrologic forces, while relatively short lived, have great potential for producing onsite enlargements of the stream channel and downstream sedimentation damage. Resistance of the component elements on and in the bank are highly variable. This section is designed to aid in rating this relative resistance to detachment and transport by floods.

A. Landform Slope: The steepness of the land adjacent to the stream channel determines the lateral extent and ease to which banks can be eroded and the potential volume of slough which can enter the water. All other factors being equal, the steeper the land adjacent to the stream, the greater the potential volume of slough materials.

The 60% limit for poor was selected as a conservative gravitational repose angle for unconsolidated soil materials. Slopes steeper than this are rated poor because they would erode into the stream by gravity alone, if denuded of their protecting vegetation. The other ratings built on this limit and are arbitrarily set as follows:

1. Excellent: Side slopes to the channel are generally less than 30 percent on both banks.
2. Good: Side slopes up to 40% on one or occasionally both banks.
3. Fair: Side slopes to 60% common on one or both banks.
4. Poor: Steep slopes, over 60%, provide larger volumes of soil for downstream sedimentation for each increment of lateral bank cutting.



PERCENT SLOPE SCALE

Hold this page at arms length..match the slope of the topography with the percent slope lines on the scale above.

B. Mass Wasting Hazard This rating involves existing or potential detachment from the soil mantle and downslope movement into waterways of relatively large pieces of ground. Mass movement of banks by slumping or sliding introduces large volumes of soil and debris into the channel suddenly, causing constrictions or complete damming followed by increased stream flow velocities, cutting power and sedimentation rates. Conditions deteriorate in this element with proximity, frequency and size of the mass wasting areas and with progressively poorer internal drainage and steeper terrain:

1. Excellent: There is no evidence of mass wasting that has or could reach the stream channel.
2. Good: There is evidence of infrequent and/or very small slumps. Those that exist may occasionally be "raw" but predominately the areas are revegetated and relatively stable.
3. Fair: Frequency and/or magnitude of the mass wasting situation increases to the point where normal high water aggrevates the problem of channel changes and subsequent undercutting of unstable areas with increased sedimentation.
4. Poor: Mass wasting is not difficult to detect because of the frequency and/or size of existing problem areas or the proximity of banks are so close to potential sides that any increases in the flow would cut the toe and trigger slides of significant size to cause downstream water quality problems for a number of years.

Mass wasting of slopes directly into the stream channel.

C. Debris Jam Potential Floatable objects are deposited on stream banks by man and as a natural process of forest ecology. By far, the bulk of this debris is natural in origin. Tree trunks, limbs, twigs, and leaves reaching the channel form the bulk of the obstructions, flow deflectors, and sediment traps to be rated below. This inventory item assess the potential for increasing these impediments to the natural direction and force of flow where they now lay. It also includes the possibility of creating new debris jams under certain flow conditions.

1. Excellent: Debris may be present on the banks, but is so situated or is of such a size, that the stream is not able to push or float it into the channel and, therefore, for all intents and purposes, it is absent. In truth, there may be none physically present. Both situations are rated the same.

2. Good: The debris present offers some bank protection for a while but is small enough to be floated away in time. Only small jams could be formed with this material alone.

3. Fair: There is a noticeable accumulation of all sizes and the stream is large enough to float it away, at certain times, thus decreasing the bank protection and adding to the debris jam potential downstream.

4. Poor: Moderate to heavy accumulations are present due to fires, insect attack, disease mortality, windthrow, or logging slash. High flows will float some debris away and the remainder will cause channel changes.

A series of debris jams of small size materials like the one shown in the center of this photo cause this item to be rated "Poor".

D. Vegetative Bank Protection: The soil in banks is held in place largely by plant roots. Riparian plants have almost unlimited water for both crown and root development. Their root mats generally increase in density with proximity to the open channel. Trees and shrubs generally have deeper root systems than grasses and forbs. Roots seldom extend far into the water table, however, and near the shore of lakes and streams they may be comparatively shallow rooted. Some species are, therefore, subject to windthrow.

In addition to the benefits of the root mat in stabilizing the banks, the stems help to reduce the velocity of flood flows. Turbulence is generated by stems in what may have been laminar flow. The seriousness of this energy release depends on the density of both overstory and understory vegetation. The greater the density of both, the more resistence displayed. Damage from turbulence is greatest at the periphery and diminishes with distance from the normal channel. Other factors to consider, in addition to the density of stems, are the varieties of vegetation, the vigor of growth and the reproduction processes. Vegetal variety is more desirable than a monotypic plant community. Young plants, growing and reproducing vigorously, are better than old, decadent stands.

1. Excellent: Trees, shrubs, grass and forbs combined cover more than 90 percent of the ground. Openings in this nearly complete cover are small and evenly dispersed. A variety of species and age classes are represented. Growth is vigorous and reproduction of species in both the under- and over-story is proceeding at a rate to insure continued ground cover conditions. A deep, dense root mat is inferred.
2. Good: Plants cover 70 to 90 percent of the ground. Shrub species are more prevalent than trees. Openings in the tree canopy are larger than the space resulting from the loss of a single mature individual. While the growth vigor is generally good for all species, advanced reproduction may be sparse or lacking entirely. A deep root mat is not continuous and more serious erosive incursions are possible in the openings.
3. Fair: Plant cover ranges from 50 to 70 percent. Lack of vigor is evident in some individuals and/or species. Seedling reproduction is nil. This condition ranked fair, based mostly on the percent of the area not covered by vegetation with a deep root mat potential and less on the kind of plants that make up the overstory.
4. Poor: Less than 50 percent of the ground is covered. Trees are essentially absent. Shrubs largely exist in scattered clumps. Growth and reproduction vigor is generally poor. Root mats discontinuous and shallow.

floods quite common as indicated by kind and condition of the bank plants and the position and accumulation of debris. Width to depth stability ratio .6 or less or 1.4 or more and becoming incised Bank Height Ratio >1.3.

B. Bank Rock Content: Examination of the materials that make up the channel bank will reveal the relative resistence of this component to detachment by flow forces. Since the banks are perennially and intermittently both aquatic and terrestrial environments, these sites are harsh for most plants that make up both types. vegetation is, therefore, generally lacking and it is the volume, size and shape of the rock component which primarily determine the resistence to flow forces.

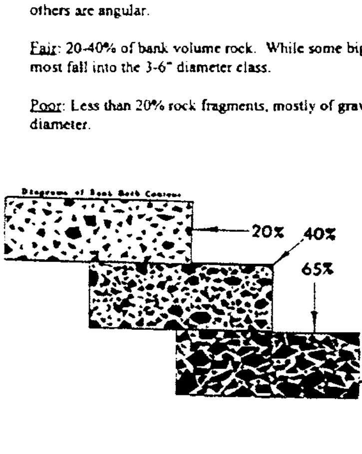
A soil pit need not be dug. Surface rock and exposed cut banks will enable you to categorize this item as listed by percentage ranges on the field form.

1. Excellent: Rock makes up 65% of more of the volume of the banks. Within this rock matrix large, angular boulders 12" (on their largest axis) are numerous.

2. Good: Banks 40-65% rock which are mostly small boulders and cobble ranging in size form 6-12" mean diameter. Some may be rounded whil others are angular.

3. Fair: 20-40% of bank volume rock. While some big rock may be present, most fall into the 3-6" diameter class.

4. Poor: Less than 20% rock fragments, mostly of gravel sizes 1-3" in diameter.



C. Obstructions and Flow Deflectors: Objects within the stream channel, like large rocks, embedded logs, bridge pilings, etc., change the direction of flow and sometimes the velocity as well. Obstructions may produce adverse stability effects when they increase the velocity and deflect the flow into unstable and unprotected banks and across unstable bottom materials. They also may produce favorable impacts when velocity is decreased by turbulence and pools are formed.

Sediment Traps: Channel obstructions which dam the flow partly or wholly form pools or slack water areas. The pools lower the channel gradient. With this loss of energy the sediment transport power is greately reduced. Coarse particles drop out first at the head of the pool. Some or all of the fine suspended particles may carry on through.

Embedded logs and large boulders can produce very stable natural dams which do not add to channel instability. Some debris dams and beaver dams, however, are quite unstable and only serve to increase the severity of channel damage when they break up.

The effectiveness of these sediment traps depends on pool length relative to entrance velocity. The swifter the current, the longer the pool needed to reach zero velocity. Turbulence caused by a falls at the head of the pool shortens the length required to reach zero velocity.

How long these traps are effective depends on depth and width as well as pool length and, of course, the rate of sediment accretion.

Items of vegetation growing in the water, like alders, willows, cattails, reeds, and sedges are also effective traps in some locations and reduce flow velocity and sediment carrying power.

Overturned shoreline trees become obstructions and flow deflectors as shown here. If frequent in the reach, rate this item "Poor".

C. Obstructions and Flow Deflectors (Continued)

1. Excellent: Logs, rocks, and other obstructions to flow are firmly embedded and produce a pattern of flow which does not erode the banks and bottom or cause sediment buildups. Poolriffle relationship stable.

2. Good: Obstructions to flow and sediment traps are present, causing cross currents which create some minor bank and bottom erosion. Some of the obstructions are newer, not firmly embedded and move to new locations during high flows. Some sediment is trapped in pools decreasing their capacity.

3. Fair: Moderately frequent and quite often unstable obstructions, cause noticeable seasonal erosion of the channel. Considerable sediment accumulates behind obstructions.

4. Poor: Obstructions and traps so frequent they are intervisible, often unstable to movement and cause a continual shift of sediments at all seasons. Since traps are filled as soon as formed, the channel migrates and widens.

Same location as shown on page 14, but looking upstream. Obstruction like this could become the nucleus of a debris jam.

Cutting and Deposition are concommittent processes. You can't have one without the other. However, it is possible for each to be taking place in different reaches of the same stream at the same time, and hence the separation for classification purposes which follows.

D. Cutting: One of the first signs of channel degradation would be a loss of aquatic vegetation by scouring or uprooting. Some channels are naturally devoid of aquatic plants and here the first stages would be an increase in the steepness of the channel banks. Beginning near the top, and later extending in serious cases to the total depth, the lower channel bank becomes a near vertical wall.

If plant roots bind the surface horizon of the adjacent upper bank into a cohesive mass, undercutting will follow. This process continues until the weight of overhang causes the sod to crack and subsequently slump into the channel. Differential horizontal compaction and texture could also result in undercut banks even with an absence of vegetative cover. There are some loosely consolidated banks that with or without vegetation are literally nibbled away, never developing much, if any, overhang.

1. Excellent: Very little or no cutting is evident. Raw, eroding banks are infrequent, short and predominately less than 6" high.

2. Good: Some intermittent cutting along channel outcurves and at prominent constrictions. Eroded areas are equivalent in length to one channel width or less and the vertical cuts are predominately less than 12".

3. Fair: Significant bank cutting occurs frequently in the reach. Raw vertical banks 12" to 24" high are prevalent as are root mat overhangs and sloughing.

4. Poor: Nearly continuous bank cutting. Some reaches have vertical cut faces over 2 feet high. Undercutting, sod-root overhangs and vertical side failures may also be frequent in the rated reach.

Poor bank conditions at this bend are evident.

E. Deposition: Lower bank channel areas are generally the steeper portions of the wetted perimeter and may be rather narrow strips of land that offer slight opportunity for deposition. Exceptions to this statement abound since deposition is often noted on the lee side of large rocks and log deflectors which form natural jetties. However, these deposits tend to be short and narrow. On the less steep, lower banks, deposition during recession from peak flows can be quite large. The appearance of sand and gravel bars where they did not previously exist may be one of the first signs of upstream erosion. These bars tend to grow, primarily in depth and length, with continued watershed disturbance(s). Width changes are in a shoreward direction as overflow deposition takes place on the upper banks. Dimensional deposition "growth" is limited by the size and orientation of the obstructions to flow along the channel banks, flow velocity and a continuing upstream sediment supply.

Deposition may also occur on the inside radii of bends, particularly if active cutting is taking place on the opposite shore. Also, deposits are found below constrictions or where there is a sudden flattening of stream gradient as occurs upstream above geologic nic points.

1. Excellent: Very little or no deposition of fresh silt, sand or gravel in channel bars in straight reaches or point bars on the inside banks of curved reaches.

2. Good: Some fresh deposits on bars and behind obstructions. Sizes tend to be predominately from the larger size classes - coarse gravels.

3. Fair: Deposits of fresh, coarse sands and gravels observed with moderate frequency. Bars are enlarging and pools are filling so riffle areas predominate.

4. Poor: Extensive deposits of predominately fresh, fine sands, some silts, and small gravels. Accelerated bar development common. Storage areas are now full and sediments are moving even during low flow periods.

Poor conditions are illustrated here.

III. Channel Bottom

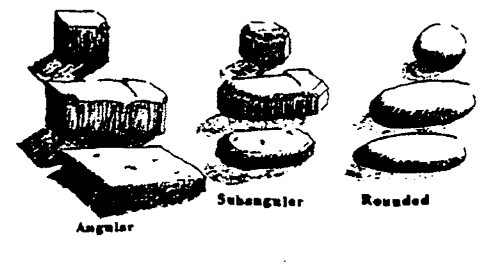
Water flows over the channel bottom nearly all of the time in perennial streams. It is, therefore, almost totally an aquatic environment, composed of inorganic rock constituents found in an infinite variety of kinds, shapes, and sizes. It is also a complex biological community of plant and animal life. This latter component is more difficult to discern and may in fact, at times and places, be totally lacking.

Both components, by their appearance alone and in combination, offer clues to the stability of the stream bottom. They are arbitrarily separated and individually rated for convenience and emphasis during the evaluation process. Because of the high reliance on the visual sense, inventory work is best accomplished during the low flow season and when the water is free of suspended or dissolved substances. If ratings must be made in high flow periods, sounds of movement may be the only clue as to the state of flux on the bottom.

A. Angularity: Rocks from stratified, metamorphic formations break out and work their way into channels as angular fragments that resist tumbling. Their sharp corners and edges wear and are rounded in time, but they resist the tumbling motion. These angular rocks pack together well and may orient themselves like shingles (imbricated). In this configuration they are resistant to detachment.

In contrast, igneous rocks often produce fragments that round up quickly, pack poorly and are easily detached and moved downstream.

Excellent to Poor ratings relate to the amount of rounding exhibited and, secondarily, the smoothness or polish the surfaces have achieved. Some rocks never do smooth up in the natural environment, but most round up in time. Both conditions, of course, are relative within the inherent capability of the respective rock types.



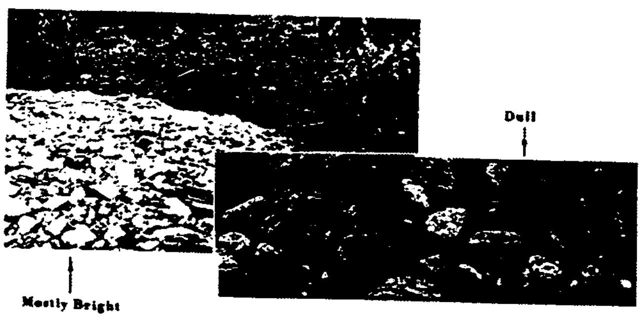
B. Brightness: Rocks in motion "gather no moss", algae or stain either. They become polished by frequent tumbling and, as a general rule, appear brighter in their chroma values than similar rocks which have remained stationary. The degree of staining and vegetative growths relate also to water temperature, seasons, nutrient levels, etc. In some areas a "bright" rock will be "dulled" in a matter of weeks or months. In another it may take years to achieve the same results. Nevertheless, even slight changes during the spring runoff should be detectable during the next summer's survey. Look first for changes in the sands and gravels.

1. Excellent: Less than 5% of the total bottom should be bright, newly polished and exposed surfaces. Most will be covered by growths or a film of organic stain. Stains may also be from minerals dissolved in the water.

2. Good: 5 to 35% of the bottom appears brighter, some of which may be on the larger rock sizes.

3. Fair: About a 50-50 mixture of bright and dull with a 15% leeway in either direction (i.e., a range of from 35 to 65% bright materials).

4. Poor: Bright, freshly exposed rock surfaces predominate with two-thirds or more of the bottom materials in motion recently.



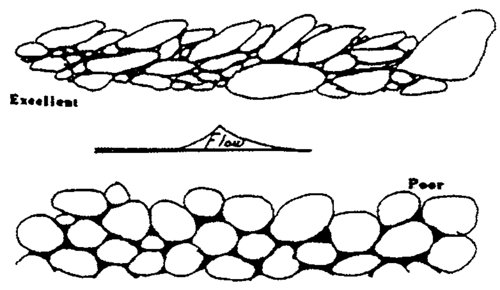
C. Consolidation (Particle Packing): Under stable conditions, the array of rock and soil particle sizes pack together. Voids are filled. Larger components tend to overlap like shingles (imbricate). So arranged, the bottom is quite resistent to even exceptional flow forces. Some rock types (granitics) are less amenable to this packing process and never reach the stable state of others like the Belt Series rocks.

1. Excellent: An array of sizes are tightly packed and wedged with much overlapping which makes it difficult to dislodge by kicking.

2. Good: Moderately tight packing of particles with fast water parts of the cross section protected by overlapping rocks. These might be dislodged by higher than average flow conditions, however.

3. Fair: Moderately loose without any pattern of overlapping. Most elements might be moved by average high flow conditions.

4. Poor: Rocks in loose array, moved easily by less than high flow conditions and move underfoot while walking across the bottom. The shape of these rocks tends to be predominantly round and sorted so that most are of similar size.



Side Views of Substrate

D. Bottom Size Distribution and Percent Stable Materials:

Rocks remaining on a stream's bottom reflect the geologic sources within the basin and the flow forces of the past. Normally, there is an array of sizes that you expect to see in any given local. After a little experience, you begin to "sense" abnormal situations. Generally, in the mature topography typical of the Northern Region of the Forest Service and much of the other western Regions as well, the flow in the small, steep upper stream reaches is sufficient to wash the soil separates and some of the gravels away. What remains is a gravelly, cobbly stream bottom. In the lower reaches where the gradient is less and flow is often slower, deposition of the "fines" eroded above begin to drop out. The separates of sand, silt, and some clay begin to cover the coarser elements. Except where trapped in still water areas, these fines tend to be in constant motion to ever lower elevations.

Two elements of bottom stability are rated in this item: (1) Changes or shifts from the natural variation of component size classes and (2) the percentage of all components which are judged to be stable materials. Bedrock, large boulders, and cobble stones ranging in size from one to three feet or more in diameter are considered "stable" elements in the average situation. Obviously, smaller rocks in smaller channels might also be classed as stable. The sizes are given only to guide thought. Bedrock as a major component of bottom and banks, no matter what size the channel or how the other elements rate, always results in an excellent classification of that reach.

1. Excellent: There is no noticeable change in size distribution. The rock mixture appears to be normal for the kind of geologic sources in the basin and the flow forces of streams of this size and location in the watershed.

   If a shift or change has taken place so there are greater percentages of large rock in the small streams and smaller sizes in large streams, the condition class most appropriate should be checked. It is a matter of degree as follows:

   (Stable Materials 80-100%).

2. Good: Slight shift in either direction.

   (Stable Materials 50-80%).

3. Fair: Moderate shift in size classes.

   (Stable Materials 20-50%).

4. Poor: Marked, a pronounced shift.

   (Stable Materials less than 20%).

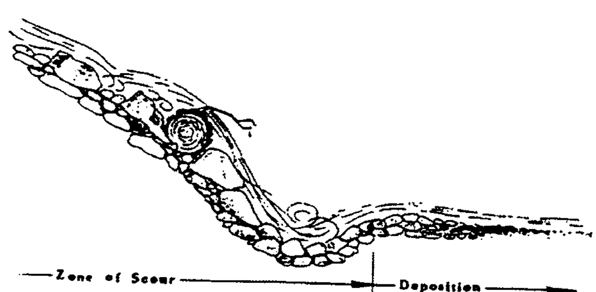
E. Scouring and/or Deposition: Items of size, angularity and brightness already rated above should lead you to some conclusions as to the amount of scouring and/or deposition that is taking place along the channel bottom.

1. Excellent: Neither scouring or deposition is much in evidence. Up to 5% of either or a combination of both may be present along the length of the reach; i.e., 0-5 feet in 100 feet of channel length.

2. Good: Affected length ranges from 5 to 30%. Cuts are found mostly at channel constrictions or where the gradient steepens. Deposition is in pools and backwater areas. Sediment in pools tends to move on through so pools change only slightly in depth but greatly in composition of their size classes.

3. Fair: Moderate changes are occurring. 30 to 50% of the bottom is in a state of flux. Cutting is taking place below obstructions, at constrictions and on steep grades. Deposits in pools now tend to fill the pool and decrease their size.

4. Poor: Both cutting and deposition are common; 50% plus of the bottom is moving not only during high flow periods but at most seasons of the year.

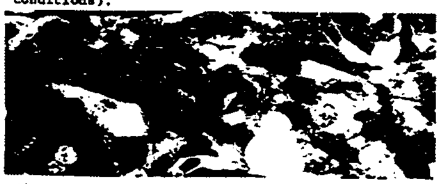


F. Aquatic Vegetation: When some measure of stabilization of the soil-rock components is achieved, the channel bottom becomes fit habitat for plant and animal life. This process begins in the slack water areas and eventually may include the swift water portions of the stream cross section. With a change in volume of flow and/or sedimentation rates, there may also be a temporary loss of the living elements in the aquatic environment. This last item attempts to assess the one macro-aquatic biomass indicator found to best express a change in channel stability.

Clinging Moss and Algae: These lower plant forms do not have roots but cling to the substrate. They are low growing and may first appear as a green to yellow-green slick spot on the bottom rocks. Moss plants continue with slight variation in color but no great change in mass form season to season. Algae by contrast have a peak of growth activity and then die off in great numbers. The slippery conditions they produce persist after death, however.

Both algae and moss inhabit the swift water areas as well as the quiet pools and backwater portions of the stream bottom.

1. Excellent: Clinging plants are abundant throughout the reach from bank to bank. A continuous mat of vegetation is not required but moss and/or algae are readily seen in all directions across the stream.
2. Good: Plants are quite common in the slower portions of the reach but thin out or are absent in the swift flowing portions of the stream.
3. Fair: Plants are found but their occurrence is spotty. They are almost totally absent from rocks in the swifter portions of the reach and may also be absent in some of the slow and still water areas.
4. Poor: Clinging plants are rarely found anywhere in the reach. (This is an unusual situation but could happen under a combination of adverse environmental conditions).



Channels with this much moss are rated "Excellent"

Management Implications

After beating the brush, getting your feet wet and fighting insects, you have established a series of channel ratings. You may now ask, "What do these numbers mean and how are they used in making a management decision?".

By now you know this subject is complicated and precludes indepth answers here. The following brief answers may satisfy you or they may raise more questions. When this happens, it's time to consult your Forest hydrologist for detailed, specific answers.

The numbers and the adjective ratings they relate to mean what they say. A stream channel reach that rates "poor" has a combination of attributes that will require more judicious upstream management of the tributary watershed lands than one rated "excellent". This rating procedure was not designed to fix blame for poor land and water management or to reward good management, although, in time, it could be used for this purpose. Before passing judgment, be aware that natural, undistrubed watersheds may exhibit poor hydrologic conditions. Conversely, a highly developed and used watershed may have a drainage network in good hydologic shape. The rating system will therefore have the most value to land managers who have definite water management goals, who can relate these to impacts of other resource uses and activities, who understand natural limitations, and are willing and able to use the system to define the risks they are willing to take to maintain or alter the status quo.

One use of this rating system is to assess conditions and define impacts along short reaches of stream. Channel conditions can be evaluated in terms of stream stability and potential for damaging water quality at culvert and bridge sites, at campgrounds and administrative sites or wherever livestock and wildlife concentrate near or across a water course. A channel rated "poor" at a culvert site, for example, cannot withstand as much constriction or gradient change as one rated "good". Armed with this additional knowledge, the decision could be to change locations, redesign the intallation or select a different type of structure to protect the aquatic habitat.

The primary use of this system is to assess entire channel systems within a watershed and to use the results in conjunction with other hydrologic analyses to augment silvicultural prescriptions. Rapid changes in the density and areal extent of vegetation on a watershed can increase stream discharges. Channel systems rated "excellent"

can withstand these increases with less damage than systems rated "poor". "Poor" systems can withstand gradual changes better than abrupt changes in the discharge regimen.

To calculate an overall rating for a stream system, (1) multiply the length of each reach by its numeric rating, (2) add the weighted products of all reaches in the system and (3) divide by the total length of the system.

For example:

Reach A	:	3.2 miles x 80 (fair)	=	256
Reach B	:	0.5 miles x 100 (poor)	=	50
Reach C	:	2.0 miles x 40 (good)	=	80
Total	:	5.7 miles		386

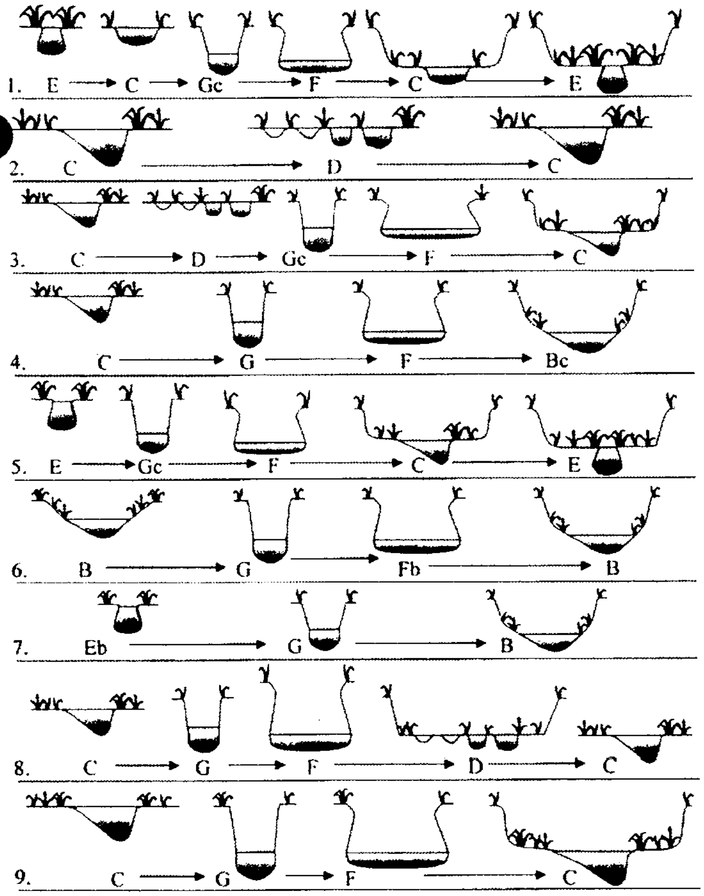
Stream system average: 386 ÷ 5.7 = 68 (Good)

Do not use this part... keep reaches separate for individual analysis. Do not average

Land and water should not be managed on the basis of averages. In the above example, the stream system is composed of three reaches which rate "good" on the average, but a "weak link" has been identified. Reach B is in "poor" condition. One of the obvious uses of this system is to identify "weak links" and to discover what, if any, opportunity exists to correct the condition. It matters little if the damaged area is natural or man-caused. The discovery of "weak links" should reasonably alter upstream land management to the extent necessary to achieve stated land and water management objectives.

The procedures should ultimately serve as a check and a measure of management success. The net effects of each new increment of change within the watershed management unit will ultimately be expressed in the condition of the stream channel responding to a new hydraulic regimen. Prudent managers will seek these trend data by periodic reappraisal of channel conditions and respond to adverse changes before impacts to the water resource become unacceptable and unalterable.

Various Stream Type Succession Scenarios



Stream:	Reach:	Date:	Observers:
LIST ALL COMBINATIONS THAT APPLY			

GENERAL CATEGORY

E	Ephemeral stream channels - flows only in response to precipitation. Often used in conjunction with intermittent (USDA SCS, 1982).
S	Subterranean stream channel - flows parallel to and near the surface for various seasons - a sub-surface flow which follows the stream bed.
I	Intermittent stream channel - one which flows only seasonally, or sporadically. Surface sources involve springs, snow melt, artificial controls, etc. Often this term is associated with flows that re-appear along various locations of a reach, then run subterranean.
P	Perennial stream channels. Surface water persists year long.

SPECIFIC CATEGORY

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring fed condition, backwater etc.
4	Stream flow regulated by glacial melt.
5	Ice flows, ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated stream flow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds, vegetation conversions (forested to grassland) that changes flow response to precipitation events.
9	Rain on snow generated runoff

Stream Size/Stream Order

Stream:	
Reach:	
Date:	
Observers:	
Stream size category (order)	

STREAM SIZE

Category	Bankfull Width meters	Bankfull Width feet	Check appropriate category
S-1	0.305	<1	
S-2	0.3 - 1.5	1 - 5	
S-3	1.5 - 4.6	5 - 15	
S-4	4.6 - 9	15 - 30	
S-5	9 - 15	30 - 50	
S-6	15 - 22.8	50 - 75	
S-7	22.8 - 30.	75 - 100	
S-8	30.5 - 46	100 - 150	
S-9	46- 76	150 - 250	
S-10	76 - 107	250 - 350	
S-11	107 - 150	350 - 500	
S-12	150 - 305	500 - 1000	
S-13	>305	>1000	

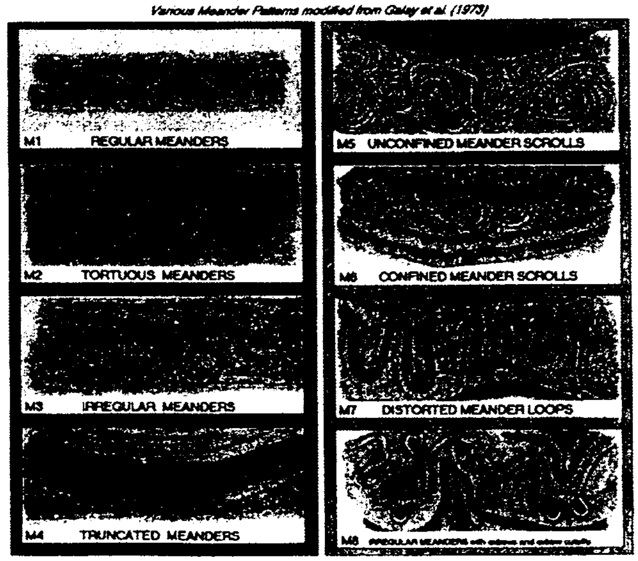
STREAM ORDER

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

Meander Patterns

Stream	Reach					
Date:	Observers					
LIST ALL CATEGORIES THAT APPLY						

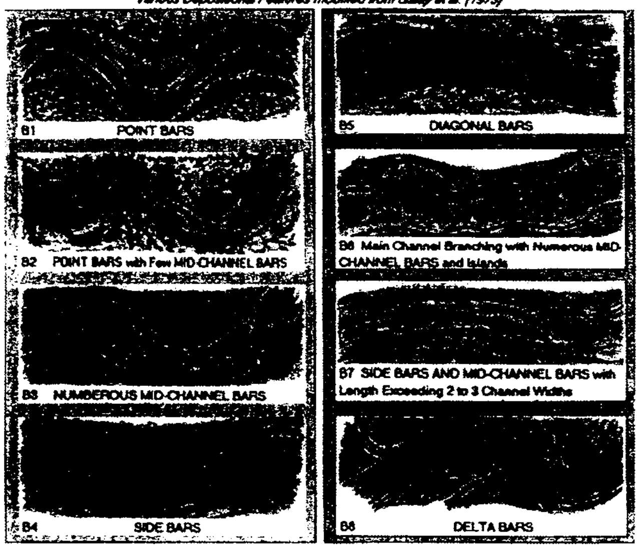
Various Meander Patterns modified from Galay et al. (1973)



Depositional Features

Stream:	Reach:
Date:	Observers:
LIST ALL CATEGORIES THAT APPLY	

Various Depositional Features modified from Galay et al. (1973)



Stream Channel Debris/Blockages

Stream: Reach: Date: Observers:

DESCRIPTION/EXTENT		Materials, which upon placement into the active channel or floodprone area may cause an adjustment in channel dimensions or conditions, due to influences on the existing flow regime.	Check all that apply
D1	NONE	Minor amounts of small, floatable material.	
D2	INFREQUENT	Debris consists of small, easily moved, floatable material; i.e. leaves, needles, small limbs, twigs, etc.	
D3	MODERATE	Increasing frequency of small to medium sized material, such as large limbs, branches and small logs that when accumulated effect 10% or less of the active channel cross-sectional area.	
D4	NUMEROUS	Significant build-up of medium to large sized materials, i.e. large limbs, branches, small logs or portions of trees that may occupy 10 to 30% of the active channel cross-section area.	
D5	EXTENSIVE	Debris "dams" of predominantly larger materials, i.e. branches, logs, trees, etc., occupying 30 to 50% of the active channel cross-section; often extending across the width of the active channel.	
D6	DOMINATING	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section. Such accumulations may divert water into the floodprone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	BEAVER DAMS - FEW	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	BEAVER DAMS - FREQUENT	Frequency of dams is such that backwater conditions exist for channel FREQUENT reaches between structures; where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	BEAVER DAMS - ABANDONED	Numerous abandoned dams, many of which have filled with sediment and/or ABANDONED breached, initiating a series of channel adjustments such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	HUMAN INFLUENCES	Structures, facilities, or materials related to land uses or development located within the floodprone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures, and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

Riparian Vegetation

Stream:	Reach:
Date:	Observers:

Existing Composition
Existing Vigor, Density
Potential

Number	Community	Density	Code	Percent of Total Stand
1	Bare		RV1	
2	Forbs only	Low	RV2a	
		Moderate	RV2b	
3	Annual grass with forbs	Low	RV3a	
		Moderate	RV3b	
		High	RV3c	
4	Perennial grass	Low	RV4a	
		Moderate	RV4b	
		High	RV4c	
5	Rhizomatous grasses (bluegrass,	Low	RV5a	
		Moderate	RV5b	
		High	RV5c	
6	Low brush	Low	RV6a	
		Moderate	RV6b	
		High	RV6c	
7	High brush	Low	RV7a	
		Moderate	RV7b	
		High	RV7c	
8	Combination grass/brush	Low	RV8a	
		Moderate	RV8b	
		High	RV8c	
9	Deciduous overstory	Low	RV9a	
		Moderate	RV9b	
		High	RV9c	
10	Deciduous with brush/grass unde	Low	RV10a	
		Moderate	RV10b	
		High	RV10c	
11	Perennial overstory	Low	RV11a	
		Moderate	RV11b	
		High	RV11c	
12	Wetland vegetation community		RV12a	
		bog	RV12b	
		fen	RV12c	
		marsh	RV12d	

Bank Erodibility Hazard Rating Guide

Bank Erosion Potential		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
EXTREME	Value	>2.8	<0.05	<5	>119	<10
	Index	10	10	10	10	10

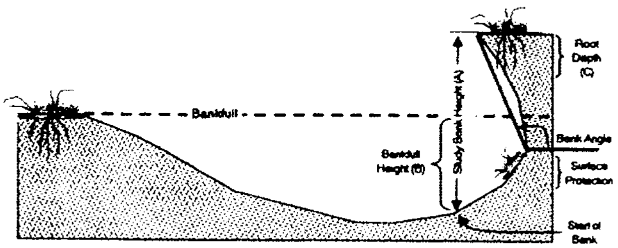
Bank Materials

- Bedrock (Bedrock banks have very low bank erosion potential)
- Boulders (Banks composed of boulders have low bank erosion potential)
- Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)
- Sand (Add 10 points)
- Silt Clay (+ 0: no adjustment)

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

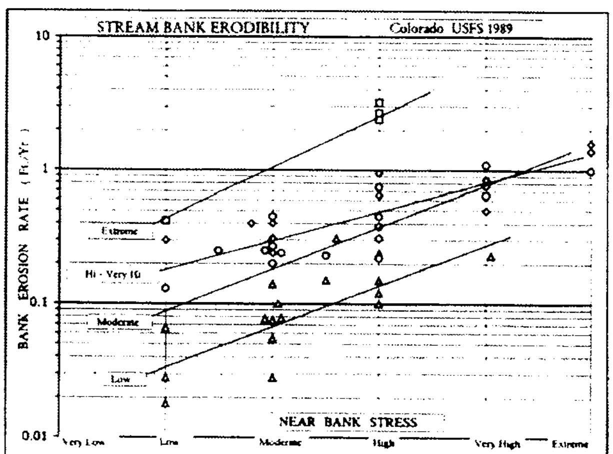
VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

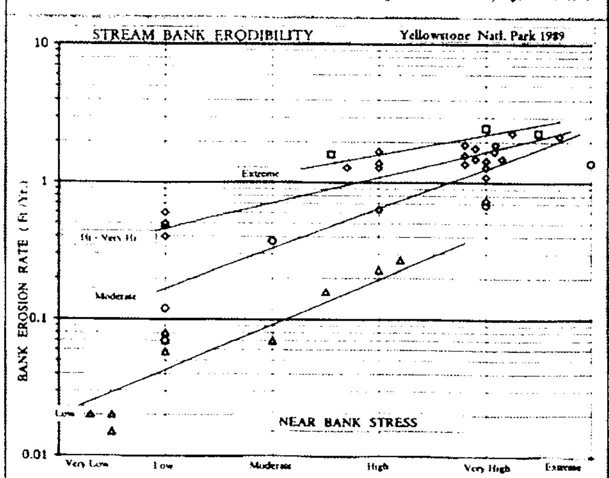


Stream: Reach: Cross Section: Date: Crew:

Bank Sketch

ERODIBILITY VARIABLE			INDEX	ERODIBILITY RATING
Bank Height/Bankfull Height	Bank Height (ft) A	Bankfull Height (ft) B	A/B	
Root Depth/Bank Height	Root Depth (ft) C		C/A	
Weighted Root Density	Root Density (%) D		D*(C/A)	
Bank Angle	Bank Angle (degrees)			
Surface Protection	Surface Protection (%)			
Materials:				
Stratification:				
GRAND TOTAL:				





Near-Bank Stress Calculation and Bank Erosion Prediction

Stream Reach Cross Section

Date Crew: Bank (Left or Right)

	Left Bankfull Station (ft)	Right Bankfull Station (ft)	Width ft	Area ft²	Wetted Perimeter ft	Hydraulic Radius ft	Water Surface Slope ft/ft	Shear Stress (γRS) lb/ft²
Total Cross Section	LBF	RBF	(W_{tot})	(A_{tot})	(Wp_{tot})	(R_{tot})	S	τ
Near-Bank 1/3	(LBF_{nb})	(RBF_{nb})	(W_{nb})	(A_{nb})	(Wp_{nb})	(R_{nb})	S_{nb}	τ_{nb}

		NBS Categories					
Near Bank Stress (τ_{nb}/τ)		< 0.8 Very Low	0.8 - 1.05 Low	1.06 - 1.14 Moderate	1.15 - 1.19 High	1.2 - 1.6 Very High	>1.6 Extreme

Near Bank Stress Rating (Category)	BEHI Rating

Bank Erosion Prediction (ft/yr)	

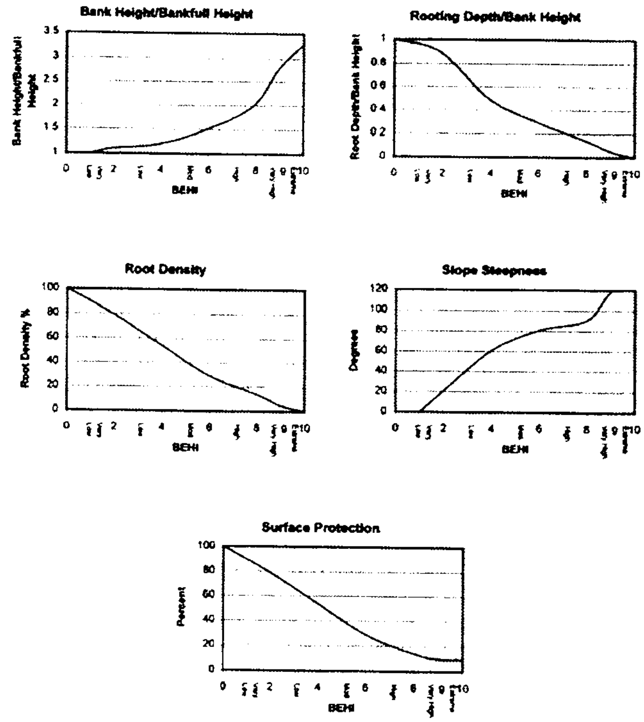
Circle Curve Used

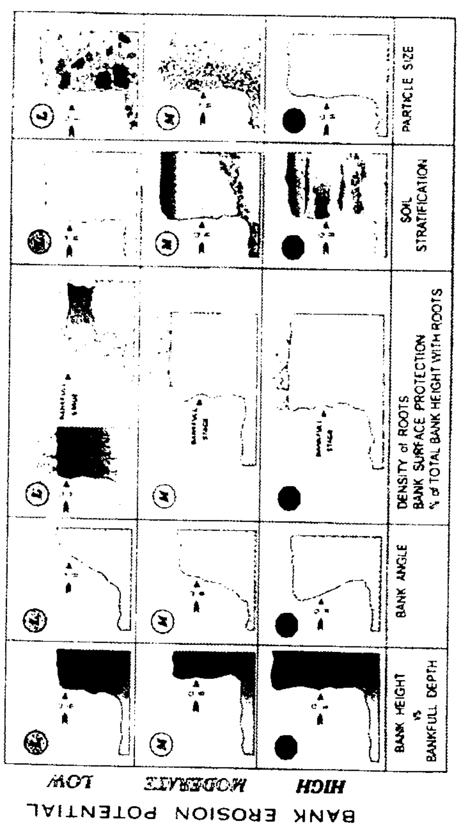
- Yellowstone
- Colorado
- Other

Total Bank Erosion Calculation

Stream:			Total Bank Length:		Stream Type:	
Observers:			Date:		Graph Used:	
	BEHI (adjective)	Near Bank Stress (adjective)	Erosion Rate (ft/yr)	Length of Bank (ft)	Bank Height (ft)	Erosion Sub-Total (ft^3/yr)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
I. Sum erosion sub-totals for each BEHI/NBS combination					Total Erosion (ft^3/yr)	
II. Divide total erosion ($feet^3$) by 27 $feet^3/yard^3$					Total Erosion (yd^3/yr)	
III. Multiply Total Erosion ($yard^3$) by 1.3 (conversion of yd^3 to tons for average material type)					Total Erosion (tons/year)	

Streambank Erodibility Variables





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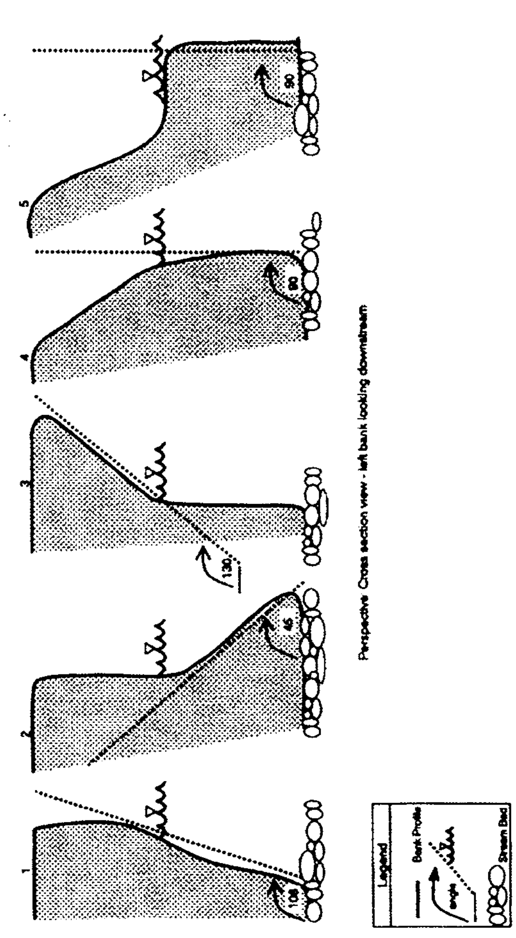
1st day RAM Forms

Five Common Bank Angle Scenarios



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1st day RAM Forms

Summary of Stability Condition Categories

Stream:		**Location:**				**Date:**	**Observers:**
Level III Variables	Stream Type:	Flow Regime:	Stream Size:	Stream Order:	Meander Pattern:	Depositional Pattern:	Debris/Channel Blockage:
	Riparian Vegetation: Current Compo/density:		Potential Comp/density:		Altered Channel State: Dimension, Pattern, Profile, Materials:		
Channel Dimension	Mean Bankfull Depth (ft):	Mean Bankfull Width (ft):	Width/Depth Ratio (ft):	Remarks:			
Channel Dimension Relationships	Existing Width/Depth Ratio(W/D_{ex}):	Reference Condition Width/Depth Ratio (W/D_{ref}):	$(W/D_{ex})/(W/D_{ref})$:	Circle:	Stable	Moderately Unstable	Unstable / Highly Unstable
Channel Pattern		MWR	Lm/W_{bkf}	Rc/W_{bkf}	Sinuosity	Remarks:	
	Mean (Range)						
River Profile and Bed Features	Circle: Riffle/Pool	Step/Pool	Plane Bed	Convergence/Divergence	Dunes/antidunes/smooth bed		
	Max Bankfull Depth (ft): Riffle	Pool	Depth Ratio (Max/Mean): Riffle	Pool	Pool to Pool Spacing:	Slope: Valley:	Slope: Average Bankfull:
Channel Stability Rating	Pfankuch Rating:			Pfankuch Adjusted by Stream Type:			
Vertical Stability	Bank Height Ratio:	Stable	Moderately unstable	Unstable	Highly Unstable	Width of Flood Prone Area (ft):	Entrenchment Ratio:
Bank Erosion Summary	Length of Bank Studied (ft):	Annual Streambank Erosion Rate (tons/yr):	Curve Used:	Dominant BEHI:	Dominant NBS:		
Stream Channel Scour/Deposition Potential	Largest Particle - Bar Sample (mm):	τ_{ci}:	Existing $Depth_{BKF}$:	Required $Depth_{BKF}$:	Existing $Slope_{BKF}$:	Required $Slope_{BKF}$:	
	Circle: Stable	Aggradation	Degradation	Enlargement			
Stream Evolution Scenario	→ → → → →					Existing Stream State (type):	Potential Stream State (type):
Sediment Supply (Channel Source)	Circle: High	Moderate	Low	Score:	Remarks:		

HABITAT ASSESSMENT FIELD DATA SHEET - RIFFLE/RUN STREAMS

Habitat Parameter	Condition Category			
	Excellent	**Good**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is <1.0 f/s, deep is >2 ft.).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand, or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5a. Channel Flow Status - Maintained Flow Volume	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	10 9	8 7 6	5 4 3	2 1 0
5b. Channel Flow Status – Flashiness	Vegetation along the stream bank is complete nearly to the waters edge. Little or no evidence of frequent changes in discharge and/or frequent high water events that scours stream bank vegetation. Channel retention devices (if present) stable and extending laterally across the stream channel.	Some evidence of bank scour approximately 4-8 inches above the waters surface. Channel retention devices (if present) mostly stable and extending partially into the active stream channel.	Bank scour evidence 9-18 inches above the waters surface. Channel retention devices (if present) tend to may more against the stream bank rather than extending into the active channel.	Bank scour (>20 inches) along the stream channel. Channel retention devices are generally absent from the active channel and/or may exist as woody debris jams along the stream bank above the active channel.
SCORE	10 9	8 7 6	5 4 3	2 1 0

Parameter	Excellent		Good			Marginal			Poor		
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.		Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging (greater than past 20 yr) may be present, but recent channelization is not present.			Channelization is continuous but not recent (>5 years). Embankments without mature trees and dominated by grasses and shrubs			Stream reach has been recently channelized (<5 years). OR Banks shored with gabion, rock, cement or bare earth. Instream habitat greatly altered or removed entirely. Bank vegetation moderately dense to absent		
SCORE	20 19 18 17 16		15 14 13 12 11			10 9 8 7 6			5 4 3 2 1 0		
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.		Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.			Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.			Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.		
SCORE	20 19 18 17 16		15 14 13 12 11			10 9 8 7 6			5 4 3 2 1 0		
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.		Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.			Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.			Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.		
SCORE (LB)	Left Bank 10	9	8	7	6	5	4	3	2	1	0
SCORE (RB)	Right Bank 10	9	8	7	6	5	4	3	2	1	0
9. Vegetative Protection (score each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.		70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.			50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.			Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.		
SCORE (LB)	Left Bank 10	9	8	7	6	5	4	3	2	1	0
SCORE (RB)	Right Bank 10	9	8	7	6	5	4	3	2	1	0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >150 feet and dominated by native vegetation including trees, shrubs, or non-woody macrophytes or wetlands; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. Human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.		Width of riparian zone 75-150 feet; human activities have impacted zone only minimally.			Width of riparian zone 10-75 feet; human activities have impacted zone a great deal.			Width of riparian zone <10 feet; little or no riparian vegetation due to human activities.		
SCORE (LB)	Left Bank 10	9	8	7	6	5	4	3	2	1	0
SCORE (RB)	Right Bank 10	9	8	7	6	5	4	3	2	1	0

Total Score________________

HABITAT ASSESSMENT FIELD DATA SHEET - GLIDE/POOL STREAMS

Habitat Parameter	Condition Category			
	Excellent	**Good**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of island or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand, or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5a. Channel Flow Status - Maintained Flow Volume	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	10 9	8 7 6	5 4 3	2 1 0
5b. Channel Flow Status – Flashiness	Vegetation along the stream bank is complete nearly to the waters edge. Little or no evidence of frequent changes in discharge and/or frequent high water events that scours stream bank vegetation. Large woody debris (if present) stable and extending laterally across the stream channel	Some evidence of bank scour approximately 4-8 inches above the waters surface. Large woody debris (if present) mostly stable and extending partially into the active stream channel.	Bank scour evidence 9-18 inches above the waters surface. Large woody debris (if present) tend to lay more against the stream bank rather than extending into the active channel.	Bank scour (>20 inches) along the stream channel. . Large woody debris are generally absent from the active channel and/or may exist as woody debris jams along the stream bank above the active channel.
SCORE	10 9	8 7 6	5 4 3	2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization is continuous but not recent (>5 years). Embankments without mature trees and dominated by grasses and shrubs	Stream reach has been recently channelized (<5 years). OR Banks shored with gabion, rock, cement or bare earth. Instream habitat greatly altered or removed entirely. Bank vegetation moderately dense to absent
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Excellent	**Good**	**Marginal**	**Poor**
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas).	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line. (Note: lack of sinuosity may be due to channelization)	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation has been removed to 2 inches or less in average stubble height.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >150 feet and dominated by native vegetation including trees, shrubs, or non-woody macrophytes or wetlands; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. Human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 75-150 feet; human activities have impacted zone only minimally.	Width of riparian zone 10-75 feet; human activities have impacted zone a great deal.	Width of riparian zone <10 feet; little or no riparian vegetation due to human activities.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ______________

Flow Regime

Stream:	Reach:	Date:	Observers:
LIST ALL COMBINATIONS THAT APPLY			

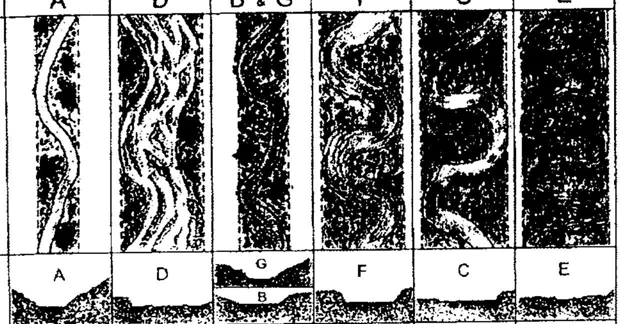
GENERAL CATEGORY

E	Ephemeral stream channels - flows only in response to precipitation. Often used in conjunction with Intermittent (USDA SCB, 1982).
S	Subterranean stream channel - flows parallel to and near the surface for various seasons - a sub-surface flow which follows the stream bed.
I	Intermittent stream channel -one which flows only seasonally, or sporadically. Surface sources involve springs, snow melt, artificial controls, etc. Often this term is associated with flows that re-appear along various locations of a reach, then run subterranean.
P	Perennial stream channels. Surface water persists year long.

SPECIFIC CATEGORY

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring fed condition, backwater etc.
4	Stream flow regulated by glacial melt.
5	Ice flows, ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated stream flow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds, vegetation conversions (forested to grassland) that changes flow response to precipitation events.
9	Rain on snow generated runoff.

Meander Width Ratio by Stream Type Categories



STREAM TYPE	A	D	B & G	F	C	E
PLAN VIEW						
CROSS SECTION VIEW						
AVERAGE VALUES	1.5	1.1	3.7	5.3	11.4	24.2
RANGE	1 - 3	1 - 2	2 - 8	2 - 10	4 - 20	20 - 40

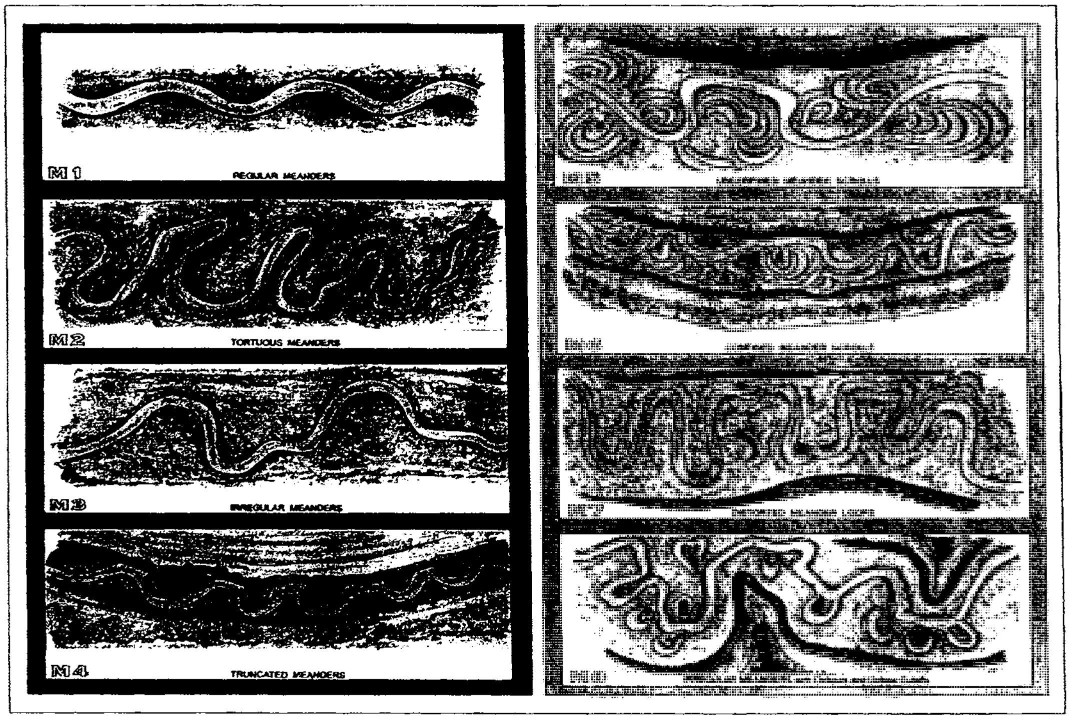
Stream Channel Debris/Blockages

Stream: Reach: Date: Observers:

DESCRIPTION/EXTENT		Materials, which upon placement into the active channel or floodprone area may cause an adjustment in channel dimensions or conditions, due to influences on the existing flow regime.	Check all that apply
D1	NONE	Minor amounts of small, floatable material.	
D2	INFREQUENT	Debris consists of small, easily moved, floatable material; i.e. leaves, needles, small limbs twigs, etc	
D3	MODERATE	Increasing frequency of small to medium sized material, such as large limbs, branches and small logs that when accumulated effect 10% or less of the active channel cross-sectional area.	
D4	NUMEROUS	Significant build-up of medium to large sized materials, i.e. large limbs, branches, small logs or portions of trees that may occupy 10 to 30% of the active channel cross-section area	
D5	EXTENSIVE	Debris "dams" of predominantly larger materials, i.e. branches, logs, trees, etc., occupying 30 to 50% of the active channel cross-section; often extending across the width of the active channel	
D6	DOMINATING	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section. Such accumulations may divert water into the floodprone areas and form fish migration barriers, even when flows are at less than bankfull	
D7	BEAVER DAMS - FEW	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams	
D8	BEAVER DAMS - FREQUENT	Frequency of dams is such that backwater conditions exist for channel FREQUENT reaches between structures, where streamflow velocities are reduced and channel dimensions or conditions are influenced	
D9	BEAVER DAMS - ABANDONED	Numerous abandoned dams, many of which have filled with sediment and/or ABANDONED breached, initiating a series of channel adjustments such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	HUMAN INFLUENCES	Structures, facilities, or materials related to land uses or development located within the floodprone area such as diversions or low head dams, controlled by-pass channels, velocity control structures, and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur	

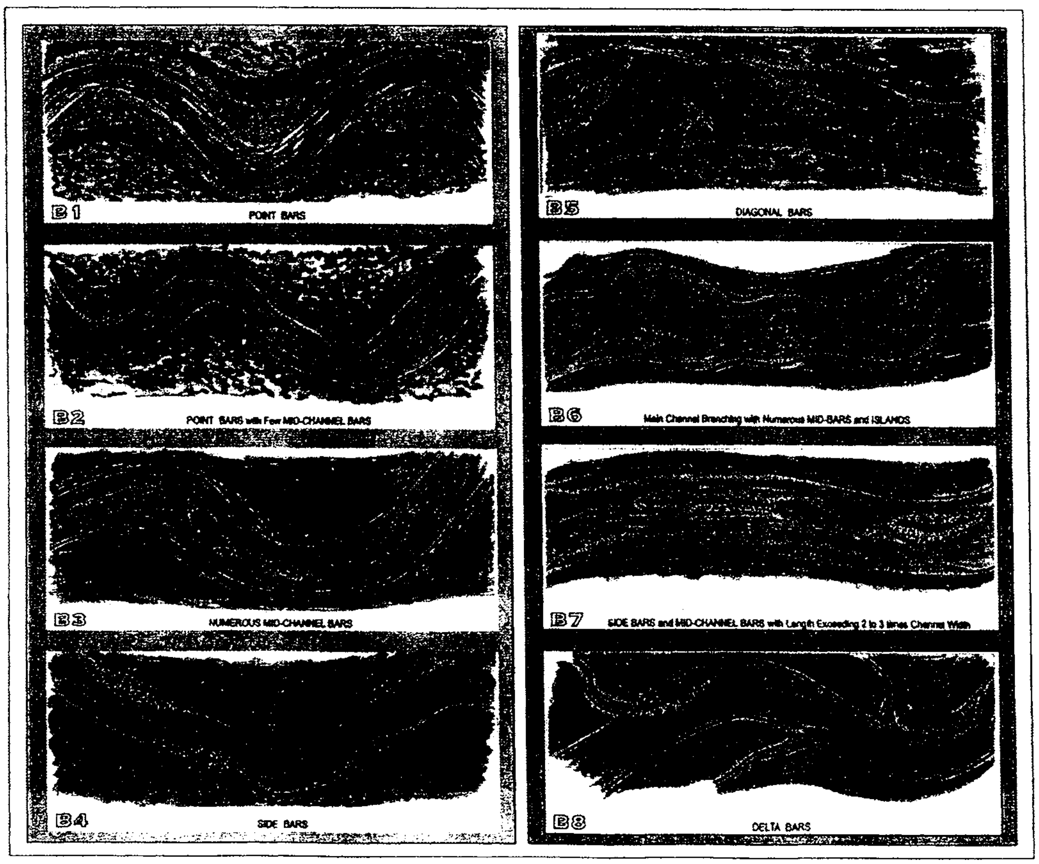
LIST ALL CATEGORIES THAT APPLY					

Various Meander Patterns modified from Galay et al. (1973)



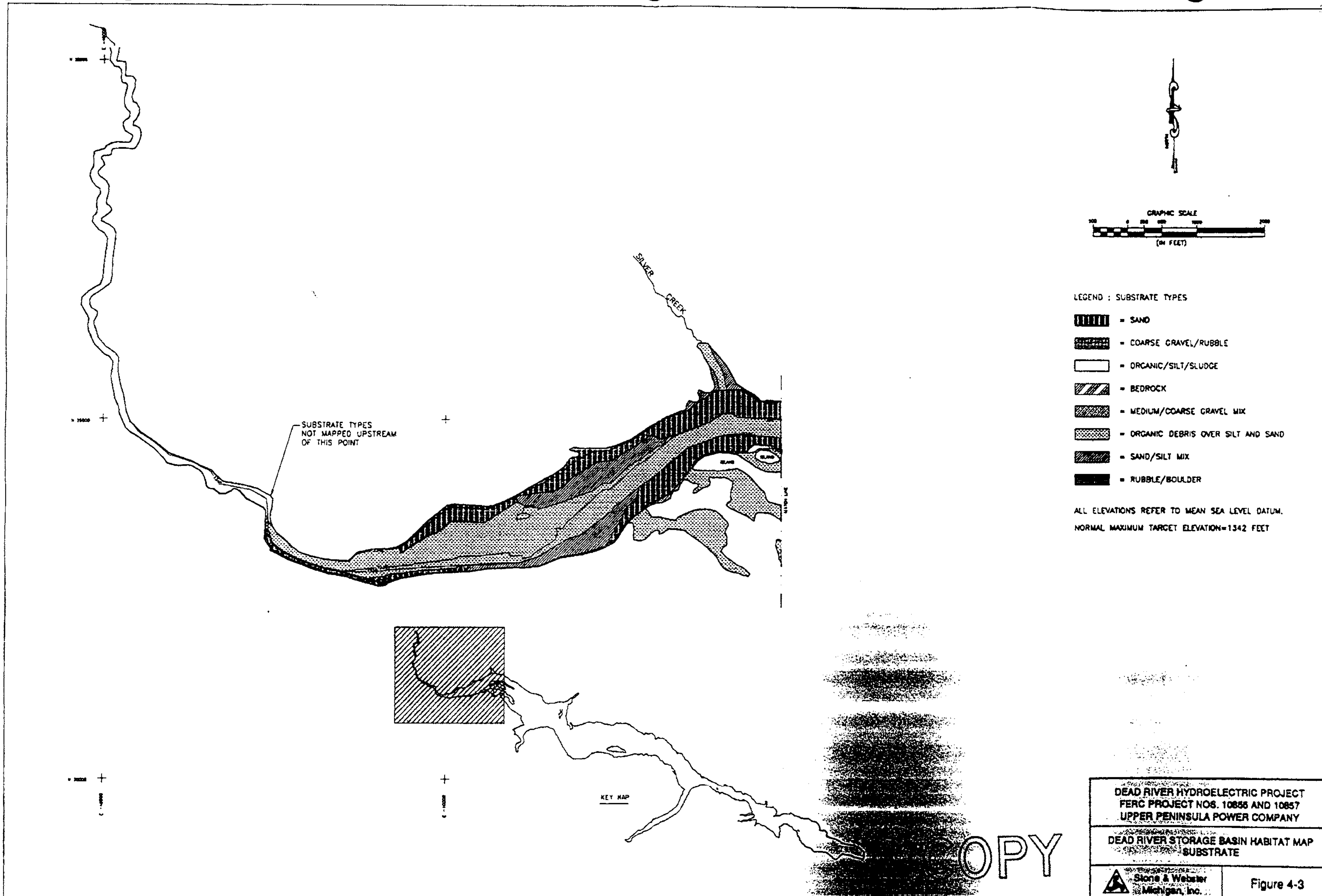
LIST ALL CATEGORIES THAT APPLY					

Various Depositional Features modified from Galay et al. (1973)



Appendix C
FERC Reservoir Figures

Stone & Webster Michigan, Inc. *Dead River Hydroelectric Project (FERC Preliminary Permit Nos. 10855 and 10857)*. Volume IV, Exhibit E. April 1994.



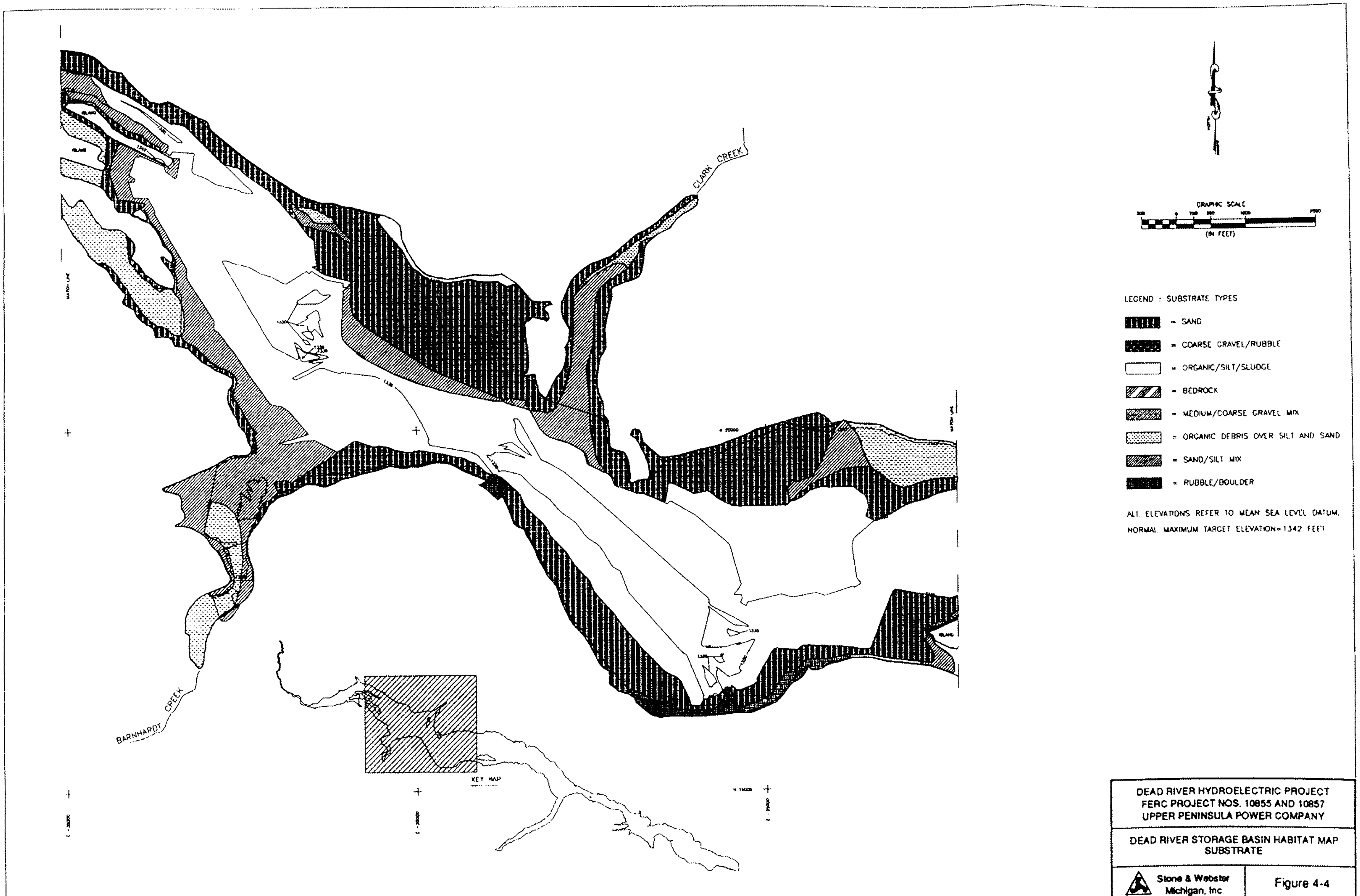
DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

DEAD RIVER STORAGE BASIN HABITAT MAP
SUBSTRATE

Stone & Webster Michigan, Inc.

Figure 4-3

Document # GB-0046

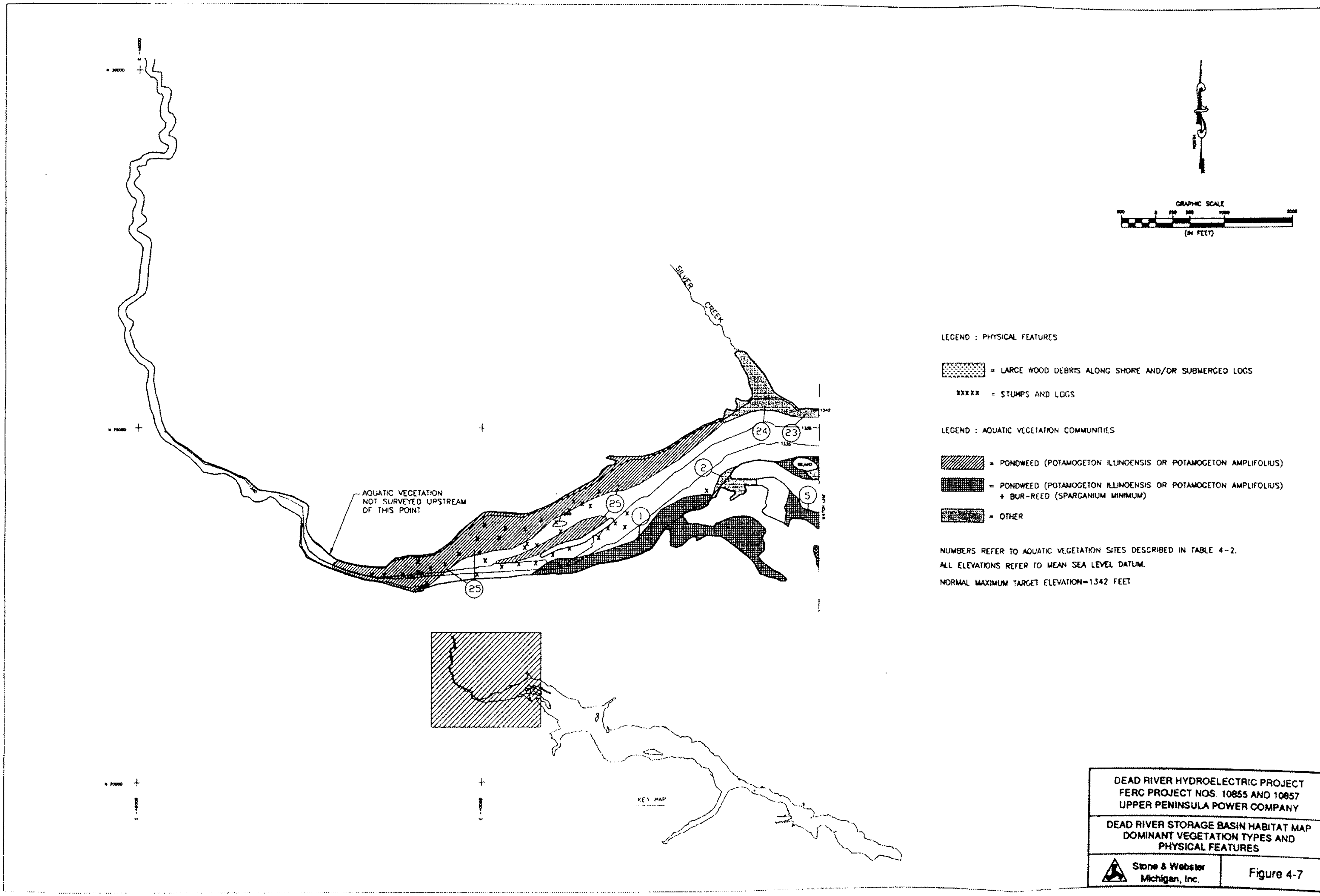


DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

DEAD RIVER STORAGE BASIN HABITAT MAP
SUBSTRATE

Stone & Webster Michigan, Inc.

