SETON RIVER INSTREAM FLOW STUDY

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2213.21/WP6823

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SETON RIVER INSTREAM FLOW STUDY

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6900 Southpoint Drive, CO3
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January 1996

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ACKNOWLEDGMENTS

Personnel from BC Hydro and Triton Environmental Consultants Ltd. contributed to this study. The study concept and design were developed by Paul Higgins, R.P.Bio. of B.C. Hydro and Adam Lewis, R.P.Bio. of Triton. The principal author and investigator was Adam Lewis.

Field studies were conducted by BC Hydro personnel Jim Scouras, Bob Westcott, Allister McLean, and Ian Ramsey. L. Marshik surveyed transect locations. Habitat suitability data were collected by BC Hydro crews and analyzed by P. Higgins using routines developed by James Bruce.

David Tesch, R.P.Bio. assisted in the data analysis and report writing and Kevin McCreight prepared the maps. Thanks to Brian Hebden for his critical review.

1. EXECUTIVE SUMMARY

The Seton River project, completed in 1956, diverts water from Seton Lake to the Fraser River, affecting flows in the Seton River. A fisheries maintenance flow has been released since the dam was completed, but the flow volume and timing has been based on professional judgment alone, and has not yet been corroborated by quantitative methods. In this study the existing flow release regime from Seton Dam was evaluated by calculating the relationship between instream flow and fish habitat, standing stock, and fish production. The research hypothesis examined was that increased flow will increase fish abundance, and the null hypothesis was that increased flow will not increase fish abundance (i.e. fish abundance will stay the same or decrease).

Seventeen whole-river transects were surveyed and depth, velocity, substrate and cover were measured at flows[1] of 12.4 m^3/s during November 1993 and 6.22 m^3/s during December 1993. The study area was from Seton Dam to the Fraser River confluence. The species of interest were chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon *(O. nerka*), pink salmon *(O. gorbuscha)*, steelhead trout *(O. mykiss)*, bull trout *(Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*).

An incremental approach, similar to Instream Flow Incremental Methodology, was used to determine the relationship between habitat and flow for the species of interest. Depth, velocity, cover, and substrate measurements were weighted with the suitability of habitat as determined either through direct observation by snorkellors in the Seton River, or with general suitability data from the literature. Weighted usable area was converted to standing stock using a simple production model developed for British Columbia by the Ministry of Environment, Lands and Parks. Adult production was calculated for Pacific salmon and steelhead trout using regional biostandards from the Department of Fisheries and Oceans.

For all six species of interest, the empirical data did not statistically support the hypothesis that increasing flow will increase rearing habitat. Similarly, the data did not statistically support the hypothesis of increased habitat for adult spawning of the six species. However, the results of the empirical analysis suggested that habitat for rearing would decrease if additional flows were provided, and that habitat for spawning would increase.

Simulation modeling of the response of habitat to flow suggested that the present rearing flow regime (minimum of 5.66 m^3/s) limits rearing habitat because flows are too high. Conversely, spawning habitat is limited because flows are too low (minimum of 11.3 m^3/s). Population modeling suggests that the fry life history stage limits production, thus increased flow is not expected to increase production of chinook salmon, coho salmon,

[1] Water Survey of Canada gauge 08ME003.

steelhead trout, and bull trout. Not enough is known about mountain whitefish to reach a conclusion. Pink salmon habitat will increase with increased flow, because this species is limited by suitable spawning habitat. However, a population response is unlikely because this species is presently overescaped. A comparison of habitat criteria showed that substrate imposed a greater limitation on pink salmon spawning habitat suitability than did flow.

Under the present flow regime, incubation habitat appears to remain watered throughout the incubation period. Only spawning sites of low suitability are likely to be dewatered. If flows during spawning are increased, fish will spawn in areas that are not wetted under the existing incubation flow regime. Accordingly, if spawning flows are increased, they should be accompanied by increased incubation flows.

Existing flows do not appear to impede upstream migration.

There is little opportunity to improve the temperature and water quality regime through withdrawal of water from the Seton Lake hypolimnion. The hypolimnion is cooler than Seton River, and so would not benefit juvenile rearing. Furthermore, withdrawal of hypolimnetic water may affect adult homing, which has been impacted by the Seton project in the past.

The primary opportunity to improve the flow regime would be to reduce the variance in flow from the Seton Dam. At present the minimum flow regime is higher than the historic regime, however, flows are more variable and flood flows are greater. The high flows reduce rearing habitat in the Seton River, and may displace juvenile salmon and trout. Furthermore, the high flows may scour substrate and organic material from the substrate, reducing productive capacity of both rearing and spawning habitats. Reduced peak flows would increase rearing habitat and would, in conjunction with gravel placement, increase spawning habitat by reducing the scour of small and large gravel.

An optimum flow regime was calculated that emulated the natural hydrograph, while optimizing the amount of habitat for the six study species. The best flow regime for juvenile rearing was traded off against the best flow regimes for pink salmon spawning, pink salmon incubation, and sockeye salmon migration. Median monthly flows calculated for the optimum regime were higher than existing flows from May through August, lower flows than existing from September to November, and similar from December through April. The optimum regime should have less variance in flow, which would require existing spills to be reduced in frequency and magnitude.

Fish habitat and production in the Seton River may be increased by habitat enhancement, either alone or in combination with an improved flow regime. Substrate strongly limits the availability of spawning habitat, and this may be overcome by placing gravel for spawning in the mainstem Seton. Rearing habitat may be improved by operating the Seton spawning channels to produce coho salmon and steelhead trout.

2. INTRODUCTION

B.C. Hydro commissioned this study to quantify the instream flow requirements of the fisheries resources of the Seton River. A fisheries maintenance flow has been released since the dam was completed in 1956, but the flow volume and timing has been based on professional judgment alone, and has not yet been corroborated by quantitative methods. This study uses physical habitat simulation to assess the relationship between instream flow and fish habitat and production in the Seton River.

2.1. Seton River Project

The Seton Project is located on the Seton River approximately 200 km northeast of Vancouver near the Village of Lillooet in southwestern British Columbia (Figure 1). The project diverts water from Seton Lake to the Fraser River via a power canal. Seton Lake receives discharge from the Bridge River project, which diverts water from Carpenter Lake under Mission Ridge to Seton Lake at Shalath, 18 km west of the Seton Lake dam. Operation of the project is affected by a private hydroelectric project that diverts water into Seton Lake from Cayoosh Creek, a tributary of Seton River.

The Seton Project consists of Seton Dam, a concrete gravity structure with a crest length of 130 m and a maximum height of 7.6 m. The dam houses a Tainter type radial spillgate, five manually operated siphons, a fishwater control and release gate and a fish ladder. Water from the Seton Dam is diverted via a concrete-lined power canal for 3700 m to the powerhouse forebay (Figure 2). A radial gate controls inflow to a steel penstock which leads to a single Francis turbine with a nameplate capacity of 42 MW.

Operation of the Seton Project is governed by water licenses issued by the B.C. Water Management Branch. Water Licence No. 21712 authorizes the diversion of 12 M m^3 (143 m^3/s) on a daily basis, and 3,215 M m^3 (102 m^3/s) on an annual basis. The operation of the Seton Project is directed by System Operating Order (SOO) No. 439 "Seton Project - Operating Requirements and Operating Responsibilities" (4 June 1992). The operating orders for Seton River have extensive provisions to protect fish, and there has been a long history of fisheries agency involvement in the Seton River project (Roos 1994). When the project was built there were provisions to protect fish and habitat, and since that time research into the effects of project operations has been used to improve project operation, thereby reducing impacts to fish. The primary concerns of regulatory agencies have been maintaining sufficient flow for fish during each life history stage, reducing the delay of migrating spawners at the Seton Powerhouse, ensuring fish passage over Seton Dam, and controlling juvenile mortality in turbines (B. Hebden, B.C. Hydro, pers.comm.).

2.2. Fish and Habitat

Seton River flows 4.6 km from the Seton Dam to its confluence with the Fraser River. Two reaches were defined for this project: Reach 1 from Cayoosh Creek to the Fraser River and Reach 2 from the dam downstream to Cayoosh Creek.

The Seton River supports a simple fish community: chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon *(O. nerka*), pink salmon *(O. gorbuscha)*, steelhead trout *(O. mykiss)*, bull trout *(Salvelinus confluentus*), longnose dace *(Rhinichthys cataractae*), sculpins (*Cottus sp.*) and suckers *(Catostomus sp.)*

Escapements of Pacific salmon to the Seton River have been estimated since 1951 (Figure 3). From 1951 through 1991 salmon escapements averaged 53 chinook salmon, 55 coho salmon, and roughly 330,000 pink salmon (DFO file data). Some sockeye spawn in Seton River (mean escapement 87), but the majority travel through the river en route to spawning grounds at Gates and Portage Creeks. Steelhead trout spawn in the Seton River downstream of the dam and population size is unknown (Hebden 1981).

A spawning channel was constructed in 1961 to compensate for spawning habitat lost when the Seton Dam was built. An additional spawning channel was built in 1967, in total providing sufficient spawning habitat for 47,000 adults. Both channels are wetted only during odd years when they accommodate spawning pink salmon.

Instream flow requirements in the Seton River were set by fisheries agency staff using professional judgment (Triton 1993). The amount of habitat provided by different flows has not been quantified, and fish carrying capacity has not been assessed. Existing instream flows are similar to the pre-development mean annual flow and are larger than pre-development minimum flows.

2.3. Objectives

The current flow release regime from Seton Dam was evaluated by calculating the relationship between instream flow and fish habitat, standing stock, and fish production. The relationship between fish passage and instream flow was inferred from depth to discharge relationships. The research hypothesis examined here was that increased flow will increase abundance, and the null hypothesis was that increased flow will not increase abundance (i.e. abundance will stay the same or decrease).

2.4. Study Bounds

The study area included the Seton River from Seton Dam to the confluence with the Fraser River. The species of interest were steelhead trout (includes rainbow trout, which could be not differentiated from steelhead), pink salmon, coho salmon, chinook salmon, sockeye salmon and bull trout.

Instream flows from 1 to 75 m^3/s were examined, a flow range designed to encompass extremes in flow that could reasonable be expected in Seton River. The field data were collected at 7 and 13 m^3/s. Errors increase with extrapolation, thus there is less confidence in estimates at extremes of the flow range.

3. METHODS

3.1. Approach

The study objectives demanded the evaluation of the population response of several species to changes in flow over the length of the river. Alternative scenarios of flow release were to be considered and the effects of several physical factors on fish production were to be investigated. To meet these challenges, the relationship between flow and fish production was assessed by modelling physical processes within the river, and the response of habitat and populations to these processes. Physical habitat simulation provides more biologically realistic results than other available methods and allows managers to assess the effects of alternative flow regimes. In contrast to standard setting methods such as the Tenant method (Tenant 1976), which is based on basin wide averages of hydraulic relationships, physical habitat simulation is based on local stream morphology, and is more realistic. Moreover, physical habitat simulation incorporates biological data specific to the study stream, allowing managers to assess the consequences of alternative flow regimes on different species.

A series of models were used to estimate the relationship between flow and physical variables and in turn, habitat, standing stock, and population size (Figure 4). River stage change, stream hydraulics, and fish distribution across and along the channel were assessed using a physical habitat model. Predictions of the relationship between usable habitat and flow were modified by a habitat capability model that quantified the effects of water quality on carrying capacity. Using the output of the habitat capability model, population biology was modelled to identify what, if any, life history stages limited the population.

Physical modelling relied primarily on stream-specific data. Hydraulic data were collected at cross-sections along the river and flow and velocity were predicted at different discharges with a hydraulic model. Habitat suitability curves developed on the Seton River were used for some species/life history types; alternatively curves from the literature were used. To estimate the suitability of depth for upstream migration, we used values from the literature (Bovee 1982, Reiser and Bjornn 1979).

The habitat suitability curves were used to weight the transects by the probability of use by the fish species and life stage of interest, and a usable transect width was calculated. The usable widths at transects were averaged among similar hydraulic unit types (riffle or run). This average usable width was multiplied by the linear extent of the hydraulic unit type in the river Reach to calculate a usable habitat area.

Water quality was incorporated into our estimates of standing stock. Temperature, oxygen, nutrients, and light are fundamental ecological determinants that influence both primary production and the metabolism of fish, effectively controlling fish growth and survival (Ryder and Kerr 1989). These factors legislate the limits to fish production over entire reaches, within which fish production may vary dependent on microhabitat conditions (depth, velocity, substrate and cover). Only two of the factors are important for an analysis of fish production in the Seton River.

Oxygen was not investigated quantitatively, as oxygen concentrations do not appear to limit fish production in the Seton Lake, based on limnological work conducted by Geen and Andrew (1961). The Seton River is well-saturated in oxygen because it flows from the surface of Seton Lake. The high gradient of Seton River ensures that the water remains well saturated.

Light may influence fish production in Seton River. Turbidity is moderate year-round and peaks during spring freshet. This may reduce light penetration and primary production. However, this factor is unlikely to be influenced by any conceivable management action, including altering flow releases from the Seton Dam, and so will not be considered further.

Water temperature influences fish production in the Seton River. Impoundment of Seton Lake altered the thermal characteristics of Seton Lake (Geen and Andrew 1961). Water temperatures control growth rates (Iwama and Tautz 1981) and incubation rates (Jensen 1988) in salmon and trout, and survival may be increased by altering Seton River releases.

Nutrients likely control fish production in Seton River. Seton Lake is oligotrophic, and primary production is modest. Accordingly growth rates of fish are likely to be low. Management actions such as withdrawing nutrient-rich water from depth may improve Seton River fish production.

The habitat capability model (Ptolemy 1993) incorporated the effects of temperature and water chemistry (alkalinity and non-filterable residue) on fish production. The model also incorporated fish size at age, which implicitly included the effects of water temperature. A growth model (Iwama and Tautz 1981) was used to confirm that the observed growth was limited by temperature.

Population biology was modelled by simulating the life history of the species from the standing stock estimates for each life stage. Fecundity and density-independent survival between lifestages were estimated from biostandards of the Department of Fisheries and Oceans (DFO 1985). Adult production was estimated from this model and compared to the observed adult production to assess validity.

Limiting life history stages were identified, since they can affect the success of enhancement activities (Hall and Baker 1982) and water releases (Lewis and Mitchell 1995). We compared the adult production estimated from each freshwater life history stage to identify which stage produced the lowest number of adults and was therefore limiting.

3.2. Hydrology

Streamflow data from the Seton River watershed were analyzed using daily flow data from Water Survey of Canada gauging stations 08ME003 (Seton River near Lillooet) and 08ME002 (Cayoosh Creek near Lillooet (Figure 2). The daily discharge record for each station was obtained from the Water Survey of Canada's HYDAT program (Environment Canada 1992). Inflows to Reaches 1 and 2 were calculated separately because of the relatively large drainage area of inflows to Reach 1, primarily from Cayoosh Creek.

3.3. Habitat Use

3.3.1. Field Studies

Fish were observed in the Seton River during snorkel surveys in August and September 1994. Observations of the juvenile forms of the study species were recorded and are available from B.C. Hydro (P.S. Higgins, BC Hydro, pers.comm. 1995). Although adult salmon and whitefish were also observed, they were too mobile for their positions to be accurately identified by snorkellors and these observations were not recorded.

To identify the positions occupied by juvenile fish, four snorkellors selected sites that were easy to access and moved upstream along the river margins. Visual observations were made of individual fish for a minimum of 60 s. The species, age class, location in distance above the substrate (± 20%), and behavior (feeding, hiding, holding, migrating) were noted on an plastic diving tablet. An individually numbered brightly-colored lead weight was placed at the focal position of the fish, for subsequent documentation of column depth, velocity, and substrate. Habitat use was observed in both day and night conditions. At night the divers illuminated the substrate intermittently with red light from a handheld flashlight.

3.3.2. Suitability Functions

Habitat use data collected in the field during 1994 were analyzed by members of the Strategic Fisheries Project at BC Hydro. Habitat use was described by calculating the probability of finding fish at particular habitat values. A probability density function was calculated by comparing each observation in each data subset (i.e. a single species and life stage) to all other observations in the subset, and weighting each observation by its distance (the difference in units of the habitat variable of interest) to all other observations. The most appropriate contrast or 'kernel' for weighting the observations was selected using an optimization model (Silverman 1986). This method of curve development differs from that typically employed in a habitat simulation. PHABSIM (Bovee 1982) and other habitat models generate histograms based on the fish observations and convert them into habitat use curves simply by running an average value line through the center of each histogram bar. The typical approach assumes a certain histogram bin width and starting point, upon which the shape of the habitat use curve will vary. The kernel optimization approach applied here avoids those assumptions.

The kernel analysis yielded univariate probability density functions for depth and velocity. These functions were scaled to 1 to match the approach taken with habitat suitability curves obtained from the literature.

Both BC Hydro data and literature values were available for steelhead fry and parr, but for all other combinations of species and life history type there were insufficient data (Table 1). In lieu of river-specific curves, general curves were applied using habitat suitability data from the literature. Spawning substrate requirements were assessed from the criteria listed in Table 1, though the criteria were interpreted to match our data collection methodology. The published criteria either described a single preferred substrate class, or a range of substrate classes. We recorded the percentage of each size class of substrate at a site. We interpreted the published criteria as follows.

Chinook salmon:	(large gravel and small cobble combined had to exceed 60% of the estimated substrate composition)
Coho salmon:	(large gravel and small cobble combined had to exceed 60% of the estimated substrate composition)
Pink salmon:	(large gravel and small gravel combined had to exceed 60% of the estimated substrate composition)
Steelhead trout:	(large gravel and small cobble combined had to exceed 60% of the estimated substrate composition)
Mountain whitefish	(small gravel, large gravel, small cobble, and large cobble combined had to exceed 60% of the estimated substrate composition)

These criteria reflect a professional judgment of what fraction of the substrate fish require within the preferred substrate size class. The criteria were not corroborated by observations of spawning fish. The substrate criteria were paired with depth and velocity criteria from the literature and from B.C. Hydro.

A review the literature suitability curve functions suggested that although juvenile salmonids may prefer a particular type of cover, they will use a broad range of cover types, including artificial cover (Bustard 1972, Shirvell 1990). In the present study, cover requirements were assessed by considering an area within a 0.5 m radius of each station. Boulders, cobble, woody debris, and undercut banks were considered to provide cover for fry. Suitability was scored at 1 if these features were present and at 0 if they were absent. Cover for parr was scored similarly, except that small cobble was scored at 0.

Cover requirements for mountain whitefish were assessed through substrate composition. Particle sizes from silt to large gravel combined had to exceed 60% of the substrate for fry cover to score 1, otherwise fry cover was scored as 0. Particle sizes from silt to large cobble combined had to exceed 60% of the substrate for parr cover to score 1, otherwise parr cover was scored as 0.

3.4. Habitat Availability

3.4.1. Transect Data Collection

Transect data were collected at 17 locations at two discharge levels in the Seton River (Figure 5). Twelve transects were located downstream of the Cayoosh Creek confluence, and five transects were located upstream. The transects occupied both riffle (n=9) and run (n=8) hydraulic unit types: other hydraulic units types were rare. Transects were located at electrofishing sites randomly selected during a study by Lister and Beniston (1995). In November 1993, at a discharge of 13 m^3/s, elevation survey data as well as depth, velocity, and cover data were collected, but the center of the channel was excluded from measurement due to high water velocity, which made wading impossible and boating unsafe. The discharge during November is termed the 'secondary calibration flow'. Data collected at the 'primary calibration flow' of 7 m^3/s during December 1993 included measurements at the middle of the channel.

At each transect the cross-sectional profile was surveyed using a Wild transit and stadia rod. Elevations were measured up to the point of rooted vegetation, and the hydraulic control was identified and surveyed. Geodetic elevations were determined by a total station survey. The results of the survey are available from B.C. Hydro. Including the hydraulic control elevation (zero flow), three water surface elevations are available at each transect, and these were used to construct an empirical stage-discharge curve for each transect.

At each transect 20 or more measurements of depth, velocity and substrate were taken across the channel during the primary calibration flow following the methods of Terzi (1981). On average stations were established every 0.9 m along transects. Flow was measured with a Swoffer propeller-type current meter, or a Marsh-McBirney electromagnetic current meter. Both meters were calibrated prior to the field trip following the manufacturer's protocol. Water velocity was measured at 0.2, 0.4 and 0.8 of depth. Substrate was assessed following the protocol of the DFO/MELP Stream Survey Guide (DFO 1990).

3.4.2. Hydraulic Modeling

Triton has developed a spreadsheet model in Excel using Visual Basic programming language to predict depth and velocity at stations across each transect at different flows.

Model algorithms are similar to those used in the IFG4 model from the U.S. National Ecology Research Center (Bovee 1982). This model uses the observed stage discharge relationship at each transect to predict water surface elevation, and distributes depths and velocities across the channel based on the observed roughness (i.e. the existing cross-channel distribution). As flows diverge from the calibration flow, simulated flows are progressively weighted to reflect the velocity predicted based on Manning's equation. Full cross-channel Manning's-type flow (i.e. velocity determined by depth and mean channel roughness alone, without consideration of calibration velocity distribution) will be achieved at some higher flow, however, the magnitude of this flow is unknown and will differ between transects. For this study, that flow was arbitrarily set to 50 m^3/s.

3.4.3. Habitat Modeling

The suitability of habitat at alternative flows was estimated by weighting the area around each station (cell) by the suitability for each habitat parameter based on habitat suitability criteria. This habitat-based method is similar to the PHABSIM component of the Instream Flow Incremental Methodology (IFIM, Bovee 1982) in that stations along whole channel transects were weighted by fish preferences for depth, velocity and cover. Unlike PHABSIM however, physical characteristics at a station were not extrapolated upstream for a distance half-way to the next transect. Our transects were selected at random, meeting an assumption of statistical analysis, but were too far apart to justify longitudinal extrapolation. We calculated wetted usable width at each transect and expanded this to area by averaging the transect values for each hydraulic unit type, and multiplying these values by the total length of a hydraulic unit type.

Weighted usable width (WUW) was calculated at each station by applying habitat suitability index values for depth, mean velocity (at 0.4 of depth), the dominant substrate within a radius of 0.5 m from the station (for adult spawning), and dominant cover within a radius of 0.5 m from the station (for juveniles). Suitability variables were applied in the following models:

1) depth and velocity alone,
$WUW_{dv} = \Sigma_i^n (W_i{*}D_i{*}V_i)$;

2) depth, velocity, and substrate (for spawning),
$WUW_{dvs} = \Sigma_i^n (W_i{*}D_i{*}V_i{*}S_i)$; and

3) depth, velocity, substrate, and cover (for rearing),
$WUW_{dvc} = \Sigma_i^n (W_i{*}D_i{*} V_i{*}C_i)$.

where W_i is the width of cell *i* on the transect, D_i is the suitability of depth at cell *i*, V_i is the suitability of velocity at cell *i*, S_i is the suitability of substrate at cell *i*, and C_i is the suitability of cover at cell *i*.

Model 1 was expected to provide the most information on the effects of flow on fish habitat, since flow affects depth and velocity directly. The inclusion of substrate (model 2) and cover (model 3) terms was expected to reduce our estimate of suitable habitat, but not necessarily alter the shape of the relationship between flow and suitable fish habitat.

Habitat measurements taken at an individual station were assumed to apply from the station to a point intermediate to the adjacent station. Thus cell width was the sum of the distances to the intermediate points on each side of the station. Along the margin, the cell from the wetted edge to a point halfway to the first station was weighted by the habitat characteristics at the first station. Thus habitat adjacent to the wetted edge was included in the calculation of weighted usable width. Since this habitat is often preferred by juvenile salmonids, this calculation avoids a negative bias in weighted usable width of 5 to 20% that would be induced if the marginal cell had been assigned a depth and velocity of zero. On the other hand, this calculation inflates weighted usable width. However, this bias is minimized by the close spacing of stations along the transects (every 0.9 m).

Differences in weighted usable width at different flows were assessed within transects through the Wilcoxon matched-pairs signed-ranks test, a non-parametric test for two related samples. The test weights pairs with large differences between them based on the ranks of the absolute differences between the two variables. The test makes no assumptions about distribution shape and is therefore more robust than the t-test, but acknowledges the magnitude of differences between pairs and therefore is more powerful than the sign test. Test power was focused on the research hypothesis through a one-tailed test.

To calculate weighted usable area (WUA), WUW was averaged within each hydraulic unit type and multiplied by the total length of hydraulic units within the study area. The hydraulic unit composition was estimated by Lister and Beniston (1995), and in the field during this study.

3.4.4. Standard Setting Methods

Standard setting methods were applied to provide a comparison to estimates based on weighted usable area. The application of these models is termed standard setting, since standards developed on other systems are used to make instream flow recommendations. The methods were Tenant's method (or the Montana method, Tenant 1975), and Swift's method based on discharge and based on drainage area (Swift 1976).

3.5. Water Temperature and Quality

Water quality data were obtained from the literature (Geen and Andrew 1961, Servizi et al. 1985) and from B.C. Hydro files (P. Higgins, pers.comm. 1995). Temperature data from Seton Lake were summarized to characterize the temperature regime for Seton River. Temperature data are available for Seton Lake as far back as 1943. This summary consists of data collected near the Seton Dam forebay between the years 1943 to 1978, excluding the periods 1944 - 1957, 1963 - 1964, and 1966 - 1969 for which there was no data. Average temperatures for the epilimnion and hypolimnion were calculated by estimating the position of the thermocline in the recorded temperature profiles.

3.6. Production Analysis

To estimate the fish produced by a particular flow regime, the total weighted useable area generated by the habitat analysis was multiplied by species/lifestage specific estimates of the standing stock per unit of habitat. Standing stock at carrying capacity was selected because it is a reasonable surrogate measure of fish production that can be readily expanded to adult production using biostandard survival rates. The standing stock and adult production estimates should not be considered accurate point estimates, but rather informative approximations for comparison to stream-specific standing stock and escapement data. The purpose of generating these estimates was not to accurately estimate Seton River salmonid production, but rather to examine if our assumption that weighted usable area controls abundance was reasonable, given the predicted and observed standing stocks and escapements.

Standing stock at carrying capacity was estimated by an empirical model developed by Ministry of Environment Lands and Parks that predicts the carrying capacity of juvenile salmonids given a particular water chemistry and habitat usability (Ptolemy 1993). These estimates were validated by comparison with observed standing stock estimated by electrofishing (Lister and Beniston 1995). Salmonid production was estimated by expanding estimated juvenile standing stocks by biostandard survival rates (DFO 1985). These estimates were compared to observed escapements to identify agreement or disagreement, acknowledging that harvest should negatively bias the escapement side of the comparison.

3.7. Limiting Factor Analysis

Limiting life history stage(s) can be identified by comparing the theoretical adult production based on the available habitat for each life history stage. This approach has been used to identify limiting factors in Oregon coho populations (Nickelson et al. 1993). By further comparing estimated and observed standing stock for each life history stage, we can assess how well our model explains limitations at each life history stage. A key assumption of this approach is that populations and standing stocks estimated in the field are at carrying capacity. Even when escapements of salmon are below average, this assumption may be true for early life history stages because of their high fecundity. For example, a tripling of the escapement of steelhead trout in the Keogh River increased smolt production by just 7% (Ward and Slaney 1992).

3.8. Optimum Flow Analysis

To integrate habitat and flow relationships among species, weighted usable area was scaled to one and plotted against flow for the limiting life history stage of each species. Where the limiting life history stage could not be determined following the methods described in Section 3.7, scaled values for potentially limiting life history stages were averaged and re-scaled to one.

Where several species experienced similar limitations within the same seasonal period, the scaled habitat values were averaged, implying equal importance among species, and re-scaled to one. The resulting aggregated habitat index represented a guild of species with similar habitat requirements and the same limiting life history stage. Species with different and conflicting habitat limitations were grouped into different guilds. Trade-offs were identified at the intersection of the habitat versus flow function for each guild, implying equal importance among guilds. The primary limitation to this approach was that not all species present in the Seton River were included in this assessment, and this reflected the practical difficulty of assessing the habitat requirements of those species infrequently found in the Seton River, and without published habitat suitability criteria.

The trade-off flows for each guild were ordered seasonally, reflecting the suspected period of habitat limitation for the guild. A seasonal hydrograph of optimum flows for fish habitat (the habitat regime) was thus created. This hydrograph was compared to the historic flow regime and adjusted to include the influence of natural hydrologic events by identifying seasons where the historic pattern of flow was not reflected in the hydrograph of optimum flows for fish habitat. In these seasons the hydrograph was adjusted by the following formula:

$\text{optimum flow}_{(\text{freshet months})} = \text{median monthly flow}_{(\text{habitat regime})} + \text{flow adjustment}.$

This formula weighted the habitat regime to create a naturally-shaped hydrograph based on the variance in the natural regime. For each freshet month, the flow adjustment was calculated as:

$$\text{flow adjustment} = \text{STD MMF}_{(\text{natural regime})} * \text{SD MAF}_{(\text{habitat regime})} * \frac{(\text{CV MAF}_{(\text{natural regime})})}{\text{CV MAF}_{(\text{habitat regime})}}$$

where STD = standardized value (to mean 0 and SD 1), SD = standard deviation, CV = coefficient of variation, MMF = median monthly flow, and MAF = median annual flow.

This factor scaled the magnitude of the natural freshet to the magnitude of the habitat regime. For each freshet month, the equation component (STD $\text{MMF}_{(\text{natural regime})}$ * SD $\text{MAF}_{(\text{habitat regime})}$) calculated the additional flow expected if the habitat regime exhibited the same variation as the natural regime. The factor CV $\text{MAF}_{(\text{natural regime})}$ /CV $\text{MAF}_{(\text{habitat regime})}$ expanded the flow adjustment to reflect the difference in the variation of the natural and habitat regimes. We used the coefficient of variation because this statistic is less sensitive to the magnitude of the mean than is standard deviation. The flow adjustment created an optimum flow consistent with the shape of the natural regime and the magnitude of the habitat regime. The resulting optimum freshet flows were higher than the base flows of the habitat regime, but consistent with the base flows of the habitat regime.

4. RESULTS

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4.1. Hydrology

For purposes of comparison, the hydrology of the Seton River has been broken into two phases: 'recent' operation, which has been characterized using the last 10 years of available data (1984-1993) and the 'pre-development' regime (flow records available for the years 1914 to 1925). Recently, flow has averaged 16.6 m^3/s, but pre-development flows averaged 20.0 m^3/s (Table 2). Regulation increased mean and minimum daily flows during the fall and winter, but decreased these flows during the spring and summer. Maximum daily flows have increased year-round, with the greatest increase in the early fall and late winter months. These changes have resulted in a flatter hydrograph with higher average flows during the later summer, fall, and winter, and lower average flows during the spring and early summer (Figure 6).

The Seton Project operating order stipulates a minimum release of 5.66 m^3/s, with a release of 11.3 m^3/s from 20 July to 13 November to protect migrating salmon, inclusive of 0.85 m^3/s for the fish ladder and 1.13 m^3/s for the upper spawning channel (BC Hydro 1992). To protect pink salmon eggs during the incubation period flow may not be less than 50% of the flow during the preceding spawning period (15 September to 29 October in odd years). These instream flow requirements have increased the minimum flow present in the Seton River above the historical flow level (Figure 7).

When the Bridge River was first diverted into the Seton watershed at Shalalth in 1934, flows in the Seton River increased by about 1 m^3/s (Geen and Andrew 1961). The development was expanded between 1948 and 1954, increasing flows in the Seton River by roughly three times. This higher flow regime persisted until B.C. Hydro diverted the Seton River for the Seton Project in 1956. At present the discharge capacity of the Seton Powerhouse generally equals the daily inflow to Seton Lake from tributaries and the Bridge River diversion. The water surface elevation of Seton Lake varies by just 0.38 m, thus the reservoir provides minimal storage. In years when Seton Lake inflow exceeds powerplant capacity, such as 1991, excess flows are spilled down the Seton River (Figure 8). To minimize the potential for spilling and maintain hydrologic balance the plant is operated at full load (base loaded), and is shut down only for maintenance. Spill from the radial gate is restricted by the operating order to a maximum of 28 m^3/s to help sockeye salmon ascend the fish ladder. Spills are limited to 57 $m^3/$ from 15 September in odd years to the following May 31, to prevent the scouring of incubating eggs.

Even with these spill restrictions, spills cannot be avoided because the Seton Generating Station is a bottleneck to the Seton project, and in most years there are periods when the total inflow to Seton Lake exceeds the capacity of the powerplant. As a result, the flow in

Seton River is more variable now than historically, even though a constant minimum flow is maintained (Figure 7).

The flows in Reach 1 are influenced by inflow from Cayoosh Creek, particularly from May through July, during the spring freshet. Cayoosh inflow has less influence in years when there are spills into Seton River, such as 1991, than in years when there is little spilling (Figure 8).

Recently the influence of Cayoosh Creek has been reduced, with the permanent diversion of flows greater than 42.5 m^3/s into Seton Lake. However, even with this permanent diversion, Cayoosh Creek inflows to Seton River will dominate the flow in Reach 1 in years with large spring freshets.

BC Hydro is required by the operating order to monitor the independent power project on Cayoosh Creek, constructed by Walden North, to ensure that the correct mix of Cayoosh and Seton water is maintained to avoid migratory delays at the Seton powerhouse. Flow is diverted through the tailrace channel of the Walden North powerhouse and the Cayoosh-Seton tunnel to Seton Lake. As stipulated in the Operating Order, during the Gates Creek sockeye run Cayoosh water may comprise not more than 20% of the Seton River flow; during the Portage Creek sockeye Cayoosh water may comprise not more than 10% of the Seton River flow. These operating requirements constrain the minimum flow that can be released to the Seton River.

4.2. Habitat Use

Both BC Hydro data and literature values were available for steelhead fry and parr, but for all other combinations of species and life history type there were insufficient data (Table 1). In lieu of river-specific curves, general curves were applied using habitat suitability data from the literature. The general criteria for juvenile salmonids are plotted for depth in Figure 9 and for velocity in Figure 10.

The BC Hydro data showed that habitat use by steelhead trout differed between day and night, as plotted in Figure 11. Steelhead trout fry were not observed during the day; as a result, nocturnal criteria were used for simulations. Chinook and coho parr were not observed in the Seton River, and chinook and coho fry were not observed during daytime sampling. The small sample size and lack of data for the parr stage reduced our confidence in the habitat use curves for these species. Accordingly, simulations were made using criteria from the literature.

Habitat suitability data were obtained from the literature for chinook, coho, and pink salmon. From these data general habitat suitability curves were prepared (Figure 12).

No bull trout or mountain whitefish juveniles were observed during the snorkel surveys. Habitat criteria from the literature were used for simulations.

4.3. Habitat Availability

4.3.1. Wetted Width, Mean Depth, and Mean Velocity

Gradient strongly influenced the hydraulics of the Seton River. The river drops 38.8 m from the plunge pool of the Seton Dam to the Fraser River, a gradient of 1% over the 3,900 m long channel. Instantaneous gradients measured between transects ranged from 0.02% at transect 3321.5 to 4.18% at transect 2205.5 (Table **3**).

The Seton River is narrow, shallow and straight, with high water velocities. Based on transect measurements during December 1993, with flows averaging 7.04 m^3/s in Reach 1 and 6.13 m^3/s in Reach 2, wetted widths averaged 24.5 m (range 38.9 to 12.2 m). Mean depths averaged 0.58 m (range 1.07 to 0.29 m) and mean velocities averaged 0.66 m/s (range 1.19 to 0.25 m/s). Wetted width increased with discharge at a greater rate in riffles than in runs.

Gradient controls the relationship between discharge and hydraulic parameters. Wetted width increased in a curvilinear relationship with discharge, and the rate of change in wetted width was most distinct at low flows (Figure 13). From 5 m^3/s to 10 m^3/s in flow, wetted width increased about 3 m, whereas from 10 to 15 m^3/s wetted width increased just 1.5 m. Water velocity increased more linearly with discharge than did wetted width (Figure 14). From 5 m^3/s to 10 m^3/s in flow, velocity increased from 0.41 to 0.67 m/s, and from 10 to 15 m^3/s in flow, velocity increased to 0.8 m/s. The relationship was similar for runs and riffles, but riffles were 30% shallower (Figure 15). Wetted width increased at a similar rate in riffles and runs.

The relationship between depth and discharge was similar to that between velocity and discharge, with velocity increasing rapidly with discharge at low flows, and less quickly at higher flows.

The hydraulic model was acceptably accurate in predicting hydraulic parameters. At the primary calibration flow, errors averaged -1.7% for wetted width, 8.7% for mean depth, and -4.4% for mean velocity (Table 4). Errors at riffles were at least twice as great at those at runs. Section 10.2, Transect Cross-sections, illustrates the source of these errors in plots of the calibration and simulated data at the primary calibration flow. The hydraulic model used here assumes a horizontal water surface across the transect, but riffles usually had a sloped water surface. At the secondary calibration flow, depth and velocity were not measured across the entire channel and so errors in these parameters cannot be assessed, as noted in methods (Section 3). Errors in wetted width at the

(Section 3). Errors in wetted width at the secondary calibration flow averaged -5.2%. Again errors in riffles were significantly higher than in runs.

4.3.2. Juvenile and Spawning Habitat

4.3.2.1. Empirical Data

Weighted usable widths averaged across all transects ranged from 0 to over 20 m, dependent on the species and life history type as well as the criteria used for weighting (Table 5). In general, habitat for juvenile life history stages decreased as flows increased from 7 to 13 m^3/s, whereas habitat for adult spawning increased. Based on WUW habitat changes for juveniles were as follows: -7% for chinook fry; -3% for chinook parr; -27% for coho fry; -32% for coho parr; -18% for steelhead fry; -3% for steelhead parr; -28% for mountain whitefish fry, -2% for mountain whitefish parr, -14% for bull trout fry, and -4% for bull trout parr. These changes were statistically significant only for coho fry and parr and mountain whitefish fry (Table 5). The lack of statistical significance resulted from the small sample size and the opposing responses between hydraulic unit strata. For example, WUW for chinook salmon fry decreased by 25% in riffles (P=0.173, n=9) and increased by 12% in runs (P=0.575, n=8), but decreased by just 7% for the strata combined (P=0.177, n=17). In general, habitat in riffles was more sensitive than habitat in runs to changes in flow.

Spawning habitat based on WUW increased with increasing flow for coho salmon (16%), pink salmon (1%), steelhead trout (2%), and bull trout (9%), but decreased for chinook salmon (-21%) and mountain whitefish (-2%). None of these changes were statistically significant.

The use of river-specific criteria did not significantly alter the results. Literature criteria predicted more usable habitat than river-specific criteria, but the direction of response to flow change did not change significantly (Table 6).

Spawning habitat usability estimated from depth and velocity (WUW_{dv}) was similar among the species examined (Table 7). At the December calibration flow, WUW_{dv} for spawning was 35% for chinook salmon, 37% for coho salmon, 40% for pink salmon, 52% for steelhead trout, 27% for mountain whitefish, and 38% for bull trout. Adding the substrate completely altered the results. WUW_{dvs} was just 1% for Pacific salmon and steelhead trout, 3% for bull trout, and 27% for mountain whitefish. The higher usability for spawning whitefish reflected broader range of substrate suitable for spawning in this species.

Rearing habitat usability based on depth and velocity at the December calibration flow was: 23% for chinook fry; 17% for chinook parr; 15% for coho fry; 11% for coho parr; 23% for steelhead fry; 33% for steelhead parr, 2% for mountain whitefish fry, 17% for mountain whitefish parr, 17% for bull trout fry, and 12% for bull trout parr. Usability decreased with increasing flow for the rearing stages of all species.

Rearing stages were insensitive to the inclusion of cover variables. Generally WUW_{dv} and WUW_{dvc} agreed well: The cover criterion decreased usability by no more than a few percent for trout and salmon species. Mountain whitefish fry and parr were considerably more sensitive to the cover criterion, reflecting their preference for gravel and cobble substrates. In contrast, juvenile salmon and trout prefer a broad range of cover including boulders, cobble, and woody debris.

Spawning habitat had very low usabilty, ranging from 1% for salmon and steelhead trout to 12% for mountain whitefish (Table 7). Spawning habitat was insensitive to changes in flow. In contrast, changes in substrate had an order-of-magnitude effect on spawning habitat usability. This effect was most extreme for salmon and steelhead, and less extreme for bull trout. Mountain whitefish habitat suitability decreased when cover variables were included, but much less than the other species.

4.3.2.2. Simulations

Habitat simulations for the six test species illustrated a general response to changes in flow. The model predicted habitat would decline for juvenile salmonids as flow increased from 1 to 75 m^3/s. In contrast, the model predicted more spawning habitat as flow increased 1 to 30 m^3/s, and less spawning habitat at greater flows.

Chinook salmon displayed the typical pattern of response (Figure 16). For chinook fry WUA peaked at 1 m^3/s and for chinook parr WUA peaked at 2 m^3/s. Spawning habitat peaked at 30 m^3/s. Juvenile coho habitat showed a similar pattern to juvenile chinook. WUA peaked at 1 m^3/s for both coho fry and parr (Figure 17). Coho spawning habitat peaked at 30 m^3/s.

The response of pink salmon spawning habitat to flow was similar to other salmon species with WUA peaking at 30 m^3/s (Figure 18). The similarity of salmon spawning habitat to flow relationships reflects the use of general curves and may be unrealistic. Figure 12 shows only minor differences between species in the suitability of depth and velocity for spawning. On one hand, general curves are weak in this application because they fail to demonstrate the suspected differences between species. On the other hand, the curves all yield the expected response — spawning habitat increases with flow up to and beyond the historic mean annual flow.

The relationship between flow and habitat for steelhead trout was similar to the Pacific salmon species. Habitat for steelhead trout fry peaked at 1 m^3/s (Figure 19), and parr habitat peaked at 2 m^3/s. Steelhead spawning habitat peaked at 75 m^3/s, but increased to 50% of the maximum habitat by 17 m[illegible]

When we used river-specific curves for steelhead trout, the response of WUA to flow was similar, with fry habitat declining with increasing flow when flows were greater than 1 m^3/s (Figure 20). The response of parr habitat to flow differed from the standard curves with an increase in habitat from 1 to 4 m^3/s, little change from 4 to 10 m^3/s, and declining habitat beyond 10 m^3/s. Note that this observation is consistent with the tests of empirical data in (Table 5). Habitat preferences are assumed to remain constant over the flow regimes examined, as suggested by Beecher et al. (1995).

For bull trout, fry and parr habitat was greatest at 1 m^3/s, whereas adult habitat peaked at 20 m^3/s (Figure 21). For mountain whitefish, fry habitat was maximized at 1 m^3/s, but parr habitat was maximized at 4 m^3/s and spawning habitat at 10 m^3/s (Figure 22).

Estimates of WUW calculated with and without substrate or cover showed a similar and in some cases identical relationship to changes in discharge. The inclusion of cover or substrate into the habitat model did affect the amount of habitat available at each flow, but had little effect on the flow at which habitat was maximized.

4.3.2.3. Validation

Weighted usable area estimates were validated by comparison to standing stock estimates from electrofishing during summer and fall 1993 (Lister and Beniston 1995). Standing stock estimates were made for the margins of the Seton River at 19 sites, 15 of which corresponded to whole river transects measured during this study. When more than one electrofishing site was within 10 m of a transect site, standing stocks were averaged among the electrofishing sites.

In site by site comparisons, no significant correlations were obtained between WUA estimates and standing stock for any species/life history category. This was not surprising as the standing stock estimates were made for the margins of the river, rather than across the entire channel. Prior to the analysis we anticipated poor agreement between the weighted usable area and standing stock estimates on a site by site basis.

Better agreement was obtained between mean observed standing stock (estimated from electrofishing by Lister and Beniston 1995) and mean predicted standing stock, estimated from WUA and standard productivity models (Table 8). Most estimates were the same order of magnitude, and in some cases within the confidence intervals for the observed data. Based on habitat criteria from the literature, predicted chinook fry standing stocks were 49% of the observed during August and 36% of the observed during November. Predicted coho fry standing stocks were 31% of the observed during August and 12% of the observed during November. Steelhead fry estimates were 4 times the observed standing stock during August, and 12.4 times the observed during November. Steelhead parr estimates were 4 times the observed during August, but 38% of the observed during

November. Some of the differences can be explained by the observed standing stock data, as explained in Lister and Beniston (1995). They noted that during August their sampling enclosures did not include faster-flowing habitats, negatively biasing their density estimates.

This comparison of predicted and observed standing stocks merely validates the habitat model. To fully validate the instream flow method multiple years of standing stock and weighted usable area data from the study stream must be paired with appropriate spatial and temporal controls (EA 1986). Recent published tests of the methodology confirm that physical habitat simulation can predict standing stocks of salmonids (Jowett 1992; Nehring and Anderson 1993) with better accuracy than simple flow statistics (i.e. standard setting methods).

4.3.3. Incubation

Empirical data from habitat transects showed that incubation habitat was unlikely to de-water under the existing flow regime. Based on a probability density function derived from empirical stage change data, there was a 50% probability that depths decreased by less than 15 cm between the November (Q =7 m^3/s) and December (Q = 13 m^3/s) sampling periods (Figure 23). There was a 5% probability that depths decreased by more than 30 cm, and a 99% probability that depths decreased by less than 50 cm. Spawning depths vary between species with chinook salmon the least sensitive, followed by coho salmon, and pink salmon, which were the most sensitive species.

Pink salmon were the most sensitive to redd dewatering. Optimum spawning depths based on habitat suitability criteria from Raleigh et al. (1985) exceed 0.36 m. A comparison of depth suitability and the probability of depth change provides an inference into the probability of dewatering. Unfortunately, no adult observations specific to the Seton River are available, hence the general suitability curves we use here are indices of abundance scaled to 1. Based on these it is apparent that the optimum spawning locations for pink salmon were unaffected by dewatering under the 1993 flow regime. For example, there was a 99% probability that transect sites with a depth suitability of 1 during November remain watered after flow reductions in December (Figure 24). Even relatively unfavorable sites remained well-watered. For example, there was a 90% probability that transects sites with a depth suitability of 0.5 during November remained watered after flow reductions in December.

In years with high escapements of pink salmon, we anticipate that low suitability habitats will be used. Nevertheless, we suspect that our estimates of the probability of nest dewatering will be insensitive to escapement. The relative density of pink salmon spawning in deep and shallow habitats will probably not change, since more fish will also spawn in deeper habitats. Furthermore, the minimum depth required by pink salmon for spawning (~ 0.1 m) will not change, regardless of escapement size, because salmon require sufficient depth to swim, excavate and nest and spawn.

Based on habitat suitability curves from the literature (Figure 12), steelhead trout preferred a similar range of depths for spawning as did Pacific salmon. In unregulated rivers, steelhead spawn on the ascending limb of the hydrograph, and their eggs develop during the spring freshet, when flows are considerably higher than during spawning. However, on the Seton River the hydrograph has an unnatural shape and in some years steelhead egg-to-fry survival may be affected. Flows during incubation may drop below those during spawning, and steelhead redds may be dewatered. Typically steelhead fry emerge in August, when flows exceed 15 m^3/s. The timing and duration of spring freshet is quite variable, and in May steelhead spawn at flows from 6 to 50 m^3/s. Stage change in the worst case scenario (flows change from 50 to 15 m^3/s) must be simulated because the calibration data were collected at 7 and 13 m^3/s, creating unknown errors. Simulation of this stage change shows that steelhead spawning at the lower range of depth suitability have a high probability of redd dewatering (Figure 25). Note that in years with a temporally compressed spring freshet, the probability of redd dewatering would be lower, since steelhead would spawn at lower flows.

Bull trout spawn in shallow water and so would be sensitive to stage changes. However, bull trout are unlikely to spawn in the Seton River, as discussed in section 3.7.

Mountain whitefish are broadcast spawners and although they spawn in deeper water than the other species examined here, their eggs may adhere to substrate in shallower areas. The eggs are less likely to dewater than other species however, because mountain whitefish spawn during the winter, when flow levels are at their annual minimum.

4.3.4. Upstream Passage (Migration)

At existing flows there was sufficient depth to accommodate upstream migrating salmonids. Under the existing low flow regime mean transect depth exceeded 0.29 m. These depths are sufficient to permit fish passage based on the criteria of 0.18 m (Bovee 1982)and 0.14 m (Reiser and Bjornn 1979). At 95% of the transects, mean depth exceeded 0.2 m (Figure 26). Mean depth analysis provides a conservative assessment of water depth for fish passage. More realistically, the distribution of maximum depths suggests that at least 0.5 m of water are present during the low flow regime — the shallowest transects measured had 0.72 m of depth.

During the remainder the year, depths are greater and fish will more easily migrate upstream. Rapids on the Seton River do not appear to create an obstruction to upstream passage, based on visual observation. The fish ladder at Seton Dam may create an impediment or barrier to migration for certain life stages of some species, but this was not examined in this study.

4.4. Water Temperature and Quality

4.4.1. Temperature

Seton River water temperatures have been characterized using water temperature data from Seton Lake near Seton Dam. Water temperatures have ranged from 22.6 °C (June 20, 1967) to 2.5 °C (March 6, 1959). Figure 27 illustrates the average temperatures of the epilimnion and hypolimnion of Seton Lake. A large scope for temperature manipulation through withdrawal of water at different depths exists, and during the height of the growing season the temperature contrast between layers reaches 10 °C. Seton River temperatures in Reach 1 are also affected by Cayoosh Creek inflows, as Cayoosh Creek is 2 to 6 °C cooler than Seton Lake (Rowland 1981)

Typically, the thermocline in Seton Lake develops in late April to early May and persists until November when in breaks down. No distinct trend in the thermocline exists from March, early April and December. Although no winter temperature data was available, it is likely that Seton Lake is homeothermic through the winter months.

The depth of the thermocline varies between seasons. In the most recent year with data (1977) the thermocline was shallowest in the spring, and moved progressively deeper as the season progressed (Figure 28). August was the month of greatest temperature contrast within the lake, and the thermocline tends to occur between 5 - 15 m. The shallowest thermocline recorded was 3.0 m in 1976. Note that the diversion of Cayoosh Creek may strongly influence the thermocline location in the vicinity of Seton Dam, and thermocline depths in recent years may be different than described above. Cayoosh inflows from the diversion descend below the surface of Seton Lake (Rowland 1981).

4.4.2. Water Quality

Based on the limited data available, water quality in Seton River was generally good, with high dissolved oxygen and low levels of suspended solids (Environment Canada 1974). Nutrient measures are typical for the region, with NO3--N concentrations less than 5 $\mu g \bullet L^{-1}$ and maximum total phosphorous of 52 $\mu g \bullet L^{-1}$. pH averages 7.5, and alkalinity averages 32.3 (Servizi et al. 1985). Coincident samples from Cayoosh Creek and Seton River during the late summer and early fall show that Cayoosh Creek tends to have higher concentrations of flouride, sulphate, and calcium, and higher alkalinity, conductance, and hardness (Fretwell 1989).

5. DISCUSSION

5.1. Factors Limiting Existing Fish Populations

We have approached instream flow assessment from a 'law of limiting factors' (Blackman 1905) perspective, prompting us to consider the life history of each species as a sequence of related habitat requirements whose effects compound as an organism ages. The abundance of a lotic fish species may be controlled at one or several life history stages. This instream flow assessment targets those life history stages which we believe, based on general species biology or stream-specific data, to be most limited by instream flow. We hypothesize explicitly that flow limits fish populations, and that instream abundance reflects this limitation.

Our research hypothesis was that increased flow will increase abundance, and our null hypothesis was that increased flow will not increase abundance (i.e. abundance will stay the same or decrease). In the case of adult salmon, this hypothesis is certainly false, for we know that commercial harvest averages 60% of adult anadromous salmonid production across species and may approach 80% for heavily fished stocks (Walters 1995). Accordingly, our assessments of the abundance of adult stocks should not be taken as tests of the primary hypothesis, but as estimates of the potential size of the resource affected by changes in flow. This study was designed with the premise that increased flow will increase fish populations, and the calculations provided here serve to bound the magnitude of the limitation, and define the life history stage(s) at which the limitation acts.

The following subsections discuss the evidence supporting limitations at each freshwater life history stage: spawning, incubation, and rearing. The first subsection is longer than the others because we develop initial arguments to explain the general pattern of habitat response to flow, and these arguments are referenced in the latter subsections.

5.1.1. Chinook Salmon

Chinook salmon spawn from September to November, and the fry emerge from March to May (Figure 29). In total chinook salmon live for 5 to 6 years and spend one winter in freshwater (jack chinook salmon, a small component of the population, may mature at younger ages). The freshwater rearing environment undoubtedly includes the Seton River, but how long they rear there is unknown. We know that other populations of stream-type chinook salmon in the Fraser basin leave the spawning stream within a few months of emergence. Seton River chinook salmon appear to follow this pattern, as juveniles have been captured migrating downstream through the Seton power canal in October (B. Hebden, B.C. Hydro, pers. comm. 1995). After leaving natal tributary streams, Fraser chinook appear to migrate downstream to rear in the Fraser River and in the lower ends of its tributaries (Levings and Lauzier 1991). This behavior allows relatively small streams to support large spawning populations. For example, Slim Creek near McBride maintains escapements of up to 5,500 spawners (DFO, Pacific Biological Station, unpublished data) with a flow of 2 m^3/s during incubation (Envirocon 1984b). This stream provides such good spawning habitat that its spawning population dwarfs that of larger rivers with greater rearing capacity.

