SECTION 1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

The planning and design of the East Orange Planned Community Area 2 & 3 and Golf Course, has necessitated the preparation of this comprehensive planning level hydrology and water quality analysis. It addresses pre-development and post-development surface water runoff, flood control and drainage systems and proposed urban runoff water quality management facilities. This study encompasses portions of the Limestone Creek and Santiago Creek watersheds in the Irvine Community Development Company's (ICDC) East Orange Planned Community (EOPC) Area 2 & 3 planned development, located primarily within the Limestone Creek drainage area of unincorporated Orange County. Existing land usage in the proposed development area is generally characterized as undeveloped open space, bounded roughly by Irvine Regional Park and the Irvine Lake, also known as the Santiago Reservoir, to the north and west, Santiago Canyon Road to the south, and Santiago Creek to the east, Figure 1.1, Project Location Map. The watershed tributary to the Irvine Lake is generally bounded by Loma Ridge and the Santa Ana Mountains within Cleveland National Forest in the County of Orange and small portions of western Riverside County.

Area 2 is currently designated for low, low-medium and medium density residential, mixed use, golf course, parks and recreation and open space. Approximately 1,200 dwelling units are proposed for Area 2. Within the open space, development would include a marina, a lodge, and a golf course, located to the north and west of Area 2. In addition, the following structures are anticipated: a fire station site and a sewer lift station in the~~are also anticipated for an~~ area south of the proposed intersection of Santiago Canyon Road and~~at~~ the proposed entrance to Area 2;~~,~~ a commercial/recreation site (existing marina) north of Santiago Canyon Road at the most westerly portion of the project site;~~,~~ a commercial recreation site which includes a water pump station located at the intersection of Santiago Canyon Road and future Jeffrey Road;~~,~~ and a future water reservoir tank located near the most southerly portion of the site and future Jeffrey Road.

Area 3 is located south of Santiago Canyon Road and at the eastern edge of the study site. Approximately 50 dwelling units are proposed in this area.

The study is intended to document existing ~~current~~ (pre-development) watershed conditions and address development runoff through appropriate infrastructure to accommodate issues of urban drainage, flood protection and stormwater quality. The proposed drainage infrastructure is based on the most current information for the proposed project, including zoning land use, master plan and preliminary engineering studies of the development area.

1.2 GENERAL OVERVIEW – HYDROLOGY & WATER QUALITY

The objective of the planning level study is to establish a framework for implementation of the project drainage facilities which: satisfies current standards for flood protection and urban runoff water quality, and minimizes impacts from developed area surface runoff water quality. In addition, this study will: evaluate storm water runoff peak flow rates and associated drainage improvements with development plans and mitigation requirements, evaluate stability of natural streambeds preserved as part of the development, evaluate the effect of development hydrology to downstream drainage features, and identify impacts and appropriate water quality BMPs (Best Management Practice) and mitigation measures for the proposed development.

As a routine structural treatment BMP, employment of the project's proposed extended detention basin systems or, for commercial sectors, bioswales, would satisfy requirements as outlined in the County's Drainage Area Management Plan (DAMP) for:

a) an appropriately sized treatment BMP, and
b) routine structural source control BMPs, which include: storm drain stenciling and signage, efficient irrigation and landscape design, and protection of slopes and channels.

The study is intended to identify potential changes to the watershed from the proposed development and identify appropriate mitigation measures for the post-development hydrology. The primary focus of the report is to develop a drainage infrastructure plan that will provide the necessary level of flood protection while ensuring the existing watershed hydrology is maintained to the extent possible. The study, in conjunction with the GeoSyntec water quality assessment, will also develop the conceptual plan for a runoff water quality control program that will adequately address the applicable National Pollutant DischargePollution Runoff Elimination System (NPDES) permit (referred to as the MS4 Permit or the Public Storm Drain Permit), Model Water Quality Management Plan requirements (WQMP), and DAMP requirements (including the Local Implementation Plan prepared by the City of Orange, pursuant to its DAMP obligations).

SECTION 2 – EXISTING WATERSHED AND FLOOD PROTECTION ASSESSMENT

2.1 BACKGROUND

The proposed planned community development of East Orange Planned Community Area (EOPC) 2 & 3, and the commercial/recreational and institutional zoning sectors (golf course/marina and miscellaneous areas) are situated within encompass a portion of the 40,788[1] acre (64 sq. mi.) watershed tributary to the Irvine Lake, composed of largely undeveloped, unincorporated land in Orange County within an unincorporated portion of the County. Commercial ranching, and cattle grazing, and sand and gravel operations formerly occurred in this area.

2.2 FLOODPLAIN MAPPING

According to Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), for Orange County and Incorporated Areas, Panels 23 and 31 of 81 dated September 15, 1989, the project site is located adjacent to a Flood Hazard Zone. The Santiago Reservoir (Irvine Lake), Limestone Creek and Santiago Creek are designated as Zone "A". Areas within the proposed development site are designated Zone "X" with the exception of the proposed golf course, where portions are within Zone "A". However, this cannot be interpreted that there are no flood hazards or 100-year floodplains within the proposed development areas, only that the minor tributaries have not been mapped by FEMA at that time. Figure 2.1, Flood Zone Map, shows the FEMA mapping and zone designations. FIRM (Flood Insurance Rate Map) panels 23 and 31 have been included as Exhibits A & B, Section 18 – Exhibits.

Flood Zone "A" has been identified in the community flood insurance study as Special Flood Hazard Areas, subject to inundation by the 100-year flood event. Flood insurance within Zone "A" is mandatory. A project design feature of EOPC Area 2 & 3 includes the placing of habitable structures outside of Zone "A".

Flood Zone "X" has been identified in the community flood insurance study as Other Areas, and determined to be outside the 500-year flood plain. This is not a special flood hazard area and not subject to inundation by the 100-year flood. Flood insurance within Zone "X" is not mandatory.

Although base flood elevations and flood hazard factors have not been determined by FEMA for the project areas, the HEC-RAS analysis in this report for Limestone and Santiago Creeks shows that the 100-year event will be contained within the creeks. (These are shown in the Technical Appendix and Exhibit D, respectively). A FEMA Letter of Map Revision will be completed by the project proponent or the golf course developer at the time of final engineering.

2.3 WATERSHED DESCRIPTION

The existing watershed tributary to EOPC Area 2 & 3 is largely undeveloped range land comprised of moderately steep upper canyons with reduced gradients towards the lower elevations. Natural vegetative growth is limited primarily to annual and scrub grasses with generally fair cover. The primary hydrologic soil

[1] Based on Orange County Hydrology Report No. E08-2A.

group classification per the Orange County Hydrology Manual is type "D" with large areas of type "C" and relatively minor areas of type "B" and "A". A more comprehensive description of the soil group classification can be found in the Orange County Hydrology Manual, including specified runoff coefficients used in the analyses contained this study. In general, Soils group "A", most pervious, has a low potential for runoff while Soils group "D", least pervious, has the highest runoff potential. A soils map showing the soil classification can be found in Section 18 - Exhibits, Exhibit C, Soil Groups Map.

