HYDROGLYPHIC
TERRAIN ANALYSTS

Zymoetz River Watershed Restoration Program:

Hydrological Assessment of Site 9,

Off-Channel Project

Submitted to:

Terrace Salmonid Enhancement Society
Deep Creek Fish Hatchery
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Submitted by:

Alan Gilchrist, Ph.D.

September 1998

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1.0 INTRODUCTION

The Zymoetz River, locally known as the Copper River, is a major watershed that drains into the Skeena River just to the east of Terrace, B.C. The Watershed Restoration Program (WRP) of Forest Renewal B.C. funded a Level I Detailed Assessment of Fish and Fish Habitat of the lower Zymoetz River which was completed by the Terrace Salmonid Enhancement Society in the early part of 1998. This study identified many specific impact sites in the watershed and suggested prescriptions for their restoration, or enhancement, of salmonid habitat. One of these sites, number 9, is in an off-channel setting and it was suggested that this site would be a good candidate for developing a groundwater fed spawning channel. Further work, primarily by Jim Culp, R. Finnigan, P.Eng. and a variety of Ministry personnel has resulted in a more detailed prescription. Overview hydrological assessments of several impact sites were completed as part of the Level I Detailed Assessment (HydroGlyphic Terrain Analysts, 1998) although site 9 was not included in that study. This report details the hydrological assessment of the proposed restoration works for site 9, which was completed by Dr. Alan Gilchrist of HydroGlyphic Terrain Analysts under contract to the Terrace Salmonid Enhancement Society.

The findings in this report are presented in several sections. The next section contains background material including the objectives of this study and an outline of the methods used. Section 3.0 provides an overview description of the Zymoetz watershed which includes descriptions of the morphological setting, hydrology and channel stability. This information is crucial to understanding the dynamics of the Zymoetz River and the processes that influence the morphology at site 9. Section 4.0 describes site 9 within the context of the entire watershed and details the channel stability of the area immediately surrounding the site. This directly influences the effectiveness and potential longevity of the proposed restoration works which are also examined in this section. Section 5.0 presents the conclusions and recommendations of this study which are categorized into those of direct relevance to site 9 and a more general discussion of restoration activities in the Zymoetz watershed. Section 6.0 lists the literature referred to in this report.

2.0 PROJECT BACKGROUND

2.1 Scope of Work

There are two main objectives of this study.

- Assess the potential impact of the proposed restoration works for site 9 with regard to the stability of the river channel and the effect, if any, on private property downstream of the site.
- Comment on the technical merits of the proposed restoration works.

To achieve these objectives a holistic approach has been used. That is, site 9 has been analyzed as part of the larger Zymoetz River system since processes acting throughout the watershed are communicated down through the main-stem channel and determine to some extent what happens at site 9. Therefore, the assimilation of background material has been an important component of this study in addition to fieldwork on site.

2.2 Methods

This study was started on 26 August 1998 and was split into three phases. During the first phase, several documents were reviewed either prior to, or just after, the site visits to gain an appreciation of the physical characteristics of the Zymoetz River. These documents are listed in section 6.0 and in addition included:

- 1991 TRIM map 103I.058 (scale 1:20,000)
- 1968 air photos, flightline BC5303-104 & 105 (scale ~ 1:40,000)
- 1995 air photos, WRP Overview Assessment photo mosaic (scale ~1:5,000)
- 1997 (Nov.) air photos, WRP Level 1 Assessment photo mosaic (scale ~ 1,400)
- 1998 (March) air photos, WRP Level 1 Assessment photo mosaic (scale ~ 1,400)
- Floodplain erosion hazard map (scale 1:10,000)
- Floodplain erosion and deposition summary map, 1949-1968 (scale 1:20,000)
- Floodplain erosion and deposition summary map, 1968-1988 (scale 1:20,000)
- WRP Zymoetz River site 9 prescription prepared by R. Finnigan, (August 1998)
- Survey of Site 9 by McElhanney Consulting Services Ltd. (July 1998)

The second phase consisted of two site visits, each with a duration of about half a day, which were made on the 27 and 28 August 1998. The first visit was made with Jim Culp from the Terrace Salmonid Enhancement Society who provided valuable background materials for the project and explained the proposed restoration activities during a walk around the site. A second visit was made the following day when more detailed observations were made. In addition, the opposite bank of the river (north) was visited where private properties are located off Copper River Road on the floodplain of the Zymoetz River.

The third phase consisted of assimilating field data with the review of existing information on the watershed, formulating conclusions and the preparation of this report.

3.0 DESCRIPTION OF ZYMOETZ WATERSHED

3.1 Morphological Setting

The Zymoetz River watershed has a drainage area of approximately 3,000 km^2 and drains into the Skeena River just to the east of Terrace, B.C. (Figure 1). The watershed drains a variety of mountainous terrain in the Bulkley Ranges including high alpine areas of Hudson Bay Mountain (2550 m), Howson Peak (2740 m) and Andesite Peak (2379 m). There are several significant tributaries in the watershed including the Clore River, Kitnayakwa River and Limonite Creek.

The Zymoetz River is divided into several uniform reaches based on channel form, stream bank materials and channel gradient (Kellerhals et al., 1976). The lower 50 km of the river has been divided into seven reaches by Weiland and Schwab (1996). The lower 25 km contain the first four reaches: One and three have relatively narrow floodplains (between 300 m and 600 m wide with the exception of the mouth which widens to 2,500 m) while two and four are steep bedrock canyons. Reaches five, six and seven have floodplains between 100 m and 1,200 m wide. The Zymoetz River is stable in the bedrock canyons but forms a wandering gravel bedded river in the floodplain reaches (1, 3, 5, 6, & 7). These reaches are characterized by periodic changes in river channel location due to the erosion of unstable banks and the transient nature of gravel bars which act to temporarily store sediment moving down through the river system.

The frequency and magnitude of the channel changes has increased over the last twenty years or so and this has been attributed to extreme rainstorms rather than the consequence of clearcut timber harvesting (Weiland and Schwab, 1996). The rationale is that less than ~ 5% of the watershed has been logged and experimental studies in Carnation Creek have shown that harvesting less than 30 % of a watershed does not greatly increase peak flows (Hetherington, 1987). On the other hand, major floods during the fall were preceded by intense rainstorms with above average temperatures so that precipitation fell as rain throughout the watershed, rather than snow at higher elevations, which directly contributed to high stream flows.

