IN-STREAM HABITAT COMPLEXING, 1996

- Pilot Testing-

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. RM96-2

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ABSTRACT

The Nechako River In-Stream Habitat Complexing Project began in 1988 with pilot tests conducted to increase the complexity of juvenile chinook habitat prior to the implementation of the Long-Term Flow Regime of the Kemano Completion Project and to design, test and monitor habitat complex structures specific to the Nechako River. Different habitat complex designs were constructed and monitored between 1988 and 1992. No new complexes were constructed after 1992. This report documents the work done and the assessment of physical performance of Nechako River habitat complexing during the 1996/97 program year (April 1, 1996 to March 31, 1997).

Two new emergent fry structures were installed in Reach 2 of the Nechako River. Physical assessment was performed in the spring of 1996 (May 24 and 25). A fall video and visual inspection were not carried out in 1996 due to high water levels in the river as a result of spilling from the Skins Lake Spillway.

Since 1988, the Nechako Fisheries Conservation Program (NFCP) pilot habitat complexing program has constructed and tested 14 different complex designs. Fifty-two (52) complexes were monitored in the Nechako River in 1996 as part of the spring physical assessment. In general, the majority of complexes were stable. Damaged or displaced complexes included:

- a pseudo beaver lodge;
- a rail-anchored sweeper;
- both emergent fry structures; and,
- two rail debris catchers.

Rail-anchored sweeper RM26.9RAS was recommended for removal as it had been reduced to a bare log.

To date, the NFCP habitat complexing project has identified the following parameters as important for biological success in habitat complexing:

- shear velocity;
- cover area; and,
- substrate.

Additionally, it was determined that adequate complex anchoring is crucial for the maintenance of structural integrity during fluctuating flows.

The rail-anchored sweepers, hand-placed anchored sweepers, and rail debris catchers have been constructed in a manner that has maintained velocity criteria. Some early structures altered velocities such that design criteria were no longer met.

INTRODUCTION

The Nechako Fisheries Conservation Program (NFCP) was established as a result of an agreement signed in 1987 by Alcan Aluminium Ltd., the Government of Canada, and the Province of British Columbia (Anon. 1987a). The goal of the NFCP is to ensure conservation of Nechako River chinook salmon populations and protection of migrating sockeye salmon populations. An integral component of the program is the testing and implementation of remedial measures including the modification of in-stream habitat and construction of habitat complexes.

This report documents the work done on the habitat complexing project during the 1996 program year (April 1, 1996 to March 31, 1997). All field work for this project was performed between May and October, and the work is identified in this report as having occurred in 1996.

The focus of this report is on the evaluation of the physical performance of habitat complexes constructed since the inception of the project in 1988 and on the modification of habitat complexes in 1996. The evaluation of the biological performance of habitat complexes from 1996 is reported elsewhere (Triton 1998a).

BACKGROUND

In August 1987, a working group of technical experts from the Department of Fisheries and Oceans (DFO), Alcan, and the Province of British Columbia was established to assess how to ensure the conservation and protection of the fisheries resource of the Nechako River. The working group recognized that changes in Nechako River flows following development of the Kemano Completion Project would influence the amount of cover habitat available to juvenile chinook that utilize the river. This fact prompted a recommendation to increase the complexity of juvenile chinook cover habitat in the Nechako River prior to the implementation of the Long-Term Flow Regime (Anon. 1987a) to replace what cover habitat might be lost due to the flow changes in the river. A preliminary assessment of the types of habitat utilized by Nechako River chinook was conducted in order to identify suitable habitat complexing designs for pilot testing. The NFCP pilot habitat complexing project was initiated in 1988 to test these habitat complexing techniques and to assess their use by Nechako River chinook.

After the 1988 pilot testing, the information on suitable designs was supplemented by a literature review of in-stream habitat complexing projects (Triton 1998b). It indicated that, although habitat complexes had been widely used to create fish habitat, most techniques had been directed to small streams supporting fish species other than chinook. In addition, quantitative assessments of the effectiveness of these techniques were limited. More potential remedial measures were researched and selected techniques appropriate to the Nechako River were pilot tested in 1989 and 1990 (Triton 1996a). Following this, a list of remedial measures was prepared, based on replicating what was found naturally in the Nechako River. In 1991, pilot testing of new complexes continued, along with the replicate construction of selected complexes (Triton 1996b). In 1992, modifications were performed on several complexes (Triton 1996c). From 1993 to 1995, no new habitat complexes were constructed, but monitoring continued and several complexes were modified or removed (Triton 1998c). In 1996, two new emergent fry structures (EFS) were constructed and the monitoring of all complexes continued (Triton 1998d). The emergent fry structures were essentially short-term habitats, and they were pilot tested to evaluate the appropriateness of their location. Long-term durability was not a consideration.

A provides the terms of reference for the pilot habitat complexing project, including the criteria used for site selection and structural design.

PROJECT IMPLEMENTATION

The 1996 habitat complexing project activities were:

- Construction of emergent fry structures at two sites in the early spring; and,
- A physical assessment of habitat complex performance during the spring

The purpose of the physical assessment was to identify any structural damage or instability incurred over the winter period and to evaluate whether the design criteria were met. The fall assessment could not be conducted because of high water levels in the Nechako River resulting from Skins Lake Spillway releases.

METHODS

Spring 1996 Physical Assessment

The spring assessment consisted of inspections and photographic documentation of all complexes remaining in the Nechako River since the pilot testing project began in 1988. They were conducted from shore, by boat and by snorkeling. The following features were noted at each habitat complex, as applicable:

- water depths and velocities upstream and downstream (at 1/3 and 2/3 of the extension), at the inside and outside shear zones, and at a flow-through point within the complex;
- cover area;
- extension from margin;
- depth of cover;
- erosion/sedimentation;
- local substrate;
- damage;
- displacement; and,
- debris accumulation or loss.

Physical condition and stability were noted with reference to durability (structural integrity since the installation of the complex) and position in the river. Recommendations or comments were noted to modify or remove some complexes, and are presented in this report. This work may be done in future years.

Velocity and water depths were measured at each complex with a Swoffer (model 2100) flow meter and with the flow meter rod. The extension and principal cover dimensions were measured with a survey tape. Cover areas were then calculated for each complex. The hydraulic characteristics were documented to determine their compliance to design criteria. The amount of debris accumulation or loss was recorded to assess the performance of habitat complexes under prevailing Nechako River conditions. Substrate composition was noted as a relative ranking of material present.

Summaries of all activities are presented in Table 1. Construction details are presented in Appendix B and results of physical assessments are presented in Appendix C. Sketches and photos of the habitat complexes are presented in Appendices D and E, respectively.

1996 Habitat Complex Construction

In 1996, the construction of emergent fry structures was completed with chain saws, power drills and oxyacetylene cutting torches. A work boat with a jet-converted outboard motor was used to transport personnel and miscellaneous materials.

The emergent fry structures installed in 1996 consisted of locally available conifers of approximately 2 to 3 m in length with abundant branches. They were placed at a 45° angle in a downstream direction and held in place with one piece of rebar through the base of the trunk and another on the downstream side of the trunk half way along its length. A large washer was placed over the rebar and held down with a large cable clamp to prevent the structure from floating up off the anchors during high flows. Five (5) trees were placed at each emergent fry structure site.

RESULTS

Spring 1996 Physical Assessment

Physical assessments of all complexes were conducted on May 24 and 25, 1996. The discharge in the Nechako River was 69.1 m^3/s (2,440 cfs), which was above the high end of the criteria range of 56.6 m^3/s. Most depths were consequently above the minimum depth limit of 0.4 m. Velocities are affected by river discharge and by structure size and condition. Despite the high flows, approximately one third of velocity measurements were within the range of 0.15 to 0.40 m/s, one third were below and one third above. Upstream velocities were generally within the criterion range, while flow-through and downstream velocities were generally below the range, indicating that most structures had a significant amount of debris cover which reduced flows within and downstream of the structures. Outside and inside shear velocities were generally above the optimal range, possibly due

Table 1
Summary of Habitat Complexing Construction Activities, 1996

Type of Habitat Complex	Abbrev.	Quantity Remaining 1995	Quantity Constructed 1996	Quantity Modified 1996	Quantity Removed 1996	Quantity Remaining 1996
STRUCTURES						
Debris Bundles						
Rootwad Sweepers	RS	1	-	-	-	1
Brush Pile	BP	1	-	-	-	1
Floating Cribs	FC	2	-	-	-	2
Pseudo Beaver Lodges	PBL	2	-	-	-	2
Rail Anchored Sweepers	RAS	9	-	-	-	9
Hand-Placed Anchored Sweepers	HAS	7	-	-	-	7
Emergent Fry Structures	EFS	-	2	-	-	2
Debris Catchers						
Pipe-Pile Debris Catchers	PDC	2	-	-	-	2
Rail Debris Catchers	RDC	20	-	-	-	20
IN-STREAM MODIFICATIONS						
Side Channel	SC	1	-	-	-	1
Side Channel Debris Boom	DB	1	-	-	-	1
Point Bars	PB	3	-	-	-	3
Pocket Pools	PP	1	-	-	-	1
Totals		50	2	0	0	52

to the higher flows. Observations and recommendations are summarized below and in Table 2. Details, including an annotated list of acronyms, are presented in Appendix C.

Structures

Debris Bundles

In 1996, the majority of the debris bundles were stable, with cover areas overall similar to 1995. Gravels and fines were the predominant substrates, with cobbles and boulders also present at some sites.

Recent damages to a pseudo beaver lodge, a rail-anchored sweeper, and both emergent fry structures were noted :

- The frame on pseudo beaver lodge RM31.1PBL had collapsed resulting in the loss of some debris, leaving a total cover area of 15 m².
- Rail debris catcher RM22.1RAS was displaced as its boom log had become detached from the outside rail.
- Emergent fry structures RM19.7EFS and LM20.1EFS had lost branches, possibly by beavers. Several trees were missing branches, and one tree had been completely stripped of all foliage. The structures had only experienced moderate flows to this time.

Finally, rail-anchored sweeper RM26.9RAS, which had previously been reduced to a bare log, failed to trap any new debris and it was recommended that it be either replaced or removed.

Debris Catchers

The majority of debris catchers maintained their cover areas in 1996, which ranged from 5 to 180 m². Two rail debris catchers were damaged in 1996 -

Table 2
Summary of Spring 1996 Physical Assessment Observations

Type of Habitat Complex	Abbr.	Quantity Remaining 1996	Damage or Displacement in 1996	Cover Area (m^2)	Cover Area Change	Sedimentation or Erosion	Substrate (In order of predominance)	Comments	Recommendations
STRUCTURES									
Debris Bundles									
Rootwad Sweepers	RS	1	No	72	Increased from 1995	No	Gravel, fines	Stable structure	None
Brush Pile	BP	1	No	2	Reduced from 4 m^2 in 1995	No	Fines, gravels	None	None
Floating Cribs	FC	2	No	39/78	Similar to 1995	No	Gravels, fines, cobbles	None	None
Pseudo Beaver Lodges	PBL	2	No/Collapsed frame - RM31.1PBL	38/15	Reduced from 1995	No	Gravels, fines, cobbles	None	None, adequate cover available in area.
Rail Anchored Sweepers	RAS	9	Boom detached from rail - RM22.1RAS	1 - 28	Similar to 1995	No	Gravel, cobble, with fines and boulders at some complexes	RM26.9RAS reduced to bare log.	Replace or remove RM26.9RAS.
Hand-Placed Anchored Sweepers	HAS	7	No	2 - 10	Similar to 1995	No	Gravels, fines, cobbles	None	None
Emergent Fry Structures	EFS	2	Defoliation/Branches stripped	12/12	-	No	Cobbles, fines, boulders	Loss of branches due to beavers and moderate flows.	None
Debris Catchers									
Pipe-Pile Debris Catchers	PDC	2	No	20/180	Smaller structure reduced	Erosion/Sedimentation	Gravel/fines	Stable despite damage to piles on both structures . Low velocities due to large cover area.	None, adequate cover available in area.
Rail-Debris Catchers	RDC	20	Broken boom - RM86.35RDC/Lost rail - RM86.375RDC	5 - 180	Similar to 1995	Erosion (6), Sedimentation (1)	Gravels, cobbles and fines	Stable complexes, low velocities due to large cover area and locations close to shore.	None
IN-STREAM MODIFICATIONS									
Side Channel	SC	1	No	15, 34 m^2 including natural cover	Reduced from 96 m^2 in 1994	n/a	n/a	Flows blocked by beaver dams since 1989, resulting in no flow.	None
Side Channel Debris Boom	DB	1	No	62	Similar to 1995	No	Fines, gravels, cobbles	Stable, despite loss of shore deadman anchor in 1992.	None
Point Bars	PB	3	No	N/A	N/A	Some sedimentation in back eddy	Cobble, with some gravel, fines and boulders	None	None
Pocket Pools	PP	1	No	N/A	N/A	Erosion of perimeter	Cobbles, gravels	Erosion of perimeter has resulted in depositing of cobbles within the pool. Difficult to define complex boundaries.	None

RM86.35RDC had broken a boom and RM86.375 had lost a rail, yet both still maintained adequate cover areas.

The outside piles have been bent on both pipe-pile debris catchers for several years. Despite the damage, which has occurred from 1991 to present, the complexes were still stable.

Erosion or sedimentation was observed at 9 of the 22 sites. Gravel was the predominant substrate. Large cover areas and positioning in the river resulted in low velocities at the complexes with flow passing to the outside, and caused erosion in some cases.

In-Stream Modifications

No damage or displacement was noted at the in-stream modifications in 1996. Cover area in the side channel had been reduced, but flow continued to be blocked by beaver dams. The side channel debris boom was stable despite the shore deadman anchor having been unearthed in 1992. No further displacement had occurred.

Some sedimentation was observed within the back eddy of one of the point bars. Cobbles and boulders had been deposited within the pocket pool, which made it very difficult to locate the complex and determine its boundaries.

Fines and gravels were predominant at the debris boom, while cobbles and gravels were the dominant substrates near the point bars and pocket pool.

1996 Habitat Complex Construction

Maps of the 1996 NFCP habitat complexing project study area for Reaches 1 and 4, including complex locations, are presented in Figures 1 and 2. Two pilot emergent fry structures (RM19.7EFS, and LM20.1EFS) were constructed in Reach 2 of the Nechako River on April 21 and 22, 1996. Both sites were located near a high density chinook spawning area. Each emergent fry structure site was 40 m in length with five (5) individual fry structures evenly spaced through the site.

Construction Costs

The construction costs totaled approximately $1,050 for the two emergent fry structures ($525 per unit) (Table 3). These include all charges associated with labour, materials, equipment, and other disbursements. It is likely that the cost per unit would decrease if several structures were constructed at the same time.

