Storm Drainage

Detention

Master Plan

Submitted in compliance with
Condition of Approval
N.2.b of the
Stanford 2000
General Use Permit

Prepared by Nolte Associates

April 10, 2001

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1. INTRODUCTION

BACKGROUND

Stanford University is preparing an Overland Flow Master Plan for its storm runoff and flood control system, specifically those elements of the system that provide protection of Campus facilities when flows exceed the capacity of the normal on-site storm drainage system. Recently, the University received approval of the Stanford Community Plan/General Use Permit, which approves academic and residential development. Condition of Approval N.2.b of the Stanford 2000 General Use Permit required Stanford University to mitigate the potential for increased storm water runoff.

SCOPE OF WORK

This study has been conducted to master plan regional management of surface runoff by using detention facilities that will facilitate Campus growth, while maximizing the protection of the Campus and the surrounding area. This report will present an analysis of runoff and recommendations for new detention facilities that are capable of integrating storm water protection with existing and future Campus functions and space needs. Joint use with athletic and recreational activities will be specifically considered. The recommendations will satisfy the condition that storm drainage improvements will be sufficient to ensure that runoff levels will not increase over the existing peak levels and cause downstream flooding.

STUDY AREA

The Campus Area investigated in this study is illustrated in Figure 1-1. Upland areas that are tributary to the study area have also been analyzed.

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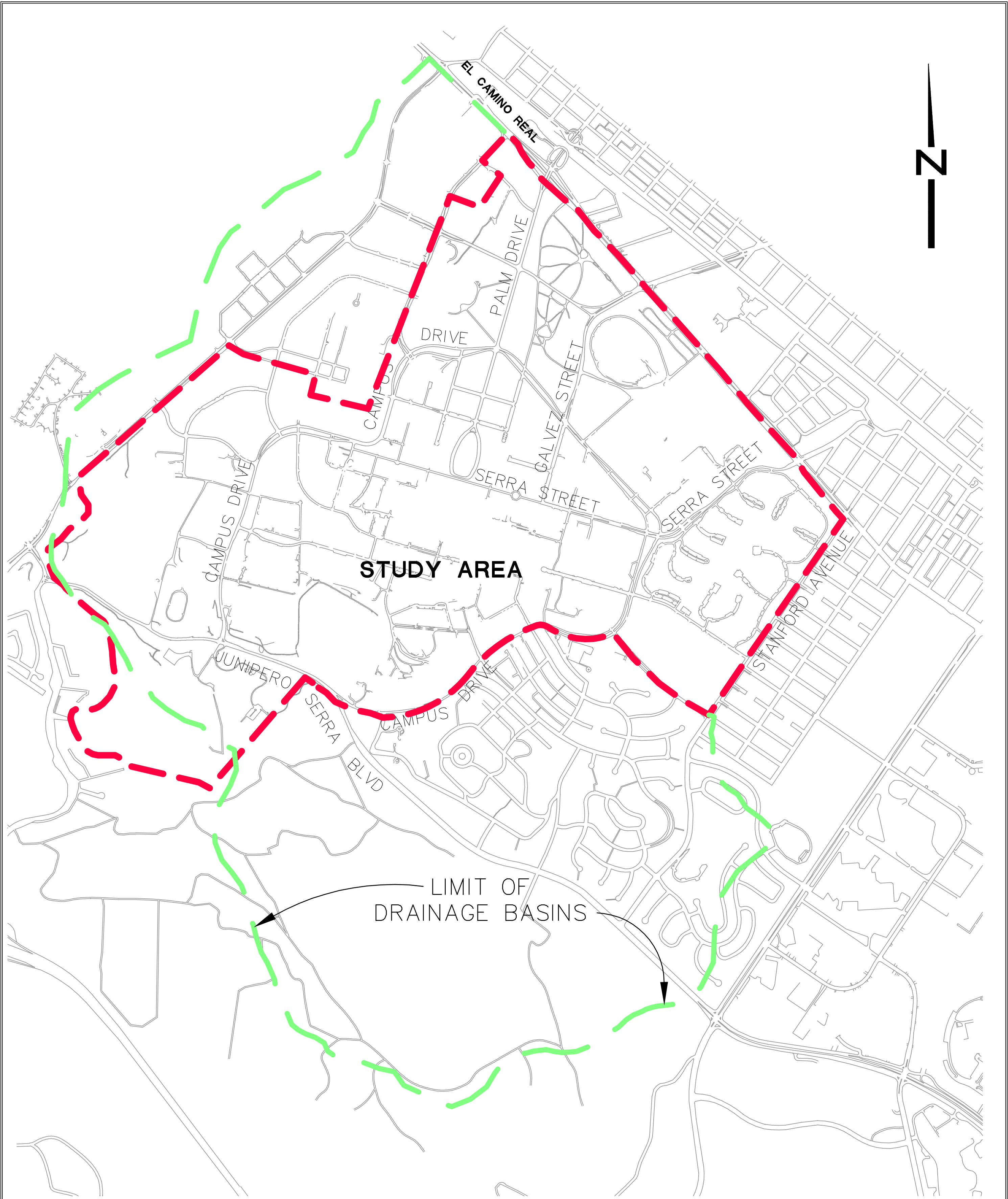

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STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 1-1
STUDY AREA

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2. Summary

The Campus area covered by this study drains to Matadero Creek and San Francisquito Creek. The specific limits are presented in Figure 1-1. The Campus is continuing to develop, and there is a need to protect both Campus facilities and neighboring communities from increases in surface runoff.

The following design criteria are proposed for the Stanford University Campus:

- Runoff from storms up through the 10-year event should be collected and conveyed by storm drainage inlets, pipes, and ditches. At this level, standing water and surface flow of runoff should be minimized.

- Runoff from storms in excess of the 10-year event, up through the 100-year event, should be managed using established overland flow paths that prevent damage to Campus facilities.

- Storm water detention basins shall be implemented to prevent increases in the peak flow rates, caused by changes in Campus surface runoff conditions, from leaving the Campus. The basins shall provide detention for both the 10-year and 100-year storms.

The Corps of Engineers' HEC-1 Flood Hydrograph computer program was used to model existing and future runoff and detention storage facilities.

The approved Stanford Community Plan/General Use Permit proposes modifications and additions to the Campus. Of the total of 1,606 acres in the study area, approximately 38.77 acres of currently pervious acres (undeveloped and unpaved) on the Campus would be changed to impervious area.

For the Matadero Creek Watershed portion of the Campus, 0.08 acre-ft of detention storage is required to reduce the projected 100-year peak flow for the future developed condition to the current peak flow. To reduce the projected 10-year flow increase to current levels, 0.08 acre-ft of detention storage is needed.

