ORIGINAL

FPL Energy Maine, 150 Main Street, Lewiston, ME 04240
207-795-1342

FPL Energy

February 28, 2007

Ms. Magalie R. Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

RE: **Indian Pond Project, FERC No. 2142**-055
Study Plans for Fisheries Enhancements

In compliance with Sections 3.3.3.3, 3.3.5 and 3.3.7 of the Indian Pond Settlement Agreement and Article 401 of the new FERC license FPL Energy Maine Hydro LLC (FPL Energy) developed draft study plans for future fisheries enhancements near the Project. These draft plans were submitted to the Maine Department of Inland Fisheries (MDIFW), U.S. Fish and Wildlife Service (USFWS), Trout Unlimited (TU), Maine Trout (MT), and the Forks Chamber of Commerce (FCC) (i.e. the Indian Pond Project Fisheries Committee Members) on October 5, 2006 for review and comment. FPL Energy planned to conduct a consultation meeting with the committee members in early November 2006 and then file the study plans including agency and Non Governmental Organizations (NGO) comments with FERC in late November 2006.

Due to a number of extenuating circumstances (i.e. one NGO member recovering from a vehicle accident, another NGO member recovering from hip replacement surgery and lastly no USFWS contact person in Maine due to recent job relocation and retirement) the consultation meeting could not take place as planned. Due to these circumstances, FPL Energy on January 2, 2007 requested an extension of time until February 28, 2007 to file the study plans with FERC. FERC subsequently approved this request on January 31, 2007

FPL Energy met with committee members (TU, MT, USFWS and MDIFW) on February 8, 2007 to review the study plans. During the meeting, consensus was reached on all three study plans. In an email dated February 16, 2007 (see attached) USFWS summed up their comments from the meeting and these comments have been incorporated into the study plans. The other committee members did not provide written comments, however they did provide oral comments during the meeting which were incorporated into the study plans. The FCC did not attend the study plan meeting, however FPL Energy contacted FCC (Joe Christopher) via phone on February 13, 2007 to go over the study plans and comments from the February 8, 2007 meeting. FCC indicated that they were in agreement with the study plans and agency and NGO comments.

During the February 8, 2007 meeting, MDIFW also discussed the issue of possible invasion of small mouth bass into the tributaries in the study area and their impact on native brook trout. This is an on going problem in many Maine rivers and streams and is a high priority issue for MDIFW. During the meeting, the Committee members decided that this issue should be further investigated using monies from the fisheries habitat restoration fund described in section 3.3.1 of the Indian Pond Settlement Agreement. As part of this process, FPL Energy in consultation with the Fisheries Committee will initiate an assessment of this issue. This assessment will include but not be limited to: 1) a review of existing information to describe the potential invasion risk from small mouth bass to streams and/or ponds in the study area; 2) define the passage criteria for small mouth bass at natural and man-made barriers; 3) locate and measure existing natural barriers in streams that are not known to have small mouth bass; 4) conduct surveys to determine if small mouth bass are present in those streams and 5) proposals to install small mouth bass barriers if deemed necessary and feasible. The assessment will take place in 2007 and an assessment report will be filed with FERC by December 31, 2007 after consultation with the committee.

FPL Energy would like to initiate some of the field work identified in the study plans in August and September of 2007 and would respectfully request that FERC approve the study plans prior to August 2007.

If you have any questions regarding these study plans, please contact Bob Richter at (207) 877-8386.

Sincerely,

Christopher L. Allen
General Manager
FPL Energy Maine Generation

Cc: Peter Yarrington (FERC)

CERTIFICATE OF SERVICE

Indian Pond Project, FERC No. 2142

I, Robert C. Richter III, Senior Environmental Specialist for FPL Energy, hereby certify that copies of the foregoing documents have been filed with the following parties of record on February 28, 2007:

Magalie R. Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Mr. Forrest Bonney
ME Department of Inland Fisheries and Wildlife
689 Farmington Road
Strong, ME. 04983

Mr. Fred Seavey
U.S. Fish and Wildlife Service
1168 Main Street
Old Town, ME 04468-2023

Mr. Steve Timpano
ME Depart. of Inland Fisheries and Wildlife
41 State House Station
Augusta, ME 04333

Mr. Jeff Reardon
Trout Unlimited
Maine Council
8 Crosby Street
Augusta, ME 04330

Mr. Joe Christopher
Forks Chamber of Commerce
Three Rivers Whitewater
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West Forks, ME 04985

Mr. Jim Lentz
ME Trout
692 Cathance Road
Topsham, ME 04086

Mr. Craig Denis
Trout Unlimited
38 Daggett Hill Rd.
Athens, ME. 04912

RCR III
Robert C. Richter III

2-28-07
Date

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Maine Field Office – Ecological Services
1168 Main Street
Old Town, ME 04468
(207) 827-5938 Fax: (207) 827-6099

In Reply Refer To:
FWS/Region5/ES/MEFO

February 16, 2007

Mr. Robert Richter
Senior Environmental Specialist
FPL Energy Maine, LLC
150 Main Street
Lewiston, Maine 04240

SUBMITTED ELECTRONICALLY

RE: Indian Pond Project, FERC No. 2142
Review of Draft Study Plans as Required by Article 401 and Sections 3.3.3.C, 3.3.5 and 3.3.7 of the Indian Pond Settlement Agreement

Dear Mr. Richter:

Thank you for the opportunity to comment on the three study plans that were developed to partially fulfill Article 401 of the Federal Energy Regulatory Commission license for the Indian Pond Project. We attended the February 8, 2007 coordination meeting to discuss the draft study plans, which was delayed, in part, to allow us to comment on the plans. We appreciate your willingness to provide us additional time to respond.

The three study plans address various stages towards assessing and restoring aquatic habitat in the tributaries that are affected by the operation of the Indian Pond Project. The plans address the methods that will be used for the field evaluation of two restoration projects identified for the Cold and Dead Streams; the methods that will be used to measure aquatic habitat and fish populations; and the methods that will be used to improve a side-channel spawning area and to evaluate four projects to reduce sedimentation. The study plans are needed as the next step to complete on-the-ground restoration projects.

We reviewed the process used to identify and select projects and found it to be appropriate. The initial project screening was completed through a desktop review, which ranked specific streams based on their restoration potential. We agree that the projects identified in the review and the basis of the study plans are consistent with the intent of the settlement agreement. These are our specific comments on each study plan:

<u>Section 3.3.3.C Field Evaluation of Potential Aquatic Restoration Projects</u>

We agree with the recommendation in the field evaluation to move forward with the necessary planning for a restoration project on Cold Stream and one for the East Branch of Enchanted Stream. The Cold Stream restoration area is located at a former dam site. The current channel is a long glide, lacking significant structure. The Enchanted Stream restoration area is located near a recent channel avulsion, which has likely caused the left bank to erode.

The stream morphology and hydrologic studies should carefully evaluate the stability of Enchanted Stream because of the recent evidence of a channel avulsion. The stream channel may be adjusting as a result of this avulsion so addressing the bank erosion may only cause further erosion downstream.

When available, cite published monitoring protocols for the stream morphology; hydrology; and fish habitat and population assessments described in the study.

Post-project monitoring should be conducted for three consecutive years to evaluate the success of each project. The monitoring studies should include an assessment of the stream morphology; hydrology; and aquatic habitat and fish population. A coordination meeting should occur at the end of the monitoring period to evaluate the monitoring results and to decide on the effectiveness of the project.

A benthic index of biotic integrity (B-IBI) should be considered as an additional monitoring element. The B-IBI is a metric constructed from benthic invertebrate taxa and may be sensitive enough to demonstrate changes that may occur as a result of the restoration projects. We are unsure if this approach has been developed or is adaptable for streams in the project area. The methods are described in Kerans and Karr (1992) and Karr and Chu (1999).

We recommend a coordination meeting after the pre-project monitoring and feasibility study is completed on each project. The purpose of the meeting would be to review the design options and to decide on the types of structures that are appropriate at each site.

Further consultation should occur to discuss the need to develop additional information or evaluate other methods that may provide a broader range of stream restoration alternatives. The current process was limited to sites that could be access by roadways because of the need to use heavy equipment to construct the project. Additional discussion may allow us to find other means to restore aquatic habitat over a broader area.

Section 3.3.5 Fish Habitat and Population Assessment

This study plan describes the type of fish habitat and population monitoring that will be completed to evaluate restoration projects. It proposes pre- and post project monitoring at both index and restored sites.

When available, cite published monitoring protocols for the stream morphology; hydrology; and fish habitat and population assessments described in the study.
The post-project monitoring should be conducted for three consecutive years to evaluate the success of each project. The monitoring studies should include an assessment of the stream morphology; hydrology; and aquatic habitat and fish population.

The study plan proposes to conduct baseline or pre-project monitoring a month prior to implementing the restoration projects. This may be appropriate for some types of monitoring, however other types may need to be completed during certain periods to be meaningful. The study plan should identify those monitoring elements that are more sensitive to seasonal changes and conduct them during the optimum period (redd counts, aquatic habitat and fish population monitoring).

Brief progress reports should be completed at the end of each year of monitoring (baseline and post-project monitoring). The reports should provide the data collected at each site and a short summary of the results. The purpose of the progress reports is to provide information early enough to evaluate the need to make minor adjustments to the restoration projects.

There was a concern raised by Maine Department of Inland Fisheries and Wildlife during the meeting about the possible invasion of smallmouth bass into streams that are dominated by brook trout. We believe that this issue should be investigated as part of the project mitigation to assess, enhance and restore coldwater fisheries. An assessment should be included in the study plan to: 1) review existing information to describe the potential invasion risk from smallmouth bass to the streams and/or ponds in the project area; 2) define the passage criteria for smallmouth bass at natural and man-made barriers; 3) locate and measure the barriers in streams that are not known to have smallmouth bass; and 4) conduct surveys to determine if smallmouth bass are present in those streams where their status is unknown.

Section 3.3.7 License Identified Restoration Plans

We concur with the selection of the four projects identified for erosion control remediation on the Salmon, Cold, Enchanted and Fish Pond Streams.

The restoration project that addresses side-channel spawning habitat should include a maintenance commitment since the area is subjected to a wide range of flows from the operation of the Indian Pond Project.

We appreciate the opportunity to review these study plans. If you have any questions, please contact me at (207) 827-5938 extension 16.

Sincerely,

/s/ Frederic G. Seavey

Frederic G. Seavey
Fish & Wildlife Biologist

cc: F. Bonney, MDIFW
S. Tipano, MDIFW
C. Denis, Trout Unlimited
J. Reardon, Trout Unlimited
J. Lentz, Maine Trout
B. Hayes, Susquehanna University
Reading File

ES: FSeavey:02/16/07:(207) 827-5938

Literature Cited

Karr, J. and E. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press. Washington D.C. 220 p.

Kerans, B.L. and J. R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4(4):768-785

FPL Energy

Fish Habitat/Fish Population Assessment Study Plan

Indian Pond Project

(FERC NO. 2142-031)

February 28, 2007

Fish Habitat/Fish Population Assessment Study Plan

Indian Pond Project

(FERC NO. 2142-031)

1.0 Introduction

This plan describes the contents of the fish habitat/fish population assessment study plan pursuant to section 3.3.5 of the Indian Pond Project Settlement Offer dated July 25, 2001.

2.0 Background

Section 3.3.5 of the July 25, 2001 Indian Pond project contains the following language:

3.3.5.1 Study Plan for Habitat/Population Assessments in the Selected Area

A. In consultation with other members of the Committee, Licensee shall develop a study plan for conducting periodic habitat/population assessments at index sites where no restoration projects are proposed and at sites where habitat restoration projects have been implemented. The assessments shall be performed consistent with the criteria set forth in Appendix 2. The purpose of the study is to compare fisheries population responses and changes at sites where a restoration project pursuant to Section 3.3.4 has been implemented (the "restoration sites") against sites where no restoration work is proposed (the "index sites").

B. The study plan shall specify that initial baseline assessments at the index sites and the restoration sites shall be conducted prior to implementation of the habitat restoration projects. The study plan also shall identify the timing, frequency, locations, and manpower requirements necessary to conduct the assessments. With regard to the restoration sites, the study plan also shall specify that a minimum of two additional assessments shall be conducted at each restoration site; the first assessment to be conducted three years after completion of the restoration project and the second assessment to be conducted three years after the previous assessment.