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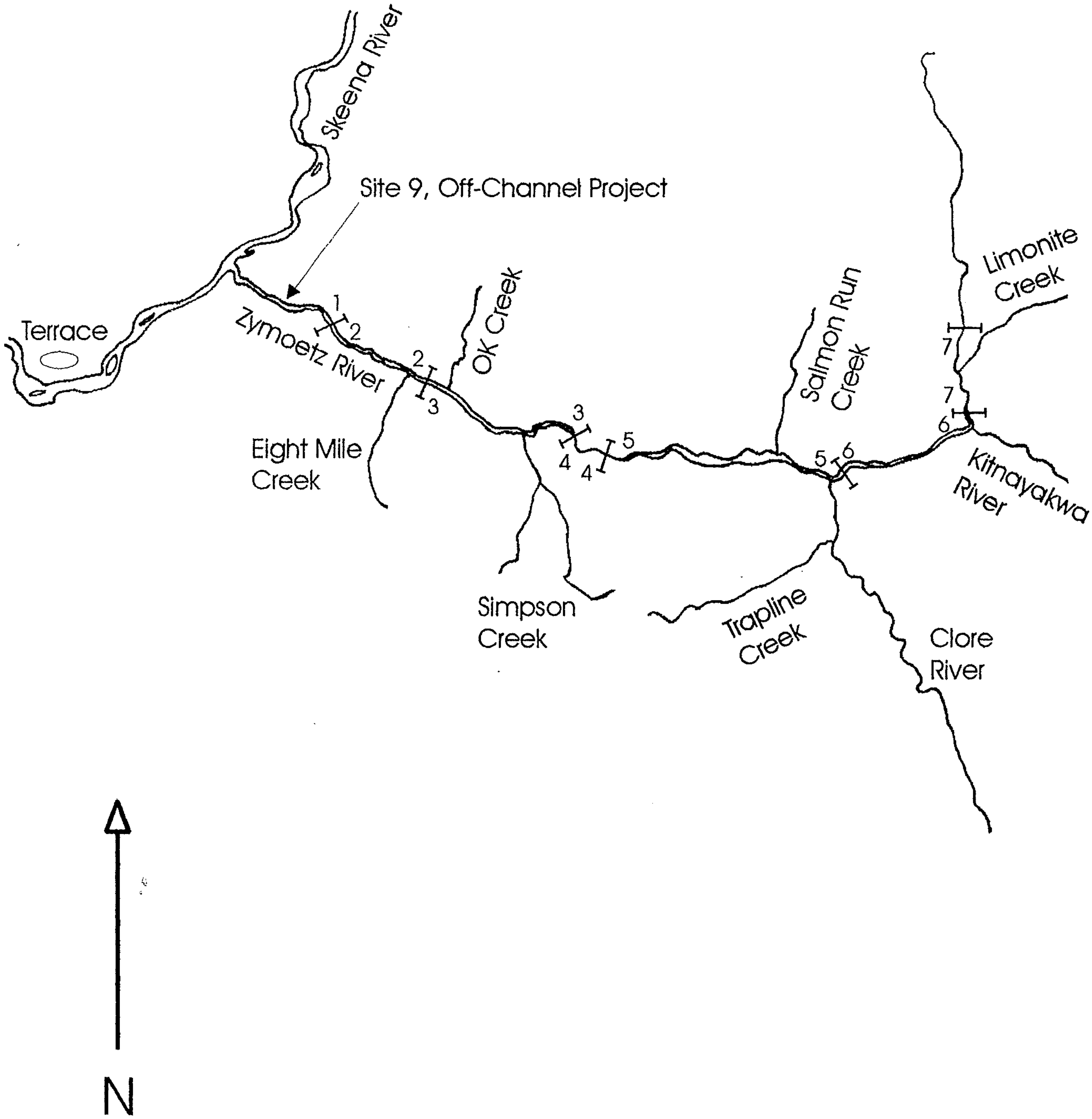

Figure 1. Study Area & Reach Breaks.

Scale 1:,325,000

3.2 Hydrology

Stream hydrology is affected by several factors, primarily the input of water to the watershed in the form of precipitation (rain and snow), loss of water by evapotranspiration and storage of water in lakes and the ground within the watershed. The balance of these factors explains the variation in flow rates in creeks throughout the year.

Precipitation is controlled by the climate of the region which is heavily influenced by maritime air masses which bring moisture laden clouds inshore from over the Pacific Ocean, and mountains which force air masses to rise and cool which causes precipitation to fall. Because of moist air and high mountains there is abundant rainfall in the Coast Mountains of British Columbia. Long-term weather records show that precipitation in the Terrace region is highest in the fall during the months of October, November and December, and lowest during the late spring and early summer in May, June and July (Figure 2).

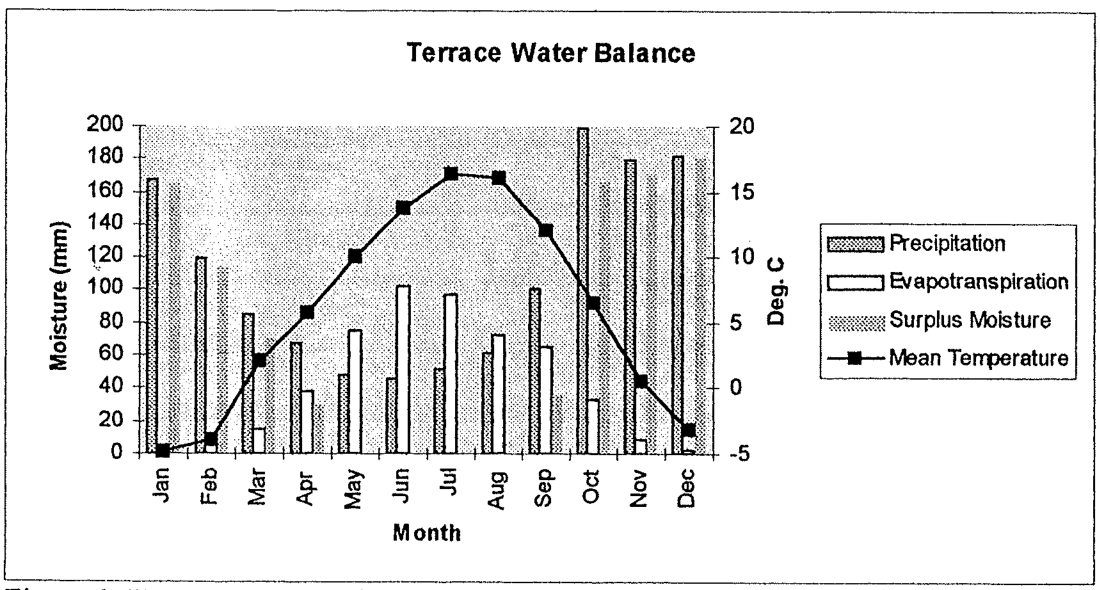

Figure 2. Terrace Water Balance.

The rate of evapotranspiration is largely controlled by the prevailing temperature which varies throughout the seasons, being lowest in winter and highest in summer. As a consequence, loss of water by evapotranspiration back into the atmosphere is highest in summer and lowest in winter (Figure 2). This reduces the amount of water that can flow in creeks or be stored within the watershed.

The storage of water in a watershed is dependent upon physical characteristics, mainly the type of surficial materials that cover the bedrock and their capacity to hold water. In addition, the presence of lakes and extensive areas of vegetation, and also the amount of precipitation falling as snow (which acts as a temporary storage medium) also influence how water is stored in a watershed. This theme will be explored in more detail later in this section.

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Discharge data (1990) for the Zymoetz River at OK Creek (Table 1) shows that the lowest mean monthly discharges are during February and increase to a peak in June, thereafter falling back to winter lows. The Zymoetz River is of moderate size, draining approximately 3,000 square kilometers of northwestern British Columbia. Because of the large amount of snowfall across this region and consistently cold temperatures below freezing in winter, the discharge data is dominated to the yearly cycle of snow accumulation and melting. The main reason for the non-coincidence of highest mean monthly discharges and highest monthly precipitation is the fact that 25% of yearly precipitation falls as snow, primarily during the months of December to February when the mean monthly temperatures are below zero degrees centigrade. The snow acts as a temporary reservoir during winter and accumulates to a significant thickness at high elevations. As the temperature rises with the onset of spring, snow melts and increases the discharge of streams with their headwaters in the alpine tundra. Snowmelt peaks in June which is a low rainfall month to give the highest monthly discharges (Table 1).

Month	Minimum Daily Discharge (m^3/s)	Mean Monthly Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)
January	22	49	98
February	18	19	22
March	21	28	42
April	42	75	121
May	96	261	521
June	238	317	476
July	140	223	399
August	62	122	192
September	45	63	81
October	33	62	178
November	23	35	47
December	16	30	108

Table 1. Discharge data for Zymoetz River, 1990.

