CHAPTER 8

Evaluation of the Value of Surrounding Vegetative Regime to Salmonids in Agricultural Waterways

8.1 Introduction to RCG Impacts to Salmonids (Goal 7)

Although there is little published information on salmonid use of small watercourses associated with agricultural areas in King County's riverine floodplains and on the Enumclaw Plateau, waterways within these areas are known to be used by various salmonid species (Berge 2002). The objective of the broader study was to determine effective and economical means to maintain agricultural watercourses while protecting fish habitat. To achieve this objective, a research plan for twelve specific goals was created. For additional detail about the development of this project and additional goals addressed as part of this study, readers are referred to the Sampling and Analysis Plan developed by Washington State University and the University of Washington (2006) and approved by KCDNRP.

The goal of this study component was to determine if reed canarygrass (*Phalaris aundinaceae*, RCG) regimes provide positive, negative, or neutral value to salmonids (*Oncorhynchus spp*.)when compared to reference systems with no vegetation or with intact riparian vegetation. Over time, many floodplain agricultural areas have become subject to more frequent and prolonged flooding due, in part, to accumulation of fine sediments and establishment of RCG within the channels. King County initiated its Agricultural Drainage Assistance Program (ADAP) to provide assistance to landowners interested in maintaining drainage in agricultural waterways in accordance with King County's Sensitive Areas Ordinance and clearing and grading code. In many waterways maintenance activities have included physical removal of accumulated RCG from the channel with unknown impacts to salmonids.

With the assistance of KCDNRP staff, the following research hypotheses were posed in relation to this study component:

1. Salmonid condition factor does not vary among agricultural waterways bordered by various riparian vegetative regimes (cleaned, natural, RCG, mixed).
2. (a) There is no difference in juvenile salmonid prey availability (species composition or abundance) among agricultural waterways surrounded by various vegetative regimes, and (b) There is no difference between the availability of food items and those consumed by juvenile salmonids in agricultural waterways surrounded by various vegetative regimes (Alternatively stated, juvenile salmonids consume prey items in proportion to their availability, regardless of surrounding vegetative regime).

The impact of surrounding vegetative regime on salmonid growth patterns in agricultural waterways has not been previously evaluated. Doing so as part of this study relied upon investigation of: (1) salmonid weight-length relationships, (2) benthic community composition, and (3) salmonid diets across a range of vegetative regimes common to agricultural waterways within King County.

Weight-length relationships of fishes are often expressed as condition factors. The relationship parameters are important in that they provide a measure of the health or well-being of fishes (Ney 1993) and can give information on a specific stock's condition (Bagenal and Tesch 1978). LeCren (1951) developed the relative condition factor (K_n) which uses the weight-length relation developed across all size groups in a particular population, addressing earlier concerns over changes in the relationship due the size of individuals observed.

A healthy and diverse benthic macroinvertebrate community is an important part of the food web connecting plants and fish (Allen 1995; Karr 1998). Benthic macroinvertebrates are animals without backbones that can be as small as 0.5 mm in length and which live in or near aquatic ecosystems during some portion of their life cycle. Because of their abundance and position in the aquatic food chain, macroinvertebrates play a critical role in the flow of energy and nutrients and act as an important food source for many fish species including the juvenile salmonids inhabiting agricultural waterways. The riparian community along streams can affect the composition of macroinvertebrates assemblages (Hawkins et al. 1982; Meehan 1996). Barbour et al. (1999) demonstrated that macroinvertebrate diversity can be used as a rapid assessment technique to indicate overall water quality and ecosystem condition including riparian vegetative cover. However, little information exists concerning the interaction of these parameters in agricultural drainage systems, or low gradient floodplain tributaries.

Macroinvertebrate sampling was conducted to evaluate differences in the community composition across different vegetative regimes typically associated with salmonid habitat in agricultural drainage watercourses. Coincidental evaluation of salmonid diet composition was conducted to determine if salmonids illustrate preference or avoidance of specific prey items from the macroinvertebrate community.

It is important to recognize that this phase of the study was designed to provide only preliminary baseline information concerning the diet of juvenile salmonids. Discussions with KCDNRP staff during initial project scoping examined the economic feasibility of conducting a comprehensive macroinvertebrate sampling plan and it was determined that such efforts were not practical. However, the macroinvertebrate/salmonid diet sampling plan did result in collection of useful baseline data regarding these topics.

8.2 Methods

8.2.1 Site Selection

Initial site selections for evaluation of salmonid use of agricultural waterways (including assessment of fish condition) were conducted in consultation with King County staff, willing landowners, and site visits. Watercourse classification with regard to vegetative regime was considered during initial site selection, and efforts were made to ensure that representative numbers of sites were selected in each vegetative regime or condition. Vegetative condition was defined by the dominant vegetation surrounding the sampling reach and was classified as:

1. Reed Canarygrass (RCG).
2. Natural (a mixture of herbaceous vegetation including trees with no or limited RCG influence).
3. Mixed Vegetation (includes both herbaceous vegetation and a moderate to abundant RCG influence).

Sites selected for macroinvertebrate and coincidental salmonid stomach content collection were a subset of the sites utilized for the broader study. Sites were selected for their prior presence of salmonid fishes and for their representation of various vegetative regimes found throughout the county's APDs. Fish length and weight data were collected from sites throughout the Snoqualmie, Lower Green, and Enumclaw APDs (See Appendix 8-A).

8.2.2 Fish Collection and Processing

For this study component, fish data collected seasonally (January/February, April, July and October) from the fall of 2002 through the spring of 2006 were analyzed. Fish were collected by electrofishing according to protocols defined by the National Marine Fisheries Service (2000). Length (mm) and wet weight (to nearest 0.5g) were recorded for the majority of individuals collected. In most cases, length and weight data were obtained from all fish collected. However, In cases when the numbers of fish collected were substantial enough to result in fish being retained for extended periods during data recording (e.g. resulting in undue stress to fish), length and weight information were collected only from a representative sample of each fish species captured.

8.2.3 Macroinvertebrate Collection and Processing

Macroinvertebrates were sampled in the summers of 2003 and 2004 from two agricultural drainage systems within King County. Sampling methodologies and level of macroinvertebrate identification varied between the two years, as the first year provided preliminary results that were modified for the second year. In both years three macroinvertebrate sampling sites were established within each drainage system, representing either a RCG, natural, or mixed riparian vegetative regime (See Appendix 8-B). The selected sampling period corresponded with the typical time window established for maintenance of agricultural waterways, and represents the most appropriate time for a single sample assessment of macroinvertebrates (Plotnikoff and Wiseman 2001).

In 2003, a total of 30 macroinvertebrate samples were collected from three sites, each representing a different riparian vegetative regime. The RCG (Olney-B-1) and natural (Olney-C-2) vegetation sites were located in the North Snoqualmie APD and were sampled in July. The mixed vegetation site (Smith-Brothers-A-1) was located in the Lower Green River APD and was sampled in August (See maps in Appendix 8-A). At each of the three sites a total of ten samples were collected, consisting of five replicate drift samples and five replicate surface fallout samples.

In 2003, drift invertebrates were gathered using a 500 µm mesh neuston net (61 cm [24"] wide and 30.5 cm [12"] long) dragged mid current below the surface at approximately 0.5m per second for 10 meters (33 feet). Surface insects that typically fall out of riparian vegetation into the agricultural watercourse were collected using fallout traps (30.5 cm [12"] x 15.3 cm [6"] pans filled with soapy water) placed on the water surface and underneath the riparian vegetation for approximately 24 hours (Toft et al. 2005). All samples were preserved in 90% isopropyl alcohol (Barbour et al. 1999; Plotnikoff and Wiseman 2001), stored at the University of Washington Center for Urban Horticulture and later identified to Order.

In July of 2004, a total of 54 macroinvertebrate samples were collected from six sites, with each riparian vegetative regime represented at two sites. The three sites sampled in 2003 were again sampled in 2004, each representing one of three vegetative regimes (RCG, natural vegetation, or mixed vegetation). Three additional sites including Decker-A-1 (Mixed vegetation; North Snoqualmie APD), Mullen-Slough-C-3 (RCG; Lower Green APD), and Mullen-Slough-A-2 (Natural vegetation; Lower Green APD) were also sampled in 2004 (See maps in Appendix 8-A). At each site, a total of nine macroinvertebrate samples were taken consisting of three replicates representing each of three aquatic sub-habitats: drift (instream current), surface (on top of the water's surface), and benthic (bottom substrate).

Benthic sub-samples were collected using an Eckman dredge at all but one sampling location. At the natural vegetation site in the North Snoqualmie APD, a one minute kick sample using the D-framed net was conducted because the bottom substrate consisted of bedrock, cobble and gravel embedded with fine silts; the Eckman dredge would have been ineffective in this substrate condition (USEPA 1998). Drift sub-samples were collected using a 1 foot wide D-framed net with 500 µm mesh net dragged for 3.28 feet (1 meter) just below the water surface in mid current. In addition, four jabs along the stream bank using the D-net were included in one of the three replicates in order to capture macroinvertebrates hiding or clinging to instream vegetation (Plotnikoff and Wiseman 2001). Surface sub-samples were collected using fallout traps (5" x 7" white plastic pans filled with soapy water) placed by the water's edge under each type of riparian vegetation for approximately 20 hours (Toft et al. 2005). All macroinvertebrate samples were preserved with 90% ethanol (Barbour et al. 1999; Plotnikoff and Wiseman 2001) and later identified to the lowest practical taxon which was typically Family or Genus.

During July, 2004 the stomach contents of 25 salmonids (22 juvenile coho; *Oncorhynchus kisutch*)and 3 cutthroat trout (*O. clarki*) were collected via a modified lavage technique (Seaberg 1957) from the same locations that macroinvertebrates were sampled; this technique is highly effective for removing prey from fish stomachs (Bowen 1983). Stomach contents were fixed in a ten percent solution of "Preservz-it", a non-carcinogenic formaldehyde alternative (http://rittelsupplies.net.html) and later transferred to a 70% aqueous solution of ethanol for preservation (Puget Sound Water Quality Authority 1987). Stomach contents were identified to the lowest practical taxon and life-stage and summarized according to the percent composition by number for comparison to the ambient community from which they were consumed.

8.2.4 Data Analysis

8.2.4.1 Fish Condition Data

In calculating and evaluating relative condition of salmonid species, length and weight measurements from quarterly field surveys were utilized. Relative error in field length and weight measurements is inversely related to fish size, with the greatest error observed in the smallest fish. For example, all fish were weighed in the field to the nearest 0.5g (±0.25g of the actual weight) so that a fish with a recorded weight of 2.5g has a relative error of ±10% associated with the recorded weight; in contrast, a fish with a recorded weight of 10.0g has a relative error of only ±2.5%. Examination of weight-length relationships suggested that the bias increased substantially for salmonids with recorded weights less than 2.5 grams, regardless of species. Therefore, in order to reduce the impacts of such bias, only salmonids with recorded weights exceeding 2.0 grams were included in the analyses of relative condition.

LeCren's relative condition factor expresses the deviation of an individual's weight from the average for fish of its length in that population; as such, it is particularly useful for within-population comparisons including seasonal or habitat related effects (Ney 1993). Weight-length relationship parameters were estimated through base-10 logarithm transformation of length and weight data and the use of least squares linear regression to evaluate:

$$\text{Log } W = \log a + b(\log L) \qquad (8.1)$$

where *L* is the measured fish length (mm), *W* is the measured fish weight (g), and *a* and *b* are regression constants.

The assessment of weight-length relationships can also provide valuable information on the manner in which fish grow while occupying a given habitat area. Weight of fish tends to increase as a cubic function of length so that for many populations *b* will be close to 3. Populations in which $b < 3$ exhibit negative allometric growth, meaning that they tend to become thinner as they grow longer. Populations in which $b > 3$ exhibit positive allometric growth, meaning that they tend to become plumper as they grow longer (Ney 1993; Anibeze 2000).

Once the condition factor relationship has been established, an approximation of average fish weight based on fish length was determined by rearranging Equation 8.1 as:

$$\hat{W} = 10^{(\log a + b * \log L)} \qquad (8.2)$$

where $\hat{W}$ is the predicted fish weight (g).

The relative condition (K_n) of an individual fish was then calculated as:

$$K_n = \frac{W}{\hat{W}} \qquad (8.3)$$

where W is the measured weight, $\hat{W}$ is the predicted weight determined by solving equation 8.2.

A distinct advantage of K_n is that means and standard deviations of K_n provide a better basis for statistical comparison than tests comparing values for *a* and *b* parameters in the weight-length equation (Anderson and Gutreuter 1983).

Weight length relationships were defined for each key salmonid species and season. Analysis of covariance (ANCOVA) was then used to evaluate seasonal differences in the weight-length relationships for each species. This procedure allowed us to determine if it was most appropriate to estimate relative condition factors separately by season (significant difference in slopes) or for a pooled data set across all seasons (no significant difference in slopes).

To evaluate the impact of surrounding vegetative regime (Cleaned, RCG, mixed or natural) on the relative condition of individual fish species, analysis of variance (ANOVA) was used. A one way ANOVA tested the impacts of surrounding vegetative regime while assuming that other factors potentially influencing fish condition (e.g. differences in feeding conditions or water temperature) were negligible based on a relatively balanced seasonal study design.

8.2.4.2 Macroinvertebrate and Fish Stomach Data

Comparison of macroinvertebrate communities across vegetative regimes was done using a benthic index of biological integrity (B-IBI) as described by Kleindl (1995) and Karr et al. (2003). Macroinvertebrates were identified to the lowest practical taxonomic level and a standard ten metric scoring system was used in calculating the B-IBI including: 1) Total Taxa Richness, 2) Mayfly Taxa Richness, 3) Stonefly Taxa Richness, 4) Caddisfly Taxa Richness, 5) Intolerant Taxa Richness, 6) Clinger Taxa Richness, 7) Long-lived Taxa Richness, 8) Percent Tolerant, 9) Percent Predator and 10) Percent Dominance. Percent dominance was based on the three most dominant taxa from each sample. Tolerance values were established using EPA's Rapid Bioassessment Protocols (Barbour et al. 1999).

