Chinook Salmon (*Oncorhynchus tshawytscha*) spawning and juvenile rearing habitat in Janet Creek: inventory, utilization and restoration.

Prepared for The Stewart Valley Salmon for the Future Society

and

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INTRODUCTION

The Stewart River originates in the Hess Mountains near the Yukon-NWT border and flows westerly across the Stewart Plateau. When it reaches Stewart Crossing, the Stewart River enters the Tintina Valley and flows northwest as it continues on its course toward the Yukon River, which it joins 100 km upstream of Dawson City. The Mayo River flows into the Stewart River at the town of Mayo. Janet Creek flows out of Janet Lake and joins the Stewart River approximately 35 km upstream of Mayo.

Chinook salmon, (*Oncorhynchus tshawytscha*) are found throughout the Stewart River system. Chinook eggs hatch around mid-April, then juveniles spend from one to two years in fresh water before migrating down the Yukon River to the Bering Sea. After two to six years in the ocean, chinook salmon return to spawn in their stream of origin. Chinook salmon are considered vulnerable at all freshwater stages of their life cycle. Spawning grounds, fry overwintering grounds and migration routes are critical habitat.

In 1984, Ennis *et al.* identified several chinook spawning sites in the Stewart sub-basin, including Janet Creek. Native elders in Mayo told Buchan (1993) that years ago Janet Creek was one of the main salmon streams in the area and that during a salmon run it was alive with salmon. Mayo old-timers also say that thirty years ago, salmon went up Janet Creek, across Janet Lake and into Williamson Creek. Anecdotal information suggests that Janet Creek still supports a chinook salmon population, but there have been no salmon habitat or spawning studies on Janet Creek.

This study will determine if Janet Creek is a chinook salmon spawning and rearing stream. Also, the habitat available for migration, spawning and rearing will be evaluated and restored if necessary.

STUDY AREA

Janet Creek flows out of the southeast corner of Janet Lake in a southwesterly direction to the Stewart River, a distance of approximately 4.5 km. It joins the Stewart River approximately 35 km upstream from Mayo. (See map #1). A rough logging road crosses the creek approximately 1 km north of the Stewart River. The bridge at this crossing had collapsed several years ago and was thought to be blocking the creek. (See map #2). The road into the area requires a four wheel drive vehicle, therefore the site was accessed by traveling upstream from Mayo by boat on the Stewart River.

OBJECTIVES

The objectives of the Janet Creek project were:

1. to do reconnaissance and mapping of Janet Creek, dividing the creek into reaches
2. to measure and observe physical parameters pertaining to chinook salmon habitat
3. to restore chinook salmon habitat by removing obstructions in the creek that block salmon migration
4. to count salmon observed swimming upstream
5. to document spawning by mapping spawning grounds and recording residence times on redds
6. to count and sex carcasses and map their locations
7. to live trap juvenile chinook fry and measure them and note what habitat they are using

METHODOLOGY

Janet Creek was partitioned into four reaches on the basis of an aerial survey, elevation contours on a topographic map and ground truthing. Physical parameters were measured every fifteen meters in Reach 1, every thirty meters in Reaches 2 and 3, and at four sites in Reach 4.

The physical parameters measured at each site were:

1. Direction of water flow, which was determined from a compass reading.
2. Channel width
3. Water depth, which was taken at three locations across the creek and averaged.
4. Water velocity, which was measured with a Scientific Instruments electronic current meter. Readings were taken at three locations across the creek and averaged.
5. Water temperature

6. Water turbidity, which was measured by lowering a meter stick into the water until the tip disappeared.

7. Type of substrate, which was determined by a visual estimate of the percent composition of fines (< 0.1cm), small gravel (0.1-4.0 cm), large gravel (4-10 cm), cobbles (10-30 cm) or boulders (>30 cm).

8. Nature of the flow was categorized as to whether it was a slough, pool, riffle, run or rapids. A slough is a stream section of very low or nil velocity. Pools are deeper than surrounding areas and have a low velocity. Riffles are regions where the water surface is broken into waves by bed material. Runs are regions of flowing water where the surface is not broken by bed material. Rapids are a very rapid whitewater cascade.

9. The amount and type of overstream cover.

10. The amount and type of organic debris in stream.

The creek was hiked daily in order to count salmon swimming upstream, to locate and map spawning grounds, to record residence times on redds and to locate and map carcasses. Carcasses were sexed and marked so they wouldn't be recounted.

This creek has several beaver dams and lodges as well as logs across it throughout its length. Before salmon migration up the creek began it was difficult to assess which of these would obstruct the salmon's passage. It was decided that an obstacle would be considered an obstruction if salmon were seen trying and failing to get beyond it. When this was the case, the obstruction was removed with a handsaw.

During the first two weeks of August, Gee minnow traps baited with chinook salmon roe were set in selected locations on the creek. A total of 23 traps were set. Traps were checked in 24 hours and captured chinook salmon fry counted. From each trap, a subsample of six fry were anesthetized by placing them in a bucket of water in which Alka Seltzer had been dissolved. The fork length (distance from the fork in the tail to nose tip) of these fish were measured to the nearest millimeter.

RESULTS

Mapping and Habitat Inventory

Janet Creek was divided into four reaches. (See map #2). Reach 1 (map #3) extends from the creek's mouth to the beginning of a canyon, a distance of 1.5 km. The average channel width of this section was 11.0 m, with channel widths ranging from 4.0-18.8 m. The average depth ranged from 0.15-0.70 m, and average water velocities ranged from 0.28-1.70m/s. At several sites, there was a considerable variation between the water velocity of near shore and mid-stream regions. Most flow was either riffle or run, with occasional pools along the edge, usually downstream from logs or gravel bars, which impeded flow. Near the mouth, substrate consisted of small and large gravel, but farther upstream, substrate was almost all cobbles and some boulders. In pools and at the inside of bends, substrate was small gravel and fines. Water turbidity was 0 throughout this reach, that is the creek was clear.