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By analyzing the monthly data for precipitation, evapotranspiration and stream discharge for the Zymoetz River watershed it is possible to show how water storage varies throughout the year in this watershed (Figure 3). The storage of water is primarily explained in terms of snow cover in the watershed and groundwater reservoirs. This shows that the lowest storage levels, and by implication the lowest groundwater levels, occur in August and September when all snow has melted and rates of evapotranspiration are high, often in excess of rainfall. During October and November, groundwater levels rise as increasing rainfall replenishes lost reserves. From December to February most precipitation falls as snow, and so storage takes the form of snowpack on the ground. From March onwards, increasing temperatures cause the snowpack to melt and storage begins to decrease as rivers swell and discharge increases. By June most snowpack has melted and storage continue to drop, due to loss of groundwater, through to September when the cycle begins again. This analysis suggests that groundwater levels in the region are lowest in August and September, rise towards December when water begins to be stored as snow, and begin to fall in late spring or early summer after the snowpack has melted and groundwater discharge helps maintains water levels in streams.

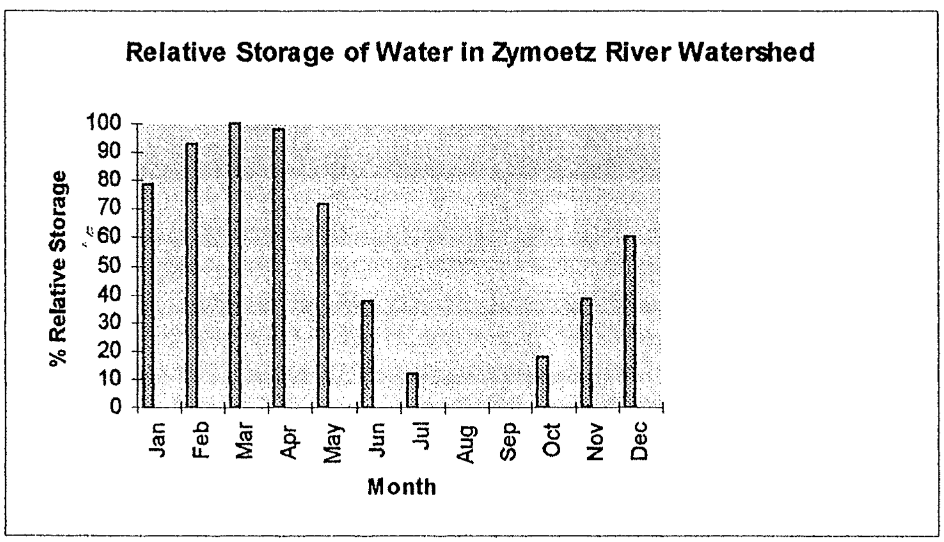

Figure 3. Relative Storage of Water in Zymoetz River Watershed.

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Major floods in the Zymoetz River are primarily due to snowmelt in spring and the consequence of rainstorms in the fall. Spring flooding tends to be long-lived due to progressive snowmelt as temperatures rise, but of moderate quantity with comparison to fall floods which are caused by rainstorms which last a few days at most. The larger fall floods have occurred when temperatures were higher and most precipitation fell as rain rather than snow higher in the watershed. Table 2 shows the largest floods that have occurred during the last 45 years with a recurrence interval of 10 years or more. Of these nine floods, only one was during the spring snowmelt season, the rest were during the fall after heavy rains.

Year	Season	Max. Daily Discharge (m^3/s)	Return Period (yr)
1954	spring	968	10
1961	fall	1050	10
1964	fall	932	10
1966	fall	1250	10
1974	fall	1470	50
1978	fall	1980	100
1988	fall	1280	10
1991	fall	1810	50
1992	fall	1380	25

Table 2. Flood events in the Zymoetz River, from Weiland & Schwab (1996).

3.3 Channel Stability

Channel stability is determined by many factors including stream morphology and hydrology, channel bank material, riparian vegetation and sediment load carried by the river. These factors are discussed in this section.

Prior to major amounts of harvesting in the watershed which began in the 1960s, air photos show that the main channel was relatively stable. Since then, however, the main channel has become less stable, especially in reaches five, six and seven, and a large amount of sediment has been mobilized and has started moving down though the watershed during flood flows. This decrease in channel stability has been due to a series of major fall floods, the largest being during 1978 (100 year flood), 1991 (50 year flood) and 1992 (25 year flood). The cause of these major fall floods is unlikely to have been a consequence of harvesting activity since only a relatively small area of the watershed (~5 %) has currently been logged. Instead, the coincidence of major floods with intense rainstorms suggests that extreme weather conditions over the last twenty years or so have been responsible for flooding and the decrease in channel stability.

Sediment moved by the Zymoetz River can be classified as fine suspended material (e.g. silt and clay) which is carried throughout the year or coarse bedload material (e.g. cobble and boulder) which is only carried during flood flows in the spring and fall. Suspended sediment may adversely affect fish but has no influence on channel stability. It is the mobilization of coarse bedload material during floods that is a major cause of channel erosion and changes in channel direction.

Bedload material can also be classified according to whether the sediment is external or internal to the Zymoetz River. External sediment is derived from tributaries, landslides or failing fluvioglacial terraces (formed by the retreat of glaciers at the end of the last ice age about 10,000 years ago). This sediment can be thought of as an input of material to a reach in the river which subsequently passes downstream to be output at the lower reach boundary into the reach below. The input of external sediment to a reach balances the output of sediment at the lower end of a reach in a stable river system. By comparison, internal sediment is derived from gravel bars within the reach and the erosion of material from the floodplain. Internal sediment can be thought of as material stored for a significant period of time within the body of the reach which is dependent upon such factors as channel gradient and floodplain width. Where sediment input and output for the reach do not balance then changes in the storage of internal sediment take place to regain a dynamic equilibrium for the river. In the case of the Zymoetz River, a series of major floods during the last twenty years or so have caused external sources of sediment to be mobilized within the upper reaches (five, six & seven) which exceed the ability of the river to move or store the new material. In these cases, channel stability has been compromised as the river tries to regain its equilibrium between sediment entering and leaving each reach.

Most changes in channel morphology, for example bank erosion and the diversion (avulsion) of channels, have been caused by fall floods which have a great power to erode and transport large material such as logs and boulders, together with gravel, sand and fines. In addition, new gravel bars are formed by sediment deposition as flood flows wane and the river can no longer move large amounts of large material. During subsequent floods, gravel bars are eroded and material is moved downstream in a series of pulses, eventually reaching the mouth of the river and entering the Skeena River.

The development of riparian vegetation is important in stabilizing the banks of channels on the floodplain by protecting and anchoring gravel substrate. Gravel bars have poorly established vegetation since floods tend to submerge the bars, scouring existing vegetation or deposition of more sediment occurs that prevents new vegetation from being established. Where a channel avulsion has taken place, old channels are often abandoned and become revegetated, becoming more stable and part of the floodplain.

4.0 DESCRIPTION & ANALYSIS OF SITE 9

4.1 Description of Site 9

A plan of site 9 is shown in Figure 4 which includes major morphological features of the site, access and property information. Site 9 can be easily accessed by traveling along the Copper River Forest Service Road to the 3 kilometer marker where a track leads off to the left onto the floodplain. This track can be followed, keeping to the left, for approximately 500 metres to beneath a hydro pylon which is next to site 9.

Site 9 is an off-channel area with gravel substrate that is next to the main channel of the Zymoetz River. During major floods, some of the water in the main channel is diverted down the off-channel for approximately 900 metres before re-entering the main channel again. The off-channel and main channel are separated by a gravel bar at the head of the off-channel and a vegetated island in the middle and lower sections (Figures 4 & 5). The crest of the gravel bar, which is similar in height to the surrounding floodplain, was about 3 metres higher than the water level in the main channel at the time of the site visits for this contract. At the crest of the bar there were significant accumulations of large woody debris and boulders with intermediate axes up to 20 centimetres long that were deposited during a major flood. This material suggests flood water depths of at least 80 centimetres at the crest of the bar (Costa, 1983) which would have overtopped the channel banks and inundated parts of the floodplain.

