VIII. SENSITIVITY ANALYSES

Recognizing hydrology, hydraulics, vegetative growth, and maintenance activities are not absolute in dimension and characteristics, it is prudent to perform analyses of various factors to determine the sensitivity of the drainage master plan facilities to differing conditions. Depending upon the sensitivity of the facilities to differing conditions, further considerations may be required to finalize the planned facilities or ongoing monitoring and maintenance.

Accordingly, Wood Rodgers will evaluate the sensitivity of the planned facilities to different hydrologic events and variable or interim channel conditions.

A. HYDROLOGIC SENSITIVITY ANALYSIS

The drainage facilities and phasing plan developed by Wood Rodgers based upon the design storm adopted by Sacramento County. This is a 100-year, 12-hour storm. This design storm results in a spill from Laguna Creek of 1,050 cfs. The updated drainage facilities, as described in this report, perform well through the phasing of development and when the NVSSP area is fully developed. Under Ultimate Conditions, when the spill from Laguna Creek is eliminated, the level of protection is enhanced.

To determine how the system responds to an event more severe than the design storm, Wood Rodgers tested the system with a 500-year storm within the Elder-Gerber Creek system, with the spill from Laguna Creek at the 100-year spill of 1,050 cfs. The results of this evaluation are presented on Figure 30. As shown on Figure 30, the increase in stage along Elder Creek, with the 500-year storm event, is less than one foot above the stage based upon the design storm (100-year). The resulting 500-year stage is significantly less than that for the 500-year Existing Conditions throughout the NVSSP area, and is essentially identical 500-year Existing Conditions downstream of Millbrook Circle.

The NVSSP area will not be adversely impacted from water levels in the detention basins or channels under the scenarios presented.

The sizing of the system within the NVSSP area was designed utilizing a 100-year, 12-hour storm event. The system was checked as part of this update by applying rainfall consistent with 100-year, 5-day and 100-year, 10-day storm events (separately modeled). The actual longer duration rainfall consists of several smaller storms (sub-storm) with breaks in-between. For the mathematical modeling program (UNET) to provide stable results during the low rainfall periods, the "minimum flow" setting was enabled to force the channels to carry some flow at all times, thereby allowing the program's calculations to continue on to the next portion of the storm event. This created, particularly in the earlier phases, an inflated channel water surface, making it more difficult for the runoff contained in the ponds to drain after each sub-storm rainfall. In other words, the detention ponds drain slower, as a result of modeling the creeks with constant "minimum" flows, than they would if the rainfall were the only contribution to runoff in the system. This introduces some conservatism in the analysis performed, by applying more water to the system than is contained in the rainfall hydrographs alone.

After refining the modeling effort, a pump was determined unnecessary at Basin E26. With modifications in the model to the channel transition near Florin Road, the E26 Pond was allowed to drain by gravity. The E26 Basin, when allowed to "float" with the channel water surfaces, is regulated by the receiving channel water surfaces. Configuring the system in this manner shows that drainage from Basin E26 does not adversely "back up" in the basin or significantly contribute to in-channel peak flows. This is occurring because the upstream peak channel flow must pass downstream before the channel is low enough to drain the majority of the water stored in Basin E26.

Pumps at each of the remaining four regional detention basins for NVSSP were turned off during the entire 5-day and 10-day storm events sensitivity analyses. Even with a lack of drainage of the channel during the storm breaks, the detention ponds operated sufficiently

to detain local runoff and release it slowly after channel peaks had passed. The weir elevations (set higher to spill with 12-hour peak event flows) were barely overtopped during the 5-day and 10-day events since the lower peak flow associated with these storm events were flowing by the detention ponds at lower elevations in the channels.

The analyses indicate that relative to the 12-hour design storm event, the longer duration storms have lower hydrologic peak flows. The UNET hydraulics clearly show that the maximum flood levels are lower when modeling the longer duration storms of the same return period. These results show that the creek is governed by channel conveyance and not by in-channel storage during a 100-year event. The 10-day and 5-day simulated storm events show there is sufficient time between the storm peaks to drain the creek channels before the net peak event occurs. Local residents have stated that the system takes a long time to drain under existing conditions. Explanations for these observations may be attributed to the channel, where surveyed cross sections show there are low spots in the channels upstream of slightly higher channel inverts, creating stepped flow. These areas will appear to be flooded longer during the receding part of a storm since the downstream channel is restricting low flow from getting out quickly. These areas are not a good indication of the channel's capacity to convey larger flow. They do not pose enough of an impediment to larger flow amounts to create a storage-governed system.