Vegetation along the creek edge was dense willows and aspen poplar. In several places these trees grew horizontally over the creek, providing cover. There were also several dead logs partially or completely submerged, caught in the creek. This reach contained one abandoned beaver lodge with a dam and one large logjam, both of which partially obstructed the creek's flow. In several places, the creek channel divided and flowed around islands. This reach contained the site of the collapsed bridge.

Reach 2 (map #4) also 1.5 km, included two canyons and the section between them. Portions of this reach were deeply incised with steep rock walls rising sharply from the creek. The average channel width was 9.6 m. Channel width ranged from 4.0-13.8 m. The average water depth in this section was .024-0.4 m. Average water velocities ranged from 0.54-2.22 m/s. In this reach, water velocity was more uniform across the creek, that is there was less variation between near shore water speed and mid-stream water speed than seen in Reach 1. Flow was generally riffle or rapids, and substrate was almost entirely boulders. Water turbidity was 0.

In the canyons, the creek's banks were sheer rock walls supporting no tree growth, so there was little overstream vegetation. Between the two canyon areas, the creek's banks were shallower and some trees grew over the creek, providing cover, The channel divided around an island in the section between the two canyons. In several places in this reach, logs had become jammed in the stream, but none completely obstructed flow.

Reach 3, the section from the limit of the second canyon to the slough leading into Janet Lake, was 1.25 km long. (See map #5). This section had an average channel width of 12.0 m, with widths ranging from 6.0-28.6 m. The average water depth was 0.26-0.56 m, and the average water velocity was between 0.43-1.28 m/s, with considerable variation in water speeds of near shore and mid-stream regions. The predominant type of flow was riffle with some sections of run and pool. Pools were mostly upstream of logs or beaver dams. At the bottom of this reach, nearer the canyon, the substrate was boulders and cobbles, but nearer Janet Lake, the substrate was a mixture of cobbles, large gravel and small gravel. In pools and on the inside of bends, the substrate was small gravel and fines. Water turbidity was 0.

This reach had heavy beaver activity, with two active beaver lodges and two beaver dams as well as several logs felled by beaver lying across and in the stream. There were also several logjams. None of these obstacles totally obstructed water flow, but some could potentially obstruct salmon passage. In three places, islands divided the creek's flow.

Reach 4 consisted of a slough 0.12 km long, extending from a large beaver dam at the top of Reach 3 to Janet Lake. (See map #5). This slough ranged in width from 15 m at the outlet of the lake to 45-50 m at its widest point. This slough was 0.1 m deep near shore, 0.7 m deep at three meters from shore and too deep to measure by wading beyond this. The current meter recorded no measurable flow in this slough. Substrate was primarily fines. Three beaver lodges were present along the shores of this slough.

Habitat Restoration

When this study was designed, the bridge that crosses Janet Creek in Reach 1 had collapsed and was obstructing chinook salmon passage. One of the original objectives of this study was to remove the bridge. During spring freshet of this year, the bridge was swept free. It was washed onto shore thirty meters downstream of its original location, where it no longer obstructs salmon migration.

There were several logjams and beaver-felled logs that might obstruct salmon migration in Janet Creek. When the salmon began moving up Janet Creek, possible obstructions were monitored to see if the salmon were getting beyond them. In two locations, both in Reach 3, salmon were seen jumping and failing to get over piled up logs. In both cases, salmon were pooling up behind the obstructions. In one location, beavers had fallen two large aspen poplar trees, one on top of the other. Sawing the top tree into small pieces and removing it allowed fish to swim over the bottom tree. The second location was a logjam at a narrow bend in the creek. The entire logjam was removed to allow fish to get through and prevent more logs from becoming caught.

Salmon Count

The first chinook salmon was spotted swimming upstream in Janet Creek on August 2. On August 5, the first salmon was seen on a redd. Monitoring of the creek continued until August 31. During this time, 137 salmon were counted swimming and 91 were seen spawning. (See tables 1 &2). It is impossible to say how many of these salmon were counted twice.

The timing of the Janet Creek run is plotted in Figure 1. Although there were peaks and valleys in the curve, overall, salmon numbers rose from August 2 until peaking between August 12 and August 22, when they began declining.

Three spawning sites were identified, two in Reach 1 and one in Reach 3. (See maps #3 &5). The site in the lower end of Reach 1 extended for 90 meters. The average water velocity at this site was 0.54 m/s, and the average depth was 0.39 m. Most redds in this site were located in large gravel (4-10 cm). The spawning site in the mid region of Reach 1 was located at a bend of the creek and extended for approximately 45 meters. The average water velocity at this site was 0.48 m/s, and the average depth was 0.39 m. The substrate here was 40% cobbles (10-30 cm) and 60% large gravel. In the inside of the bend, where a few redds were located, the substrate was small gravel (0.1-4.0 cm). The spawning site in Reach 3 was located downstream from the beaver dam that divided Reach 3 from the slough before Janet Lake. This spawning site extended for 150 meters. The substrate here was a mixture of cobbles and large gravel, with some areas of small gravel. The average velocity of the water was 0.50m/s, and the average depth was 0.35 m. The water temperature at the spawning sites ranged from 14° C on August 5 to 9° C on August 31.

Almost equal numbers of spawning females were recorded at the spawning site in the lower end of Reach 1 and the upper end of Reach 3. Approximately half this number of females were seen on redds in the spawning site in the middle of Reach 1.

By mapping the spawning sites, residence times on redds were estimated. It appears that some female salmon stayed on their redds between 24 and 48 hours, but most stayed on their redds between 48 and 72 hours. During the last two weeks in August, monitoring residence times on redds became difficult because of the presence of a grizzly bear at two of the spawning sites. I was forced to schedule my time at the sites around his presence.