C. Licensee shall file the study plan with FERC, for its approval, within six months of approval by FERC of the report required by Section 3.3.3.2. In the event that the Committee does not reach consensus on the study plan as set forth in Appendix 1, Licensee shall include in the filing with FERC the comments of other Committee members and Licensee's responses to those comments and an explanation why Licensee did not incorporate those comments in the study plan.

3.0 Study Area

The Draft Study Plan for Field Evaluation pursuant to section 3.3.3.3 of the Settlement Offer was submitted to the Indian Pond Fisheries Committee on October 5, 2006 for review and comment. This study plan identified two study areas (See Figure 1), one at Upper Enchanted Stream (ES3) a tributary to the Dead River and one at Lower Cold Stream (CS1) a tributary to the Kennebec River. These areas had specific locations of degraded habitat requiring restoration activities. In addition, one other study area on Upper Enchanted Stream just upstream of the proposed restoration site and one other area on Lower Cold Stream just upstream of the proposed restoration site will be used as index sites.

4.0 Baseline Fish Habitat/Fish Population Assessments at Restoration and Index Sites

The initial baseline assessments at the restoration sites and at the index sites are planned for late summer into late fall of 2007. The exact timing of the initial assessments will be based on conducting these assessments at the optimum time to adequately collect the necessary data. FPL Energy will conduct initial stream morphology and hydrology measurements including but are not limited to: depth, velocity, volume, wetted width, bank full width, substrate type, plan, longitudinal and cross-section profiles. In addition, these sites will be monitored by electrofishing following protocols used by MDIFW for its statewide monitoring program and will also include water quality parameters (benthic macro-invertebrate assemblages, DO, temperature, pH, specific conductivity, and alkalinity) and redd counts. The macro-invertebrate monitoring will follow rapid bio-assessment protocols used by MDEP and temperature will be monitored by continuous data loggers. The other water quality parameters will be measured using standard MDIFW sampling protocols.

All the above measurements and data collection will form the baseline for comparison with future post-construction monitoring activities. The initial baseline assessments will be conducted by two FPLE staff persons trained in environmental sciences and quantitative electrofishing and one fisheries committee member.

5.0 Post-Restoration Project Assessments

At this time, FPL Energy envisions that the restoration projects will be constructed in late summer/early fall of 2008 after FERC approval. In the following fall, one year after completion of the restoration projects at Upper Enchanted Stream and Lower Cold Stream, follow-up assessments will be conducted to monitor changes in stream geometry, aquatic habitat, fish populations, spawning activity and stability of improvements at the restoration sites. The two index sites will also be assessed at the same time. These assessments will include stream morphology and hydrology measurements including but not limited to depth, velocity, volume, wetted width, bank full width, substrate type, plan, longitudinal and cross-section profiles. In addition, these sites will be monitored by electrofishing following protocols used by MDIFW for its statewide monitoring program and will also include water quality parameters (benthic macro-invertebrate assemblages, DO, temperature, pH, specific conductivity, and alkalinity) and redd counts. The macro-invertebrate monitoring will follow rapid bio-assessment protocols used by MDEP and temperature will be monitored by continuous data loggers. The other water quality parameters will be measured using standard MDIFW sampling protocols.

Two additional annual assessments, the same type as the first assessment, will be completed following the first assessment. The follow-up assessments will be conducted by two FPLE staff persons trained in environmental sciences and quantitative electrofishing and one fisheries committee member.

6.0 Reporting

Within six months of completion of the third assessment, FPLE will file a report with FERC documenting the findings of the assessments. A draft of this report will be submitted to the Indian Pond Fisheries Committee for review and comment prior to the FERC submittal. The report filed with FERC will contain Committee comments and recommendations for continuation or termination of the assessments and for any additional enhancements or maintenance commitments, if any, deemed necessary by the Committee.

In addition to the final three year report, brief progress reports will be completed annually by December 31 and submitted to the Fisheries Committee. The reports will include data collected at each site and a short summary of the results. The purpose of the progress reports is to provide information early enough to evaluate the need to make minor adjustments to the restoration projects.

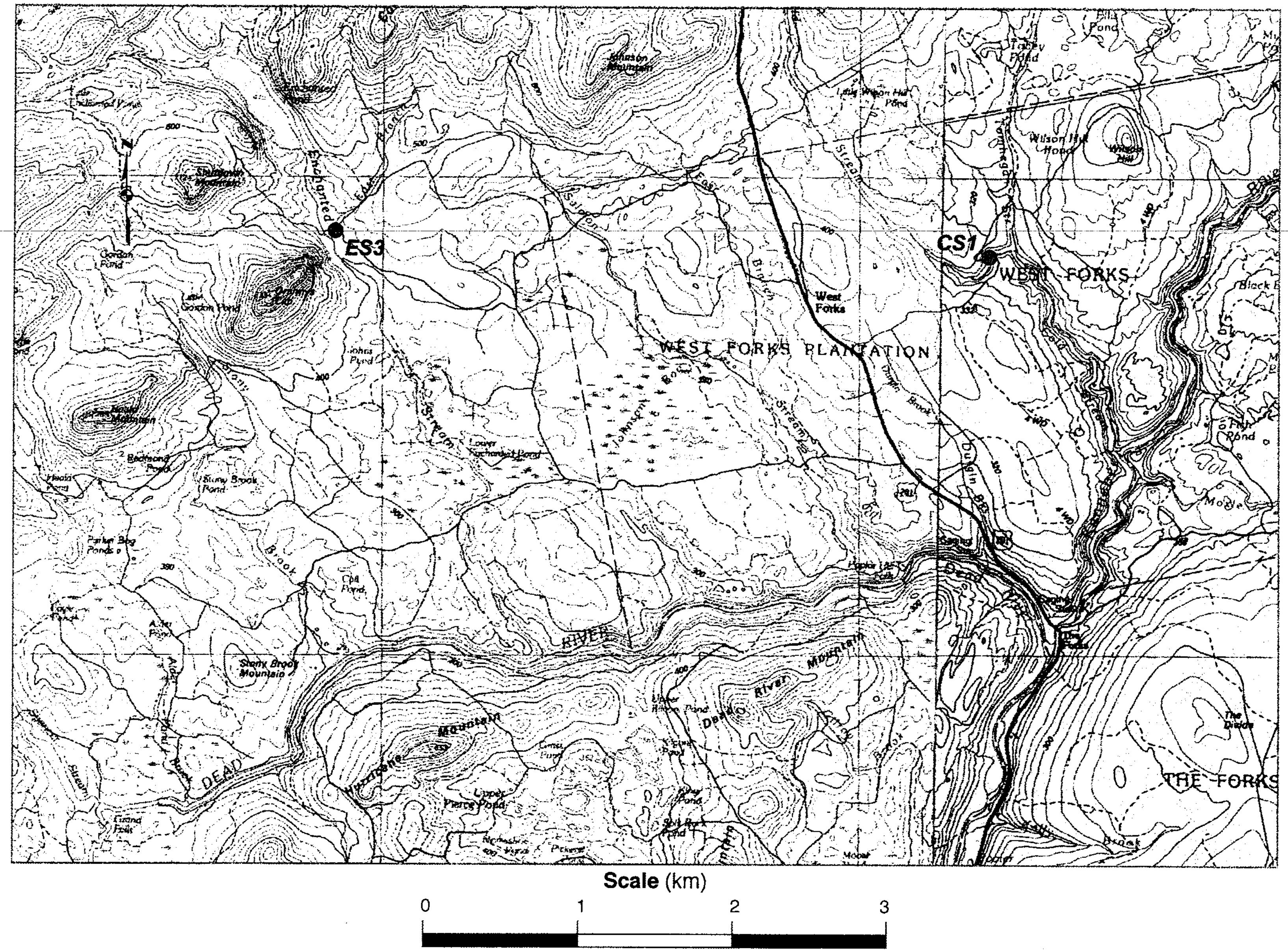

Figure 1. Map showing locations of 3.3.5. fish habitat/fish population assessment sites.

FPL Energy

Licensee Funded Restoration Project Study Plan

Indian Pond Project

(FERC No. 2142-031)

February 28, 2007

Licensee Funded Restoration Project Study Plan

Indian Pond Project

FERC No. 2142-031

1.0 Introduction

This plan describes the contents of the licensee funded restoration project study plan pursuant to section 3.3.7 of the Indian Pond Project Settlement Offer dated July 25, 2001.

2.0 Background

Section 3.3.7 of the July 25, 2001 Indian Pond project contains the following language:

A. Within three years of FERC's approval of the report required by Section 3.3.3.2, Licensee shall construct the following fisheries habitat restoration projects:

- Creation of a side-channel spawning area above the "ball field" in order to provide salmonid spawning habitat (equivalent to 160 hours of Licensee staff time and $8,000 for construction/material/equipment costs).

- Remediation of erosion at four sites within the Project Area to be identified during the field evaluations required by Section 3.3.3.4 in order to improve salmonid habitat (equivalent to 180 hours Licensee staff time and $9,500 for construction/material/equipment costs).

B. In the event that Licensee, in consultation with the Committee, determines, pursuant to the development of the report required by Section 3.3.3.4, that other fisheries habitat restoration projects should be implemented as opposed to the projects identified in this Section, Licensee shall commit the equivalent resources identified in this Section to implementation of these other fisheries habitat restoration projects.

C. In consultation with other members of the Committee, Licensee shall develop a study plan for construction of the habitat restoration projects (or their equivalent) and for post-construction monitoring of these projects. Post-construction monitoring shall include provisions to document the long-term stability of the restoration projects, use of restored and/or created habitat by fish, any unintended changes in adjacent unrestored habitat, and maintenance of the projects so that they are serving their intended purposes. Licensee shall be responsible for the post-construction monitoring. Licensee staff performing the monitoring shall have training and field experience in fisheries biology.

D. Licensee shall file the study plan with FERC, for its approval, within six months of approval by FERC of the report required by Section 3.3.3.2. In the event that the Committee does not reach consensus on the study plan as set forth in Appendix 1, Licensee shall include in the filing with FERC the comments of other Committee members and Licensee's responses to those comments and an explanation why Licensee did not incorporate those comments in the study plan.

3.0 Study Area

The Desktop Review Report pursuant to section 3.3.3.2 of the Settlement Offer was filed with FERC on October 28, 2006, and subsequently approved by FERC on May 11, 2006. The Desktop Review Report identified three study areas (See Figure 1), Salmon Stream (SS1) a tributary to the Dead River and Cold Stream (CS1) and Fish Pond Stream (FPS1), both tributaries to the Kennebec River that had specific locations that require remediation of erosion pursuant to section 3.3.7 A. of the Settlement Offer. In addition, during the August 2006 Fisheries Committee site visit to the selected tributaries there were sites (See Figure 1) on Enchanted Stream (ES3) and Durgin Brook (DB1) both tributaries to the Dead River that were identified as areas with erosion issues. Section 3.3.7 of the Settlement Offer also identified that FPLE needed to create a side channel spawning area (See Figure 1) in the vicinity of the ballfield (BF1) in the Kennebec River.

The Salmon Stream erosion site is located near the mouth of Salmon Stream, just upstream of the new snowmobile bridge. There is an ATV crossing at this location causing some erosion into the stream.

The Cold Stream erosion site is located on lower Cold Stream, just downstream of the old road crossing and former log driving dam. There is an ATV crossing at this location causing some erosion into the stream.

The Enchanted Stream erosion site is located on the East branch of upper Enchanted Stream, just downstream of the existing logging road crossing. There is an ATV crossing at this location causing some erosion into the stream.

The Fish Pond Stream erosion site is located on lower Fish Pond Stream a few hundred yards upstream of its mouth. At this location the stream has jumped its banks and formed a new channel down an adjacent old road. This is causing some erosion into the Kennebec and is causing loss of water volume from the main channel of the stream.

The Durgin Brook Stream erosion site is located at the mouth of Durgin Brook. There is a snowmobile bridge just upstream of the mouth of Durgin Brook that is presently lying

Study Plan for Field Evaluation

on tributaries to the Kennebec and Dead Rivers, Maine

Section 3.3.3.C

Indian Pond Project

FERC No. 2142

prepared by

Benjamin R. Hayes, Ph.D.

for

FPL Energy Maine Hydro LLC

150 Main Street, Lewiston, ME 04240

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

FPL Energy Maine Hydro, LLC (FPLE) owns and operates the Indian Pond Project, a hydroelectric facility in the upper Kennebec River basin in Somerset county, Maine.