For the San Francisquito Creek Watershed, 0.21 acre-ft of detention storage is required to reduce the projected 100-year peak flow for the future developed condition to the current peak flow. To reduce the projected 10-year flow increase to current levels, 0.12 acre-ft of detention storage is needed. These volumes assume the detention basins are located at the downstream end of the drainage area.

Five detention basin systems are recommended to attenuate increases in flows from Campus development proposed by the approved Stanford Community Plan/General Use Permit and possible future development. The basin locations are presented in Figure 5-1.

The Serra Street at El Camino Detention Basin location is in the Matadero Creek Watershed portion of the Campus. A two-basin system is recommended at this location to reduce flows for both the 10-year and the 100-year event.

The Serra Street at Campus Drive East Detention Basin location is also in the Matadero Creek Watershed portion of the Campus. A single basin system is recommended at this location to reduce flows from the 100-year event.

The West Campus Detention Basin locations are in the San Francisquito Creek Watershed portion of the Campus. Two-stage basin systems or two-basin systems to reduce flows for both the 10-year and the 100-year are recommended at these locations. These detention basin systems will reduce off-site flows, as well as reduce flows to Campus drainage facilities.

The Quarry Road Detention Basin locations are in the San Francisquito Creek Watershed portion of the Campus. The locations are only conceptual in plan and five sites are indicated. The specific location will be selected at the time of initial design. One or more of the sites may be used to achieve the full protection desired. The sites are envisioned as either two-stage basins or two-basin systems that will provide reductions in flow near the source for both the 10-year and 100-year events.

The specific size and configuration of the basins will be selected during the design process. Basins located close to the project site need to be larger than basins located at the downstream end of the drainage area. The basin locations near the project site, however, may be able to minimize improvements to the existing piped storm drainage system between the project site and the downstream end of the drainage basin.

The proposed detention basin locations are large enough to provide flow reductions for current and future growth needs. Each of the basins may be sized to meet the needs of a specific project or to accommodate several future projects within the watershed. Since the joint use of the sites is a significant factor in determining the size of a basin, any one of the basins may provide a significant reserve of peak flow attenuation capacity.

The capacity of a detention basin to reduce peak flows will be documented at the time the permit for construction of the detention basin is submitted to the County of Santa Clara for approval. This capacity will be equated to a specific number of square feet of impervious area for which the detention basin will attenuate flow and will be designated as a reserve of impervious area for use by future development. This reserve of impervious area will be reduced as campus development projects are constructed. The permit for each individual development project will identify the detention basin that is providing the flow attenuation, state the change in impervious area caused by the project, and indicate the balance in the reserve of impervious area for the identified basin before and after the project.

3. DESIGN CRITERIA AND CALCULATION METHODOLOGY

In this section, the design criteria will be presented along with the methodology used to perform the required calculations in this report. The design criteria will include the setting for the facilities that are being protected, the frequency event that is used for planning, and drainage principles that are applicable to these systems. The methodology and assumptions for use in calculating runoff detention volumes using the Corps of Engineers' HEC-1 will also be presented.

In this report two terms will be used to describe surface runoff or the analysis of runoff. These terms are hydrology and hydraulics. The following definitions are provided for clarity:

- Hydrology refers to the calculation of the quantity of runoff.
- Hydraulics refers to the calculation or quantification of the water conveying capacity of the storm drainage systems.

CAMPUS SETTING

Drainage facilities require space and occupy land. Drainage facilities should be designed, when possible, to share the land with other uses such as parking, roadways, recreational activities, and open space.

The most significant factor that affects the planning and ultimately the design of the storm water facilities is the Campus itself. At all times it must be realized that the facilities on the Campus exist to serve the community of students, faculty, and staff that use them. The drainage facilities must be integrated into the Campus, as well as provide protection.

The Campus has a long history that is perpetuated in its building and landscape architecture. The quality of this setting must be respected. The development of the Campus must also accommodate the realities of storm water runoff and its management.

DESIGN STORM EVENT DEFINITION

Protection of facilities from flooding is usually defined in terms of the probability of the storm event occurring, which would impact the facility. This probability is characterized in terms of the frequency of the event returning or the return frequency for a rainfall event. As an example, an event that has a 1-percent chance of occurring is an event that would occur an average of once in every 100 years. This is commonly referred to as a 100-year event. The lower the probability an event has, the larger the event is. A storm that occurs at least once each year is much smaller than a storm that occurs an average of once in each 50 years.

DESIGN CRITERIA

The following levels of protection are recommended as design criteria for the Stanford University Campus:

1. Runoff from storms up through the 10-year event should be collected and conveyed by storm drainage inlets, pipes, and ditches. At this level, standing water and surface flow of runoff should be minimized.

2. Runoff from storms in excess of the 10-year event, up through the 100-year event, should be managed using established overland flow paths that prevent damage to Campus facilities.

3. Storm water detention basins shall be implemented to prevent increases in the peak flow rates, caused by changes in Campus surface runoff conditions, from leaving the Campus. The basins shall provide detention for both the 10-year and 100-year storms.

These design criteria, specifically criteria number 3, implement the Condition of Approval N.2.b of the Stanford 2000 General Use Permit.

CALCULATION METHODOLOGIES

The Corps of Engineers' HEC-1 model will be used for runoff calculations, detention basin performance analysis, and detention volume calculations.

Detention Calculation Methodology

Detention of surface runoff is the process of absorbing peak flow rate from an area by storage, and then releasing the flow in a controlled manner at a lower flow rate. This process reduces the impact of a high peak flow on downstream drainage facilities. The Corps of Engineers' HEC-1 Flood Hydrograph computer program model (P.C. version 4.0.3E, dated June 1992) was used to model detention storage facilities. The volume of rainfall and the variation of the rainfall over time are the most important elements in analyzing the size and effectiveness of storm water detention.