Seton River holds an average spawning population of 53 spawners and the largest population recorded was 200 in 1956. The glacial tint of the river makes observation difficult, but cannot obscure large numbers of spawning adults. Important chinook spawning streams are difficult to miss, since the fish are large. The Seton chinook population is small relative to other B.C. chinook rivers: Based on data presented in Healey (1994) the population falls within the 8^{th} percentile (7^{th} out of 84).

Rivers downstream of large lakes tend to provide good spawning habitat for chinook salmon. A review of Fraser system escapement data shows that the major populations are found downstream of Chilko Lake, Mabel Lake, and Harrison Lake, to name just a few (DFO 1995). Lakes on these rivers reduce flow and temperature fluctuations and trap sediment, reducing variability in the environment and promoting local adaptation, thereby increasing fitness (survival and production) during the spawning stage.

Historically, a substantial lake headed the Seton River, providing some of these benefits. Following the Seton Project, flows were regulated, increasing the median flow during the incubation period by 20%, and arguably increasing egg-to-fry survival. Although cooler, the relative stability in temperature afforded by the higher flows suggests that Seton River could provide a better spawning environment. Offsetting these improvements is the greater variance in flow which may have increased the scouring of incubating eggs. Although maximum flows on the Seton River have increased, the magnitude of recent floods is not extreme relative to coastal streams, and scouring does not appear to be the primary limiting factor. The small spawning population argues abundance is controlled at another stage of the life history.

In the present study, substrate criteria drastically reduced the estimate of weighted usable area for chinook salmon spawning, even though the criteria were fairly lax (large gravel and small cobble combined had to exceed 60% of the estimated substrate composition). Weighted usable area calculated using just depth and velocity criteria were at least 10 times greater, dependent on discharge. At first this result suggest that Seton River doesn't have enough gravel to support a large chinook population, but the production estimates predict that over 2,000 adults could be supported by the existing flow regime, based on standard egg-to-fry survival criteria. Our production estimates could be out by a factor of 10, and still we would estimate that the spawning habitat presently available in the Seton River exceeded that required by the existing population.

Chinook salmon production in the Seton River may be limited by incubation habitat. Although adequate spawning habitat may be present, the survival of eggs in that habitat may be poor due to dewatering or a low rate of intragravel flow. At the present time, the median reduction in water depth from November to December was 15 cm, sufficient to dewater only those habitats with a suitability of 0.1 or less, based on general criteria. At only 5% of the transects did depth reduction exceed 30 cm, sufficient to dewater spawning habitats with a suitability of 0.4 or less.

Instream flow affects intragravel flow, particularly in preferred chinook salmon spawning areas. There are no data on intragravel conditions in the Seton River. The high gradient and large substrate size suggest that intragravel conditions for egg incubation are good.

The best hypothesis given the data is that rearing space limits the chinook salmon population in the Seton River. With a length of just 4,000 m, the Seton is among the shorter chinook salmon rivers of the upper Fraser. We estimate the total usable area at the base rearing flow of 5.66 m^3/s to be 25,500 m^2, and based on standing stock models an average population of 38 adults could be supported by the available fry habitat (Figure 30). This figure agrees reasonably well with the observed escapement of 53.

Flow may limit the production of juvenile chinook salmon by a variety of mechanisms but there are insufficient data specific to the Seton River to help us choose among these hypotheses. Survival may be reduced shortly after emergence by high flows that displace fry from the rearing area, particularly during spills. Later, during the growing season, low flows may limit food production, decreasing growth and survival. Another potential, but less likely limitation comes from frazzle ice which during the winter may encapsulate juvenile chinook.

5.1.2. Coho Salmon

Coho salmon spawn from October through January, and emerge from the gravel in March and April (Figure 29). Coho salmon live for three and, rarely, four years, and spend one and, rarely, two winters in freshwater. Coho rearing habitat is atypical of most Pacific salmon, for they use low water velocity habitats more than do chinook salmon or steelhead trout. Typically coho salmon rear in small streams and juvenile densities in larger rivers tend to be lower (Sandercock 1991).

As with chinook salmon, Seton River coho salmon populations are far below that estimated from available adult spawning habitat. Similarly, this study found that incubation habitat was well watered over the winter, so we suspect egg-to-fry survival does not limit population size. Available fry habitat likely limits population size. The preference for low water velocity habitats further suggests that coho salmon will not be abundant in the Seton River.

Production models suggest that habitat for fry limits population size. At the minimum rearing flow of 5.66 m^3/s, there are 15,000 m^2 of weighted usable area for coho fry (Figure 31). Based on production modeling with biostandards, a population of approximately 57 coho salmon could be supported. This estimate agrees reasonably well with the observed mean escapement of 55 coho salmon (if harvest of Seton coho is low the figures agree well; if harvest is high the production estimate is an underestimate).

The mechanism of limitation is unknown, and potential mechanisms described for chinook salmon may also limit coho (see 5.1.1). Empirical studies of streams on the east coast of Vancouver Island show that coho salmon are limited by low flow during the summer and fall, which limits food availability and through territory defense effects the emigration of smaller individuals to habitats where survival is poor (Mason 1976). On the west coast of Vancouver Island, the critical period appears to be overwinter, when high flows scour mainstem habitats and off-channel habitats provide an essential refuge (Tschaplinski and Hartman 1983). In the interior of B.C., coho biology is less well studied, but low water events in mainstem rivers may have little effect, as here this species overwinters in off-channel habitats (Swales et al. 1988).

If overwintering habitat for coho juveniles limits the Seton River population, altering mainstem discharge may not improve production. Providing access to off-channel habitats could be an effective method of enhancement. The existing spawning channels provide 23,000 m^2 wetted stream habitat (Roos 1994). At an estimated usability of 50%, the habitat provided would be equivalent to the existing habitat in the Seton River mainstem. Moreover, this habitat would not be subject to high flows during freshet which may limit the capacity of Seton River to produce coho salmon, beyond the limitations imposed by minimum flows.

5.1.3. Steelhead Trout

Steelhead trout spawn in May and early June and the fry emerge in late July to early August (Figure 29). The observed age distribution in the freshwater population was 84% age 1, 10% age 2, 4% age 3, and 2% age 4 and age 5 (Lister and Beniston 1995). Specimens older than 3 years may be stream residers or rainbow trout from Seton Lake, rather than steelhead.

Steelhead spawning habitat rarely limits population size because of the high fecundity of this species and because juveniles usually live in freshwater for two winters, giving ample time for food and space limitations to act. Based on weighted usable spawning habitat and standard egg-to-fry survival criteria, the spawning habitat available at existing flows could support over 500 adults.

Production modeling suggests that the habitat available for fry limits population size in the Seton River (Figure 33). At a rearing flow of 5.66 m^3/s, the weighted usable area was approximately 24,500 m^2, sufficient to support an adult population of 51 steelhead, based on production modeling use biostandards for steelhead fry. Fry represent the limiting life history stage regardless of whether general or river-specific criteria are used. River-specific criteria for fry yielded a population estimate of less than 10 steelhead. This estimate reflects the use of nocturnal criteria which were used in the absence of any day-time data.

Steelhead fry prefer low water velocity, shallow habitats with cobble or boulder cover. These habitats are typically found along stream margins. In a large, high gradient river like the Seton, the extent of these habitats is quite limited, particularly at high flows. For example, simulation modeling predicts that weighted usable area will decrease by 50% as flows increase from 2 to 12 m^3/s. In contrast, stream hydraulics provide good parr habitat. The abundant boulder substrate provides cover and a velocity refuge, which minimizes energy expenditure. Nearby the rapidly flowing current provides a continuous stream of prey. The contrast of low and high velocity habitats creates shear zones that provide the optimum feeding environment from an energetic perspective (Fausch 1984).

The capacity of Seton River to produce steelhead trout is probably limited by high and variable discharges during the summer. As flows increase above the existing minimum regime, juvenile habitat is confined to narrow bands along the shore. High discharges may also reduce steelhead carrying capacity by displacing newly emerged fry. This phenomenon has been documented for rainbow trout on several U.S. rivers (Nehring and Anderson 1993).

Regulation of the Seton River has resulted in a more variable flow regime. In some years the spring freshet may be absent in Reach 2. In other years the freshet may begin earlier and persist longer than happened historically. Steelhead production in this river is expected to be highly variable between years.

Rivers with highly variable flow regimes may sustain substantial steelhead populations if smaller tributaries provide the low water velocity habitat preferred by steelhead fry. The Seton River spawning channels could produce as many juvenile steelhead as the Seton River mainstem, if they were complexed to increase usability and operated to meet steelhead life history requirements. The Seton River has only one tributary, Cayoosh Creek, where prior to regulation fry habitat was probably limited by the high gradient and prolonged spring freshet. At present a small hydro project regulates flows in Cayoosh Creek and the production of juvenile steelhead may be increasing.

5.1.4. Pink Salmon

Pink salmon spawn in October and November, and fry emigration begins in mid-April and continues through to mid-May (Figure 29). Seton River pink salmon populations are limited by spawning habitat because the young do not feed extensively in freshwater. The International Pacific Salmon Commission constructed the Seton River spawning channels to provide spawning habitat, and the pink salmon population has increased an order of magnitude, emphasizing the importance of spawning habitat.

Production estimates for the Seton River are approximately 11,000 adults at existing spawning flows of 11.3 m^3/s. This number is just one-thirtieth of the observed escapement, but the existing escapement includes the progeny of the spawning channels, which are closed once they reach capacity, forcing surplus spawners to spawn in the Seton River mainstem.

We suspect that substrate availability presently limits pink salmon production. Spawning habitat could be increased ten-fold under the existing flow regime by increasing the amount of gravel substrate, but only doubled by increasing the flow regime to the optimum minimum release (roughly 30 m^3/s) (Figure 18).

The paucity of pink salmon spawning substrate in the Seton River may relate to the well documented sediment-trapping ability of dams (Mundie 1991). However, we caution against that conclusion, for the earliest biological surveys of Seton Creek reported that the stream was generally rocky. Reach 2 was described by Tubb (1938) as follows:

> "the bed of the stream (where visible) shows little gravel and is composed of rubble and boulders (4″- 2′)."

These observations contrast with those made in Reach 1, most of which was flooded by the Seton Dam. Here Tubb noted:

> "Passing as it does through a glacial moraine, the bed of the stream is composed largely of coarse gravel and rubble, intermixed with fine gravel (¼″- 4″)."

These observations suggest that the availability of suitable substrates limited spawning habitat prior to the construction of the Seton Dam, particularly in the lower reach. We note that in general streams along the west side of the Fraser River from Hope to Williams Lake drop steeply into the Fraser canyon, and provide few opportunities for gravel to accumulate. The coarse substrate conditions in Seton River are not anomalous, and cannot primarily be ascribed to the effects of the dam.

5.1.5. Sockeye Salmon

Questions of stock identity cloud investigation of this species in the Seton River. Thousands of sockeye salmon pass through the Seton River en route to Gates and Portage Creeks. Some of these migrants may be exhausted or become confused by the fishway and spawn in the Seton River. Alternatively, small numbers of sockeye may stray into Seton River from the major runs that pass by in the Fraser River. The Bridge River rapids lie just 10 km upstream of the Seton confluence, and rebuffed migrants fall back and foray up the Seton (Roos 1994). These factors reduce the probability that a discrete stock uses the Seton River.

The spawning habitat requirements of pink salmon overlap with those of chinook and coho salmon, although they do prefer certain ranges of depth and velocity, based on general habitat criteria (Figure 12). The relationship between flow and habitat for sockeye salmon will be similar to that for other species of Pacific salmon.

Only small numbers of age 0+ sockeye have been captured in the Seton River (Lister and Beniston 1995), and these may have been entrained from Seton Lake. There is negligible rearing habitat for sockeye in the Seton River, suggesting that a viable population could not be maintained. Furthermore, the existing spawning habitat in the Seton River is probably sufficient to maintain a much larger population than presently exists. Increases in spawning habitat are not expected to increase the population, since those fish present are probably strays.

Sockeye migrating through Seton River to Gates and Portage Creeks can be delayed if Seton River flows are not sufficiently high. From mid-July to mid-August the Portage Creek run requires that Seton River have enough flow to dilute Cayoosh Creek inflows to 10% of the total flow. During the Gates Creek run, from late September to mid-November, a dilution to 20% of the total flow is required.

5.1.6. Bull Trout

Adult bull trout have been reported by anglers, and are present in Seton Lake and in the Fraser River and so likely migrate through the Seton River. Juvenile bull trout were not captured in a recent sampling of the Seton River (Lister and Beniston 1995), although they were captured at the mouth of Cayoosh Creek in 1981 (B. Hebden, B.C. Hydro, pers.comm. 1995) and were occasionally observed during recent snorkel surveys (P. Higgins, B.C. Hydro, pers.comm. 1995). The scarcity of juvenile stages suggests that Seton River is not important as a spawning site or a juvenile rearing area.

Alternatively, juvenile bull trout may be absent due to high fishing mortality and the loss of the reproductive members of the population (the local population may be sustained by the immigration of immature fish from other populations). We judge this latter explanation as less plausible for two reasons. First, bull trout are generally restricted to streams with water temperatures of 15 °C or less (Reiman and McIntyre 1993) and Seton River exceeds these temperatures each summer. Secondly, a relatively small bull trout female of 1.5 kg can produce 1,400 eggs in a single reproduction. At a moderately good egg-to-fry survival of 25% (Reiman and McIntyre 1993), 350 fry would emerge from the nests of a single female. A small reproductive population of 50 females could produce 17,500 fry. During bull trout emergence in April, flows of 7 m^3/s could provide 18,000 m^2 of usable habitat (Figure 21), theoretically resulting in densities at prime habitats near 1 m^{-2}, well above those observed during electrofishing or snorkel surveys.

We conclude that bull trout production in the Seton River is probably limited during the adult life history stage. Seton River serves as a feeding ground for migratory bull trout, which spawn in other streams. Physical habitat requirements for adult bull trout are not strict, as they will rear in rivers or lakes. Adult bull trout production appears to be most heavily dependent on an adequate food supply (Ford et al. 1995). Seton River provides numerous foraging opportunities including salmon fry during the spring, salmon eggs during the fall and juvenile fish and insects entrained from Seton Lake year-round. Flow regimes which maximize salmon production are likely to maximize adult bull trout production in the Seton River.

5.1.7. Mountain Whitefish

Mountain whitefish spawn in the late fall and winter, and the eggs hatch from February to March (Figure 29). Unlike the other species examined in this study, mountain whitefish are broadcast spawners and distribute their eggs over the substrate. No data on inter lifestage survivals was obtained for mountain whitefish, so the limiting life history stage could not be identified. In the Seton River fry habitat could be limited, as whitefish fry are poor swimmers. Suitable habitat was restricted to the stream margins and declined as flow increased above 1 m^3/s. In contrast, parr (or juvenile) mountain whitefish habitat changed little between flows of 2 and 10 m^3/s, suggesting that even if this life history stage is limiting, mountain whitefish are not limited by the existing flow regime. Adult habitat in the Seton River also appears to be insensitive to changes in flow: adult habitat peaked at 12 m^3/s, but decreased by just 10% as flows declined to 6 m^3/s.

Mountain whitefish live year-round in rivers and sometimes in lakes, and make migrations of up to 100 km between foraging and spawning areas (Ford et al. 1995). The migratory characteristics of the Seton River population are unknown. Adult mountain whitefish were abundant during 1995 snorkel surveys (P.S. Higgins, B.C. Hydro, pers.comm.), but the extent to which this population relies on immigration from other stocks is unknown.

5.2. Potential Consequences of Alternative Flow Regimes

5.2.1. Juvenile Rearing

For all species examined, juvenile rearing habitat could be increased by reducing flows during the growing season, particularly during the late summer and early fall. Chinook salmon fry, coho salmon fry, and steelhead trout fry are negatively impacted by high water velocities and are implicated as limiting life history stages for these species in the Seton River. Habitat for mountain whitefish fry increased with decreasing flow, but decreased for juveniles. The limiting life history stage for mountain whitefish is unknown, however, the relative gain in mountain whitefish fry habitat was greater than the loss in parr habitat. This suggests that lower flows would benefit mountain whitefish. Habitat for bull trout fry and parr increased with decreasing flow in the Seton River. However, the limiting life history stage for bull trout is suspected to be the adult stage.

Juvenile habitat in Reach 2 would benefit most from a reduction in flow from Seton Dam. The benefits to Reach 1 would be less because high flows from Cayoosh Creek would reduce available habitat during the late spring and summer. Although Cayoosh Creek has been permanently diverted into Seton Lake, discharges in excess of 42.5 m^3/s flow into the Seton River. Even with this diversion Cayoosh Creek would contribute an average daily flow of 16.8 of m^3/s during June, based on the hydrologic record (1963 to 1993). In 9 out of 10 years, flows from Cayoosh Creek would be greater than the base flow from Seton Dam, effectively doubling flow and, for the juvenile life history phases of many species, halving usable habitat in Reach 1.

The existing rearing flows exceed the optimum calculated from weighted usable area data, but meet the predicted optimum requirements as predicted by the average of three standard setting methods (Table 9). More faith is placed in weighted usable area estimates, for they use more detailed site-specific data than do standard setting methods.

Although not requested in the terms of reference, enhancement opportunities were evident during this assessment. The Seton River spawning channels could juvenile rearing habitat equivalent to that presently available in the mainstem. If the channels were operated year-round and complexed to increase habitat suitability, steelhead trout and coho salmon would likely benefit.

5.2.2. Spawning

Adult spawning habitat for all species could be increased by increasing the flow during spawning. Pink salmon and bull trout are expected to be limited by adult habitat: other species are expected to be limited by juvenile life history stages.

Higher flows could theoretically increase pink salmon spawning habitat, however, pink populations may not increase. At present escapements are well in surplus of the carrying capacity, probably because the spawning channel produces large numbers of returns. The habitat gained from increasing water levels could support 10% the existing surplus, but with superimposition of spawning sites, the effective increase could be lower.

Existing flows are lower than that predicted as optimum by the average of three standard setting methods (Table 9).

5.2.3. Incubation

Little if any improvement in egg-to-fry survival is anticipated from increasing flows during incubation. At present Pacific salmon eggs remain wetted at high suitability sites throughout the incubation period. (Note that potential mortality from icing was not investigated.)

5.2.4. Temperature and Water Quality

Seton River temperature and water quality is strongly influenced by Seton Lake which is oligotrophic and of low productivity, partly a result of glacial turbidity. Since regulation, water has been withdrawn from the epilimnion. Present water temperatures are probably slightly lower than those present historically, a result of the diversion of colder water from the Bridge River watershed and from Cayoosh Creek (Geen and Andrew 1961). This colder water regime has probably increased the duration of egg incubation, reduced thermal stress on early spawning adult pink salmon, and reduced primary productivity.

Mitigating effects on aquatic production through an altered pattern of water flow would be difficult. Withdrawing water from the hypolimnion would reduce water temperatures during summer, and increase the cooling influence of the Seton project. At present the dam withdraws water from the epilimnion, which is warmer than the hypolimnion, particularly during the summer. The diversion of cooler water from the hypolimnion may benefit incubating eggs during winter by providing warmer water from depth. We don't how significant this benefit would be.

No major impediments to fish production from water quality were identified from the available data. Biological production and fish growth could improve if water were withdrawn from depth in Seton Lake, and if this water had higher concentrations of nutrients than surface water. Such vertical gradients in nutrient concentration are common in reservoirs (Kennedy and Walker 1990), although no data were obtained for Seton Lake. Countering the potential benefit of withdrawing water from depth would be the lower temperature of this water, which would reduce fish growth. Furthermore, nutrient-rich water could create build-ups of algae downstream of the dam in slow-flowing habitats, reducing habitat for juvenile salmon and trout.

Even if it were desirable to release water from the hypolimnion, there would be significant technical challenges in doing so. The normal operating range for Seton Lake, the reservoir impounded by Seton Dam, is between 235.80 m and 236.18 m, a fluctuation of 0.38 m. Generally the lake level remains constant to ensure maximum operating head for the Seton powerplant, but the reservoir can be drafted to the extreme low of 235.62 m, the sill elevation of the low level outlet. These physical constraints limit the potential to manipulate Seton River water temperature and quality through subsurface withdrawals. With the existing facility, the maximum depth that can be withdrawn from is just 0.56 m.

Even if a structure were built at the dam to withdraw deeper water, the thermocline may not be accessed, as the thermocline is often below the base of the dam. Effective temperature manipulation would require an intake placed some distance from the dam in a deeper part of the lake.

5.2.5. Upstream Migration

There is no evidence that upstream migration is negatively affected by the existing flow regime, based on an analysis of transect data and observations of fish migration (Fretwell 1989). Reductions in flow would increase the risk of delaying upstream migration.

5.2.6. Homing

A significant consequence of altering the present flow regime would be the effect on migrating salmon. The delay of homing adult salmon at the Seton Powerhouse has been well studied (Fretwell 1989), and the problem has been managed by carefully regulating flow in the Seton River and Cayoosh Creek. The key factor responsible for migratory delays is the concentration of Cayoosh Creek water in the Seton River. Concentrations of Cayoosh Creek water in excess of 10% reduce the probability of successful migration up the Seton River. Increasing flows during spawning would not necessarily reduce delays at the Seton powerhouse, since at present the flow regime is managed to keep the concentration of Cayoosh Creek water below 10% for the Portage Creek sockeye stock, and above 20% for the Gates Creek sockeye stock.[2] Homing experiments show that the magnitude of flow in the Seton River does not affect upstream migration, thus increasing spawning flows is not expected to increase homing success.

Rearing flows in the Seton River are constrained by the flows required for sockeye migration. Reducing Seton River flows to increase rearing habitat may increase the delay at the Seton powerhouse by increasing the concentration of Cayoosh Creek water. The existing mixture of Seton and Cayoosh water could be maintained if Cayoosh Creek flows were in turn reduced, however, that might reduce the rearing and spawning habitat in that stream. The conflict between the best flows for rearing and the required flows for sockeye migration presents a trade-off of fisheries values.

Withdrawing water from depth in Seton Lake might entrain a higher percentage of Cayoosh Creek water, since water from the Cayoosh Creek diversion tends to be colder than Seton Lake water and sinks below the surface of Seton Lake. However, withdrawing water from the hypolimnion of Seton River to warm the river during egg incubation would have little effect on migration, since no species are actively migrating during the

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2 Under normal operating conditions the diversion of Cayoosh Creek into Seton Lake through the Walden North IPP satisfies these requirements. A minimum flow of ~ 1 m^3/s is maintained.

winter months. Adult steelhead may hold at the Seton River during this period, but probably do not migrate to spawn until spring.

5.3. Optimum Flow Regime

Flow affects juvenile rearing, adult spawning, upstream migration, and the homing of salmon, trout, and whitefish in the Seton River. These effects are similar among some species within a particular life history stage, and less similar between life history stages within a species. Changes in flow may increase the habitat for one life history stage, but decrease habitat for another. If only one stage is critical to the production of the species, then a decline in the other may have no effect on production. For example, coho salmon are limited by fry habitat, so a reduction in flow is expected to increase coho salmon production, even though the amount of spawning habitat would decline. When more than one species is considered, the probability of finding a single optimum flow declines. For example, pink salmon spawning habitat will increase with increased flow, but this increase will decrease the amount of habitat for rearing steelhead fry. This trade-off can be optimized only if the relative importance of pink salmon and steelhead trout production can be specified before-hand. For this analysis we assumed that all six study species are equally valuable.

To calculate an optimum flow regime, habitat and flow relationships among species were integrated by scaling to one the weighted usable area for the limiting life history stage of each species. Where the limiting life history stage was unknown, scaled values for potentially limiting life history stages were averaged and re-scaled to one.

When several species were considered, solutions to the instream flow problem diverged, complicating the prescription of an optimum flow regime. Where several species were limited within the same season, the scaled values were averaged, implying equal importance among species, then re-scaled to one. The resulting aggregated habitat index represented a guild of species with a similar habitat index versus flow relationship. Species with different and conflicting habitat index versus flow relationships were grouped into different guilds (guilds may contain a single species (Pianka 1978)). The rearing limited species; chinook salmon, coho salmon, steelhead trout, mountain whitefish, and bull trout; occupied the same guild of habitat index versus flow relationship. Pink salmon were limited by spawning and incubation habitat, and sockeye salmon were limited by migration habitat and these species were assigned to separate guilds.

Trade-off flows were identified at the intersection of the habitat versus flow function for each guild, implying equal importance among guilds (Figure 34). Trade-off flows for the comparison of these latter guilds with the rearing guild are presented in Table 10. Trade-offs resulted in losses of habitat for the rearing guild of 15% to 45%. Although not representing separate guilds, trade-offs with steelhead spawning habitat and spring freshet were also calculated to identify the habitat costs of these constraints.

The trade-off flows for each guild were ordered seasonally, reflecting the suspected period of habitat limitation for each guild and constraint. This hydrograph was termed the 'habitat regime' (Figure 35). The habitat regime assumes that gravel placement will be used to increase spawning habitat, thereby protecting rearing habitat from higher flows that would otherwise be required to increase pink salmon spawning habitat.

The fidelity of the existing regime to the shape of the natural hydrograph was evaluated by standardizing flows to a mean of 0 and a standard deviation of 1. Relative changes in standardized flow by season were obvious (Figure 35). The natural hydrograph peaked earlier in the season than the existing flow regime, but was considerably lower in the fall. The standardized habitat regime was higher than the natural regime in the winter, summer and fall. A comparison of median monthly flows reflects these differences (Table 10). Since regulation, flows have increased in the low flow months, but decreased by up to 86% in the spring. In most years, the Seton River does not have a spring freshet.

The possibility that natural flow regimes are superior was considered in the calculation of the optimum flow regime. Mundie (1991) described the benefits to physical habitat of a natural flow regime. Beyond those benefits, we know that flow changes and resultant changes in temperatures, velocity, and turbidity, act as cues to salmon and trout, helping them to predict future stream events. These physical cues stimulate behavioural responses, such as migration, feeding, and cryptic behaviors that evolved in response to natal flow and temperature regimes over many generations. We speculate that natural flow regimes should provide fish with the appropriate stimuli, invoking behaviors that increase fitness (surivall and production). But we don't know if the regulated regime in the Seton River continues to provide the correct stimuli. Moreover, we don't know how much fitness improves from responding to these stimuli, or if this improvement could exceed the benefit provided by increased physical habitat that this study has shown could result from stream regulation and enhancement.

The optimum regime combines the habitat regime with the natural flow regime based on the rationale that the natural flow regime may be providing benefits (as described above) that are difficult to quantify. The habitat regime relies on empirical data and habitat models, and so while it has a defined quantitative rationale, its weakness lies in that it does not include what we don't know about cues and other biological interactions. In combining the regimes, we hedge our ignorance by betting that fish have evolved to the natural flow regime.

The optimum regime would provide higher minimum rearing flows than the historic regime and feature a spring freshet scaled in magnitude to match the base rearing flows (Figure 35). To increase rearing habitat, optimum flows would be lower in the fall than under the existing regime, which is primarily focused on providing adequate flows for spawning. This study concludes that spawning habitat may limit pink salmon production but does not limit coho and chinook salmon production. The optimum flow regime provides benefits to rearing species and to pink salmon and to migrating sockeye salmon, but trades-off these benefits to strike a balance based on an equal valuing of each species or guild.

A crucial feature of the optimum regime in Table 10 is that the flows are median flows. The natural regime had highly variable minimum flows, and minimum daily flows were well below the existing regime, the habitat regime, or the optimum regime. Regardless of the median flow regime implemented in the Seton River, flow variability should be reduced if fish production is to be increased. As was shown in Figure 7, existing maximum flows are more variable than the natural regime. The habitat analyses show that the existing maximum daily flow regime is expected to limit juvenile production. The median daily flows shown by month for each optimum regime in Figure 35 and Table 10 provide targets that, ideally, would be met as consistently as possible. Spills were a common feature of flow regimes in the past decade, but these should be reduced if fish production is to be increased. Some spilling may be advantageous to flush substrate of fines and organic debris, and although a quantitative analysis was not undertaken, it is likely that the existing spill frequency and magnitude exceeds that required to maintain adequate spawning and rearing substrate. If spills are required in the future, they not need happen every year, and monitoring could identify when they are needed.

Our analyses are limited by the amount of data collected and the assumptions of our models. Field data were collected at 6.22 and 12.4 m^3/s, and outside of this range of flow the accuracy of our predictions decreases. We caution that our analysis is more adequate to identify the directional response of habitat to flow changes than to identify the optimum flow level for fish production.

River-specific habitat suitability curves were available only for steelhead trout fry, and then only at night, and for steelhead trout parr. A comparison of river-specific and general curves showed that the direction of habitat response to flow was similar. However, the magnitude of response differed between the two types of curves. No curves were available to describe winter habitat use, and optimum flows prescribed during winter assume that flow needs are the same as in summer.

Critical life history stages were identified using regional biostandards — Seton River values are expected to vary. We don't know enough about the annual variation in abundance of each life history stage to know if the limiting life history stage changes from year to year. For whitefish there are few data to help us determine which life history stage is limiting. Finally, some physical phenomena have not been investigated, such as stream-bed icing.

These analyses provide the first quantitative assessment of the flow needs of fish in the Seton River. Although we have forecast optimum flow regimes from these results, complicating and unknown biological and physical phenomena suggest that this recommendation should be viewed as one of many possible solutions to the instream flow problem in this river. The following conclusions and recommendations should be viewed from that perspective.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Flow Regimes

1. Empirical data did not allow us to reject the null hypothesis that rearing habitat for chinook salmon, coho salmon, and steelhead trout, will stay the same or decrease with increased flow. Albeit insignificantly, the data do suggest that coho salmon and steelhead trout production in the Seton River are limited by high flows during the rearing period. Chinook salmon populations may be similarly limited, although the plastic life history of chinook makes us less confident in this assessment.[3] A reduction in the base rearing flow to 2 m^3/s is supported by the weighted usable area data and the production analysis. However, the uncertainty created by the use of general curves for some species and life history stages, and the negative effects of lower flows (described below in 2) suggest flows should not be reduced to this level.
2. Reducing rearing flows to 2 m^3/s during the late summer and fall would increase the delay of spawners at the Seton powerhouse because the concentration of Cayoosh Creek water in the Seton River would increase. Any significant reduction in Seton River flow during the migration period would require a reduction in Cayoosh Creek flows and would probably reduce rearing habitat in that stream.
3. Pink salmon production is primarily limited by suitable substrate and secondarily limited by sufficient flow. Although more habitat is available at 30 m^3/s, it is questionable whether more pink salmon could be produced with changes in flow alone. Higher flows would also increase spawning habitat for other species, but would not increase their production, since the juvenile life history is the limited phase. The data suggest that spawning flows of 30 m^3/s would reduce rearing habitat during the fall, and based on this spawning flows should not be increased to this magnitude.
4. Higher spawning flows would require higher incubation flows to ensure that the eggs remained wetted. These higher incubation flows may in turn reduce rearing habitat, although we are uncertain, because we have no river-specific habitat suitability information during the winter, and that is when incubation flows are required.
5. Increased incubation flows would reduce the probability of redd dewatering at low suitability spawning sites. High suitability spawning sites remain wetted under the existing incubation flow regime.
6. Water temperature regimes for rearing will not be improved by withdrawing water from depth. The diversion of both Bridge River and Cayoosh Creek water has cooled Seton Lake and withdrawing water from the hypolimnion would increase this effect.
7. By varying the depth of withdrawal from the reservoir, water temperature could be manipulated to synchronize emergence timing with windows of high survival. The timing of these windows is not known, and the potential benefits of such optimization have not been quantified here. There are significant technical constraints to withdrawing flow from the hypolimnion.

3 If juvenile chinook salmon emigrate to the Fraser River to rear, they may be limited by conditions in the Fraser River.

8. An optimum flow regime was calculated by valuing all six test species equally and grouping species with similar flow requirements into guilds. Conflicts between guilds were traded-off to optimize the effects of flow on habitat. The natural flow regime was incorporated into the optimum regime by weighting trade-off flows by the variance in the natural regime. The optimum flow regime prescribes base rearing flows similar to those presently released, lower flows during the fall spawning season, and higher flows during the spring freshet. The optimum regimes implies that flow variance in the Seton River would be controlled. This requires a reduction of spill magnitude and duration.

6.2. Enhancement

Although not part of the terms of reference, opportunities for enhancement were identified and are listed. This may be implemented with or independently of flow releases.

1. Coho salmon and steelhead trout spawning habitat may be increased by allowing access to the spawning channels and operating the channels year-round. With physical enhancements, it is conceivable that juvenile production of coho salmon and steelhead trout from the channels would exceed the existing juvenile production from the mainstem Seton River.
2. Gravel could be added in areas where depths and velocities are suitable for spawning but substrate is not. The optimum flow regime assumes that this enhancement will be made.

6.3. Additional Research

1. Identify river-specific habitat suitability for adult salmon and recalculate the optimum spawning flows using the habitat model.
2. Survey spawning sites, identify sites affected by dewatering, and measure egg-to-fry survival. Monitor icing in the gravel at redd sites and assess impacts to egg survival.
3. Identify the feasibility of increasing spawning habitat through gravel platforms in the mainstem Seton.

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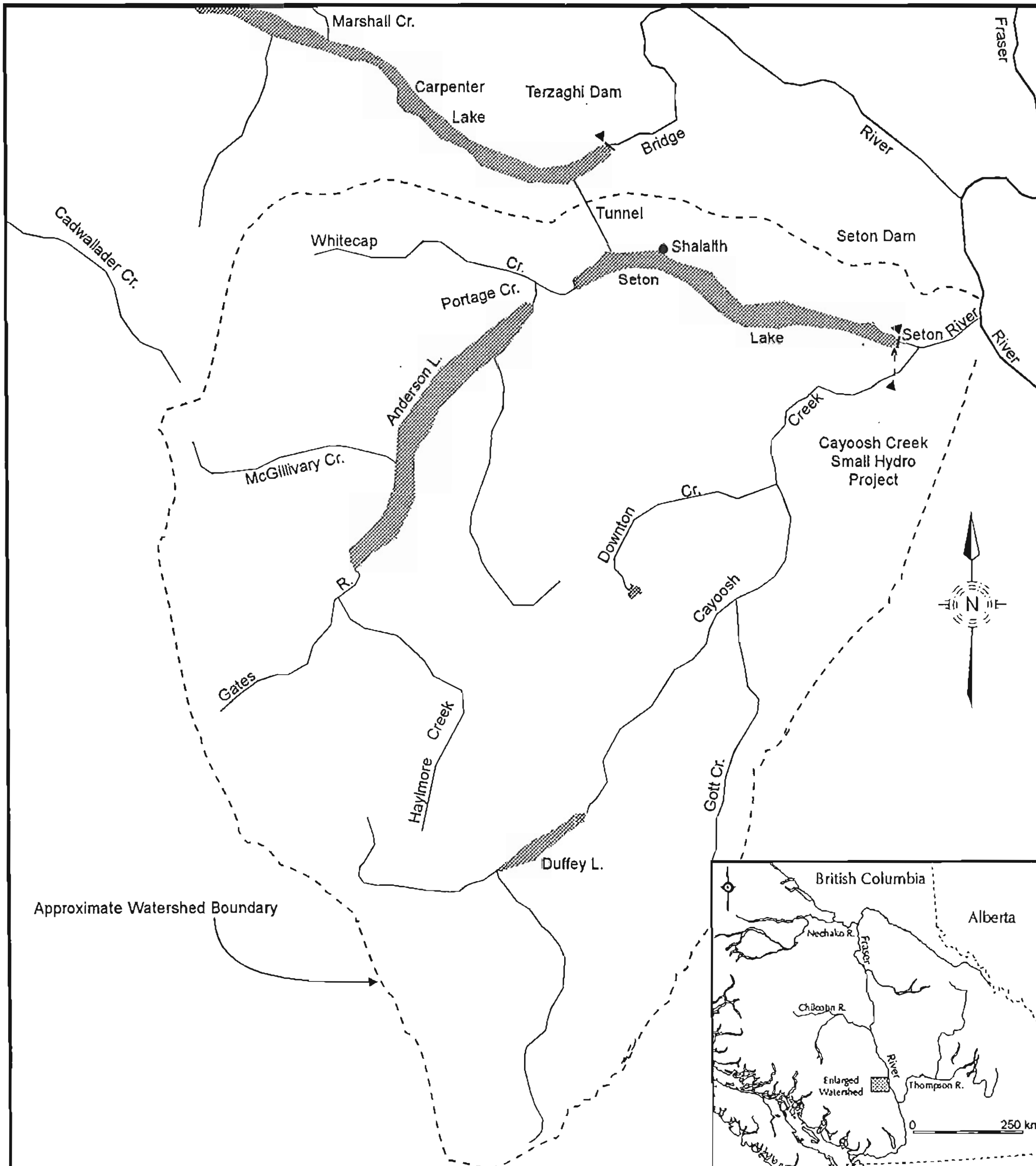
8. FIGURES



Seton River Instream Flow Study	Map # 221321-1	0 10 km

FIGURE 1. Seton River Watershed.

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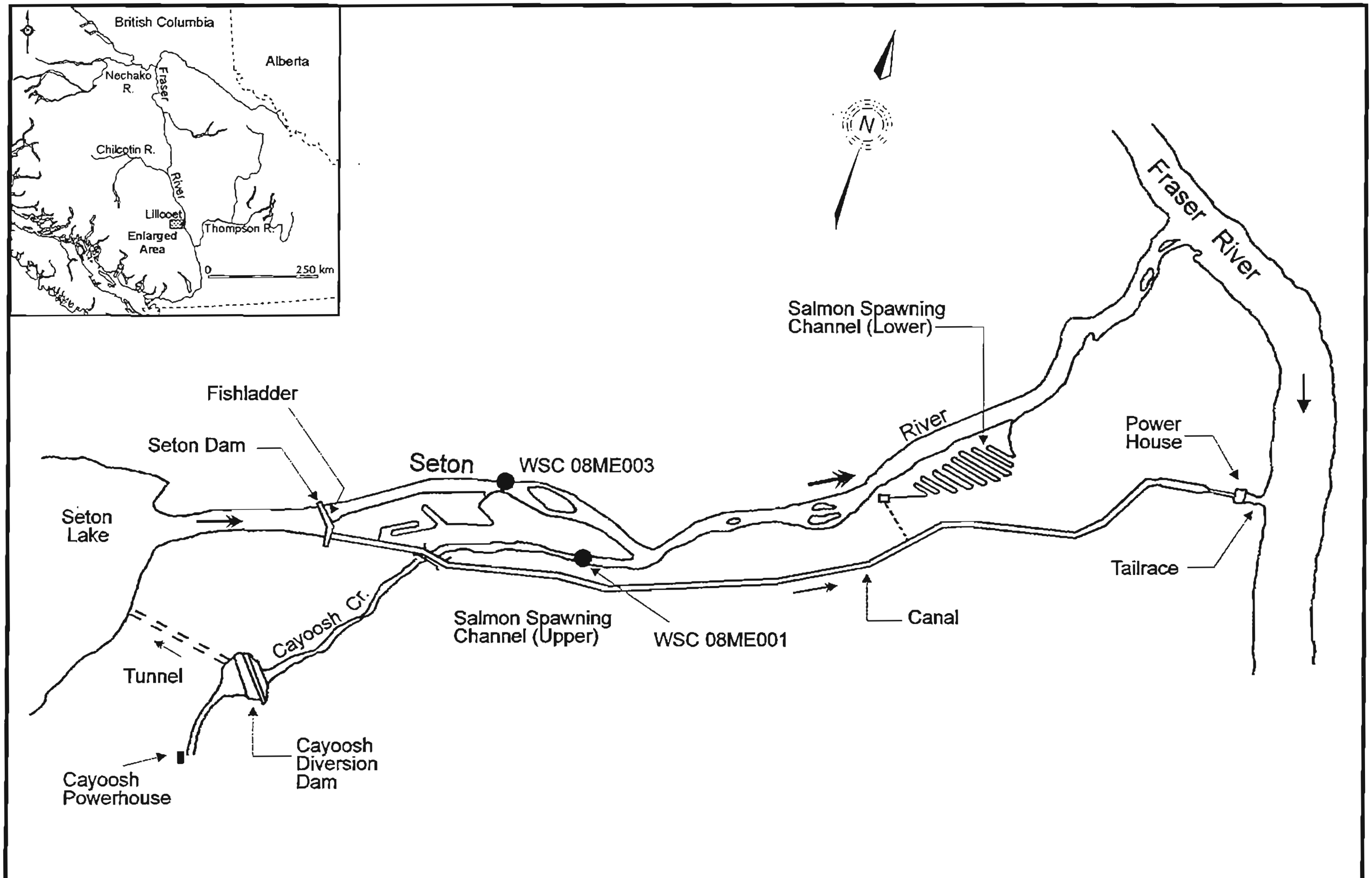
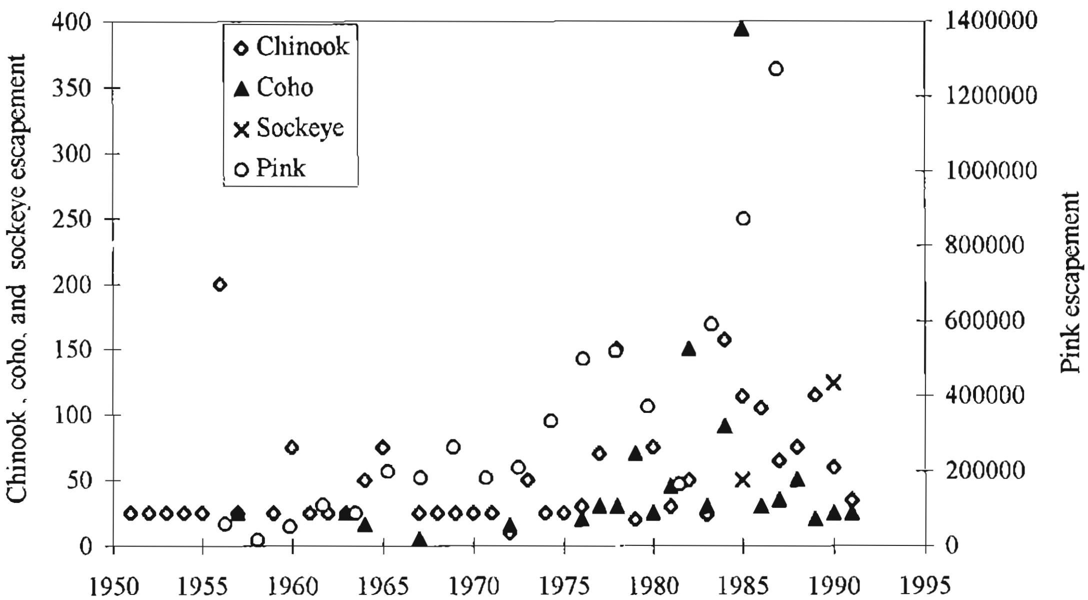


Seton River Instream Flow Study	Map # 2213-3	SCALE 1:23 000 (approx.)
FIGURE 2. Seton River study area.		TRITON Environmental Consultants Ltd.

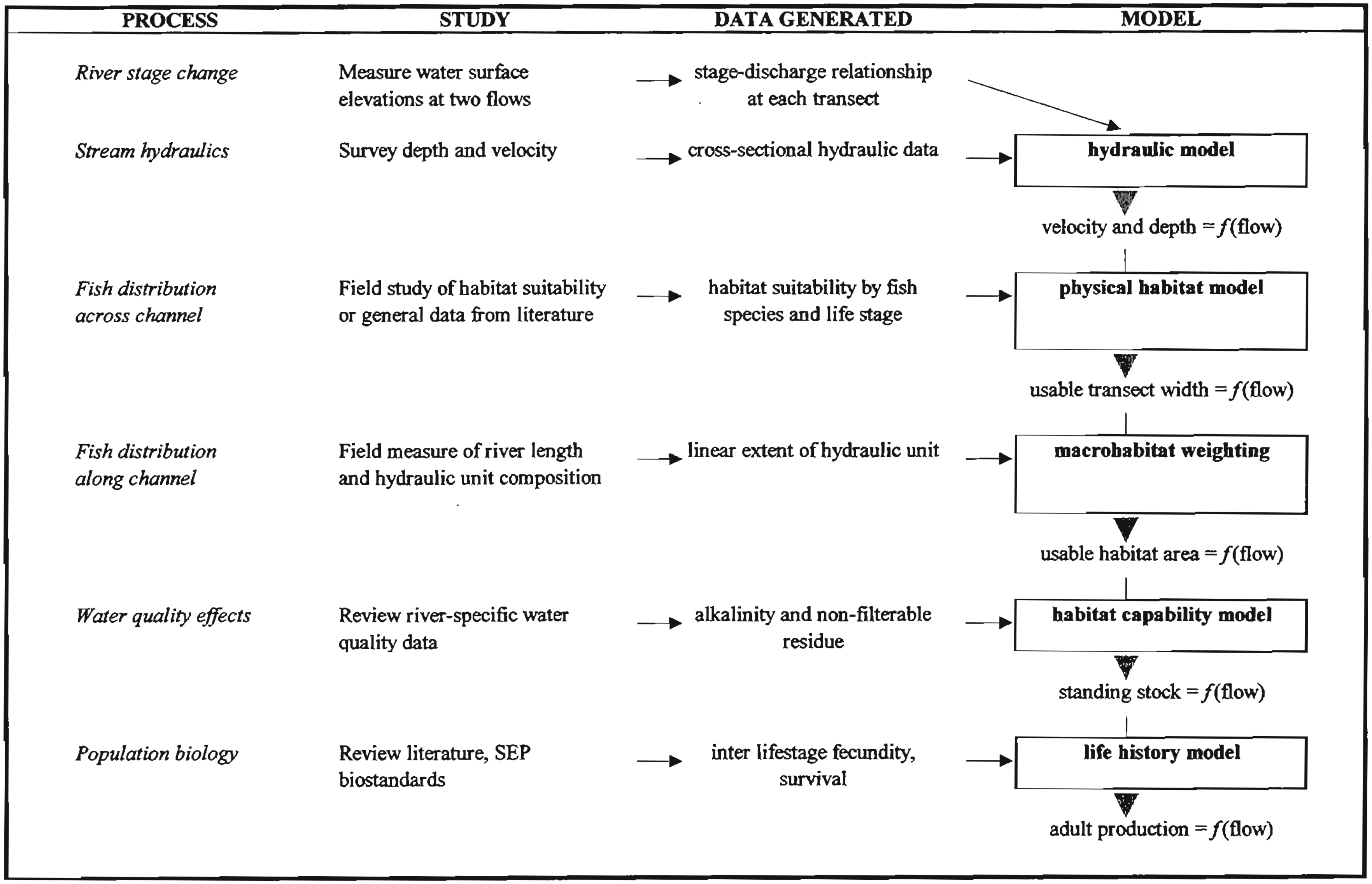
Figure 3. Escapements of Pacific salmon to the Seton River.

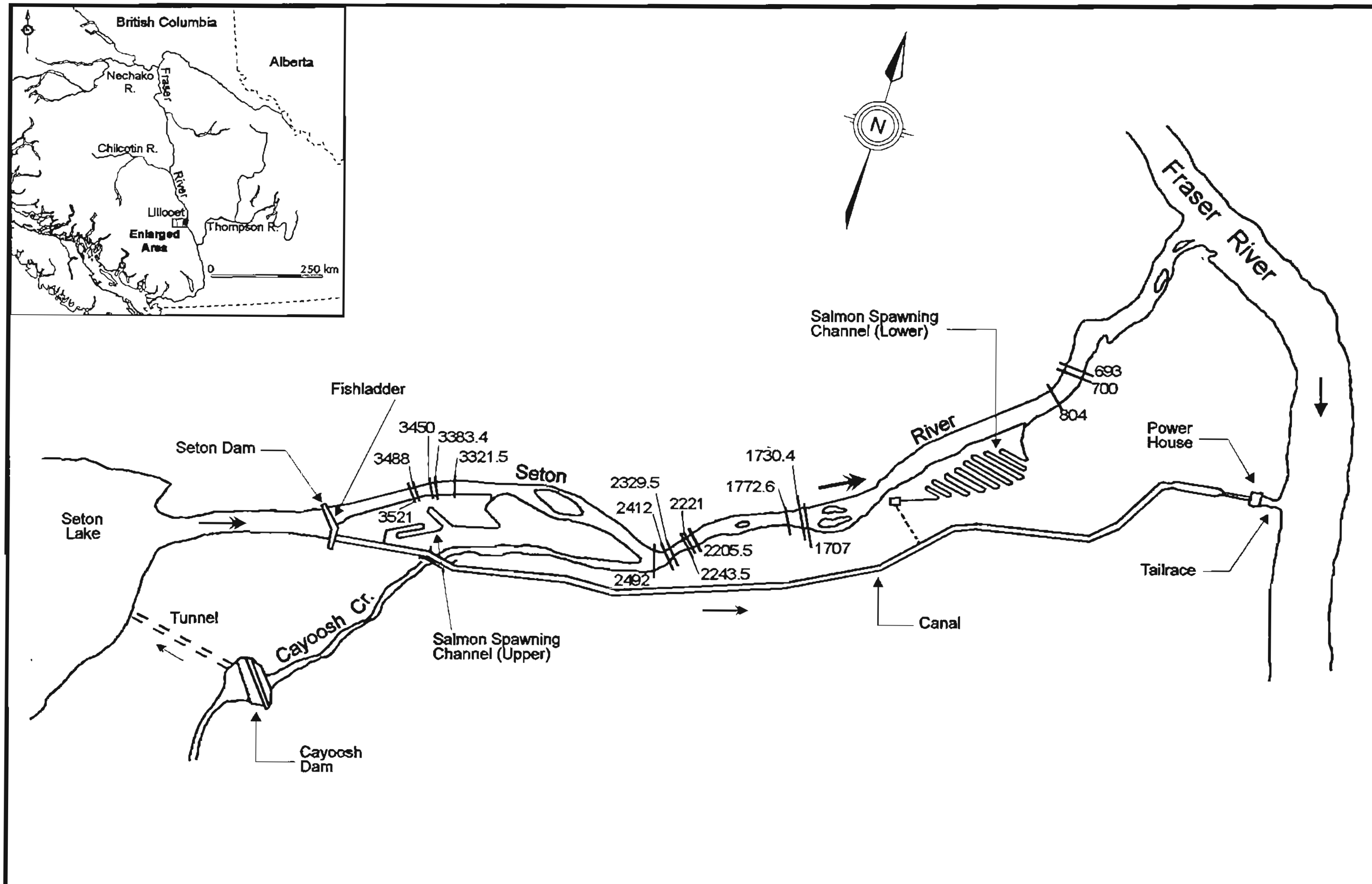


		Chinook	Coho	Pink	Sockeye
1951-1995	Average	53	55	331,703	87
	Minimum	10	5	14,887	50
	Maximum	200	394	1,273,343	124
1980-1995	Average	75	77	631,779	87
	Minimum	24	20	163,337	50
	Maximum	157	394	1,273,343	124

Notes: 1) a single chum salmon was observed in 1983.
2) additional sockeye migrate through the river en route to Gates and Portage Creeks.

Figure 4. Flow chart of biophysical processes, studies, and models for the Seton River Instream Flow Study.





Seton River Instream Flow Study	Map # 2213-2	SCALE 1:23 000 (approx.)

Figure 5. Transect locations along the Seton River.

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Fig. 6. Seton River hydrograph (WSC 08ME003) prior to regulation and in the past decade.