On August 7, the first salmon carcass was recovered from Janet Creek at the large logjam in Reach 1. Carcass retrieval continued was continued until August 31. During this time, 24 carcasses, 17 female and 7 male, were found. Many were caught on logjams or beaver dams. In five locations, three or more carcasses were found. The sites of carcass recovery are plotted on maps # 3, 4 & 5.

Juvenile Trapping

The locations of minnow traps to catch juvenile chinook salmon were selected to sample a variety of habitats. The trapping results are shown in Table 3. Fry were trapped in riffle, pool and run habitats in the lower half of Reach 1 and the upper section of Reach 3. No fry were trapped in Reach 2 and 4. The presence or absence of overstream vegetation and instream cover (boulders or logs) at a site seemed to have no effect on whether fry would be present. Fry were trapped at water velocities ranging from 0.32-0.50 m/s. Sampling sites where no fry were trapped had velocities ranging from nil in the slough to 1.94 m/s in the rapids of Reach 2. Other than the slough, sampling sites where no fry were trapped had water velocities greater than 0.52 m/s. The average length of the juvenile chinook salmon ranged from 50-60 mm.

DISCUSSION

This study showed that Janet Creek is a salmon spawning and rearing creek with suitable habitat to support a run of at least 137 returning salmon and 91 spawning females. This is not considered to be the total number of returning salmon since this study did not employ a counting weir. It is likely that not all migrating salmon were spotted during daily hikes due to deep pools and sunlight reflecting off the water making salmon difficult to see at times.

Carcass recovery rates of chinook salmon are estimated to be between 10% and 30% of the total run. The number of carcasses recovered in Janet Creek, 24, suggests that the total spawning population in Janet Creek was between 80 and 240. It is difficult to say what percentage of Janet Creek carcasses were recovered. Portions of this creek have a rapid flow, which would wash carcasses away, but the creek is narrow with several logjams and beaver dams where carcasses tended to get caught. Also, in several places there were was evidence on the shore that a bear had eaten a fish, therefore some of the carcasses were probably eaten before they were counted.

Chinook salmon have spawning requirements with regards to substrate size and stream velocity and depth. Chinook salmon can successfully construct spawning redds in substrate ranging from fines to cobbles. The upper size limit on gravel depends on the size of the fish. Raleigh *et al.* (1986) suggest that substrate of 15 cm in diameter is approaching the upper usable limit of spawning substrate, and that most chinook salmon spawn in large gravel (4-10 cm). In Janet Creek, the substrate in the lower two spawning grounds was predominantly large gravel, and the substrate in the spawning grounds at the top end of the creek was a mixture of large gravel and cobbles. In the portions of Reach 1 and 3 where no spawning occurred the substrate tended to be more cobbles and less large gravel than in the spawning sites. In Reach 2, where there was no spawning, the substrate was boulders.

Raleigh *et al.*, (1986) state that for chinook salmon the usable spawning and embryo incubation water velocity ranges from 0.2-1.5 m/s, with an optimal range of 0.3-0.9 m/s. The average water velocity for spawning sites in Janet Creek was from 0.48-0.54 m/s. Water velocity in other portions of the creek tended to be higher than this. In Reach 2 where there was no spawning, the lowest water velocity was 0.70 m/s.

A minimal depth for spawning is required to prevent embryos from freezing or drying. For chinook salmon, an acceptable minimal spawning depth is 0.2 m (Raleigh *et al.*, 1986). Most of Janet

Creek had a depth greater than 0.2 m. The average depth of the spawning sites in Janet Creek was from 0.35-0.30 m.

During a helicopter flight on August 20, salmon were spotted near the outlet of Janet Lake, (Gail Falkner, pers. comm). indicating that they swim the entire length of the creek. It appears that stream velocity and substrate size were the factors that limited the bounds of spawning grounds in Janet Creek.

For chinook salmon to use the spawning grounds at the top end of Janet Creek, they must pass through an area where there are several beaver dams and lodges as well as beaver-felled logs. Although two obstructions to salmon migration were removed this summer, beaver activity is ongoing, therefore next summer another obstacle might obstruct salmon passage. This could be prevented by monitoring the creek during future salmon runs and removing obstructions if necessary.

If chinook salmon are to survive in a stream there must be adequate juvenile rearing habitat. Janet Creek appears to have juvenile rearing habitat with fry present in Reach 1 and 3. Canopy cover and instream logs and boulders have been found to be important in the survival of juvenile chinook salmon (Raleigh *et al.* 1986), however in Janet Creek, the presence or absence of overstream or instream cover seemed to have no effect on the presence of chinook fry. In Reach 1, water velocity seemed to control the distribution of fry, while in Reach 3, water velocity and the presence of natural barriers like beaver dams seemed to limit the distribution of chinook fry.

In conclusion, Janet Creek appears to have a significant chinook spawning and juvenile population with sufficient habitat to support it. The major habitat concern is recurring blockages of upstream migration routes by beaver dams and lodges and logjams.

REFERENCES

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Falkner, Gail. Habitat Biologist, Dept. of Fisheries and Oceans, Whitehorse, Yukon.