Ivlev's electivity index (Ivlev 1961; Jacobs 1974; Strauss 1979) was used to determine whether salmonids prefer or avoid specific prey items within the biological stream community. Stomach contents of juvenile salmonids were examined and compared to the macroinvertebrate population found in the surrounding environment. The proportion of food in the salmonid diet was compared to it's proportion in the stream habitat using Ivlev's electivity index as:

$$E_i = \frac{P_i - A_i}{P_i + A_i} \quad (8.4)$$

where P_i is the percentage of prey "i" in the stomach contents of the fish, A_i is the percentage of the prey available in the natural environment, and E_i is Ivlev's electivity index. The calculated index ranges from a value of -1 (strong avoidance) to +1 (strong preference).

This index has been frequently used in the study of prey selection by fish predators (Gras and Saint-Jean 1982). Despite some concerns that the index may be overly influenced by the abundance of prey in the natural environment, a brief review of the more recent literature has found the index to be widely used in a variety of competition and foraging studies involving fish, birds, coral, and zooplankton (Kreb 1989; Arcos et al. 2001).

8.3 Results

8.3.1 Fish Condition

Salmonid species were collected in 58% (147 of 255) of the sampling events (site/date combinations) conducted between October, 2002 and April, 2006 (Appendix 8-C). Five species of salmonids accounting for nearly 2,600 individuals were collected. As illustrated in Table 8-1, Coho salmon accounted for the vast majority (88 percent, 2,275 individuals) of the salmonid catch. Chinook salmon (*O. tshawytscha*) and cutthroat trout accounted for approximately 7 and 4 percent, respectively, of the total salmonid catch (189 and 108 individuals, respectively) whereas rainbow trout/steelhead (6) and chum salmon (*O. keta*, 3) were encountered only in minimal numbers during this study.

Assessment of condition factors across vegetative regimes was limited to coho and Chinook salmon. Cutthroat trout condition was not assessed due to the diversity of life history strategies (anadromous and resident) and stages (juvenile-adult) collected as well as the inability of this study to account for those factors which may substantially affect fish condition. Chum salmon and rainbow/steelhead trout (*O. mykiss*) were not collected in numbers sufficient to perform an assessment of fish condition across vegetative regimes.

Table 8-1. Seasonal summary of electrofishing effort and salmonid catch.

Year / Season (Month)	Coho Salmon	Chinook Salmon	Chum Salmon	Cutthroat Trout	Rainbow/ Steelhead Trout	Unid. Salmonid	Total Salmonids
2002							
Fall (Oct.)	278	.	.	20	.	.	298
2003							
Winter (Feb.)	240	3	.	12	.	.	255
Spring (Apr.)	202	5	.	16	.	.	223
Summer (July)	199	.	.	8	.	.	207
Fall (Oct.)	116	.	.	5	.	.	121
2004							
Winter (Jan.)	78	1	.	2	2	.	83
Spring (Apr.)	119	66	2	6	.	.	191
Summer (July)	195	1	.	6	.	.	202
Fall (Oct.)	109	51	.	4	.	.	164
2005							
Winter (Jan.)	71	30	.	7	1	.	109
Spring (Apr.)	209	16	.	8	3	.	236
Summer (July)	276	3	.	10	.	.	289
Fall (Oct.)	166	8	.	1	.	.	175
2006							
Winter (Feb.)	8	5	.	2	.	.	13
Spring (Apr.)	9	.	.	1	.	3	13
Totals	**2,275**	**189**	**2**	**108**	**6**	**3**	**2,581**

8.3.1.1 Coho Salmon

Correlation (r^2) of weight-length relationships for coho salmon exceeded 0.85 in all seasons and for all vegetative regimes. For data pooled across all seasons and vegetative regimes, the correlation of the weight-length relationship was 0.916, illustrating a strong relationship between length and weight of juvenile coho salmon across seasons and habitat types. Statistics and sample size (*n*) by season and vegetation type are shown in Table 8-2.

Parameter estimates for the weight-length relationship of coho salmon collected from agricultural waterways were generally similar across seasons and vegetative regimes as indicated by the results presented in Table 8-2. Across seasons, intercept values ranged from -4.48 (Summer) to -4.91 (Fall) and slopes ranged from 2.84 (Winter) to 2.93 (Fall). Across vegetative regimes, intercept values ranged from -4.68 (RCG) to -4.99 (Cleaned) and slopes ranged from 2.83 (RCG) to 2.98 (Cleaned). For coho salmon, differences in slopes of seasonal weight length regressions were not found to be statistically significant (p=0.3755). This coupled with a high r^2 for the pooled data set was taken as evidence that pooled data from all seasons could appropriately be used for subsequent calculation of relative condition factors.

Table 8-2. Weight-length relationship parameters for coho salmon >2.0 grams in weight collected from agricultural watercourses in King County by season and vegetative regime.

Variable	***n***	**Intercept (a)**	**Slope (b)**	**Correlation (r^2)**	**Slope ≠ Pooled (p-value)**
Season					
Winter (Jan/Feb.)	391	-4.6940	2.8439	0.867	N/A*
Spring (April)	216	-4.8549	2.9182	0.950	N/A
Summer (July)	374	-4.4826	2.7220	0.851	N/A
Fall (Oct.)	491	-4.9130	2.9317	0.891	N/A
Dominant Vegetation					
Natural Vegetation	302	-4.7373	2.8537	0.940	No (0.331)
Mixed Vegetation	704	-4.8282	2.8976	0.891	No (0.927)
Reed Canarygrass	405	-4.6845	2.8350	0.912	No (0.178)
Cleaned	61	-4.9890	2.9841	0.952	No (0.306)
Pooled	1,472	-4.8137	2.8941	0.916	--

* Not Applicable – prior ANCOVA determined that no difference in seasonal slopes existed, resulting in use of the pooled data set. Subsequent comparison of seasonal slopes to that of the pooled data is therefore inappropriate.

Across vegetative regimes, juvenile coho salmon illustrated an isometric growth pattern relative to a pooled sample of coho salmon collected from agricultural waterways. Slopes of the weight-length relationship from each of the four vegetative regimes evaluated did not differ significantly from that of the pooled data (p>0.17; Table 8-2). The biological interpretation of this finding is that coho salmon in each of the four vegetative habitats increase similarly in weight as their length increases; in no habitat do they tend to become either thinner or plumper as they grow longer.

For coho salmon, relative condition varied significantly across habitat types (one way ANOVA; $p<0.0001$). The mean relative condition of coho salmon collected from RCG dominated habitats was significantly greater than that of coho salmon collected from sites dominated by either natural ($p<0.0104$) or mixed ($p<0.0001$) vegetation, but was not significantly different than that of coho salmon collected from habitats recently cleaned of vegetative cover ($p>0.35$; Table 8-3). Relative condition of coho salmon collected from cleaned waterways did not differ significantly from that of coho salmon collected from natural or mixed vegetative habitats ($p>0.80$). In addition, no significant difference in relative condition was observed between coho salmon collected from natural or mixed vegetative habitats ($p>0.50$).

Table 8-3. Comparison of relative condition (K_n) summary statistics for coho salmon collected from various vegetative habitat regimes in King County's agricultural waterways.

Habitat	***n***	**Mean**	**Minimum**	**Maximum**	**Standard Deviation**	**Statistical Differences**[1]
Cleaned	61	1.010	0.703	1.292	0.121	a b
RCG	405	1.043	0.627	1.697	0.149	a
Mixed	704	0.994	0.565	1.742	0.153	b
Natural	302	1.008	0.563	1.632	0.147	b

[1] Vegetative regimes with the same letter are not statistically different from one another.

8.3.1.2 Chinook Salmon

For Chinook salmon, correlation of estimated weight-length relationships exceeded 0.85 in all seasons and vegetative regimes with the exception of those waterways cleaned of vegetation (r^2=0.80). It should be noted that the number of Chinook salmon collected from cleaned waterways was very low (6 individuals collected) in comparison to other vegetative regimes sampled, possibly impacting the observed correlation. For data pooled across all seasons and vegetative regimes, the correlation of the weight-length relationship was 0.91, illustrating a strong relationship between length and weight of juvenile Chinook salmon across seasons and habitat types (Table 8-4).

Parameter estimates for the weight-length relationship of Chinook salmon collected from agricultural waterways were more variable than those observed for coho salmon. Across seasons, intercept values ranged from -3.98 (winter) to -6.34 (summer) and slopes ranged from 2.47 (winter) to 3.66 (summer). Both intercept and slope values of the weight-length relationship were most extreme (high or low) in the seasons with the lowest sample sizes (Table 8-4). Across vegetative regimes, intercept values ranged from -3.97 (RCG) to -4.62 (Natural) and slopes ranged from 2.47 (RCG) to 2.80 (Natural). For Chinook salmon, growth patterns (as differences in slopes of seasonal weight length regressions) were found to differ significantly across seasons (ANCOVA; p=0.0031). Summer and winter growth patterns (slopes) were significantly different than that of other seasons and significantly different from each other. Statistical significance of these slope differences is most likely an artifact of limited sample sizes ($n \leq 15$) in two of four seasons. Since no significant differences were observed between seasons with greater sample sizes of Chinook, nor for other similar species (coho), pooled data from all seasons was used to calculate relative condition of Chinook salmon.

Juvenile Chinook salmon illustrated an isometric growth pattern across both vegetative regimes and seasons relative to a pooled sample of Chinook salmon collected from agricultural waterways. Slopes of weight-length relationship from cleaned, natural, mixed and reed canarygrass vegetative regimes did not differ significantly from that of the pooled data (p>0.11; Table 8-4). Comparison of seasonal slopes for Chinook salmon yielded similar results, with no season having a slope significantly different than that of the pooled sample (p>0.25; Table 8-4). The biological interpretation of this finding is that across both seasons and vegetative habitat regimes, Chinook salmon increase similarly in weight as their length increases; in no season or vegetative regime do they tend to become either thinner or plumper as they grow longer.

For Chinook salmon, relative condition was found to vary significantly across habitat types (one way ANOVA; p=0.0107). The relative condition of Chinook salmon collected from sites dominated by a natural vegetative regime was found to be significantly greater than that of those collected from sites dominated by a mixed vegetative regime (p=0.0173). Relative condition of Chinook salmon collected from cleaned, RCG, or mixed vegetative regimes did not differ across habitat types (p>0.75). There was also no significant difference observed in relative condition of Chinook salmon collected from either cleaned or RCG regimes when compared to those collected from a natural vegetative regime (p>0.42; Table 8-5).

Table 8-4. Weight-length relationship parameters for Chinook salmon >2.0 grams in weight collected from agricultural watercourses in King County by season and vegetative regime.

Habitat	***n***	**Intercept (a)**	**Slope (b)**	**Correlation (r^2)**	**Slope ≠ Pooled (p-value)**
Season					
Winter (Jan/Feb.)	15	-3.9835	2.4722	0.859	No (0.452)*
Spring (April)	79	-4.4816	2.7178	0.932	No (0.720)
Summer (July)	4	-6.3445	3.6674	0.945	No (0.259)
Fall (Oct.)	59	-4.2975	2.6369	0.829	No (0.750)
Dominant Vegetation					
Natural Vegetation	86	-4.6297	2.7990	0.926	No (0.202)
Mixed Vegetation	28	-4.3638	2.6516	0.938	No (0.788)
Reed Canarygrass	37	-3.9729	2.4727	0.908	No (0.114)
Cleaned	6	-4.4331	2.6838	0.801	No (0.996)
Pooled	157	-4.4130	2.6877	0.918	--

* Prior ANCOVA determined that significant differences in seasonal slopes existed so comparison of seasonal slopes to that of the pooled data is appropriate. Seasonal differences were however believed to be due to limited sample size and the finding of no significant difference for these four comparisons supports that conclusion.

Table 8-5. Comparison of relative condition (K_n) summary statistics for Chinook salmon collected from various vegetative habitat regimes in King County's agricultural waterways.

Habitat	***n***	**Mean**	**Minimum**	**Maximum**	**Standard Deviation**	**Statistical Differences**[1]
Cleaned	6	0.956	0.717	1.314	0.215	a b
RCG	37	0.987	0.786	1.303	0.127	a b
Mixed	28	0.956	0.608	1.270	0.150	a
Natural	86	1.038	0.746	1.348	0.110	b

[1] Vegetative regimes with the same letter are not statistically different from one another.

8.3.2 Macroinvertebrates

8.3.2.1 2003 Macroinvertebrate Collections

The RCG dominated site had the highest average number of taxa (7) and intermediate abundance (avg. 102 organisms) of the three vegetative regimes sampled (Table 8-6). The site with mixed vegetative regime exhibited the greatest average number of individuals collected in drift samples (606), but intermediate taxa richness (average of 4.75 taxa) relative to other vegetative regimes (Table 8-7). Both average taxa richness and average number of individuals collected from drift samples were lower in the natural vegetative regime (average of 3.6 taxa and 36 organisms) than in other vegetative regimes sampled during 2003 (Table 8-8).

Dominant taxa observed in drift samples were variable across vegetative regimes and, in the case of RCG dominated habitat, variable across individual samples. Within the RCG dominated habitat Diptera, Heteroptera and Coleoptera were most commonly amongst the dominant taxa collected although Odonata numbers were also substantial in some drift samples (Table 8-6). At the mixed vegetative site, Coleoptera dominated drift sample collections by a wide margin over any other taxa collected (Table 8-7). Drift samples from the site dominated by natural vegetation were comprised primarily of Coleoptera and Heteroptera (Table 8-8).

Table 8-6. Macroinvertebrates collected from a channel dominated by RCG habitat during summer, 2003.

Order ↓	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Fallout Traps (5)**	**Total #**
Psocoptera	0	0	0	0	0	0	0
Collembola	2	0	4	0	0	9	15
Thysanoptera	0	0	0	0	1	1	2
Ephemeroptera	0	0	0	0	0	0	0
Plecoptera	0	0	0	0	0	0	0
Neuroptera	0	0	0	0	0	0	0
Trichoptera	1	1	0	0	1	0	3
Dermaptera	0	0	0	0	0	0	0
Odonata	20	2	18	2	7	2	51
Orthoptera	0	0	0	0	0	0	0
Heteroptera	14	11	33	8	15	44	125
Lepidoptera	0	0	0	0	0	0	0
Diptera	86	22	100	4	39	30	281
Coleoptera	32	15	14	5	9	11	86
Hymenoptera	6	5	7	9	3	22	52
Araneae	4	2	4	0	3	2	15
Total #	165	58	180	28	78	121	630
# of Taxa	8	7	7	5	8	8	10

Table 8-7. Macroinvertebrates collected from channel dominated by mixed vegetation during summer, 2003.