In July 2001, as part of the relicensing of the facility, an agreement was reached between Federal Energy Regulatory Commission (FERC), the licensee (FPLE), and a "Fisheries Committee" consisting of representatives from FPLE, Maine Department of Inland Fisheries and Wildlife, U.S. Fish and Wildlife Service, Trout Unlimited, Maine Trout, and The Forks Chamber of Commerce. The settlement agreement proposed that modifications to the main channels of the Kennebec and Dead Rivers were not necessary and that continued investigation of fish habitat in tributaries be performed.

In October 2005, the licensee submitted a desktop review of twenty-four tributaries in the project region (FPL Energy Maine Hydro LLS, 2005). On the basis of numerous factors, this review concluded that eight streams be considered as possible candidates for habitat enhancement: Cold Stream, Tomhegan Stream, Fish Pond Stream, Durgin Brook, Salmon Stream, Alder Pond Brook, Stony Brook, and Enchanted Stream.

In May 2006, FERC approved the desktop review, allowing FPL and the Fisheries Committee to move forward with assessing these streams for fish habitat enhancement. As a first step, a joint field visit by members of the committee was proposed to examine these streams where they are accessible via logging roads.

2. PRELIMINARY STREAM ASSESSMENT

On August 22 and 23, 2006 representatives from the Fisheries Committee inspected the eight streams at seventeen locations where logging roads provided access (Figure 1). This was not an detailed field investigation involving the measurements of hydrogeomorphic parameters or collection of biologic data, but a preliminary assessment of the streams to determine which locations might warrant further investigation. At each locations, the channel conditions were examined and areas of degradation and poor habitat were identified (Table 1). The participants discussed the need and feasibility of modifying the stream channel or installing structures at these locations.

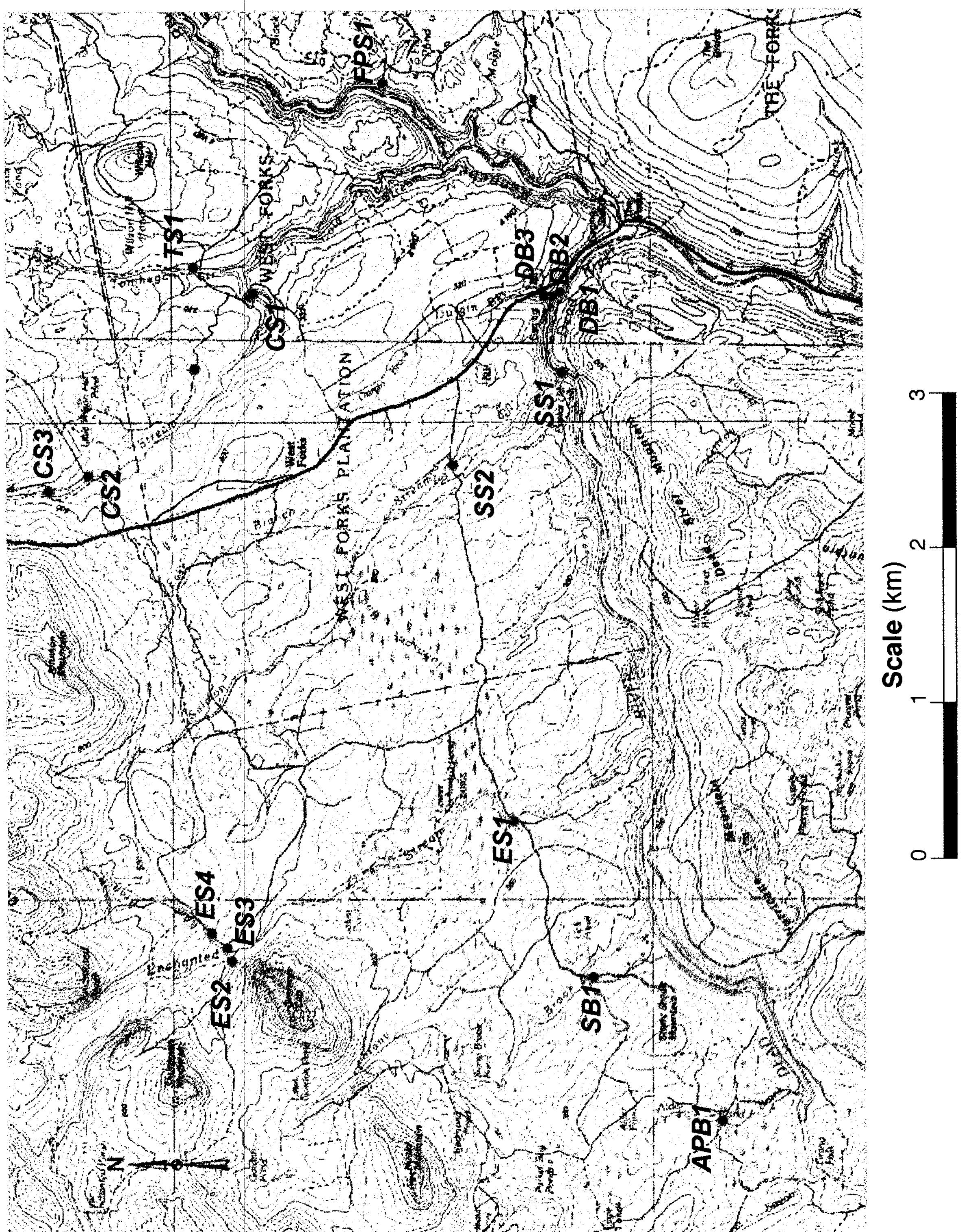

Figure 1. Locations visited during preliminary stream assessment, August 22 and 23, 2006.

Stream	Biologic Factors	Geomorphic Factors	Feasibility Factors
Cold Stream Inspected at three locations, labeled "CS1," "CS2," and "CS3" on Figure 1.	Suitable temperatures and flows for salmonids. A previous study by Bonney (2005) found good trout habitat conditions over most of its length.	Tributary to Kennebec River upstream of the Dead River. Narrow (<10 m), steep, boulder-strewn stream, with abundant pools and riffles, adequate habitat structure and little to no bank erosion. At CS1, the site of former dam, the stream gradient decreases and channel becomes wide and shallow.	Habitat enhancement proposed at CS1 site. Logging road provides accessibility for trucks and excavators. Nearby gravel pit provides source of gravel and boulders. Valley slope on east side of site CS1 is very steep.
Tomhegan Stream Inspected at one location: labeled "TS1" on Figure 1.	Suitable temperatures and flows for salmonids. Good channel habitat and cover over most of its length.	Tributary to Cold Stream and upper Kennebec River upstream of Dead River. Narrow (<10 m), steep, boulder-strewn stream, with abundant pools, riffles, and habitat structure.	Channel modification measures considered unnecessary at this location.
Fish Pond Stream Inspected at several locations; most closely at lower 0.8 km where stream enters Kennebec River, labeled "FPS1" on Figure 1.	Suitable temperatures for salmonids; Small-mouth bass may be present in lower reaches (no data available)	Stream flows out of Fish Pond, a stocked lake on the east side of Kennebec River upstream of the Dead River. Narrow, very steep, boulder-strewn channel cascading down east side of Kennebec river valley near gorge.	Remediation of breached section of channel at FPS1 is recommended. Very steep slopes make access difficult. Also, area receives ATV traffic close to the stream channel at some locations.
Durgin Brook Inspected at several locations in lower 0.6 km where stream enters Dead River, labeled "DB1," "DB2," and "DB3," on Figure 1.	Suitable temperatures and flows for salmonids. Relatively good channel habitat and cover over lower 0.3 km downstream of Rt. 201 culvert.	Channel is narrow and bouldery, with numerous pools and riffles. Thick brush-lined banks and fallen woody debris provide cover and structure. Culvert at Rt. 201 imposes major grade control and fish passage barrier. At DB1, near its junction with Dead River, a collapsed snowmobile bridge causes minor disruption to channel.	Accessible at several locations downstream of Rt 201. Enhancement measures considered unnecessary along downstream reaches, except removal of collapsed snowmobile bridge at DB1.
Salmon Stream Inspected at two locations labeled as "SS1" and "SS2" on Figure 1.	Suitable temperatures and flows for salmonids. Good channel habitat and cover over most of its length.	Channel is narrow and bouldery, with numerous pools and riffles. Thick brush-lined banks and fallen woody debris provide cover and structure.	Channel modification measures considered unnecessary at this location.
Enchanted Stream Inspected at four locations labeled as "ES1," "ES2," "ES3," and "ES4" on Figure 1.	Suitable temperatures and flows for salmonids. Good channel habitat and cover over most of its length.	Channel contains numerous pools and riffles, thick brush-lined banks and fallen woody debris provide cover and structure. East Branch near its junction with mainstem downstream of Enchanted Pond is highly degraded downstream of logging bridge.	Habitat enhancement proposed at ES3 site. Logging road provides accessibility for trucks and excavators. Nearby gravel pit provide source of gravel and boulders.
Stony Brook Inspected at one location labeled as "SB1" on Figure 1.	Suitable temperatures and flows for salmonids. Good channel habitat and cover over most of its length.	Channel is narrow and bouldery, with pools and riffles. Thick brush-lined banks and fallen woody debris provide cover and structure.	Channel modification measures considered unnecessary at this location.
Alder Pond Brook Inspected at one location labeled as "APB1" on Figure 1.	Suitable temperatures and flows for salmonids. Good channel habitat and cover over most of its length.	Channel is narrow and bouldery, with numerous pools and riffles. Thick brush-lined banks and fallen woody debris provide cover and structure.	Channel modification measures considered unnecessary at this location.

Table 1. Factors considered during August 22, 2006 preliminary stream assessment.

3. FINDINGS

3.1. Cold Stream

Channel conditions in Cold Stream were assessed at three locations (CS1, CS2, and CS3 on Figure 1). For most of its length, Cold Stream provides excellent brook trout habitat for both adults and juveniles (Bonney, 2005, p. 7). In its upper reaches at the CS3 site (and probably upstream to the falls in Cold Stream valley), the channel is moderately entrenched, boulder-dominated, with a high width/depth ratio (B2 type) and steep gradient (0.02, estimated from the USGS 7.5 minute quadrangle map). The channel is relatively narrow (4 to 6 m) with low, stable banks composed predominantly of cobble and boulder materials. Pools 1 to 3 m wide and estimated to be 0.5-1 m deep occur every 18 to 20 m, with irregularly-spaced ones formed by large woody organic debris fallen into the channel (Figure 2). Channel bed material appeared to consist predominantly of well-armored cobble and rubble.

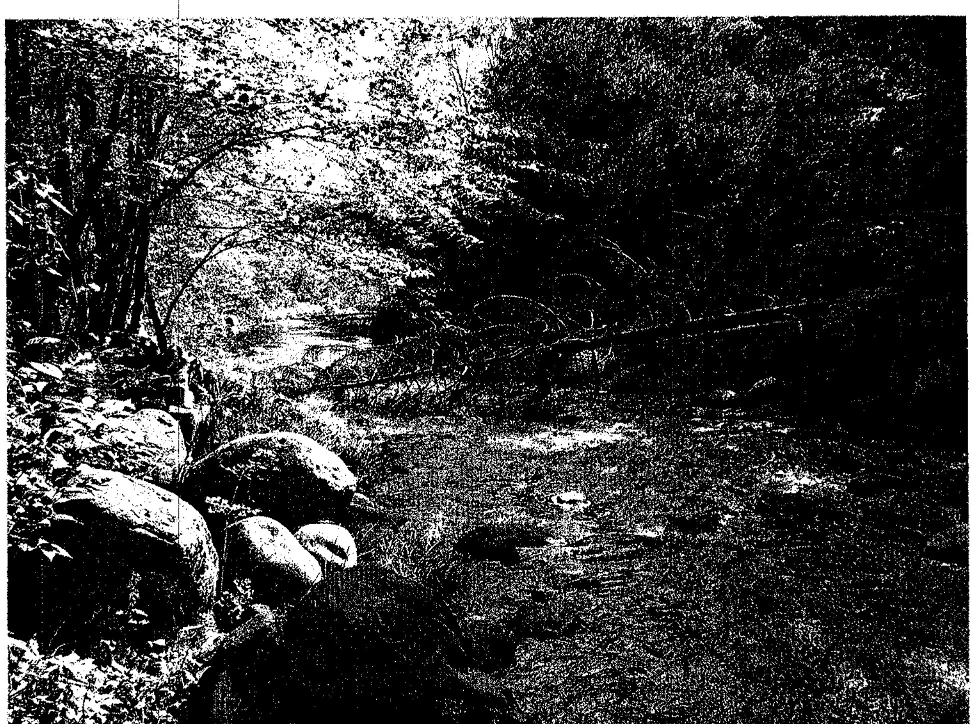

Figure 2. Cold Stream at CS3 (view downstream).