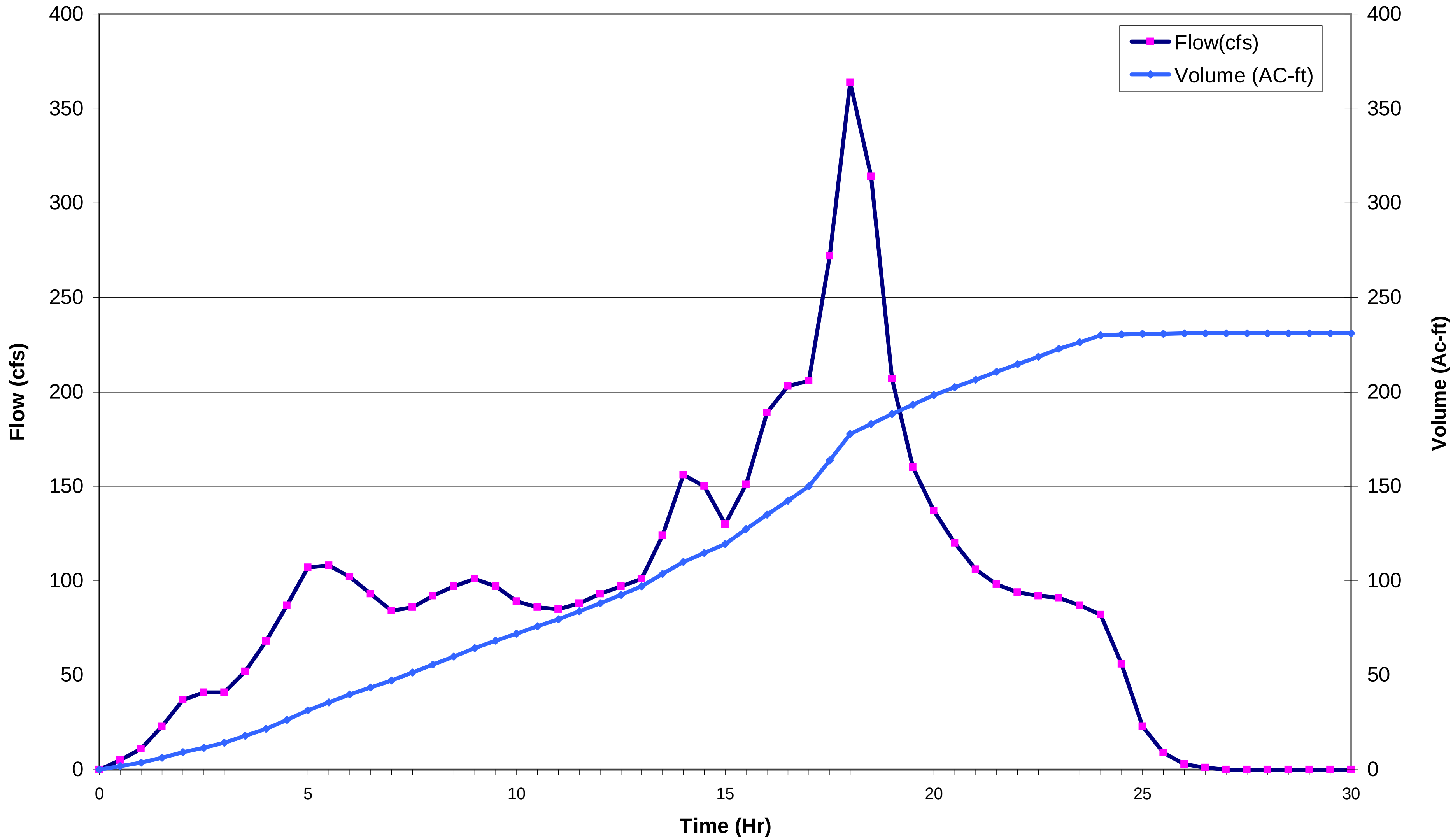
The HEC-1 model, therefore, does not use the Rational Method (a surface runoff calculation procedure) to determine peak flow rates. The HEC-1 model uses a design storm for rainfall and uses the characteristics of the watershed for calculating runoff over time. This calculation is generally appropriate for larger watersheds. The characteristics of the watershed can be determined and adjusted through a calibration process using stream gage data. Santa Clara Valley Water District (SCVWD) has developed and calibrated watershed data for most of Santa Clara County.

The study area covers a portion of the Matadero Creek Watershed as delineated by SCVWD and a portion of the San Francisquito Creek Watershed. The data used to model the Campus, therefore, starts with data acquired from SCVWD for these watersheds. The data are then prorated based on the specific drainage areas being analyzed.

The rainfall data used in the model for both 100-year and 10-year design storms have been acquired and analyzed. The SCVWD design storms are synthesized storm events with 24-hour duration. The pattern of rainfall generally reflects previous high intensity events that have caused flooding in this area. The design event can be described as an event with low to moderate intensities for a period of approximately 18 hours, followed by the intensities increasing sharply to a peak, and then tapering off and stopping in the remaining 6 hours of the event. A typical runoff hydrograph calculated using the design storm is presented in Figure 3-1. The type of event illustrated is typical of the area, creating saturated surface conditions and also realistically stressing the capacity of storage systems used for detention.

The two most significant model parameters, which are specifically applicable to the Stanford Campus and to the specific analysis being performed, are the pervious area and the impervious area. Pervious areas are typically areas like open fields, undeveloped land, and parks. Impervious areas are typically parking lots, roads, sidewalks, and building roofs. As an area develops, the use of the land often changes from pervious areas, like open space, to roads and roofs, and the runoff correspondingly increases. However, development that changes a parking lot to a building does not necessarily increase the runoff.

Figure 3-1: Typical 100 Yr Flow and Volume Hydrograph



4. EXISTING DRAINAGE SYSTEMS

The purpose of this chapter is to describe the existing drainage systems and tributary drainage areas. This discussion will provide a framework for the analysis that is required. The natural drainage boundaries controlled by the topography of the Campus will be presented. This description will be followed by a presentation of off-campus systems and on-campus systems. Off-campus systems are major drainage works that are operated and maintained by others. On-campus systems are operated and maintained by the University. A discussion of the probable growth will also be presented for the 2010 time frame.

NATURAL TOPOGRAPHY

The overall runoff pattern through the study area is from the hills toward San Francisco Bay. The flow progresses in a predominately north to northeast direction and is collected in Matadero Creek or San Francisquito Creek. The general topography is presented in Figure 4-1. The drainage boundaries defined by the existing contour lines and surface terrain features are also presented.