Order ↓	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Fallout Traps (5)	Total #
Psocoptera	0	0	0	0	0	8	8
Collembola	0	0	0	0	0	0	0
Thysanoptera	0	1	0	0	0	0	1
Ephemeroptera	0	0	0	2	1	0	3
Plecoptera	0	0	0	0	0	0	0
Neuroptera	0	0	0	0	0	0	0
Trichoptera	0	0	0	2	0	0	2
Dermaptera	1	1	0	0	0	0	2
Odonata	0	0	0	0	0	0	0
Orthoptera	0	0	0	0	0	0	0
Heteroptera	1	5	2	0	1	0	9
Lepidoptera	0	0	0	0	0	13	13
Diptera	3	3	7	1	3	86	103
Coleoptera	570	803	941	400	280	100	2,294
Hymenoptera	0	1	1	0	1	34	37
Araneae	0	0	0	0	0	15	15
Total #	575	814	951	405	286	256	3,287
# of Taxa	4	6	4	4	5	6	11

As indicated by fallout trap collections, surface macroinvertebrates were more abundant (256 invertebrates; Table 8-7) in the mixed vegetation site than at sites dominated by either a natural (165 invertebrates; Table 8-8) or RCG (121 invertebrates; Table 8-6) regime. In contrast, the number of taxa (Orders) observed from fallout traps in the mixed vegetative regime (6) was lower than that observed in either the natural (10 taxa) or RCG (8 taxa) regimes.

In RCG dominated habitat, the dominant macroinvertebrate taxa collected in fallout traps was similar to those collected from drift samples (Heteroptera, Diptera, Hymenoptera; Table 8-6). In the mixed vegetative regime, surface samples were dominated by Coleoptera similar to drift samples although Diptera and Hymenoptera were much more important the surface samples than the corresponding drift samples (Table 8-7). In the natural vegetative regime, fallout traps were dominated by Diptera, Collembola and Araneae (Table 8-8), none of which were dominant in corresponding drift samples.

No index of biological integrity (or associated metrics) was calculated for the 2003 data, as identification of macroinvertebrates was only to Order. Additionally, the benthic macroinvertebrates needed to calculate this index were not collected in 2003.

Table 8-8. Macroinvertebrates collected from a channel dominated by natural vegetation during summer, 2003.

Order ↓	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Fallout Traps (5)	Total #
Psocoptera	0	0	0	0	0	1	1
Collembola	0	0	0	0	0	22	22
Thysanoptera	0	0	0	0	0	1	1
Ephemeroptera	0	0	2	0	0	0	2
Plecoptera	0	0	0	0	0	1	1
Neuroptera	0	0	0	0	0	0	0
Trichoptera	0	1	0	0	0	0	1
Dermaptera	0	0	0	0	0	0	0
Odonata	0	0	0	0	0	1	1
Orthoptera	0	0	0	0	0	0	0
Heteroptera	41	5	1	20	6	3	76
Lepidoptera	0	0	0	0	0	0	0
Diptera	5	1	1	12	0	98	117
Coleoptera	31	7	4	37	2	10	91
Hymenoptera	0	0	0	0	1	10	11
Araneae	0	0	0	0	1	18	19
Total #	77	14	8	69	10	165	343
# of Taxa	3	4	4	3	4	10	12

8.3.2.2 2004 Macroinvertebrate Collections

Raw data from 2004 macroinvertebrate collections are included in Appendix 8-B. Summary information is presented in this section as it pertains to the calculation of B-IBI metrics used to assess differences between vegetative regimes and to subsequent comparison to fish diets.

A number of B-IBI metrics scored very low or zero for all three vegetative regimes sampled during 2004 (Table 8-9). Mayfly, stonefly, clinger and long-lived taxa richness were zero for all samples from all three vegetative regimes. Mixed vegetation was the only regime sampled from which caddisfly or intolerant taxa were collected although the richness of these groups was limited to two taxa. *Micrasema* sp. and *Lipostoma* sp. were intolerant caddisfly taxa collected from the mixed vegetative regime (See Appendix 8-B).

Average macroinvertebrate taxa richness was greater for sites with a mixed vegetative regime (10 taxa) than those with a natural (8 taxa) or RCG dominated vegetative regime (4.5 taxa; Table 8-9). In all vegetative regimes a few taxa dominated the macroinvertebrate community as evidenced by average percent dominance scores ranging from 72-79 percent. The percent tolerant organisms was greatest at sites dominated by RCG (87 percent), intermediate at naturally vegetated sites (73.5 percent), and lowest at sites with a mixed vegetative regime (54 percent). The percent of macroinvertebrates classified as predators was relatively low (average < 9 percent) in all vegetative regimes but was greatest in mixed vegetation habitats (8.5 percent) and lowest at sites with a natural vegetative regime (< 1 percent). Predatory macroinvertebrates made up 4 percent of the benthic communities sampled in RCG dominated habitats.

The 2004 data from benthic samples was used to calculate the B-IBI for comparison of the three vegetative regimes (Table 8-10). Combining all ten biological metrics used in determining the health of the biological community, the mixed riparian sites scored the highest B-IBI of 16. Natural and RCG vegetative regimes had comparable B-IBI scores of 11 and 10, respectively.

8.3.3 Salmonid Diet Evaluation

Stomach contents were collected from coho salmon and cutthroat trout during summer 2003 and 2004; no other salmonid species were encountered during diet sampling efforts. In 2003, stomach contents of 13 coho salmon and 1 cutthroat trout were collected, all from the natural vegetative regime (Table 8-11). In 2004, stomach contents were collected from 5 coho salmon in natural vegetative regimes, and 4 coho salmon and 2 cutthroat trout in mixed vegetative regimes (Table 8-12). Efforts to collect salmonids from RCG habitats coincident with macroinvertebrate collections during 2003 and 2004 were unsuccessful, as were efforts in mixed vegetative habitats during 2003.

During 2003 evaluations, coho salmon collected from a natural vegetative regime had a diverse diet with 28 different taxa/life stages identified from their stomach contents (Table 8-11). Most prey organisms however were rarely encountered with only 1-3 individuals observed in the stomach contents of 13 coho salmon evaluated. Chironomidae were the only organisms abundantly observed in the stomach contents of coho salmon. Chironomidae larvae were observed in eight of thirteen stomachs evaluated; Chironomidae pupae and adult life phases were each observed in four of thirteen stomachs evaluated. Larval Chironomidae were the dominant prey item consumed with an average of nearly 10 individuals observed per coho stomach. Adult Chironomidae were the only other taxa accounting for more than one organism per coho stomach on average (avg. 1.07) although that finding was largely driven by a single fish which had consumed 12 individuals.

Stomach contents from a single cutthroat trout were evaluated during 2003. The diet of that individual consisted primarily of snails (*Gyraulus* sp.) which accounted for approximately 95% of the organisms found in its stomach. One larval midge and one adult alderfly (Chironomidae and *Sialis* spp., respectively) accounted for the remaining diet contents of the sampled cutthroat trout.

During 2004 evaluations, diet composition of coho salmon collected from natural and mixed vegetative regimes was similarly diverse with twelve and fifteen prey taxa consumed, respectively, from each habitat (Table 8-12). The diets of 2 cutthroat trout collected from mixed vegetative regimes showed similar diversity to that of coho salmon, with 12 prey taxa consumed.

Table 8-9. B-IBI metrics scores for benthic macroinvertebrate samples taken from three vegetative regimes in July 2004.

	Reed Canarygrass				**Mixed**				**Natural**		
Metric	**Site 1**	**Site 2**	**Avg.**		**Site 1**	**Site 2**	**Avg.**		**Site 1**	**Site 2**	**Avg.**
Total Taxa Richness	3	6	4.5		9	11	10		8	8	8
Mayfly Taxa Richness	0	0	0		0	0	0		0	0	0
Stonefly Taxa Richness	0	0	0		0	0	0		0	0	0
Caddisfly Taxa Richness	0	0	0		0	2	1		0	0	0
Intolerant Taxa Richness	0	0	0		0	2	1		0	0	0
Clinger Taxa Richness	0	0	0		0	0	0		0	0	0
Long-lived Taxa Richness	0	0	0		0	0	0		0	0	0
Percent tolerant	77	97	87		60	48	54		72	75	73.5
Percent predator	4	4	4		14	3	8.5		<1	<1	<1
Percent dominance	81	76	78.5		69	78	73.5		62	82	72

Table 8-10. B-IBI values for benthic macroinvertebrate samples taken from three vegetative regimes in July 2004.

	Reed Canarygrass				**Mixed**				**Natural**		
Metric	**Site 1**	**Site 2**	**Avg.**		**Site 1**	**Site 2**	**Avg.**		**Site 1**	**Site 2**	**Avg.**
Total Taxa Richness	1	1	1		1	3	2		1	1	1
Mayfly Taxa Richness	1	1	1		1	1	1		1	1	1
Stonefly Taxa Richness	1	1	1		1	1	1		1	1	1
Caddisfly Taxa Richness	1	1	1		1	1	1		1	1	1
Intolerant Taxa Richness	1	1	1		1	3	2		1	1	1
Clinger Taxa Richness	1	1	1		1	1	1		1	1	1
Long-lived Taxa Richness	1	1	1		1	1	1		1	1	1
Percent tolerant	1	1	1		1	3	2		1	1	1
Percent predator	1	1	1		5	1	3		1	1	1
Percent dominance	1	1	1		3	1	2		3	1	2
B-IBI	**10**	**10**	**10**		**16**	**16**	**16**		**12**	**10**	**11**

In the natural vegetative regime, larval Chironomidae were the prey item most commonly consumed by coho salmon and were found in four of five stomachs evaluated with an average of thirteen organisms per stomach (Table 8-12). Adult beetles (Coleoptera) were also observed in the stomach content of four of five coho salmon evaluated from natural vegetation, but accounted for only 1.4 organisms per stomach on average. Hydrophillidae, Culicidae larvae, and Trichoptera larvae were each observed in the diets of multiple coho salmon, but accounted for less than one organism per fish stomach on average. All other prey items were observed in the diet of only one coho salmon collected from natural vegetation in 2004 and accounted for less than one organism per fish stomach on average.

Coho salmon collected from mixed vegetative habitats during 2004 exhibited less redundancy in their diet than those collected from natural vegetative habitats (Table 8-12). Only one prey organism (Baetidae) was observed in the diet of multiple coho salmon collected from the mixed vegetative regime; all other prey items observed were unique to the diet of a single coho salmon. No prey item observed accounted for more than one individual per coho stomach, on average, in mixed vegetative regimes.

Cutthroat trout diet in a mixed vegetative regime differed from that of coho salmon in that eight of twelve prey items observed in cutthroat trout stomachs were not observed in coho stomachs from the same habitats (Table 8-12). However, as was seen for coho salmon, no prey items consumed by cutthroat trout were abundant in the stomach contents (1-2 individuals) and most prey items consumed were unique in the diet of a single fish.

Due to the rarity of most prey items in the stomach contents of fish collected and/or in the environment from which they were collected (see Appendix 8-B), no electivity indices were calculated. Attempts to derive meaningful results using Equation 8.4 failed since electivity of rare prey or diet items cannot be accurately assessed with many available indices including Ivlev’s E (Jacobs 1974).

Table 8-11. Diet composition observed for salmonids collected from within a natural vegetative regime during July, 2003.

Taxa	Probable Origin	Order	Individual Coho Salmon (13)													Coho Avg.	Cutthroat Trout (1)
Hyallela sp.	Aquatic	Amphipoda				1	1									0.15	
Araneae	Terrestrial	Araneae				1			1							0.15	
Gyraulus sp.	Aquatic	Basommatophora														0	33
Coleoptera	Aquatic	Coleoptera		1							1				1	0.20	
Curculionidae	Terrestrial	Coleoptera										1				0.07	
Ceratopogonidae	Aquatic	Diptera											2			0.15	
Chironomidae	Aquatic	Diptera	45		7	16	45	9	25	1			1			9.93	1
Chironomidae-A	Terrestrial	Diptera					12					1	2		1	1.07	
Chironomidae-P	Aquatic	Diptera			1			3	6	2						0.80	
Diptera	Terrestrial	Diptera							2							0.15	
Muscidae	Terrestrial	Diptera										1				0.07	
Tabanidae-A	Terrestrial	Diptera									1					0.07	
Tipulidae	Aquatic	Diptera					3		1					1		0.33	
Corixidae	Aquatic	Hemiptera						1								0.07	
Gerridae-A	Aquatic	Hemiptera									1					0.07	
Hemiptera	Aquatic	Hemiptera						2								0.15	
Hemiptera-A	Terrestrial	Hemiptera										1				0.07	
Hemiptera-A	Aquatic	Hemiptera								1						0.07	
Collembola	Aquatic	Hexapoda						1							1	0.15	
Eulophidae	Terrestrial	Hymenoptera												1		0.07	
Eulophidae-A	Terrestrial	Hymenoptera												1		0.07	
Braconidae	Aquatic	Lepidoptera						1							1	0.15	
Sialis sp. (A)	Terrestrial	Neuroptera														0	1
Odonata	Aquatic	Odonata						2								0.15	
Oligochaeta	Aquatic	Oligochaeta						1								0.07	
Orthoptera	Terrestrial	Orthoptera		1											1	0.15	
Piscicolidae	Aquatic	Rhynchobdellida								1						0.07	
Lepidostoma sp.	Aquatic	Trichoptera									1					0.07	
Unidentified	Unidentified	Unidentified						2								0.15	
Unidentified	Terrestrial	Unidentified				1	1									0.15	

Table 8-12. Diet composition observed for salmonids collected from natural and mixed vegetative regimes during July, 2004.