Figure 4-4

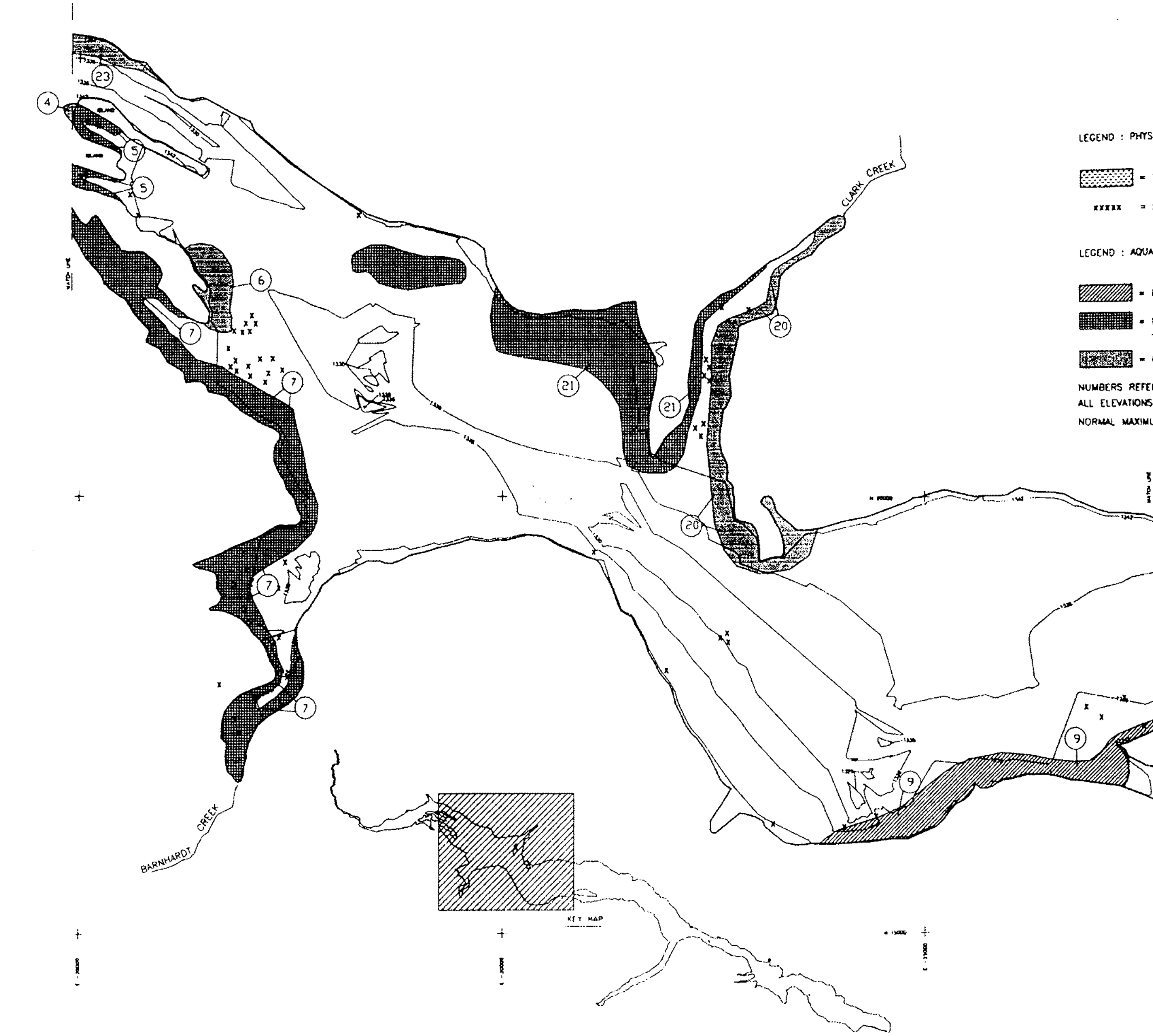


DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

DEAD RIVER STORAGE BASIN HABITAT MAP
DOMINANT VEGETATION TYPES AND PHYSICAL FEATURES

Stone & Webster Michigan, Inc.

Figure 4-7



LEGEND : PHYSICAL FEATURES

= LARGE WOOD DEBRIS ALONG SHORE AND/OR SUBMERGED LOGS

xxxxx = STUMPS AND LOGS

LEGEND : AQUATIC VEGETATION COMMUNITIES

= PONDWEED (POTAMOGETON ILLINOENSIS OR POTAMOGETON AMPLIFOLIUS)

= PONDWEED (POTAMOGETON ILLINOENSIS OR POTAMOGETON AMPLIFOLIUS) + BUR-REED (SPARGANIUM MINIMUM)

= OTHER

NUMBERS REFER TO AQUATIC VEGETATION SITES DESCRIBED IN TABLE 4-2.
ALL ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
NORMAL MAXIMUM TARGET ELEVATION=1342 FEET

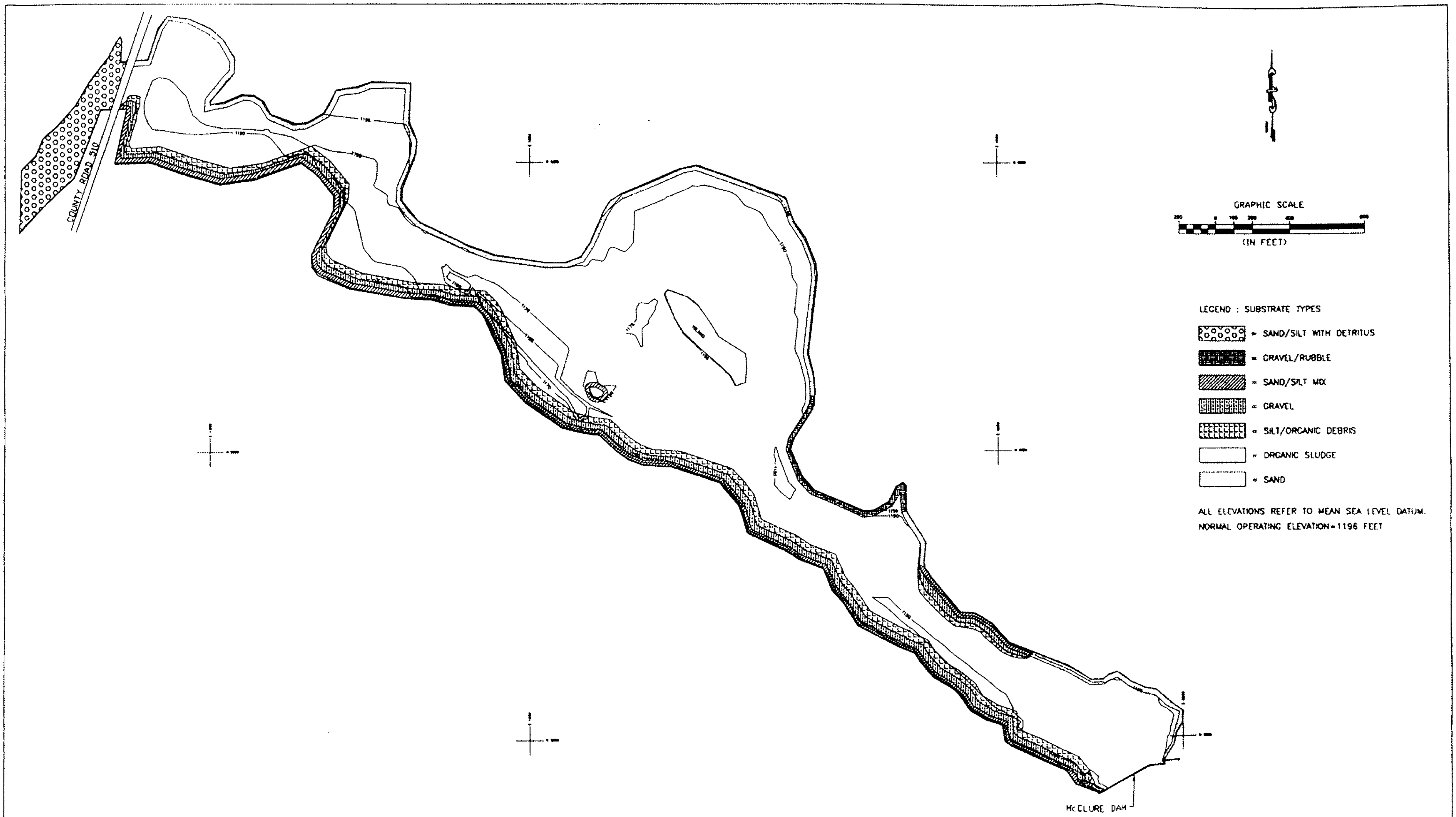
GRAPHIC SCALE (IN FEET)

DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

DEAD RIVER STORAGE BASIN HABITAT MAP
DOMINANT VEGETATION TYPES AND
PHYSICAL FEATURES

Stone & Webster Michigan, Inc.

Figure 4-8

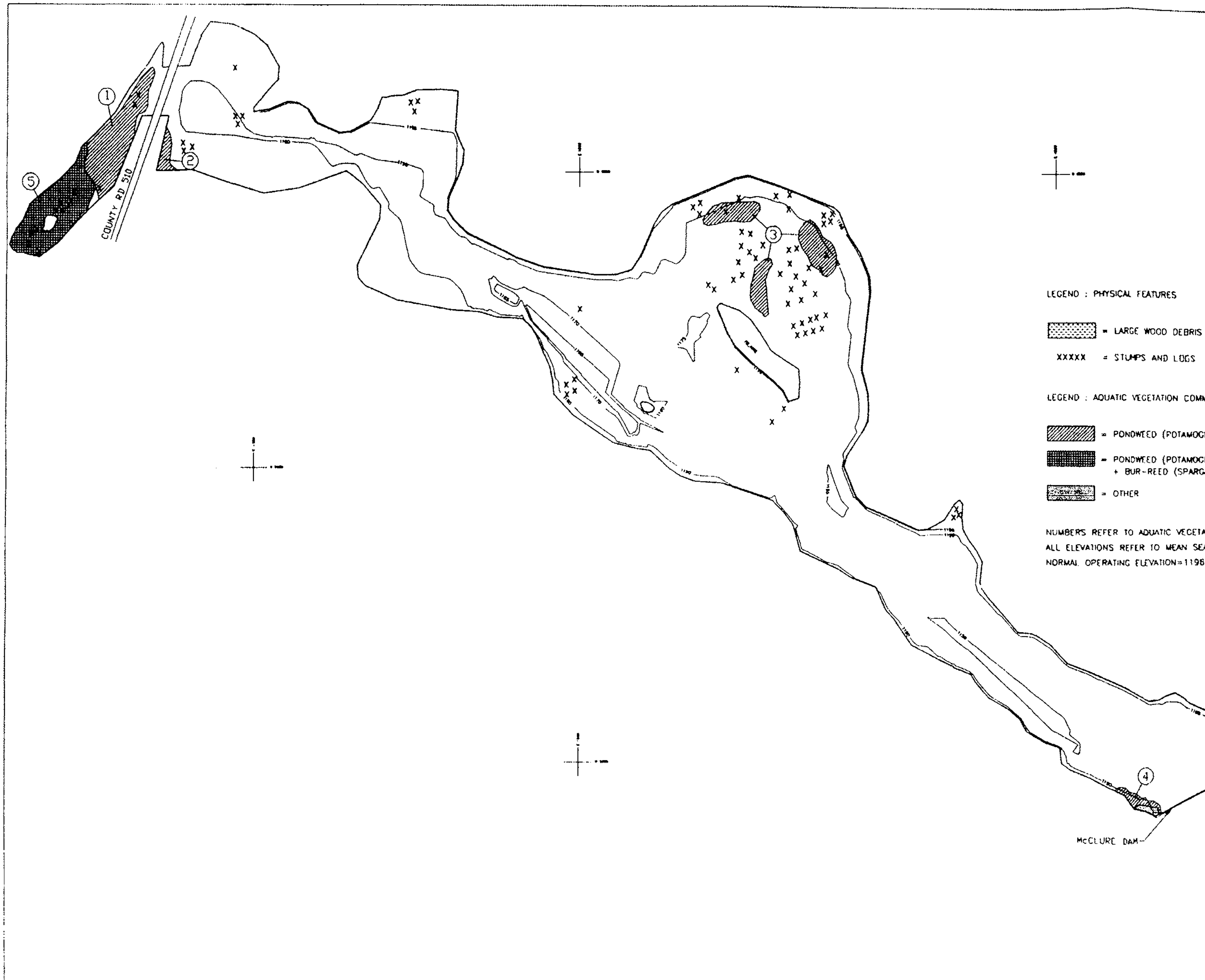


DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

McCLURE STORAGE BASIN HABITAT MAP
SUBSTRATE

Stone & Webster Michigan, Inc.

Figure 4-11



DEAD RIVER HYDROELECTRIC PROJECT
FERC PROJECT NOS. 10855 AND 10857
UPPER PENINSULA POWER COMPANY

McCLURE STORAGE BASIN HABITAT MAP
DOMINANT VEGETATION TYPES AND PHYSICAL FEATURES

Stone & Webster Michigan, Inc.

Figure 4-12

Appendix D
Selected Field Reconnaissance Photos

Photos have been selected to illustrate stream conditions observed during the field assessment (August 18-23, 2003). First are photos that are typical (representative) of reach conditions, followed by those that are atypical (non-representative), but are worthy of note.

Photos are presented from upstream to downstream, starting from upstream of Silver Lake. The photo label is presented in the following format: Reach # - Sub-reach # - Photo # - Direction photographer was facing (N, NE, E, SE, S, SW, W, NW). Lake photos do not have sub-reach designators. Stream "left bank" and "right bank" descriptions are on the left and right, respectively, while looking downstream.

Reach 0 Upstream of Silver Lake Basin—Typical Conditions Observed (Reference Reach)

Stream Sub-Reach R00-01 (reference reach). R00-01-P126-NW.JPG. Looking upstream at riffle.

Stream Sub-Reach R00-01 (reference reach). R00-01-P135-E.JPG. Looking downstream at riffle.

Reach 1 Former Silver Lake Basin—Typical Conditions Observed

Stream Sub-Reach R01-03 (former Silver Lake Basin). R01-03-P109-S.JPG. Looking upstream.

Stream Sub-Reach R01-02 (former Silver Lake Basin). R01-02-P102-W.JPG. Looking upstream.

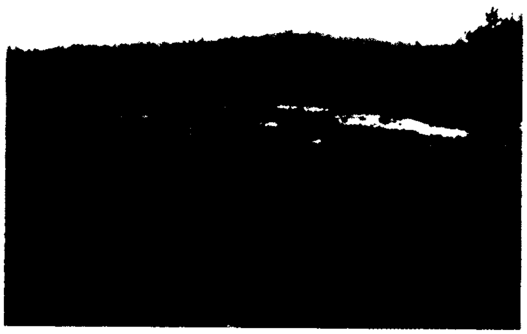
Stream Sub-Reach R01-01 (downstream of current Silver Lake Basin to fuse plug). R01-01-P41-N.JPG. Looking upstream into Silver Lake Basin.

Stream Sub-Reach R01-01 (downstream of current Silver Lake Basin to fuse plug). R01-01-P27-E.JPG. Looking upstream toward right bank.

Reach 2 Downstream of Silver Lake Basin—Typical Conditions Observed

Stream Sub-Reach R02-12 (downstream of Silver Lake dam). R02-12-P05-E.JPG. Looking downstream in channel below original Silver Lake outlet structure. Downstream end of this channel is blocked with sand.

Stream Sub-Reach R02-11 (downstream of R02-12, downstream of dam). R02-11-P150-NE.JPG. Looking upstream toward ponded area (pond is not visible; it is behind sandbar).



Stream Sub-Reach R02-10 (downstream of fuse plug, upstream of confluence with original channel). R02-10-P69-SW.JPG. Looking downstream over R02-10 from far left bank.

Stream Sub-Reach R02-09. R02-09-P129-N.JPG. Looking upstream at left bank.

Stream Sub-Reach R02-08. R02-08-P104-N.JPG. Looking upstream at left bank.

Stream Sub-Reach R02-07 (upstream of Connors Creek). R02-07-P84-S.JPG. Looking upstream at left bank.

Stream Sub-Reach R02-06 (Connors Creek confluence). R02-06-P56-W.JPG. Looking upstream.

Stream Sub-Reach R02-05. R02-05-P25-SE.JPG. Looking upstream.

Stream Sub-Reach R02-04 (upstream of Mulligan Creek confluence, high banks area). R02-04-P27-SE.JPG. Downstream from top of cobble island, above confluence.

Stream Sub-Reach R02-04 (upstream of Mulligan Creek confluence, high banks area). R02-04-P19-SE.JPG. Looking upstream at main channel.

Stream Sub-Reach R02-04 (at confluence with Mulligan Creek). R02-04-P118-W.JPG. Depositional area near confluence with Mulligan Creek.

Stream Sub-Reach R02-03 (at confluence with Mulligan Creek). R02-03-P96-NW.JPG. Looking upstream.

Stream Sub-Reach R02-02 (upstream of County Road AAO Bridge). R02-02-P69-N.JPG. Looking upstream, right bank with new rip-rap.

Stream Sub-Reach R02-01 (downstream of County Road AAO Bridge, upstream of Dead River Storage Basin). R02-01-P45-E.JPG. From west side of former County Road AAO Bridge.

Stream Sub-Reach R02-01 (downstream of County Road AAO Bridge, upstream of Dead River Storage Basin). R02-01-P09-N.JPG. From on top of sand deposition looking at riffle.

Reach 2 Downstream of Silver Lake Basin—Other Conditions Observed

Stream Sub-Reach R02-10. R02-10-PT06-E.JPG. Potential wetland area south of former Silver Lake Basin, along east side of the new channel.

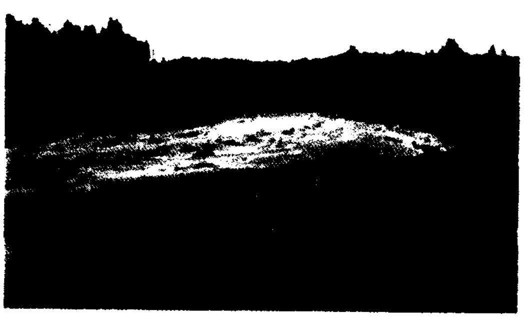
Stream Sub-Reach R02-09. R02-09-P140-W.JPG. Looking at slumped right bank.

Stream Sub-Reach R02-09. R02-09-P142-N.JPG. Looking upstream at confluence, eroded right bank, trees falling into channel.

Stream Sub-Reach R02-06. R02-06-P47-S.JPG. Looking upstream near Connors Creek confluence with the Dead River.

Stream Sub-Reach R02-06. R02-06-P66-N.JPG. Looking at left bank of high flow area near confluence of Connors Creek and the Dead River.

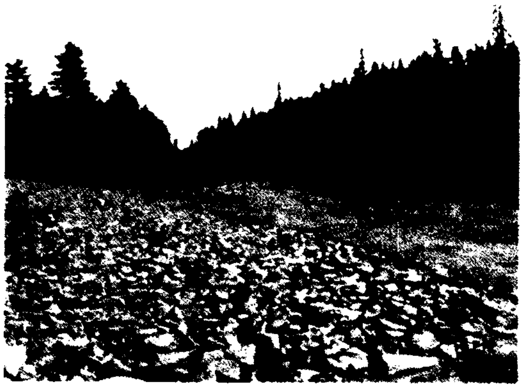
Stream Sub-Reach R02-04. R02-04-P109-W.JPG. Ponded area draining to Mulligan Creek.



Stream Sub-Reach R02-04. R02-04-P125-W.JPG. Secondary channel along south and southwestern banks (70-120 ft high, 80-90 degrees).

Stream Sub-Reach R02-03. R02-03-P99-NW. JPG. Downstream end of Mulligan Creek, looking up Mulligan Creek. Mouth is blocked with sand.

Stream Sub-Reach R02-03. R02-03-P100-SW.JPG. Looking across sand deposition at mouth of Mulligan Creek. Dead River is behind photographer.



Stream Sub-Reach R02-03. R02-03-P72-N.JPG. Looking upstream of County Road AAO Bridge.

Stream Sub-Reach R02-02. R02-02-P47-NE.JPG. Looking downstream of County Road AAO Bridge.

Stream Sub-Reach R02-01. R02-01-P33-N.JPG. Side channel forming downstream of County Road AAO Bridge, potential wetland area.

Stream Sub-Reach R02-01. R02-01-P44-N.JPG. West side of channel downstream of County Road AAO Bridge, potential wetland area.

Reach 3 Dead River Storage Basin — Typical Conditions Observed

Reach 03. R03-P006-SE.JPG. Facing southeast. Sand deposit in upper Dead River Storage Basin.

Reach 03. R03-P010-S.JPG. Facing south. Sand deposit in upper Dead River Storage Basin.

Reach 03. R03-P012-W.JPG. Facing west. Sand deposit in upper Dead River Storage Basin.

Reach 03. R02E-P205-SW.JPG. Facing southwest. Overbank sand deposit adjacent to apparent scoured channel just upstream of the Dead River Storage Basin.

Reach 4 Downstream of Dead River Storage Basin—Typical Conditions Observed

Stream Sub-Reach R04-01 (downstream of Dead River Storage Basin penstock release). R04-02-P07-SE.JPG. Looking downstream from Hoist Dam spillway.

Stream Sub-Reach R04-01 (downstream of Dead River Storage Basin penstock release). R04-01-P01-SE.JPG. Looking downstream, vegetated gravel bar divides stream flow.

Reach 5 McClure Basin —Typical Conditions Observed

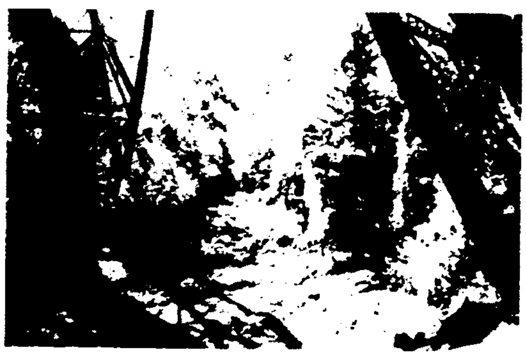
Reach 05. R05-P074-W.JPG. Facing west. Typical channel reach upstream of the boat ramp in the riverine backwater approach to the reservoir.

Reach 05. R05-P075-E.JPG. Facing east. Typical channel reach u/s of the boat ramp in the riverine backwater approach to the reservoir.

Reach 05. R05-P081-W.JPG. Facing west. Looking upstream at County Road 510 bridge.

Reach 05. R05-P084-S.JPG. Facing south. Looking across channel from the boat ramp.

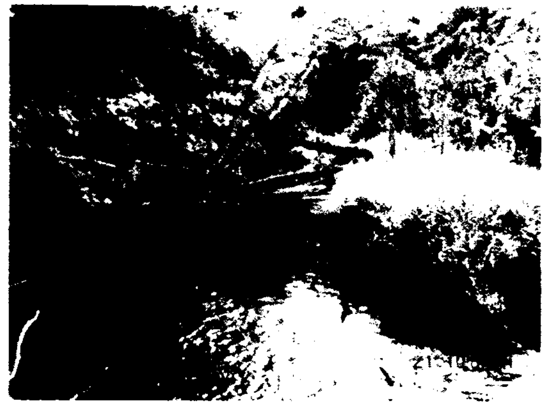
Reach 6 Downstream of McClure Basin—Typical Conditions Observed



Stream Sub-Reach R06-10 (downstream of McClure Dam. R06-10-P80-W.JPG. Looking upstream under railroad trestle.

Stream Sub-Reach R06-09-DEQ-A (downstream of Railroad trestle). R06-09-P76-SW.JPG. Looking upstream at gravel bars and stable banks.

Stream Sub-Reach R06-08. R06-08-P50-SW.JPG. Looking downstream, woody debris on left bank.



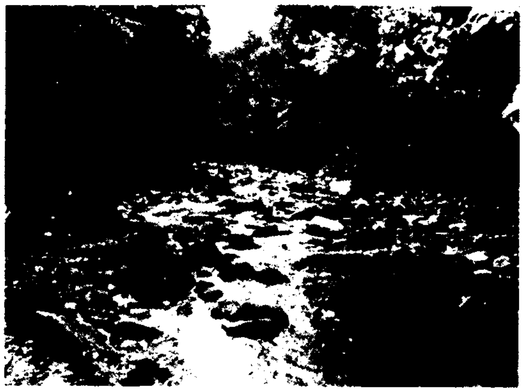
Stream Sub-Reach R06-07-DEQ-B. R06-07-P56-E.JPG. Looking downstream at woody debris.

Stream Sub-Reach R06-06 (near power line crossing). R06-06-P65-SE.JPG. Looking downstream.

Stream Sub-Reach R06-05. R06-05-P41-SW.JPG. Looking upstream.

Stream Sub-Reach R06-04 (upstream of waterfalls). R06-04-P25-NE.JPG. Riffle, looking upstream.

Stream Sub-Reach R06-03 (waterfalls). R06-03-P20-S.JPG. Waterfall.

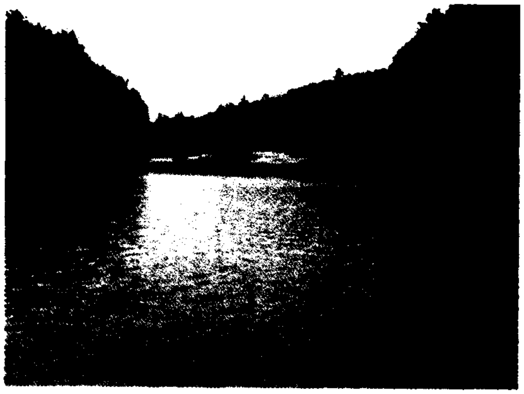


Stream Sub-Reach R06-02 (downstream of waterfalls, near McClure penstock release). R06-02-P17-SW.JPG. Looking upstream at high gradient riffle.

Stream Sub-Reach R06-01 (upstream of Forestville Basin). R06-01-P05-NW.JPG. Looking downstream at top of large pool.

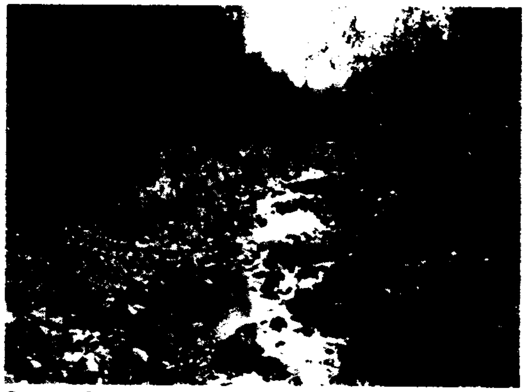
Reach 7 Forestville Basin — Typical Conditions Observed

Reach 07. R07-P090-E.JPG. Facing east. Typical reach photo looking d/s in the riverine backwater approach channel to the reservoir (upstream of the boat ramp).



Reach 07. R07-P096-W.JPG. Facing west. Sand deposits on the downstream end of a mid-channel island east of Forestville Road Bridge.

Reach 8 Downstream of Forestville Basin—Typical Conditions Observed



Stream Sub-Reach R08-05 (downstream of Forestville Dam). R08-05-P23-SE.JPG. Looking downstream, left side channel flow around cobble bar.

Stream Sub-Reach R08-04 (impoundment created by historic Dam No. 1). R08-04-P24-SE.JPG. Looking downstream at top of impoundment.

Stream Sub-Reach R08-03 (spillway below historic Dam No. 1). R08-03-P15-W.JPG. Looking upstream.

Stream Sub-Reach R08-02 (upstream of Forestville penstock release). R08-02-P08-W.JPG. Looking upstream at riffle and cobble bar.

Stream Sub-Reach R08-01 (downstream of Forestville penstock release). R08-01-P28-E.JPG. Looking upstream at low flow.

Stream Sub-Reach R08-01 (downstream of Forestville penstock release). R08-01-P05-W.JPG. Looking upstream at high flow.

Reach 8 Downstream of Forestville Basin—Other Conditions Observed

Stream Sub-Reach R08-01. R08-01-P01-NW.JPG. Looking at left bank (at high flow) with new grass on lower bench.

Stream Sub-Reach R08-01. R08-01-P30-S.JPG. Looking at right bank, bank height estimated to be 30 feet (low flow condition).

Reach 9 Former Tourist Park Basin—Typical Conditions Observed

Stream Sub-Reach R09-01 (Tourist Park Basin). R09-01-P08-E.JPG. Looking downstream, grasses overbanks, low flow.

Stream Sub-Reach R09-01 (Tourist Park Basin). R09-01-P09-NW.JPG. Looking upstream, tree stumps and woody debris on bank.

Reach 9 Former Tourist Park Basin—Other Conditions Observed

Stream Sub-Reach R09-01. R09-01-P02-SE.JPG. Recently placed rip-rap to protect property looking downstream.

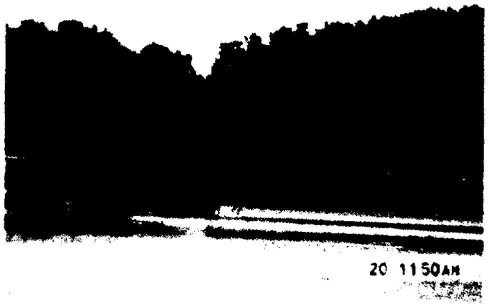
Stream Sub-Reach R09-01. R09-01-P04-SE.JPG. Sand point bar at bend in Dead River just upstream of Tourist Park Basin, looking downstream.

Stream Sub-Reach R09-01. R09-01-P11-W.JPG. Looking upstream at meander, woody debris, sandy substrate (low flow conditions).

Stream Sub-Reach R09-01. R09-01-P15-E.JPG. Looking downstream at split flow around island (low flow conditions).

Reach 10 Downstream of Former Tourist Park Basin—Typical Conditions Observed

Stream Sub-Reach R10-02 (downstream of Tourist Park Basin). R10-02-P10-SW.JPG. Looking upstream at sand deposition (low flow condition).



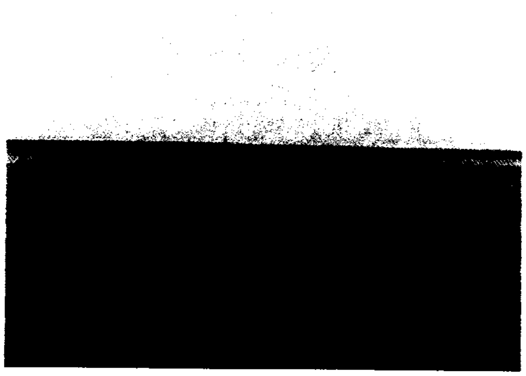
Reach 10. R10-P121-S.JPG. Facing south. Sand deposits and woody debris southwest of the power plant near the Dead River mouth.

Reach 10 Downstream of Former Tourist Park Basin—Other Conditions Observed

Sub-Reach R10-02. R10-02-P11-N.JPG. Sand deposition in potential wetland area.

Sub-Reach R10-02. R10-02-P06-NE.JPG. Looking downstream at sand deposition (low flow conditions).

Reach 11 Lake Superior — Typical Conditions Observed



Reach 11. R11-P123-NE.JPG. Facing northeast. Lake Superior from mouth of Dead River.

Appendix E
Water Quality Monitoring Results

3360

[redacted]

Dead River Basin

Water Quality Monitoring Report

August 2003 Sampling Period

RA

Upper Peninsula Power Company

Dead River Basin - Water Quality Monitoring Report - July 2003

Water quality monitoring was performed during the week of August 25th, 2003. The water quality monitoring documents the current state of the water quality in the Dead River. Water quality monitoring was performed at eleven locations along the Dead River from below the Silver Lake Basin to the mouth of the Dead River in Marquette, MI. The scope of the monitoring plan was developed through consultation with the Michigan Department of Natural Resources (MDNR), Michigan Department of Environmental Quality (MDEQ), U.S. Fish and Wildlife Service (FWS), and the Keweenaw Bay Indian Community (KBIC).

Water Quality Sampling - Parameters and Results

The water quality monitoring and sampling was conducted by Wisconsin Public Service Corporation (WPSC) for Upper Peninsula Power Company (UPPCO) on August 25th and 26th. The water quality monitoring was performed as described in the monitoring plan, with a modification to the sampling at locations DRB-3 and MCB-1. At these locations, a sample was collected from the epilimnion 1 meter below the surface, and from the hypolimnion, approximately 1 meter from the bottom. Samples were collected at mid-depth at all other monitoring stations. The monitoring stations along the Dead River are listed in Table 1:

TABLE 1
Proposed Monitoring Stations

River Reach	Monitoring Stations ID
Silver Lake to Dead River Basin	DR-1
Dead River Basin	DRB-1, DRB-2, DRB-3, DRB-4
Dead River Basin to McClure Basin	DR-2
McClure Basin	MCB-1
Forestville Basin	FVB-1
Forestville to Tourist Park Basin	DR-3
Tourist Park Basin to Lake Superior	DR-4
Lake Superior at the mouth of the river	SM-1

For all monitoring stations, the coordinates for each location were recorded using a differential GPS unit. The coordinates of each monitoring location can be found in Table 2. A map of the monitoring locations can be found in Figure 1.

TABLE 2

Monitoring Station	GPS Coordinates (UTM)	Monitoring Station	GPS Coordinates (UTM)
DR-1	5164636	MCB-1	5155511
DRB-1	5161780	FVB-1	5157896
DRB-2	5160796	DR-3	5157264
DRB-3	5150851	DR-4	5157699
DRB-4	5157039	SM-1	5158186
DR-2	5156344		

Water quality parameters measured in the field include dissolved oxygen (DO), temperature, pH, specific conductivity, and turbidity. Secchi disk depth readings were also taken at each of the monitoring stations. At the time of monitoring, water samples were also collected for laboratory analysis of TSS at all monitoring stations.

Table 3 lists the water quality parameters at the respective sampling stations:

TABLE 3

Monitoring Stations and Parameters

Monitoring Stations	DO	Temp	pH	Specific Conductivity	Turbidity	TSS
DR-1	X	X	X	X	X	X
DRB-1	X	X	X	X	X	X
DRB-2, DRB-3, DRB-4					X	X
DR-2	X	X	X	X	X	X
MCB-1	X	X	X	X	X	X
FVB-1	X	X	X	X	X	X
	X	X	X	X	X	X
	X	X	X	X	X	X
	X	X	X	X	X	X

TSS analysis was performed at the WPSC Central Lab (WDNR ID 405029790). All other data was collected in the field using portable meters.

Monitoring Results

	Jun-03	Jul-03	Aug-03	Jun-03	Jul-03	Aug-03
Monitoring Location ID	Collection Depth	Collection Depth	Collection Depth	D.O. (mg/L)	D.O.(mg/L)	D.O.(mg/L)
DR-1	1 ft	1 ft	1 ft	7.87	7.85	7.27
DRB-1	2 ft	1 ft	6"	7.46	7.68	7.71
DRB-2	2.5 m	2.5 m	2.5 m			
DRB-3 Epilimnion	7 m	1 m	1 m			
DRB-3 Hypolimnion		10 m	10 m			
DRB-4	7 m	7 m	7 m			
DR-2	2 ft	2 ft	2 ft	7.90	7.74	7.50
MCB-1 Epilomnion	4 m	1 m	1 m	7.51	7.43	7.40
MCB-1 Hypolimnion		7 m	7 m		5.32	1.54
FVB-1	1 m	1 m	1 m	8.35	7.31	7.32
DR-3	0.5 m	0.5 m	0.5 m	8.31	8.63	6.95
	1 ft	1 ft	1 ft	9.41	9.40	8.75
	1.5 m	1.5 m	1.5 m	9.44	8.74	8.36

Monitoring Location ID	Temperature (Celcius)	Temperature (Celcius)	Temperature (Celcius)	pH (S.U.)		
DR-1	20.1	16.3	20.7	6.61		
	24.3	21.0	23.9	6.45	6.95	6.67
DRB-2						
DRB-3 Epilimnion						
DRB-3 Hypolimnion						
DR-2	15.7	19.3	24.5	6.26	6.39	6.59
MCB-1 Epilomnion	15.0	19.6	22.0	6.18	6.18	6.53
MCB-1 Hypolimnion		15.9	16.7		6.15	6.17
FVB-1	16.3	18.2	21.6	6.20	6.25	6.60
DR-3	16.9	17.9	20.9	6.16	6.85	6.61
DR-4	17.5	15.3	19.4	6.35	6.77	6.95
SM-1	17.8	15.9	20.8	6.46	6.54	6.85

Monitoring Location ID	Conductivity (uS/cm)	Conductivity (uS/cm)	Conductivity (uS/cm)	Turbidity (NTU)	Turbidity (NTU)	Turbidity (NTU)
DR-1	73.4	133.0	121.4	3.5	4.5	6.0
DRB-1	67.9	123.9	129.0	5.0	3.0	6.0
DRB-2				20.0	15.0	6.3
DRB-3 Epilimnion				100.0	30.0	6.5
DRB-3 Hypolimnion					60.0	50.0
DRB-4				90.0	50.0	20.0
DR-2	47.4	63.1	78.2	110.0	45.0	9.0
MCB-1 Epilomnion	45.3	58.2	71.6	170.0	40.0	10.0
MCB-1 Hypolimnion		58.1	68.6		40.0	15.0
FVB-1	54.0	80.2	90.7	120.0	40.0	9.8
DR-3	57.7	186.9	91.4	120.0	20.0	15.0
DR-4	62.1	217.0	187.8	115.0	20.0	9.0
SM-1	61.8	97.0	100.5	120.0	30.0	5.5

Monitoring Location ID	Secchi Disk Depth	Secchi Disk Depth	Secchi Disk Depth	T.S.S. (mg/L)	T.S.S. (mg/L)	T.S.S. (mg/L)
DR-1	1' 6" **	2' **	6" **	8.0	6.8	5.8
DRB-1	3' 7" **	1' 6" **	1 ft **	1.0	2.0	1.6
DRB-2	1' 2"	1' 6"	4' 3"	3.0	4.4	0.4
DRB-3 Epilimnion	6"	1'	4' 8"	28.0	3.6	1.2
DRB-3 Hypolimnion		N/A	N/A		7.6	272.4 *
DRB-4	5"	1'	4' 8"	21.0	7.6	0.8
DR-2	6"	10"	2.5 ft **	20.0	14.0	1.6
MCB-1 Epilomnion	5"	1'	4' 5"	68.0 *	5.6	1.6
MCB-1 Hypolimnion		N/A	N/A		3.2	1.2
FVB-1	6"	1'	4' 6" **	32.0	6.4	2.8
DR-3	6"	1' 3"	3' 2"	30.0	6.4	2
DR-4	5"	1'	2' **	27.5	19.2	2.8
SM-1	5"	1' 3"	4'9"	27.0	8.4	2.4

** Secchi disk on bottom of river/reservoir.

Note: June monitoring period

The sample bottle for MCB-1 leaked during shipping prior to analysis. Approximately 200 mL of sample was lost. The actual TSS concentration for MCB-1 is most likely closer to the field duplicate result due to the loss of sample.

Field duplicates were collected at two locations along the Dead River for total suspended solids. The results are as follows:

F.D. DRB-1 2.0 mg/L F.D. MCB-1 40.0 mg/L

Notes: July monitoring period

Significant shoreline stabilization and construction activities have occurred upstream of monitoring station DR-1. Rocks have been pushed into the water at station DR-1.

Water levels in the Hoist Basin have decreased since the previous monitoring period. The depth at DRB-1 was 3' 7" on 6/18/03, and was 1' 6" on 7/10/03.

Samples for all stations except the Dead River Basin samples were collected while it was raining.

Field duplicates were collected at two locations along the Dead River for total suspended solids. The results are as follows:

F.D. DRB-4 5.6 mg/L F.D. SM-1 9.2 mg/L

Notes: August monitoring period

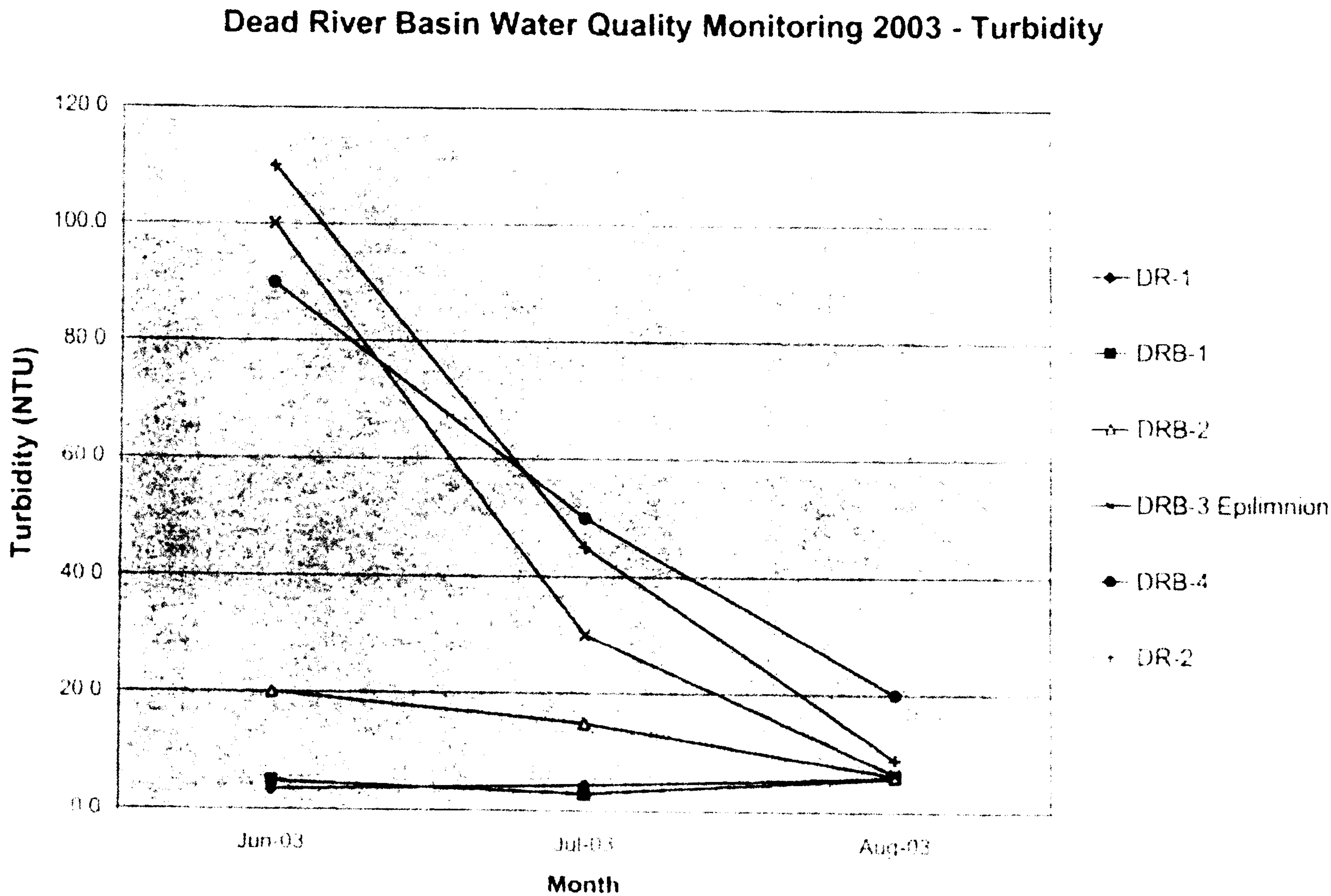
Secchi disk readings at locations FVB-' , DR-3, and SM-1 were taken from bridges crossing the river at the monitoring locations.

Field duplicates were collected at two locations along the Dead River for total suspended solids. The results are as follows:

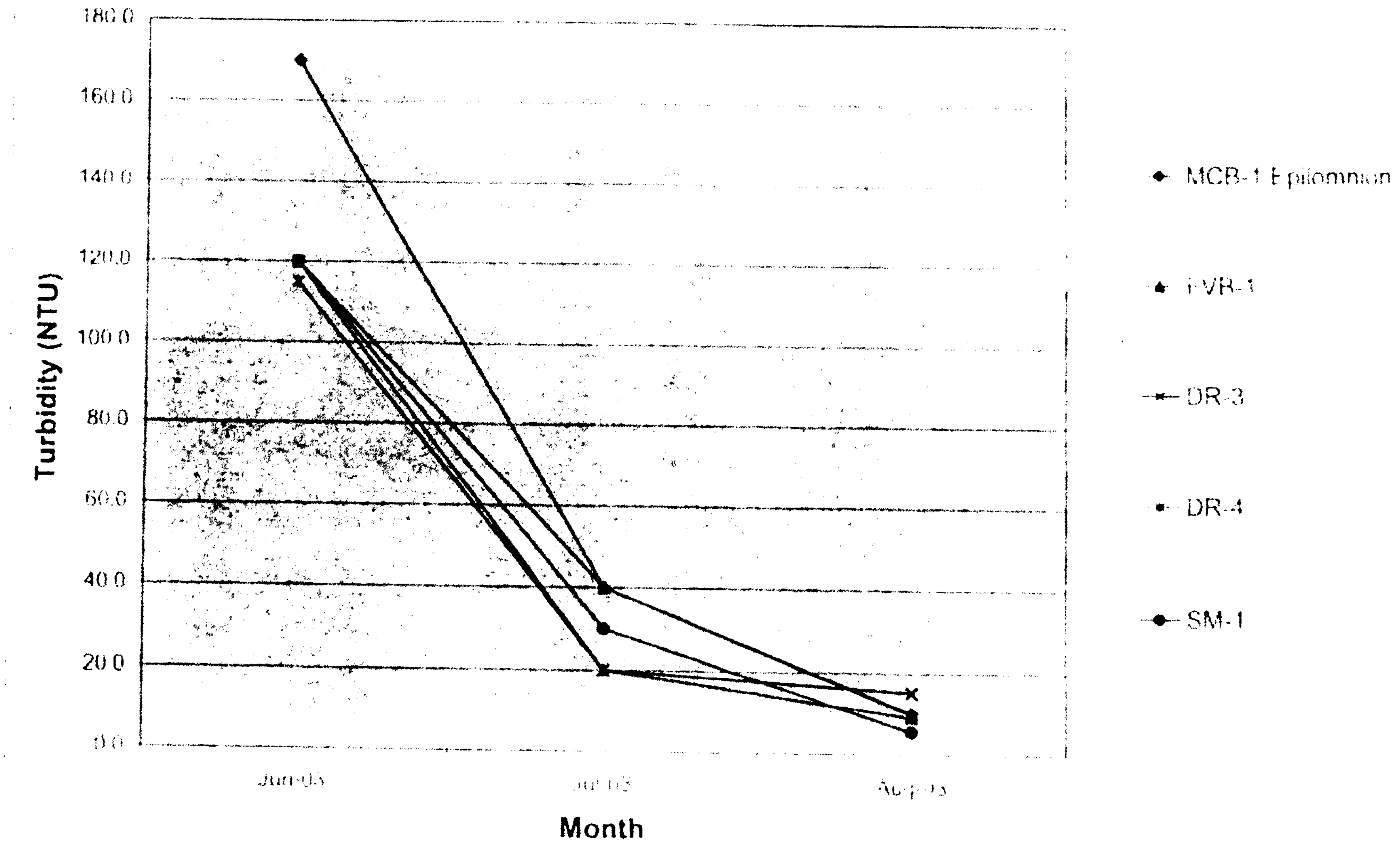
F.D. DR-2	1.6 mg/L	F.D. DR-4	3.2 mg/L

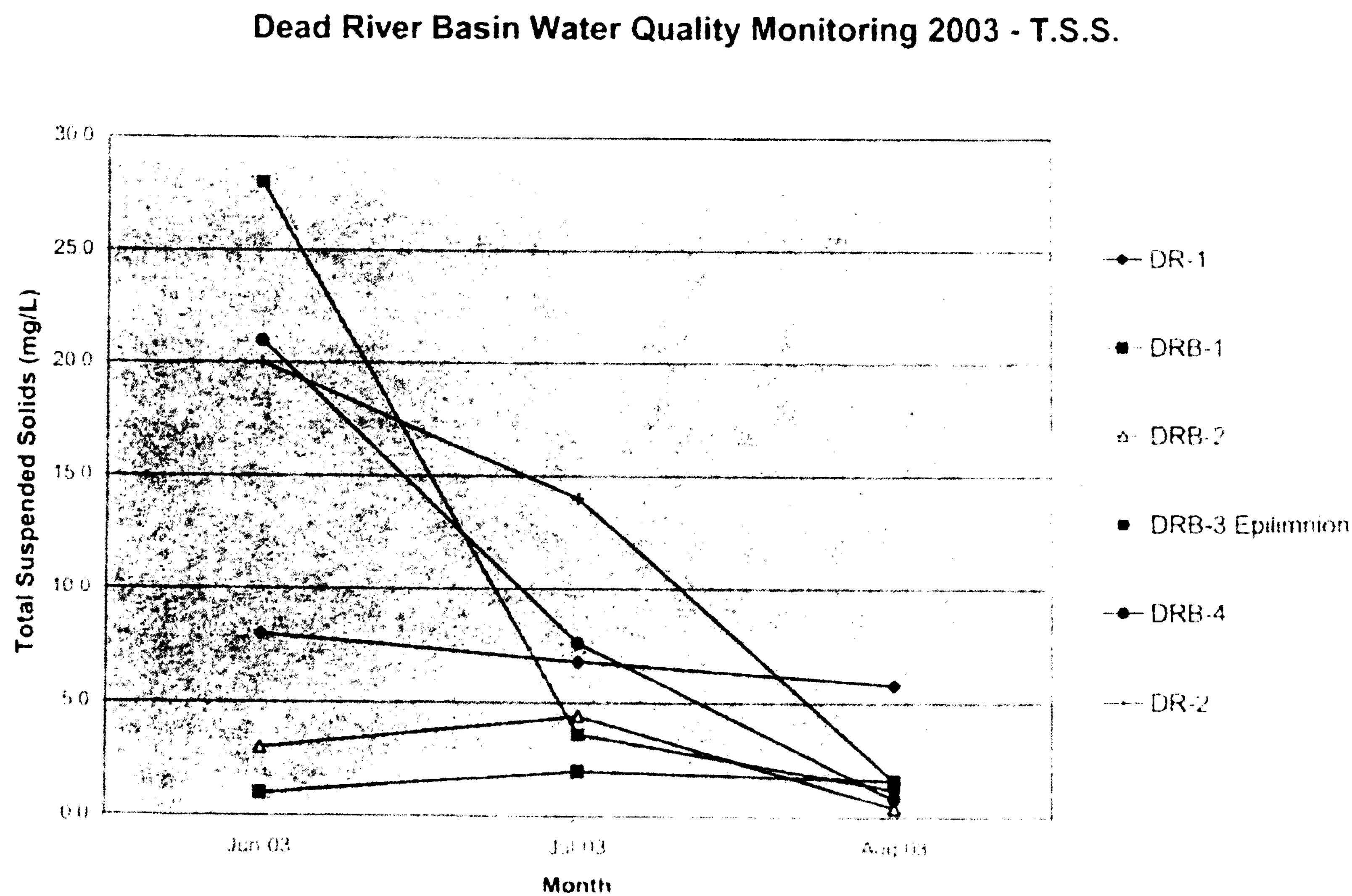
Total suspended solids results for DRB-3 Hypolimnion are elevated compared to previous monitoring periods. Sediment from the bottom of the reservoir may have been disturbed during sampling, contributing to the elevated result.

Duplicate samples were collected at each monitoring location. The samples were given to We Energies for analysis of colloidal silica.

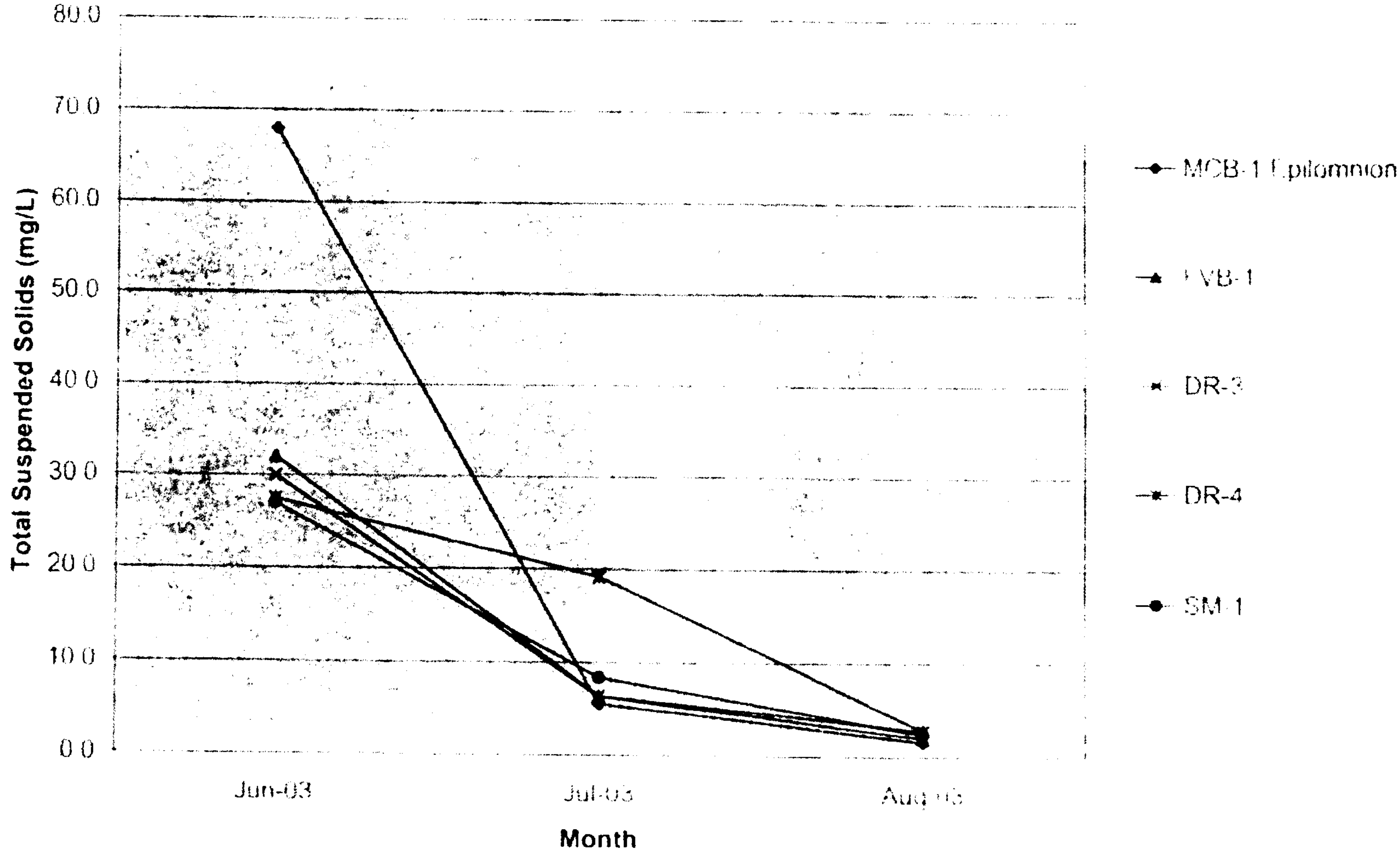

Dead River Basin Water Quality Monitoring 2003 - Turbidity
Turbidity (NTU)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Jun-03
Jul-03
Aug-03
Month
DR-1
DRB-1
DRB-2
DRB-3 Epilimnion
DRB-4
DR-2

Dead River Basin Water Quality Monitoring 2003 - Turbidity




Dead River Basin Water Quality Monitoring 2003 - T.S.S.
Total Suspended Solids (mg/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jun 03
Jul 03
Aug 03
Month
DR-1
DRB-1
DRB-2
DRB-3 Epilimnion
DRB-4
DR-2

Dead River Basin Water Quality Monitoring 2003 - T.S.S.



APPENDIX F
Interim Actions

Due to the nature of some of the channel areas, UPPCo, in consultation with the regulatory agencies, decided that interim actions to help stabilize select locations within the Dead River system were warranted. These are considered to be interim measures because they are designed to address interim needs and may or may not be what is needed from a longer-term perspective. It is anticipated that these issues are likely to be addressed within the context of a more comprehensive recovery plan in the future (see Figure 1-2 of the Report).

Reach 1

Interim Action 1: Silver Lake Outlet

The first Area of Particular Interest (API) identified as a potential concern early in the project (May 2003) was the post-event outlet of Silver Lake Basin. This has persisted as a condition for which interim actions might be needed throughout the initial phase of the EA. This area was located at the downstream portion of Reach 1, where the Dead River transitioned from Silver Lake to the Dead River. This location is the area of the former headcut that occurred after the Silver Lake Basin release.

Of particular interest at this location is the potential for the continued decline of the water surface elevation in the post-event Silver Lake pool and the potential for the pool to release as the result of channel degradation (headcut) along new outlet. The following actions were proposed:

- Perform detailed geomorphic survey of a reference reach on the Dead River system upstream of the pre-event Silver Lake pool.
- Survey and evaluate the current post-event Silver Lake/ Dead River system interface.
- The basis of analysis for an interim action was the 2-year return period flow as discussed with MDEQ rather than a regional bankfull calculation, since regional bankfull information is unavailable. Large flows may cause additional channel migration.

On September 18, 2003, a field survey was conducted of the Dead River upstream of the pre-event Silver Lake and at the post-event Silver Lake/Dead River interface. The measurements and analysis of the survey data were submitted in the Silver Lake Interim Stabilization Report (Document #GB-0696) on September 30, 2003.

Upon review of the Silver Lake Interim Stabilization Report, MDEQ agreed that the existing outlet is sufficient for interim purposes. (See Attachment F-1, MDEQ letter dated October 15, 2003.)

Reach 2

Two interim actions were identified in Reach 2 during the August field effort. These are the braided channel with high banks and a clay seam (Interim Action 2) and the Mulligan Creek confluence with the Dead River (Interim Action 3).

Interim Action 2: Braided Channel with High Banks

Braided channels typically cannot maintain proper sediment transport regimes. Therefore, the channel in this reach will likely continue to aggrade versus degrade. Erosion potential will be limited to areas with high near bank shear stress, or, for example, where the stream flow is directed into or adjacent to unprotected banks.

Interim Action 2 is located just upstream of Mulligan Creek and extends for about 2,800 linear feet. Interim Action 2 was identified because the potential for erosion of unprotected slopes due to the stream location and near bank shear stress. At the upstream end, a clay seam and a vertical bank area have separated flow and caused a secondary channel to flow along unprotected sand and gravel slopes that range between 70 and 100 feet tall, and vary between 80 and 90 degrees vertical. This area has the potential to supply sediment loads to the Dead River if the secondary channel is allowed to cut into and along the unprotected sand and gravel banks.

The following activities are under consideration by UPPCo for an interim action at this location:

- It is proposed that an Interim Stream Redirection Plan be developed where data would be collected through a land survey to design a channel cross section.
- Excavate the cross section through the braided channel section in order to divert flow into an alternate existing channel to keep flow away from the high banks.
- The channel cross section would be based upon the 2-year return period flow, not a regional bankfull relationship, since the regional bankfull information is not available.

Interim Action 3: Mulligan Creek

The second Interim Action in Reach 2 is the Mulligan Creek confluence with the Dead River. At this location, sand and gravel deposits have cut off Mulligan Creek from the Dead River and thus, Mulligan Creek was not flowing as a natural channel at this downstream section of the creek. The issue at this location is the potential for negative impact on channel stability and habitat upstream in Mulligan Creek as the result of debris and sediment blockage. Therefore, the following actions are under consideration by UPPCo:

- Perform land survey of Mulligan Creek upstream of the confluence with Dead River to determine fall to Dead River.
- Design interim channel confluence for Mulligan Creek/Dead River. This will include a channel cross section that will be excavated through the plugged confluence.
- The channel cross section would be based upon the 2-year return period flow, not a regional bankfull relationship, since the regional bankfull information is not available.

Attachment F-1

MDEQ letter dated October 15, 2003

Document # GB-0713

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
UPPER PENINSULA DISTRICT OFFICE

JENNIFER M. GRANHOLM
GOVERNOR

STEVEN E. CHESTER
DIRECTOR

October 15, 2003

Mr. Gary Erickson, Vice President
Upper Peninsula Power Company
P.O. Box 357
Ishpeming, Michigan 49849

Dear Mr. Erickson:

SUBJECT: Withdrawal of the required action to control head cutting erosion at the outlet of the Silver Lake Basin.

The August 11, 2003, letter required the construction of a structure to control head cutting and continued channel erosion at the Silver Lake Basin. As a result of continuing discussions with the Upper Peninsula Power Company (UPPCO), the Michigan Department of Environmental Quality (MDEQ) remained receptive to the results of a detailed assessment of the issue. UPPCO and their consultants completed and then distributed the "Silver Lake Outlet Interim Stabilization Report" on October 10th to the MDEQ and other resource agencies for review.

Upon review of the report, MDEQ agrees to withdraw the requirement of constructing the Silver Lake Basin head cutting structure at this time. This decision is based on the report's recommendation that the existing "conglomerate formation should adequately control head cutting downstream of the (present post-event Silver Lake Basin) throughout the winter of 2003 and spring of 2004." The MDEQ also agrees with the reports recommendations that "the exposed conglomerate may not be suitable as a long-term solution…and a detailed geological/materials testing and evaluation of the conglomerate would be required" if this solution is to be used beyond the spring 2004.

As stated in the August 11th letter, the MDEQ maintains the desire to keep the existing size of the Silver Lake Basin intact until a long term management strategy is finalized. Therefore, if the existing conglomerate material does not prevent future head cutting and erosion in this region the MDEQ may require UPPCO to take action to stop active erosion and restore the area to the current condition. Please provide a report assessing the amount of head cutting (including the change in Silver Lake area/elevation) as a result of spring snowmelt to me by June 1, 2004. That report must include a long range plan for controlling head cutting at Silver Lake Basin.

Please call me if you would like to further discuss the contents of this letter.

Sincerely,

Steve Casey
District Supervisor
Water Division
906-346-8535

MK:SC:DN
cc: Mr. Bernie Huetter, NRCS
Mr. George Madison, MDNR
Ms. Jessica Mistak, MDNR
Mr. Shawn Puzen, UPPCO
Mr. Hampton Waring, Marquette Conservation District
Mr. Ralph Reznick, MDEQ-WD
Mr. Robert Schmeling, MDEQ-WHMD
Ms. Joan Duncan, MDEQ-GLMD
Mr. Mark Feldhauser, MDEQ-GLMD
Mr. Mitch Koetje, MDEQ-WD
File: Dead River Basin file

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www.michigan.gov • (906) 346-8300

Appendix 2

Longitudinal Survey

Longitudinal Profile Survey

The Consultant shall survey a longitudinal profile of the stream thalweg for each reference reach. Measurements shall be to the nearest 0.01 ft vertically. The longitudinal profile survey shall begin with station 10+00.

The longitudinal profile survey shall include at a minimum the following survey points:

1) Thalweg *
2) Left Or Right Water Surface Edge
3) Water Surface Elevation *
4) Left Or Right Bankfull **
5) Left and Right Top Of Bank

*** MDEQ parameters. Refer to Section 1.2.3.2 DRSR Survey Procedures.**
**** Bankfull indicators may not be present for Dead River sub-reaches.**

The survey points, listed above, shall be taken at each of the following bed feature locations within the reach: start of reach, end of riffle, end of run, mid-pool (max. depth), head of glide, start of riffle, and end of reach.

In addition to the bed feature points the Consultant shall take continuous points along the left or right water surface edge, in sufficient number, to determine channel sinuosity. The points must be taken from the same side throughout the longitudinal profile survey. The longitudinal profile survey shall tie to the cross-section(s) surveys.

Longitudinal Photo Log

The Consultant shall take, at a minimum, the following photographs at each surveyed stream reach:

Photo Description	Perspective
A sufficient number of photographs to provide a continuous visual documentation of the survey reach	facing downstream
Stream upstream of the reach	standing mid-stream at the start of the longitudinal profile
Stream downstream of the reach	standing mid-stream at the end of the longitudinal profile

Appendix 3

Cross-Section Survey

Cross-Section Survey(s)

The cross-section survey(s) shall include at a minimum the following survey points:

1) Left And Right Floodplain
2) Left And Right Top Of Bank *
3) Left And Right Bankfull (Minimum Left Or Right) **
4) Left And Right Toe Of Bank
5) Water Surface Elevation *
6) Thalweg *
7) Additional Shots At Breaks In The Grade (Left And Right) *

*** MDEQ parameters. Refer to Section 1.2.3.2 DRSR Survey Procedures.**
**** Bankfull indicators may not be present for Dead River sub-reaches.**

The cross-section shall include a minimum of twenty (20) points, to accurately portray the channel shape. The minimum cross-section width surveyed shall be the distance sufficient to capture the entrenchment ratio (typically 2-3 times the bankfull width of the stream but may be wider). The Consultant shall install rebar endpoints for both sides of the cross section. The cross-section survey(s) shall be measured left-to-right facing downstream, with station 1+00 as the left benchmark. Measurements shall be to the nearest 0.1 ft horizontally and 0.01 ft vertically.

Cross-Section Photo Log

The Consultant shall take, at a minimum, the following photographs at each surveyed cross section:

Photo Description	Perspective
Bankfull stage indicator	location that best depicts indicator (Rosgen, 1996)
Stream downstream of the cross-section	standing mid-stream at the tape
Stream upstream of the cross-section	standing mid-stream at the tape
Cross-section photo	downstream of the cross-section facing upstream
Cross-section photo	upstream of the cross-section facing downstream
Right floodplain	right top of bank at the cross-section
Left floodplain	left top of bank at the cross-section

Appendix 4

Data Presentation Format:

Site Sketches

Morphological Characteristics

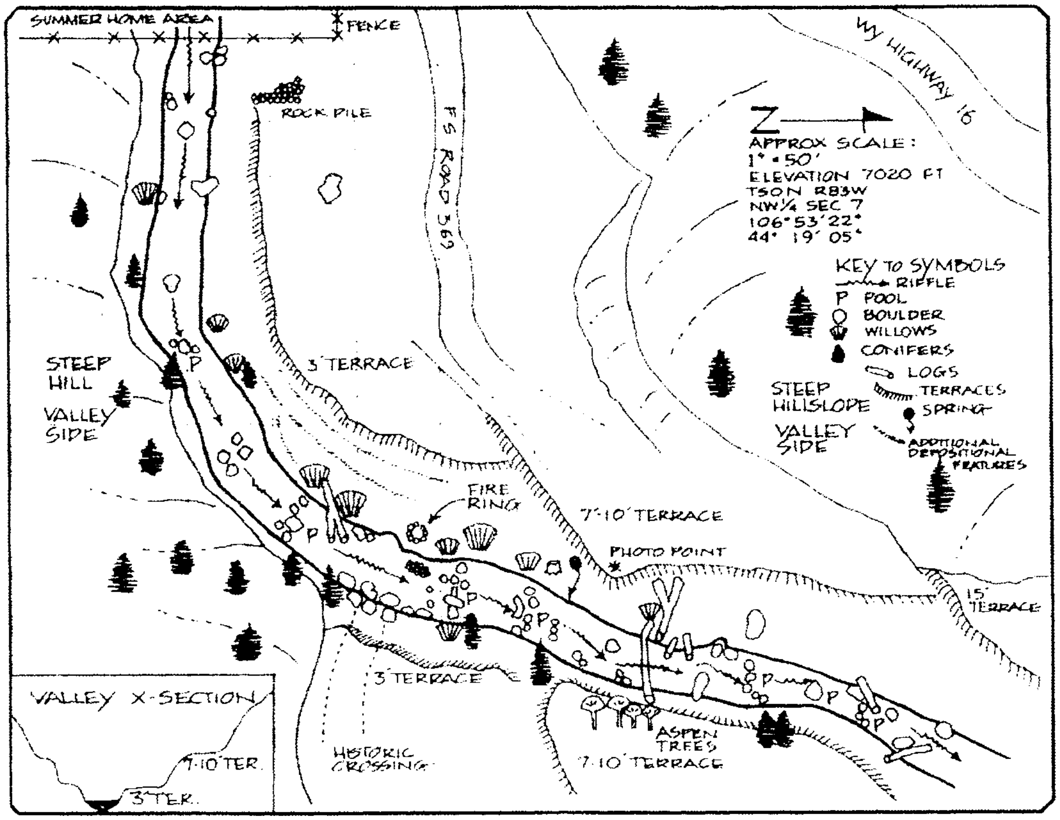
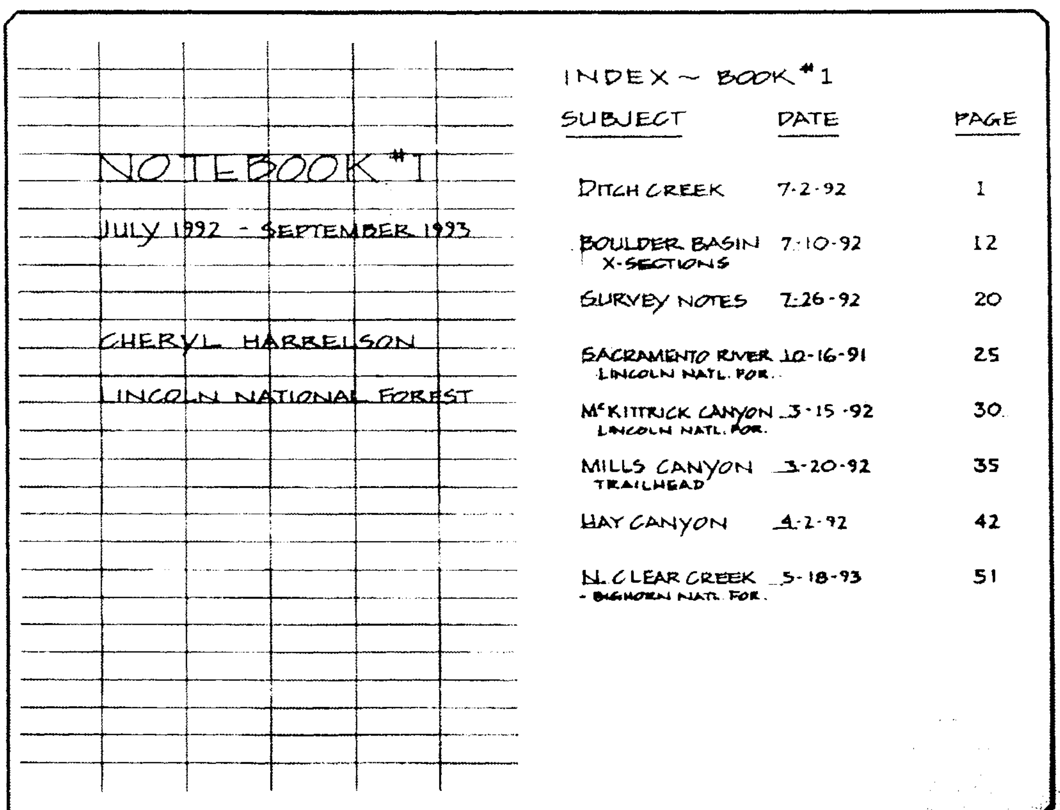


Figure 7. – Initial site map of North Clear Creek, Buffalo Ranger District, Bighorn National Forest.



SUBJECT	DATE	PAGE
DITCH CREEK	7-2-92	1
BOULDER BASIN X-SECTIONS	7-10-92	12
SURVEY NOTES	7-26-92	20
SACRAMENTO RIVER LINCOLN NATL. FOR.	10-16-91	25
McKITTRICK CANYON LINCOLN NATL. FOR.	3-15-92	30
MILLS CANYON TRAILHEAD	3-20-92	35
HAY CANYON	4-2-92	42
N. CLEAR CREEK - BIGHORN NATL. FOR.	5-18-93	51

Figure 8. – Title page and index from field notebook.