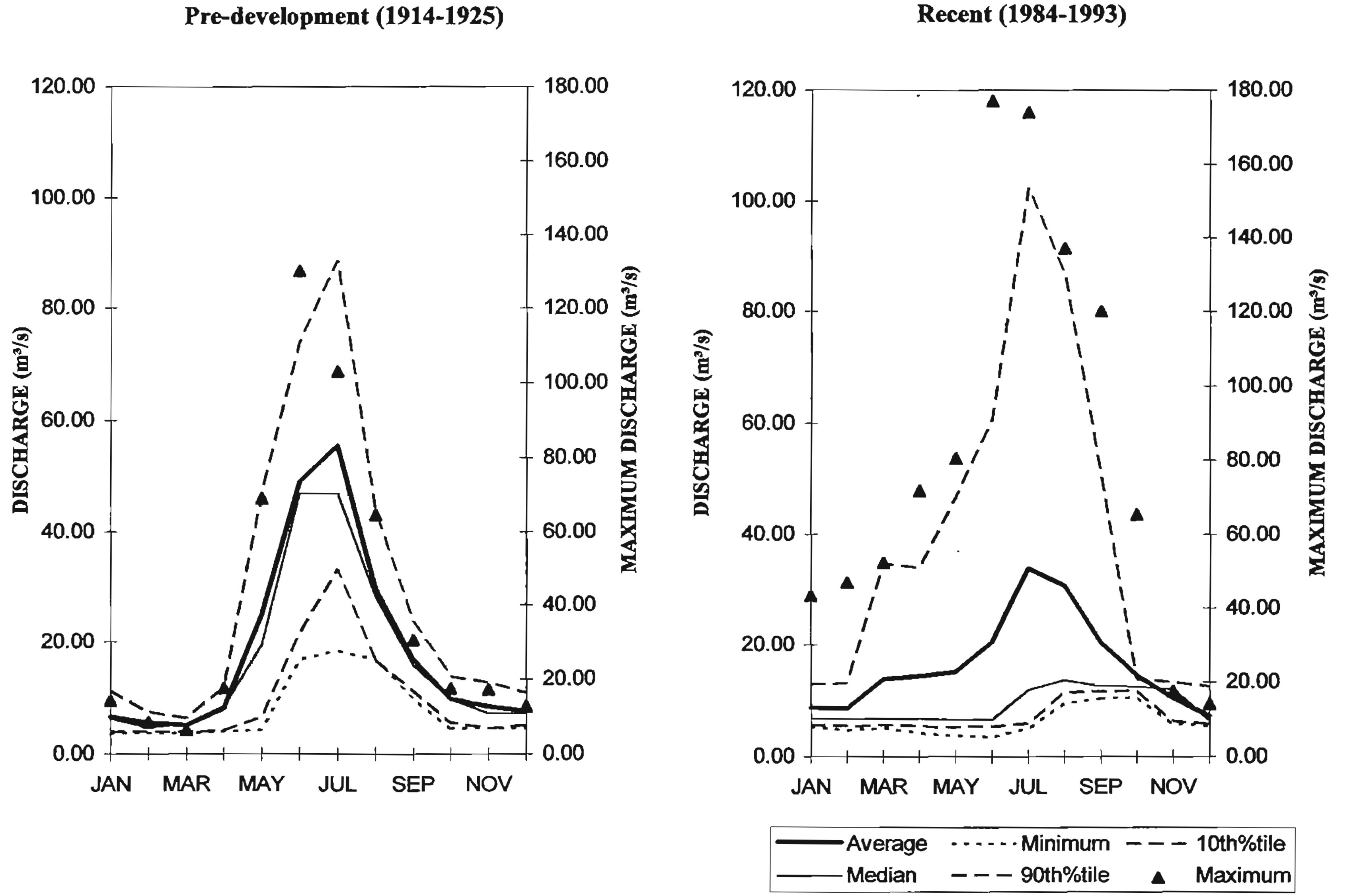


Fig. 7. Examples of the annual hydrograph in Reach 2 of the Seton River during pre-project (1915 to 1917) and post-project (1990 to 1993) periods.

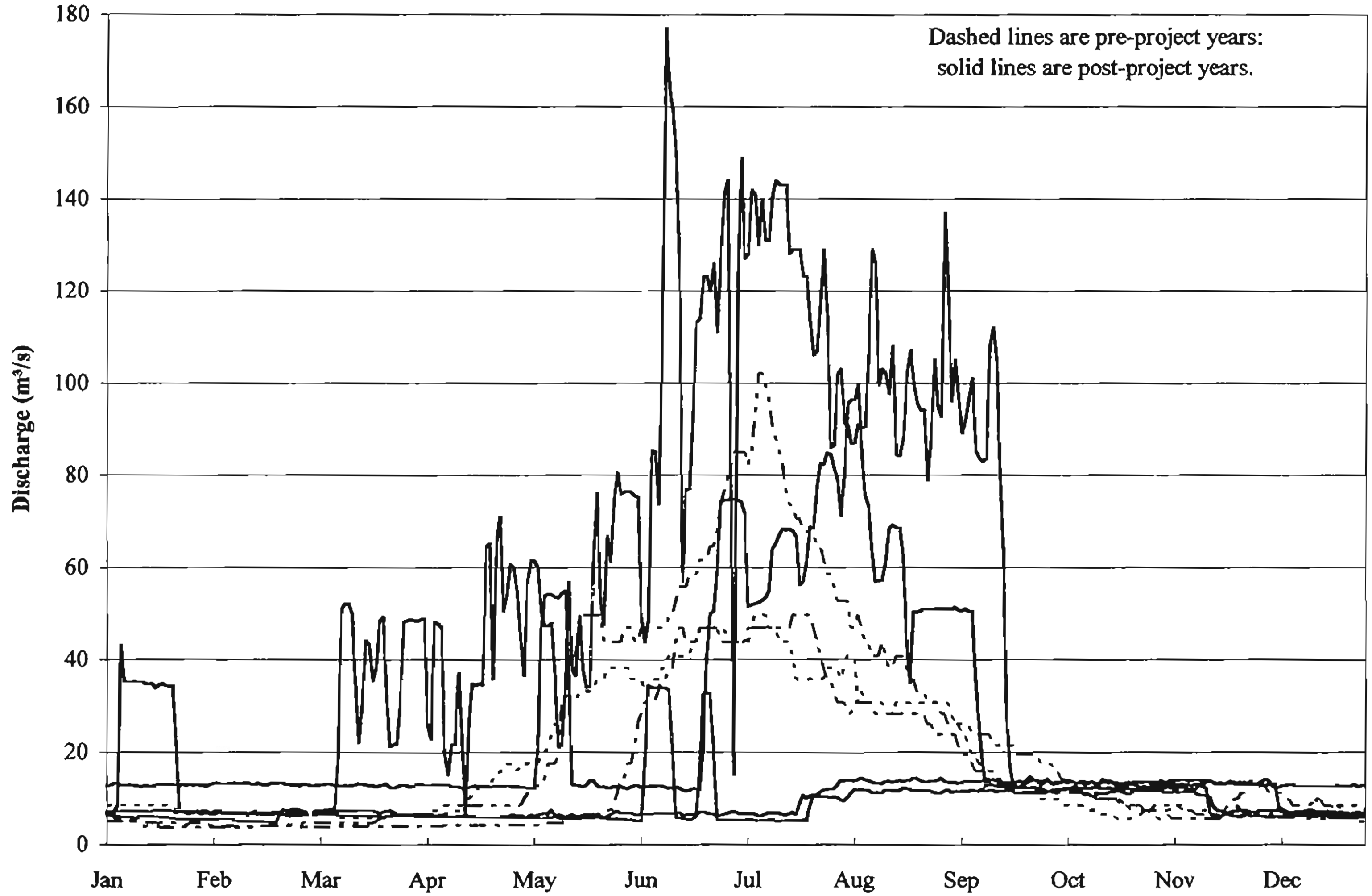


Fig. 8. Annual hydrograph in Seton River during 1991 and 1993, showing influence of Cayoosh Creek inflows to Reach 1.

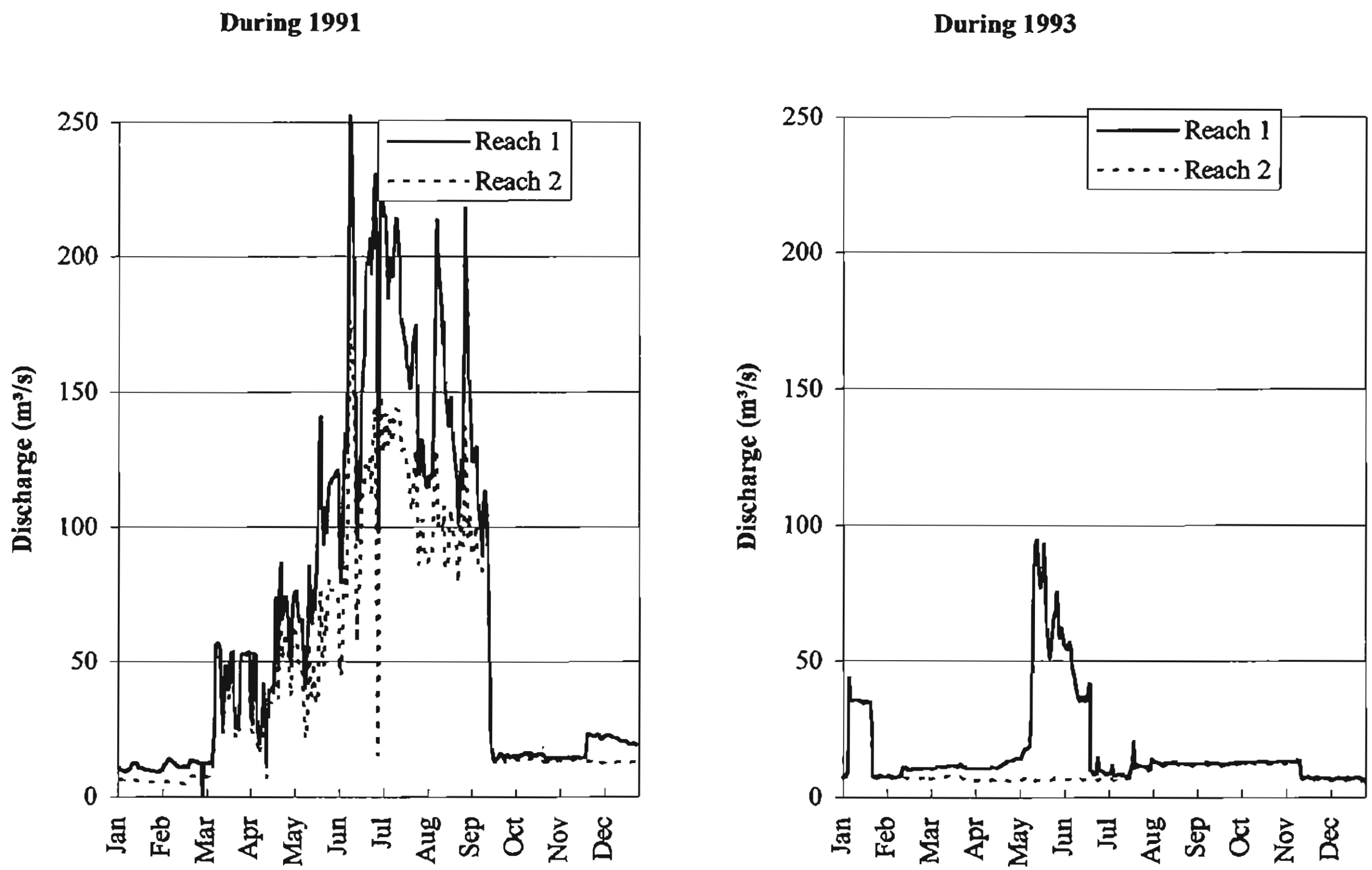
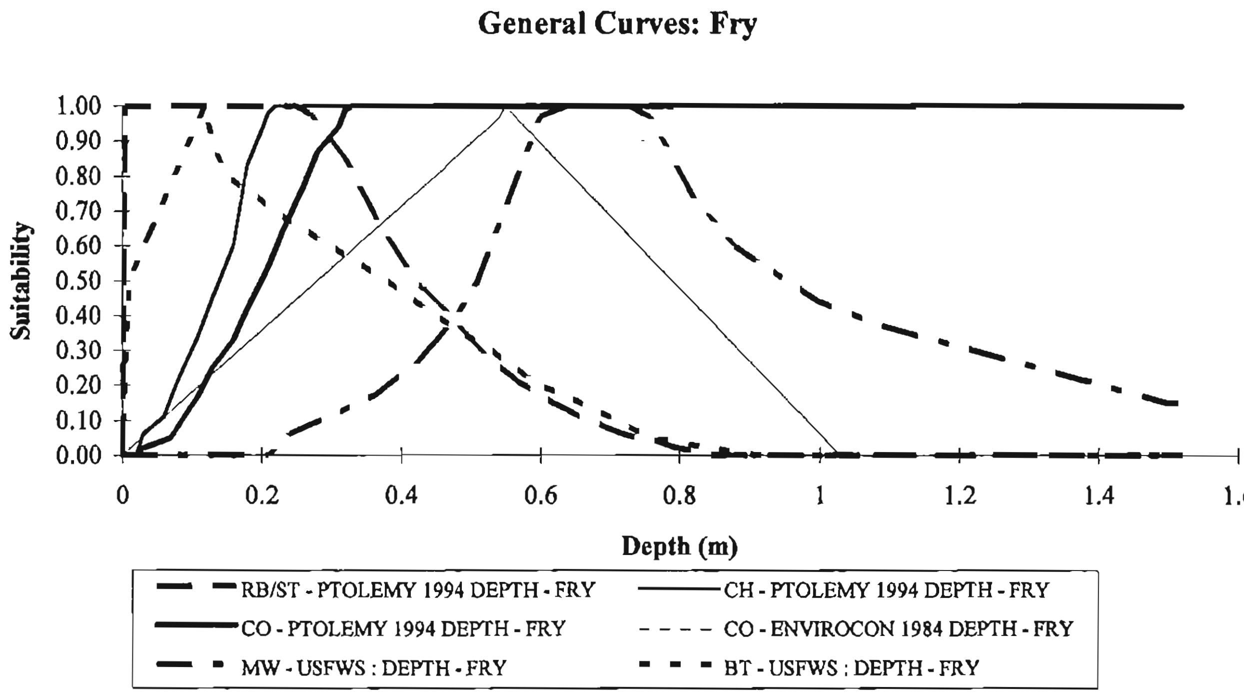


Figure 9. Habitat suitability for juvenile salmonids: general curves for depth.



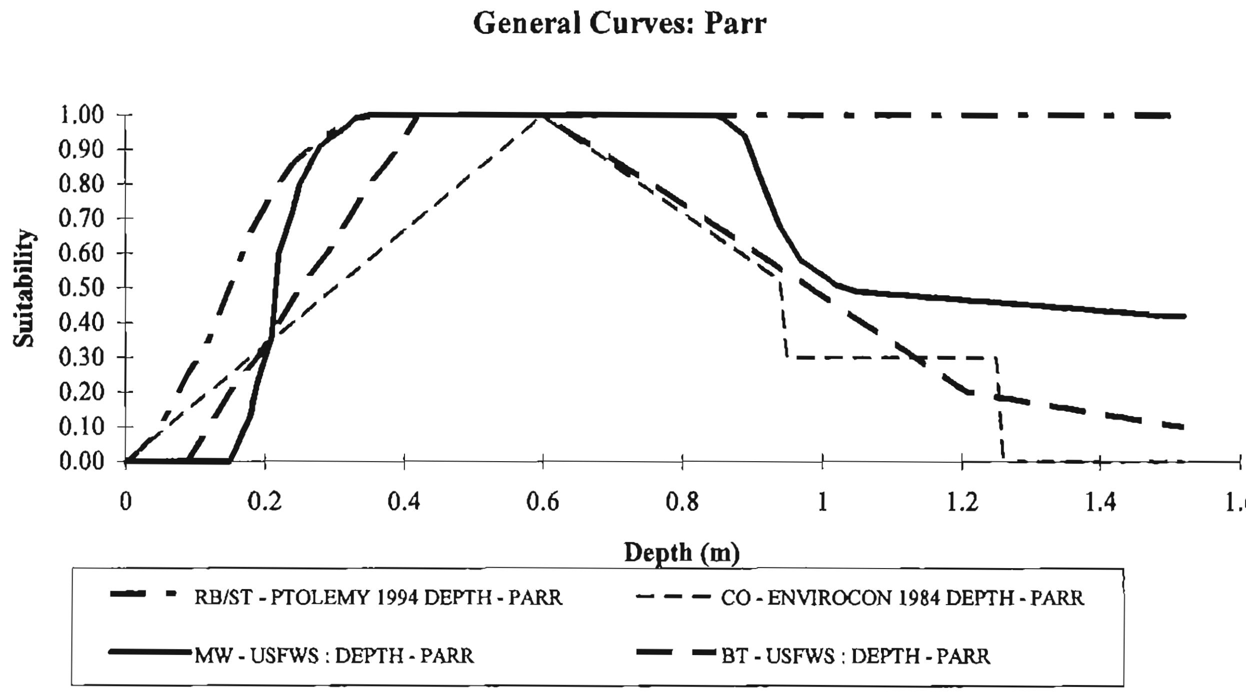
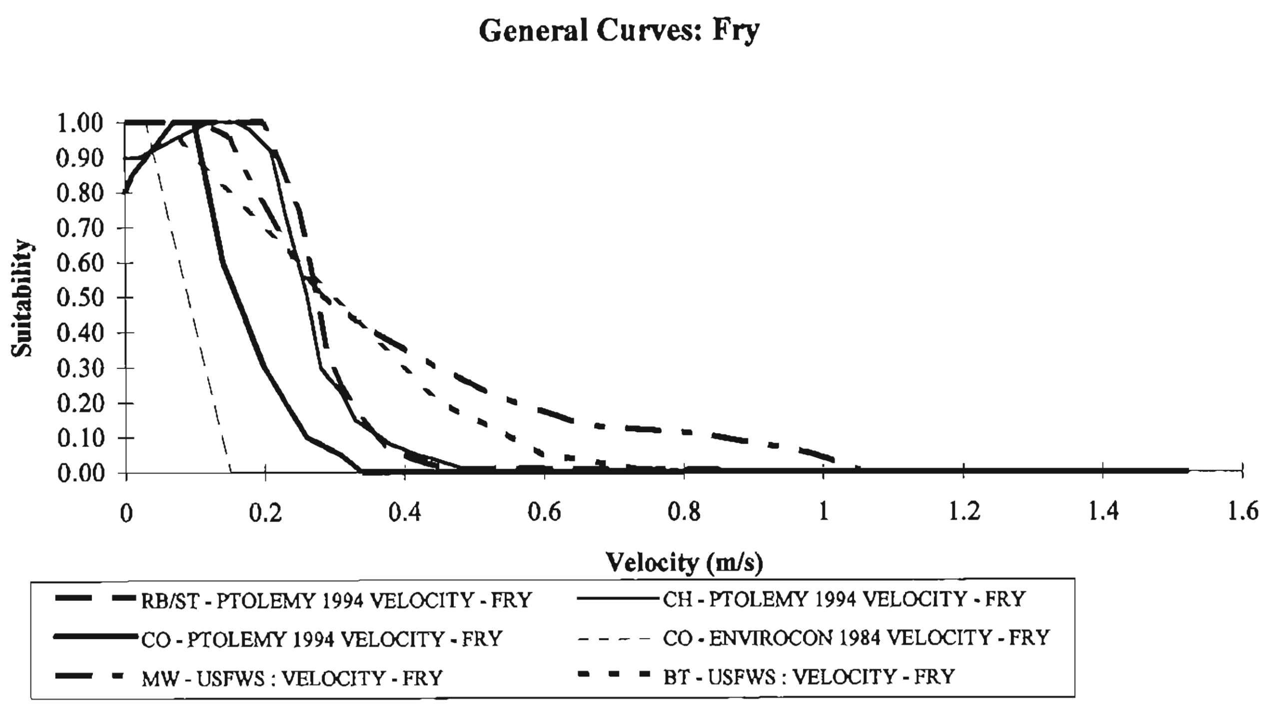


Figure 10. Habitat suitability for juvenile salmonids: general curves for velocity.



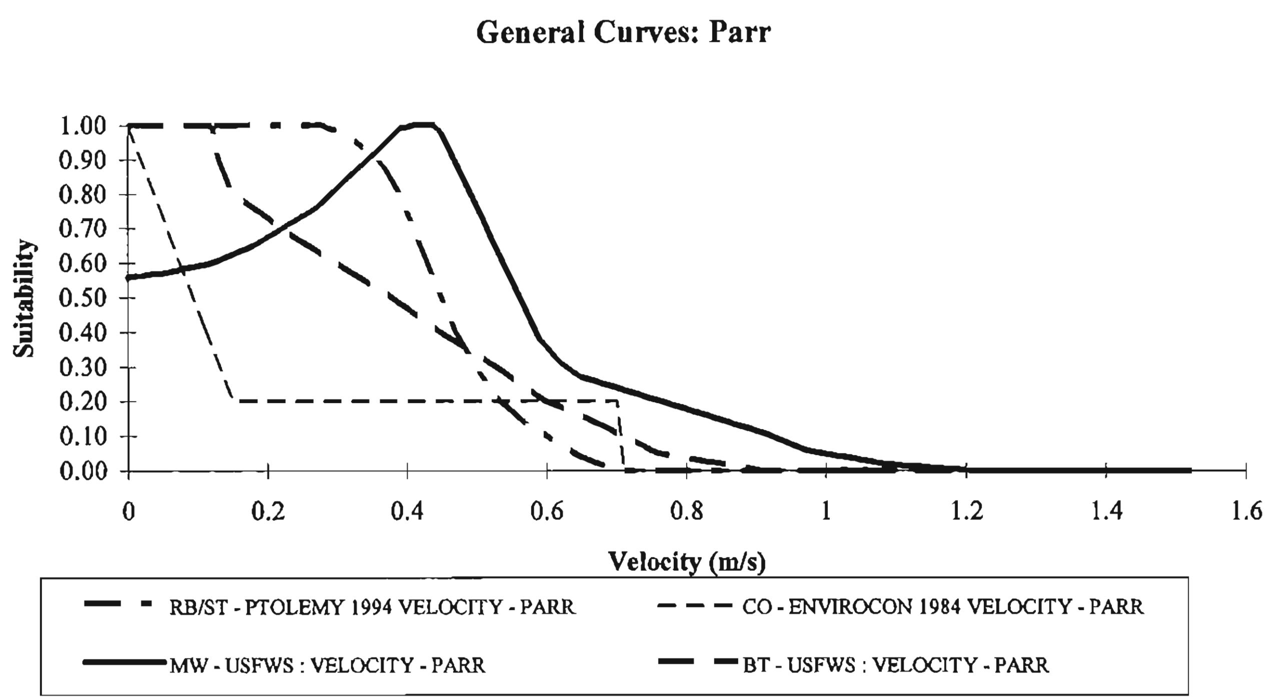
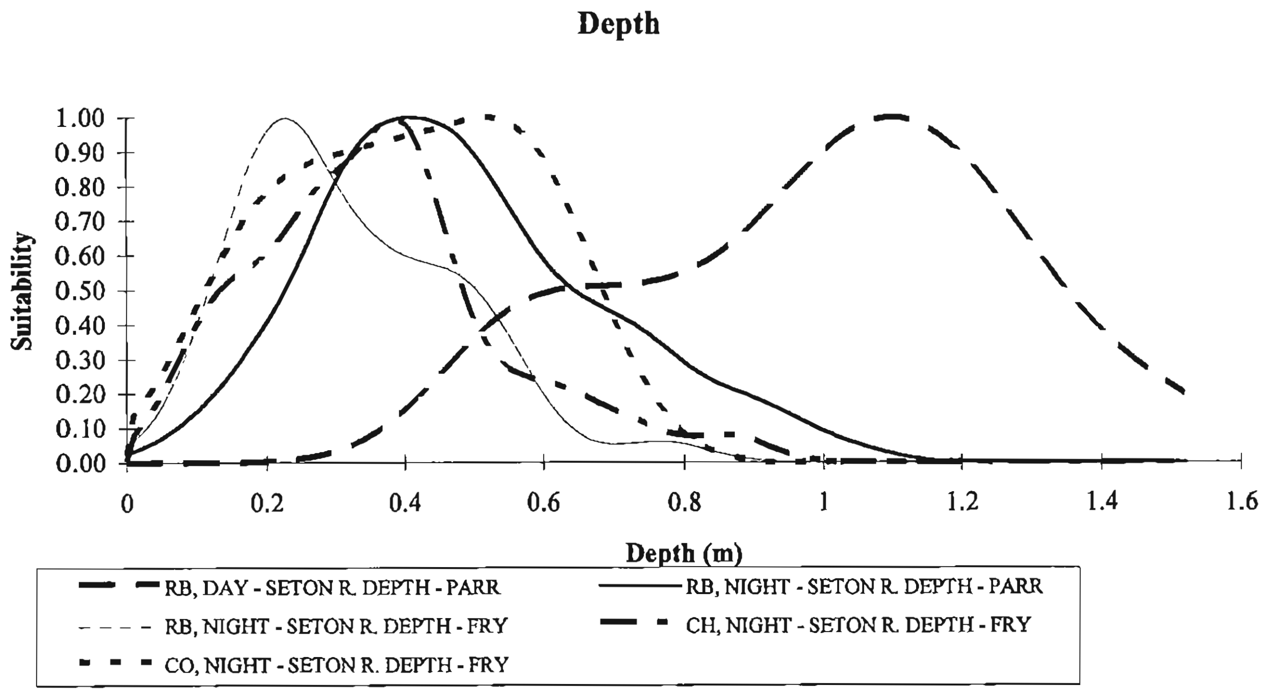


Figure 11. Habitat suitability for juvenile salmonids: river-specific curves for depth and velocity.



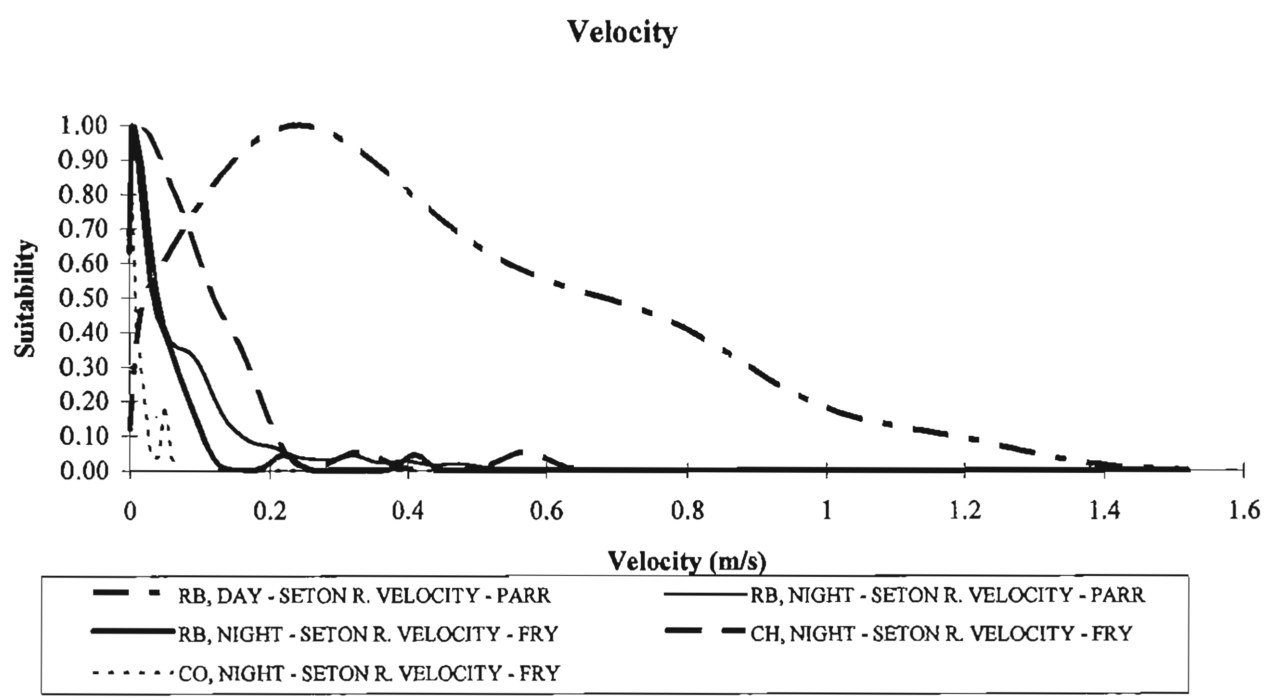
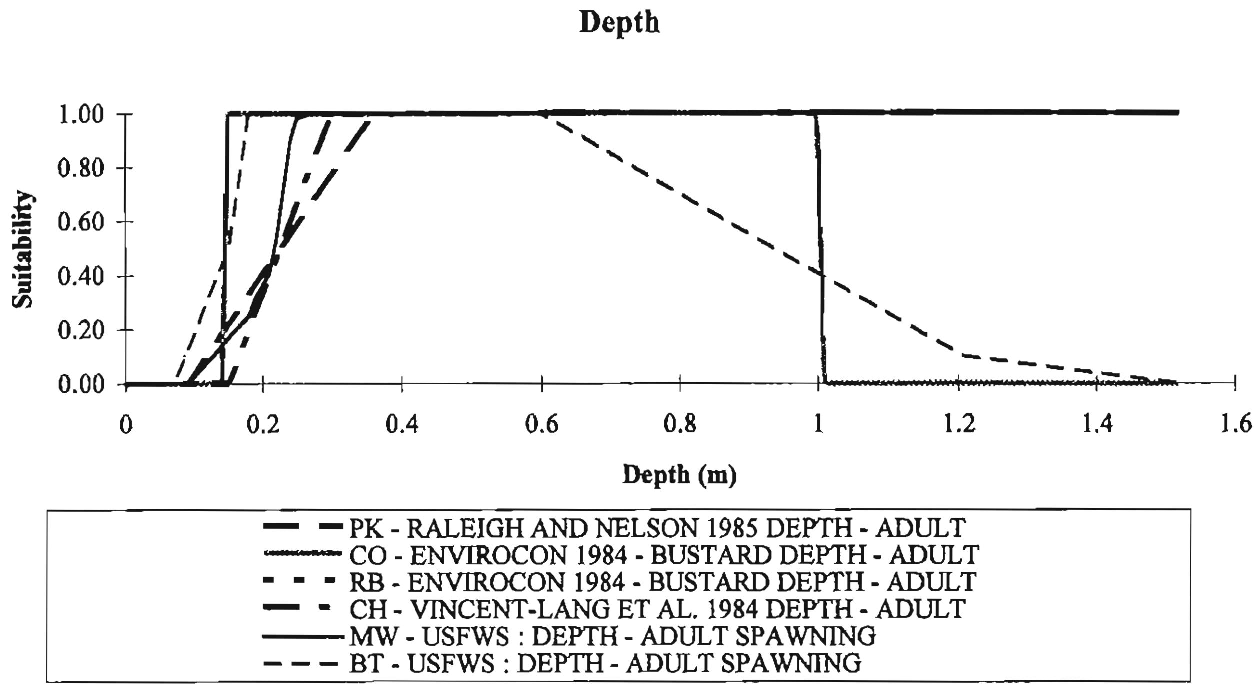
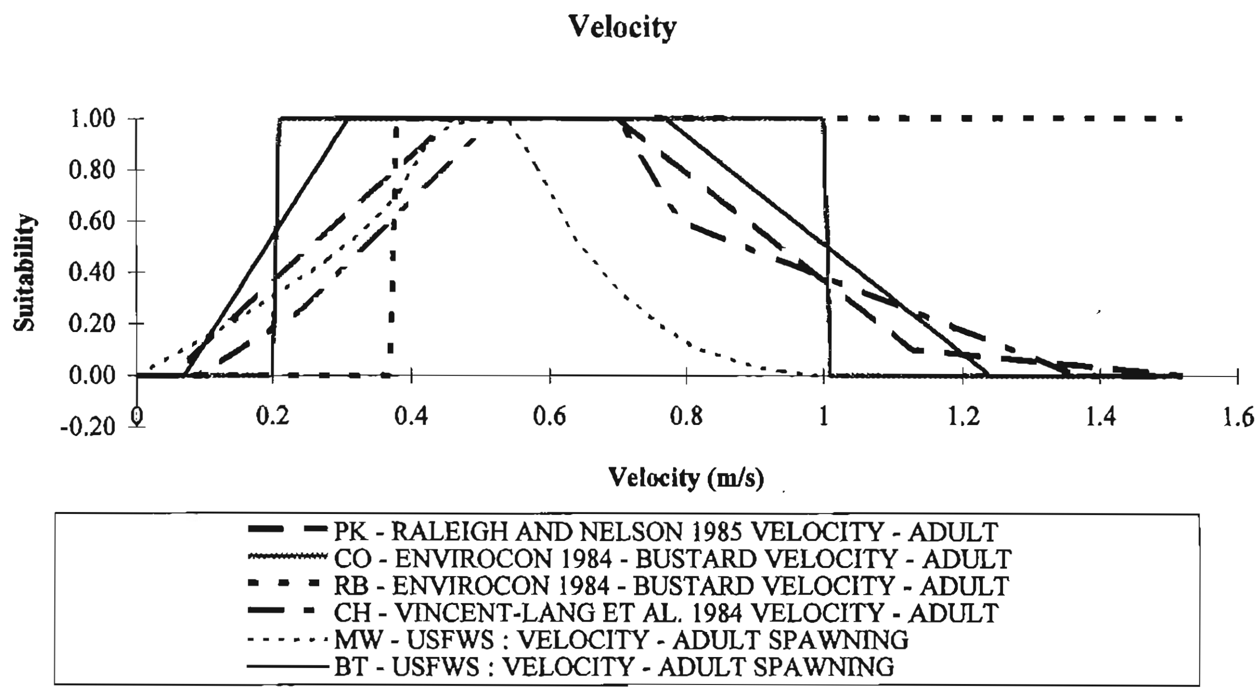


Figure 12. Habitat suitability for adult salmonids: general curves for depth and velocity.





Wetted Width vs Q

Figure 13. Response of wetted width to discharge in the Seton River.

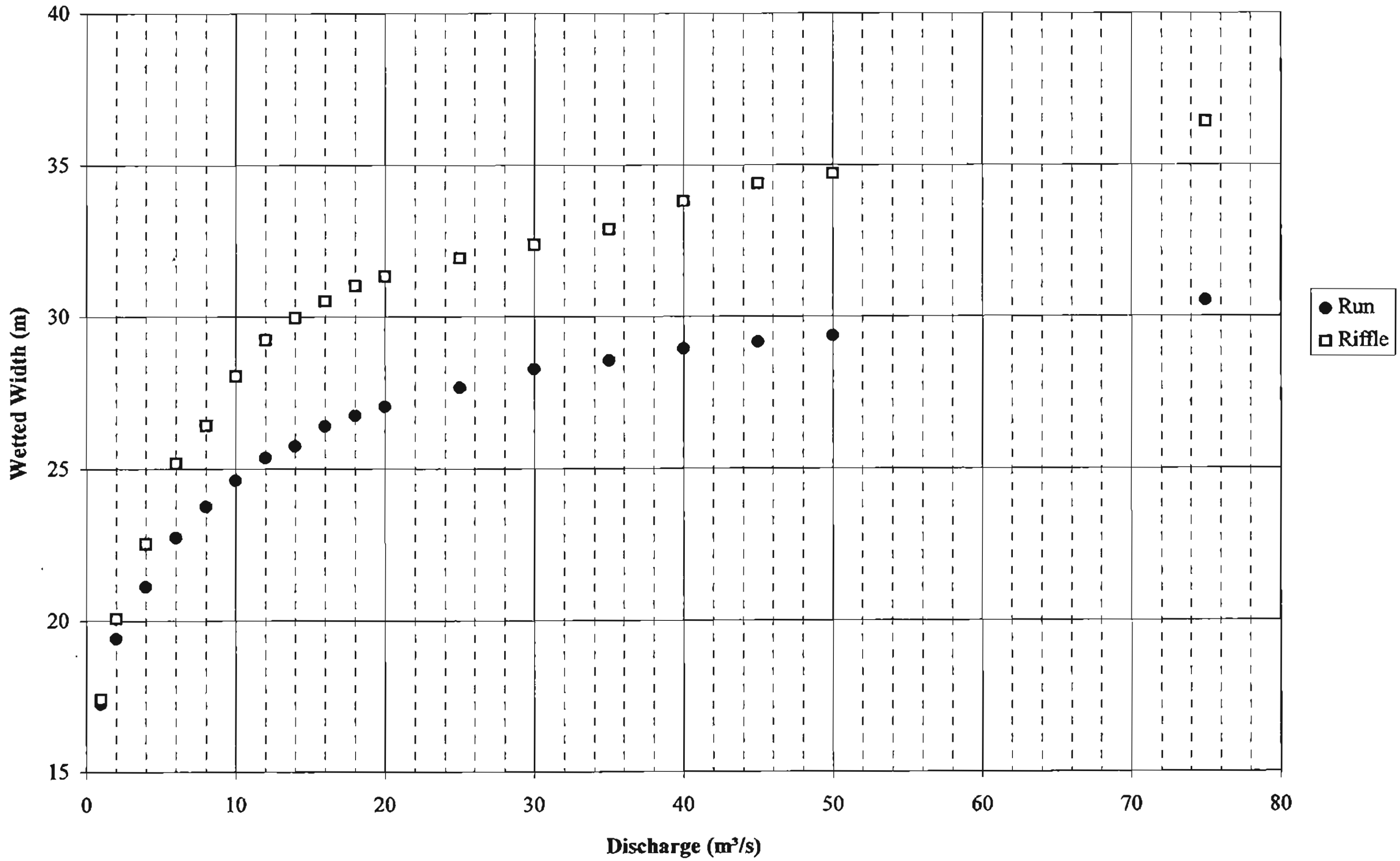


Figure 14. Response of average depth to discharge in the Seton River.

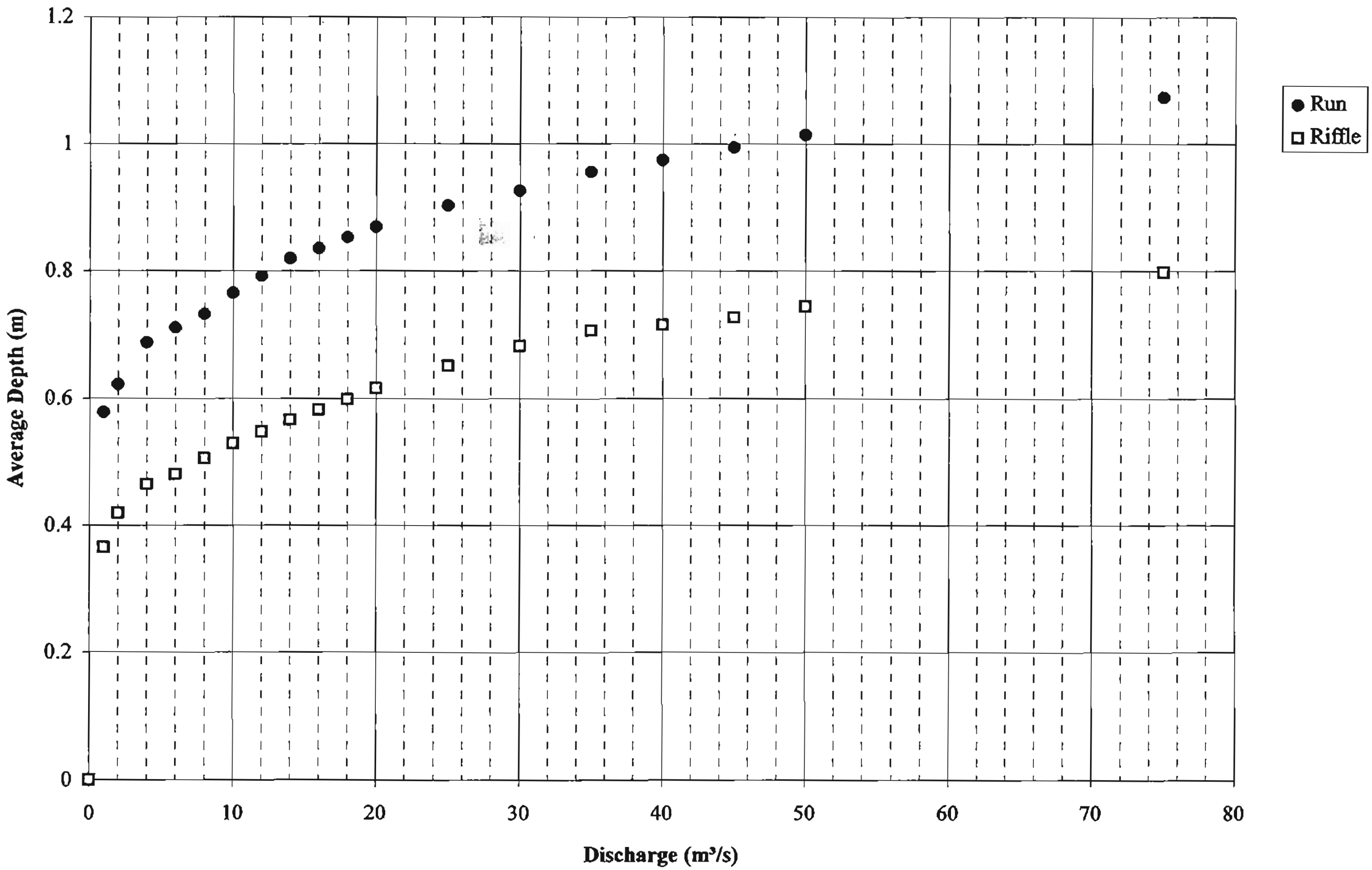


Figure 15. Response of average velocity to discharge in the Seton River.

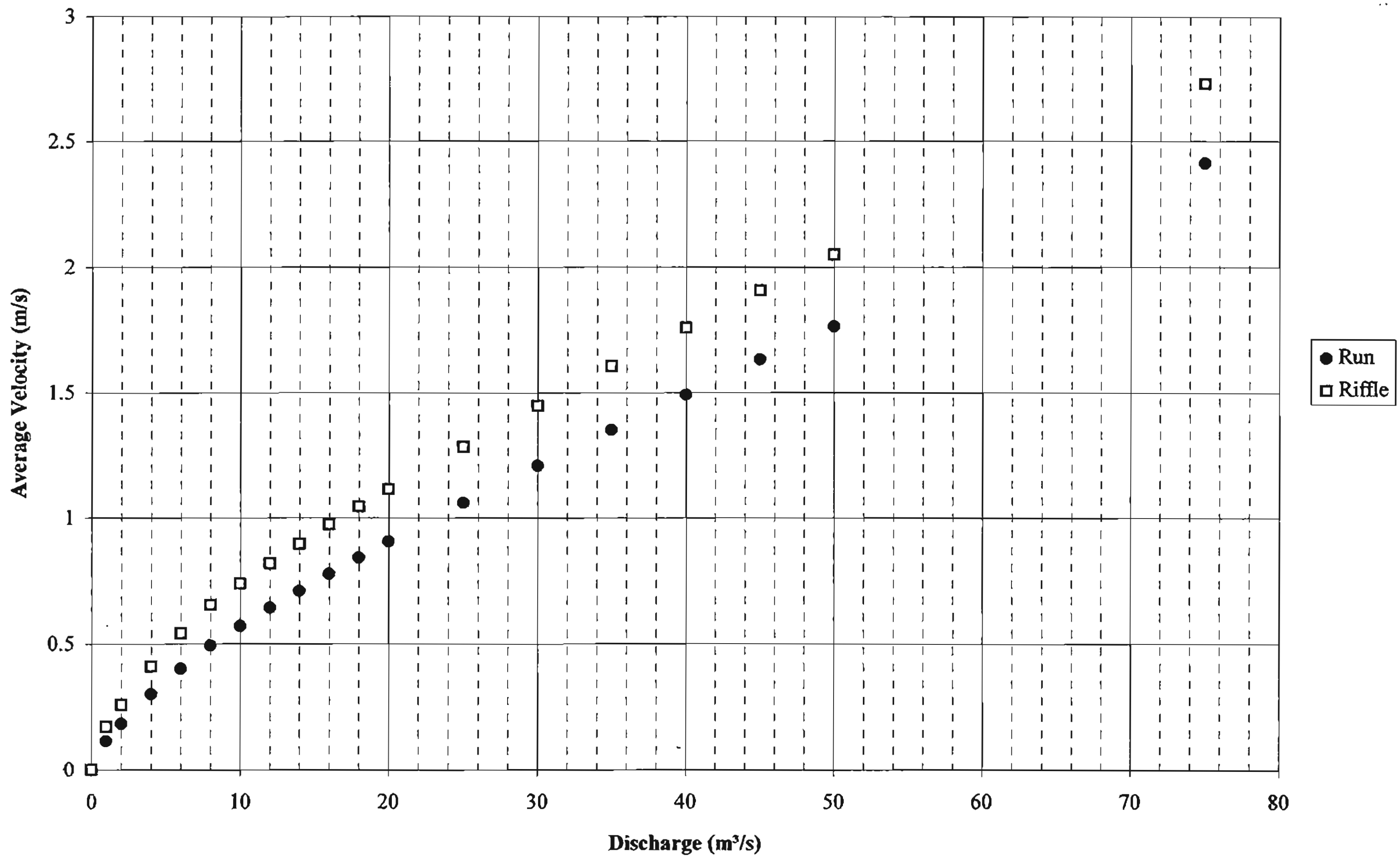


Figure 16. Response of weighted usable area for chinook salmon to changes in flow in the Seton R.
Criteria: CH - Ptolemy 1994, CH - Raleigh et al 1986, CH - Vincent-Lang 1984

a) Zero to 75 m³/s

b) Zero to 15 m³/s

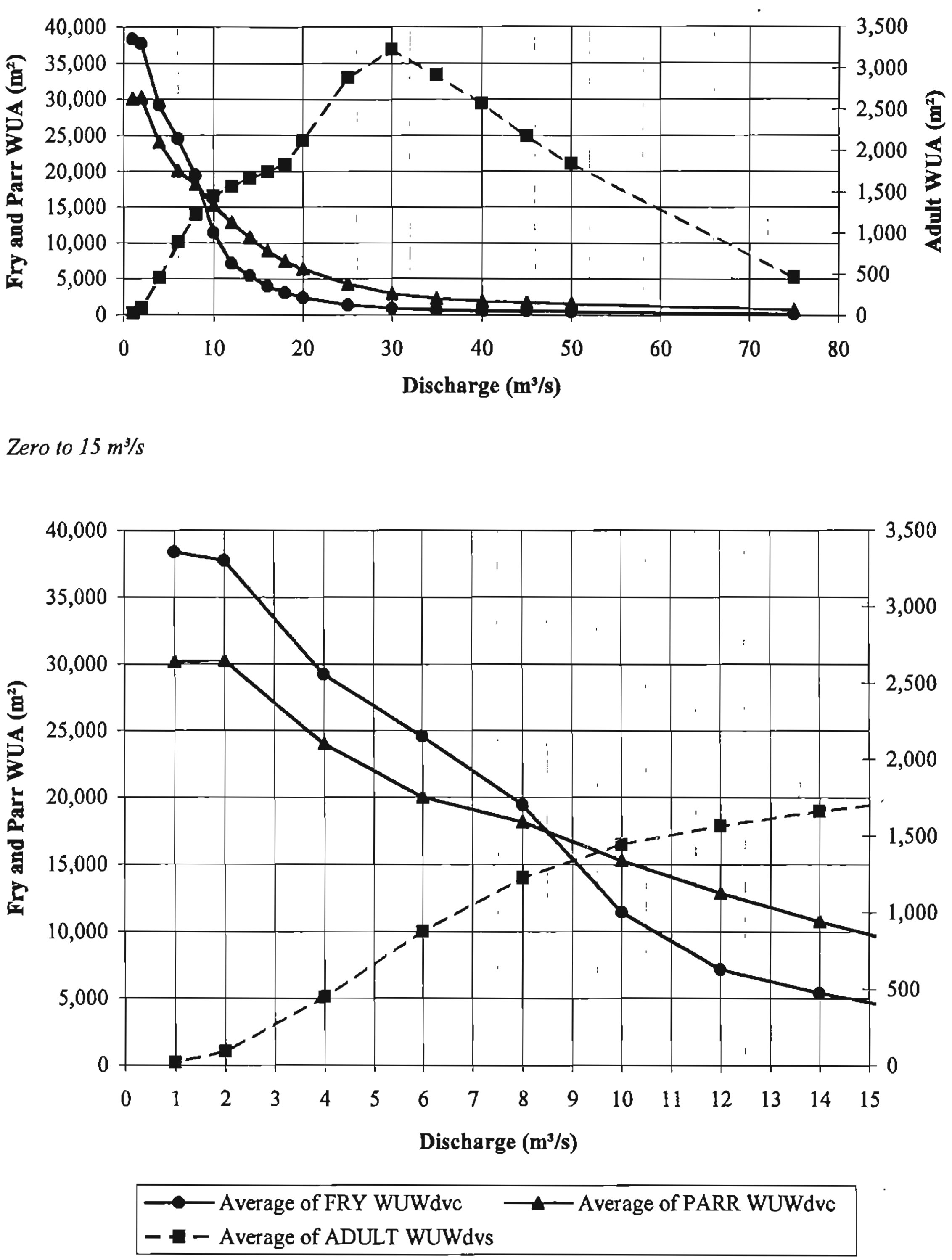
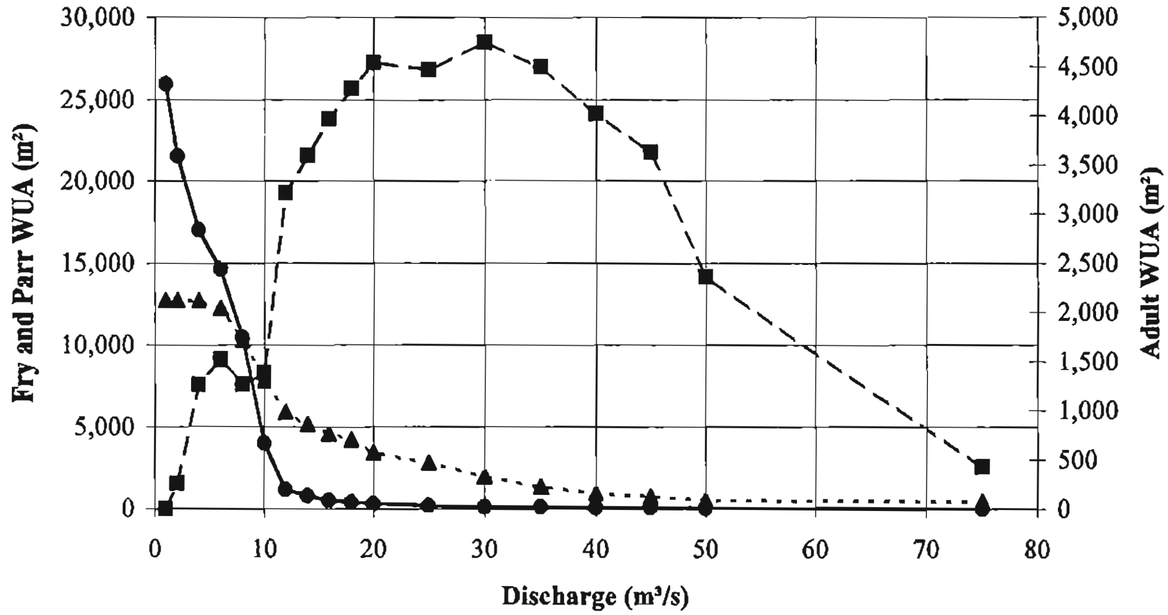