The overall watershed area tributary to the Irvine Lake is approximately 40,788[2] acres (64 sq. mi.), generally bounded by Loma Ridge to the south, Santiago Peak to the east, and the Santa Ana Mountains to the north.

The watershed tributary to the site can be divided into three primary subwatersheds, Figure 2.2, Primary Watersheds. For purposes of clarity for this report, they shall be called the Santiago Creek Tributary Area, the Limestone Creek Tributary Area, and the Irvine Lake Tributary Area, as shown on Figure 2.2.

The Santiago Creek Tributary Area, approximately 33,940[2] acres in size, encompasses the most northerly portion of the project site including the golf course. The Limestone Creek Tributary Area, approximately 3,528[2] acres in size, encompasses all of Area 3, the majority of Area 2, a proposed commercial recreation site adjacent to proposed Jeffrey Road extension, and a future water reservoir site. The Irvine Lake Tributary Area, approximately 3,320[2] acres in size, encompasses the most westerly portion of the project site including a portion of Area 2, an abandoned sand and gravel operation (mining ceased in 2003), the existing marina site, a proposed commercial recreation site, a proposed sewer lift pump station, a proposed fire station, and Woody's Cove as discussed in the Santiago Hills II Planned Community and East Orange Planned Community, Area 1, Runoff Management Plan, by RBF Consulting.[3]

Although there are no clearly defined points at which Santiago and Limestone Creeks end, and Irvine Lake (Santiago Reservoir) beginsends, and Santiago and Limestone Creeks begin, all flows ultimately enter into the lake.

Figure 2.3, Tributary Area Exhibit, shows a graphic/tabular representation of the watershed areas in comparison to the areas proposed for development.

[2] Based on Orange County Hydrology Report E08-2A.
[3] Santiago Hills Phase II Planned Community and East Orange Planned Community, Area 1, Runoff Management Plan, by RBF Consulting (2005August 2004).

SECTION 3 – REGULATORY REQUIREMENTS AND DESIGN CRITERIA

3.1 FLOOD PROTECTION REQUIREMENTS

The City of Orange is the lead agency for this project. All flood protection (storm drain) facilities shall be designed in accordance with the County of Orange standards,Standards and City of Orange policiesPolicy and requirements where they are more stringentstrict than the County of Orange. Final facility design and locations will be reviewed as part of the final engineering plans and grading plans. Minimum City of Orange criteria require all on-site storm drain facilities to be designed to convey flows expected from a 10-year High Confidence (HC) design storm with additional design factors of safety and freeboard to provide a 100-year HC level of flood protection to all inhabited structures. The major backbone system will be constructed for a 100-year HC level of flood protection as a project design feature. Storm drains with tributary areas less than 640 acres are to be designed for a minimum of 10-year HC frequency, with water surfaces below top of curb, using a combination of street and storm drain flow. In sump conditions, catch basins and the connecting storm drains should be designated to a 25-year HC frequency. Systems which drain sumps with no secondary outlets should be designed for a minimum of 100-year HC storm events. During storms of intensity greater than the 10-year HC design, additional flood protection is provided by utilizing the local drain systems' capacity and conveying excess runoff above the storm drain capacity within the streets or drainage channels, as recommended per the County of Orange Local Drainage Manual Chapter 1 Design Criteria[4]. Also as a project design feature, flows in Limestone Creek along the project site will be safely conveyed across Santiago Canyon Road in order to provide a 100-year HC level of flood protection for this existing street.

3.2 HYDRAULIC DESIGN

To provide a 100-year HC level of flood protection and reduce potential public safety hazards, an underground drainage system will be provided to intercept and convey the storm water flow generated by the site. These flows shall be determined by methods described further in this report. The conceptual drainage system illustrated in this study, Figure 3.1, Conceptual Drainage System, indicates preliminary pipe size requirements and proposed facility alignments. A more detailed analysis will be performed during the final engineering design to confirm the drainage system requirements at the tentative map level.

[4] Per County of Orange Local Drainage Manual Figure 1.1.

Storm Drains: The following is an outline of the design for the development of the storm drain criteria and the local flood protection requirements:

- Drainage facilities shall be designed in accordance with the City of Orange Policy and requirements, and secondarily, the County of Orange Flood Control District Design Manual, and County of Orange Local Drainage Manual, and secondarily, the City of Orange policies and requirements where they are more stringent than the County of Orange.

- Runoff generated from the project shall be directed to and intercepted by an underground storm drain facility.

- Street interception inlets will be designed for a 10-year HC capacity and those inlets in a sump condition with a secondary outlet will be designed for a 25-year HC capacity.

- Sump locations with no secondary outlets will be designed for a 100-year HC capacity.

- Local area drains and the landscaping or common area drainage systems will connect to the storm drain at street inlet locations or manholes, to provide locations of adequate maintenance.

- Local surface inlets for the common area or the landscaped area will be sized with the appropriate clogging factors, minimum of 50% to account for debris.

- Dedicated emergency overflow paths will be provided along the drainage system at sump locations based upon an "extreme analysis" (i.e., 100-year HC). The dedicated flow path is the path that overland flow can escape without causing flood damage to any of the facilities. The emergency overflow paths may consist of pedestrian walk paths which can confine and direct the flow without causing erosion.

- Dedicated right-of-way must be provided for the public storm drain facilities which traverse the site. The horizontal alignment and right-of-way width must follow the minimum requirements outlined by the City of Orange. No structural encroachments are allowed in these easements.

- The finished floor elevations of the commercial and habitable structures will be elevated one foot above the 100-year HC water surface in the street or one-foot above the top of curb, whichever is greater.

- The drainage system will be designed to provide a 100-year HC level of protection to all habitable structures through a combined hydraulic conveyance of the underground storm drain section and the street section.

- Provisions for maintenance will be incorporated in the proposed drainage system which includes providing manholes at the appropriate spacing and locations.

- Maximum velocities in standard wall reinforced concrete (RCP) storm drain pipe is limited to 20 feet per second (fps). Velocities between 20 fps and 45 fps will require special wall RCP. Above 45 fps, velocities will be reduced using: less steep pipe slopes, larger diameter pipes/culverts, velocity rings.

- Street inlets will be provided at a minimum for those locations where the street hydraulic capacity will be exceeded or locations where the product of velocity and flow depth[5] exceeds 6 ft^2/sec, or locations to reduce pedestrian hazards. Hydraulic capacity here is defined as the maximum volume of water that a drainage system can convey, in this case, the street.

- Project design features will be implemented such that velocities of the post-development runoff into Limestone Creek will be maintained at or below the pre-development levels to prevent any downstream erosion due to the project.

3.3 EXTENDED DETENTION BASINS

The specific runoff mitigation techniques employed in this planning level hydrology analysis are based on the most current Best Management Practices (BMPs) contained in the WQMP, the DAMP, and the EIR. A number of extended detention basins are proposed at certain locations in the development area. The purpose of these basins is to accept low storm flows and dry-weather flows that detain the runoff volume from the water quality design storm (the 85th percentile 24-hour event) for 36 hours to allow particles and associated pollutants to settle out. A more detailed discussion regarding these extended detention basins can be found in Section 10.4 – Ultimate Development Requirements.