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Rosgen, 1996)

Restoration Site (Name of stream & location):
USGS Station (Number & location):
Reference Reach (Name of stream & location):

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
1. Stream Type				
2. Drainage Area, mi^2				
3. Bankfull Width, ft (W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
4. Bankfull Mean Depth, ft (d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
5. Width/Depth Ratio (W_{bkf}/d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
6. Bankfull Cross-Sectional Area, ft^2 (A_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
7. Bankfull Mean Velocity, ft/s (u_{bkf})				
8. Bankfull Discharge, ft^3/s (Q_{bkf})				
9. Bankfull Maximum Depth, ft (d_{mbkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
10. Max Riffle Depth/Mean Riffle Depth (d_{mbkf}/d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
11. Low Bank Height to Max Riffle Depth (LBH/d_{mbkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
12. Width of Floodprone Area, ft (W_{fpa})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
13. Entrenchment Ratio (W_{fpa}/W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
14. Meander Length, ft (L_m)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
15. Meander Length Ratio (L_m/W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Rosgen, 1996)

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
16. Radius of Curvature, ft (R_c)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
17. Ratio of Radius of Curvature to Bankfull Width (R_c/W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
18. Belt Width, ft (W_{blt})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
19. Meander Width Ratio (W_{blt}/W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
20. Sinuosity (K)				
21. Valley Slope (VS)				
22. Average Water Surface Slope (S) = (VS/K)				
23. Pool Slope (water surface facet slope) (S_p)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
24. Ratio of Pool Slope/Average Water Surface Slope (S_p/S)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
25. Riffle Slope (water surface facet slope) (S_{rif})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
26. Ratio Riffle Slope to Average Water Surface Slope (S_{rif}/S)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
27. Run Slope (water surface facet slope) (S_{run})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
28. Ratio Run Slope/Average Water Surface Slope (S_{run}/S)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
29. Glide Slope (water surface facet slope) (S_g)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
30. Ratio Glide Slope/Average Water Surface Slope (S_g/S)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Rosgen, 1996)

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
31. Max Pool Depth, ft (d_{mbfkp})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
32. Ratio Max Pool Depth/Bankfull Mean Depth (d_{mbfkp}/d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
33. Max Run Depth, ft (d_{run})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
34. Ratio Max Run Depth/ Bankfull Mean Depth (d_{run}/d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
35. Max Glide Depth, ft (d_g)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
36. Ratio Max Glide Depth/ Bankfull Mean Depth (d_g/d_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
37. Pool Width, ft (W_{bkfp})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
38. Ratio of Pool Width to Bankfull Width (W_{bkfp}/W_{bkf})	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
39. Ratio of Pool Area to Bankfull Area	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
40. Point Bar Slope	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
41. Pool to Pool Spacing, ft (p-p)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:
42. Ratio of p-p Spacing to Bankfull Width ($p\text{-}p/W_{bkf}$)	Mean: Range:	Mean: Range:	Mean: Range:	Mean: Range:

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Rosgen, 1996)

Variables	Existing Channel	Proposed Reach	USGS Station	Reference Reach
MATERIALS				
43. Particle Size Distribution of Channel Material (active bed)				
D16 (mm)				
D35 (mm)				
D50 (mm)				
D84 (mm)				
D95 (mm)				
44. Particle Size Distribution of Bar Material				
D16 (mm)				
D35 (mm)				
D50 (mm)				
D84 (mm)				
D95 (mm)				
Largest size particle at the toe (lower third) of bar (mm)				

SEDIMENT TRANSPORT VALIDATION (Based on Bankfull Shear Stress)	Existing	Proposed
Calculated shear stress value (lb/ft^2) from curve		
Size from Shields Diagram (mm)		
Largest size to be moved (D_i)		
Critical dimensionless shear stress (τ_{ci})		
Mean d_{bkf} calculated using critical dimensionless shear stress equations for given slope		

Remarks:

Appendix 5

Re-Survey of MDEQ Sites

R06-09 MDEQ-A

Initials	Work Item
SDC	Collect the following data at a minimum for each sub-reach.

Reach R06-09, DEQ-A

- ☑ ✓ Survey longitudinal profile in the same location (beginning point to ending point) of the 2000 MDEQ survey.
- ☑ ✓ Survey the same cross sections surveyed by MDEQ in 2000 including no less than thirty (30) points, fifteen (15) of which must be within the wetted perimeter.
- ☑ ✓ Velocity at each cross section, measured at 0.6 of the depth measured from the surface.
- ☑ ✓ Sketch site per Harrelson et al., 1994
- ☑ ✓ Photograph site, including two (2) photos with tape/line stretched across stream. (TOTAL STATION SURVEY - NO TAPE)

Initials	Work Item
SDC	Provide the following items for each sub-reach in electronic and hard copy format.

Reach 06-09, DEQ-A

- ☑ ✓ Plot of longitudinal profile
- ☑ ✓ Plot of cross-sections
- ☑ ✓ Site sketch
- ☑ ✓ Photographs and photo log

Table: Summary Data for the Dead River Bypassed Channel, August 2000 vs 2004

Reach Name	2004 A	2000 A	2004 A	2000 A	2004 A	2000 B	2004 B	2000 B	2004 B	2000 B	2004 B	2000 C	2004 C	2000 C	2004 C	2000 C	2004 C
Reach Length (ft)		484	**606**	484	**606**	464	**543**	464	**543**	464	**543**	392	**472**	392	**472**	392	**472**
Water Surface Slope (ft/mile)		15.2	**17.96**	15.2	**17.96**	4.32	**1.58**	4.32	**1.58**	4.32	**1.58**	2.96	**5.28**	2.96	**5.28**	2.96	**5.28**
Average Thalweg Depth (ft) [3]		0.78	**1.33**	0.78	**1.33**	1.81	**2.15**	1.81	**2.15**	1.81	**2.15**	1.42	**2.3**	1.42	**2.3**	1.42	**2.3**
Transect Name		1	**1**	2	**2**	1	**1**	2	**2**	3	**3**	1	**1**	2	**2**	3	**3**
Transect Location [1]	0+00	1+17	**1+17 (1+85)**	3+62	**3+62 (4+66)**	1+60	**1+60 (2+32)**	2+86	**2+86 (3+58)**	4+64	**4+64 (5+43)**	0+00	**0+00 (0+34)**	1+57	**1+57 (1+90)**	3+50	**3+50 (4+05)**
Transect Width (ft) [3]		43	**32.7**	26.3	**37.3**	17.4	**22.6**	20	**22.5**	22.9	**25.7**	11.5	**16.0**	25.8	**25.4**	21.5	**24.8**
Transect Cross Sectional Area (sq. ft) [3]		48.4	**75.1**	8.13	**16.5**	21.9	**34.9**	47.8	**41.1**	30.5	**41.4**	9.4	**36.8**	17.9	**51.8**	18.9	**68.3**
Average Depth in Transect (ft) [3]		1.12	**2.3**	0.31	**0.4**	1.26	**1.5**	2.4	**1.8**	1.33	**1.6**	0.81	**2.3**	0.69	**2.0**	0.88	**2.8**
Average Measured Velocity (fps) [2]		--	--	--	--	0.13	--	--	--	--	--	0.51	--	0.28	--	0.26	--
Calculated Velocity by flow/area (fps)		0.06	**1.5**	0.36	**0.5**	0.14	**1.2**	0.06	**1.3**	0.1	**1.3**	0.49	**1.2**	0.26	**1.2**	0.24	**1.4**
Stream flow (cfs)	**2.0**			1.5		3	**3.8**	3		3	**6.2**	4.6	**6.7**	4.6	**8.5**	4.6	**8.8**

1. Transect location in ( ) is the station from the 2004 survey starting at station 0+00.
2. Average Measured Velocities were provided by MDEQ in 2000.
3. Cross sectional area, transect width, average depth in transect are based on average water surface depth.
4. Assumed horizontal coordinates were used for the resurvey of reaches A, B, and C. No horizontal datum was used for the 2000 survey of these three reaches. Vertical data for all three reaches of the 2004 resurvey were tied to benchmarks established during the 2000 survey. These vertical benchmarks were also assumed and were not tied to each other.

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Dead River Reach A, SE 1/4, NW 1/4 Section 13, T48N, R26W, Marquette County
46.5593 N 87.5041 W

7/28/04

Pygmy Meter y-0060

Transect is of poor quality for flow measurement but the best available in the reach.
Transect is near 0+00

distance		observations at 0.6 depth				
from initial	depth	rev	time	velocity	flow	
(ft)	(ft)	#	(sec)	(ft/sec)	(ft^3/sec)	Comments
0	0					Bank
4	0.6			<-0.1	-0.09	eddy
6	0.7			<-0.1	-0.07	eddy
8	0.9			<-0.1	-0.09	eddy
10	1.1			<-0.1	-0.11	eddy
12	1.2			<0.1	0.12	
14	1.2	7	73	0.13505479	0.324132	
16	1.1	15	42	0.38585714	0.848886	
18	1.2	15	46	0.35604348	0.854504	
20	1.2			<0.1	0.18	
24	0				0	Bank
			Approximate total flow		1.967522	

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Table 2. Longitudinal profile of Reach A of the Dead River bypassed channel.

Benchmark 1 (elevation = 100 ft): nail in 2 ft diameter maple on left bank at Station 0+96

	Elevations		Residual Pool	Residual	Average Residual	Height of	Minus Sights		Calculated	Calculated Water
Location	Water Surf (ft)	Thalweg (ft)	Surface (ft)	Pool Depth (ft)	Pool Depth (ft)	Instrument (ft)	Water Surf (ft)	Thalweg (ft)	Water Surface (ft)	Depth (ft)
0	94.01	93.87				100.55	6.54	6.68	94.01	0.14
30		93.26	93.54	0.28		100.55		7.29	94	0.74
60		92.87	93.54	0.67		100.55		7.68	93.98	1.11
90		93.09	93.54	0.45		100.55		7.46	93.97	0.88
120		92.07	93.54	1.47		100.55		8.48	93.95	1.88
150	93.94	92.74	93.54	0.8		100.55	6.61	7.81	93.94	1.2
177		92.27	93.54	1.27		100.55		8.28	93.94	1.67
205		91.84	93.54	1.7		100.55		8.71	93.94	2.1
235	93.94	92.86	93.54	0.68		100.55	6.61	7.69	93.94	1.08
260		93.54	93.54	0	0.915	100.55		7.01	93.87	0.33
290	93.8	93.17	93.52	0.35		100.55	6.75	7.38	93.8	0.63
320		93.31	93.52	0.21		100.55		7.24	93.78	0.47
350	93.76	93.52	93.52	0	0.28	100.55	6.79	7.03	93.76	0.24
380		93.3				100.55		7.25	93.51	0.21
410	93.26	93.06				99.86	6.6	6.8	93.26	0.2
440		92.99				99.86		6.87	93	0.01
484	92.62	92.33				99.86	7.24	7.53	92.62	0.29

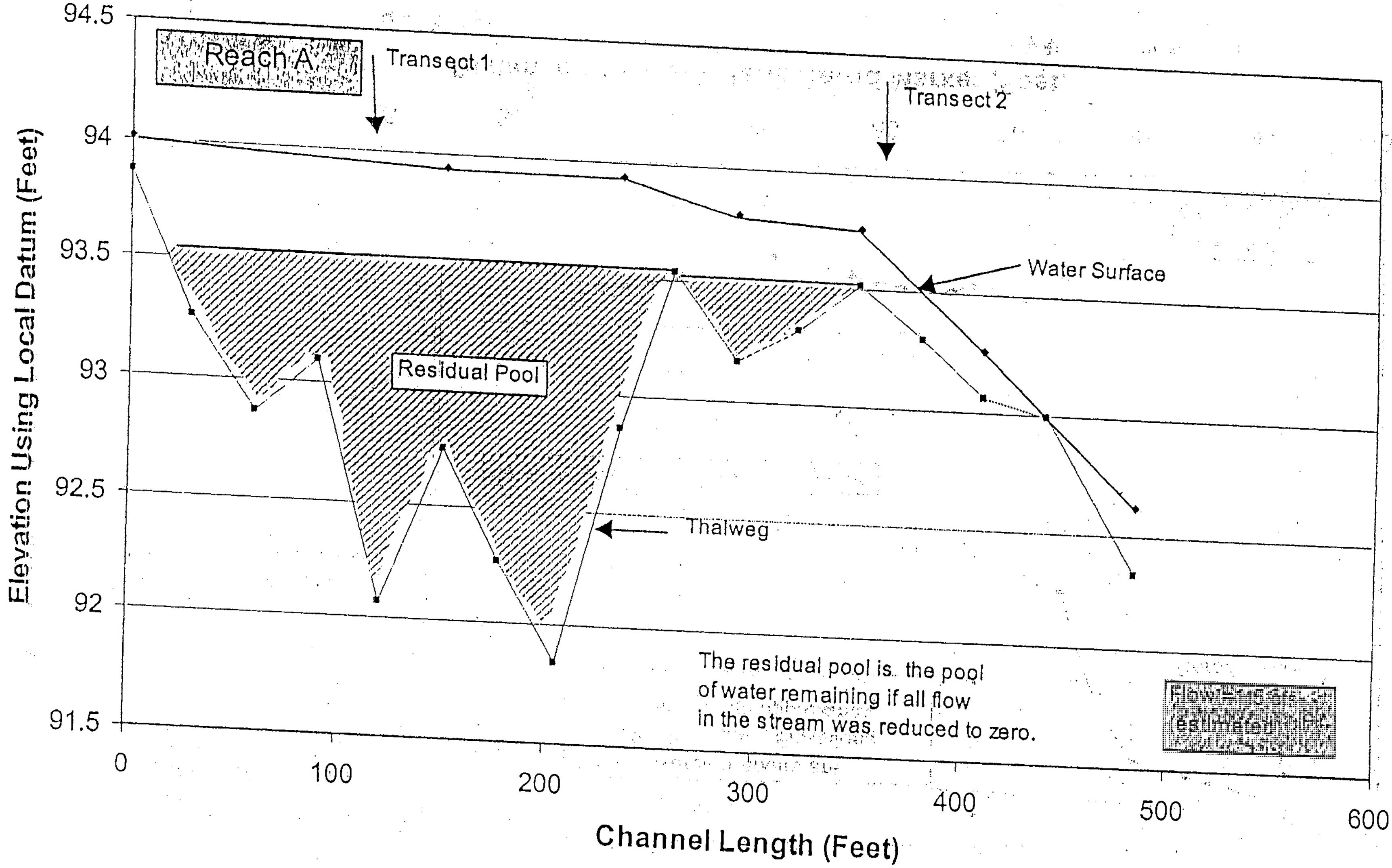

Figure 5. Longitudinal profile of Reach A on August 9, 2000.

MDEQ Reach A, Profile 2004

Descriptor =	TWG		Descriptor =	W-SF
Station	Elevation		Station	Elevation
0.0	95.21		-0.1	95.29
13.8	94.40		88.6	94.73
26.5	93.48		125.8	94.60
82.1	93.42		144.4	94.59
123.2	92.26		184.7	94.71
145.1	92.21		288.3	94.71
184.9	91.34		308.1	94.65
243.3	92.21		326.9	94.48
270.3	91.59		348.1	94.36
289.1	91.98		381.4	94.42
310.1	94.12		439.8	94.43
324.2	93.14		466.2	94.13
345.3	92.83		493.9	93.50
360.0	92.92		539.9	93.02
377.4	92.24		557.2	92.87
392.6	92.28		585.8	92.70
408.4	92.83			
420.6	92.14			
436.3	93.80			
444.4	93.73			
454.3	93.74			
465.3	93.66			
469.9	93.31			
495.2	93.00			
514.5	92.72			
539.1	92.32			
558.5	92.34			
568.0	92.19			
582.8	92.01			
597.6	91.93			
606.2	90.53			

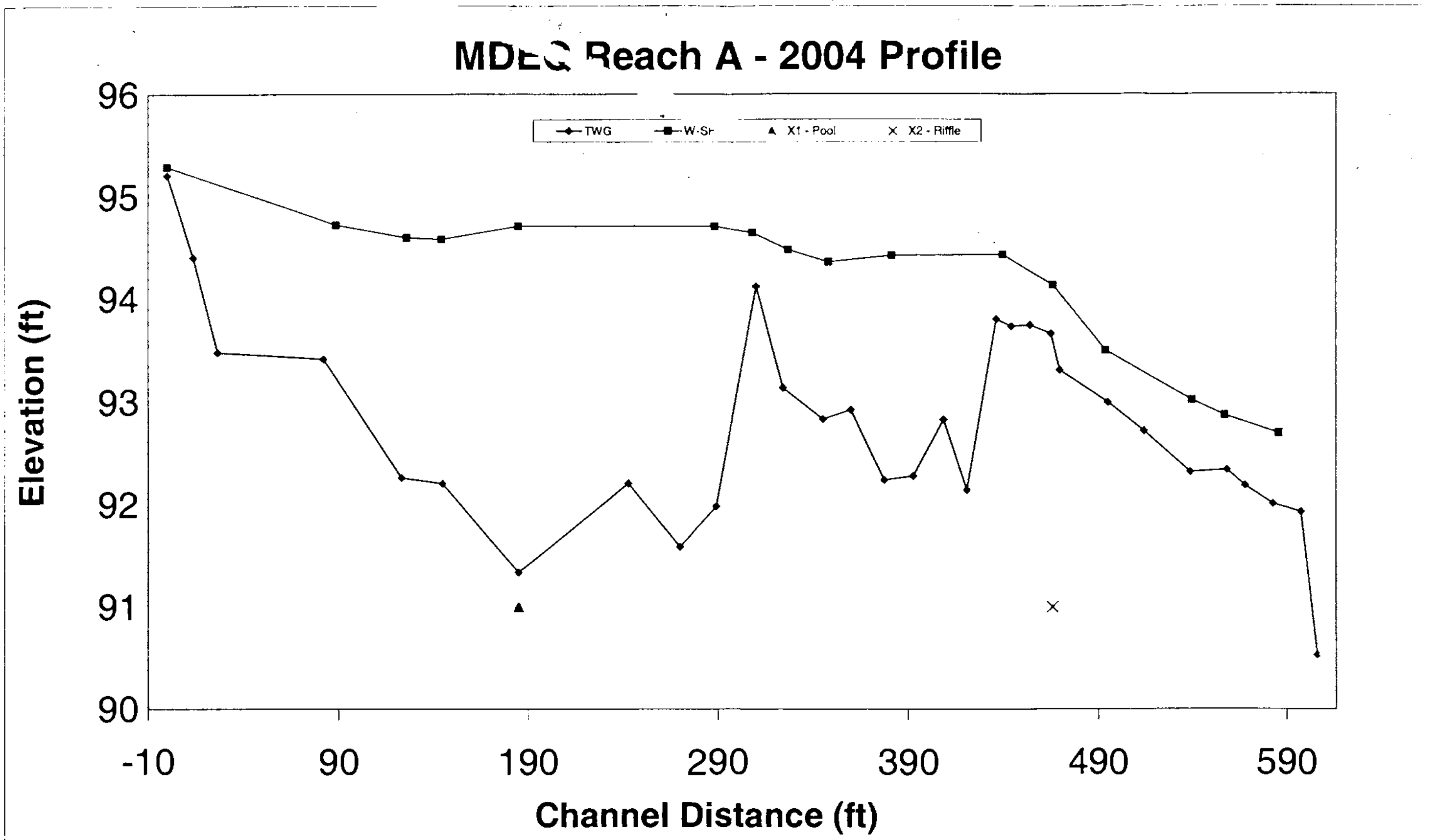
MDEQ Reach A - 2004 Profile
TWG
W-S
X1 - Pool
X2 - Riffle
Elevation (ft)
96
95
94
93
92
91
90
-10
90
190
290
390
490
590
Channel Distance (ft)

Table 3. Cross-section data for Reach A, Transect 1 (Station 1+17).

Station:	Dead River bypassed channel, Reach A (Station 1+17)
Benchmark:	Nail in 2 ft. diam. maple on left bank at Station 0+96 (elevation=100 ft)
Height of Instrument:	99.87
Water Surface Elevation:	93.85
Channel Width (ft):	43
Date:	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	0.35		99.52	
	3.4	1.55		98.32	
	7.4	2.5		97.37	
	12.4	3.2		96.67	
	16.4	3.91		95.96	
	20.4	4.54		95.33	
	24.4	4.85		95.02	
	28.4	5.44		94.43	
	31.4	6.02	0	93.85	0.1
	33.4		0.23	93.62	0.46
	35.4		0.6	93.25	1.2
	37.4		0.88	92.97	1.76
	39.4		0.93	92.92	1.86
	41.4		1.05	92.8	2.1
	43.4		1.2	92.65	2.4
	45.4		1.66	92.19	3.32
	47.4		1.79	92.06	3.58
	49.4		1.82	92.03	3.64
	51.4		1.73	92.12	3.46
	53.4		1.68	92.17	3.36
	55.4		1.44	92.41	2.88
	57.4		1.33	92.52	2.66
	59.4		1.2	92.65	2.4
	61.4		1.09	92.76	2.18
	63.4		0.97	92.88	1.94
	65.4		0.99	92.86	1.98
	67.4		1.16	92.69	2.32
	69.4		1.04	92.81	2.08
	71.4		0.83	93.02	1.245
	72.4	4.17	0.73	95.7	1.095
	74.4	0		99.87	0.35
	80.4	-4		103.87	
Right Bank Rerod Marker	92.9			105	

Total cross-sectional area (sq. ft.) 48.37

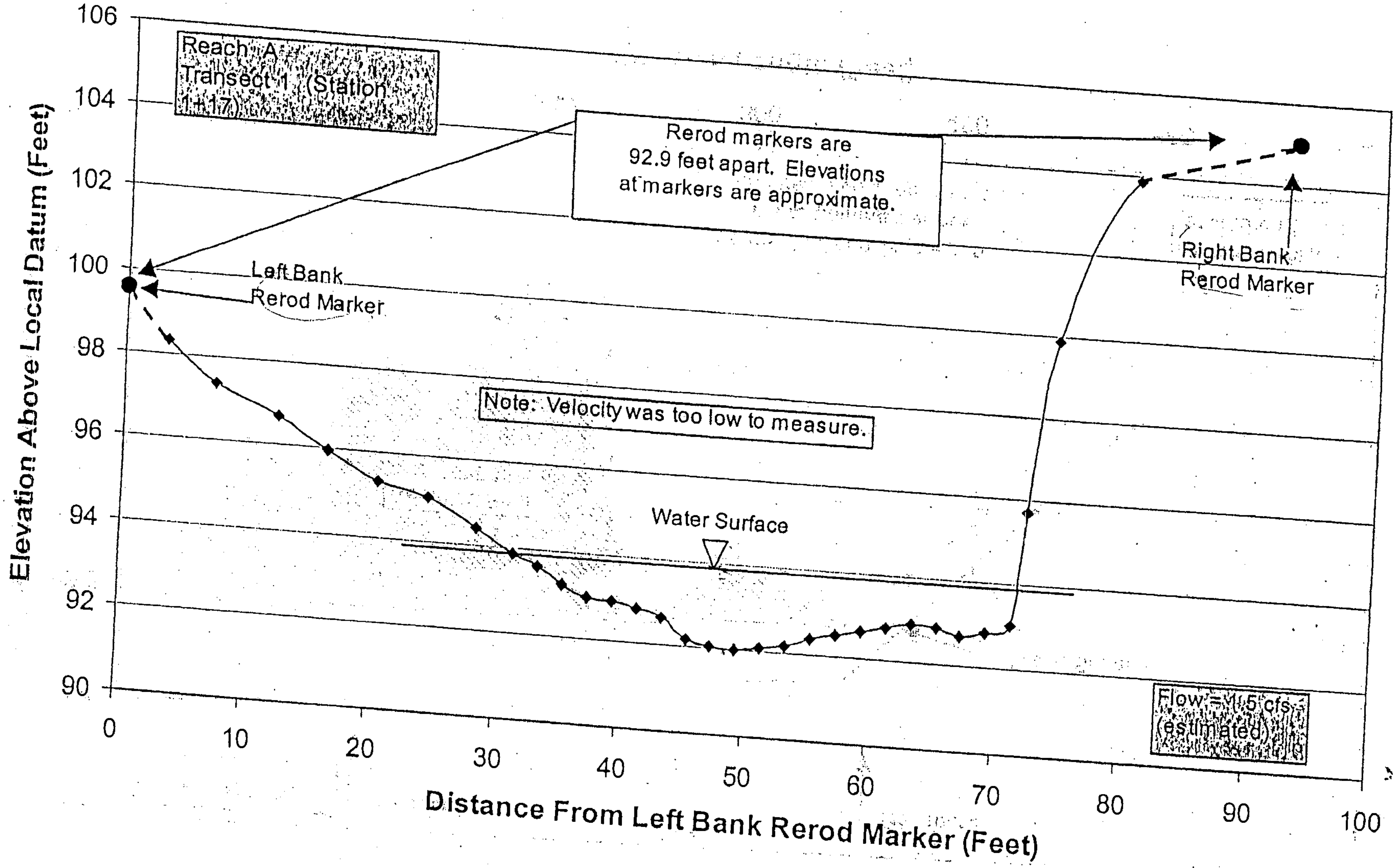

Figure 6. Cross-section profile of Reach A, Transect 1 (Station 1+17) on August 9, 2000.

Reach A, Transect 1, 2004

Pt #	North	East	Elevation	Note	Station
9035	5058.58	4907.09	101.63	X1 TOPO	0.0
9036	5053.67	4930.09	99.76	X1 TOPO	23.5
9037	5051.40	4940.73	98.78	X1 TOPO	34.4
9038	5049.61	4948.99	98.49	X1 TOPO	42.8
9039	5048.03	4957.64	100.08	X1 LTB	51.6
9040	5045.45	4975.06	99.98	X1 TOPO	69.2
9003	5044.65	4977.02	99.92	X1 leBF 5\8	71.3
9041	5043.33	4981.27	98.00	X1 LTO	75.7
9042	5040.23	4991.72	97.23	X1 TOPO	86.6
9043	5039.29	4994.92	97.43	X1 TOPO	89.9
9044	5038.00	5002.32	96.83	X1 TOPO	97.4
9045	5037.07	5006.69	95.92	X1 TOPO	101.9
9046	5036.48	5010.33	95.33	X1 TOPO	105.6
9047	5035.46	5016.86	94.68	X1 LCH WSF	112.2
9048	5035.36	5019.27	94.31	X1 TOPO	114.6
9049	5035.15	5021.16	94.03	X1 TOPO	116.4
9050	5034.95	5023.28	93.46	X1 TOPO	118.6
9051	5034.80	5026.10	92.95	X1 TOPO	121.4
9057	5035.10	5027.58	92.58	X1 TOPO	122.7
9056	5035.17	5030.33	91.90	X1 TOPO	125.4
9055	5034.50	5032.19	91.77	X1 TOPO	127.4
9054	5034.15	5033.40	91.77	X1 TOPO	128.6
9053	5033.38	5035.51	91.44	X1 TOPO	130.9
9052	5033.21	5037.67	91.34	X1 TWG	133.0
9058	5033.04	5041.73	91.61	X1 TOPO	137.0
9059	5031.84	5046.44	91.79	X1 TOPO	141.9
9060	5031.19	5048.63	91.90	X1 TOPO RTO	144.2
9061	5031.03	5048.99	94.71	X1 W-SF	144.5
9062	5028.24	5056.51	103.51	X1 RTB	152.5
9063	5025.49	5066.75	102.66	X1 TOPO	163.1
9033	5025.22	5067.86	102.82	X1 ReBF 5\8	164.2

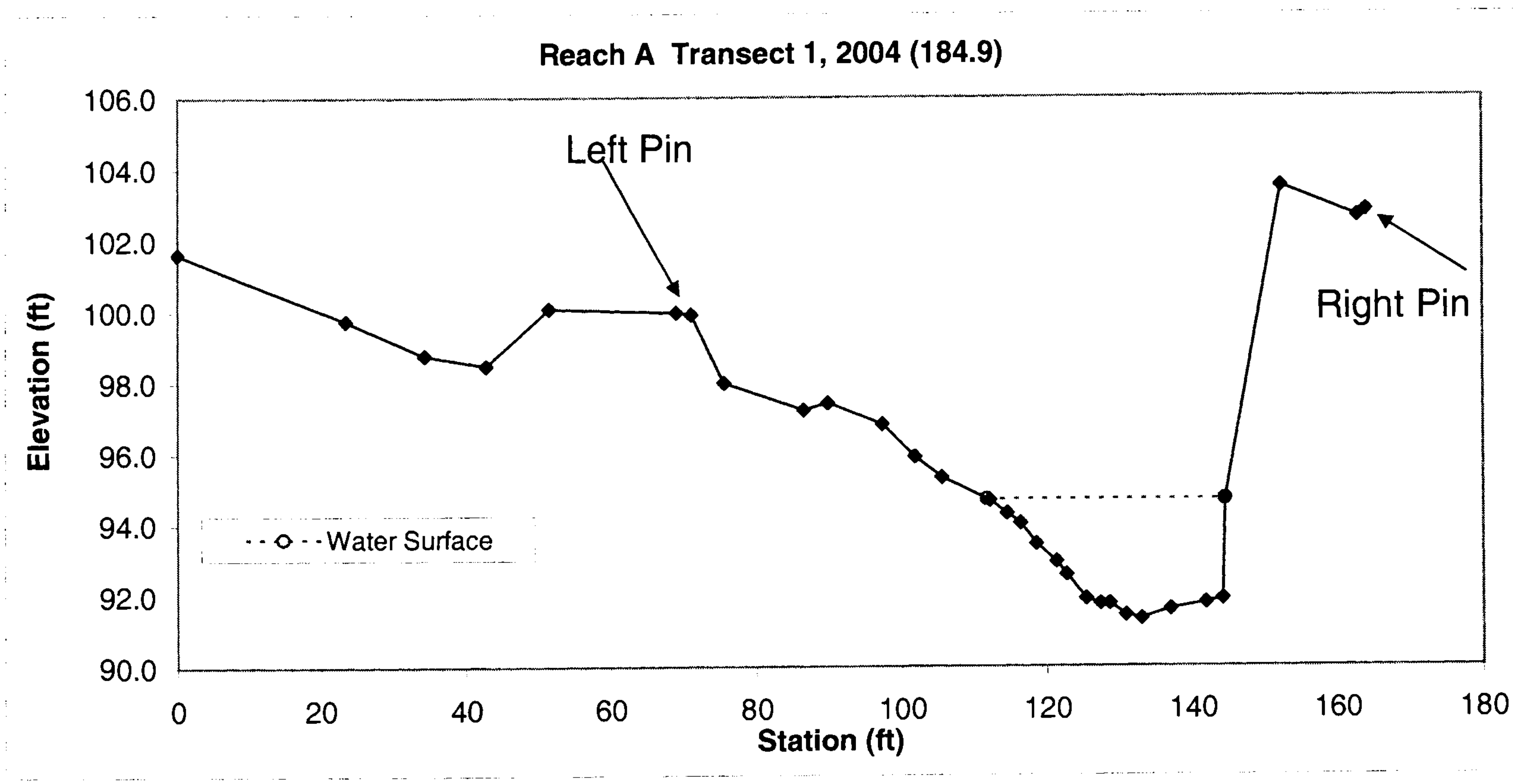

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Table 4. Cross-section data for Reach A, Transect 2 (Station 3+62).

Station:	Dead River bypassed channel, Reach A (Station 3+62)
Benchmark:	Nail in 2 ft diam. maple on left bank at Station 0+96 (Elevation=100 ft)
Height of Instrument	99.86
WaterSurface Elevation:	93.61
Channel Width (ft)	26.3
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross-sectional Area (sq. ft.)
Left Bank Rerod Marker	0			100.5	
	1.5	0		99.86	
	2.5	0.56		99.3	
	4.5	1.38		98.48	
	7.5	2.59		97.27	
	12.5	2.99		96.87	
	17.5	4.4		95.46	
	21.5	4.81		95.05	
	24.5	5.6		94.26	
	27.2	6.25	0	93.61	0.12
	29.5		0.23	93.38	0.4945
	31.5		0.32	93.29	0.64
	33.5		0.34	93.27	0.68
	35.5		0.4	93.21	0.8
	37.5		0.48	93.13	0.96
	39.5		0.3	93.31	0.6
	41.5		0.18	93.43	0.36
	43.5		0.25	93.36	0.5
	45.5		0.28	93.33	0.56
	47.5		0.44	93.17	0.88
	49.5		0.39	93.22	0.78
	51.5		0.3	93.31	0.6
	53.5	6.18	0	93.61	0.15
	57.5	6.05		93.81	
	62.5	5.95		93.91	
	67.5	5.34		94.52	
	72.5	4.2		95.66	
	77.5	3.11		96.75	
	82.5	2.53		97.33	
	87.5	1.38		98.48	
	90.5	0		99.86	
Right Bank Rerod Monument	98.5			101	

Total cross-section area (sq. ft.) 8.12

BUST

Bust

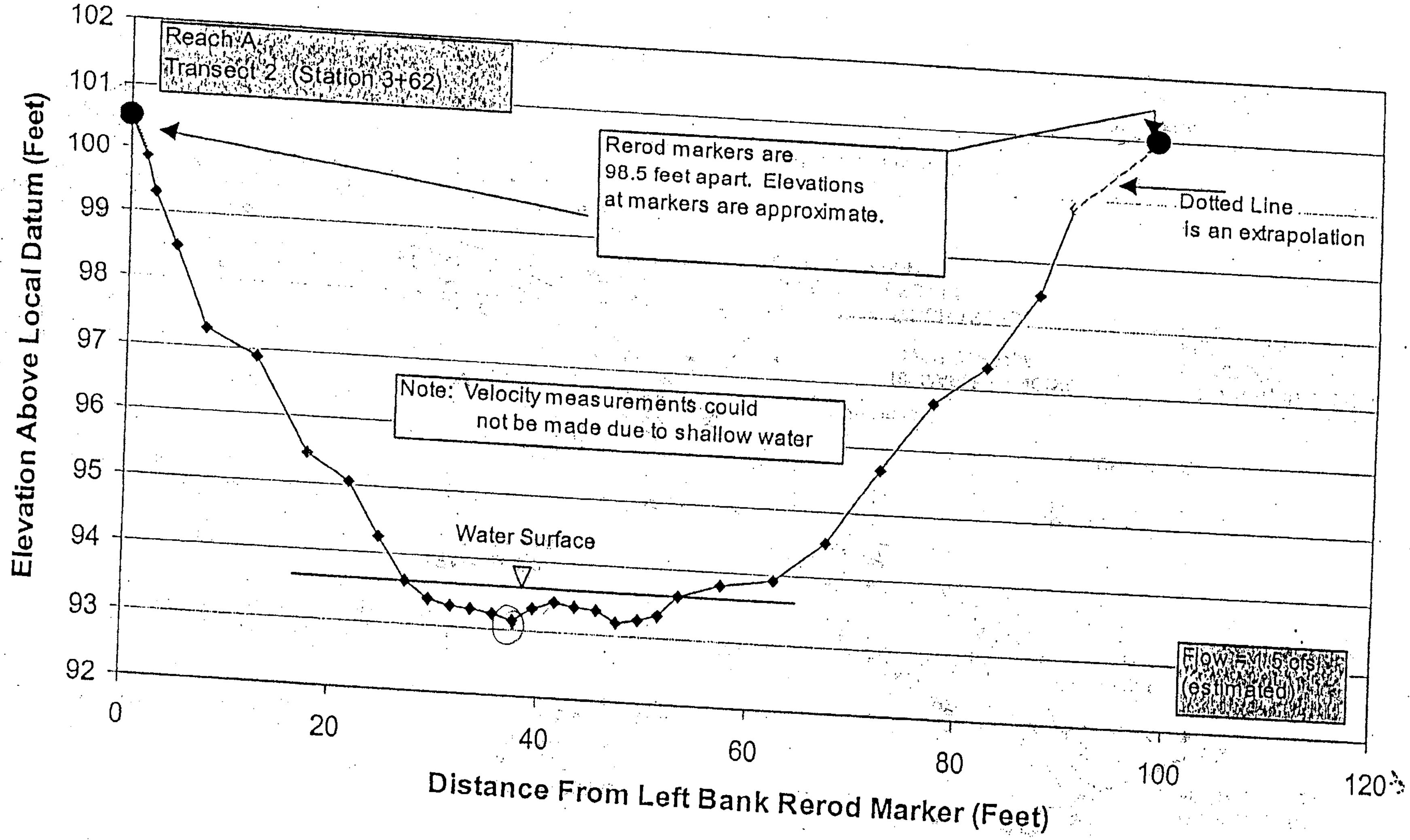
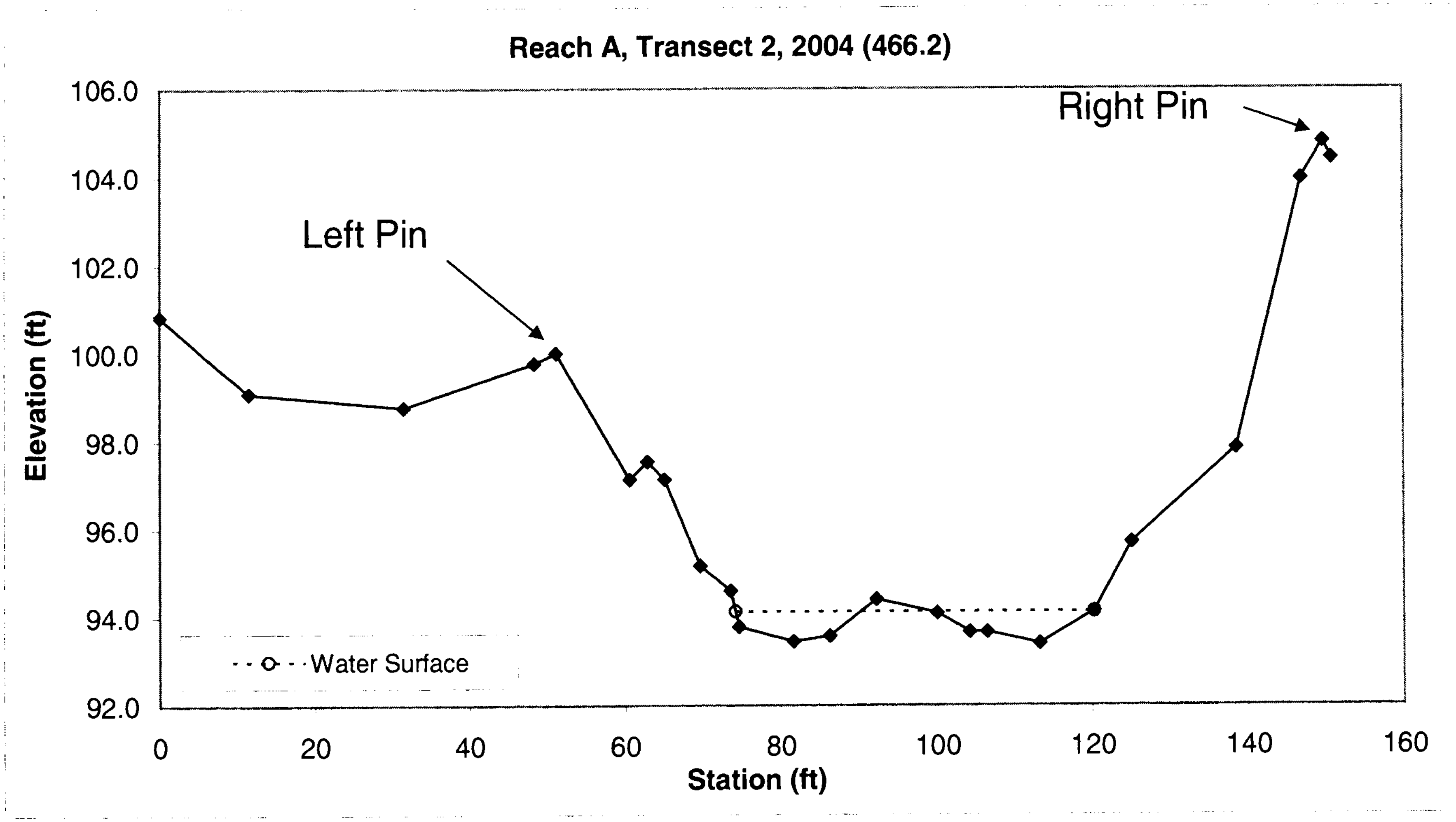


Figure 7. Cross-section profile of Reach A, Transect 2 (Station 3+62) on August 9, 2000.

Reach A, Transect 2, 2004

Pt #	North	East	Elevation	Note	Station
9184	5111.80	4904.02	100.84	X2 TOPO	0.0
9185	5123.46	4904.32	99.10	X2 TOPO	11.7
9186	5143.28	4905.75	98.78	X2 TOPO	31.5
9187	5160.14	4907.29	99.78	X2 TOPO	48.5
9188	5162.96	4907.37	100.02	X2 leBF 5\8	51.3
9189	5172.32	4908.07	97.14	X2 TOPO	60.7
9177	5174.67	4906.95	97.55	X2 LTB	62.9
9190	5176.73	4908.65	97.14	X2 TOPO	65.1
9191	5181.27	4908.65	95.17	X2 TOPO	69.6
9192	5185.17	4908.90	94.60	X2 TOPO	73.5
9193	5186.21	4908.99	93.79	X2 LCH	74.6
9194	5193.24	4910.06	93.45	X2 sch2	81.7
9195	5197.84	4910.56	93.57	X2 MCB 1	86.3
9196	5203.85	4910.66	94.41	X2 TOPO	92.3
9197	5211.55	4911.51	94.10	X2 MCB 1	100.0
9198	5215.71	4911.38	93.67	X2 TOPO	104.2
9199	5217.94	4911.72	93.66	X2 TWG	106.4
9200	5224.72	4912.08	93.40	X2 TOPO	113.2
9201	5231.77	4913.35	94.13	X2 RCH W-SF	120.3
9202	5236.65	4913.32	95.70	X2 TOPO	125.2
9203	5250.16	4911.95	97.85	X2 RTO	138.6
9204	5258.45	4912.70	103.96	X2 RTB	146.9
9205	5261.26	4913.06	104.80	x2 ReBF 5\8	149.7
9206	5262.31	4913.21	104.42	X2 TOPO	150.8


Reach A, Transect 2, 2004 (466.2)
Elevation (ft)
Station (ft)
Left Pin
Right Pin
Water Surface
106.0
104.0
102.0
100.0
98.0
96.0
94.0
92.0
0
20
40
60
80
100
120
140
160

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9000	5000	5000	95.3	SPIKE
9001	5175.856	5009.216	94.7319	SPIKE
9002	5030.979	4977.633	100	BM1
9003	5044.654	4977.022	99.9191	X1 leBF 5\8
9004	4935.244	4927.936	98.8328	LTB
9005	4937.534	4930.049	97.7352	LTB
9006	4943.694	4933.159	98.2229	LTB
9007	4946.724	4932.015	99.1169	LTB
9008	4924.364	4944.537	96.4895	TOPO
9009	4890.262	4941.972	95.485	LCH WSF
9010	4883.58	4944.116	95.2089	TWG
9011	4878.332	4946.004	95.294	MCB1 w-sf
9012	4876.507	4951.96	94.8754	MCB1
9013	4868.4	4953.092	94.5614	MCB1
9014	4859.498	4949.026	94.7265	MCB1
9015	4857.552	4953.97	94.0675	mcb-1 T-WG
9016	4854.939	4956.936	94.679	RCH WS F
9017	4858.626	4963.435	95.41	RTO
9018	4875.981	4954.441	94.6829	MCB1
9019	4885.723	4957.734	94.4043	TWG
9020	4895.652	4956.953	94.7328	LCH WSF
9021	4892.635	4968.426	93.4797	TWG
9022	4955.403	4956.92	95.0613	LTO
9023	4947.522	4975.071	95.53	TOPO
9024	4946.131	4980.791	94.7509	LCH WSF
9025	4941.302	4995.176	93.416	TWG
9026	4938.254	5012.071	94.7258	RCH W-SF
9027	4986.373	4997.127	94.7614	LCH WSF
9028	4979.173	5012.635	92.8566	TOPO
9029	4974.128	5019.936	92.2636	TWG
9030	4972.084	5028.136	94.6044	RCH W-SF RTO
9031	4991.579	5035.514	94.5851	RCH W-SF RTO
9032	4995.483	5024.935	92.2065	TWG
9033	5025.221	5067.861	102.8244	X1 ReBF 5\8
9034	5006.15	5006.398	94.7249	LCH WSF
9035	5058.581	4907.092	101.6299	X1 TOPO
9036	5053.674	4930.085	99.7579	X1 TOPO
9037	5051.404	4940.733	98.7815	X1 TOPO
9038	5049.615	4948.987	98.49	X1 TOPO
9039	5048.025	4957.64	100.0847	X1 LTB
9040	5045.449	4975.06	99.9764	X1 TOPO
9041	5043.329	4981.274	97.9969	X1 LTO
9042	5040.231	4991.717	97.2278	X1 TOPO
9043	5039.285	4994.923	97.4307	X1 TOPO
9044	5037.995	5002.322	96.827	X1 TOPO
9045	5037.072	5006.691	95.9151	X1 TOPO
9046	5036.484	5010.329	95.3316	X1 TOPO
9047	5035.462	5016.858	94.6804	X1 LCH WSF
9048	5035.36	5019.275	94.3141	X1 TOPO
9049	5035.154	5021.158	94.0343	X1 TOPO
9050	5034.949	5023.278	93.4552	X1 TOPO
9051	5034.796	5026.102	92.9512	X1 TOPO
9052	5033.209	5037.671	91.339	X1 TWG
9053	5033.381	5035.506	91.4434	X1 TOPO
9054	5034.152	5033.396	91.7707	X1 TOPO
9055	5034.501	5032.185	91.7688	X1 TOPO

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9056	5035.17	5030.328	91.9033	X1 TOPO
9057	5035.098	5027.578	92.5827	X1 TOPO
9058	5033.042	5041.735	91.6108	X1 TOPO
9059	5031.837	5046.438	91.7902	X1 TOPO
9060	5031.19	5048.634	91.9025	X1 TOPO RTO
9061	5031.033	5048.993	94.7131	X1 W-SF
9062	5028.237	5056.512	103.5063	X1 RTB
9063	5025.485	5066.75	102.6586	X1 TOPO
9064	5090.729	5026.268	94.706	LCH WSF
9065	5091.377	5042.886	92.2088	TWG
9066	5094.321	5060.243	94.5273	RCH
9067	5094.386	5060.037	92.9052	RTO
9068	5110.759	5023.306	94.7465	LCH WSF
9069	5117.252	5035.128	91.5876	TWG
9070	5134.932	5028.935	91.9847	HOG TWG
9071	5137.695	5046.531	94.711	RCH W-SF
9072	5154.071	5034.784	94.6477	RCH W-SF
9073	5155.898	5027.403	94.1206	HOR TWG
9074	5159.314	5019.238	94.7131	LCH WSF
9075	5168.292	5022.884	94.4678	LCH WSF
9076	5170.036	5028.033	93.1358	TWG
9077	5173.232	5033.547	94.4818	RCH W-SF
9078	5195.046	5027.837	94.3595	RCH W-SF
9079	5190.697	5024.217	92.8329	TWG
9080	5193.835	5009.832	92.9232	TWG
9081	5180.092	5008.543	94.4742	LCH WSF
9082	5109.867	4992.673	98.2948	TOPO
9083	5122.211	5007.908	97.5962	TOPO
9084	5112.464	4991.858	98.3945	TOPO
9085	5091.906	5000.633	97.389	TOPO
9086	5078.263	5007.882	95.615	TOPO
9087	5098.254	5016.696	96.395	TOPO
9088	5121.424	5008.761	97.6016	TOPO
9089	5137.409	4999.026	96.7739	TOPO
9090	5151.135	4997.321	95.204	TOPO
9091	5176.602	4990.017	94.3014	TOPO
9092	5177.637	4989.188	94.4682	LCH WSF
9093	5171.448	4980.612	94.9866	TOPO
9094	5169.618	4979.345	96.0049	TOPO
9095	5181.02	4984.871	95.9444	TOPO
9096	5200.496	4993.72	92.2396	TWG
9097	5210.851	4994.906	94.4247	RCH W-SF
9098	5209.431	4981.495	92.277	TWG
9099	5214.914	4966.623	92.8289	TWG
9100	5219.3	4955.233	92.1433	TWG
9101	5215.814	4939.939	93.8027	TWG
9102	5213.538	4932.114	93.7321	HOR TWG
9103	5219.886	4935.34	94.4335	RCH W-SF
9104	5236.798	4942.115	96.4637	RTO
9105	5189.628	4956.329	94.4979	LCH
9106	5195.799	4942.274	94.1892	LCH
9107	5187.369	4938.229	93.8355	LCH
9108	5216.033	4860.326	93.5779	SPIKE
9109	5187.201	4926.723	93.7918	LCH WSF
9110	5183.585	4924.243	95.4006	TOPO
9111	5195.922	4938.757	94.2078	sch2

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9112	5190.798	4936.673	93.9114	sch2
9113	5189.436	4928.355	93.6949	sch2
9114	5192.581	4915.492	93.5332	sch2
9115	5191.067	4907.349	93.6721	LCH WSF
9116	5189.984	4888.784	93.6011	LCH WSF
9117	5184.917	4887.527	94.4378	TOPO
9118	5194.212	4887.159	93.3661	sch2
9119	5202.027	4853.716	93.208	sch2
9120	5195.169	4851.324	93.3844	LCH LTO WSF
9121	5207.542	4830.401	93.4251	LCH LTO WSF
9122	5207.605	4830.427	93.4002	LCH LTO WSF
9123	5210.993	4834.318	93.1925	sch2
9124	5227.084	4818.832	92.8175	sch2
9125	5229.532	4801.637	92.3337	sch2
9126	5223.202	4804.045	92.6251	LCH WSF
9127	5202.328	4932.371	94.1197	sch3
9128	5193.693	4916.386	93.6376	sch3
9129	5192.1	4935.153	93.9683	MCB2
9130	5193.637	4924.286	93.9006	MCB2
9131	5197.175	4929.696	94.221	MCB2
9132	5198.279	4936.744	94.3509	MCB2
9133	5195.52	4931.443	94.2927	TOPO
9134	5202.348	4928.89	94.2811	MCB2
9135	5196.159	4917.008	93.8019	MCB2
9136	5202.849	4885.178	93.4684	MCB2
9137	5204.371	4865.612	93.6801	MCB2
9138	5208.325	4842.642	93.38	MCB2
9139	5215.583	4838.828	93.1966	MCB2
9140	5220.071	4850.052	93.1604	MCB2 WS-F
9141	5211.737	4886.912	93.6346	MCB2 WS-F
9142	5214.107	4905.332	93.9245	MCB2 WS-F
9143	5208.842	4926.237	94.4433	MCB2 WS-F
9144	5203.956	4929.802	94.4596	MCB2 WS-F
9145	5215.409	4922.395	93.7446	TWG
9146	5218.215	4907.165	93.3079	TWG
9147	5229.659	4922.053	94.0982	RCH
9148	5224.15	4906.15	93.8544	RCH
9149	5228.436	4885.129	93.5005	RCH W-SF
9150	5222.825	4882.308	92.9962	TWG
9151	5229.896	4864.297	92.7184	TWG
9152	5241.593	4865.499	93.0731	RCH
9153	5254.923	4850.439	93.0199	RCH W-SF
9154	5245.278	4845.167	92.3186	TWG
9155	5253.69	4827.612	92.3393	TWG
9156	5259.013	4831.129	92.8712	RCH W-SF
9157	5255.81	4818.378	92.1852	TWG
9158	5262.106	4805.001	92.0068	TWG
9159	5266.216	4790.751	91.9267	HOP TWG
9160	5270.024	4783.018	90.529	TWG
9161	5277.917	4807.771	92.6963	RCH W-SF
9162	5232.749	4831.403	92.8984	MCB3
9163	5242.051	4816.587	92.908	MCB3 WS-F
9164	5246.71	4813.813	92.8047	MCB3 WS-F
9165	5251.199	4802.204	92.5729	MCB3
9166	5250.259	4798.585	92.7519	MCB3 END REACH
9167	5241.79	4801.117	92.6144	MCB3

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9168	5232.599	4806.042	92.6914	MCB3
9169	5230.633	4823.055	92.8829	MCB3
9170	5230.443	4829.253	92.9184	MCB3
9171	5217.212	4804.911	93.5916	TOPO
9172	5205.482	4786.33	95.399	LTB
9173	5207.107	4817.337	97.3898	LTB
9174	5194.684	4832.871	99.7745	LTB
9175	5182.109	4862.713	99.1152	LTB
9176	5171.018	4900.496	98.5968	LTB
9177	5174.665	4906.948	97.5464	X2 LTB
9178	5182.643	4923.373	95.5472	LTB
9179	5177.71	4934.643	97.9492	LTB
9180	5182.632	4956.6	96.9064	LTB
9181	5177.589	4963.157	98.5159	LTB
9182	5170.631	4973.21	99.8087	LTB
9183	5160.44	4917.026	99.3438	BM2
9184	5111.797	4904.024	100.8407	X2 TOPO
9185	5123.456	4904.324	99.0991	X2 TOPO
9186	5143.282	4905.753	98.7834	X2 TOPO
9187	5160.144	4907.294	99.7799	X2 TOPO
9188	5162.961	4907.365	100.0233	X2 leBF 5\8
9189	5172.321	4908.067	97.1388	X2 TOPO
9190	5176.733	4908.652	97.1402	X2 TOPO
9191	5181.274	4908.653	95.1748	X2 TOPO
9192	5185.167	4908.904	94.6035	X2 TOPO
9193	5186.206	4908.986	93.7857	X2 LCH
9194	5193.243	4910.056	93.4496	X2 sch2
9195	5197.84	4910.562	93.5741	X2 MCB 1
9196	5203.85	4910.661	94.405	X2 TOPO
9197	5211.553	4911.514	94.0979	X2 MCB 1
9198	5215.712	4911.38	93.6652	X2 TOPO
9199	5217.937	4911.717	93.6616	X2 TWG
9200	5224.719	4912.077	93.3994	X2 TOPO
9201	5231.767	4913.348	94.1342	X2 RCH W-SF
9202	5236.645	4913.315	95.7034	X2 TOPO
9203	5250.16	4911.947	97.8503	X2 RTO
9204	5258.447	4912.696	103.9577	X2 RTB
9205	5261.263	4913.065	104.7987	x2 ReBF 5\8
9206	5262.313	4913.213	104.4181	X2 TOPO
9207	5258.156	4875.367	101.9586	RTB
9208	5272.979	4852.649	101.3454	RTB
9209	4910.446	4996.477	95.0295	RTO FORD
9210	4923.253	5005.931	96.1589	RTO FORD
9211	4921.655	5013.432	100.3035	RTB FORD
9212	4916.122	5011.888	98.9595	RTB FORD
9213	4913.431	5011.446	99.4843	RTB FORD

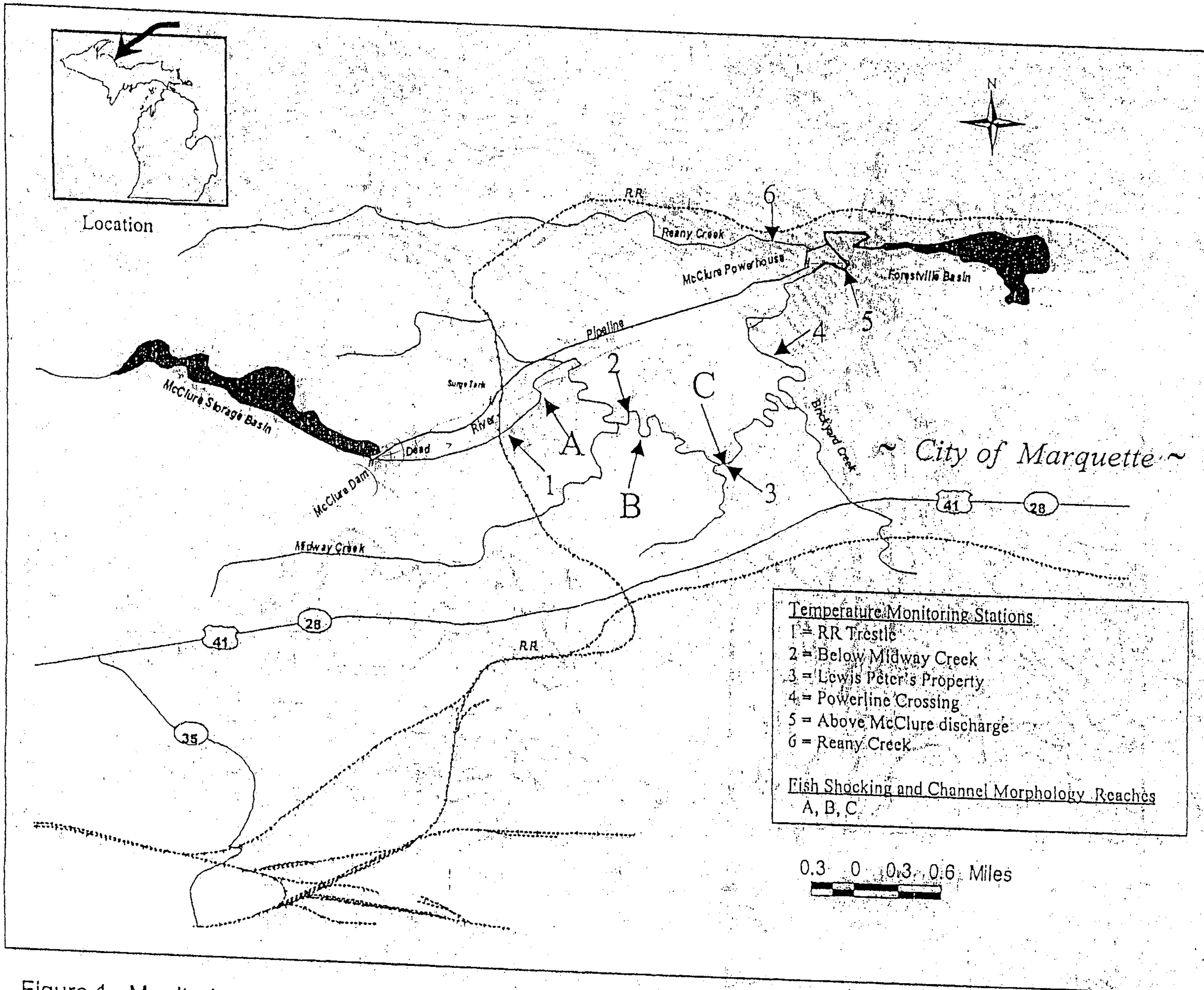


Figure 1. Monitoring locations in the Dead River bypassed channel, August 2000.

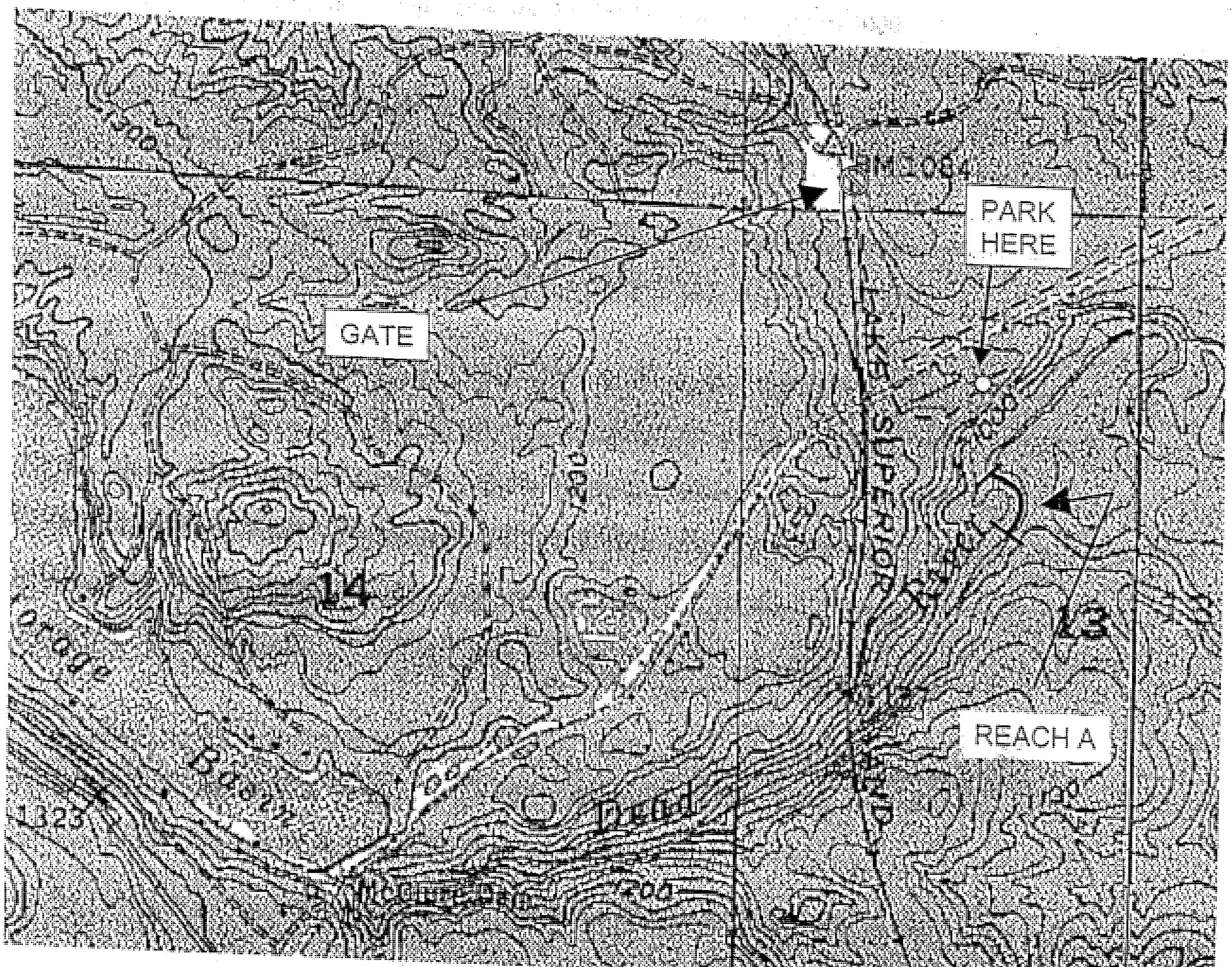
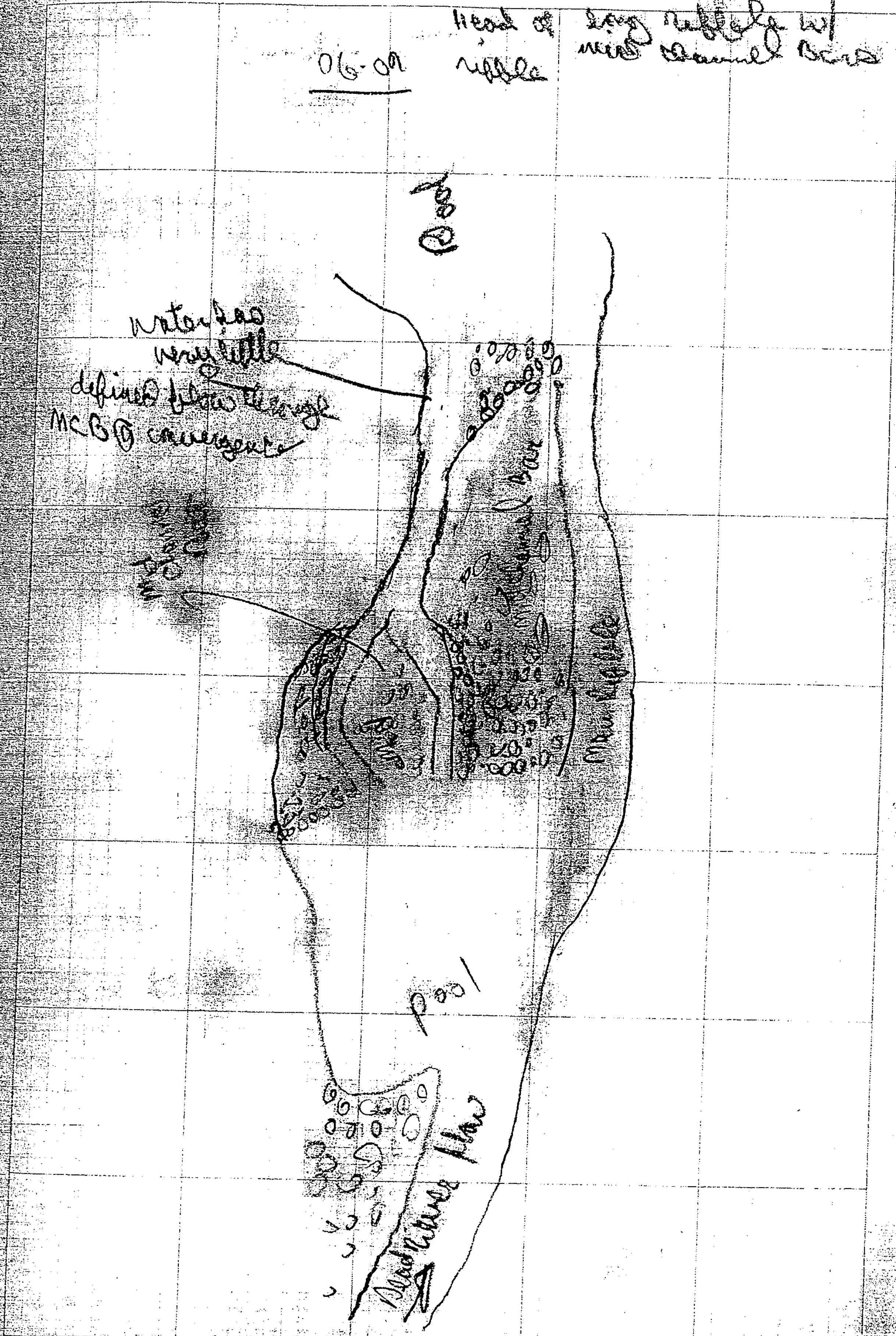


Figure 2. Location of Reach A on the Dead River bypassed channel.


Head of riffle
long riffle w/ mid channel bars
Pool
water has very little defined flow through MCB @ convergence
Pool

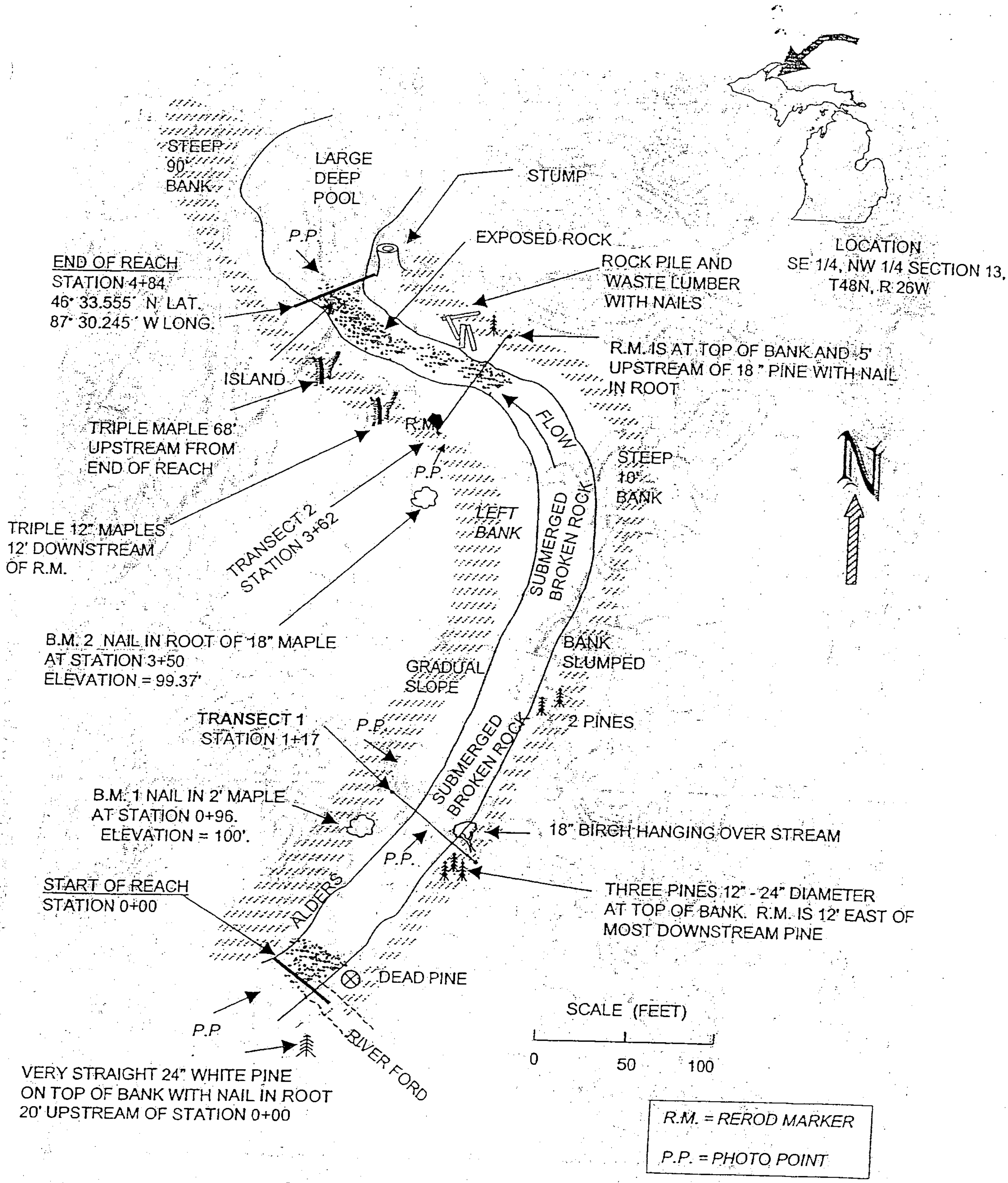


Figure 4. Map of Reach A on the Dead River bypassed channel, August 2000.

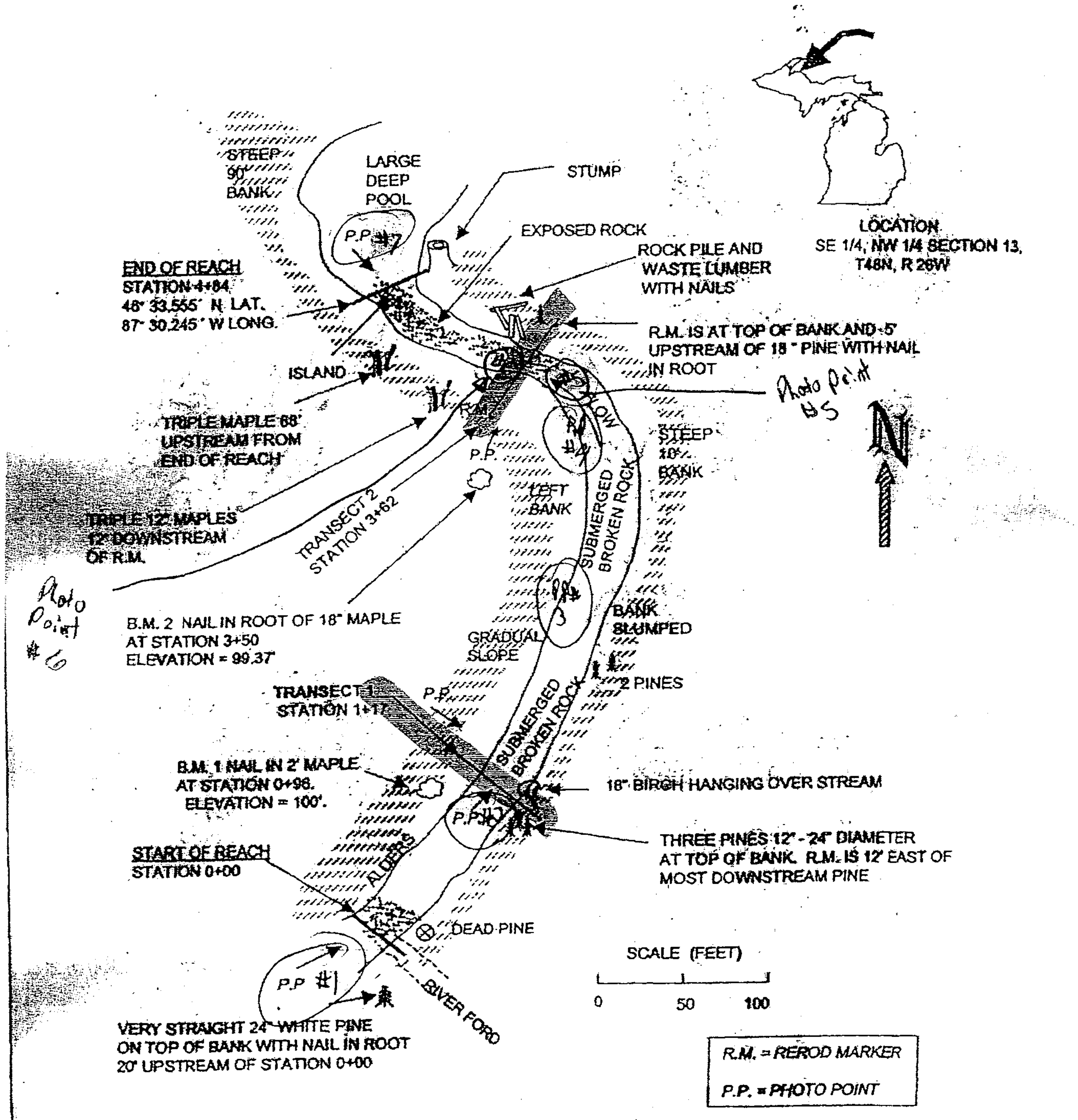


Figure 4. Map of Reach A on the Dead River bypassed channel, August 2000.