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Table 1. Salmon Counted swimming upstream in Janet Creek in August 1996

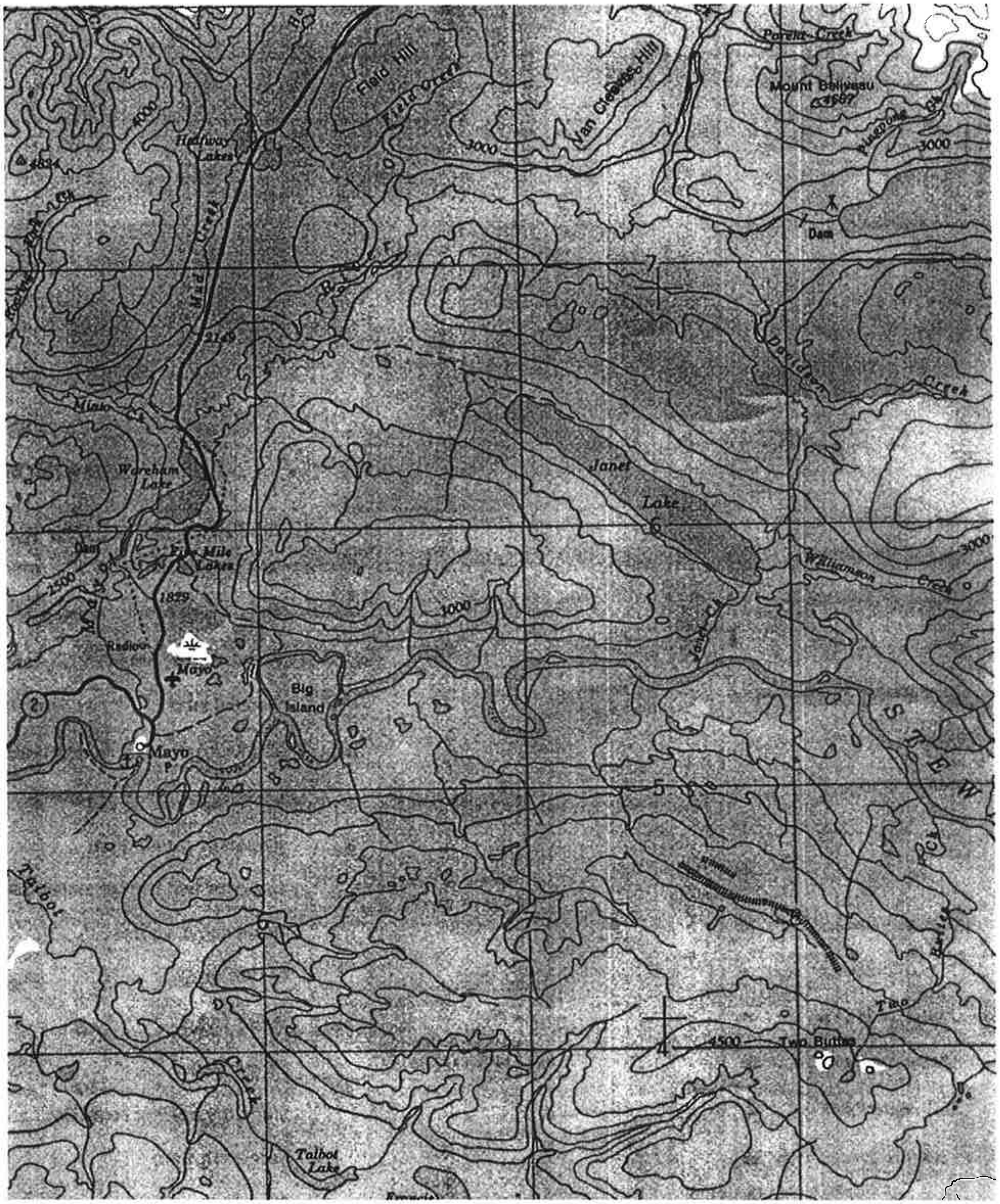
Date	Number
Aug 2	1
Aug 5	4
Aug 6	4
Aug 7	3
Aug 8	2
Aug 9	8
Aug 10	5
Aug 12	12
Aug 13	10
Aug 14	7
Aug 15	14
Aug 16	5
Aug 17	9
Aug 18	10
Aug 21	14
Aug 22	8
Aug 23	8
Aug 24	3
Aug 27	5
Aug 28	2
Aug 29	0
Aug 30	1
Aug 31	2
Total	137

Table 2. The daily numbers of new spawners at the three spawning sites.

Date	Lower Reach 1	Middle of Reach 1	Upper Reach 3
Aug 5	1	0	0
Aug 6	1	1	0
Aug 7	1	0	0
Aug 8	2	1	0
Aug 9	0	0	0
Aug 10	2	2	2
Aug 12	4	1	1
Aug 13	3	1	2
Aug 14	2	1	3
Aug 15	1	1	2
Aug 16	3	0	2
Aug 17	2	1	4
Aug 18	4	2	5
Aug 21	3	2	6
Aug 22	0	1	3
Aug 23	2	0	1
Aug 24	1	0	2
Aug 27	2	1	3
Aug 28	1	1	1
Aug 29	0	0	1
Aug 30	0	0	1
Aug 31	1	0	0
Total	36	16	39