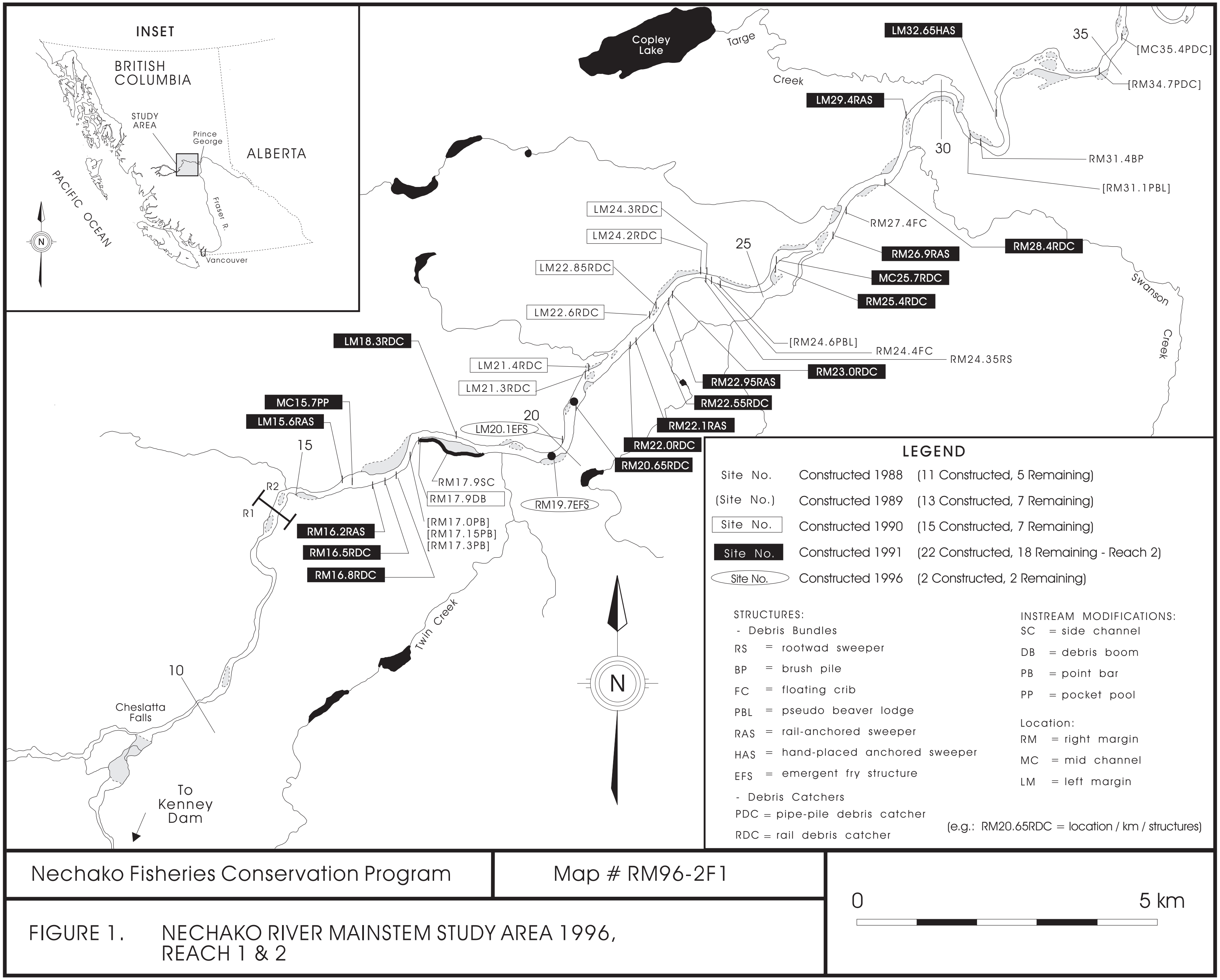
Table 3
Summary of Habitat Complexing Construction Costs in 1996

Type of Habitat Complex	Quantity Modified (Units)	Cost ($/Unit)*	Total Cost	Comments
Emergent Fry Structures	2	$525	$1,050	Two sites, with 5 individual structures per site.
Total Construction Cost - 1996			$1,050	

* Cost estimates include fees and disbursements for each unit, excluding GST.
Note: See Appendix D for drawings.

OBSERVATIONS ON HABITAT COMPLEXING PERFORMANCE

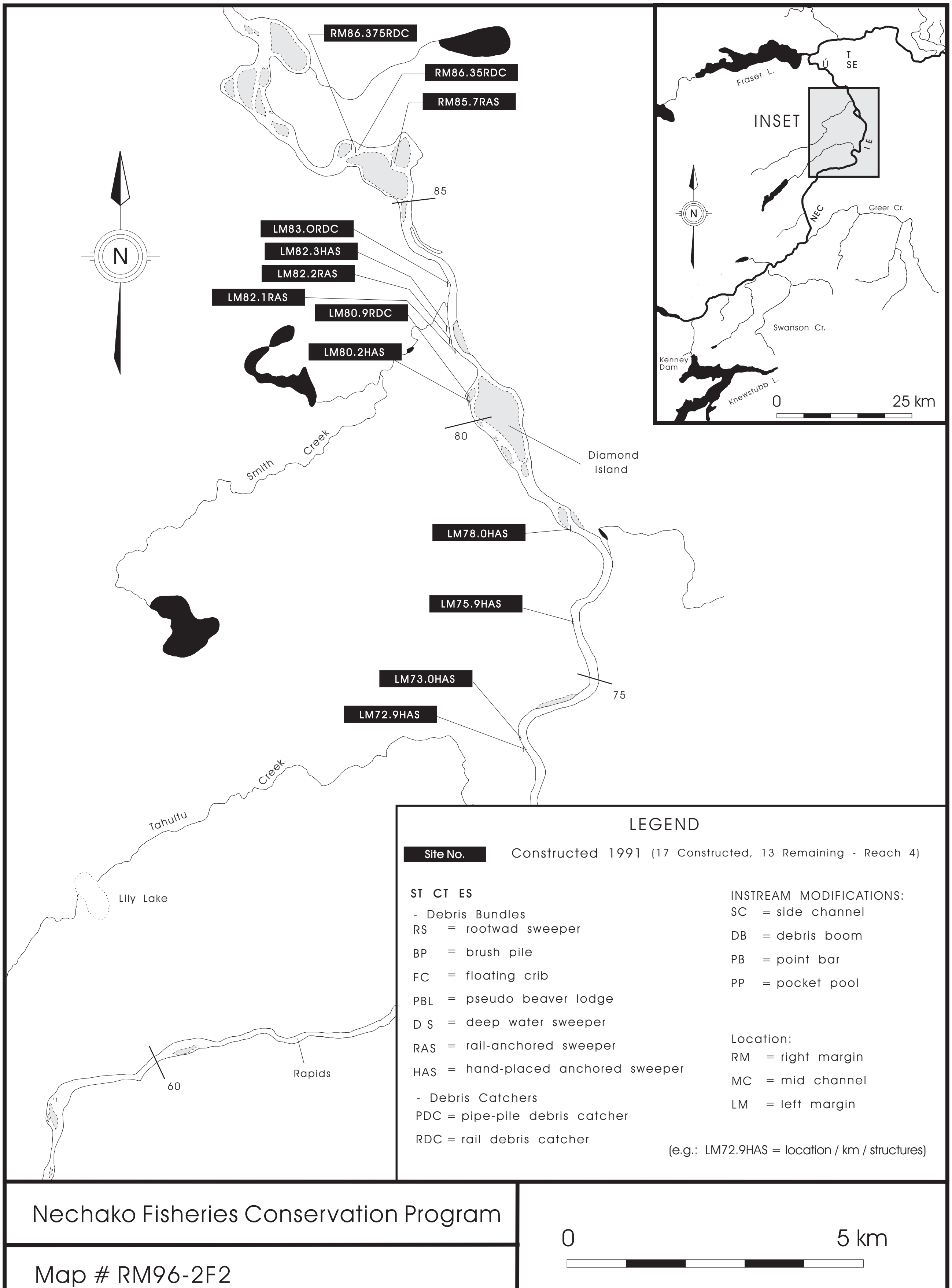
The evaluation of the structural performance of some complexes is still at an early stage. It is also early to judge the long term durability of the items used in the anchoring of complexes (cable, chain, clamps) as these items may corrode within 1 to 10 years. However, it is instructive to examine the performance of the habitat complexes constructed to date to develop some understanding of the factors affecting complex durability and/or performance. These observations can be used to further evaluate the design criteria and site selection of the complexes. This section summarizes the condition of complexes since their construction and the factors affecting biological and physical performance.



Nechako Fisheries Conservation Program

Map # RM96-2F1

FIGURE 1. NECHAKO RIVER MAINSTEM STUDY AREA 1996, REACH 1 & 2



Nechako Fisheries Conservation Program

Map # RM96-2F2

FIGURE 2. NECHAKO MAINSTEM STUDY AREA 1996, REACH

Structures

Debris Bundles

Rootwad Sweepers

The last remaining rootwad sweeper complex from the original four complexes constructed in 1988 had been modified in 1990 to reduce seeded material. Since then, this complex has remained stable, with no damage or displacement noted. No modifications to this complex were recommended as it has been performing satisfactorily.

Brush pile

The brush pile complex installed in 1988 has remained stable. However, cover area has fluctuated from as high as 37 m^2 in the spring of 1991 to as low as 2 m^2 in the spring of 1996 due to movement of the river bank. The small sample size (1) cannot generate any conclusion about stability, design, performance and durability of this type of complex.

Floating Cribs

The two floating cribs installed in 1988 have generally provided significant amounts of cover. In 1991, the smaller complex was moved further into the current to increase flow-through velocities. Anchoring was improved by securing the complex to two steel rails driven into the river bed. However, this complex was displaced onto the shore in 1992 and its downstream stiff-leg was broken by one of the rails. The upstream floating crib was colonized by beavers in the fall of 1989 and has been left untouched since. In recent years, the cover areas of these complexes have been reduced, with the smaller complex not providing much cover as its middle portion is uncovered and it is partially de-watered. Both floating cribs have generally been stable, with no damage or displacement noted since 1993.

Pseudo Beaver Lodges

The design of the pseudo beaver lodges was modified in the fall of 1989 to improve their position in the river following flow recession. However, in 1991, three modified units continued to lose debris and, in an effort to provide additional flotation to assist in debris retention, an extra boom was added to one complex prior to reseeding in the spring of 1992. Although this modification appeared to have helped retain debris over the summer cooling flows, this complex and two others were again damaged or displaced at higher flows. Due to continued loss of debris, two pseudo beaver lodges were removed from further assessment.

In 1996, one of the two remaining complexes had its structure collapse and both complexes lost debris. No recommendations for modifications have been made but it is not recommended that further units be constructed as these designs have experienced problems during fluctuating flows.

Rail-anchored Sweepers

During the summer of 1991, 10 rail-anchored sweepers were installed along the Nechako River. Three sweepers were repaired in 1992 after damage incurred during 1991 and 1992 summer cooling flows. In 1993, two sweepers were modified with the addition of downstream tree booms to improve debris capture and one of the rail-anchored sweepers was removed due the second loss of its shore anchor after having been repaired in 1992. The downstream booms were not very effective as they became submerged under the load of debris at high flows. Between 1993 and 1995, four of the nine sweepers were damaged, with several stripped to bare logs. In 1996, one of the remaining nine sweepers (RM22.1RAS) had become detached from its outside rail.

As reported in Triton (1996c) the rail-anchored sweepers have required significant repairs during their rather short lives in the Nechako River. The shorter rails installed for these complexes allow less vertical movement of the sweeper as water levels rise, which may account for the lack of collected debris. Additionally, the single tree that serves to collect debris is susceptible to loss of branches as well as damage under increased flows.

Hand-Placed Anchored Sweepers

As with rail-anchored sweepers, these complexes were not successful at capturing additional debris, and tended to be stripped, damaged or displaced during winter ice movements and high summer flows. Four of the structures have been removed since their installation in 1991. Downstream booms added to two complexes in 1993 did not prevent one unit from being stripped to bare log. The second modified unit was significantly reduced in size between 1993 and

1995. As the booms are placed by hand only smaller logs can be used, which are more susceptible to damage and stripping of branches.

Emergent Fry Structures

The assessment of the two emergent fry structures is at a very early stage as they had not yet been exposed to high flows or winter ice conditions. The structures are designed to be completely submerged at high flows and therefore are not expected to trap enough debris to be self maintaining. Anchoring systems were effective at maintaining the structures in position under spring flow conditions. Both structures experienced loss of branches within a short time of their installation, but long-term durability was not a consideration in their design.

Debris Catchers

Pipe-Pile Debris Catchers

Since their installation in 1989, the pipe-pile debris catchers have generally been stable under variable flow conditions, despite their pilings being bent or pulled from the river bed. Sedimentation was observed at both sites due to the large size of the complexes and low velocities. In 1995 (following the loss of its downstream piling) and 1996, the smaller complex lost a significant amount of debris. No recommendations were made for any repairs as the structures are still intact and maintain relatively large cover areas.

Rail Debris Catchers

Seven large rail debris catchers were constructed in 1990. In 1991, 16 additional smaller catchers were constructed to maintain debris piles of a more manageable size. The initial large rail debris catchers have been generally quite durable. However, the smaller structures have required regular repairs and reseeding following summer cooling flows.

From 1993 to 1995, three rail debris catchers (two built in 1991 and one built in 1990) were removed from the assessments due to loss of logs and debris following summer cooling flows. Triton (1996c) suggested that the repeated damage to the newer complexes might be partially due to the down-scaling of complex size in 1991.

To match the durability of the older complexes, the log boom diameter of future complexes may have to be increased to prevent breakage at the anchor points. Stronger cable anchoring should also be considered. In addition, using chains to connect the booms to the rails should be reconsidered to prevent loss of accumulated debris and loss of boom logs over the rails during high summer flows. The chains could be directly attached to eyes in the rails with sufficient slack to allow the logs to rise and fall with changes in water level. Finally, the aesthetics of these structures have been an issue since their construction. Methods to camouflage the steel rails are being investigated.

In-Stream Modifications

Side Channel

The original side channel built in 1988 with full spanning complexes and a debris boom had problems with excessive debris accumulation. The debris boom was moved upstream of the channel entrance in 1990 to prevent excessive loading within the channel. In addition, the full spanning habitat complexes in the side channel were removed and replaced with smaller single logs buried at intervals along the margins (Triton 1996a). Despite these modifications, low flows and subsequent construction of beaver dams within the side channel have resulted in velocities well below criteria limits. No recommendations for improvements have been made as lack of adequate flow and continual beaver dam blockage has made the complex undesirable for long term use.

The debris boom installed upstream of the side channel in 1990 was designed to prevent excessive debris accumulation in the side channel. Although the shore deadman anchor was unearthed in 1992, the complex has been stable, successful at retaining debris, and no further displacement has occurred. The complex should be monitored for displacement during subsequent visits.

Point Bars

The point bars were modified in 1991 to reduce their extension and to increase their elevation. This was done to encourage the formation of a back eddy and to reduce erosion of the surface during overtopping of the complexes during high summer flows. No damage has resulted since. Fines have been deposited in the back eddy pools, indicating that downstream velocities are low.

Pocket Pools

The two pocket pools constructed during the summer of 1991 were subject to either low velocities and sedimentation, or high velocities and channel scouring, depending on their location.

In 1994, due to significant erosion of the high velocity pocket pool, this complex was removed from further assessment. The remaining lower velocity complex continues to provide adequate cover area, although some erosion has resulted in cobbles and boulders being deposited within the pool.

Resistance to Winter Physical Conditions

During 1991, complexes were installed in Reach 4 of the Nechako River in an effort to expose the complexes to more severe ice conditions. These complexes were assessed for winter resistance for the first time in 1992.

From 1993 to 1995, several rail-anchored sweepers and hand-placed anchored sweepers lost branches or were damaged. In 1993, two hand-placed anchored sweepers located in high velocity areas of Reach 4 were severely damaged by ice and were removed from biological and physical assessments. Rail-anchored sweepers located in Reach 2 have experienced similar damage.

In addition, both pipe-pile debris catchers in Reach 2 have had their pilings lifted from the river bed by the ice. Rails used in the construction of other habitat complexes have also been uplifted. If this trend continues, these structures may suffer the same problems as RM34.7PDC, and lose much or all of their debris. No specific damage due to ice was noted in 1996.

As some sites in Reach 4 experience higher velocities and stage changes than in Reach 2, damage to structures in Reach 4 may also occur in the summer cooling flows. It should be noted that in addition to more severe ice and high flow conditions, Reach 4 also experiences lower debris recruitment which limits the size of its structures compared to Reach 2.

Factors affecting Biological Performance

Visual observations confirm that the man made habitat structures are well used by juvenile chinook salmon during the spring rearing period. Large schools of chinook are often seen in the debris and the shear zones of various structures during the biological assessments (Triton 1996d, e, f, g, and 1998a and d). Electrofishing results have shown that the man made structures are also used by overwintering chinook juveniles.

The physical factors affecting the observed density of chinook juveniles in habitat complexes during snorkel surveys has been analyzed since 1991 (Triton 1996d, e, f, g, and 1998a and d). Chinook abundance is usually positively correlated with cover area and negatively correlated with fines deposited within the complex area (Triton 1996d). Other important variables include shear velocity.

Site selection is essential in establishing a complex that fulfills velocity design criteria over the full range of flows. The fish target species will also influence the cover area design range and the type of complex. In the case of chinook salmon, habitat complexes which impede velocities should be avoided. Complexes should therefore be located in areas of gravel and cobble to provide sufficient velocity, and should have the appropriate cover density to maintain adequate flow-through to minimize deposition of fines.