			Natural Vegetation						Mixed Vegetation							
Taxa	**Probable Origin**	**Order**	**Coho (5)**					**Avg.**	**Coho (4)**				**Cutthroat Trout (2)**		**Coho Avg.**	**Cutthroat Avg.**
Hyallela sp.	Aquatic	Amphipoda						0						1	0	0.50
Coleoptera	Aquatic	Coleoptera	1					0.20							0	0
Coleoptera-A	Terrestrial	Coleoptera	1	3		1	2	1.40		1			2	1	0.25	1.50
Hydrophillidae	Aquatic	Coleoptera		1	1			0.40							0	0
Staphylinidae-A	Terrestrial	Coleoptera						0					1		0	0.50
Chironomidae	Aquatic	Diptera		18	30	2	15	13.00				2			0.50	0
Chironomidae-A	Terrestrial	Diptera						0	1				1		0.25	0.50
Culicidae	Aquatic	Diptera		1		1		0.40		1					0.25	0
Culicidae-A	Terrestrial	Diptera						0				4			1.00	0
Diptera	Terrestrial	Diptera		2				0.40		1					0.25	0
Diptera	Aquatic	Diptera						0					2		0	1.00
Dixidae-A	Terrestrial	Diptera			2			0.40	1						0.25	0
Ephidridae	Aquatic	Diptera						0		1					0.25	0
Muscidae	Terrestrial	Diptera			1			0.20						2	0	1.00
Sciomyzidae	Aquatic	Diptera						0						1	0	0.50
Tipulidae	Aquatic	Diptera						0					1	1	0	1.00
Tipulidae-A	Terrestrial	Diptera						0						1	0	0.50
Baetidae	Aquatic	Ephemeroptera						0	1			2			0.75	0
Gerridae-A	Aquatic	Hemiptera						0		1					0.25	0
Corixidae	Aquatic	Heteroptera						0		1					0.25	0
Collembola	Aquatic	Hexapoda	1					0.20		1					0.25	0
Coenagrionidae	Aquatic	Odonata						0					1		0	0.50
Acrididae	Terrestrial	Orthoptera	1					0.20							0	0
Tettigoniidae	Terrestrial	Orthoptera						0			1				0.25	0
Trichoptera	Aquatic	Trichoptera				1	1	0.40							0	0
Trichoptera-A	Terrestrial	Trichoptera						0		1					0.25	0
Teleostei	Aquatic	Unidentified						0					1		0	0.50
Unidentified	Unidentified	Unidentified						0			1				0.25	0
Unidentified	Terrestrial	Unidentified	1					0.20							0	0
Unidentified	Aquatic	Unidentified						0						1	0	0.50

8.4 Discussion

Results of this study suggest that surrounding vegetative regime does influence water quality (as indicated by macroinvertebrate community structure), salmonid food base, and salmonid growth and condition in agricultural waterways. The direction of that influence (positive or negative) appears to vary between trophic levels investigated (macroinvertebrates and fish) and potentially between salmonid species as well.

Both salmonid growth and relative condition and macroinvertebrate communities were assessed as indicators of potential positive or negative influences of vegetative regime on salmonid populations. Although macroinvertebrates and B-IBI are commonly used indices to evaluate biotic responses, the evaluation of fish growth and condition has numerous benefits in this study:

1. Condition factors were calculated for large numbers of salmonids collected from a wide variety of sites representing each vegetative regime, thereby providing a larger and potentially more representative sample across vegetative regimes,
2. The temporal nature of fish sampling (seasonally across multiple years) provided more detailed evaluation than was possible from limited macroinvertebrate/stomach collection period, and
3. Evaluation of fish growth and condition provides more direct information about impacts of vegetative regimes to fish; information from macroinvertebrate analysis, although complimentary in nature to the fish data, requires more speculation as to the potential meaning or impacts to salmonids.

Evaluation of fish relative condition suggests a positive influence[1] of RCG dominated habitats for coho salmon, and a positive influence of natural vegetative regimes for Chinook salmon in agricultural waterways (Table 8-13). This illustrates that, on average, coho salmon in RCG habitats and Chinook salmon in natural habitats tend to be plumper than individuals of the same species found in other vegetative regimes. Survival of juvenile salmonids has frequently been linked to fish condition (Beckman et al. 1998, Beckman et al. 1999, Zabel and Williams 2001) or related factors such as fish size (Ward and Slaney 1988; Ward et al. 1989; Hagar and Noble 1976, Bilton et al. 1982; Parker 1971) or lipid storage (Congleton et al. 2001) prior to outmigration to the ocean. Based on this fact, an underlying assumption in this analysis is that plumper fish are desirable and potentially indicative of better rearing habitat condition and may potentially experience higher survival.

We assumed that, during this study, fish reared for extended periods in localized areas so that their growth pattern and relative condition were related to the vegetative habitat regime from which they were collected. This assumption could not be tested as part of this study, but the fact that significant differences in fish condition were found between vegetative regimes suggests that it is likely to be true.

[1] In this case the influence is designated as positive or negative when the mean relative condition is statistically greater or less than that in most other vegetative regimes, respectively, and neutral if the mean relative condition is not statistically different than that in most other vegetative regimes.

Table 8-13. Summary of relative benefit of vegetative regime to salmonid food base (macroinvertebrates), relative condition (K_n), and growth pattern.

Vegetative Regime	Macro-invertebrates	Salmonid Condition (K_n)		Salmonid Growth Pattern	
		Coho	Chinook	Coho	Chinook
Reed Canarygrass	Negative	Positive	Neutral	Isometric	Isometric
Mixed	Positive	Neutral	Neutral	Isometric	Isometric
Natural	Neutral	Neutral	Positive	Isometric	Isometric
Cleaned	Not Sampled	Neutral	Neutral	Isometric	Isometric

The growth pattern of both Chinook and coho salmon was isometric across all vegetative regimes evaluated meaning that, as fish in each habitat grow in length, they add weight at similar rates (Table 8-13). Intuitively, this finding may seem to conflict with results from relative condition analysis which illustrate that salmonids from some vegetative regimes are plumper than those captured elsewhere. However, it is possible for fish to add weight at the same rate (show isometric growth) while exhibiting differences in relative condition if the fish in one vegetative regime are consistently heavier at any given length than those collected from other vegetative regimes. Fish in the two habitats would thereby exhibit differences in weight, but such differences would be fractionally constant in regards to length (Gartz 2005). In this manner, fish may exhibit a similar growth pattern and increased (or decreased) condition in one habitat area relative to another as was seen in this study.

The mechanism by which RCG regimes provide positive benefits to coho salmon condition remains unclear and likely involves a complex interaction of vegetative regime with other related factors. Benthic monitoring illustrates a more limited taxonomic diversity and overall abundance of macroinvertebrate prey items in RCG dominated habitats relative to other habitats evaluated, suggesting that food abundance (overall or preferred items) may not be the driving factor. In addition, related study components (See Goal 1 - Chapter 2 of this report) found no significant difference in the abundance of coho salmon in RCG dominated habitats relative to that of other vegetative regimes, suggesting that the apparent increase in fish condition is not a function of fish density in these habitats. Factors such as fish activity levels, searching time/distance required to find prey items, and variations in water quality (e.g. temperature) may vary across vegetative regimes and would likely impact fish condition. Investigation of these other factors however was beyond the scope of this particular research project.

One mechanism that may explain the increased weight and relative condition of coho salmon in RCG dominated habitats is the relative density of the vegetative cover and its probably function as substrate for macroinvertebrate prey items[2]. Reed canarygrass found in agricultural waterways commonly invades not only the surrounding land area, but also the wetted channel

[2] We assumed that, during this study, fish reared for extended periods in localized areas so that their growth pattern and relative condition were related to the vegetative habitat regime from which they were collected although this assumption could not be tested as part of this study.

width as well, and is commonly very dense in those channels. Because of its density and potential as a substrate for prey items, RCG may function to bring prey closer to salmonids, making the prey items more easily accessible to the fish without the need for extensive searching. Both distance to and apparent size of prey have been shown to influence fish prey selection for other fish species (Wetterer and Bishop 1985; O'Brien et al. 1976; O'Brien et al. 1984), and such relationships may hold true for coho salmon in agricultural waterways as well. Although hypothetical at this point, this scenario would potentially explain the apparent increased plumpness (relative condition) of coho salmon in agricultural channels dominated by a RCG regime.

The mechanism by which natural vegetative regimes provide positive benefits to Chinook salmon condition (relative to other vegetative regimes) could not be definitively determined. Related study components (See Goal 1 - Chapter 2 of this report) found no significant difference in the abundance of Chinook salmon in natural vegetative regimes relative to that of other vegetative regimes, suggesting that the apparent increase in fish condition is not a function of fish density in these habitats.

Increased condition of Chinook salmon in areas dominated by natural vegetation may be due to increased abundance of suitable food items. Chinook salmon diet has been shown to be dominated by prey items found in the drift in both riverine (Sagar and Glova 1987) and floodplain (Sommer et al. 2001) type channels. Of regimes evaluated, macroinvertebrate abundance in drift samples was greatest in naturally vegetated habitats in which the numbers of organisms collected were nearly twice that observed in other vegetative regimes (see Appendix 8-B). Prey selection or preference across various habitats could not be assessed as part of this study due to the relative rarity of most available prey and diet items. For this reason, additional work will be required to better evaluate the influence of prey availability on juvenile Chinook condition in naturally vegetated habitats.

In a relative sense, benthic monitoring results imply that in terms of both overall biological integrity and diversity of food items available for salmonids, mixed vegetative regimes potentially provide some level of positive impact to salmonids (Table 8-13). Concurrently, relatively neutral and negative impacts to biological integrity and diversity of salmonid food items available can be inferred for natural and RCG regimes, respectively based on this study. The degree to which these impacts translated to salmonid populations was not clear. Diet analysis from this study suggested that salmonids in agricultural waterways were generally opportunistic feeders. Stomach contents contain, in general, a wide variety of prey items most of which were consumed only in limited numbers despite their abundance in the environment. Therefore, although macroinvertebrate metrics may indicate more abundant or diverse communities in certain vegetative regimes, it remains unclear if and how salmonids within the agricultural waterways utilized those resources.

Calculated B-IBI scores observed for agricultural waterways indicate 'Very Poor' biological condition for all vegetative regimes sampled during 2004 although differences were noted across regimes. Mixed, natural, and RCG dominated vegetative regimes exhibited the highest, intermediate and lowest B-IBI scores, respectively. Patterns in macroinvertebrate diversity were similar to B-IBI scores, with greatest numbers of taxa (benthic and drift samples) observed in sites with a mixed vegetative regime and lowest numbers of taxa observed at those dominated by RCG.

Due to the high diversity of vegetative cover along most agricultural waterways within King County, the differences in B-IBI scores probably resulted primarily from differences in local cover type and vegetation density rather than from substantial differences in water quality. Although classified as a particular vegetative regime, all monitoring sites existed within a drainage system containing of a wide mixture of vegetative regimes upstream along the same drainage system. Water quality in all study reaches was therefore impacted by a similar mixture of upstream land uses and vegetative regimes found, effectively creating a 'mixed' water quality regime at all sites. The major difference between sites then was the vegetative regime.

Although based on macroinvertebrate assemblages, the B-IBI is an index of overall biological integrity and therefore has relevance to salmonids associated with the same waterway. Salmonid survival has been linked to a healthy and diverse macroinvertebrate community since macroinvertebrates are an important part of the food web (Allen 1995, Karr 1998) and channel degradation has been shown to coincidentally result in responses by macroinvertebrate and salmonid populations (Plotnikoff and Polayes 1999).

Benthic-IBI scores observed for agricultural waterways in King County were well below that reported for many non-agricultural streams which have been monitored throughout King County, although not outside the range of reported values for all streams (King County DNRP 2002; City of Federal Way, no date; Berge 2002). Low B-IBI scores in agricultural waterways were driven by a lack of species diversity resulting in high dominance of a few species and by a lack of intolerant species and those species generally indicative of increased water quality (e.g. mayflies, stoneflies and caddisflies).

8.5 Conclusions and Recommendations

Results of this study suggest that surrounding vegetative regime does influence water quality (as indicated by macroinvertebrate community structure), salmonid food base, and salmonid growth and condition in agricultural waterways. The direction of that influence (positive or negative) appears to vary between trophic levels investigated (macroinvertebrates and fish) and potentially between salmonid species as well. Calculated B-IBI scores observed for agricultural waterways indicate 'Very Poor' biological condition for all vegetative regimes sampled. Differences in B-IBI scores were noted between vegetative regimes however with B-IBI scores in mixed habitats greater than those in natural habitats, and those in natural habitats greater than in RCG dominated habitats.

The study data disproved the first research hypothesis and found that salmonid condition factor does vary amongst different riparian vegetation regimes. However, the results were somewhat different than what might have been anticipated with specific regard to the following:

1. Evaluation of fish relative condition suggests a positive influence of RCG dominated habitats for coho salmon, and a positive influence of natural vegetative regimes for Chinook salmon in agricultural waterways. Following any maintenance activities in waterways, mitigation efforts aimed at mimicking these conditions would likely benefit salmonids inhabiting these areas.

2. The growth pattern of both coho and Chinook salmon was isometric across all vegetative regimes evaluated meaning that, as fish in each habitat grow in length, they add weight at similar rates.

3. For Chinook salmon collected from agricultural waterways, comparison of seasonal weight-length relationship parameters (slope) showed differences in growth patterns. Differences may have been driven by low sample sizes in some seasons. Efforts should be made to gather additional data (new or existing) to increase sample sizes of Chinook considered and allow for more detailed evaluation of seasonal growth patterns.

The study data shows that, related to hypothesis 2(a), prey availability in the form of macroinvertebrate abundance does differ across vegetative regimes. Mixed vegetative regimes appear to have greater numbers of macroinvertebrates available and, based on 2004 data, potentially more taxa available as well. Hypothesis 2(b) could not be addressed by this study due to the apparent opportunistic feeding patterns of juvenile salmonids in agricultural waterways and the scarcity of most prey items in salmonid diets. Based on macroinvertebrate monitoring it remains unclear if and how salmonids within the agricultural waterways are directly impacted by variations in macroinvertebrate communities for the following reasons:

1. Although macroinvertebrate abundance and possibly macroinvertebrate taxa richness are greater in mixed vegetative regimes, a corresponding increase in salmonid

condition was not noted in the same vegetative regime. This suggests that salmonids do not realize a direct benefit (in terms of condition) from observed differences in the macroinvertebrate community.

2. Based on corresponding diet analyses, salmonids in agricultural waterways appear to be opportunistic feeders suggesting that, at least across the range of conditions observed during this study, changes in macroinvertebrate density and taxa richness across vegetative regimes do not directly impact feeding behavior or success of salmonids.

3. Although differences exist in macroinvertebrate abundance and taxonomic richness across vegetative regimes, B-IBI scores in agricultural waterways are illustrative of 'Very Poor' biological condition for all vegetative regimes.