SECTION 4 – DESCRIPTION OF EXISTING DRAINAGE FACILITIES

The major existing natural drainage courses within the site are characterized by the relatively steep incised channels with generally rectilinear geometries in the upper canyons and moderately steep incised sections exhibiting some meander at the lower elevations. Existing drainage improvements within the development

[5] Per Orange County Local Drainage Manual, page 1-3.

area are limited primarily to those that were constructed as a part of Santiago Canyon Road.

4.1 EXISTING CULVERTS AND STORM DRAIN FACILITIES

Santiago Canyon Road borders most of the southerly portion of the development site - Area 2, the golf course, the ceased sand and gravel operation, the existing marina, and the proposed commercial recreation site. Santiago Canyon Road is north of Area 3, the proposed commercial recreation site at future Jeffrey Road, the proposed fire station, sewer lift, water pump stations, the future water reservoir, and roughly parallels Limestone Creek. As a result of the construction of Santiago Canyon Road, there are a number of existing drainage improvements and culverts along the roadway that allow flows to runoff into the Irvine Lake (Santiago Reservoir) via Limestone Creek, Figure 4.1, Existing Drainage Structures (sizes and locations are approximate). The level of protection these existing facilities currently provide is unknown. These existing facilities are proposed to remain in place with the possibility of new storm drain facilities to be constructed parallel to them to maintain flood protection levels as outlined in the report. These existing facilities include corrugated steel metal (CMP) which vary in size from 18” to 48”, a 2’H x 3’W CMP arch, a 72” reinforced concrete pipe (RCP), and a double 12’W x 10’H reinforced concrete box (RCB) culvert. Aside from these facilities in Santiago Canyon Road, there are no other known storm drain facilities existing in the project area.

The future ownership of Santiago Canyon Road to the east of the centerline of SR 241 has not yet been determined. The City does not intend to take over from the County ownership of Santiago Canyon Road east of SR 241 as part of its annexation request, though the ultimate boundaries of the City will be determined by the Local Area Formation Commission (LAFCO) during the annexation process. If the County continues to own the road segment after annexation, it will continue to be responsible for the ownership and maintenance of all existing storm drains, culverts, and related appurtenances, and will take ownership and maintenance responsibility for any future improvements therein or new facilities constructed in parallel. Should the eastern segment of Santiago Canyon Road ultimately be included in the annexation agreement, then the City will own and maintain all new or existing storm drain infrastructure in Santiago Canyon Road.

4.2 EXISTING CHANNEL FACILITIES

Santiago Creek (Facility E08)

Santiago Creek is the largest tributary of the Santa Ana River downstream of the Prado Dam. The headwater of the creek is in the vicinity of Santiago Peak of the Santa Ana Mountains in the northeastern part of Orange County. Santiago Creek within EOPC is an This reach contains intermittent stream, meaning that it exhibits flows due to groundwater seepage for periods beyond the rainy season. This reachand contains little to no vegetation at the flowline to moderate vegetation along the banks. The stream flows in the northwest direction for a distance of about 15 miles, then turns southwest for about another 7 miles before joining the Santa Ana River in the City of Santa Ana. The total drainage area of Santiago Creek is about 102 square miles. This report focuses on approximately 64 square miles of the total drainage area. The runoff from a portion of the drainage area is partially controlled by the existing Santiago Dam (a water supply reservoir built by The Irvine Company in 1933, spillway releases are uncontrolled) and Villa Park Dam (a flood control structure constructed by Orange County in 1963).[6]

Santiago Creek flows approximately in a southwesterly direction where it borders the northerly portion of the project site. Santiago Creek flows into the Irvine Lake at the westerly portion of the project site. Below the Irvine Lake spillway it continues downstream, through the Villa Park Dam, and eventually confluences with the Santa Ana River.

Limestone Creek (E14)

Limestone Creek is a tributary of the Santiago Creek and is located in the southwesterly portion of the Santiago Creek drainage area. This stream is a natural channel within EOPC with intermittent flows and is ephemeral in dry years (zero baseflow), and intermittent in wetter years (zero to negligible flow). Because baseflows are negligible, they would have no appreciable effect on hydrologic calculations, therefore for purposes of the hydrograph calculations in the report, baseflows are considered zero. This reach contains varies from little to no vegetation at the flowline, to moderate vegetation along the banks. The stream flows in the northwest direction approximately 3.5 miles before debouching into Irvine Lake. The total drainage area of Limestone Creek is about 3,500 acres. Limestone Creek roughly parallels Santiago Canyon Road and borders most of the southerly portion of the project area. A majority of runoff from the project area will flow into Limestone Creek.

4.3 EXISTING RESERVOIRS AND FLOOD CONTROL FACILITIES

Irvine Lake (Santiago Reservoir)/Santiago Dam

[6] U.S. Army Corps of Engineers, Los Angeles District, 1988. Santa Ana River, Design Memorandum No. 1, Phase II GDM (General Design Memorandum) on the Santa Ana River Mainstem including Santiago Creek, Volume 6, Santiago Creek (August 1988).

The runoff from the overall drainage area is partially controlled by the existing Santiago Dam and Villa Park Dam. Santiago Dam is currently maintained and operated jointly by the Serrano Water District and the Irvine Ranch Water District, primarily for the storage of imported water.

Irvine Lake encompasses the most westerly portions of the site and is the confluence point for Santiago and Limestone Creeks. Flows from the development and zoned areas ultimately enter the lake.

The Santiago Dam, located at the lake's westerly side, controls outflows from the Irvine Lake. The dam has a spillway elevation of 791.6[7] (795.6 with flash boards) and a top of dam elevation of 811.6[7].

Table 4.1, Irvine Lake Water Elevations, shows lake levels at the 100-year and 500-year Expected Value (EV)expected value runoffs.

Table 4.1 – Irvine Lake Water Elevations

STORM EVENT (YEAR)	EXPECTED VALUEDESIGN RUNOFF (CFS)[8]	WATER SURFACE ELEVATION[7]ELEVATION[1]
100	19,900	799.54
500	31,700	803.23

Figures 4.2A & 4.2B, Recommended Design Runoffs, show the overall expected design year runoffs and locations along Santiago Creek.

SECTION 5 – WATERSHED HYDROLOGY

5.1 SURFACE HYDROLOGY

5.1.1 Precipitation

Precipitation data for the various hypothetical storm frequencies utilized in the watershed hydrologic analysis for this study were based on methodologies in the Orange County Hydrology Manual and data contained in the Orange County

[7] Based on vertical datum NAVD 88, per RBF survey May 14, 2000.
[8] Based on Orange County Hydrology Reports No.., E08-2 and E08-2A.

Environmental Management Agency's Hydrology Report No. E08-2A, Hydrology Report, Santiago Creek, Facility No. E08, from Villa Park Dam to Santiago Peak.