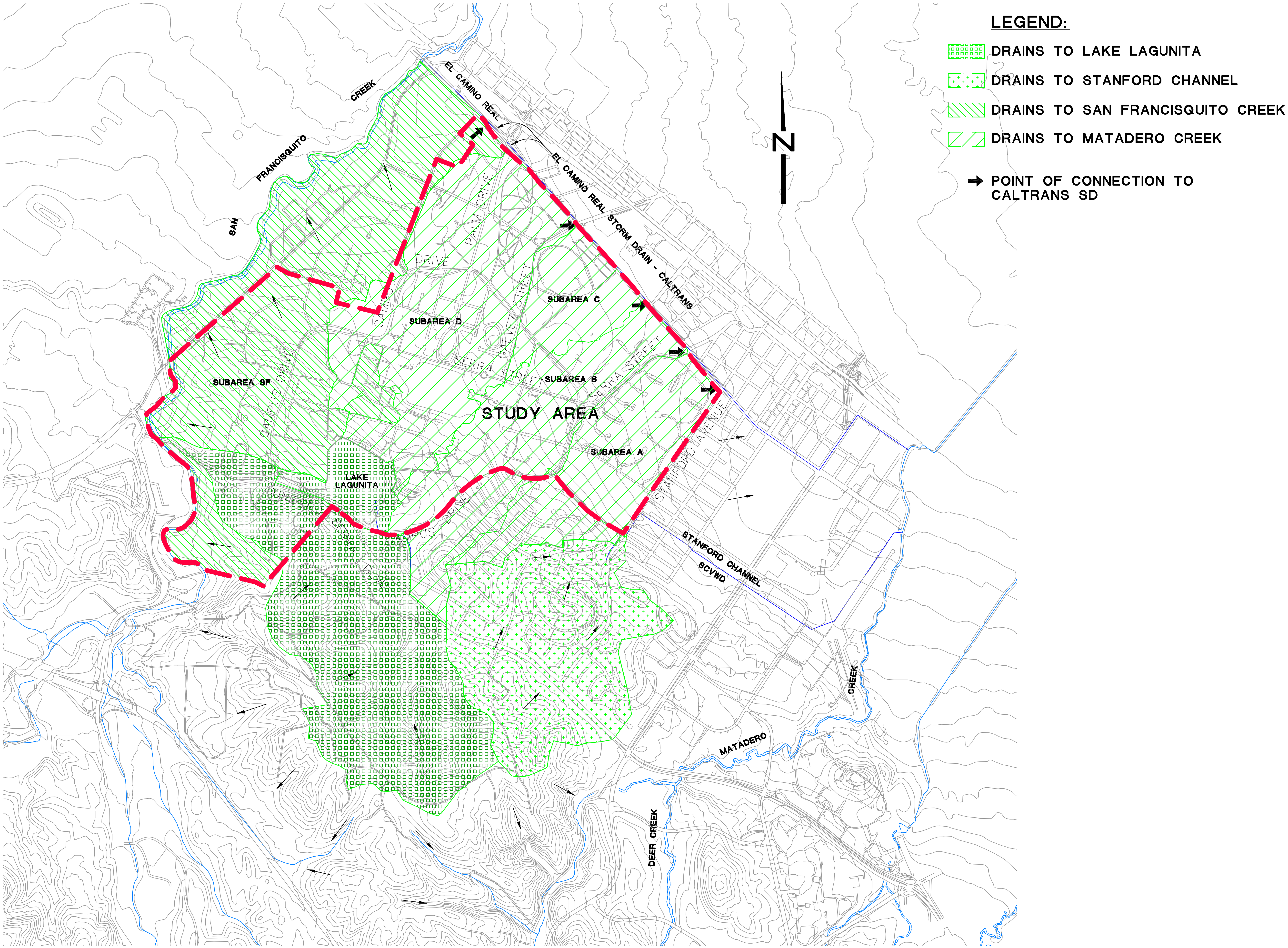
For the purpose of this study a new topographic map was developed. Aerial photographs were taken for mapping purposes during August of 1998 for the eastern side of the Campus and January of 2000 for the western side of the Campus. For purposes of mapping, Palm Drive and its extension to the foothills represents the division between the east and west mapping effort. The new mapping was prepared at a map scale of 1 inch equal to 40 feet, with a 1-foot contour interval.

OFF-SITE DRAINAGE SYSTEMS

The study area is roughly divided into four major drainage systems. The drainage facility locations, along with owners of the facility and drainage areas as they relate to the study area, are presented in Figure 4-1.

The most easterly off-site facility is Stanford Channel owned by Santa Clara Valley Water District (SCVWD). This facility is a 48-inch pipe starting near the intersection of Stanford Avenue and Amherst Street. An existing ditch along Stanford Avenue discharges flow into this facility. The pipe, named Stanford Channel, follows Stanford Avenue to Dartmouth and then travels east along Dartmouth and ultimately north to Matadero Creek. Failure of the Stanford Channel or flows in excess of the design capacity would cause surface runoff to flow along Stanford Avenue and sheet flow north and east away from the study area.

The northerly off-site drainage facility is a Caltrans storm drain. The storm drain was constructed in El Camino Real (State Highway 82) by Caltrans in the mid 1960s. This storm drain continues along El Camino Real, turning north onto Page Mill Road and ultimately connecting to Matadero Creek. This pipe has four major points of connection to the study area. The most upstream point is at the southwest corner of Galvez Street



STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 4-1

OFF-SITE DRAINAGE SYSTEM

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and El Camino Real. The next downstream connection point is at the southwest corner of Sam McDonald Road and El Camino Real. The third connection point is at the southwest corner of Serra Street and El Camino Real. The remaining connection point is at the southwest corner of Stanford Avenue and El Camino Real.

The westerly off-site drainage facility is San Francisquito Creek. The westerly portion of the Campus drains to San Francisquito Creek. A Caltrans storm drain extends westerly in El Camino Real from University Avenue to San Francisquito Creek. Flows entering the under crossing of El Camino Real at University Avenue are pumped to the westerly flowing storm drain in El Camino Real.

A significant drainage feature on the southwestern side of the study area is Lake Lagunita. The hills generally drain toward Lake Lagunita. The location and drainage area is specifically noted in Figure 4-1. A storm drain, the Junipero Serra Foothills Storm Drain, has recently been designed to augment the existing Gerona Ditch to collect flows from the hills south of Lake Lagunita. The arm of the lake, extending to the west, intercepts flows from the hills southwest of the lake. Initial flows from very large storm events that exceed the storage capacity of Lake Lagunita are released by the spillway, and are captured by a storm drain that is routed to San Francisquito Creek. Flows from the spillway that exceed the storm drain capacity flow overland across the Campus northeasterly toward Matadero Creek.

ON-SITE DRAINAGE SYSTEMS

There are two basic systems for carrying water across the Campus. The first system is the existing constructed storm drain inlets, pipes, and ditches. The second system is the overland flow system, which consists of primary and secondary flow paths. The primary flow paths are generally the roadways, as defined by the elevation of the curb and gutter where they exist. The slope of the ground and other physical features, which impact the movement of water in its travels downhill, define the secondary flow paths.

Considering the combined capability of these two systems, the Campus can be further divided into subareas. These subareas are internal basins that drain to the perimeter of the Campus. The collected flows either enter off-campus drainage facilities, or are controlled by the terrain features along the perimeter of the Campus. This subdivision of the Campus into subareas is also necessary to analyze the detention requirements for each specific site where detention basins will be used to decrease the runoff that is created by Campus development.