Based on the findings of this study component, recommendations for future work can be summarized as follows:

1. As part of this study we assumed that fish reared for extended periods in localized areas so that their growth pattern and relative condition were related to the vegetative habitat regime from which they were collected. This assumption could not be tested as part of this study, but the fact that significant differences in fish condition were found between vegetative regimes suggests that it may be true. Consideration should be given to a more detailed evaluation of fish growth across multiple vegetative habitat regimes available in King County's agricultural waterways. By using short timeframes (e.g one week – one month) and/or blocked study reaches to ensure that fish do not migrate between habitat areas, the need for this assumption to be made could be effectively eliminated.

2. Although differences exist in macroinvertebrate abundance and taxonomic richness across vegetative regimes, B-IBI scores in agricultural waterways are illustrative of 'Very Poor' biological condition for all vegetative regimes. Given their apparent importance to juvenile salmonids, any planning, restoration, or mitigation efforts which can be practically implemented while retaining the functionality of these waterways for land drainage should be implemented to improve the biological conditions of these waterways. Effectiveness monitoring of such actions should occur following their implementation.

3. Consideration might be given to a more detailed assessment of RCG as a potentially important colonization substrate by macroinvertebrates in agricultural waterways. Any further study should evaluate the potential effect that varying densities of that substrate would have on feeding efficiency or patterns by coho (or other) salmon found within those habitat areas. Dense RCG is known to inhibit the intended drainage function of these waterways; lesser densities may however provide important cover for juvenile salmonids as well as valuable colonization substrate(s) for their potential prey items while still allowing for effective land drainage.

4. Evaluation of prey selection or selectivity by juvenile salmonids in agricultural waterways using Ivlev's (or a similar) electivity index should be considered if it can be made to coincide with an existing macroinvertebrate monitoring program to reduce the relative cost of the information to be gained. Given the apparent opportunistic feeding pattern of salmonids in agricultural waterways which was observed during this study, substantially larger numbers of fish stomachs will be required to adequately address this issue. Based on the sporadic distribution and collection of salmonids from most agricultural waterways, the likelihood of collecting large numbers of stomach samples from any given site on any given date is questionable (but potentially feasible). Given the findings of this study regarding fish condition and growth in agricultural waterways, it is important to note that the findings of any future study of prey selectivity may provide interesting scientific information although the practical applicability of that information for management and maintenance of agricultural waterways is likely to be limited.

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Appendix 8-A: Locator maps of sampling sites.

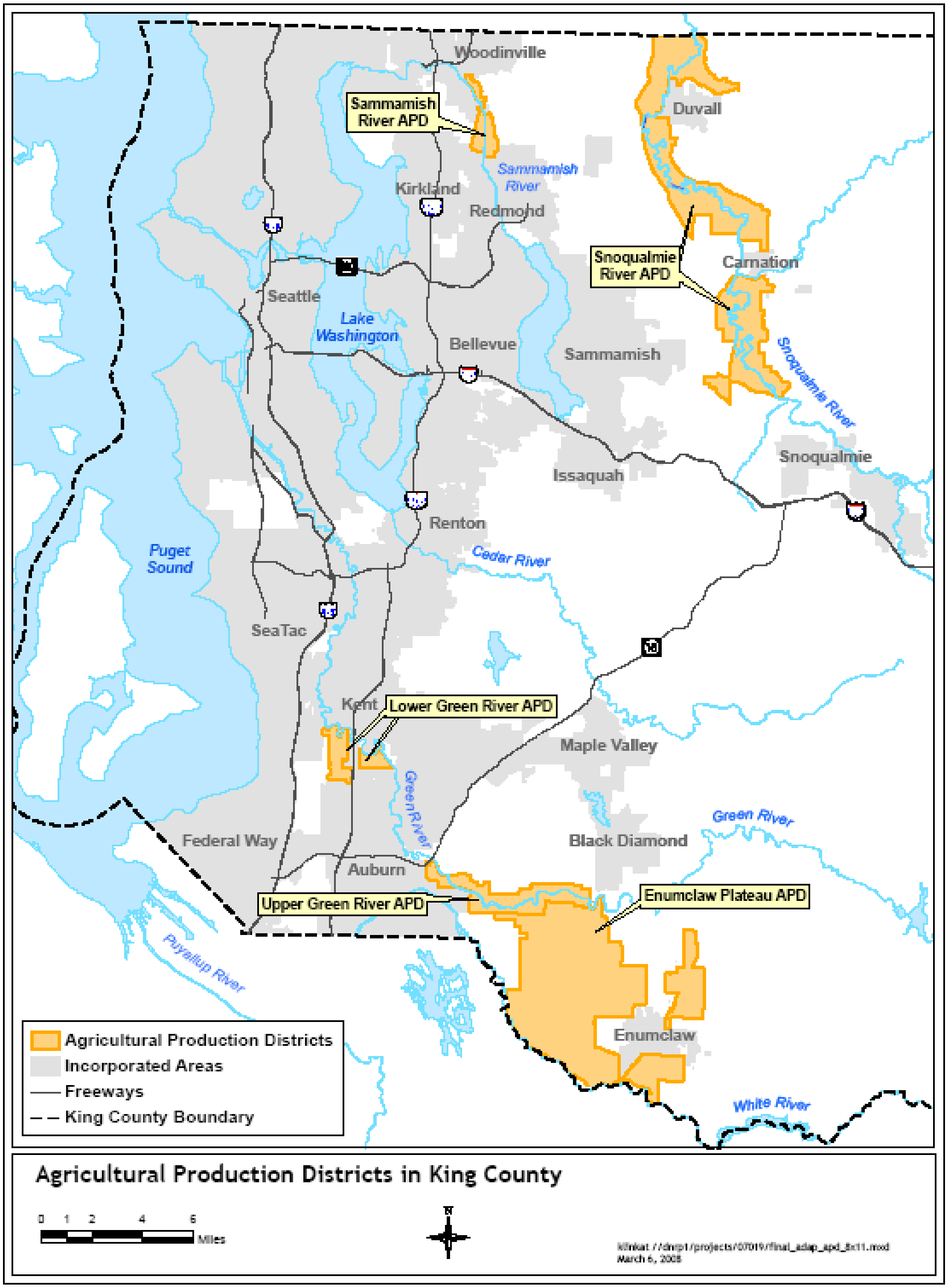

Figure 8-A-1. Agricultural Production Districts and incorporated areas within King County.

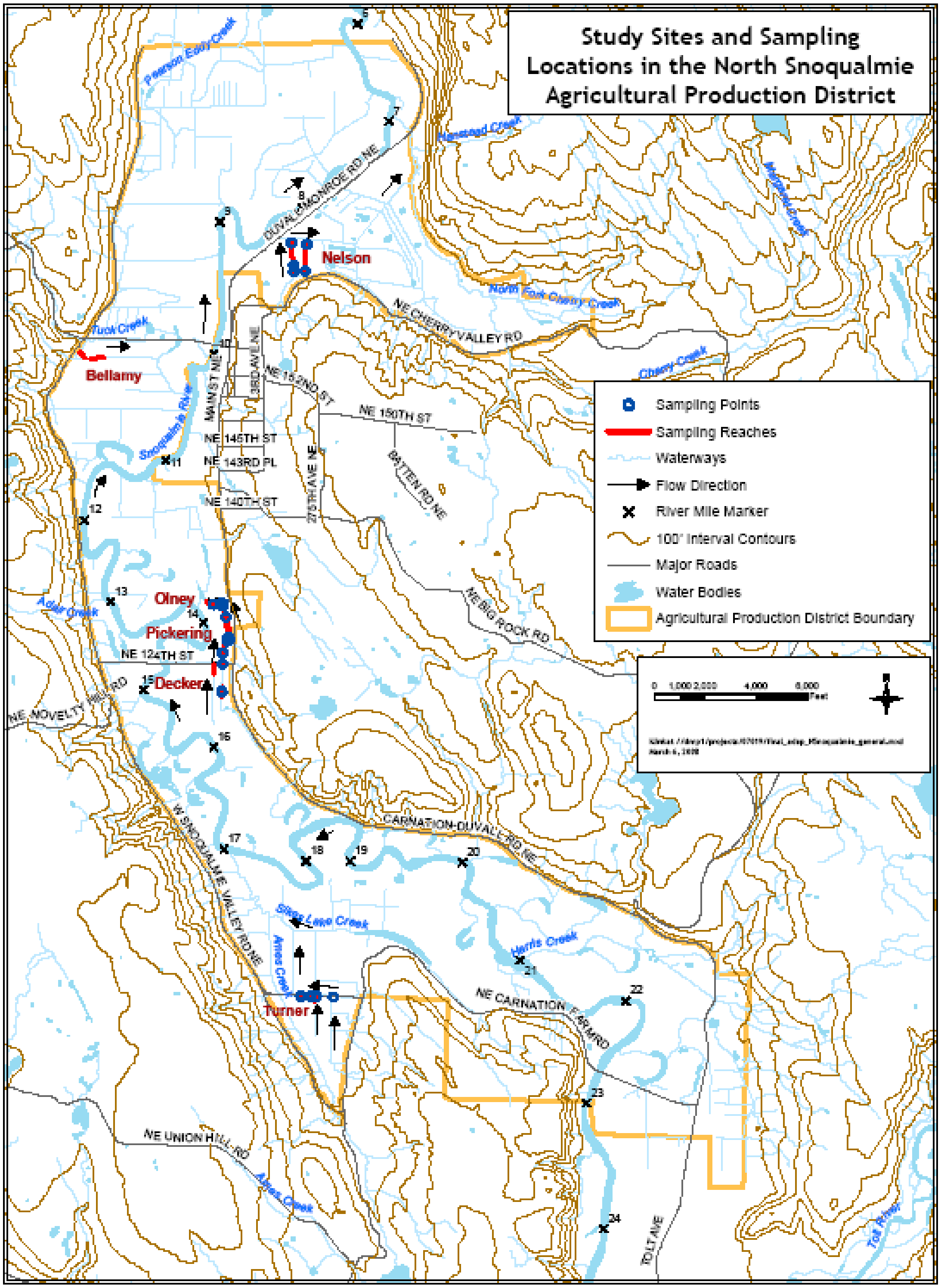

Figure 8-A-2. Overview of study sites and sampling locations in the North Snoqualmie Agricultural Production District.

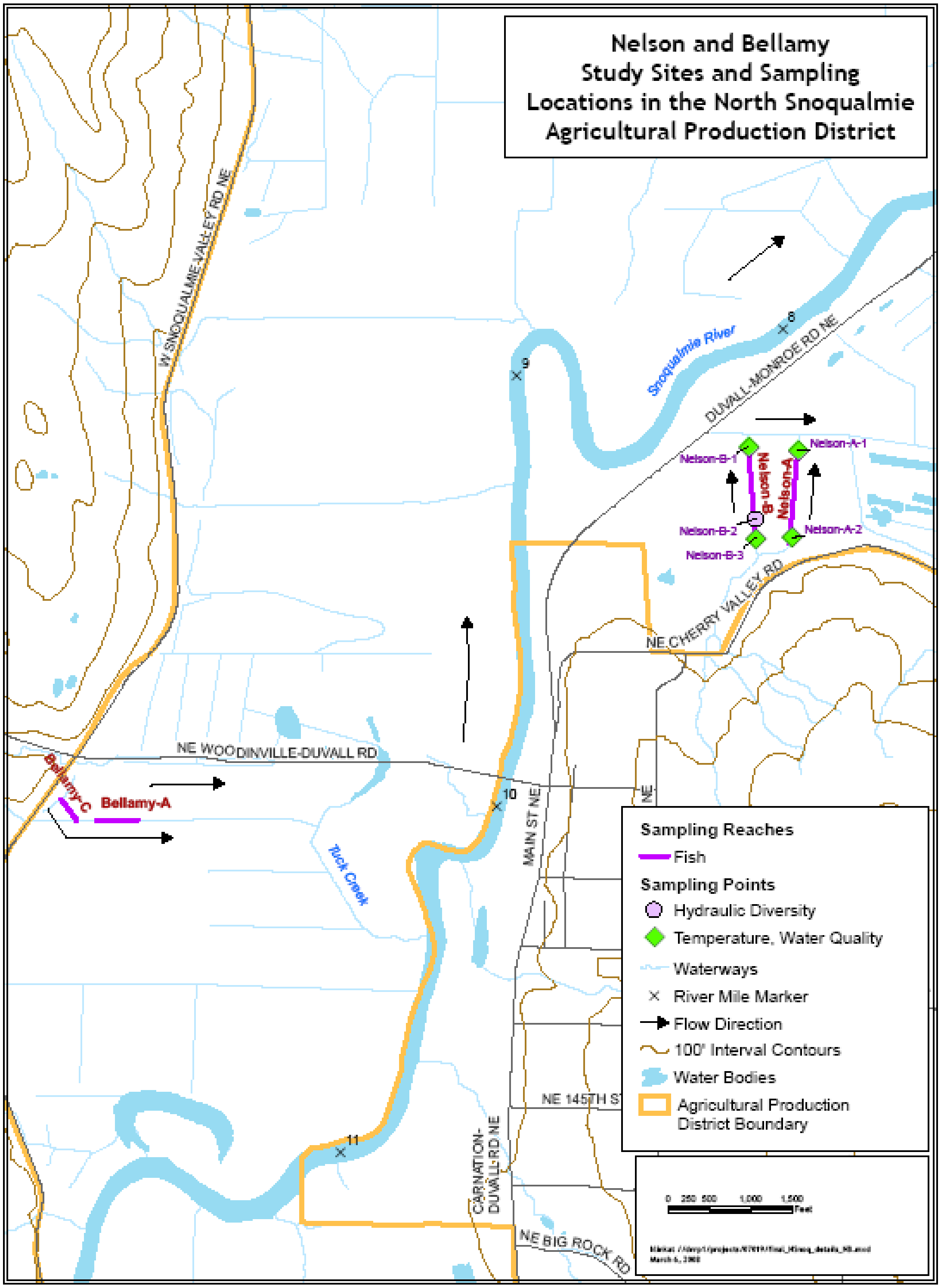

Figure 8-A-3. Detail of study sites and sampling locations in the northern portions of the North Snoqualmie Agricultural Production District.