Since the beginning of this project, the rail-anchored sweepers, hand-placed anchored sweepers, and rail debris catchers have generally provided acceptable velocities and cover areas.

Factors Affecting Physical Performance

Anchoring systems for habitat complexes must be secured adequately. The deadman and rail anchoring systems used in the NFCP habitat complexing project have been successful in that regard. The suggested method of attaching cable to anchors and LWD is the looping and threading method. Stapling of cable has proved to be unsuccessful. It is also necessary that anchoring systems be designed to function under variable and transient flow conditions. The adaptability of habitat complex anchoring systems to changing flow conditions and to site-specific conditions is particularly important for maintaining position and stability following flow recession. Successful complexes move with fluctuating flows so the structure does not become submerged during high flows. Stripping or other damage to the structure is therefore less likely, and accumulated debris do not drift out of the complex.

SUMMARY

Since 1988, the NFCP pilot habitat complexing program has constructed and tested 14 different complex designs.

In 1996, two new emergent fry structures were built in areas of high chinook spawning density. Fifty-two (52) complexes were monitored in the Nechako River in 1996 as part of the spring physical assessment. In general, the majority of complexes were stable.

Damaged or displaced complexes included:

- a pseudo beaver lodge;
- a rail-anchored sweeper;
- both emergent fry structures; and,
- two rail debris catchers.

Rail-anchored sweeper RM26.9RAS was recommended for removal as it had been reduced to a bare log.

To date, the NFCP habitat complexing project has identified the following parameters as important for biological success in habitat complexing:

- shear velocity;
- cover area; and,
- substrate.

It has also been determined that adequate complex anchoring is crucial for the maintenance of structural integrity during fluctuating flows.

The rail-anchored sweepers, hand-placed anchored sweepers, and rail debris catchers have generally provided acceptable velocities and cover areas.

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APPENDIX A

NFCP In-Stream Habitat Complexing Pilot Testing Terms of Reference

1.0 INTRODUCTION

In August 1987, a working group of technical experts from the Department of Fisheries and Oceans (DFO), Alcan, and the Province of British Columbia was established to assess how to ensure the conservation and protection of the fisheries resource of the Nechako River. The working group recognized that changes in Nechako River flows following development of the Kemano Completion Project would influence the amount of cover habitat available to juvenile chinook in the river. This fact prompted a recommendation to increase the complexity of juvenile chinook cover habitat in the Nechako River prior to the implementation of the Long-Term Flow Regime (Anon. 1987a) to replace what cover habitat might be lost due to the flow change in the river. Although the KCP has been has been cancelled assessment of structural durability of habitat complexes has continued. A preliminary assessment of the types of habitat utilized by Nechako River chinook was conducted via snorkeling surveys in early 1988. Observations from these surveys were used to identify suitable habitat complexing designs for pilot testing. The design also benefited from the experience of NFCP Technical Committee members and from the results of previous studies on the Nechako River (Envirocon 1984a), which had developed basic criteria (e.g., depth, velocity, substrate). The NFCP pilot habitat complexing project was initiated in 1988 to test these habitat complexing techniques and to assess their use by Nechako River chinook.

2.0 OBJECTIVES

The objectives of the habitat complexing project are:

- to determine the hydraulic performance and durability of a variety of potential habitat complexes through a series of small scale pilot tests;
- to continue the physical assessment of previously constructed habitat complexes; and,
- to identify cost effective methods of achieving the habitat complexing goals set out in the Nechako River Working Group Report.

Additional objectives of the project for 1996 were:

- to monitor existing structures; and,
- to construct structures with habitat values suitable for emergent fry.

3.0 SCOPE

The scope of the NFCP habitat complexing project consisted of the following:

(1) Construction of a limited number of habitat complexes that have been demonstrated to work on other river systems for other species of salmon;

(2) Construction of a limited number of habitat complexes that could duplicate naturally occurring habitat on the Nechako River;

(3) Installation of these habitat complexes at accessible sites downstream of known spawning grounds; and,

(4) Assessment of habitat complexes under varying flow and meteorological conditions to determine their hydraulic performance and durability.

4.0 TYPES OF HABITAT COMPLEXES

The selection of habitat complexes types considered for installation in the Nechako River was based on a review of similar work on other river systems, on Nechako River conditions, and on local availability of materials. Woody debris were identified as the preferred “cover habitat” (Triton 1998b and Lister 1994). Habitat complexes identified for pilot testing in the Nechako River were of two types, structures and in-stream modifications.

Structures consist of debris bundles and debris catchers placed along the river to provide additional cover habitat for rearing chinook juveniles. Debris bundles are trees or root masses cabled to anchors on the river bank. Debris catchers are structures placed at various locations along the stream margin to intercept and hold any large woody debris (LWD) floating downstream. These complexes trap the river’s natural supply of debris to provide fish habitat.

In-stream modifications involve the excavation or placement of river bed materials to replicate existing natural morphological features found on the Nechako River.

Since 1988, 14 different habitat complex designs have been tested in the Nechako River. These designs are categorized below as either "structures" (debris bundles or debris catchers), or "in-stream modifications".

STRUCTURES

Debris Bundles

1) Rootwad Sweepers
2) Brush Piles
3) Floating Cribs
4) Pseudo Beaver Lodges
5) Deep Water Sweepers
6) Rail-anchored Sweepers
7) Hand-Placed Anchored Sweepers
8) Emergent Fry Structures

Debris Catchers

1) Channel Jacks
2) Pipe-Pile Debris Catchers
3) Rail Debris Catchers

IN-STREAM MODIFICATIONS

1) Excavation of a Side Channel, complexed with debris bundles and a debris boom.
2) Construction of Point Bars with back eddy pools on the Nechako River shoreline.
3) Excavation of Pocket Pools from the Nechako River bed.

Detailed descriptions of habitat complexes constructed from 1988 to 1990 are presented in Triton (1996a). Complexes constructed in 1991 and work performed in 1992 are described in Triton (1996b) and Triton (1996c). Descriptions of the modifications made to the complexes from 1993 to 1995 are detailed in Triton (1998c).

5.0 SITE SELECTION AND DESIGN CRITERIA

Since 1988, the criteria utilized for site selection and for design of all habitat complexes were based on the following:

- a review of the general literature (Everest and Chapman 1972; Lister and Genoe 1970)
- chinook life history data collected during field studies on the Nechako River (Envirocon Ltd. 1984a and Russell *et al.* 1983).
- criteria developed by the Department of Fisheries and Oceans (Anon. 1987b) and Envirocon Ltd. (1984b), and
- Nechako River physical characteristics and natural habitats.

They are as follows:

Parameter	**Criterion**	**Preferred**
Velocity (m/s)	0.15 - 0.4	0.3
Depth (m)	not less than 0.4	0.75-1.0
Substrate	gravel to cobble	gravel to cobble
Extension (m)	site specific	5.0

Note that extension is defined as the perpendicular distance from the wetted edge to the outer edge of the structure.

Habitat complexes installed in the mainstem Nechako River from 1988 through 1990 were designed to operate at the Short-Term Flow Regime spring and summer rearing flows of 56.6 m^3/s (2,000 cfs), and at fall and winter flows of 31.1 m^3/s (1,100 cfs) (Anon. 1987a). By comparison, complexes installed in the mainstem Nechako River in 1991 were designed to operate at expected Long-Term rearing flows of 31.1 m^3/s (1,100 cfs) and were located so that they could also operate during lower water levels and river widths associated with future Long-Term winter flows of 14.2 m^3/s (500 cfs). However all complexes were only evaluated for design criteria fulfillment at approximate Nechako River high and low flows of 56.6 m^3/s (2,000 cfs) and 31.1 m^3/s (1,100 cfs).

The site selection and design criteria followed in the construction of the side channel in the spring of 1988 were developed by DFO (Anon. 1987b) and Envirocon Ltd. (1984b) and are presented below.

Parameter	Criterion
Maximum Depth (m)	0.6
Average Cross-Sectional Velocity (m/s)	approx. 0.5
Side Channel Flow Range (m3/s)	1 - 2
Nechako River Flow Range (m3/s)	31.1 - 56.6

The construction of the side channel was such that depth and velocity at each complex in the side channel would be similar to preferred depth and velocity of complexes in the mainstem Nechako River. The criteria were developed for the side channel sources for approximate Nechako River high and low flows of 56.6 m^3/s (2,000 cfs) and 31.1 m^3/s (1,100 cfs).

Side channel bank slopes were graded such that the right bank approximated the existing stable slope of 1.5H:1V and the left bank provided shallow habitat for newly emergent fry through a lower slope of 3.5H:1V.

It was expected that the installation of a given habitat complex would modify velocities at the site, but that the velocities throughout the complex would remain within the criteria range. Therefore, the criteria ranges apply to both the site selection and to the design of the habitat complexes.

APPENDIX B

1996 Summary of Habitat Complexing Construction, Modification and/or Rationale for Removal

APPENDIX B

1996 Summary of Habitat Complexing Construction, Modification and / or Rationale for Removal

Location (km)	Site Number	1996 Activity	Nature of Modification	Modification and/or Removal Rationale
REACH 2				
15.6	LM15.6RAS		-	-
15.7	MC15.7PP		-	-
16.2	RM16.2RAS		-	-
16.5	RM16.5RDC		-	-
16.8	RM16.8RDC		-	-
17.0	RM17.0PB		-	-
17.15	RM17.15PB		-	-
17.3	RM17.3PB		-	-
17.9	RM17.9DB		-	-
17.9-18.6	RM17.9SC		-	-
18.3	LM18.3RDC		-	-
19.7	RM19.7EFS	C	Constructed April 21, 1996	-
20	LM20.0EFS	C	Constructed April 22, 1996	-
20.65	RM20.65RDC		-	-
21.3	LM21.3RDC		-	-
21.4	LM21.4RDC		-	-
22.0	RM22.0RDC		-	-
22.1	RM22.1RAS		-	-
22.55	RM22.55RDC		-	-
22.6	LM22.6RDC		-	-
22.85	LM22.85RDC		-	-
22.95	RM22.95RAS		-	-
23.0	RM23.0RDC		-	-
24.2	LM24.2RDC		-	-
24.3	LM24.3RDC		-	-
24.35	RM24.35RS		-	-
24.4	RM24.4FC		-	-
24.6	RM24.6PBL		-	-
25.4	RM25.4RDC		-	-
25.7	MC25.7RDC		-	-
26.9	RM26.9RAS		-	-
27.4	RM27.4FC		-	-
28.4	RM28.4RDC		-	-
29.4	LM29.4RAS		-	-
31.1	RM31.1PBL		-	-
31.4	RM31.4BP		-	-
32.65	LM32.65HAS		-	-
34.7	RM34.7PDC		-	-
35.4	MC35.4PDC		-	-

APPENDIX B (continued)
1996 Summary of Habitat Complexing Construction, Modification and / or Rationale for Removal

Location (km)	Site Number	1996 Activity	Nature of Modification	Modification and/or Removal Rationale
REACH 4				
72.9	LM72.9HAS		-	-
73.0	LM73.0HAS		-	-
75.9	LM75.9HAS		-	-
78.0	LM78.0HAS		-	-
80.2	LM80.2HAS		-	-
80.9	LM80.9RDC		-	-
82.1	LM82.1RAS		-	-
82.2	LM82.2RAS		-	-
82.3	LM82.3HAS		-	-
83.0	LM83.0RDC		-	-
85.7	RM85.7RAS		-	-
86.35	RM86.35RDC		-	-
86.375	RM86.375RDC		-	-

Where,	RS = rootwad sweeper	Sp = Spring
	BP = brush pile	Su = Summer
	FC = floating crib	
	PBL = pseudo beaver lodge	
	RAS = rail-anchored sweeper	C= constructed
	HAS = hand-placed anchored swee	M = modified
	EFS = emergent fry structure	R = removed
	PDC = pipe-pile debris catcher	
	RDC = rail-debris catcher	
	SC= side channel	
	DB = debris boom	
	PB = point bar	
	PP = pocket pool	

APPENDIX C

1996 Physical Assessments of Habitat Complexes

Appendix C

Spring 1996 Physical Assessment of Habitat Complexes

Spring 1996 Habitat Complex Assessment (May 24 - 25, 1996 - Complexes, May 1, 1996 - EFS Sites): Discharge = 69.1 m³/s (2,440 cfs)

