A. GENERAL

Discussed in this section is the approach taken to formulate and evaluate drainage facilities required to provide adequate drainage and flood protection for new development without adversely affecting existing flooding. The facilities defined in the Preferred Drainage Plan and the associated hydrologic and hydraulic models provide the basis for the work performed by Wood Rodgers.

B. HYDROLOGY

The hydrologic modeling accepted by SCDWR for drainage within the NVSSP area utilizes runoff hydrographs generated with the HEC-1 modeling program to simulate rainfall and runoff in the Elder Creek Basin. The HEC-1 models developed by Mr. Hamilton, to establish Existing Conditions runoff, were used by Wood Rodgers to simulate runoff in areas of the basin where no change in land use occurs.

The NVSSP area was essentially "cut out" of the basin model and isolated in separate HEC-1 models to update the runoff within the NVSSP area consistent with changed land use, while leaving the Existing Conditions model outside the NVSSP area unmodified.

The development phases, as defined for the NVSSP area, were used to update the hydrologic subbasins within the NVSSP area. The increased runoff due to each phase of development was incrementally reflected in the hydrologic parameters for each subbasin for each phase and the SACPRE and HEC-1 programs were utilized to update each subbasin storm runoff. Each runoff hydrograph was imported into the respective UNET model to combine the effects of phased development within the NVSSP area with the surrounding Existing Conditions subbasins.

The original NVSSP DMP included on-line and off-line detention basins. At the locations of the off-line basins, storm runoff discharges directly to the creeks, with a diversion of the flow from the creeks into the nearest downstream water quality/detention basin. This method was problematic for phasing when faced with the hydraulic constraints of draining into unimproved channels with both high invert and water surface elevations. The approach by Wood Rodgers differs with on-site Basin G41 and Basin G46 treated as on-line basins, with respect to the pipe drainage system. The pipes discharge directly into the detention basins, allowing all flow from frequent storm events, for which water quality treatment is most critical, to drain through the basins before entering the creeks. To preserve as much flood control volume in the basins as possible, runoff in excess of the capacity of the storm drain pipe system was routed as overland flow to discharge directly into the creeks. Grading for development will need to be designed accordingly, to ensure that overland conveyance drains directly to the creeks.

Modeling (100-year) to account for the runoff routed through the pipe system and the overland flow concurrent with external runoff in the creeks is complex because flow into the basin through the pipe system is not only limited by the hydraulic capacity of the pipe system (designed using the *Nolte Method*), but may be limited by the downstream water surface, thus volume of water in the basin as well. The water in the basin is affected by the flow out (gravity or pump), as well as the flow in from the creek over the weir. The hydraulic analysis required to accurately evaluate such a complex flow system was beyond the scope of this assignment. For purposes of this analysis, Wood Rodgers' approach was to use a worst-case scenario to conservatively determine the size of the storage facilities. The methodology employed for Basin E24A, Basin G41, and Basin G46 is described below and illustrated on Figure 5.

1. Worst-Case Scenario for Creeks

The 100-year developed conditions hydrographs were modeled utilizing HEC-1. During a 100-year design event, the maximum overland flow and volume assumed to reach the

creek directly was estimated by subtracting the Nolte peak flow from the 100-year runoff hydrograph for each time-step of the hydrograph simulation. This assumes flow only reaches the pond through the pipe system or over the weir from the creek. The flow actually reaching the creeks (from local basins) should be less since the storm drains are designed to carry the Nolte peak flow when the basin contains the entire 10-year storm volume. The local 100-year runoff is generally conveyed within the channels while the basins are being filled through the pipe system, with only minor flow entering over the weirs from the creeks. Additional flow was added to the creek systems using "minimum flows" values to maintain stable calculations in the UNET model, creating conservatism in the volume of water in the system.

2. Worst-Case Scenario for Basins

The reciprocal approach was used to estimate the worst-case volumes reaching the basins during the 100-year event. The hydraulic capacity of the pipe system controls flow into the basins. The 100-year subbasin runoff hydrograph was used to direct flow up to the pipe capacity into its respective detention basin. Directing up to the full hydraulic pipe capacity during the entire storm is conservative since the basins may also receive water from the creeks at the same time.

