CHAPTER 14

Project Summary

14.1 Final Recommendations

The goal of the study was to determine effective and economical means to maintain agricultural watercourses while protecting fish habitat. Each of the previous chapters provided specific recommendations based on individual component investigations without necessarily looking at the process as a whole. In this final chapter, a holistic summary of key points is made.

Results of this study suggest that salmonid density (as indexed by capture frequency and/or catch rates) varies temporally, spatially, and in relation to physical factors such as surrounding vegetative regime and flow type in King County's agricultural waterways. Temporally, salmonids tend to be least widely distributed but more concentrated during the summer period, and most widely (but less densely) distributed during the winter and/or spring periods. Spatially, salmonids tend to be found more frequently and in greater abundance in close proximity to the mouth of the drainage system in which they are collected, although catch frequency and catch rates do not appear to decline directly with increased distance from the mouth. Salmonids in agricultural waterways appear to avoid both habitats dominated by RCG and those which have been recently cleaned/maintained, and appear to prefer habitats with a mixed or natural vegetative regime. Salmonids appear to avoid channels in which flows are dominated by drainage flow and lack at least some component of natural flow. These findings directly support the continued application of King County public rule 21A-24 sub-sections 374, 375, and 383(b) regarding maintenance timing, fish removal prior to, and mitigation planting activities following maintenance activity. Additionally, installation of short term cover following maintenance activities (consistent with subsection 383(a) of the public rule) appears warranted based on findings of this study although the cost effectiveness of measures currently described in that subsection was not investigated and is questioned based on other components of this research.

Electrofishing catch-per-unit-effort (CPUE) was found to provide a meaningful index of relative salmonid abundance across the range of habitat conditions commonly observed in agricultural waterways. Electrofishing CPUE should not be used to predict or estimate numerical abundance of salmonids within agricultural waterways. To maximize the utility of electrofishing CPUE to index salmonid abundance, it is recommended that the average CPUE across multiple surveys be used when feasible, and that surveys be conducted under relatively undisturbed (clean) conditions. If adherence to these recommendations is not feasible, potentially meaningful but less accurate indices can be derived via single surveys or multiple surveys conducted in both undisturbed and disturbed conditions.

Findings of this study largely support continuation of the existing King County protocol for effective removal of salmonids from agricultural waterways prior to maintenance activities in agricultural waterways. We recommend the continued use of multiple sampling methods

(trapping and electrofishing) for such fish removal, with a minimum of 6-8 fish removal or sampling events prior to any maintenance activity; this is consistent with general methods currently used by King County. However, based on the findings of this study, some additions or modifications to that protocol are recommended for consideration by King County. When practical, additional electrofishing activities should be conducted over the several days prior to maintenance activities when trapping activities are already being conducted. Optimally this would include a single electrofishing pass conducted prior to the setting of fish traps each day for five days prior to maintenance activity. Inclusion of additional electrofishing effort would not preclude continuation of the existing protocol of multi-pass electrofishing conducted on the final day prior to maintenance activities. Findings of this study illustrated that in some circumstances of reduced water quality, fish mortality during overnight trapping exercises can be very high. We therefore recommend development of minimum water quality criteria (presumably measured during daylight hours) under which overnight trapping would occur and an explanation of conditions that would potentially lead to termination of overnight trapping exercises.

This study evaluated the hypothesis that the mean difference in catch rates between sub-reaches with and without installed LWD was zero. Statistically, no significant difference ($\alpha = 0.10$) in catch rates was noted between sub-reaches with and without LWD installed for Chinook or coho salmon or for all salmonids combined. Although statistical analyses indicate that no significant differences exist ($p > 0.10$) between salmonid abundance in reaches with and without, numerous factors contributed to significant uncertainty in the statistical results. Therefore, based on this study, it is largely unclear if salmonid distribution in agricultural waterways is preferentially associated with installed LWD.

Results of dissolved oxygen (DO) modeling illustrated that DO levels in agricultural waterways differ significantly from those in adjacent non-agricultural reaches, and that maintenance activities contributed to improved DO levels in the water column. However, high sediment oxygen demand (SOD) following maintenance activity inhibits improvement of DO to levels meeting EPA standards. Based on this study it is unclear if the observed SOD increase is a short or long-term effect of maintenance activities. Nevertheless, the long-term improvements are clearly in favor of removing vegetation and sediments from agricultural watercourses. It is this report's recommendation to continue with hand-removal of vegetation but to consider mechanical dredging to remove loose sediments, increase sustainable habitat and potentially elevate dissolved oxygen concentrations. Ultimately, the economics of obtaining the costly permit for mechanical dredging will need to be weighed against the labor costs of hand cleaning but insufficient data currently exists to make a definitive claim as to which is superior.

The study of large woody debris (LWD) found that the practice of installing LWD in agricultural waterways was not effective in creating hydraulic diversity under typical velocity conditions found in these waterways. While some might argue about the added benefit of temporary cover (not researched in this project). If temporary cover is deemed vital, more cost effective strategies for temporary cover should be explored. However, based on the question being asked by this chapter and given the high installation costs (~$600 per piece), farmers should not be required to install LWD based solely on improving hydraulic diversity.