A test channel was excavated to find groundwater at this site in July 1998 (Figure 6) which was about 300 metres long and 3 metres deep at the head, declining to no excavation and the original channel bed at the lower end, which merged with a pool of slowly moving water. Discharge in the excavated channel near the head was 0.02 m^3/s. The pool (Figure 7) continued downstream, past a small stream that entered from the south, to a point some 100 metres from the off-channel exit back into the main channel of the Zymoetz River. The off-channel area was dry downstream of the pool (Figure 8). A survey of the site was conducted by McElhanney Consulting Services Ltd. after the test channel was dug. The plan view and five cross sections are shown in Figures 9 and 10.

Fine grained sediments (e.g. silt and sand) had accumulated in some sections of the pool area and towards the sides of the off-channel area in the middle and lower sections. Fine sediments covering the base of the pool suggest that flows from the small stream are limited, so that fine materials settle from suspension. Fine sediments along the sides of the off-channel area (Figure 8) were likely deposited during declining flood waters as stream velocity slowed, allowing smaller particles to settle. The crest of the gravel bar, separating the off-channel and main channel was also covered by fine grained deposits laid down during waning flood flows.

The survey by McElhanney (Figures 9 & 10) shows that water levels in the main channel and in the excavated channel were almost the same (within 1 cm of each other at a given point along the axis of the valley). This suggests that there is no hydraulic gradient across the valley and there is no tendency for sub-surface water to move across the floodplain from side to side. Instead, sub-surface water simply moves down the axis of the river valley. This is to be expected in the coarse gravel substrate that makes up the floodplain. In addition, sub-surface water levels likely fluctuate rapidly in response to changing water levels in the main channel. The sub-surface water probably has a relatively short residence time in the floodplain gravels since they are very porous and permeable. Therefore, the geochemical properties of the sub-surface water are likely to be similar to surface waters.

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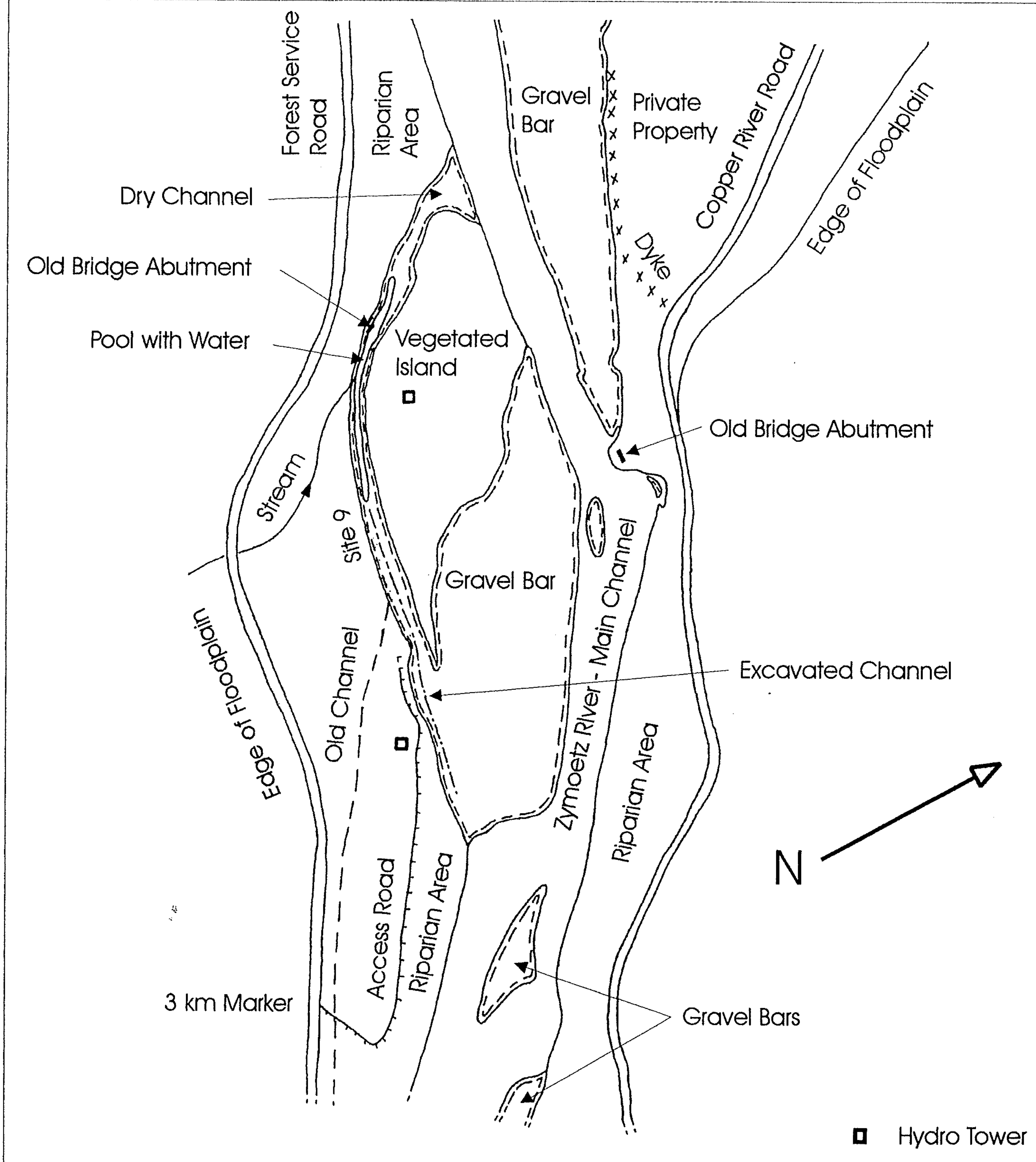


Figure 4. Site 9 Plan (August 1998).

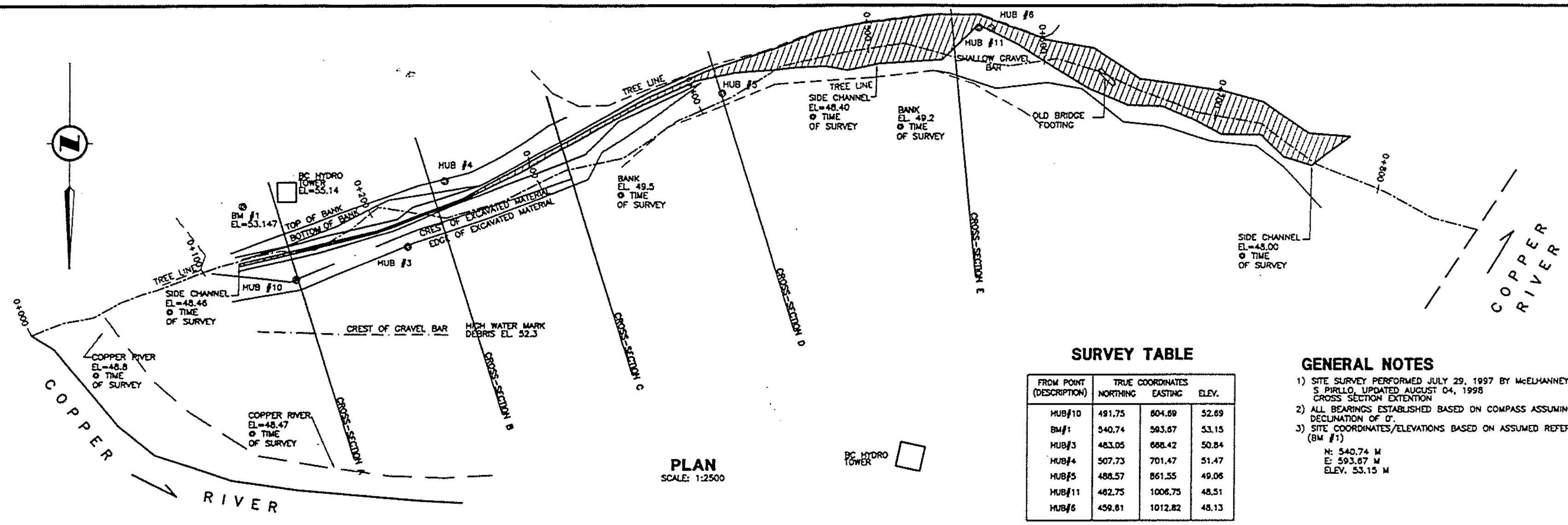
Scale 1:6,875

Figure 5. View of main channel and gravel bar (off-channel site 9 just beyond) from northern old bridge abutment.