LAND USE CHANGES

The approved Stanford Community Plan/General Use Permit allows modifications and additions to the Campus. Increases in the number of residential housing units and academic buildings are proposed. These additions can potentially increase the amount and location of impervious area on the Campus, thus increasing the surface runoff.

An estimate of the increase in the impervious area was developed by Parsons for Santa Clara County's Environmental Impact Report for the Stanford Community Plan/General Use Permit and is presented in Table 4-1. This estimate is based on:

- The square footage of building additions and other improvements allowed by the General Use Permit.
- Estimates of the number of floors in the new structures.
- Existing use of the proposed building sites (currently pervious or impervious).
- An increase of 15 percent to the estimated change in impervious area for miscellaneous site modifications.

Additional details of this calculation are presented in Appendix 1.

Table 4-1, Increased Impervious Area for Matadero and San Francisquito Creek Watersheds for Next Ten Years

Land Use	Matadero Creek Areas, sq. ft.				San Francisquito Creek Area, sq. ft	Total, sq. ft
	Subarea A	Subarea B	Subarea C	Subarea D		
Academic and Residential Housing	202,580	34,911			688,960	926,450
Academic Building		12,938	107,813	76,116	106,303	303,169
Parking Inventory		217,178		72,795	169,050	459,023
Total (sq. ft.) (acres)	202,580 4.65	265,026 6.08	107,813 2.48	148,911 3.48	964,313 22.07	1,688,641 38.77

5. HYDROLOGIC / HYDRAULIC ANALYSIS

The purpose of this chapter is to document the hydrologic / hydraulic analysis and provide an understanding of the analysis used in selecting the recommended improvements. This discussion will identify detention requirements to prevent an increase in peak runoff flow and a potential increase in downstream flooding.

STORAGE DETENTION REQUIREMENTS

The Corps of Engineers' HEC-1 Model was used for the hydrology analysis of the Campus. Two scenarios have been studied. The two scenarios are the current condition (Year 2000) and the future condition (Year 2010). As discussed earlier, the source data for the existing condition is the current model for Matadero Creek and the current model for San Francisquito Creek, each prepared by SCVWD. To develop the data for the future condition, the numerical value for the developed (impervious) area was increased from that of the existing data by the amounts presented in Chapter 4 and the corresponding decrease in the undeveloped (pervious) area was also made. The Quarry Road / Arboretum Housing site is located on the watershed boundary and the site grading may need an adjustment of approximately 4 acres from the Matadero Creek Watershed (subarea D) to the San Francisquito Watershed for the 2010 condition. The need for this adjustment will be resolved during the design process. At this time the adjustment has been analyzed as a worst case condition. An analysis of the existing condition and the future condition for the 10-year and 100-year runoff was performed.

The results for Matadero Creek are listed in Table 5-1, and the results for San Francisquito Creek are presented in Table 5-2. The flow in 2010 is increased compared to the current condition.

Table 5-1, HEC-1 Subarea Data and Calculated Flows For Matadero Creek

Subarea		2000			2010		
		Drainage Area,(Acres)	Flow (cfs)		Drainage Area,(Acres)	Flow (cfs)	
			10 yr	100 yr		10 yr	100 yr
D							
	Undeveloped	168			163.5		
	Developed	267			267.1		
	Total	435			430.6		
	Cumulative Total Flow		179	268		177	266

Subarea		2000			2010		
		Drainage Area,(Acres)	Flow (cfs)		Drainage Area,(Acres)	Flow (cfs)	
			10 yr	100 yr		10 yr	100 yr
C							
	Undeveloped	39			36.5		
	Developed	69			71.5		
	Total	108			108		
	Cumulative Total Flow		219	330		219	329
B							
	Undeveloped	38			29.7		
	Developed	259			267.3		
	Total	297			297		
	Cumulative Total Flow		357	532		358	533
A							
	Undeveloped	28			23.4		
	Developed	195			199.6		
	Total	223			223		
	Cumulative Total Flow		460	684		462	686
Required Detention Volume, Acre Feet						0.08	0.08

The model for Matadero Creek was then tested, as presented in Table 5-1, to determine the volume of storage necessary to reduce the peak flow rate for the future condition to the peak flow rate for the existing condition. For this analysis it was assumed that a detention storage site is available at the intersection of Serra Street and El Camino Real. The site is open fields and adjacent to existing channels. To reduce the projected 100-year peak flow for the future developed condition to the current peak flow, 0.08 acre-ft of detention storage is required. To reduce the projected 10-year flow increase to current levels, 0.08 acre-ft of detention storage is needed.

Table 5-2, HEC-1 Subarea Data and Calculated Flows For San Francisquito Creek

Subarea		2000			2010		
		Drainage Area,(Acres)	Flow (cfs)		Drainage Area,(Acres)	Flow (cfs)	
			10 yr	100 yr		10 yr	100 yr
SF							
	Undeveloped	186			163.8		
	Developed	435			461.6		
	Total	621			625.4		
	Total Flow		226	341		229	346
Required Detention Volume, Acre Feet						0.12	0.21

The model for San Francisquito Creek was then tested, as presented in Table 5-2, to determine the volume of storage necessary to reduce the peak flow rate for the future condition to the peak flow rate for the existing condition. For this analysis it was assumed that a detention storage site is available at the downstream end of the watershed. To reduce the projected 100-year peak flow for the future developed condition to the current peak flow, 0.21 acre-ft of detention storage is required. To reduce the projected 10-year flow increase to current levels, 0.12 acre-ft of detention storage is needed.

ALTERNATIVE LOCATIONS

This discussion describes the process used to select detention basin sites and to size the detention storage that is required. Detention sites are chosen based on the ability to modulate flows leaving the individual drainage subbasin, effectiveness of detention at the possible location, feasibility of constructing storage, and existing land usage. Primary sites were open fields and areas adjacent to existing channels.

Location Constraints

The following constraints are considered in the selection of detention storage sites.

- Location adjacent to a main flow path.
- Adjacent to flow path with sufficient capacity/runoff to fill the basin and be adequate to carry away the attenuated runoff without being detrimentally affected by downstream hydraulic conditions.
- Topography that can be developed into a basin site economically.
- Current land use that is capable of being adapted for use as a storage detention basin.
- Capability of being integrated into the overall Campus setting and land uses as a detention basin.
- Capability of being designed for the relatively infrequent and seasonal use as a detention basin.

- Capability of being committed to this use.

These detention basins will only be utilized for a relatively short period during a high intensity rainfall event. The actual flooding will last for less than 36 hours for the 100-year event. Therefore, damage to permanent vegetation like trees or grass is not expected. The time when standing water is present in the detention basins is also less than the breeding cycle of mosquitoes. If the multiple use of a site includes use as an unpaved parking lot, this use could be delayed for several days until the ground dries out after a major storm event.