Figure 17. Response of weighted usable area for coho salmon to changes in flow in the Seton R.
Criteria: CO - Ptolemy 1994, CO - Envirocon 1984, CO - Envirocon 1984

a) Zero to 75 m³/s



b) Zero to 15 m³/s

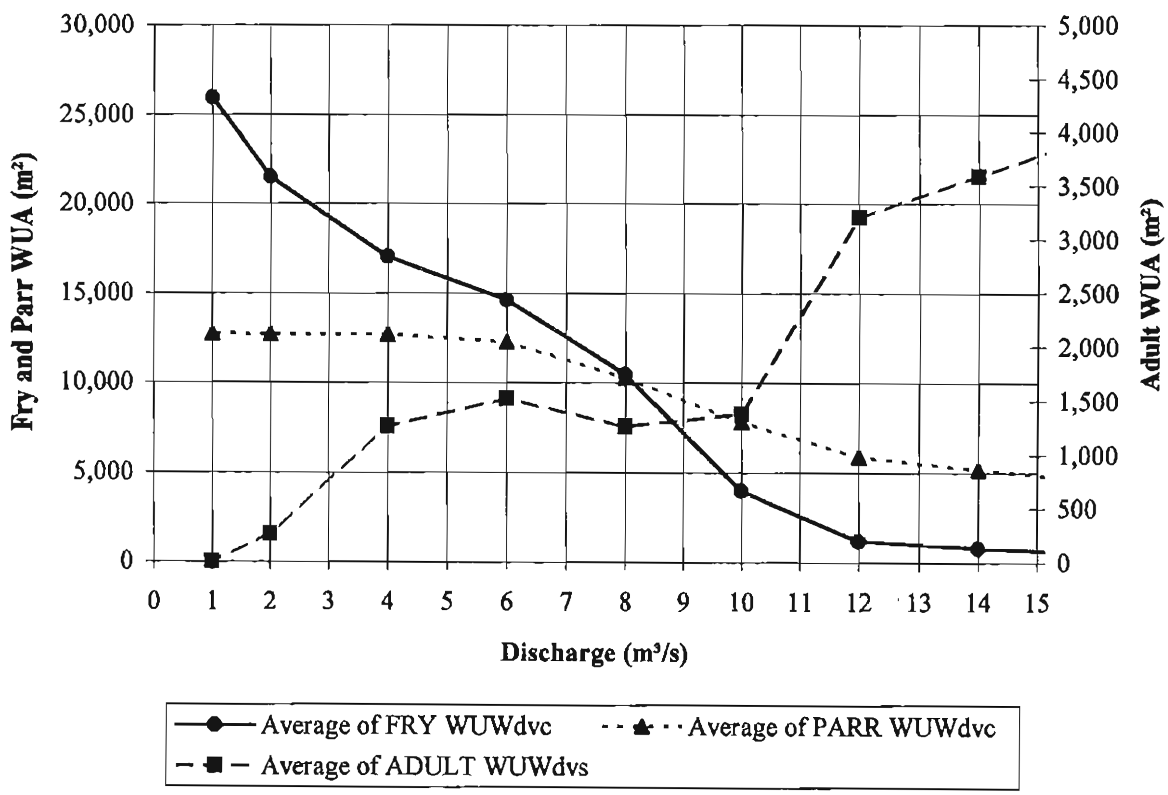
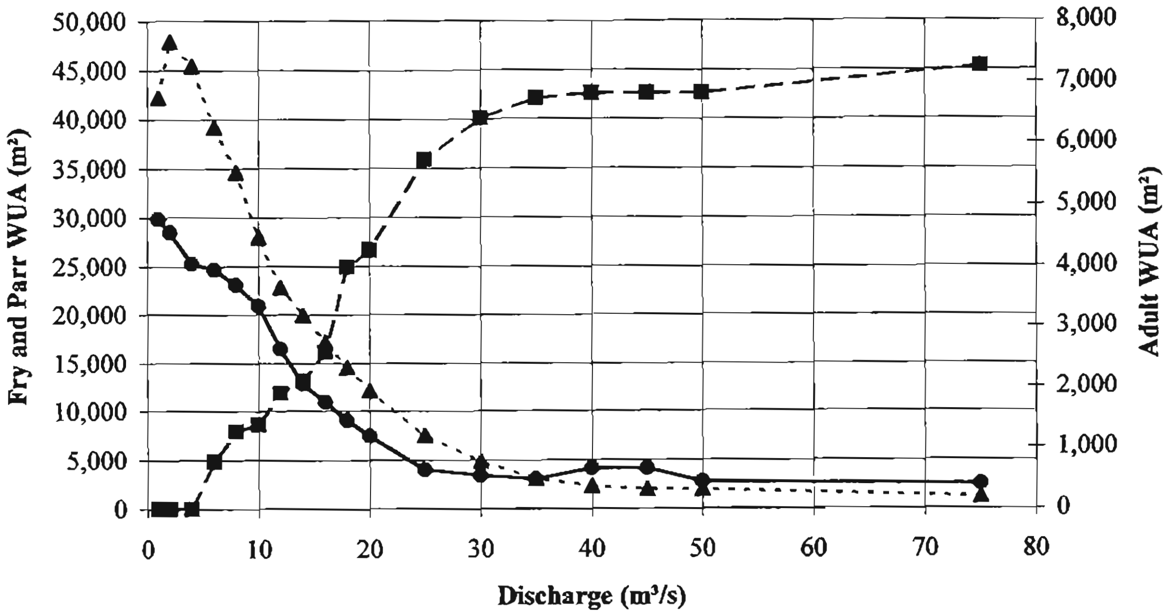


Figure 19. Response of weighted usable area for steelhead trout to changes in flow in the Seton R.
Criteria: RB/ST - Ptolemy 1994, RB/ST - Ptolemy 1994, RB - Envirocon 1984

a) Zero to 75 m³/s



b) Zero to 15 m³/s

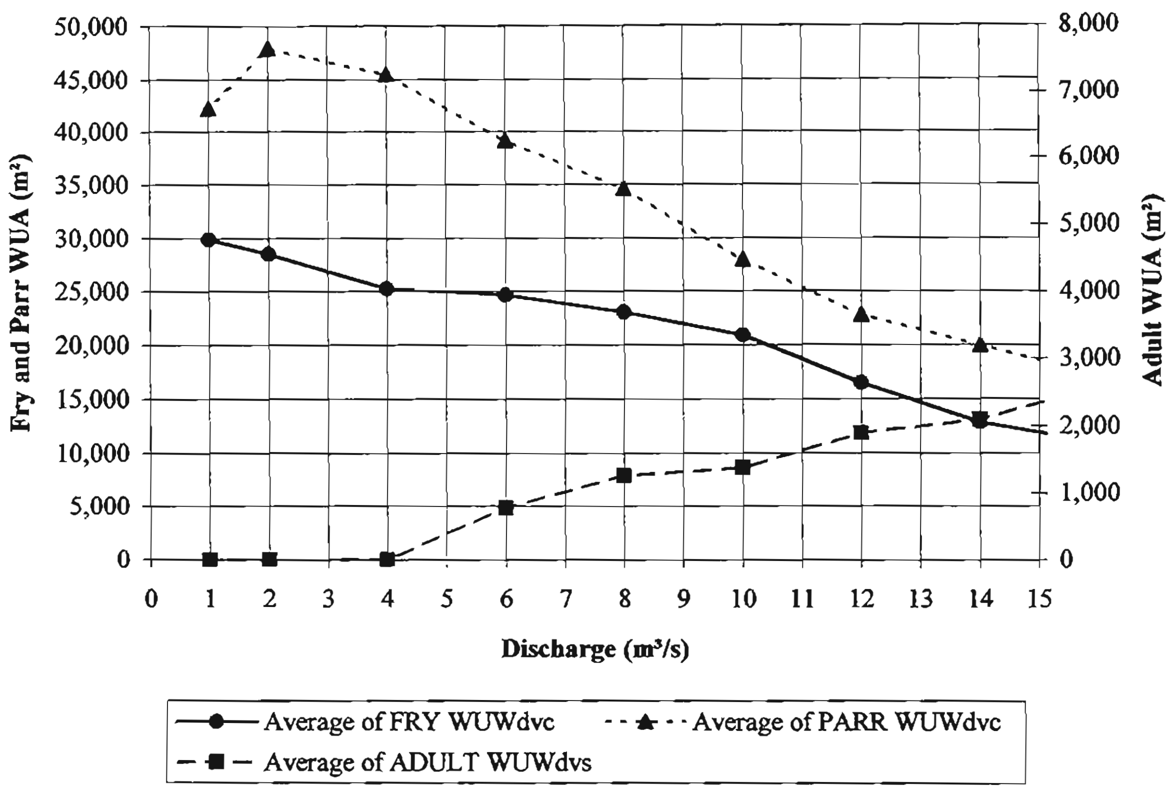
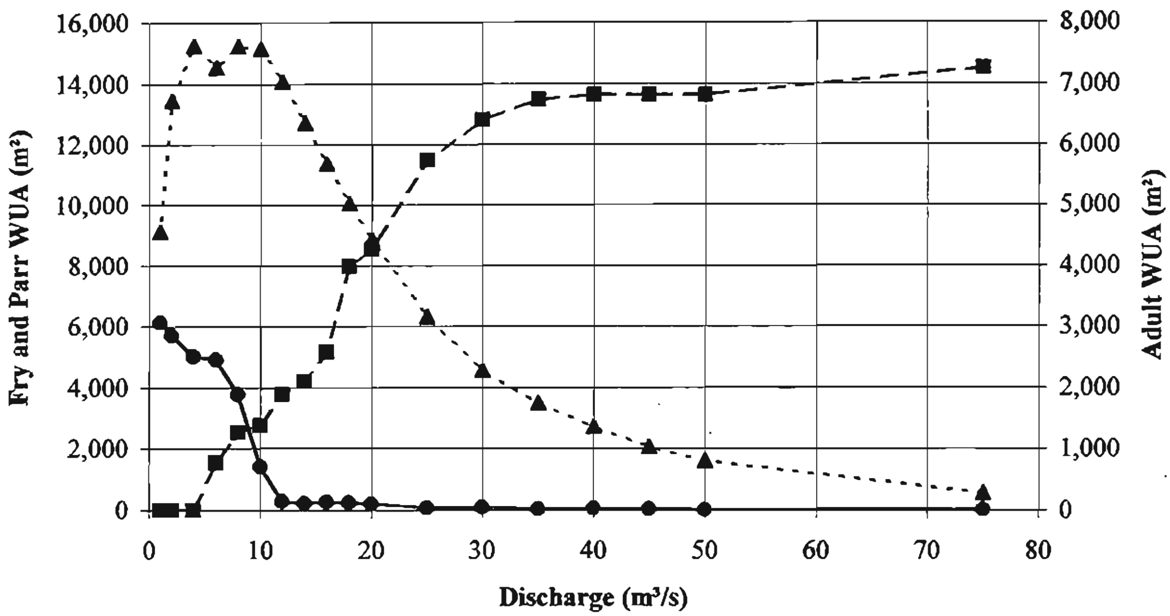


Figure 20. Response of weighted usable area for steelhead trout to changes in flow in the Seton R.
Criteria: RB, Night - Seton R. 1995, RB, Day - Seton R. 1995, RB - Envirocon 1984

a) Zero to 75 m³/s



b) Zero to 15 m³/s

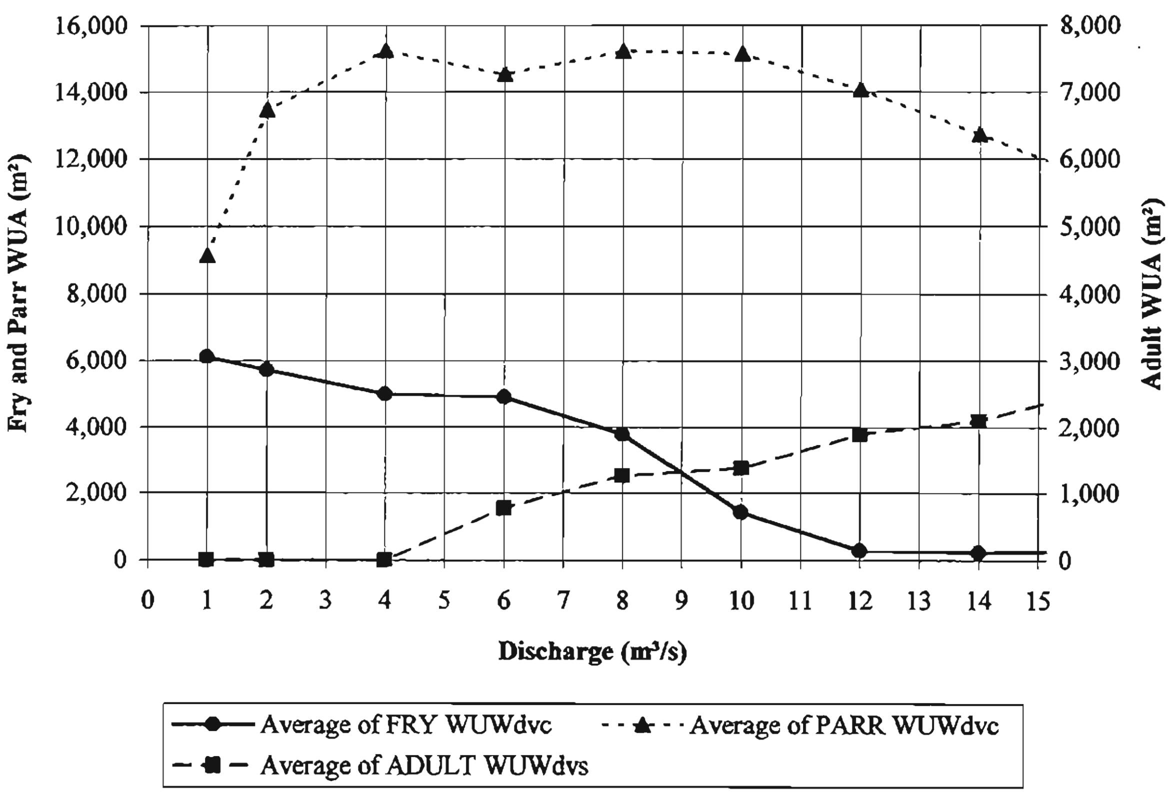
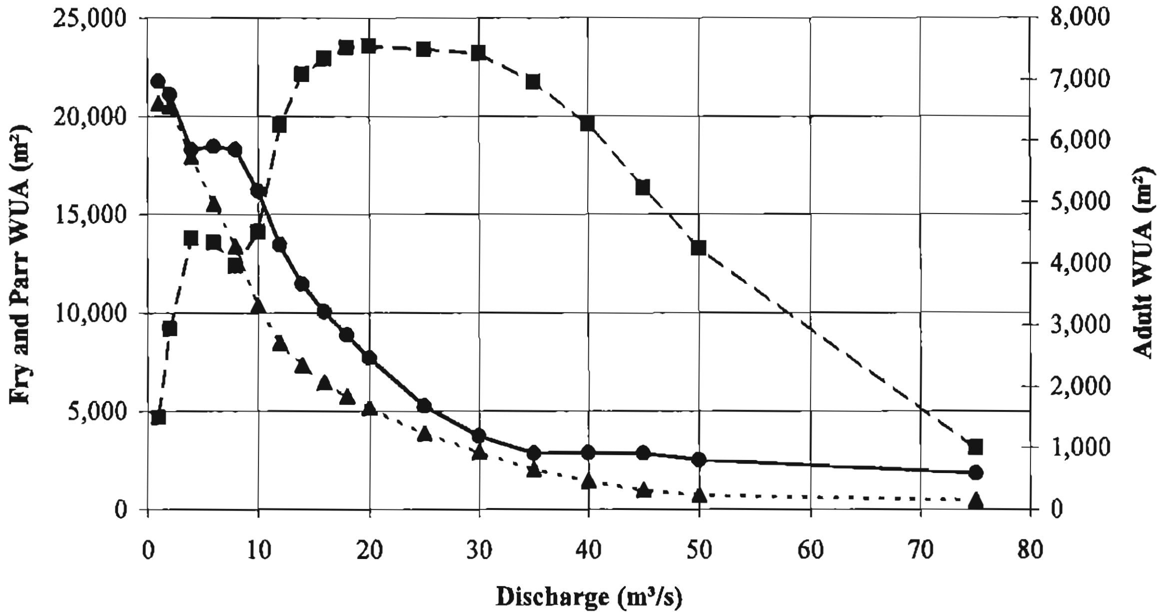


Figure 21. Response of weighted usable area for bull trout to changes in flow in the Seton R.
Criteria: BT - USFWS, BT - USFWS, BT - USFWS Spawning

a) Zero to 75 m³/s



b) Zero to 15 m³/s

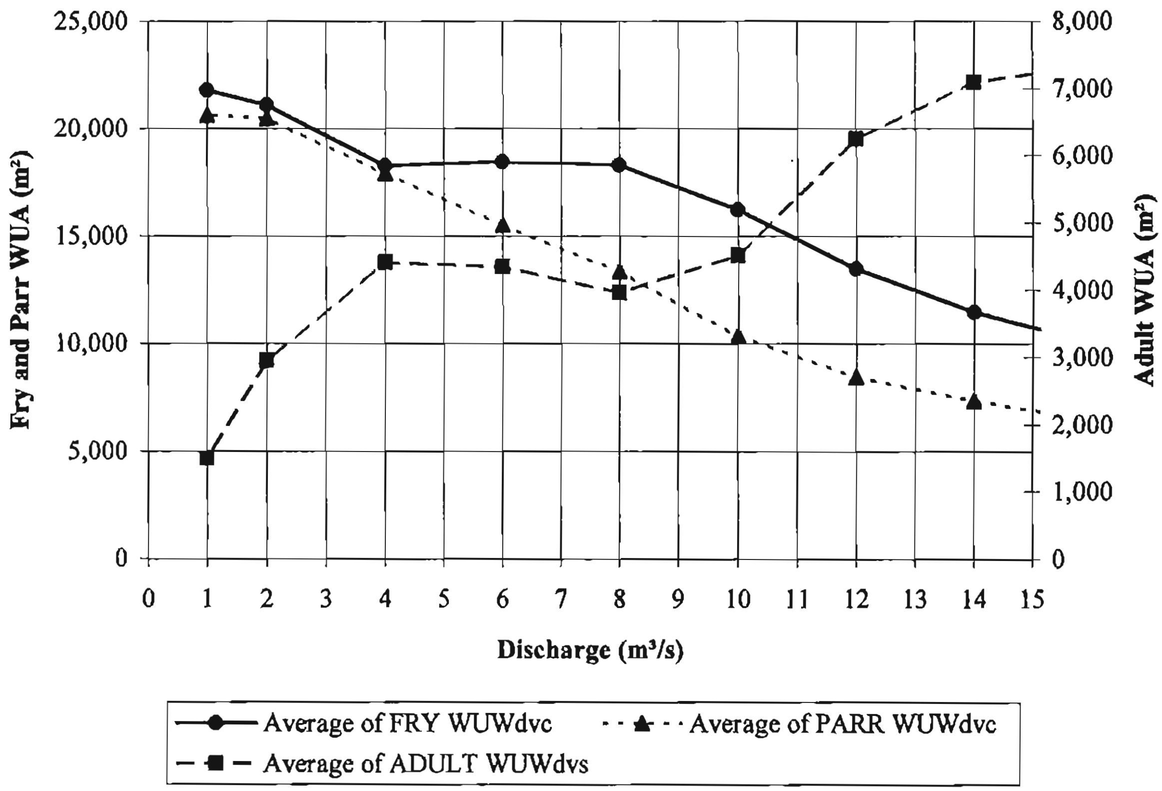
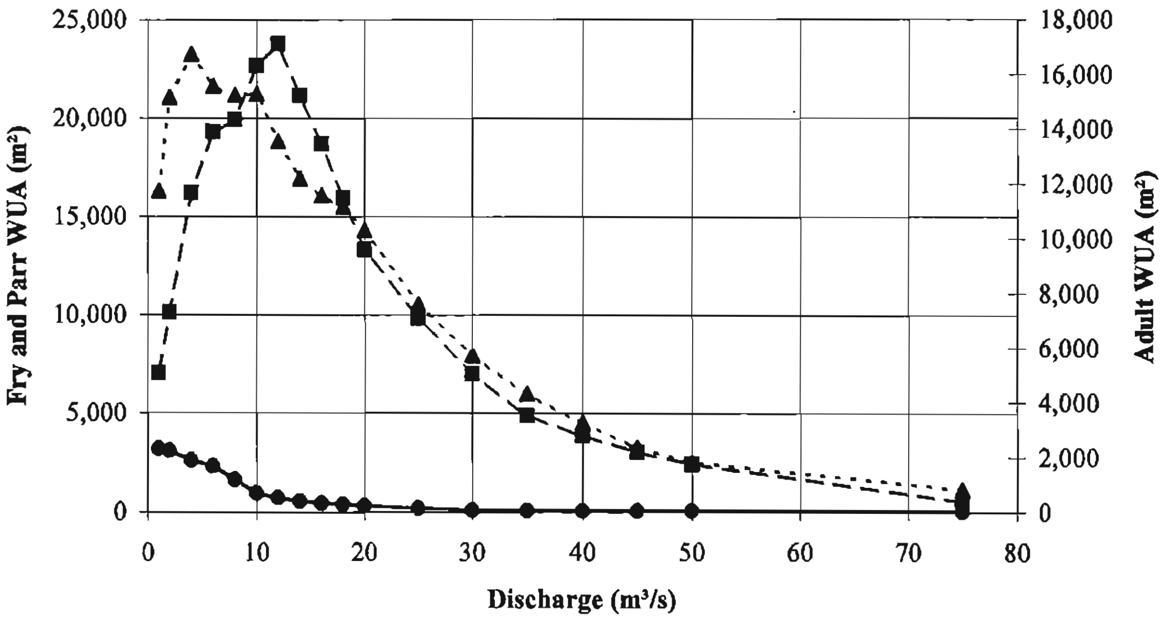


Figure 22. Response of weighted usable area for mountain whitefish to changes in flow in the Seton R.
Criteria: MW - USFWS, MW - USFWS, MW - USFWS Rearing

a) Zero to 75 m³/s



b) Zero to 15 m³/s

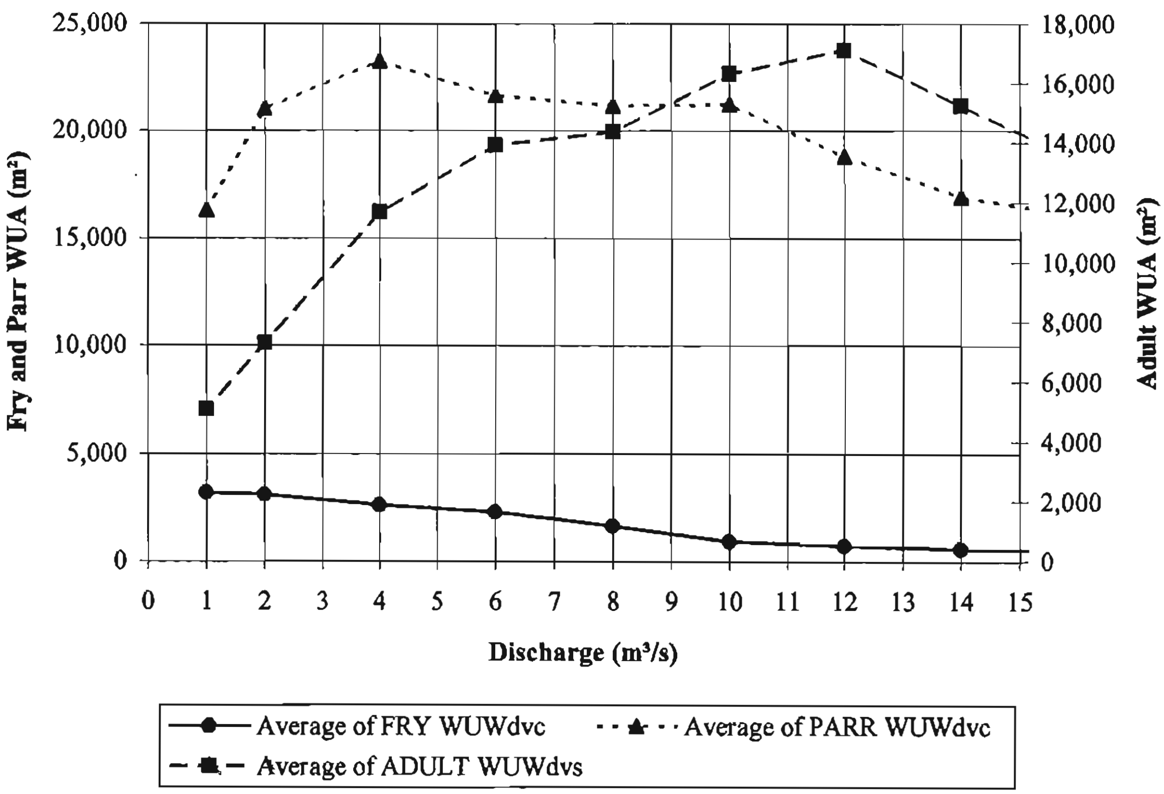


Figure 23. Probability density function of water surface elevation change between November and December flows in the Seton River.

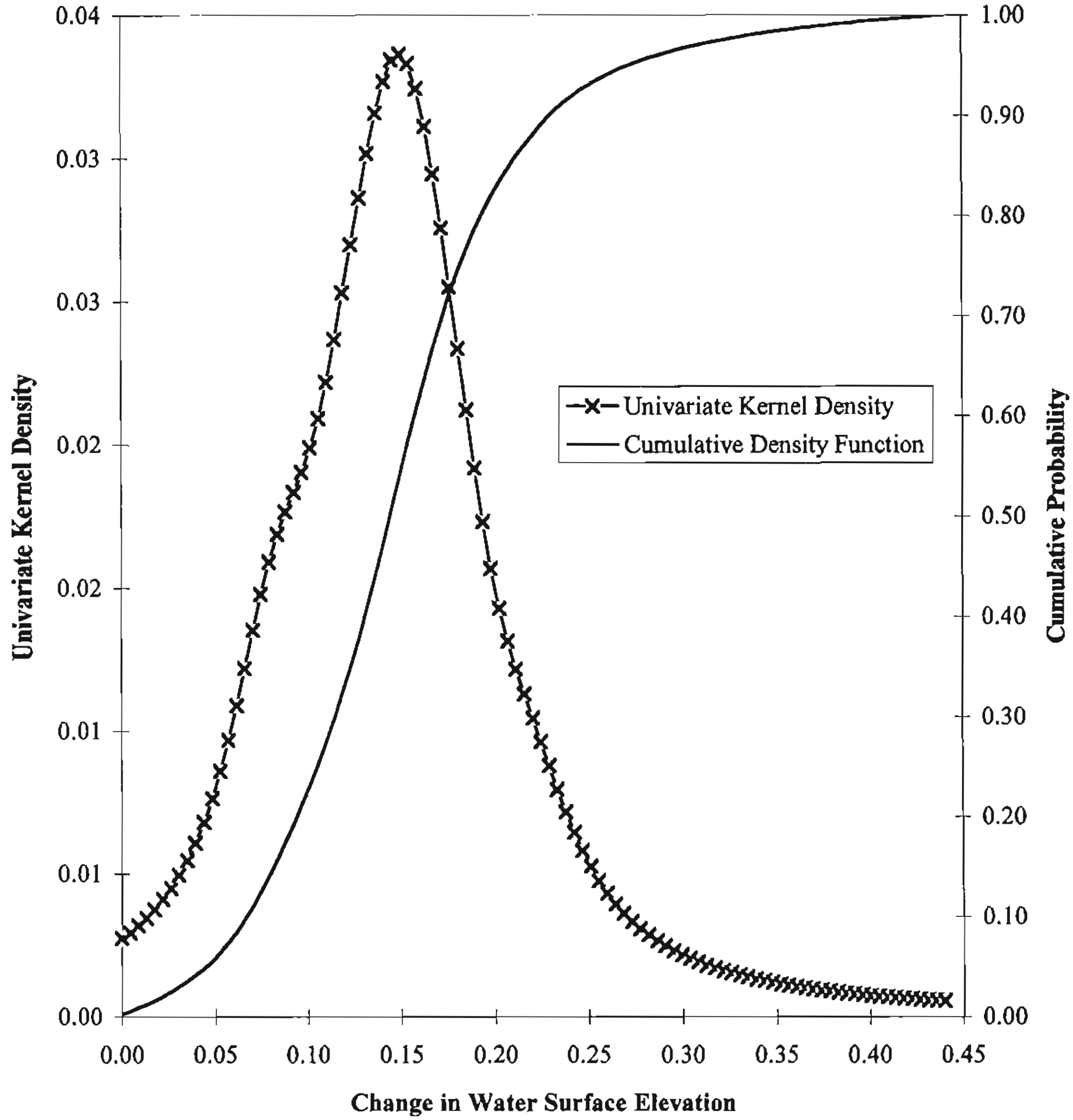


Figure 24. Cumulative probability of depth change after November 15 in the Seton River, and the suitability of depth for pink salmon spawning (from Raleigh and Nelson 1985).

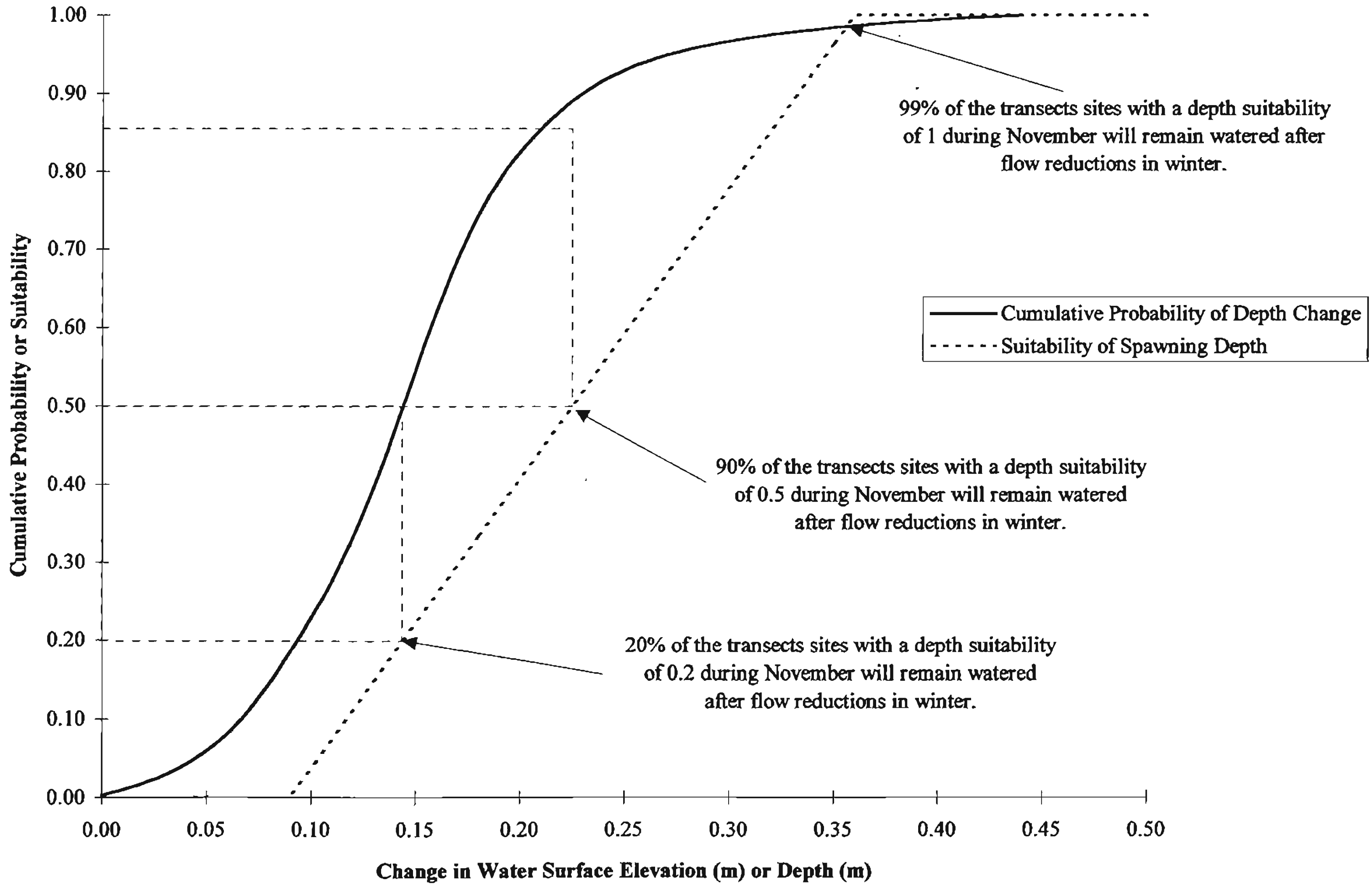


Figure 25. Cumulative probability of depth change between 50 and 10 m^3/s in the Seton River compared to the suitability of depth for steelhead trout spawning (from Envirocon 1984).

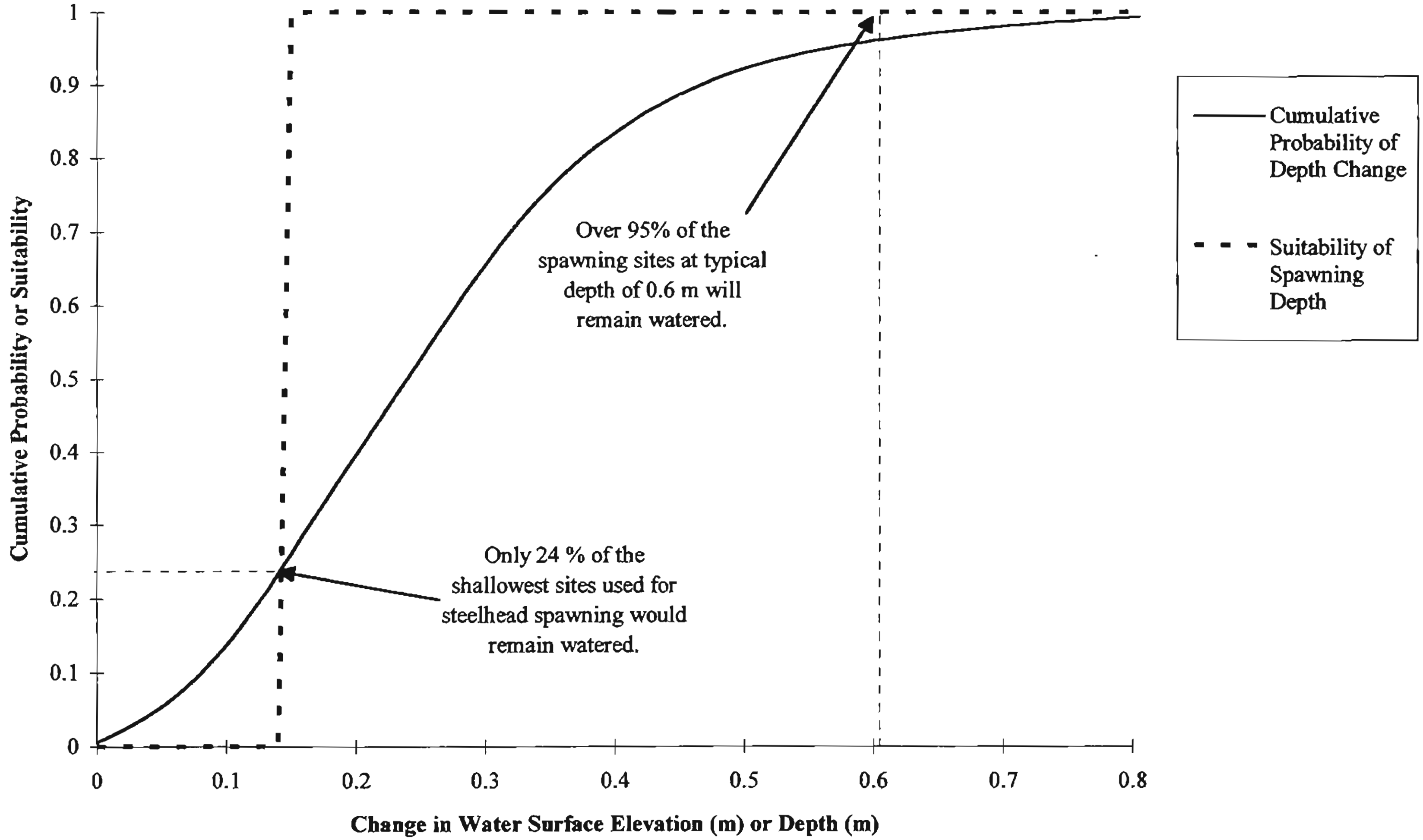
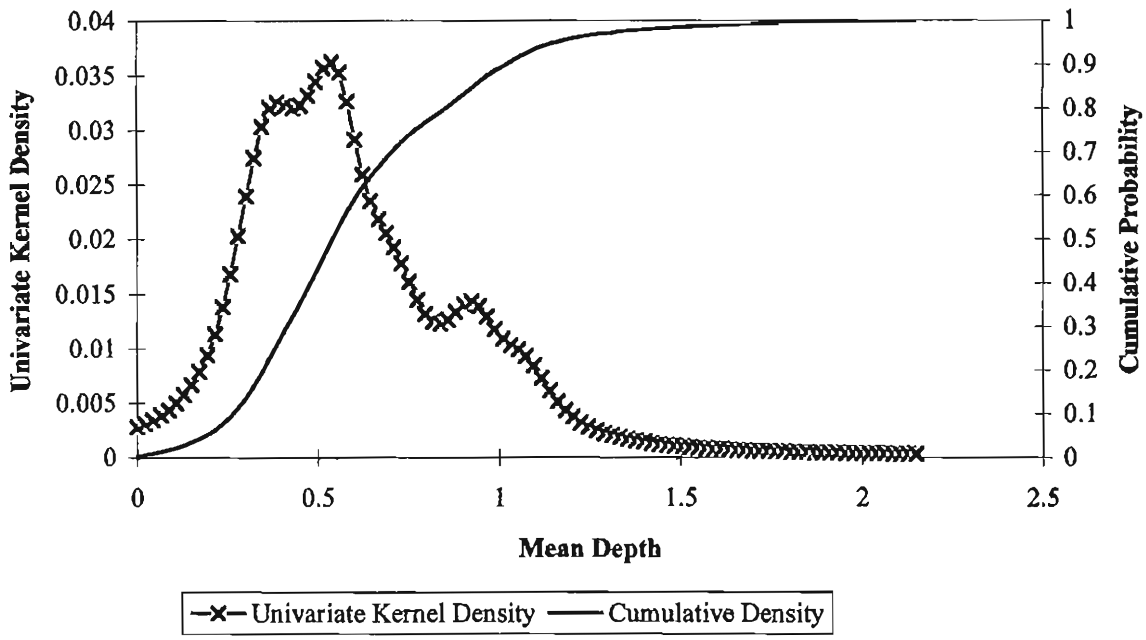


Figure 26. Probability density function for depth in the Seton River observed at a flow of 7 m³/s.



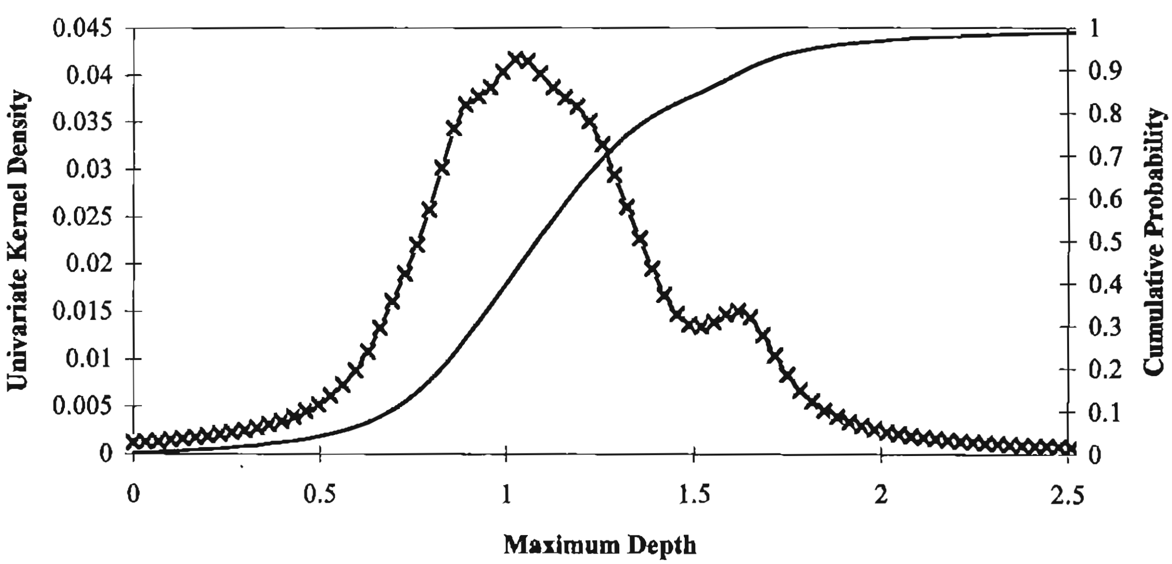


Figure 27. Seton Lake Temperatures.

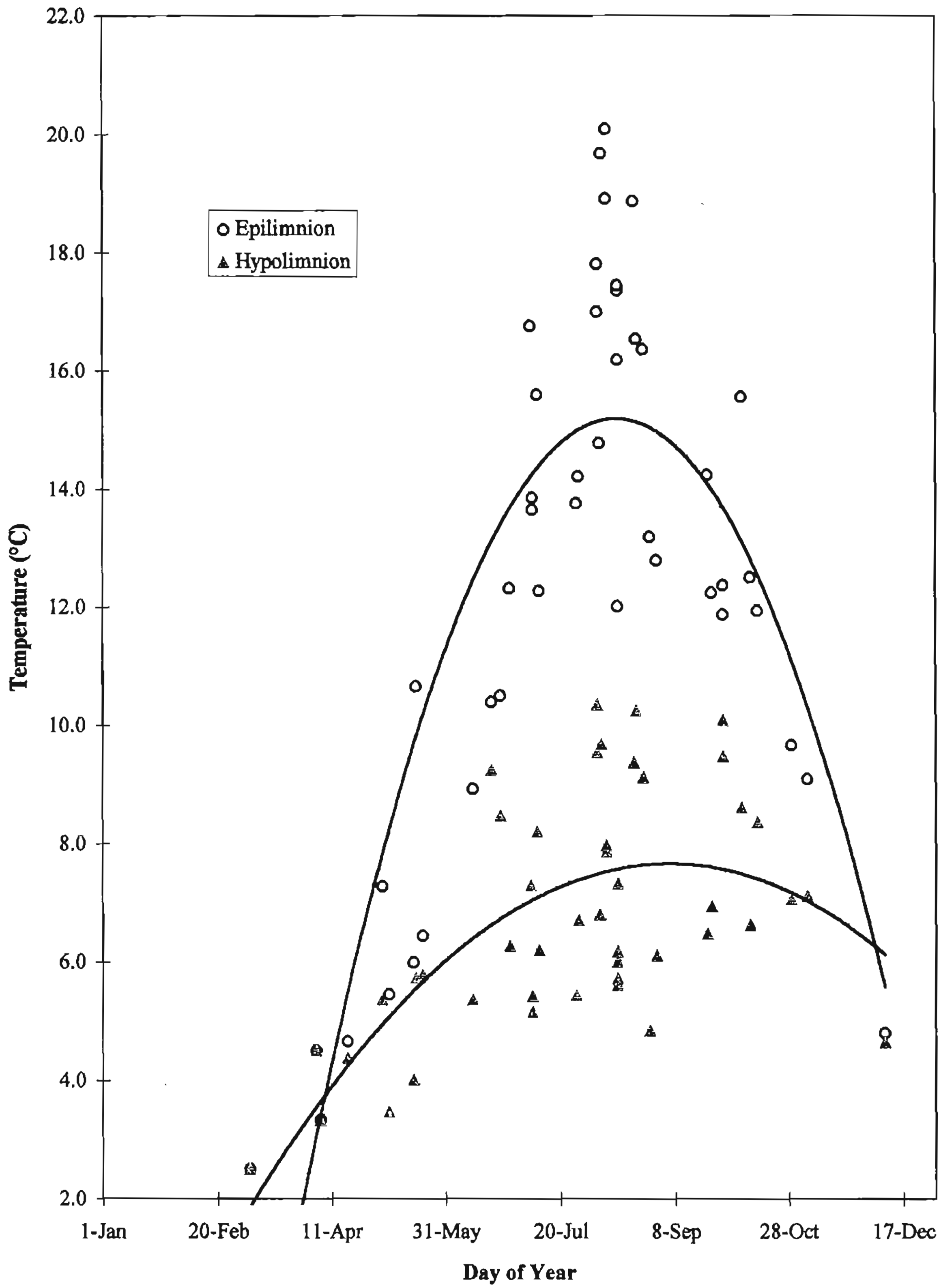


Figure 28. Thermoclines in Seton Lake by date, during 1977.

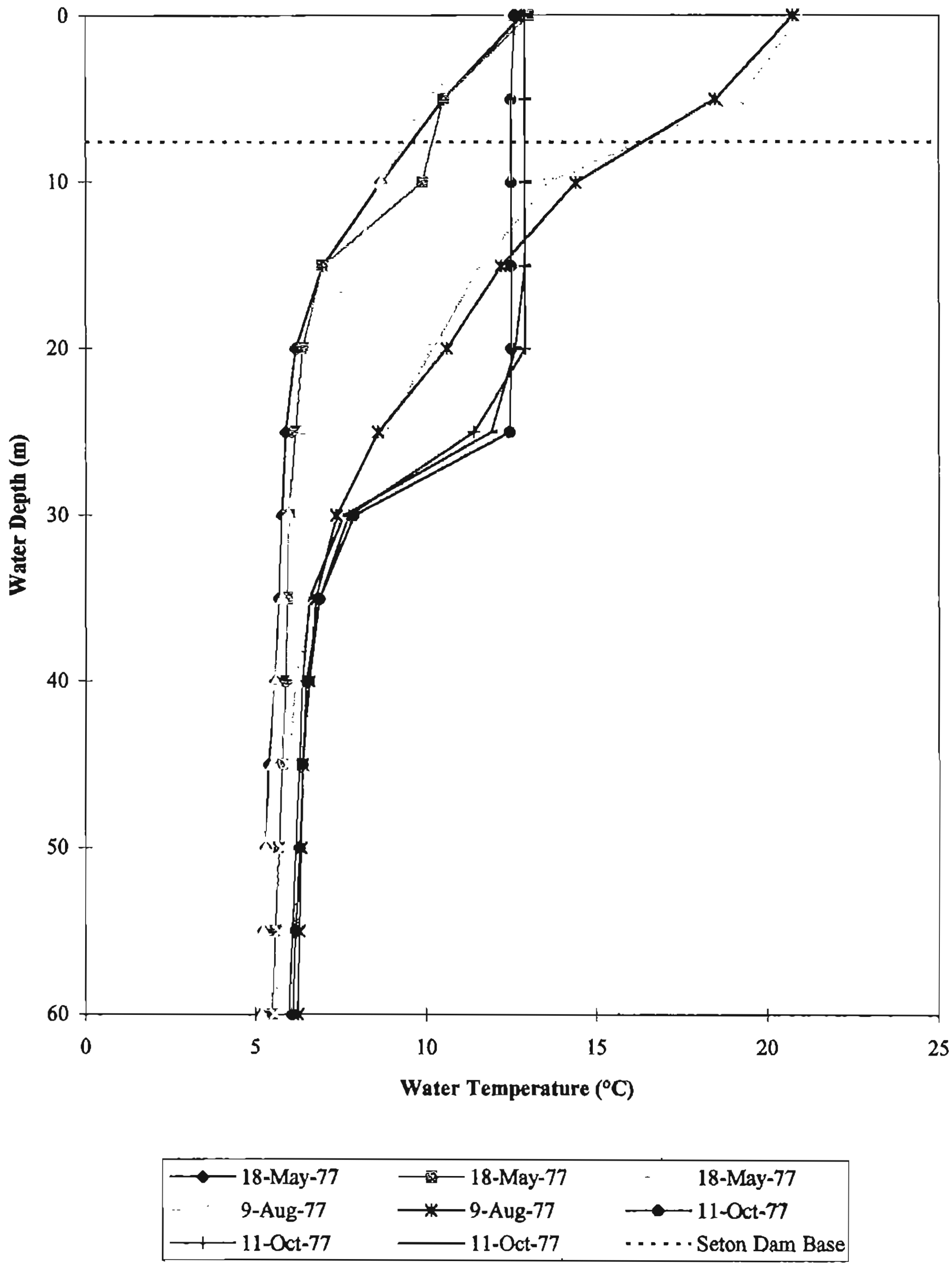


Figure 29. Timing of life history events of Seton River salmon stocks.

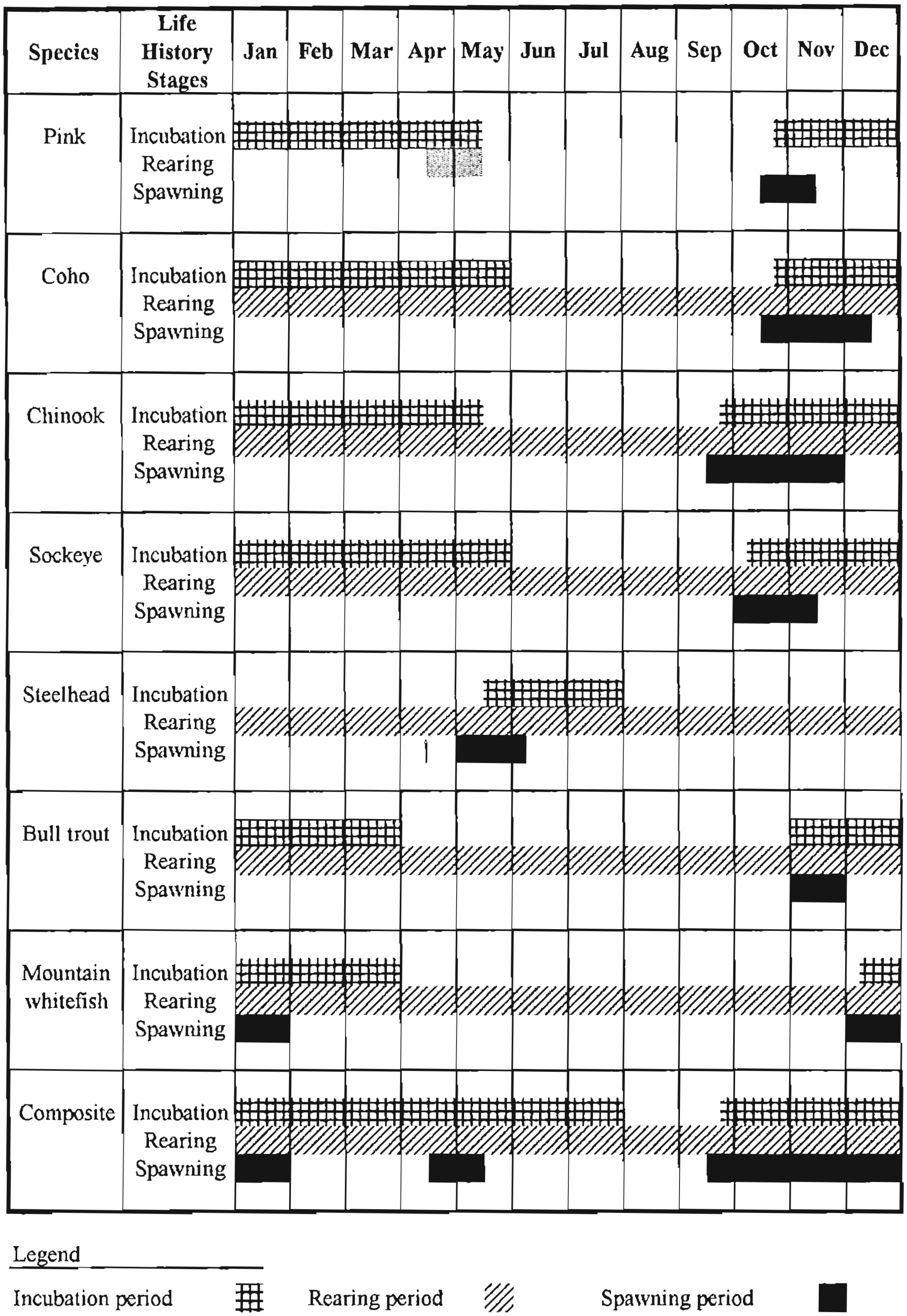
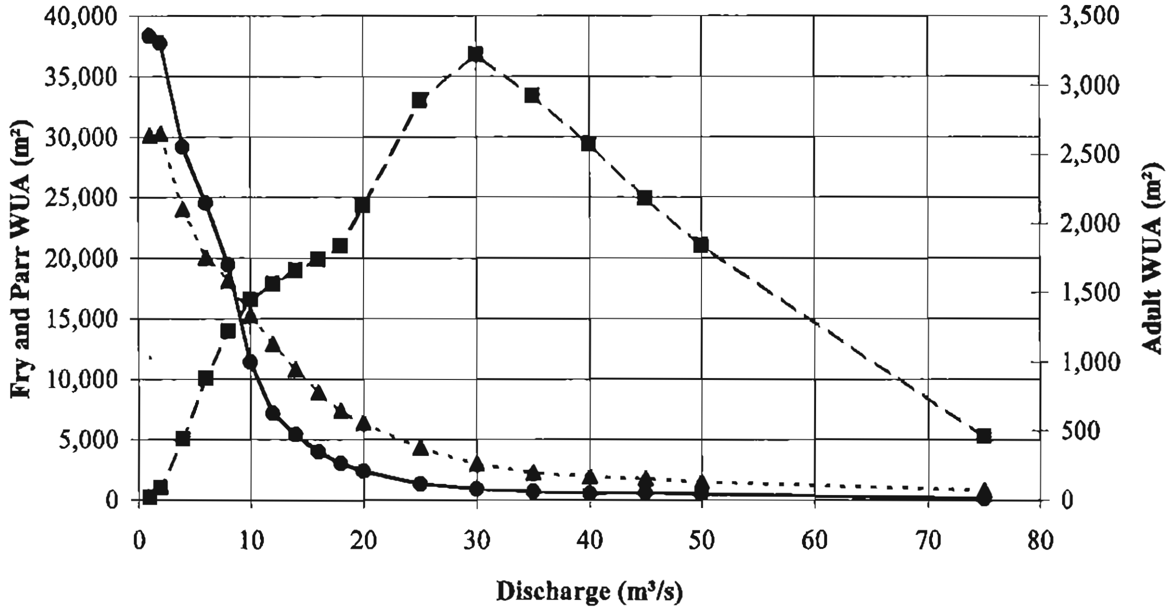


Figure 30. Habitat and production estimates versus discharge for chinook salmon in the Seton R.
Criteria: CH - Ptolemy 1994, CH - Raleigh et al 1986, CH - Vincent-Lang 1984
a) Weighted usable area



b) Production estimates

Adult equivalents calculated assuming SEP biostandard survivals and observed productivity data (or estimates from the literature).