Figure 6. View of upper portion of excavated test channel looking east. Old channel runs to right of hydro pylon.

Figure 7. Central pool section of off-channel site 9. Note old bridge abutment to right of photo centre.

Figure 8. Lower dry section of off-channel site 9. Note fines at channel edge and dyke on other side of main stem.



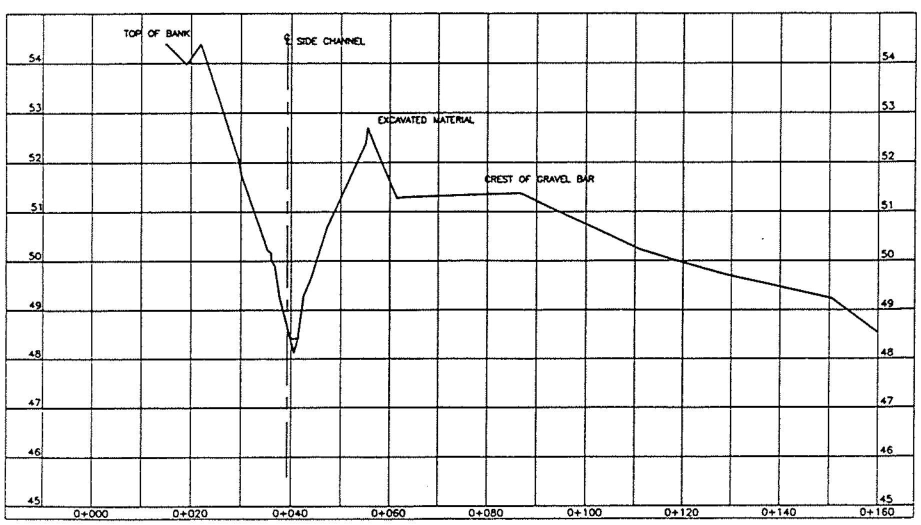
PLAN
SCALE: 1:2500

SURVEY TABLE

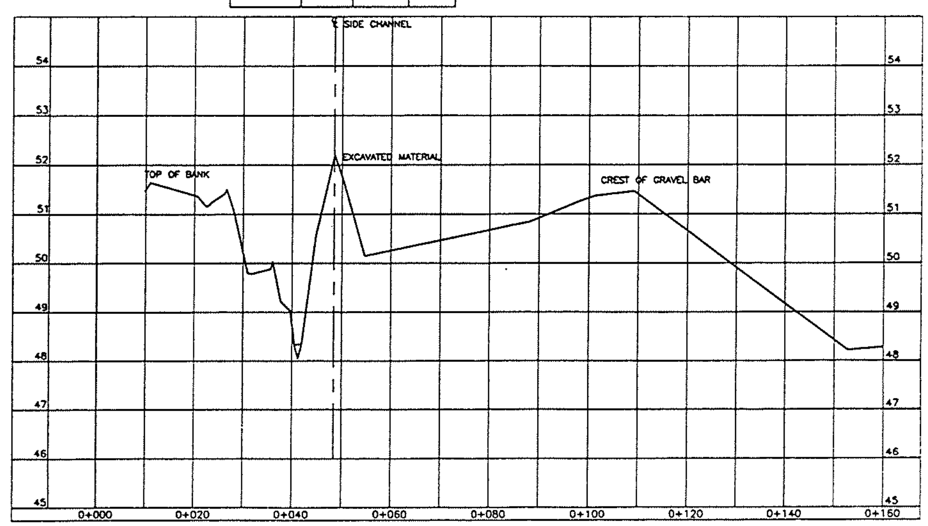
FROM POINT (DESCRIPTION)	TRUE COORDINATES NORTHING	EASTING	ELEV.
HUB#10	491.75	604.69	52.69
BM#1	540.74	593.67	53.15
HUB#3	483.05	668.42	50.84
HUB#4	507.73	701.47	51.47
HUB#5	488.57	861.55	49.06
HUB#11	462.75	1006.75	48.51
HUB#6	459.61	1012.82	48.13

GENERAL NOTES

1) SITE SURVEY PERFORMED JULY 29, 1997 BY McELHANNEY CONSULTING SERVICES LTD S PIRLLO, UPDATED AUGUST 04, 1998 CROSS SECTION EXTENTION
2) ALL BEARINGS ESTABLISHED BASED ON COMPASS ASSUMING DECLINATION OF 0°.
3) SITE COORDINATES/ELEVATIONS BASED ON ASSUMED REFERENCE POINT (BM #1)
N: 540.74 M
E: 593.67 M
ELEV. 53.15 M



CROSS-SECTION A
HOR SCALE: 1:1000
VERT SCALE: 1:100



CROSS-SECTION B
HOR SCALE: 1:1000
VERT SCALE: 1:100

NO.	DATE	REVISION LIST	BY

LEGEND
- TRAVERSE CONTROL HUB
- SIDE CHANNEL AS SURVEYED

McElhanney

McELHANNEY CONSULTING SERVICES LTD.
Suite #1-5008 Pohle Avenue, Terrace, B.C., Canada, V8G-4S8
Tel: (250)-635-7163, Fax: (250)-635-9586

TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
3KM SIDE CHANNEL
SITE 9 - PLAN / CROSS-SECTIONS

SURVEYED: SGP	DATE: JULY 1998
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DRAWN: SGP	TASK: 2000
CHECKED:	DRAWING No. 416-02
SCALE: AS NOTED	REV. 1