Local residents have stated that, at times, Gerber Creek flows backwards. While this is not apparent in the modeling performed under this study, it could happen during an alternate storm centering scenario. If the primary runoff is coming through the Elder Creek system, and Gerber Creek (and/or Laguna Creek) have not had significant rainfall, the lower end of Gerber Creek will receive flow from Elder Creek and backflow lower Gerber Creek, possibly as far back as the railroad crossing. The worst-case scenario for design, however, remains when the Gerber Basin and Elder Basin are both receiving rainfall, and the Laguna Basin is also spilling water along the railroad.

During the analysis and report effort in developing the concept of interim pumping to implement phasing of the drainage facilities, the modeling checking effort included the application of a 100-year storm followed by a 10-year storm event within the next day. These same rainfall conditions were applied to the Phase C models as another means of verifying the sizes of the proposed facilities. This effort yielded similar results to the longer storm duration evaluations previously discussed. The maximum water surfaces from the 100-year event within the channels and storage basins receded enough within one day (without pumping) to allow for a 10-year storm to pass through without exceeding existing conditions 100-year maximum water surfaces.

B. "n" VALUE SENSITIVITY ANALYSIS

Higher "n" Values

Wood Rodgers checked the Ultimate and Stand-Alone Conditions using an "n" value of 0.08. Ultimate Conditions did not show a flow increase downstream or overtop the channel banks likely due to the channel capacity present when designed with the Laguna Creek spill. Under Stand-Alone Conditions peak flows downstream did not exceed Existing Condtions, however, water surface elevations increased, exceeding freeboard in some locations within the Plan area. Therefore, it is necessary to evaluate the effort to maintain channel "n" values at design levels of 0.06, as well as the likelihood of the channel reaching "n" values higher than design levels in the operational future of the system.

Currently the Elder Creek and Gerber Creek channels are dry in the summer and wet in the rainy season and support some limited vegetation as evidenced during a field investigation by Wood Rodgers in August 2002. The majority of the areas in the creek beds were dry, with some exception in the Elder Creek channel just downstream of Florin Road. The wet area in Elder Creek appeared to be man-made with watering animals present during the site visit. The Gerber Creek system has undeveloped land as well as a golf course upstream of

the NVSSP area. There is standing water in the creek upstream of the golf course during a good part of the year, with very little flow downstream of the golf course.

The presence of moisture in the Gerber Creek and Elder Creek channels may gradually transition with development from a seasonal stream system (rainy season only) to a perennial stream, due to runoff that typically occurs from developed areas. It is anticipated that flow from the developed areas and the detention facilities will only produce water in the low-flow areas during the summer months if sufficient over-watering occurs. Levels sufficient to maintain low flow in the channel will not likely occur until development is closer to build-out conditions.

Earlier phases of development will not likely supply enough water to sustain flow in a low-flow channel, considering construction storm water pollution prevention plans tend to keep low-flow waters on-site and keep erosion to a minimum. This makes more difficult growing conditions for trees to get established, when subjected to prolonged drying conditions in the summer months. Currently, the generally observed predominant vegetation are grasses and hardy weed plants, plants that typically germinate early in the season when conditions are still moist and then mature early. These types of vegetation are relatively short and lack the rigidness necessary to resist bending under velocities of 2-4 fps associated with storms producing high runoff.

To give some perspective as to obstructions that are produced by volunteer vegetation, Wood Rodgers visited several creek/channel systems in the Sacramento Valley area. The example sites are channels where volunteer vegetation was allowed to grow and were subject to high runoff from urban development.

The Covell Drain in the Davis area is the first example. The Covell Drain was realigned in 1982, between Highway 113 and F Street, with an improved flood conveyance capacity of over 1,000 cfs. This channel has had very little maintenance and vegetation removal

since constructed. Field investigations show the channel bottom is where predominant growth occurs. A photograph is included to show the vegetation in the Covell Drain (Photograph 1).