Suggested Sites

Five detention basin sites are suggested at this time. These sites are presented in Figure 5-1. The detention basin sites were chosen based on the benefit to the individual drainage subbasin, downstream location, and existing land usage. Primary sites were open fields and areas adjacent to existing channels. These sites appear to best meet the presented constraints.

The first suggested site is at the corner of Serra Street and El Camino Real. This site is relatively close to the edge of the Campus and the major flow paths of El Camino Real and Serra Street. This site provides excellent opportunity for reducing the flow as it leaves the Campus.

The second suggested site is at Serra Street and Campus Drive East. This site is nearer to the center of the Campus and provides excellent opportunities to reduce flow that may be associated with changes in Campus development. This site, being internal to the Campus, may allow some modulation of flows and internal protection of downstream areas, specifically, Escondido Village, the vicinity of the corporation yard, and the Credit Union.

The third and fourth suggested sites are the West Campus Drainage sites at Stock Farm Road and Oak Road and at Pasteur Drive and Sand Hill Road. These sites would assist in modulating flows from the areas proposed for residential development and other development internal to the Campus. These sites provide an excellent opportunity to reduce flows near the source, which will provide a local benefit to Campus areas downstream of the protection, as well as a regional benefit of reduced total flow from the Campus. The design must consider both the local and regional benefits when sizing the outlet to assure that flows are not released in a manner that can increase regional flows. A basin that is larger than the recommended size may be constructed to maximize the benefit to the Campus piped drainage system.

The fifth site will be located near the proposed development adjacent to Quarry Road. Several possible locations exist in this area. One location is adjacent to the Hoover Pavilion. Other locations are along Quarry Road either as part of the development or in the adjacent parking lot. Another location is between Sand Hill Road and San Francisquito Creek near El Camino Real. The last of these possibilities is the most efficient site for providing detention before flows leave the Campus. The upstream sites offer opportunities to reduce flows that leave the Campus as well as maximizing the benefit to the local Campus piped drainage system.

Site / Location Interactions

Detention basins achieve their effectiveness by capturing the peak flow of a rainfall event and releasing the captured flow later in time, effectively altering the shape of the runoff hydrograph downstream of the detention basin.

The peak storm flow rate at any location along a stream or flow path is created by combining all of the runoff from the areas upstream of the point of interest. The runoff from the farthest point is adjusted for travel time in channels and pipes, and then combined with the flow from the nearest point to develop the peak flow rate. This time and space interaction must be considered in the design of a detention basin.

The most effective basin is close to the location where the attenuation of the peak flow is desired. The most effective basin is also at a location where all or most of the peak flow rate is present.

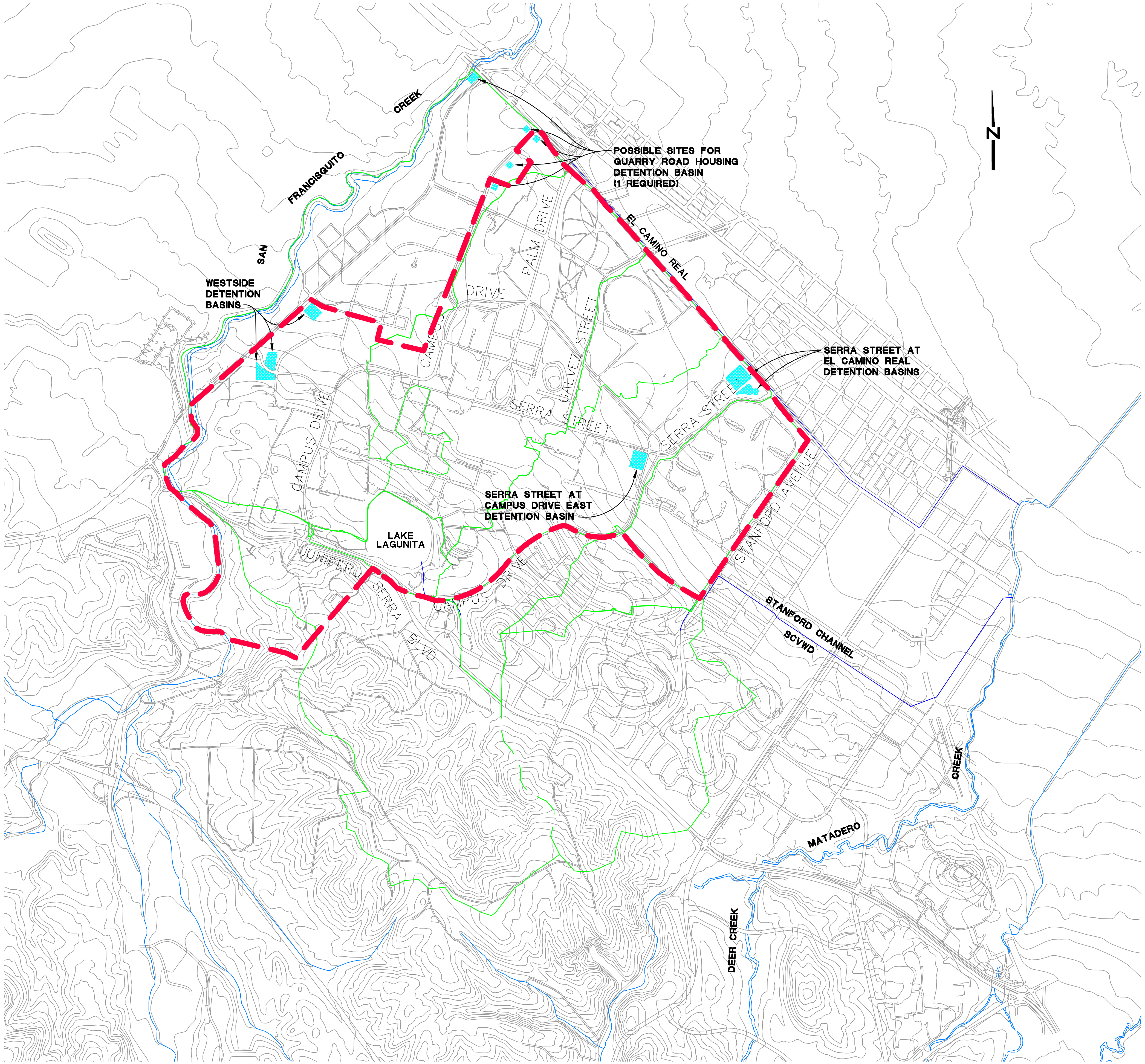
A detention basin that is remote from the location where the attenuation of the peak flow is desired may be used to reduce flow at a downstream point. The remote detention basin requires a modified volume or release rate (possibly modifications to both) to achieve the desired downstream benefit. The modifications will typically result in a significantly larger storage volume than the basin located at the most effective downstream location.