Near the Capitol Road bridge (CS2), Cold Stream is moderately entrenched (C2-type), with a moderately steep gradient (0.011) and 5 to 6 m wide, stable banks. A meandering thalweg flows between alternating longitudinal bars and riffles spaced every 10 to 15 m. Flow depths estimated to be up to 0.5 m. Channel substratum looked to be mostly gravel and cobbles; point bars were entirely submerged during our visit (Figure 3). The adjacent stream banks and floodplain are well-vegetated with grass and low shrubs. Old wooden bridge abutments were sticking out of the bank beneath the modern-day wooden bridge. The extent to which log drives have altered the channel morphology is indeterminable, but its current condition appears stable.

Figure 3. Cold Stream at CS2 (wooden bridge near Capitol Road bridge; view upstream).

Approximately 0.5 km upstream its junction with Tomhegan Stream, Cold Stream is accessible from a gravel road (CS1). Old topographic maps indicate a dam was built here, presumably for logging. Remains of the dam were not detected during the site assessment and its precise location remains unknown. However, the valley width narrows to 17.5 m at this location and steep slopes on east banks (visible in Figure 4) suggest the headwall of the dam was located near the present-day gravel road abutments on either side of the valley. Upstream of this point, the channel becomes noticeably wider and shallower, and the stream bifurcates around several large, vegetated bars (Figure 4). From the vantage point of the west valley side, it appears that channel continues to store a significant quantity of coarse sediment upstream of the former dam site. It is well vegetated and appears stable and not actively being transported. However the channel gradient is reduced and the stream because wide and shallow for a distance of several hundred meters downstream.

Several broad, shallow pools exist in this reach. The channel widens downstream of the gravel road abutment (Figure 5). Elongated bars up to 5 m long and composed of what appeared to be gravel and cobble-sized material create two or three broad pools. However, the channel lacks significant structure. Large organic debris was absent from the channel in this reach. Further downstream, an overbank flow channel, with flood debris jammed in the riparian vegetation, exists in the low-lying area on the right side of the channel. The stream appears to steepen and narrow further downstream.

Figure 4. Cold Stream at CS1 (view upstream of channel at former dam site).

Figure 5. Cold Stream at CS1 (view downstream from gravel road abutment toward right bank).

3.2. Tomhegan Stream

Tomhegan stream is accessible by an unpaved logging road at TS1. Here the stream is moderately entrenched (B3c type) and developed in very coarse glacial materials with a channel gradient of approximately 0.027 (estimated from USGS topographic map). The channel bed morphology appears to be dominated by cobble and boulders and characterized by a series of rapids with irregularly spaced pools up to 4 m across and estimated to be up to 0.5 m deep. Channel width was 5.6 m wide with stable banks extending 0.5 m above channel bottom. The large boulders in the channel are not actively being transported and are believed to be lag deposits. Numerous chutes and eddies are formed as flow diverts around large boulders in the channel or near its edges. Stream was mostly wooded and well-shaded, with numerous fallen trees and roots providing fish habitat. The water was clear, cold (15 °C), and appeared well-oxygenated. Numerous invertebrates could be found on the undersides of rocks picked up from the stream bottom.

Figure 6. Tomhegan Stream at TS1 (view upstream).

3.3. Fish Pond Stream

Over most of its length, Fish Pond stream is a steep, cascading stream (A2b type) flowing down the steep east valley side of Kennebec River near its gorge section. The stream channel is generally narrow, 2 to 4 m wide, with low banks. The water was clear, cold (15 °C), and flowing in and out of hyporheic zone in the bouldery stream banks. Water flow in the main channel plunges through small intermittent pools up to 1 m across and 0.65 m deep and spaced every 6 to

10 m. The substratum consisted of loose, coarse gravel and cobbles. Large boulders within channel provided numerous chutes and pools. Stream flows most of its length through a mature forest, with well-vegetated floodplain.

Figure 7. Fish Pond Stream at FPS1, near its junction with the Kennebec River (view upstream).

3.4. Durgin Brook

Durgin Brook is accessible downstream of a Route 201 (DB1, DB2, and DB3). Here, the stream is a B3c type, moderately entrenched channel developed in very coarse materials with a steep channel gradient of 0.025 (estimated from USGS topographic map). The channel bed morphology appears to be dominated by cobble and boulders and characterized by a series of rapids with irregularly spaced pools up to 3 m across and estimated to be 0.2 to 0.6 m deep. Channel widths averaged 5 to 6 m wide with stable banks extending 0.8 to 1 m above the channel bottom. The large cobbles and boulders originated from lag deposits that are the result of continental glaciation. Gravelly substratum, with numerous chutes and eddies behind boulders near edges of channel. Mostly wooded, shaded reach, with fallen trees and roots providing fish habitat a places along the channel. Water was clear, cold, and appeared well-oxygenated. Numerous invertebrates could be found on the undersides of rocks picked up from the stream bottom.

Figure 8. Durgin Brook at DB2, approximately 150 m downstream from Route 201 culvert.

3.5. Salmon Stream

Salmon stream is accessible downstream of a logging road crossing (SS1). Here, the stream is a C3 to C2 type, slightly entrenched system developed in very coarse glacial materials with an approximate channel gradient of 0.010 (estimated from USGS topographic map). Further upstream, the channel becomes wider and less steep (B3-type morphology). The channel bed is dominated by cobble and boulders and is characterized by a series of rapids with irregularly spaced pools 2 to 4 m across and estimated to be 0.5 to 1.5 m deep (Figure 9). Channel widths were generally less than 8 m, with stable banks extending 0.5 to 2 m above channel bottom (Figure 10). Substratum appeared to be predominantly gravel and cobbles, with numerous boulders up to 1.5 m scattered throughout the channel. Stream was well shaded by the forest canopy, with fallen trees providing good habitat a several places along the channel (Figure 11). Water was clear, cold, and appeared well-oxygenated. Numerous invertebrates could be found on undersides of rocks picked up from the stream bottom.

Figure 9. Salmon Stream at SS1 (lower road along Dead River; view upstream).

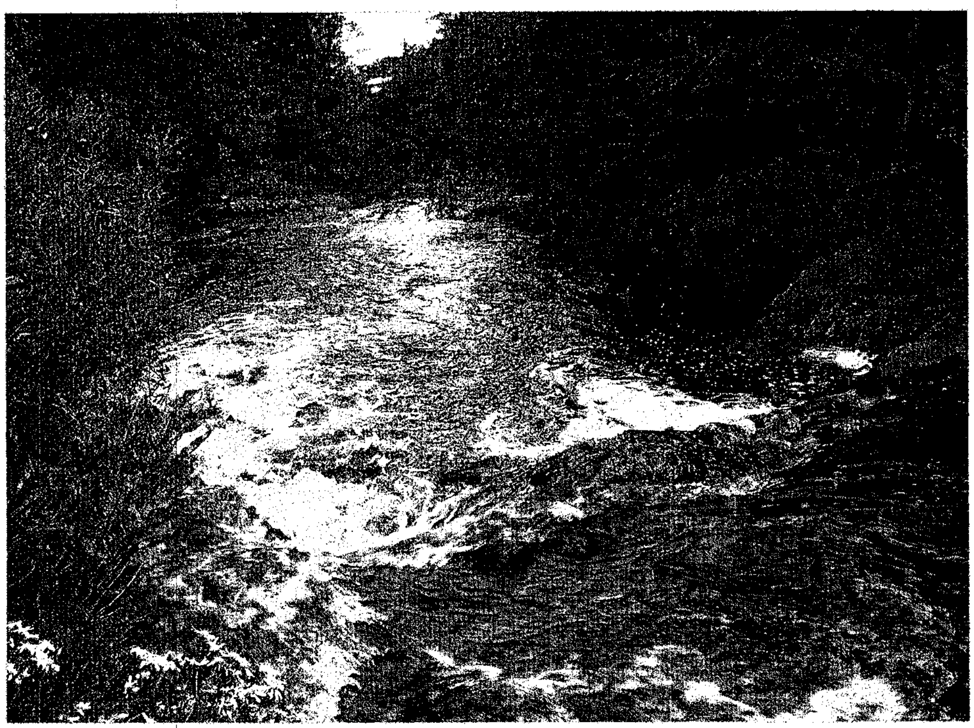

Figure 10. Salmon Stream at SS2 (Lower Enchanted Road bridge; view downstream).

Figure 11. Salmon Stream at SS2 (Lower Enchanted Road bridge; view upstream).

3.6. Alder Pond Brook

Alder Pond stream is accessible by an unpaved logging road along the Dead River (APS1). Here, the stream is a E4 type, with slightly entrenched channel developed in coarse gravel and cobble materials and a gentle gradient of 0.003 (estimated from USGS topographic map). The channel is characterized by a moderately high width/depth ratio and series of rapids with irregularly spaced pools. Bankfull width were estimated to be less than 6 m wide with stable banks extending 1 to 1.5 m above channel bottom (Figure 12). Substratum appeared to consist predominantly of gravel and cobbles, with small, elongated pockets of gravel along the channel banks in places. Stream is moderately well-shaded, with riparian shrub roots providing limited cover along the edges of channel (Figure 13). Water was clear, slow flowing, and moderately warm (20 °C) as it flows out of Alder Pond, located 0.5 km upstream. Invertebrates were be found on undersides of rocks picked up from the stream bottom.

Figure 12. Alder Pond Brook at APB1 (view upstream).

Figure 13. Alder Pond Brook at APB1 (view downstream).

3.7. Stony Brook

Stony Brook is accessible by an unpaved logging road along the Dead River (SB1). Here, the stream is a E3 type, slightly entrenched system developed in coarse gravel and cobble materials with an approximate channel gradient of 0.006 (estimated from USGS topographic maps). The channel is characterized by a moderately high width/depth ratio and series of rapids with irregularly spaced pools up to 4 m long and estimated to be 0.5 to 1 m deep (Figure 14). Channel widths ranged from 5 to 8 m wide with stable banks extending 0.8 to 2 m above channel bottom. Substratum appeared to consist predominantly of cobbles and boulders, with numerous chutes and eddies behind boulders near edges of channel. Mostly wooded, shaded reach, with fallen trees and roots providing fish habitat a places along the channel. Numerous invertebrates could be found on the undersides of rocks picked up from the stream bottom.

Figure 14. Stony Brook at SB1 (view upstream).

3.6. Enchanted Stream

In its lower reaches, Enchanted Stream is accessible as it flows out of Lower Enchanted Pond (ES1). Here the stream is 11.9 m wide and relatively warm (18.5 °C). On the downstream side of Lower Enchanted Road bridge the channel widens downstream of the bridge, due to a bedrock grade control (Figure 15). A broad backwater area with lily pads exists on the right side of the channel downstream of the bridge. Further downstream, an old pulp chute is present on the left bank (behind the aluminum travel trailer in Figure 15). This feature, along with an unnatural-looking line of boulders in the woods further downstream, are believed to be remnants of former logging operations. A broad, vegetated floodplain is present on both sides of the stream with water flowing visibly through the bouldery hyporheic zone where it exposed around tree roots.