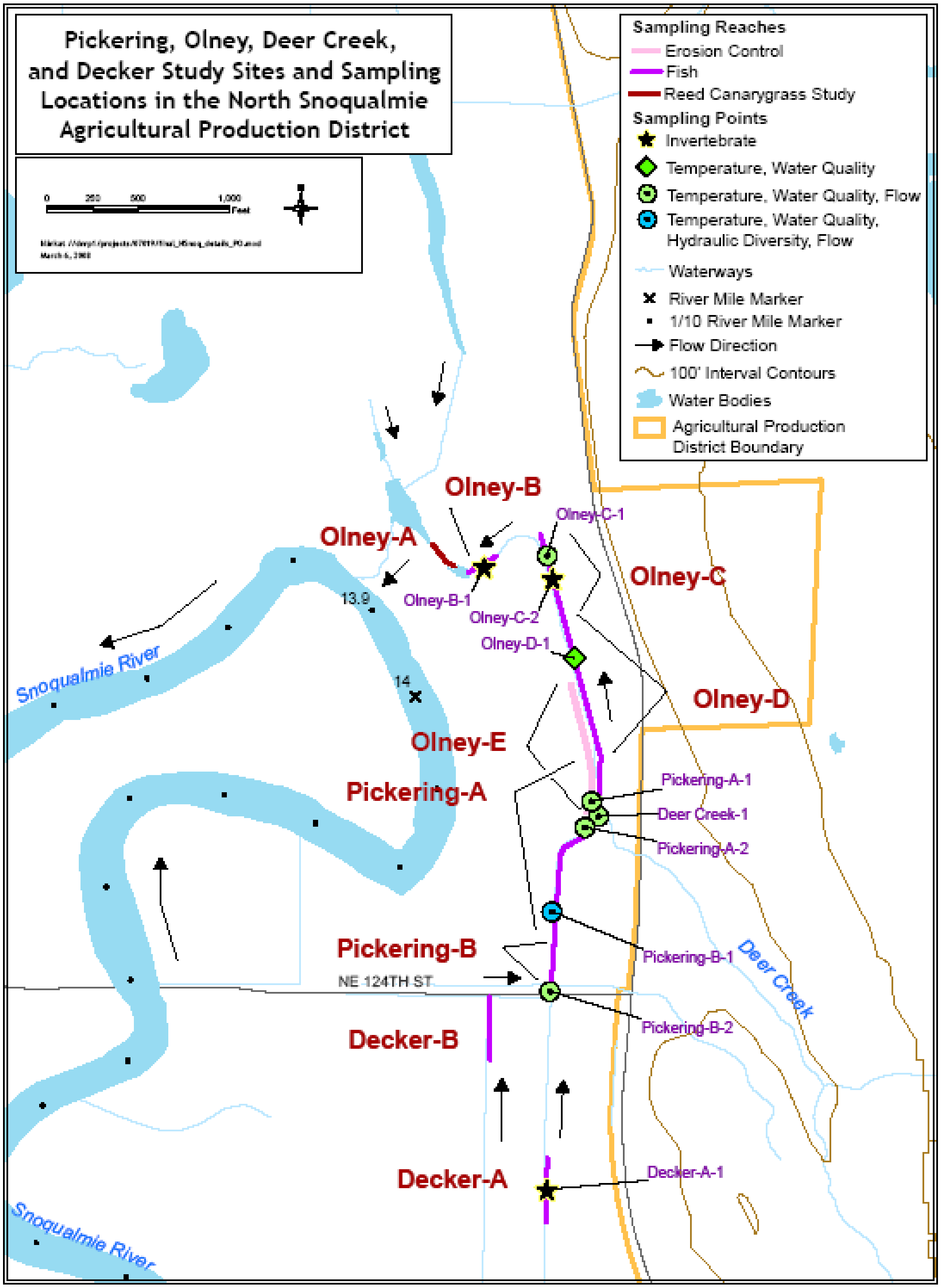

Figure 8-A-4. Detail of study sites and sampling locations in the central portions of the North Snoqualmie Agricultural Production District.

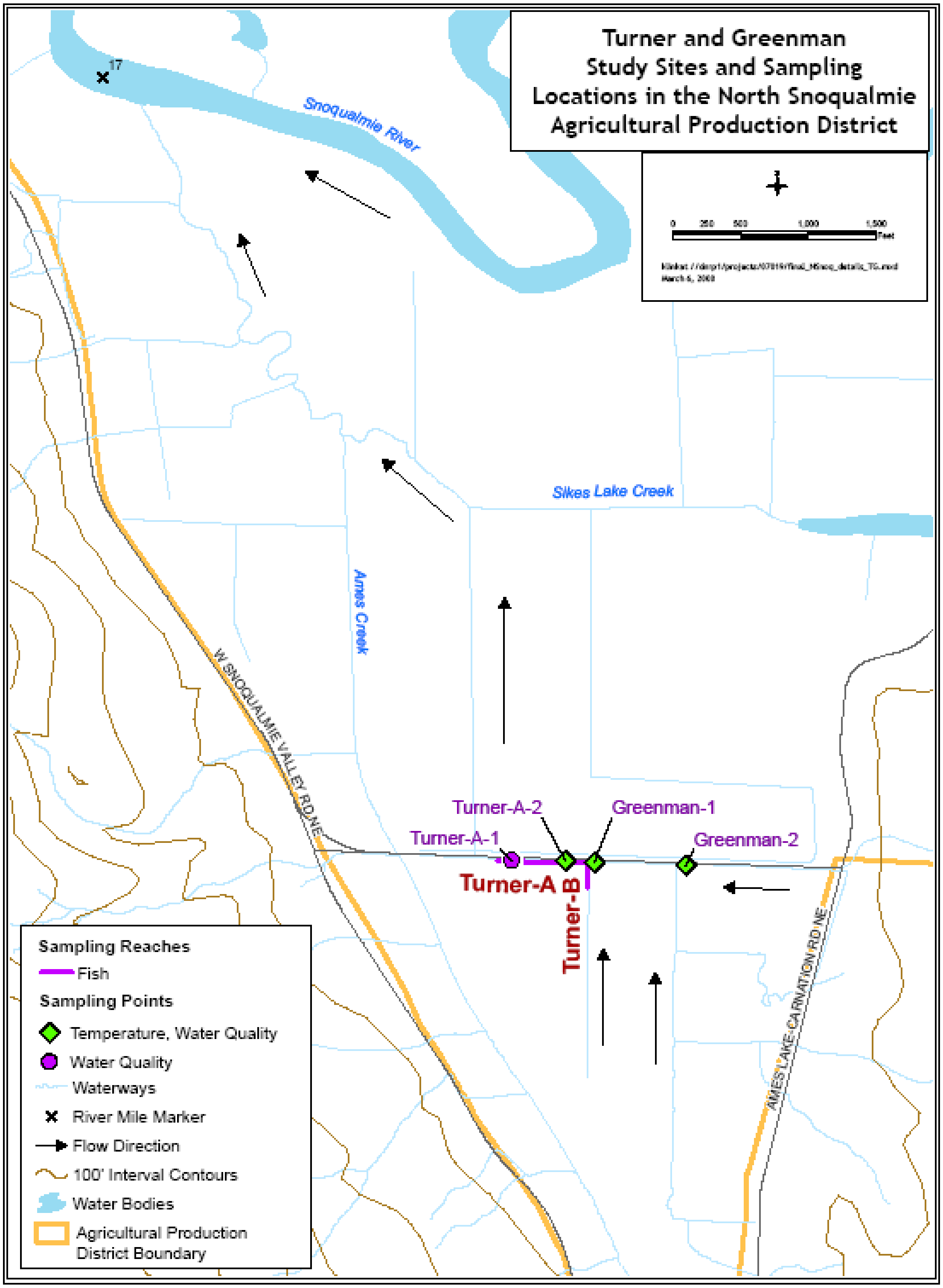

Figure 8-A-5. Detail of study sites and sampling locations in the southern portions of the North Snoqualmie Agricultural Production District.

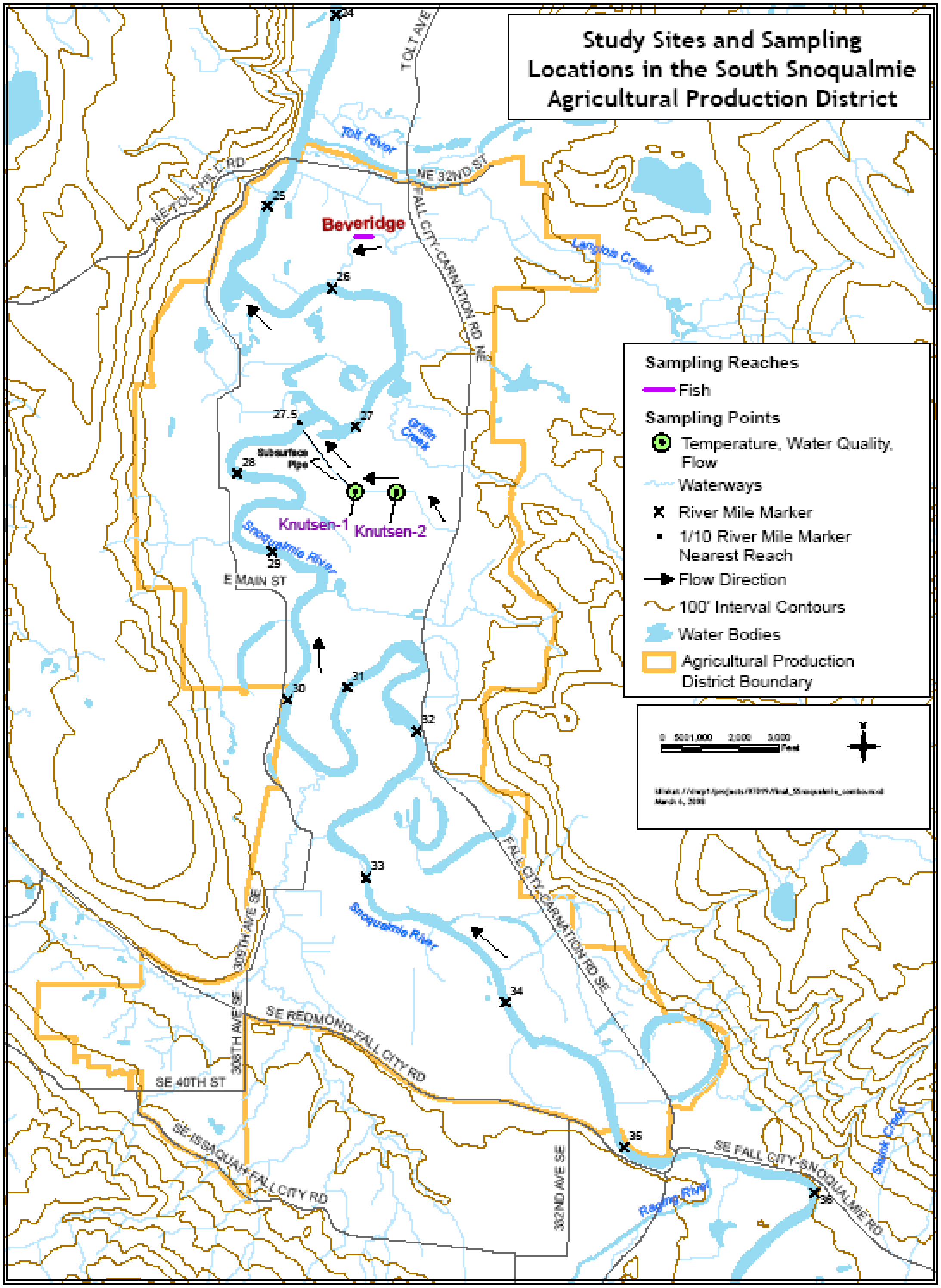

Figure 8-A-6. Detail of study sites and sampling locations in the South Snoqualmie Agricultural Production District.

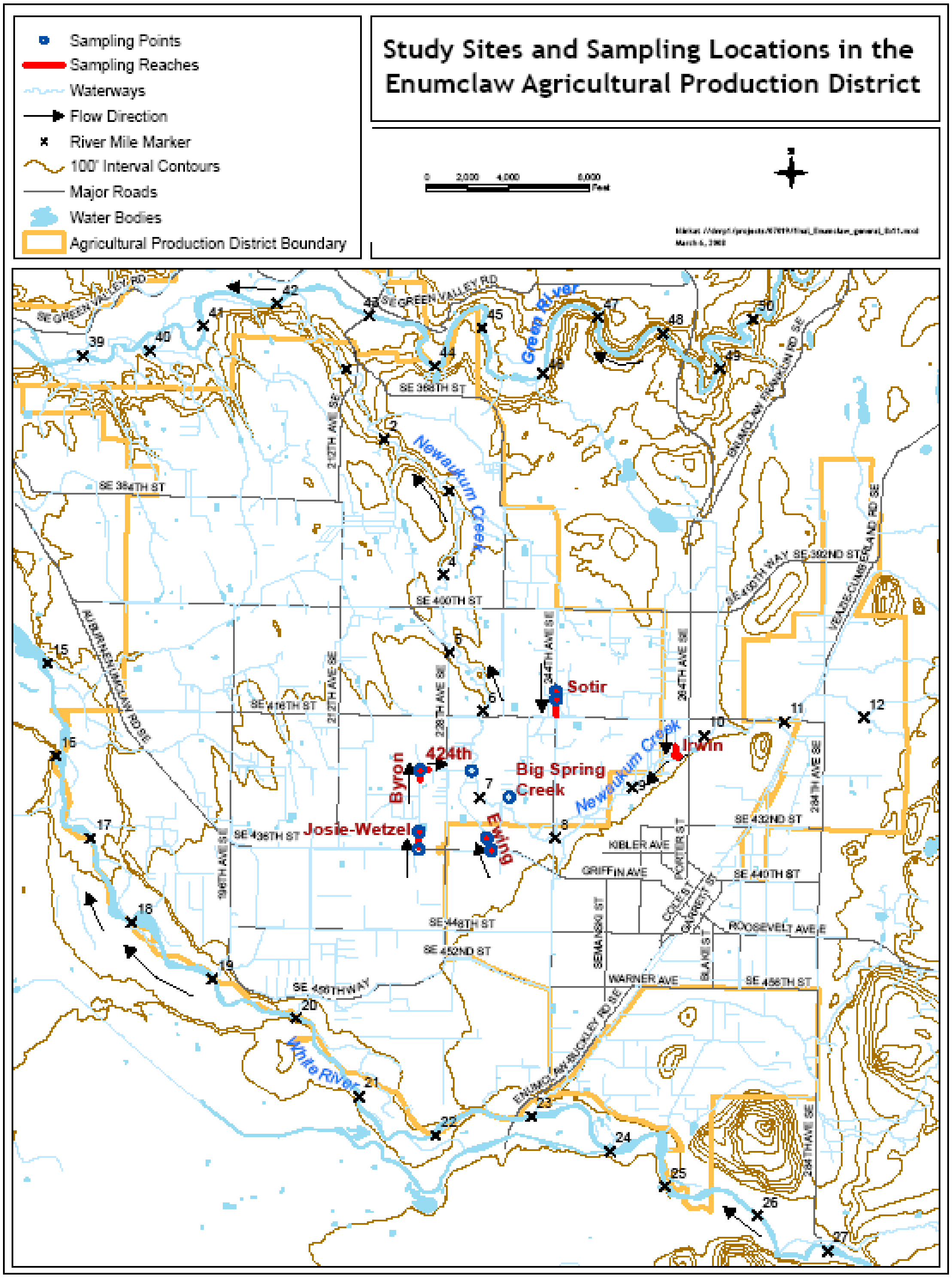

Figure 8-A-7. Overview of study sites and sampling locations in the Enumclaw Agricultural Production District.