E R06-09 DEQ A

MDEQ Photo Log –Reach A

The following is the photo log that was created for each MDEQ reach (A, B and C). Each photo point (labeled either as PP or Photo point) had a number of different pictures taken and were subsequently described in the filed book. In the cases where panoramas were attempted to be taken, each picture number is sequential, and in most cases only the beginning shot and ending shot of the panoramic are identified with a detailed description. Field notes of the photos have been scanned in and are included in the electronic files. Upon return back to the office and the pictures downloaded, each photo was renamed to the same photo number taken in the field with a brief descriptor and photo point added.

Reach 06-06, DEQ Reach A. Pictures were taken on 7-28-04. Picture 53 is missing, because I accidentally shot a movie instead of a picture.

Photo #	Description
37	PP #1 Photo #37 upstream of beginning point of reach
38	PP#1 Photo #38 downstream of beginning point for reach
39	PP#1 Photo #39 right bank beginning point of reach
40	PP#1 photo #40 left bank beginning of reach
41	PP#2 Photo #41 x-sect. #1 looking left to right bank
42	PP#2 Photo #42 x-sect #1
43	PP#2 photo #43 x-sect #1
44	PP#2 photo #44 x-sect #1
45	PP#2 photo #45 upstream from x-section #1
46	PP#2 photo #46 downstream from x-section #1
47	PP#2 Photo #47 left bank from x-section #1
48	PP#3 Photo #48 downstream shot in pool near turn in river
49	PP#3 Photo #49 upstream shot in pool near turn in river
50	PP#4 Photo #50 downstream shot from turning point
51	PP#4 photo #51 upstream shot from turning point
52	PP#4 photo #52 upstream shot from turning point 2
54	PP#5 Photo #54 Panoramic of head of main riffle with small side channels
55	PP#5 Photo #55 panoramic of head of main riffle with small side channel left bank
56	PP#5 Photo #56 panoramic of head of main riffle
57	PP#5 Photo #57 panoramic of head of main riffle middle of river-right bank
58	PP#5 Photo #58 panoramic #2 head of main riffle with small side channel left bank
59	PP#5 Photo #59 panoramic #2
60	PP#5 Photo #60 panoramic #2
61	PP#5 Photo #61 panoramic #2
62	PP#5 Photo #62 panoramic #2

63	PP#5 Photo #63 panoramic #2 right bank
64	PP#6 Photo #64 upstream from convergence with side channel and main channel
65	PP#6 Photo #65 upstream from convergence with side channel 2
66	PP#6 Photo #66 Panoramic of convergence with side channel and dead river left bank
67	PP#6 Photo #67 panoramic of convergence with side channel
68	PP#6 Photo #68 panoramic with side channel 3
69	PP #6 Photo #69 panoramic right bank
70	PP #7 Photo #70 upstream from end of reach
71	PP#7 Photo #71 panoramic from end of reach upstream left bank to right bank
72	PP#7 Photo #72 panoramic 2
73	PP #7 Photo #73 panoramic 3
74	PP#7 Photo #74 panoramic 4
75	PP#7 Photo #75 panoramic right bank
76	PP#7 Photo #76 panoramic of pool downstream of end of reach left bank to right bank
77	PP#7 Photo #77 panoramic 2
78	PP#7 Photo #78 panoramic 3
79	PP#7 Photo #79 panoramic right bank


PP #1 Photo #37 upstream of beginning point of reach


PP#1 Photo #38 downstream of beginning point for reach


PP#1 Photo #39 right bank beginning point of reach


PP#1 photo #40 left bank beginning of reach


PP#2 Photo #41 x-sect. #1 looking left to right bank


PP#2 photo #45 upstream from x-section #1

PP#2 photo #46 downstream from x-section #1

PP#3 Photo #48 downstream shot in pool near turn in river

PP#3 Photo #49 upstream shot in pool near turn in river

PP#4 Photo #50 downstream shot from turning point

PP#4 photo #51 upstream shot from turning point

PP#5 Photo #56 panoramic of head of main riffle

PP#5 Photo #57 panoramic of head of main riffle middle of river-right bank

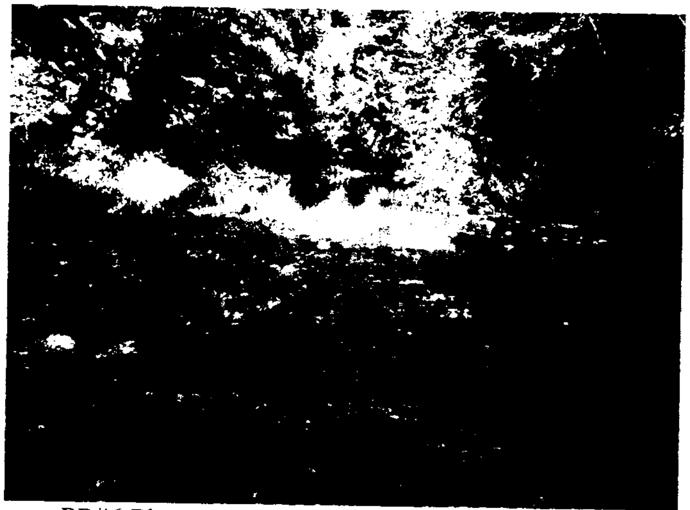
PP#5 Photo #61 panoramic #2

PP#5 Photo #62 panoramic #2

PP#5 Photo #63 panoramic #2 right bank

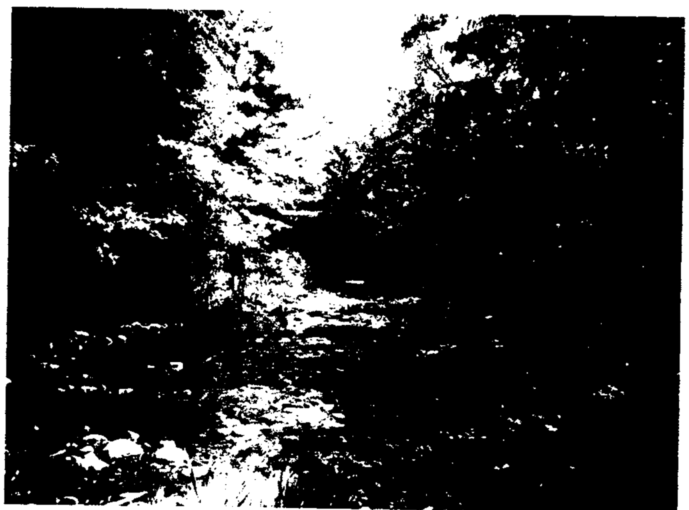
PP#6 Photo #65 upstream from convergence with side channel 2

PP#6 Photo #66 Panoramic of convergence with side channel and dead river left bank



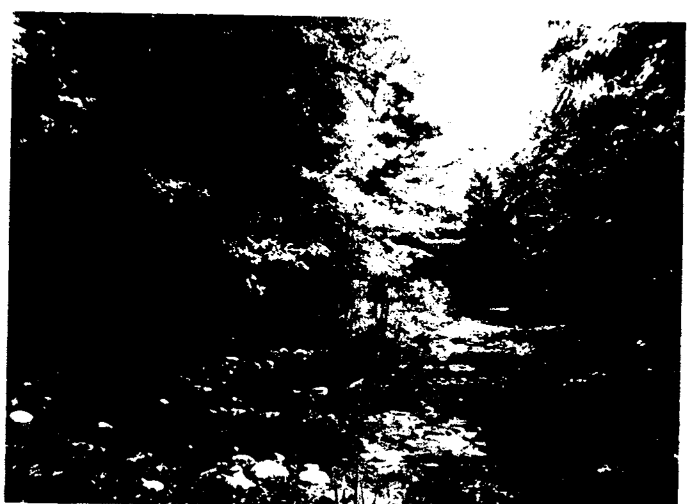
PP#6 Photo #68 panoramic with side channel 3

PP#6 Photo #69 panroamic right bank



PP#7 Photo #70 upstream from end of reach

PP#7 Photo #71 panoramic from end of reach upstream left bank to right bank



PP#7 Photo #72 panoramic 2

PP#7 Photo #73 panoramic 3


PP#7 Photo #74 panoramic 4


PP#7 Photo #75 panoramic right bank


PP#7 Photo #77 panoramic 2

R06-07 MDEQ-B

Initials | Work Item

SDC Collect the following data at a minimum for each sub-reach.

Reach R06-07, DEQ-B

- ☑ ✓ Survey longitudinal profile in the same location (beginning point to ending point) of the 2000 MDEQ survey.
- ☑ ✓ Survey the same cross sections surveyed by MDEQ in 2000 including no less than thirty (30) points, fifteen (15) of which must be within the wetted perimeter.
- ☑ ✓ Velocity at each cross section, measured at 0.6 of the depth measured from the surface.
- ☑ ✓ Sketch site per Harrelson et al., 1994
- ☑ ✓ Photograph site, including two (2) photos with tape/line stretched across stream. (TOTAL STATION SURVEY - NO TAPE)

Initials	Work Item
SDC	Provide the following items for each sub-reach in electronic and hard copy format.

Reach 06-07, DEQ-B

- ☑ Plot of longitudinal profile
- ☑ Plot of cross-sections
- ☑ Site sketch
- ☑ Photographs and photo log

Table: Summary Data for the Dead River Bypassed Channel, August 2000 vs 2004

Reach Name	2004 A	2000 A	2004 A	2000 A	2004 A	2000 B	2004 B	2000 B	2004 B	2000 B	2004 B	2000 C	2004 C	2000 C	2004 C	2000 C	2004 C
Reach Length (ft)		484	606	484	606	464	543	464	543	464	543	392	472	392	472	392	472
Water Surface Slope (ft/mile)		15.2	17.96	15.2	17.96	4.32	1.58	4.32	1.58	4.32	1.58	2.96	5.28	2.96	5.28	2.96	5.28
Average Thalweg Depth (ft) [3]		0.78	1.33	0.78	1.33	1.81	2.15	1.81	2.15	1.81	2.15	1.42	2.3	1.42	2.3	1.42	2.3
Transect Name		1	1	2	2	1	1	2	2	3	3	1	1	2	2	3	3
Transect Location [1]	0+00	1+17	1+17 (1+85)	3+62	3+62 (4+66)	1+60	1+60 (2+32)	2+86	2+86 (3+58)	4+64	4+64 (5+43)	0+00	0+00 (0+34)	1+57	1+57 (1+90)	3+50	3+50 (4+05)
Transect Width (ft) [3]		43	32.7	26.3	37.3	17.4	22.6	20	22.5	22.9	25.7	11.5	16.0	25.8	25.4	21.5	24.8
Transect Cross Sectional Area (sq. ft) [3]		48.4	75.1	8.13	16.5	21.9	34.9	47.8	41.1	30.5	41.4	9.4	36.8	17.9	51.8	18.9	68.3
Average Depth in Transect (ft) [3]		1.12	2.3	0.31	0.4	1.26	1.5	2.4	1.8	1.33	1.6	0.81	2.3	0.69	2.0	0.88	2.8
Average Measured Velocity (fps) [2]		--	--	--	--	0.13	--	--	--	--	--	0.51	--	0.28	--	0.26	--
Calculated Velocity by flow/area (fps)		0.06	1.5	0.36	0.5	0.14	1.2	0.06	1.3	0.1	1.3	0.49	1.2	0.26	1.2	0.24	1.4
Stream flow (cfs)	2.0			1.5		3	3.8	3		3	6.2	4.6	6.7	4.6	8.5	4.6	8.8

1. Transect location in ( ) is the station from the 2004 survey starting at station 0+00.
2. Average Measured Velocities were provided by MDEQ in 2000.
3. Cross sectional area, transect width, average depth in transect are based on average water surface depth.
4. Assumed horizontal coordinates were used for the resurvey of reaches A, B, and C. No horizontal datum was used for the 2000 survey of these three reaches.
Vertical data for all three reaches of the 2004 resurvey were tied to benchmarks established during the 2000 survey.
These vertical benchmarks were also assumed and were not tied to each other.

Table 1. Summary of channel morphology, flow, and velocity measurements for the Dead River bypassed channel, Agust 2000.

Reach Name	Reach Length (ft)	Water Surface Slope (ft/mile)	Average Thalweg Depth (ft)	Transect Name	Transect Location	Transect Width (ft)	Transect Cross Sectional Area (sq. ft.)	Average Depth in Transect (ft)	Average Measured Velocity (fps)	Calculated Velocity by flow/area (fps)	Stream Flow (cfs)
A	484	15.2	0.78	-	-	-	-	-	-		1.5*
				1	1+17	43	48.4	1.12	-	0.06	
				2	3+62	26.3	8.13	0.31	-	0.36	
B	464	4.32	1.81	-	-	-	-	-	-		3
				1	1+60	17.4	21.9	1.26	0.13	0.14	
				2	2+86	20	47.8	2.4	-	0.06	
				3	4+64	22.9	30.5	1.33	-	0.1	
C	392	2.96	1.42	-	-	-	-	-	-		4.6
				1	0+00	11.5	9.4	0.81	0.51	0.49	
				2	1+57	25.8	17.9	0.69	0.28	0.26	
				3	3+50	21.5	18.9	0.88	0.22	0.24	

* Estimate

Dead River Reach B, NE 1/4, SE 1/4 Section 13, T48N, R26W, Marquette County
46.5553 N 87.4928 W

7/28/04 Afternoon

Pygmy Meter y-0060
Flow Measurement

Spin test before measurement 42
Spin test after measurement 30

distance from initial (ft)	depth (ft)	observations at 0.6 depth rev #	time (sec)	velocity (ft/sec)	flow (ft^3/sec)	Comments
3	0.3	0				Bank
3.5	0.3	15	33	0.48	0.07	
4	0.5	15	35	0.45	0.11	
4.5	0.7	15	33	0.48	0.17	
5	0.8	25	36	0.71	0.26	
5.4	0.8	40	44	0.92	0.29	
5.8	0.8	30	31	0.97	0.31	
6.2	0.9	40	41	0.98	0.35	
6.6	0.95	35	37	0.95	0.32	
6.9	0.9	40	43	0.94	0.25	
7.2	0.9	40	45	0.90	0.24	
7.5	1	40	42	0.96	0.29	
7.8	1	40	43	0.94	0.28	
8.1	0.9	35	38	0.93	0.25	
8.4	0.9	40	45	0.90	0.24	
8.7	0.8	40	43	0.94	0.22	
9	0.8	40	43	0.94	0.22	
9.3	0.8	40	44	0.92	0.22	
9.6	0.7	35	44	0.81	0.17	
9.9	0.65	25	43	0.60	0.12	
10.2	0.5	15	57	0.30	0.04	
10.5	0.35	5	90	0.10	0.01	
10.9	0.2	0				start of dead water
					4.4	

Velocity Measurements for Station 1+60

distance from initial point on right bank (ft)	depth (ft)	observations at 0.6 depth rev #	time (sec)	velocity (ft/sec)	flow (ft^3/sec)	Comments
3	0.2	0		0		right bank
6	1.4			<0.1	0	
8	2.1			<0.1	0	
10	2.5			<0.1	0	
12	2.5	5	60	0.12	0.62	
14	1.8	15	41	0.39	1.42	
16	1.3	15	38	0.42	1.10	
18	1.1	10	38	0.30	0.65	
20	0.7			<0.1	0	
23	0			0	0	left bank
				Total	3.78	

Dead River Reach B, NE 1/4, SE 1/4 Section 13, T48N, R26W, Marquette County
46.5553 N   87.4928 W

Velocity Measurements for Station 2+86

distance from right bank (fraction of total width)	depth (ft)	observations at 0.6 depth rev #	time (sec)	velocity (ft/sec)	Comments
1/4	2.2	0		0	
1/2	2.7	7	45	0.19	
3/4	2	4	35	0.15	
7/8	1.5	3	52	0.10	

Note: Tape was not stretched at this staiton. Poisiton in the transect was determined
Flow can not be calculated on this section due to the distance measurements not being actual distances.

Velocity Measurements for Station 4+64

distance from initial point on left bank (ft)	depth (ft)	observations at 0.6 depth rev #	time (sec)	velocity (ft/sec)	flow (ft^3/sec)	Comments
8				0		bank
10				0	0	
12				0	0	
14				0	0	
16	1.6	5	38	0.169316	0.541811	
18	1.5	10	32	0.343	1.029	
20	2	10	28	0.385857	1.543429	
22	2.4	15	37	0.432189	2.074508	
24	2.1	7	35	0.235	0.987	
26	1.3			0	0	
				Total	6.18	

Table 5. Longitudinal profile of Reach B of the Dead River bypassed channel.

Benchmark 1 (elevation=100 ft): nail in base of 2 ft diam. white pine on left bank

	Elevations		Residual Pool	Residual	Average Residual	Height of	Minus Sights		Thalweg
Location	Water Surf (ft)	Thalweg (ft)	Surface (ft)	Pool Depth (ft)	Pool Depth (ft)	Instrument (ft)	Water Surf (ft)	Thalweg (ft)	Depth (ft)
0	95.24	94.52				101.89	6.65	7.37	0.72
21	95.23	93.59	94.41	0.82		101.89	6.66	8.3	1.64
31	95.21	92.62	94.41	1.79		101.89	6.68	9.27	2.59
51	95.2	93.55	94.41	0.86		101.89	6.69	8.34	1.65
72	95.21	94.16	94.41	0.25		101.89	6.68	7.73	1.05
92	95.2	91.64	94.41	2.77		101.89	6.69	10.25	3.56
113	95.2	93.74	94.41	0.67		101.89	6.69	8.15	1.46
135	95.2	93.97	94.41	0.44		101.89	6.69	7.92	1.23
159	95.17	92.72	94.41	1.69		101.89	6.72	9.17	2.45
182	95.16	93.84	94.41	0.57		101.89	6.73	8.05	1.32
202	95.17	94.02	94.41	0.39		101.89	6.72	7.87	1.15
224	95.17	94.01	94.41	0.4		101.89	6.72	7.88	1.16
247	95.13	92.47	94.41	1.94		101.41	6.28	8.94	2.66
267	95.1	92.65	94.41	1.76		101.41	6.31	8.76	2.45
288	95.11	91.31	94.41	3.1		101.41	6.3	10.1	3.8
313	95.11	92	94.41	2.41		101.41	6.3	9.41	3.11
333	95.11	92.76	94.41	1.65		101.41	6.3	8.65	2.35
365	95.11	94.41	94.41	0	1.34	101.41	6.3	7	0.7
388	95.08	94.41				101.41	6.33	7	0.67
413	94.91	92.96	94.23	1.27		101.41	6.5	8.45	1.95
435	94.89	94.23	94.23	0	1.27	101.41	6.52	7.18	0.66
464	94.86	93.34				101.41	6.55	8.07	1.52

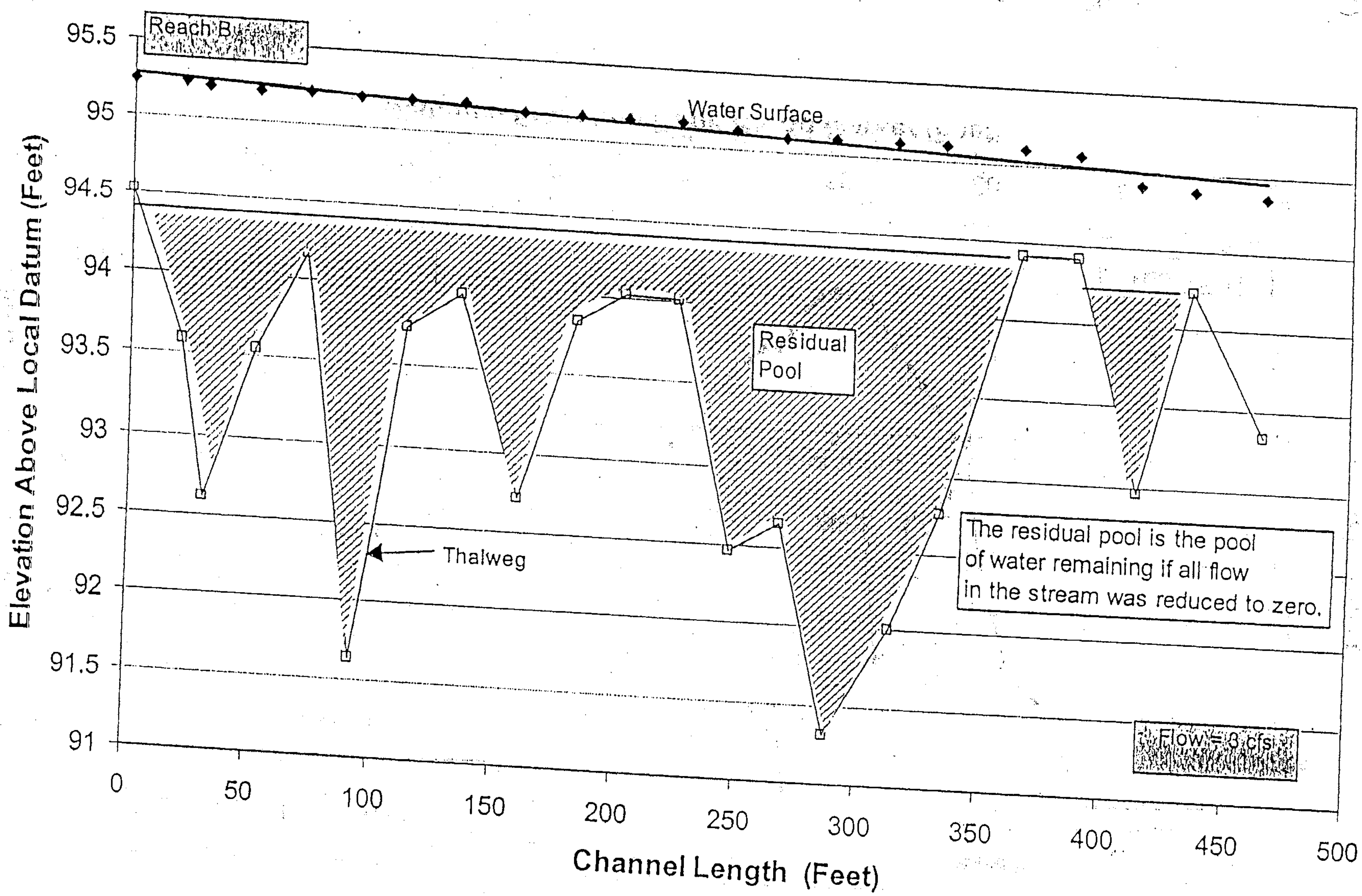


Figure 9. Longitudinal profile of Reach B on August 9, 2000.

MDEQ Reach B, Profile 2004

Descriptor =	TWG		Descriptor =	WSF
Station	**Elevation**		**Station**	**Elevation**
0.0	94.41		1.9	95.45
0.6	94.35		60.8	95.34
10.7	94.18		154.3	95.37
21.2	94.29		179.8	95.35
40.6	94.71		198.8	95.31
44.9	94.10		220.0	95.31
50.6	94.24		231.7	95.34
60.8	94.10		253.1	95.33
74.5	91.86		303.5	95.31
78.6	93.36		333.9	95.33
85.7	93.38		360.4	95.35
98.6	93.14		382.2	95.33
111.9	92.19		412.4	95.34
130.4	92.47		434.7	95.35
152.9	91.88		452.5	95.29
163.6	92.14		477.6	95.14
177.4	93.03		506.8	95.25
195.4	93.75		532.8	95.27
222.5	93.45			
232.3	92.79			
237.9	92.13			
241.0	92.33			
252.0	93.39			
285.1	92.67			
300.5	93.68			
333.6	92.92			
349.9	92.78			
358.2	92.39			
365.8	92.43			
380.1	92.04			
411.4	92.95			
432.1	93.90			
454.5	94.25			
476.6	94.15			
488.3	93.61			
504.9	93.70			
542.7	92.75			

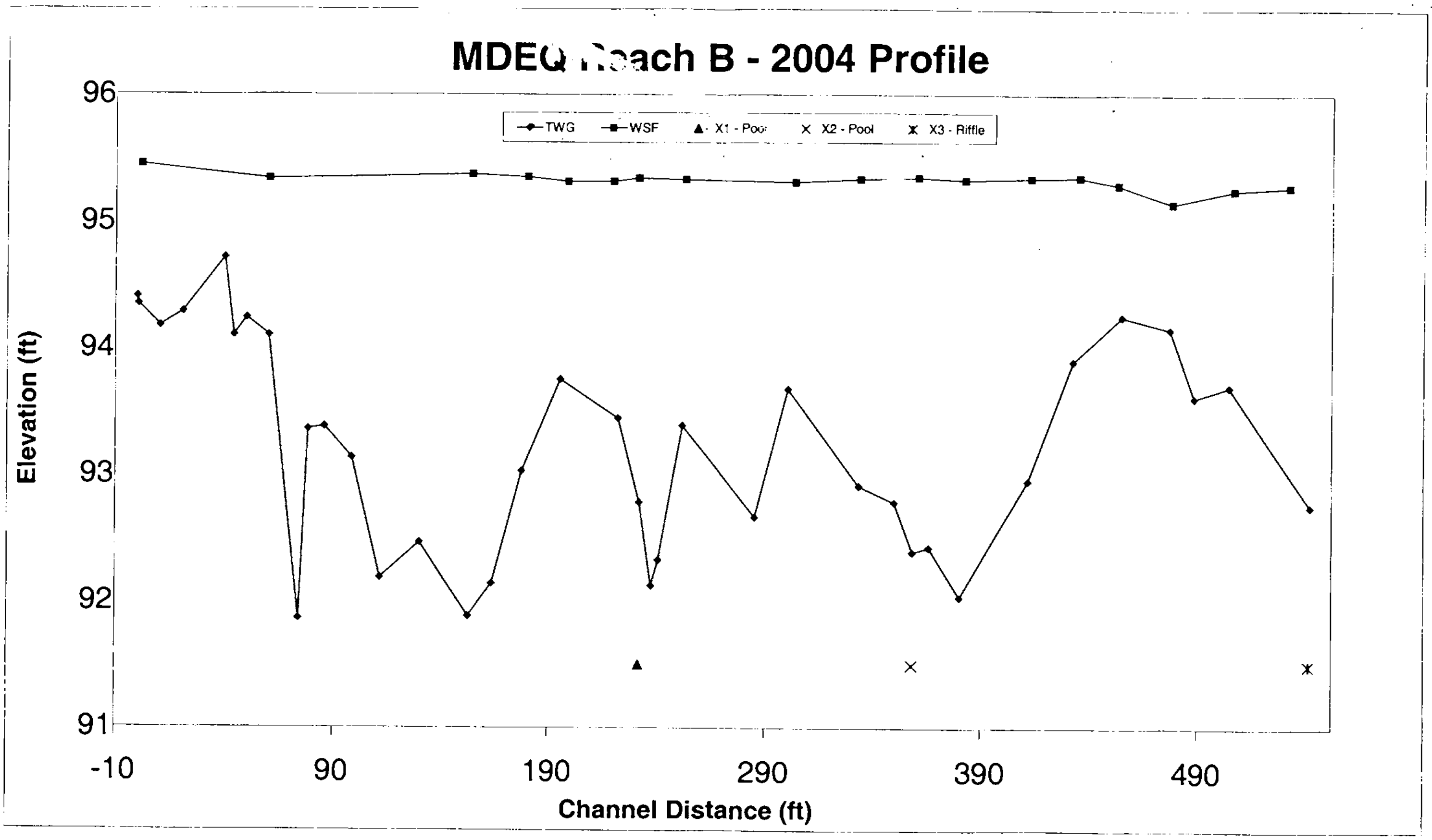

MDEQ Reach B - 2004 Profile
TWG
WSF
X1 - Pool
X2 - Pool
X3 - Riffle
Elevation (ft)
96
95
94
93
92
91
-10
90
190
290
390
490
Channel Distance (ft)

Table 6. Cross-section data for Reach B, Transect 1 (Station 1+60).

Station:	Dead River bypassed channel, Reach B (Station 1+60)
Benchmark:	Nail in base of 2 ft diam. white pine on left bank (elevation=100 ft)
Height of Instrument	100.73
WaterSurface Elevation:	95.17
Channel Width (ft)	17.4
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	2.45		98.28		
	2	2.81		97.92		
	4	3.24		97.49		
	9	3.5		97.23		
	14	3.72		97.01		
	19	3.81		96.92		
	24	4.26		96.47		
	29	4.79		95.94		
	34	4.79		95.94		
	39	5.31		95.42		
	40.6		0	95.17	0	0.18
	42		0.6	94.57	0.05	0.72
	43		0.8	94.37	0.05	0.8
	44		1	94.17	0.05	1
	45		1.2	93.97	0.05	1.2
	46		1.2	93.97	0.27	1.2
	47		1.5	93.67	0.46	1.5
	48		1.8	93.37	0.23	1.8
	49		2	93.17	0.05	2
	50		2.1	93.07	0.05	2.1
	51		2.1	93.07	0.05	2.1
	52		2.1	93.07	0.05	2.1
	53		1.7	93.47	0.26	1.7
	54		1.3	93.87	0.16	1.3
	55		1	94.17	0.05	1
	56		0.7	94.47	0.05	0.7
	57		0.4	94.77	0.05	0.4
	58		0	95.17	0	0.1
	59	5.5		95.23		
	60	3.66		97.07		
	61	2.9		97.83		
	62	2.12		98.61		
	63	1.79		98.94		
	64	1.63		99.1		
	65	1.34		99.39		
	66	0.72		100.01		
	68	0.05		100.68		
Right Bank Rerod Marker	75	0.05		100.68		

Total cross-sectional area (sq. ft.) 21.9

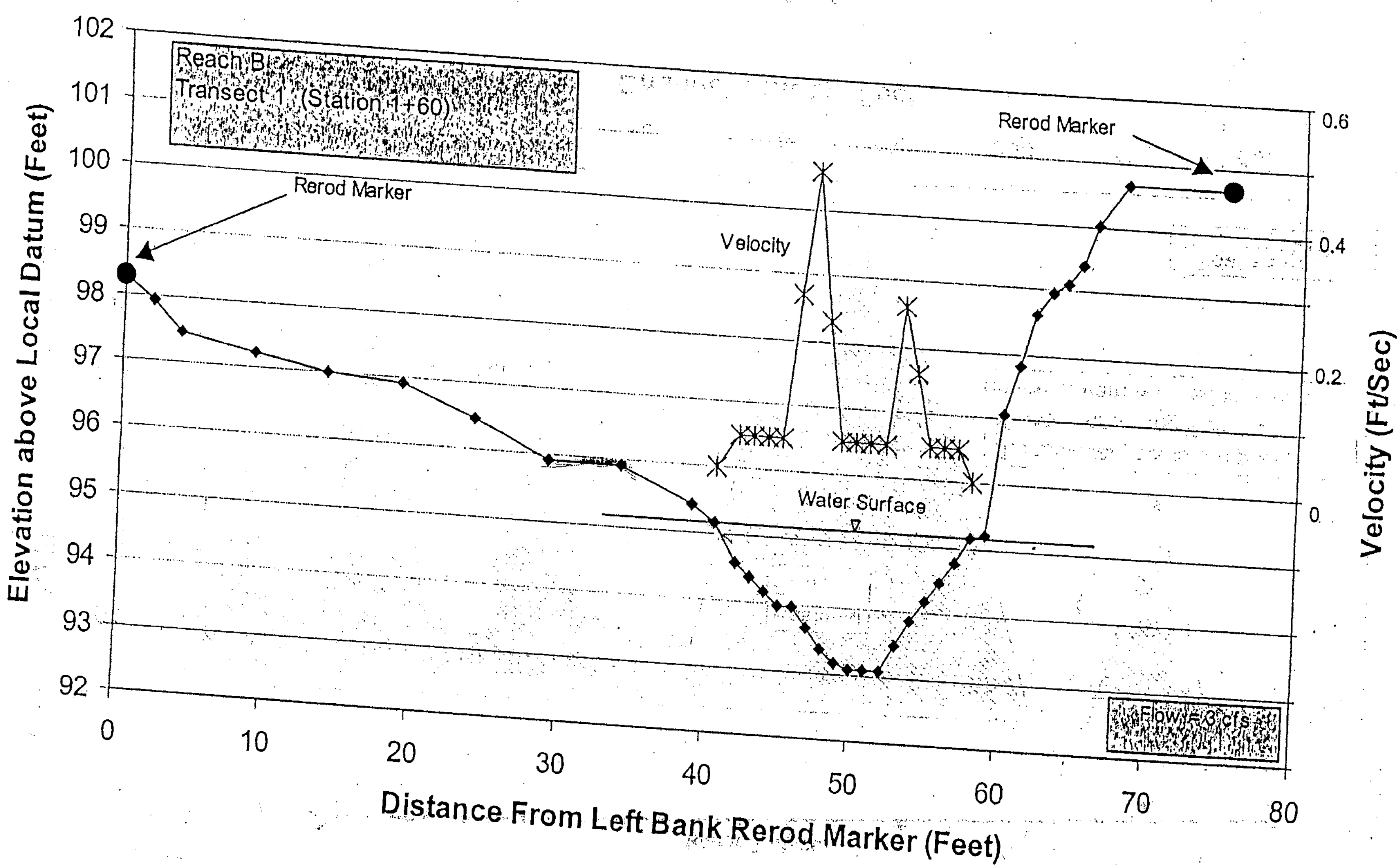


Figure 10. Cross-section profile of Reach B, Transect 1(Station 1+60) on August 9, 2000.

Reach B, Transect 1, 2004

Pt #	North	East	Elevation	Note	Station
9465	5022.17	5101.89	98.54	X1 TOPO	0.0
9466	5010.11	5105.17	98.74	X1 LEBF 5\8	12.5
9467	5008.05	5105.27	98.00	X1 TOPO	14.5
9468	5002.30	5105.90	97.28	X1 TOPO	20.3
9469	4986.80	5108.69	97.19	X1 TOPO	36.0
9470	4976.82	5110.62	96.63	X1 TOPO	46.2
9471	4972.27	5111.32	96.34	X1 TOPO ltb	50.8
9472	4971.18	5111.35	95.34	X1 LCH WSF	51.8
9473	4966.77	5112.00	94.16	X1 TOPO	56.3
9474	4964.38	5112.45	93.93	X1 TOPO	58.7
9475	4962.82	5112.95	93.60	X1 TOPO	60.4
9476	4961.89	5113.35	93.29	X1 TOPO	61.3
9477	4960.79	5113.44	93.00	X1 TOPO	62.4
9478	4959.60	5113.62	92.79	X1 TWG	63.6
9479	4957.82	5113.79	93.04	X1 TOPO	65.4
9480	4955.24	5114.28	93.32	X1 TOPO	68.0
9481	4953.31	5114.63	93.54	X1 TOPO	70.0
9482	4950.83	5115.29	94.27	X1 TOPO	72.6
9483	4949.61	5115.18	94.80	X1 TOPO	73.7
9484	4948.93	5115.03	95.38	X1 RCH W-SF	74.4
9485	4948.02	5116.09	97.73	X1 TOPO	75.5
9486	4945.15	5116.70	99.89	X1 TOPO	78.4
9487	4942.94	5117.75	101.18	X1 RTB	80.8
9488	4939.33	5118.63	101.87	X1 REBF 5\8	84.5
9489	4936.95	5119.25	102.45	X1 REBF 5\8	87.0
9490	4936.59	5119.26	101.90	X1 TOPO	87.3
9491	4925.51	5122.29	101.99	X1 TOPO	98.8

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Reach B, Transect 1, 2004 (232.3)

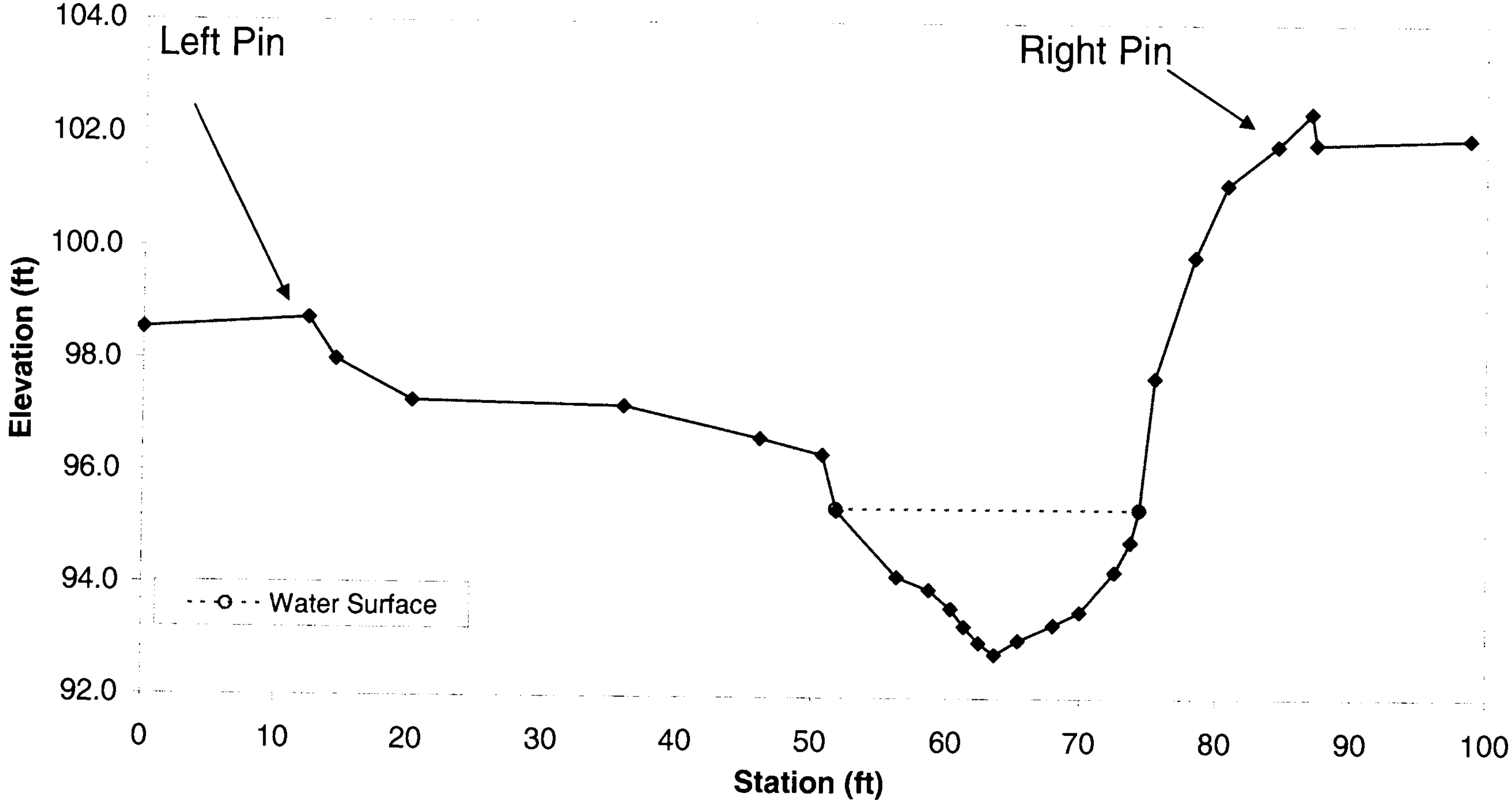

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Table 7. Cross-section data for Reach B, Transect 2 (Station 2+86).

Station:	Dead River bypassed channel, Reach B (Station 2+86)
Benchmark:	Nail in base of 2' diam. white pine on left bank (elevation=100 ft)
Height of Instrument:	100.71
Water Surface Elevation:	95.05
Channel Width (ft)	20
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	2.04		98.67	
	5	3.16		97.55	
	10	3.62		97.09	
	15	3.31		97.4	
	20	4.33		96.38	
	25	4.72		95.99	
	30	4.31		96.4	
	35	4.52		96.19	
	40	5.3		95.41	
	45	5.21		95.5	
	50	4.75		95.96	
	55	4.58		96.13	
	56	5.16		95.55	
	57.5		2.1	92.95	3.15
	59		3	92.05	4.5
	60.5		3.5	91.55	5.25
	62		3.9	91.15	5.85
	63.5		3.4	91.65	5.1
	65		3.3	91.75	4.95
	66.5		3.1	91.95	4.65
	68		2.8	92.25	4.2
	69.5		2.4	92.65	3.6
	71		1.8	93.25	2.7
	72.5		1.5	93.55	2.25
	74		0.9	94.15	1.35
	75.5		0.2	94.85	0.23
	76.3	5.66	0	95.05	0.05
	78	2.82		97.89	
	79	2.21		98.5	
	80	1.48		99.23	
	82.5	0		100.71	
Right Bank Rerod Marker	91			101.5	

Total cross-sectional area (sq. ft.) 47.83

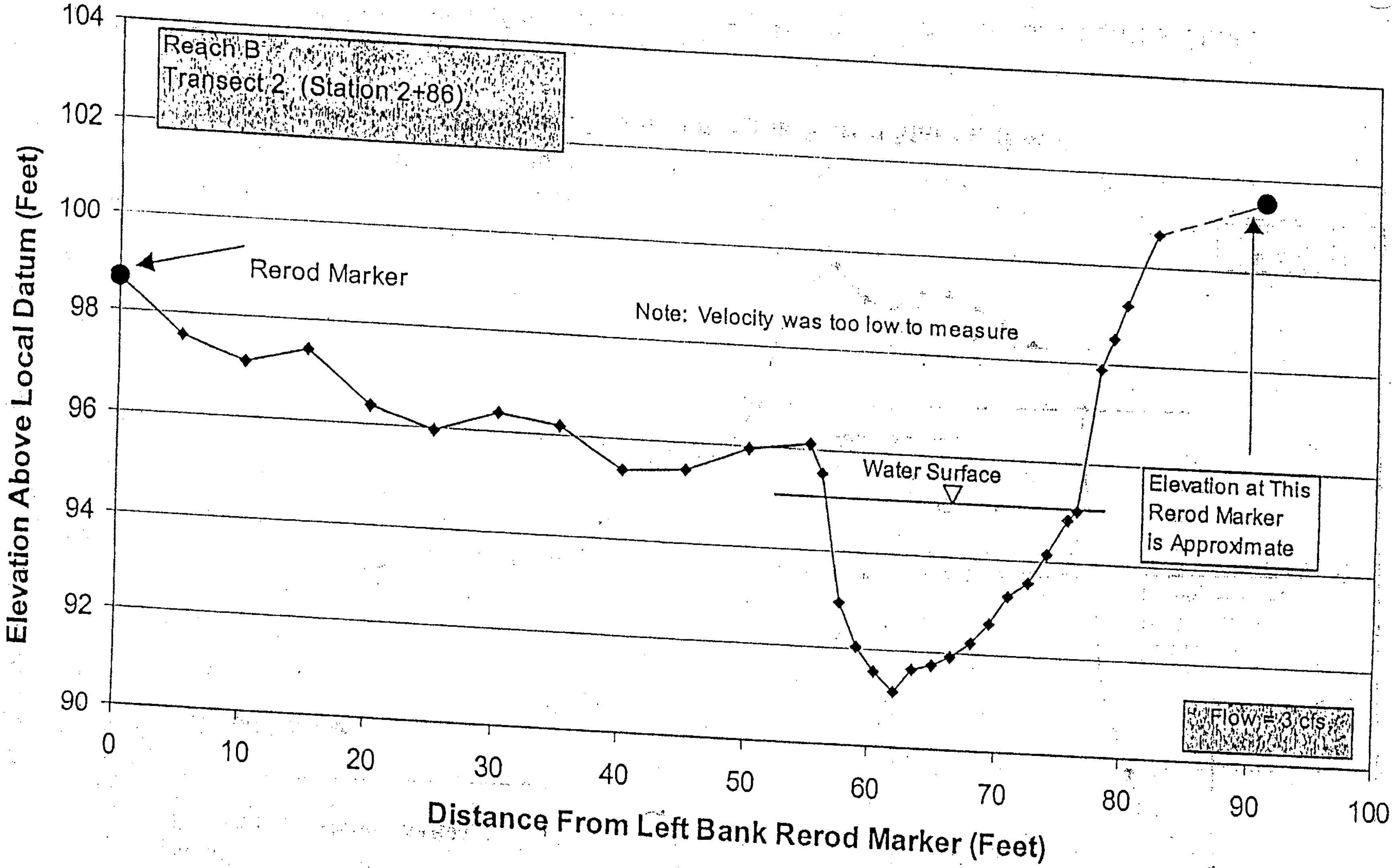

Figure 11. Cross- section profile of Reach B, Transect 2 (Station 2+86) on August 9, 2000.

Reach B, Transect 2, 2004

Pt #	North	East	Elevation	Note	Station
9505	5060.20	5167.43	99.21	X2 LEBF 5\8	0.0
9506	5058.43	5169.55	97.89	X2 TOPO	2.8
9507	5056.02	5172.39	97.13	X2 TOPO	6.5
9508	5052.32	5176.19	97.20	X2 TOPO	11.8
9509	5049.91	5179.68	97.09	X2 TOPO	16.0
9510	5047.64	5183.17	96.19	X2 TOPO	20.1
9511	5041.65	5190.82	96.24	X2 TOPO	29.9
9512	5034.23	5199.23	96.21	X2 TOPO	41.1
9513	5032.34	5201.76	97.03	X2 TOPO	44.2
9514	5029.08	5205.93	96.87	X2 TOPO	49.5
9515	5026.74	5208.89	96.73	X2 LTB	53.3
9516	5025.56	5210.46	95.97	X2 TOPO	55.2
9517	5024.95	5211.58	95.35	X2 LCH WSF	56.5
9518	5023.83	5213.79	94.57	X2 TOPO	58.9
9519	5022.47	5215.07	93.94	X2 TOPO	60.8
9520	5021.82	5216.05	93.75	X2 TOPO	61.9
9521	5020.75	5216.97	93.65	X2 TOPO	63.3
9522	5019.58	5218.19	93.54	X2 TOPO	65.0
9523	5018.68	5219.36	93.05	X2 TOPO	66.5
9524	5017.84	5220.65	92.64	X2 TOPO	68.0
9525	5016.63	5221.72	92.39	X2 TWG	69.6
9526	5015.66	5222.69	92.40	X2 TOPO	71.0
9527	5014.72	5223.86	93.25	X2 TOPO	72.5
9528	5013.87	5224.63	93.42	X2 TOPO	73.6
9529	5013.14	5225.77	93.48	X2 TOPO	75.0
9530	5012.09	5227.08	93.26	X2 TOPO	76.6
9531	5011.04	5228.09	93.29	X2 RTO	78.1
9532	5010.41	5228.77	95.34	X2 RCH W-SF	79.0
9533	5009.22	5230.43	97.52	X2 TOPO	81.0
9534	5008.47	5232.04	98.99	X2 TOPO	82.8
9535	5007.79	5232.60	99.83	X2 TOPO	83.6
9536	5007.12	5233.29	101.37	X2 TOPO	84.6
9537	5005.58	5234.92	102.45	X2 TOPO	86.8
9538	5004.01	5236.77	102.80	X2 TOPO	89.2
9539	5002.65	5237.67	103.50	X2 REBF 5\8	90.8

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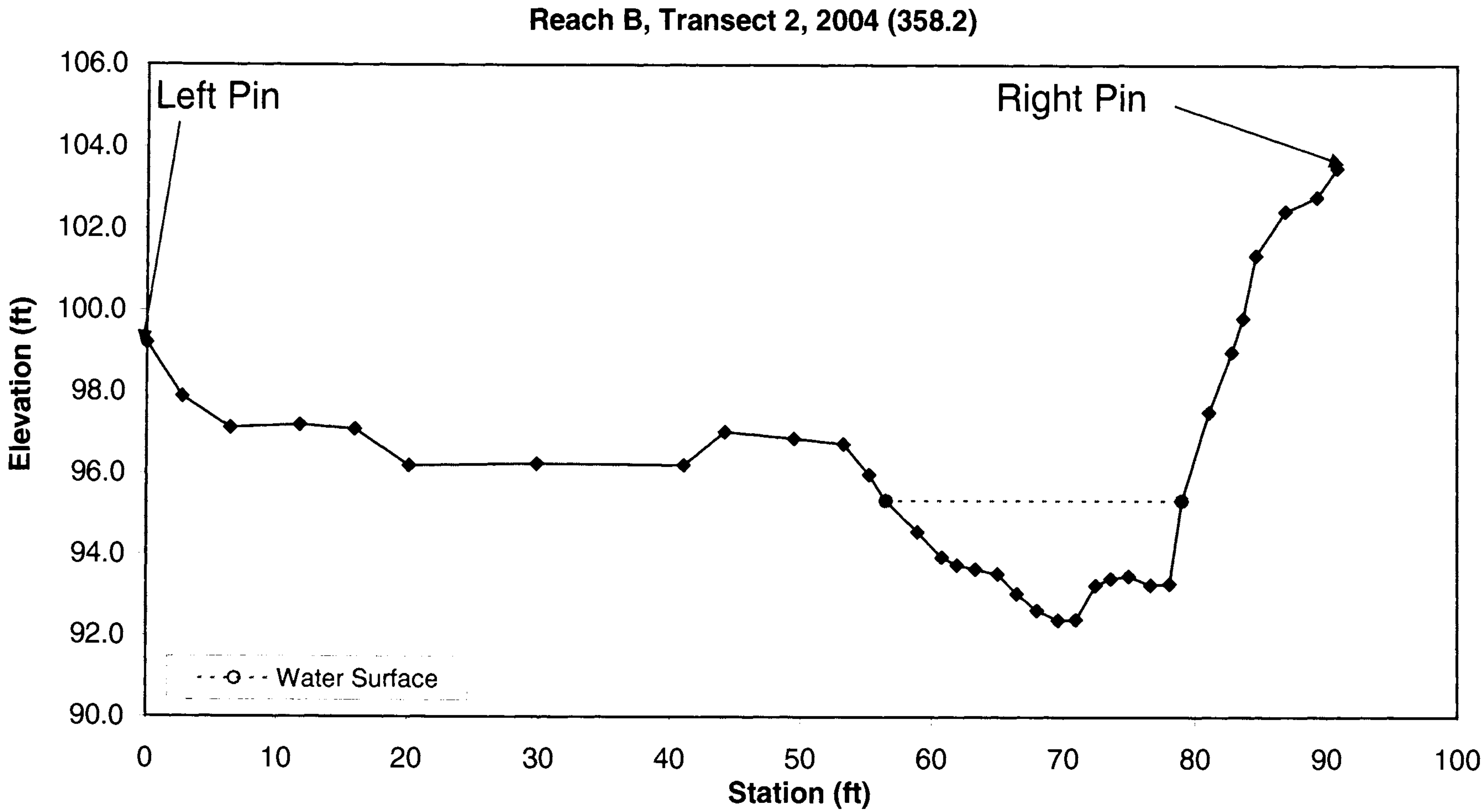

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Table 8. Cross-section data for Reach B, Transect 3 (Station 4+64).

Station:	Dead River bypassed channel, Reach B (Station 4+64)
Benchmark:	Nail in base of 2' diam. white pine on left bank (elevation=100 ft)
Height of Instrument	100.64
Water Surface Elevation:	94.86
Channel Width (ft)	22.9
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq.ft.)
Left Bank Rerod Marker	0	0		100.64		
	3.4	1.12		99.52		
	7.4	1.63		99.01		
	11.4	2.72		97.92		
	15.4	3.13		97.51		
	19.4	3.24		97.4		
	23.4	3.02		97.62		
	27.4	3.18		97.46		
	31.4	3.44		97.2		
	35.4	4.07		96.57		
	39.4	4.92		95.72		
	43.4	4.98		95.66		
	45.9	5.75	0	94.89		0.4375
	47.4		1	93.86	0	1.75
	49.4		1.7	93.16	0	3.4
	51.4		2	92.86	0	4
	53.4		1.5	93.36	0	3
	55.4		1.4	93.46	0.05	2.8
	57.4		1.6	93.26	0.52	3.2
	59.4		1.6	93.26	0.43	3.2
	61.4		1.4	93.46	0	2.8
	63.4		1.2	93.66	0.1	2.4
	65.4		0.9	93.96	0.12	1.8
	67.4		0.8	94.06	0.05	1.36
	68.8	5.83	0	94.81		0.34
	70.4	1.83		98.81		
	71.4	1.16		99.48		
	72.4	0.58		100.06		
	73.4	0		100.64		
	78.4			101.5		

Total cross-sectional area (sq.ft.) 30.4875

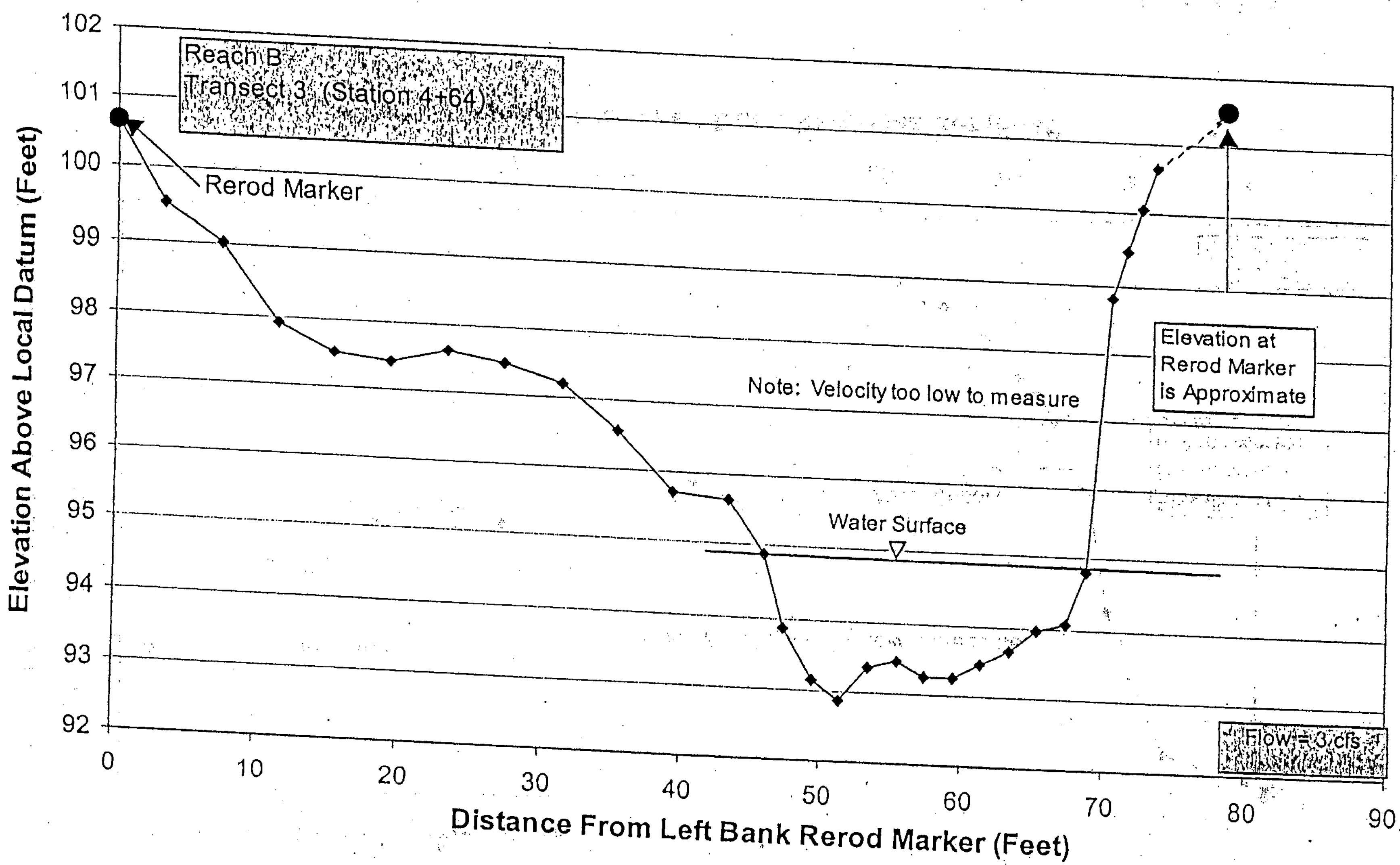
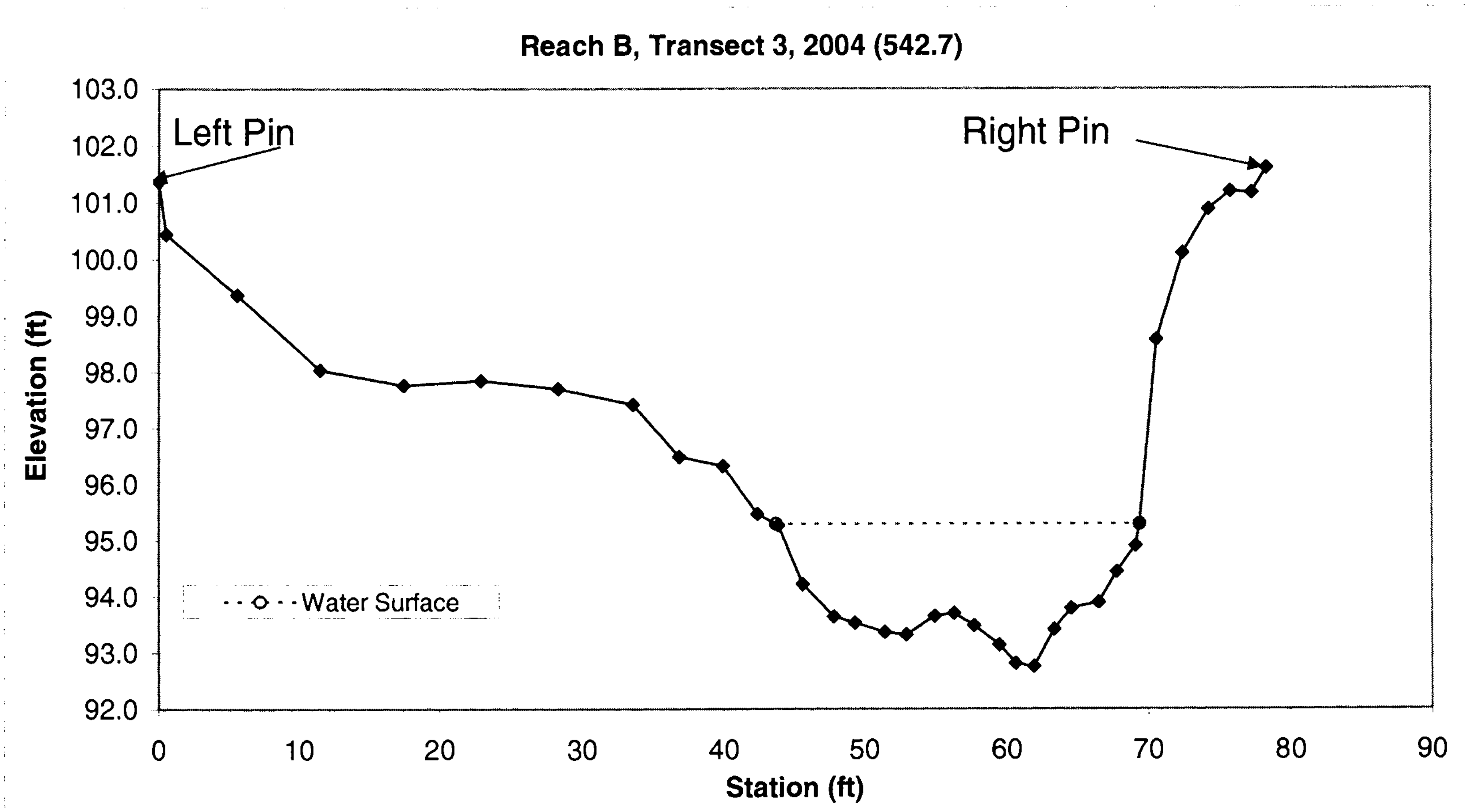


Figure 12. Cross- section profile of Reach B, Transect 3 (Station 4+64) on August 9, 2000.

Reach B, Transect 3, 2004

Pt #	North	East	Elevation	Note	Station
9561	5158.50	5300.52	101.37	X3 LEBF 5\8	0.0
9562	5158.08	5300.87	100.44	X3 TOPO	0.5
9563	5154.66	5304.81	99.37	X3 TOPO	5.7
9564	5151.49	5309.69	98.04	X3 TOPO	11.5
9565	5148.18	5314.65	97.77	X3 TOPO	17.5
9566	5145.31	5319.27	97.85	X3 TOPO	22.9
9567	5142.59	5323.99	97.71	X3 TOPO	28.3
9568	5139.58	5328.29	97.43	X3 LTB	33.6
9569	5137.65	5330.90	96.50	X3 TOPO	36.8
9570	5135.90	5333.48	96.33	X3 TOPO	39.9
9571	5134.66	5335.60	95.47	X3 TOPO	42.4
9572	5133.91	5336.90	95.27	X3 LCH WSF	43.9
9573	5133.09	5338.43	94.22	X3 TOPO	45.6
9574	5131.38	5339.98	93.65	X3 TOPO	47.9
9575	5130.74	5341.33	93.53	X3 TOPO	49.3
9576	5129.92	5343.31	93.37	X3 TOPO	51.5
9577	5129.01	5344.51	93.32	X3 TOPO	52.9
9578	5128.04	5346.24	93.65	X3 TOPO	54.9
9579	5127.37	5347.44	93.71	X3 TOPO	56.3
9580	5126.63	5348.65	93.48	X3 TOPO	57.7
9581	5125.89	5350.26	93.14	X3 TOPO	59.5
9582	5125.36	5351.28	92.81	X3 TOPO	60.6
9583	5124.71	5352.43	92.75	X3 TWG	61.9
9584	5123.67	5353.47	93.42	X3 TOPO	63.4
9585	5123.00	5354.46	93.79	X3 TOPO	64.6
9586	5122.07	5356.14	93.90	X3 TOPO	66.5
9587	5121.32	5357.18	94.45	X3 TOPO	67.8
9588	5120.64	5358.33	94.91	X3 TOPO	69.1
9589	5120.35	5358.50	95.30	X3 RCH W-SF	69.4
9590	5119.62	5359.47	98.57	X3 TOPO	70.6
9591	5119.02	5361.29	100.11	X3 TOPO	72.5
9592	5118.01	5362.84	100.88	X3 TOPO	74.3
9593	5117.25	5364.16	101.20	X3 RTB	75.8
9594	5116.80	5365.66	101.18	X3 TOPO	77.3
9595	5116.52	5366.69	101.61	X3 REBF 5\8	78.4



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9400	5000	5000	97.05	SPIKE
9401	4945.0905	5135.9077	101.6536	SPIKE
9402	5063.9325	4955.3954	94.4078	HOR TWG
9403	5063.3526	4955.5434	94.3488	TWG
9404	5054.1699	4959.6577	94.1769	TWG
9405	5048.8208	4963.1775	94.1985	BEG BREACH
9406	5064.4606	4961.2576	95.4481	LCH WSF
9407	5062.599	4949.2721	95.3996	RCH W-SF
9408	5050.3989	4969.9247	95.3974	LCH
9409	5044.6108	4958.618	95.356	RCH W-SF
9410	5056.3473	4976.632	95.3589	LCH
9411	5060.2402	4983.8884	95.2715	LCH
9412	5060.9578	4983.7706	96.0994	LCH
9413	5044.2323	4986.6712	95.323	LCH
9414	5035.8654	4982.5191	95.3651	LCH
9415	5044.2047	4979.1763	92.2752	BACK EDDY T-wG
9416	5052.1771	4979.967	92.3638	BACK EDDY T-wG
9417	5036.5386	4977.8821	94.1471	BACK EDDY T-wG
9418	5047.3327	4971.6118	94.8687	TOPO
9419	5039.8774	4974.4998	94.6591	TOPO
9420	5042.8995	4959.9045	95.293	RCH W-SF
9421	5033.7093	4965.5795	95.2922	RCH W-SF
9422	5045.4642	4965.6517	94.2886	TWG
9423	5028.1101	4974.2401	94.7133	TWG
9424	5025.6737	4977.7442	94.1044	TWG
9425	5029.3326	4981.9858	95.3355	LCH
9426	5027.0987	4983.3177	96.6525	TOPO
9427	5023.4746	4969.9112	95.4239	RCH
9428	5006.5463	4972.5533	94.9962	RCH
9429	5009.4372	4980.8422	95.335	LCH WSF
9430	5010.0803	4977.9257	94.1027	TWG
9431	5020.1972	4976.1599	94.2405	TWG
9432	5001.2713	4974.1039	93.3597	TWG
9433	4997.7155	4972.1204	91.8636	TWG
9434	4991.4559	4975.4524	91.7761	BACK EDDY TW-G
9435	4986.0755	4978.447	91.7957	BACK EDDY TW-G
9436	4983.2832	4982.9795	93.1794	BACK EDDY TW-G
9437	4999.2011	4961.916	95.21	RCH
9438	4995.5037	4956.3352	95.0932	RCH
9439	4979.2426	4975.3287	95.0644	RCH
9440	4997.5061	4980.1994	93.3824	TWG
9441	4987.3937	4988.0847	93.1368	TWG
9442	5000.1748	4986.7449	95.1039	LCH
9443	4987.1877	5005.4161	95.2315	LCH
9444	4976.9588	4996.4474	92.1893	TWG
9445	4969.8935	4992.8975	95.2336	RCH W-SF
9446	4961.4976	5006.966	95.0369	RCH
9447	4969.0747	5013.1854	92.466	TWG
9448	4986.5143	5021.0874	95.2676	LCH
9449	4981.174	5040.6056	95.3707	LCH WSF
9450	4963.2939	5034.8801	91.8831	TWG
9451	4957.5482	5029.8848	95.3111	RCH W-SF
9452	4961.3778	5045.4108	92.1431	TWG
9453	4959.1265	5059.0588	93.0306	TWG
9454	4952.5181	5055.8793	95.3385	RCH W-SF
9455	4975.0633	5062.8342	95.3484	LCH WSF

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9456	4969.3004	5080.887	95.3115	LCH WSF
9457	4958.6277	5077.0505	93.7529	TWG
9458	4948.5817	5075.0937	95.3507	RCH W-SF
9459	4949.0427	5105.9209	95.3686	RCH W-SF
9460	4957.1343	5104.0873	93.4477	TWG
9461	4968.7866	5101.1726	95.3149	LCH WSF
9462	4960.3982	5122.0409	92.3287	TWG
9463	4953.2388	5119.5747	95.3473	RCH W-SF
9464	5018.6524	5044.8905	100	BM1B
9465	5022.1663	5101.8878	98.5447	X1 TOPO
9466	5010.1126	5105.1657	98.735	X1 LEBF 5\8
9467	5008.0463	5105.2655	98.0027	X1 TOPO
9468	5002.2954	5105.8999	97.2756	X1 TOPO
9469	4986.8037	5108.6916	97.1907	X1 TOPO
9470	4976.8167	5110.622	96.6281	X1 TOPO
9471	4972.2663	5111.3245	96.3403	X1 TOPO ltb
9472	4971.182	5111.3527	95.341	X1 LCH WSF
9473	4966.7668	5111.9993	94.1601	X1 TOPO
9474	4964.3792	5112.4456	93.9342	X1 TOPO
9475	4962.8154	5112.9461	93.6005	X1 TOPO
9476	4961.8918	5113.3464	93.285	X1 TOPO
9477	4960.7877	5113.44	92.995	X1 TOPO
9478	4959.5993	5113.6248	92.7854	X1 TWG
9479	4957.8225	5113.7879	93.0379	X1 TOPO
9480	4955.2443	5114.2844	93.3151	X1 TOPO
9481	4953.3085	5114.6285	93.5441	X1 TOPO
9482	4950.825	5115.2886	94.267	X1 TOPO
9483	4949.6111	5115.1762	94.8008	X1 TOPO
9484	4948.9283	5115.0317	95.3761	X1 RCH W-SF
9485	4948.0169	5116.0861	97.7292	X1 TOPO
9486	4945.1484	5116.7045	99.8926	X1 TOPO
9487	4942.9398	5117.7452	101.1769	X1 RTB
9488	4939.3311	5118.6261	101.8695	X1 REBF 5\8
9489	4936.9549	5119.2535	102.4495	X1 REBF 5\8
9490	4936.5884	5119.262	101.8975	X1 TOPO
9491	4925.5089	5122.2867	101.9915	X1 TOPO
9492	4959.1448	5119.1317	92.1261	TWG
9493	4964.3341	5132.2655	93.3887	TWG
9494	4979.4582	5128.4879	95.3295	LCH WSF
9495	4958.1499	5143.3192	95.3087	RCH W-SF
9496	4974.1458	5163.8943	92.6684	TWG
9497	4981.6888	5177.2661	93.6805	TWG
9498	4994.3082	5173.6427	95.3106	LCH WSF
9499	4970.5847	5180.2192	95.3008	RCH W-SF
9500	5009.3116	5198.6667	95.3342	LCH WSF
9501	4998.0406	5206.1288	92.9154	TWG
9502	4988.4367	5209.9259	95.3336	RCH W-SF
9503	5009.2202	5217.9465	92.7843	TWG
9504	5120.876	5251.487	102.0777	SPIKE
9505	5060.197	5167.4257	99.2118	X2 LEBF 5\8
9506	5058.4324	5169.5494	97.892	X2 TOPO
9507	5056.0192	5172.3939	97.1276	X2 TOPO
9508	5052.3215	5176.1906	97.2016	X2 TOPO
9509	5049.9145	5179.6811	97.0946	X2 TOPO
9510	5047.6429	5183.1748	96.1949	X2 TOPO
9511	5041.6482	5190.8209	96.2423	X2 TOPO

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9512	5034.2251	5199.2279	96.2096	X2 TOPO
9513	5032.3394	5201.7619	97.0289	X2 TOPO
9514	5029.0779	5205.9314	96.8658	X2 TOPO
9515	5026.7393	5208.8859	96.7296	X2 LTB
9516	5025.5562	5210.4572	95.9749	X2 TOPO
9517	5024.9479	5211.5779	95.3473	X2 LCH WSF
9518	5023.8301	5213.787	94.5664	X2 TOPO
9519	5022.4656	5215.0725	93.942	X2 TOPO
9520	5021.8166	5216.0452	93.7532	X2 TOPO
9521	5020.7541	5216.9737	93.6541	X2 TOPO
9522	5019.5844	5218.1911	93.535	X2 TOPO
9523	5018.6752	5219.3613	93.0489	X2 TOPO
9524	5017.8414	5220.6525	92.6353	X2 TOPO
9525	5016.6308	5221.7193	92.3942	X2 TWG
9526	5015.6639	5222.6944	92.4046	X2 TOPO
9527	5014.7233	5223.8594	93.2504	X2 TOPO
9528	5013.8706	5224.6284	93.4228	X2 TOPO
9529	5013.1374	5225.7726	93.4834	X2 TOPO
9530	5012.0927	5227.0836	93.2628	X2 TOPO
9531	5011.0445	5228.0871	93.2929	X2 RTO
9532	5010.4084	5228.7733	95.3409	X2 RCH W-SF
9533	5009.2203	5230.4298	97.5226	X2 TOPO
9534	5008.4734	5232.0386	98.9939	X2 TOPO
9535	5007.7876	5232.6014	99.8338	X2 TOPO
9536	5007.1152	5233.2904	101.3689	X2 TOPO
9537	5005.5764	5234.9166	102.4483	X2 TOPO
9538	5004.0092	5236.7671	102.795	X2 TOPO
9539	5002.6492	5237.6747	103.5026	X2 REBF 5\8
9540	5022.9589	5225.8248	92.4299	TWG
9541	5035.2224	5233.1975	92.0384	TWG
9542	5028.1673	5236.4969	95.3714	RCH W-SF
9543	5043.0233	5221.454	95.3284	LCH WSF
9544	5069.4723	5236.9534	95.3426	LCH WSF
9545	5064.2998	5244.7933	92.9543	TWG
9546	5057.7128	5259.0104	95.2883	RCH W-SF
9547	5079.1236	5266.3658	95.273	RCH W-SF
9548	5080.9543	5257.1298	93.8987	TWG
9549	5088.9234	5250.2535	95.3495	LCH WSF
9550	5107.2868	5261.7226	95.2886	LCH WSF
9551	5099.7207	5269.3418	94.2532	TWG
9552	5092.4571	5275.4439	95.3507	RCH W-SF
9553	5097.1794	5289.0116	95.2024	RCH W-SF
9554	5104.965	5290.8715	94.1533	TWG
9555	5113.0966	5290.6603	95.1422	LCH WSF
9556	5103.783	5302.4715	93.6112	TWG
9557	5108.0577	5318.5345	93.7003	TWG
9558	5117.7279	5316.6517	95.2469	LCH WSF
9559	5104.7642	5331.823	95.1113	RCH W-SF
9560	5103.8175	5343.4295	95.2423	RCH W-SF
9561	5158.5049	5300.5161	101.3659	X3 LEBF 5\8
9562	5158.0817	5300.8691	100.4389	X3 TOPO
9563	5154.6618	5304.8123	99.3713	X3 TOPO
9564	5151.4906	5309.6894	98.0371	X3 TOPO
9565	5148.1757	5314.6477	97.7668	X3 TOPO
9566	5145.3139	5319.2711	97.8534	X3 TOPO
9567	5142.5856	5323.9854	97.7075	X3 TOPO

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9568	5139.5785	5328.2919	97.4263	X3 LTB
9569	5137.6501	5330.9008	96.4956	X3 TOPO
9570	5135.9029	5333.4784	96.331	X3 TOPO
9571	5134.6562	5335.5965	95.4737	X3 TOPO
9572	5133.9111	5336.9019	95.2737	X3 LCH WSF
9573	5133.0915	5338.4327	94.2244	X3 TOPO
9574	5131.3756	5339.9775	93.6452	X3 TOPO
9575	5130.7439	5341.3289	93.5314	X3 TOPO
9576	5129.9152	5343.3087	93.3655	X3 TOPO
9577	5129.0129	5344.5077	93.3243	X3 TOPO
9578	5128.0358	5346.2428	93.6541	X3 TOPO
9579	5127.3742	5347.4366	93.7064	X3 TOPO
9580	5126.6301	5348.6498	93.4816	X3 TOPO
9581	5125.8939	5350.2565	93.1394	X3 TOPO
9582	5125.3645	5351.2823	92.807	X3 TOPO
9583	5124.7082	5352.4275	92.7536	X3 TWG
9584	5123.6682	5353.4702	93.4191	X3 TOPO
9585	5122.995	5354.4596	93.7934	X3 TOPO
9586	5122.0669	5356.1446	93.9022	X3 TOPO
9587	5121.3167	5357.1776	94.4466	X3 TOPO
9588	5120.6393	5358.332	94.909	X3 TOPO
9589	5120.3494	5358.4956	95.2991	X3 RCH W-SF
9590	5119.6206	5359.4654	98.5737	X3 TOPO
9591	5119.0196	5361.2898	100.1102	X3 TOPO
9592	5118.0103	5362.8428	100.8812	X3 TOPO
9593	5117.2546	5364.1642	101.2017	X3 RTB
9594	5116.7971	5365.6579	101.1756	X3 TOPO
9595	5116.5175	5366.6898	101.614	X3 REBF 5\8
9596	5055.4161	5289.7591	99.5358	BM2B
9597	4945.0684	5135.8932	101.6551	BS

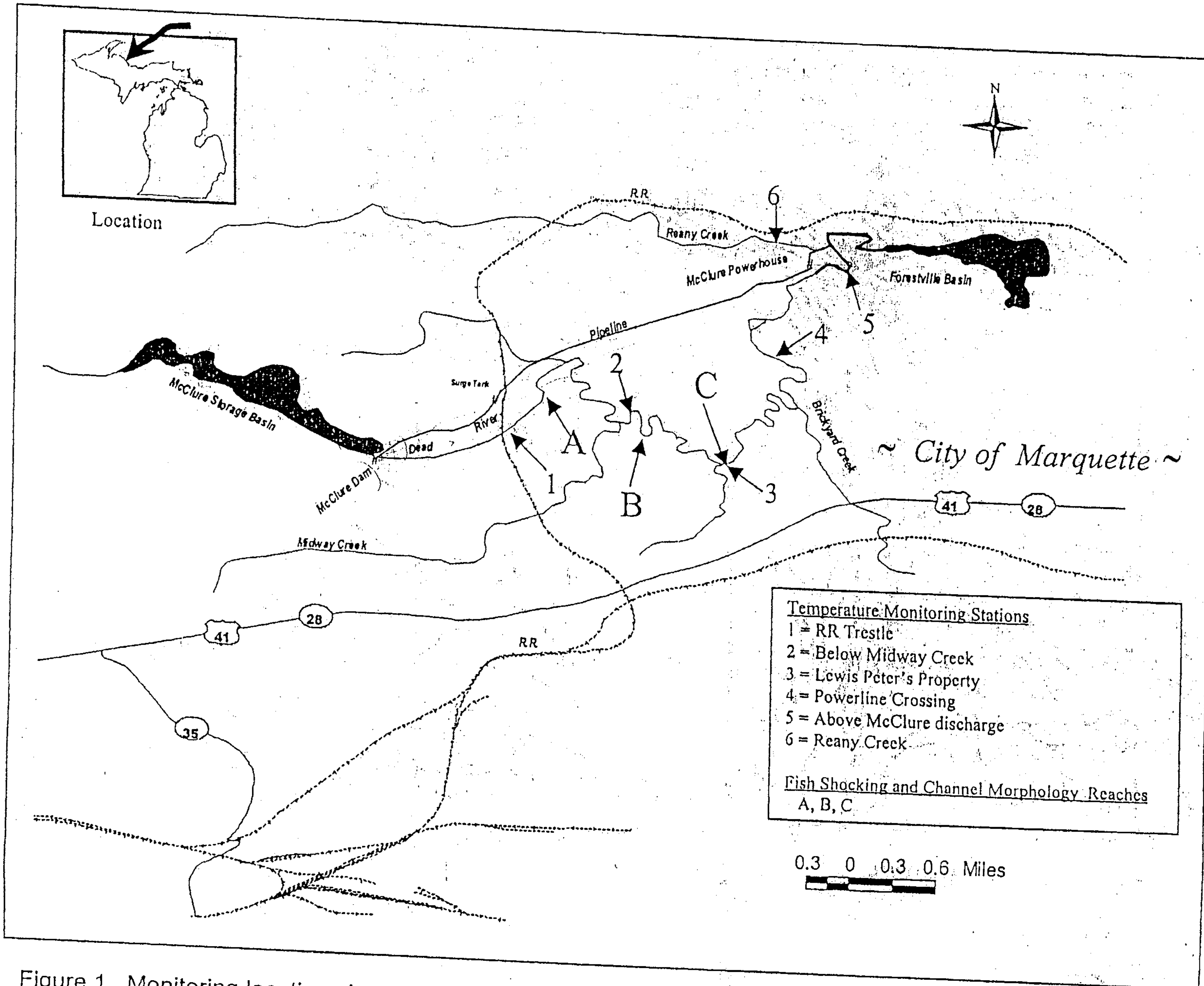

Figure 1. Monitoring locations in the Dead River bypassed channel, August 2000.