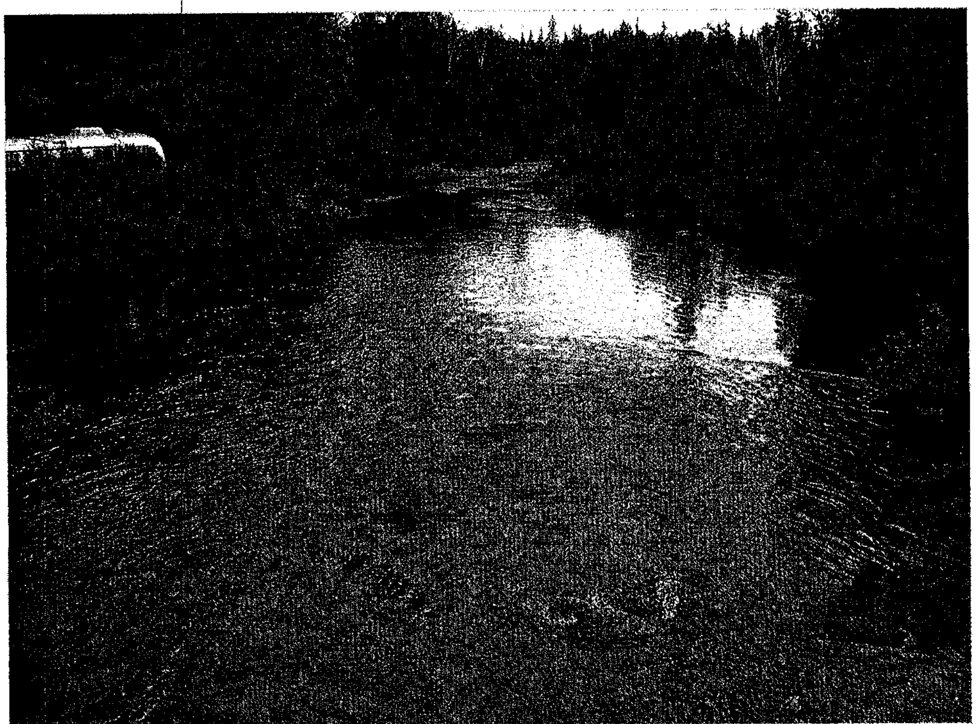

Figure 15. Enchanted Stream at ES1 (Lower Enchanted Road bridge; view downstream).

Figure 16. Enchanted Stream at ES1 (Lower Enchanted Road bridge).
View is upstream toward Lower Enchanted Pond.

As it flows out of Enchanted Pond in its headwater reaches (ES2) is a low-gradient, meandering stream (E3 type), with narrow, grassy channel flowing through broad alluvial valley. Channel bottom appeared to be composed of predominantly cobble-sized material, with elongated pools and occasional alternate gravel bars (Figure 17). The stream meanders through a low-gradient marsh area that has developed naturally on the broad, glaciated "bench" on the side of the Dead River. This regional, low-gradient, bog region extends east-west in a broad band about 1 km wide and is easily visible on topographic map (Figure 1). Numerous natural ponds exist in this area, including Alder Pond, Stony Brook Pond, Lower Enchanted Pond, and Johnson Pond.

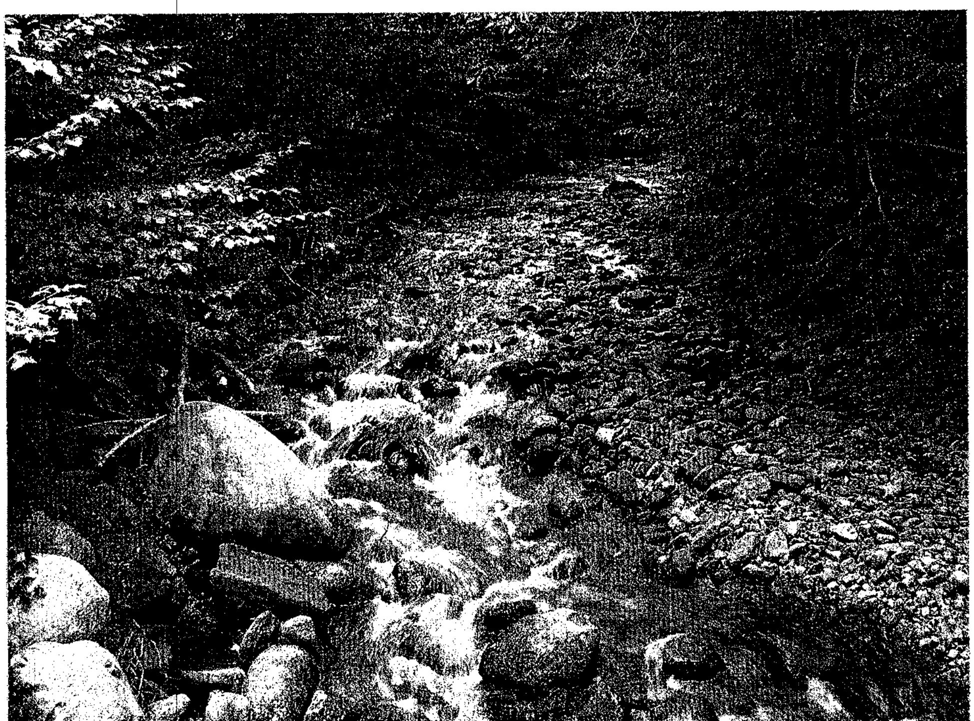

Figure 17. Enchanted Stream at ES2 (view upstream).

The East Branch of Enchanted Stream is accessible by an unpaved logging road near its junction with Enchanted Stream (ES3). In its upstream reaches (ES4) the stream is well-entrenched, steep B2/B3-type system, with numerous pools and riffles and stable banks. However, further downstream at ES3, the channel is degraded with bank erosion along its left bank extending 40 to 50 m downstream of the logging road bridge. An ATV crossing on the downstream side of the stream further acerbates the channel condition (Figure 18). Here the channel 10.8 m wide, 0.2 m deep and relatively warm. Organic material was largely absent from the stream channel substratum and only one mayfly larvae was found on the rocks picked up off the bottom. Approximately 50 m downstream from the bridge, an abandoned channel is present on the right outside of the meander (Figure 19).

Figure 18. East Branch of Enchanted Stream at ES3 (view downstream).
The line of boulders crossing the stream in the foreground is the edge of an ATV crossing.

Figure 19. East Branch of Enchanted Stream ES3, approximately 50 m downstream from logging road bridge (view downstream). Abandoned overflow channel extends into woods on floodplain.

4. RECOMMENDED PLAN

During the August 2006 preliminary stream assessment, representatives from the Fisheries Committee arrived at a general consensus was reached as to which sites were the best candidates for stream habitat enhancement projects. It was agreed that:

(*a*) Stream improvement measures are not warranted at access points in Tomhegan Stream, Durgin Brook, Salmon Stream, Stony Brook, and Alder Pond Brook.

(*b*) Stream improvement measures are recommended in Cold Stream at CS1 (Figure 20) and the East Branch of Enchanted Stream at ES3 (Figure 21). A "natural streams design" approach (Rosgen, 1996; 2001) should be used to design habit enhancement structures and modify existing channel features. Details regarding this improvement effort is provided in sections 4.1 through 4.3 below.

(*c*) Stream improvement measures are needed in Fish Pond Stream near its junction with the Kennebec River at FPS1, where the stream has breached its left bank and a portion of the flow is now down a secondary channel cut into an old jeep trail running parallel to the stream. The coarse material comprising the breached banks will inhibit efforts to divert water back to the original channel. This improvement effort is addressed in a separate document, Section 3.3.7 licensee-funded restoration project study plan.

(*d*) Low-level concrete barriers could be installed on bedrock outcroppings in streams such as Salmon Stream at SS2 to prevent upstream migration of small-mouth bass. This improvement effort is addressed in a separate document, Section 3.3.7 licensee-funded restoration project study plan.

(*e*) Recreational vehicle (ATV) crossings next to logging road bridges should be barricaded to prevent degradation of the stream bank and channels at these locations. An example of this is shown in Figure 18 for the East Branch of Enchanted Stream. This improvement effort is addressed in a separate document, Section 3.3.7 licensee-funded restoration project study plan

(*f*) After restoration of the CS1 and ES3 sites is completed, it may be a good idea for the Fisheries Committee to consider using the remaining settlement funds to purchase riparian easements in selected areas of the watershed. These easements would help ensure the long-term integrity of the riparian corridors and better protect the streams from adverse impacts from logging and gravel mining in the region.

4.1. Detailed site characterization studies

Based on the preliminary stream assessment, we propose a detailed site investigation be performed at sites CS1 and ES3 to characterize the topographic, geomorphic, hydrologic, and biologic conditions at these locations (Figures 20 and 21).

A. Topographic surveys

Topographic surveys locate and measure the elevations of the stream channel and adjacent floodplain features. Survey boundaries should extend several hundred meters downstream and upstream of the degraded reach. The survey data can then be used to develop a digital terrain model of the stream reach which includes cross sections, longitudinal profiles and contour maps of existing channel features. Topographic data collected should include measurements of channel bed and water surface and bankfull elevations where structures are proposed.

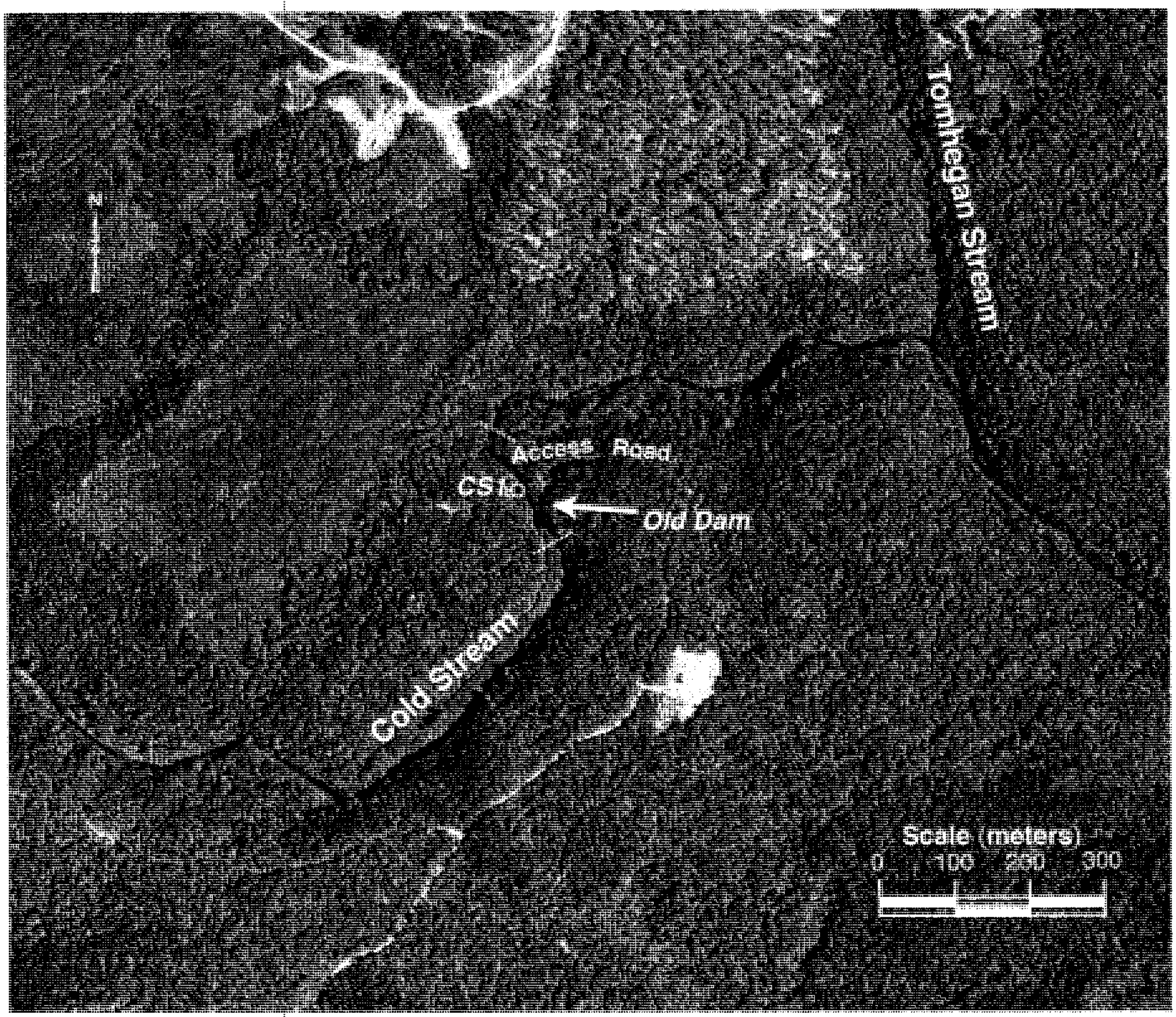

Figure 20. Aerial photograph of Cold Stream at CS1, old dam site near its junction with Tomhegan Stream. Section of channel between the two dotted lines is where detailed field studies for channel modification and habitat enhancement measures are proposed.