Design Storm Interactions

Similar to the interactions with location, detention basins are also tailored for the specific level of protection desired. The detention basin is designed to allow water to enter the basin when the flow rate exceeds a predetermined level. Flow rates below the target level are allowed to flow past the basin. The specified level of protection (typically 10-year or 100-year event) usually determines the target level.

The inlet and outlet portions of the basin system are therefore designed to perform and interact differently for the different storm events. A two-stage storage and release system can be designed into a single basin allowing the basin to operate at two different design storm flow rates or a system using two different basins can be designed on the same site, or adjacent sites, to accommodate the different desired levels of protection. The specific solution is dependent on site constraints and conditions. This concern can impact site selection and land area requirements and is addressed during the detailed design of the basin system.

SITE SPECIFIC RECOMMENDATIONS



STORM DRAINAGE DETENTION MASTER PLAN

FIGURE 5-1

DETENTION BASIN LOCATIONS

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Each site is unique and the specific ability to provide protection is dependent on the site location, the site geometry, the flow paths that are being intercepted, and the location of the storm drain for emptying the basin.

Serra Street at El Camino Detention Basins

This site is located at the intersection of two converging flow paths. One path is along the Campus side of El Camino Real and the other is north along Serra Street. The area has a local flooding problem immediately upstream of the intersection on Serra Street.

This site lends itself to a two-basin system. The portion of the site closest to the intersection can be tailored for the 10-year event. This portion of the system can assist in controlling and reducing the peak flow rate that is associated with development and also assist in relieving the local flooding condition. The portion of the site that is more westerly of the intersection can be tailored for the 100-year event and be used to assist in preventing excess flow from releasing past the Campus.

Serra Street at Campus Drive East Detention Basin

This basin will be most effective if it is tailored for the 100-year event. It is located at the intersection of two flow paths. These flow paths can be mutually served. The elevations of the pavements and the cross-sections of the roads in this area will generally allow the 10-year event to pass through the area. These existing terrain features become weirs at the higher flow rates, at which time they will create water surface elevations that will move flow into the basin for release into the storm drains as the storm subsides.

West Campus Detention Basins

These basin sites are associated with a new residential development project and other possible future development, and they are only conceptual in plan. The sites are envisioned as either two-stage basins or two-basin systems that will provide reductions in flow near the source for both the 10-year and 100-year events. Basins located close to the project site need to be larger than basins located at the downstream end of the drainage area. The basin locations near the project site, however, may be able to minimize improvements to the existing piped storm drainage system between the project site and the downstream end of the drainage basin.

Quarry Road Detention Basins

These basin sites are associated with new residential and Campus development near Quarry Road. The locations are only conceptual in plan and several sites are indicated. The specific location will depend on the final design of the projects. One or more of the sites may be used to achieve the full protection desired. The sites are envisioned as either two-stage basins or two-basin systems that will provide reductions in flow near the source for both the 10-year and 100-year events. Basins located close to the project site need to be larger than basins located at the downstream end of the drainage area. The basin locations near the project site, however, may be able to minimize improvements to the existing piped storm drainage system between the project site and the downstream end of the drainage basin. Since multiple locations are possible, one site may be tailored for ten-year storm attenuation and another site tailored for the 100-year event.

DETENTION BASIN CAPACITY USE DOCUMENTATION

Once a location is selected and the requirements for the shared use of the facility are determined, the precise capacity of the basin can be established. The specific ability to reduce peak flows at the downstream end of the watershed can also be calculated based on the established capacity. This calculated reduction in peak flow may be equated to the ability to accommodate a specific amount of conversion of pervious area to impervious area associated with new projects. A basin can therefore be used for a specific project or as a reserve for attenuation of peak flows from several, current or future, projects within the same watershed.

The capacity of a detention basin to reduce peak flows will be documented at the time the permit for construction of the detention basin is submitted to the County of Santa Clara for approval. This capacity will be equated to a specific number of square feet of impervious area for which the detention basin will attenuate flow and will be designated as a reserve of impervious area for use by future development. This reserve of impervious area will be reduced as campus development projects are constructed. The permit for each individual development project will identify the detention basin that is providing the flow attenuation, state the change in impervious area caused by the project, and indicate the balance in the reserve of impervious area for the identified basin before and after the project.

APPENDIX 1

Impervious Area Allocation to Drainage Basins

Impervious Area Allocation to Drainage Basins

Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undeveloped (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
ACADEMIC CAMPUS HOUSING										
Lagunita	Mayfield	125	500	62,500	3.5	100	17,857	100	17,857	B
	Knoll	200	500	100,000	3.5	100	28,571	100	28,571	SF
	Searsville	250	500	125,000	3.5	50	17,857	100	17,857	SF
	Driving Range	350	500	175,000	3.5	100	50,000	100	50,000	SF
Quarry	Rectangle/ECR	350	1,000	350,000	3	40	46,667	25	11,667	D
								75	35,000	SF
East Campus	Manzanita	100	500	50,000	4	100	12,500	100	12,500	B
	EV infill	725	500	362,500	4	33	29,906	100	29,906	A
	EV @ ECR	250	500	125,000	4	100	31,250	100	31,250	A
Total Academic Campus Housing		2,350					234,609		234,609	
CAMPUS RESIDENTIAL (maximum)										
West Campus		570	2,000	1,140,000	2.5	100	456,000	100	456,000	SF
Lagunita		-13								
East Campus		75	2,000	150,000	2	100	75,000	100	75,000	A
San Juan		40	2,000	80,000	2	100	40,000	100	40,000	A
Total Campus Residential		632							571,000	