Location (km)	Site Number	Depth u/s 1/3 ext. (m)	Depth u/s 2/3 ext. (m)	Depth Outside Shear (m)	Depth d/s 2/3 ext. (m)	Depth d/s 1/3 ext. (m)	Depth Through (m)	Depth Inside Shear (m)	Velocity u/s 1/3 ext. (m/s)	Velocity u/s 2/3 ext. (m/s)	Velocity Outside Shear (m/s)	Velocity d/s 2/3 ext. (m/s)	Velocity d/s 1/3 ext. (m/s)	Velocity Through (m/s)	Velocity Inside Shear (m/s)	Cover Area (m²)	Ext. from Margin (m)	Dist. from Shore	Cover to Bottom?	Debris Entrapment (yes, no, lost)	Erosion/Sedimentation	Substrate B	C	G	F
Reach 2																									
15.6	LM15.6RAS	0.18	0.35	0.95	0.33	0.28	0.21	N/A	0.22	0.41	1.20	0.00	0.00	0.14	N/A	27.0	8.0	0.00	Y	Y	No		1	2	
15.7	MC15.7PP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A		
16.2	RM16.2RAS	0.32	0.68	1.10	0.61	0.44	0.25	N/A	0.44	0.57	1.40	0.47	0.26	0.46	N/A	5.0	8.0	0.00	N	Y	No	3	1	2	
16.5	RM16.5RDC	0.26	0.50	1.35	0.69	0.39	0.50	N/A	0.02	0.37	1.43	0.50	0.67	0.60	N/A	5.0	9.0	0.00	N	Y	No	2	1		
16.8	RM16.8RDC	0.40	0.70	1.00	0.82	0.71	0.55	0.26	0.06	0.05	0.81	0.05	0.10	0.31	0.55	9.0	8.0	1.00	Y	Y	No		1	2	
17	RM17.0PB	-	-	0.50	-	-	-	-	-	-	0.61	-	-	-	-	-	8.0	-	-	-	No		1		
17.15	RM17.15PB	-	-	0.85	-	-	-	-	-	-	0.75	-	-	-	-	-	8.5	-	-	-	No/ Yes (sedimentation in back eddy)		1		2
17.3	RM17.3PB	-	-	0.45	-	-	-	-	-	-	0.79	-	-	-	-	-	6.5	-	-	-	No	2	1	3	
17.9	RM17.9DB	0.25	0.40	0.65	0.45	0.35	0.41	N/A	0.17	0.23	0.55	0.00	0.18	0.27	N/A	62.0	11.0	0.00	y	y	No		3	2	1
17.9	RM17.9SC	-	-	-	-	-	0.79	-	-	-	-	-	-	0.00	-	34.0	-	-	-	-	N/A	-	-	-	-
18.3	LM18.3RDC	0.38	0.79	1.65	0.48	0.11	0.26	N/A	0.28	0.38	1.22	0.00	0.03	0.05	N/A	77.0	11.0	0.00	Y	Y	No	3	1	2	
19.7	RM19.7EFS	-	-	0.31	-	-	-	-	-	-	0.13	-	-	-	-	12.0	3.00	0.00	Y	N	No		3	1	2
20.1	LM20.1EFS	-	-	0.30	-	-	-	-	-	-	0.24	-	-	-	-	12.0	3.00	0.00	Y	N	No		3	1	2
20.65	RM20.65RDC	0.58	0.85	1.21	1.01	0.65	0.16	N/A	0.24	0.40	1.12	0.08	0.02	0.35	N/A	135.0	7.5	0.00	Y	Y	Yes (outside edge)/No		1	2	
21.3	LM21.3RDC	0.55	0.85	1.20	0.70	0.35	0.31	N/A	0.21	0.64	0.75	0.05	0.06	0.24	N/A	76.5	9.0	0.00	Y	Y	No		2	1	3
21.4	LM21.4RDC	0.78	1.11	2.00	0.85	0.46	0.51	0.78	0.80	0.61	0.60	0.09	0.33	0.26	0.43	51.0	14.5	6.00	y	y	Yes (under complex and outside shear)/No		1	2	3
22	RM22.0RDC	0.40	0.76	0.90	0.45	0.20	0.28	N/A	0.47	0.85	1.05	0.04	0.00	0.15	N/A	93.5	8.5	0.00	Y	Y	No		1	2	
22.1	RM22.1RAS	0.11	0.19	0.45	0.36	0.22	0.33	N/A	0.28	0.27	0.26	0.08	0.00	0.09	N/A	27.5	5.5	1.00	y	y	No	3	1	2	
22.55	RM22.55RDC	0.65	0.92	1.50	0.62	0.35	0.14	N/A	0.18	0.84	0.90	0.00	0.02	0.20	N/A	50.0	10.0	0.00	Y	Y	No		3	1	2
22.6	LM22.6RDC	0.42	0.85	1.00	0.64	0.36	N/A	N/A	0.00	0.35	0.45	0.00	0.00	N/A	N/A	99.0	11.0	0.00	Y	L	No		1	2	
22.85	LM22.85RDC	0.38	0.64	1.10	1.00	0.66	0.64	0.31	0.11	0.02	1.05	0.49	0.36	0.09	0.56	40.5	11.0	2.00	y	y	No		2	1	3
22.95	RM22.95RAS	0.30	0.47	0.25	0.50	0.27	0.50	N/A	0.02	0.22	0.73	0.27	0.01	0.17	N/A	2.5	2.5	0.50	N	Y	No		3	1	2
23	RM23.0RDC	0.45	0.80	1.15	0.88	0.60	0.51	0.15	0.13	0.66	0.87	0.06	0.09	0.19	0.30	32.0	10.0	2.00	Y	Y	No		1	2	3
24.2	LM24.2RDC	0.20	0.61	1.40	1.05	0.59	0.20	N/A	0.16	0.09	1.05	0.59	0.00	0.17	N/A	180.0	9.0	0.00	Y	Y	No		2	1	
24.3	LM24.3RDC	0.59	0.75	1.08	0.98	0.80	0.17	0.51	0.19	0.10	0.68	0.23	0.13	0.13	0.34	15.0	14.0	6.50	Y	Y	No		2	1	3
24.35	RM24.35RS	0.30	0.60	0.78	0.77	0.66	0.52	0.85	0.05	0.25	0.45	0.14	0.11	0.10	0.69	72.0	11.5	0.00	Y	Y	No			1	2
24.4	RM24.4FC	0.46	0.65	0.56	0.59	0.50	N/A	N/A	0.09	0.08	0.47	0.00	0.00	N/A	N/A	77.5	6.0	0.00	Y	Y	No			1	2
24.6	RM24.6PBL	0.22	0.64	0.85	0.55	0.35	N/A	N/A	0.20	0.27	0.69	0.00	0.00	N/A	N/A	37.5	6.5	0.00	Y	Y	No			1	2
25.4	RM25.4RDC	0.57	0.71	2.00	1.01	1.01	2.00	1.80	0.47	0.74	1.05	0.18	0.20	0.16	0.27	9.0	15.0	9.00	y	y	Yes (around and under RDC)/No	3	1	2	
25.7	MC25.7RDC	0.81	0.91	0.60	0.47	0.41	0.55	0.72	0.35	0.48	0.48	0.08	0.19	0.14	0.82	11.3	11.0	7.50	y	y	No		2	1	
26.9	RM26.9RAS	0.31	0.42	N/A	N/A	N/A	N/A	N/A	0.74	0.85	N/A	N/A	N/A	N/A	N/A	1.0	3.7	3.50	Y	N	No		2	1	
27.4	RM27.4FC	0.92	1.45	1.03	0.40	0.40	0.64	N/A	0.05	0.33	0.83	0.06	0.00	0.28	N/A	39.0	6.5	0.00	Y	Y	No		2	1	3
28.4	RM28.4RDC	0.55	0.85	1.40	0.78	0.53	N/A	N/A	0.44	0.77	0.79	0.00	0.00	N/A	N/A	102.0	12.0	0.00	Y	Y	No		1	2	
29.4	LM29.4RAS	0.27	0.40	0.41	0.75	0.65	N/A	0.42	0.61	1.06	0.62	0.02	0.03	N/A	0.29	7.5	7.0	2.00	N	Y	No		1	2	
31.1	RM31.1PBL	0.47	0.74	1.05	0.72	0.45	0.55	N/A	0.21	0.28	0.76	0.04	0.02	0.08	N/A	15.0	3.0	0.00	N	Y	No		2	1	3
31.4	RM31.4BP	0.15	0.25	0.54	0.44	0.28	N/A	N/A	0.16	0.19	0.28	0.07	0.02	N/A	N/A	2.0	1.5	0.00	n	y	No			2	1
32.65	LM32.65HAS	0.38	0.50	0.72	0.44	0.31	0.30	N/A	0.21	0.26	0.75	0.26	0.18	0.32	N/A	6.0	4.0	0.00	Y	Y	No		2	1	3
34.7	RM34.7PDC	0.45	0.66	1.20	0.85	0.74	0.48	N/A	0.02	0.18	0.79	0.00	0.00	0.13	N/A	19.5	9.0	0.00	N	Y	Yes (mud has been carried away)/No			1	2
35.4	MC35.4PDC	1.01	1.08	1.14	N/A	N/A	N/A	1.20	0.34	0.42	0.38	N/A	N/A	N/A	0.37	180.0	45.0	30.00	na	na	No/Yes (behind structure silt)				1
Reach 4																									
72.9	LM72.9HAS	0.50	0.85	0.85	0.80	0.50	0.85	N/A	0.09	0.30	0.37	0.39	0.00	0.37	N/A	10.0	N/A	0.00	y	y	No	3	1	2	
73	LM73.0HAS	0.40	0.75	0.82	0.50	0.37	0.40	N/A	0.34	0.06	0.29	0.03	0.16	0.18	N/A	2.0	4.0	0.00	n	n	No	3	1	2	
75.9	LM75.9HAS	0.45	0.55	0.90	0.55	0.40	N/A	N/A	0.40	0.82	0.57	0.05	0.04	N/A	N/A	10.0	10.0	0.00	n	n	No				
78	LM78.0HAS	0.45	0.65	1.00	0.90	0.40	0.55	N/A	0.11	0.21	0.57	0.44	0.26	0.36	N/A	3.8	N/A	5.00	y	n	No		3	2	1
80.2	LM80.2HAS	0.75	1.20	2.00	1.10	0.50	1.10	N/A	0.24	0.48	0.57	0.28	0.05	0.28	N/A	2.0	0.0	3.50	n	n	No			2	1
80.9	LM80.9RDC	N/A	1.00	N/A	1.00	0.75	0.75	N/A	N/A	1.15	N/A	0.79	0.04	0.72	N/A	5.0	N/A	20.00	n	y	Yes (around back)/No			2	1
82.1	LM82.1RAS	0.90	N/A	1.50	0.80	0.45	0.50	N/A	0.43	N/A	1.38	0.10	0.68	0.43	N/A	7.5	6.5	0.00	n	y	No		2	1	3
82.2	LM82.2RAS	0.45	1.00	1.30	0.78	0.45	0.40	N/A	0.13	0.39	0.59	0.33	0.22	0.37	N/A	2.0	7.5	0.00	y	y	No		3	1	2
82.3	LM82.3HAS	0.60	0.80	0.95	0.90	0.55	0.70	N/A	0.45	0.60	0.53	0.29	0.32	0.28	N/A	4.0	N/A	0.00	y	y	No		3	1	2
83	LM83.0RDC	N/A	N/A	0.85	0.70	0.70	0.80	0.80	N/A	N/A	1.87	0.50	0.13	1.19	1.19	4.5	16.0	12.00	n	y	No	3	1	2	
85.7	RM85.7RAS	1.30	N/A	2.00	N/A	1.10	1.15	0.55	0.70	N/A	1.14	N/A	0.13	0.67	0.26	1.0	11.0	2.00	n	y	No			2	1
86.35	RM86.35RDC	0.45	1.15	2.00	0.65	0.40	1.20	N/A	0.08	0.44	1.06	0.05	0.12	0.80	N/A	8.1	12.0	1.00	n	y	Yes/No			2	1
86.375	RM86.375RDC	2.00	2.00	2.00	2.00	2.00	2.00	N/A	0.30	1.16	0.09	0.02	0.20	1.02	N/A	9.5	12.0	15.00	n	y	Yes (around both sides)/Yes (behind)			2	1

Where,
RM = right margin
MC = mid-channel
LM = left margin

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail anchored sweeper

HAS = hand-placed anchored sweeper
EFS = Emergent Fry Structure
PDC = pipe-pile debris catcher
RDC = rail debris catcher
SC= side channel

DB = debris boom
PB = point bar
PP = pocket pool

u/s = upstream
d/s = downstream
N/A - not available

B = boulder
C = cobble
G = gravels
F = fines

APPENDIX C
1996 Physical Assessments of Habitat Complexes

Location (km)	Site Number	Damage	Displacement	Debris Accumulation/Loss	Recommendation /Comments
REACH 2					
15.6	LM15.6RAS	No	No	-	-
15.7	MC15.7PP	No	No	-	-
16.2	RM16.2RAS	No	No	Very little debris; cover sparse	-
16.5	RM16.5RDC	No	No	Little debris left	-
16.8	RM16.8RDC	No	No	-	-
17	RM17.0PB	No	No	-	-
17.15	RM17.15PB	No	No	-	-
17.3	RM17.3PB	No	No	-	-
17.9	RM17.9DB	No	No	-	-
17.9	RM17.9SC	No	No	-	-
18.3	LM18.3RDC	No	No	-	-
19.7	RM19.7EFS	No	No	-	-
20.1	LM20.1EFS	No	No	-	-
20.65	RM20.65RDC	No	No	Same as last year	-
21.3	LM21.3RDC	No	No	-	-
21.4	LM21.4RDC	No	No	-	-
22	RM22.0RDC	No	No	-	-
22.1	RM22.1RAS	No	Detached from outside rail	-	-
22.55	RM22.55RDC	No	No	-	-
22.6	LM22.6RDC	No	No	Beaver lodge	-
22.85	LM22.85RDC	No	No	-	-
22.95	RM22.95RAS	No	No	-	-
23	RM23.0RDC	No	No	-	-
24.2	LM24.2RDC	No	No	-	-
24.3	LM24.3RDC	No	No	-	-
24.35	RM24.35RS	No	No	-	-
24.4	RM24.4FC	No	No	-	-
24.6	RM24.6PBL	No	No	-	-
25.4	RM25.4RDC	No	No	-	-
25.7	MC25.7RDC	No	No	-	-
26.9	RM26.9RAS	No	No	Bare log	Fix or remove
27.4	RM27.4FC	No	No	-	-
28.4	RM28.4RDC	No	No	Beaver lodge	-
29.4	LM29.4RAS	No	No	-	-
31.1	RM31.1PBL	Structure collapsed	No	-	-
31.4	RM31.4BP	No	No	-	-
32.65	LM32.65HAS	No	No	-	-
34.7	RM34.7PDC	One pipe gone last year	No	Lost all of its debris	-
35.4	MC35.4PDC	No	No	-	-

APPENDIX C (continued)
1996 Physical Assessments of Habitat Complexes

Location (km)	Site Number	Damage	Displacement	Debris Accumulation/Loss	Recommendation /Comments
REACH 4					
72.9	LM72.9HAS	No	No	-	-
73	LM73.0HAS	No	No	-	-
75.9	LM75.9HAS	No	No	-	-
78	LM78.0HAS	No	No	-	-
80.2	LM80.2HAS	No	No	-	-
80.9	LM80.9RDC	No	No	-	-
82.1	LM82.1RAS	No	No	-	-
82.2	LM82.2RAS	No	No	-	-
82.3	LM82.3HAS	No	No	-	-
83	LM83.0RDC	No	No	-	-
85.7	RM85.7RAS	No	No	-	-
86.35	RM86.35RDC	Break through in center of RDC	No	-	-
86.375	RM86.375RDC	Lost a rail	No	-	-

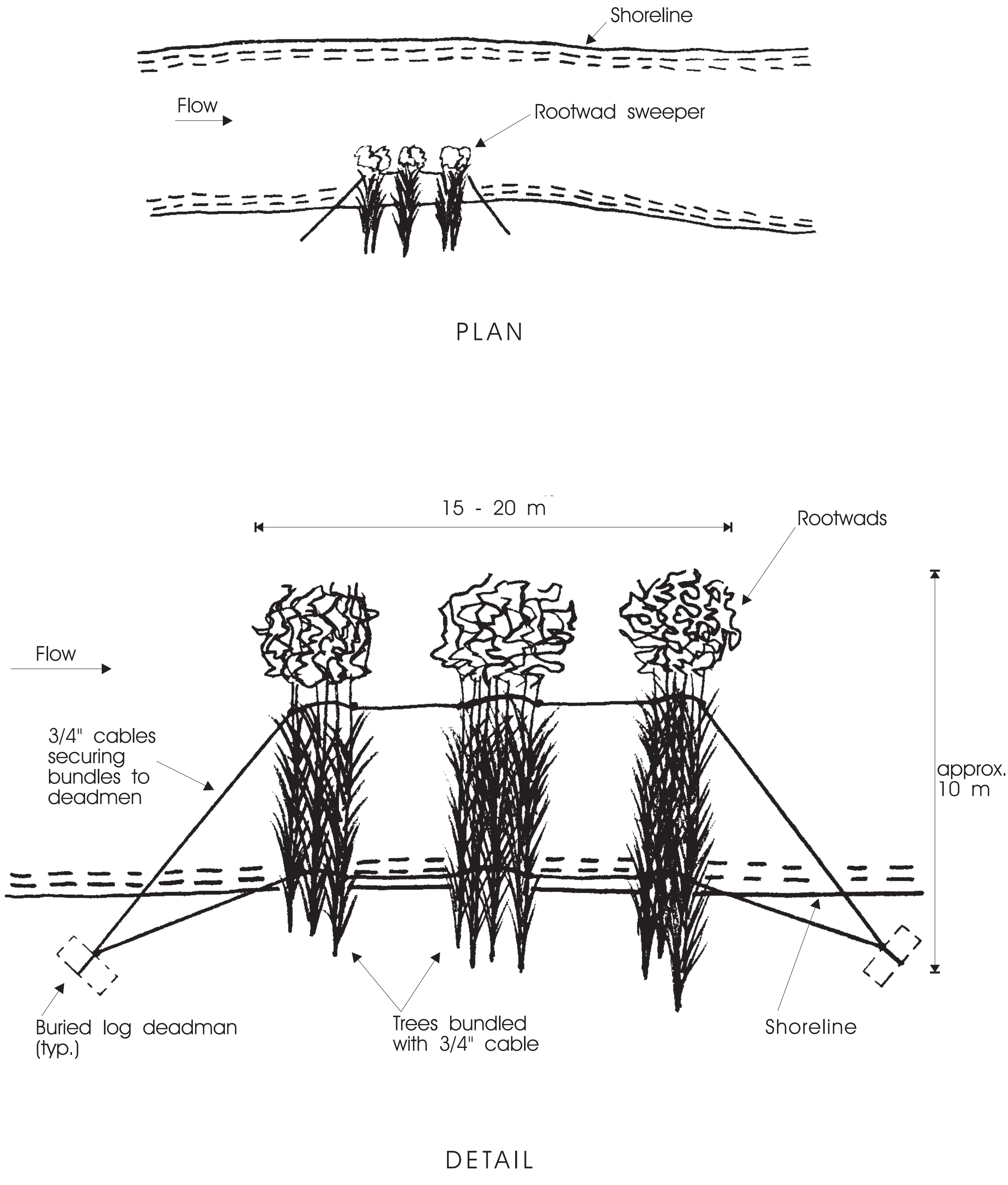
Where,
RM = right margin
MC = mid-channel
LM = left margin

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail-anchored sweeper
HAS = hand-placed anchored sweeper