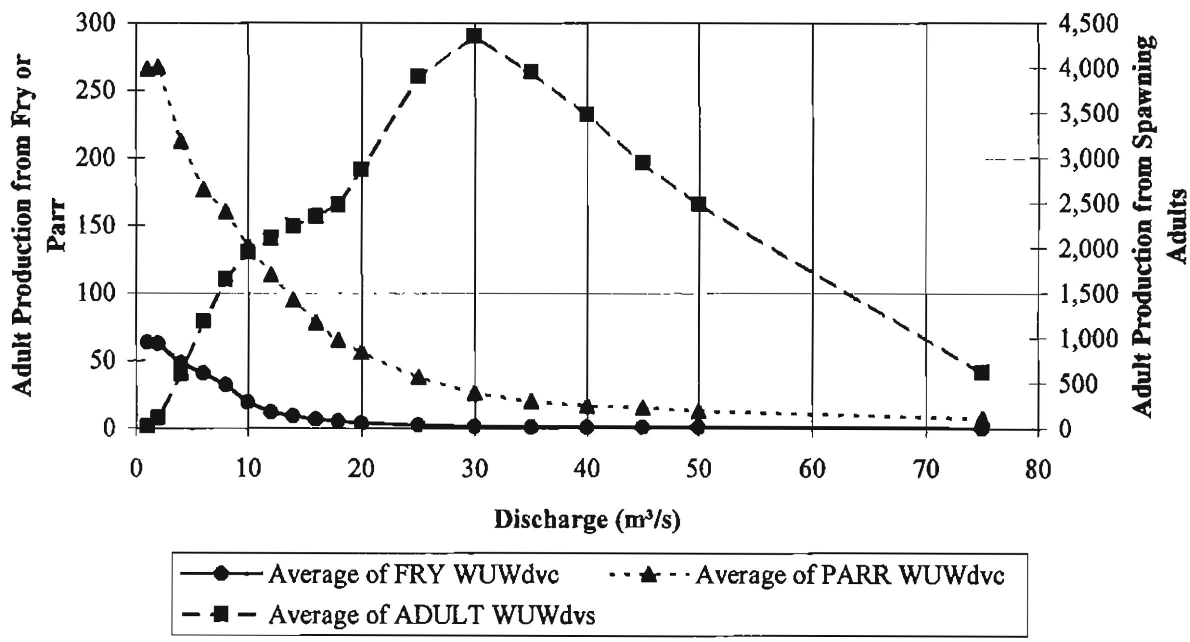
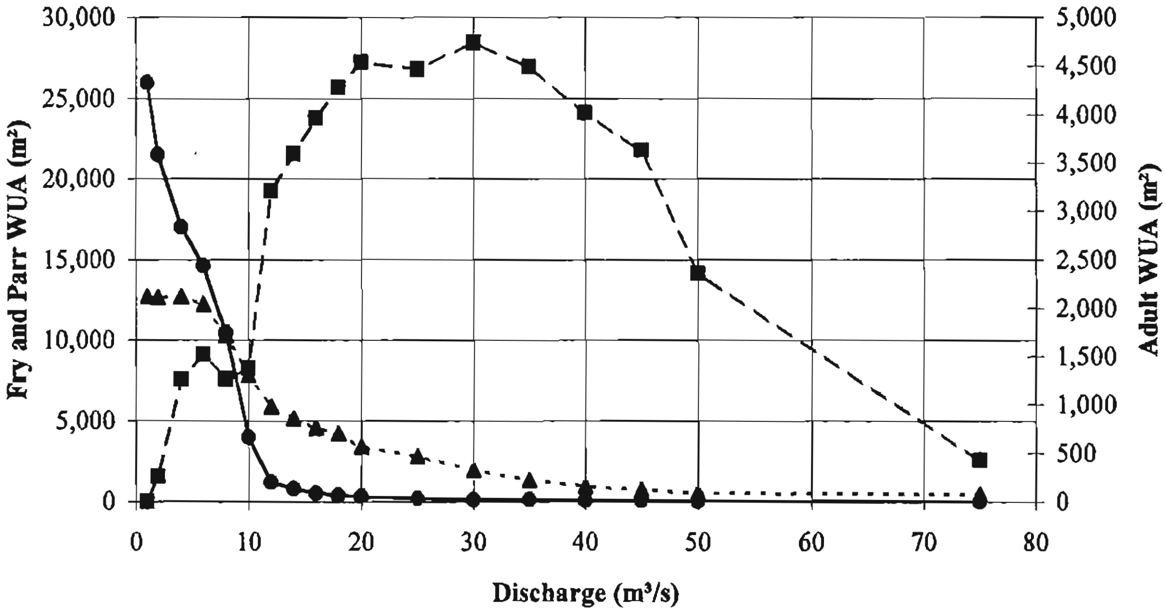


Figure 31. Habitat and production estimates versus discharge for coho salmon in the Seton R.
Criteria: CO - Ptolemy 1994, CO - Envirocon 1984, CO - Envirocon 1984
a) Weighted usable area



b) Production estimates

Adult equivalents calculated assuming SEP biostandard survivals and observed productivity data (or estimates from the literature).

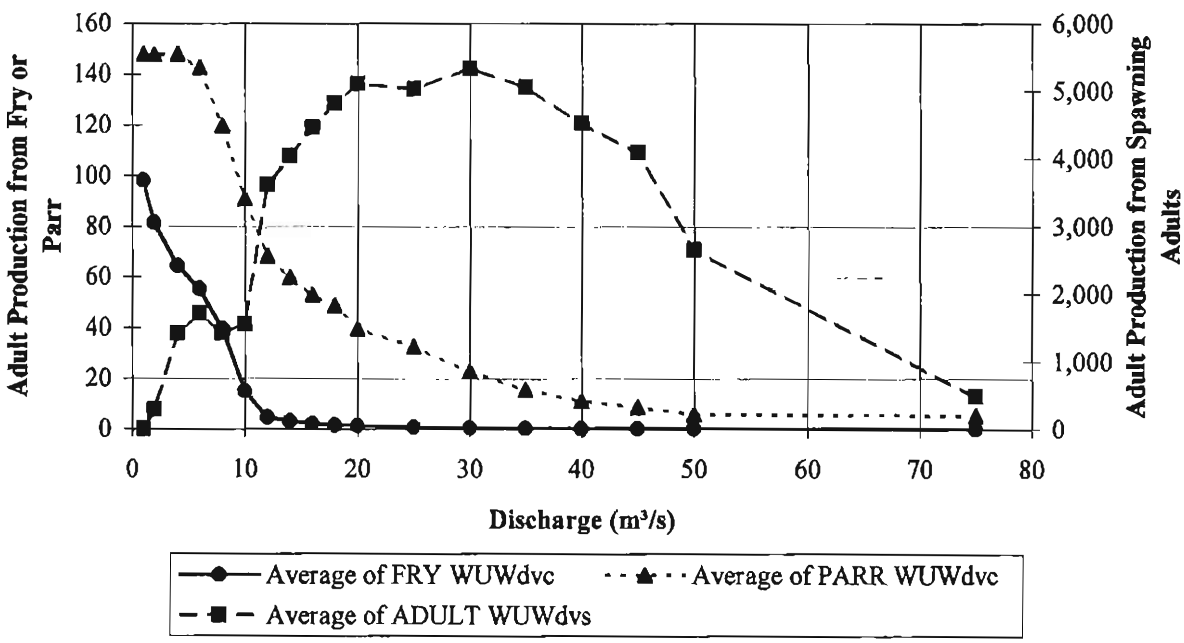
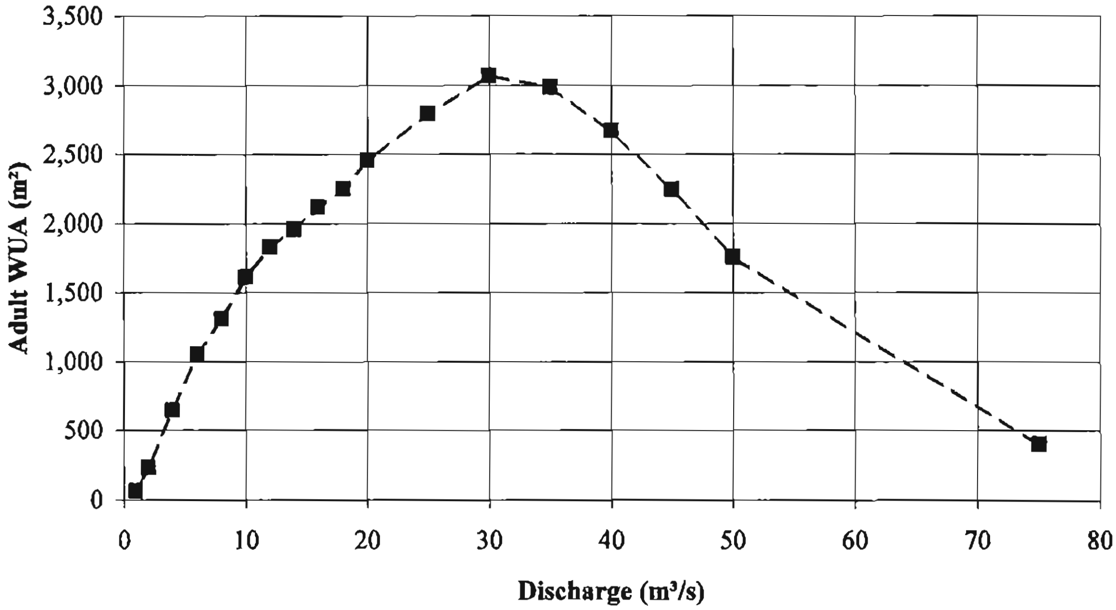


Figure 32. Habitat and production estimates versus discharge for pink salmon in the Seton R.
Criteria: PK - Raleigh and Nelson 1985
a) Weighted usable area



b) Production estimates

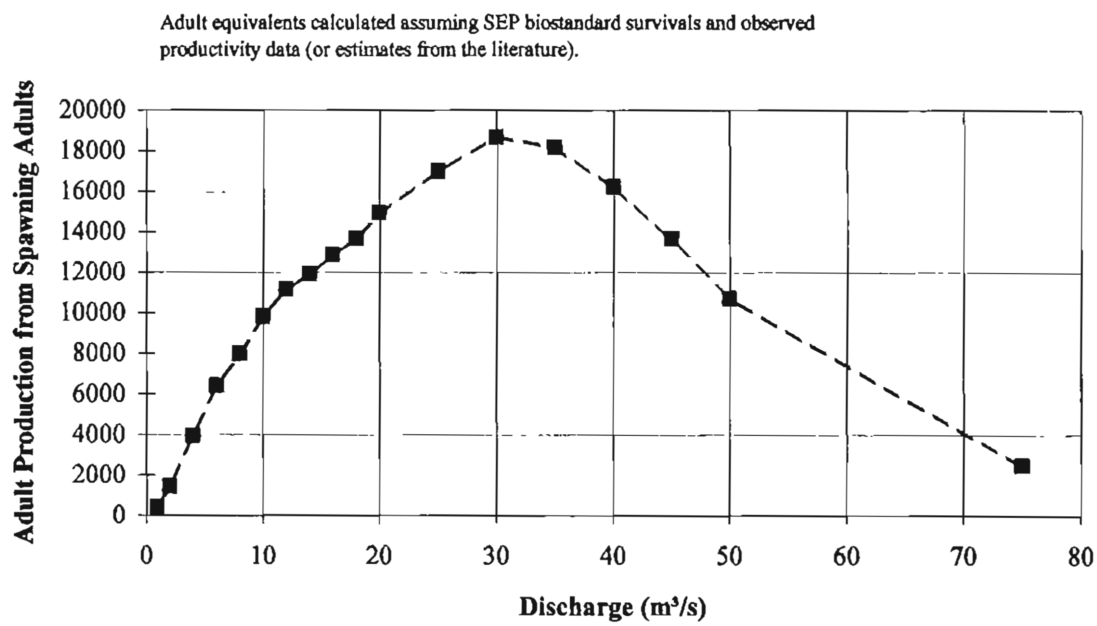
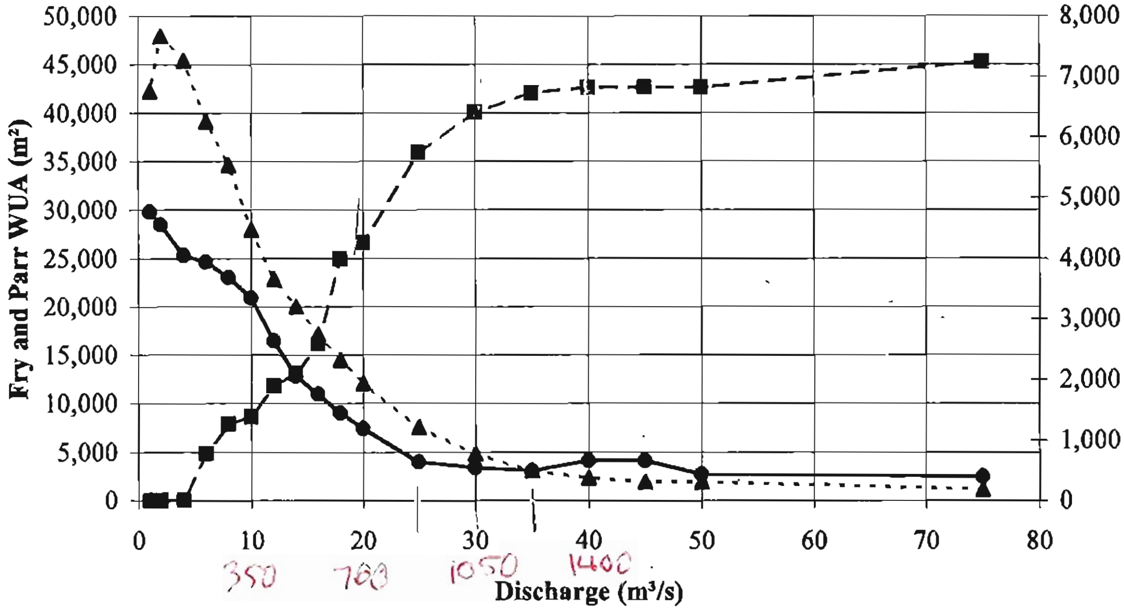


Figure 33. Habitat and production estimates versus discharge for steelhead trout in the Seton R.
Criteria: RB/ST - Ptolemy 1994, RB/ST - Ptolemy 1994, RB - Envirocon 1984
a) Weighted usable area



b) Production estimates

Adult equivalents calculated assuming SEP biostandard survivals and observed productivity data (or estimates from the literature).

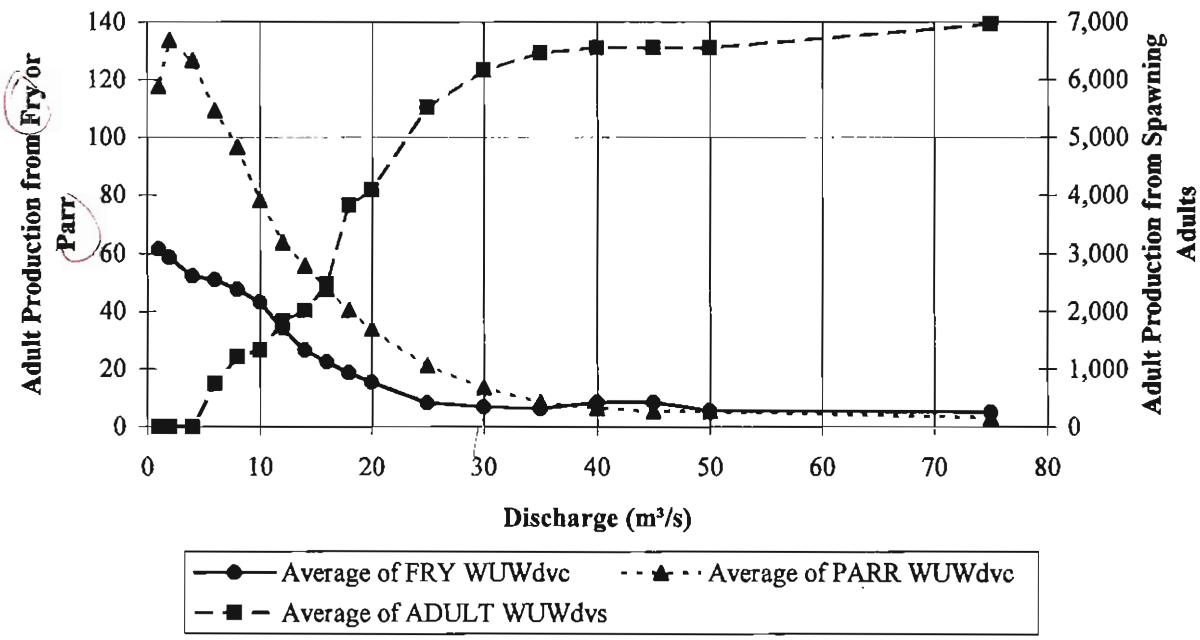


Figure 34. Trade-offs between juvenile rearing of all species and pink salmon spawning and sockeye migration.

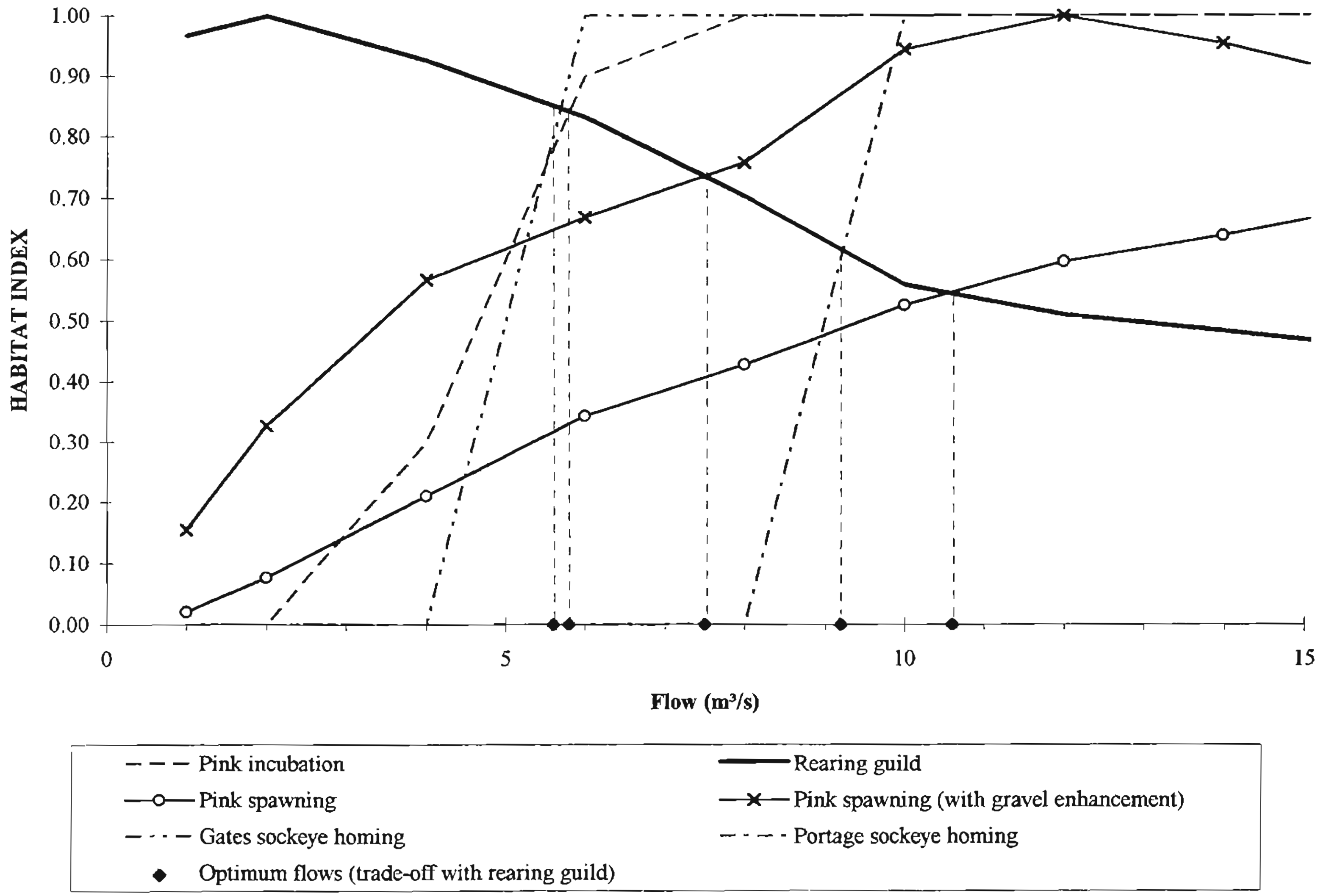
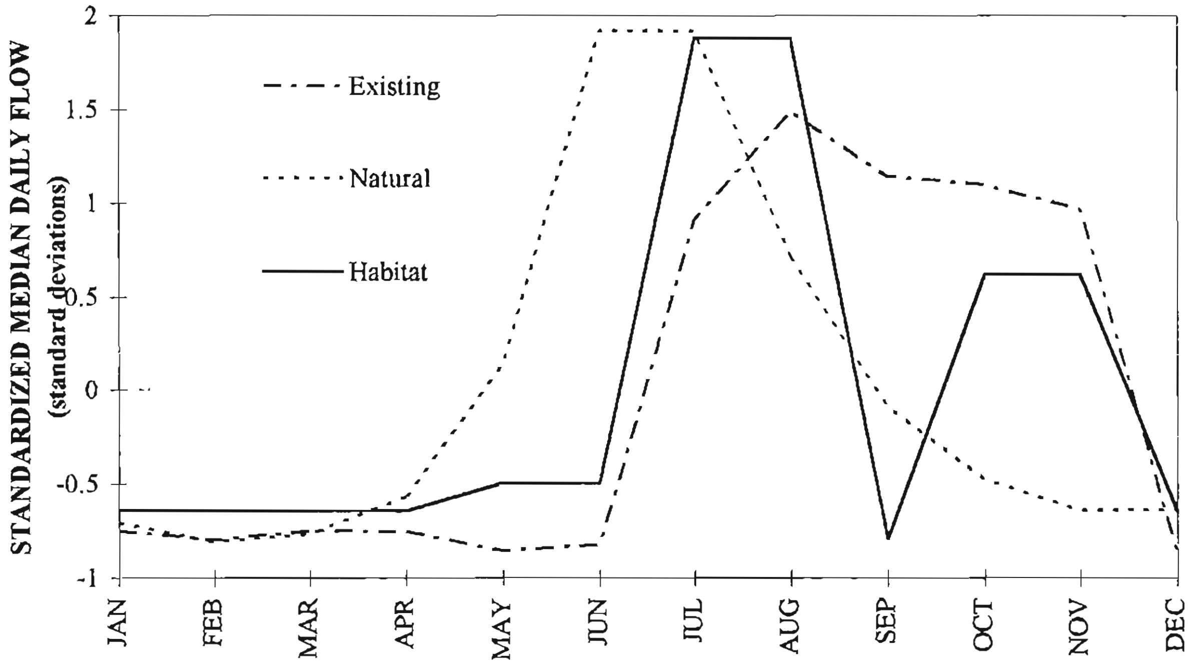
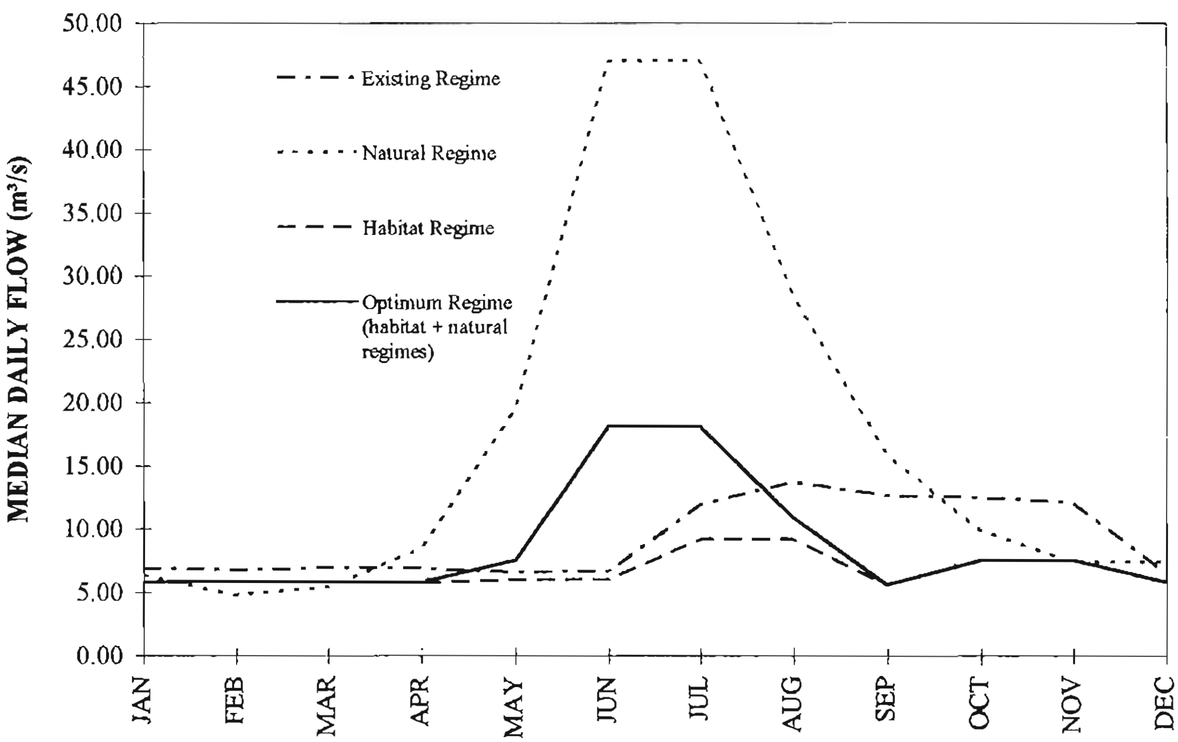


Figure 35. Indices of physical habitat and optimum flow regimes in the Seton River.

a) Standardized flows



b) Natural, existing and optimum flow regimes in the Seton River



9. TABLES

Table 1. Summary of general and river-specific habitat suitability curves for the Seton River.

Species	Life History Stage	Sources	
		River-specific (sample size, day/night)	General (citation, location)
Steelhead	fry (0+)	0/37[1]	Ptolemy 1994, BC wide
	parr (>=1+)	45/171[1]	Ptolemy 1994, BC wide
	adult (spawning)	0/0	Envirocon 1984a, Morice R.
Coho	fry (0+)	0/8[1]	Ptolemy 1994, BC wide
	parr (>=1+)	0/0	Envirocon 1984a, Morice R.
	adult (spawning)	na	Envirocon 1984a, Morice R.
Chinook	fry (0+)	0/38[1]	Ptolemy 1994, BC wide
	parr (>=1+)	0/0	Raleigh et al. 1986, North America
	adult (spawning)	na	Vincent Lang et al. 1985, Middle Susitna River, AK
Pink	adult (spawning)	na	Raleigh et al. 1986, North America
Mountain	fry (0+)	0/0	U.S. Fish and Wildlife Service, Fort Collins, CO
whitefish	parr (>=1+)	0/0	U.S. Fish and Wildlife Service, Fort Collins, CO
	adult (spawning)	na	U.S. Fish and Wildlife Service, Fort Collins, CO
Bull trout	fry (0+)	0/0	U.S. Fish and Wildlife Service, Fort Collins, CO
	parr (>=1+)	0/0	U.S. Fish and Wildlife Service, Fort Collins, CO
	adult (spawning)	na	U.S. Fish and Wildlife Service, Fort Collins, CO

[1] P.S. Higgins, B.C. Hydro, unpublished data

Table 2. Seton River discharges prior to regulation and in the past decade.

Month	Average			Minimum			Maximum		
	pre-regulation (1914-1925)	recent (1984-1993)	change (%)	pre-regulation (1914-1925)	recent (1984-1993)	change (%)	pre-regulation (1914-1925)	recent (1984-1993)	change (%)
JAN	6.70	8.79	31%	3.68	5.36	46%	14.2	43.3	205%
FEB	5.58	8.60	54%	3.68	4.70	28%	8.50	47.0	453%
MAR	5.21	13.8	165%	3.68	5.13	39%	6.51	52.3	703%
APR	8.16	14.3	76%	3.96	4.17	5%	17.6	71.8	308%
MAY	25.0	15.1	-40%	4.25	3.62	-15%	69.1	80.5	16%
JUN	49.0	20.4	-58%	16.8	3.52	-79%	130	177	36%
JUL	55.5	33.9	-39%	18.4	5.05	-73%	103	174	69%
AUG	29.8	30.8	3%	16.8	9.54	-43%	64.6	137	112%
SEP	16.9	20.4	21%	9.91	10.3	4%	30.6	120	292%
OCT	9.91	14.5	47%	4.53	10.5	132%	17.6	65.3	271%
NOV	8.51	10.5	24%	4.53	5.84	29%	17.3	17.6	2%
DEC	7.66	7.33	-4%	4.53	5.50	21%	12.7	14.2	12%
YEAR	20.0	16.6	-17%	3.68	3.52	-4%	130	177	36%

Table 3. Summary of hydraulic parameters for Seton River transects in December 1993.
Flow was approximately 7 m^3/s.

Transect	Reach	Gradient (m/m)	Average depth (m)	Maximum depth (m)	Average velocity (m^3/s)	Maximum velocity (m^3/s)	Wetted width (m)
653	1	0.0088	0.57	1.35	0.70	1.35	22.9
700	1	0.0081	0.57	1.25	0.77	1.14	23.5
840	1	0.0078	0.29	0.74	1.00	1.87	36.5
1707	1	0.0018	0.35	1.00	0.64	1.14	39.0
1730.4	1	0.0024	0.56	0.89	0.54	1.04	27.0
1772.6	1	0.0027	0.91	1.25	0.45	0.78	19.3
2205.5	1	0.0418	0.53	0.78	0.95	1.57	12.2
2221	1	0.0345	0.37	0.72	1.17	2.17	24.4
2243.5	1	0.0295	0.35	0.83	0.89	1.80	30.9
2329.5	1	0.0029	0.38	0.72	0.62	1.30	36.1
2412	1	0.0025	0.73	1.20	0.50	0.87	23.9
2492	1	0.0021	0.68	1.03	0.68	1.37	20.6
3321.5	2	0.0002	0.49	1.15	0.69	1.14	22.3
3383.4	2	0.0002	0.94	1.65	0.37	0.75	17.9
3450	2	0.0042	0.44	0.92	0.66	1.49	25.5
3488	2	0.0043	1.07	1.60	0.24	0.91	25.1
3521	2	0.0044	0.54	1.11	0.59	1.00	22.2

Table 4. Errors in wetted width, depth, and velocity simulation.

A) Primary calibration flow (December 1993)

Hydraulic Unit	Parameter	Calibration	Simulation	Difference	% Difference
RIFFLE	Wetted width	27.47	25.82	-1.65	-6%
	Mean depth	0.43	0.49	0.06	13%
	Mean velocity	0.77	0.69	-0.08	-12%
RUN	Wetted width	22.72	23.24	0.53	2%
	Mean depth	0.74	0.72	-0.01	-2%
	Mean velocity	0.52	0.52	0.00	0%
COMBINED	Wetted width	25.23	24.61	-0.63	-3%
	Mean depth	0.57	0.60	0.03	5%
	Mean velocity	0.66	0.61	-0.04	-7%

B) Secondary calibration flow (November 1993)

Hydraulic Unit	Parameter	Calibration	Simulation	Difference	% Difference
RIFFLE	Wetted width	32.21	28.03	-4.18	-15%
	Mean depth	NA	NA	NA	NA
	Mean velocity	NA	NA	NA	NA
RUN	Wetted width	25.42	24.62	-0.80	-3%
	Mean depth	NA	NA	NA	NA
	Mean velocity	NA	NA	NA	NA
COMBINED	Wetted width	29.01	26.42	-2.59	-10%
	Mean depth	NA	NA	NA	NA
	Mean velocity	NA	NA	NA	NA

Table 5. Average weighted usable widths in the Seton River based on depth, velocity and substrate.

Species	Hydraulic Unit	Life History Stage	Discharge @ 7 m^3/s	Discharge @ 13 m^3/s	% Change	P value[1]
Chinook	*Riffle*	Fry	5.37	4.04	-25%	0.087
		Parr	4.73	4.22	-11%	0.130
		Adult	0.58	0.46	-21%	0.358
	Run	Fry	5.85	6.57	12%	0.288
		Parr	3.73	4.05	9%	0.444
		Adult	0.00	0.00	na	0.500
	Combined	Fry	5.60	5.23	-7%	0.089
		Parr	4.26	4.14	-3%	0.246
		Adult	0.31	0.24	-21%	0.358
Coho	*Riffle*	Fry	3.02	1.87	-38%	0.055
		Parr	2.54	1.92	-24%	0.069
		Adult	0.77	0.89	16%	0.297
	Run	Fry	3.99	3.33	-17%	0.081
		Parr	2.94	1.81	-39%	**0.013**
		Adult	0.00	0.00	na	0.500
	Combined	Fry	3.48	2.56	-27%	**0.020**
		Parr	2.73	1.87	-32%	**0.002**
		Adult	0.41	0.47	16%	0.297
Pink	*Riffle*	Adult	0.59	0.60	1%	0.358
	Run	Adult	0.00	0.00	na	0.500
	Combined	Adult	0.31	0.32	1%	0.250
Rainbow	*Riffle*	Fry	7.38	6.52	-12%	0.430
		Parr	7.60	6.50	-14%	0.107
		Adult	0.66	0.67	2%	0.395
	Run	Fry	4.70	3.33	-29%	0.062
		Parr	8.67	9.38	8%	0.337
		Adult	0.00	0.00	na	0.500
	Combined	Fry	6.12	5.02	-18%	0.143
		Parr	8.10	7.86	-3%	0.105
		Adult	0.35	0.35	0%	0.395
Mountain whitefish	*Riffle*	Fry	0.15	0.17	9%	0.233
		Parr	3.09	3.79	23%	**0.010**
		Adult	2.22	2.97	34%	0.087
	Run	Fry	0.96	0.63	-35%	**0.014**
		Parr	5.62	5.48	-2%	0.444
		Adult	3.79	2.84	-25%	0.164
	Combined	Fry	0.53	0.38	-28%	**0.037**
		Parr	4.28	4.59	7%	0.123
		Adult	2.96	2.91	-2%	0.491
Bull trout	*Riffle*	Fry	5.61	5.21	-7%	0.339
		Parr	2.33	2.45	5%	0.430
		Adult	1.32	1.51	14%	0.500
	Run	Fry	3.73	2.75	-26%	**0.032**
		Parr	3.99	3.59	-10%	0.368
		Adult	0.52	0.48	-8%	0.250
	Combined	Fry	4.72	4.05	-14%	0.204
		Parr	3.11	2.99	-4%	0.344
		Adult	0.94	1.02	9%	0.297

1 One-tailed P value determined by a Wilcoxon Matched-Pairs Signed-Ranks Test

Table 6. Weighted usable widths in the Seton River based on depth and velocity comparison of general and river-specific criteria.

Species	Life History Stage	Period	Criteria Type	Criteria Source	Discharge @ 7 m³/s	Discharge @ 13 m³/s	% Change	P value[1]
Chinook	Fry	day	general	Ptolemy 1994, BC wide	6.28	6.00	-4%	0.089
	Fry	night	river-specific	B.C. Hydro data, Seton River[2]	2.23	1.92	-14%	0.293
Rainbow	Fry	day	general	Ptolemy 1994, BC wide	6.58	5.93	-10%	0.472
	Fry	night	river-specific	B.C. Hydro data, Seton River[2]	1.32	1.07	-19%	0.123
	Parr	day	general	Ptolemy 1994, BC wide	9.31	8.98	-4%	0.123
	Parr	day	river-specific	B.C. Hydro data, Seton River[2]	3.80	4.30	13%	0.416
	Parr	night	river-specific	B.C. Hydro data, Seton River[2]	1.51	0.98	-35%	0.004

1 One-tailed P value determined by a Wilcoxon Matched-Pairs Signed-Ranks Test
2 P.S. Higgins, B.C. Hydro, pers.comm.

Table 7. Usability of habitat in the Seton River by species and life history stage.

Usability equals weighted usable width as a percent of wetted width.

a) sensitivity of usability to flow change

Species	Life History	Discharge	
	Stage	@ 7 m³/s	@ 13 m³/s
Chinook	*fry*	23%	19%
	parr	17%	14%
	adult	1%	1%
Coho	*fry*	15%	9%
	parr	11%	7%
	adult	1%	1%
Pink	*adult*	1%	1%
Steelhead	*fry*	23%	17%
	parr	33%	28%
	adult	1%	1%
Mountain whitefish	*fry*	2%	2%
	parr	17%	16%
	adult	12%	10%
Bull trout	*fry*	17%	13%
	parr	12%	11%
	adult	3%	3%

b) sensitivity of usability to habitat model variables

Species	Life History	Habitat Model Variables	
	Stage	depth, velocity and cover	depth and velocity
Chinook	*fry*	23%	26%
	parr	17%	19%
	adult	1%	35%
Coho	*fry*	15%	17%
	parr	11%	13%
	adult	1%	37%
Pink	*adult*	1%	40%
Steelhead	*fry*	23%	24%
	parr	33%	38%
	adult	1%	52%
Mountain whitefish	*fry*	2%	12%
	parr	17%	29%
	adult	12%	27%
Bull trout	*fry*	17%	19%
	parr	12%	21%
	adult	3%	38%

Table 8. Validation of standing stock estimates calculated from weighted usable area.

a) August 1993

Species/Life History	Observed Standing Stock[1]		Predicted Standing Stock[2]
	point estimate	95% confidence interval	
chinook fry	2,900	1900 to 4000	1,423
coho fry	1,400	200 to 2600	435
steelhead fry	1,200	700 to 1800	5,097
steelhead parr	100	0 to 300	403

b) November 1993

Species/Life History	Observed Standing Stock[1]		Predicted Standing Stock[2]
	point estimate	95% confidence interval	
chinook fry	1,800	900 to 2700	646
coho fry	1,000	400 to 1600	121
steelhead fry	400	0 to 1200	4,975
steelhead parr	1,200	200 to 2200	463

NOTES:
[1] Based on electrofishing by Lister and Beniston (1995)
[2] Weighted usable area calculated using general habitat suitability curves at average flow during low flow period.

Table 9. Predicted flow requirements in the Seton River using the Montana and Swift's methods.

	Summary Reach data		REACH 1	REACH 2
	River Length	(m)	2600	2100
	Existing Mean Annual Flow (MAF)[1]	(m^3/s)	30.5	16.6
	Pre-project MAF[2]	(m^3/s)	39.3	19.1
	Drainage area	(km^2)	1918	1040
(1) Montana method based on Mean Annual Flow (MAF)			**REACH 1**	**REACH 2**
Existing	Spawning flow (@ 30% MAF)	(m^3/s)	9.16	4.98
	Rearing flow (@ 20% MAF)	(m^3/s)	6.11	3.32
Pre-project	Spawning flow (@ 30% MAF)	(m^3/s)	11.8	5.74
	Rearing flow (@ 20% MAF)	(m^3/s)	7.85	3.83
(2) Swift's method based on Mean Annual Flow (MAF)			**REACH 1**	**REACH 2**
Existing	Preferred spawning flow	(m^3/s)	22.0	14.0
	Preferred rearing flow	(m^3/s)	6.13	3.71
Pre-project	Preferred spawning flow	(m^3/s)	26.6	15.5
	Preferred rearing flow	(m^3/s)	7.54	4.17
(3) Swifts's method based on drainage area			**REACH 1**	**REACH 2**
Existing	Preferred spawning flow	(m^3/s)	42.7	28.0
	Preferred rearing flow	(m^3/s)	13.6	8.41
Pre-project	Preferred spawning flow	(m^3/s)	42.7	28.0
	Preferred rearing flow	(m^3/s)	13.6	8.41
AVERAGE - all three methods (1) - (3)			**REACH 1**	**REACH 2**
Existing	Spawning flow	(m^3/s)	24.6	15.7
	Rearing flow	(m^3/s)	8.62	5.15
Pre-project	Spawning flow	(m^3/s)	27.0	16.4
	Rearing flow	(m^3/s)	9.67	5.47

[1] Period 1984 to 1993
[2] Period 1915 to 1926

Table 10. Flow trade-offs and optima for the Seton River.

a) Trade-offs with rearing guild

Conflicting Guild	Period	Flow preferred for conflicting guild	Optimum flows (trade-off with rearing guild)	Loss in habitat for rearing guild
Portage sockeye homing[1]	mid-July to late August	>5	9.2	15%
Gates sockeye homing[1]	late September to mid November	>10	5.6	40%
Pink incubation	November to February	5.8	5.8	15%
Pink spawning	October and November	30.0	10.6	45%
Pink spawning (gravel enhanced)	October and November	15.0	7.5	27%
Steelhead spawning	May and June	>6	6.0	12%
Spring freshet	May to August	47.0	15.0	60%

[1] Median Cayoosh inflow assumed to be 1 m^3/s.

b) Median daily flow by month in m^3/s.

Month	Existing Regime	Natural Regime	% Change (percent change relative to natural)	Habitat Regime	Optimum Regime (habitat + natural regimes)
JAN	6.90	6.37	8%	5.80	5.80
FEB	6.75	4.76	42%	5.80	5.80
MAR	6.90	5.38	28%	5.80	5.80
APR	6.89	8.50	-19%	5.80	5.80
MAY	6.58	19.5	-66%	6.00	7.52
JUN	6.68	47.0	-86%	6.00	18.1
JUL	12.0	47.0	-75%	9.20	18.1
AUG	13.7	28.3	-52%	9.20	10.9
SEP	12.7	15.9	-20%	5.60	5.60
OCT	12.5	9.91	26%	7.50	7.50
NOV	12.1	7.36	64%	7.50	7.50
DEC	6.53	7.36	-11%	5.80	5.80

10. APPENDICES

APPENDIX 10.1. STUDY PLAN

STUDY PLAN — SETON RIVER INSTREAM FLOW STUDY

Introduction

B.C. Hydro initiated a study to quantify the instream flow requirements of the fisheries resources of the Seton River. A fisheries maintenance flow has been released since the commissioning of the dam, but professional judgement was used to set instream flows. This plan details the activities required to complete an instream flow study that will assess the relationship between flow and fish habitat.

Objective

The objective is to evaluate the current flow release regime from Seton Dam. This assessment will quantitatively consider the seasonal flow needs for habitat protection and maintenance of fish stocks in the Seton River and required fish passage flows for Gates/Portage system stocks.

Study Area

The geographic boundaries of the study area are the Seton River from Seton Dam to the confluence with the Fraser River.

Species of Interest

The study will focus on pink salmon and rainbow trout, but also consider coho and chinook salmon. There are few data on the habitat used by sockeye salmon and Dolly Varden char (bull trout?) in the Seton River, accordingly the assessment of these species will be restricted.

Flows of Interest

The flow regime of the Seton River is influenced by the operation of the La Joie and Shalalth inflows, and the operation of the Seton River generating station. For the purpose of this assessment the flow record has been broken into three periods;

Pre-Bridge Diversion/Seton Dam	1914 - 1926
Pre-Seton Dam	1950 - 1958
Current	1959 - 1992

Historically the flow averaged 30.7 $m^3 s^{-1}$ during the growing season, 12.7 $m^3 s^{-1}$ during the spawning season, and 18.9 $m^3 s^{-1}$ during incubation. Following the diversion of the Bridge River into the Seton watershed at Shalath, the flow increased 233% during the growing season, 446% during spawning, and 354 % during incubation. This higher flow regime persisted for just 8 years at which time the Seton Project was developed. The existing flow regime is similar to the original flow with 84% of the historical flow during the growing season, 140% of the historical flow during spawning, and 187% of the historical flow during incubation. The attached figure shows the flow during each season for each period.

The assessment will examine flows from 2 to 22 $m^3 \cdot s^{-1}$. The upper limit is dictated by our confidence in extrapolation from the field data, which were collected at flows of 5.6 and 11.2 $m^3 \cdot s^{-1}$.

Methodology

The Instream Flow Incremental Methodology (IFIM) is proposed as the most appropriate technique to accomplish the objectives of the study. The potential response of a number of species to changes in flow will be evaluated over the length of the river. Several scenarios of flow release will be examined. Hydraulic models will be needed to predict flow conditions outside those measured to date.

IFIM will be used to assess existing habitat conditions and predict total habitat at different flows. The output from the IFIM study will be used to generate total habitat time series for each reach and the total river area. Habitat available under historical (pre-dam) and existing flow conditions will be compared (see next section for a description of the flow regime and alternatives). These time series data will allow comparison of total habitat from alternative flow regimes.

Hydraulic Data Collection

Detailed field surveys have been completed. At each transect the cross-sectional profile was surveyed up to the point of rooted vegetation, and the hydraulic control was identified and surveyed. During 1993 the water surface elevation (WSE) was surveyed at two flow levels (5.6 and 11.2 m^3.s-1). Including the hydraulic control elevation (zero flow), three water surface elevations are available at each transect, and these can be used to construct an empirical stage-discharge curve for each transect.

At each transect 20 or more measurements of depth, velocity and substrate were taken across the channel during the lower flow observed. Water velocity was measured at 0.2, 0.4 and 0.8 of depth.

Habitat Preferences

Habitat preferences were measured in the field during 1994 and have been analyzed by the Strategic Fisheries Project at BC Hydro. These data will be used to assess available habitat at higher flows.

Modelling

We will apply an Excel spreadsheet model resembling the IFG4 model from the U.S. National Ecology Research Center (Colorado). This model uses the observed stage discharge relationship at each transect to predict water surface elevation, and distributes depths and velocities across the channel based on the observed roughness (i.e. the existing cross-channel distribution). This model will predict depth and velocity at stations across each transect at higher and or lower flows.

The suitability of habitat at alternative flows will be determined by weighting the area around each station (cell) by the suitability for each habitat parameter as determined in the field and provided to Triton by BC Hydro. Suitability during daytime and nighttime may be considered if these curves are provided to Triton. We note that there are no data on winter habitat suitability and suspect that data on adult spawning and incubating habitat are limited. Furthermore, there is no accepted *apriori* way to weight the importance of day and night or summer and winter habitats and it is certainly easier just to select one set of criteria and use them.

Alternative flow regimes will be compared by calculating the amount of habitat available over the season and creating a 'habitat time series'. The habitat time series will be used to infer habitat limitations. Minimum, mean, and cumulative habitat will be compared between different time series.

Macrohabitat

To estimate the fish produced by a particular flow regime, the total weighted useable area time series generated by the IFIM analysis will be multiplied by species/lifestage specific estimates of the standing stock per unit of habitat. Standing stock has been selected because it is a reasonable surrogate measure of fish production. Standing stock will be estimated by:

1. empirical models dependent on macrohabitat characteristics including temperature and water chemistry, and
2. from standing stocks estimates calculated by Lister and Beniston.

Temperature and water chemistry affect habitat at the macrohabitat level and therefore affect standing stock. Seton River water quality is sufficiently homogeneous to be characterized by a single set of values. An empirical model developed by Ministry of Environment Lands and Parks could be used to predict the carrying capacity of juvenile salmonids given a particular water chemistry and habitat usability assemblage.

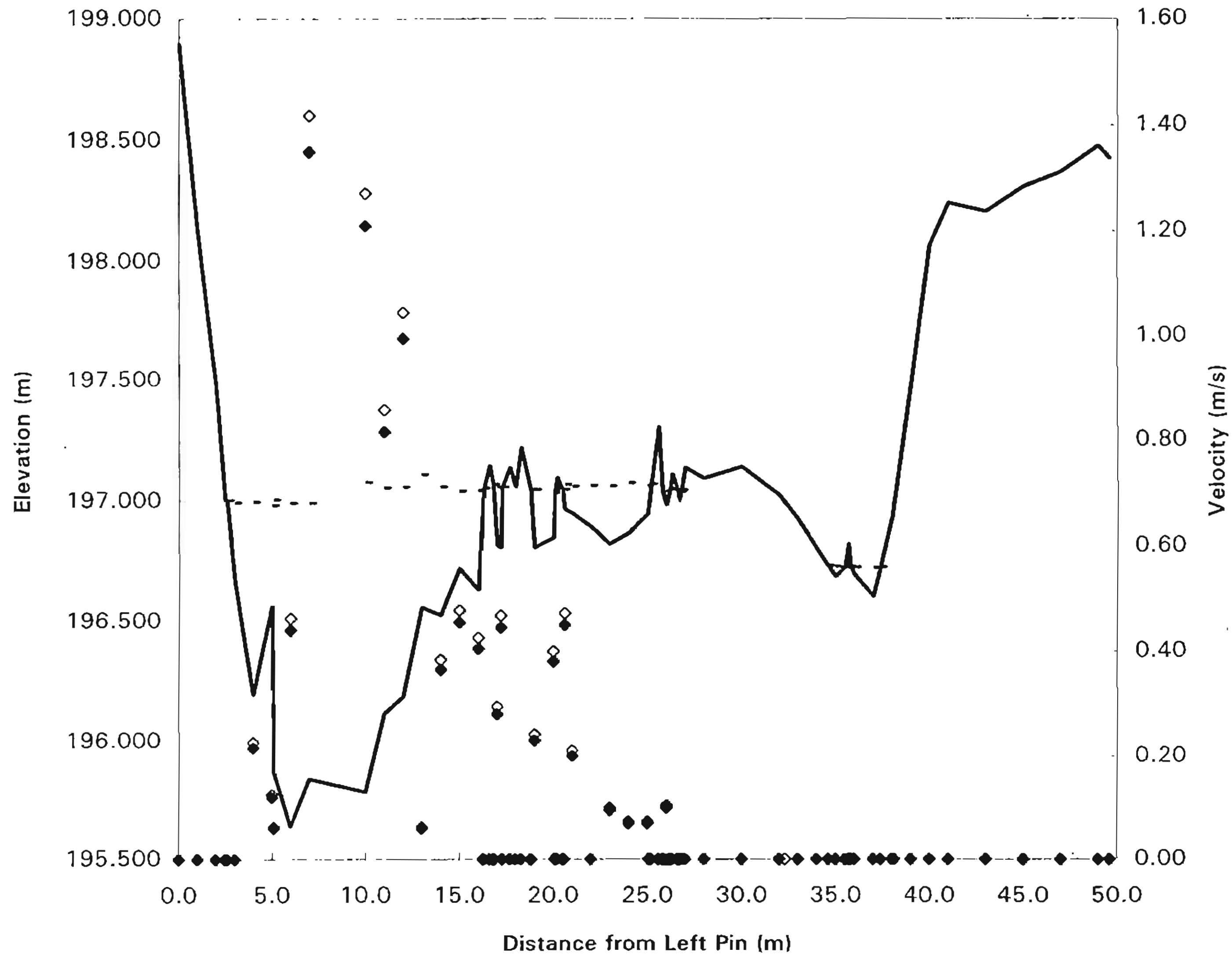
The limiting life history stage(s) can be identified by comparing the theoretical standing stock to the standing stock estimated during field sampling. However, populations and standing stocks estimated in the field may not be at carrying capacity. We will identify potentially limiting habitats by calculating the populations and standing stocks at each life history phase with fecundity, egg-to-smolt (or parr), smolt (or parr)-to-adult survival rates. It is recognized that this component of the project is quite theoretical and of limited value.

Flushing Flow

No assessment of this issue is planned at present. A cursory evaluation using standard setting models shows can be applied is desired, but we believe the results would be of limited use.

APPENDIX 10.2. TRANSECT CROSS-SECTIONS

Seton River Field Survey - Dec '93



Seton R.