5.1.2 Watershed Characteristics

Figure 5.1, Ultimate Land Use, shows the proposed land use plan for the EOPC Area 2 & 3. Generally, the proposed development plan consists mostly of dedicated open space and residential densities ranging from 3-7 dwelling units per acre (du/ac), single family residential to attached single-family residential, proposed commercial recreation sites along the north side of Santiago Canyon Road and at the intersection of Santiago Canyon Road and future Jeffrey Road extension, an existing marina, and proposed fire station, water pump station, sewer lift station and water reservoir sites. Figure 5.1.1, East Orange Area 2, 3, Golf Course Ultimate Land Use, indicates proposed land uses, densities and recommended imperviousness associated with each category.

5.1.3 Floodplain Characteristics

There are two natural tributaries within the EOPC Area 2 & 3 development, described in Section 4.2. The first is Santiago Creek which borders the northerly side of the site. Flows to Santiago Creek will be largely unaltered by the project, with the exception of a small portion (24 acres) of EOPC2 at the western-most terminus of Santiago Creek, from which storm flows will be rerouted from the Limestone Creek tributary directly to Irvine Lake. For this reason, Santiago Creek was analyzed with respect to velocity, scour and erosion, and not for impacts due to changes in peak flows. This is discussed further in Section 5.4 of this report. The second is Limestone Creek and borders the southerly side of the site. The areas within the site are characterized by relatively steep profile with little vegetation in the canyons and proposed residential areas. The stream beds within Santiago Creek and Limestone Creek are characterized by relatively flat to moderate profiles with moderate to heavy vegetation. As the creeks enter the Irvine Lake, the stream is generally wide and follows a mild gradient with little or no incisement.

5.2 WATERSHED MODEL DEVELOPMENT

Hydrologic calculations to evaluate surface runoff associated with the 100-, 25-, and 10-, 5- and 2-year HC hypothetical design storm frequency from the project watershed were performed using the rational method, the unit hydrograph method, and HEC-RAS. The rational method is a surface hydrology procedure which allows evaluation of the peak flow generated from a watershed area. This method only evaluates peak flow and does not analyze runoff volumes or the time variation of runoff. Unit hydrograph method was utilized to evaluate runoff volume and provide a time distribution of watershed runoff. HEC-RAS is intended for calculating water surface profiles for steady gradually varied flow in natural or man-made channels. Unit hydrograph method was utilized to evaluate runoff volume and provide a time distribution of watershed runoff.

The watershed subboundaries within the project site were delineated utilizing topographic mapping of the area for the proposed conceptual grading plan to determine the development drainage patterns. Hydrologic parameters used in this analysis such as rainfall and soil classification areas presented in the Orange County Hydrology Manual were identified. A hydrology analysis was performed to evaluate the anticipated runoff generated from the proposed development. The hydrology analysis of the proposed development included determining a conceptual storm drain collection system which corresponds to the development drainage patterns. The drainage areas and subarea boundaries within the study area were delineated based on a conceptual grading plan.

In addition to the watershed subboundaries delineated on the hydrology maps, the existing marina, characterized as commercial recreation, and a proposed fire station and sewer lift station, located south of the proposed Area 2, have been included as shown on Figure 1.1. These miscellaneous sites are tentative. Their final configurations have not yet been determined and the areas they encompass are approximate. Drainage structures for these sites will be determined when final engineering is performed. Estimated 100-, 25-, and 10-year HC flows have been calculated for these areas and can be found in Section 17 – Technical Appendix. Structural runoff water quality BMPs, an extended detention basin or other water quality features, shall be incorporated in the drainage of these areas, and will be outlined in Section 10 – Design Considerations.

5.2.1 Watershed Parameters/Characterization

The watershed parameters used in the hydrologic calculations include soil type, infiltration rates, and rainfall intensity-duration curves. The following paragraphs discuss each of the watershed parameters.

The Rational Method hydrology includes the effects of infiltration caused by soil surface characteristics. Soils maps from the Orange County Hydrology Manual and Hydrology Report No. E08-2A indicate the Soil Types “A”, “B”, “C”, and “D” are representative of the project location. The prominent soil type in the EOPC 2 & 3Lake Village watershed is “D”. Hydrologic soil ratings are based on a scale of “A” through “D”, where “D” is the least pervious, providing greatest storm runoff.

The infiltration rate is also affected by the type of vegetation or ground cover and percent of impervious surfaces. The runoff coefficients used were based on the proposed land use.

Standard rainfall intensity-duration curve data were taken from the Orange County Hydrology Manual dated October 1986.

5.2.2 Design Rainfall

The hydrologic analysis was performed to analyze the 100-, 25-, ~~and~~ 10-, 5- and 2-year HC storms for the design of flood control facilities, and 100-, 25-, 10-, 5-, and 2-year EV storms for analyzing development mitigation impacts.

5.2.3 Rational Method

The hydrologic calculations to determine the 100-, 25-, ~~and~~ 10- ,5- and 2-year HC design flows were performed using the County of Orange Rational Method from the Orange County Hydrology Manual dated October 1986. The rational method is an empirical computation procedure for developing a peak runoff rate (flow) for watersheds and storms of a given recurrence interval. This procedure is the most common method for small area urban flow drainage design since the peak flow is generally the only parameter for hydraulic design of drainage facilities. The rational method equation is based on the assumption that the peak flow rate is directly proportional to the drainage area, rainfall intensity, and a loss coefficient related to land use and soil type. The peak flow from a drainage area using the rational method occurs at a critical time when the entire drainage area is contributing runoff known as the “time of concentration” for the watershed area. The design flows were computed by generating a hydrologic “link-node” model which divides the analysis area into drainage subareas (none greater than 640 acres, the maximum size of a subarea allowed by the rational method), each tributary to a concentration point or hydrologic “node” point determined by existing terrain.

The rational method hydrology analysis of the 2-, 5-, 10-, 25- ~~was performed for the proposed development~~ and 100-year HC events for the proposed development areas can be found in Section 17 - Technical Appendix. ~~Analysis of the 10-, 25- and 100-year events for the project areas have been included.~~ Table 5.1, East Orange Post-Development 10-, 25- and 100-year High Confidence Storm Flows, shows the results of the 10~~0~~-, 25-, and 100-year HC rational method hydrology analysis of these areas. ~~(Additional storm year analyses will be performed, if required, at the time storm drain improvement plans are prepared.)~~

5.2.4. Unit Hydrograph (UH)

For large drainage areas, the absence of depth-area adjustments in the Rational Method can result in significant differences in the estimate of the average depth of catchment point rainfalls. While the rational method provides only peak flows, the UH method provides a time distribution of watershed runoff. The UH method is a statistically based model which assumes that watershed flow is related to the total volume of runoff, and that the time factors which affect the unit hydrograph shape are invariant, and that watershed flow storm rainfall relationships are characterized by watershed area, slope and shape factors. The UH method is used to estimate the time distribution of watershed runoff in drainage basins where stream gage information is unavailable. For the study area, the 100-,- and 25-, 10-, 5- and 2-year EVdesign flow was computed by generating a hydrograph for the watershed tributary to the concentration points, and compared to the results of the 100-year unit hydrograph from the County of Orange Hydrology Report below. The following assumptions/guidelines were applied for use of the Unit Hydrograph Method:

1. The information in this report was based on the data from Orange County Hydrology Report No. E08-2A, Hydrology Report, Santiago Creek, Facility No. E08, from Villa Park Dam to Santiago Peak.