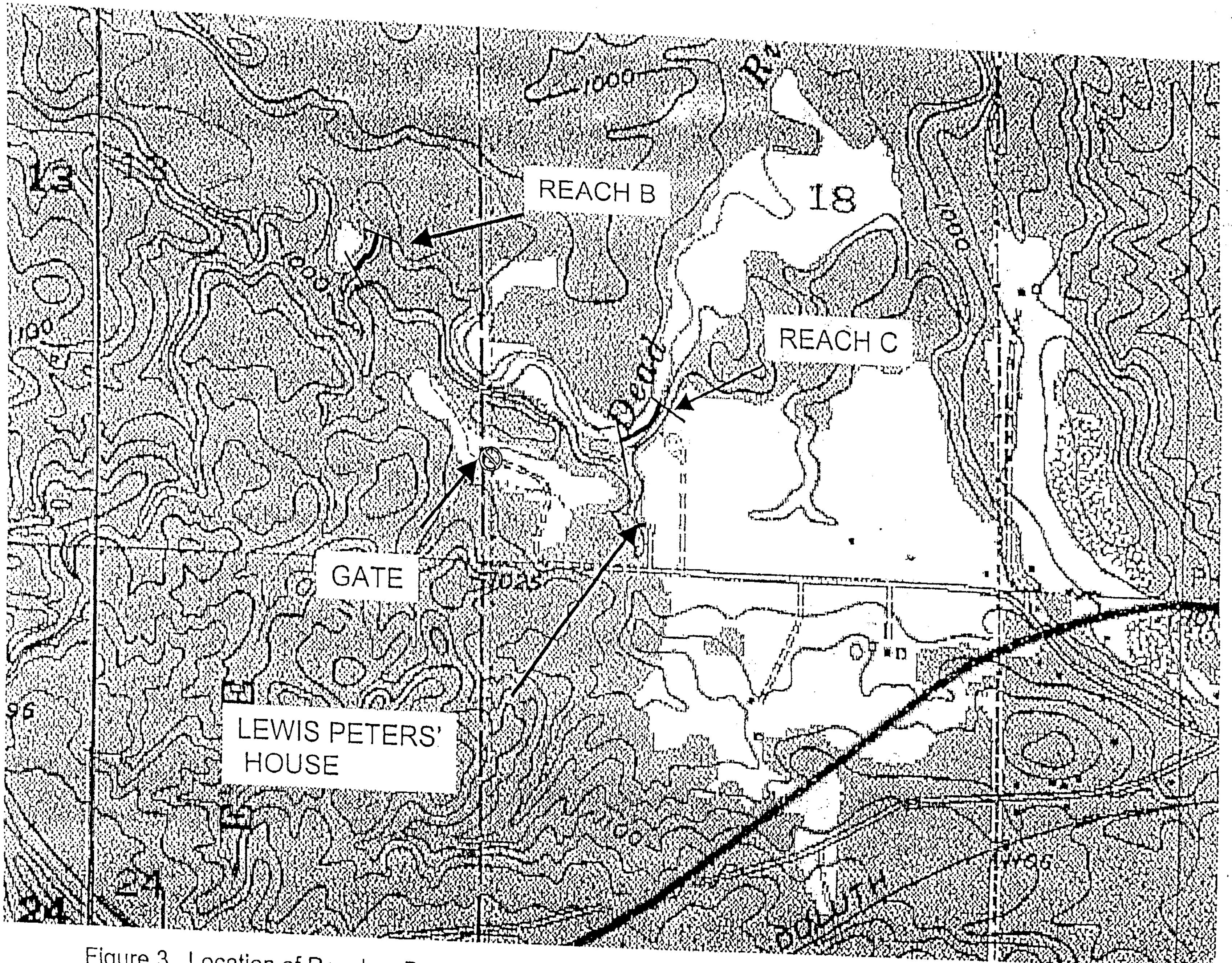

Figure 3. Location of Reaches B and C on the Dead River bypassed channel.

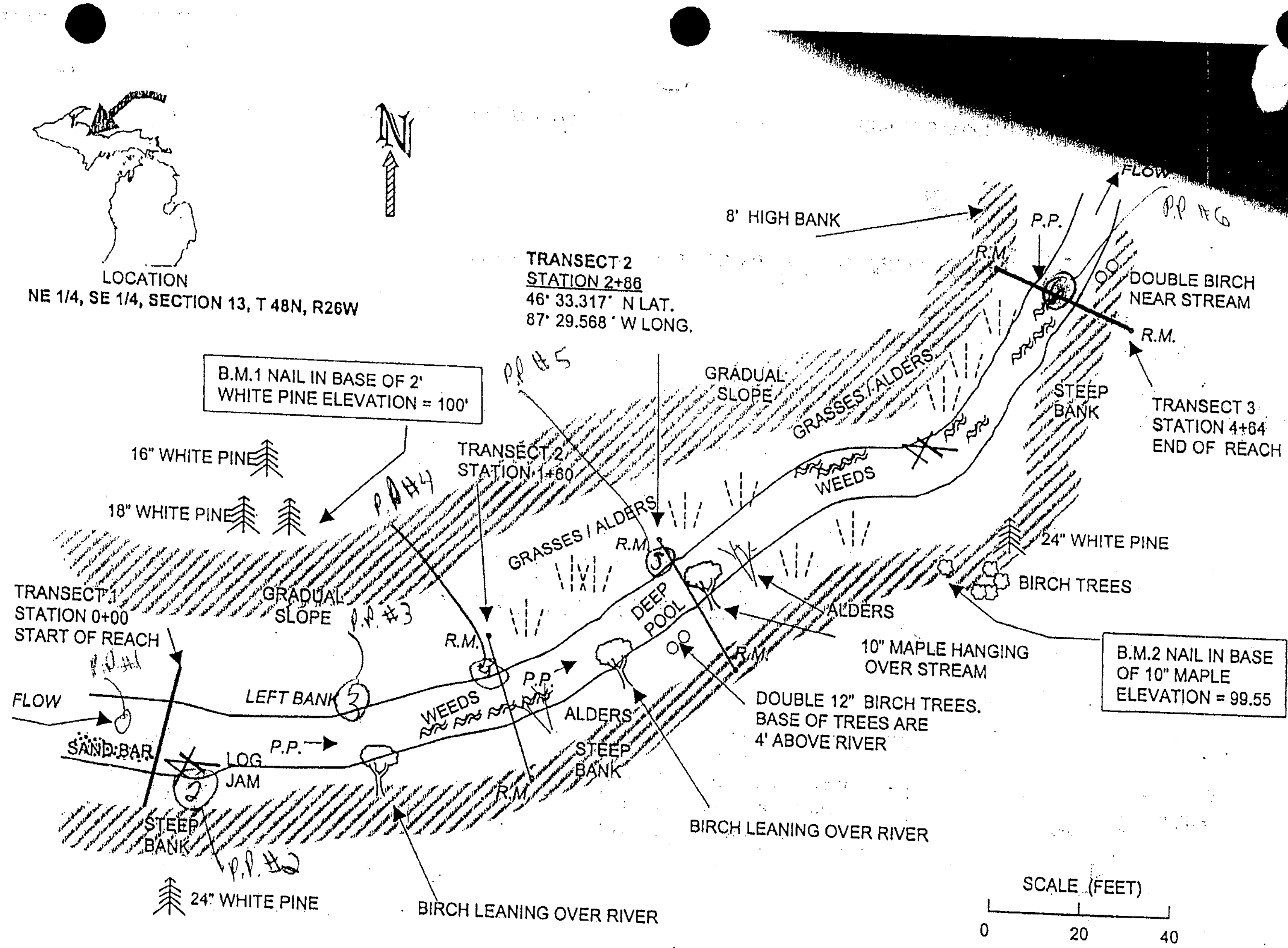

Figure 8. Map of reach B on the Dead River bypassed channel, August 2000.

R.M. = REROD MARKER
P.P. = PHOTO POINT

MDEQ Photo Log – Reach B

The following is the photo log that was created for each MDEQ reach (A, B and C). Each photo point (labeled either as PP or Photo point) had a number of different pictures taken and were subsequently described in the filed book. In the cases where panoramas were attempted to be taken, each picture number is sequential, and in most cases only the beginning shot and ending shot of the panoramic are identified with a detailed description. Field notes of the photos have been scanned in and are included in the electronic files. Upon return back to the office and the pictures downloaded, each photo was renamed to the same photo number taken in the field with a brief descriptor and photo point added.

Reaches B and C, have slightly different labeling. The photo point is mentioned after the picture number as opposed to before the picture number.

Reach 06-07, MDEQ Reach B. Pictures 80 and 102 were mistake movies. Pictures were taken on 7-28-04.

Picture #	Description
81	Photo #81 photo point #1 downstream shot from beginning of Reach 1
82	Photo #82 photo point #1 downstream shot from beginning of reach 2
83	Photo #83 photo point #1 upstream shot from beginning of reach
84	Photo #84 photo point #2downstream shot of second eddy
85	Photo #85 photo point #2 downstream shot of 2nd back eddy 2
86	Photo #86 photo point #2 upstream
87	Photo #87 photo point 2 right bank
88	Photo #88 photo point 2 left bank
89	Photo #89 photo point #3 downstream
90	Photo #90 photo point #3 upstream
91	Photo #91 photo point #3 right bank
92	Photo #92 photo point #3 left bank
93	Photo #93 photo point #4 downstream
94	Photo #94 photo point #4 upstream
95	Photo #95 photo point #4 left bank
96	Photo #96 photo point #4 right bank
97	photo #97 photo point #5 upstream 1
98	photo #98 photo point #5 upstream 2
99	photo #99 photo point #5 downstream
100	photo #100 photo point #5 left bank
101	Photo #101 photo point #5 right bank
103	Photo #103 photo point #6 upstream
104	Photo #104 photo point #6 downstream
105	Photo #105 photo point #6 left bank
106	photo #106 photo point #6 right bank

Photo #82 photo point #1 downstream shot from beginning of reach 2

Photo #83 photo point #1 upstream shot from beginning of reach

Photo #84 photo point #2downstream shot of second eddy

Photo #86 photo point #2 upstream

Photo #87 photo point 2 right bank

Photo #88 photo point 2 left bank

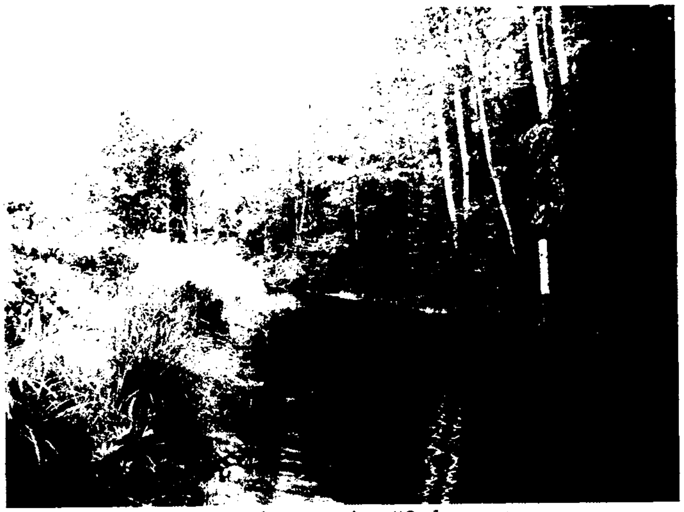
Photo #89 photo point #3 downstream


Photo #90 photo point #3 upstream


Photo #91 photo point #3 right bank


Photo #92 photo point #3 left bank


Photo #93 photo point #4 downstream


Photo #94 photo point #4 upstream


Photo #95 photo point #4 left bank


Photo #96 photo point #4 right bank


photo #97 photo point #5 upstream 1


photo #99 photo point #5 downstream


photo #100 photo point #5 left bank


Photo #101 photo point #5 right bank

Photo #104 photo point #6 downstream

Photo #105 photo point #6 left bank

photo #106 photo point #6 right bank

R06-06 MDEQ-C

Initials | Work Item

SDC — Collect the following data at a minimum for each sub-reach.

Reach R06-06, DEQ-C

- ☑ Survey longitudinal profile in the same location (beginning point to ending point) of the 2000 MDEQ survey.
- ☑ Survey the same cross sections surveyed by MDEQ in 2000 including no less than thirty (30) points, fifteen (15) of which must be within the wetted perimeter.
- ☑ Velocity at each cross section, measured at 0.6 of the depth measured from the surface.
- ☑ Sketch site per Harrelson et al., 1994
- ☑ Photograph site, including two (2) photos with tape/line stretched across stream. (TOTAL STATION SURVEY – NO TAPE)

Initials	Work Item
SDC	Provide the following items for each sub-reach in electronic and hard copy format.

Reach 06-06, DEQ-C

- ☑ Plot of longitudinal profile
- ☑ Plot of cross-sections
- ☑ Site sketch
- ☑ Photographs and photo log

Table: Summary Data for the Dead River Bypassed Channel, August 2000 vs 2004

Reach Name	2004 A	2000 A	2004 A	2000 A	2004 A	2000 B	2004 B	2000 B	2004 B	2000 B	2004 B	2000 C	2004 C	2000 C	2004 C	2000 C	2004 C
Reach Length (ft)		484	**606**	484	**606**	464	**543**	464	**543**	464	**543**	392	**472**	392	**472**	392	**472**
Water Surface Slope (ft/mile)		15.2	**17.96**	15.2	**17.96**	4.32	**1.58**	4.32	**1.58**	4.32	**1.58**	2.96	**5.28**	2.96	**5.28**	2.96	**5.28**
Average Thalweg Depth (ft) [3]		0.78	**1.33**	0.78	**1.33**	1.81	**2.15**	1.81	**2.15**	1.81	**2.15**	1.42	**2.3**	1.42	**2.3**	1.42	**2.3**
Transect Name		1	**1**	2	**2**	1	**1**	2	**2**	3	**3**	1	**1**	2	**2**	3	**3**
Transect Location [1]	0+00	1+17	**1+17 (1+85)**	3+62	**3+62 (4+66)**	1+60	**1+60 (2+32)**	2+86	**2+86 (3+58)**	4+64	**4+64 (5+43)**	0+00	**0+00 (0+34)**	1+57	**1+57 (1+90)**	3+50	**3+50 (4+05)**
Transect Width (ft) [3]		43	**32.7**	26.3	**37.3**	17.4	**22.6**	20	**22.5**	22.9	**25.7**	11.5	**16.0**	25.8	**25.4**	21.5	**24.8**
Transect Cross Sectional Area (sq. ft) [3]		48.4	**75.1**	8.13	**16.5**	21.9	**34.9**	47.8	**41.1**	30.5	**41.4**	9.4	**36.8**	17.9	**51.8**	18.9	**68.3**
Average Depth in Transect (ft) [3]		1.12	**2.3**	0.31	**0.4**	1.26	**1.5**	2.4	**1.8**	1.33	**1.6**	0.81	**2.3**	0.69	**2.0**	0.88	**2.8**
Average Measured Velocity (fps) [2]		--	--	--	--	0.13	--	--	--	--	--	0.51	--	0.28	--	0.26	--
Calculated Velocity by flow/area (fps)		0.06	**1.5**	0.36	**0.5**	0.14	**1.2**	0.06	**1.3**	0.1	**1.3**	0.49	**1.2**	0.26	**1.2**	0.24	**1.4**
Stream flow (cfs)	**2.0**			1.5		3	**3.8**	3		3	**6.2**	4.6	**6.7**	4.6	**8.5**	4.6	**8.8**

1. Transect location in ( ) is the station from the 2004 survey starting at station 0+00.
2. Average Measured Velocities were provided by MDEQ in 2000.
3. Cross sectional area, transect width, average depth in transect are based on average water surface depth.
4. Assumed horizontal coordinates were used for the resurvey of reaches A, B, and C. No horizontal datum was used for the 2000 survey of these three reaches. Vertical data for all three reaches of the 2004 resurvey were tied to benchmarks established during the 2000 survey. These vertical benchmarks were also assumed and were not tied to each other.

Dead River Reach C, SW 1/4, SW 1/4 Section 18, T48N, R25W, Marquette County
46.5522 N 87.4855 W
7/29/04

Transect 1 Station 0+00

Pygmy Meter y-0060

distance from initial (ft)	depth (ft)	observations at 0.6 depth rev #	time (sec)	velocity (ft/sec)	approximate flow (ft^3/sec)	Comments
4.2	0					Bank
5	0.3			0.05	0.01	
6	1.4	7	37	0.22	0.31	
7	2	10	35	0.32	0.63	
8	2.5	15	44	0.37	0.93	
9	2.7	10	39	0.29	0.78	
10	2.8	20	22	0.92	2.56	
11	3	30	34	0.89	2.67	
12	3	30	37	0.82	2.46	
13	3	15	45	0.36	1.09	
14	3	5	48	0.14	0.43	
15	3.1	10	47	0.25	-0.77	eddy
16	3	10	21	0.50	-1.50	eddy
17	2.9	15	37	0.43	-1.57	eddy
18.5	1.5	15	36	0.44	-1.33	eddy
21	0					bank
		Total Approximate Flow			6.72	

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Dead River Reach C, SW 1/4, SW 1/4 Section 18, T48N, R25W, Marquette County
46.5522 N 87.4855 W
7/29/04

Transect 2 Station 1+57

distance		observations at 0.6 depth			approximate	
from initial	depth	rev	time	velocity	flow	
(ft)	(ft)	#	(sec)	(ft/sec)	(cfs)	Comments
3	0			0		bank
5	0.7			0		
7	0.9	7	50	0.18	0.32	
9	1.3	12	42	0.32	0.82	
11	2.2	10	35	0.32	1.40	
13	2.4	10	29	0.37	1.80	
15	2.3	10	39	0.29	1.33	
17	2.1	7	35	0.24	0.99	
19	2.2	7	46	0.19	0.83	
21	3			<0.1	0.30	
23	2.8			<0.1	0.28	
25	2.2			<0.1	0.22	
27	1.6			<0.1	0.18	
29.5	0			0		bank
			Total approximate flow		8.46	

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Dead River Reach C, SW 1/4, SW 1/4 Section 18, T48N, R25W, Marquette County
46.5522 N 87.4855 W
7/29/04

Transect 3 Station 3+50

Spin test after measurements in three transects = 34 seconds

distance		observations at 0.6 depth			approximate	
from initial	depth	rev	time	velocity	flow	
(ft)	(ft)	#	(sec)	(ft/sec)	(cfs)	
3	0					bank
6	2.3	10	46	0.25	1.74	
9	2.2	7	45	0.19	1.27	
12	2.4	10	41	0.28	2.00	
15	3	7	41	0.21	1.55	
17	3.7	5	46	0.15	1.09	
19	>3.7			<0.1	0.28	
20	3.7			<0.1	0.37	
23	2.5			<0.1	0.53	
28.5	0					bank
			Total approximate flow		8.82	

Table 9. Longitudinal profile of Reach C of the Dead River bypassed channel.

Benchmark 1 (elevation=100 ft): nail in base of 6" diam. spruce on left bank

Location	Elevations Water Surface (ft)	Elevations Thalweg (ft)	Thalewg Depth (ft)	Residual Pool Surface (ft)	Residual Pool Depth (ft)	Average Residual Pool Depth (ft)	Height of Instrument (ft)	Minus Sights Water Surf (ft)	Minus Sights Thalweg (ft)
0	91.13	89.71	1.42				101.01	9.88	11.3
15	91.15	89.83	1.32				101.01	9.86	11.18
38	91.11	90.45	0.66				101.01	9.9	10.56
49	91.14	89.36	1.78	90.42	1.06		101.01	9.87	11.65
64	91.1	88.99	2.11	90.42	1.43		101.01	9.91	12.02
79	91.1	89.62	1.48	90.42	0.8		101.01	9.91	11.39
94	91.1	88.57	2.53	90.42	1.85		101.01	9.91	12.44
109	91.08	89.06	2.02	90.42	1.36		101.01	9.93	11.95
135	91.06	90.42	0.64	90.42	0	1.3	101.01	9.95	10.59
150	91.07	89.41	1.66	90.41	1		101.01	9.94	11.6
177	91.05	89.82	1.23	90.41	0.59		96.56	5.51	6.74
191	91.03	88.77	2.26	90.41	1.64		96.56	5.53	7.79
211	91.01	90.28	0.73	90.41	0.13		96.56	5.55	6.28
231	91	89.72	1.28	90.41	0.69		96.56	5.56	6.84
251	91	90.41	0.59	90.41	0	0.81	96.56	5.56	6.15
281	90.97	89.75	1.22	89.97	0.22		96.56	5.59	6.81
316	90.97	89.29	1.68	89.97	0.68		96.56	5.59	7.27
336	90.94	89.5	1.44	89.97	0.47		96.56	5.62	7.06
360	90.94	89.53	1.41	89.97	0.44		96.56	5.62	7.03
392	90.91	89.97	0.94	89.97	0	0.4525	96.56	5.65	6.59

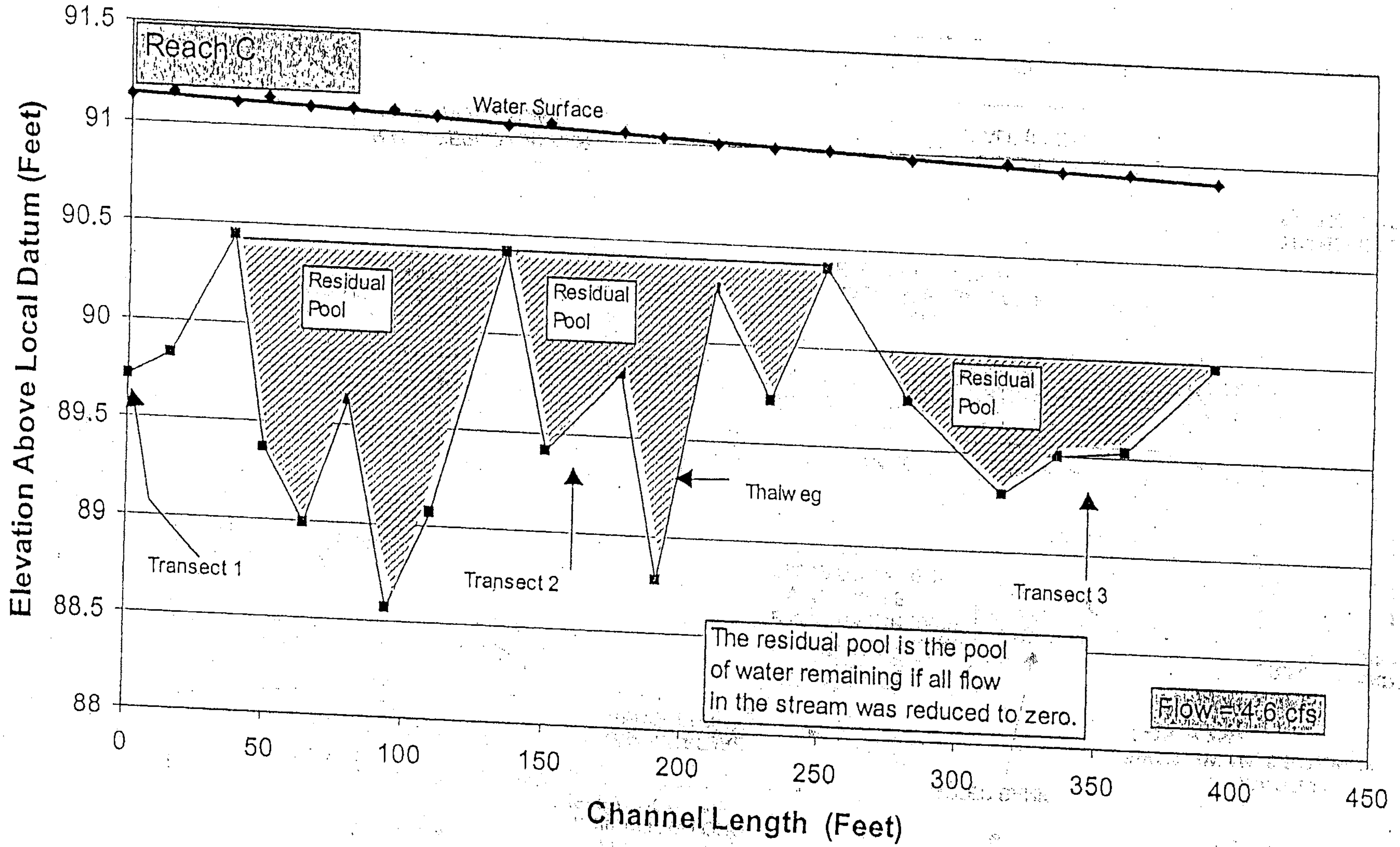
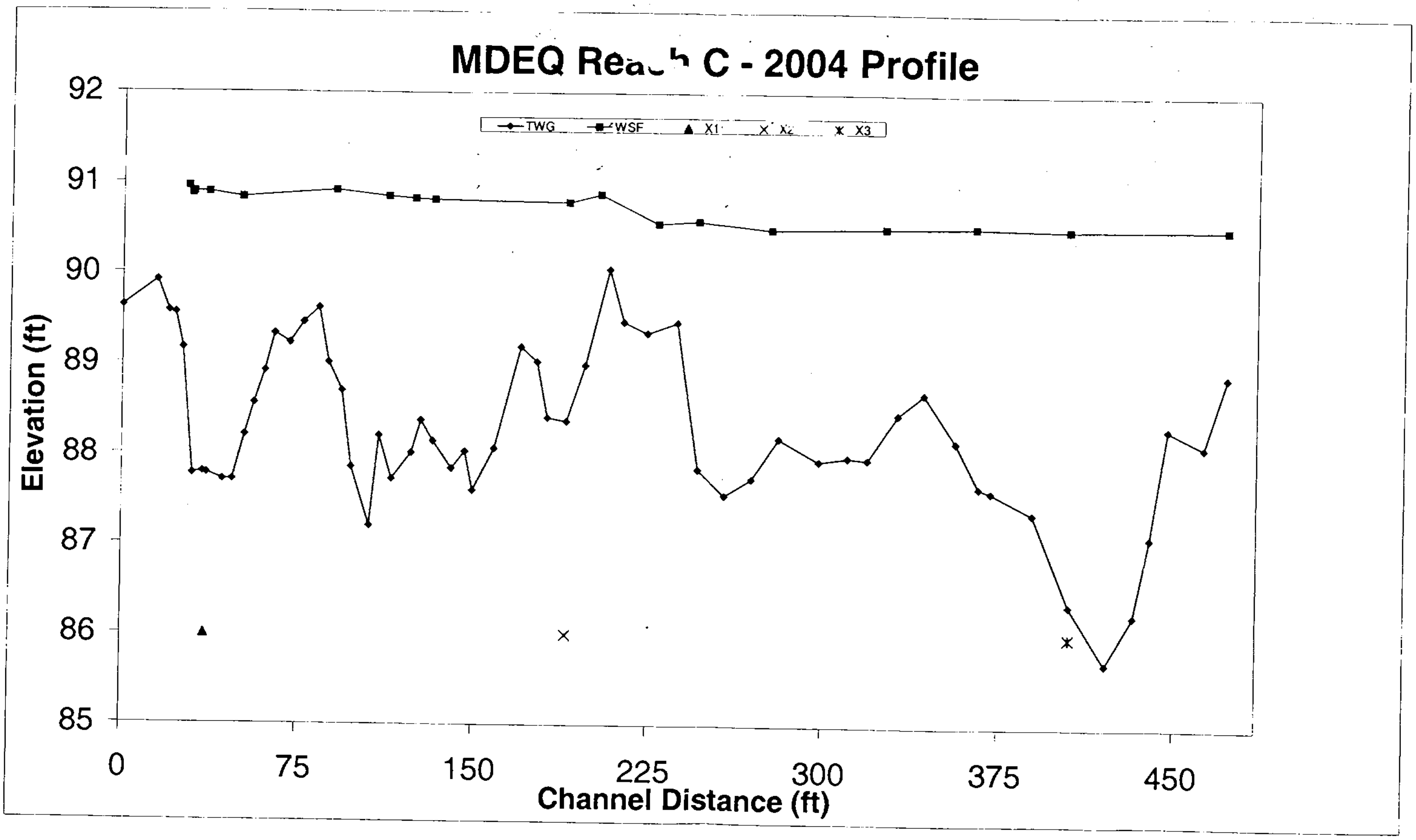


Figure 14. Longitudinal profile of Reach C on August 8, 2000.

MDEQ Reach C, Profile 2004

Descriptor =	TWG		Descriptor =	WSF
Station	**Elevation**		**Station**	**Elevation**
0.0	89.63		28.0	90.96
14.9	89.91		29.7	90.88
20.0	89.57		30.3	90.90
22.8	89.55		36.8	90.89
26.1	89.17		51.1	90.84
30.5	87.78		90.4	90.92
34.8	87.80		113.1	90.85
36.6	87.79		124.5	90.83
43.5	87.71		132.7	90.82
47.5	87.72		190.1	90.79
52.7	88.21		203.7	90.88
56.6	88.56		228.5	90.56
61.1	88.92		245.5	90.59
65.1	89.33		277.0	90.50
71.5	89.22		325.6	90.52
77.3	89.45		364.3	90.54
83.6	89.61		404.1	90.52
87.9	89.01		472.1	90.53
93.6	88.70			
97.8	87.86			
105.7	87.21			
109.7	88.21			
115.3	87.73			
123.7	88.02			
127.7	88.38			
132.8	88.15			
140.6	87.85			
146.3	88.04			
149.5	87.60			
158.6	88.07			
169.8	89.19			
176.9	89.03			
181.6	88.41			
189.7	88.37			
197.8	88.99			
208.0	90.05			
214.3	89.47			
224.4	89.35			
237.0	89.46			
246.0	87.85			
257.5	87.56			
269.1	87.75			
280.9	88.20			
298.3	87.95			
310.3	87.99			
318.7	87.97			
331.3	88.47			
342.5	88.70			
356.3	88.17			
366.4	87.67			
371.5	87.62			
389.3	87.38			
405.0	86.36			
420.6	85.72			
432.5	86.25			
439.4	87.12			
447.0	88.32			
462.7	88.13			
472.3	88.90			



MDEQ Rea h C - 2004 Profile
TWG
WSF
X1
X2
X3
Elevation (ft)
92
91
90
89
88
87
86
85
0
75
150
225
300
375
450
Channel Distance (ft)

Table 10. Cross-section data for Reach C, Transect 1 (Station (0+00).

Station:	Dead River bypassed channel, Reach C (Station 0+00)
Benchmark:	Nail in base of 6" diam. spruce on left bank (elevation=100 ft)
Height of Instrument:	102.06
WaterSurface Elevation:	91
Channel Width (Ft)	11.5
Date:	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	6.36		95.7		
	6.7	10.2		91.86		
	13.7	10.2		91.86		
	17.2	10.62		91.44		
	21.7	10.62		91.44		
	24.7	10.6		91.46		
	28.2	9.91		92.15		
	29.2	9.81		92.25		
	32.2	10.01		92.05		
	32.7	11.06		91		0.01
	33.2		0.1	90.9		0.05
	33.7		0.6	90.4	0.05	0.3
	34.2		0.7	90.3	0.23	0.35
	34.7		0.8	90.2	0.44	0.4
	35.2		0.7	90.3	0.39	0.35
	35.7		0.7	90.3	0.35	0.35
	36.2		0.7	90.3	0.46	0.35
	36.7		0.8	90.2	0.43	0.4
	37.2		0.9	90.1	0.24	0.45
	37.7		1	90	0.62	0.5
	38.2		1.1	89.9	0.70	0.55
	38.7		1.3	89.7	0.79	0.65
	39.2		1.3	89.7	0.74	0.65
	39.7		1.2	89.8	0.63	0.6
	40.2		1.1	89.9	0.53	0.55
	40.7		0.9	90.1	0.72	0.45
	41.2		0.7	90.3	0.78	0.35
	41.7		0.8	90.2	0.81	0.4
	42.2		1	90	0.60	0.5
	42.7		0.9	90.1	0.17	0.45
	43.2		0.7	90.3	0.14	0.35
	43.7		0.6	90.4	0.19	0.3
	44.2	11.04		91.02		0.07
	46.2	10.43		91.63		
	48.2	10.53		91.53		
	51.2	10.45		91.61		
	53.2	10.45		91.61		
	56.2	10.51		91.55		
	58.2	9.83		92.23		
	60.2	9.57		92.49		
	62.2	8.61		93.45		
	64.2	7.05		95.01		
	66.2	6.31		95.75		
	70.2	5.68		96.38		
	73.2	4.68		97.38		
	76.2	3.33		98.73		
Right Bank Rerod Marker	77.7	2.34		99.72		

Total cross-sectional area (sq. ft.) 9.38

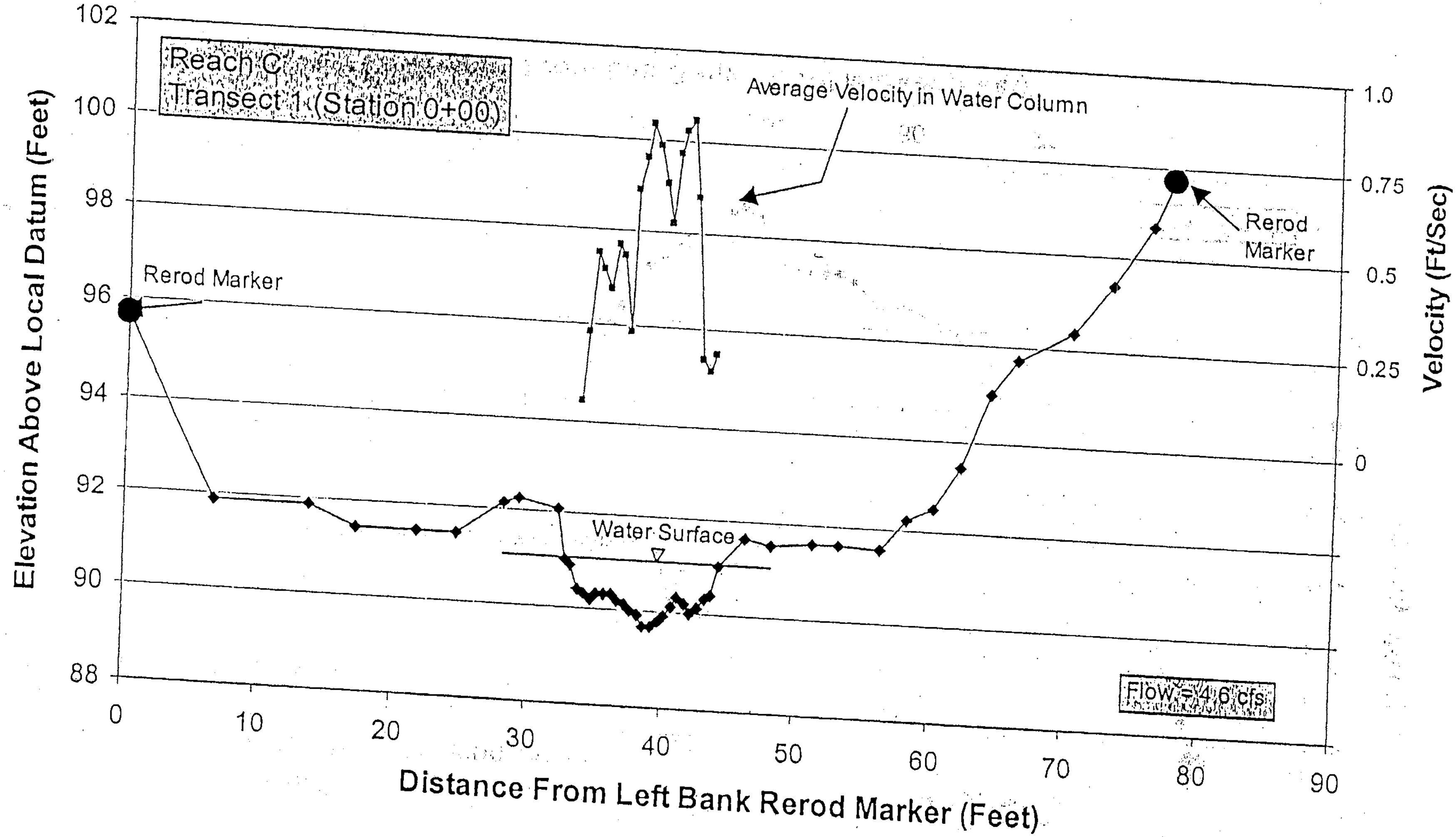


Figure 15. Cross- section profile of Reach C, Transect 1 (Station 0+00) on August 8, 2000.

Reach C, Transect 1, 2004

Pt #	North	East	Elevation	Note	Station
9619	5048.64	5000.93	95.96	X1 LEBF	0.0
9620	5048.47	5000.55	95.51	X1 TOPO	0.3
9621	5047.23	5000.02	94.76	X1 TOPO	1.7
9622	5046.08	4999.48	93.90	X1 TOPO	2.9
9623	5045.34	4998.94	92.98	X1 TOPO	3.9
9624	5044.09	4998.42	92.29	X1 TOPO	5.2
9625	5042.74	4997.51	92.07	X1 TOPO	6.8
9626	5040.24	4996.15	92.02	X1 TOPO	9.7
9627	5038.45	4994.68	91.98	X1 TOPO	11.9
9628	5037.37	4994.12	92.23	X1 TOPO	13.2
9629	5035.20	4993.03	92.33	X1 TOPO	15.6
9630	5033.57	4992.72	92.17	X1 TOPO	17.2
9631	5031.21	4991.39	92.17	X1 TOPO	19.9
9632	5029.04	4989.81	91.84	X1 TOPO	22.5
9633	5027.65	4989.12	91.87	X1 TOPO	24.1
9634	5026.04	4988.12	92.13	X1 TOPO	26.0
9635	5024.18	4987.38	92.47	X1 TOPO	28.0
9636	5022.90	4986.78	92.42	X1 TOPO ltb	29.4
9637	5022.35	4986.47	92.30	X1 TOPO	30.0
9638	5021.69	4986.24	91.09	X1 TOPO	30.7
9639	5020.92	4985.69	90.89	X1 WSF LCH LTO	31.6
9640	5020.28	4985.24	90.55	X1 TOPO	32.4
9641	5019.29	4985.01	89.21	X1 TOPO	33.4
9642	5018.28	4984.44	88.40	X1 TOPO	34.6
9643	5017.06	4984.18	88.11	X1 TOPO	35.7
9644	5016.38	4983.10	87.97	X1 TOPO	36.9
9645	5015.40	4982.81	87.88	X1 TOPO	37.9
9646	5014.63	4982.30	87.79	X1 TWG	38.8
9647	5012.64	4980.97	87.80	X1 TOPO	41.2
9648	5011.37	4980.35	87.82	X1 TOPO	42.6
9649	5010.39	4979.82	87.97	X1 TOPO	43.7
9650	5009.88	4979.51	88.08	X1 TOPO	44.3
9651	5009.53	4979.34	89.31	X1 TOPO	44.7
9652	5008.47	4978.66	89.28	X1 TOPO	45.9
9653	5007.57	4978.31	89.83	X1 TOPO	46.9
9654	5007.11	4978.02	90.33	X1 TOPO	47.4
9655	5006.98	4977.96	90.31	X1 RCH	47.6
9656	5007.11	4977.60	90.87	X1 W-SF	47.6
9657	5006.67	4977.86	91.26	X1 RTB	47.9
9658	5005.52	4977.23	91.39	X1 TOPO	49.2
9659	5004.67	4976.79	91.39	X1 TOPO	50.2
9660	5003.53	4976.07	91.55	X1 TOPO	51.5
9661	5001.39	4975.22	91.78	X1 TOPO	53.8
9662	5000.00	4973.90	91.51	X1 TOPO	55.6
9663	4998.08	4973.49	91.90	X1 TOPO	57.5
9664	4996.74	4973.16	92.19	X1 TOPO	58.9
9665	4995.19	4972.23	92.75	X1 TOPO	60.7
9666	4994.50	4971.70	93.33	X1 TOPO	61.5
9667	4994.41	4971.75	93.31	X1 TOPO	61.6
9668	4992.77	4970.67	94.24	X1 TOPO	63.5
9669	4991.45	4969.86	95.40	X1 TOPO	65.1
9670	4989.79	4968.80	96.09	X1 TOPO	67.1
9671	4988.00	4967.82	96.29	X1 TOPO	69.1
9672	4985.47	4966.42	97.09	X1 TOPO	72.0
9673	4983.92	4965.26	97.87	X1 TOPO	73.9
9674	4982.50	4964.61	98.88	X1 TOPO	75.5
9675	4982.13	4964.46	99.47	X1 TOPO	75.9
9676	4980.93	4963.81	99.94	X1 REBF	77.2

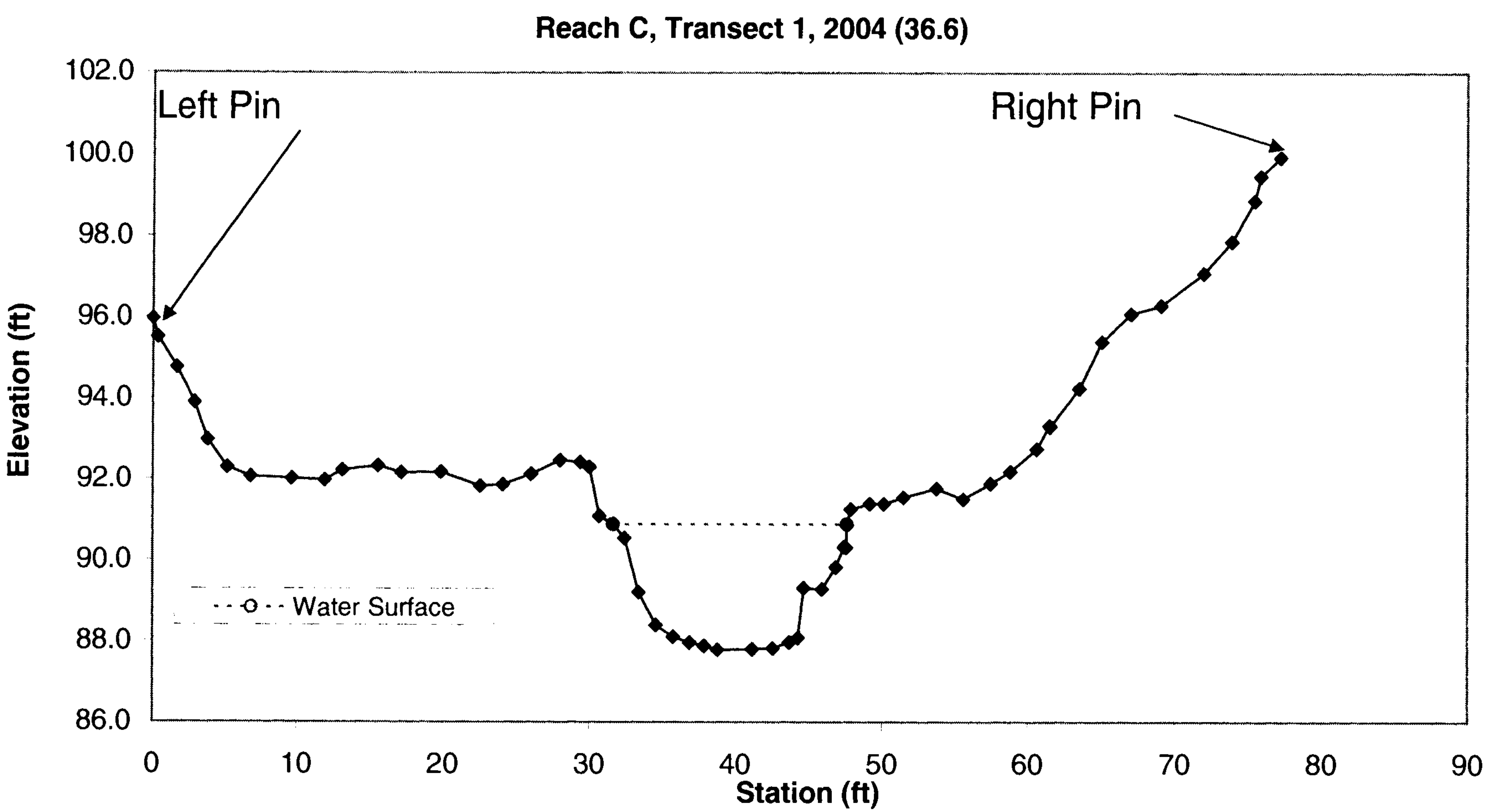


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Table 11. Cross-section data for Reach C, Transect 2 (Station (1+57).

Station:	Dead River bypassed channel, Reach C (Station 1+57)
Benchmark:	Nail in base of 6" spruce on left bank (elevation=100 ft)
Height of Instrument:	100.39
Water Surface Elevation:	91.06
Channel Width (Ft):	25.8
Date:	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq.ft.)
Left Bank Rerod Marker	0	3.82		96.57		
	2	4.55		95.84		
	3	4.85		95.54		
	4	5.01		95.38		
	6	5.89		94.5		
	7.5	6.77		93.62		
	9	7.54		92.85		
	12	7.75		92.64		
	15	8.57		91.82		
	17.5	8.3		92.09		
	19	8.37		92.02		
	21	8.23		92.16		
	24	8.09		92.3		
	27	8.32		92.07		
	29	8.09		92.3		
	32	8.32		92.07		
	35	8.29		92.1		
	36	8.23		92.16		
	37	8.82		91.57		
	38.2	9.33	0	91.06	0	0.045
	39		0.2	90.86	0.00	0.18
	40		0.3	90.76	0.00	0.3
	41		0.7	90.36	0.16	0.7
	42		0.8	90.26	0.38	0.8
	43		1	90.06	0.49	1
	44		1	90.06	0.42	1
	45		1	90.06	0.53	1
	46		1.2	89.86	0.49	1.2
	47		1.4	89.66	0.42	1.4
	48		1.5	89.56	0.40	1.5
	49		1.4	89.66	0.41	1.4
	50		1.1	89.96	0.43	1.1
	51		0.8	90.26	0.30	0.8
	52		0.7	90.36	0.15	0.7
	53		0.7	90.36	0.05	0.7
	54		0.7	90.36	0.05	0.7
	55		0.7	90.36	0.00	0.7
	56		0.6	90.46	0.00	0.9
	58		0.3	90.76	0.00	0.6
	60		0.3	90.76	0.00	0.9
	64		0	91.06	0.00	0.225
	67	8.87		91.52		
	69	8.19		92.2		
	71	7.7		92.69		
	73	7.07		93.32		
	75	6.61		93.78		
	77	6.19		94.2		
	79	5.54		94.85		
	81	4.66		95.73		
Right Bank Rerod Marker	82	4.19		96.2		

Total cross-sectional area (sq. ft.) 17.85

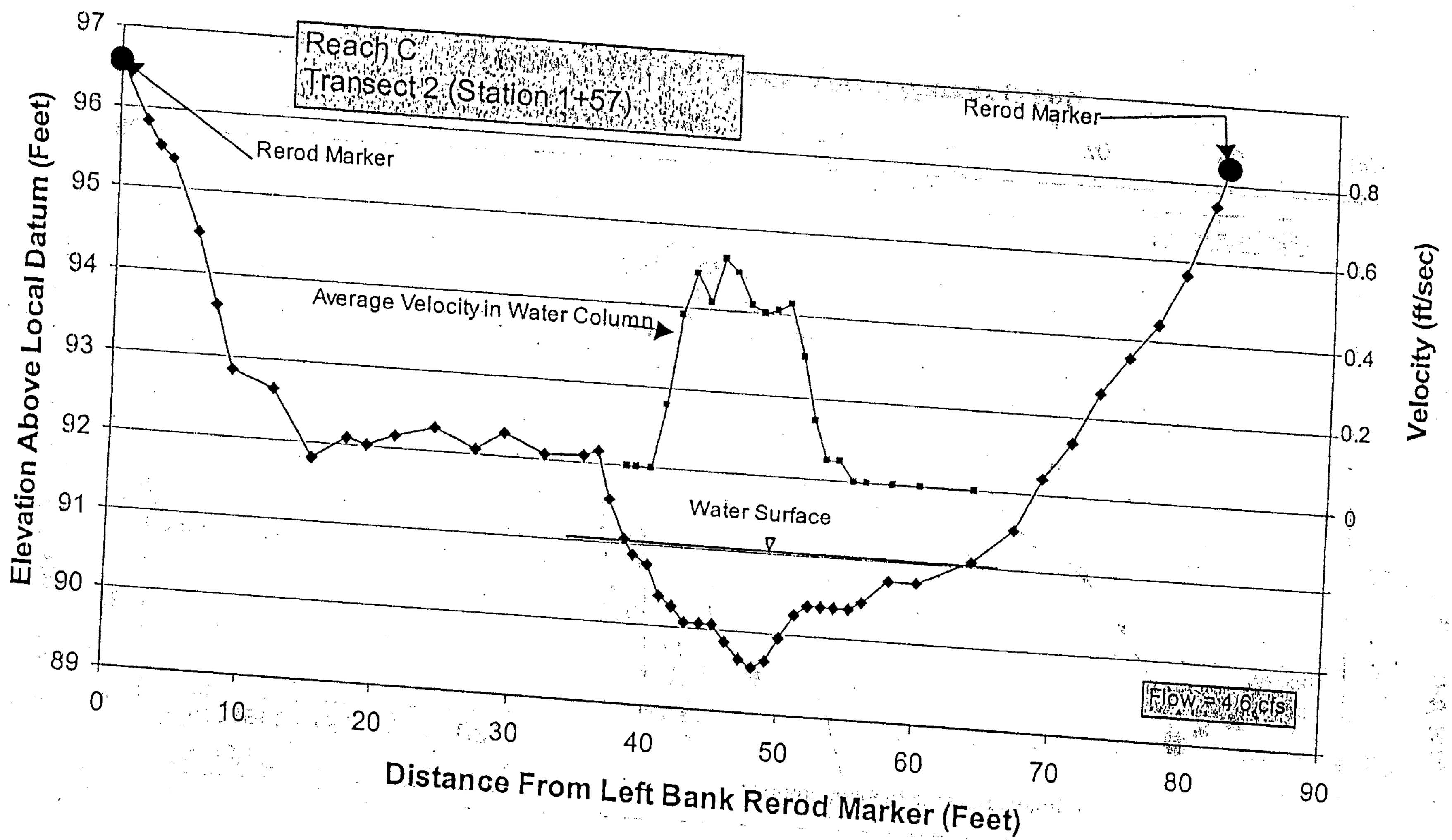

Figure 16. Cross- section profile of Reach C, Transect 2 (Station 1+57) on August 8, 2000.

Reach C, Transect 2, 2004

Pt #	North	East	Elevation	Note	Station
9747	5010.50	5096.63	96.89	X2 LEBF	0.0
9748	5010.23	5096.51	96.48	X2 TOPO	0.3
9749	5006.86	5095.58	95.47	X2 TOPO	3.8
9750	5005.75	5095.36	94.98	X2 TOPO	4.9
9751	5003.99	5094.60	93.94	X2 TOPO	6.8
9752	5002.61	5094.19	93.24	X2 TOPO	8.3
9753	5000.50	5093.33	92.75	X2 TOPO	10.5
9754	4996.53	5092.30	92.15	X2 TOPO	14.6
9755	4991.33	5090.25	92.18	X2 TOPO	20.2
9756	4987.60	5089.52	92.28	X2 TOPO	24.0
9757	4983.68	5087.48	92.11	X2 TOPO	28.3
9758	4981.62	5086.86	92.42	X2 TOPO	30.4
9759	4979.05	5086.93	91.80	X2 TOPO	32.9
9760	4978.49	5086.37	91.30	X2 TOPO	33.6
9761	4977.78	5085.92	90.79	X2 LCH WSF	34.4
9762	4977.68	5085.73	90.11	X2 TOPO	34.5
9763	4976.24	5085.37	89.79	X2 TOPO	36.0
9764	4973.71	5084.15	89.53	X2 TOPO	38.8
9765	4971.96	5083.87	88.92	X2 TOPO	40.5
9766	4971.78	5083.51	89.10	X2 TOPO	40.8
9767	4971.41	5083.57	88.68	X2 TOPO	41.2
9768	4970.59	5083.53	88.37	X2 TWG	42.0
9769	4969.88	5083.38	88.33	X2 TOPO	42.7
9770	4967.76	5082.33	88.34	X2 TOPO	45.0
9771	4965.72	5081.64	88.44	X2 TOPO	47.2
9772	4962.35	5081.26	88.15	X2 TOPO	50.5
9773	4960.01	5080.86	88.10	X2 TOPO	52.9
9774	4957.81	5079.89	88.26	X2 TOPO	55.2
9775	4955.48	5079.93	88.70	X2 TOPO	57.5
9776	4954.26	5079.64	89.41	X2 TOPO	58.7
9777	4953.33	5079.33	90.52	X2 TOPO	59.7
9778	4953.26	5079.24	90.82	X2 RCH W-SF	59.8
9779	4952.88	5078.65	90.92	X2 TOPO	60.3
9780	4949.94	5078.31	91.20	X2 TOPO	63.3
9781	4948.42	5078.03	91.33	X2 TOPO	64.8
9782	4946.94	5078.44	91.46	X2 TOPO	66.1
9783	4946.22	5077.80	91.80	X2 TOPO	67.0
9784	4945.81	5077.55	91.97	X2 TOPO	67.4
9785	4945.17	5077.36	92.22	X2 TOPO	68.1
9786	4943.86	5077.23	92.46	X2 TOPO	69.4
9787	4942.92	5076.66	92.70	X2 TOPO	70.5
9788	4941.78	5076.51	93.09	X2 TOPO	71.6
9789	4939.64	5076.22	93.72	X2 TOPO	73.7
9790	4937.83	5076.01	94.09	X2 TOPO	75.5
9791	4936.48	5075.61	94.45	X2 TOPO	77.0
9792	4934.81	5075.23	95.06	X2 TOPO	78.7
9793	4933.30	5074.94	95.81	X2 TOPO	80.2
9795	4932.33	5075.16	96.30	X2 TOPO	81.1
9794	4932.26	5075.15	96.30	X2 TOPO	81.1
9796	4932.06	5074.95	96.75	X2 REBF	81.4

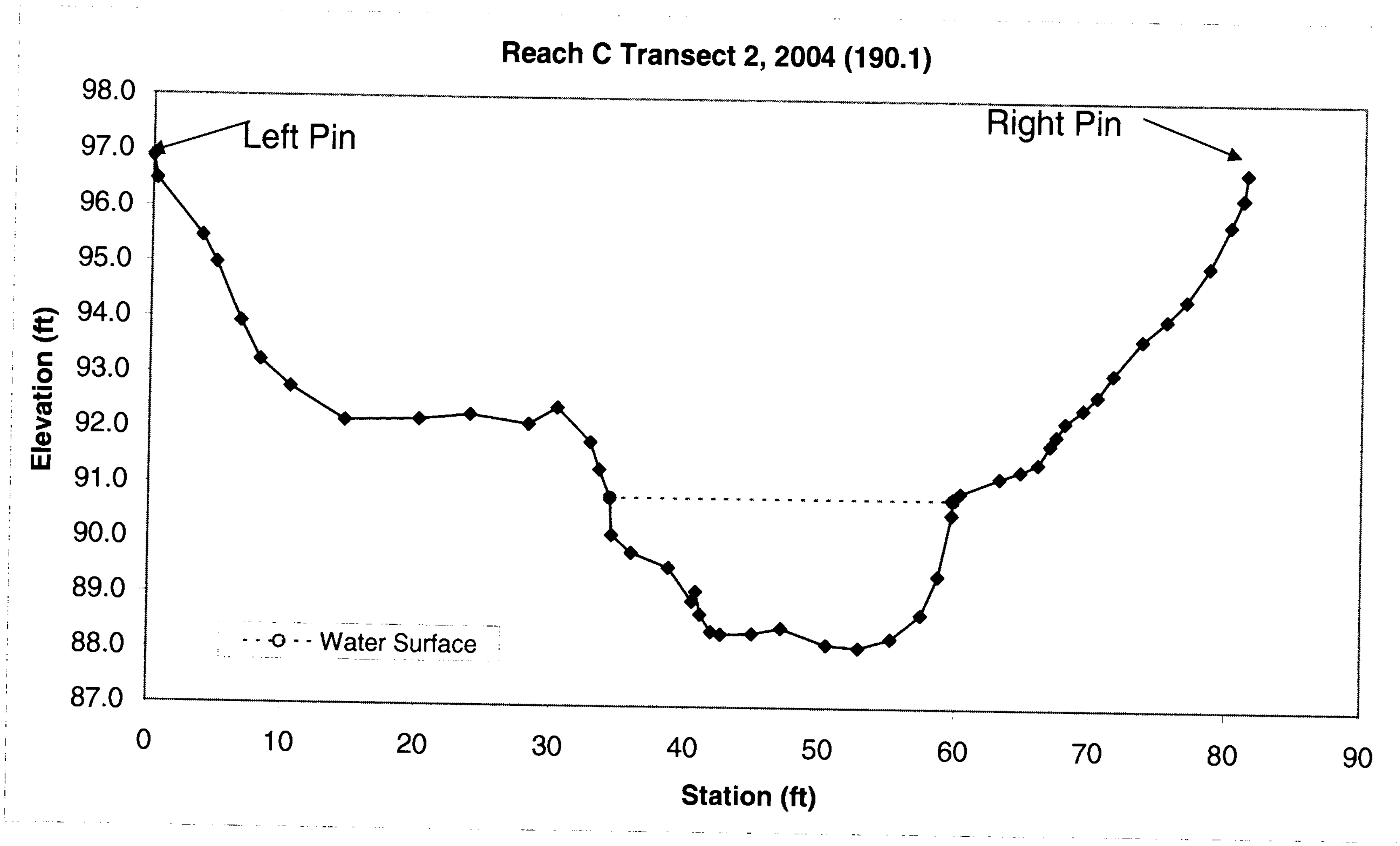

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Table 12. Cross-section data for Reach C, Transect 3 (Station 3+50).

Station:	Dead River bypassed channel, Reach C (Station 3+50)
Benchmark:	Nail in base of 6" diam. spruce on left bank (elevation=100 ft)
Height of Instrument:	97.11
WaterSurface Elevation:	90.94
Channel Width (ft)	21.5
Date	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	1.06		96.05		
	1.5	2.22		94.89		
	2.5	3.2		93.91		
	4.5	4.22		92.89		
	5.5	4.64		92.47		
	7.5	5.19		91.92		
	9.5	5.33		91.78		
	12.5	5.85		91.26		
	15.5	5.7		91.41		
	17.5	5.75		91.36		
	19.5	5.41		91.7		
	21.5	5.11		92		
	23.5	5.01		92.1		
	24.5	5.06		92.05		
	25.5	5.41		91.7		
	27	6.13		90.98		0.3
	28.5		0.4	90.54	0.05	0.6
	30		0.4	90.54	0.44	0.6
	31.5		0.5	90.44	0.62	0.75
	33		0.5	90.44	0.56	0.75
	34.5		0.5	90.44	0.56	0.75
	36		0.6	90.34	0.52	0.9
	37.5		0.8	90.14	0.36	1.2
	39		1.6	89.34	0.31	2.4
	40.5		2	88.94	0.05	3
	42		2.2	88.74	0.15	3.3
	43.5		1.7	89.24	0.05	2.55
	45		1	89.94	0.05	1.5
	46.5		0.1	90.84	0.05	0.15
	48		0.1	90.84	0.00	0.1
	48.5	6.16		90.95		0.05
	50.5	5.4		91.71		
	52.5	5.41		91.7		
	54.5	5.5		91.61		
	56.5	4.31		92.8		
	57.5	3.2		93.91		
	58.5	1.75		95.36		
	59.5	1.3		95.81		
	61.5	0.35		96.76		

Total cross-sectional area (sq. ft.) 18.9

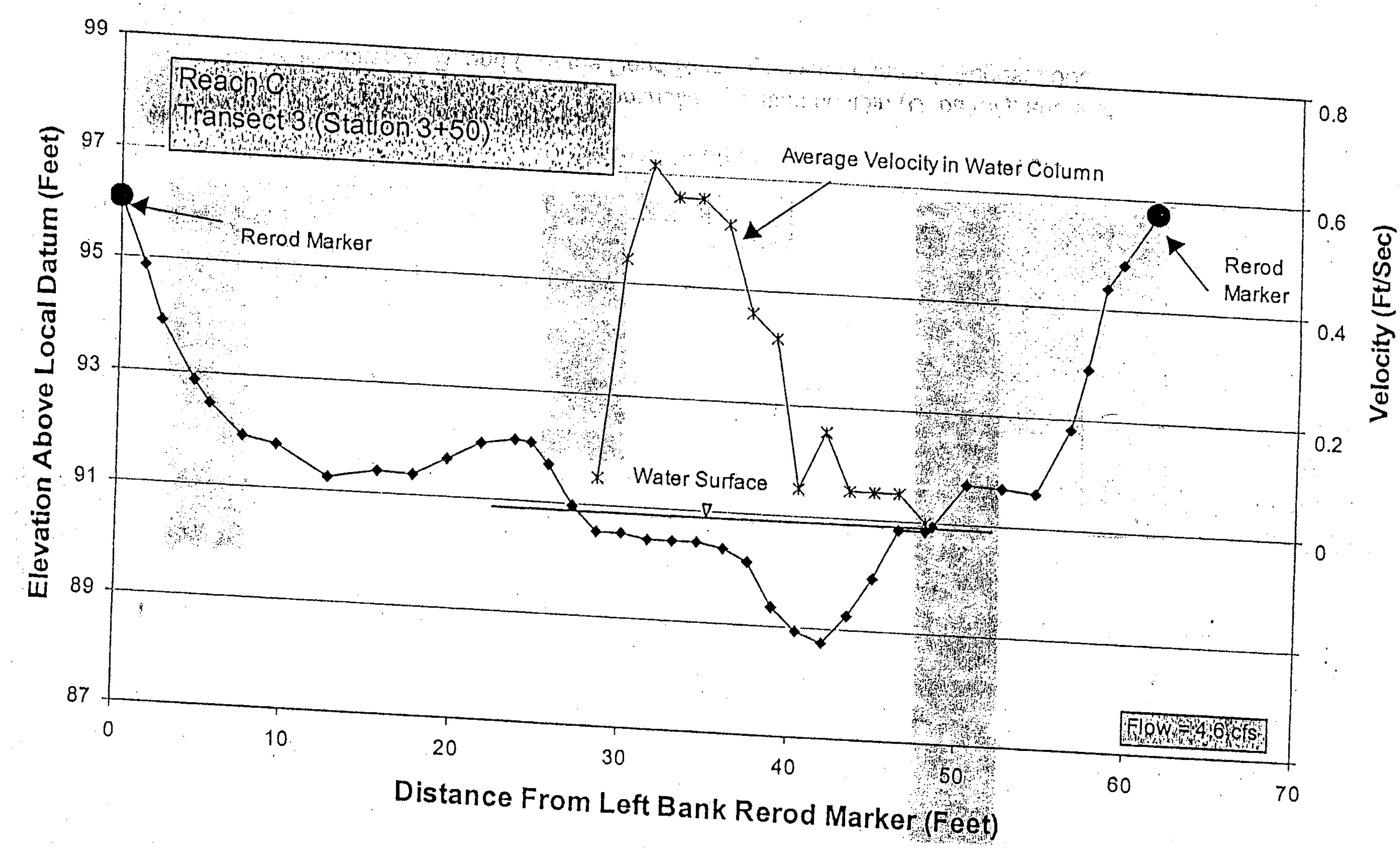

Figure 17. Cross- section profile of Reach C, Transect 3 (Station 3+50) on August 8, 2000.