Consequently, both worst-case scenarios were input into the UNET model at the same time (i.e., worst-case residual runoff to creeks and worst-case basin volume to basins). This approach results in slightly oversizing the basins, but has little effect on the peak flow in the creeks (downstream of Basin G41) since the spill from Laguna Creek, which governs, occurs after the local storm peak has passed and creates the worst-case peak flow conditions in Gerber Creek and Elder Creek downstream of the confluence.

As noted above, the runoff to the basin and to the creeks was divided only for Basin E24A, Basin G41, and Basin G46 along Gerber Creek. Basin E24B and Basin E26 are designed as on-line basins that receive the entire 100-year storm runoff (i.e., pipe flow

and overland flow) from the adjacent NVSSP subbasins in all phases and did not require the application of the methodology described above.

A critical component of the detention/storage concept in the original NVSSP DMP is the ability of the detention basin to receive water from the creek <u>only</u> when the creek is reaching peak flow levels. To be acceptable to FEMA, it must be demonstrated that a designed flood control system can operate as intended during a critical flood event. For FEMA to accept the NVSSP storm drainage concept, levees and weir structures separating the creeks and basins must be designed to ensure the hydraulic and structural integrity of the system.

The basins are being sized to have enough volume available during a specific flow range of a storm. If any proposed levees do not meet FEMA's requirements for structural certification, FEMA will require evaluating scenarios where such a levee is failed. If a failure scenario were evaluated in the NVSSP area, the detention basins would become full earlier in the storm, removing the effectiveness to mitigate downstream increases i flow and stage (due to development) when the system reaches peak flows. Therefore, the proposed levees, being significant components of control structures between channels and basins, will need to be designed and constructed with the dimension (freeboard and side slopes) and quality control acceptable to FEMA to be considered functional or "not failed" during any "worst-case" flooding scenario.

C. HYDRAULICS

1. Storm Drain Pipe System

Wood Rodgers utilized the *Nolte Method* and Nolte charts in "Volume 2: Hydrology Standards," of the "Drainage Manual" prepared by the Sacramento City/County to calculate the peak design flow to size the storm drain pipes.

The Manning's equation was used to calculate the HGL. In accordance with Sacramento County Standards, the HGL is a minimum of 0.5 foot below the proposed drain inlet.

All the storm drain trunks sized by Wood Rodgers drain into water quality/detention basins. The starting water surface at each detention basin was assumed to be for the volume associated with storing the runoff volume from a 10-year, 24-hour storm. The maximum 10-year basin stage is based upon the drain pumps being off to reflect a worst-case condition for the fully developed condition. When the pumps are working, the basin elevations will be lower. Wood Rodgers developed UNET models to determine if any other flow enters the basins from the creeks under the 10-year, 12-hour (maximum peak flow) phased conditions. Under each of the phases, the channels convey the 10-year creek flow (with pumps running) without flow spilling over the weirs into the basins. Thus the detention basins and the creeks are essentially hydraulically disconnected under the 10-year event, except for the pumps or flap-gated gravity outlet pipes.

2. Detention Basins

To phase development using interim pumping, detention basins will likely require storage volumes greater than identified in the NVSSP DMP. With this understanding, Wood Rodgers' approach was to keep the creek (channel) improvements the same as those identified in the NVSSP DMP, and to increase the detention basin capacity, as necessary, to provide the desired flood control protection and mitigation.

Pumping from the detention basins is at the rate of 10 cfs. In developing the Phasing Concept (Borcalli & Associates, April 10, 2001) it was determined that, in the case of a 100-year, 12-hour storm event followed by a local 10-year, 12-hour storm within a day, the available detention basin storage would not be exceeded. This pumping capacity of 10 cfs was, therefore, kept as the criteria in Wood Rodgers' approach for sizing the detention basins during the phasing of development. This storm sequence scenario was

rechecked for Phase C and determined to remain valid (see Section VIII for further discussion).

3. Channel Improvements

By virtue of Wood Rodgers' approach, all the creek channel improvements are the same as defined for the Preferred Drainage Plan. These channels, or portions thereof, were incorporated into the UNET models where improved conveyance was required to mitigate impacts of phased development.