B. Geomorphic surveys

Geomorphic surveys provide information regarding dominant discharge, shear stresses, and the size of the sediment in the channel, as well as the size of sediment being transported and deposited during high-flow conditions. Geomorphic surveys are critical because the particle size and local hydraulic conditions determines the type of channel structure (e.g. a flow constrictor, step pools, or riffle grade control) will be used to enhance fish habitat. Data to be collected in this phase includes pebble counts on the stream bed and entrainment particle size measurements on any side, point, and mid-channel bars. Procedures for conducting geomorphic surveys may be found in Rosgen (1996) and Appendix A of this study plan. A list of geomorphic parameters to be measured and computed is also provided in Appendix 1. As a general rule, if the dominant particle size is sand or gravel, riffle grade controls are the structure of choice. Flow constrictors or step pools are preferred if the median particle size is cobbles or boulders.

On the basis of these detailed topographic and geomorphic surveys, a conceptual model of each stream is developed. Since both CS1 and ES3 reaches are degraded and appear to be in a period of adjustment, the field investigation will also require looking at the stream in undisturbed sections to develop a "natural reference" model of equilibrium channel conditions. This "reference" reach model then serves as a basis for the "natural channel design."

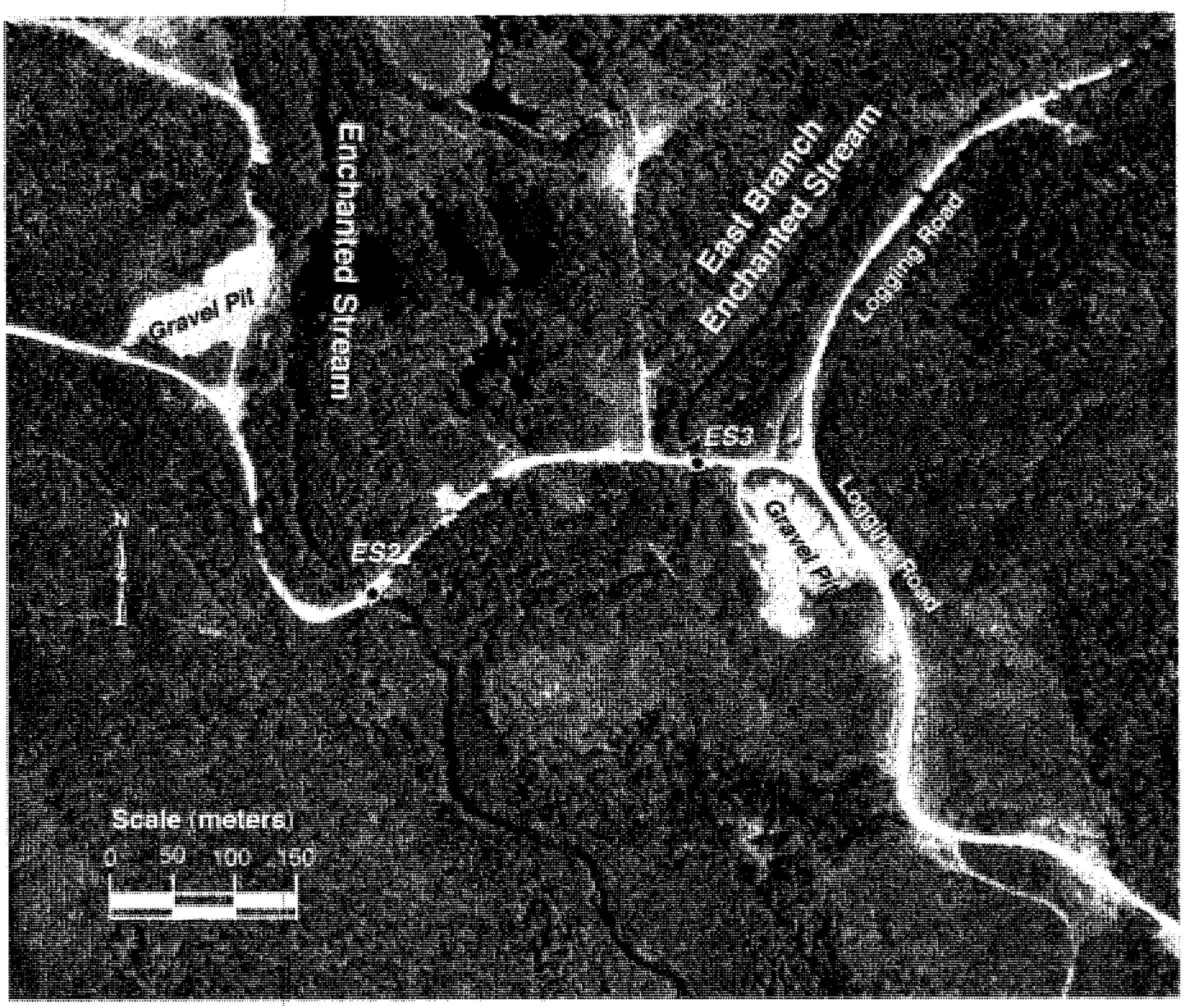

Figure 21. Aerial photograph of East Branch of Stream (ES3), near its junction with Enchanted Stream downstream of Enchanted Pond. Section of channel between the two dotted lines is where detailed field studies for channel modification and habitat enhancement measures are proposed.

C. Hydrologic assessment

None of these tributaries are gauged for discharge or bankfull stage data. Therefore, proxy data must be used to develop an understanding of the timing and magnitude of discharges that may occur in these streams during times of snowmelt and peak runoff events. Mean daily discharge data from unregulated streams in the region can be obtained from the U.S. Geological Survey. From a range of available gage sites, bankfull discharge values can be correlated with drainage area. This correlation can then be used to estimate bankfull discharges at CS1 and ES3 sites by measuring drainage area from U.S. Geological Survey quadrangle maps. Bankfull discharge is needed to design the most stable channel dimensions for a given geomorphic and hydrologic regime.

If accurate bankfull discharge-drainage area relations cannot be developed from regional hydrologic data, then actual stream flow measurements will need to be done under a range of discharge conditions at the stream sites. This is labor-intensive and potentially dangerous work, involving wading into stream and taking flow velocity measurements at various depths and locations within the channel. This information is combined with channel cross-section surveyed at these locations to compute accurate discharges. The flow velocity measurements also provide one to accurately determine shear stresses along channel boundaries.

D. Habitat assessment to determine improvement goals

Within the study boundaries, a generalized assessment of the fish habitat should be conducted to identify what adverse conditions are affecting the trout populations. These may include:

- (*a*) poor depth at low flow runoff periods
- (*b*) extreme water temperatures
- (*c*) lack of in-stream cover
- (*d*) lack of overhead cover important for sense of security for trout, terrestrial insects, and shade;
- (*e*) lack of spawning habitat;
- (*f*) lack of rearing habitat; and
- (*g*) excessive sediment deposition.

Limiting factors determined from this assessment are combined with information from the hydrogeomorphic data to determine specific habitat improvement goals (type and number of structures) at CS1 and ES3 sites.

An assessment of the fish habitat conditions at the sites enables one to compile a matrix of limiting factors can be used in designing a solution (Table 2).

Element	Existing Condition	Desired Condition
Riparian Condition	Poor to fair 1. Presence of draw bottom roads, ATV crossings (reduced habitat quality 2. Lack of and/or very early stages of hydrophotic vegetation 3. Canopy closure < 60% 4. % deciduous cover < 40%	No data, but well vegetated banks and floodplains ideal.
Streambank Stability	1. CS1 = 85% *(rough estimate)* 2. ES3 <60% *(rough estimate)*	Greater than 90%
Floodplain Connectivity/ Entrenchment	No data	Facilitate development of single thread channel, appropriate sinuosity, and gradient with reduced channel widening
Width/Depth Ratio (Bankfull)	No data; estimated to be poor to good 1. CS1 = 40 to 70 *(rough estimate)* 2. ES3 = 25 to 30 *(rough estimate)*	Generally less than 18 for Rosgen B-type channels
Substrate embeddedness	No data	No data
Large Woody Debris (LWD)	1. Poor at CS1, very little in channel. 2. Large log jam exists at downstream end of ES3, but none in main reach.	More than 20 pieces per km
Pool frequency and area	No data; estimated to be: 1. fair at CS1 2. poor to fair at ES3	1. Variable depending on channel type. More than 15 pools per km desirable, with a channel morphology that maintains and develops suitable pool/ riffle sequences. 2. Greater than 35% area ideal
Off-channel rearing habitat	No data	Single thread channel and more stable geometry to provide greater floodplain/ riparian recovery.
Water quality (temperature) and quantity	No data	Cool (<20 C) and sediment-free.
Flow regime	No data	Unknown. Moderate frequency and magnitude of flood events, dependent on floodplain connectivity and riparian condition.

Table 2. Limiting factors to consider during design and installation of fish habitat enhancement measures on Cold Stream at CS1 and East Branch of Enchanted Stream at ES3.

4.2. Design and construction considerations

The selection of appropriate channel modification measures and design of structures will be based on the hydrogeomorphic information collected during the site characterization study. Construction activities will be performed only when site conditions meet the basic requirements described below.

Some structures may involve small-scale isolation of working areas in the stream bed. Work site isolations would be designed site specifically and may require the use of small, temporary coffer dams and sand bags. Such isolation of the work area would be used to facilitate wood and rock placement while minimizing turbidity. Complete, large-scale and long-term stream diversion will not be necessary. The scenario resulting in the largest impact would involve moving the thalweg at either site during construction. The contractor would work closely with Fisheries Committee to minimize impacts.

A. Gravel placement associated with structure installation

For work in gravel poor areas, clean, washed, 4-inch gravel may be imported and placed upstream of the structure. When placing large woody debris on the outside of meander bends, bar material can be removed from the inside of the meander bend and relocated immediately up and/or downstream of the new structure without use of a coffer dam. Typically this encourages realignment of the thalweg and resulting scour and also protects the new structure. During the summer low flow conditions, some of the gravel bar may be dry. A maximum of five to ten scoops may be removed with water contact. Piling up the gravel near the structure would result in only the first five scoops having water contact. The sand and gravel removal and sand and gravel placement would result in a total maximum increase in turbidity of approximately one hour. Turbidity levels would be sublethal because of work with very coarse material and short duration of activity in the wet portions of the channel.

B. Large woody debris collectors

Storage of organic material is critically important to restore aquatic productivity and several structures, such as logjams and root-wad clusters, can be constructed to capture and store organic material. These engineered logjams also store and sort sediment and increase usable pools and spawning habitats. If necessary to ensure stability, large woody debris may be anchored with rocks, stakes, cables, or be partially buried in the bank.

C. Habitat complexity

Complexity is needed to enhance rearing and spawning conditions for salmonids. We propose adding appropriately sized large woody debris collectors and/or boulder clusters where needed, using tracked excavator or direct falling of trees into streams depending on site conditions. Trees will only be felled from the riparian zone into the stream if the riparian zone is intact, cover will not be decreased below 70 percent, elevated temperatures are not a problem in the stream, and hydrology, riparian and bank conditions are such that no avulsion will occur. To ensure stability and long-term function, it may be necessary to bury logs into stream banks, cable trees to bedrock/boulder anchors, increase mass of the log jam by bolting and/or cabling logs together, or use long logs that will wedge against streamside trees. Boulders placed on bedrock may require pinning to ensure long-term stability.

D. Constructing log weirs

If determined necessary, log weirs can be built by a contracted crew using hand-operated, electric or battery powered, or pneumatic drills run by an air compressor. A track hoe and trucks may be utilized to haul the equipment to areas where needed. Gas powered equipment such as Hilti drills and chainsaw winches will be used if electric or battery operated tools are not available. Stainless steel cable will be used to attach the logs to eyebolts drilled and anchored or epoxy glued into the bedrock stream bed using the Hilti method. The epoxy glue is pre-mixed in standard glass vials that are placed in the bottom of the drilled hole. The eyebolt is inserted in the hole and a hammer is used to drive the eyebolt down onto the glass tube containing the epoxy, breaking and mixing the glue in one motion.