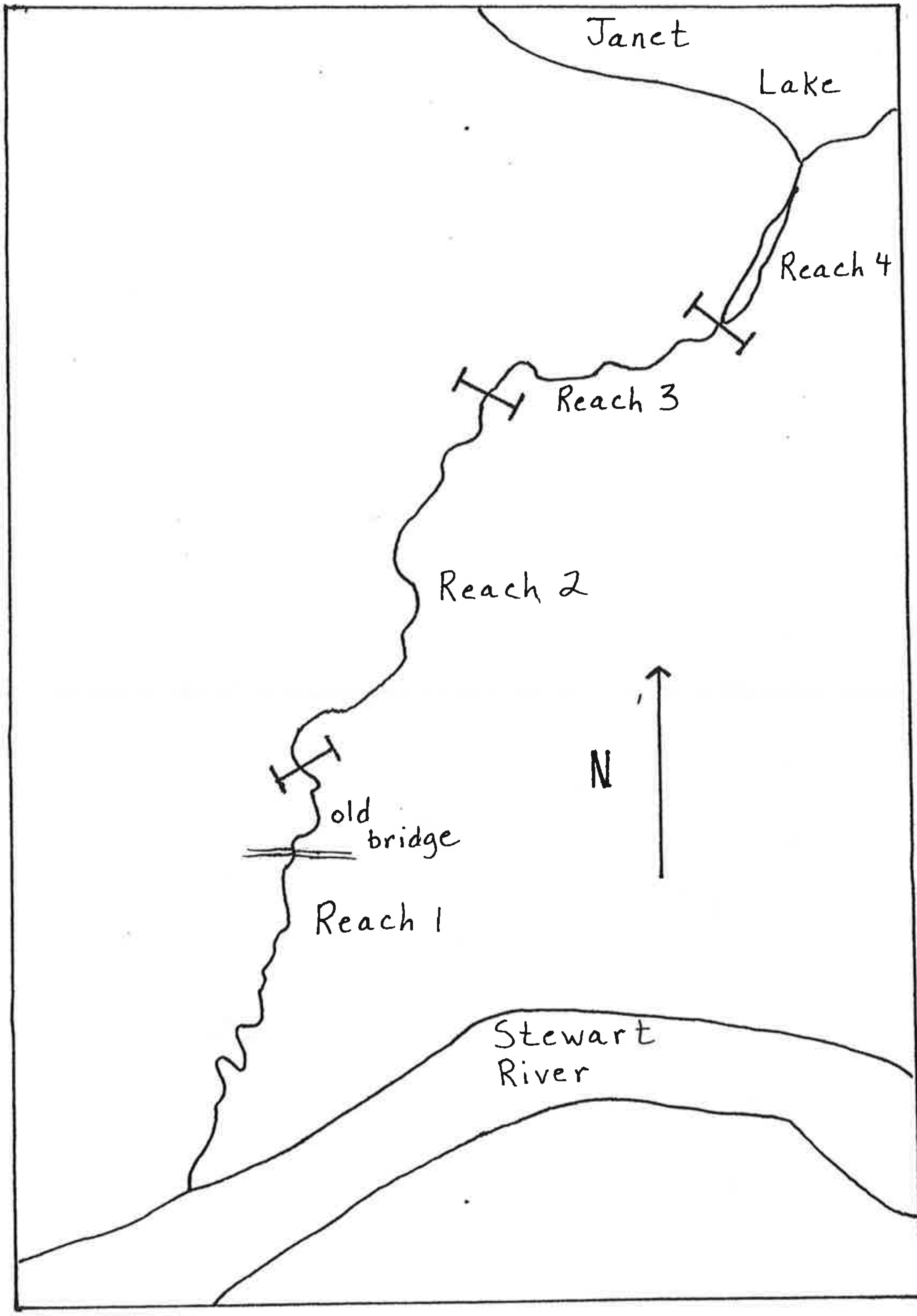
Table 3. Results of Juvenile Chinook Salmon Trapping

Location	Flow	Velocity (m/s)	Overstream Cover	Instream Cover	Fry/ Trap	Average Length (mm)
Reach 1	riffle	0.49	trees	logs	14	52
Reach 1	pool	0.32	trees	none	17	50
Reach 1	run	0.59	trees	none	6	56
Reach 1	riffle	0.46	none	logs	13	55
Reach 1	run	0.73	none	logs	0	
Reach 1	pool	0.47	none	none	26	60
Reach 1	riffle	0.96	trees	none	0	
Reach 1	run	1.17	none	logs	0	
Reach 2	riffle	1.05	none	logs	0	
Reach 2	rapids	1.94	none	logs	0	
Reach 2	riffle	1.68	none	logs	0	
Reach 2	pool	0.88	none	logs	0	
Reach 2	riffle	1.40	none	logs	0	
Reach 3	riffle	0.78	trees	none	0	
Reach 3	riffle	1.02	none	logs	0	
Reach 3	pool	0.52	none	none	0	
Reach 3	run	0.96	none	none	0	
Reach 3	run	0.44	trees	none	16	51
Reach 3	riffle	0.43	none	logs	12	54
Reach 3	run	0.50	trees	none	13	55
Reach 4	slough	0.00	none	none	0	
Reach 4	slough	0.00	none	none	0	
Reach 4	slough	0.00	none	none	0	



Scale 5 km = 2 cm

Map 1.