TRANSECT 653.0

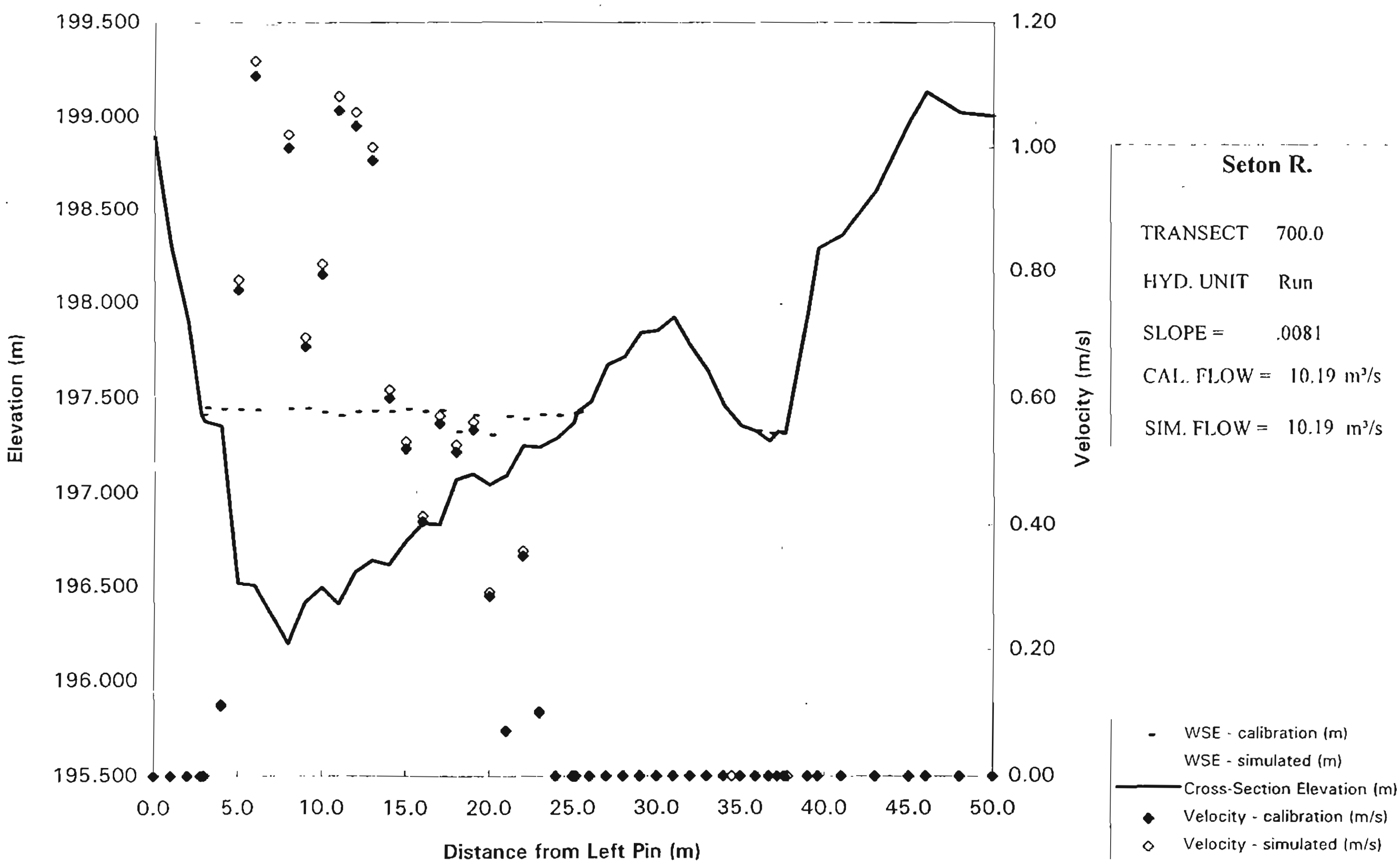
HYD. UNIT Run

SLOPE = .0088

CAL. FLOW = 9.36 m^3/s

SIM. FLOW = 9.36 m^3/s

Seton River Field Survey - Dec '93



Seton R.

TRANSECT 700.0

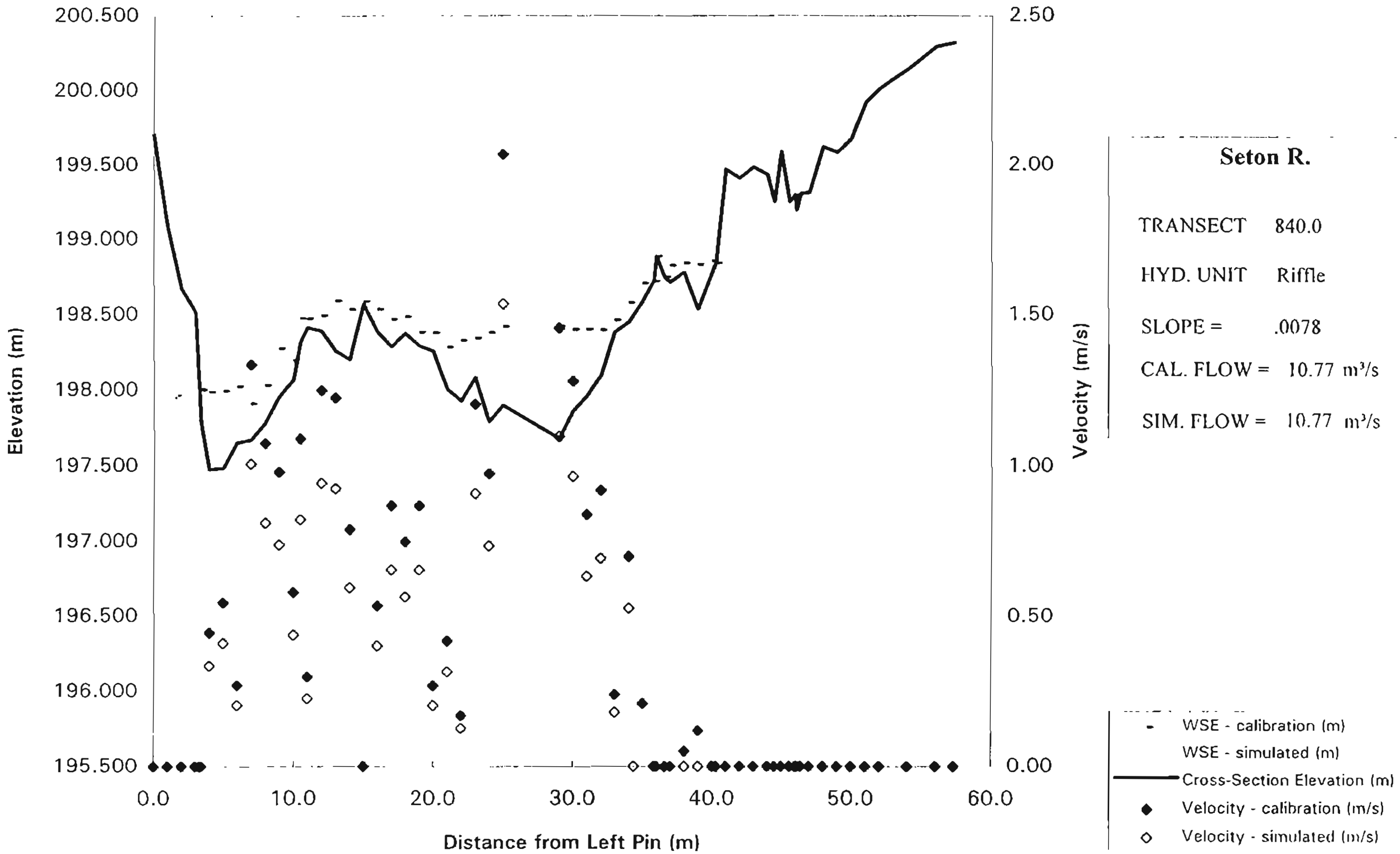
HYD. UNIT Run

SLOPE = .0081

CAL. FLOW = 10.19 m^3/s

SIM. FLOW = 10.19 m^3/s

Seton River Field Survey - Dec '93



Seton R.

TRANSECT 840.0

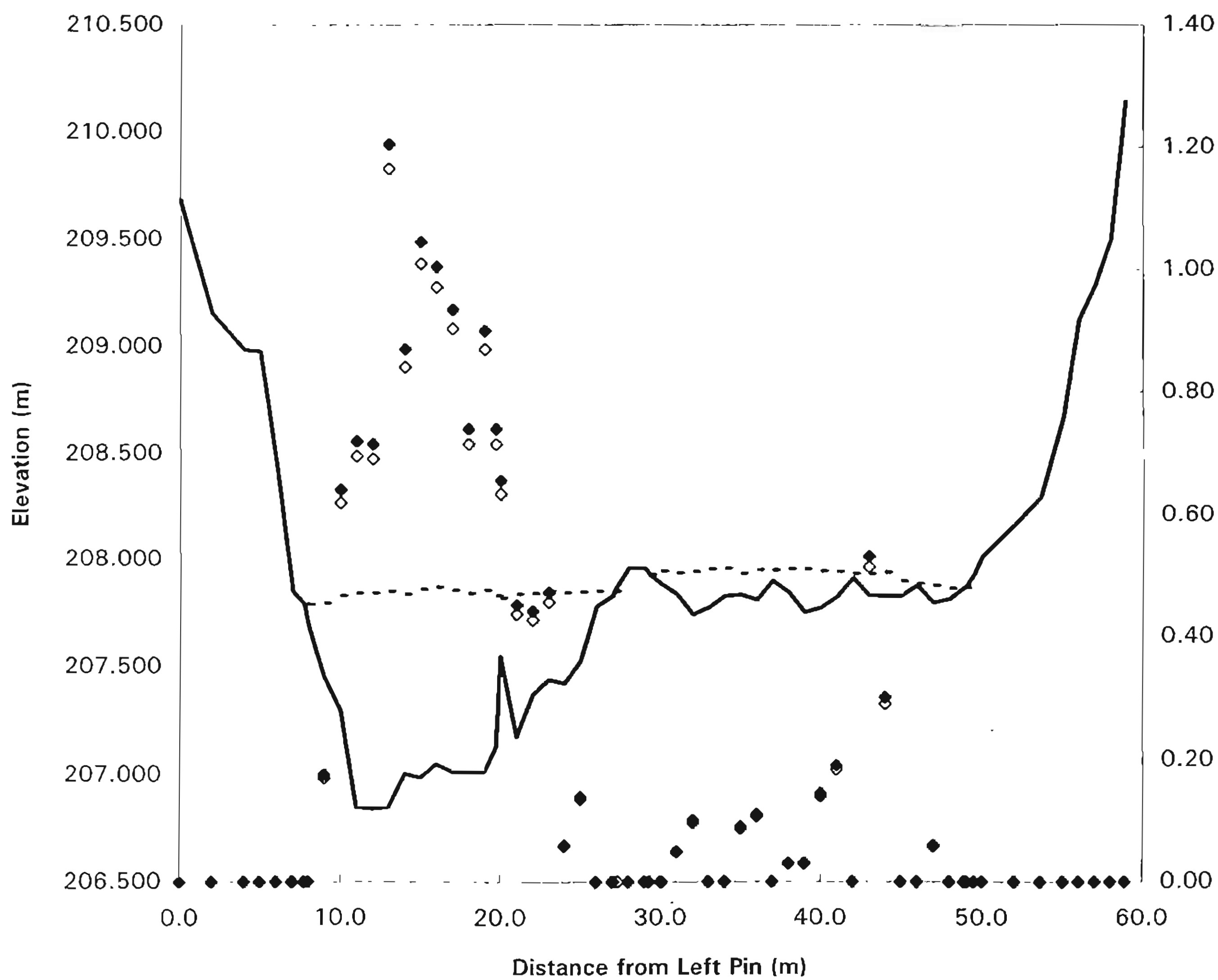
HYD. UNIT Riffle

SLOPE = .0078

CAL. FLOW = 10.77 m³/s

SIM. FLOW = 10.77 m³/s

Seton River Field Survey - Dec '93

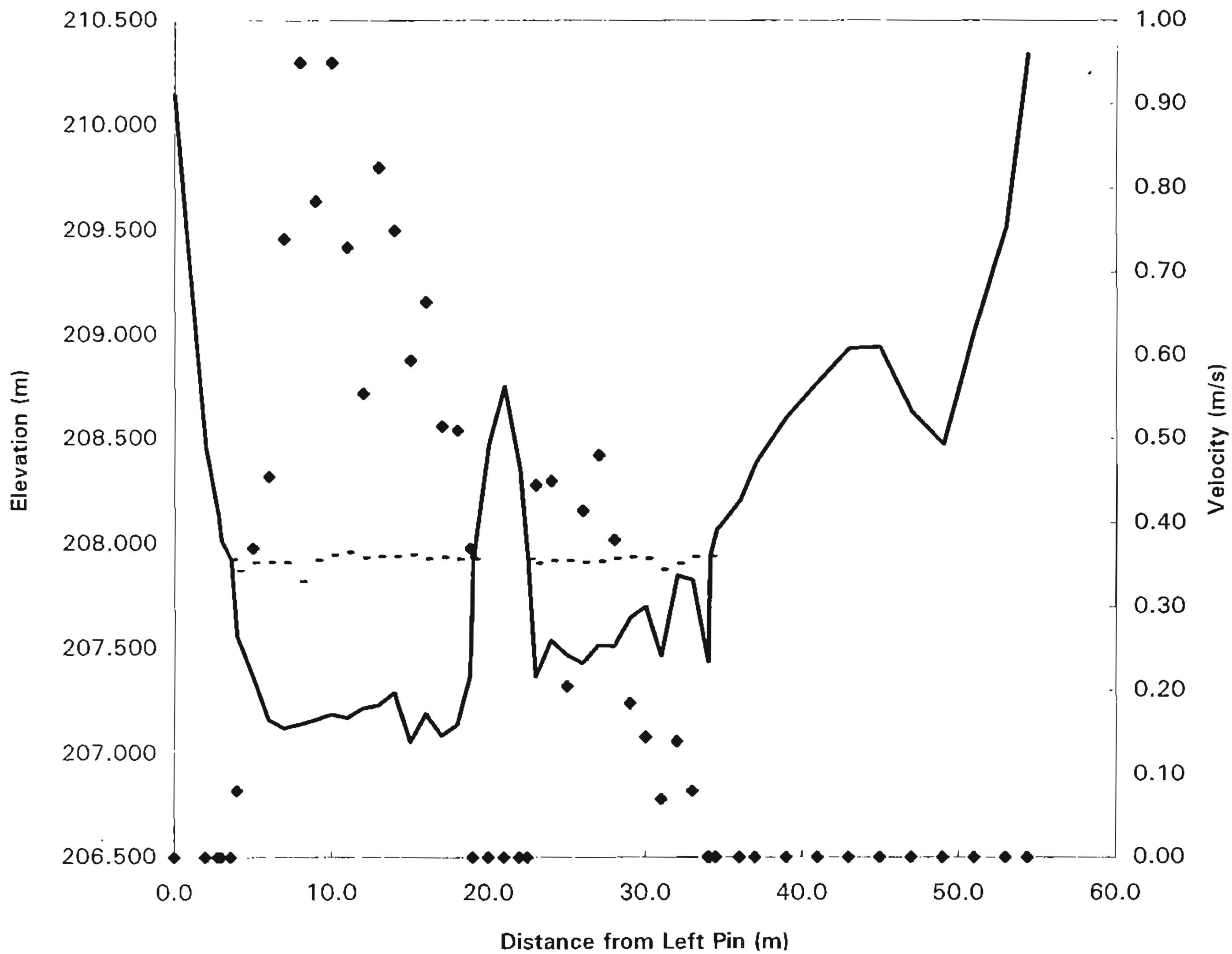


Seton R.

TRANSECT 1707.0
HYD. UNIT Riffle
SLOPE = .0018
CAL. FLOW = 8.87 m^3/s
SIM. FLOW = 8.87 m^3/s

- WSE - calibration (m)
- WSE - simulated (m)
- Cross-Section Elevation (m)
- Velocity - calibration (m/s)
- Velocity - simulated (m/s)

Seton River Field Survey - Dec '93



Seton R.

TRANSECT 1730.4

HYD. UNIT Run

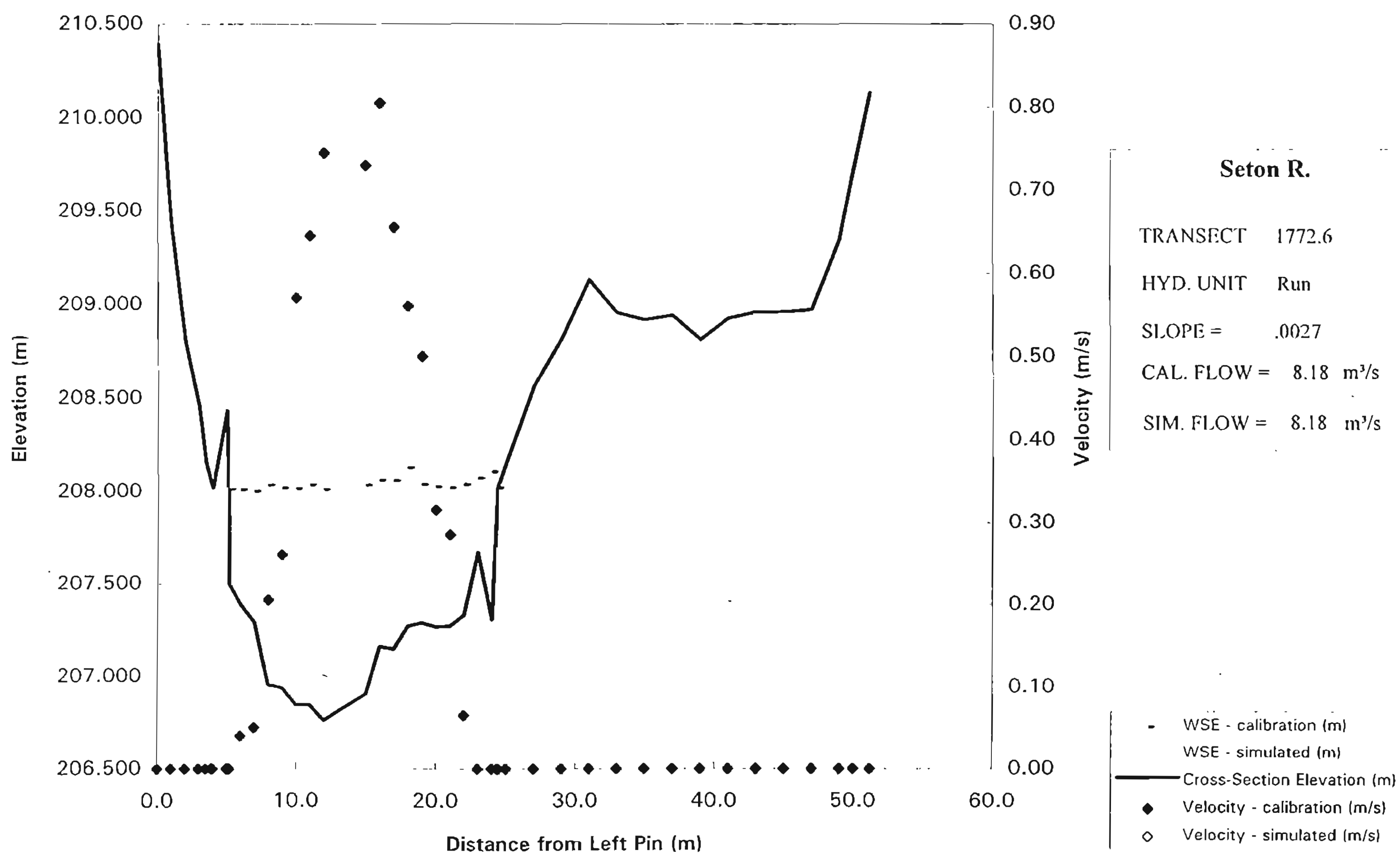
SLOPE = .0024

CAL. FLOW = 8.30 m^3/s

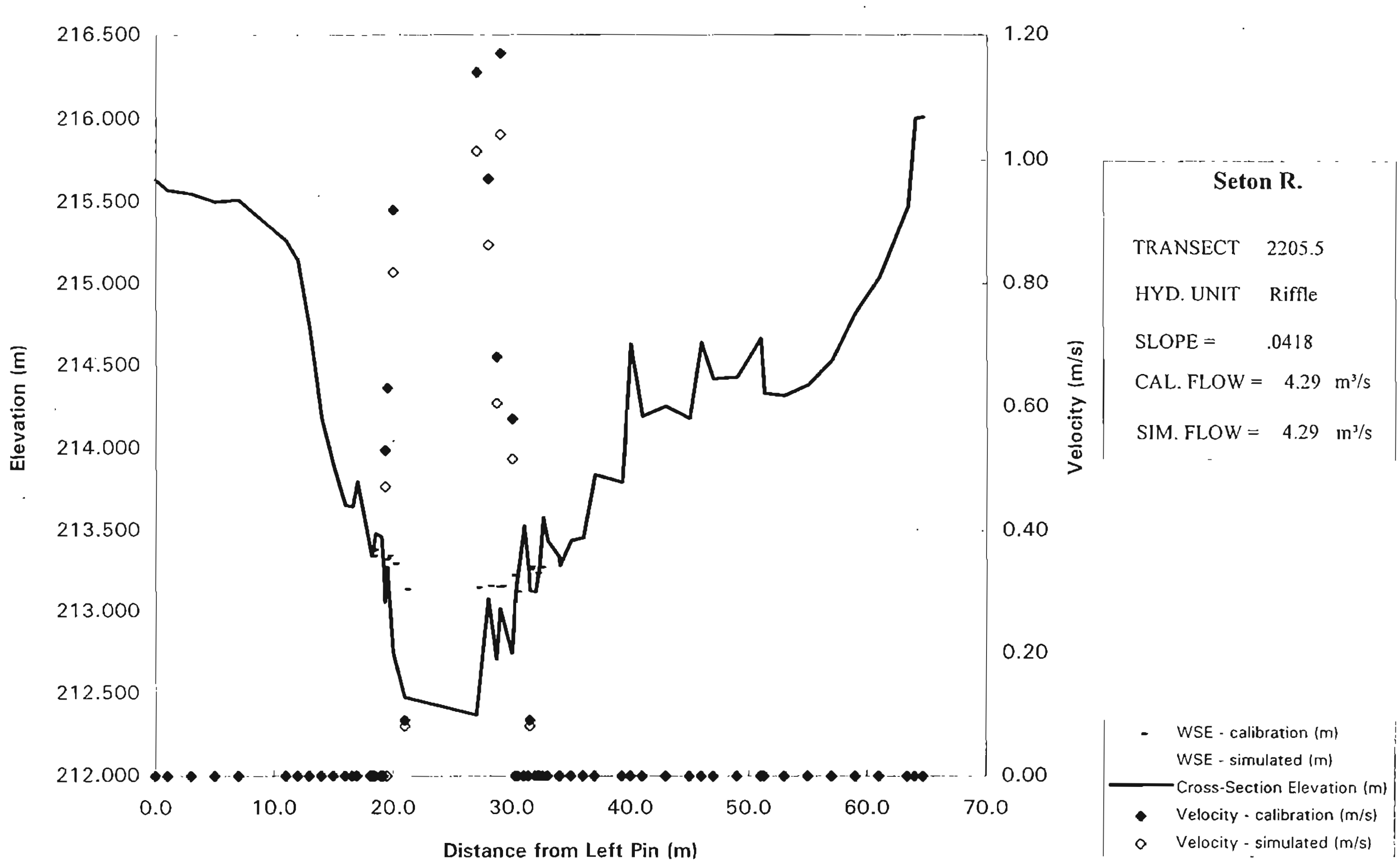
SIM. FLOW = 8.30 m^3/s

- WSE - calibration (m)
- WSE - simulated (m)
- Cross-Section Elevation (m)
- Velocity - calibration (m/s)
- Velocity - simulated (m/s)

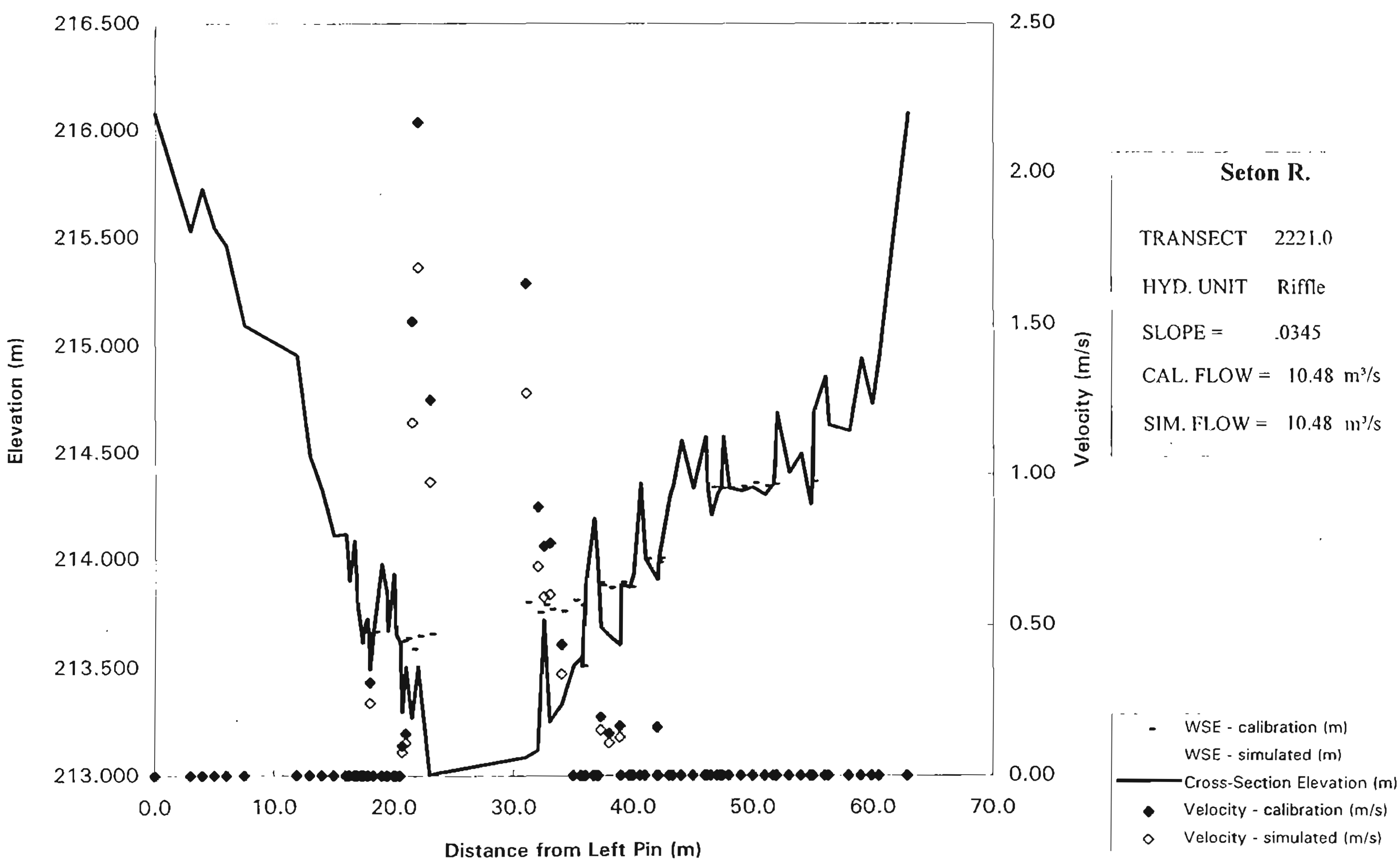
Seton River Field Survey - Dec '93



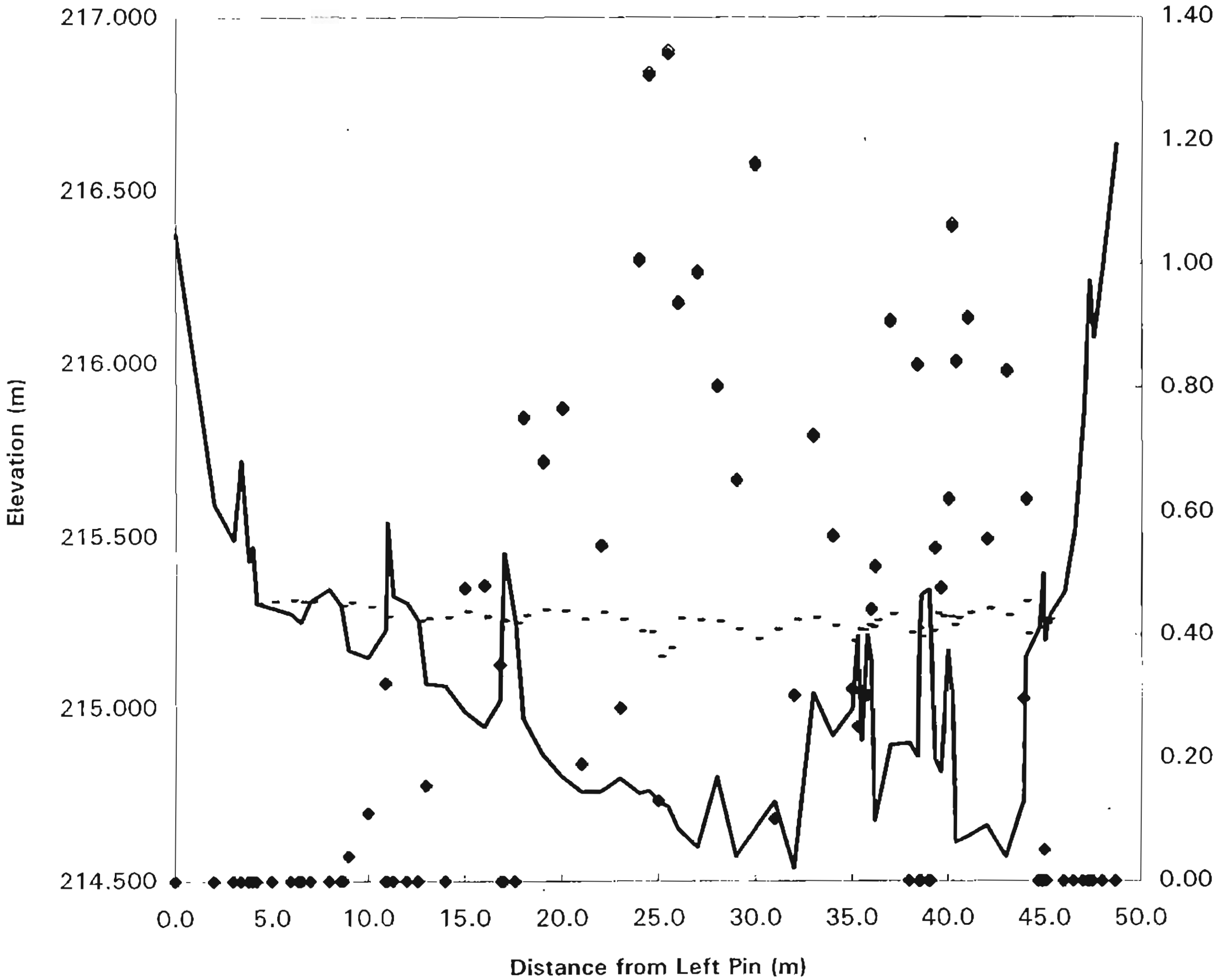
Seton River Field Survey - Dec '93



Seton River Field Survey - Dec '93



Seton River Field Survey - Dec '93



Seton R.

TRANSECT 2329.5

HYD. UNIT Riffle

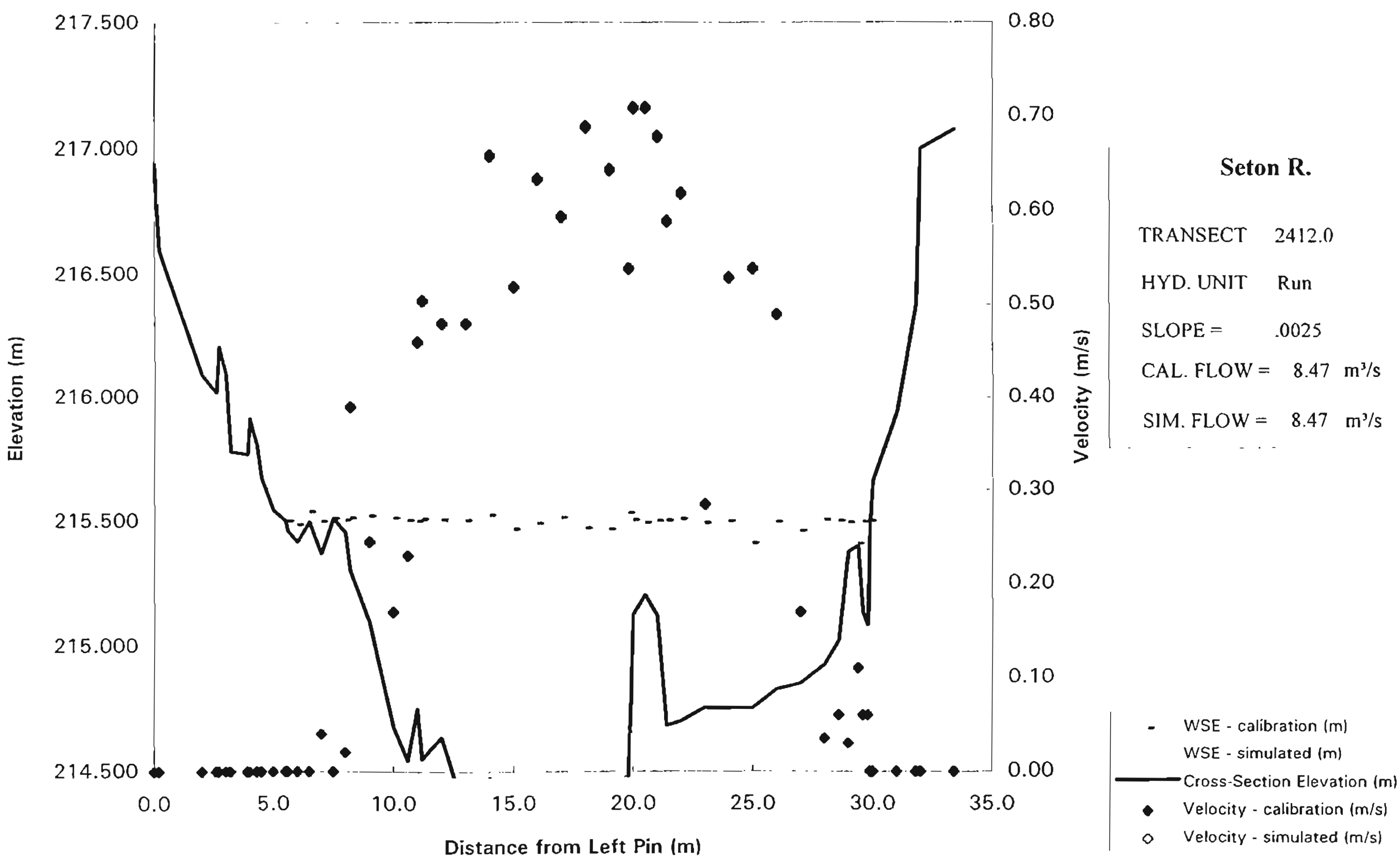
SLOPE = .0029

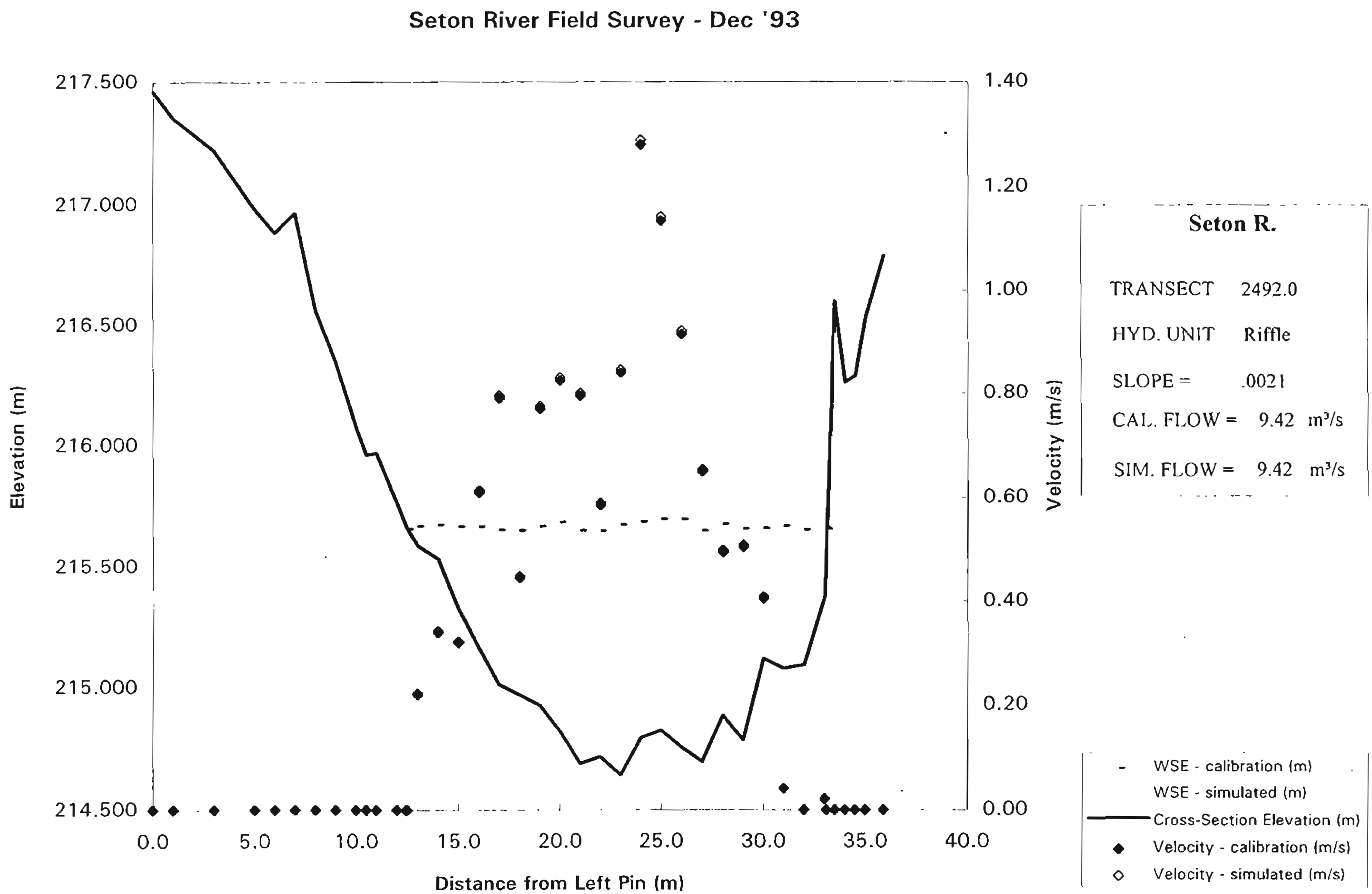
CAL. FLOW = 8.39 m³/s

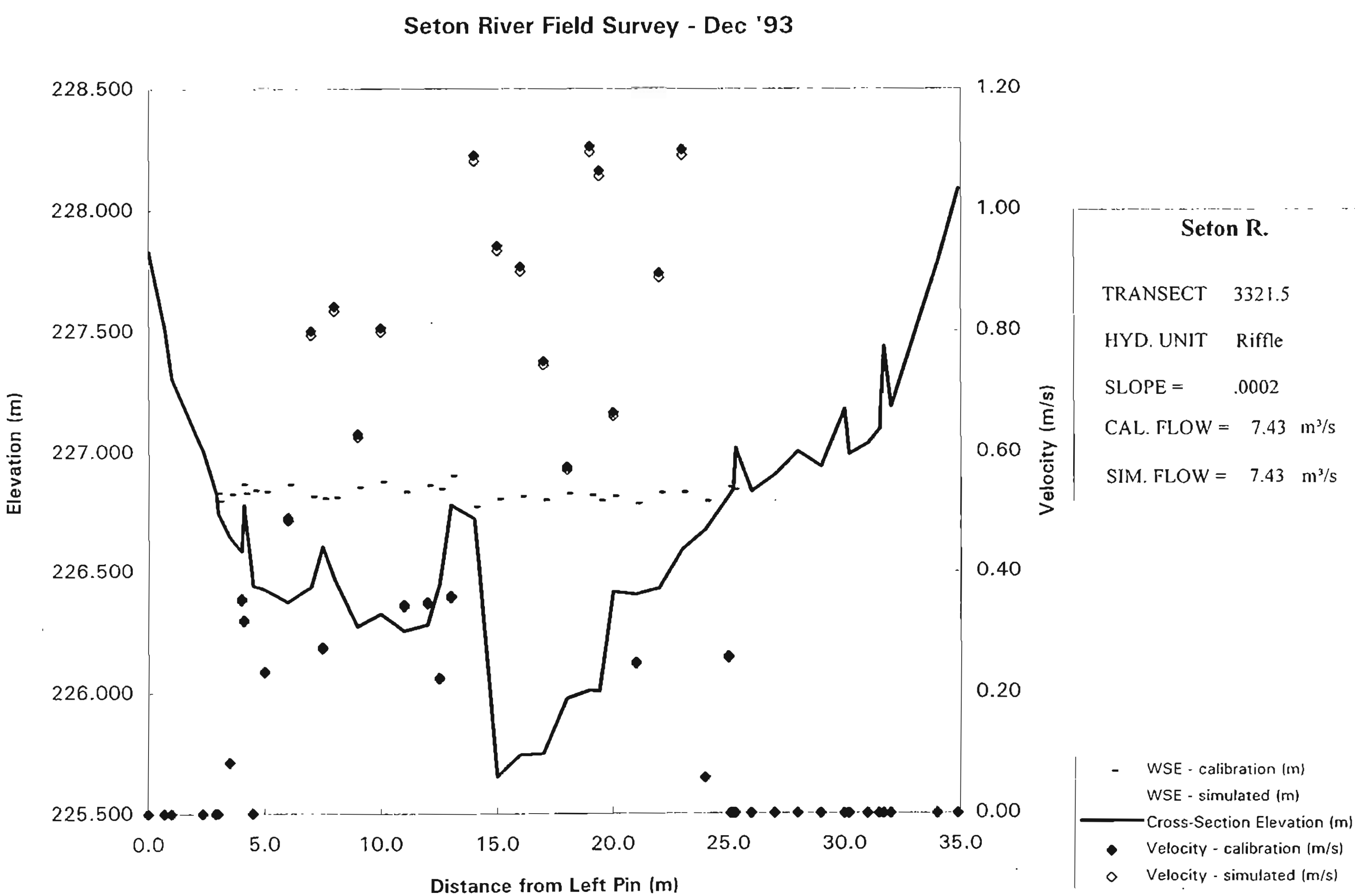
SIM. FLOW = 8.39 m³/s

- WSE - calibration (m)
- WSE - simulated (m)
- Cross-Section Elevation (m)
- Velocity - calibration (m/s)
- Velocity - simulated (m/s)

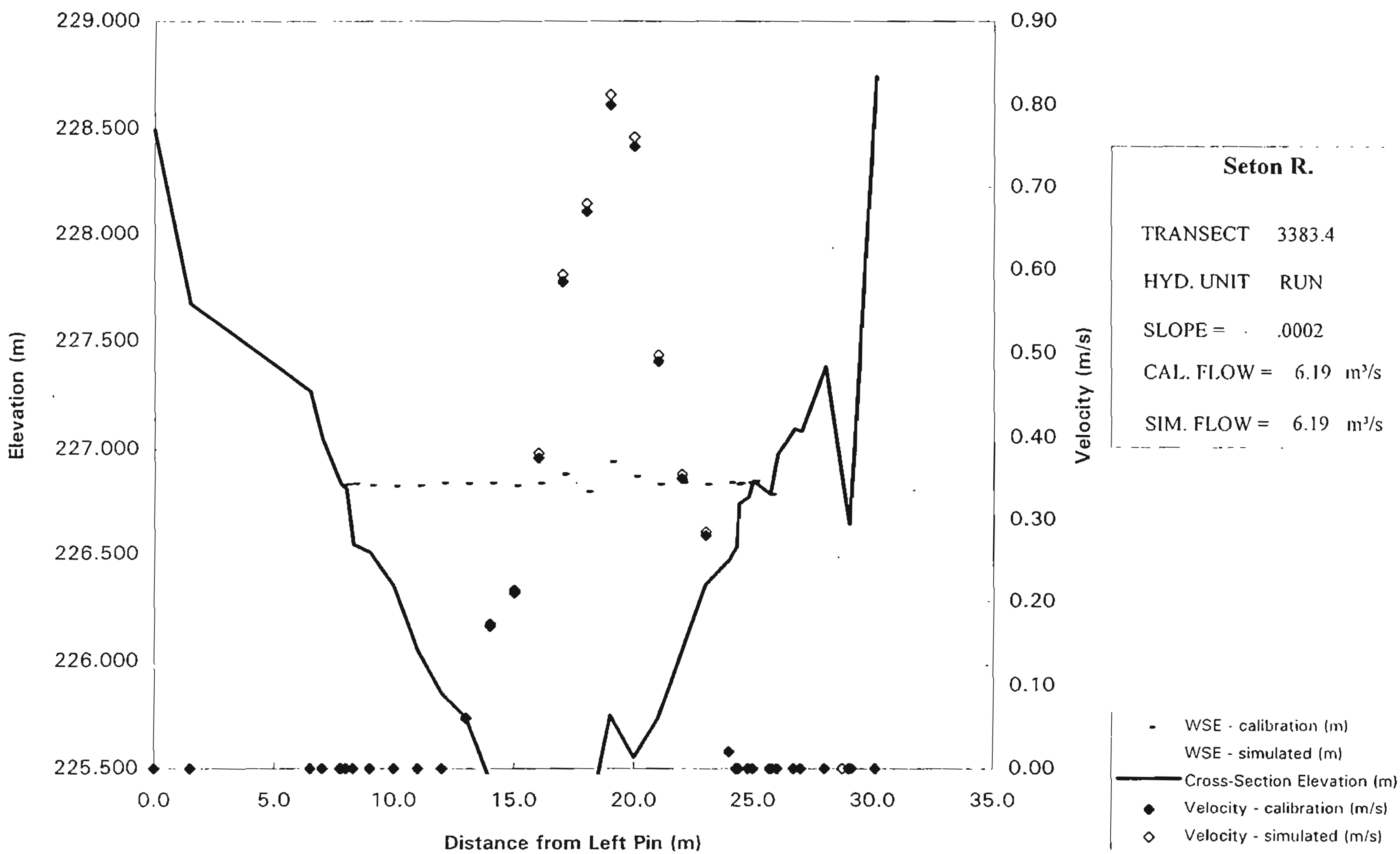
Seton River Field Survey - Dec '93



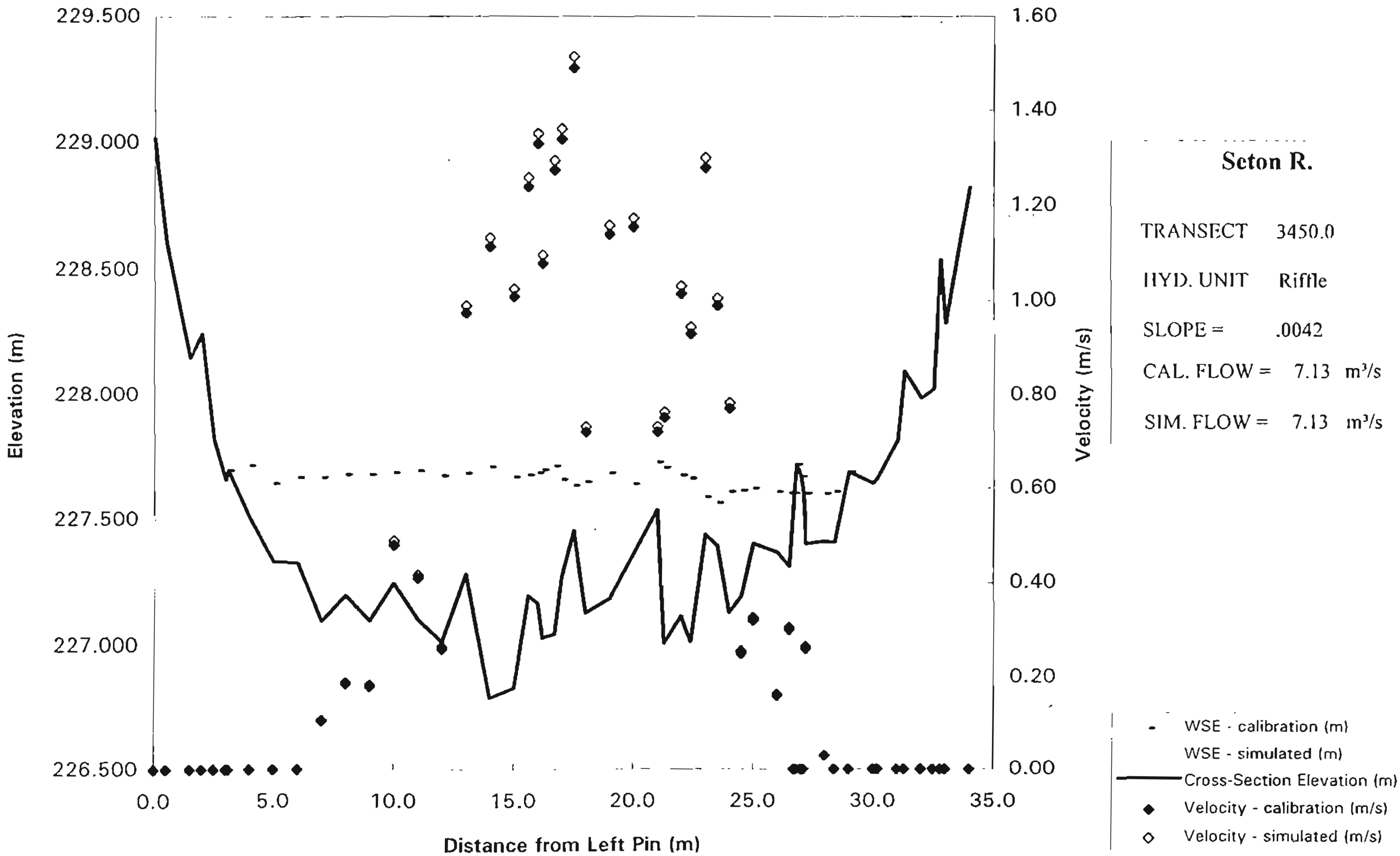

Seton River Field Survey - Dec '93
217.500
217.000
216.500
216.000
215.500
215.000
214.500
Elevation (m)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Velocity (m/s)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
Distance from Left Pin (m)
Seton R.
TRANSECT 2492.0
HYD. UNIT Riffle
SLOPE = .0021
CAL. FLOW = 9.42 m³/s
SIM. FLOW = 9.42 m³/s
WSE - calibration (m)
WSE - simulated (m)
Cross-Section Elevation (m)
Velocity - calibration (m/s)
Velocity - simulated (m/s)


Seton River Field Survey - Dec '93
228.500
228.000
227.500
227.000
226.500
226.000
225.500
Elevation (m)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Velocity (m/s)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Distance from Left Pin (m)
Seton R.
TRANSECT 3321.5
HYD. UNIT Riffle
SLOPE = .0002
CAL. FLOW = 7.43 m³/s
SIM. FLOW = 7.43 m³/s
WSE - calibration (m)
WSE - simulated (m)
Cross-Section Elevation (m)
Velocity - calibration (m/s)
Velocity - simulated (m/s)

Seton River Field Survey - Dec '93



Seton River Field Survey - Dec '93



Seton R.