E. Structures to improve channel-floodplain connection

A number of "natural channel design" structures may be used: boulder clusters, individual boulders, log/pile cribs, cross-vanes, j-hooks, w-vanes, and engineered riffle construction (Rosgen, 1996; and Rosgen 2001). The goal of constructing any of these structures would be to modify flow in the existing channel in ways that would:

- (*a*) improve floodplain connections to channels habitats;
- (*b*) restore low flow channel formation;
- (*c*) improve riffle-pool and width-depth ratios;
- (*d*) increase sub-surface (hyporheic) flow;
- (*e*) reduce water temperatures;
- (*f*) increase macro-invertebrate habitat; and
- (*g*) increase formation of active channel riparian plant growth in stable gravel bars.

The type, number, and dimensions of any structure will depend upon information collected during the topographic and geomorphic surveys.

F. Bank stabilization

At the ES3 site, bank stabilization measures may improve conditions downstream from the logging road bridge. The banks may be stabilized using bioengineering (deformable) techniques that incorporate elements of large woody debris and anchor rock placement to address near bank shear stress. The intent is to reduce/eliminate stream bank erosion and to stabilize the stream banks while riparian treatments mature. Work will be conducted in areas where there is no evidence of recent spawning. A tracked excavator will most likely be used for placement of rock and wood. Work would occur in areas where access is easy and minimal disturbance of riparian habitat would occur. In-water work would be limited to areas with low flow near the edges of the wetted channel on gravel bars and solid banks. No methods with hard rock (bank hardening) that prevent meandering will be used such as riprap and toe rock. These structures are intended to enhance and provide habitat as well as survival of listed species. The benefits should be felt throughout the seasonal variations in the river systems where they are constructed. Technical expertise for the design of these structures will come from consultants.

G. Minimizing sedimentation during construction

Downstream impacts from sedimentation will be minimized by limiting excavation in the wetted channel width to no more than 45 minutes to an hour at each excavation location or a cumulative total of six to eight hours to install an individual structure such as cross-vein, log-weir, or j-hook.

4.3. Manpower requirements

Stream enhancement efforts will be overseen by a team of at least three individuals:
(1) a fisheries biologist from FPLE who is familiar with the project area,
(2) a fluvial geomorphologist experienced in field mapping and natural channel design methods, and (3) a representative from the Fisheries Council.

Their work load will consist primarily of the following:

(*a*) collection and analysis of spatial data (topographic surveys, maps and digital images);
(*b*) collection and analysis of hydrologic data (flow velocities and discharges);
(*c*) characterization of channel and floodplain morphology (including pool/riffles, stream banks, channel bars, and thalweg) and sedimentology of alluvial materials;
(*d*) accurate topographic surveying of channel cross sections and longitudinal profiles;
(*e*) development of "reference" reach models and "design" reach models;
(*f*) design and installation of habitat structures;
(*g*) design and installation of bank erosion or in-channel modification measures.

This team will require additional help at various stages of the project.

During the **site characterization phase** (items "*a*" through "*d*" above and described in section 4.1), one to three field technicians may be required to help collect field topographic, geomorphic, and hydrologic data.

During the **construction and installation phase** (items "*f*" and "*g*" above and described in section 4.2) a construction crew comprised of: (a) tracked backhoe operator, (b) logging truck driver/operator, and (c) one or two individuals to assist in the drilling and installation of logs, boulders, rock bolts, and steel cables. If bank stabilization is required at any location and methods using live plants (such as willow-mats) are used, a bioengineering specialist may be employed to procure the materials and oversee the installation of the root mats.

Site **cleanup and post-monitoring** will be overseen by the team of biologist, geomorphologist, and Fisheries Committee representative. Post-monitoring efforts will include at a minimum, inspection of the channel and habitat structures in the late spring/early summer after annual snowmelt and during low-flow conditions in late summer/early fall.

5. CONCLUSIONS

Based on a preliminary stream assessment conducted by representatives of the Fisheries Committee in August 22, 2006, habitat improvement is warranted and feasible at two locations: Cold Stream at an old dam site and East Branch of Enchanted Stream near its junction with the main stem of Enchanted Stream.

At both these sites, the channels may be in a protracted phase of morphologic adjustment which can adversely impact the long-term effectiveness of the restorative structures. Changes in sediment and water yield that have occurred, or are occurring, due to historical land use changes and/or major flood events in upstream portions of the drainage basins may need to be considered.

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Rosgen, D. 2001. *River Restoration & Natural Channel Design*, Wildland Hydrology, Pagosa Springs, CO.

APPENDIX 1

A. Morphological parameters determined for stream channel *(after Rosgen, 1996)*.

Variable	Existing Channel	Proposed Reach	Reference Reach	As Built
1. Stream Type (*Rosgen classification*)				
2 Drainage area, sq. mile (A)				
3. Bankfull width (W_{bkf})				
4. Bankfull mean depth (d_{bkf})				
5. Width/depth ratio (W_{bkf}/d_{bkf})				
6. Bankfull cross-sectional area (A_{bkf})				
7. Bankfull mean velocity (V_{bkf})				
8. Bankfull discharge, cfs (Q_{bkf})				
9. Bankfull Maximum depth (d_{max})				
10. d_{riff}/d_{bkf} ratio				
11. Low bank height to max. d_{bkf} ratio				
12. Width of flood prone area (W_{fpa})				
13. Entrenchment ratio (W_{fpa}/W_{bkf})				
14. Meander length (L_m)				
15. Ratio of meander length to bankfull width (L_m/W_{bkf})				
16. Radius of curvature (R_c)				
17. Ratio of radius of curvature to bankfull width (R_c/W_{bkf})				
18. Belt Width (W_{blt})				
19. Meander width ratio (W_{blt}/W_{bkf})				
20. Sinuosity (stream length/valley distance) (k)				
21. Valley slope (*ft/ft*)				

Variable	Existing Channel	Proposed Reach	Reference Reach	As Built
22. Average slope (S_{avg})=(S_{valley}/k)				
23. Pool Slope (S_{pool})				
24. Ratio of pool slope to average slope (S_{pool}/S_{bkf})				
25. Maximum pool depth (d_{pool})				
26. Ratio of pool depth to average bankfull depth (d_{pool}/d_{bkf})				
27. Pool width (W_{pool})				
28. Ratio of pool width to bankfull width (W_{pool}/W_{bkf})				
29. Ratio of pool area to bankfull area				
30. Pool to pool spacing (p-p)				
31. Ratio of pool to pool (p-p) spacing to bankfull width (p-p/W_{bkf})				

B. Sediment transport parameters to determine for channel bed materials

1. Particle size distribution of channel material: d_{16}, d_{35}, d_{50},.d_{80}, d_{95}
2. Particle size distribution of bar material: d_{16}, d_{35}, d_{50},.d_{80}, d_{95}
3. Largest size particle at the toe (lower third) of bar
4. Lithology of channel material (rock type, mineral composition)

Sediment Transport Regime	Existing	Proposed
Calculated τ value (mm) from curve		
τ value from Shield Diagram (lb/ft^2)		
Critical dimensionless shear stress τ^*		
Minimum mean d_{bkf} calculated using critical dimensionless shear stress equations		

C. Field survey procedures for characterizing stream morphology *(after Rosgen, 1996)*

On the stream under consideration, locate a reach for a minimum of 20 channel widths. This reach should characterize or represent the dimension, pattern, profile, and materials of the stream selected for habitat enhancement. Select the reach starting point for the survey at the upstream location. Locate reach on aerial photo and topographic map.

1. Channel cross-section morphology and dimensions

A. Establish a cross-section at the start of the survey reach.

Establish a permanent benchmark to tie both cross-section and longitudinal profile to an elevation control for future comparison. The benchmark should be located a sufficient distance from the edge of the bank to prevent loss of the reference elevation by lateral erosion. The benchmark should be of a permanent installation using concrete with stove bolt into a "cone hole". Another alternative is to drive a length or 5/8" rebar into the ground and place a cap over it. (Figure A1.1).

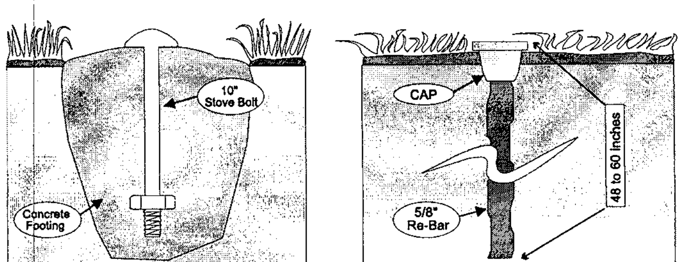


Figure A1.1. Installation of survey benchmarks.

B. Survey channel cross-sections. Each cross-section needs to show:

- Benchmark elevation and location
- Terraces and floodplain width (W_{FPA})
- Flood prone area width and depth
- Bankfull width and stage (both left and right banks)
- Existing left and right edge of water
- Variability in shape of cross-section
- Thalweg

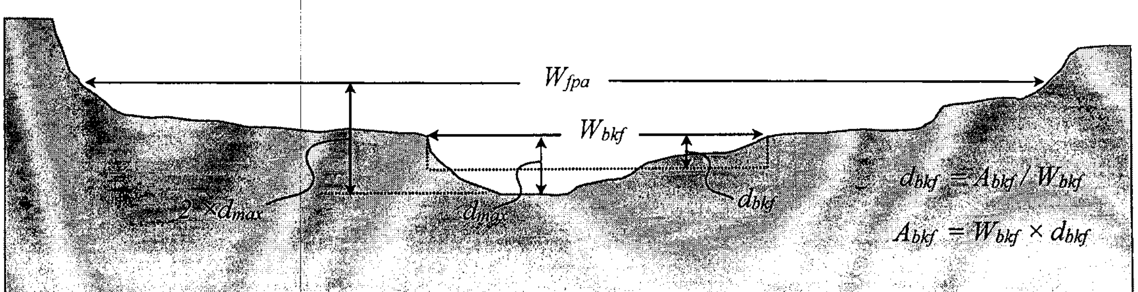


Figure A1.2. Channel cross-section parameters (from Rosgen, 1996).

C. Start cross-section with the zero end of tape on left bank (looking downstream)

D. The following information is obtained from the cross-section (Figure A1.2):

(1) Bankfull width (W_{bkf})

(2) Mean bankfull depth (d_{bkf}) (cross sectional area (A_{bkf})/(W_{bkf})

(3) Width/depth ratio W_{bkf}/d_{bkf}

(4) Entrenchment ratio = W_{FPA}/W_{bkf}

Flood prone Area width (W_{FPA}) = (width at an elevation x maximum bankfull depth)

(5) Cross-sectional area at the bankfull stage (A_{bkf})

Cross-sectional area is obtained by computing the sum of the products of the intervals of width times depth across the section.

(6) Wetted perimeter at the bankfull stage (WP)

a) measure from plotted cross section or;

b) approximate by computation:

$$WP = \left(2\bar{d}_{bkf}\right) + \overline{W}_{bkf}$$

$$Where: \overline{W} = \frac{\left(W_{top} + W_{bottom}\right)}{2}$$

OR:

$$WP = W_{bottom} + 2\sqrt{\bar{d}^{2}_{bkf} + \left(\overline{W}_{bkf} - W_{bottom}\right)^{2}}$$

$$Where: \overline{W} = \frac{\left(W_{top} + W_{bottom}\right)}{2}$$

(7) Compute bankfull hydraulic radius (R_{bkf} = mean hydraulic depth)

(8) Estimate mean bankfull flow velocity (V_{bkf}) in ft/sec.

(9) Estimate bankfull discharge (Q_{bkf}) = A_{bkf} x V_{bkf}.

(10) Obtain drainage area (mi^2) from topographic map. Compare regional curves at the bankfull stage for; cross-sectional area, width, depth, velocity and discharge by drainage area.

2. Longitudinal profile

A. Start the longitudinal profile from first cross-section and tie-into a permanent elevation control for replicate measurements (Figure A1.3).