2. Baseflow is usually a minor factor in developing flood hydrographs for relatively rare flood events in Orange County. Generally, 10 cfs per watershed square mile is adequate for unlined channels that intercept mountainous regions where many geological strata are crossed by the stream bed.[9] Limestone Creek is a natural channel within EOPC and is ephemeral in dry years (zero baseflow), and intermittent in wetter years (zero to negligible). Because baseflows are negligible, they would have no appreciable effect on hydrologic calculations. For purposes of this report, baseflow was assumed to be zero.

3. Standard Intensity-Duration Curve was taken from the Orange County Hydrology Manual (October 1986).

4. The UH Method includes the effects of infiltration caused by soil surface characteristics. The soils map from the Orange County Hydrology Manual indicates that the study area consists of soil types “A”, “B”, “C” and “D”. The dominant soil type at the project is soil “D”. Hydrologic soil ratings are based on a scale of A through D, where D is the least pervious, providing the greatest storm runoff.

5. The infiltration rate of a given soil type is also affected by the type of vegetation or ground cover and percentage of impervious surfaces. Loss rates were determined from the SCS curve number corresponding to the land use category.

6. The Orange County FoothillValley (developed) S-curve was selected to represent a percentage of watershed runoff response to unit rainfall only in the developed condition (watershed of project areas below 2000 feet in elevation are considered non-mountainous despite steep topography).

Additional storm year analyses will be performed, if required, at the time storm drain improvement plans are prepared.

[9] Per Orange County Hydrology Manual.

5.2.5. HEC-RAS (Hydrologic Engineering Center – River Analysis System)

The hydrologic calculations to determine the 100- and 25-year EV and HC water surface elevations and velocities in Santiago Creek and Limestone Creek were performed using the United States Army Corp of Engineers HEC-RAS (Hydrologic Engineering Center – River Analysis System (HEC-RAS) as incorporated in Haestad Methods Civil Engineering Software for channel analysis and water surface profiles. The program is intended for calculating water surface profiles for steady gradually varied flow in natural or man-made channels. The effects of various obstructions such as bridges, culverts, weirs and structures in the floodplain may be considered in the computations. The computational procedure is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's Equation. The computational procedure is generally known as the standard step method. The program is also designed for application in floodplain management and flood insurance studies to evaluate floodway encroachments. Also, capabilities are available for assessing the effects of channel improvements and levees on water surface profiles.

Water surface elevation calculations for Santiago Creek and Limestone Creek for the 100- and 25-year EV and HC storm events using HEC-RAS can be found in Section 17 – Technical Appendix.

5.2.6. Concentration points used for comparison

Concentration points were used for comparison of the computed flows between the existing baseline condition (from Orange County Hydrology Report No. E08-2A) and the proposed developed condition. Figure 5.2 - Concentration Point Santiago Dam, Figure 5.3 - Concentration Points Existing Condition Limestone Creek, and Figure 5.34 - Concentration Points Developed Condition Limestone Creek, show these points. 100-year flows were used for this comparison. Subareas downstream of Node 301 in Limestone Creek are adjusted to reflect various intermediate concentration points.

5.3 EXISTING BASELINE WATERSHED ANALYSIS

The pre-development hydrology was established for the project watershed which will serve as the "benchmark" for comparison and evaluate potential hydrologic impacts from the development. The baseline hydrology will allow quantifying the "pre-development" watershed runoff values. These numbers are based on the data obtained from Orange County Hydrology Report No. E08-2A, Hydrology Report, Santiago Creek, Facility No. E08, from Villa Park Dam to Santiago Peak. The data obtained from this report were modeled and duplicated using current hydrologic software as incorporated in the AES (Advanced Engineering Software) Rational Method Hydrology and Flood Routing Analysis.

-The E08-2A report is the existing regionalresults of the Existing Condition Unit Hydrograph hydrology report for the project area, and the report evaluates and defines the flood control facilities, and the capacities and operational characteristics of the facilities required to implement flood control requirements for the area. When Report No. E08-2A was publishedare shown in 1995, it was intended as a forecast of discharges for the overall Santiago Creek watershed from the Cleveland National Forest boundary to the Villa Park Dam. Therefore, the land use data used as inputs for the hydrologic models in Report No. E08-2A reflected both existing and predicted development in the watershed, based on zoning and the County General Plan in existence at that time. Within the EOPC Area Table 5.2 & 3 development area, Report E08-2A assumed natural cover and developed open space land uses.

While this assumption is for the most part consistent with actual land uses within the project boundary, there are some minor discrepancies between Report No. E08-2A's forecasted land uses and the actual existing conditions. Therefore for purposes of establishing baseline conditions within the project area, the data from E08-2A were modified slightly to reflect actual conditions. For example, in the vicinity of EOPC Area 3, Report E08-2A assumes a Developed Open Space land use as an existing use, where in fact there is currently natural cover. In EOPC Area

Table 5.2, Report E08-2A did not account for the existing marina. These minor discrepancies in land use assumptions within the project boundary were corrected in the hydrologic calculations in order to establish accurate baseline conditions. – Existing Condition Hydrology Summary

Outside and upstream from the project area, there are also some discrepancies between the land uses forecasted in Report No. E08-2A, and actual conditions. For example, subsequent to the County's preparation of Report No. E08-2A, several areas upstream of the project, including large portions of Modjeska and Silverado Canyon, were re-designated from future areas of development (presumed by E08-2A), to open space preserves. Nonetheless, until the entire 102 square mile watershed is remapped, and the County updates Report No. E08-2A, then the existing project Report No. E08-2A remains the most current and best available hydrologic study of the area upstream of the project area. Because Report No. E08-2A assumes greater intensity land uses upstream from the project, and because the data from the Report were used as inputs in both the existing and developed condition calculations for the report, the overall flows calculated in this report are overestimated for both the existing and developed conditions, resulting in a conservative analysis of flood design requirements. The analysis of hydrologic impacts is discussed further in Section 6.