Reach C, Transect 3, 2004

Pt #	North	East	Elevation	Note	Station
9841	5051.95	5227.60	96.78	X3 LEBF	0.0
9842	5051.82	5227.81	96.08	X3 TOPO	0.2
9843	5051.18	5228.11	95.29	X3 TOPO	0.9
9844	5050.52	5229.34	93.94	X3 TOPO	2.3
9845	5048.93	5231.11	92.70	X3 TOPO	4.6
9846	5047.25	5233.18	91.90	X3 TOPO	7.3
9847	5046.62	5234.06	91.77	X3 TOPO	8.4
9848	5045.05	5236.28	91.48	X3 TOPO	11.1
9849	5043.61	5237.87	91.70	X3 TOPO	13.2
9850	5042.27	5239.09	92.16	X3 TOPO	15.0
9851	5040.22	5241.45	92.00	X3 TOPO	18.1
9852	5038.02	5243.89	92.44	X3 TOPO	21.4
9853	5036.09	5246.27	92.01	X3 LTB	24.5
9854	5034.97	5246.68	90.52	X3 WSF	25.5
9855	5035.06	5246.79	90.81	X3 LCH	25.6
9856	5034.77	5247.08	89.03	X3 TOPO	26.0
9857	5034.29	5247.55	88.01	X3 TOPO	26.6
9858	5032.46	5248.94	87.94	X3 TOPO	28.9
9859	5030.84	5250.83	88.07	X3 TOPO	31.4
9860	5028.99	5253.24	87.83	X3 TOPO	34.4
9861	5027.60	5254.41	87.52	X3 TOPO	36.2
9862	5026.54	5255.93	87.01	X3 TOPO	38.0
9863	5025.48	5258.50	86.36	X3 TWG	40.7
9864	5023.88	5259.68	86.59	X3 TOPO	42.6
9865	5022.28	5261.40	87.65	X3 TOPO	45.0
9866	5021.40	5263.05	88.06	X3 TOPO	46.8
9867	5019.79	5263.78	88.76	X3 TOPO	48.4
9868	5018.98	5265.00	90.06	X3 TOPO	49.9
9869	5018.67	5265.52	90.52	X3 RCH W-SF	50.4
9870	5018.20	5265.66	90.83	X3 TOPO	50.9
9871	5017.22	5266.91	91.76	X3 RTB	52.4
9872	5015.66	5267.98	92.02	X3 TOPO	54.3
9873	5014.60	5269.57	92.94	X3 TOPO	56.2
9874	5012.69	5271.51	95.40	X3 TOPO	58.9
9876	5011.35	5272.49	97.31	X3 REBF	60.5
9875	5011.19	5272.42	96.43	X3 TOPO	60.6

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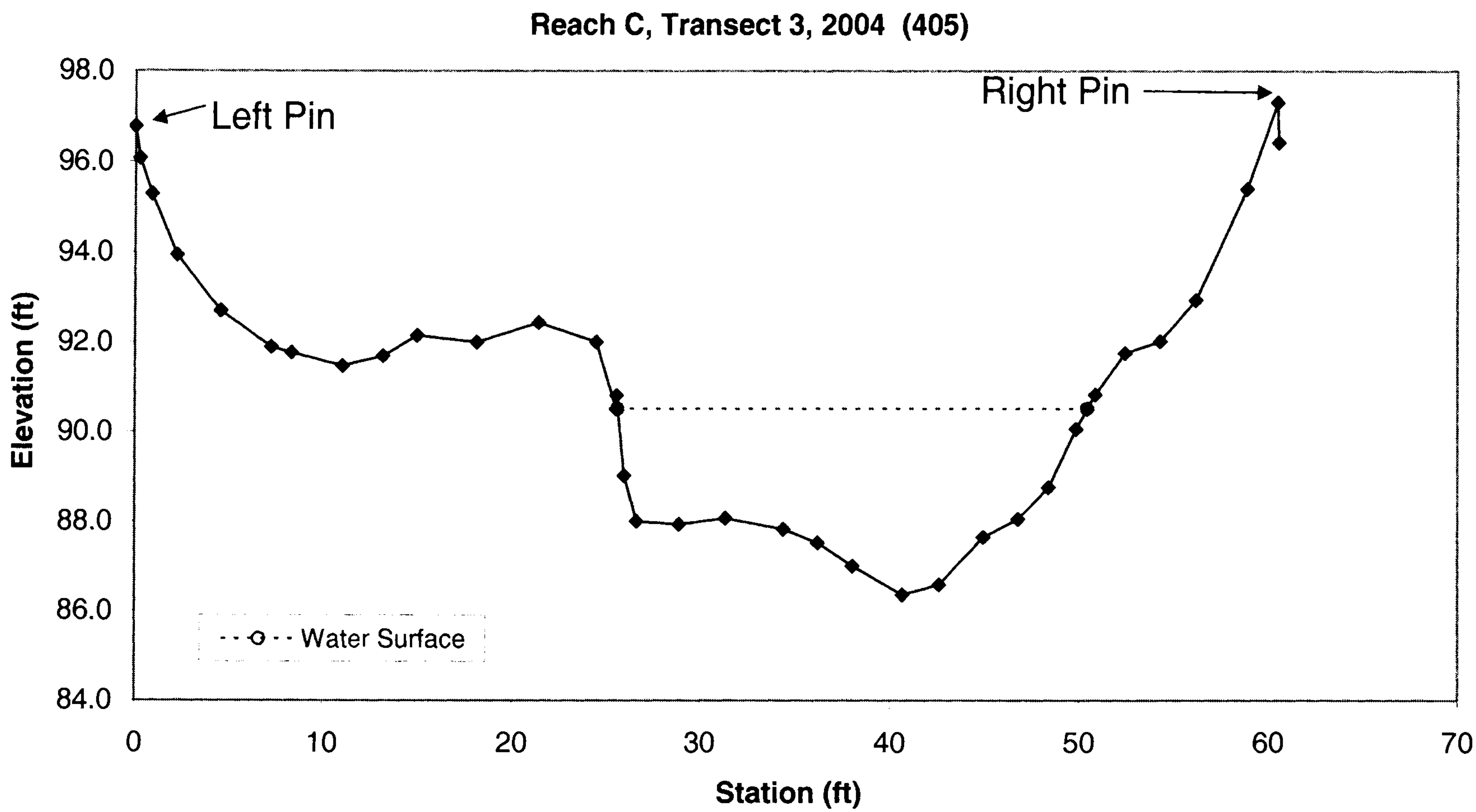

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MDEQ R06-07-C

9600	5000	5000	92.02	SPIKE
9601	4955.8576	5121.2874	91.6568	SPIKE
9602	5022.1596	4958.7699	91.0319	MCB1 WS-F
9603	5021.1227	4961.3755	90.9688	MCB1 WS-F
9604	5022.7717	4962.6996	90.9764	MCB1 WS-F
9605	5024.9519	4963.056	90.9948	MCB1 WS-F
9606	5018.6912	4957.6226	89.6278	TWG
9607	5012.8172	4956.559	90.9734	RCH W-SF
9608	5027.4395	4972.6802	90.957	LCH WSF
9609	5027.1238	4969.8933	89.9139	TWG
9610	5022.0905	4969.184	89.5727	TWG
9611	5019.4887	4970.2688	89.5522	TWG
9612	5017.8532	4973.1771	89.1674	TWG
9613	5016.4401	4977.2622	87.7789	TWG
9614	5013.7972	4980.6899	87.8001	TWG
9615	5024.1581	4975.0473	90.8971	LCH LTO WSF
9616	5023.231	4980.0663	90.8779	LCH LTO WSF
9617	5025.395	4980.7249	92.1684	LTB
9618	5025.9564	4977.3266	91.8208	LTB
9619	5048.6396	5000.933	95.9633	X1 LEBF
9620	5048.4715	5000.5452	95.5052	X1 TOPO
9621	5047.2322	5000.0224	94.7626	X1 TOPO
9622	5046.0827	4999.4841	93.8982	X1 TOPO
9623	5045.34	4998.9359	92.9786	X1 TOPO
9624	5044.085	4998.4211	92.2947	X1 TOPO
9625	5042.7402	4997.5123	92.0715	X1 TOPO
9626	5040.2352	4996.1543	92.0236	X1 TOPO
9627	5038.4499	4994.681	91.9771	X1 TOPO
9628	5037.3666	4994.119	92.2255	X1 TOPO
9629	5035.2028	4993.0307	92.3332	X1 TOPO
9630	5033.5671	4992.7173	92.1664	X1 TOPO
9631	5031.214	4991.3925	92.1749	X1 TOPO
9632	5029.0424	4989.8139	91.8395	X1 TOPO
9633	5027.6547	4989.1231	91.8681	X1 TOPO
9634	5026.0354	4988.1246	92.1313	X1 TOPO
9635	5024.1805	4987.3753	92.4705	X1 TOPO
9636	5022.9047	4986.7799	92.4241	X1 TOPO ltb
9637	5022.3527	4986.4656	92.3014	X1 TOPO
9638	5021.6914	4986.2417	91.0945	X1 TOPO
9639	5020.9211	4985.6902	90.8941	X1 WSF LCH LTO
9640	5020.2833	4985.2393	90.5492	X1 TOPO
9641	5019.2878	4985.0135	89.21	X1 TOPO
9642	5018.2774	4984.4366	88.3957	X1 TOPO
9643	5017.0573	4984.1847	88.1125	X1 TOPO
9644	5016.3831	4983.0987	87.9676	X1 TOPO
9645	5015.4033	4982.8062	87.8846	X1 TOPO
9646	5014.631	4982.3021	87.7854	X1 TWG
9647	5012.643	4980.968	87.803	X1 TOPO
9648	5011.3705	4980.3517	87.8245	X1 TOPO
9649	5010.3877	4979.8224	87.9695	X1 TOPO
9650	5009.8765	4979.5143	88.0824	X1 TOPO
9651	5009.5286	4979.3415	89.3119	X1 TOPO
9652	5008.4718	4978.6569	89.2801	X1 TOPO
9653	5007.5745	4978.3068	89.8267	X1 TOPO
9654	5007.1054	4978.0207	90.3276	X1 TOPO
9655	5006.9785	4977.9587	90.3122	X1 RCH

9656	5007.1056	4977.5998	90.8744	X1 W-SF
9657	5006.6685	4977.8599	91.2616	X1 RTB
9658	5005.5213	4977.2254	91.3937	X1 TOPO
9659	5004.6747	4976.7851	91.3915	X1 TOPO
9660	5003.5274	4976.0718	91.5537	X1 TOPO
9661	5001.3871	4975.216	91.7761	X1 TOPO
9662	5000.0019	4973.9001	91.5089	X1 TOPO
9663	4998.0811	4973.4915	91.9008	X1 TOPO
9664	4996.7369	4973.1637	92.1924	X1 TOPO
9665	4995.1922	4972.2258	92.7491	X1 TOPO
9666	4994.5049	4971.7025	93.3335	X1 TOPO
9667	4994.4137	4971.7533	93.3055	X1 TOPO
9668	4992.7738	4970.6669	94.2437	X1 TOPO
9669	4991.4479	4969.8606	95.399	X1 TOPO
9670	4989.7882	4968.8029	96.0855	X1 TOPO
9671	4988.0033	4967.8213	96.2913	X1 TOPO
9672	4985.472	4966.4174	97.0869	X1 TOPO
9673	4983.92	4965.2602	97.8686	X1 TOPO
9674	4982.5049	4964.6135	98.875	X1 TOPO
9675	4982.1286	4964.4573	99.4715	X1 TOPO
9676	4980.927	4963.8083	99.9419	X1 REBF
9677	5013.7902	4971.372	90.9029	RCH W-SF
9678	5011.0564	4973.4706	90.8981	RCH W-SF
9679	5001.9264	4984.0808	90.3249	RCH
9680	5000.9184	4987.1794	90.8097	RCH
9681	4999.1346	4992.4721	90.9078	RCH W-SF
9682	5006.1323	4999.9564	90.6898	RCH
9683	5006.2998	5001.1523	90.7928	RCH W-SF
9684	5002.7345	5006.9653	90.7285	RCH W-SF
9685	5001.4548	5013.19	90.6687	RCH
9686	5018.9306	4994.8537	90.8364	LCH WSF
9687	5018.974	4998.9148	90.753	LCH
9688	5019.2039	5004.7046	90.6565	LCH
9689	5016.6869	5016.3963	90.3981	LCH
9690	5010.6963	4987.9235	87.7132	TWG
9691	5009.8843	4991.9326	87.7158	TWG
9692	5010.223	4997.043	88.21	TWG
9693	5010.5082	5000.9578	88.563	TWG
9694	5009.1146	5005.2719	88.9184	TWG
9695	5006.531	5008.2363	89.3265	TWG
9696	5005.3267	5014.5798	89.2248	TWG
9697	5006.5731	5020.1801	89.4537	TWG
9698	5009.303	5025.9482	89.6129	TWG
9699	5013.2168	5027.5478	89.0096	TWG
9700	5003.3865	5024.9244	90.7024	RCH
9701	5003.4469	5028.6178	89.9741	RCH
9702	5007.1079	5029.9608	89.9957	RCH
9703	5009.428	5030.7263	89.6448	RCH
9704	5010.1794	5030.9351	90.8914	W-SF
9705	5002.6309	5020.4021	91.6199	RTB
9706	5017.7766	5024.5833	91.7985	LTB
9707	5017.4932	5024.9625	90.92	LCH WSF
9708	5017.9946	5030.7671	88.701	TWG
9709	5019.9672	5034.4679	87.859	TWG
9710	5022.6629	5031.9567	90.7301	LCH
9711	5023.1237	5041.7453	87.205	TWG
9712	5023.5368	5045.7125	88.2054	TWG
9713	5027.3427	5049.7242	87.7254	TWG

9714	5030.8717	5047.7524	90.8524	LCH WSF
9715	5015.6178	5043.7786	90.7497	RCH W-SF
9716	5016.3849	5051.6215	90.8127	RCH
9717	5025.0727	5057.8527	88.0169	TWG
9718	5021.6541	5059.9888	88.3757	TWG
9719	5028.8798	5061.0252	89.3535	LCH
9720	5028.4152	5060.2224	90.8281	WSF
9721	5051.6534	5083.9951	100	BM1
9722	5016.7363	5061.2273	88.148	TWG
9723	5013.4954	5054.6076	90.8306	RCH W-SF
9724	5017.4933	5068.2454	90.8163	LCH WSF
9725	5017.2841	5069.0361	92.467	LTB
9726	5012.8416	5052.8109	92.6085	RTB
9727	5008.9249	5061.2466	87.8462	TWG
9728	5003.4137	5062.5262	88.0361	TWG
9729	5000.1686	5062.7969	87.6033	TWG
9730	4992.1572	5067.0006	88.0688	TWG
9731	4988.7492	5062.5273	90.8351	RCH
9732	4993.5116	5073.6709	90.3366	LCH
9733	4981.4654	5070.4207	89.1907	TWG
9734	4974.8127	5072.9253	89.0251	TWG
9735	4970.834	5075.3656	88.4106	TWG
9736	4978.6215	5064.844	90.8451	RCH
9737	4972.1544	5068.5614	90.7998	RCH W-SF
9738	4970.3885	5068.2393	90.773	RCH
9739	4970.6443	5065.6205	90.7776	RCH
9740	4973.9188	5052.8468	90.8362	RCH W-SF
9741	4974.603	5038.5304	90.8221	RCH W-SF
9742	4966.7182	5036.0422	90.0952	RCH
9743	4957.891	5046.8099	90.795	RCH W-SF
9744	4952.4717	5063.7775	90.8563	RCH W-SF
9745	4968.0109	5048.7748	89.5306	BACK EDDY TW-G
9746	4961.9703	5062.6924	88.7272	BACK EDDY TW-G
9747	5010.5024	5096.6294	96.891	X2 LEBF
9748	5010.2342	5096.5121	96.4849	X2 TOPO
9749	5006.856	5095.5766	95.4658	X2 TOPO
9750	5005.749	5095.3565	94.9847	X2 TOPO
9751	5003.9892	5094.5982	93.936	X2 TOPO
9752	5002.6053	5094.1927	93.2352	X2 TOPO
9753	5000.5022	5093.3272	92.7546	X2 TOPO
9754	4996.5271	5092.3005	92.1505	X2 TOPO
9755	4991.3293	5090.252	92.1823	X2 TOPO
9756	4987.6033	5089.5175	92.2757	X2 TOPO
9757	4983.6759	5087.4761	92.1126	X2 TOPO
9758	4981.6207	5086.8583	92.4155	X2 TOPO
9759	4979.0525	5086.9259	91.797	X2 TOPO
9760	4978.4889	5086.3683	91.3013	X2 TOPO
9761	4977.7775	5085.9194	90.7915	X2 LCH WSF
9762	4977.6812	5085.7296	90.1097	X2 TOPO
9763	4976.2433	5085.3653	89.7924	X2 TOPO
9764	4973.714	5084.147	89.5312	X2 TOPO
9765	4971.963	5083.8657	88.9169	X2 TOPO
9766	4971.7805	5083.5127	89.0976	X2 TOPO
9767	4971.4122	5083.5715	88.6821	X2 TOPO
9768	4970.5945	5083.525	88.3716	X2 TWG
9769	4969.8759	5083.3849	88.3267	X2 TOPO
9770	4967.755	5082.3297	88.3396	X2 TOPO
9771	4965.7237	5081.6423	88.4414	X2 TOPO

9772	4962.3517	5081.2597	88.145	X2 TOPO
9773	4960.0109	5080.8581	88.0983	X2 TOPO
9774	4957.8077	5079.8933	88.2629	X2 TOPO
9775	4955.4789	5079.9322	88.7032	X2 TOPO
9776	4954.2608	5079.6374	89.4081	X2 TOPO
9777	4953.3251	5079.3264	90.5223	X2 TOPO
9778	4953.2606	5079.2438	90.8175	X2 RCH W-SF
9779	4952.8773	5078.6513	90.92	X2 TOPO
9780	4949.9363	5078.3084	91.1961	X2 TOPO
9781	4948.4168	5078.0285	91.3273	X2 TOPO
9782	4946.9442	5078.4409	91.4612	X2 TOPO
9783	4946.2191	5077.7977	91.8048	X2 TOPO
9784	4945.8145	5077.5478	91.9724	X2 TOPO
9785	4945.1735	5077.3641	92.2168	X2 TOPO
9786	4943.8572	5077.2256	92.46	X2 TOPO
9787	4942.9155	5076.662	92.7003	X2 TOPO
9788	4941.7821	5076.5063	93.0949	X2 TOPO
9789	4939.6417	5076.2219	93.7239	X2 TOPO
9790	4937.8337	5076.008	94.0922	X2 TOPO
9791	4936.4751	5075.6145	94.4504	X2 TOPO
9792	4934.8092	5075.2294	95.0577	X2 TOPO
9793	4933.2964	5074.9412	95.8136	X2 TOPO
9794	4932.2568	5075.1459	96.2993	X2 TOPO
9795	4932.3314	5075.1583	96.2951	X2 TOPO
9796	4932.0643	5074.9526	96.7465	X2 REBF
9797	4952.7417	5099.1614	90.7813	RCH
9798	4954.0203	5104.3971	90.8038	RCH
9799	4950.4888	5106.0583	90.7745	RCH W-SF
9800	4946.7844	5111.7537	90.5782	RCH
9801	4942.1742	5114.0568	90.5917	RCH
9802	4943.9104	5121.3736	90.5798	RCH W-SF
9803	4949.8777	5132.2989	90.5838	RCH W-SF
9804	4954.6521	5141.8189	90.6135	RCH W-SF
9805	4959.4814	5134.7571	90.6311	MCB2
9806	4955.0298	5127.8723	90.5858	MCB2
9807	4963.2255	5123.2319	90.518	MCB2
9808	4956.8503	5108.5995	90.8291	MCB2
9809	4948.4475	5112.3408	90.5985	MCB2
9810	4970.9754	5114.2961	89.3452	TWG
9811	4965.2977	5105.9434	89.4671	TWG
9812	4968.3352	5100.433	90.0513	TWG
9813	4966.469	5090.4242	88.9897	TWG
9814	4974.1452	5096.6306	90.8821	LCH WSF
9815	4981.3696	5113.07	90.5592	LCH WSF
9816	4976.6213	5125.5941	89.4636	TWG
9817	4982.6041	5131.5872	90.5874	LCH WSF
9818	4983.7245	5133.5097	92.669	LTB
9819	4968.6966	5129.9209	87.8487	TWG
9820	4967.685	5141.3154	87.56	TWG
9821	4976.1029	5149.3888	87.7481	TWG
9822	4973.3496	5160.8883	88.1962	TWG
9823	4981.4849	5160.7417	90.498	LCH WSF
9824	4960.3682	5160.2774	90.5745	RCH
9825	4973.195	5172.8078	89.1097	TOPO
9826	4948.0893	5134.8115	95.6009	BM2
9827	5010.1181	5212.9769	92.3896	SPIKE
9828	4963.2641	5174.9921	87.9456	TWG
9829	4963.7871	5187.0301	87.9901	TWG

9830	4968.3896	5193.9849	87.9694	TWG
9831	4963.2787	5195.0108	90.4613	RCH W-SF
9832	4985.0982	5189.4454	90.5227	LCH WSF
9833	4976.9947	5203.2878	88.4684	TWG
9834	4983.2061	5212.5388	88.6966	TWG
9835	4992.4961	5222.7795	88.1674	TWG
9836	4998.9032	5230.5251	87.6665	TWG
9837	5006.2257	5221.8555	90.5367	LCH WSF
9838	4988.0812	5236.1357	90.5631	RCH W-SF
9839	5002.1099	5234.5194	87.6171	TWG
9840	5014.9783	5246.8481	87.38	TWG
9841	5051.9487	5227.6019	96.7819	X3 LEBF
9842	5051.8177	5227.813	96.0798	X3 TOPO
9843	5051.1756	5228.1141	95.2944	X3 TOPO
9844	5050.5175	5229.3432	93.9437	X3 TOPO
9845	5048.9273	5231.1111	92.703	X3 TOPO
9846	5047.2484	5233.177	91.8966	X3 TOPO
9847	5046.6246	5234.0561	91.7696	X3 TOPO
9848	5045.0463	5236.2756	91.4753	X3 TOPO
9849	5043.6083	5237.874	91.6962	X3 TOPO
9850	5042.2728	5239.0908	92.1556	X3 TOPO
9851	5040.2201	5241.4513	92.0044	X3 TOPO
9852	5038.0194	5243.8858	92.4418	X3 TOPO
9853	5036.0886	5246.2652	92.0074	X3 LTB
9854	5034.974	5246.6818	90.5181	X3 WSF
9855	5035.0564	5246.7936	90.8138	X3 LCH
9856	5034.7675	5247.0845	89.0256	X3 TOPO
9857	5034.2883	5247.5517	88.0093	X3 TOPO
9858	5032.4615	5248.9357	87.941	X3 TOPO
9859	5030.8445	5250.8289	88.0746	X3 TOPO
9860	5028.9866	5253.2397	87.8305	X3 TOPO
9861	5027.5982	5254.4132	87.5238	X3 TOPO
9862	5026.5446	5255.9288	87.0061	X3 TOPO
9863	5025.4815	5258.4971	86.3635	X3 TWG
9864	5023.8769	5259.6762	86.5889	X3 TOPO
9865	5022.2844	5261.4001	87.6528	X3 TOPO
9866	5021.3989	5263.053	88.0578	X3 TOPO
9867	5019.7879	5263.7779	88.7638	X3 TOPO
9868	5018.9782	5265.0037	90.0636	X3 TOPO
9869	5018.6702	5265.5161	90.5185	X3 RCH W-SF
9870	5018.2027	5265.6569	90.8337	X3 TOPO
9871	5017.2244	5266.9084	91.7581	X3 RTB
9872	5015.6613	5267.9813	92.0204	X3 TOPO
9873	5014.596	5269.5659	92.9393	X3 TOPO
9874	5012.6931	5271.505	95.4035	X3 TOPO
9875	5011.1925	5272.4161	96.4297	X3 TOPO
9876	5011.354	5272.4916	97.3138	X3 REBF
9877	5038.0214	5267.8382	85.7185	TWG
9878	5046.6079	5275.9985	86.2506	TWG
9879	5052.1558	5280.0855	87.1179	TWG
9880	5059.2417	5282.849	88.3239	TWG
9881	5072.4913	5291.3448	88.1261	TWG
9882	5072.7306	5302.4283	90.4638	RCH W-SF
9883	5079.2942	5298.1606	88.8983	TWG
9884	5087.8203	5289.2733	90.5261	LCH WSF
9885	5018.9878	5190.2637	96.2939	BM3
9886	4955.7919	5121.3062	91.6478	BS

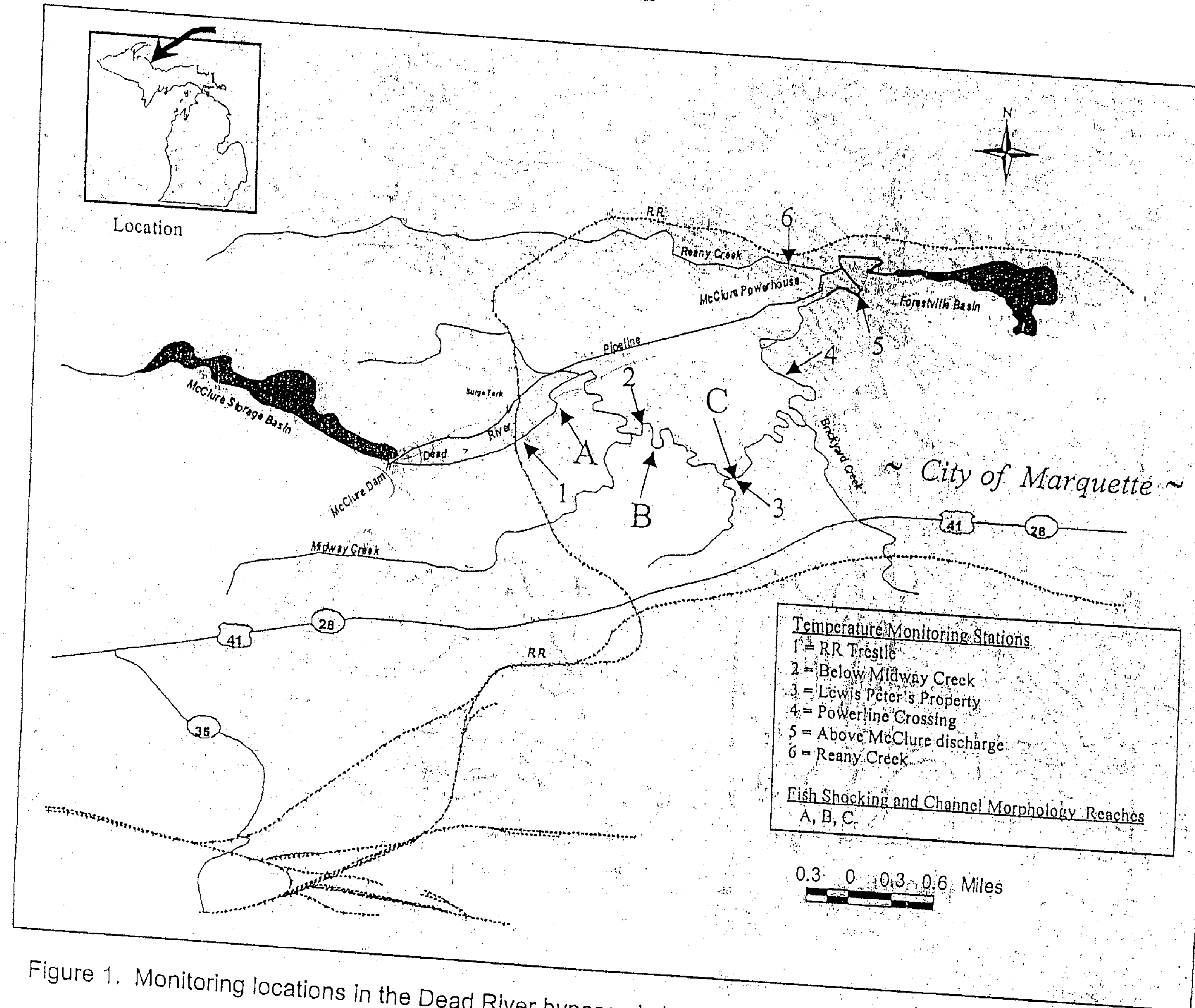

Figure 1. Monitoring locations in the Dead River bypassed channel, August 2000.

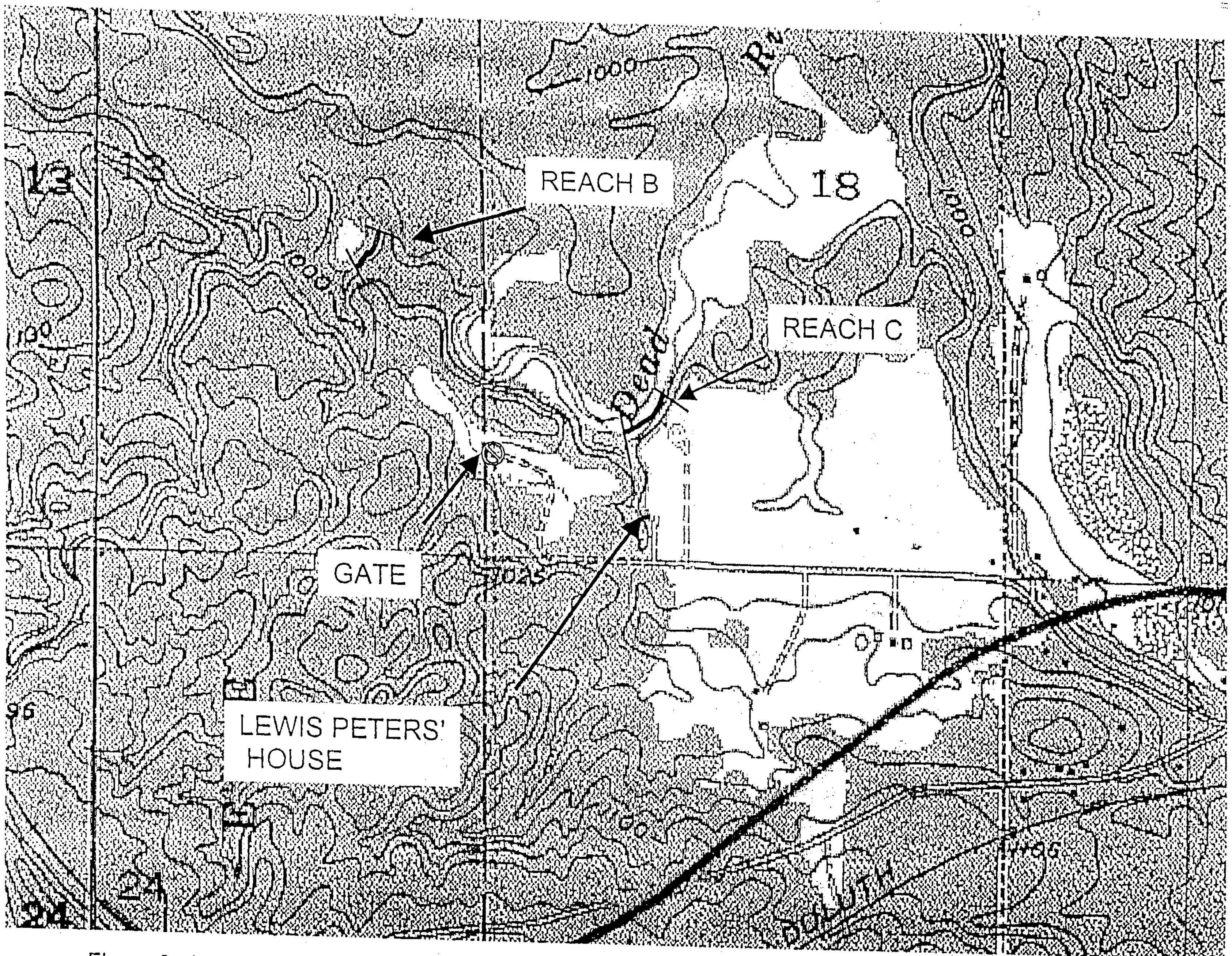

Figure 3. Location of Reaches B and C on the Dead River bypassed channel.

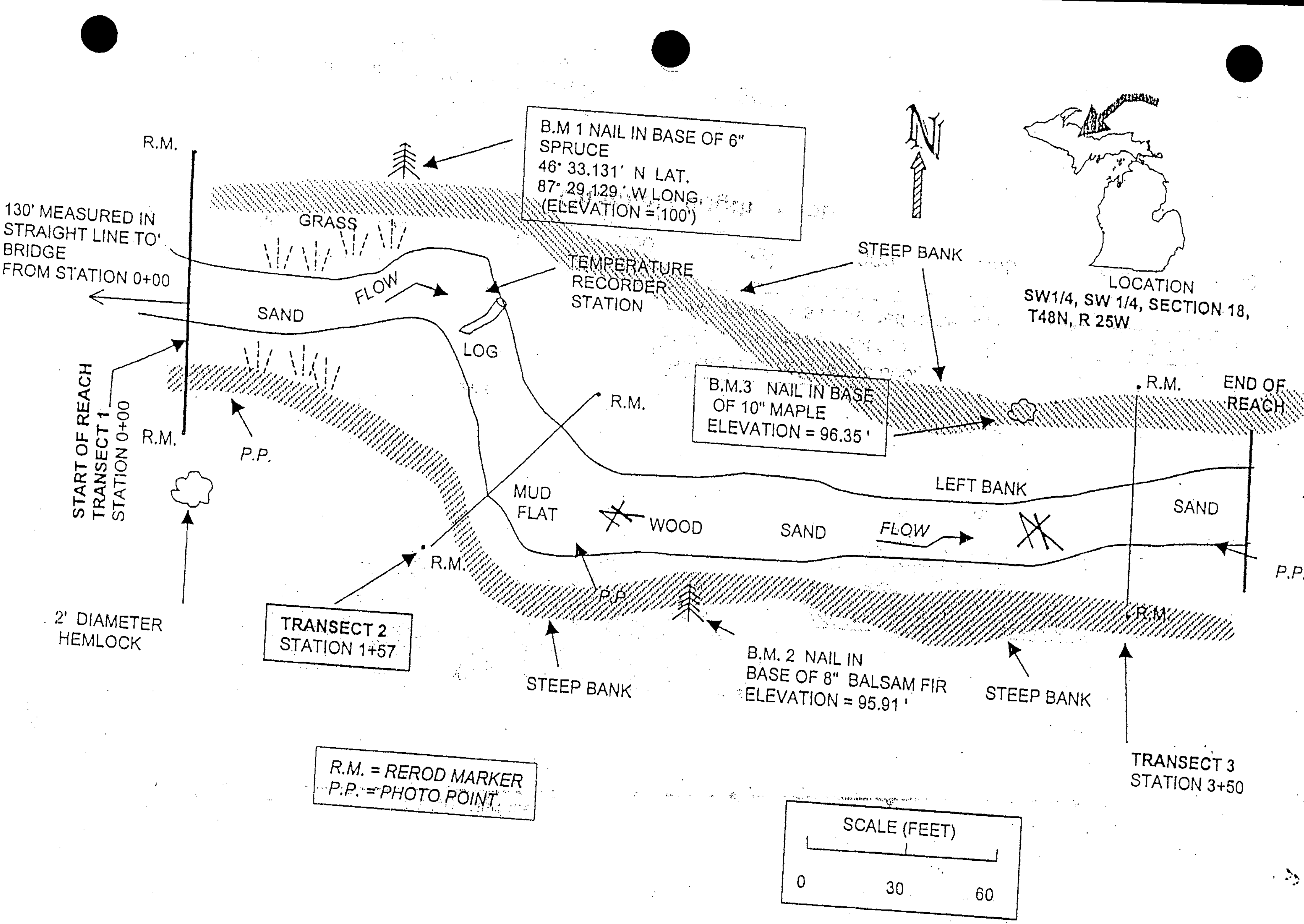

Figure 13. Map of Reach C on the Dead River bypassed channel, August 2000.

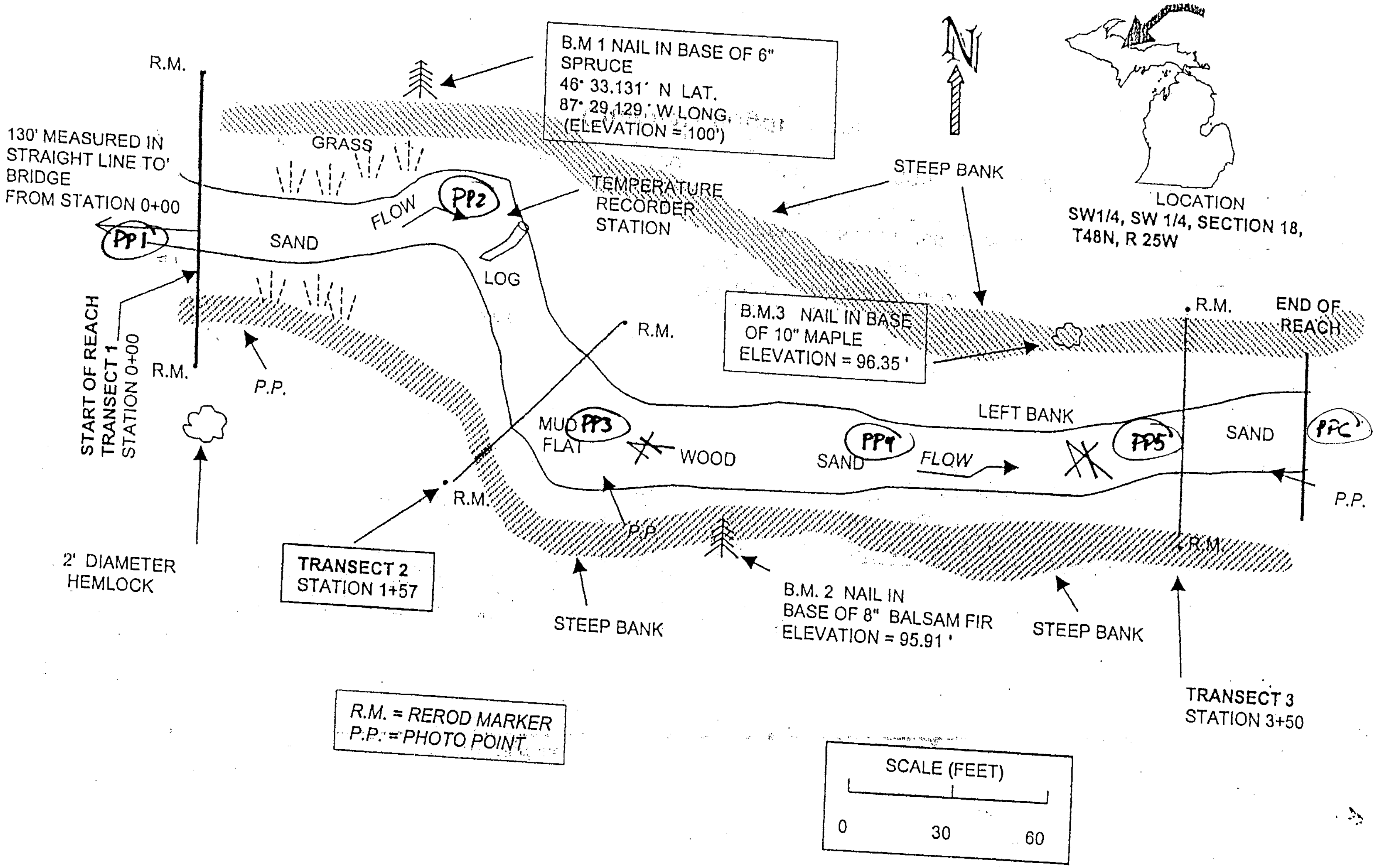

Figure 13. Map of Reach C on the Dead River bypassed channel, August 2000.

MDEQ Photo Log - Reach C

The following is the photo log that was created for each MDEQ reach (A, B and C). Each photo point (labeled either as PP or Photo point) had a number of different pictures taken and were subsequently described in the filed book. In the cases where panoramas were attempted to be taken, each picture number is sequential, and in most cases only the beginning shot and ending shot of the panoramic are identified with a detailed description. Field notes of the photos have been scanned in and are included in the electronic files. Upon return back to the office and the pictures downloaded, each photo was renamed to the same photo number taken in the field with a brief descriptor and photo point added.

Reaches B and C, have slightly different labeling. The photo point is mentioned after the picture number as opposed to before the picture number.

Reach 06-06, MDEQ Reach C. Pictures were taken 7-29-04.

Photo #	Description
107	Photo #107 photo point #1 downstream from beginning of longpro ~15' upstream of transect #1
108	Photo #108 photo point #1 upstream
109	Photo #109 photo point #1 left bank
110	Photo #110 photo point #1 right bank
111	Photo #111 photo point #2 upstream
112	Photo #112 photo point #2 downstream
113	Photo #113 photo point #3 upstream
114	Photo #114 photo point #3 downstream
115	Photo #115 photo point #3 right bank 1
116	Photo #116 photo point #3 right bank 2
117	Photo #117 photo point #4 upstream
118	photo #118 photo point #4 downstream
119	Photo #119 photo point #4 left bank
120	Photo #120 photo point #4 right bank
121	Photo #121 photo point #5 upstream
122	Photo #122 photo point #5 downstream
123	Photo #123 photo point #5 left bank
124	Photo #124 photo point #5 right bank
125	Photo #125 photo point #6 upstream
126	Photo #126 photo point #6 downstream
127	Photo #127 photo point #6 left bank
128	Photo #128 photo point #6 right bank


Photo #107 photo point #1 downstream from beginning of longpro ~15' upstream of transect #1


Photo #108 photo point #1 upstream

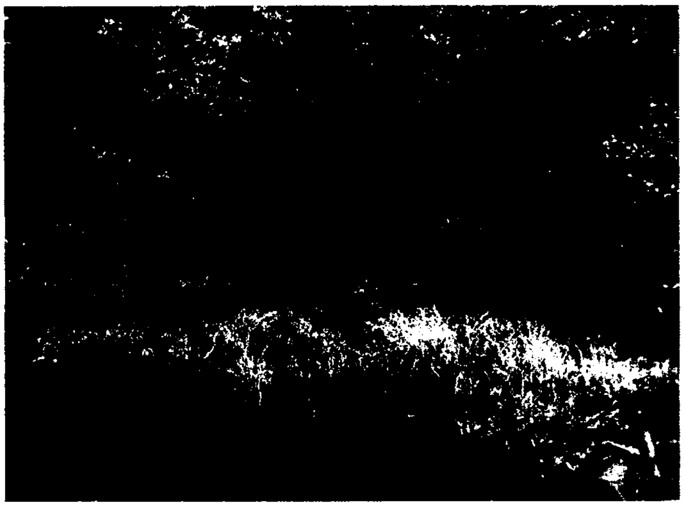
Photo #109 photo point #1 left bank

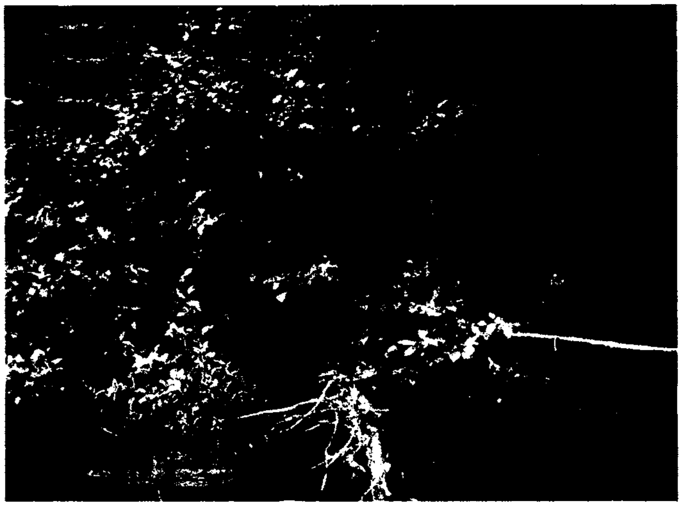
Photo #110 photo point #1 right bank


Photo #111 photo point #2 upstream


Photo #112 photo point #2 downstream


Photo #113 photo point #3 upstream


Photo #114 photo point #3 downstream


Photo #115 photo point #3 right bank 1


Photo #116 photo point #3 right bank 2


Photo #117 photo point #4 upstream


photo #118 photo point #4 downstream


Photo #119 photo point #4 left bank


Photo #120 photo point #4 right bank

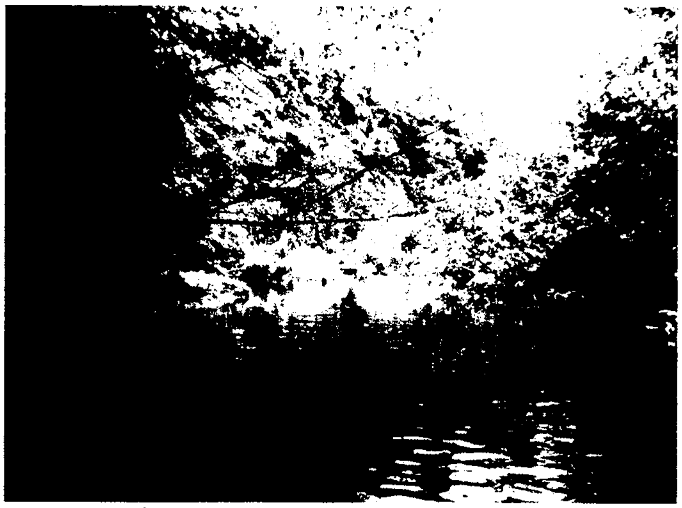
Photo #121 photo point #5 upstream


Photo #122 photo point #5 downstream


Photo #123 photo point #5 left bank

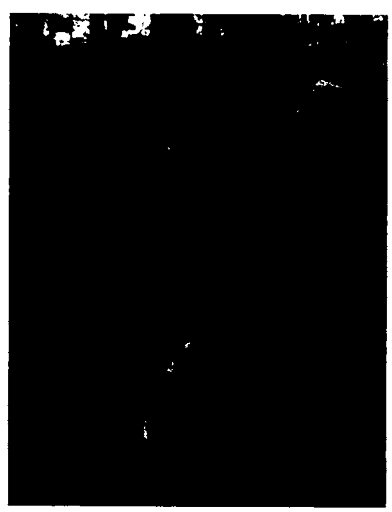
Photo #124 photo point #5 right bank


Photo #125 photo point #6 upstream


Photo #126 photo point #6 downstream

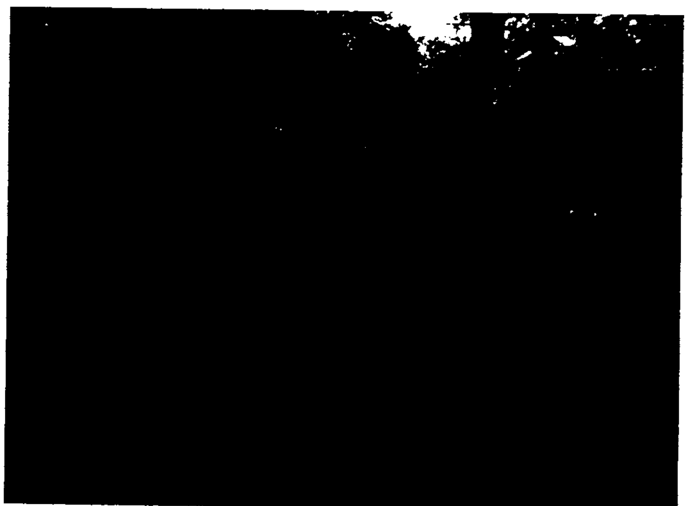
Photo #127 photo point #6 left bank

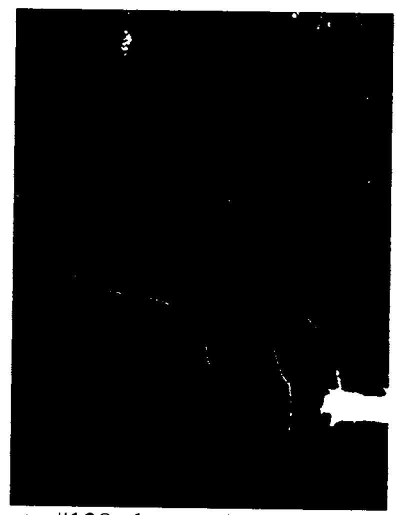
Photo #128 photo point #6 right bank

Appendix 6

June 2001 MDEQ Staff Report

COPY

Document # GB-0031

MI/DEQ/SWQ-00/104

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
SURFACE WATER QUALITY DIVISION
JUNE 2001

STAFF REPORT

CHANNEL MORPHOLOGY, FISH COMMUNITY, AND TEMPERATURE CONDITIONS OF THE DEAD RIVER BYPASSED CHANNEL PRIOR TO FLOW AUGMENTATION (MARQUETTE COUNTY, MICHIGAN)

August 7-9, 2000

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SECTION 1.0

INTRODUCTION

The Dead River is located in Marquette County, in Michigan's Upper Peninsula. The river is 34 miles long with a contributing watershed of 164 mi^2. Five dams (Silver Lake, Hoist, McClure, Forestville, and Tourist Park) are located on the Dead River as it flows to Lake Superior.

The Dead River basin lies in a region characterized by ancient Precambrian bedrock, and exposed pillow lava is common within the watershed (Dorr and Eschman 1970). Basin topography varies from gentle to very steep grades. Riparian vegetation is variable, ranging from tag alders to mature forests, while upland areas typically have mature hemlock, oak, and maple forests.

Since about 1919, flow in the Dead River has been bypassed around a 6.1-mile reach downstream of the McClure Dam (Figure 1). This reach currently receives only dam leakage and tributary flow, estimated to total about 7 cubic feet per second (cfs) at the low end of the reach under summer low flow conditions, based on measurements made in June 1998 by the Michigan Department of Environmental Quality (MDEQ) staff. On February 24, 1999, as part of the Federal Energy Regulatory Commission (FERC) relicensing process, a Section 401 Water Quality Certification was issued by the MDEQ to the Upper Peninsula Power Company (UPPCO), which is owned by the Wisconsin Public Service Corporation, for its Dead River Hydroelectric Project. The Certification requires a minimum flow release of 20 cfs to the bypassed river channel within two construction seasons following license issuance by FERC. The Certification further states that:

> "Beginning 12 years after license issuance, the MDEQ may re-evaluate the 20 cfs minimum flow release for the bypassed channel and reopen this Certification to make appropriate modifications of this Section on the basis of convincing scientific evidence."

To obtain baseline data for this bypassed reach prior to the change in flow regimes, staff from the MDEQ, Michigan Department of Natural Resources (MDNR), and UPPCO conducted channel morphology and fish community surveys in three selected reaches of the Dead River on August 7-9, 2000 (Figure 1). Additionally, temperature data were collected from five sites on the Dead River and one site on Reany Creek, a tributary to the Dead River, from July to September of 2000 using Onset® temperature dataloggers.

SECTION 2.0

SUMMARY

- The channel morphology and fish community were evaluated quantitatively at three reaches in the Dead River bypassed channel.
- Temperature data were collected at five stations in the Dead River bypassed channel and one station in Reany Creek.
- Brook trout was the most abundant fish species in all three reaches. The vast majority of these brook trout were small; only 2.7% of those caught were of legal size (7 inches in length or greater). Approximately 63% of all brook trout captured were young-of-the-year (YOY).
- The Dead River bypassed channel has a much smaller standing crop (kg/ha) of brook trout when compared to other northern Michigan rivers.
- Habitat was not suitable for large brook trout because of the low volume of water in the bypassed channel. Stream flows of only 1.5-4.6 cfs were found in the three selected study reaches, while average depth, width, and velocity were only 1.1 feet, 24 feet, and 0.21 feet per second (fps), respectively.
- Temperatures increased an average of 5.2 °C (from 12.2 °C to 17.4 °C) from the upstream end to the downstream end of the bypassed channel during the 2000 monitoring period.
- All temperature monitoring stations were suitable for trout and met the coldwater temperature standard (Rule 323.1082 of the Michigan Water Quality Standards).
- Flow augmentation is expected to substantially improve the fish community by increasing the habitat suitable for larger trout.

SECTION 3.0

METHODS

3.1 Study Area

Three reaches were selected in the Dead River bypassed channel for detailed channel morphology and fish community assessments, based on their accessibility, wadability, and representativeness of habitat types within the bypassed channel. These reaches were located downstream of the Lake Superior and Ishpeming (LS&I) railroad tressel (Reach A), upstream of Lewis Peters' property (Reach B), and downstream of Lewis Peters' property (Reach C). Reach lengths were 484 feet, 464 feet, and 392 feet, respectively (Table 1). Figures 1-3 show the location of the reaches as well as routes for accessing the sites.

3.2 Channel Morphology

Channel morphology measurement methods were adapted from procedures described by Bovee and Milhous (1978). A unique local elevation benchmark was established for each reach, and was arbitrarily assigned an elevation of 100 feet. The longitudinal elevation profiles of the thalweg and the water surface relative to the benchmark were then determined for the reach. The thalweg is the deepest part of the channel at any cross section. Observations were made in increments of about 10-30 feet, depending on the variability of the bottom elevation, and at the tops of riffles and the deepest parts of pools. Increments were longer (up to 30 feet) when the thalweg elevation was uniform, and shorter when the thalweg elevation was variable. Elevation benchmarks consisted of a nail driven into the base of a large, easily identified tree. All distances were determined with a fiberglass tape, and elevations were determined with a laser level.

Transects within each reach were marked by 4-feet lengths of 5/8-inch rebar driven into the ground on either side of the stream and were used to define 2 or 3 transects in each reach. Transect locations that were visually representative of the overall reach were selected. The cross channel profile of the ground surface was recorded for each transect using a laser level and fiberglass tape. In the wetted channel of some transects, the ground surfaces were determined by subtracting the water depth from the water surface elevation.

Water velocity was measured at 0.6 depth at each observation point in the wetted channel with a pygmy current meter. If velocity was too low to move the cup wheel, then it was recorded as either 0 fps or < 0.1 fps based on a visual observation. Any value of <0.1 fps was assumed to be 0.05 fps in all subsequent calculations.

Flow was measured in Reaches B and C using Great Lakes and Environmental Assessment Section (GLEAS) Procedure #77 for stream gauging (GLEAS 1995). A suitable cross-section for an accurate flow measurement could not be found in Reach A due to shallow depths and low velocity, so flow was estimated by GLEAS staff using best professional judgment. The location of the flow measurements in Reaches B and C did not coincide with the locations of the cross channel transects for several reasons. Flow must be measured at a transect where: 1) velocity lines are parallel, 2) velocity is high enough to measure, 3) velocity is nearly uniform across the transect, and 4) flow obstructions such as wood and aquatic macrophytes are absent.

A map of each reach was drawn during the longitudinal leveling (Figures 4, 8, and 13). Features recorded include the beginning and end of the reach, photo points, transect locations, elevation benchmark locations, general topography of the bank, and other easily recognizable features that would assist in locating the reach and the transects in the future. Latitude and longitude coordinates were determined with a Garmin® II Plus global positioning system (GPS).

3.3 Fish Community

Abundance and density of fish populations were estimated from samples collected on August 7-9, 2000. Fish populations within each reach were estimated using standard three pass-depletion fish sampling methods employed by the MDNR, Fisheries Division (Zippin 1956 and Zippin 1958). This method assumes constant effort, a closed population, and an equal probability of capture for each individual fish (Everhart and Youngs 1981, Lockwood and Schneider 2000). Total population (N) for the fish community was estimated by the following equation (Van Den Avyle 1993):

$$N=C/(1-p^s),$$

where "C" is the total catch, "s" is the number of passes, and "p" is the probability of escape. The "p" values, calculated per Van Den Avyle (1993), were 0.674, 0.51, and 0.426 for Reaches A, B, and C, respectively. Population estimates for individual species were calculated by multiplying the total population estimate calculated above by that species' proportion of the total catch. Three passes were made in each reach using Model ABP-3 (University of Wisconsin) backpack shocking units for the depletion sampling, with block nets placed at the upstream and downstream ends of the reach. Density (number per hectare) was calculated by dividing the population estimate by the area sampled. Area was determined by multiplying average width by transect length. Individual lengths and weights were recorded for brook trout, while numbers and batch weights were recorded for other species.

3.4 Temperature

Onset® temperature loggers were programmed in Lansing by GLEAS staff to record every hour. In 1999, loggers were deployed at one station in the Dead River and one station in Reany Creek. In 2000, temperature monitoring was expanded to five stations in the Dead River and one station in Reany Creek (Figure 1). Temperature was recorded in Reany Creek (Station 6) to serve as a control for year-to-year weather variability since no change in flow regime is expected there. Loggers were secured in the stream by wiring them to a piece of rebar driven into the stream bottom in the deepest part of the channel. Data were downloaded to a spreadsheet by GLEAS staff.

Since daily average temperature was of interest in this study, only full days of data are reported. Temperature was recorded for 30 full days from July 20 through August 18, 1999, at two stations. Temperature was recorded for 62 full days from July 11 through September 9, 2000, at all 6 stations (Table 17) with the exception of Station 5 (upstream of McClure discharge), where the recorder did not function from July 11 through August 6. Due to microhabitat problems with the initial recorder placement at Lewis Peters' property (Station 3), temperature data from a nearby MDNR temperature recorder are reported instead.

Two temperature data sets were evaluated for their usefulness as variables to explain day-to-day temperature variations in the Dead River. These two data sets included the daily average temperature in Reany Creek and the daily average air temperature at the Marquette County airport. The daily average temperature of Reany Creek produced better correlations than air temperature and will be used in future analysis as an independent variable to explain day-to-day temperature differences in the Dead River.

SECTION 4.0

RESULTS AND DISCUSSION

4.1 Conditions Prior to Flow Augmentation

The results of channel morphology measurements are summarized in Table 1, with raw data in Tables 2-12. Reach maps, plots of longitudinal profiles and plots of transect profiles are presented in Figures 4-17. Results of the fish community assessment are summarized in Tables 13-16. Length frequency charts and graphs of fish density and standing crop estimates are presented in Figures 18-22. Temperature data are presented in Tables 17-19 and Figures 23-29.

Brook trout was the most dominant fish species in the Dead River bypassed channel in terms of numbers and biomass. While all reaches were dominated by brook trout, almost all of the brook trout were small in size. The YOY age class comprised 77%, 39%, and 73% of the total brook trout catch in Reaches A, B, and C, respectively (Figures 20-22). Very few yearling and older brook trout were found in the selected study reaches. Only 23 (2.7%) of the 865 brook trout captured were of legal size (>7").

Habitat, particularly the low water level, is responsible for the low numbers of large fish found in the three study reaches. The remote location and difficult access to the bypassed channel discourage angling pressure.

4.1.1 Reach A

Reach A was the uppermost reach in this study, and was located just downstream of the LS&I railroad trestle. The reach was 484 feet long, and shallow with a rocky substrate. The upper 250 feet of this reach was characterized by an average depth of 1 foot, barely perceptible velocity (<0.1 foot/sec), and channel widths of approximately 40-45 feet. The lower 236 feet of this reach had a relatively high gradient and velocity, with widths of 25-40 feet and a depth of only about 0.3 feet. Large fractured bedrock in the riffles resulted in turbulent flows in the stream channel. Depths were too shallow to submerge the current meter and therefore velocity observations could not be made. The GLEAS staff estimated flow to be 1.5 cfs based on best professional judgment. There were two residual pools in this reach (Figure 5) with maximum depths of approximately 1.7 feet and 0.3 feet. Residual pools are those that remain if all flow to the stream was ceased and the channel drained down to the pools. Aquatic macrophytes were absent, but pool areas had abundant algal growth. The stream banks in Reach A were predominantly covered by mature maple-hemlock forest, although there was very little woody debris in the channel. This reach was affected by the low volume of water it receives, a lack of woody debris, and the rocky channel.

Reach A had excellent shallow-water nursery habitat for young salmonids, but lacked sufficient deep water habitat to support older trout. Fish species found in Reach A were, in decreasing order of abundance, brook trout (*Salvelinus fontinalis*), mottled sculpin (*Cottus bairdi*), blacknose dace (*Rhinichthys atratulus*), brown trout (*Salmo trutta*), and bluntnose minnow (*Pimephales notatus*). Brook trout (5214 per hectare) and mottled sculpin (3772 per hectare) were by far the most abundant taxa encountered (Table 14). Seventy-seven percent of the brook trout captured in this reach were YOY (Figure 20). Only 6 of the 517 brook trout (1.2%) captured were of legal size (7 inches or longer).

Of the study reaches, Reach A had the highest densities (#/ha) of brook trout, mottled sculpin, and total fish (Figure 18), as well as the greatest biomass (g/ha), or standing crop, of mottled sculpin and total fish (Table 13, Figure 19).

Station 1 was the temperature monitoring point closest to Reach A, and was located just upstream of that reach. The average temperature at Station 1 during the 2000 monitoring period was 12.2 °C, with temperatures ranging from 9.4 to 14.7 °C .

4.1.2 Reach B

Reach B was 464 feet long with sand substrate and was generally narrower than Reach A. The stream was approximately 20 feet wide, with average cross-sectional depths of 1-2.5 feet. Velocities at individual points in the three transects ranged from 0 to 0.5 feet per second (fps), but almost all locations were unmeasurable (<0.1 fps). This reach had areas of dense aquatic macrophytes and a few small log jams (Figure 8). The riparian zone was composed of tag alder (*Alnus sp.*), with hard maples and hemlock above the floodplain. Instream habitat included pools and riffles (Figure 9).

Reach B had more deep pool habitat than Reach A, but the velocity was much slower. The ten fish species found in Reach B, in decreasing order of abundance, were brook trout, bluntnose minnow, mottled sculpin, brook stickleback (*Culaea inconstans*), blacknose dace, creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), brown trout, northern redbelly dace (*Phoxinus eos*), and fathead minnow (*Pimephales promelas*). Several beaver dams are located in the bypassed channel between Reaches A and B. These beaver dams are having a warming effect on the stream and are partly responsible for the fact that fish species diversity was highest at Reach B. The warmer water temperatures may explain the presence of several warmwater species (i.e., brook stickleback, creek chub, and fathead minnow) at this site.

Brook trout (1582/ha) was the most abundant fish species in Reach B, followed by bluntnose minnow (598/ha) and mottled sculpin (372/ha) (Table 15). The presence of more pool habitat at Reach B seemed to improve the length-frequency distribution of the brook trout population (Figure 21). Only 39% of the brook trout found here were YOY, compared to 77% and 73% in Reaches A and C, respectively. Of the 119 brook trout captured in this reach, 9 were of legal size (7.6%). Despite the better length distribution of brook trout, Reach B ranked third in biomass due to lower overall fish density (Table 13, Figure 19).

Station 2 was the temperature monitoring point closest to Reach B, and was located just upstream of that reach. The average temperature at Station 2 during the 2000 monitoring period was 14.6 °C, with temperatures ranging from 11.9 to 17.0 °C.

4.1.3 Reach C

Reach C was 392 feet long with sand and organic substrate and was more narrow and shallow than Reach B. Stream widths were 10-25 feet and average cross-sectional depths were 0.5-1.0 feet. Average cross-sectional velocities measured in this reach (0.22-0.51 fps) were greater than the other two reaches. The reach contained some woody debris and macrophytes similar to Reach B. Instream habitats included pools and riffles (Figure 14).

Of the three reaches studied, Reach C had the best habitat conditions for larger trout, including more riffles and pools and a higher velocity. Only three species of fish were captured in this reach (brook trout, mottled sculpin, and brook stickleback). Although species diversity was lowest in this reach, Reach C did have the largest standing crop (42.8 kg/ha) of brook trout

(Figure 19). Brook trout (3898/ha) was the most abundant fish species in this reach, followed by mottled sculpin (732 per hectare) (Table 16). Seventy-three percent of the brook trout captured were YOY (Figure 22). Eight (3.5%) of the 229 brook trout captured were of legal size. Only 1 brook stickleback was found in this reach.

The Station 3 temperature monitoring point was located within Reach C. The average temperature at Station 3 during the 2000 monitoring period was 14.5 °C, with temperatures ranging from 11.6 to 17.2 °C.

4.1.4 Temperature

The data show a general pattern of increasing temperature in the Dead River bypassed channel from Station 1 (railroad trestle) to Station 4 (powerline crossing), during the 2000 monitoring period (Tables 18-19, Figure 24). Average temperature increased by 2.4 °C from Station 1 to Station 2, but remained stable between Stations 2 and 3 due to the cooling influence of an unnamed tributary upstream of Station 3. Average temperature at Station 4 was 2.9 °C warmer than at Station 3, and 5.2 °C warmer than at Station 1. During the July 20-22, 1999 monitoring period, the water at Station 1 (Railroad Trestle) was much warmer than normal because water from the surface of the McClure impoundment was spilling over the top of the dam, which is an unusual occurrence. All stations in the Dead River bypassed channel and Reany Creek met the coldwater temperature standard (Rule 323.1082 of the Michigan Water Quality Standards).

Two temperature data sets were evaluated for their usefulness as variables to explain day-to-day temperature variations in the Dead River. Of these two data sets, temperatures in Reany Creek provided better correlations with temperatures in the Dead River bypassed channel. Regressions of temperatures in the Dead River bypassed channel on temperatures in Reany Creek produced R^2 values of 0.64-0.84 (Figures 25-29). Regressions of the Dead River bypassed channel temperatures on air temperature data from the Marquette County Airport were not as strong, producing R^2 values of 0.3 - 0.6.

4.2 Comparison of the Trout Population in the Dead River Bypassed Channel with other Northern Michigan Trout Streams

Compared to other northern Michigan brook trout streams, the Dead River bypassed channel clearly has a reduced capability to produce large fish. The Carp River, which is adjacent to the Dead River, has a brook trout density that is 71% less than that in the Dead River bypassed channel (1022/ha compared to 3565/ha), but the Carp River has a much higher standing crop of brook trout. The standing crop of brook trout in the Carp River is three times greater than that in the Dead River bypassed channel (119.9 kg/ha versus 38.2 kg/ha), despite having fewer fish (MDNR Fisheries Division 2000). Benjamin Creek, a tributary to the Chippewa River in Osceola County, has fewer brook trout (2213/ha) than the Dead River, but the brook trout standing crop (101.9 kg/ha) is much greater. The West Branch of the Maple River in Emmet County has only 1966 brook trout per hectare, but has a standing crop of 51.7 kg/ha of brook trout. A similar relationship between brook trout density and standing crop also exists between the Dead River bypassed channel and Silver Creek - Alcona County, Wallace Creek - Alcona County, Hinton Creek - Manistee County, and Irontone Springs - Otsego County (MDNR Fisheries Division 2000). These streams all have lower densities but higher standing crops of brook trout than the Dead River bypassed channel. The standing crop of brook trout in the Dead River bypassed channel is low because the population is dominated by small fish.

4.3 Expected Changes Following Flow Augmentation

4.3.1 Channel Morphology

After the release of 20 cfs from the McClure Dam, the following changes are expected to occur in Reach A: 1) moderate increase in the average velocity, 2) substantial increase in the average thalweg depth, 3) substantial increase in the average depth at the transects, and 4) slight increase in the average width at the transects . The steep banks and rough channel bottom favor greater changes in depth than width for a given flow increase. Residual pool depth is not expected to change because the substrate in this reach is bedrock, which prevents downcutting by the increased flow. Additional woody debris in this reach would be desirable to create overhead cover and velocity breaks for fish.

After the release of 20 cfs from the McClure Dam, the following changes are expected to occur in Reach B: 1) substantial increase in velocity, 2) slight increase in thalweg depth, 3) slight increase in average depth at the transects, and 4) slight increase in width at the transects. These predictions are based upon the lack of gradient and the ponded nature of this reach. Assuming no increase in the cross-sectional area, velocities are expected to increase to 0.7 fps from 0.1 fps with the proposed flow augmentation. The channel dimensions may change slightly from the increased base flow by scouring out some silty deposits. However, since the basic channel shape is normally controlled by the magnitude and frequency of flood flows (Rosgen 1996), future channel shape may depend primarily on the flushing flow release plan required by the Section 401 Water Quality Certification. A flushing flow release plan must be developed by the UPPCO within one year after FERC license issuance.

Reach C has a narrower channel with a more developed floodplain than the other reaches (Figures 15-17). The higher base flows provided by flow augmentation may carve out a wider and/or deeper channel in this reach. However, UPPCO's flushing flow release plan may be the dominant factor that determines channel shape in this reach. In the event that flow augmentation and the flushing flow release do not carve out a new channel, the following changes are expected to occur in Reach C following flow augmentation: 1) moderate increase in velocity, 2) moderate increase in thalweg depth, 3) moderate increase in depth at the transects, and 4) moderate increase in width at the transects.

4.3.2 Fish Community

The Dead River bypassed channel currently supports a good population of young-of-the-year brook trout. The virtual absence of larger fish in the study reaches was due to a lack of habitat diversity and adequate pool habitat for adult brook trout. In Reach A, for instance, extremely shallow riffle areas dominate, making feeding and foraging difficult from an energetics standpoint. The lack of energetically efficient foraging habitat can be the limiting factor for salmonid production (MDNR 1999). Both juvenile and adult salmonids require riffle-pool-run habitat for proper feeding, growth and survival. The planned flow augmentation is expected to improve habitat conditions by making the water generally deeper and faster throughout the bypassed channel, which will also maintain cold water temperatures. Instream flow incremental methodology (IFIM) studies done by the MDNR for the bypassed reach predict that a flow augmentation of 20 cfs will markedly improve foraging habitat for adult brook trout (MDNR 1999). The flow augmentation should also improve brook trout age and length-frequency distributions within the bypassed channel. These predictions are based on the assumption that the deep water draw at the McClure Dam will provide adequate amounts of cold water to the bypassed channel during summer low flow conditions.

4.3.3 Temperature

In general, water temperatures in the Dead River bypassed channel are expected to be cooler following flow augmentation due to shortened time-of-travel. This expectation is based on the assumption that the deep water draw at McClure Dam will provide adequate cold water to the bypassed reach. Temperature regimes could be further improved through management of the beaver population.

Section 4.4 Recommendations

1) This study should be repeated 10 years following FERC license issuance. Channel morphology and fish community changes should be assessed by comparing the pre- and post-flow augmentation data. Changes in daily average stream temperature should be assessed by comparing temperatures measured in the bypassed channel with temperatures in Reany Creek before and after flow augmentation.
2) The placement of appropriate habitat improvement structures in the bypassed channel, such as large woody debris and log jams to provide more pools and velocity breaks, would result in an improved fishery.
3) Management of the beaver population and dams would decrease time-of-passage and improve thermal regimes in the bypassed channel.

SECTION 5.0

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Table 1. Summary of channel morphology, flow, and velocity measurements for the Dead River bypassed channel, Agust 2000.

Reach Name	Reach Length (ft)	Water Surface Slope (ft/mile)	Average Thalweg Depth (ft)	Transect Name	Transect Location	Transect Width (ft)	Transect Cross Sectional Area (sq. ft.)	Average Depth in Transect (ft)	Average Measured Velocity (fps)	Calculated Velocity by flow/area (fps)	Stream Flow (cfs)
A	484	15.2	0.78	-	-	-	-	-	-		1.5*
				1	1+17	43	48.4	1.12	-	0.06	
				2	3+62	26.3	8.13	0.31	-	0.36	
B	464	4.32	1.81	-	-	-	-	-	-		3
				1	1+60	17.4	21.9	1.26	0.13	0.14	
				2	2+86	20	47.8	2.4	-	0.06	
				3	4+64	22.9	30.5	1.33	-	0.1	
C	392	2.96	1.42	-	-	-	-	-	-		4.6
				1	0+00	11.5	9.4	0.81	0.51	0.49	
				2	1+57	25.8	17.9	0.69	0.28	0.26	
				3	3+50	21.5	18.9	0.88	0.22	0.24	

* Estimate

Table 2. Longitudinal profile of Reach A of the Dead River bypassed channel.