Map 2. Janet Creek

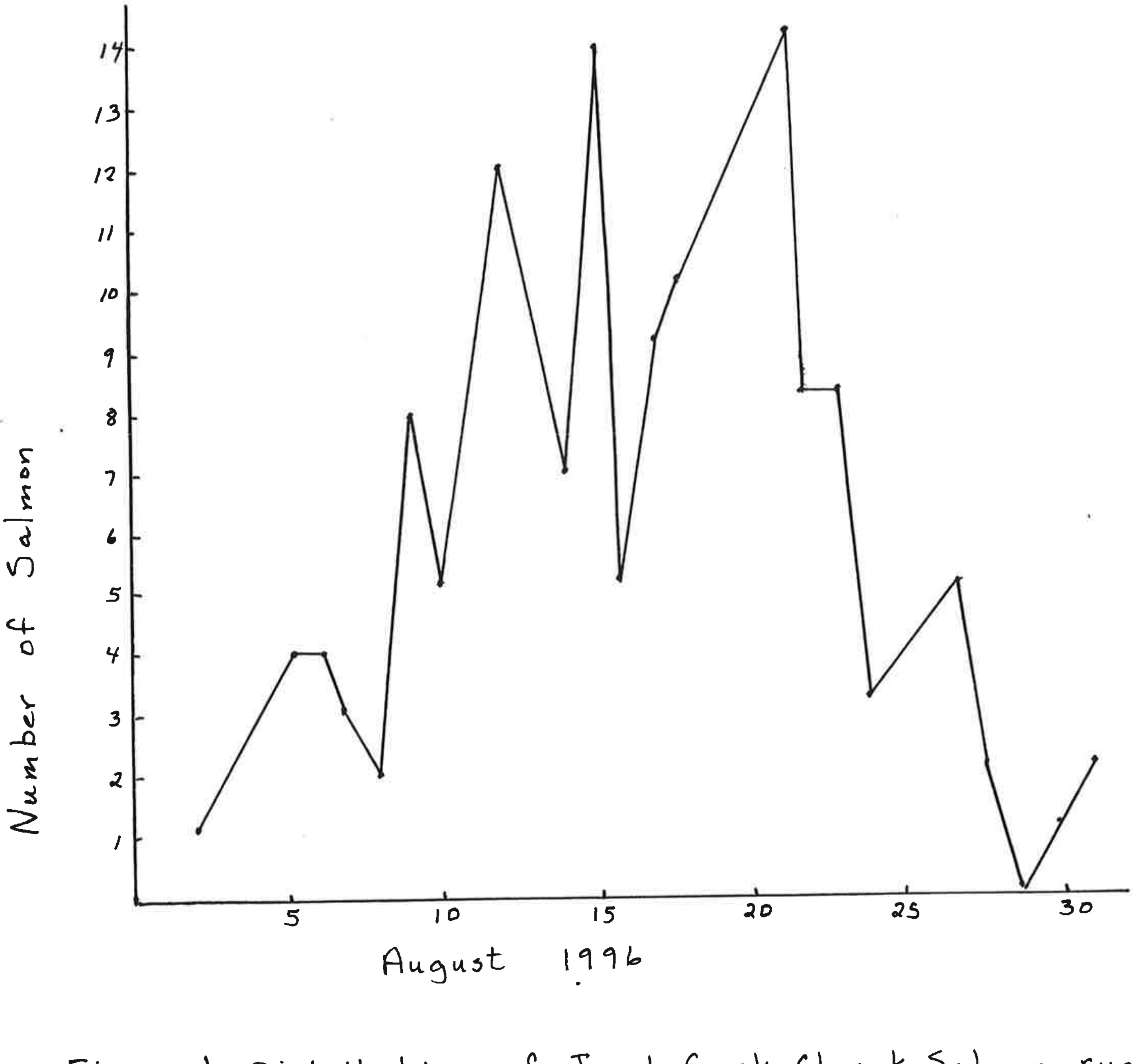


Figure 1. Distribution of Janet Creek Chinook Salmon run

Appendix

Physical Parameters of Reach 1 (S after the number indicates spawning occurred at the station; SG = small gravel, LG = large gravel, C = cobbles, B = boulders)

Station	Average Depth (m)	Channel Width (m)	Average Velocity (m/s)	Flow Type	Substrate	Notes
1	.32	12.0	0.56	run	50% LG 50% SG	gravel bar at mouth
2	.34	13.7	0.54	run	50% LG 50% SG	
3	.30	15.3	0.53	riffle	50% LG 50% SG	
4	.36	18.0	0.60	run	50% LG 50 SG	overstream trees
5	.35	11.6	0.77	run	20% C 40% LG 40% SG	
6	.26	12.5	0.74	run	10% C 60% LG 30% SG	overstream tree
7	.29	13.1	0.49	riffle	10% C 60% LG 30% SG	overstream trees, log submerged
8	.26	14.5	0.76	riffle	40% C 40% LG 20% SG	cutbank
9S	.28	11.9	0.55	run/ pool	40% C 40% LG 20% SG	overstream trees
10S	.27	12.4	0.48	run	30% C 60% LG 10% SG	logjam 1/3 way across creek
11S	.23	12.5	0.59	run	20% C 60% LG 20% SG	overstream creek
12S	.30	10.2	0.59	run/ pool	50% LG 50% SG	gravel bar in creek
13S	.38	10.6	0.45	run/ pool	50% LG 50% SG	overstream trees
14S	.44	10.0	0.46	run	10% C 50% LG 40% SG	overstream trees
15S	.54	12.2	0.63	run	50% LG 50% SG	submerged log
16S	.70	9.0	0.57	run	50% LG 50% SG	submerged log
17	.26	9.9	0.67	riffle	20% C 50% LG 30% SG	submerged log
18	.26	9.2	0.87	riffle	10% C 60% LG	

					30% SG	
19	.31	11.5	0.65	riffle	10% C 70% LG 20% SG	
20	.47	4.0	0.55	run	40% C 40% LG 20% SG	beaver dam 2/3 across creek
21	.39	8.3	0.45	pool	25% C 50% LG 25% SG	submerged logs
22	.26	10.0	0.28	run/ pool	50% LG 50% SG	
23	.26	4.0	0.65	run	30% C 50% LG 20% SG	submerged log
24	.33	6.3	0.72	run	40% C 40% LG 20% SG	
25	.27	8.1	0.72	riffle	40% C 40% LG 20% SG	overstream tree, log submerged
26	.27	9.5	0.59	run	60% C 30% LG 10% SG	submerged log
27	.33	9.6	0.63	run	60% C 30% LG 10% SG	overstream tree
28	.32	11.4	0.62	run	40% C 40% LG 20% SG	
29	.38	14.5	0.70	run	30% C 50% LG 20% SG	island in creek
30	.20	18.8	0.46	riffle	40% C 40% LG 20% SG	submerged log, island
31	.27	16.5	0.91	run	40% C 40% LG 20% SG	overstream trees, island
32	.22	19.8	0.52	pool/ riffle	60% C 30% LG 10% SG	logjam, island
33	.38	12.0	0.56	run	20% C 60% LG 20% SG	submerged log
34	.26	11.1	0.90	run	30% C 50% LG 20% SG	
35	.37	9.5	0.94	run	10% C 50% LG 40% SG	
36S	.41	6.2	0.41	run	50% LG 50% SG	
37S	.27	11.0	0.58	riffle	20% C	