TRANSECT 3450.0

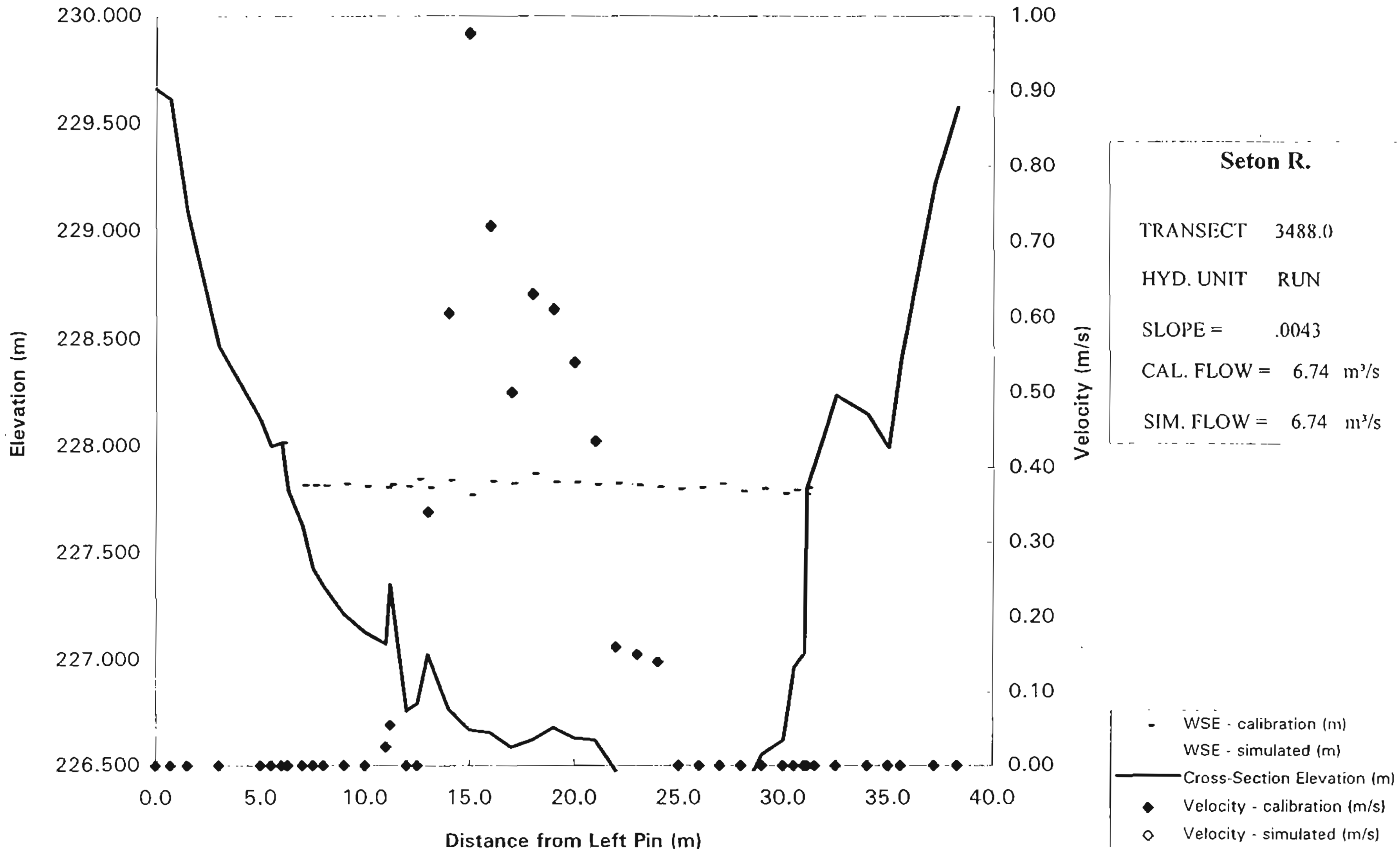
HYD. UNIT Riffle

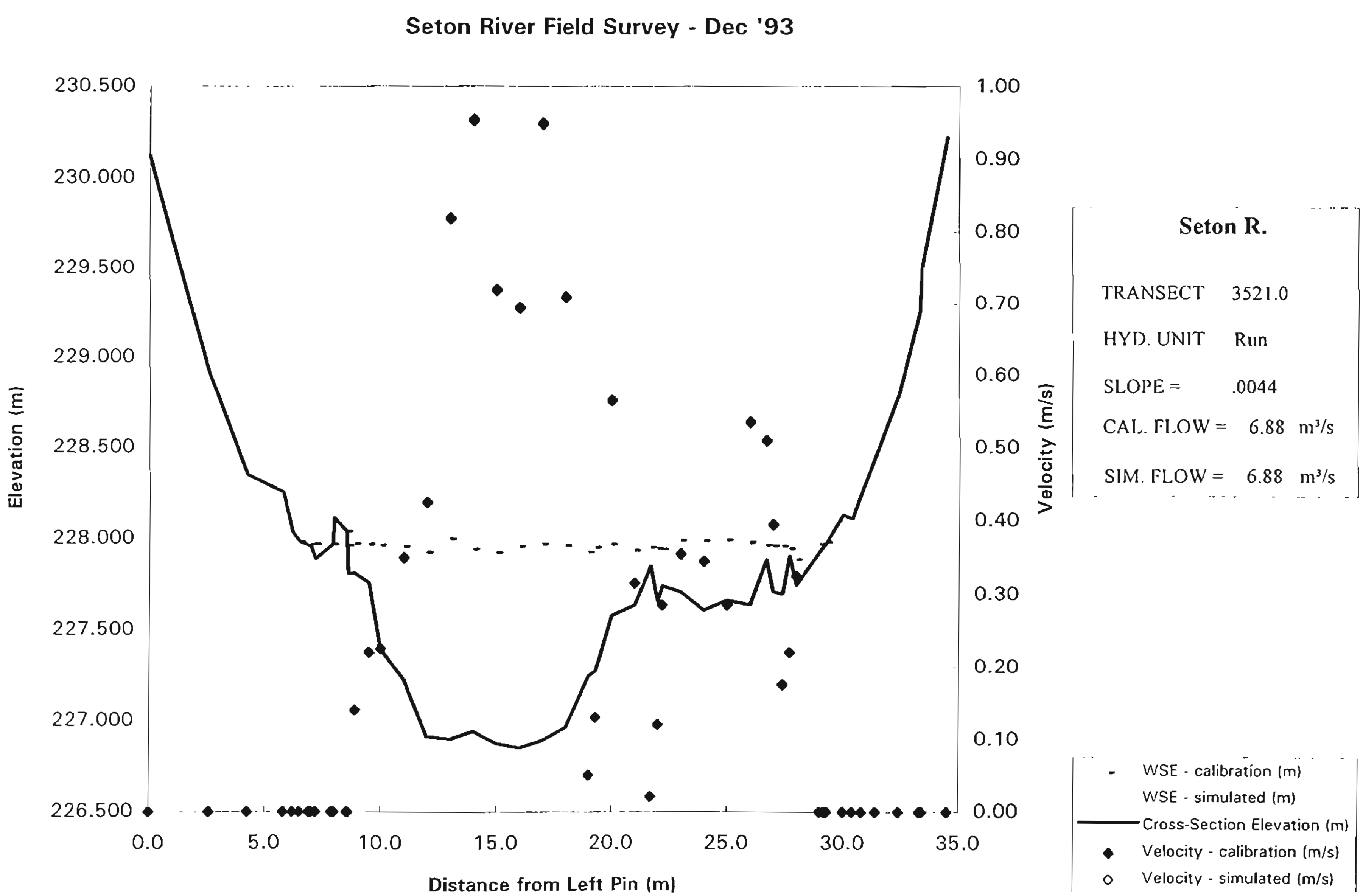
SLOPE = .0042

CAL. FLOW = 7.13 m^3/s

SIM. FLOW = 7.13 m^3/s

Seton River Field Survey - Dec '93




Seton River Field Survey - Dec '93
Elevation (m)
230.500
230.000
229.500
229.000
228.500
228.000
227.500
227.000
226.500
Velocity (m/s)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Distance from Left Pin (m)
Seton R.
TRANSECT 3521.0
HYD. UNIT Run
SLOPE = .0044
CAL. FLOW = 6.88 m³/s
SIM. FLOW = 6.88 m³/s
WSE - calibration (m)
WSE - simulated (m)
Cross-Section Elevation (m)
Velocity - calibration (m/s)
Velocity - simulated (m/s)

APPENDIX 10.3. TRANSECT DATA BY STATION

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT3521.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	3521.0	Channel type	Single	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 6/93	Channel Slope	.0044	surveyed value (m/m)	
Time	09:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/BP/BW	Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 1 2 3

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.691	230.362		229.671														
PIN	0.000			0.24	230.122		10	60	20	10			OV BO CO						
	2.600			1.450	228.912		20	40	20	20			OV BO CO						
	4.250			2.012	228.35		20	40	5	5	10	20	OV BO CO						
	5.800			2.108	228.254		10	20	40	10	10	10	CO						OLD LWE
	6.200			2.326	228.036		10	20	40	10	10	10	CO						
LWE	6.500			2.376	227.986		20	40	20	10		10	BO CO						
	7.000			2.403	227.959			60	20	10		10	CO	0.01	0.00	0.00	0		
	7.200			2.471	227.891			60	20	10		10	CO	0.08	0.00	0.00	0		
RWE	7.950			2.391	227.971		40	20	20	10		10	BO CO						Beside Rock
	8.000			2.250	228.112		40	20	20	10		10	BO CO						On Rock
LWE	8.550			2.322	228.04		40	20	20	10		10	BO CO						On Rock
	8.600			2.548	227.814		30	30	20	10		10	BO CO	0.15	0.00	0.00	0		Beside Rock
	8.900			2.548	227.814			60	20	10		10	CO	0.16	0.14	0.14	0.14		
	9.500			2.601	227.761			60	20	10	5	5	CO	0.21	0.15	0.17	0.29		
	10.000			2.965	227.397		10	35	5	10	20	20	CO	0.57	0.10	0.25	0.35		
	11.000			3.134	227.228		50			5	15	30	BO CO	0.73	0.20	0.45	0.50		Behind Rock
	12.000			3.446	226.916		60		5	5	10	20	BO CO	1.01	0.25	0.35	0.60		Behind Rock
	13.000			3.462	226.9									1.10	0.75	0.94	0.89		
	14.000			3.417	226.945									1.00	0.85	1.00	1.06		
	15.000			3.485	226.877									1.05	0.58	0.85	0.86		
	16.000			3.513	226.849									1.11	0.56	0.96	0.83		DEPTH AT 400 CFS =
	17.000			3.470	226.892									1.08	0.65	0.78	1.25		
	18.000			3.397	226.965									1.00	0.46	0.56	0.96		To cloudy to see substrat
	19.000			3.114	227.248		20	60	10	10			BO CO	0.68	0.00	0.05	0.47		On Rock
	19.300			3.089	227.273		20	60	10	10			BO CO	0.68	0.00	0.13	0.72	340	
	20.000			2.783	227.579		40	50	5	5			BO CO	0.39	0.25	0.55	0.88	320	

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT3521.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	3521.0	Channel type	Single	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 6/93	Channel Slope	.0044	surveyed value (m/m)	
Time	09:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/BP/BW	Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 1 2 3

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	21.000			2.725	227.637		50	30	10	10			BO CO	0.30	0.28	0.33	0.35		
	21.700			2.509	227.853		30	50	10	10			BO CO	0.10	0.02	0.02	0.02		
	22.000			2.704	227.658		30	50	10	10			BO CO	0.29	0.08	0.14	0.16		
	22.200			2.618	227.744		50	30	10	10			BO CO	0.20	0.09	0.30	0.48		Behind Rock
	23.000			2.651	227.711		50	50					BO CO	0.28	0.26	0.50	0.45		
	24.000			2.752	227.61		50	40	5	5			BO CO	0.38	0.26	0.33	0.43		In Front of Rock
	25.000			2.698	227.664		40	30	10	10	10		BO CO	0.33	0.14	0.38	0.43		In Front of Rock
	26.000			2.720	227.642		20	50	10	10	10		BO CO	0.34	0.48	0.60	0.59		
	26.700			2.475	227.887		50	10	10	10	20		BO CO	0.08	0.51	0.51	0.51		On Rock
	27.000			2.648	227.714		40	10	10	20	20		BO CO	0.25	0.38	0.43	0.41		Beside Rock
	27.400			2.661	227.701		10	10	20	10	20	30	BO CO	0.26	0.07	0.21	0.28		Behind Rock
	27.700			2.453	227.909		20	50		10	10	10	BO CO	0.04	0.22	0.22	0.22		On rock
	28.000			2.612	227.75		20	60		5	5	10	BO CO	0.14	0.14	0.28	0.51		
	29.000			2.429	227.933			60		10	10	20	CO	0.04	0.00	0.00	0.00		
RWE	29.300			2.378	227.984		10	40	20	10	10	10	BO CO						
	30.000			2.231	228.131		10	40	20	10	10	10	BO CO						
	30.400			2.250	228.112			30	30	10	10	20	CO						
	30.800			2.108	228.254			30	30	10	10	20	CO						OLD RWE
	31.400			1.907	228.455		50	30	5	5	5	5	BO CO						
	32.400			1.570	228.792		30	10	10	10	10	30	BO CO OV						
	33.300			1.116	229.246				10	10	30	50	OV CO						
	33.400			0.854	229.508				10	10	30	50	OV CO						
PIN	34.500			0.139	230.223				20	10	20	50	OV						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT3488.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool	
Transect	3488.0	Channel type	SINGLE	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 6/94	Channel Slope	.0043	surveyed value (m/m)	
Time	12:55	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.17	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 4 5 6

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.105	229.776		229.671														
PIN	0.000			0.115	229.661		30	30	10	5	5	20	BO CO						
	0.700			0.162	229.614		60				10	20	BO						
	1.500			0.680	229.096		50	20	10			20	BO CO						
	3.000			1.308	228.468		20	40	20	5	5	10	BO CO						
	5.000			1.653	228.123			60	20	5	5	10	CO IV						
	5.500			1.776	228			60	20	5	5	10	CO IV						OLD LWE
LWE	6.000			1.760	228.016		50	30	10	5	5		BO CO						
	6.300			1.983	227.793		50	30	10	5	5		BO CO						
	7.000			2.150	227.626			40	30	10	10	10	CO	0.19		0.00			
	7.500			2.350	227.426			40	30	10	10	10	CO	0.39		0.00			
	8.000			2.432	227.344			20	30	20	10	20	CO	0.47		0.00			
	9.000			2.563	227.213			40	20	10	10	20	CO	0.61					
	10.000			2.645	227.131			40	20	10	10	20	CO	0.68	0.00	0.00	0.06	340	
	11.000			2.698	227.078		20	50	10			20	BO CO	0.73	0.01	0.01	0.04		
	11.200			2.425	227.351		54.5	18.2	9.09			18.2	BO CO	0.47	0.03	0.05	0.08		
	12.000			3.015	226.761		20	30	20			30	BO CO	1.05	0.00	0.00	0.07		
	12.500			2.980	226.796		20	30	20			30	BO CO	1.05	0.00	0.00	0.21		
	13.000			2.750	227.026		20	30	20			30	BO CO	0.78	0.23	0.25	0.45		
	14.000			3.005	226.771		20	40	20			20	BO CO	1.07	0.40	0.60	0.81		
	15.000			3.105	226.671									1.10	0.77	0.91	1.18		No visibility of bottom
	16.000			3.120	226.656									1.18	0.41	0.73	1.03		No visibility of bottom
	17.000			3.190	226.586									1.24	0.30	0.42	0.70		No visibility of bottom
	18.000			3.155	226.621									1.25	0.24	0.55	1.02		No visibility of bottom
	19.000			3.095	226.681		20	30	30		10	10	BO CO	1.15	0.45	0.60	0.77		DEPTH AT 400 CFS =
	20.000			3.145	226.631		20	40	20		10	10	BO CO	1.20	0.31	0.44	0.77		
	21.000			3.156	226.62		20	50	10			20	BO CO	1.20	0.18	0.30	0.69		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT3488.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool	
Transect	3488.0	Channel type	SINGLE	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 6/94	Channel Slope	.0043	surveyed value (m/m)	
Time	12:55	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.17	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 4 5 6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	22.000			3.300	226.476		20	40	10			30	BO CO	1.35	0.04	0.12	0.28		
	23.000			3.490	226.286			30	20			50	CO	1.53	0.05	0.04	0.25		
	24.000			3.568	226.208			20	10			70	IV LOD CO	1.60	0.03	0.08	0.25		Beaver Dam
	25.000			3.308	226.468			20	10			70	IV LOD CO	1.33			0.30		CAN'T READ VELOCI
	26.000			3.512	226.264			10	10			80	IV LOD CO	1.54			0.06		DUE TO DEBRIS
	27.000			3.533	226.243			10	10			80	IV LOD CO	1.58			0.06	30	Beaver Dam
	28.000			3.428	226.348			10	10			80	IV LOD CO	1.44				30	Beaver Dam
	29.000			3.225	226.551			10	10			80	IV LOD CO	1.25			0.05	0	Beaver Dam
	30.000			3.157	226.619			5	5			90	IV LOD CO	1.16	0.00	0.00	0.00		Beaver Dam
	30.500			2.812	226.964			5	5			90	IV LOD CO	0.83					Beaver Dam
	31.000			2.741	227.035			5	5			90	IV LOD CO	0.74					Beaver Dam
RWE	31.100			1.970	227.806			5	5			90	IV LOD CO						Beaver Dam
	31.500			1.853	227.923			5	5			90	IV LOD CO						
	32.500			1.537	228.239				5	10	5	80	IV LOD CO						
	34.000			1.625	228.151				10	5	5	80	IV LOD CO						
	35.000			1.780	227.996				10	5	5	80	IV LOD CO						
	35.600			1.363	228.413			20	20	10	10	40	IV CO						
	37.200			0.558	229.218			20	20	10	10	40	IV CO						
PIN	38.300		229.776	0.200	229.576			20	20	10	10	40	IV CO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT3450.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	3450.0	Channel type	Single	single or multiple	
Reach	2	D90	0.7	90th %tile substrate si=e (m)	
Date	Dec 6/93	Channel Slope	.0042	surveyed value (m/m)	
Time	1500	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/IR	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 7 8 9

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.369	229.298		228.929														AT 100M
PIN	0.000			0.281	229.017			70	20	10			OV						
	0.500			0.688	228.61			70	20	10			OV						
	1.500			1.148	228.15		50	40	10				BO OV						
	2.000			1.053	228.245		90		10										
	2.500			1.477	227.821		90	0	0	10			BO OV						OLD LWE
	3.000			1.639	227.659		80	10	10				BO CO						
LWE	3.100			1.600	227.698		80	10	10				BO CO	0.09	0.00	0.00	0		
	4.000			1.791	227.507		10	40	40	10			BO CO	0.21	0.00	0.00	0		
	5.000			1.964	227.334		80	20						0.31		0.00			
	6.000			1.970	227.328		90	10					BO	0.34		0.00			
	7.000			2.200	227.098		50	20	30				BO LOD	0.57	0.11	0.12	0.1		
	8.000			2.099	227.199		70	20	10				CO BO	0.48	0.03	0.16	0.34		
	9.000			2.198	227.1		40	20	20	10			CO BO	0.58	0.00	0.18	0.41	330	
	10.000			2.050	227.248		60	20	20				CO BO	0.44	0.56	0.57	0.40	330	
	11.000			2.192	227.106		80	10	10				CO BO	0.59	0.17	0.26	0.65	330	
	12.000			2.283	227.015								BO CO	0.66	0.05	0.40	0.47		
	13.000			2.012	227.286		100						BO	0.40	0.83	1.17	1.12		ON ROCK
	14.000			2.506	226.792			80	10	10			CO	0.92	0.80	1.27	1.43		DEPTH AT 400 CFS =
	15.000			2.468	226.83		60	20	10	10			BO CO	0.84	0.80	1.11	1.22		boulder
	15.600			2.100	227.1985		100						BO	0.48	1.22	1.39	1.26		boulder
	16.000			2.131	227.167		80	10	10				BO	0.52	1.31	1.33	1.35		boulder
	16.200			2.268	227.03		80	0	10	5	5		BO	0.67	0.92	1.17	1.24		boulder
	16.700			2.253	227.045									0.67	1.19	1.32	1.36		
	17.000			2.028	227.27		80				10	10	BO	0.39	1.22	1.37	1.46		
	17.500			1.842	227.456		80				20		BO	0.18		1.49			
	18.000			2.168	227.13		60		10	10	20		BO	0.52	0.21	1.19	1.23		

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT3450.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool			
Transect	3450.0	Channel type	Single	single or multiple			
Reach	2	D90	0.7	90th %tile substrate si=e (m)			
Date	Dec 6/93	Channel Slope	.0042	surveyed value (m/m)			
Time	1500	Meter Used	M&M	M&M, Swoffer, Gurley etc.			
Crew	BW/BP/IR	Roughness Height (m)	0.2	height of roughness (m)			

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 7 8 9

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	19.000			2.113	227.185		38.1	28.6	4.76	23.8	4.76		BO	0.50	1.09	1.03	1.19		
	20.000			1.936	227.362		60	20	10	5	5		BO	0.28	1.17	1.24	1.14		
	21.000			1.759	227.539		95			5			BO	0.19		0.72			
	21.300			2.290	227.008		90		10				BO	0.70	0.57	0.88	0.93		
	22.000			2.182	227.116		70	20	5	5				0.56	0.94	1.16	1.09		
	22.400			2.284	227.014									0.65	0.87	0.99	0.99		
	23.000			1.858	227.44		70	10	10	10				0.15		1.28			
	23.500			1.902	227.396									0.17		0.99			
	24.000			2.167	227.131		50			40	10		BO	0.48	0.52	0.82	1.02		
	24.500			2.103	227.195		70	10		10	10		BO	0.42	0.00	0.25	0.38		BEHIND BOULDER
	25.000			1.893	227.405		60				30	10	BO	0.22	0.00	0.32	0.51		
	26.000			1.928	227.37		10	40	20	5	25		BO CO	0.24	0.20	0.21	0.12		
	26.500			1.983	227.315		60	20	10		10		BO CO	0.29	0.52	0.64	0.08		
RWE	26.700			1.693	227.605								BO CO	0.00	0.00	0.00			
	26.800			1.578	227.72								BO CO	0.00	0.00				
	27.000			1.627	227.671								BO CO	0.00					DRY
LWE	27.100			1.694	227.604		100						BO CO	0.00	0.00				
	27.200			1.893	227.405		80	10	10				BO CO	0.20		0.26			
	28.000			1.885	227.413		30	40	20			10	BO CO	0.19		0.03			
	28.400			1.888	227.41		44.4	22.2	22		11.1		BO CO	0.20		0.00			
RWE	29.000			1.607	227.691		60	10	10		5	15	BO CO	0.00					
	30.000			1.654	227.644		27.3	9.09		18.2	45.5		BO CO						
	30.200			1.628	227.67		77.8	5.56		5.56	11.1		BO CO						
	31.000			1.483	227.815		33.3	11.1	22.2	11.1	22.2		BO CO						
	31.300			1.203	228.095		77.8		11.1	5.56	5.56		BO CO						
	32.000			1.312	227.986		5		35	20	40		BO CO IV						
	32.500			1.275	228.023														

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT3488.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool	
Transect	3488.0	Channel type	SINGLE	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 6/94	Channel Slope	.0043	surveyed value (m/m)	
Time	12:55	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.17	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 4 5 6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT3488.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool
Transect	3488.0	Channel type	SINGLE	single or multiple
Reach	2	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 6/94	Channel Slope	.0043	surveyed value (m/m)
Time	12:55	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/IR/BW	Roughness Height (m)	0.17	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 4 5 6

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT3450.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	3450.0	Channel type	Single	single or multiple
Reach	2	D90	0.7	90th %tile substrate si=e (m)
Date	Dec 6/93	Channel Slope	.0042	surveyed value (m/m)
Time	1500	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BW/BP/IR	Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 7 8 9

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	32.800			0.759	228.539														
	33.000			1.011	228.287		30	10	20		30	10	BO IV						
PIN	34.000		229.468	0.646	228.822			60	40				IV						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT3450.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool		
Transect	3450.0	Channel type	Single	single or multiple		
Reach	2	D90	0.7	90th %tile substrate si=e (m)		
Date	Dec 6/93	Channel Slope	.0042	surveyed value (m/m)		
Time	1500	Meter Used	M&M	M&M, Swoffer, Gurley etc.		
Crew	BW/BP/IR	Roughness Height (m)	0.2	height of roughness (m)		

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 7 8 9

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT33834.XLS

Location	Seton R.
Transect	3383.4
Reach	2
Date	Dec 7/93
Time	10:10 am
Crew	BP/BW/IR

Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool
Channel type	SINGLE	single or multiple
D90	0.5	90th %tile substrate si=e (m)
Channel Slope	.0002	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 10-11-12

D/S U/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM																			Note IV is growing vegit
PIN	0.000		228.769	0.274	228.495			30			30	40	OV IV						in would-be channel
	1.500			1.094	227.675		60	30				10	OV IV BO						Vegetation
	6.500			1.501	227.268		VEGETATION						IV BO						Vegetation
	7.000			1.719	227.05		10	40	40	10			IV BO CO						Vegetation, OLD LWE
LWE	7.800			1.938	226.831		10	60	10		10	10	BO CO						
	8.000			1.956	226.813		10	60	10		10	10	BO CO	0.02	0.00	0.00	0		
	8.300			2.222	226.547		10	60	10		10	10	BO CO	0.29	0.00	0.00	0		
	9.000			2.260	226.509		60	20				20	BO CO	0.32	0.00	0.00	0		
	10.000			2.423	226.346		80					20	BO	0.48	0.00	0.00	0		
	11.000			2.720	226.049						50	50		0.78	0.00	0.00	0		
	12.000			2.918	225.851						50	50		0.99	0.00	0.00	0		
	13.000			3.030	225.739							100		1.10	0.08	0.02	0.04		DEPTH AT 400CFS = 1
	14.000			3.318	225.451							100		1.39	0.14	0.18	0.2		LIMIT OF WADING R
	15.000			3.561	225.208							100		1.62	0.15	0.25	0.27		
	16.000			3.579	225.19									1.65	0.30	0.48	0.45		
	17.000			3.506	225.263									1.62	0.44	0.55	0.73		(1.10 @ 80% DEPTH)
	18.000			3.580	225.189									1.61	0.32	0.72	1.02		can't quite get 0.8..too de
	19.000			3.019	225.75		70	30					BO CO	1.19	0.75	0.75	0.85		CAN'T SEE SUBSTRA
	20.000			3.217	225.552		60	40					BO CO	1.32	0.50	0.75	1.00		
	21.000			3.035	225.734		40	60					BO CO	1.10	0.30	0.40	0.68		
	22.000			2.725	226.044		40	60					BO CO	0.80	0.20	0.32	0.5		
	23.000			2.414	226.355		30	60	10				BO CO	0.48	0.39	0.30	0.17		
	24.000			2.295	226.474		30	60	10				BO CO	0.37	0.02	0.03	0.02		
	24.300			2.233	226.536		70	20	10				BO CO	0.30	0.00	0.00	0.00		
	24.400			2.028	226.741		70	20	10				BO CO	0.10		0.00			
	24.800			1.993	226.776		40	50	10				BO CO	0.07	0.00	0.00	0.00		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT33215.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	3321.5	Channel type	Single	single or multiple	
Reach	2	D90	0.4	90th %tile substrate si=e (m)	
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 1
Photo #'s 13-14-15
u/s d/s

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT33834.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool
Transect	3383.4	Channel type	SINGLE	single or multiple
Reach	2	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)
Time	10:10 am	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/BW/IR	Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
CO	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 10-11-12
D/S U/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	25.000			1.918	226.851		40	50	10				BO CO	0.00	0.00	0.00	0.00		
RWE	25.700			1.981	226.788		10	60	10	20			BO CO						TIED IN ELEVATION
	26.000			1.792	226.977		10	40	30	20			BO CO						
	26.700			1.674	227.095		10	40	30	20			BO CO						OLD RWE
	27.000			1.683	227.086		20	40	10	10	10	10	BO CO						
	28.000			1.386	227.383		10	50	20	5	5	10	BO CO						
	29.000			2.122	226.6468								BO CO						
PIN	30.100		228.769	0.025	228.744		20	50	10	5	5	10	BO CO						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT33834.XLS

Location	Seton R.	Hydraulic Unit Type	RUN	cascade, riffle, glide, run, pool	
Transect	3383.4	Channel type	SINGLE	single or multiple	
Reach	2	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)	
Time	10:10 am	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/BW/IR	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 10-11-12
D/S U/S

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT33215.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool		
Transect	3321.5	Channel type	Single	single or multiple		
Reach	2	D90	0.4	90th %tile substrate si=e (m)		
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)		
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.		
Crew	BP/IR/BW	Roughness Height (m)	0.2	height of roughness (m)		

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 1
Photo #'s 13-14-15
u/s d/s

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT33215.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	3321.5	Channel type	Single	single or multiple	
Reach	2	D90	0.4	90th %tile substrate si=e (m)	
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 1
Photo #'s 13-14-15
u/s d/s

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	19.000			2.985	226.01		40	50				10	BO CO	0.81	0.84	1.14	1.37		
	19.400			2.988	226.007		80	20					BO CO	0.79	0.91	1.10	1.22		
	20.000			2.580	226.415		80	20					BO CO	0.40	0.53	0.56	0.80	340	ROCK
	21.000			2.590	226.405		90	10					BO CO	0.38	0.00	0.25	0.97		
	22.000			2.565	226.43		40	30	10	20			BO CO	0.40	0.90	0.88	0.89		
	23.000			2.403	226.592		50	20	10	20			BO CO	0.24	1.10	1.10	1.10		
	24.000			2.320	226.675		30	20	30	10	10		BO CO	0.12	0.06	0.06	0.06	45	
	25.000			2.182	226.813		40	20	20	10	10		BO CO	0.04	0.26	0.26	0.26		
RWE	25.200			2.152	226.843		30	40	10	10		10	BO CO						
	25.300			1.978	227.017		30	30	20	10		10	BO CO						
	26.000			2.160	226.835		30	30	20	5	5	10	BO CO						
	27.000			2.092	226.903		40	20	20	5	5	10	BO CO						
	28.000			1.992	227.003		30	30	15	10	5	10	BO CO						
	29.000			2.055	226.94		60	20		5		5	BO CO						
	30.000			1.820	227.175		40	20	10	5	5	20	BO CO						
	30.200			2.005	226.99		40	20	10	5	5	20	BO CO						
	31.000			1.960	227.035		10	30	40	5	5	10	BO CO						
	31.500			1.900	227.095		40	20	30			10	BO CO						
	31.700			1.560	227.435		30	30	30	10			BO CO						OLD RWE
	32.000			1.808	227.187		20	30	40	10			BO CO						
	34.000			1.214	227.781		40	30	20	10			BO CO						
PIN	34.900			0.908	228.087		40	30	20	10			BO CO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT33215.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	3321.5	Channel type	Single	single or multiple	
Reach	2	D90	0.4	90th %tile substrate si=e (m)	
Date	Dec 7/93	Channel Slope	.0002	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/IR/BW	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 1

Photo #'s 13-14-15

u/s d/s

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		1.102	228.995		227.893														
PIN	0.000		228.995	1.162	227.833		30	20	30	5	5	10	BO OV IV CO						
	0.700			1.485	227.51		20	40	20	5	5	10	BO CO OV						
	1.000			1.690	227.305			40	20	5	5	20	CO BO OV						
	2.350			1.988	227.007		20	50	20	10			BO CO						OLD LWE
LWE	2.900			2.165	226.83		20	50	20	10			BO CO						
	3.000			2.248	226.747		20	50	30					0.05		0.00			
	3.500			2.350	226.645		30	30	30			10	BO CO	0.18	0.03	0.05	0.14		
	4.000			2.410	226.585		40	50	10				BO CO	0.28	0.33	0.36	0.38		
	4.100			2.216	226.779		40	50	10				BO CO	0.05		0.32			
	4.500			2.555	226.44		60	20	10			10	BO CO	0.40	0.00	0.00	0		
	5.000			2.570	226.425		30	40	20			10	BO CO	0.41	0.13	0.33	0.34		
	6.000			2.622	226.373		10	40	40			10	BO CO	0.49	0.25	0.45	0.73		
	7.000			2.560	226.435		50	30	10	5	5		BO CO	0.38	0.60	0.66	1		
	7.500			2.389	226.606		50	30	10	5	5		BO CO	0.20	0.22	0.26	0.33	45	ROCK
	8.000			2.525	226.47		80	10				10	BO CO	0.34	0.17	0.75	1.51		
	9.000			2.723	226.272		40	40	10	5	5		BO CO	0.58	0.28	0.58	0.98		
	10.000			2.670	226.325		10	60	20			10	BO CO	0.55	0.71	0.91	0.90		
	11.000			2.740	226.255		50	20		5	5	20		0.58	0.05	0.06	0.64		BEHIND ROCK
	12.000			2.714	226.281		80	10	10				BO CO	0.58	0.09	0.29	0.61		
	12.500			2.548	226.447		90	10					BO CO	0.40	0.07	0.18	0.38		
	13.000			2.215	226.78		100						BO	0.12	0.36	0.36	0.36		
	14.000			2.272	226.723		100						BO	0.05	1.09	1.09	1.09	45	ROCK
	15.000			3.340	225.655		70	30					BO CO	1.15	0.87	0.73	1.01		DEPTH AT 400CFS = 1
	16.000			3.250	225.745		70	20				10	BO CO	1.07	0.81	0.86	1.00		
	17.000			3.245	225.75		50	20		10	10	10	BO CO	1.05	0.55	0.80	0.95		
	18.000			3.018	225.977		40	20		10	10	20	BO CO	0.85	0.13	1.04	1.02		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT2492.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2492.0	Channel type	Single	single or multiple
Reach	1	D90	0.4	90th %tile substrate si=e (m)
Date	Dec 8/93	Channel Slope	.0021	surveyed value (m/m)
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/BW/IR	Roughness Height (m)	0.25	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 16-17-18

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT2492.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2492.0	Channel type	Single	single or multiple
Reach	1	D90	0.4	90th %tile substrate si=e (m)
Date	Dec 8/93	Channel Slope	.0021	surveyed value (m/m)
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/BW/IR	Roughness Height (m)	0.25	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 16-17-18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT2492.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2492.0	Channel type	Single	single or multiple
Reach	1	D90	0.4	90th %tile substrate si=e (m)
Date	Dec 8/93	Channel Slope	.0021	surveyed value (m/m)
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/BW/IR	Roughness Height (m)	0.25	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 16-17-18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	26.000			2.715	214.757									0.94	0.23	0.19	1.60		
	27.000			2.773	214.699								BO	0.95	0.34	0.65	0.96		
	28.000			2.586	214.886		80	10				10		0.79	0.53	0.68	0.46		
	29.000			2.685	214.787		60	20				20	BO	0.87	0.36	0.42	0.65		
	30.000			2.353	215.119		80	10				10	BO	0.54	0.43	0.51	0.38		
	31.000			2.394	215.078		70				10	20	BO	0.59	0.07	0.08	0.01		
	32.000			2.379	215.093		30					70	BO	0.56	0.00	0.00	0.00		
	33.000			2.098	215.374		60					40	BO	0.29		0.02			
RWE	33.100			1.815	215.657								BO						OLD RWE
	33.500			0.874	216.598		70					30	BO						
	34.000			1.212	216.26		85.7				9.52	4.76	BO						
	34.500			1.186	216.286		100						BO						
	35.000			0.945	216.527		100												
PIN	35.900			0.683	216.789		95	5					BO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT2492.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2492.0	Channel type	Single	single or multiple	
Reach	1	D90	0.4	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0021	surveyed value (m/m)	
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/BW/IR	Roughness Height (m)	0.25	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3

Photo #'s 16-17-18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.442	217.472		217.030														
PIN	0.000			0.01	217.462								IV						
	1.000			0.120	217.352								IV						
	3.000			0.251	217.221								IV						
	5.000			0.488	216.984						80	20	IV						
	6.000			0.589	216.883														
	7.000			0.506	216.966		55.6	11.1	11	11	11								
	8.000			0.909	216.563				40	40	20								
	9.000			1.126	216.346		50	20	20	10									
	10.000			1.396	216.076		50		20	20	10								OLD LWE
	10.500			1.510	215.962		50		20	20	10								
	11.000			1.503	215.969		50	5	20		20	5							
	12.000			1.709	215.763			60	20	10		10							
LWE	12.500			1.815	215.657									0.00					
	13.000			1.884	215.588		20	50			20	10		0.08		0.22			
	14.000			1.938	215.534		40	20			20	20	BO	0.14		0.34			
	15.000			2.145	215.327		40	20	10	10	20		CO	0.34	0.32	0.32	0.32		
	16.000			2.306	215.166		20	40	20	5	15			0.50	0.49	0.65	0.73		
	17.000			2.459	215.013		55.6	5.56	22.2	5.56	11.1			0.64	0.74	0.81	0.84		
	18.000			2.502	214.97		60		10	10	20			0.68	0.07	0.76	0.82		
	19.000			2.545	214.927			50	20	10	20			0.74	0.65	0.78	0.89		
	20.000			2.648	214.824				▲					0.86	0.66	0.71	0.99		DEPTH AT 400CMS = 1
	21.000			2.782	214.69									0.96	0.63	1.00	0.96		
	22.000			2.754	214.718									0.93	0.47	0.67	0.70		
	23.000			2.829	214.643				NOT					1.03	0.91	1.01	0.77		NOT
	24.000			2.677	214.795				VISIBLE					0.89	1.17	1.29	1.39		WADEABLE IN NOV
	25.000			2.645	214.827									0.87	0.48	1.37	1.79		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT2412.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	2412.0	Channel type	Single	single or multiple	
Reach	1	D90	0.55	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0025	surveyed value (m/m)	
Time	12:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/ BW/BP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 3
Photo #'s 19-20-21
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT2412.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	2412.0	Channel type	Single	single or multiple	
Reach	1	D90	0.55	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0025	surveyed value (m/m)	
Time	12:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/ BW/BP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 3

Photo #'s 19-20-21

U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	31.000			1.792	215.94		100						BO						
	31.800			1.360	216.372		100						BO						
	32.000			0.735	216.997		100						BO						
PIN	33.400		217.732	0.661	217.071		100						BO						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT2412.XLS

Location	Seton R.
Transect	2412.0
Reach	1
Date	Dec 8/93
Time	12:00
Crew	IR/ BW/BP

Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Channel type	Single	single or multiple
D90	0.55	90th %tile substrate si=e (m)
Channel Slope	.0025	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 3
Photo #'s 19-20-21
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	12.000			3.096	214.6365		40			10	20	30	BO	0.87	0.45	0.54	0.51		ON ROCK (SOLITARY
	13.000			3.398	214.334		50	20			10	20	BO CO	1.17	0.34	0.40	0.62		
	14.000			3.258	214.474		70					30	BO	1.05	0.63	0.65	0.69		
	15.000			3.464	214.268		50				20	30	BO	1.20	0.22	0.74	0.82		
	16.000			3.441	214.291				30	20	20	30	CO	1.20	0.55	0.61	0.72		
	17.000			3.348	214.384				30	20	20	30	CO	1.13	0.46	0.71	0.73		DEPTH AT 400CFS = 1
	18.000			3.400	214.332				20	30	20	30	CO	1.14	0.62	0.66	0.76		
	19.000			3.315	214.417					40	40	20		1.05	0.64	0.67	0.65		
	19.800			3.250	214.482		50			20	20	10	BO	1.05	0.49	0.55	0.59		BESIDE ROCK
	20.000			2.607	215.125		100						BO	0.38	0.72	0.73	0.70		ON ROCK
	20.500			2.529	215.203		100						BO	0.29	0.68	0.81	0.74		ON ROCK
	21.000			2.610	215.122		100						BO	0.38	0.54	0.87	0.82		ON ROCK
	21.400			3.049	214.683		50			20	20	10	BO	0.82	0.37	0.75	0.81		BESIDE ROCK
	22.000			3.033	214.699					40	40	20		0.81	0.50	0.69	0.74		
	23.000			2.979	214.753					40	40	20		0.74	0.43	0.29	0.14		
	24.000			2.982	214.75					40	40	20		0.75	0.39	0.58	0.67		
	25.000			2.980	214.752					40	40	20		0.66	0.51	0.57	0.57		
	26.000			2.904	214.828					10	40	50		0.67	0.47	0.52	0.51		
	27.000			2.881	214.851					10	40	50		0.61	0.06	0.25	0.28		
	28.000			2.806	214.926						20	80		0.58	0.01	0.02	0.06		
	28.600			2.711	215.021		50				10	40	BO	0.48	0.01	0.06	0.00		
	29.000			2.357	215.375		90				5	5	BO	0.12	0.03	0.03	0.03		
	29.400			2.332	215.4		90				5	5	BO	0.01	0.11	0.11	0.11		
	29.600			2.594	215.138		80				10	10	BO	0.36	0.04	0.14	0.08		
	29.800			2.648	215.084		80			10		10	BO	0.42	0.04	0.14	0.08		
RWE	29.900			2.231	215.501		80			10		10	BO						OLD RWE
	30.000			2.073	215.659		100						BO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT2412.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	2412.0	Channel type	Single	single or multiple	
Reach	1	D90	0.55	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0025	surveyed value (m/m)	
Time	12:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/ BW/BP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 3

Photo #'s 19-20-21

U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.448	217.478		217.030														
PIN	0.000			0.79	216.942		50	40	10				BO CO						
	0.200			1.133	216.599		50	40	10				BO CO						
	2.000			1.641	216.091			60	20	10	10		CO						
	2.600			1.712	216.02		40	30	10	10	10		BO CO						
	2.700			1.526	216.206		40	30	10	10	10		BO CO						
	3.000			1.634	216.098		50	20	10	10	10		BO CO						
	3.200			1.951	215.781		70	10	10	10			BO CO						
	3.900			1.962	215.77		40	50	10				BO CO						
	4.000			1.819	215.913		40	50	10				BO CO						
	4.300			1.923	215.809		50	30	10			10	BO CO						
	4.500			2.058	215.674		50	30	10			10	BO CO						OLD LWE
	5.000			2.188	215.544		60	30	10				BO CO						
LWE	5.500			2.230	215.502		60	20	10			10	BO CO						
	5.600			2.270	215.462		10	50	20		20		BO CO	0.04	0.00	0	0.00		
	6.000			2.315	215.417		10	50	20		20		BO CO	0.07	0.00	0.00	0.00		
	6.500			2.234	215.498		30	30	20		10	10	BO CO	0.04	0.00	0.00	0.00		
	7.000			2.363	215.369		50	30	10			10	BO CO	0.13	0.04	0.04	0.04		
	7.500			2.221	215.511		70	10	10			10	BO CO	0.00	0.00	0.00	0.00		
	8.000			2.277	215.455		70	30					BO CO	0.05	0.02	0.02	0.02		
	8.200			2.429	215.303		80	20					BO CO	0.21	0.51	0.23	0.27		
	9.000			2.631	215.101		90		5			5	BO CO	0.42	0.19	0.25	0.3	45	
	10.000			3.050	214.682		100						BO	0.83	0.07	0.17	0.27		BACK EDGE OF ROC
	10.600			3.188	214.544		80					20	BO	0.96	0.14	0.42	0.32		
	11.000			2.981	214.751		70	10				20	BO	0.75	0.49	0.47	0.43		ON ROCK
	11.200			3.183	214.549		33.3	33.3				33.3	BO CO	0.96	0.44	0.38	0.57		

Seton River Field Survey - Dec '93

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Tie into previous site
BM = 0.105

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2329.5	Channel type	Single	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0029	surveyed value (m/m)	
Time	3:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/BW/BP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 22-23-24
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	48.000			0.810	216.29		60	30	10				BO CO						
PIN	48.700			0.468	216.632		50	10	10	5	5	20	BO CO						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT23295.XLS

Tie into previous site
BM = 0.105

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2329.5	Channel type	Single	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 8/93	Channel Slope	.0029	surveyed value (m/m)	
Time	3:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	IR/BW/BP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 22-23-24
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	37.000			2.206	214.894		60	20	10	5	5		BO CO	0.38	0.67	0.91	1.14		
	38.000			2.200	214.9		40	30	20	5	5		BO CO	0.32	0.00	0.00	0.00		BEHND ROCK
	38.400			2.238	214.862		60	20	10	5		5	BO CO	0.37	0.86	0.86	0.81		
RWE	38.500			1.892	215.208		60	20	10	5		5	BO CO						
	38.600			1.771	215.329		80	10	10				BO CO						
	39.000			1.755	215.345		80	10	10				BO CO						ON ROCK
LWE	39.100			1.875	215.225		60	20	10		5	5	BO CO						
	39.300			2.245	214.855		60	20	10		5	5	BO CO	0.42	0.46	0.65	0.62		BEHIND ROCK
	39.600			2.283	214.817		50	10	20	5	10	5	BO CO	0.45	0.44	0.57	0.51		
	40.000			1.935	215.165		90	5	5				BO CO	0.10	0.62	0.62	0.62	20	ON ROCK
	40.200			2.068	215.032		90	5	5				BO CO	0.21	1.07	1.10	1.05	20	
	40.400			2.488	214.612		50	20	15	5	5	5	BO CO	0.65	0.73	0.90	0.95	20	BESIDE ROCK
	41.000			2.473	214.627		20	30	30	5	10	5	BO CO	0.65	0.77	0.80	1.05	20	
	42.000			2.440	214.66		20	50	10	5	5	10	BO CO	0.63	0.46	0.64	0.65		DEPTH AT 400CFS = 0
	43.000			2.530	214.57		40	30	20	5		5	BO CO	0.70	0.53	0.43	1.12		ON ROCK
	43.900			2.368	214.732		50	10	5	5	10	20	BO CO	0.58	0.10	0.14	0.49	340	
	44.000			1.952	215.148		50	10	5	5	10	20	BO CO	0.07	0.62	0.62	0.62	340	
RWE	44.700			1.865	215.235		80	10				10	BO CO						
	44.900			1.707	215.393		80	10				10	BO CO						
LWE	44.950			1.845	215.255		80	10				10	BO CO						
	45.000			1.902	215.198		60	20				20	BO CO	0.05	0.05	0.05	0.05		
RWE	45.100			1.841	215.259		60	20				20	BO CO						
	46.000			1.762	215.338		40	30	10	5	5	10	BO CO						OLD RWE
	46.500			1.591	215.509		50	20	20	5	5		BO CO						
	47.000			1.230	215.87		50	20	20	10			BO CO						
	47.300			0.863	216.237		30	40	10	5	5	10	BO CO						
	47.500			1.028	216.072		30	40	10	5	5	10	BO CO						

Seton River Field Survey - Dec '93

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Tie into previous site
BM = 0.105

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2329.5	Channel type	Single	single or multiple
Reach	1	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 8/93	Channel Slope	.0029	surveyed value (m/m)
Time	3:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	IR/BW/BP	Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 22-23-24
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	17.000			1.647	215.453		90	10					BO CO						ON ROCK
LWE	17.600			1.850	215.25		60	10	10	10	5	5	BO CO						
	18.000			2.128	214.972		44.4	22.2	11.1	11.1	5.56	5.56	BO CO	0.30	0.70	0.78	0.80		BESIDE ROCK
	19.000			2.232	214.868			40	20	20	10	10	CO	0.42	0.63	0.64	0.73		
	20.000			2.295	214.805			20	15	40	20	5	CO	0.48	0.64	0.82	0.89		
	21.000			2.340	214.76			20	15	40	20	5	CO	0.50	0.15	0.34	0.23		
	22.000			2.340	214.76		5	30	20	30	10	5	CO	0.52	0.49	0.51	0.60		
	23.000			2.301	214.799		40	10	15	20	10	5	BO CO	0.46	0.00	0.28	0.62		IN FRONT OF ROCK
	24.000			2.345	214.755		10	20	20	30	20		BO CO	0.47	0.74	1.22	1.27		
	24.500			2.338	214.762		40	5	10	30	10	5	BO CO	0.46	1.18	1.22	1.43		
	25.000			2.370	214.73		60		10	20	5	5	BO CO	0.42	0.00	0.13	0.75		BEHIND ROCK
	25.500			2.385	214.715		60	5	5	20	5	5	BO CO	0.46	1.27	1.30	1.41		
	26.000			2.448	214.652		30	20	20	20	5	5	BO CO	0.61	0.86	1.15	1.01		
	27.000			2.503	214.597		30	20	30	10	5	5	BO CO	0.66	1.17	1.06	0.80		
	28.000			2.297	214.803		30	10	30	20	10		BO CO	0.45	0.77	0.79	0.83		
	29.000			2.529	214.571		20	40	10	10	15	5	BO CO	0.66	0.55	0.50	0.75		
	30.000			2.448	214.652		20	40	10	10	15	5	BO CO	0.55	1.22	0.82	1.10		
	31.000			2.370	214.73		40	20	10	15	10	5	BO CO	0.50	0.00	0.10	0.06		BEHIND ROCK
	32.000			2.562	214.538		50	10	10	15	10	5	BO CO	0.72	0.00	0.30	1.10	30	
	33.000			2.056	215.044		30	10	20	20	5	5	BO CO	0.22	0.70	0.73	0.74		ON ROCK
	34.000			2.179	214.921			10	20	45	15	10	BO CO	0.32	0.49	0.62	0.63		
	35.000			2.104	214.996		70		10	5	10	5	BO CO	0.20	0.46	0.48	0.16		
	35.300			1.890	215.21		80		5	5	5	5	BO CO	0.02	0.25	0.25	0.25	270	ON ROCK
	35.500			2.192	214.908		70		10	5	10	5	BO CO	0.32	0.26	0.32	0.35		BEHIND ROCK
	35.800			1.888	215.212		70	10	10	5	5		BO CO	0.03	0.30	0.30	0.30		TOP OF ROCK
	36.000			1.963	215.137		70	10	10	5	5		BO CO	0.10	0.44	0.44	0.44		TOP OF ROCK
	36.200			2.425	214.6755		50	30	10	5	5		BO CO	0.58	0.37	0.57	0.65		BESIDE ROCK

Seton River Field Survey - Dec '93
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Tie into previous site
BM = 0.105

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2329.5	Channel type	Single	single or multiple
Reach	1	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 8/93	Channel Slope	.0029	surveyed value (m/m)
Time	3:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	IR/BW/BP	Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 3
Photo #'s 22-23-24
U/S D/S

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.070	217.100		217.030														
PIN	0.000			0.726	216.374		40	40	15			5	BO CO						
	2.000			1.504	215.596		20	60	10		5	5	BO CO						
	3.000			1.608	215.492		30	40	5	5		20							
	3.400			1.380	215.72		40	30	5	10	5	10							
	3.800			1.670	215.43		40	30	5	10	5	10							OLD LWE
	4.000			1.628	215.472		20	40	10	5	15	10	BO CO						
LWE	4.200			1.794	215.306		20	40	10	5	15	10	BO CO						
	5.000			1.808	215.292		5	50	20	5	10	10	BO CO	0.02					
	6.000			1.825	215.275		20	10	10	30	20	10	BO CO	0.04	0.00	0.00	0		
	6.500			1.849	215.251		20	10	10	30	20	10	BO CO	0.06	0.00	0.00	0		
RWE	7.000			1.788	215.312		70	20	5			5	BO CO						
	8.000			1.753	215.347		70	20	5			5	BO CO						
LWE	8.600			1.801	215.299		70	20	5			5	BO CO						
	9.000			1.932	215.168		30	40	10	10	5	5	BO CO	0.14	0.04	0.09	0.04		
	10.000			1.954	215.146		30	40	5	5	10	10	BO CO	0.15	0.12	0.12	0.10		
	10.900			1.872	215.228		30	40	5	10	10	5	BO CO	0.04	0.32	0.32	0.32	270	
	11.000			1.558	215.542		60	20		10	5	5	BO CO						ON ROCK
	11.300			1.773	215.327		40	30	10	5	5	10	BO CO						
	12.000			1.793	215.307		40	30	10	5	5	10	BO CO						
LWE	12.600			1.845	215.255		30	30	15	5	10	10	BO CO						
	13.000			2.028	215.072		40	20	15	5	10	10	BO CO	0.19	0.17	0.14	0.14	320	
	14.000			2.035	215.065		60	20	10		5	5	BO CO	0.20	0.00	0.00	0.35		BEHIND ROCK
	15.000			2.108	214.992			10	20	50	10	10	CO	0.29	0.23	0.53	0.72		
	16.000			2.152	214.948		20		30	40	5	5	BO CO	0.32	0.03	0.88	0.93		
	16.800			2.078	215.022		60	10		15	10	5	BO CO	0.24	0.19	0.51	0.51		BESIDE ROCK
RWE	16.900			1.843	215.257		90	10											

O:\2213\SETON\TRANSECT\SRT22435.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2243.5	Channel type	Multiple	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0295	surveyed value (m/m)	
Time	11:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/PP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

Photo Roll Label: SE 4
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2221.0	Channel type	MULTI	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 12/93	Channel Slope	.0345	surveyed value (m/m)	
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/AM/BW	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
RWE	42.100			2.307	214.005		70	20	5			5	BO CO						
	43.000			2.023	214.289		70	20	5			5	BO CO						ON ROCK
	43.300			1.965	214.347		80	15	5				BO CO						OLD RWE
	44.000			1.752	214.56		90	5	5				BO CO						
	45.000			1.979	214.333		85	5	5			5	BO CO						
	46.000			1.735	214.577		75	10	10			5	BO CO						ON ROCK
	46.200			1.980	214.332		55	25	10			10	BO CO						OLD LWE (This is likel
	46.500			2.106	214.206		55	25	10			10	BO CO	0.13		0.00			
	47.000			2.007	214.305		55	25	10			10	BO CO	0.03					
RWE	47.300			1.979	214.333		55	25	10			10	BO CO						BEHIND ROCK
	47.500			1.735	214.577		70	15	10			5	BO CO						
LWE	48.000			1.979	214.333		60	25	5			10	BO CO						
	49.000			1.992	214.32		60	25	5			10	BO CO	0.02		0.00			
	50.000			1.976	214.336		70	15	5			10	BO CO	0.02		0.00			BESIDE ROCKS
	51.000			2.010	214.302		30	60	5			5		0.04		0.00			
RWE	51.700			1.960	214.352		80	5	5			10	BO CO						
	52.000			1.622	214.69		90	5	5				BO CO						
	53.000			1.905	214.407		50	30	15			5	BO CO						ON ROCK
	54.000			1.815	214.497		80	10	5			5	BO CO						IN ROCKS
	54.800			2.054	214.258		70	20	5			5	BO CO						
RWE	54.900			1.947	214.365		60	25	10			5	BO CO						
	55.000			1.623	214.689		80	10	5			5	BO CO						
	56.000			1.454	214.858		50	20				30	BO CO						
	56.300			1.679	214.633		50	20				30	BO CO						
	58.000			1.705	214.607		50	20				30	BO CO LOD						
	59.000			1.370	214.942		70	20				10	BO CO						
	59.900			1.580	214.732		70	20				10	BO CO						