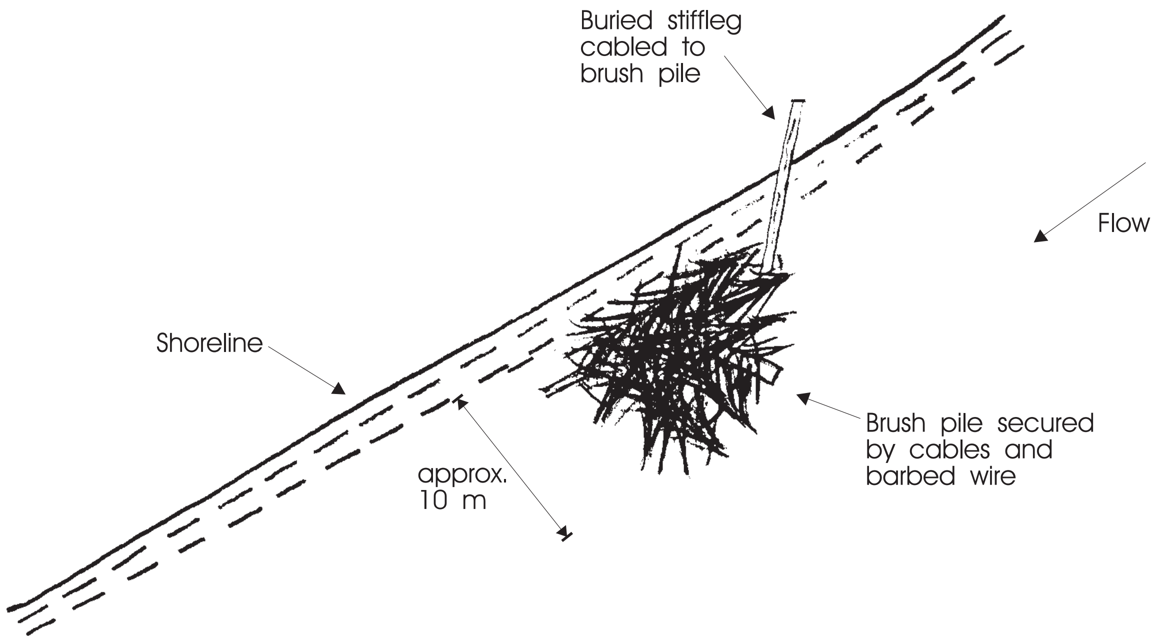
PDC = pipe-pile debris catcher
RDC = rail-debris catcher
SC= side channel
DB = debris boom
PB = point bar
PP = pocket pool

u/s = upstream
d/s = downstream
N/A - not available

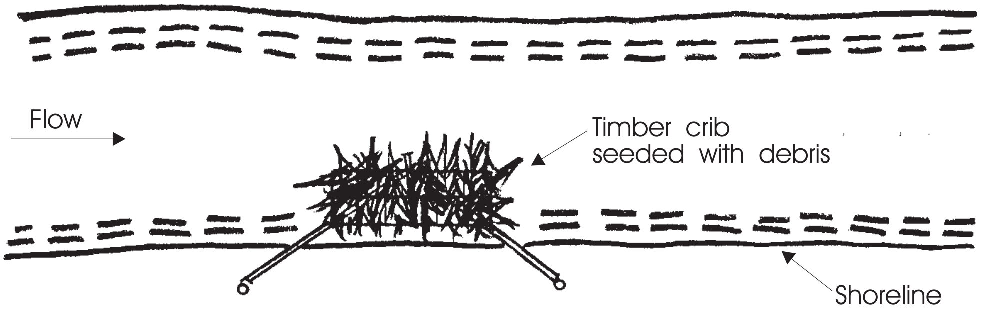
APPENDIX D
1996 Sketches of Habitat Complexes (As Built)



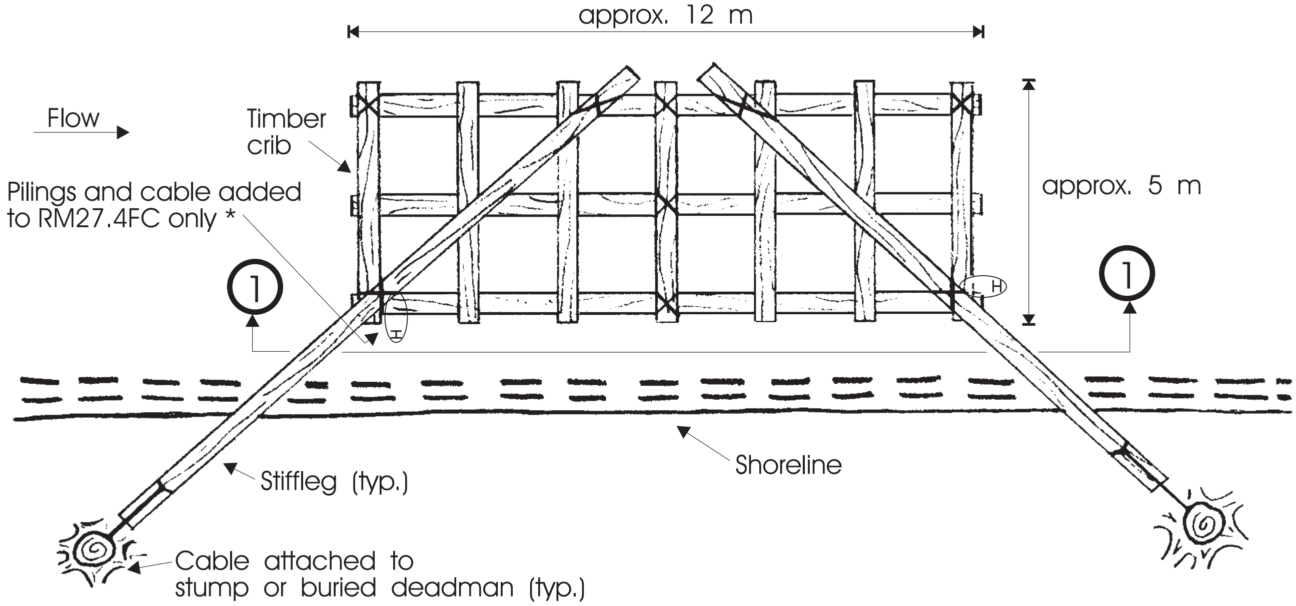
Nechako Fisheries Conservation Program	Map # RM962-1a	Not To Scale
FIGURE 1. ROOT WAD SWEEPER (1988)		



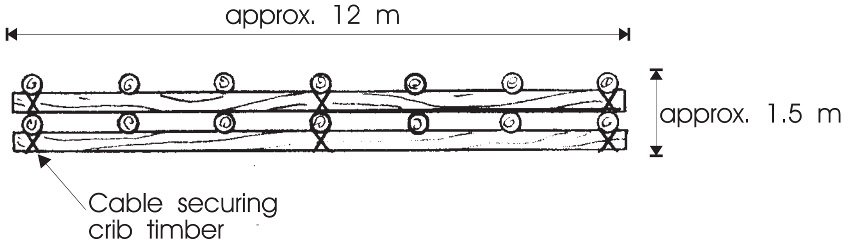
Nechako Fisheries Conservation Program	Map # RM962-2a	Not To Scale
FIGURE 2. MAINSTEM BRUSH PILE (1988)		



PLAN



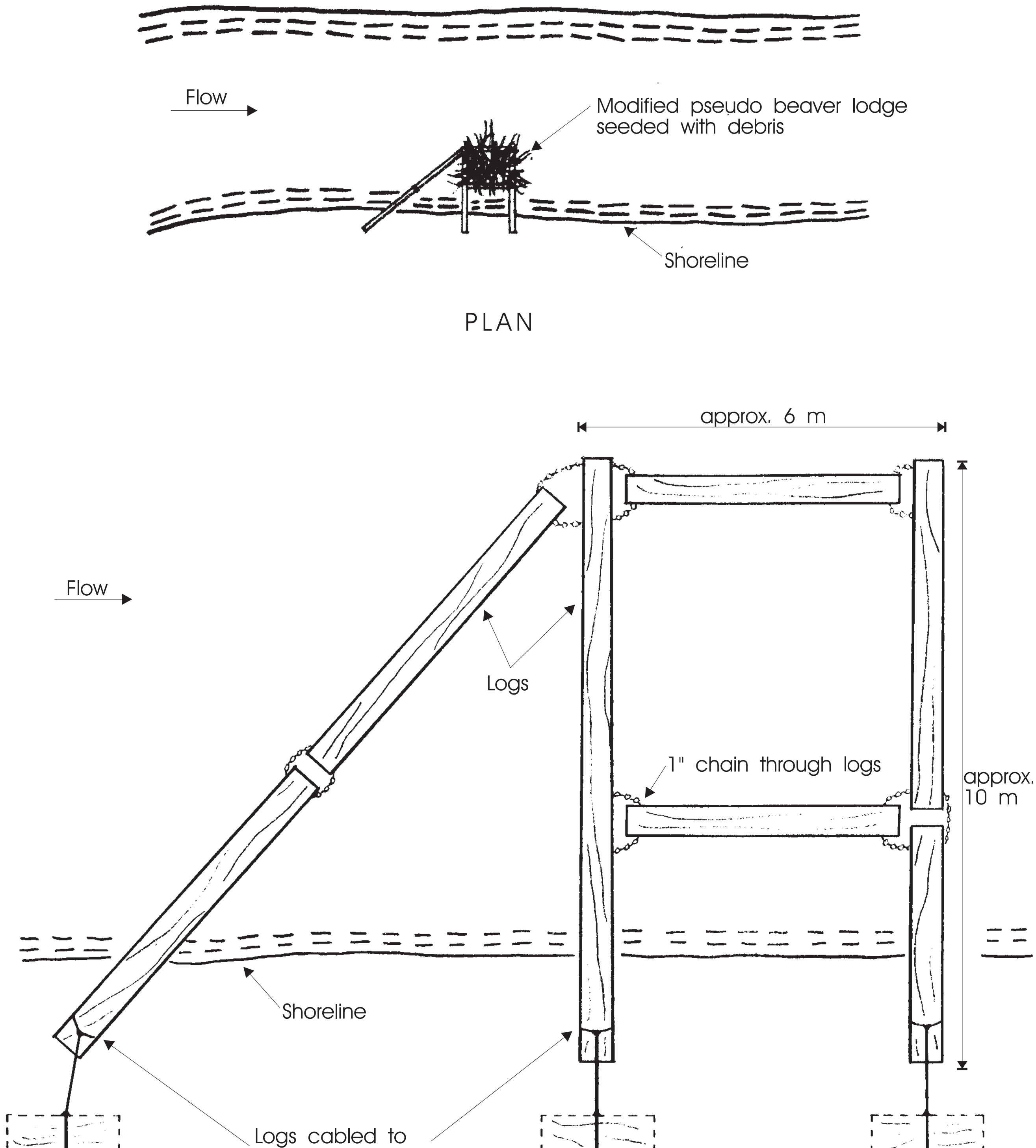
DETAIL



SECTION 1

* RM27.4FC was modified in Spring 1991. Structure was removed offshore to increase flow through velocities and 2 rails were installed to secure the structure in place offshore.

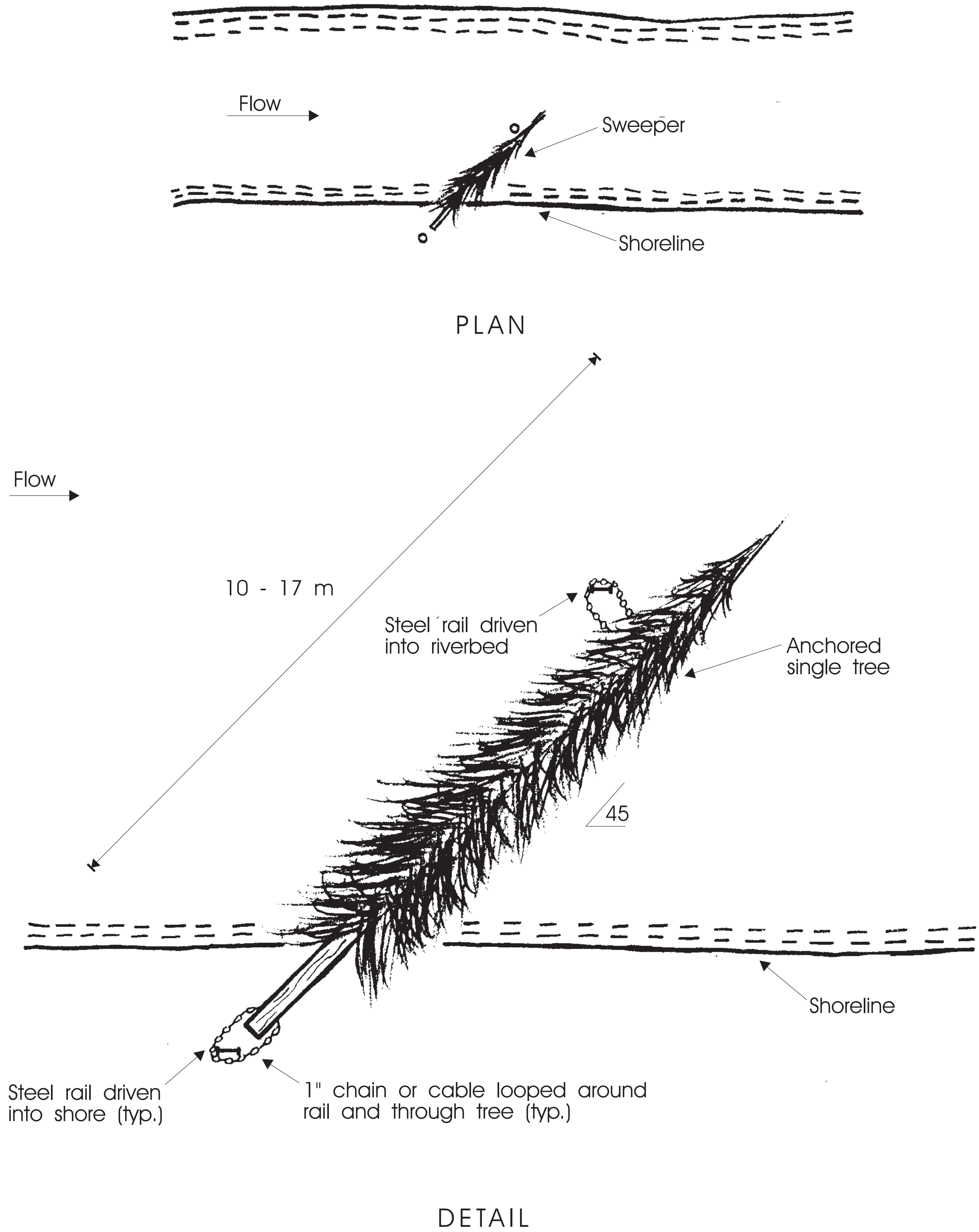
Nechako Fisheries Conservation Program	Map # RM962-3a	Not To Scale
FIGURE 3. FLOATING CRIB (1988)		