Photograph 1 - Looking West From F Street

It is important to note the Covell Drain acts as an irrigation drain during the summer and hence has wetter conditions to sustain a longer growing season. Even with such conditions, the growth is not occurring across the entire channel bottom, but more along a narrower low-flow alignment. Given the growth present in the Covell Drain, Wood Rodgers assesses the "n" value of the channel bottom at approximately 0.045-0.055. Information was used from USGS Paper 2339 entitled, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains," which evaluates roughness in open channels using a cumulative increment approach. Different channel flow factors are evaluated separately and the cumulative effect is summed at the end to achieve a separate total "n" value for the channel and overbank. The Yolo County Flood Control & Water Conservation District, which has the responsibility for maintenance confirmed that very little has been done to maintain the channel since it was constructed.

Another illustrative example is a smaller tributary development (drainage area) along Laguna Creek, crossing under Bond Road east of Waterman Road. The system was intended to remain wetter during the summer months with some controlled outlet channel facilities connecting to Laguna Creek. The residential development (contributing lands) is consistent with planned development in the NVSSP area and the channel has been in service for approximately four years (Photograph 2). There has been very little established vegetation in the channel that would obstruct flow, due to the development producing lower flows in the summer than necessary to sustain heavier plant growth. It is not known at this time whether low flows are less than anticipated, or whether evapotranspiration and infiltration effects are more substantial than originally estimated.

Photograph 2 - Looking South From Bond Road.

While what is occurring in the last example may not have been the intent of the designer, it clearly demonstrates that residential development in this part of the Sacramento Valley (adjacent to the NVSSP area), by itself, will not necessarily create sufficient water to sustain significant vegetation in a receiving channel. This particular channel example could more closely be compared to the water quality treatment portions of the proposed NVSSP detention ponds. These areas will capture water from the development before allowing the water to pass to the main creeks/channels. If the developments do not produce enough runoff during the summer, the water will be consumed in the detention basins before it

reaches the creeks, possibly creating an even drier creek environment in the summer than occurs presently.

Given these examples, Wood Rodgers proposes to have lower levels of sustainable heavy "volunteer" vegetation in Elder Creek and Gerber Creek after development occurs. In fact, the several small planned areas for planted vegetation will likely need water to become established. None of the planned vegetation is intended for planting in the channel bottom. If the channel bottom is allowed to simply grow "uncontrollably" it will likely take a long time to reach vegetation levels that will create the design "n" value of 0.06 or greater as the predominant plant growth will be grasses and weeds. The side slopes of the channels will be even drier and will generally sustain less vegetation than the channel bottom, being subjected to less seed pod deposition and less moist soils.

Given what has been encountered in the greater Sacramento area, with periodic tree/brush removal every 5-10 years, the County should be able to sustain channel roughness values that do not exceed 0.06 in the channel bottom, or 0.045 along the channel side slopes.

<u>Lower "n" Values</u>

A greater concern during the phased implementation of drainage facilities is the lower "n" values in the improved channel sections where vegetation has not fully matured to design "n" value levels. If the ultimate channel prism has a lower roughness coefficient during a 100-year storm event, more water will travel downstream at a lower water surface, upsetting the balance of spilling to the detention basin.

The problem of too much channel conveyance capacity is easy to solve in the interim period before vegetation matures. Considering the key locations are spills from the Gerber Creek and Elder Creek systems, the "obstruction" of vegetation will need to be replaced with a temporary berm or weir across the channel(s) just downstream of a proposed spill location. This will require some flexibility on the part of Sacramento County to re-estimate the "n"

value periodically and adjust the "in-channel" weir up or down depending upon the lack of or presence of vegetation in the channel. This weir structure will act as a "flow control" device, simulating the effects of downstream vegetation, to maintain spilling flood volumes into the detention basins. Once design vegetation levels are achieved, the artificial obstruction can be removed. Then it will be necessary to periodically remove tree and brush vegetation to maintain design flood levels, as discussed above.

The cost to construct a berm/weir is considered minimal, as it can be constructed of compacted earth along the bottom of the channel during channel excavation. If it is intended in the design to adjust the elevation of the earth berm/weir in the future, sufficient survey control can be located adjacent to the site to make earthwork grading easier. It will likely require less than one day with standard earthwork and hauling equipment. Access should not be troublesome, as they will be located at planned controlled diversions from the creek to the detention ponds where access is also currently planned.