					50% LG 30% SG	
38S	.37	11.2	0.52	run/ pool	50% LG 50% SG	
39S	.50	7.0	0.40	run/ pool	40% LG 60% S	
40	.29	15.0	0.75	run	40% C 30% LG 30% SG	island
41	.26	15.8	0.70	run	40% C 40% LG 20% SG	island
42	.15	16.0	0.56	run	50% LG 50% SG	island
43	.26	14.1	0.73	run	30% C 40% LG 30% SG	submerged log, island
44	.36	12.0	0.53	run	10% C 60% LG 30% SG	
45	.36	8.3	0.45	run/ pool	10% C 50% LG 40% SG	overstream trees
46	.5	7.8	0.34	run	50% LG 50% SG	
47	.45	8.0	1.10	run	20% C 50% LG 30% SG	
48	.45	14.5	0.45	run	50% LG 50% SG	island
49	.24	16.0	0.90	riffle	40% C 50% LG 10% SG	submerged log, island
50	.35	15.2	0.67	riffle	30% C 40% LG 30% SG	island, logjam
51	.30	16.7	0.63	riffle	20% C 50% LG 30% SG	island
52	.29	15.2	0.70	pool/ riffle	30% C 50% LG 20% SG	island
53	.60	8.0	0.56	run	50% C 50% LG	logjam
54	.30	8.2	0.47	pool/ riffle	50% C 50% LG	pool above logjam
55	.42	7.0	0.90	run	50% C 40% LG 10% SG	
56	.18	14.0	0.97	riffle	60% C 40% LG	island
57	.18	13.8	0.95	riffle	60% C 40% LG	
58	.20	13.6	1.1	riffle	70% C	

					30% LG	
59	.28	12.0	0.61	run	50% C 50% LG	submerged log
60	.30	10.5	0.55	run	50% C 40% LG 10% SG	
61	.36	9.2	0.82	run	70% C 20% LG 10% SG	
62	.25	8.1	1.70	riffle	70% C 30% LG	
63	.26	12.8	1.10	riffle	20% B 60% C 20 % LG	
64	.29	12.0	0.78	riffle	20% B 70% C 10% LG	overstream trees, logjam
65	.30	12.2	0.80	riffle	20% B 70% C 10% LG	
66	.20	12.0	0.58	riffle	20% B 70% C 10% LG	submerged log
67	.33	11.6	1.30	riffle	30% B 70% C	
68	.30	7.0	1.50	riffle	20% B 70% C 10% LG	
69	.30	9.2	1.10	riffle	20% B 60% C 20% LG	
70	.38	5.4	0.78	run	10% B 60% C 30% LG	submerged log
71	.36	9.0	0.70	run	10% B 60% C 30% LG	
72	.38	7.3	0.64	run/ pool	50% C 50% LG	submerged log
73	.20	12.0	0.82	riffle	30% B 60% C 10% LG	
74	.34	7.2	0.84	riffle	30% B 60% C 10% LG	
75	.32	12.1	1.10	riffle	40% B 60% C	
76	.33	12.0	0.98	riffle	40% B 60% C	
77	.38	8.4	1.2	riffle	30% B 60% C 10% LG	
78	.36	8.5	0.88	riffle	40% B 60% C	site of bridge

79	.38	7.0	0.96	riffle	40% B 60% C	
80	.33	7.2	1.10	riffle	40% B 60% C	
81	.28	8.0	1.06	riffle	40% B 60% C	
82	.30	11.2	0.95	riffle	50% B 50% C	
83	.46	4.2	1.20	run	50% B 50% C	
84	.40	8.0	1.12	run	30% B 60% C 10% LG	island
85	.28	12.2	1.26	riffle	50% B 50% C	submerged logs
86	.24	13.0	1.08	riffle	50% B 50% C	
87	.15	13.8	0.96	riffle	50% B 50% C	island
88	.22	10.0	0.90	riffle	50% B 50% C	
89	.28	7.2	1.02	riffle	60% B 40% C	overstream trees
90	.24	11.8	0.88	riffle	60% B 40% C	
91	.22	12.0	0.98	riffle	60% B 40% C	submerged logs
92	.30	12.3	1.06	riffle	60% B 40% C	
93	.28	12.0	1.10	riffle	60% B 40% C	overstream trees
94	.60	9.1	1.22	run	50% B 50% C	
95	.56	9.0	1.15	run	50% B 50% C	
96	.24	11.6	0.97	riffle	60% B 40% C	
97	.46	8.0	1.12	run	70% B 30% C	
98	.40	7.3	1.20	run	70% B 30% C	
99	.36	7.8	1.17	run	70% B 30% C	submerged logs
100	.15	12.2	0.93	riffle	50% B 50% C	island
101	.24	13.0	0.88	riffle	50% B 50% C	island
102	.33	12.4	1.06	run	60% B 40% C	island
103	.30	11.0	1.10	run	60% B 40% C	