CONCENTRATION POINT	100-YEAR FLOW (CFS)

(NODE)	
301.1	2738
301.2	2775
302.1	2739
302.2	2887
303.1	2953
304	3089
304.1	3175
304.2	3219
305.1	3100
305.2	3526
306	3559
306.1	3581
306.2	3599
306.3	3447
307	3493 (3400)[10]
307.1	3991
307.2	3820
307.3	3823
308	19,867 (19,900)[10]

5.4 PROJECT WATERSHED ANALYSIS

The post-development hydrology was established using the data and analysis based on the existing unit hydrographs contained in Orange County Hydrology Report No. E08-2A, and modifying parameters in each hydrologic area to reflect the post-development condition. The majorityresults of the project development will take placeProject Watershed Analysis are shown in the Limestone Creek watershed, and an analysis of peak flows for Limestone Creek was performed. Santiago Creek was not analyzed for changes in peak flows because storm flows to Santiago Creek will not be altered by the project. Rather, the Santiago Creek watershed was analyzed for impacts which may result from alterations to the streambed associated with the golf course development, such as erosion due to increased velocities in the Creek. It should be noted that in the developed condition, a small portion of the project area, approximately 24 acres, is diverted from the Limestone Creek Tributary Area to the most downstream portion of Santiago Creek, at its confluence with Irvine Lake. Discussion regarding variations in pre- and post-development conditions can be found in Section 6 – Hydrologic Impacts.

[10] Per Orange County Hydrology Report No. E08-2A.

[11] The leading edge or "first-flush" event approximates the 85th percentile runoff event, per Urban Runoff Quality Management, WEF Manual of Practice No. 23, ASCE Manual and report on Engineering Practice No. 87, by Water Environment Federation and American Society of Civil Engineers (1998).

Table 5.2 shows a comparison of the existing and developed condition peak flows in Limestone Creek for the 100-year expected value storm event at various nodes. In addition, Table 5.3 shows a comparison of the existing and developed condition peak flows and volumes in Limestone Creek for the 2-, 5-, 10-, 25-, and 100-year expected value storm events. .

Table 5.2 – Comparison of Pre- and Post-Development Flows
100-Year Expected Value (Limestone Creek)

CONCENTRATION POINT (NODE)	PRE-DEVELOPMENT FLOW (CFS)	PRE-DEVELOPMENT TRIBUTARY AREA (ACRES)	POST - DEVELOPMENT FLOW (CFS)	POST-DEVELOPMENT TRIBUTARY AREA (ACRES)	DIFFERENCE (CFS)[12]	PERCENT CHANGE (%)
301.1	2738	1991	2738	1991	0	0.0%
301.2	2775	2020	2768	2014	-7	-0.3%
302.1	2728	2073	2703	2043	-25	-0.9%
302.2	2883	2120	2828	2070	-55	-1.9%
303.1	2943	2502	2954	2498	+11	+0.4%
304	3087	2580	3065	2541	-22	-0.7%
304.1	3164	2613	3180	2609	+16	+0.5%
304.2	3210	2716	3171	2667	-39	-1.2%
305.1	3097	2747	3107	2739	+10	+0.3%
305.2	3513	3290	3490	3230	-23	-0.6%
306	3541	3300	3576	3296	+35	+1.0%
306.1	3570	3307	3606	3303	+36	+1.0%
306.2	3594	3374	3610	3363	+16	+0.4%
306.3	3436	3496	3412	3439	-24	-0.7%
307	3433	3528	3409	3450	-24	-0.7%
307.1	3981	4128	4045	4155	+64	+1.6%
307.2	3808	4265	3821	4220	+13	+0.3%
307.3	3810	4319	3868	4295[a]	+58	+1.5%

Drainage devices will be constructed in the proposed drainage system to capture and treat low flows, or nuisance flows, and leading edge, or "first flush" events[11].

[12] Minor variations due to land use changes, longer flow routing and delineation of tributary sub-areas.
[a] Approximately 24 acres diverted to Irvine Lake on northerly side of EOPC2 near the proposed golf course.

These devices will be similar to a typical manhole with a mainline invert which will drop out the low flows. These devices will direct flows, based on a calculated volume, to the proposed water quality basin system. Figure 5.4.1, shows a conceptual low-flow diversion structure. Final design for the device will not be specified until storm drain improvement plans are prepared for review.

~~Results of the rational hydrology and unit hydrograph calculations are located in Section 17 – Technical Appendix.~~

~~Table 5.3 – Proposed Condition Hydrology Summary~~

~~CONCENTRATION POINT (NODE)~~	~~100-YEAR FLOW (CFS)~~
~~301.1~~	~~2738~~
~~301.2~~	~~2768~~
~~302.1~~	~~2703~~
~~302.2~~	~~2828~~
~~303.1~~	~~2954~~
~~304~~	~~3065~~
~~304.1~~	~~3180~~
~~304.2~~	~~3172~~
~~305.1~~	~~3107~~
~~305.2~~	~~3490~~
~~306~~	~~3576~~
~~306.1~~	~~3606~~
~~306.2~~	~~3610~~
~~306.3~~	~~3412~~
~~307~~	~~3409~~
~~307.1~~	~~4045~~
~~307.2~~	~~3821~~
~~307.3~~	~~3849~~
~~308~~	~~19,833~~

~~Table 5.4 shows a comparison of the pre- and post-development flows in Limestone Creek at various locations. Discussion regarding variations in pre- and post-development conditions can be found in Section 6.~~

[11] The leading edge or "first flush" event approximates the 85th percentile runoff event, per Urban Runoff Quality Management, WEF Manual of Practice No. 23, ASCE Manual and report on Engineering Practice No. 87, by Water Environment Federation and American Society of Civil Engineers (1998).

Table 5.4 – Comparison of Pre- and Post-Development Flow (Limestone Creek)

CONCENTRATION POINT (NODE)	PRE-DEVELOPMENT FLOW (CFS)	POST - DEVELOPMENT FLOW (CFS)	DIFFERENCE (CFS)[12]	PERCENT CHANGE (%)
301.1	2738	2738	0	0.0%
301.2	2775	2768	-7	-0.25%
302.1	2739	2703	-36	-1.3%
302.2	2887	2828	-59	-2.0%
303.1	2953	2954	+1	+0.03%
304	3089	3065	-24	-0.78%
304.1	3175	3180	+5	+0.16%
304.2	3219	3172	-47	-1.5%
305.1	3100	3107	+7	+0.02%
305.2	3526	3490	-36	-1.0%
306	3559	3576	-17	-0.5%
306.1	3581	3606	+25	+0.70%
306.2	3599	3610	+11	+0.3%
306.3	3447	3412	-35	-1.0%
307	3493	3409	-84	-2.4%
307.1	3991	4045	+54	+1.4%
307.2	3820	3821	+1	+0.03%
307.3	3823	3849	+26	+.70%
308	19,867	19,833	-34	-0.17%

SECTION 6 – HYDROLOGIC IMPACTS

The hydrology calculations for the proposed EOPC Area 2 & 3 development were completed using the guidelines established in the Orange County Hydrology

[12] Minor variations due to land use changes, longer flow routing and delineation of tributary sub-areas.

Manual, October 1986. Preliminary calculations were computed using the Rational Method to establish a master plan storm drain layout. Peak flows using this method, in the existing and developed condition, are shown on the included hydrology maps. Unit hydrographs were developed, based on the Orange County Hydrology Report No. E08-2A, to compare the pre-development and post-development conditions at concentration points within the project area. See Section 5

~~The E08-2A report is the existing regional hydrology report~~ for additional discussion of the watershed model development.