D. WATER QUALITY TREATMENT

Wood Rodgers' approach to water quality treatment of urban runoff differs from the original NVSSP DMP approach. Due to hydraulic limitations relating to the storm drain design discussed above, it was not feasible to divert water from the creek into the basins for water quality treatment in advance of the creeks being excavated to the size and elevation established for the Preferred Drainage Plan.

Therefore, Wood Rodgers' approach was to direct runoff from developed areas within the NVSSP area through the storm drain pipe system directly to the basins for water quality treatment. Areas within the NVSSP area that are isolated by physical features (i.e., creeks and topography) from larger water quality/detention basins, are still assumed to require water quality treatment basins. These smaller water quality treatment facilities are proposed at the downstream ends of smaller storm drains, and have overflow weirs that would spill directly into improved channels. These smaller water quality basins could be considered "on-site" infrastructure rather than master plan facilities, however, at the direction of SCDWR, they are combined, where applicable, and included in this report. Evaluating the hydraulics for each of these isolated areas will have to be addressed as they plan for development. Presented on Figure 6 is a typical cross section of the proposed treatment

swale. The aggregate of the land in this category amounts to 142 acres, which represents approximately nine percent of the NVSSP area.

Within the major part of the NVSSP area, the initial runoff is directed to five primary water quality/detention basins that were identified as part of the Preferred Drainage Plan (Figure 4). To maximize the available flood control volumes in these basins, while minimizing the footprints of these basins, Wood Rodgers sized the water quality features as wet water quality basins with the top of the water quality pool at the invert of the adjacent channels when constructed to the ultimate channel section. The wet water quality pond concept has been, and is currently being, implemented within the Sacramento Region including Sacramento County for development similar to that proposed for the NVSSP area. During the interim drainage scenarios, the evacuation pumps will be operated to pump storm water from the basins into the existing channels at higher elevations to maintain the flood control storage volume for the respective basin. When designed, the basins are to be configured for purposes of water quality treatment to ensure that "short circuiting" of the flow does not occur from the storm drain outlets to the basin outlets.

Currently, Sacramento County does not have a standard to size wet water quality basins, however, after consulting with SCDWR, Wood Rodgers was advised to size the wet water quality basins utilizing the City of Sacramento Department of Utilities' "North Natomas Drainage Design and Procedures Manual," dated July 1998. The City's standards have been accepted, unofficially, by SCDWR for sizing wet water quality treatment facilities. Wood Rodgers used the Wet Basin Option "b," as shown on Figure 6-5, of the "North Natomas Drainage Design and Procedures Manual," as the basis for sizing and draining water quality volumes. This option allows for the efficient evacuation of water quality volumes and flood control volumes with a submerged outlet pipe (with flap gate) configuration. Whenever the downstream outlet water surface elevation is lower than the basin elevation, the excess volume will drain effectively.

There are several hydraulically isolated areas adjacent to Gerber Creek that are proposed for development in later phases. As part of this study, the development of such areas was assumed to follow downstream channel and storage basin improvements, therefore it is unknown what water quality treatment facilities would be best suited to develop these areas if developed ahead of the earlier phases. Regardless of the phasing, when areas within the NVSSP plan area are developed, storm water quality treatment facilities will be required.

With adjacent channel improvements, the most effective and equitable means of implementing water quality treatment for these areas is to construct linear swales parallel to the main channels with overflow spill structures, or overland releases to the main channel. The topography of the isolated areas is conducive to storm drain design with this concept. The proposed dimensions for a treatment swale are a 7-foot bottom width with 2:1 side slopes for a total width of approximately 30-32 feet. These swales are not intended to "convey" flows as a high-velocity conveyance channel, and are not intended to be deeper than 5.5 feet. Presented on Figure 6 is a conceptual schematic representation of the proposed treatment. The smaller swale outlet pipe drains at a different location than the overflow weir(s) and storm drain outlet. The two outlet features of the water quality treatment swale are ideally separated to detain smaller water quality flow while flood flow has a direct path out, relatively unimpeded into the adjacent channel.

Unlike the larger regional detention/water quality basins, the calculated volume is directly based upon the *Sato Method* (dry extended basin). The water quality volume below the weir elevation will drain slowly, directly to the channel through a smaller pipe, after channel flows (or larger events) have subsided, in accordance with County criteria for dry-extended water quality treatment basins.

These treatment swales are proposed to fit outside current delineations of proposed drainage parkways, where applicable.