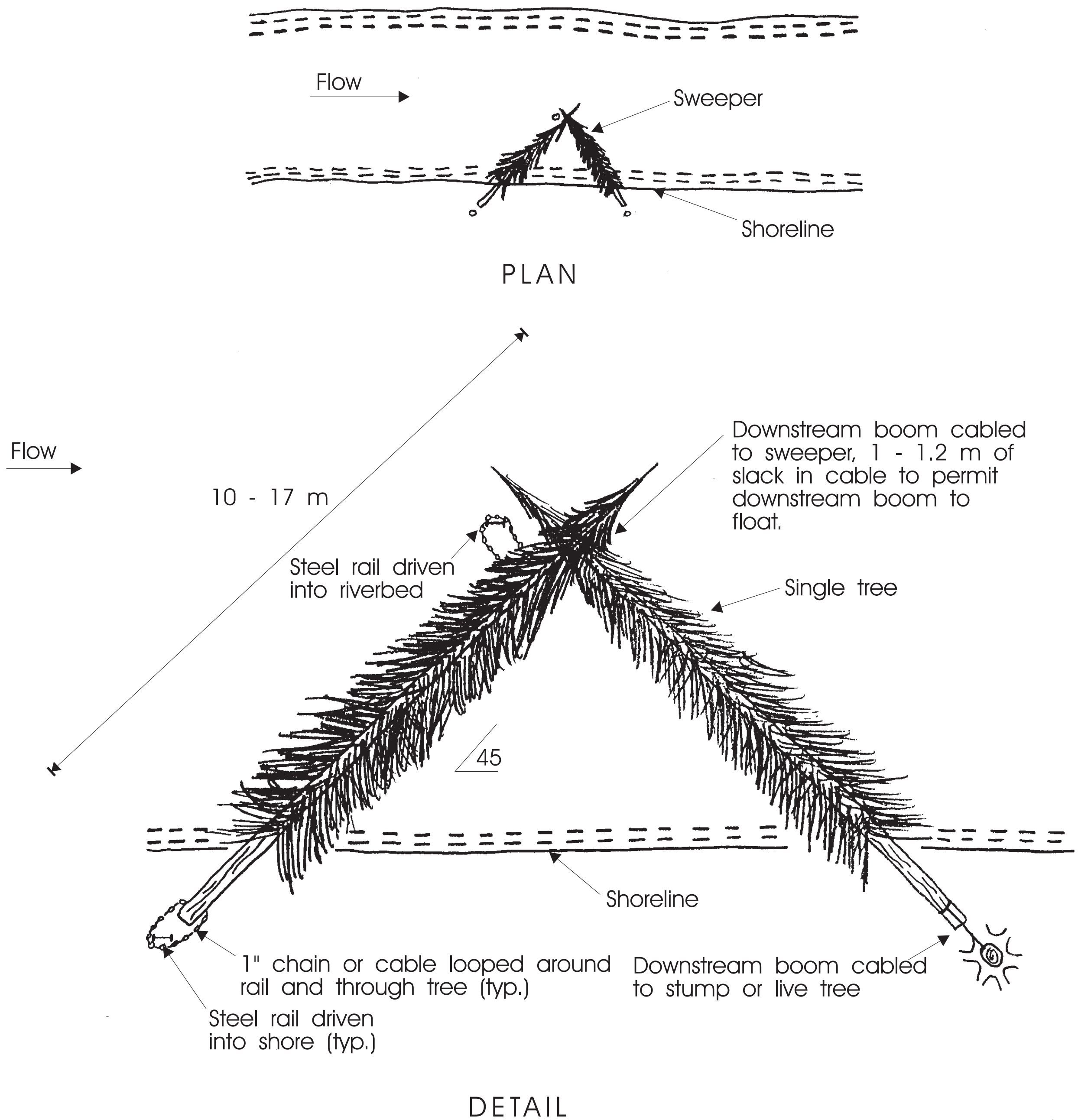
Nechako Fisheries Conservation Program	Map # RM962-4a

FIGURE 4. PSEUDO BEAVER LODGE (FALL 1989)

Not To Scale

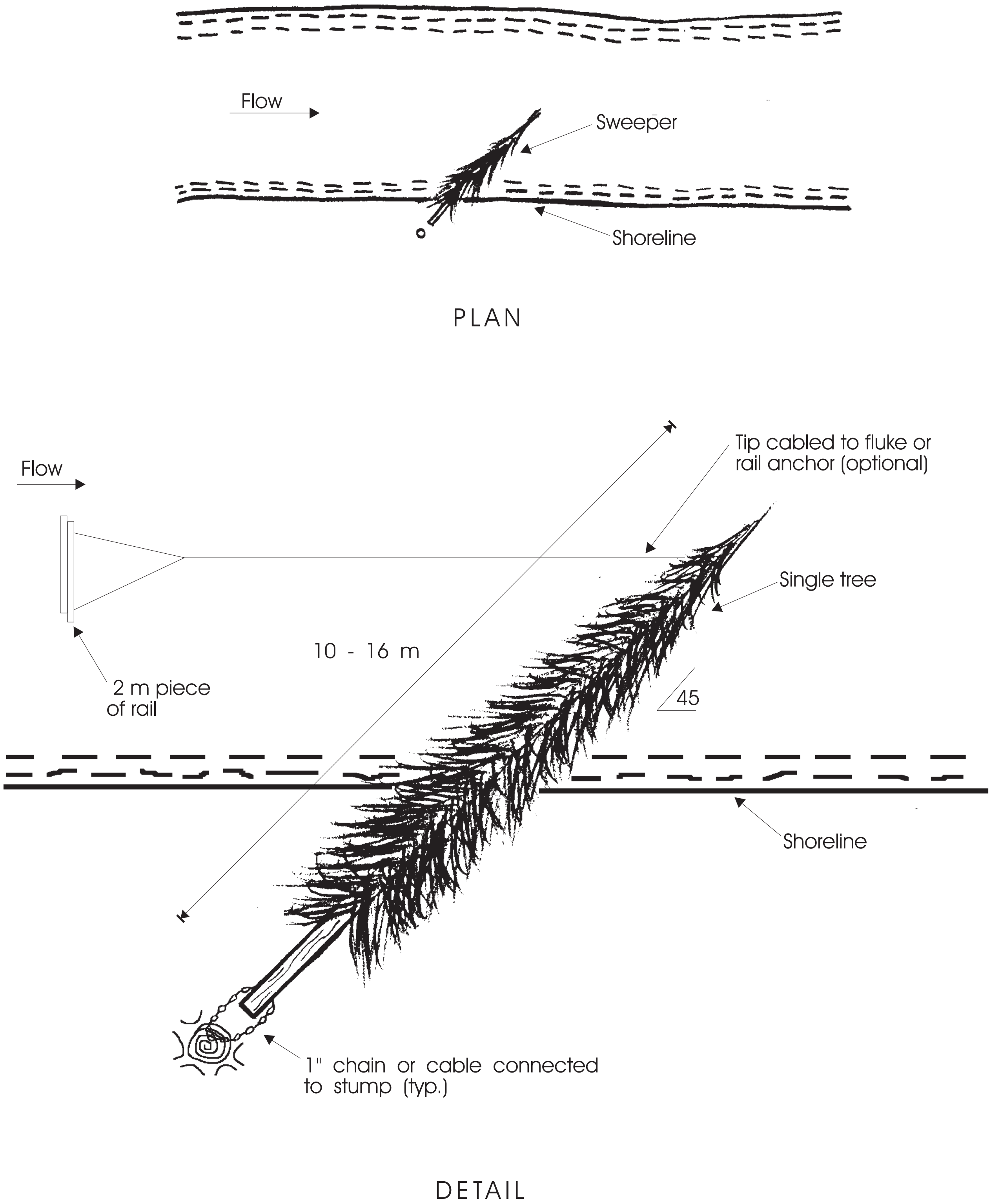


Nechako Fisheries Conservation Program	Map # RM962-5a	Not To Scale
FIGURE 5. RAIL ANCHORED SWEEPER (1991)		

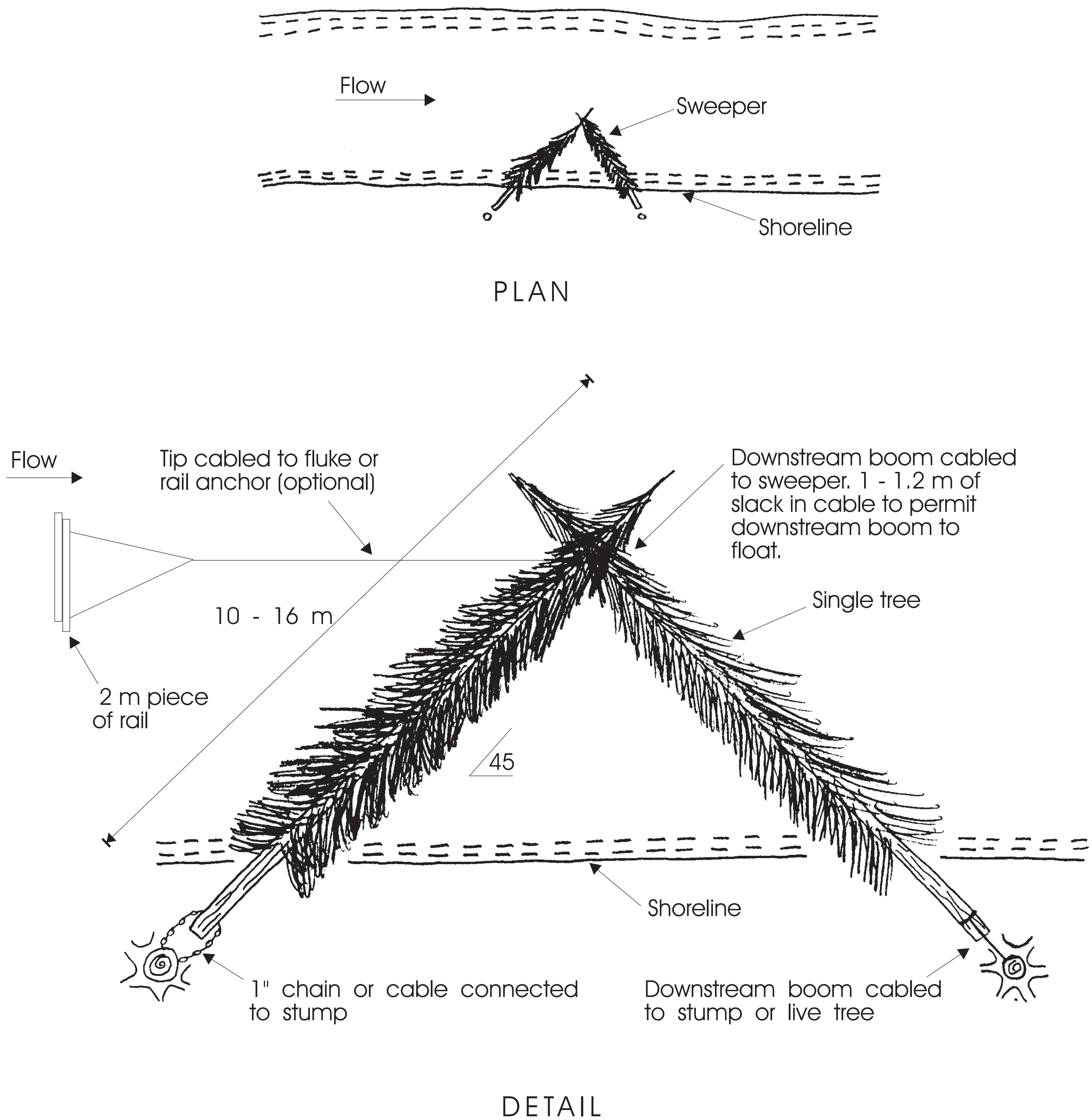


Note: Tree added to two existing rail anchored sweepers (LM82.1RAS and RM85.7RAS) in 1993 as a downstream boom to improve debris capture.

Nechako Fisheries Conservation Program	Map # RM962-6a	Not To Scale
FIGURE 6. MODIFIED RAIL ANCHORED SWEEPER (1993)		

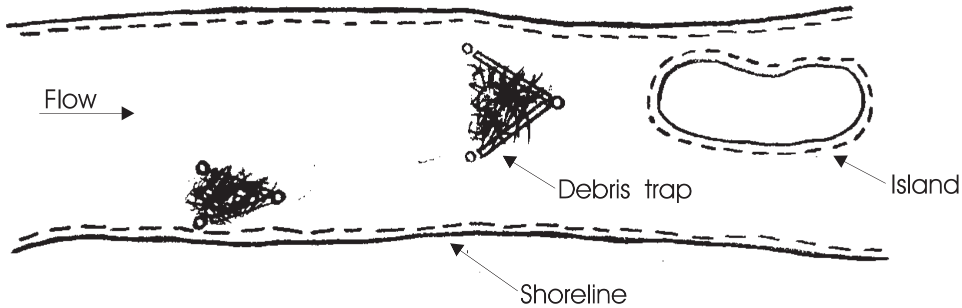


Nechako Fisheries Conservation Program	Map # RM962-7a	Not To Scale
FIGURE 7. HAND-PLACED ANCHORED SWEEPER (1991)		

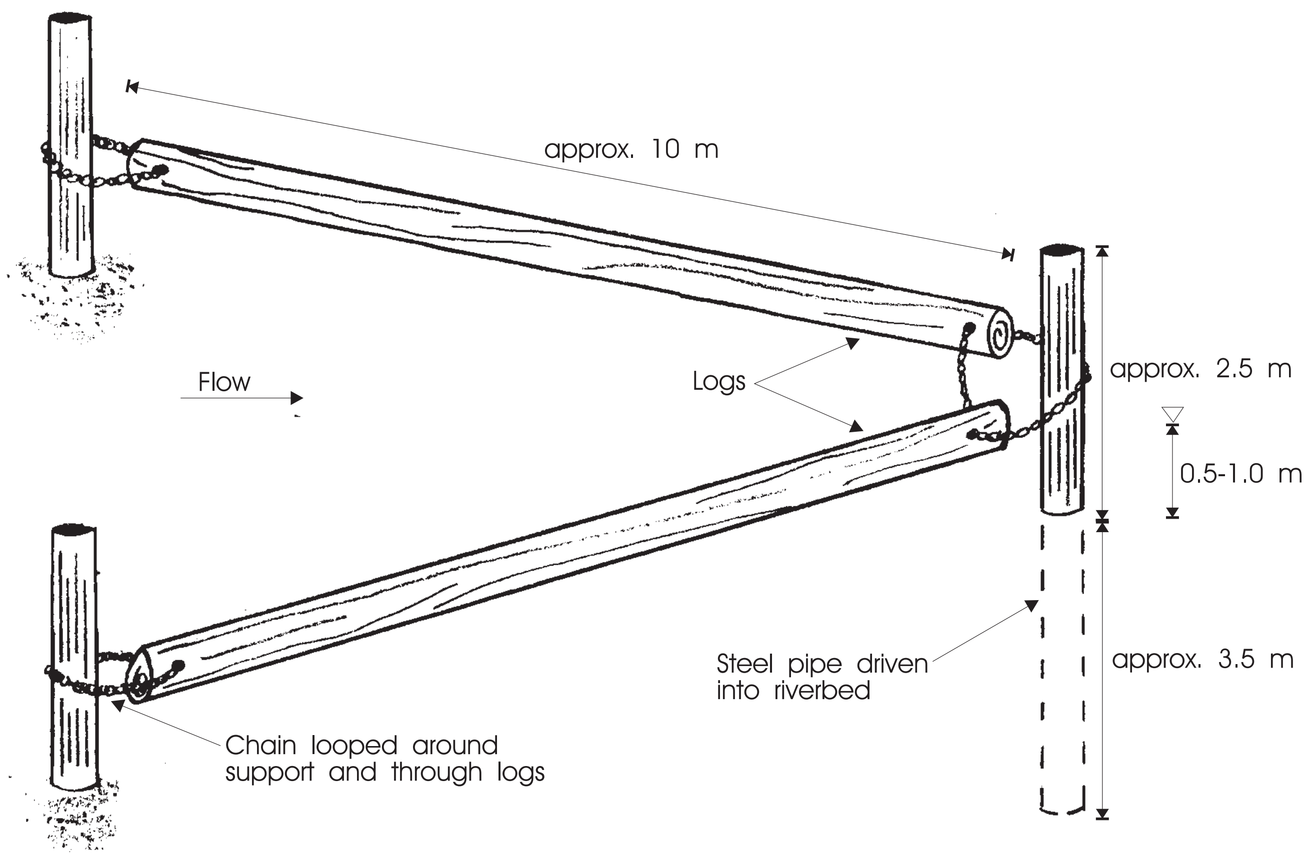


Note: Tree added to two existing hand-placed anchored sweepers (LM72.9HAS and LM75.9HAS) in 1993 as a downstream boom to improve debris capture.