Seton River Field Survey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	2221.0	Channel type	MULTI	single or multiple
Reach	1	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 12/93	Channel Slope	.0345	surveyed value (m/m)
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/AM/BW	Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
LWE	20.500			2.689	213.623		90	5				5	BO CO						
	20.700			3.015	213.297		90	5				5	BO CO	0.33	0.00	0.10	0.00		BESIDE ROCK
	21.000			2.805	213.507		90	5	5				BO CO	0.13		0.14			
	21.500			3.042	213.27		80	10	5	5			BO CO	0.32	1.39	1.42	1.63	340	
	22.000			2.803	213.509		80	15	5				BO CO	0.14		2.17			
	23.000			3.305	213.007		80	15	5				BO CO	0.65	1.11	0.89	1.39		UNWADEABLE BEYO
	31.000			3.228	213.084		80	15	5				BO CO	0.72	1.24	2.04	2.03		
	32.000			3.195	213.117		70	20	10				BO CO	0.64	0.21	0.92	1.57		BESIDE ROCK, 400CF
	32.500			2.590	213.722		90	5	5				BO CO	0.07		0.76			ON ROCK
	33.000			3.060	213.252		70	20	10				BO CO	0.52	0.76	0.65	0.78		BESIDE ROCK
	34.000			2.980	213.332		70	20	10				BO CO	0.43	0.03	0.49	0.84		
	35.000			2.800	213.512		60	30	5			5	BO CO	0.30	0.00	0.00	0.04		
	35.600			2.763	213.549		50	30	10			10	BO CO	0.24	0.00	0.00	0.00		
RWE	35.700			2.800	213.512		50	30	10			10							BESIDE ROCK
	36.000			2.423	213.889		60	20	5	5		10	BO CO						
	36.700			2.121	214.191		60	20	5	5	5	5	BO CO						
	37.000			2.315	213.997		80	20					BO CO						
LWE	37.100			2.420	213.892		80	20					BO CO						
	37.300			2.622	213.69		70	20	5			5	BO CO	0.19	0.22	0.23	0.17		
	38.000			2.664	213.648		40	50				10	BO CO	0.22	0.13	0.17	0.15		
	38.900			2.705	213.607		50	20	10	5	5	10	BO CO	0.27	0.11	0.13	0.22		
	39.000			2.429	213.883		50	20	10	5	5	10	BO CO	0.01		0.00			
RWE	39.700			2.440	213.872		50	20	10	5	5	10	BO CO						ON ROCK
	40.000			2.385	213.927		50	20	10	5	5	10	BO CO						
	40.600			1.957	214.355		70	20	5			5	BO CO						
LWE	41.000			2.308	214.004		70	20	5			5	BO CO						
	42.000			2.405	213.907		70	20	5			5	BO CO	0.08		0.16			

Seton River Field Survey - Dec '93

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Location	Seton R.
Transect	2221.0
Reach	1
Date	Dec 12/93
Time	9:00
Crew	BP/AM/BW

Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Channel type	MULTI	single or multiple
D90	0.5	90th %tile substrate si=e (m)
Channel Slope	.0345	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM																			
PIN	0.000			0.75	216.08							100	IV OV LOD						
	3.000			0.780	215.532							100	IV OV LOD						
	4.000			0.585	215.727		40	10	10			30	OV LOD BO						
	5.000			0.765	215.547		20	40	10			30	OV LOD BO						
	6.000			0.847	215.465			10	10			80	CO LOD OV						
	7.500			1.215	215.097		30	30				40	V OV CO BO						
	11.900			1.355	214.957		60	15	5			20	BO CO OV						
	13.000			1.827	214.485		50	15	5			30	BO CO OV						
	14.000			1.988	214.324		22.2	55.6	11.1			11.1	BO CO OV						
	15.000			2.200	214.112		40	25	10	10	10	5	BO CO						
	16.000			2.195	214.117		40	20	20	10	5	5	BO CO						
	16.300			2.412	213.9		40	20	20	10	5	5	BO CO						
	16.700			2.225	214.087		70	10	10	5		5							
	17.000			2.530	213.782		65	15	10	5		5	BO CO						ROCK, OLD LWE
LWE	17.300			2.643	213.669		65	15	10	5		5	BO CO						
	17.400			2.695	213.617		50	25	10	5	5	5	BO CO	0.05					FLOW UNDETERMIN
RWE	17.500			2.625	213.687		50	25	10	5	5	5	BO CO						BOULDER
	17.800			2.585	213.727		50	25	10	5	5	5	BO CO						BEHIND ROCK
LWE	17.900			2.645	213.667		50	25	10	5	5	5	BO CO						
	18.000			2.817	213.495		40	30	15	5	10		BO CO	0.17	0.27	0.36	0.35		ON ROCK
RWE	18.300			2.645	213.667		40	30	15	10	5		BO CO						
	19.000			2.335	213.977		80	5	5		5	5	BO CO						BACK EDDY
	19.400			2.456	213.856		80	5			5	10	BO CO						
	19.500			2.640	213.672		80	5			5	10	BO CO						
	20.000			2.381	213.931		90	5				5	BO CO						
	20.200			2.655	213.657		90	5				5	BO CO						

Seton River Field Survey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	***Input all cover types present - single space between types, no commas or slashes**		
Transect	2205.5	Channel type	Single	single or multiple			
Reach	1	D90	0.8	90th %tile substrate si=e (m)	BO	bolder	**SKETCH TRANSECTS ON THE BACK OF THIS SHEET**
Date	Dec 13/93	Channel Slope	.0418	surveyed value (m/m)	C0	cobble	
Time	1430	Meter Used	M&M	M&M, Swoffer, Gurley etc.	LOD	large organic debris	
Crew	BW/AM/BP	Roughness Height (m)		height of roughness (m)	IV	instream vegetation	
					OV	overstream vegetation	Photo Roll Label: SE 4
					CU	cutbank	Photo #'s 7,8,9
					ICE	ice	

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2243.5	Channel type	Multiple	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0295	surveyed value (m/m)	
Time	11:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/PP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

Photo Roll Label: SE 4
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2243.5	Channel type	Multiple	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0295	surveyed value (m/m)	
Time	11:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/PP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

Photo Roll Label: SE 4

Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	38.000			2.461	214.273		30	50	20				BO CO	0.27	0.07	0.01	0.01	320	
	39.100			2.470	214.264		80		20				BO CO	0.27	0.21	0.23	0.24		behind rock
	40.000			2.576	214.158		80		20				BO CO	0.37	0.20	0.60	0.60	320	D.S. OF ROCK
	41.000			2.429	214.305		80		20				BO CO	0.19	0.44	0.78	0.68		behind rock
	42.000			2.258	214.476		40	20	40				BO CO	0.17	0.82	0.82	1.08		
	43.000			2.377	214.357		70	20	10				BO CO	0.36	0.25	0.38	0.72	340	EMBEDDED CABLE
	44.000			2.251	214.483		30	30	40				BO CO	0.21	0.38	0.38	0.40		
	45.000			2.148	214.586		60	20	20				BO CO	0.11	0.00	0.00	0.00		behind rock
RWE	45.800			2.049	214.685									0.00					
	46.000			1.886	214.848		70	15	15					0.00					on rock
LWE	46.500			2.054	214.68									0.00					
	47.000			2.249	214.485		70	20			10		BO CO	0.21	0.63	0.75	0.78		behind rock
	48.000			2.380	214.354		15	30		10	20	25	BO CO	0.36	0.26	0.28	0.30		
	49.000			2.211	214.523		30	70					BO CO	0.14	0.43	0.43	0.73	45	behind rock
	50.000			2.312	214.422		30	60	10				BO CO	0.25	0.20	0.34	0.03		
RWE	50.300			2.067	214.667									0.00					
	50.600			1.904	214.83									0.00					
LWE	50.900			2.041	214.693									0.00					BESIDE ROCK
	51.000			2.210	214.524		70	20		10			BO CO	0.19		0.01			
	52.000			2.020	214.714		70		30				BO CO	0.00					ON ROCK
	52.300			2.172	214.562		70		30				BO CO	0.15		0.07			
RWE	52.700			2.019	214.715									0.00					
	53.000			1.941	214.793		70	20	10										BEHIND ROCK
	54.000			1.966	214.768		40	10		40		10							
	54.500			1.963	214.771		50	30	10	10									OLD RWE
	55.000			1.637	215.097		80		20										
	56.000			1.598	215.136		50		30			20	BO CO						EMBEDDED COBBLE
	57.000			1.261	215.473		50		30			20	BO CO						
	58.000			1.355	215.379		30	20	10	10		30							
	59.000			1.113	215.621			80	20										
PIN	60.500		216.734	0.395	216.339		20	70	10										

Seton River Field _urvey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2243.5	Channel type	Multiple	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0295	surveyed value (m/m)	
Time	11:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/PP	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

Photo Roll Label: SE 4
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		1.166																	
PIN	0.000			0.139	216.595		20					80	IV						
	3.000			1.070	215.664			18.2			18.2	63.6	IV LOD						
	5.000			1.121	215.613		80	10				10	BO						
	6.000			1.426	215.308		20	20	40			20	BO						
	8.000			1.652	215.082		40	20	5	5		30	BO						
	10.000			1.589	215.145		20	10	30			40	BO						
	12.000			1.550	215.184		14.3	42.9	14.3	28.6			CO						
	14.000			1.715	215.019		30	20	15	15	10	10							
	15.000			1.808	214.926		40		20	20		20							
	15.700			1.584	215.15														
	15.900			1.910	214.824		60	40											
	16.500			2.122	214.612		30	30			20	20							
	17.500			2.059	214.675		10	10		10	40	30							
	18.600			2.111	214.623		20		40		20	20							
	19.000			2.227	214.507			11.1	44.4		11.1	33.3							
LWE	19.900			2.341	214.393														
	20.000			2.416	214.318		60		10		10	20	BO	0.08		0.08			
	21.000			2.637	214.097		30	20	20		15	15	BO	0.28	0.40	0.48	0.58		
	22.000			2.591	214.143			40			40	20	BO	0.24	0.27	0.47	0.28		
	23.000			2.500	214.234		60	10			20	10	BO	0.15	0.70	0.84	0.91		
	24.000			2.547	214.187		60	40					BO	0.22	1.71	1.72	1.47		
	25.000			2.849	213.885		34	33	33				BO	0.50	1.43	1.61	1.96		
	26.000			2.910	213.824		34	33	33				BO	0.55	1.90	1.80	2.03		UNWADEABLE BEY
	31.000			3.209	213.525								BO	0.83	1.32	1.35	0.80		
	32.000			2.822	213.912		45	45	10				BO	0.43	0.40	0.40	0.38		
	33.000			2.925	213.809			60	20			20	C0	0.54	0.00	0.00	0.00		behind rock backeddy
	34.000			2.661	214.073		30	20	50				BO	0.26	1.77	1.76	1.69		DEPTH AT 400CFS =
	34.500			2.468	214.266									0.17	1.05	0.90	0.77	340	
	36.000			2.545	214.189		20	80					BO CO	0.31	0.11	0.04	0.86	280	PROBE POINTED INT
	37.000			2.500	214.234		60	20	20				BO CO	0.30	0.11	0.01	0.00	270	

Seton River Field Survey - Dec '93
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Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2221.0	Channel type	MULTI	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 12/93	Channel Slope	.0345	surveyed value (m/m)	
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/AM/BW	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	60.500			1.348	214.964		70	20				10	O CO IV OV						
R PIN	62.900		216.312	0.232	216.08		30	30	20			20	BO OV CO						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT22055.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2205.5	Channel type	Single	single or multiple	
Reach	1	D90	0.8	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0418	surveyed value (m/m)	
Time	1430	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/BP	Roughness Height (m)		height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 7,8,9

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	57.000			2.250	214.53			30	30		40								
	59.000			1.960	214.82			40			60								
	61.000			1.743	215.037			10	75	10	5		CO						
	63.400			1.310	215.47		40		10	40	5	5	BO CO LOD						
	64.000			0.778	216.002		60			30	5	5	BO						
PIN	64.700		216.780	0.770	216.01			10	5	45	40		CO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT22055.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2205.5	Channel type	Single	single or multiple	
Reach	1	D90	0.8	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0418	surveyed value (m/m)	
Time	1430	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/BP	Roughness Height (m)		height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 7,8,9

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	29.000			3.763	213.017		70	30					BO CO	0.14	1.17	1.17	1.17		
	30.000			4.032	212.748		70	30					BO CO	0.48	0.26	0.96	0.90		
RWE	30.300			3.655	213.125		70	30					BO CO						
	31.000			3.250	213.53		70	30					BO CO						
LWE	31.400			3.515	213.265		70	30					BO CO						
	31.500			3.650	213.13		70	30					BO CO	0.15	0.09	0.09	0.09		
	32.000			3.659	213.121		70	30					BO CO	0.12	0.00	0.00	0.00		
RWE	32.300			3.503	213.277		10	30	30	30			BO CO						
	32.600			3.200	213.58		10	30	30	30			BO CO						
	33.000			3.340	213.44		10	30	30	30			BO CO						
	34.000			3.440	213.34		10	30	30	30			BO CO						
	34.050			3.492	213.288		10	30	30	30			BO CO						OLD RWE
	35.000			3.340	213.44		10	30	30	30			BO CO						
	36.000			3.323	213.457		15	30	30	20	5		BO CO						ON ROCK
	37.000			2.940	213.84		50	30	20										
	39.300			2.983	213.797		50	30	20										
	40.000			2.152	214.628		100												
	41.000			2.588	214.192		100												
	43.000			2.528	214.252		70	30											
	45.000			2.600	214.18		70	30											
	46.000			2.141	214.639		50	50											
	47.000			2.362	214.418		10	40	30	20									
	49.000			2.352	214.428		10	40	40	10									
	51.000			2.118	214.662		10	30	30	30									
	51.300			2.449	214.331		10	30	30	30									
	53.000			2.465	214.315		20	10	50	10	10								
	55.000			2.400	214.38			60	30	10									

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT22055.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	2205.5	Channel type	Single	single or multiple	
Reach	1	D90	0.8	90th %tile substrate si=e (m)	
Date	Dec 13/93	Channel Slope	.0418	surveyed value (m/m)	
Time	1430	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/AM/BP	Roughness Height (m)		height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
CO	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 7,8,9

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		1.166																	
PIN	0.000		216.78	1.145	215.635					10	30	60	LOD OV						
	1.000			1.208	215.572					10	30	60	LOD OV						
	3.000			1.230	215.55				5	5	20	70	LOD OV						
	5.000			1.278	215.502				5	5	20	70	LOD OV						
	7.000			1.268	215.512				5	5	20	70	LOD OV						
	11.000			1.515	215.265			20	20	20	20	20	LOD OV						
	12.000			1.635	215.145		30	30	30			10	BO LOD OV						
	13.000			2.052	214.728		10	30	40		10	10	BO LOD OV						
	14.000			2.600	214.18			10	40	30	10	10	CO						
	15.000			2.880	213.9			10	40	30	10	10	CO						
	16.000			3.124	213.656		30	30	10	30			BO CO						
	16.600			3.133	213.647			35	35	20	5	5	CO						OLD LWE
	17.000			2.982	213.798			33.3	33.3	22.2	5.56	5.56	CO						WATER IN WAVES
LWE	18.100			3.402	213.378			33.3	33.3	22.2	5.56	5.56	CO						
	18.200			3.435	213.345			40	40		20		CO	0.00	0.00	0.00			
RWE	18.300			3.395	213.385			40	40		20		CO						
	18.500			3.298	213.482			40	40		20		CO						
	19.000			3.315	213.465			50	30	10	10		CO						
LWE	19.200			3.502	213.278		10	60	30				BO CO						
	19.300			3.723	213.057		30	40	30				BO CO	0.27	0.43	0.62	0.63		
	19.500			3.512	213.268		30	40	30				BO CO	0.08	0.63	0.63	0.63	340	
	20.000			4.020	212.76		30	40	30				BO CO	0.54	0.76	1.02	1.08		DEPTH AT 400 CFS =
	21.000			4.300	212.48		50	50					BO CO	0.66	0.00	0.09	1.92		BEHIND ROCK/HEIG
	27.000			4.410	212.37		50	50					BO CO	0.78	0.57	1.57	1.71		
	28.000			3.700	213.08		60	40					BO CO	0.08	0.97	0.97	0.97		
	28.700			4.065	212.715		80	20					BO CO	0.44	0.66	0.86	0.70		

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT17726.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	1772.6	Channel type	Multi	single or multiple	
Reach	1	D90	0.65	90th %tile substrate si=e (m)	
Date	Dec 14/93	Channel Slope	.0027	surveyed value (m/m)	
Time	9:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF	Roughness Height (m)	0.4	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 10,11,12

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT17726.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	1772.6	Channel type	Multi	single or multiple	
Reach	1	D90	0.65	90th %tile substrate si=e (m)	
Date	Dec 14/93	Channel Slope	.0027	surveyed value (m/m)	
Time	9:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF	Roughness Height (m)	0.4	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 10,11,12

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
RWE	24.400			2.585	208.022		30	30	20	5	5	10	BO CO						
	25.000			2.452	208.155		30	30	20	10	5	5	BO CO						OLD RWE
	27.000			2.040	208.567		20	30	20	10	10	10	BO CO						
	29.000			1.789	208.818		50	20	10	5	5	10	BO CO						
	31.000			1.473	209.134			20	40	20	10	10	CO IV						
	33.000			1.652	208.955			30	30	20	10	10	CO						
	35.000			1.691	208.916		20	20	10	10	10	30	BO CO						
	37.000			1.667	208.94		50	10	10	10	5	15	BO CO						
	39.000			1.798	208.809		30	20	10	5	5	30	BO CO						
	41.000			1.684	208.923		50	10	10			30	BO CO						
	43.000			1.650	208.957		50	10	10			30	BO CO						
	45.000			1.650	208.957		30	10	10	5	5	40	BO CO						
	47.000			1.635	208.972		30	20	10	10		30	BO CO OV						
	49.000			1.262	209.345		25	15				60							
	50.000			0.894	209.713			10	10			80	BO IV OV						
PIN	51.200			0.472	210.135			10	10			80	OV IV CO						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT17726.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Transect	1772.6	Channel type	Multi	single or multiple
Reach	1	D90	0.65	90th %tile substrate si=e (m)
Date	Dec 14/93	Channel Slope	.0027	surveyed value (m/m)
Time	9:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BW/BP/PF	Roughness Height (m)	0.4	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 10,11,12

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.957	210.607		209.650														
PIN	0.000			0.509	210.392			10	5	25	10	50	IV						
	1.000			1.168	209.439			30	10	20	10	30	CO IV						
	2.000			1.802	208.805		40	20	20	10	5	5	BO CO						
	3.000			2.146	208.461		40	20	20	10	5	5	BO CO		0.00	0.00	0		
	3.500			2.451	208.156		30	30	20	10	5	5	BO CO		0.00	0.00	0		OLD LWE
	4.000			2.587	208.02		30	30	20	10	5	5	BO CO		0.00	0.00	0		
	5.000			2.173	208.434		40	30	10	20			BO CO		0.00	0.00	0		
LWE	5.120			2.596	208.011		40	30	10	20			BO CO						
	5.200			3.106	207.501		40	30	10	20			BO CO	0.51	0.00	0.00	0		
	6.000			3.218	207.389		70	10	10			10	BO CO	0.62	0.00	0.04	0.15		Depth at 400 cfs = 0.84
	7.000			3.315	207.292		60			25	5	10	BO CO	0.71	0.00	0.05	0.04		BEHIND SUBMERGE
	8.000			3.653	206.954		30	30	5	5	10	20	BO CO	1.08	0.16	0.20	0.25		BEHIND SUBMERGE
	9.000			3.668	206.939				10	20	30	40		1.08	0.24	0.32	0.28		UNWADEABLE
	10.000			3.762	206.845		20	40	30			10	CO	1.17	0.44	0.47	0.70		
	11.000			3.762	206.845		20	30	10	20	10	10	BO CO	1.19	0.42	0.51	0.87		
	12.000			3.847	206.76		20	30	10	20	10	10	BO CO	1.25	0.60	0.61	0.89		
	15.000			3.702	206.905		60	20	10	5	5		BO CO	1.13	0.58	0.64	0.88		
	16.000			3.446	207.161		60	20	10	5	5		BO CO	0.90	0.49	0.78	1.12		
	17.000			3.458	207.149		30	40	20	15	5		BO CO	0.91	0.40	0.48	0.91		
	18.000			3.337	207.27		20	30	20	20	5	5	BO CO	0.86	0.30	0.64	0.82		
	19.000			3.318	207.289		30	30	10	10	10	10	BO	0.75	0.36	0.58	0.64		
	20.000			3.340	207.267		30	30	10	10	10	10	BO CO	0.76	0.29	0.31	0.34		
	21.000			3.335	207.272		20	30	10	5		35		0.75	0.24	0.36	0.33		
	22.000			3.276	207.331		40	10	10			40	BO CO	0.71	0.06	0.06	0.07		
	23.000			2.933	207.67425		70	10	5	5	5	5	BO CO	0.40	0.01	0.00	0.00		
	24.000			3.300	207.3075		30	30	10	10	5	15	BO CO	0.80	0.00	0.00	0.00		

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT17304.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	1730.4	Channel type	Single	single or multiple	
Reach	1	D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 14/93	Channel Slope	.0024	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew		Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 13,14,15

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT17304.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	1730.4	Channel type	Single	single or multiple	
Reach	1	D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 14/93	Channel Slope	.0024	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew		Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 13,14,15

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT17304.XLS

Location	Seton R.
Transect	1730.4
Reach	1
Date	Dec 14/93
Time	12:30
Crew	

Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Channel type	Single	single or multiple
D90	0.3	90th %tile substrate si=e (m)
Channel Slope	.0024	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.15	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 13,14,15

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	23.000			2.742	207.368		30	20	40	5		5	BO CO	0.54	0.33	0.43	0.56		
	24.000			2.570	207.54		10	30	20	10	10	20	BO CO	0.38	0.00	0.45	0.51		BESIDE ROCK
	25.000			2.640	207.47		27.3	27.3	9.09	4.55	13.6	18.2	BO CO	0.45	0.11	0.19	0.30		
	26.000			2.678	207.432		20	40	20	5	5	10		0.48	0.39	0.49	0.44		
	27.000			2.594	207.516		60	20	10	5	5		BO CO	0.40	0.27	0.35	0.69		
	28.000			2.599	207.511		40	30	10	5	10	5	BO CO	0.42	0.33	0.37	0.43		
	29.000			2.463	207.647		50	20	10	5	10	5	BO CO	0.29	0.14	0.20	0.23		
	30.000			2.409	207.701		50	20	10	5	10	5	BO CO	0.23	0.05	0.16	0.24		
	31.000			2.642	207.468		60	10	20		5	5	BO CO	0.41	0.00	0.07	0.25		
	32.000			2.262	207.8485		30	30	10	10	5	15	BO CO	0.06		0.14			
	33.000			2.281	207.829		30	30	10	10	5	15	BO CO	0.11		0.08			
	34.000			2.670	207.44			10	30	40	15	5		0.50	0.00	0.00	0.00		
RWE	34.100			2.169	207.941														
	34.500			2.044	208.066		20	30	30	10	5	5	BO CO						
	36.000			1.902	208.208		20	20	40	10	5	5	BO CO						
	37.000			1.727	208.383			20	50	20	5	5	CO						
	39.000			1.504	208.606			30	40	20	5	5	IV CO						
	41.000			1.336	208.774			20	30	40	5	5	IV CO						
	43.000			1.178	208.932			10	10	20	10	50	IV CO OV						
	45.000			1.169	208.941			10			10	80	IV CO OV						
	47.000			1.478	208.632			40	20	5	5	30	OD IV OV CO						
	49.000			1.638	208.472		10	20	10	5		55	V OV BO CO						
	51.000			1.083	209.027			30	10		5	55	OV IV CO						
	53.000			0.598	209.512			20				80	OV IV CO						
PIN	54.400			-0.230	210.34							100	OV IV						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT17304.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	1730.4	Channel type	Single	single or multiple	
Reach	1	D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 14/93	Channel Slope	.0024	surveyed value (m/m)	
Time	12:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew		Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 13,14,15

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.460	210.110	209.650	209.650														
PIN	0.000			0.288	210.148			10	5	5	30	50	CO						
	2.000			1.653	208.457			10	30	20	10	30							
	2.800			1.969	208.141														
	3.000			2.092	208.018		20	30	20	20	5	5							
LWE	3.600			2.183	207.927														
	4.000			2.548	207.562		20	50	20	5		5	BO CO	0.31	0.10	0.05	0.06		
	5.000			2.738	207.372		50	30	10		5	5		0.54	0.32	0.34	0.42		
	6.000			2.947	207.163		30	20	10	20	15	5	BO CO	0.75	0.30	0.41	0.61		
	7.000			2.988	207.122		20	30	20	5	15	10	BO CO	0.79	0.60	0.69	0.88		
	8.000			2.970	207.14			40	30	5	20	5	CO	0.68	0.91	1.04	0.99		
	9.000			2.948	207.162			50	30	10	5	5		0.76	0.61	0.67	0.96		
	10.000			2.923	207.187		20	40	20	5	10	5		0.76	0.74	0.91	1.16		
	11.000			2.939	207.171		10	50	20	10	5	5		0.79	0.42	0.72	1.04		
	12.000			2.895	207.215		30	50	10	5		5		0.72	0.17	0.4	0.94		
	13.000			2.879	207.231		10	60	20	5		5	BO CO	0.71	0.66	0.74	0.99		
	14.000			2.820	207.29		50	30	10		5	5	CO	0.65	0.72	0.67	0.78		
	15.000			3.052	207.058		60	10	5	5	5	15	BO CO	0.89	0.46	0.86	0.73		
	16.000			2.920	207.19		70	10	5	10		5	BO CO	0.74	0.50	0.69	0.83		
	17.000			3.023	207.087		40	20	20	10	5	5	BO CO	0.85	0.28	0.59	0.75		Depth at 400 cfs = 1.05
	18.000			2.972	207.138		50	30	5	5	5	5	BO CO	0.79	0.00	0.51	0.76		BEHIND ROCK
	18.800			2.742	207.368		80	10				10	BO CO	0.57	0.00	0.37	0.63		BEHIND ROCK
RWE	19.000			2.181	207.929		80	10				10	BO CO						
	20.000			1.638	208.472		100						BO						
	21.000			1.355	208.755		100						BO						
	22.000			1.753	208.357		100						BO						
LWE	22.500			2.181	207.929														

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT1707.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	1707.0	Channel type	Single	single or multiple	
Reach	1	D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 15/93	Channel Slope	.0018	surveyed value (m/m)	
Time	8:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF	Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 4

Photo #'s 16,17,18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT1707.XLS

Location	Seton R.		Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	1707.0		Channel type	Single	single or multiple	
Reach	1		D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 15/93		Channel Slope	.0018	surveyed value (m/m)	
Time	8:30		Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF		Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
CO	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 4

Photo #'s 16,17,18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	49.000			2.378	207.87				50	35	5	10	CO						
	49.500			2.317	207.931														RWE
	50.000			2.236	208.012				30	30	10	30	CO						
	52.000			2.081	208.167		20	10	40	10		20	BO CO						
	53.600			1.952	208.296		30		10	10		50	BO CO						
	55.000			1.575	208.673		30	20	20	30			OV BO CO						
	56.000			1.123	209.125			30	40	30			OV						
	57.000			0.964	209.284		30			10		60	BO OV						
	58.000			0.751	209.497					20		80	OV						
PIN	58.900			0.106	210.142							100	OV						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT1707.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	1707.0	Channel type	Single	single or multiple	
Reach	1	D90	0.3	90th %tile substrate si=e (m)	
Date	Dec 15/93	Channel Slope	.0018	surveyed value (m/m)	
Time	8:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF	Roughness Height (m)	0.15	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 4

Photo #'s 16,17,18

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	25.000			2.721	207.527		30	20	20	10	10	10	BO	0.32	0.13	0.13	0.15		
	26.000			2.469	207.779		30	20		30	20			0.07	0.00	0.00	0.00		
	27.000			2.420	207.828			20	40	10	10	20		0.02	0.00	0.00	0.00		
RWE	27.100			2.398	207.85			20	40	10	10	10							
	28.000			2.288	207.96			10	30	30	20	10							
	29.000			2.290	207.958			30	20	10	20	20	CO						
LWE	29.300			2.321	207.927			30	20	10	20	20	CO						
	30.000			2.363	207.885			20	40	20	10	10	CO	0.06	0.00	0.00	0.00		
	31.000			2.412	207.836		30	20	30	5	10	5	BO CO	0.10		0.05		340	
	32.000			2.506	207.742		50		30	5	10	5	BO CO	0.20	0.00	0.10	0.10		
	33.000			2.473	207.775		30	20	20	5	5	20	BO CO	0.18	0.00	0.00	0.00		BEHIND ROCK
	34.000			2.421	207.827		50	20			5	25	BO CO	0.13	0.00	0.00	0.00		ROCK
	35.000			2.415	207.833		30	30	15	10	5	10	BO CO	0.10	0.09	0.09	0.09		ROCK
	36.000			2.438	207.81		10	20	30	15	20	5	CO	0.14	0.11	0.11	0.11	30	
	37.000			2.349	207.899			30	20	10	20	20	CO	0.05					ON ROCK
	38.000			2.404	207.844		15	15	10	20	30	10	BO CO	0.11	0.03	0.03	0.03	45	BEHIND ROCK
	39.000			2.495	207.753		20	30	30	5	5	10	BO CO	0.20	0.00	0.03	0.11	90	ON ROCK
	40.000			2.475	207.773			30	20	25	5	20	CO	0.17	0.11	0.23	0.18	30	
	41.000			2.426	207.822			20	30	30	10	10	CO	0.12	0.19	0.19	0.19	45	
	42.000			2.337	207.911				40	20	20	20	CO	0.02					
	43.000			2.417	207.831			30	10	30	10	20	CO	0.10		0.53		45	
	44.000			2.420	207.828		10	10	40	20	10	10	BO CO	0.11		0.30		45	
	45.000			2.420	207.828		20	30	20	10	10	10	BO CO	0.07	0.00	0.00	0.00		BESIDE ROCK
	46.000			2.371	207.877			10	60	20	10		CO	0.01					
	47.000			2.450	207.798				40	40	10	10		0.08		0.06		50	
	48.000			2.434	207.814				60	10	15	15	CO	0.05					
RWE	48.900			2.380	207.868														

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT1707.XLS

Location	Seton R.
Transect	1707.0
Reach	1
Date	Dec 15/93
Time	8:30
Crew	BW/BP/PF

Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Channel type	Single	single or multiple
D90	0.3	90th %tile substrate si=e (m)
Channel Slope	.0018	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.15	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: Se 4
Photo #'s 16,17,18

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.598	210.248	209.650	209.650														AT 100M
PIN	0.000			1.026	209.687		50	5	5			40	OV IV						
	2.000			1.091	209.157						10	90	OV IV						
	4.000			1.263	208.985				15	10	25	50	OV IV						
	5.000			1.271	208.977		25	15	10	10	15	25	LOD IV OV						
	6.000			1.780	208.468		15	40	30	15			LOD						
	7.000			2.368	207.88		40	20	15	10	5	10	BO CO						
	7.050			2.400	207.848		40	20	15	10	5	10	BO CO						OLD LWE
LWE	7.750			2.458	207.79		10	15	40		15	20	BO CO						
	8.000			2.550	207.698		10	15	40		15	20	BO CO	0.09		0.00			ON ROCK (BEHIND R
	9.000			2.794	207.454		20	40	10	30			BO CO	0.34	0.12	0.23	0.23		
	10.000			2.950	207.298		40	40	10	10			BO CO	0.53	0.57	0.66	0.71		BEHIND ROCK
	11.000			3.399	206.849		40		50		10			0.99	0.56	0.66	0.88		Depth at 400 cfs = 1.10
	12.000			3.408	206.84		15	25		20	30	10		1.00	0.59	0.74	0.84		
	13.000			3.400	206.848		15	15	10	15	20	25		1.00	0.99	1.12	1.42		
	14.000			3.244	207.004		40	20	10		15	15	BO	0.83	0.64	0.76	1.10		
	15.000			3.260	206.988		40	20	20	5	5	10		0.87	0.72	1.14	1.37		
	16.000			3.199	207.049		40	20	20		10	10	BO	0.82	0.77	0.90	1.24		
	17.000			3.233	207.015		30	10	20	10	20	10	BO	0.84	0.81	0.92	1.06		
	18.000			3.238	207.01			10	30	30	20	10		0.83	0.45	0.82	1.03		
	19.000			3.234	207.014		30	30	15	5	10	10	BO	0.84	0.65	1.01	1.15		
	19.700			3.119	207.129		60	15	5		5	15	BO	0.70	0.63	0.79	0.85		BESIDE ROCK
	20.000			2.700	207.548		60	10	5	5	5	15	BO	0.27	0.62	0.72	0.69		ON ROCK
	21.000			3.072	207.176		10	30	20	20		20	CO	0.66	0.33	0.61	0.57		
	22.000			2.879	207.369		30	15		10	15	30	BO CO	0.47	0.00	0.44	0.50		BEHIND ROCK
	23.000			2.808	207.44		25			30	20	25	BO	0.41	0.37	0.44	0.57		
	24.000			2.825	207.423		20	20	30	10	10	10	CO	0.42	0.03	0.03	0.09		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT840.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	***Input all cover types present - single space between types, no commas or slashes**		
Transect	840.0	Channel type	Multiple	single or multiple			
Reach	1	D90	0.5	90th %tile substrate si=e (m)	BO	bolder	
Date	Dec 15/93	Channel Slope	.0078	surveyed value (m/m)	C0	cobble	
Time	11:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.	LOD	large organic debris	
Crew	BW/BP/PF	Roughness Height (m)	0.3	height of roughness (m)	IV	instream vegetation	
					OV	overstream vegetation	
					CU	cutbank	
					ICE	ice	

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 19.20.21.22.23

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT840.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool	
Transect	840.0	Channel type	Multiple	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 15/93	Channel Slope	.0078	surveyed value (m/m)	
Time	11:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BW/BP/PF	Roughness Height (m)	0.3	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4

Photo #'s 19.20.21.22.23

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
RWE	46.400			1.386	199.306														
	47.000			1.380	199.312		40	30	10	5	5	10	OD BO CO						
	48.000			1.070	199.622		40	40	10			10	BO CO						
	49.000			1.107	199.585		20	30	20	5		25	BO CO						
	50.000			1.012	199.68		20	50	10			20	OD BO CO						
	51.000			0.769	199.923		40	20	20	5		15	LOD BO CO						
	52.000			0.678	200.014		20				10	70	IV OV						
	54.000			0.549	200.143		20	20				60	IV OV						
	56.000			0.400	200.292		10	30				60	IV OC BO						
PIN	57.300		200.692	0.375	200.317			10	5			85	IV OV						

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT840.XLS

Location	Seton R.	Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Transect	840.0	Channel type	Multiple	single or multiple
Reach	1	D90	0.5	90th %tile substrate si=e (m)
Date	Dec 15/93	Channel Slope	.0078	surveyed value (m/m)
Time	11:50	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BW/BP/PF	Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 19.20.21.22.23

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	23.000			2.606	198.086			60	20	10	5	5	CO	0.26	1.27	1.22	1.14		
	24.000			2.898	197.794			40	50		10		CO	0.59	0.46	0.17	1.49		DEPTH AT 400 CFS =
	25.000			2.790	197.902			40	50		10		CO	0.52	1.60	1.87	2.47		Unwadeable beyond
	29.000			3.008	197.684			50	40	10			CO	0.74	0.62	1.79	2.29		
	30.000			2.831	197.861			40	50	5	5		CO	0.54	0.90	1.18	1.66		
	31.000			2.729	197.963			50	30	10	5	5	CO	0.44	0.69	0.73	0.99		
	32.000			2.593	198.099			30	50	15	5		CO	0.30	0.95	0.86	0.89		
	33.000			2.308	198.384			60	20	10	10		CO	0.08		0.24		270	
	34.000			2.243	198.449		30	50	10	5	5		BO CO	0.13		0.70		315	
	35.000			2.105	198.587		18.2	54.5	13.6	13.6			BO CO	0.12		0.21		330	
RWE	35.800			1.968	198.724								BO CO	0.00					
	36.000			1.805	198.887		60	30	10				BO CO	0.00					
LWE	36.600			1.943	198.749								BO CO	0.00					
	37.000			1.976	198.716		60	25	10	5			BO CO	0.11		0.00			
	38.000			1.910	198.782		40	40	15	5			BO CO	0.06		0.05		290	
	39.000			2.158	198.534		10	60	20	5		5	BO CO	0.30	0.06	0.12	0.00		
	40.000			1.915	198.777		10	40	30	10	5	5		0.08		0.00			
RWE	40.300			1.850	198.842														
	41.000			1.223	199.469		30	30	20	15	5		BO CO						
	42.000			1.283	199.409		40	30	20	5	5		LOD BO CO						
	43.000			1.208	199.484		30	40	10	15	5		BO CO						
	44.000			1.257	199.435		40	40	10	5		5	OD BO CO						
	44.500			1.440	199.252														
	45.000			1.102	199.59		20	50	10	5	5	10	OD BO CO						
	45.600			1.443	199.249														
LWE	46.000			1.395	199.297		10	60	5	5		20	OD BO CO						BACK EDDY
	46.100			1.500	199.192									0.10		0.00			

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT840.XLS

Location	Seton R.
Transect	840.0
Reach	1
Date	Dec 15/93
Time	11:50
Crew	BW/BP/PF

Hydraulic Unit Type	Riffle	cascade, riffle, glide, run, pool
Channel type	Multiple	single or multiple
D90	0.5	90th %tile substrate si=e (m)
Channel Slope	.0078	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.3	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 4
Photo #'s 19.20.21.22.23

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		1.150																	
PIN	0.000		200.692	0.979	199.713		60	20	10	5		5	BO CO						
	1.000			1.600	199.092		40	20	20	15		5	BO CO						
	2.000			2.018	198.674		80	5		10	2	3	BO CO						
	3.000			2.170	198.522		80	15	5				BO CO						
LWE	3.300			2.681	198.011								BO CO						
	3.400			2.899	197.793		80	10		5		5	BO CO	0.21		0.00			
	4.000			3.213	197.479		30	20	20	20	5	5	BO CO	0.51	0.45	0.54	0.44	340	
	5.000			3.206	197.486			20	50	20	5	5	CO	0.51	0.41	0.65	0.68		
	6.000			3.038	197.654			10	50	30	5	5	CO	0.37	0.24	0.22	0.3	315	
	7.000			3.020	197.672		30	60	10				BO CO	0.24	0.78	1.17	1.89	270	
	8.000			2.907	197.785		50	40	10				BO CO	0.25	0.11	0.17	2.04	280	BEHIND ROCK
	9.000			2.734	197.958		30	70					BO CO	0.32	1.10	0.86	0.86	280	
	10.000			2.622	198.07		30	65	5				BO CO	0.13		0.58		290	
	10.500			2.375	198.317		30	65	5				BO CO	0.16		1.09		280	
	11.000			2.278	198.414		40	40	20				BO CO	0.06		0.30		290	
	12.000			2.298	198.394		40	30	20	10			BO CO	0.10		1.25		330	
	13.000			2.429	198.263		20	60	15	5			BO CO	0.33	0.98	1.35	1.47	330	
	14.000			2.485	198.207		50	40	10				BO CO	0.33	0.74	0.87	0.84	330	
	15.000			2.123	198.569		10	40	20	20	5	5	BO CO	0.02		0.00			
	16.000			2.304	198.388		40	30	20	10			BO CO	0.15	0.21	0.64	0.86	30	
	17.000			2.402	198.29		10	40	30	10	5	5	BO CO	0.18	0.38	0.73	1.36	30	
	18.000			2.314	198.378			60	30	10			CO	0.11		0.75		45	
	19.000			2.396	198.296			50	20	20	5	5	CO	0.09		0.87		45	
	20.000			2.430	198.262		20	40	20	10	5	5	BO CO	0.12		0.27		60	
	21.000			2.682	198.01		30	40	20		5	5	BO CO	0.28	0.00	0.42	1.13	90	BEHIND ROCK
	22.000			2.760	197.932			70	10	5	10	5	CO	0.40	0.14	0.34	0.20		

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT700.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool		
Transect	700.0	Channel type	Single	single or multiple		
Reach	1	D90	0.4	90th %tile substrate si=e (m)	BO	bolder
Date	Dec 15/93	Channel Slope	.0081	surveyed value (m/m)	C0	cobble
Time	2:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	LOD	large organic debris
Crew	BP/BW/PF	Roughness Height (m)	0.2	height of roughness (m)	IV	instream vegetation
					OV	overstream vegetation
					CU	cutbank
					ICE	ice

***Input all cover types present - single space between types, no commas or slashes**

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT700.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	700.0	Channel type	Single	single or multiple	
Reach	1	D90	0.4	90th %tile substrate si=e (m)	
Date	Dec 15/93	Channel Slope	.0081	surveyed value (m/m)	
Time	2:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew	BP/BW/PF	Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT700.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Transect	700.0	Channel type	Single	single or multiple
Reach	1	D90	0.4	90th %tile substrate si=e (m)
Date	Dec 15/93	Channel Slope	.0081	surveyed value (m/m)
Time	2:30	Meter Used	M&M	M&M, Swoffer, Gurley etc.
Crew	BP/BW/PF	Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
CO	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5
Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
RWE	25.200			1.916	197.427														
	26.000			1.863	197.48		20	30	20	10	10	10	BO						
	27.000			1.670	197.673		22.2	22.2	22.2	22.2	5.56	5.56	BO CO						
	28.000			1.630	197.713		16.7	33.3	22.2	16.7	5.56	5.56	BO CO						
	29.000			1.501	197.842			40	20	25	10	5	CO						
	30.000			1.489	197.854			20	40	30	10		CO						
	31.000			1.418	197.925		10	30	40	15	5		BO CO						
	32.000			1.575	197.768			10	40	40	5	5	CO						
	33.000			1.699	197.644					70	20	10							
	34.000			1.883	197.46				5	20	35	40							
	35.000			1.988	197.355				40	20	10	30	CO						
LWE	35.900			2.017	197.326				50	30	10	10	CO						POOL
	36.700			2.068	197.275				80	20			CO	0.04	0.00	0.00	0.00		POOL
RWE	37.200			2.018	197.325		30	20	50				BO CO						
	37.600			2.031	197.312		30	20	50				BO CO						
	39.000			1.380	197.963			20	30	25	20	5	CO						
	39.600			1.052	198.291			40	30	30			CO						
	41.000			0.983	198.36		10		60	10		20	BO CO						
	43.000			0.739	198.604				40	30	20	10	IV CO						
	45.000			0.364	198.979			30	30	20		20	IV CO						
	46.000			0.212	199.131							100	IV CO						
	48.000			0.322	199.021							100	IV CO						
PIN	50.000		199.343	0.340	199.003							100	IV OV LOD						

Seton River Field Survey - Dec '93

O:\2213\SETON\TRANSECT\SRT700.XLS

Location	Seton R.
Transect	700.0
Reach	1
Date	Dec 15/93
Time	2:30
Crew	BP/BW/PF

Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Channel type	Single	single or multiple
D90	0.4	90th %tile substrate si=e (m)
Channel Slope	.0081	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5

Photo #'s 1,2,3

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate: BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.548																	
PIN	0.000			0.448	198.895		20	30	30	20			BO CO						*Old LWE Likely wrong
	1.000			1.044	198.299		60	10	10	10	5	5	BO CO						(3.8?)
	2.000			1.435	197.908		50	10	30	5		5	BO CO						
LWE	2.800			1.929	197.414														
	3.000			1.964	197.379		60	30	10				BO CO	0.07		0.00			
	4.000			1.990	197.353		55.6	22.2	11.1	5.56	5.56		BO CO	0.09		0.11		90	
	5.000			2.824	196.519		100						BO	0.92	0.66	0.81	0.88		
	6.000			2.836	196.507		60	20		10				0.93	1.06	1.14	1.17		UNWADEABLE BEYO
	8.000			3.149	196.194			50	20	10	20			1.25	0.99	1.02	1.01		
	9.000			2.928	196.415		30	20	20	30			BO	1.03	0.51	0.87	0.85		
	10.000			2.847	196.496		20	20	30	5	5	20	CO	0.93	0.64	0.80	0.95		
	11.000			2.935	196.408		30	10	30	15	15		BO	1.00	0.81	1.07	1.31		
	12.000			2.763	196.58		30	20	30		10	10		0.85	0.90	0.98	1.17		
	13.000			2.701	196.642		40	10	20	20	5	5	BO	0.79	0.72	1.12	1.24		IN FRONT OF ROCK
	14.000			2.723	196.62		20	20	30		15	15	CO	0.81	0.32	0.56	0.88		Depth at 400cfs= 0.86
	15.000			2.600	196.743		40	10	20	20	5	5	BO CO	0.70	0.11	0.37	0.93		IN FRONT OF ROCK
	16.000			2.502	196.841		30	30	25	5		10	BO CO	0.59	0.26	0.41	0.55		IN FRONT OF ROCK
	17.000			2.508	196.835		20	35	25	5	10	5	BO CO	0.60	0.49	0.52	0.63	30	
	18.000			2.271	197.072		20	40	20	10	10		BO CO	0.25	0.44	0.51	0.59		
	19.000			2.242	197.101		40	30	10	10		10	BO CO	0.31	0.48	0.55	0.62		ON ROCK
	20.000			2.296	197.047		10	50	20	10		10	CO	0.26	0.30	0.29	0.27		
	21.000			2.249	197.094		30	20	20	10	10	10	BO	0.31	0.00	0.07	0.16	270	BEHIND ROCK
	22.000			2.093	197.25		10	30	10	10	20	20	CO	0.14		0.35			
	23.000			2.100	197.243		20	40	10	20	5	5	CO	0.17	0.03	0.16	0.17		BEHIND ROCK
	24.000			2.054	197.289			10	40	20	10	20	CO	0.12	0.00	0.00	0.00		
	25.000			1.973	197.37		30	20	10	20	10	10	CO	0.05	0.00	0.00	0.00		

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT653.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	653.0	Channel type	Multi	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 19/93	Channel Slope	.0088	surveyed value (m/m)	
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew		Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	18.300			2.090	197.219														
LWE	18.800			2.261	197.048														
	19.000			2.502	196.807		20	40	20	5	10	5	BO CO	0.24	0.16	0.20	0.30		
	20.000			2.464	196.845		40	20	20	10	5	5	BO	0.19	0.38	0.49	0.38		BESIDE ROCK
RWE	20.100			2.258	197.051														
	20.200			2.213	197.096														
LWE	20.500			2.262	197.047														
	20.600			2.342	196.967									0.10		0.45			
	21.000			2.360	196.949		10	40	20	10	5	15	BO CO	0.11		0.20			
	22.000			2.416	196.893		10	30	30	15	10	5	BO CO	0.17	0.00	0.00	0.05	45	BEHIND ROCK
	23.000			2.488	196.821			50	30	10	5	5	CO	0.24	0.05	0.04	0.14		
	24.000			2.445	196.864			30	30	25	10	5	CO	0.21		0.07			
	25.000			2.365	196.944		30	30	20	5	5	10	BO CO	0.12		0.07			
RWE	25.200			2.239	197.07														
	25.600			2.006	197.303														
LWE	25.800			2.268	197.041														
	26.000			2.324	196.985		40	30	10	10	5	5	BO CO	0.06		0.10			
RWE	26.200			2.261	197.048														
	26.300			2.200	197.109														
LWE	26.600			2.260	197.049														
	26.700			2.301	197.008									0.03	0.00	0.00	0.00		
RWE	26.800			2.262	197.047														
	27.000			2.173	197.136		20	50	10	10	5	5	CO						
	28.000			2.217	197.092			30	30	20	15	5							
	30.000			2.170	197.139			20	40	25	10	5	CO						
	32.000			2.285	197.024			10	40	30	10	10	CO						
	33.000			2.384	196.925			10	30	30	15	15							

Seton River Field Survey - Dec '93
O:\2213\SETON\TRANSECT\SRT653.XLS

Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool	
Transect	653.0	Channel type	Multi	single or multiple	
Reach	1	D90	0.5	90th %tile substrate si=e (m)	
Date	Dec 19/93	Channel Slope	.0088	surveyed value (m/m)	
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.	
Crew		Roughness Height (m)	0.2	height of roughness (m)	

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
BM		0.579																	
PIN	0.000			0.412	198.897				5		45	50							
	1.000			1.168	198.141		40	20		5	5	30	BO CO						
	2.000			1.828	197.481		85	10		5			BO CO						
	2.500			2.305	197.004														
LWE	2.600			2.306	197.003														
	3.000			2.637	196.672		80	15				5	BO CO	0.32	0.00	0.00	0		
	4.000			3.113	196.196		95					5		0.80	0.12	0.03	0.31	330	BEHIND ROCK
	5.000			2.747	196.562		100						BO	0.42	0.09	0.04	0.15	330	
	5.100			3.435	195.874									1.13	0.00	0.06	0.09	330	
	6.000			3.668	195.641		80		10	5		5		1.35	0.63	0.73	0.25	330	Depth at 400cfs = 1.41
	7.000			3.468	195.841									1.15		1.35			
	10.000			3.522	195.787		60	20	5	5	5	5		1.29	0.00	1.21	1.73		BEHIND ROCK
	11.000			3.195	196.114		50	10	10	5	20	5	BO	0.94	0.15	0.96	1.48		BEHIND ROCK
	12.000			3.122	196.187		10	40	20	10	15	5	CO	0.87	0.66	1.06	1.33		
	13.000			2.751	196.558		40	20	10	5	20	5	BO CO	0.55	0.00	0.06	1.22		BEHIND ROCK
	14.000			2.782	196.527		40	20	20	10	5	5	BO CO	0.53	0.05	0.33	0.68		
	15.000			2.588	196.721		50	30	5	5	5	5	BO CO	0.32	0.48	0.42	0.43		ON ROCK
	16.000			2.676	196.633		20	50	10	5	10	5	BO CO	0.41	0.27	0.36	0.54		
RWE	16.300			2.255	197.054														
	16.600			2.165	197.144														
LWE	16.800			2.239	197.07														
	17.000			2.492	196.817		50	30	5	5	5	5	BO	0.24	0.05	0.29	0.51		
	17.200			2.501	196.808									0.25	0.35	0.43	0.54		
RWE	17.300			2.251	197.058														
	17.700			2.172	197.137														ON ROCK
	18.000			2.250	197.059		30	40	20	10			BO CO						

Seton River Field Survey - Dec '93

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Location	Seton R.	Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool		
Transect	653.0	Channel type	Multi	single or multiple		
Reach	1	D90	0.5	90th %tile substrate si=e (m)		
Date	Dec 19/93	Channel Slope	.0088	surveyed value (m/m)		
Time	9:00	Meter Used	M&M	M&M, Swoffer, Gurley etc.		
Crew		Roughness Height (m)	0.2	height of roughness (m)		

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5
Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.
NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments

Seton River Field Survey - Dec '93

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Location	Seton R.
Transect	653.0
Reach	1
Date	Dec 19/93
Time	9:00
Crew	

Hydraulic Unit Type	Run	cascade, riffle, glide, run, pool
Channel type	Multi	single or multiple
D90	0.5	90th %tile substrate si=e (m)
Channel Slope	.0088	surveyed value (m/m)
Meter Used	M&M	M&M, Swoffer, Gurley etc.
Roughness Height (m)	0.2	height of roughness (m)

***Input all cover types present - single space between types, no commas or slashes**

BO	bolder
C0	cobble
LOD	large organic debris
IV	instream vegetation
OV	overstream vegetation
CU	cutbank
ICE	ice

SKETCH TRANSECTS ON THE BACK OF THIS SHEET

Photo Roll Label: SE 5

Photo #'s 4,5,6

NOTE THE PIN, LWE AND RWE STATIONS.

NOTE NON-METRIC MEASUREMENTS, IF ANY.

Station	Distance (m)	Backsight (m)	Height of Instrumen	Foresight (m)	Elevation (m)	% Substrate BED ROC	BO >256 mm	LC 128-256	SC 64-128	LG 16-64	SG 2-16	FI <2 mm	Cover*	Depth (m)	Velocity m/s @ 0.2	@ 0.4	@ 0.8	Flow angle (°)	Comments
	34.000			2.506	196.803			30	40		20	10							
LWE	34.600			2.578	196.731														
	35.000			2.621	196.688		20	30	25	10	10	5	BO CO	0.04	0.00	0.00	0.00		
RWE	35.500			2.584	196.725														
	35.700			2.488	196.821														ON ROCK
LWE	35.800			2.580	196.729														
	36.000			2.613	196.696			40	30	5	10	15	CO	0.03	0.00	0.00	0.00		
	37.000			2.705	196.604			50	20		10	20	CO	0.12	0.00	0.00	0.00		
RWE	37.400			2.582	196.727														
	38.000			2.380	196.929		25	35	20	10	5	5	BO CO						
	39.000			1.820	197.489		40	20	20	10	5	5	BO CO						
	40.000			1.243	198.066			50	25	15	10		CO						
	41.000			1.068	198.241			50	20	10	15	5	CO						
	43.000			1.103	198.206		30	40	15	5		10	BO CO						
	45.000			1.000	198.309			60	10	10	10	10	CO						
	47.000			0.940	198.369			30	30	10	15	15	IV, CO						
	49.000			0.832	198.477			30	30	10	5	25	CO IV						
PIN	49.600		199.309	0.883	198.426														