Macroinvertebrate and fish studies together 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. Differences in macroinvertebrate B-IBI scores were noted between vegetative regimes (mixed > natural > RCG) although all vegetative regimes were characterized as being of 'Very Poor' biological condition. Prey availability (macroinvertebrate abundance) is found to differ across vegetative regimes with mixed vegetative regimes having the greatest numbers and potentially more taxa. Due to the opportunistic feeding patterns of juvenile salmonids and the scarcity of most prey items in salmonid diets, it remains unclear if and how salmonids within the agricultural waterways are directly impacted by variations in macroinvertebrate community. 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. Growth of both coho and Chinook salmon was found to be isometric across vegetative regimes evaluated meaning that, as fish in different habitats grow in length, they add weight at similar rates. For Chinook salmon, comparison of weight-length relationship parameters (slope) showed seasonal differences in growth although it is unclear to what degree these findings were driven by low sample sizes in some seasons.

A temperature model was developed that can be applied to any agricultural waterway in King County. The model demonstrated that improved riparian condition as a result of mitigation planting will decrease water temperatures (prevent additional temperature increase) along a watercourse. However, the change in temperature is typically very small ($\leq 0.7\ ^{o}C$). Even though, due to the limited length of most channel segments, improvements in water temperatures due to riparian habitat at any one project will likely be modest, the aggregate benefits could help salmonid populations. Lower temperatures generally mean better dissolved oxygen conditions which were found to be low in several locations and additional shade will help suppress RCG growth as well as provide cover for the salmonids. Therefore, given the cumulative benefits, farmers should be required to plant native tree species in accordance with current King County practices.

The riparian vegetation enhancement section of this project related to finding a BMP protocol for effective control/eradication of RCG) and establishment of native ground cover and woody riparian vegetation. The study involved a pilot project, a principal project and a greenhouse investigation. The pilot project used small-scale treatment cells to investigate the use of Salal, clover, shade (old carpet), red cedar hog fuel (mulch), and steam in reducing RCG growth. Two treatments were particularly successful in reducing RCG regrowth. The hogfuel and shade material treatments (whether used with or without steam) suppressed the reed canarygrass significantly when compared to the control plots and the other treatments. In the principal project eight types of vegetation and a RCG barrier were evaluated. The RCG barrier alone was the least successful at reducing RCG regrowth. The treatments involving the Hogfuel/Willow (HF/Willow) and the HF/RCG barrier combinations were the most successful at reducing RCG regrowth, although the relative success of these treatments differed by test site. Greenhouse experiments were conducted to investigate the alleoathic tendencies of hogfuel and hogfuel tea on seedling growth RCG rhizome regrowth. The studies found growth and regrowth to be significantly reduced when hogfuel tea (as opposed to water) was used as a moisture source, illustrating the allelopathic tendencies of red cedar hogfuel on RCG rhizome regrowth.

Of the various options tested for temporary cover to reduce initial sediment loads, hydroseeding with existing straw mulch requirements appeared to be the best treatment in terms of effectiveness and cost. Sedimentation from ditch banks and relatively flat lands surrounding the watercourses was found to be minimal. Our data suggests that the best way to extend maintenance cycles would be to better control of sediment erosion from upland sources like development. In short, it appears that upstream development is resulting in the filling in agricultural waterways more than erosion of relatively flat farm lands in many instances. Natural and anthropogenic sources of sediment from the adjacent hill sides surrounding the agricultural lands appear to provide most of the in-channel sediment deposition. Further work needs to assess whether stricter enforcement of erosion ordinances or solutions such as constructing sediment detention ponds at the slope breaks that could be frequently dredged was not addressed in this study.

Channel maintenance will improve drainage and flooding in nearly all low-gradient systems containing significant amounts of sediment and RCG. The HEC-RAS model predictions as well as the field measurements clearly support this claim. This will improve the overall usability of farmland in King County. In keeping with the desire of the local citizens to preserve farm property, adequate channel maintenance should be encouraged. Moreover, in addition to improving drainage, antidotal evidence suggests that when RCG becomes too dense, salmonids are prevented from using the habitat. Such conditions developed at the Smith Brothers property in Mullen Slough during the project span. Upon hand and mechanical cleaning of the main ditch, salmonids were spotted south of 277th on the Boscolo property, something that had not occurred in recent memory.

In summary, ditch maintenance is an important process for drainage and providing juvenile salmonid rearing habitat in King County. Post-maintenance water quality testing found significant improvements in dissolved oxygen levels; the temperature model predicted of temperature improvements as riparian buffers grow; and visual reports of salmonids using much larger sections of the Mullen Slough/Boscolo complex all strongly suggest that maintenance activities benefit the fish. Furthermore, reports also support the assumption that better drainage help the farmers by allowing better use of their lands. By following the general processes discussed in this report, farming and salmonids should be able to successfully co-exist.