Nechako Fisheries Conservation Program	Map # RM962-8a	Not To Scale
FIGURE 8. MODIFIED HAND-PLACED ANCHORED SWEEPER (1993)		

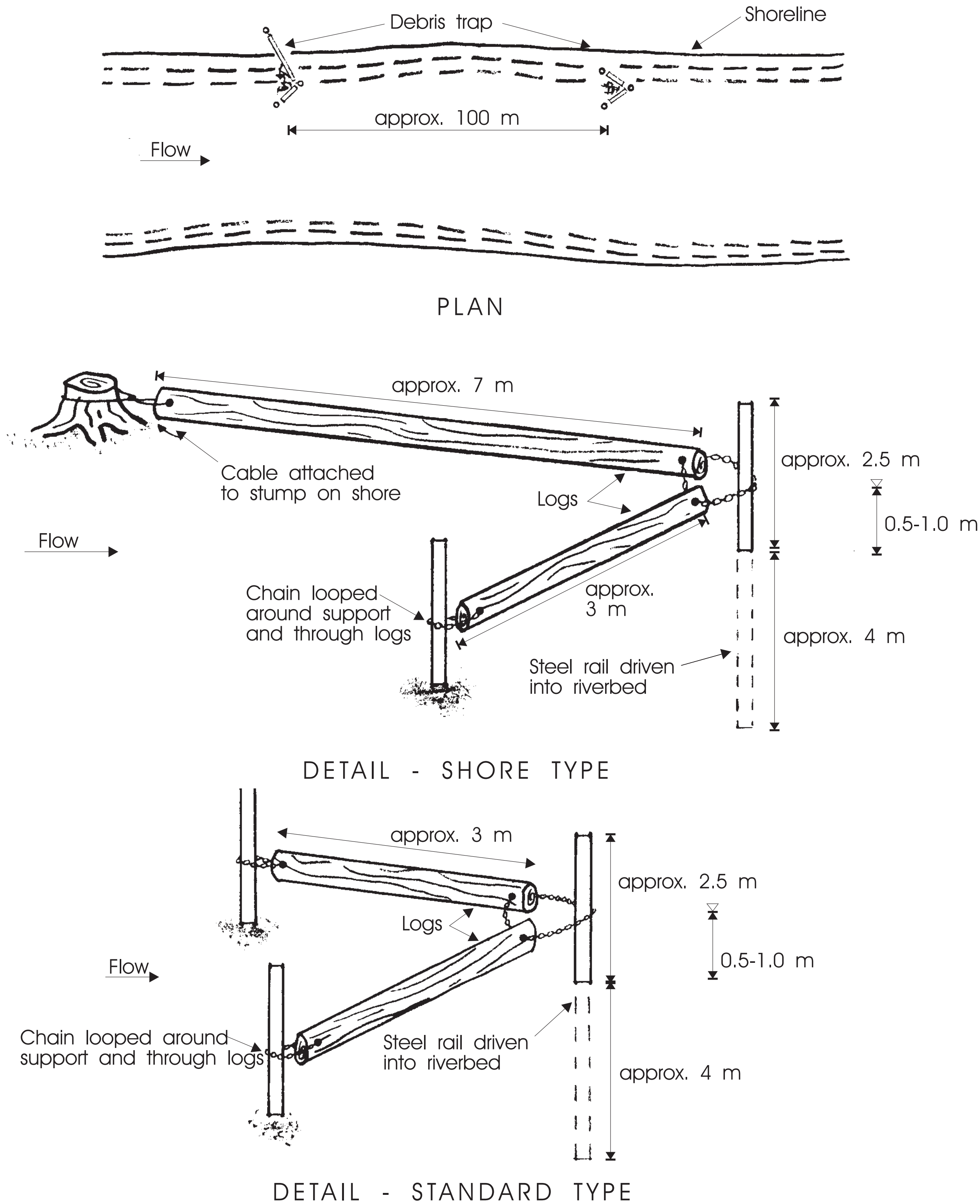


PLAN

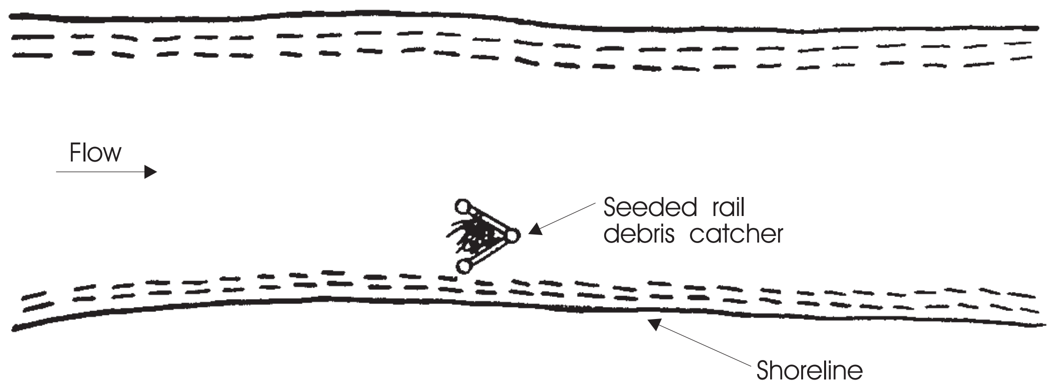


DETAIL

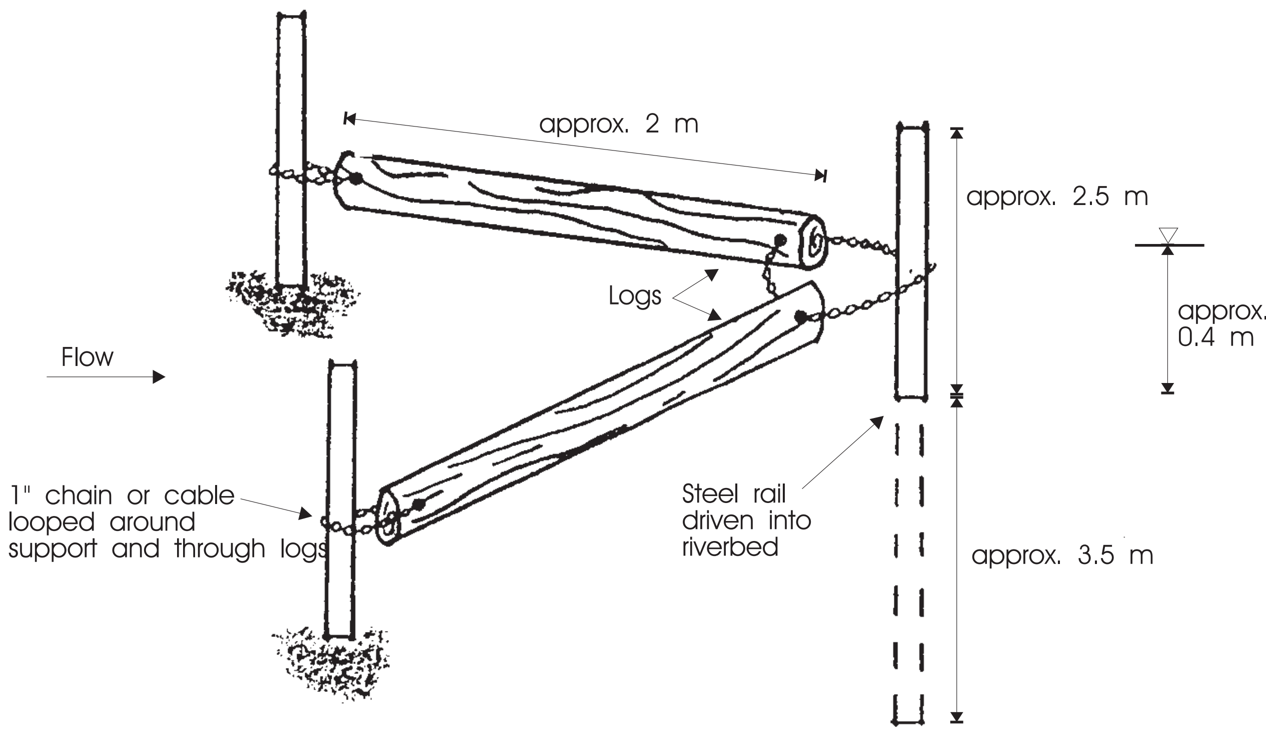
Nechako Fisheries Conservation Program	Map # RM962-9a	Not To Scale
FIGURE 9. PIPE PILE DEBRIS CATCHER (1989)		



Nechako Fisheries Conservation Program	Map # RM96210a	Not To Scale
FIGURE 10. RAIL DEBRIS CATCHER (1990)		

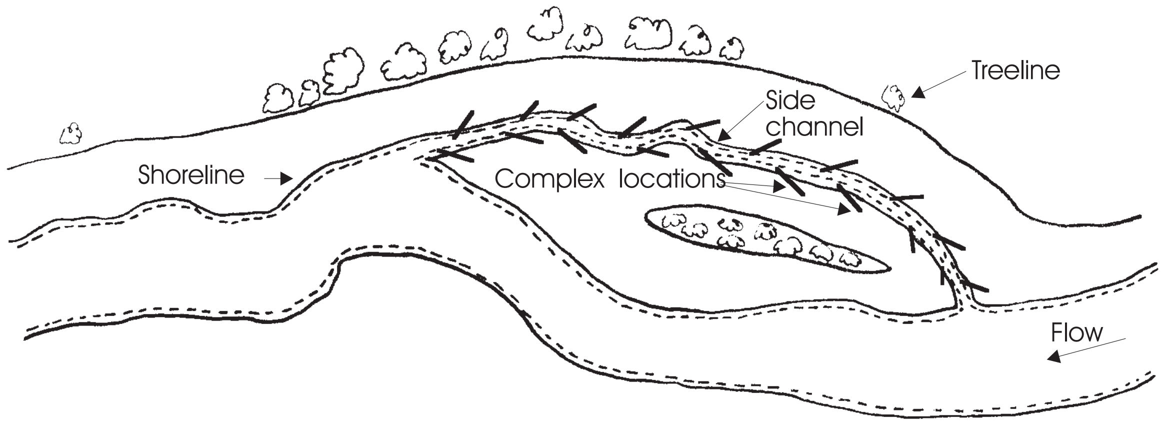


PLAN

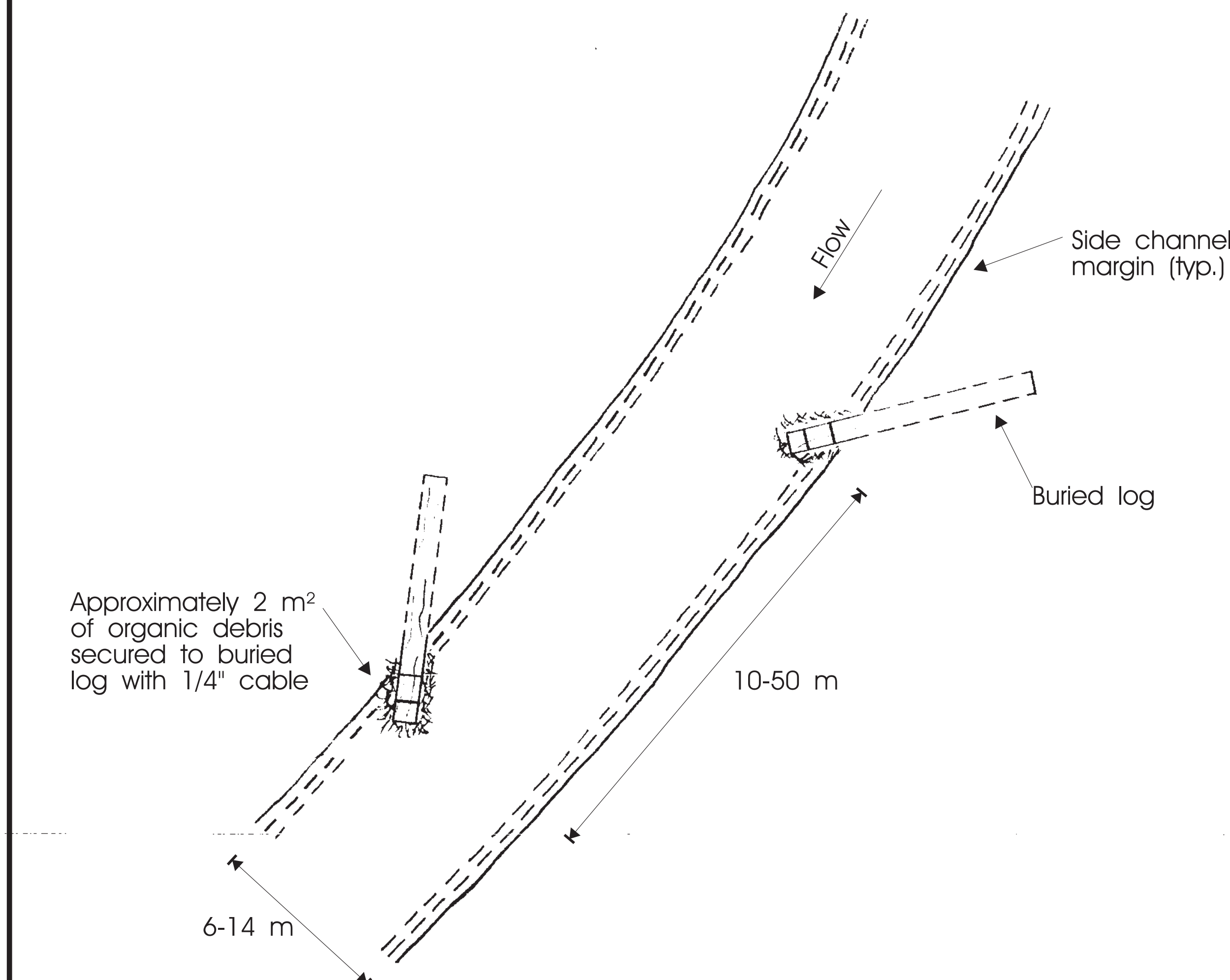


DETAIL

Nechako Fisheries Conservation Program	Map # RM96211a	Not To Scale
FIGURE 11. RAIL DEBRIS CATCHER (1991)		