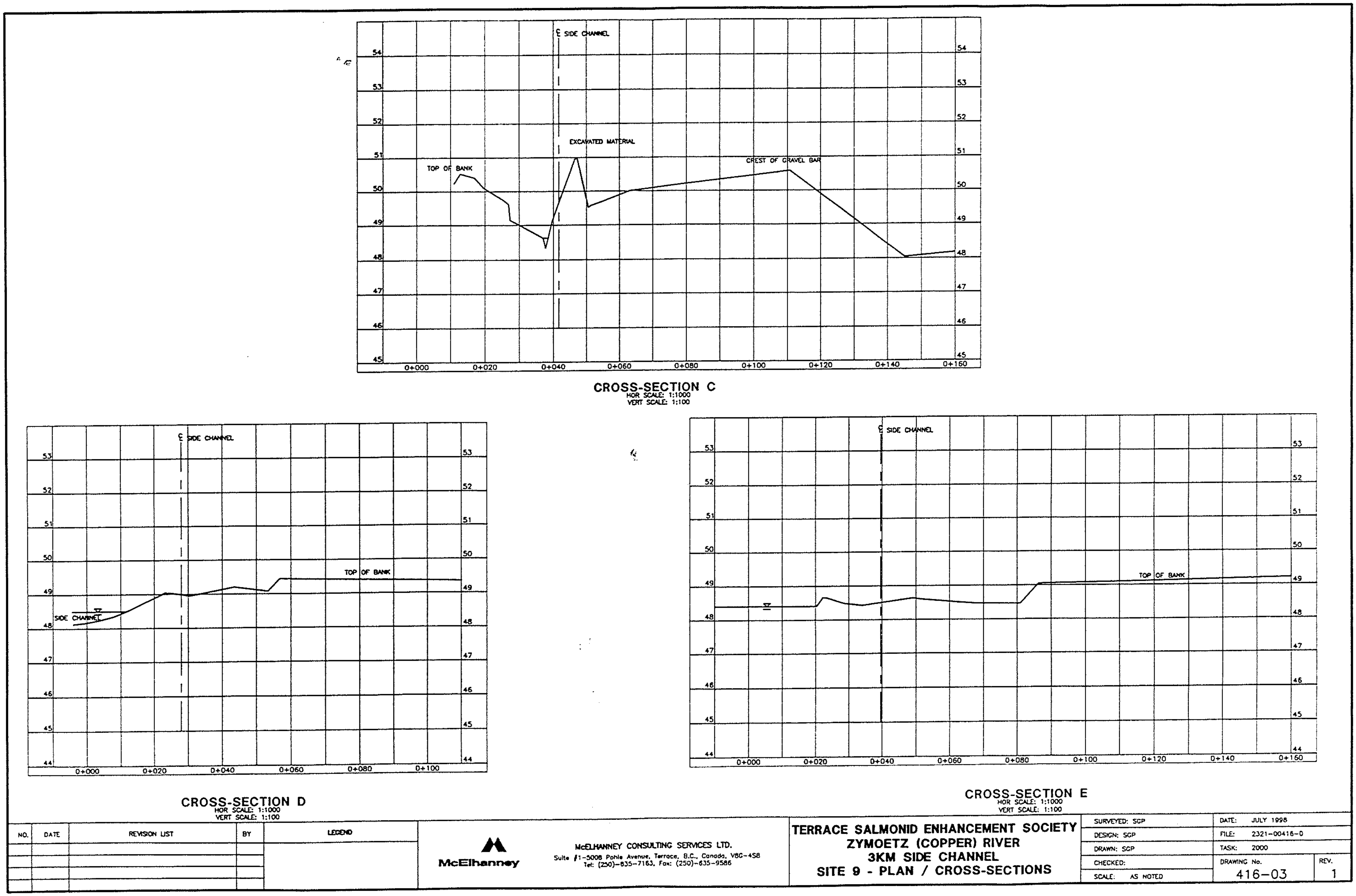
CROSS-SECTION C
HOR SCALE: 1:1000
VERT SCALE: 1:100
TOP OF BANK
EXCAVATED MATERIAL
CREST OF GRAVEL BAR
℄ SIDE CHANNEL
CROSS-SECTION D
HOR SCALE: 1:1000
VERT SCALE: 1:100
SIDE CHANNEL
TOP OF BANK
CROSS-SECTION E
HOR SCALE: 1:1000
VERT SCALE: 1:100
NO.
DATE
REVISION LIST
BY
LEGEND
McElhanney
McELHANNEY CONSULTING SERVICES LTD.
Suite #1-5008 Pohle Avenue, Terrace, B.C., Canada, V8G-4S8
Tel: (250)-635-7163, Fax: (250)-635-9586
TERRACE SALMONID ENHANCEMENT SOCIETY
ZYMOETZ (COPPER) RIVER
3KM SIDE CHANNEL
SITE 9 - PLAN / CROSS-SECTIONS
SURVEYED: SGP
DESIGN: SGP
DRAWN: SGP
CHECKED:
SCALE: AS NOTED
DATE: JULY 1998
FILE: 2321-00416-0
TASK: 2000
DRAWING No. 416-03
REV. 1

FIGURE 10

4.2 Current Channel Stability

A general discussion of channel stability in the Zymoetz River watershed has already been given in section 3.3. Channel stability in the upper reaches above the two rock canyons (reaches two and four) has degraded over the last 20 years or so in response to a series of major floods associated with heavy rains in the fall. This has mobilized large amounts of externally derived sediment that is slowly traveling down the river system, and being stored in transient gravel bars between flood events.

The analysis of air photos and floodplain erosion and deposition summary maps suggests that the lower floodplain reaches (one and three) have not been degraded to the same extent as the upper floodplain reaches. However, there is evidence of accelerated rates of bank erosion in reach 1, where site 9 is located, since the early 1970s, a period that has included a 100 year flood (1978), two 50 year floods (1974 and 1991) and a 25 year flood (1992). To show these changes, the channel centre line near site 9, as determined from air photos taken in 1949, 1968, 1988 and 1998 have been plotted at the same scale in Figure 11. In addition, the edge of the vegetated island that separates the main channel and off-channel have also been plotted to show how much erosion has occurred over the last 50 years. Several significant points can be made:

- A major gravel bar, level with the upstream edge of the vegetated island, used to divide the river into two main arms on the 1949 and 1968 air photos. There is very little difference in the location of the channel centre line between 1949 and 1968.
- Since the 1988 air photos, the major gravel bar splitting the main channel has been absent and the main channel has consistently been on the northern side of the floodplain. However, downstream of the vegetated island, the channel has dramatically moved laterally to the south, eroding away about 150 metres of the floodplain. This period of accelerated erosion is likely the direct consequence of the several large floods in the river since the early 1970s.

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- The 1968 air photos show that an off-channel, filled with water during floods, entered the main channel where the upper end of site 9 is now. This has been abandoned and revegetated since 1968 and is approximately located along the current hydro right of way.
- The off-channel area referred to as site 9 has remained in almost the same position since 1949. The main changes have been functional in nature. Up until 1968, the air photos show that water often flowed down this off-channel. Between 1968 and 1988, a large gravel bar formed which effectively dammed the entrance to the off-channel so that water only flowed down it during floods. The size of this bar has remained almost the same between 1988 and 1998.
- The vegetated island separating the off-channel and main channel has been reduced in size during the period 1949 to 1998. The southern margin, adjacent to the off-channel, has been almost constant throughout the period. In contrast, the northern margin has been eroded in response to changes in the location of the main channel. With the formation of the large gravel bar upstream of the vegetated island, erosion has decreased and there has been little change in the northern margin between 1988 and 1998.