Benchmark 1 (elevation = 100 ft): nail in 2 ft diameter maple on left bank at Station 0+96

Location	Elevations		Residual Pool Surface (ft)	Residual Pool Depth (ft)	Average Residual Pool Depth (ft)	Height of Instrument (ft)	Minus Sights		Calculated Water Surface (ft)	Calculated Water Depth (ft)
	Water Surf (ft)	Thalweg (ft)					Water Surf (ft)	Thalweg (ft)		
0	94.01	93.87				100.55	6.54	6.68	94.01	0.14
30		93.26	93.54	0.28		100.55		7.29	94	0.74
60		92.87	93.54	0.67		100.55		7.68	93.98	1.11
90		93.09	93.54	0.45		100.55		7.46	93.97	0.88
120		92.07	93.54	1.47		100.55		8.48	93.95	1.88
150	93.94	92.74	93.54	0.8		100.55	6.61	7.81	93.94	1.2
177		92.27	93.54	1.27		100.55		8.28	93.94	1.67
205		91.84	93.54	1.7		100.55		8.71	93.94	2.1
235	93.94	92.86	93.54	0.68		100.55	6.61	7.69	93.94	1.08
260		93.54	93.54	0	0.915	100.55		7.01	93.87	0.33
290	93.8	93.17	93.52	0.35		100.55	6.75	7.38	93.8	0.63
320		93.31	93.52	0.21		100.55		7.24	93.78	0.47
350	93.76	93.52	93.52	0	0.28	100.55	6.79	7.03	93.76	0.24
380		93.3				100.55		7.25	93.51	0.21
410	93.26	93.06				99.86	6.6	6.8	93.26	0.2
440		92.99				99.86		6.87	93	0.01
484	92.62	92.33				99.86	7.24	7.53	92.62	0.29

Table 3. Cross-section data for Reach A, Transect 1 (Station 1+17).

Station:	Dead River bypassed channel, Reach A (Station 1+17)
Benchmark:	Nail in 2 ft. diam. maple on left bank at Station 0+96 (elevation=100 ft)
Height of Instrument:	99.87
Water Surface Elevation:	93.85
Channel Width (ft):	43
Date:	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	0.35		99.52	
	3.4	1.55		98.32	
	7.4	2.5		97.37	
	12.4	3.2		96.67	
	16.4	3.91		95.96	
	20.4	4.54		95.33	
	24.4	4.85		95.02	
	28.4	5.44		94.43	
	31.4	6.02	0	93.85	0.1
	33.4		0.23	93.62	0.46
	35.4		0.6	93.25	1.2
	37.4		0.88	92.97	1.76
	39.4		0.93	92.92	1.86
	41.4		1.05	92.8	2.1
	43.4		1.2	92.65	2.4
	45.4		1.66	92.19	3.32
	47.4		1.79	92.06	3.58
	49.4		1.82	92.03	3.64
	51.4		1.73	92.12	3.46
	53.4		1.68	92.17	3.36
	55.4		1.44	92.41	2.88
	57.4		1.33	92.52	2.66
	59.4		1.2	92.65	2.4
	61.4		1.09	92.76	2.18
	63.4		0.97	92.88	1.94
	65.4		0.99	92.86	1.98
	67.4		1.16	92.69	2.32
	69.4		1.04	92.81	2.08
	71.4		0.83	93.02	1.245
	72.4	4.17	0.73	95.7	1.095
	74.4	0		99.87	0.35
	80.4	-4		103.87	
Right Bank Rerod Marker	92.9			105	

Total cross-sectional area (sq. ft.) 48.37

Table 4. Cross-section data for Reach A, Transect 2 (Station 3+62).

Station:	Dead River bypassed channel, Reach A (Station 3+62)
Benchmark:	Nail in 2 ft diam. maple on left bank at Station 0+96 (Elevation=100 ft)
Height of Instrument	99.86
WaterSurface Elevation:	93.61
Channel Width (ft)	26.3
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross-sectional Area (sq. ft.)	
Left Bank Rerod Marker	0			100.5		BUST
	1.5	0		99.86		
	2.5	0.56		99.3		
	4.5	1.38		98.48		
	7.5	2.59		97.27		
	12.5	2.99		96.87		
	17.5	4.4		95.46		
	21.5	4.81		95.05		
	24.5	5.6		94.26		
	27.2	6.25	0	93.61	0.12	
	29.5		0.23	93.38	0.4945	
	31.5		0.32	93.29	0.64	
	33.5		0.34	93.27	0.68	
	35.5		0.4	93.21	0.8	
	37.5		0.48	93.13	0.96	
	39.5		0.3	93.31	0.6	
	41.5		0.18	93.43	0.36	
	43.5		0.25	93.36	0.5	
	45.5		0.28	93.33	0.56	
	47.5		0.44	93.17	0.88	
	49.5		0.39	93.22	0.78	
	51.5		0.3	93.31	0.6	
	53.5	6.18	0	93.61	0.15	
	57.5	6.05		93.81		
	62.5	5.95		93.91		
	67.5	5.34		94.52		
	72.5	4.2		95.66		
	77.5	3.11		96.75		
	82.5	2.53		97.33		
	87.5	1.38		98.48		
	90.5	0		99.86		
Right Bank Rerod Monument	98.5			101		BUST

Total cross-section area (sq. ft.) 8.12

Table 5. Longitudinal profile of Reach B of the Dead River bypassed channel.

Benchmark 1 (elevation=100 ft): nail in base of 2 ft diam. white pine on left bank

Location	Elevations Water Surf (ft)	Elevations Thalweg (ft)	Residual Pool Surface (ft)	Residual Pool Depth (ft)	Average Residual Pool Depth (ft)	Height of Instrument (ft)	Minus Sights Water Surf (ft)	Minus Sights Thalweg (ft)	Thalweg Depth (ft)
0	95.24	94.52				101.89	6.65	7.37	0.72
21	95.23	93.59	94.41	0.82		101.89	6.66	8.3	1.64
31	95.21	92.62	94.41	1.79		101.89	6.68	9.27	2.59
51	95.2	93.55	94.41	0.86		101.89	6.69	8.34	1.65
72	95.21	94.16	94.41	0.25		101.89	6.68	7.73	1.05
92	95.2	91.64	94.41	2.77		101.89	6.69	10.25	3.56
113	95.2	93.74	94.41	0.67		101.89	6.69	8.15	1.46
135	95.2	93.97	94.41	0.44		101.89	6.69	7.92	1.23
159	95.17	92.72	94.41	1.69		101.89	6.72	9.17	2.45
182	95.16	93.84	94.41	0.57		101.89	6.73	8.05	1.32
202	95.17	94.02	94.41	0.39		101.89	6.72	7.87	1.15
224	95.17	94.01	94.41	0.4		101.89	6.72	7.88	1.16
247	95.13	92.47	94.41	1.94		101.41	6.28	8.94	2.66
267	95.1	92.65	94.41	1.76		101.41	6.31	8.76	2.45
288	95.11	91.31	94.41	3.1		101.41	6.3	10.1	3.8
313	95.11	92	94.41	2.41		101.41	6.3	9.41	3.11
333	95.11	92.76	94.41	1.65		101.41	6.3	8.65	2.35
365	95.11	94.41	94.41	0	1.34	101.41	6.3	7	0.7
388	95.08	94.41				101.41	6.33	7	0.67
413	94.91	92.96	94.23	1.27		101.41	6.5	8.45	1.95
435	94.89	94.23	94.23	0	1.27	101.41	6.52	7.18	0.66
464	94.86	93.34				101.41	6.55	8.07	1.52

Table 6. Cross-section data for Reach B, Transect 1 (Station 1+60).

Station:	Dead River bypassed channel, Reach B (Station 1+60)
Benchmark:	Nail in base of 2 ft diam. white pine on left bank (elevation=100 ft)
Height of Instrument	100.73
WaterSurface Elevation:	95.17
Channel Width (ft)	17.4
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	2.45		98.28		
	2	2.81		97.92		
	4	3.24		97.49		
	9	3.5		97.23		
	14	3.72		97.01		
	19	3.81		96.92		
	24	4.26		96.47		
	29	4.79		95.94		
	34	4.79		95.94		
	39	5.31		95.42		
	40.6		0	95.17	0	0.18
	42		0.6	94.57	0.05	0.72
	43		0.8	94.37	0.05	0.8
	44		1	94.17	0.05	1
	45		1.2	93.97	0.05	1.2
	46		1.2	93.97	0.27	1.2
	47		1.5	93.67	0.46	1.5
	48		1.8	93.37	0.23	1.8
	49		2	93.17	0.05	2
	50		2.1	93.07	0.05	2.1
	51		2.1	93.07	0.05	2.1
	52		2.1	93.07	0.05	2.1
	53		1.7	93.47	0.26	1.7
	54		1.3	93.87	0.16	1.3
	55		1	94.17	0.05	1
	56		0.7	94.47	0.05	0.7
	57		0.4	94.77	0.05	0.4
	58		0	95.17	0	0.1
	59	5.5		95.23		
	60	3.66		97.07		
	61	2.9		97.83		
	62	2.12		98.61		
	63	1.79		98.94		
	64	1.63		99.1		
	65	1.34		99.39		
	66	0.72		100.01		
	68	0.05		100.68		
Right Bank Rerod Marker	75	0.05		100.68		

Total cross-sectional area (sq. ft.) 21.9

Table 7. Cross-section data for Reach B, Transect 2 (Station 2+86).

Station:	Dead River bypassed channel, Reach B (Station 2+86)
Benchmark:	Nail in base of 2' diam. white pine on left bank (elevation=100 ft)
Height of Instrument:	100.71
Water Surface Elevation:	95.05
Channel Width (ft)	20
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	2.04		98.67	
	5	3.16		97.55	
	10	3.62		97.09	
	15	3.31		97.4	
	20	4.33		96.38	
	25	4.72		95.99	
	30	4.31		96.4	
	35	4.52		96.19	
	40	5.3		95.41	
	45	5.21		95.5	
	50	4.75		95.96	
	55	4.58		96.13	
	56	5.16		95.55	
	57.5		2.1	92.95	3.15
	59		3	92.05	4.5
	60.5		3.5	91.55	5.25
	62		3.9	91.15	5.85
	63.5		3.4	91.65	5.1
	65		3.3	91.75	4.95
	66.5		3.1	91.95	4.65
	68		2.8	92.25	4.2
	69.5		2.4	92.65	3.6
	71		1.8	93.25	2.7
	72.5		1.5	93.55	2.25
	74		0.9	94.15	1.35
	75.5		0.2	94.85	0.23
	76.3	5.66	0	95.05	0.05
	78	2.82		97.89	
	79	2.21		98.5	
	80	1.48		99.23	
	82.5	0		100.71	
Right Bank Rerod Marker	91			101.5	

Total cross-sectional area (sq. ft.) 47.83

Table 8. Cross-section data for Reach B, Transect 3 (Station 4+64).

Station:	Dead River bypassed channel, Reach B (Station 4+64)
Benchmark:	Nail in base of 2' diam. white pine on left bank (elevation=100 ft)
Height of Instrument	100.64
Water Surface Elevation:	94.86
Channel Width (ft)	22.9
Date	8/9/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	0		100.64		
	3.4	1.12		99.52		
	7.4	1.63		99.01		
	11.4	2.72		97.92		
	15.4	3.13		97.51		
	19.4	3.24		97.4		
	23.4	3.02		97.62		
	27.4	3.18		97.46		
	31.4	3.44		97.2		
	35.4	4.07		96.57		
	39.4	4.92		95.72		
	43.4	4.98		95.66		
	45.9	5.75	0	94.89		0.4375
	47.4		1	93.86	0	1.75
	49.4		1.7	93.16	0	3.4
	51.4		2	92.86	0	4
	53.4		1.5	93.36	0	3
	55.4		1.4	93.46	0.05	2.8
	57.4		1.6	93.26	0.52	3.2
	59.4		1.6	93.26	0.43	3.2
	61.4		1.4	93.46	0	2.8
	63.4		1.2	93.66	0.1	2.4
	65.4		0.9	93.96	0.12	1.8
	67.4		0.8	94.06	0.05	1.36
	68.8	5.83	0	94.81		0.34
	70.4	1.83		98.81		
	71.4	1.16		99.48		
	72.4	0.58		100.06		
	73.4	0		100.64		
	78.4			101.5		

Total cross-sectional area (sq.ft.) 30.4875

Table 9. Longitudinal profile of Reach C of the Dead River bypassed channel.

Benchmark 1 (elevation=100 ft): nail in base of 6" diam. spruce on left bank

Location	Elevations		Thalewg Depth (ft)	Residual Pool Surface (ft)	Residual Pool Depth (ft)	Average Residual Pool Depth (ft)	Height of Instrument (ft)	Minus Sights	
	Water Surface (ft)	Thalweg (ft)						Water Surf (ft)	Thalweg (ft)
0	91.13	89.71	1.42				101.01	9.88	11.3
15	91.15	89.83	1.32				101.01	9.86	11.18
38	91.11	90.45	0.66				101.01	9.9	10.56
49	91.14	89.36	1.78	90.42	1.06		101.01	9.87	11.65
64	91.1	88.99	2.11	90.42	1.43		101.01	9.91	12.02
79	91.1	89.62	1.48	90.42	0.8		101.01	9.91	11.39
94	91.1	88.57	2.53	90.42	1.85		101.01	9.91	12.44
109	91.08	89.06	2.02	90.42	1.36		101.01	9.93	11.95
135	91.06	90.42	0.64	90.42	0	1.3	101.01	9.95	10.59
150	91.07	89.41	1.66	90.41	1		101.01	9.94	11.6
177	91.05	89.82	1.23	90.41	0.59		96.56	5.51	6.74
191	91.03	88.77	2.26	90.41	1.64		96.56	5.53	7.79
211	91.01	90.28	0.73	90.41	0.13		96.56	5.55	6.28
231	91	89.72	1.28	90.41	0.69		96.56	5.56	6.84
251	91	90.41	0.59	90.41	0	0.81	96.56	5.56	6.15
281	90.97	89.75	1.22	89.97	0.22		96.56	5.59	6.81
316	90.97	89.29	1.68	89.97	0.68		96.56	5.59	7.27
336	90.94	89.5	1.44	89.97	0.47		96.56	5.62	7.06
360	90.94	89.53	1.41	89.97	0.44		96.56	5.62	7.03
392	90.91	89.97	0.94	89.97	0	0.4525	96.56	5.65	6.59

Table 10. Cross-section data for Reach C, Transect 1 (Station (0+00).

Station:	Dead River bypassed channel, Reach C (Station 0+00)
Benchmark:	Nail in base of 6" diam. spruce on left bank (elevation=100 ft)
Height of Instrument:	102.06
WaterSurface Elevation:	91
Channel Width (Ft)	11.5
Date	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	6.36		95.7		
	6.7	10.2		91.86		
	13.7	10.2		91.86		
	17.2	10.62		91.44		
	21.7	10.62		91.44		
	24.7	10.6		91.46		
	28.2	9.91		92.15		
	29.2	9.81		92.25		
	32.2	10.01		92.05		
	32.7	11.06		91		0.01
	33.2		0.1	90.9		0.05
	33.7		0.6	90.4	0.05	0.3
	34.2		0.7	90.3	0.23	0.35
	34.7		0.8	90.2	0.44	0.4
	35.2		0.7	90.3	0.39	0.35
	35.7		0.7	90.3	0.35	0.35
	36.2		0.7	90.3	0.46	0.35
	36.7		0.8	90.2	0.43	0.4
	37.2		0.9	90.1	0.24	0.45
	37.7		1	90	0.62	0.5
	38.2		1.1	89.9	0.70	0.55
	38.7		1.3	89.7	0.79	0.65
	39.2		1.3	89.7	0.74	0.65
	39.7		1.2	89.8	0.63	0.6
	40.2		1.1	89.9	0.53	0.55
	40.7		0.9	90.1	0.72	0.45
	41.2		0.7	90.3	0.78	0.35
	41.7		0.8	90.2	0.81	0.4
	42.2		1	90	0.60	0.5
	42.7		0.9	90.1	0.17	0.45
	43.2		0.7	90.3	0.14	0.35
	43.7		0.6	90.4	0.19	0.3
	44.2	11.04		91.02		0.07
	46.2	10.43		91.63		
	48.2	10.53		91.53		
	51.2	10.45		91.61		
	53.2	10.45		91.61		
	56.2	10.51		91.55		
	58.2	9.83		92.23		
	60.2	9.57		92.49		
	62.2	8.61		93.45		
	64.2	7.05		95.01		
	66.2	6.31		95.75		
	70.2	5.68		96.38		
	73.2	4.68		97.38		
	76.2	3.33		98.73		
Right Bank Rerod Marker	77.7	2.34		99.72		

Total cross-sectional area (sq. ft.) 9.38

Table 11. Cross-section data for Reach C, Transect 2 (Station (1+57).

Station:	Dead River bypassed channel, Reach C (Station 1+57)
Benchmark:	Nail in base of 6" spruce on left bank (elevation=100 ft)
Height of Instrument:	100.39
Water Surface Elevation:	91.06
Channel Width (Ft):	25.8
Date:	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq.ft.)
Left Bank Rerod Marker	0	3.82		96.57		
	2	4.55		95.84		
	3	4.85		95.54		
	4	5.01		95.38		
	6	5.89		94.5		
	7.5	6.77		93.62		
	9	7.54		92.85		
	12	7.75		92.64		
	15	8.57		91.82		
	17.5	8.3		92.09		
	19	8.37		92.02		
	21	8.23		92.16		
	24	8.09		92.3		
	27	8.32		92.07		
	29	8.09		92.3		
	32	8.32		92.07		
	35	8.29		92.1		
	36	8.23		92.16		
	37	8.82		91.57		
	38.2	9.33	0	91.06	0	0.045
	39		0.2	90.86	0.00	0.18
	40		0.3	90.76	0.00	0.3
	41		0.7	90.36	0.16	0.7
	42		0.8	90.26	0.38	0.8
	43		1	90.06	0.49	1
	44		1	90.06	0.42	1
	45		1	90.06	0.53	1
	46		1.2	89.86	0.49	1.2
	47		1.4	89.66	0.42	1.4
	48		1.5	89.56	0.40	1.5
	49		1.4	89.66	0.41	1.4
	50		1.1	89.96	0.43	1.1
	51		0.8	90.26	0.30	0.8
	52		0.7	90.36	0.15	0.7
	53		0.7	90.36	0.05	0.7
	54		0.7	90.36	0.05	0.7
	55		0.7	90.36	0.00	0.7
	56		0.6	90.46	0.00	0.9
	58		0.3	90.76	0.00	0.6
	60		0.3	90.76	0.00	0.9
	64		0	91.06	0.00	0.225
	67	8.87		91.52		
	69	8.19		92.2		
	71	7.7		92.69		
	73	7.07		93.32		
	75	6.61		93.78		
	77	6.19		94.2		
	79	5.54		94.85		
	81	4.66		95.73		
Right Bank Rerod Marker	82	4.19		96.2		

Total cross-sectional area (sq. ft.) 17.85

Table 12. Cross-section data for Reach C, Transect 3 (Station 3+50).

Station:	Dead River bypassed channel, Reach C (Station 3+50)
Benchmark:	Nail in base of 6" diam. spruce on left bank (elevation=100 ft)
Height of Instrument:	97.11
WaterSurface Elevation:	90.94
Channel Width (ft)	21.5
Date	8/8/00

Station	Distance From Left (ft)	Minus Sight (ft)	Water Depth (ft)	Elevation of Substrate (ft)	Velocity (fps)	Cross Sectional Area (sq. ft.)
Left Bank Rerod Marker	0	1.06		96.05		
	1.5	2.22		94.89		
	2.5	3.2		93.91		
	4.5	4.22		92.89		
	5.5	4.64		92.47		
	7.5	5.19		91.92		
	9.5	5.33		91.78		
	12.5	5.85		91.26		
	15.5	5.7		91.41		
	17.5	5.75		91.36		
	19.5	5.41		91.7		
	21.5	5.11		92		
	23.5	5.01		92.1		
	24.5	5.06		92.05		
	25.5	5.41		91.7		
	27	6.13		90.98		0.3
	28.5		0.4	90.54	0.05	0.6
	30		0.4	90.54	0.44	0.6
	31.5		0.5	90.44	0.62	0.75
	33		0.5	90.44	0.56	0.75
	34.5		0.5	90.44	0.56	0.75
	36		0.6	90.34	0.52	0.9
	37.5		0.8	90.14	0.36	1.2
	39		1.6	89.34	0.31	2.4
	40.5		2	88.94	0.05	3
	42		2.2	88.74	0.15	3.3
	43.5		1.7	89.24	0.05	2.55
	45		1	89.94	0.05	1.5
	46.5		0.1	90.84	0.05	0.15
	48		0.1	90.84	0.00	0.1
	48.5	6.16		90.95		0.05
	50.5	5.4		91.71		
	52.5	5.41		91.7		
	54.5	5.5		91.61		
	56.5	4.31		92.8		
	57.5	3.2		93.91		
	58.5	1.75		95.36		
	59.5	1.3		95.81		
	61.5	0.35		96.76		

Total cross-sectional area (sq. ft.) 18.9

Table 13. Summary of fish community density (#/ha) and standing crop (kg/ha). Densities are rounded to the nearest whole number, standing crop to the nearest tenth of a kg.

	Reach A	Reach B	Reach C	Mean
Density of brook trout (#/ha)	5214	1582	3898	3565
Density of all fish species (#/ha)	9027	3217	4647	5630
Standing crop of brook trout (kg/ha)	39.7	32.2	42.8	38.2
Standing crop of all fish species (kg/ha)	57.8	39.6	47.0	48.1

Table 14. Fish community density (#/ha) and standing crop (g/ha) based on total catch for Reach A. Values are rounded to the nearest whole number.

Species	Popn. Est.	Biomass (g)	Density (#/ha)	Standing crop (g/ha)
Brook trout	745	5674	5214	39708
Mottled sculpin	539	2545	3772	17808
Blacknose dace	3	18	20	126
Brown trout	1	17	10	117
Bluntnose minnow	1	6	10	44

Table 15. Fish community density (#/ha) and standing crop (g/ha) based on total catch for Reach B. Values are rounded to the nearest whole number.

Species	Total Catch	Popn. Est.	Biomass (g)	Density (#/ha)	Standing crop (g/ha)
brook trout	119	137	2795	1582	32224
mottled sculpin	28	32	192	372	2212
brook stickleback	24	28	22	319	254
white sucker	1	1	15	13	171
brown trout	1	1	50	13	578
blacknose dace	11	13	89	146	1032
northern redbelly dac	1	1	3	13	40
creek chub	11	13	115	146	1329
bluntnose minnow	45	52	150	598	1726
fathead minnow	1	1	2	13	21

Table 16. Fish community density (#/ha) and standing crop (g/ha) based on total catch for Reach C. Values are rounded to the nearest whole number.

Species	Total Catch	Popn. Est.	Biomass (g)	Density (#/ha)	Standing Crop (g/ha)
brook trout	229	248	2726	3898	42806
mottled sculpin	43	47	265	732	4168
brook sticklebacl	1	1	2	17	34

Table 17. Temperature Monitoring Locations on the Dead River and Reany Creek

Station #	Description	Section Twn. Range	Latitude / Longitude
1	Dead River at LS&I Railroad Trestle	NW 1/4 SW ¼ Sec. 13, T48N R 26W	46.5550 N 87.5068 W
2	Dead River downstream of Midway Creek	NE 1/4 SE ¼ Sec. 13, T48N R 26W	46.5562 N 87.4938 W
3	Dead River at Lewis Peters' Property	SW 1/4 SW ¼ Sec. 18, T48N R 25W	46.5524 N 87.4861 W
4	Dead River at Powerline Crossing	NE 1/4 NW ¼ Sec. 18, T48N R 25W	46.5633 N 87.4816 W
5	Dead River 1500 feet Upstream of McClure turbine discharge	NW 1/4 SE ¼ Sec. 7, T48N R 25W	46.5705 N 87.4774 W
6	Reany Creek 100 feet downstream of McClure powerhouse access road	SW 1/4 NE ¼ Sec. 7, T48N R 25W	46.5738 N 87.4762 W

Table 18. Summary of temperature data from the Dead River bypassed channel and Reany Creek for the 1999 and 2000 monitoring periods. Temperatures are reported in °C.

			Railroad Trestle Station 1	Below Midway Ck. Station 2	Peters Property Station 3	Powerline Crossing Station 4	Upstream of McClure Station 5	Reany Creek Station 6
1999	July 20 - August 18	Average	15.1	no data	no data	no data	no data	14.8
		Range	11.8 - 21.6**	no data	no data	no data	no data	12.3 - 17.8
2000	July 11 - Sept. 10	Average	12.2	14.6	14.5	17.4	*	13.5
		Range	9.4 - 14.7	11.9 - 17.0	11.6 - 17.2	13.5 - 20.9	*	10 - 15.7
2000	Period 1 (July 11 - August 6)	Average	12.7	15.1	15.2	18.3	no data	13.8
		Range	10 - 14.7	12.1 - 17.0	11.9 - 17.2	14.2 - 20.9	no data	10.9 - 15.6
2000	Period 2 (August 8 - Sept. 10)	Average	11.9	14.1	14.0	16.6	16.6	13.2
		Range	9.4 - 13.9	11.9 - 16.2	11.6 - 16.3	13.5 - 19.4	13.1 - 19.4	10 - 15.7

* complete data unavailable for this time period

** maximum value was during surface spillage from McClure Dam

Table 19. Daily average temperature values for the Dead River bypassed channel and Reany Creek for the 1999 and 2000 monitoring periods. Temperatures are in °C.

Date	Station 1 (Railroad Trestle)	Station 2 (Below Midway Ck.)	Station 3 (Peters' Property)	Station 4 (Powerline Crossing)	Station 5 (Upstream McClure)	Sation 6 (Reany Creek)
7/20/99	21.4	-	-	-	-	14.5
7/21/99	21.6	-	-	-	-	15.7
7/22/99	19.7	-	-	-	-	16.7
7/23/99	18.3	-			-	16.9
7/24/99	17.4				-	17.2
7/25/99	16.6				-	16.9
7/26/99	17.0				-	17.2
7/27/99	15.3				-	15.6
7/28/99	16.0				-	16.1
7/29/99	16.7				-	16.8
7/30/99	17.4				-	17.6
7/31/99	16.6	-			-	17.8
8/1/99	14.7	-	-	-	-	15.4
8/2/99	14.3	-	-	-	-	14.2
8/3/99	14.4	-	-	-	-	14.5
8/4/99	13.6	-	-	-	-	14.0
8/5/99	12.5	-	-	-	-	12.9
8/6/99	13.1	-	-	-	-	13.5
8/7/99	13.5	-	-	-	-	13.3
8/8/99	12.8	-	-	-	-	13.1
8/9/99	12.0	-	-	-	-	12.0
8/10/99	13.1	-	-	-	-	13.3
8/11/99	13.4	-	-	-	-	13.5
8/12/99	13.7	-	-	-	-	14.0
8/13/99	12.7	-	-	-	-	14.0
8/14/99	12.4	-	-	-	-	13.0
8/15/99	13.1	-	-	-	-	13.3
8/16/99	15.4	-	-	-	-	15.3
8/17/99	13.6	-	-	-	-	14.5
8/18/99	11.8	-	-	-	-	12.3
11-Jul-00	13.2	15.4	15.3	19.7	-	13.1
12-Jul-00	12.8	14.8	15.0	18.6	-	13.2
13-Jul-00	14.0	16.6	16.2	19.3	-	15.2
14-Jul-00	14.7	17.0	17.2	20.7	-	15.6
15-Jul-00	14.4	16.9	16.9	20.9	-	15.2
16-Jul-00	14.2	16.6	16.6	20.8	-	14.6
17-Jul-00	13.7	17.0	16.7	20.4	-	14.6
18-Jul-00	11.4	15.2	14.3	17.8	-	11.8
19-Jul-00	10.9	14.5	13.5	16.3	-	10.9
20-Jul-00	12.1	14.5	14.4	16.8	-	12.1
21-Jul-00	11.0	13.0	13.3	16.2	-	11.7
22-Jul-00	10.0	12.3	11.9	14.4	-	11.0
23-Jul-00	10.5	12.1	12.2	14.2	-	11.1
24-Jul-00	12.4	13.6	14.3	16.9	-	13.5
25-Jul-00	13.4	14.4	15.4	18.9	-	14.9
26-Jul-00	13.8	15.1	15.9	19.5	-	15.4
27-Jul-00	13.2	15.3	15.6	19.1	-	15.2
28-Jul-00	12.4	15.6	15.3	17.7	-	14.8
29-Jul-00	12.8	15.8	15.7	18.1	-	14.7

Table 19 -cont. Daily average temperature values for the Dead River bypassed channel and Reany Creek for the 1999 and 2000 monitoring periods. Temperatures are in °C.

Date	Station 1 (Railroad Trestle)	Station 2 (Below Midway Ck.)	Station 3 (Peters' Property)	Station 4 (Powerline Crossing)	Station 5 (Upstream McClure)	Sation 6 (Reany Creek)
30-Jul-00	13.3	16.0	16.1	19.2	-	14.6
31-Jul-00	13.5	15.8	16.2	19.8	-	14.6
1-Aug-00	13.4	16.0	16.3	19.9	-	15.1
2-Aug-00	12.8	15.9	15.5	18.4	-	14.6
3-Aug-00	11.5	14.6	14.2	17.2	-	12.3
4-Aug-00	12.0	14.7	14.6	17.3	-	12.7
5-Aug-00	12.4	14.9	15.2	18.0	-	13.8
6-Aug-00	13.2	15.1	15.6	18.6	-	14.9
7-Aug-00	13.0	15.6	15.4	18.3	-	14.9
8-Aug-00	11.8	14.0	14.0	17.0	17.3	13.5
9-Aug-00	11.9	14.5	14.0	16.5	17.1	13.9
10-Aug-00	12.5	14.9	14.5	17.0	17.1	13.9
11-Aug-00	12.9	14.8	15.0	18.0	17.6	14.0
12-Aug-00	12.7	14.8	15.0	18.2	18.0	14.3
13-Aug-00	13.5	15.8	15.6	18.6	18.7	15.3
14-Aug-00	12.8	15.0	15.2	18.5	18.2	13.9
15-Aug-00	13.9	16.2	16.3	19.4	19.4	15.7
16-Aug-00	12.7	15.6	15.3	18.9	18.3	13.7
17-Aug-00	11.3	14.2	13.8	17.2	17.1	12.2
18-Aug-00	11.4	14.5	13.7	16.1	16.6	12.8
19-Aug-00	10.8	13.9	13.1	15.7	15.3	11.2
20-Aug-00	10.4	13.1	12.8	15.3	14.8	10.7
21-Aug-00	11.1	13.3	13.0	15.1	15.2	11.6
22-Aug-00	12.5	14.2	14.5	16.8	16.6	13.8
23-Aug-00	12.1	14.3	14.5	17.5	17.0	13.3
24-Aug-00	11.8	14.2	14.3	17.4	17.0	12.9
25-Aug-00	12.7	14.9	14.9	17.8	17.9	14.1
26-Aug-00	12.8	15.2	15.2	18.2	18.4	14.8
27-Aug-00	11.7	14.0	13.9	17.1	17.3	13.3
28-Aug-00	12.4	14.6	14.5	17.2	17.5	14.0
29-Aug-00	13.0	15.2	15.5	18.3	18.0	14.8
30-Aug-00	11.5	14.1	14.0	17.5	17.0	12.8
31-Aug-00	13.4	15.7	15.4	18.0	18.3	15.4
1-Sep-00	12.2	14.9	14.5	17.0	17.1	13.9
2-Sep-00	11.0	13.6	13.0	15.0	15.7	12.8
3-Sep-00	10.8	13.3	12.8	14.3	14.7	12.7
4-Sep-00	10.1	12.8	12.4	13.8	13.9	11.6
5-Sep-00	9.4	11.9	11.6	13.6	13.1	10.0
6-Sep-00	10.0	11.9	11.8	13.5	13.5	10.9
7-Sep-00	11.3	12.4	12.6	14.0	14.3	12.6
8-Sep-00	10.8	12.3	12.6	14.6	14.2	12.1
9-Sep-00	11.1	12.5	12.5	14.6	14.6	12.1
10-Sep-00	12.9	13.9	14.5	16.3	16.4	14.8
11-Sep-00	-	-	-	-	16.8	-
12-Sep-00	-	-	-	-	16.1	-

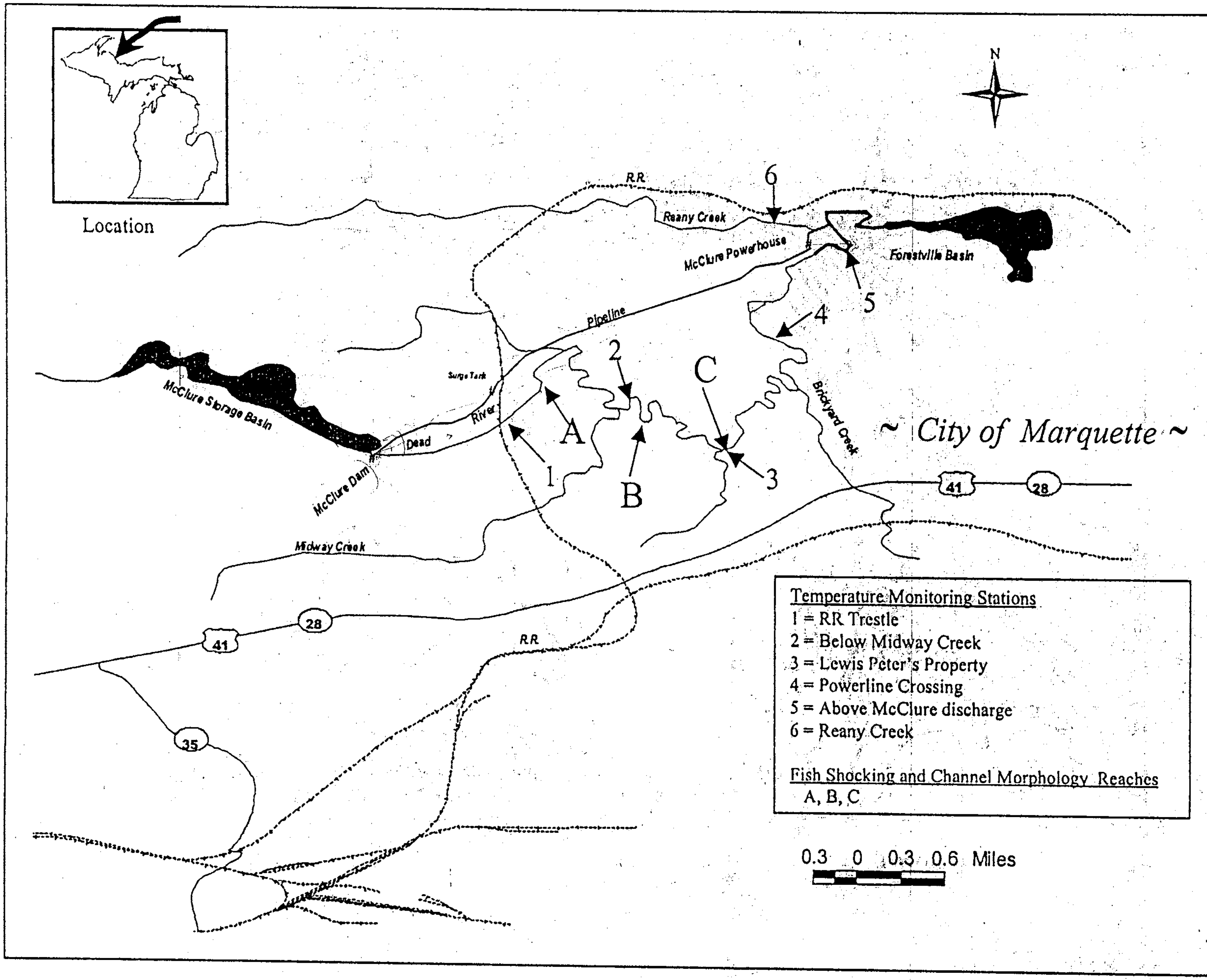

Figure 1. Monitoring locations in the Dead River bypassed channel, August 2000.

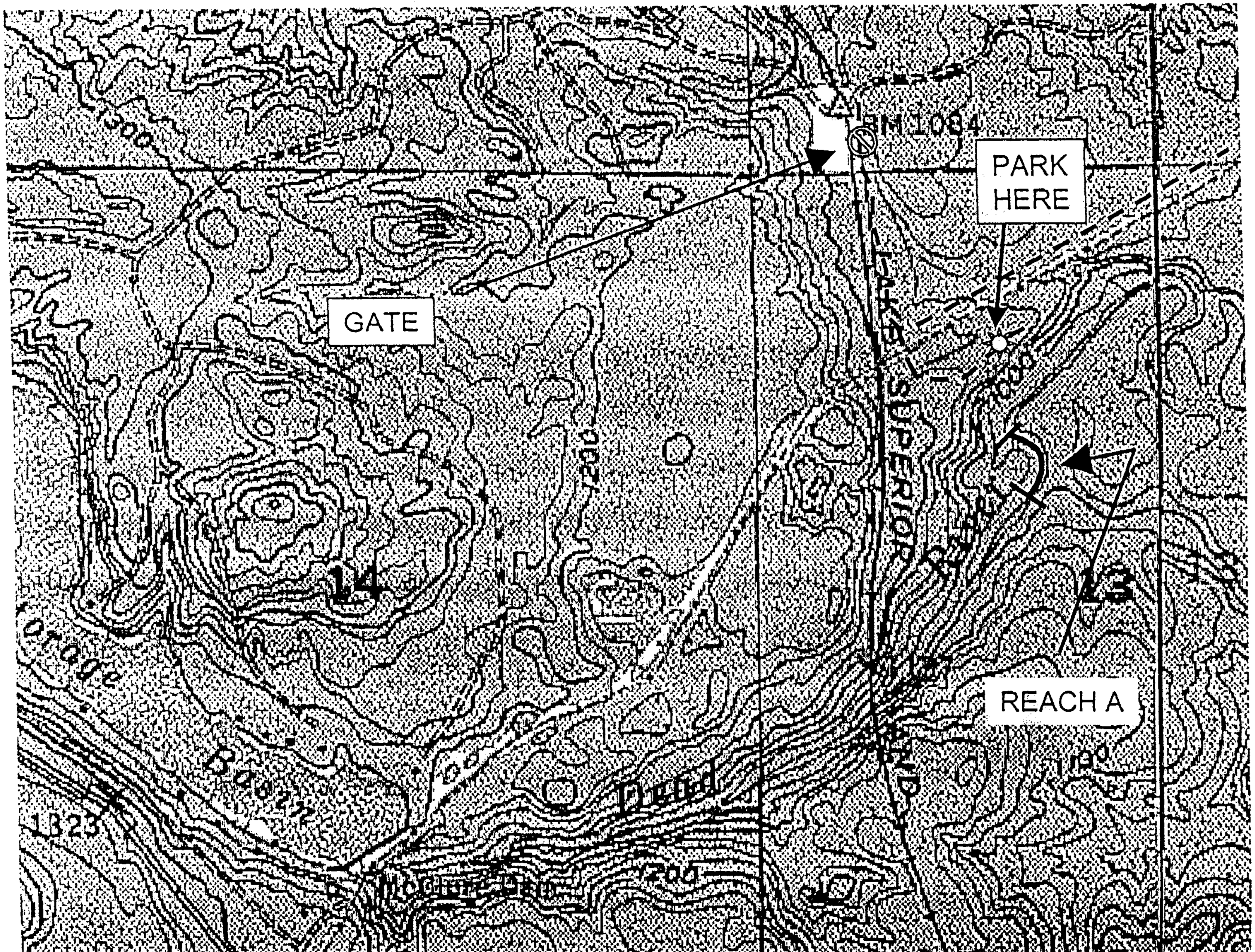

Figure 2. Location of Reach A on the Dead River bypassed channel.

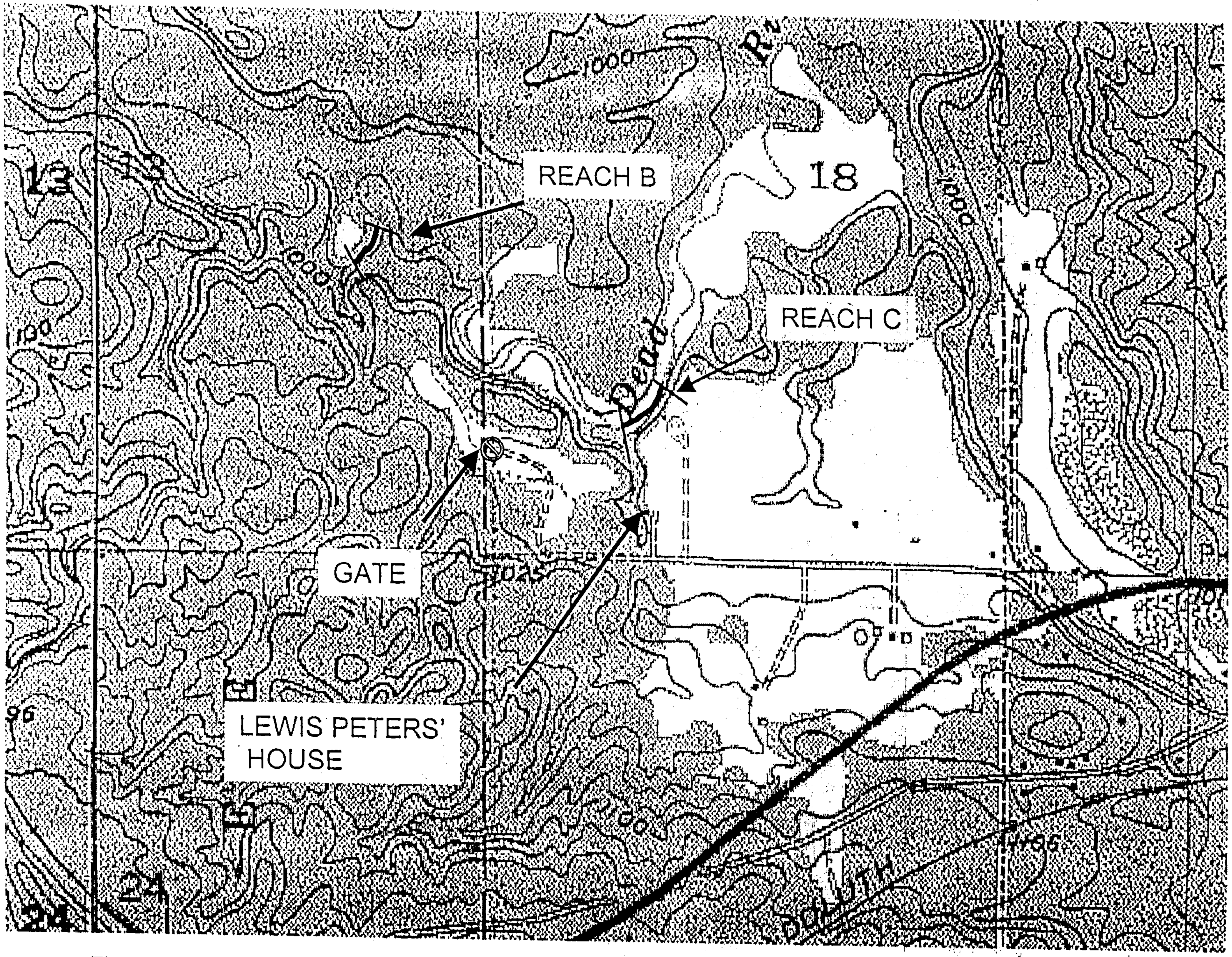

Figure 3. Location of Reaches B and C on the Dead River bypassed channel.

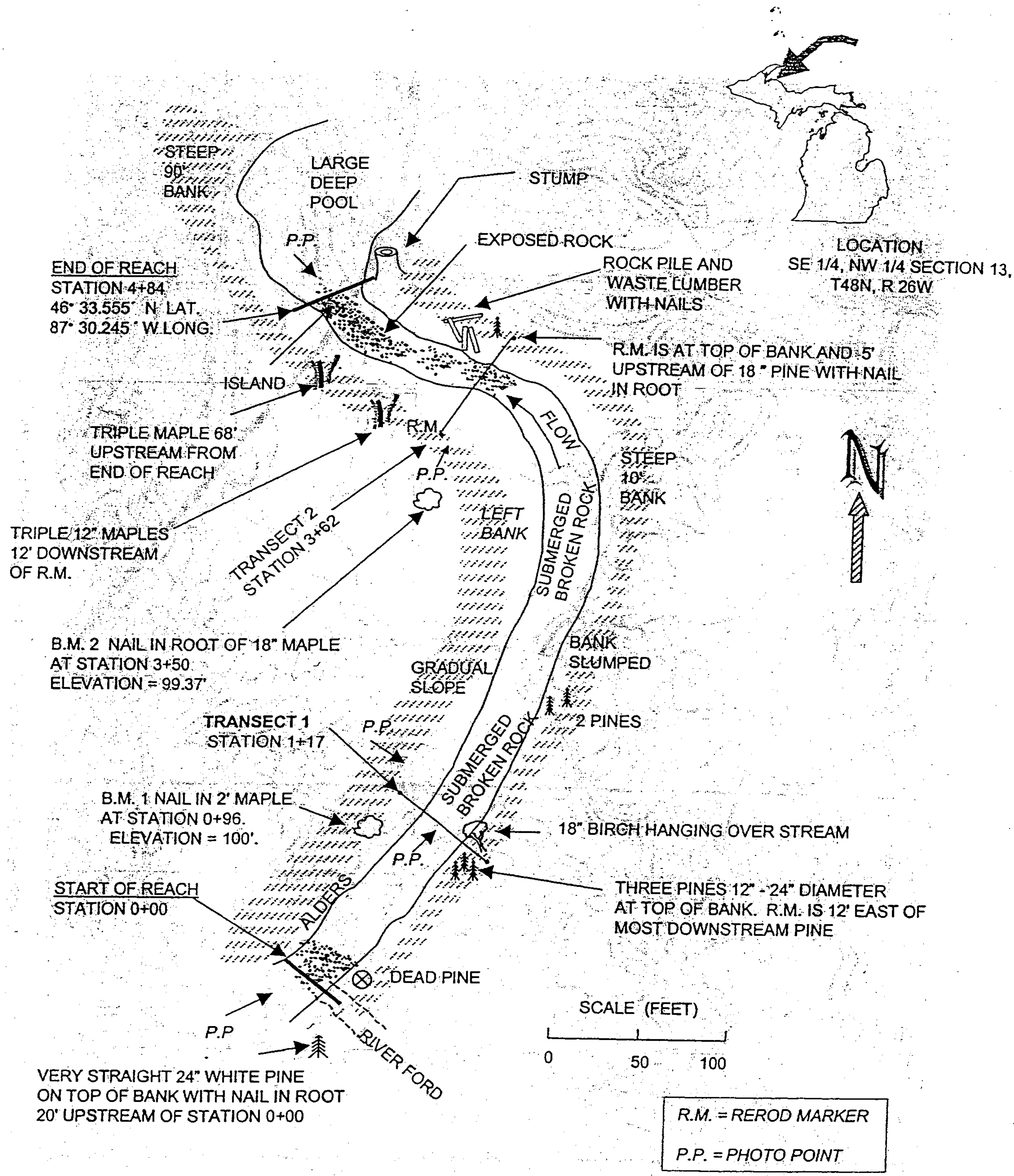

Figure 4. Map of Reach A on the Dead River bypassed channel, August 2000.

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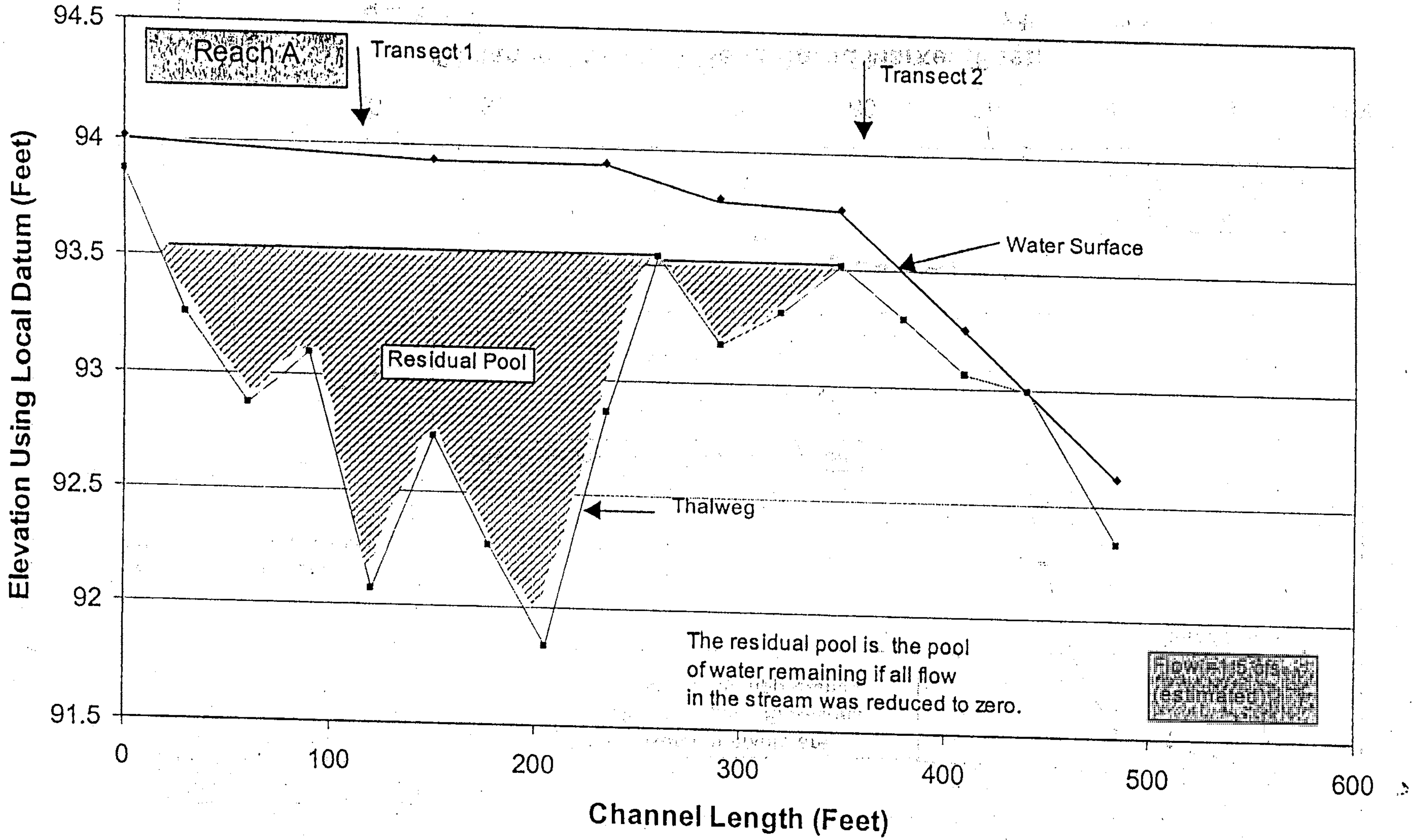

Figure 5. Longitudinal profile of Reach A on August 9, 2000.

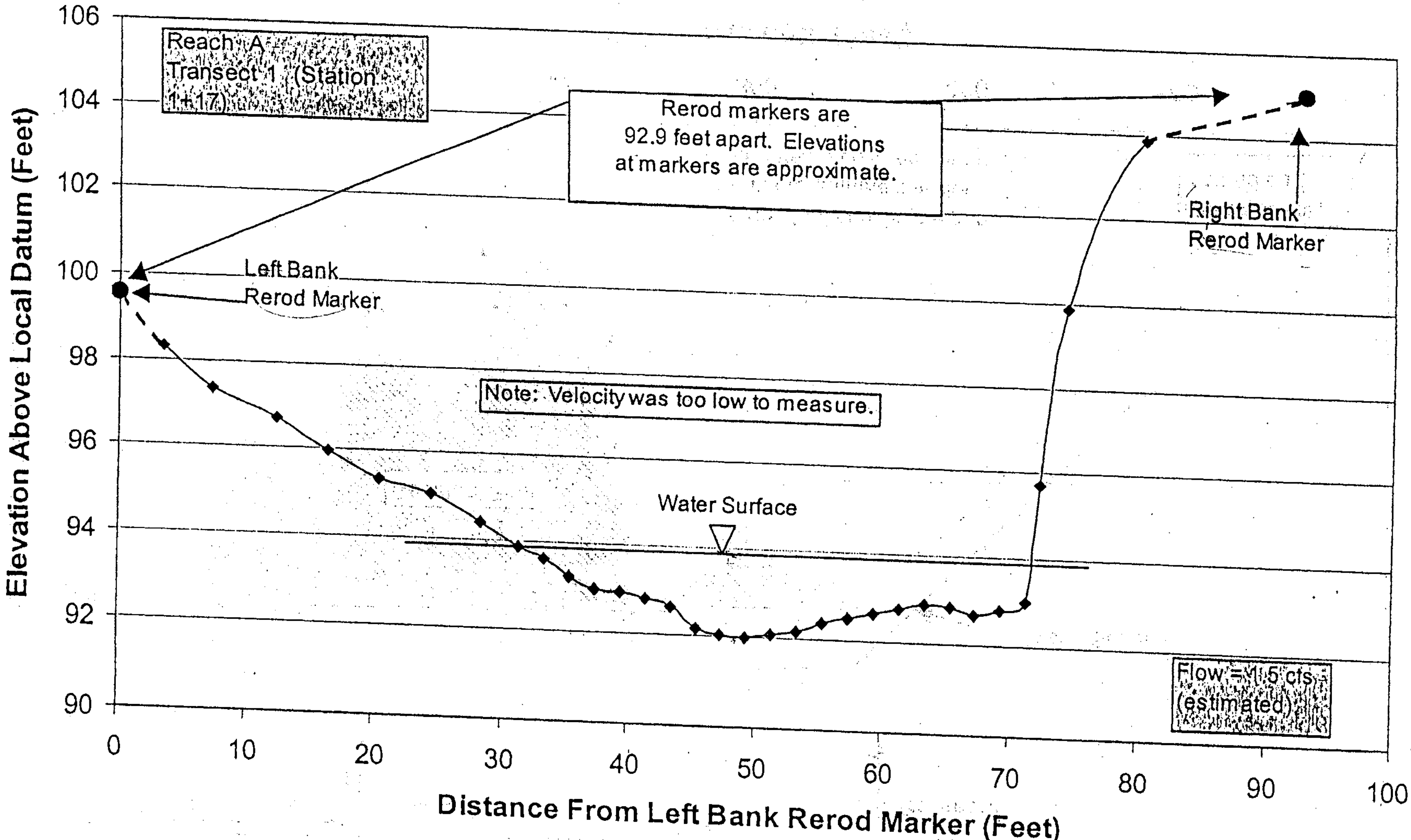

Figure 6. Cross-section profile of Reach A, Transect 1 (Station 1+17) on August 9, 2000.

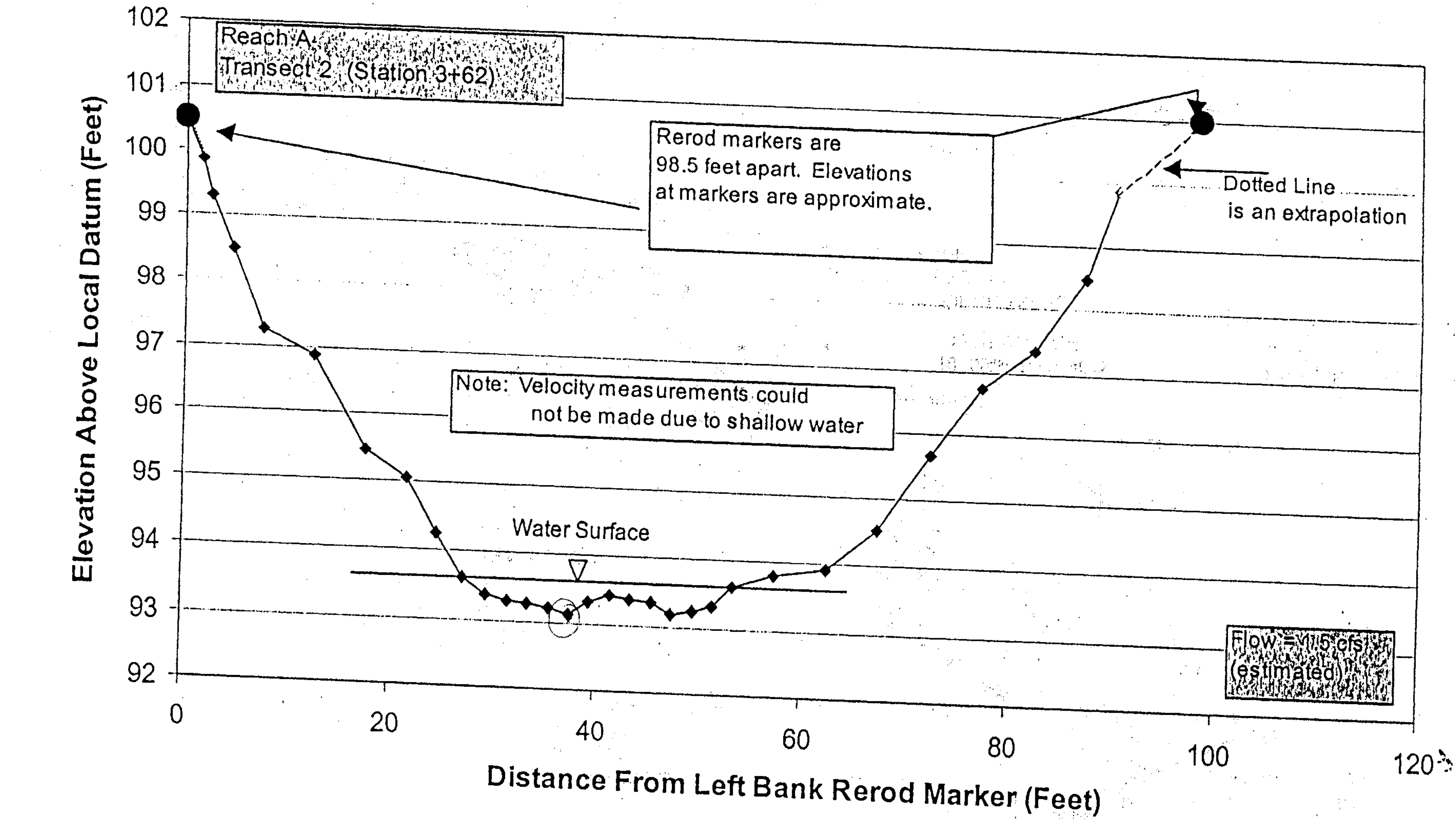

Figure 7. Cross-section profile of Reach A, Transect 2 (Station 3+62) on August 9, 2000.

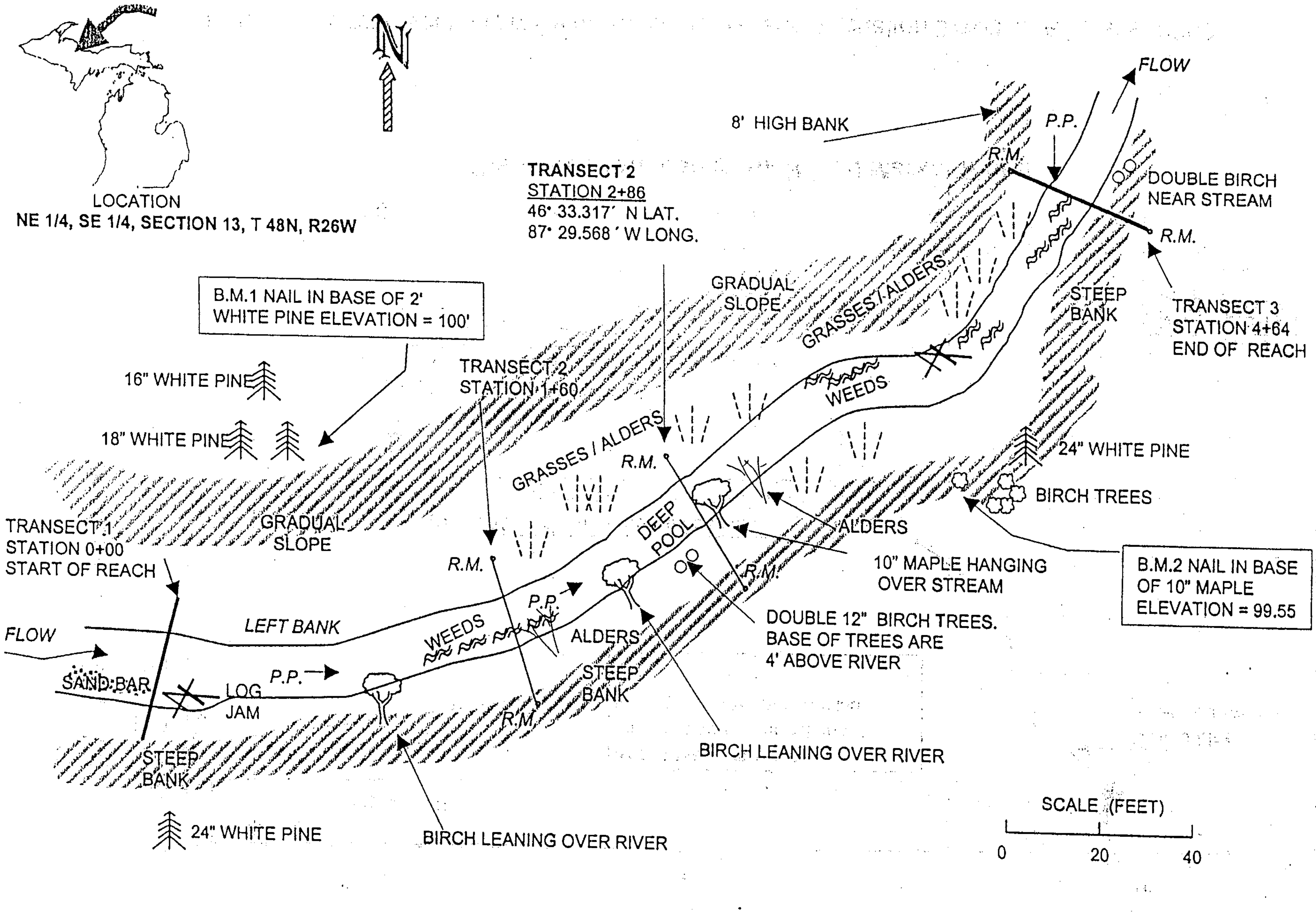

Figure 8. Map of reach B on the Dead River bypassed channel, August 2000.

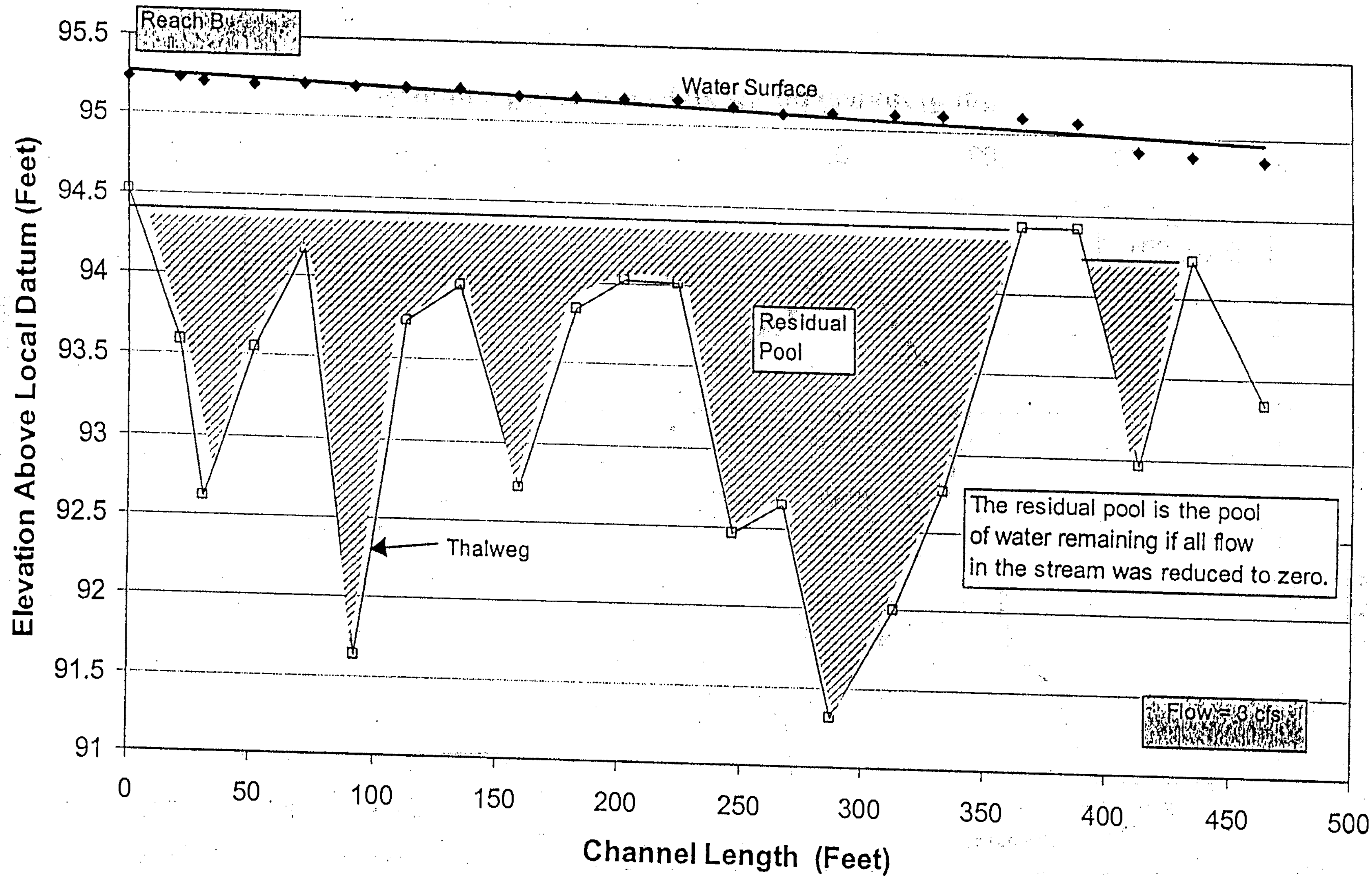

Figure 9. Longitudinal profile of Reach B on August 9, 2000.

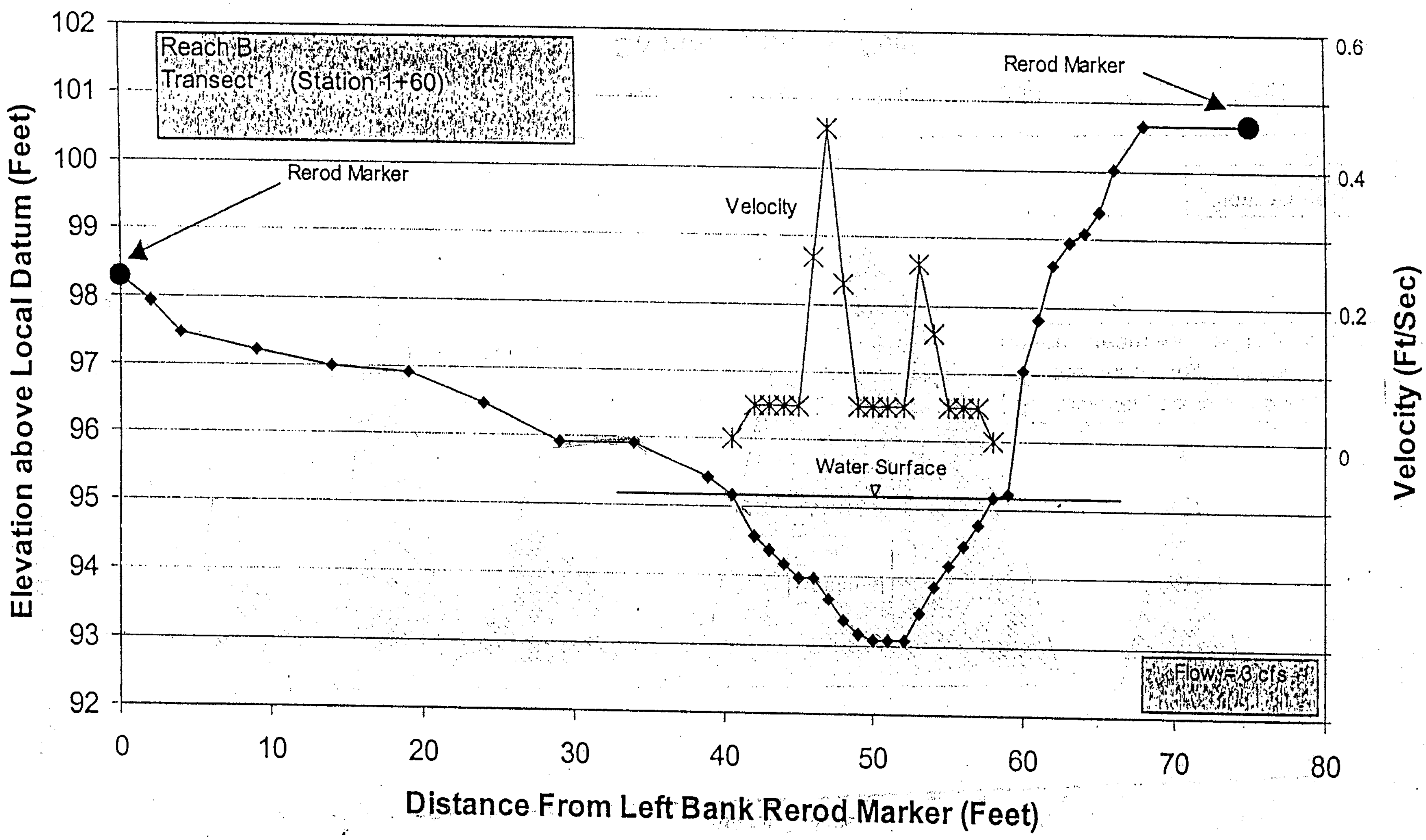

Figure 10. Cross-section profile of Reach B, Transect 1(Station 1+60) on August 9, 2000.