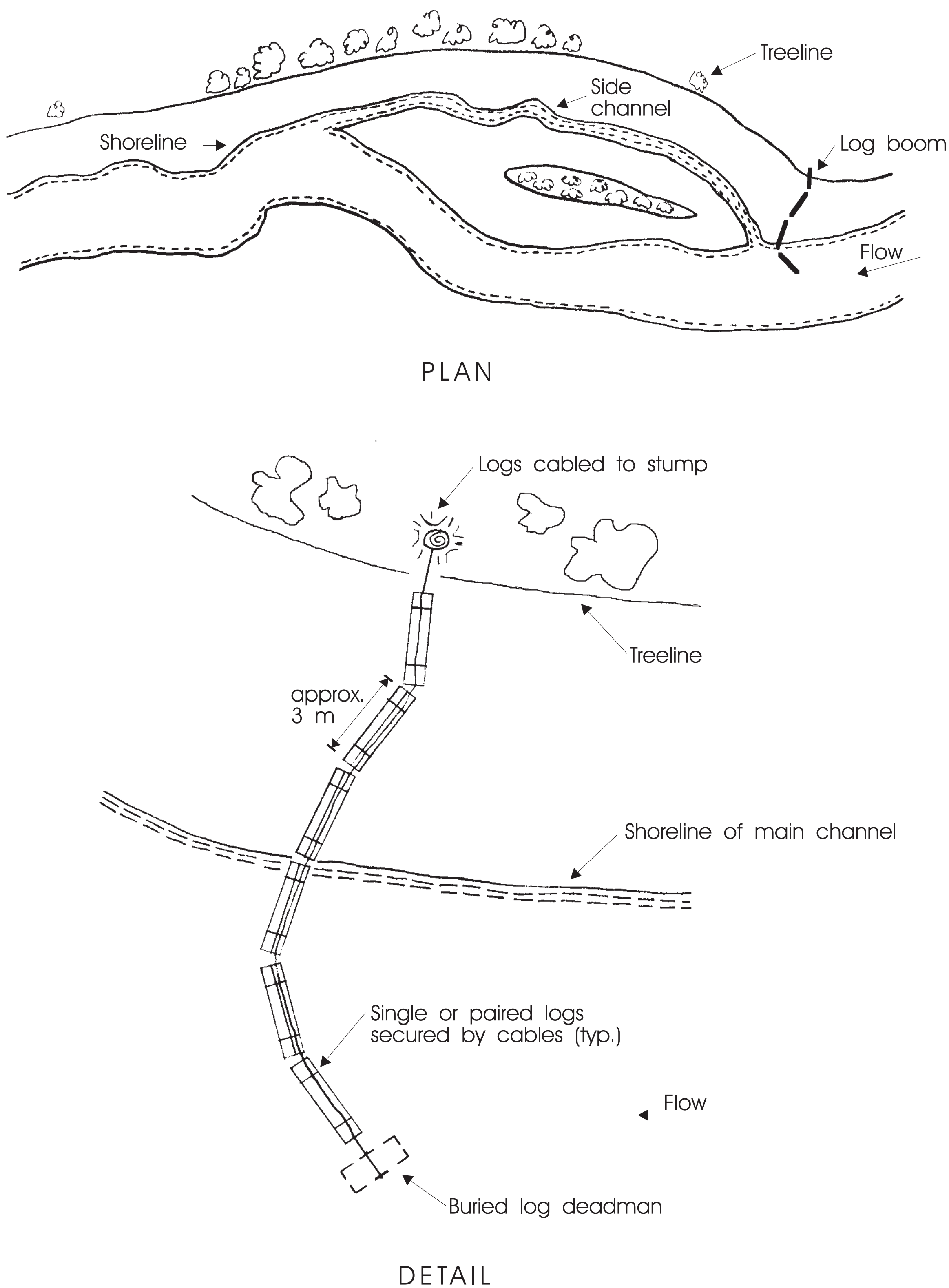


PLAN



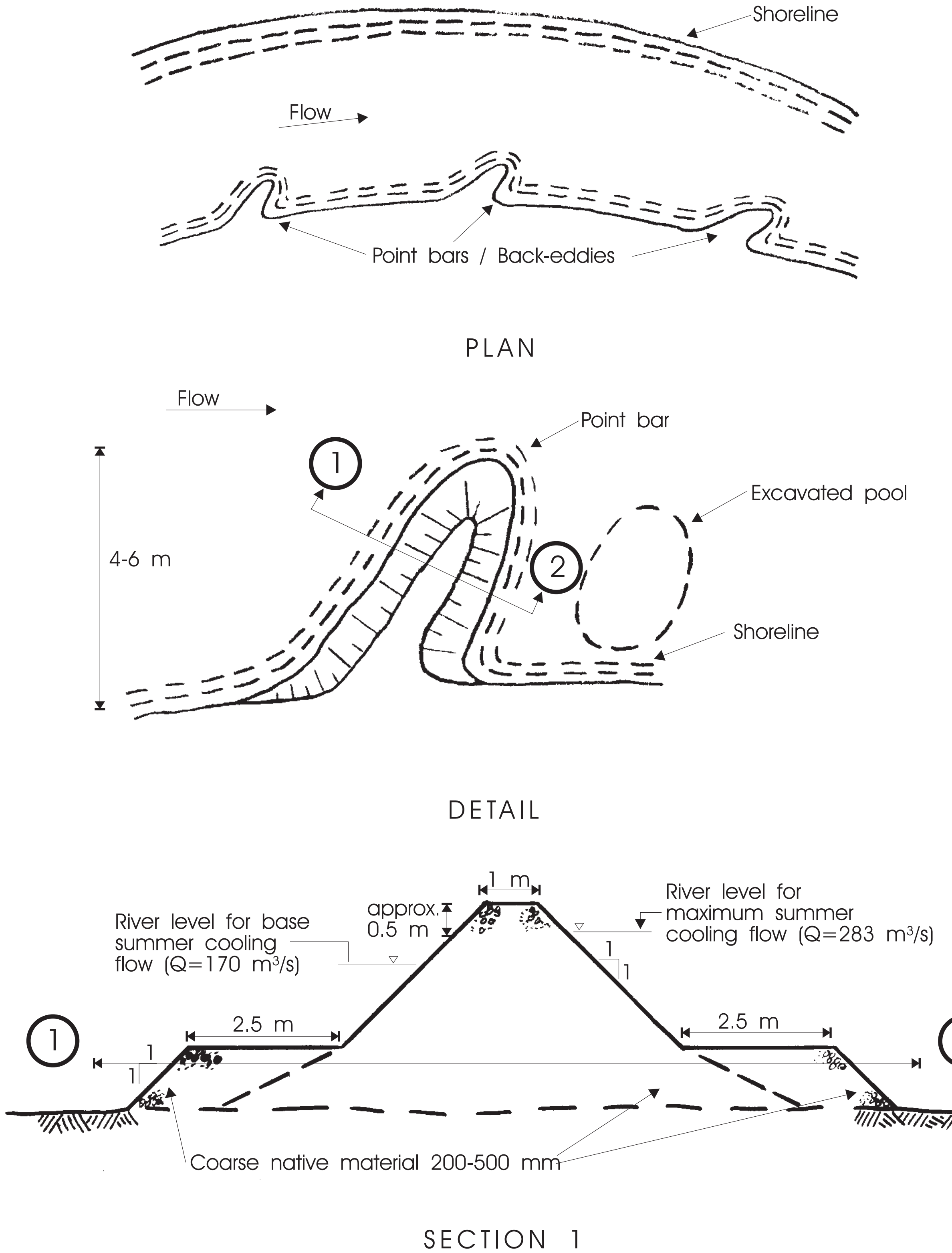
DETAIL

Nechako Fisheries Conservation Program	Map # RM96212a
FIGURE 12. SIDE CHANNEL COMPLEX (1990)	Not To Scale

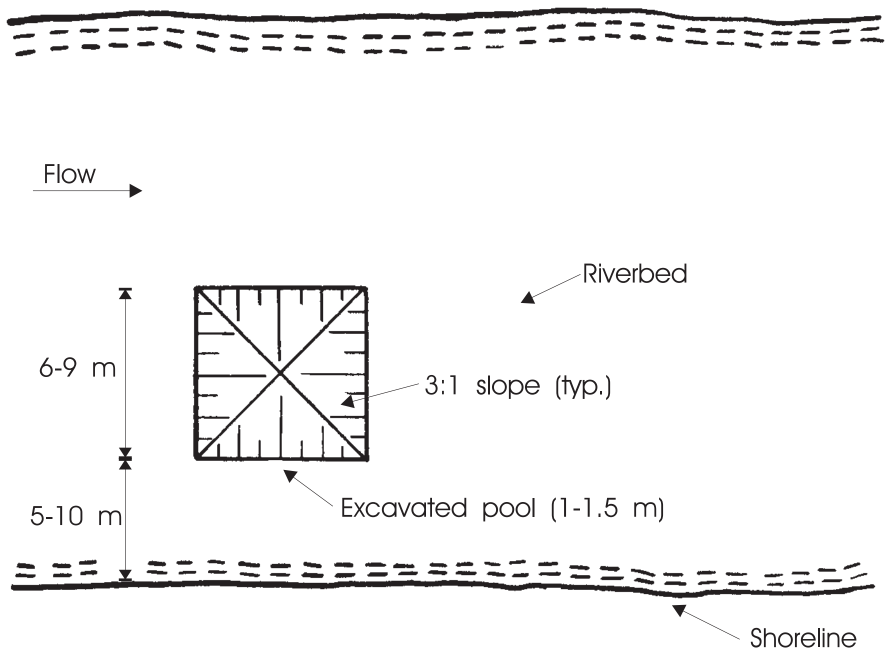


Nechako Fisheries Conservation Program	Map # RM96213a	Not To Scale

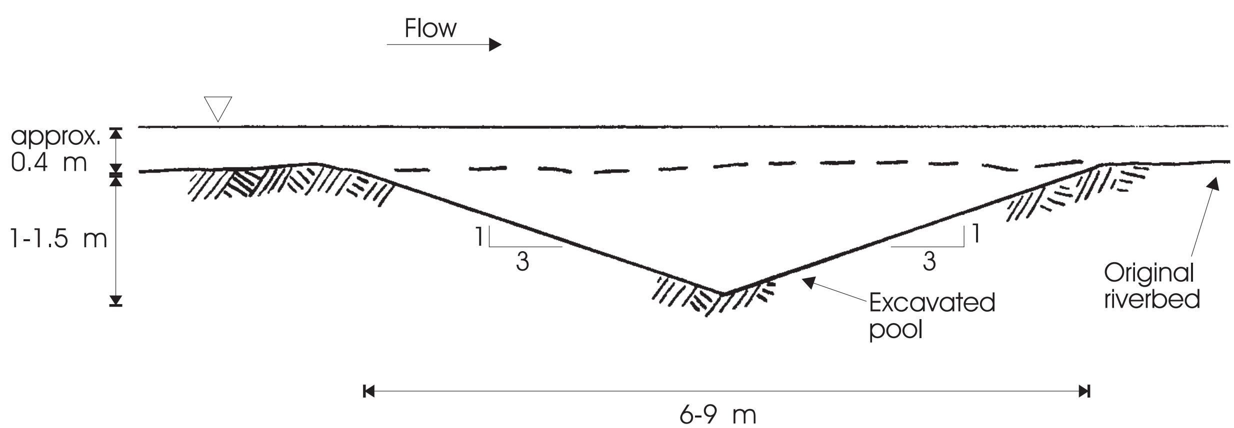
FIGURE 13. SIDE CHANNEL DEBRIS BOOM (1990)



Nechako Fisheries Conservation Program	Map # RM96214a	Not To Scale
FIGURE 14. MODIFIED POINT BAR (1991)		



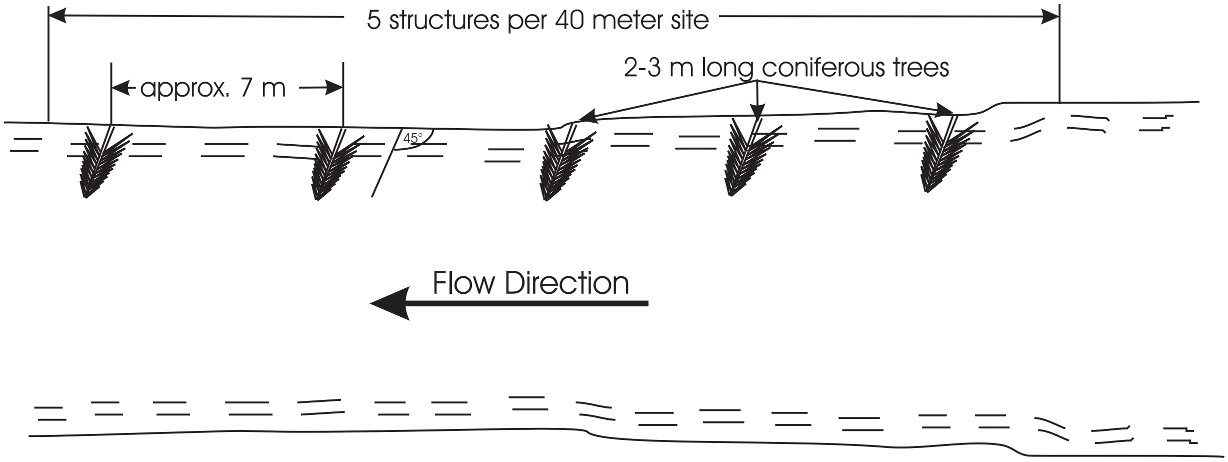
PLAN



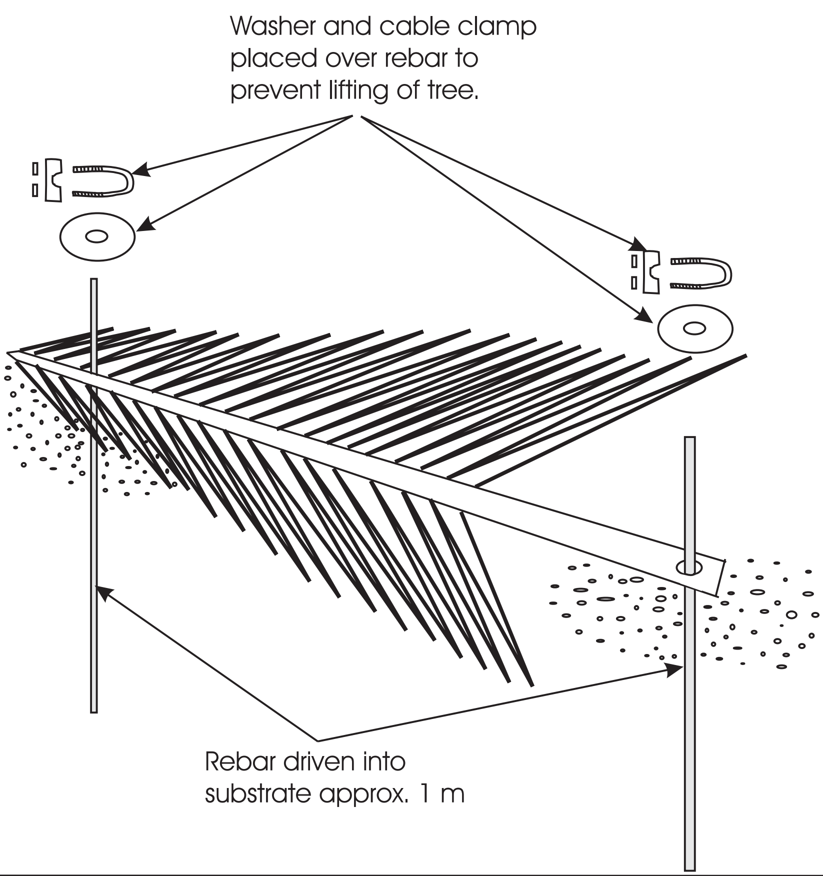
DETAIL

Nechako Fisheries Conservation Program	Map # RM96215a	Not To Scale
FIGURE 15. POCKET POOL 1991		

Typical Emergent Fry Structure Site



Typical Emergent Fry Structure



Nechako Fisheries Conservation Program	Drawing # RM96216a	Not To Scale
FIGURE 16. EMERGENT FRY STRUCTURES (1996)		

APPENDIX E

1996 Habitat Complex Physical Assessment Photos

Photograph 1: Stable rootwad sweeper (RM24.35RS) providing 72 m² of cover area (May 1996).

Photograph 2: Brushpile (RM31.4BP) with little cover area due to mobile river bank (May 1996).

Photograph 3: Stable floating crib (RM24.4FC) showing large cover area of 78 m² (May 1995).

Photograph 4: Floating crib (RM27.4FC) not providing much cover as its upstream end pushed onto the shore (May 1996).

Photograph 5: Pseudo beaver lodge (RM24.6PBL) still retaining debris, providing 38 m² of cover area (May 1996).

Photograph 6: Pseudo beaver lodge (RM31.0PBL) only providing a cover area of 15 m² due to collapsed frame (May 1996).

Photograph 7: Rail-anchored sweeper (RM16.2RAS) stripped of majority of branches and not providing much cover area (May 1996).

Photograph 8: Rail-anchored sweeper (RM22.1RAS) with boom detached from the outside rail (May 1996).

Photograph 9: Rail-anchored sweeper (RM22.95RAS) with boom detached from the outside rail (May 1996).

Photograph 10: Rail-anchored sweeper (RM26.9RAS) stripped of majority of branches and not providing much cover area (May 1996).

Photograph 11: Smaller pipe-pile debris catcher (RM34.7PDC) providing 20 m² of cover area despite loss of one pile in the previous year (May 1996).

Photograph 12: Large accumulation (180 m²) at pipe-pile debris catcher (MC35.4 PDC, May 1996).

Photograph 13: Rail debris catcher (RM16.5RDC) showing very little debris capture (May 1996).

Photograph 14: Beaver lodge built at rail debris catcher (LM22.6RDC, May 1996).

Photograph 15: Rail debris catcher (LM24.2RDC) showing significant debris capture (May 1996).

Photograph 16: Beaver lodge built at rail debris catcher (RM28.4RDC, May 1996).

Photograph 17: Break through in the center of the rail debris catcher (RM86.35RDC, May 1996).

Photograph 18: Stable debris boom (RM17.9DB) providing 62m² of cover area (May 1996).

Photograph 19: Side channel (RM17.9SC) showing low water level and no velocity due to beaver dam blockage (May 1996).

Photograph 20: Stable point bar (RM17.15PB) showing shear zone (May 1996).