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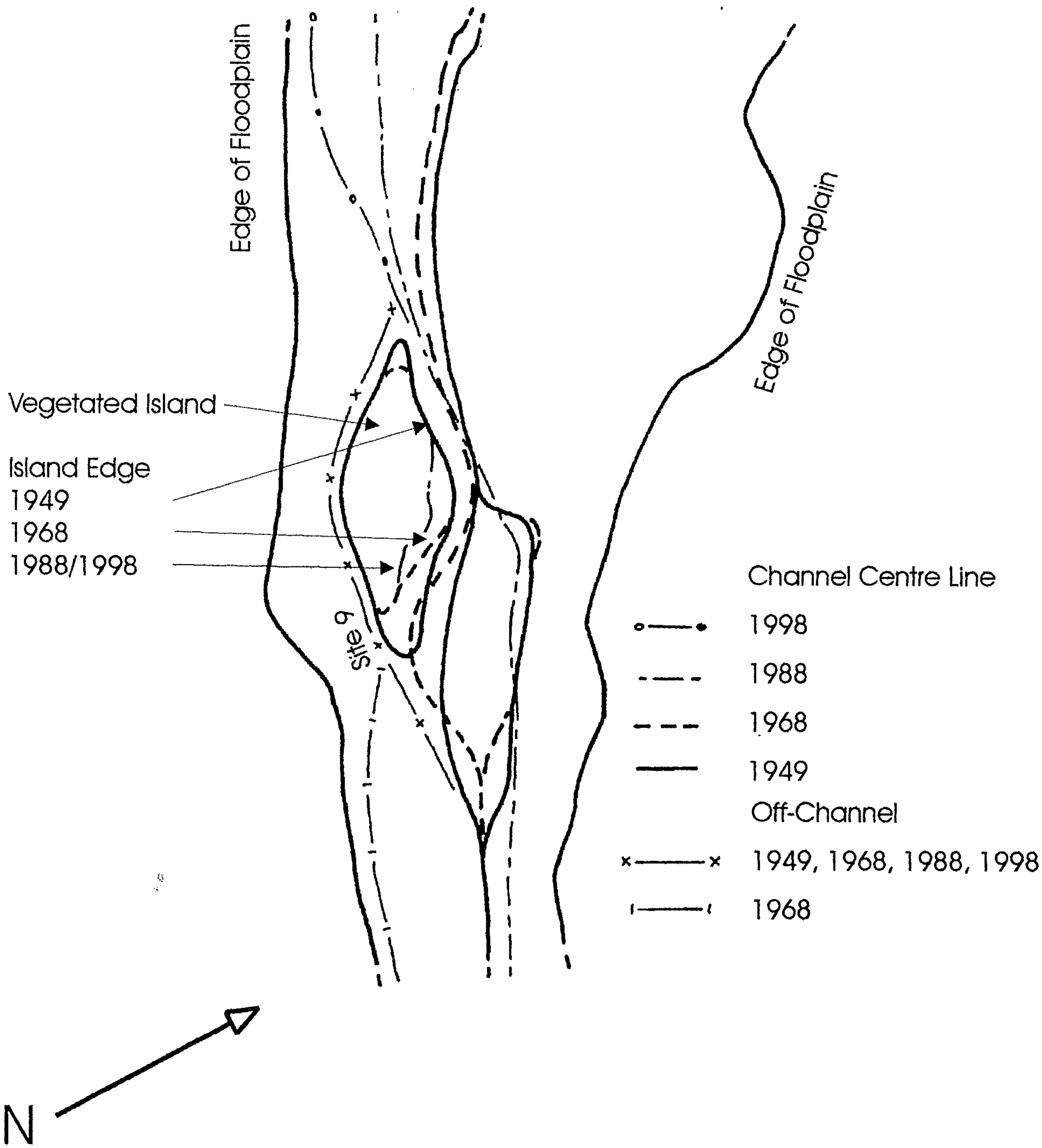

Figure 11. Site 9 Channel Stability.

Scale 1:10,000

4.3 Prescription

The prescription developed by R. Finnigan, P.Eng. for site 9 is shown in Figure 12. This requires a few words of explanation. The prescription is not definitive in that several other variants were also discussed with the author of this report by Jim Culp and R. Finnigan. A detailed analysis of these other options is not possible since few specific details were given. However, the basic elements of all prescriptions for a groundwater fed channel were the same as outlined below.

- Excavate a channel down to the water table across at least the upper part of the off-channel area. If surface flows in the lower portions are not sufficient after these initial works, consider excavating out the lower portion to allow unimpeded fish access during low water levels.
- Install a dike (A on figure 12) to prevent flood flows from entering the excavated channel and altering it's morphology.
- Complex the excavated channel to provide cover for fish.

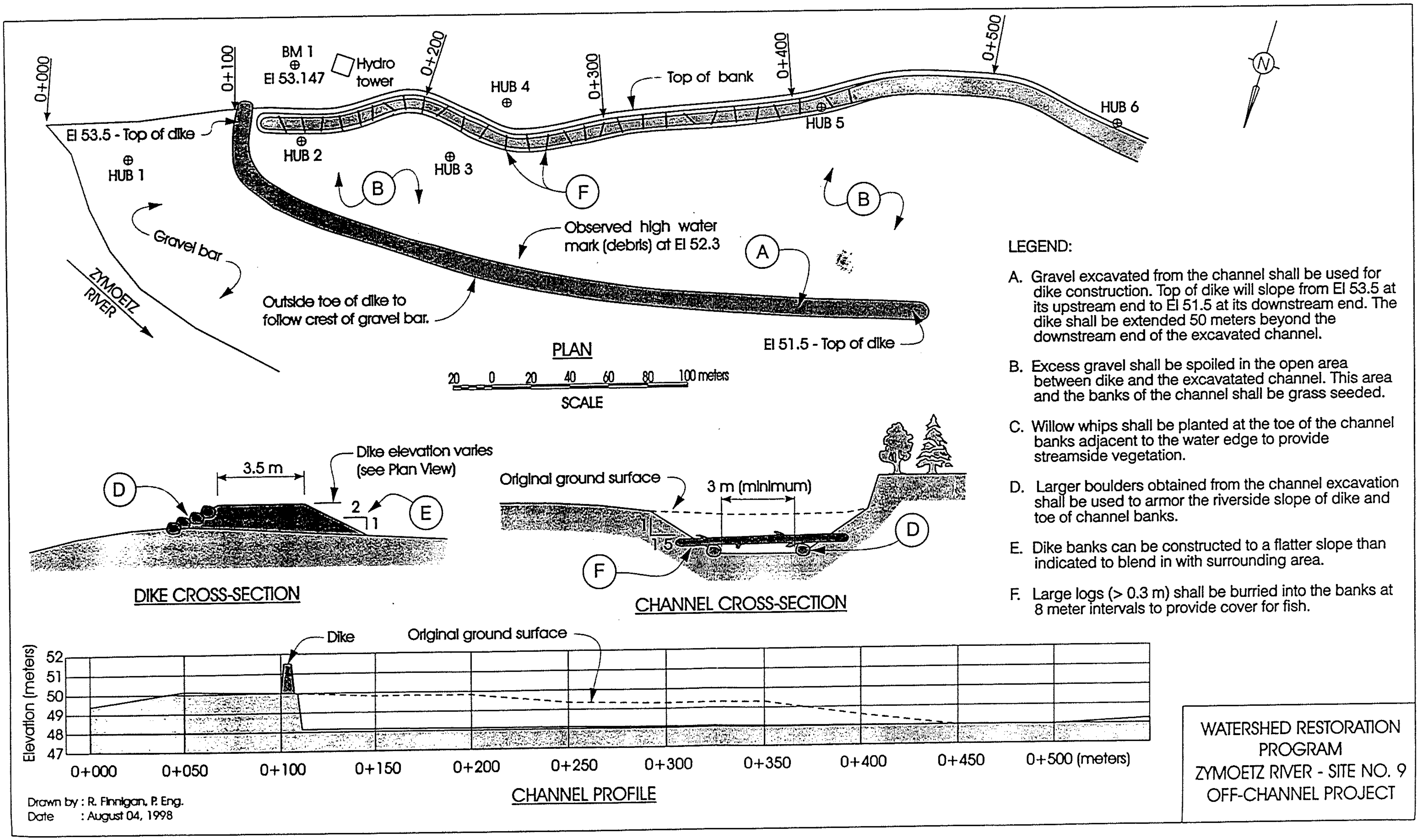
0+000
0+100
0+200
0+300
0+400
0+500
BM 1
El 53.147
Hydro tower
HUB 1
HUB 2
HUB 3
HUB 4
HUB 5
HUB 6
Top of bank
El 53.5 - Top of dike
Gravel bar
ZYMOETZ RIVER
Outside toe of dike to follow crest of gravel bar.
Observed high water mark (debris) at El 52.3
El 51.5 - Top of dike
PLAN
20 0 20 40 60 80 100 meters
SCALE
LEGEND:
A. Gravel excavated from the channel shall be used for dike construction. Top of dike will slope from El 53.5 at its upstream end to El 51.5 at its downstream end. The dike shall be extended 50 meters beyond the downstream end of the excavated channel.
B. Excess gravel shall be spoiled in the open area between dike and the excavatated channel. This area and the banks of the channel shall be grass seeded.
C. Willow whips shall be planted at the toe of the channel banks adjacent to the water edge to provide streamside vegetation.
D. Larger boulders obtained from the channel excavation shall be used to armor the riverside slope of dike and toe of channel banks.
E. Dike banks can be constructed to a flatter slope than indicated to blend in with surrounding area.
F. Large logs (> 0.3 m) shall be burried into the banks at 8 meter intervals to provide cover for fish.
3.5 m
Dike elevation varies (see Plan View)
2
1
DIKE CROSS-SECTION
Original ground surface
3 m (minimum)
1.5
CHANNEL CROSS-SECTION
Dike
Original ground surface
Elevation (meters)
52
51
50
49
48
47
0+000 0+050 0+100 0+150 0+200 0+250 0+300 0+350 0+400 0+450 0+500 (meters)
CHANNEL PROFILE
Drawn by : R. Finnigan, P. Eng.
Date : August 04, 1998
WATERSHED RESTORATION PROGRAM
ZYMOETZ RIVER - SITE NO. 9
OFF-CHANNEL PROJECT