Impervious Area Allocation to Drainage Basins

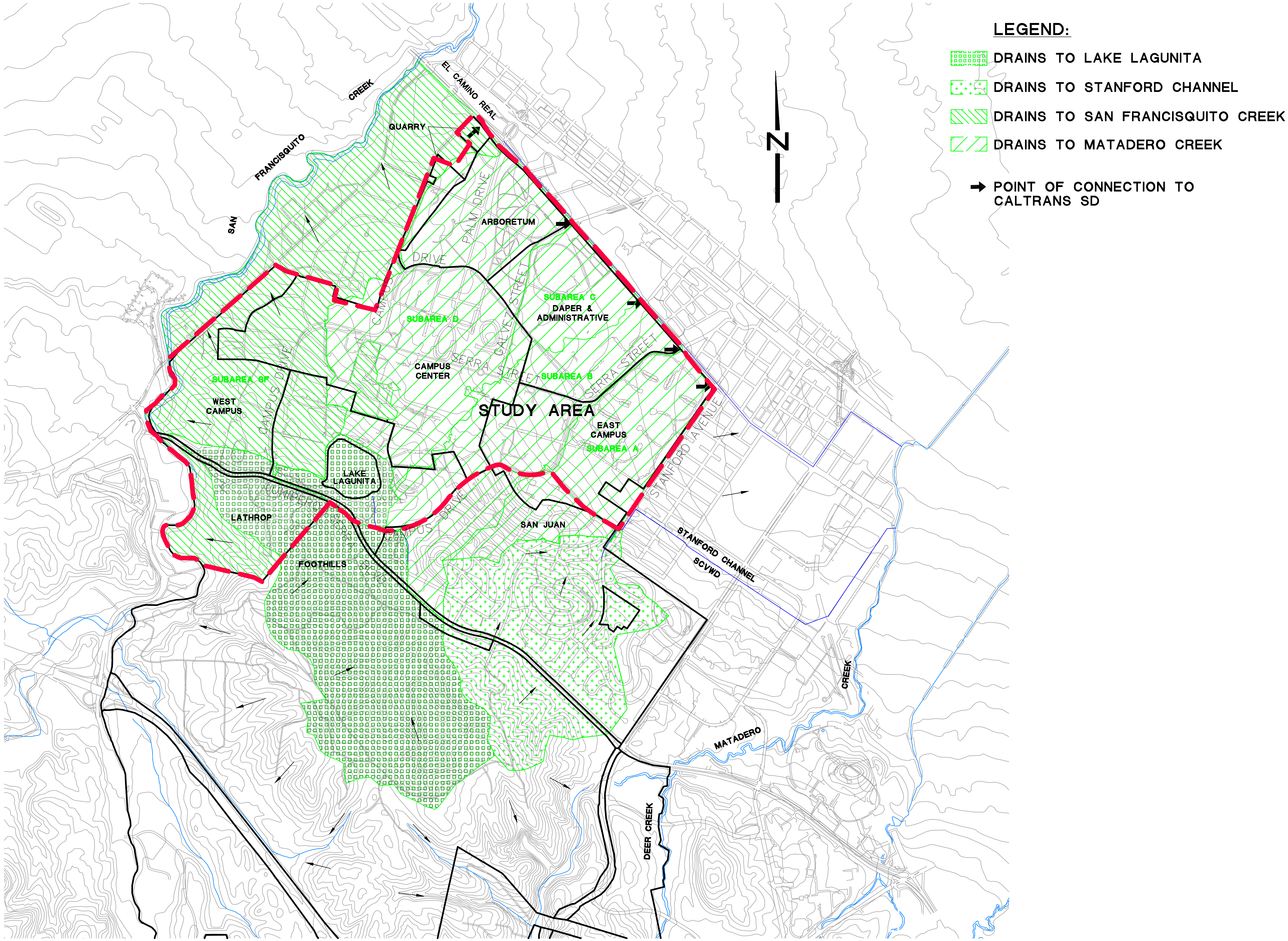
Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undeveloped (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
ACADEMIC/SUPPORT/ATHLETIC/CULTURAL										
Lathrop	Total GSF			20,000						
	Academic			15,000	2	100	7,500	100	7,500	SF
	Athletic & Student Activities			5,000	1	100	5,000	100	5,000	SF
Campus Center	Total GSF			1,590,000						
	Academic & Cultural			1,185,000	4	10	29,625	50	14,813	D
								50	14,813	SF
	Cu;tural			135,000	2	100	90,000	50	45,000	D
								50	45,000	SF
	Academic Support			270,000	3	10	9,000	50	4,500	D
								50	4,500	SF
Quarry	Total GSF			50,000						
	Academic			40,000	3	75	10,000	25	2,500	D
								75	7,500	SF
	Academic Support			10,000	1	75	7,500	25	1,875	D
								75	5,625	SF
DAPER & Administrative	Total GSF			250,000						
	Academic Support			50,000	2	75	18,750	100	18,750	C
	Athletic & Student Activities			200,000	2	75	75,000	100	75,000	C
East Campus	Total GSF			110,000						
	Academic			60,000	3	25	5,000	100	5,000	B
	Academic Support			50,000	2	25	6,250	100	6,250	B
Total Academic				2,020,000			263,625		263,625	

Impervious Area Allocation to Drainage Basins

Development District	Development Projections	No. of Units	Assumed square feet per unit	Est. Add'tl GSF	No. of Floors	Undeveloped (%)	Increase Impervious (sf)	Split	Increase Impervious (sf)	Nolte Drainage Basin
PARKING PERMIT INVENTORY										
Lagunita		695	300	208,500	1	100	208,500	50	104,250	SF
								50	104,250	B
Campus Center										
		633	300	189,900	3	100	63,300	100	63,300	D
		-722	300	-216,600	1				0	SF
Quarry		570	300	171,000	1	25	42,750	25	10,688	D
								75	32,063	SF
Arboretum		-134	350	-46,900						
DAPER & Administrative		1,267	300	380,100	1		0		0	C
East Campus		564	300	169,200	1	50	84,600	100	84,600	B
Total Parking		2,873							399,150	
TOTAL INCREASE IN IMPERVIOUS SURFACE AS A RESULT OF GUP APPROVED GENERAL USE PERMIT									**1,468,384**	

Drainage Basin allocation prepared by Nolte. All other Data provided by Stanford University Planning Department

Summary of Drainage Basin Areas					
Areas Increased 15 percent for miscellaneous site improvements.					
	Acres*1.15	(sf)*1.15	Acres	(sf)	Basin
	4.65	202580	4.04	176,156	A
	6.08	265026	5.29	230,457	B
	2.48	107813	2.15	93,750	C
	4.07	177493	3.54	154,342	D
	21.48	935730	18.68	813,679	SF
Total	38.77	1688641	33.71	1,468,384	



STORM DRAINAGE DETENTION MASTER PLAN

APPENDIX - 1

DEV. DISTRICTS & DRAINAGE SYS.

PREPARED FOR: STANFORD UNIVERSITY

DATE SUBMITTED: 04-06-01

NOLTE

BEYOND ENGINEERING

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CAUTION

The engineer preparing these plans will not be responsible for, or liable for, unauthorized changes to or uses of these plans. All changes to the plans must be in writing and must be approved by the preparer of these plans.

NO.	BY	DATE	REVISIONS

SHEET NUMBER

OF SHEETS

SCALE
VERTICAL: 1"=
HORIZONTAL: 1"= 1000'

JOB NUMBER
SJ0663