As explained in Section 5.3, areas upstream from the project area that were slated ~~, and the report evaluates and defines the flood control facilities, and the capacities and operational characteristics of the facilities required to implement flood control requirements~~ for development when~~the area.~~ Report No. E08-2A was prepared have subsequently been designated ~~E08-2A considers the project areas~~ as ~~natural or developed~~ open space preserve areas. To the extent that the E08-2A report considers these areas developed, it also assumes that greater runoff is being conveyed through existing facilities than actually occurs. These land use assumptions for upstream project areas are utilized in the hydrologic calculations for both existing and ~~, and therefore adequately and properly describes the existing condition of the project area. The report analysis then projects the~~ post-development conditions. ~~hydrology, and compares the resulting information to the information in Report E08-2A to evaluate impacts of the proposed development in comparison to the existing condition and established flood protection requirements.~~

~~Report E08-2A assumes some development, rather than existing open space, in off-site areas located in the Silverado and Modjeska Canyon areas. To the extent that the E08-2A report considers these areas developed, it also assumes that greater runoff is being conveyed through existing facilities than actually occurs.~~ Therefore, the flood control protection requirements set by E08-2A require flood control facilities to handle higher storm flow volumes and rates than the existing condition actually requires. Because the post-development condition is analyzed ~~compared~~ with these higher flood control assumptions~~criteria~~, the analysis of post-development flows~~,~~ of the project areas~~, combined with existing flows~~ is conservative, in that it overestimates post-development flow levels.

In addition, because the areas considered developed in E08-2A are relatively small when compared to the entire watershed, ~~so~~ any discrepancy in upstream land uses does not affect the results of the hydrologic modeling or the analysis of impacts in a material way, other than to make the design parameters~~but makes it~~ more conservative.

Hydrology analyses~~analysis~~ of Santiago Creek, Limestone Creek and Irvine Lake indicate that predicted ~~the~~ pre- and post-project peak flows from the project area are~~have a~~ negligible ~~impact~~ when compared to Orange County Hydrology Report No. E08-2A. This is due to the fact that project development areas are small in comparison to the total watershed area. ~~(At the time it was published, Report No. E08-2A considered most portions of EOPC Area 2 & 3 as natural or developed open space.)~~

The change in peak runoff that will occur as a result of the proposed project is insignificant due to the high percentage of open space and the difference in the relative size of the project watershed compared to the entire Irvine Lake watershed area.

Because almost all urban runoff for the proposed development will flow into Limestone Creek, an analysis of peak flows in this tributary area (3,528 acres) was performed. A pre-development 100-year EV~~A comparison of the computed pre-development and post-development flows are shown in Table 6.1. A pre-development condition~~ peak flow at Node 307.3~~308~~ of about 3,810~~19,867~~ cfs ~~(inflow at Irvine Lake)~~ is shown. A post-development analysis indicates a post-development 100-year EV peak flow of about 3,868~~19,833~~ cfs, a decrease of about 58~~34~~ cfs, or about +1.5%, see Table 6.1. Also~~. The flows are essentially the same, a difference of about 0.17% of the total flow over the entire watershed area.~~

~~Because almost all urban runoff for the proposed development will flow into Limestone Creek, an analysis of this tributary area (3,528 acres) was performed. A pre-development peak flow at Node 307.3 of about 3,823 cfs is shown where Limestone Creek flows into the Irvine Lake. A post-development analysis indicates a peak flow of about 3,849 cfs at~~ this ~~same concentration~~ point, there is an increase in volume from 931 to 941 acre-feet~~of about 26 cfs~~, or about +1~~.0~~%. This can be attributed to the land use within the project tributary area and associated imperviousness. In the existing condition, the area is primarily ~~considered~~ natural and undeveloped. In the proposed condition, the same tributary area is considered developed with some impervious surfaces, therefore increasing peak runoff. This increase at this point will have a negligible impact on the water surface elevation of Irvine Lake compared to the total runoff over the entire watershed area.

Minor changes in peak flow rates can also be attributed to: land use changes, longer flow routing and travel time of streams within the same development area, differences in times of concentration, and delineation of tributary sub-areas in the pre- vs. post-development conditions. For example, Node 307.1 shows an increase in 100-year EV peak flows from 3981~~3991~~ cfs in the existing condition, to 4045 cfs in the developed condition. This is primarily because the tributary area boundary has increased in size from the existing to the developed condition. An area which has decreased in size would show a decrease in peak flows, as seen at Node 307.

Additionally, combinations of these factors within tributary subareas can also increase or decrease peak flows.

Table 6.1 – Comparison of Pre- and Post-Development Flows[13]
100-Year Expected Value at Node 307.3

NODE	LOCATION	TRIBUTARY AREA (acres)[14]	PRE-DEVELOPMENT FLOW (cfs)	POST-DEVELOPMENT FLOW (cfs)	DIFFERENCE (cfs)	PERCENT CHANGE (%)
307.3	Limestone Creek	3,528	3,810~~823~~	3,868~~849~~	+58~~26~~	+1.5%~~+0.7%~~

As shown in Table 5.3, the 2-, 5-, 10-, and 25-year Expected Value storm events were also analyzed. Similar to the 100-year storm event, the analysis of smaller storm events indicates only minor increases in peak flows and volumes in Limestone Creek as a result of the development. As is true of the 100-year storm event, any predicted increases in flows and velocities are negligible relative to flows in the overall watershed, and do not result in any significant impacts with the implementation of the proposed project design features.

Per the County of Orange E08-2 Hydrology Report, the recommended discharge into Irvine Lake, as Limestone Creek and Santiago Creek confluence, is approximately 19,900 cfs with an outflow at the spillway of 12,600 cfs. The addition of 58 cfs from the project is about a 0.29% increase, assuming a 100-year event and that the lake is at maximum capacity. This increase will have a negligible impact on the water surface elevation in the lake, spillway discharge, and the natural downstream area between the spillway and Villa Park Dam.

~~308~~	~~Santiago Dam~~	~~40,788~~	~~19,867~~	~~19,833~~	~~-34~~[15]	~~-0.17%~~

6.1 SANTIAGO CREEK – Expected Value Flows

Development of the golf course may narrow portions of Santiago Creek along its southerly banks. This may lead to increased velocities in the creek during large storm events. Another possibility is scour and/or erosion of the streambed and/or banks during large storm events at times of low lake levels. In order to analyze

[13] All runoffs computed by the Unit Hydrograph Method.
[14] Acreages are approximate.
~~[15] This decrease indicates a difference of less than 2/10ths of one percent, which is essentially the same peak flow at this node when compared to the E08-2A study. Non-physical factors such as numerical computational rounding, updated versions of the hydrologic software or precision in the data may contribute to the indicated decrease. Nonetheless, this variation is insignificant when compared to the overall peak flow at this point.~~

the potential impacts, aA floodplain HEC-RAS analysis was performed of Santiago Creek in the existing and developed (Golf Course) conditions in the reach along the project site. This analysis compared velocities and water surface elevations at various cross-sections in the dry (low-lake level) and ponded (high-lake level) conditions using the 100-year expected value storm event. Exhibit D – Santiago Creek Floodplain Study, shows velocities and water surface elevations for the above conditions.

