5. SUMMARY AND CONCLUSIONS – SNOQUALMIE SYSTEM

Water resources are limited and there are many competing demands for instream and out-of-stream uses. Additionally, potential drought or climate changes require new innovative approaches to water resource management. EKCRWA decided to explore the potential to conjunctively manage surface and groundwater in the Snoqualmie Basin to minimize potential impacts to sensitive premier salmon section of the Snoqualmie River. The ability to manage surface water and groundwater resources conjunctively can improve or maintain adequate stream habitat for threatened and endangered species during critical low-flow periods.

Preliminary evaluations of conjunctive use indicated a potential for streamflow enhancement in a section of the Snoqualmie River during low instream flow periods. The upper Snoqualmie Basin was seen as an ideal “test bed” to evaluate potential opportunities for seasonal river enhancement using water from the deeper aquifer system present in the basin based on previous studies.

The EKCRWA and others have been studying the upper Snoqualmie River Basin groundwater system for approximately 10 years. Technical investigations during this time have included geophysical investigations, exploratory drilling, pump testing, and groundwater elevation monitoring. These studies have resulted in a good understanding of the upper Snoqualmie Aquifer System, which were integrated in to a steady-state and transient model of the basin to evaluate streamflow augmentation scenarios.

The technical investigations led to the development of the conceptual model of the upper Snoqualmie Valley as a complex heterogeneous mixture of coarse- and fine-grain sediments that tend to become finer and less permeable in the northwest. A highly productive shallow aquifer near the city of North Bend has a strong hydraulic connection of this aquifer with the Middle and South Forks of the Snoqualmie River. There is a thick sequence of glacial till in the upper Snoqualmie Basin that acts as a semi-confining layer between the shallow and deep gravel aquifers. The deep gravel aquifer is also highly productive and recharged by the high local precipitation and storage within the Middle Fork Embankment.

The valley-fill sediments are underlain by impermeable bedrock deposits that have been incised during glacial advance and retreat to create a steep-walled subsurface valley. The top of bedrock varies significantly within the basin resulting in narrow sub-surface channel features and areas with relatively thin sequences of permeable materials. These areas constrict groundwater flow and create large head gradients in the upper portions of the Middle Fork Snoqualmie Valley, down-gradient of the Middle Fork Embankment. This constriction is a significant control on groundwater through-flow toward the central portion of the aquifer.

Recharge throughout the Snoqualmie Valley is a significant component of the water budget for the upper valley and directly controls the seasonal variation in groundwater elevations and river flows. Lateral boundary flows into the Snoqualmie Basin provided by seepage from the Masonry Pool in the Cedar River watershed that enters the Snoqualmie Basin near Rattlesnake Lake and Boxley Creek are also significant, but do not appear to control the seasonal head variability within the aquifer system in the central portion of the upper Snoqualmie Valley.

Steady-state and transient models of the upper Snoqualmie Basin were generally able to match observed heads and reproduce the timing of seasonal variations in water-level elevations. The long history and variable hydrologic conditions during the period of record allowed for careful consideration of the sources of flow to the basin and the primary flow paths. Both models were calibrated to observed streamflows.

The steady-state flow model of the Snoqualmie Valley was analyzed to determine the local parameter sensitivity and correlations to aid in determining the key areas of the flow system that control the heads and river flows. Generally, the model calibration was most sensitive to the horizontal hydraulic conductivity of units in the shallow portions of the model where many of the wells are located. The dominant direction of flow through the center of the valley is lateral, which is reflected in the small sensitivity coefficient for the vertical conductivity.

The bedrock configuration and hydraulic properties of the sediments downstream of Grouse Ridge are a significant control on the introduction of water into the Middle Fork of the Snoqualmie River. This area appears to channelize the mountain front recharge along the northern edge of the model near the Middle Fork Embankment and directs that water to the alluvial valley west of Grouse Ridge (near Tanner).

Lateral flow entering the model from the leakage of Masonry Pool into the upper Snoqualmie Valley was a very important control on the groundwater system. This flow component from the south edge of the model was important in controlling the trajectory of water in the central portion of the Snoqualmie Valley and helped to direct flow that originates near the Middle Fork Embankment along the Middle Fork Snoqualmie River.

Over the long term, a flow system is in a dynamic equilibrium when the average discharge from the aquifer approximates the average recharge. The equilibrium is dynamic because the groundwater and surface water systems fluctuate seasonally and annually in response to numerous stressors (for example, large-scale stressors such as climate changes). Anthropogenic stressors, such as pumping an aquifer, disrupt the natural dynamic equilibrium and replace it with a new dynamic equilibrium. For stressors such as these to be sustainable, the attainment of an acceptable new dynamic equilibrium is necessary. The long-term stability and predictability of these components (hydraulic heads and internal fluxes) are the most direct measures of the sustainability of the new dynamic equilibrium, and can determine whether these changes are acceptable.

The transient model was the basis from which streamflow augmentation scenarios were evaluated. All of the seasonal streamflow augmentation scenarios considered within the upper Snoqualmie Basin achieved a new dynamic equilibrium. Residual streamflow depletion was observed in the model, but residual groundwater level declines were negligible. The new equilibrium established under a seasonal pumping scenario was equivalent to the existing equilibrium and the modeling showed no long-term cumulative impacts to the new dynamic equilibrium.

The highest magnitude of augmentation was always achieved during the first month of an augmentation cycle. As the duration of augmentation increased, the fraction of water from storage decreased and higher volumes of water were removed from the river. Additionally, as the duration of augmentation increased, the time required to recover after pumping increased. Because the greatest impact from stream depletion occurred immediately after pumping stopped, the timing of stoppage was also very important. Planning for the use of augmentation must take each of these variables into account (time of initiation, rate of withdrawal, and duration of withdrawal).

The model demonstrated that distributing groundwater withdrawals over a larger area of the aquifer results in greater streamflow augmentation and maximizes recovery before the next cycle of augmentation.

Investigations of streamflow augmentation scenarios in the upper Snoqualmie Basin provided a good understanding of how groundwater can be manipulated to improve threatened and endangered species habitat during critical time periods. A thorough understanding of basin morphology and aquifer-stream interactions is necessary. A performance metric, such as residual stream depletion and average net augmentation, is also necessary for evaluating the sustainability of an augmentation concept and can be used to compare scenarios. These metrics can be used to compare relative augmentation benefits between basins.