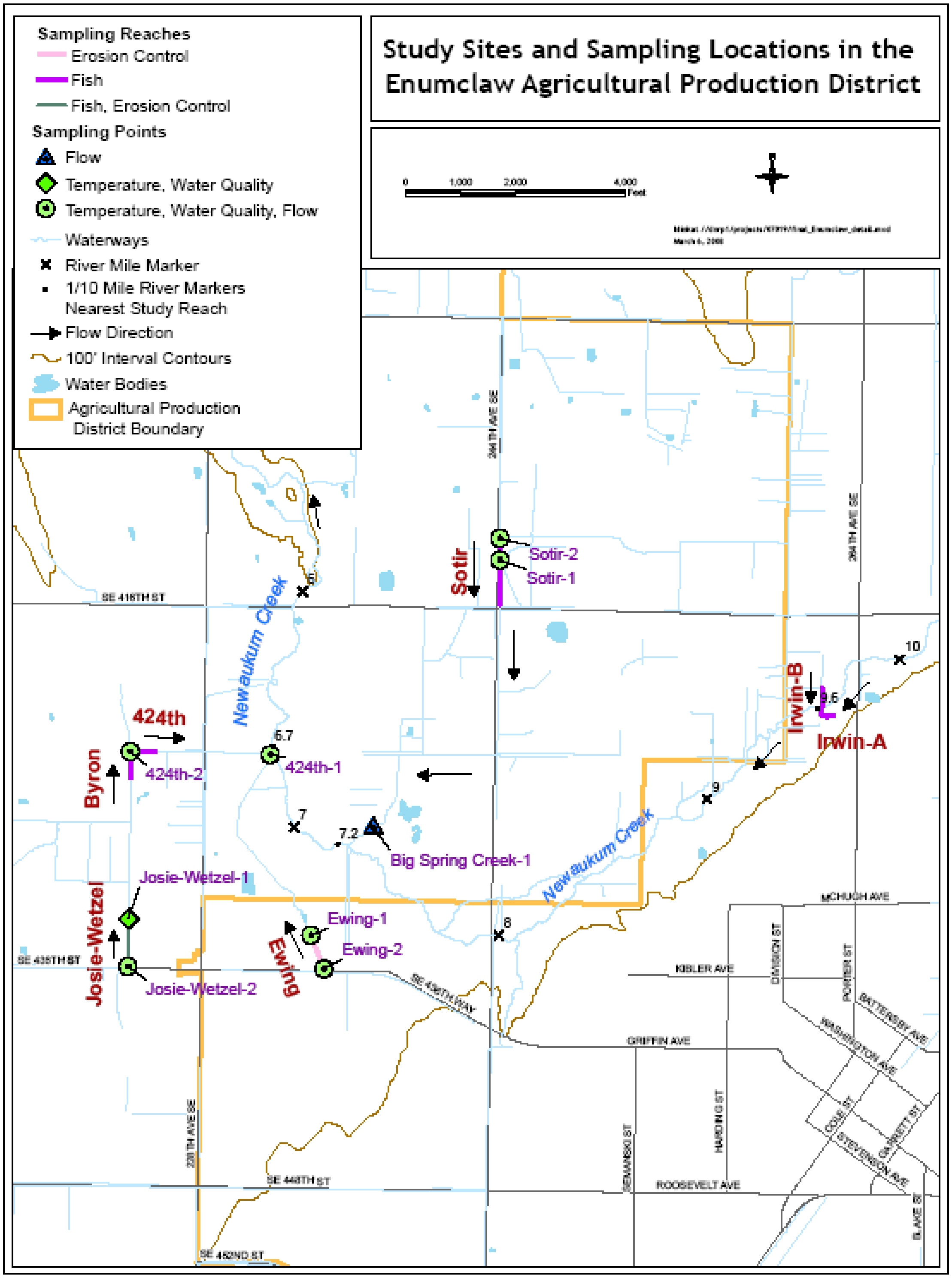

Figure 8-A-8. Detail of study sites and sampling locations in the Enumclaw Agricultural Production District.

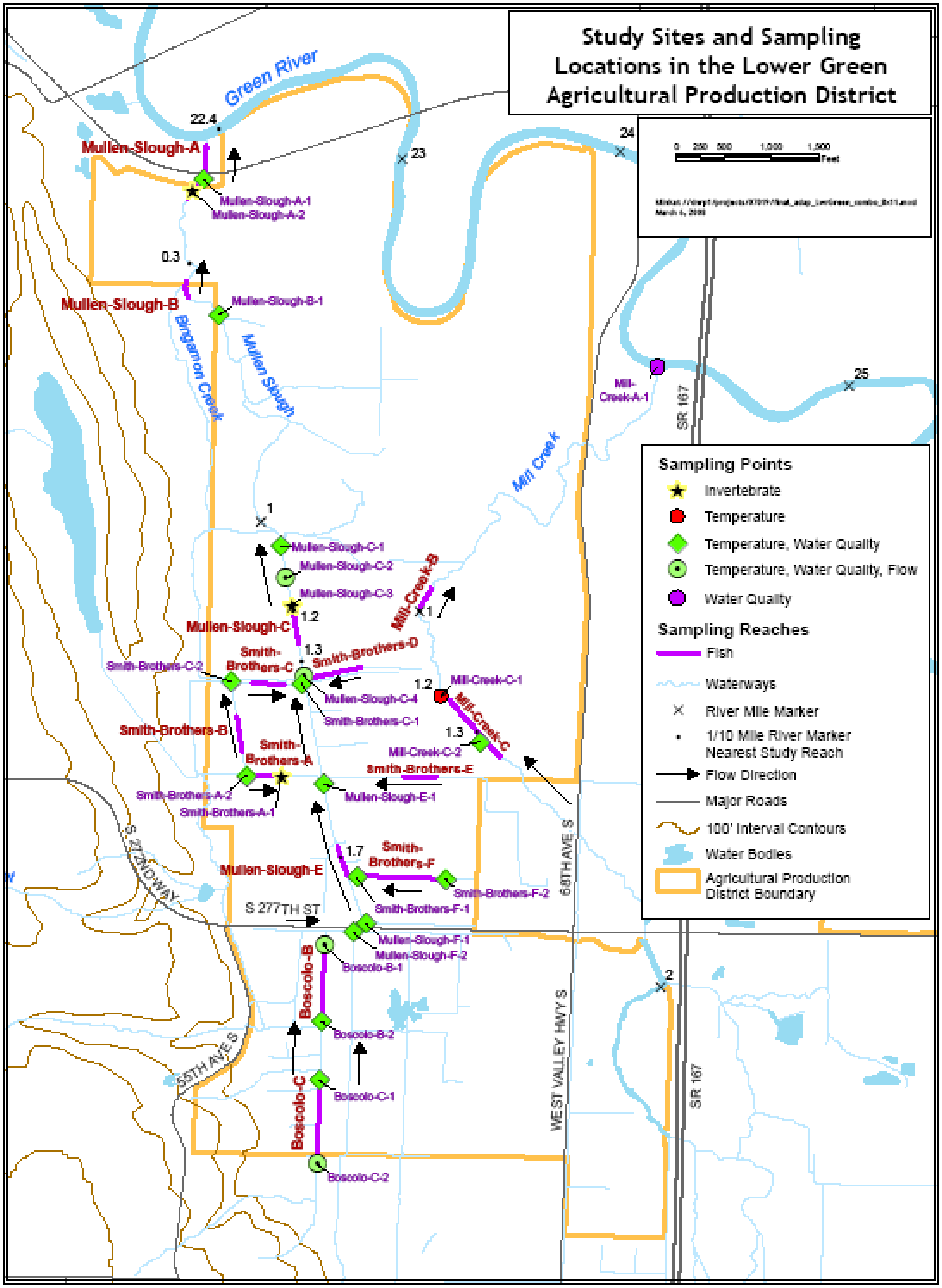

Figure 8-A-9. Study sites and sampling locations in the Lower Green Agricultural Production District.

Appendix 8-B: Macroinvertebrate data from 2004 collections.

Appendix 8-B 1. Benthic macroinvertebrates collected from sites with RCG vegetative regime.

	Lower Green APD (Mullen-Slough-C-3)			Snoqualmie APD (Olney-B-1)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
COLEOPTERA							
Hydrochus sp.				1			1
Dytiscidae (Adult)						1	1
DIPTERA							
Chironominae	1	3	3				7
Chaoboridae		1					1
Culicinae						9	9
ISOPODA							
Asellus sp.						9	9
AMPHIPODA							0
Hyalella azteca				52		29	81
GASTROPODA							
Physella sp.				5			5
Gyraulus sp.				53	1	9	63
Promenetus sp.				3		2	5
Fossaria sp.				4			4
Pisidium sp.	1	1		5			7
GNATHOBDELLIDA							
Boreobdella verrucata						6	6
Erpobdella punctata punctata						1	1
OLIGOCHAETA	2	4	26	3	2	1	38
Total individuals	**4**	**9**	**29**	**126**	**3**	**67**	**238**

Appendix 8-B 2. Drift macroinvertebrates collected from sites with RCG vegetative regime.

	Lower Green APD (Mullen-Slough-C-3)			Snoqualmie APD (Olney-B-1)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
EPHEMEROPTERA							
Callibaetis sp.		2	1				3
COLEOPTERA							
Hydrophilidae			4	1			5
Tropisternus sp.					3		3
Agabus sp.					1		1
Hydraena sp.				1	1		2
ODONATA							
Coenagrionidae	1		1				2
HEMIPTERA							
Aphididae				4			4
Cicadellidae				1	7		8
Hemiptera (Unidentified)				1			1
LEPIDOPTERA					1		1
DIPTERA							
Micropsectra sp.	4	11	31		4		50
Brillia sp.	3	1	1	1			6
Chironominae					10		10
Tabanidae		1					1
Dixa sp.		2					2
Ceratopogonidae			1				1
Culicinae				41	70		111
Chironominae (Adult)				2	1		3
ISOPODA							
Asellus sp.				1	9		10
AMPHIPODA							
Hyalella azteca		9	3	181	225	472	890
GASTROPODA							
Gyraulus sp.		1		1	216		218
Promenetus sp.					2		2
Pisidium sp.		1					1
Physella sp.				1	11	4	16
Fossaria sp.						36	36
OLIGOCHAETA	3		1		9	40	53
GNATHOBDELLIDA							
Boreobdella verrucata					2	6	8
ARANEAE							
Spider (Unidentified)				5	4		9
Total individuals	**11**	**28**	**43**	**241**	**576**	**558**	**1,457**

Appendix 8-B 3. Surface macroinvertebrates collected in pitfall traps from sites with RCG vegetative regime.

	Lower Green APD (Mullen-Slough-C-3)			Snoqualmie APD (Olney-B-1)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
COLLEMBOLA			1	1			2
THYSANOPTERA							
Thripidae				1			1
HEMIPTERA							
Aphididae					1		1
Cicadellidae	10	14	2	1	1		28
Saldidae		1		1			2
ODONATA							
Coenagrionidae		1					1
COLE0PTERA							
Hydraena sp.		2					2
Hydrohilidae					2		2
Ptilidae					1	2	3
Staphylinidae	1				1	1	3
HYMENOPTERA							
Braconidae				2	8	1	11
Ichneumonidae		1					1
Formicidae					1		1
Mymaridae			2				2
Eulophidae			1	1			2
DIPTERA							
Chironomidae	2	1	1		2		6
Culicinae	1	1		1		2	5
Dolichopodidae	1			2	1	9	13
Ephydridae				3	5	4	12
Muscidae	1			2			3
Psychodidae				17	75	15	107
Sepsidae					1		1
Sphaeroceridae						1	1
ARANEAE							
Spider (Unidentified)	1			4	1		6
OPILIONES							
Leiobunidae		1					1
Total individuals	**17**	**22**	**7**	**36**	**100**	**35**	**217**

Appendix 8-B 4. Benthic macroinvertebrates collected from sites with a natural vegetative regime.

	Lower Green APD (Mullen-Slough-A-2)			**Snoqualmie APD (Olney-C-2)**			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
MEGALOPTERA							
Sialis sp.		2	2		1		5
COLEOPTERA							0
Hydrocus sp. (Adult)			1				1
DIPTERA							0
Chironominae	1		2				3
Micropsectra sp.	2		9			52	73
Brillia sp.	2	1	3			8	15
ISOPODA							0
Asellus sp.	11	4	1	2	8	6	32
AMPHIPODA							0
Hyalella azteca	15	1			25	12	53
GASTROPODA							0
Pisidium sp.	3	1	4	19	80		107
Physella sp.	1						1
Gyraulus sp.		2		10	31		43
GNATHOBDELLIDA							0
Erpobdella punctata punctata				1	3	4	8
Helobdella stagnalis	1	1		5	17	1	25
Boreobdella verrucata					1		1
Placobdella translucens					3		3
OLIGOCHAETA	19	1	11	13	10	2	56
Total individuals	**55**	**13**	**33**	**50**	**179**	**85**	**426**

Appendix 8-B 5. Drift macroinvertebrates collected from sites with a natural vegetative regime.