Physical Parameters of Reach 2

Station	Average Depth (m)	Channel Width (m)	Average Velocity (m/s)	Flow Type	Substrate	Notes
1	.36	8.0	1.18	run	100% B	
2	.28	8.2	1.05	riffle	100% B	
3	.30	8.0	1.10	riffle	100% B	
4	.32	8.2	1.20	riffle	100% B	
5	.30	7.8	1.56	riffle	100% B	canyon
6	.32	8.0	1.48	riffle	100% B	
7	.28	8.8	1.80	rapids	100% B	
8	.33	8.3	1.94	rapids	100% B	
9	.34	9.1	2.22	rapids	100% B	island
10	.24	13.8	0.98	riffle	70% B 30% C	island
11	.33	11.2	0.70	riffle	100% B	
12	.30	9.2	0.88	riffle	70% B 30% C	
13	.28	10.8	0.96	riffle	100% B	logjam
14	.40	8.2	0.54	pool	100% B	
15	.38	8.0	1.10	riffle	100% B	
16	.33	7.8	1.22	riffle	100% B	
17	.36	8.2	1.48	riffle	100% B	
18	.32	10.2	1.70	rapids	100% B	
19	.34	9.7	1.82	rapids	100% B	
20	.26	13.8	1.68	riffle	80% B 20% C	submerged log
21	.33	8.0	1.36	riffle	100% B	
22	.36	7.8	1.26	riffle	100% B	
23	.34	8.2	1.14	riffle	100% B	
24	.30	8.0	1.22	riffle	100% B	
25	.40	10.1	0.88	pool/ riffle	80% B 20% C	submerged log
26	.28	10.0	1.02	riffle	100% B	
27	.26	8.3	1.15	riffle	100% B	
28	.27	9.8	1.54	riffle	100% B	
29	.30	10.2	1.20	riffle	100% B	
30	.32	10.0	1.22	riffle	100% B	
31	.33	10.2	1.28	riffle	100% B	
32	.34	10.0	1.42	rapids	100% B	
33	.30	10.3	1.60	rapids	100% B	
34	.38	10.2	1.76	rapids	100% B	
35	.30	10.0	1.64	rapids	100% B	
36	.33	10.6	1.56	rapids	100% B	logjam
37	.36	10.2	1.67	rapids	100% B	
38	.28	9.6	1.82	rapids	100% B	
39	.30	9.2	1.48	rapids	100% B	
40	.30	4.0	1.70	rapids	100% B	
41	.24	7.1	1.40	riffle	80% B 20% C	
42	.26	12.0	1.30	riffle	80% B 20% C	logjam

43	.38	11.2	0.70	pool/ riffle	80% B 20% C
44	.34	10.3	1.08	riffle	80% B 20% C
45	.30	13.0	0.98	riffle	100% B
46	.28	13.2	0.96	riffle	100% B
47	.33	12.2	0.88	riffle	80% B 20% C
48	.30	12.8	0.88	riffle	80% B 20% C
49	.28	9.2	1.44	rapids	100% B
50	.28	10.6	1.30	rapids	100% B

Physical Parameters of Reach 3 (S beside station number indicates spawning occurred at station)

Station	Average Depth (m)	Channel Width (m)	Average Velocity (m/s)	Flow Type	Substrate	Notes
1	.26	18.0	0.98	riffle	80% B 20% C	island
2	.30	12.2	1.03	riffle	80% B 20% C	
3	.32	12.0	1.12	riffle	80% B 20% C	
4	.34	10.2	0.88	riffle	60% B 40% C	
5	.34	10.0	0.96	riffle	60% B 40% C	
6	.27	9.8	0.78	riffle	60% B 40% C	overstream trees
7	.30	9.8	0.93	riffle	50% B 50% C	
8	.28	12.2	0.87	riffle	50% B 50% C	
9	.31	12.0	0.90	riffle	50% B 50% C	
10	.34	11.8	1.02	riffle	50% B 50% C	
11	.30	12.1	0.96	riffle	50% B 50% C	
12	.42	6.0	1.22	rapids	80% B 20% C	
13	.30	6.0	1.02	riffle	80% C 20% LG	submerged log
14	.32	7.8	1.28	rapids	100% B	
15	.29	10.2	0.88	riffle	20% B 80% C	logjam
16	.30	10.0	0.78	riffle	20% B 80% C	
17	.40	6.2	0.52	pool/ run	50% C 50% LG	beaver dam
18	.42	12.2	0.80	run	50% C 50% LG	island
19	.30	9.0	0.70	riffle	50% C 50% LG	
20	.32	8.3	0.82	riffle	20% B 60% C 20% LG	
21	.42	8.1	0.96	run	20% B 80% C	
22	.38	8.0	0.93	run	100% C	
23	.38	8.8	0.88	run	100% C	
24	.27	12.2	0.78	riffle	100% C	
25	.38	20.0	0.88	run	100% C	island
26	.29	9.2	0.78	riffle	20% B	

27	.44	9.0	0.70	run	80% C 50% C 50% LG	
28	.56	28.6	0.66	pool/ run	40% C 60% LG	
29	.34	10.3	0.68	pool/ riffle	40% C 60% LG	beaver dam
30	.29	10.2	0.65	riffle	30% B 40% C 30% LG	overstream trees
31	.33	9.8	0.56	riffle	20% B 40% C 40% LG	
32	.30	9.8	0.60	riffle	50% C 50% LG	overstream trees
33	.43	11.2	0.68	run	50% C 50% LG	
34S	.46	12.5	0.44	pool	20% C 60% LG 20% SG	beaver dam, overstream trees
35S	.27	15.0	0.56	riffle	50% C 50% LG	logjam
36S	.32	19.8	0.46	riffle	50% C 50% LG	
37S	.34	20.2	0.50	riffle	50% C 50& LG	
38S	.36	20.0	0.43	riffle	30% C 40% LG 30% SG	submerged logs
39	.36	14.3	0.58	run	80% LG 20% SG	
40	.33	15.0	0.50	run	80 % LG 20% SG	
41	.36	15.2	0.56	run	100% LG	beaver dam

Physical parameters for Reach 4

Station	Average Depth (m)	Channel Width (m)	Average Velocity (m/s)	Flow Type	Substrate	Notes
1		45	nil	slough	fines	
2		45	nil	slough	fines	
3		30	nil	slough	fines	
4		15	nil	slough	fines	at lake outlet