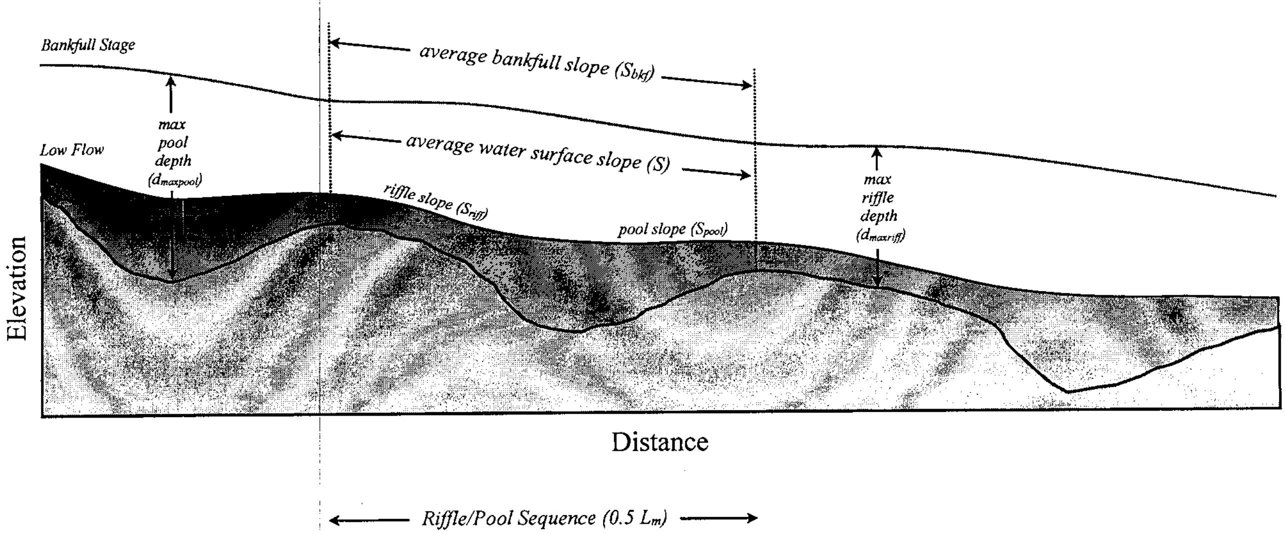


Figure A1.3. Longitudinal profile (from Rosgen, 1996).

B. Obtain the following elevations on the longitudinal profile:

- surface of channel bed
- water surface
- bankfull stage
- bank height, noting left and /or right bank. *(optional)*

C. Measure thalweg position, stationing and distance, i.e. maximum depth. Make sure to measure changes in elevation that indicate the shape, depth, and length of pools and other features to accurately define the bed features along the profile.

D. Locate other cross-sections with longitudinal stationing as reach identifiers (i.e. cross-section 3+50 is located 350 feet down from start of profile.)

E. The number of points (elevations) obtained along the profile should be sufficient to describe the show the length and depth of pools and well as other bed features such as runs and glides.

F. Where possible, the following data is obtained from the longitudinal profile.

(1) average slope (S) (using water surface)

(2) bankfull slope (S_{bkf}) (for certain hydraulic and sediment computations.)

(3) maximum riffle depth ($d_{maxriff}$)

(4) ratio of maximum riffle depth/average depth ($d_{maxriff} / d_{bkf}$)

(5) riffle slope (S_{riff})

(6) ratio of riffle slope to average water surface slope (S_{riff} /S)

(7) pool slope (S_{pool})

(8) ratio of pool slope to average water surface slope (S_{pool} / S)

(9) maximum pool depth (d_{pool})
(10) ratio pool depth to average bankfull depth (d_{pool} / d_{bkf})
(11) riffle/pool spacing or pool to pool distance ($r\text{-}p / W_{bkf}$)

3. Channel pattern

From aerial photos or from field survey obtain the following information:

A. Radius of curvature (R_c) Obtain for minimum, maximum and average values. Besides measuring on aerial photo or in field, another technique for field measurement is the chord length/mid-ordinate method where $R_c = C^2/8M + M/2$ (Figure A.4).

B. Meander wavelength (L_m) Obtain minimum maximum and average values (Figure 4).

C. Ratio of meander wavelength to bankfull width (L_m / W_{bkf}).

E. Meander width ratio (*belt width/ bankfull width*, or lateral containment) (W_{BLT}/W_{bkf}) Measure minimum, maximum and average meander width ratios (Figure A1.4).

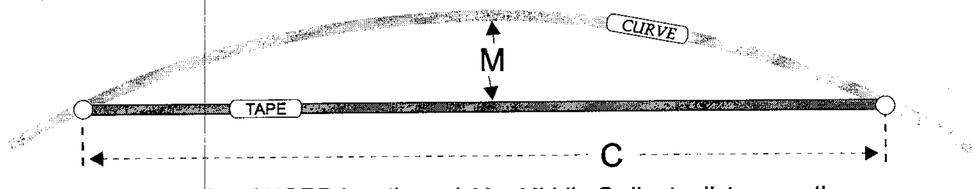
F. Arc length (L_{arc}).

G. Sinuosity (*stream length / valley distance*, or *valley slope / channel slope*) (Figure A1.5).

Determining RADIUS of CURVATURE (R_c) for a Existing Curve

Extend a known length of tape between two points on a curve, to form a chord (C).

Determine the mid-point of the chord, and measure the length of the perpendicular middle ordinate (M).



Where: C = CHORD length, and M = Middle Ordinate distance,...then:

$$R_c = C^2/8M + M/2$$

Curve RADIUS Ft.	Table of MIDDLE ORDINATES.....with Data in Feet (to nearest tenth)									
				CHORD LENGTH.....FEET						
	20	25	30	40	50	60	70	80	90	100
20	2.7	4.4	6.8							
30	1.7	2.8	4.0							
40	1.3	2.0	2.9	5.4	8.8	13.5	20.6			
50	1.0	1.6	2.3	4.2	6.7	10.0	14.3	20.0	28.2	
70	.7	1.1	1.6	2.9	4.6	6.8	9.4	12.6	16.4	21.0
80	.6	1.0	1.4	2.5	4.0	5.8	8.1	10.7	13.9	17.6
90	.6	.9	1.3	2.3	3.5	5.1	7.1	9.4	12.1	15.2
100	.5	.8	1.1	2.1	3.2	4.6	6.3	8.4	10.7	13.4
110	.5	.7	1.0	1.8	2.9	4.2	5.7	7.5	9.6	12.0
130	.4	.6	.9	1.6	2.4	3.5	4.8	6.1	8.0	10.0
140	.4	.6	.8	1.4	2.3	3.3	4.5	5.9	7.4	9.2
150	.3	.5	.8	1.3	2.1	3.0	4.1	5.4	6.9	8.6
160	.3	.5	.7	1.3	2.0	2.8	3.9	5.1	6.5	8.0
180	.3	.4	.6	1.1	1.7	2.5	3.4	4.5	5.7	7.1
200	.3	.4	.6	1.0	1.6	2.3	3.1	4.0	5.1	6.4
250	.2	.3	.5	.8	1.3	1.8	2.5	3.2	4.1	5.1
300	.2	.3	.4	.7	1.1	1.5	2.1	2.7	3.4	4.2

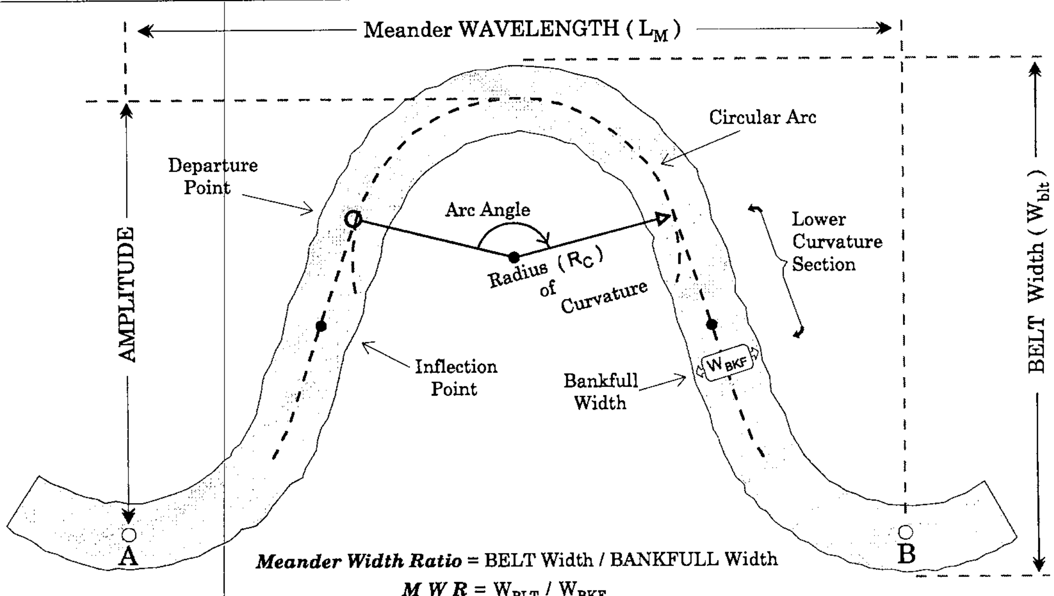


Figure A1.4. Channel curvature (from Rosgen, 1996)

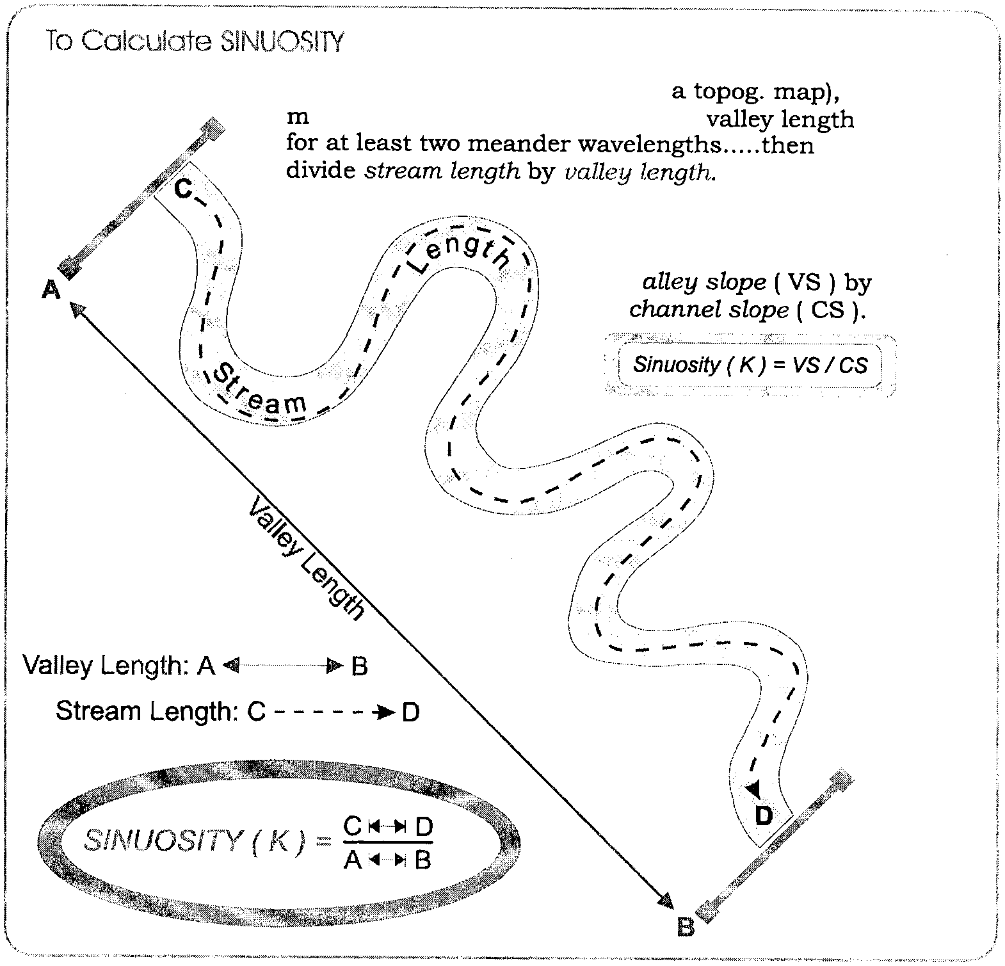


Figure A.5. Sinuosity (from Rosgen, 1996).