	Lower Green APD (Mullen-Slough-A-2)			Snoqualmie APD (Olney-C-2)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
MEGALOPTERA							
Sialis sp.			1				1
COLEOPTERA							
Agabus sp.	2			1			3
Dytiscidae (Adult)				1	1	5	7
Hydrocus sp. (Adult)	13	10	2	1	1		27
Hydrohilidae (Adult)					1		1
ODONATA							
Aeschnidae		1					1
HEMIPTERA							
Corixidae		1		1	1		3
Gerridae (Adult)	2	1		1			4
Aphididae	1						1
DIPTERA				1			1
Chironominae				2	1		3
Chironominae (Adult)	1						1
Micropsectra sp.	15	3	4	285	253	173	733
Brillia sp.	3	3	3		33		42
Culicinae		1			3		4
Dixa/Dixella sp.	14	5	9				28
Tipulidae	1						1
Tabanidae		1					1
COLLEMBOLA							
Isotomidae	1	2	2		5		10
ISOPODA							
Asellus sp.			10	1	17	31	59
AMPHIPODA							
Hyalella azteca	10	12	5	346	294	394	1,061
GASTROPODA							
Physella sp.		3		2		2	7
Promenetus sp.				4			4
Gyraulus sp.		1	1	4	54	44	104
Pisidium sp.					10	35	45
OLIGOCHAETA	1			0		2	3
GNATHOBDELLIDA				3			3
Erpobdella punctata punctata		1			6	1	8
Helobdella stagnalis		1			2		3
Placobdella translucens						1	1
ARANEAE							
Spider (Unidentified)	1				1		2
ORTHOPTERA							
Grasshopper (Unidentified)					1		1
PETROMYZONTIFORMES							
Lamprey					1		1
Total individuals	**65**	**46**	**37**	**653**	**685**	**688**	**2,174**

Appendix 8-B 6. Surface macroinvertebrates collected in pitfall traps from sites with a natural vegetative regime.

	Lower Green APD (Mullen-Slough-A-2)			Snoqualmie APD (Olney-C-2)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
COLLEMBOLA	4			11		7	22
HEMIPTERA							
Cicadellidae		1				1	2
Gerridae				1			1
COLEOPTERA							
Coccinellidae	2		1				3
Staphylinidae				3			3
HYMENOPTERA							
Braconidae				1			1
Eulophidae		1				1	2
DIPTERA							
Chironomidae		1	1	1		6	9
Dolichopodidae	1		4	2		1	8
Empididae				3		2	5
Ephydridae		2	5	4			11
Muscidae						2	2
Phoridae		1	1	1			3
Psychodidae			1	1			2
ARANEAE							
Spider (Unidentified)		1		1		3	5
Total individuals	**7**	**7**	**13**	**29**	**0**	**23**	**79**

Appendix 8-B 7. Benthic macroinvertebrates collected from sites with a mixed vegetative regime.

	Lower Green APD (Smith-Brothers-A-1)			Snoqualmie APD (Decker-A-1)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
COLLEMBOLA							
Isotomidae					2		2
HEMIPTERA							
Aphididae			1				1
TRICHOPTERA							
Micrasema sp.				2	5	3	10
Asynarchus sp.						5	5
Lepidostoma sp.						1	1
Hydroptilidae						1	1
MEGALOPTERA							
Sialis sp.	1	8	1			1	11
COLEOPTERA							
Dytiscidae (Larvae)					1		1
Dytiscidae (Adult)					1		1
Hydrohilidae			1				1
Laccobius sp. (Adult)		1					1
Tropisternus sp.			1		1	1	3
Staphylinidae (Adult)					1		1
ODONATA							
Coenagrionidae					1		1
DIPTERA							
Micropsectra sp.	2		1	4	198	43	248
Brillia sp.		2		1	14	28	45
Tipulidae	1						1
ISOPODA							
Asellus sp.	1	2	38	2	19		62
AMPHIPODA							
Hyalella azteca	1		20	23	27	25	96
GASTROPODA							
Fossaria sp.	2	2	1				5
Pisidium sp.	2	8	6		8	11	35
Physella sp.						3	3
Gyraulus sp.		1			35	12	48
Margaratiferidae	2						2
GNATHOBDELLIDA							
Erpobdella punctata punctata			1	1	2		4
Helobdella stagnalis	1					2	3
OLIGOCHAETA			12		2	11	25
PETROMYZONTIFORMES							
Lamprey	1					2	3
Total individuals	**14**	**24**	**83**	**33**	**317**	**149**	**620**

Appendix 8-B 8. Drift macroinvertebrates collected from sites with a mixed vegetative regime.

	Lower Green APD (Smith-Brothers-A-1)			**Snoqualmie APD (Decker-A-1)**			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
EPHEMEROPTERA							
Baetis tricaudatus	3				1	1	5
TRICHOPTERA *							
Micrasema sp.				8	25	39	72
Lepidostoma sp.				1			1
MEGALOPTERA							
Sialis sp.	2					13	15
COLEOPTERA							
Tropisternus sp.	2	1	2		1		6
Haliplus sp.	4	4					8
Hydraena sp. (Adult)	2			3	7	71	83
Laccobius sp. (Adult)	4						4
Hydrobius sp.		1					1
Staphylinidae (Adult)		1		8	3		12
Agabus sp.		1					1
Dytiscidae (Adult)			2		6	5	13
Hydrophilidae			1				1
Helophorus sp.				1			1
Helophorus sp. (Adult)					2		2
Enochorus sp.				1			1
Carabidae (Adult)					1		1
Anacaena sp.					3	3	6
Peltodytes sp.						1	1
ODONATA							
Coenagrionidae	3	9	1		3	1	17
Aeschnidae	1				1		2
HEMIPTERA							
Aphididae	21	25		1			47
Cicadellidae	1			3			4
Corixidae	1	5					6
Saldula sp.				2			2
Gerridae (Nymph)					1		1
HYMENOPTERA							
Hymenoptera (Unidentified Adult)	2						2
DIPTERA							
Micropsectra sp.	82	23	2		14	27	148
Brillia sp.	36	22	3	2	16	33	112
Ptychoptera sp.			4				4
Dixa/Dixella sp.			1	1	4		6
Tipulidae (Adult)				2			2
Tipulidae						1	1
Forcipomyiinae					4	1	5
COLLEMBOLA							
Isotomidae	2			1	4		7
ISOPODA							

Asellus sp.	2	2	40		8	4	56
AMPHIPODA							
Hyalella azteca	20	52	42	5	32	38	189
GASTROPODA							
Fossaria sp.	35	11	1				47
Pisidium sp.	26	2	15		2	64	109
Margaratiferidae	1						1
Gyraulus sp.		3			126	59	188
Physella sp.					7	1	8
GNATHOBDELLIDA							
Erpobdela punctata punctata						1	1
NOTOSTRACA		3					3
OLIGOCHAETA		4	4			21	29
PETROMYZONTIFORMES							
Lamprey						1	1
ARANEAE							
Spider				2			2
Total individuals	**250**	**169**	**118**	**41**	**271**	**385**	**1,234**

*Many *Lepidostoma* sp. (250) and *Micrasema* sp. (40) cases

Appendix 8-B 9. Surface macroinvertebrates collected in pitfall traps from sites with a mixed vegetative regime.

	Lower Green APD (Smith-Brothers-A-1)			Snoqualmie APD (Decker-A-1)			
Taxa	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**	**Total**
COLLEMBOLA		6					6
THYSANOPTERA							
Thripidae					1	1	2
ODONATA							
Coenagrionidae						1	1
ORTHOPTERA						1	1
HEMPITERA		1					1
Aphididae	18	2	2		1		23
Cicadellidae	4			1			5
Gerridae		1					1
Saldidae					1		1
COLEOPTERA							
Colydiidae					1		1
Curculianidae		1					1
Hydraenidae		1			1		2
Hydrophilidae				1	1	2	4
Lathridiidae					1		1
Ptilidae				62	8	2	72
Staphylinidae			1	2	5		8
HYMENOPTERA							
Cynipidae				1			1
Eulophidae		1		1	2	1	5
Mymaridae				2	1		3
DIPTERA							
Braconidae	1			1	2	4	8
Calliphoridae			1				1
Cecidomyiidae				2	1		3
Chironomidae	10	5	10	2	18	4	49
Culicinae			1				1
Dolichopodidae		3		5	4	21	33
Drosophilidae				1			1
Ephydridae			1	14	10	11	36
Muscidae	4	1	2	3		2	12
Opomyzidae				1			1
Phoridae		1					1
Pyschodidae	1	2	4		2	3	12
Sciomyzidae					1		1
Sphaeroceridae	1	4					5
Syrphidae			1				1
GASTROPODA							
Fossaria sp.		1					1
Physella sp.		2					2
ARANEAE Spider (Unidentified)				1	1		2
Total Individuals	**39**	**32**	**23**	**100**	**62**	**53**	**309**

Appendix 8-C: Summary of seasonal fish collections between October, 2002 and April, 2006.

Appendix 8-C 1. Summary of seasonal fish collections between October, 2002 and April, 2006. Shading represents that sampling occurred; '**S**' indicate salmonids were collected; 'x' indicates that only non-salmonid fishes were collected.

Site Name	APD	Vegetative Class	Flow Class	'02	2003				2004				2005				2006	
				Oct	Feb	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Feb	Apr
424th[1]	Enum	Cleaned	Mixed	--	--	--	--	--	--	--	--	--	--	--	--	**S**	--	--
Byron	Enum	Natural	Mixed	--	--	**S**		--	**S**	**S**	x	x			x	--	--	--
Irwin-A	Enum	Mixed	Natural	**S**	**S**	**S**	--	--	--	--	--	--	--	--	--	--	--	--
Irwin-B	Enum	Mixed	Drainage	**S**	**S**	**S**	**S**	**S**	x	**S**	**S**	**S**	**S**	**S**	**S**	--	--	--
Josie-Wetzel[2]	Enum	Cleaned	Mix	--	--	--	--	--	--	--	--						--	--
Sotir	Enum	Natural	Mixed	**S**	**S**	**S**	**S**	x	**S**	x	**S**	**S**	**S**	**S**	**S**	--	--	--
Boscolo-B[3]	Lgreen	Mixed	Mixed	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boscolo-C[3]	Lgreen	Mixed	Mixed	x	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mill-Ck-B	Lgreen	Mixed	Natural	**S**	--	**S**	**S**	**S**	--	**S**	**S**	--	--	--	--	--	--	--
Mill-Ck-C	Lgreen	Grass	Natural	**S**	--	**S**	**S**	**S**	--	**S**	**S**	--	--	--	--	--	--	--
Mullen-Slough-A	Lgreen	Natural	Mixed	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	--	--	--
Mullen-Slough-B	Lgreen	Mixed / Cleaned[5]	Mixed	x	**S**		--	x	**S**				**S**	**S**	x	**S**	**S**	x
Mullen-Slough-C	Lgreen	Grass / Cleaned[5]	Mixed	**S**	**S**	**S**	x	x	x							x	x	x
Mullen-Slough-E	Lgreen	Grass / Cleaned[5]	Mixed	**S**	x	x	x	x			x				x	x	x	x
Smith-Bros-A	Lgreen	Mixed / Cleaned[5]	Natural	**S**	**S**	**S**	x	x	**S**	**S**	**S**	**S**	**S**	**S**	x	x	x	x
Smith-Bros-B	Lgreen	Grass / Cleaned[5]	Natural	**S**	**S**	**S**	x	x	x	x					x	x	x	x
Smith-Bros-C	Lgreen	Grass / Cleaned[5]	Mixed	**S**	**S**	**S**			--		--	--	--	--	x	x	x	x
Smith-Bros-E	Lgreen	Grass / Cleaned[5]	Drainage	x					--			--	--	--	--	--	--	--
Smith-Bros-F	Lgreen	Natural	Drainage	--		--	--	--	--	--	--	--	--	--	--	--	--	--
Bellamy-C	Nsnoq	Mixed	Mixed	--	--	--	--	--	--	--	--	--	--	--	--	**S**	--	--
Bellamy-A	Nsnoq	Mixed	Natural	--	--	--	--	--	--	--	--	--	--	--	--	**S**	--	--
Beveridge	Nsnoq	Grass	Natural	--	--	--	--	--	--	--	--	--	**S**	**S**	--	--	--	--
Decker-A	Nsnoq	Mixed	Natural	**S**	**S**	**S**	**S**	x	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	--	x
Decker-B	Nsnoq	Grass	Drainage		--			x	x				x	x		--	--	--
Nelson-A	Nsnoq	Grass	Drainage	--	--	x	--	--	**S**	x	--	--	--	--	--	--	--	--
Nelson-B	Nsnoq	Grass	Natural	--	--	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	--	--
Olney-C	Nsnoq	Natural	Mixed	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
Olney-D	Nsnoq	Cleaned	Mixed	--	--	--	--	--	--	--	--	**S**	**S**	--	**S**	**S**	x	**S**
Pickering[5]	Nsnoq	Grass	Mixed	**S**	**S**	**S**	x	x	**S**	**S**	x	--	--	--	--	--	--	--
Pickering-A[5]	Nsnoq	Cleaned	Mixed	--	--	--	--	--	--	--	--	**S**	**S**	**S**	x	x	**S**	
Pickering-B[5]	Nsnoq	Cleaned	Mixed	--	--	--	--	--	--	--	--	**S**	**S**	**S**		x	**S**	**S**
Turner A/B	Nsnoq	Mixed	Mixed	--	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	--	--	--

1 Site was surveyed at the request of KCDNRP after maintenance activities occurred. Since no pre-maintenance data was collected at this site, it has been excluded from data analyses.
2 Site was incorporated at the request of KCDNRP after maintenance activities occurred. Since no fish were collected, it has been excluded from data analyses.
3 Sites on Boscolo property were sampled at the project outset only to validate past findings that salmonids were not present at these sites; All sites have been excluded from data analyses.
4 Reach had a probable blockage (culvert) at the mouth; following multiple sampling events without fish collection, the site was removed from further study (including data analyses).
5 Vegetative designations changed following cleaning activities conducted in 2005 between the spring and summer sampling events. At the Pickering site, two sub-reaches were created following maintenance activities, one of which had LWD installed (Pickering-B) and one of which did not (Pickering-A).