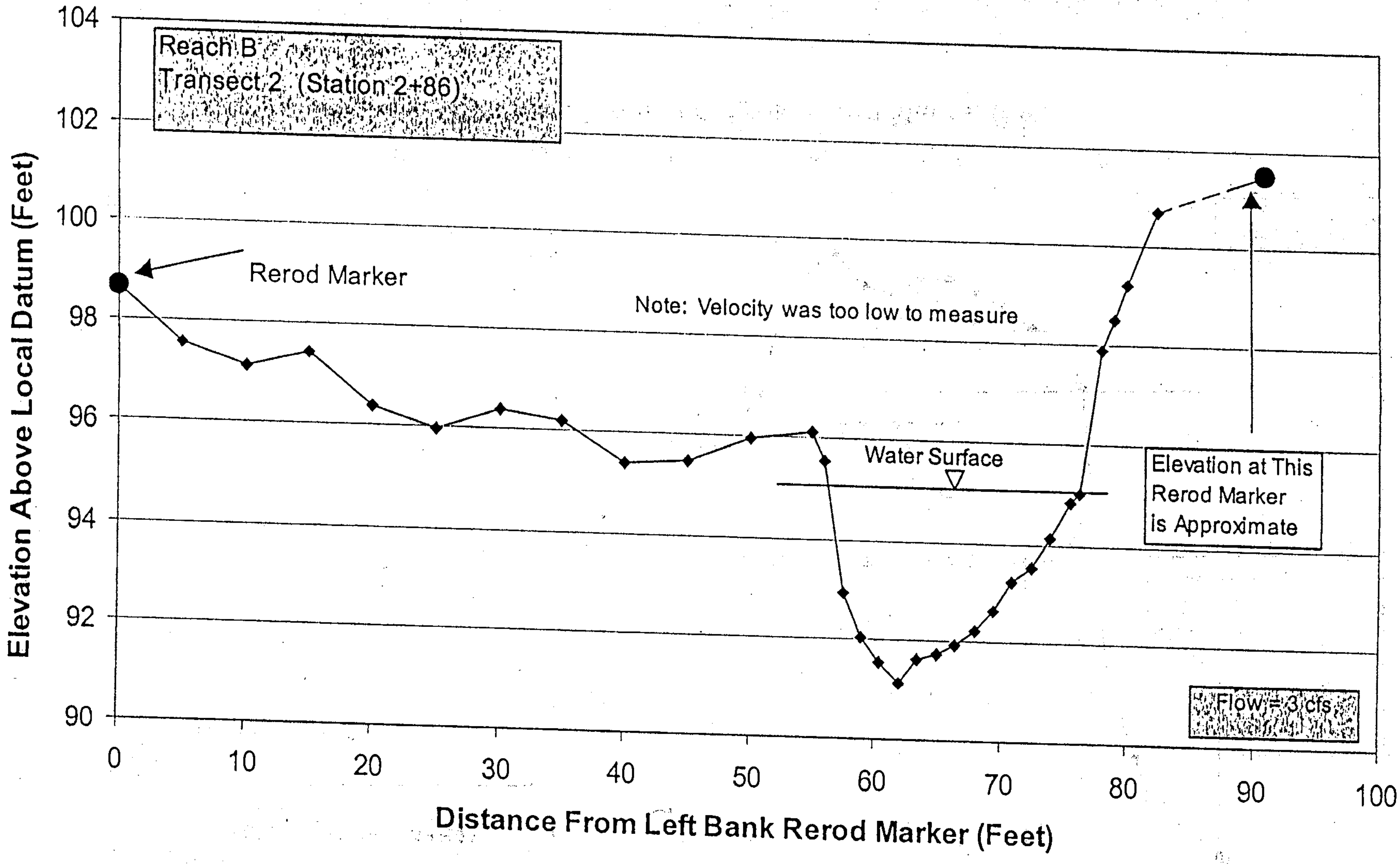

Figure 11. Cross- section profile of Reach B, Transect 2 (Station 2+86) on August 9, 2000.

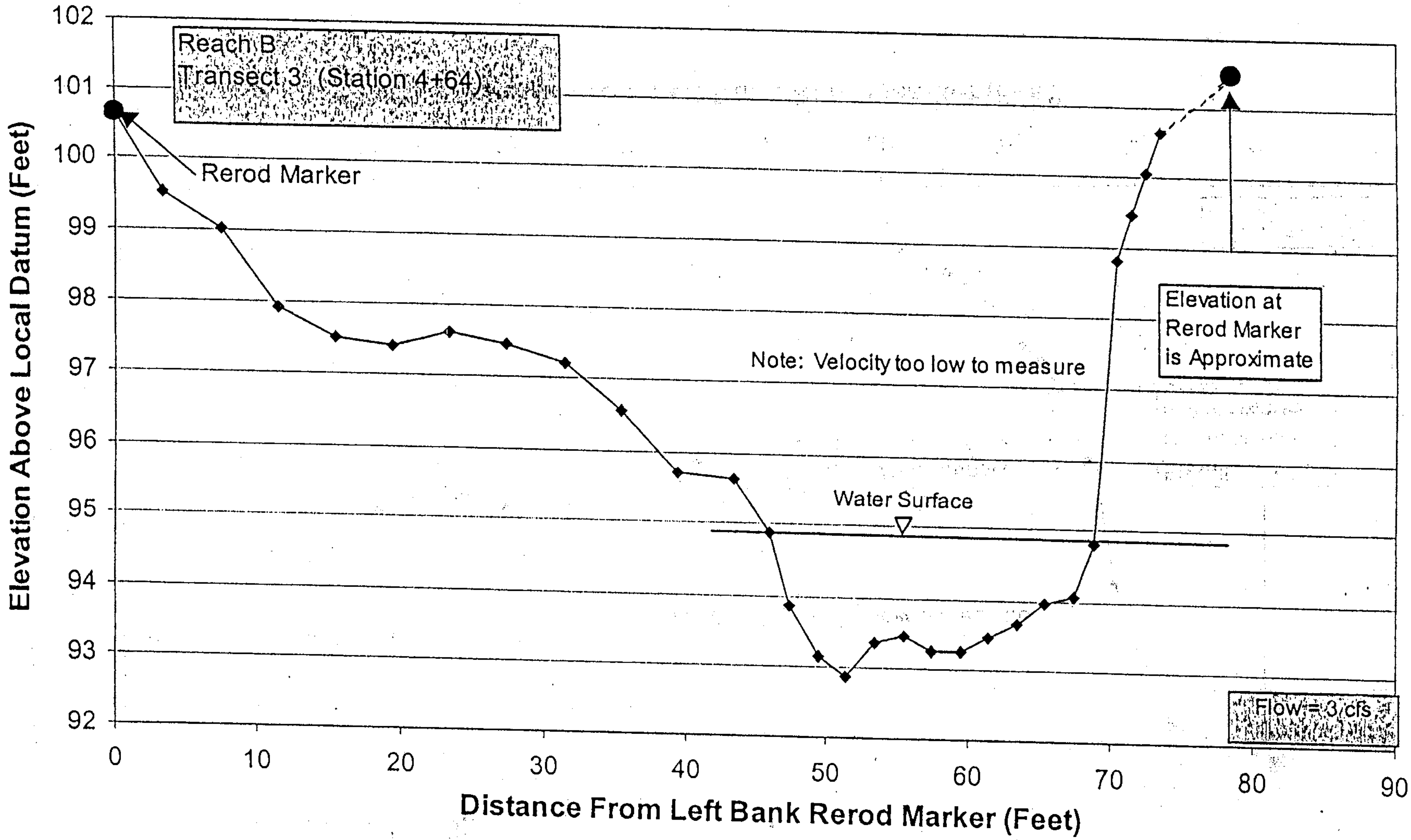

Figure 12. Cross- section profile of Reach B, Transect 3 (Station 4+64) on August 9, 2000.

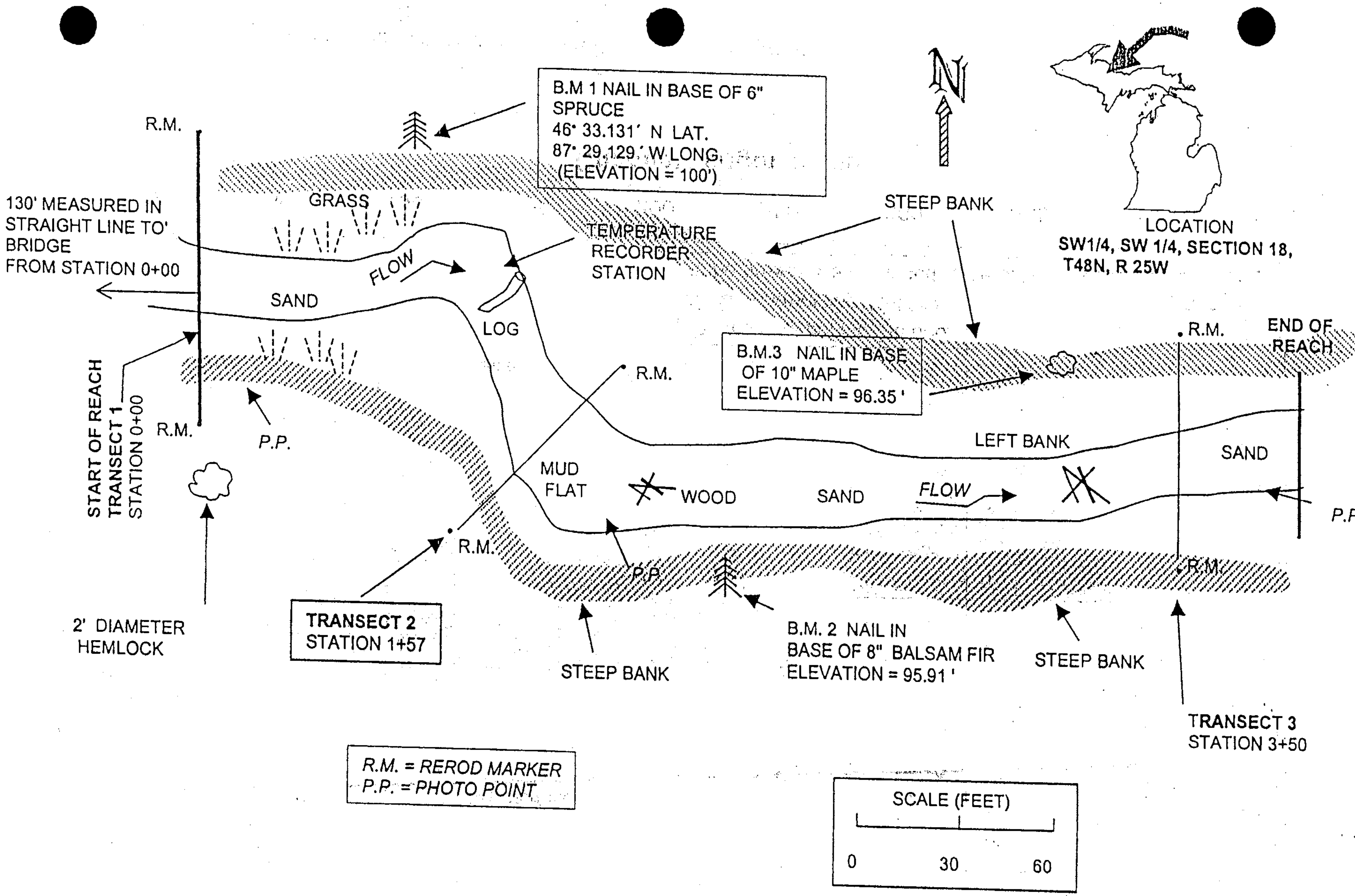

Figure 13. Map of Reach C on the Dead River bypassed channel, August 2000.

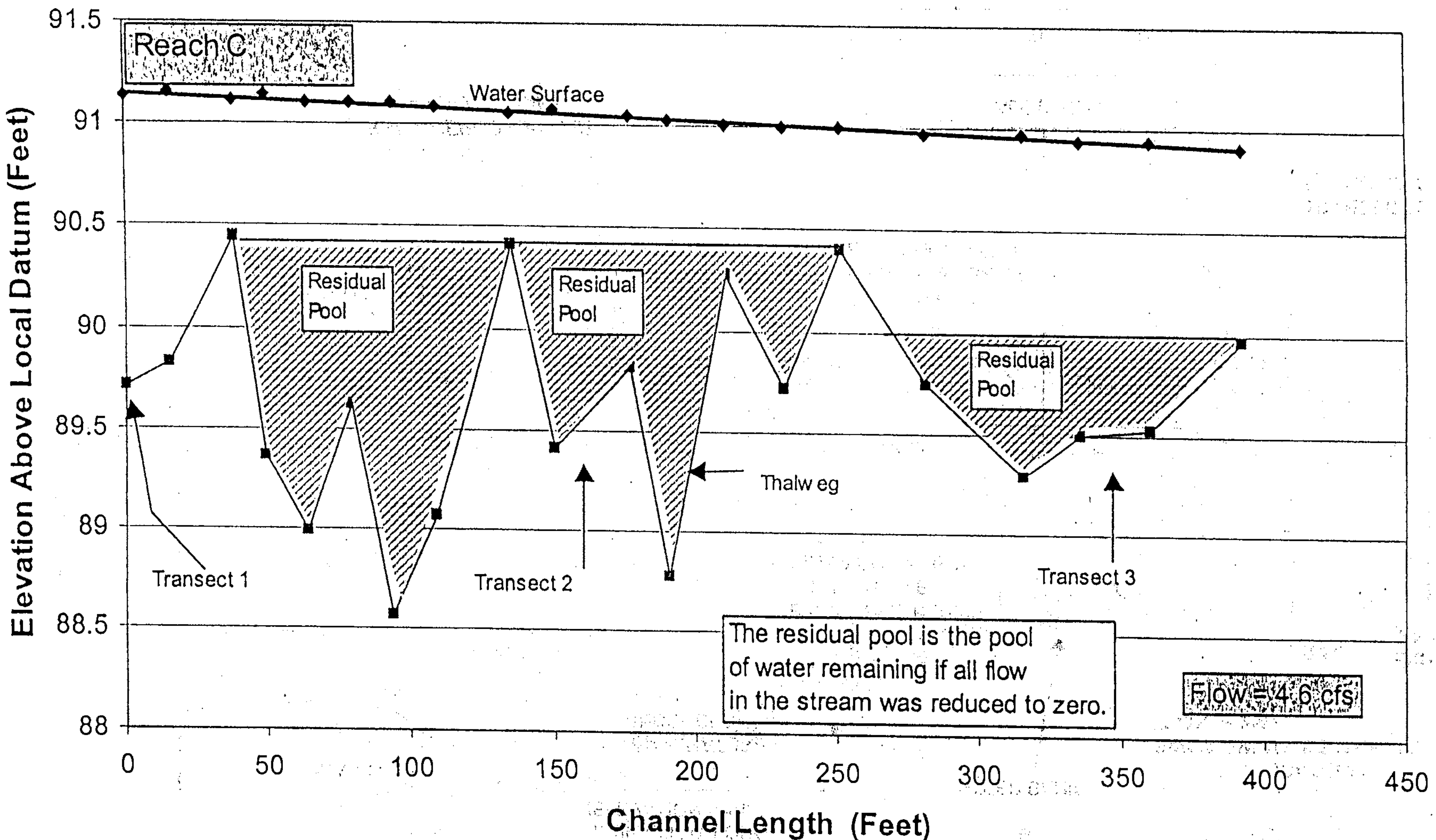

Figure 14. Longitudinal profile of Reach C on August 8, 2000.

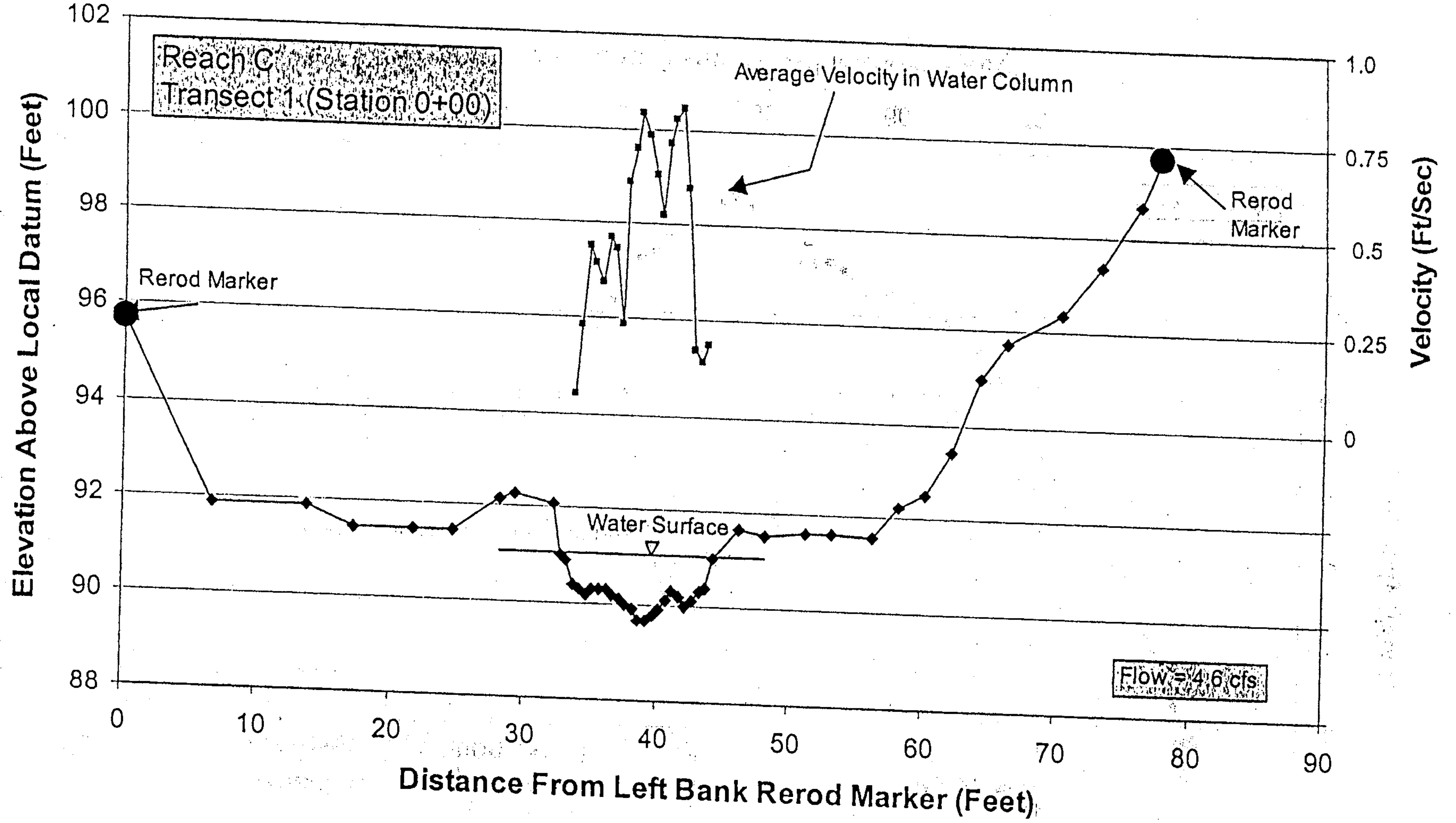

Figure 15. Cross- section profile of Reach C, Transect 1 (Station 0+00) on August 8, 2000.

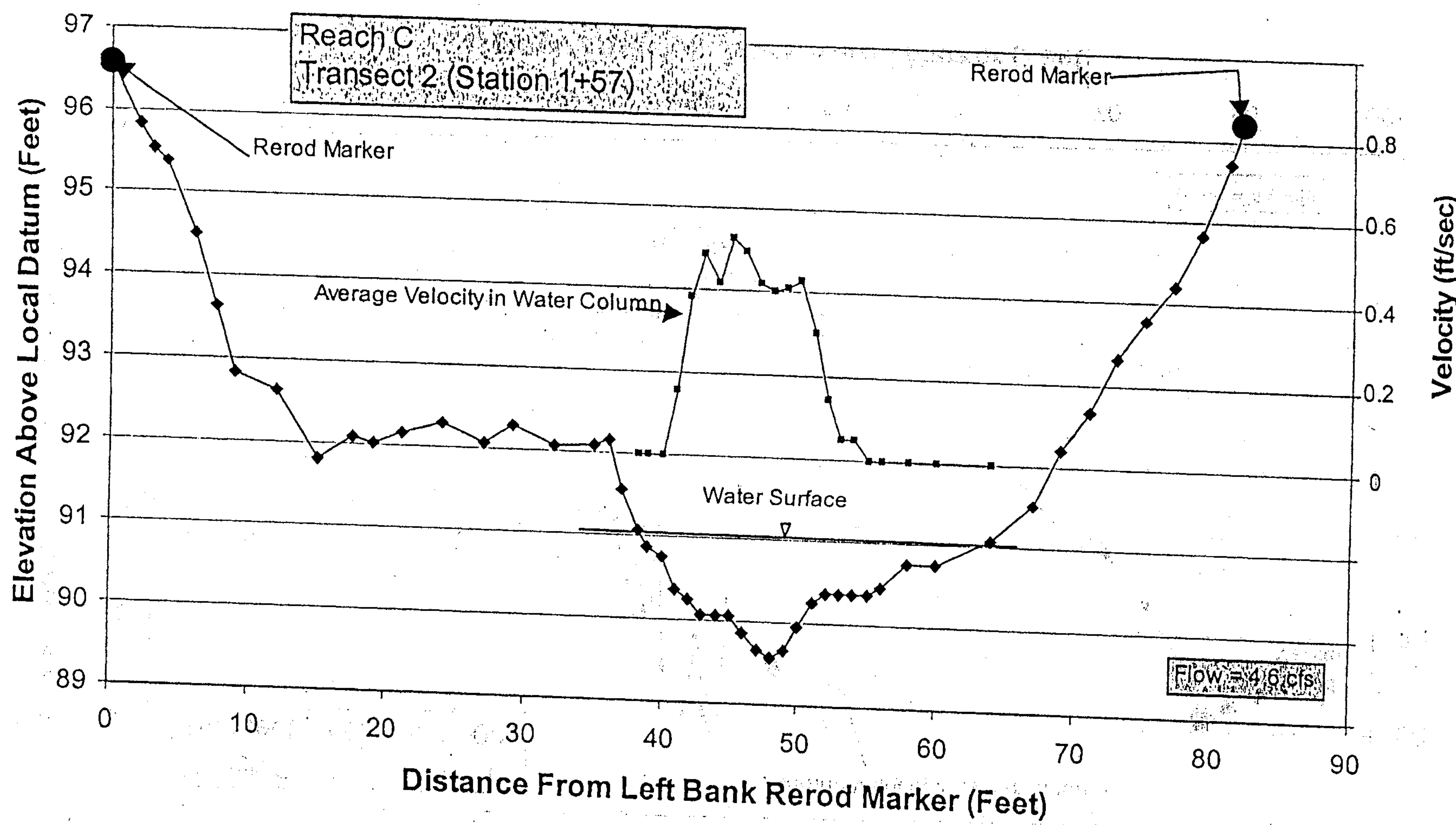

Figure 16. Cross- section profile of Reach C, Transect 2 (Station 1+57) on August 8, 2000.

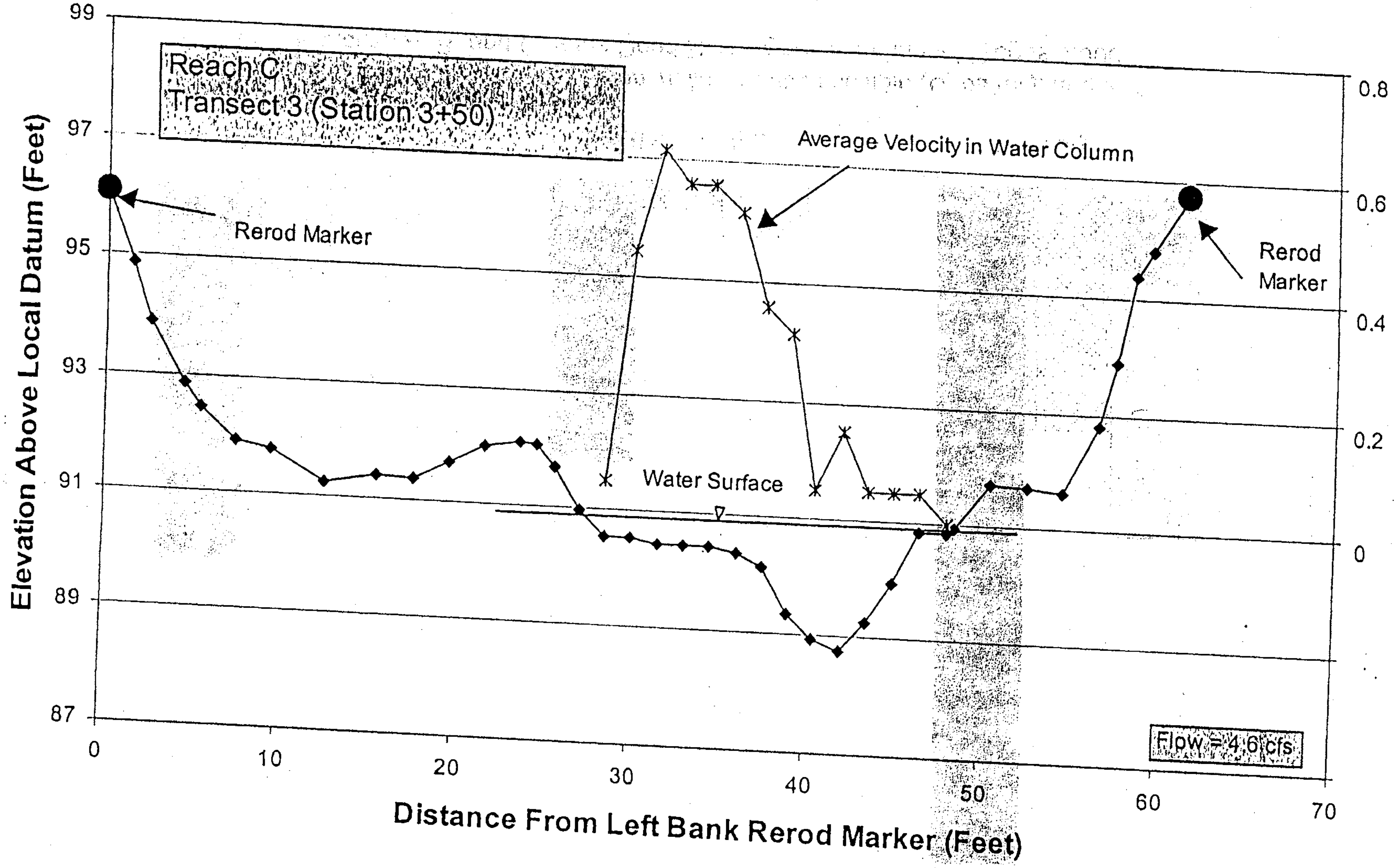

Figure 17. Cross- section profile of Reach C, Transect 3 (Station 3+50) on August 8, 2000.

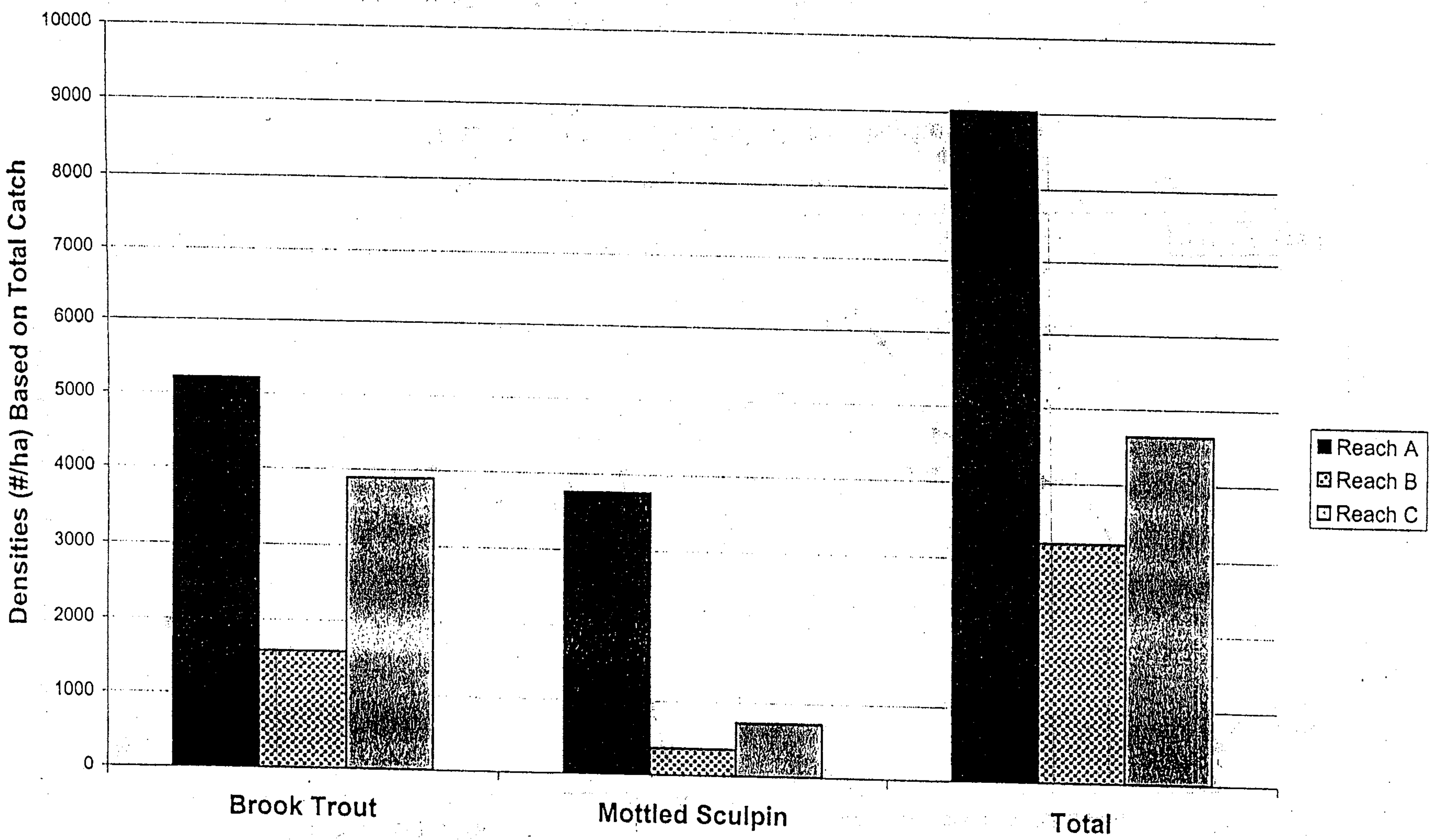

Figure 18. Densities (#/ha) of brook trout (*S. fontinalis*), mottled sculpin (*C. bairdi*), and total fish in Reaches A, B, and C of the Dead River bypassed channel, August 2000.

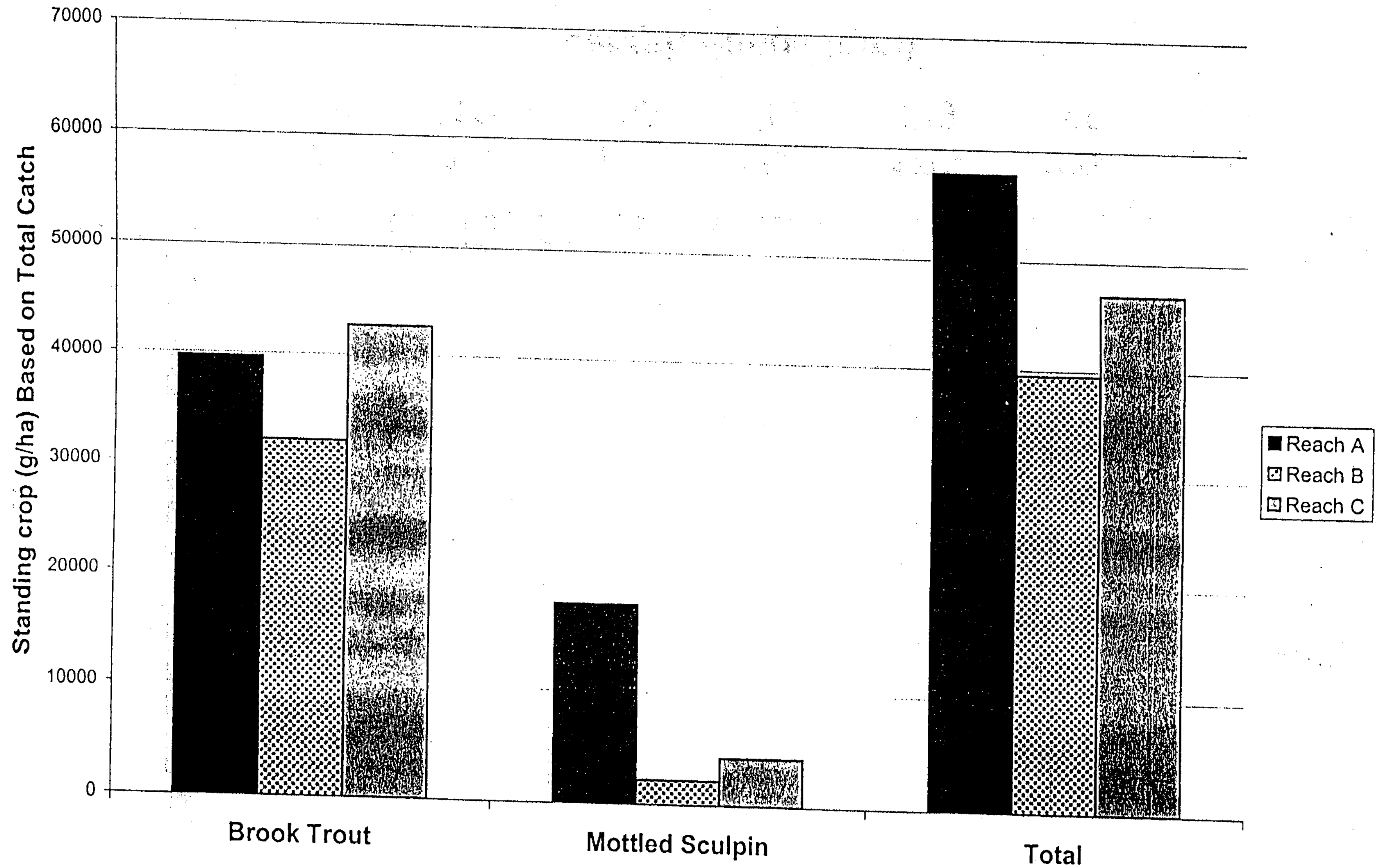

Figure 19. Standing crop (g/ha) of brook trout (*S. fontinalis*), mottled sculpin (*C. bairdi)*, and total fish in Reaches A, B, and C of the Dead River bypassed channel, August 2000.

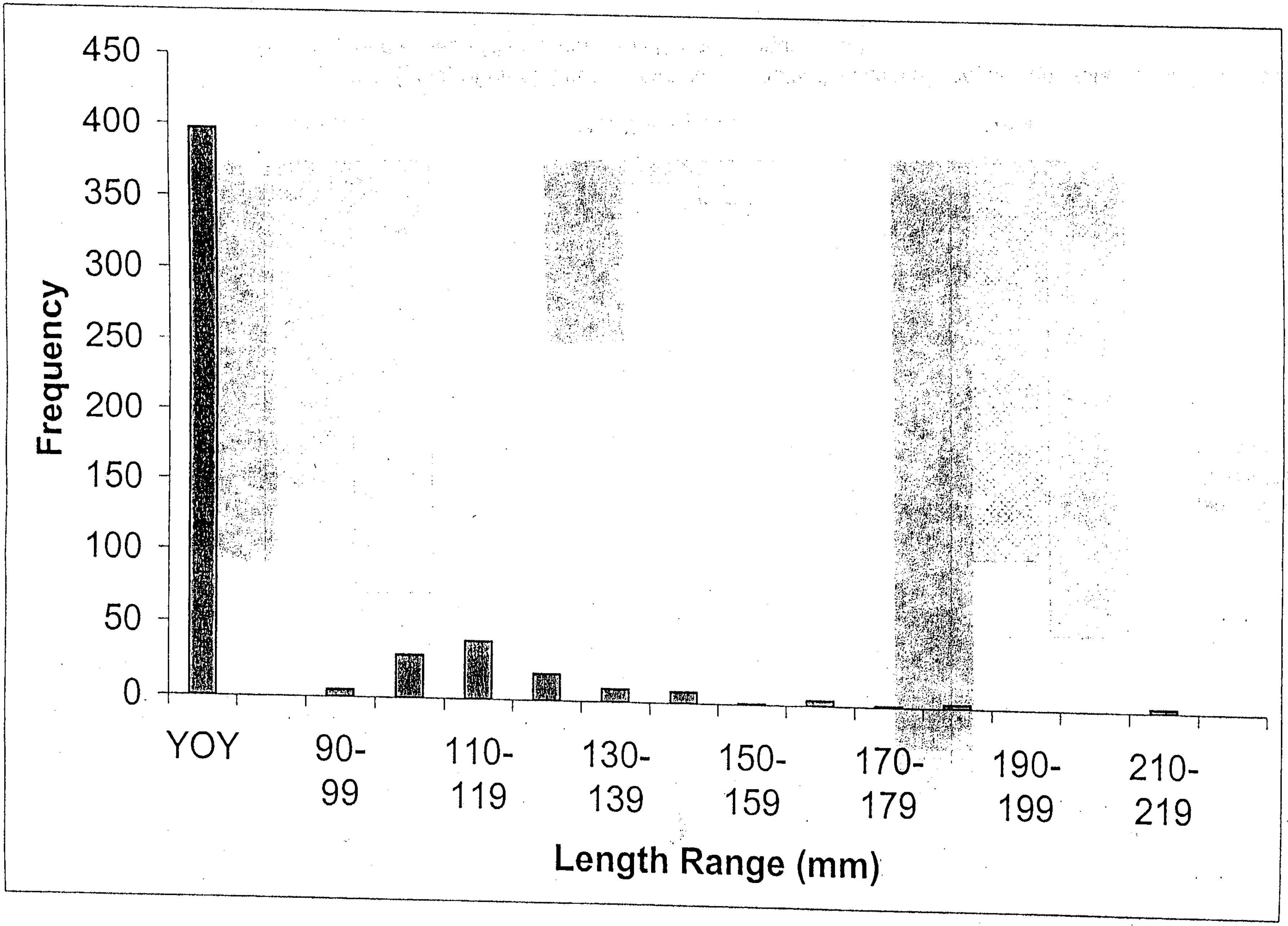

Figure 20. Length-frequency chart for brook trout in Reach A of the Dead River bypassed channel, August 2000.

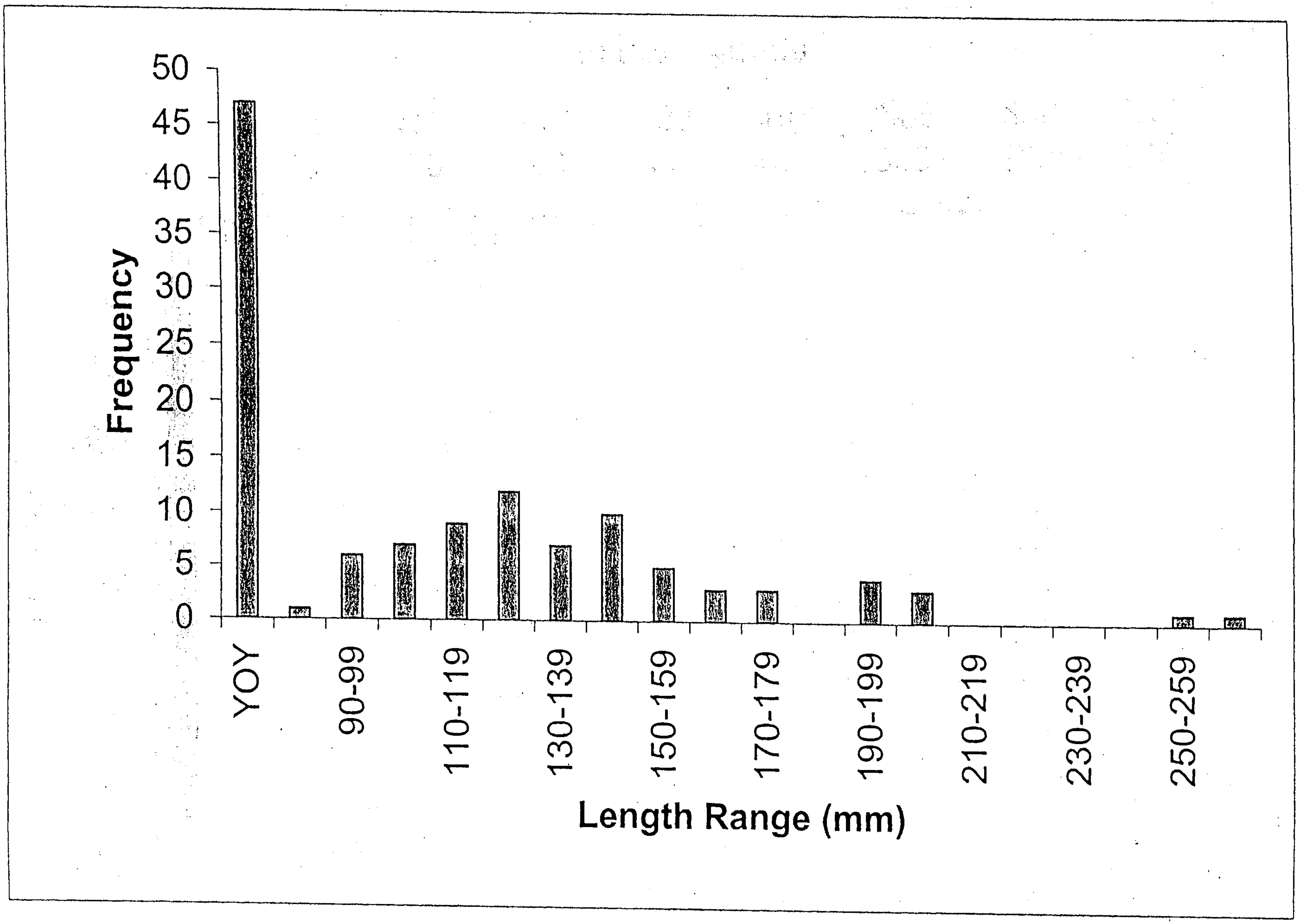

Figure 21. Length-frequency chart for brook trout in Reach B of the Dead River bypassed channel, August 2000.

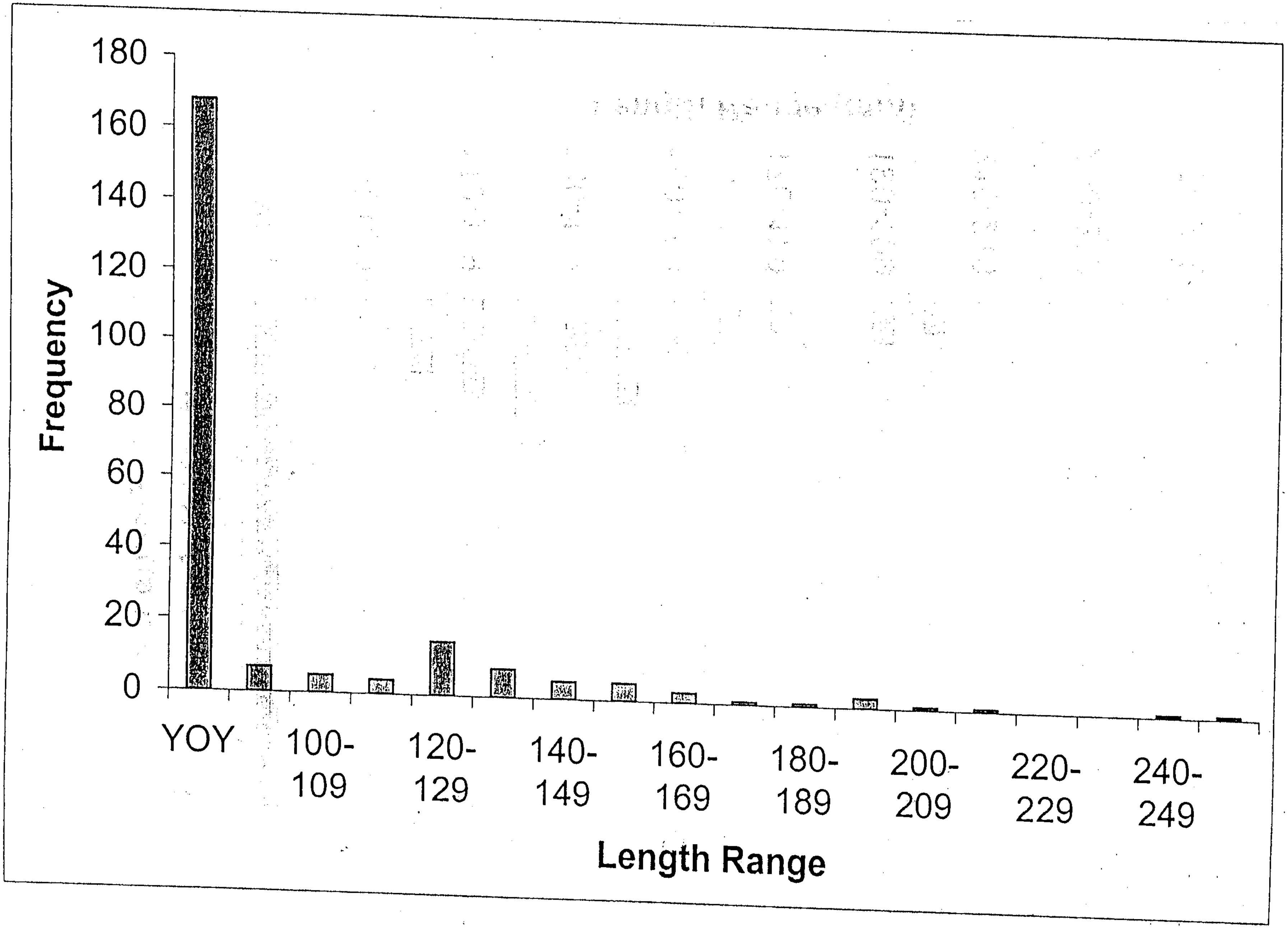

Figure 22. Length-frequency chart for brook trout in Reach C of the Dead River bypassed channel, August 2000.

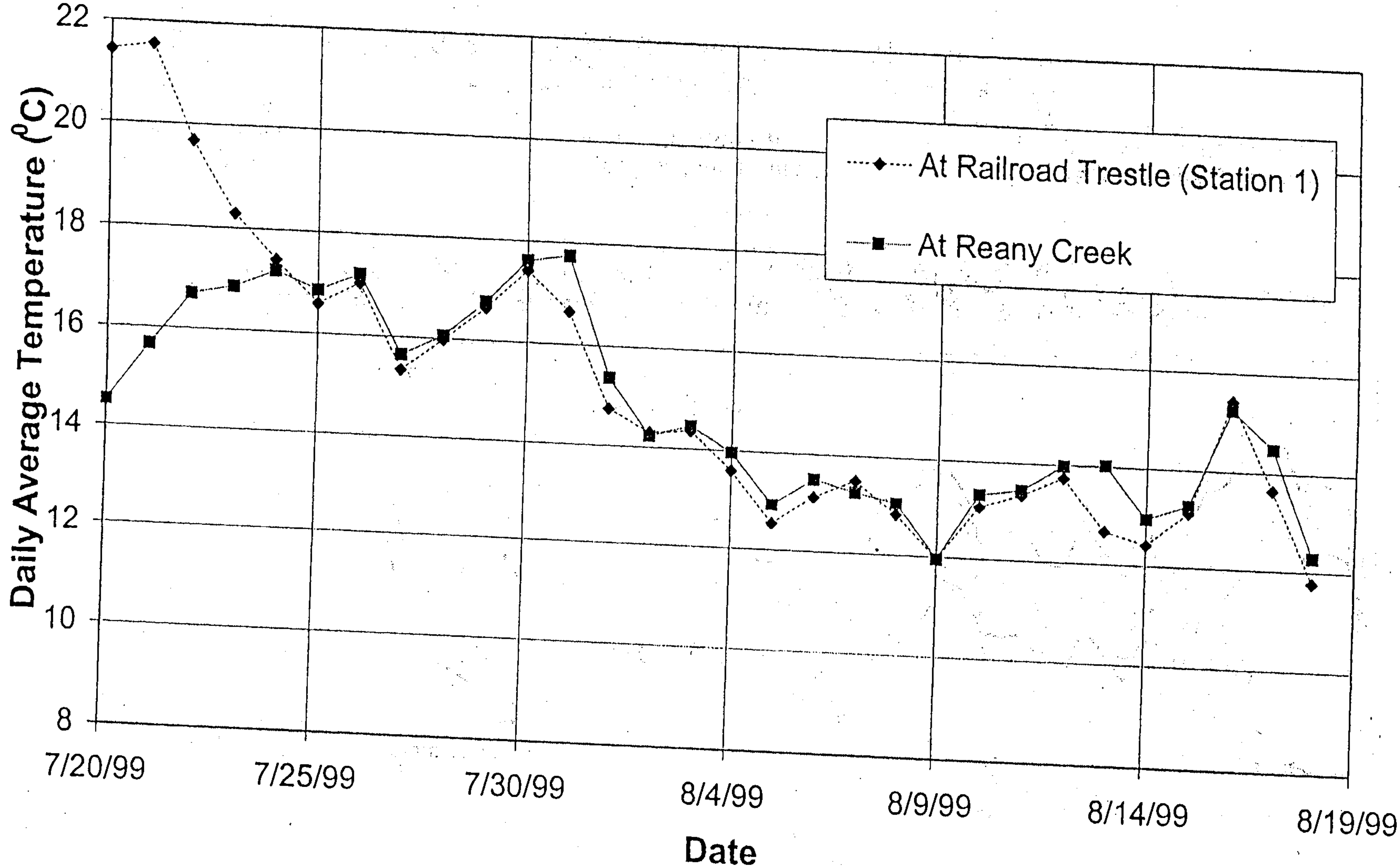

Figure 23. Daily average temperature of the Dead River bypassed channel (Station 1) and Reany Creek (July 20, 1999 through August 18, 1999).

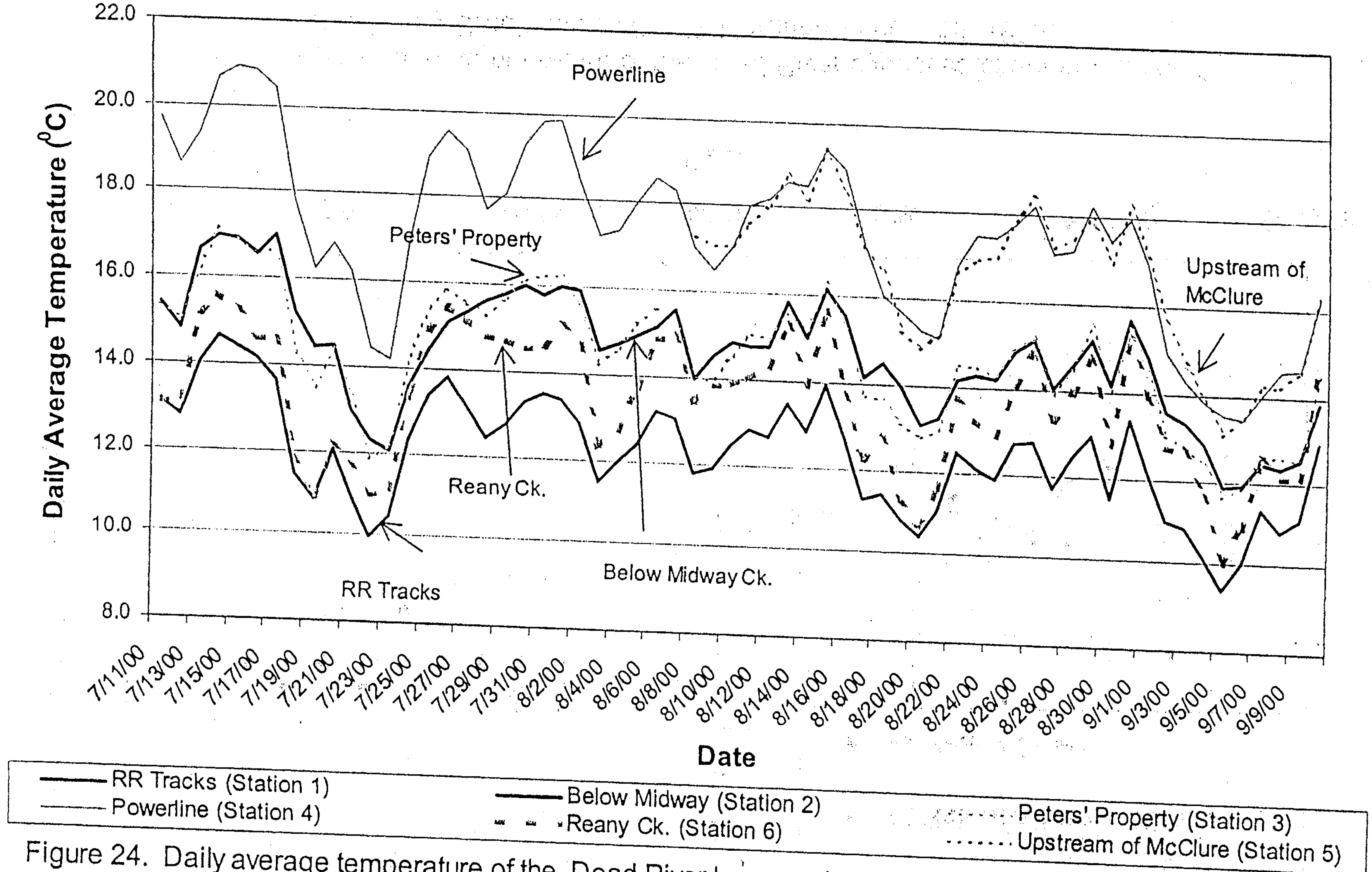

Figure 24. Daily average temperature of the Dead River bypassed channel and Reany Creek (July 11-September 10, 2000). Data at Station 3 were collected by MDNR Fisheries Division.

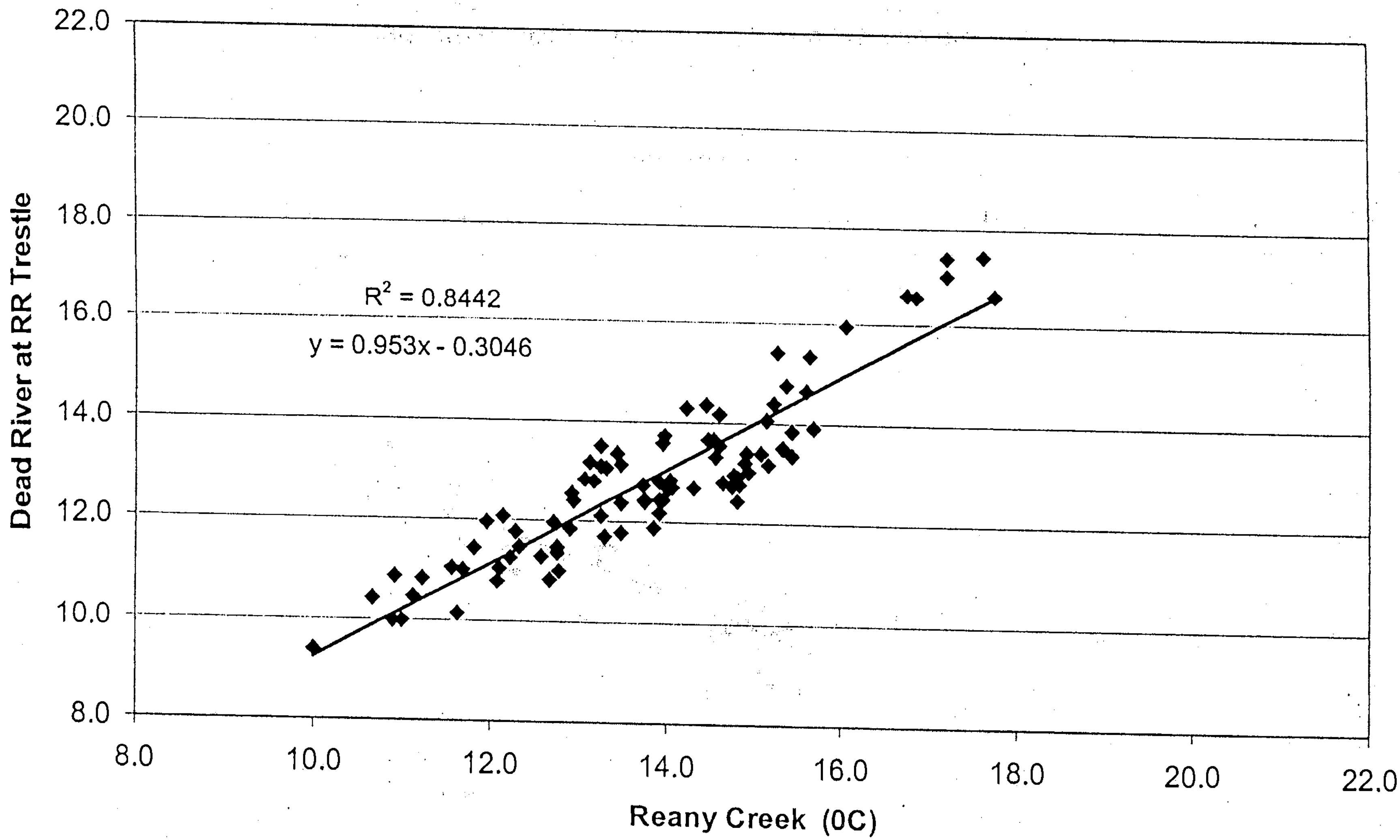

Figure 25. Daily average temperature in the Dead River bypassed channel(Station 1) versus daily average temperature in Reany Creek (Station 6).

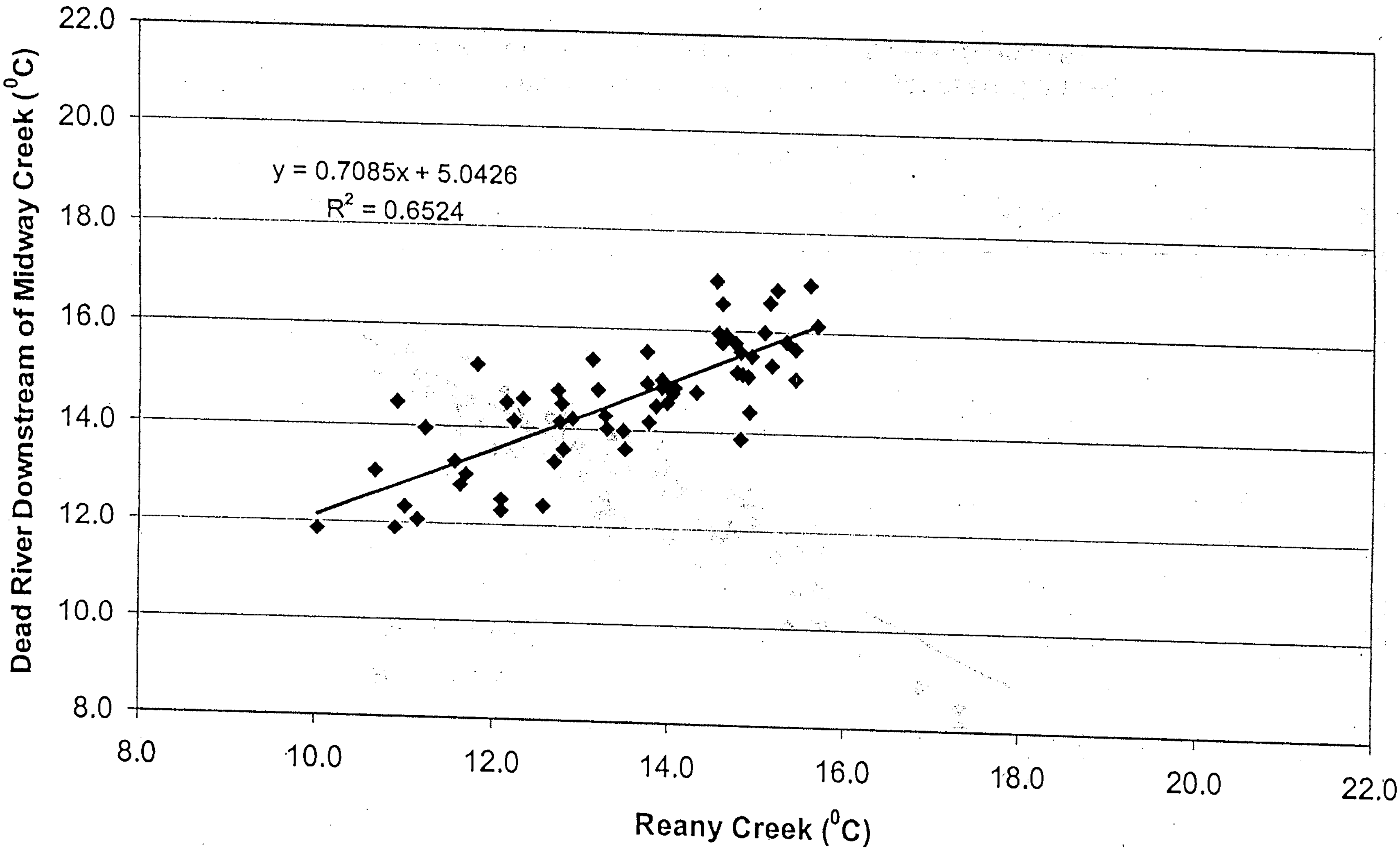

Figure 26. Daily average temperature of the Dead River bypassed channel (Station 2) versus daily average temperature of Reany Creek (Station 6).

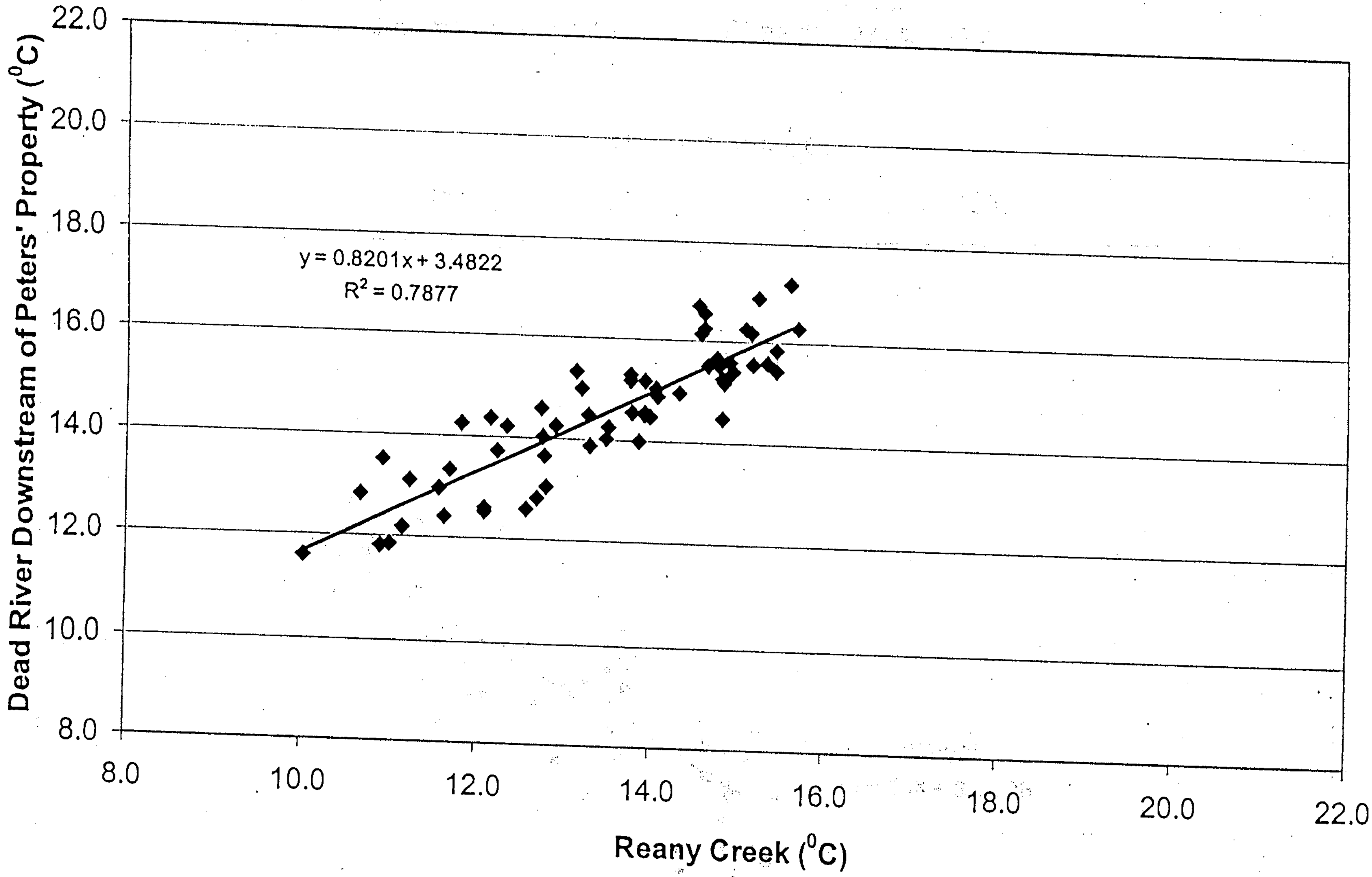

Figure 27. Daily average temperature of the Dead River bypassed channel (Station 3) versus daily average temperature of Reany Creek (Station 6).

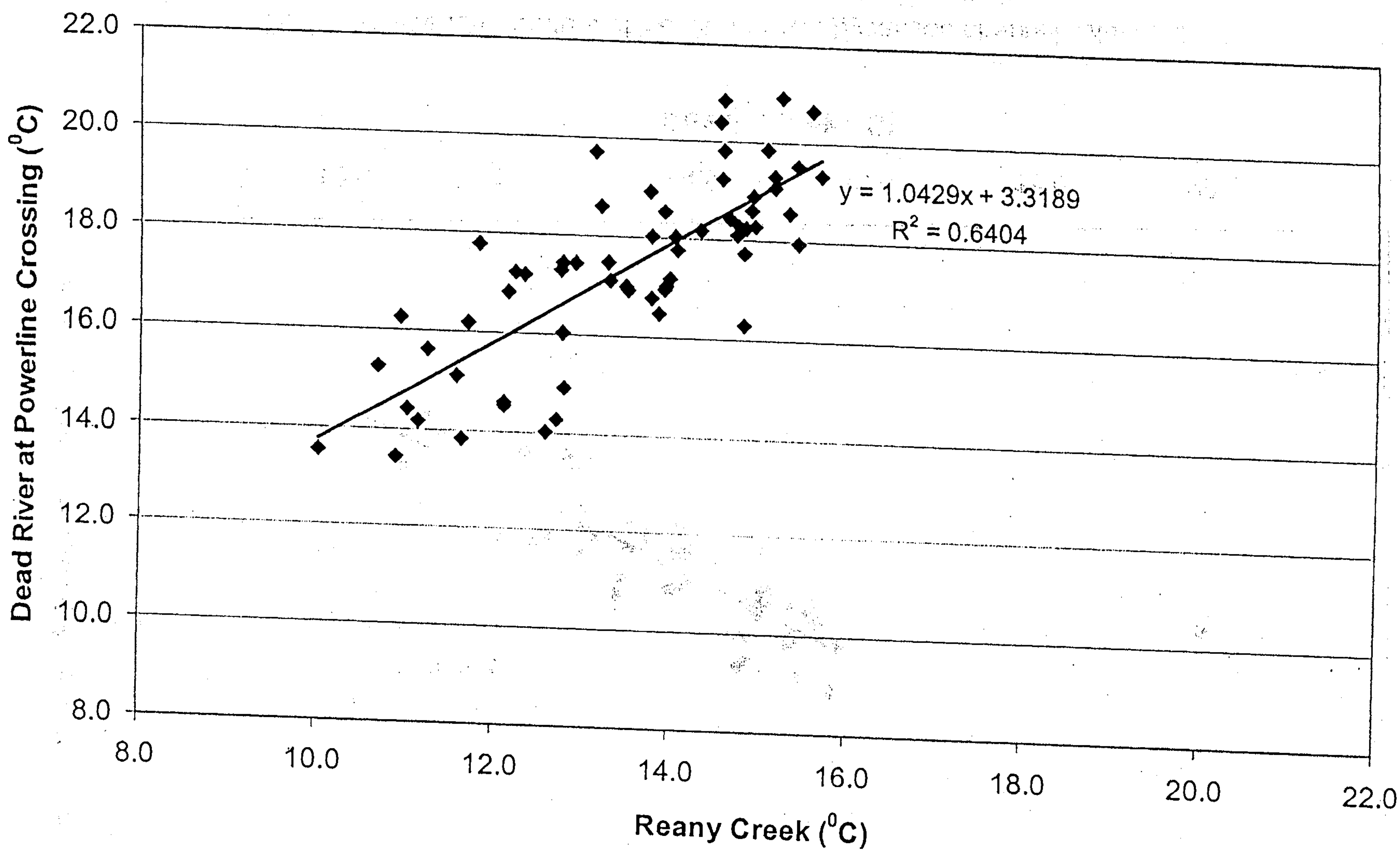

Figure 28. Daily average temperature of the Dead River bypassed channel (Station 4) versus daily average temperature of Reany Creek (Station 6).

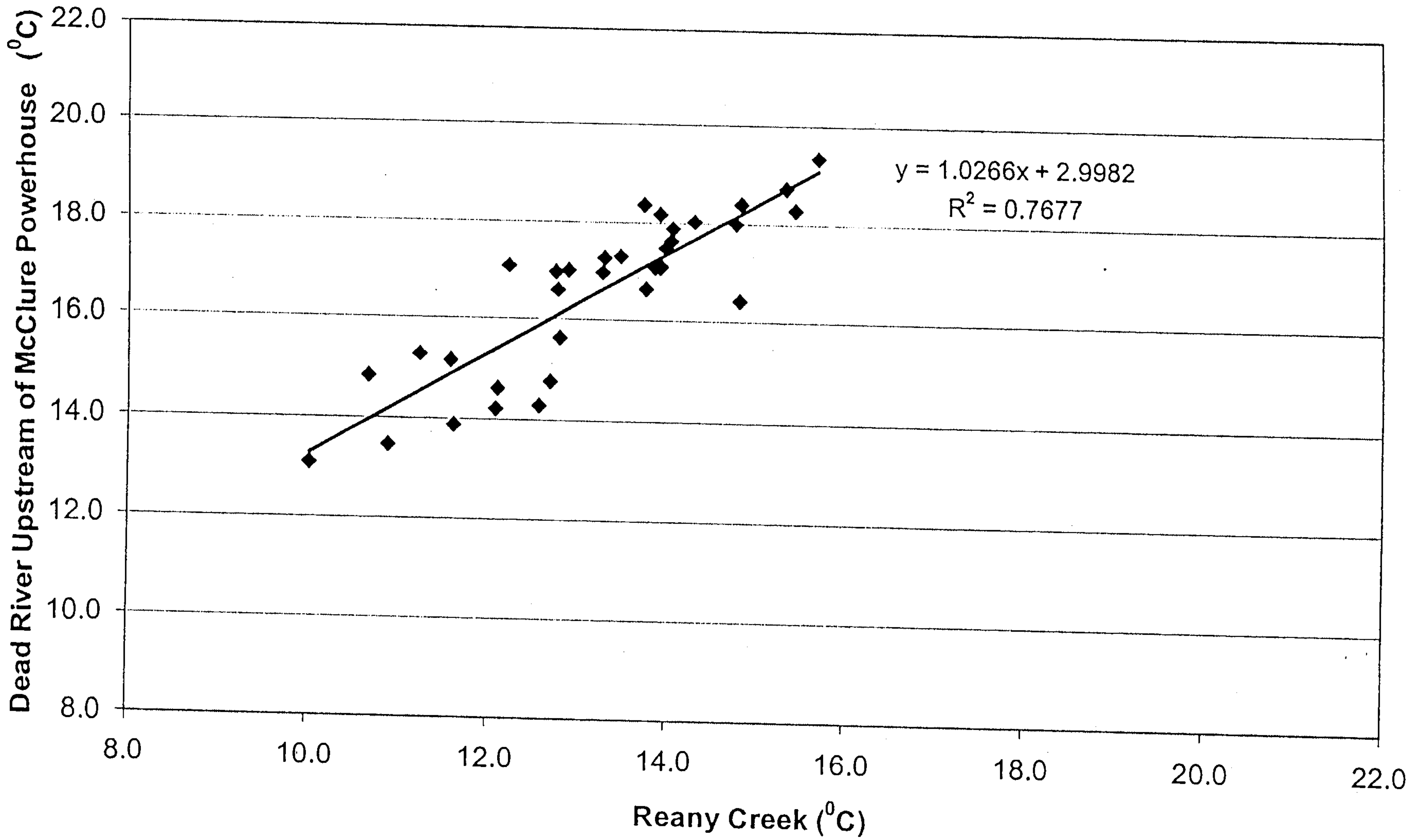

Figure 29. Daily average temperature of the Dead River bypassed channel (Station 5) vs. the daily average temperature of Reany Creek (Station 6).