FIGURE 12

4.4 Impact of Prescription on Channel Stability

The historical stability of the main channel of the Zymoetz River in the vicinity of site 9 has already been discussed in section 4.2. It is apparent that the configuration of site 9 changed significantly between the 1968 and 1988 air photos but has been relatively stable since that time, with the exception of the southern margin of the main channel downstream of site 9 which has continued to erode (Figure 11). This may be a consequence of the installation of a major dike along the northern margin of the main channel to protect private property on the adjacent floodplain. This dike was installed after the 1978 flood.

The prescription will prevent all but major floods from flowing down the off-channel area of site 9. Given the height of the proposed dike and the configuration of the channel, it is estimated that the dike will prevent floods up to about the 10 year recurrence interval from entering the off-channel. Floods of greater size will overtop the dike and some water will be directed down the off-channel. This will have several possible effects on the excavated channel. It is likely that the head of the channel will undergo scouring and erosion, depending upon the armoring applied to the channel. The middle and lower sections of the channel will likely be filled with sedimentary debris as the gradient of the excavated channel will be lower than at present. Fine grained deposits will be laid down ontop of the infilling debris as flood waters decrease and stream velocity slows. In any event, when the dike is overtopped with flood waters, significant damage to the project will occur which will have to be rectified to maintain it's effectiveness as a spawning channel.

Of perhaps greater importance is the effect of preventing all but major floods from passing down the off-channel. During these smaller floods, more water is maintained in the main channel, hence the water level is higher than previously for a similar magnitude flood. The main channel narrows just below the entrance to the off-channel area and is defined by a rock outcrop with an old bridge abutment on the north bank. The opposing bank is the vegetated island which will be prone to increased rates of erosion as more water is passing at a greater velocity. The effect of the prescription will be to effectively increase the erosive capability of the waters in the main channel, which can only erode the vegetated island, at lower water levels.

Downstream of the off-channel exit there will likely be little effect as the total amount of water passing down through this part of the channel will be unchanged from before implementation of the prescription. However, increased erosion of the northern edge of the vegetated island may provide additional debris which will form additional gravel bars downstream in the main channel. The dike installed along the northern edge of the river by the property owner is significant, rising about 2 metres above the level of the floodplain. It is unlikely that the prescription as proposed would have any effect on the stability of this structure, especially as channel erosion has increased along the opposite bank since installation.

5.0 CONCLUSIONS & RECOMMENDATIONS

This report has given an overview of the Zymoetz watershed and an analysis of a potential off-channel project (site 9) identified in the Detailed Level 1 Assessment of Fish and Fish Habitat. The project for site 9 was conceived as a groundwater fed spawning channel for chum and coho salmon and rearing habitat for coho and others species. This report specifically addresses the concern that the prescription may compromise the stability of the river channel around the site and may impact private property downstream. In addition, other comments on the hydrologic setting and implications of the prescription have also been discussed.

The conclusions and recommendations are presented in two sections. The first provides a series of comments about site 9 and the second provides a general discussion about general restoration activities that should be considered in the Zymoetz watershed.

5.1 Site 9, Off-Channel Project

- Implementation of the prescription will prevent water from flowing down the off-channel area with the exception of flood flows with recurrence intervals of more than about 10 years. This will decrease the stability of the main channel and cause increased erosion of the margin of the vegetated island. In time this will compromise the stability of the off-channel area.
- The prescription as it stands will need to be modified to allow year round fish access since the lower part of the off-channel area is currently dry at a time when salmon are moving up the Zymoetz River to spawn. This will probably require excavation of the lower part of the off-channel area.
- Because of the close proximity of site 9 to the main channel, and the morphology of the surrounding area, the dike will only be able to prevent floods with about a 10 year recurrence interval from entering the off-channel area. This is a relatively short period of time. With the likely consequences of flooding (infilling of the excavated channel with coarse and fine sediments) significant effort (and money) would be required to maintain the functionality of the prescription at this site.

The above points suggest that the prescription as it stands may have consequences that are not desirable in terms of the environment or the required budget. However, several opportunities do present themselves which are listed below.

- The site could be developed as a surface water channel by the diversion of water from the main channel of the Zymoetz River. This would provide valuable additional fish habitat and would not compromise the stability of the main channel. However, this option would have a few caveats. First, a significant amount of material would have to be excavated to provide year round flows, more than 3 metres near the head of the channel. Second, an intake would have to be engineered with particular attention to prevent the diversion of the main channel down the site. Third, the projected lifespan of the project would still be limited as flood flows would tend to infill the excavated channel with sedimentary debris. Therefore, a well funded maintenance program would be required.
- At least one other off-channel area is located next to site 9, but further away from the main channel, which could be examined for possible development as a groundwater fed spawning channel. This off-channel is shown on Figure 4 and also Figure 6. The benefit of this off-channel is that it is located towards the edge of the floodplain and is therefore better protected to start with from large floods. In addition, the area around the off-channel is already revegetated and so some cover already exists which could be utilized. Of course a study would have to be done to find out if it is suitable from a hydrologic point of view. In addition, something would also have to be done to allow fish access up the lower part of site 9 that is currently dry.

5.2 Watershed Restoration Activities in the Zymoetz Watershed

The Copper River is contained in a glaciated U-shaped valley that has quite a variation in the width of the valley floor which depends upon the location of resistant bedrock outcrops. Reaches 1, 3, 5, 6 & 7 have relatively wide floodplains, especially 5, while reaches 2 and 4 are confined within narrow bedrock canyons. Because the valley is U-shaped, tributaries are steep and often contain falls which may prevent fish migration. These steep tributaries are generally inhabited by resident fish populations that may be isolated from the main stem of the Zymoetz River.

The most valuable habitat for salmonids in the Zymoetz River system is located in the main stem and off-channel areas in the floodplain reaches (1, 3, 5, 6 & 7), major tributaries such as the Clore River and Salmon Run Creek, and in the first few hundred meters of tributaries that cross the floodplain reaches before the stream gradient increases up the steep sides of the valley. Therefore, restoration activities for salmonid species should be concentrated in these areas.

It has been noted in section 3.3 that the Zymoetz River is currently in an unstable phase, which is characterized by accelerated bank erosion and changes in channel location, relative to the period prior to the 1960s. Restoration activity within the main channel will generally be less effective and relatively short-lived with comparison to restoring and enhancing habitat in off-channels and tributaries away from the main channel. This is because the main channel is currently in a process of trying to re-establish an equilibrium between sediment supply, transport and deposition within each reach which is causing major changes in channel pattern that has reduced channel stability.

In the case of side channel and tributary projects, these offer the greatest possibility of increasing the amount of fish habitat in the watershed. The sites with the highest potential are those with consistent water sources that are near the edge of the floodplain, away from the main stem of the Zymoetz River. Areas closer to the main channel will be impacted more by major floods which will likely modify the restoration work making it less effective. As a consequence, projects developed next to the main channel will tend to have a shorter working life.

6.0 REFERENCES

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