Various concentration points were used to compare 100-year EV flow pre- and post-development average stream velocities in Santiago Creek. Figure 6.1 – Concentration Points Santiago Creek shows these stream velocities at those particular points. Table 6.1.0 summarizes these velocities.

Table 6.1.0 – Pre- and Post-Development Average Stream Velocities
Santiago Creek
(various locations)

NODE POINT NODE POINT CONCENTRATION POINT (reach)[16]	**PRE-DEVELOPMENT AVERAGE STREAM VELOCITY**[17] (fps)	**POST-DEVELOPMENT AVERAGE STREAM VELOCITY**[17] (fps)	**VELOCITY CHANGE** (fps)	**PERCENT CHANGE** (%)
116	0.44	0.44	0.00	0.00%
127	3.01	4.17	1.16	38.5%
136	9.01	7.36	-1.65	-18.3%
147	12.26	11.53	-0.91	7.4%

Results indicate that flows, average stream velocities and water surface elevations vary insignificantly in the dry and ponded states when compared to the existing and proposed conditions. Velocities along the southerly and northerly banks of Santiago Creek vary from an increase of 9.12 ft/sec to a decrease of 16.59 ft/sec at various sections shown on the Exhibit D and Table 6.1.1. These variations are due to the grading, narrowing and widening of the creek from the golf course development along the southerly bank, and due to the nature of the existing natural topography along the northerly bank. For example, a volume of water along one of the creek banks in a deep area would have a lower velocity than the same volume of water in a shallow area. Exhibit D also shows the approximate pre- and post-development flood levels along Santiago Creek.

[16] See Exhibit D – Santiago Creek Floodplain Study.
[17] Velocities determined by HECHES-RAS.

Scouring that may occur due to increased velocities would be limited to the upper one to two feet in the drainage areas and would be limited to sandy materials.[18] The underlying pebble/cobble to boulder sized material would tend to remain in place due to the size and density and energy level required to transport such material.

Revetment and/~~A~~or slope protection will be incorporated into the development plans, as a project design feature, along the golf course to decrease the possibility of erosion or scour along its northerly edge adjacent to Santiago Creek, and to protect the golf course development. Examples of possible erosion protection along the golf course edge/slope include: planting of dense vegetation, placing of a layered geo-grid matrix, an interlocking wall system and rip-rap.

The proposed revetment and slope protection to Santiago Creek adjacent to the proposed golf course development will be engineered and designed to meet current engineering standards. The improvements will be owned and maintained by the eventual owner/operator of the golf course.

In addition, similar control measures along the banks of Santiago Creek opposite the golf course may be necessary since velocities show a potential ~~an~~ increase at various locations. Confirmation of any ~~Further research will be considered in order to determine the~~ actual potential for scour and/or erosion along the northerly banks of Santiago Creek opposite the proposed golf course will be made during the final engineering phase. Such activities may~~. This could~~ include, but may not be limited to;~~,~~ additional hydraulic analysis to determine velocities at specific locations along this reach, additional surface and subsurface investigation of the materials encountered in this area. This analysis will be performed to verify the storm drain system design has met the objectives outlined, and whether or not additional quantitative analysis is needed. Once the potential for erosion is more specifically characterized, appropriate project design features, such as the ones previously mentioned, will be incorporated during the final engineering phase to insure erosion and scour potential impacts are reduced to less than significant levels or eliminated.

6.2 LIMESTONE CREEK – Expected Value Flows

As shown in Tables 5.2, 5.3 and 6.1 previously, development of the site results in an insignificant increase in the 100-year EV storm event as Limestone Creek enters Irvine Lake, as demonstrated in the rational and unit hydrograph analysis. ~~Table 6.2.1 – Summary of 100-year Pre- and Post-Development Flows for Limestone Creek, shows that flows vary from an increase of 1.4% to a decrease of 2.4% at various nodes.~~ A HEC-RAS analysis of Limestone Creek along the

[18] Per Limited Geotechnical Analysis of Existing Drainage Facilities, East Orange – Area 2/3, City of Orange, County of Orange, California, by GeoSoils, Inc. (November 2003), see Appendix B.

project site was performed to determine water surface elevations in the existing and proposed condition. As expected, water surface elevations along the creek at various cross-sections are nearly identical. Table 6.2.1 2 shows the pre- and post-development 100-year Expected Value average velocities and their differences at various nodes along Limestone Creek. Average velocities within the natural stream bed vary from an increase of 7.2% to a decrease of 0.46% at various sections of Limestone Creek. These minor variations in flows and velocities are due to changes in flows from the existing to the proposed condition along the same sections. Since no narrowing of the stream edges are anticipated, minor variations in flow and velocities will have no significant impact within Limestone Creek. Flows will be released in a non-erosive manner through implementation of velocity/energy dissipation devices at the outlets.

As described in Section 6.0 above, minorMinor changes in peak flow rates can be attributed to a variety of reasons such as land use changes, longer flow routing and delineation of tributary sub-areas in the pre- vs. post-development conditions. Flows will be released in a non-erosive manner.

Table 6.2.1 12 – Pre- and Post-Development Stream Velocities
100-Year Expected Value, Limestone Creek
(various locations)[19]

NODE	PRE-DEVELOPMENT AVERAGE VELOCITY (fps)	POST-DEVELOPMENT AVERAGE VELOCITY (fps)	VELOCITY CHANGE (fps)	PERCENT CHANGE (%)
301.2	9.23	9.23	0	0%
303.1	13.91	14.91	1	7.2%
304.2	12.41	12.46	.05	.40%
305.1	10.95	10.90	-.05	-.46%
305.2	4.2	4.27	.05	.12%
306.3	8.3	8.36	.06	.72%
307.3	6.76	7.03	.27	.40%

There is the potential for erosion or scour from the peninsular outlet located at the westerly most portion of Area 2, as shown on Figure 3.1, in the vicinity of Node 307.3, as shown on Figure 5.4, which flows into Limestone Creek. Flows will be released in a non-erosive manner. Project design features to be included as a part of the storm drain improvementimprovements plans to decrease the possibility of erosion or scour at this location may include:

- Extending the outlet pipes directly into the stream bed,

[19] Velocities determined by HEC-RAS.

- Construction of energy dissipators,
- Placing a hard bottom at the outlet,
- Placing rock or rip-rap at the outlet, and/or
- Installing slope protection.

The precise project design feature or features will be determined at the time of final engineering. In addition, an analysis of the existing double 12'W x 10'H culvert structure and crossing at the Santiago Creek Bridge was performed. Existing and developedDeveloped 100-year expected valueevent flows can be adequately conveyed through these locations and not affect (flood) Santiago Canyon Road during thisa theoretical 100-year storm event.

Results of the rational hydrology, unit hydrograph, HEC-RAS analysis and capacity calculations are located in Section 17 - Technical Appendix.

SECTION 7 – STORM DRAIN FACILITIES

7.1 STORM DRAIN FACILITIES

The preliminary hydraulic sizing for the storm drain system was taken from the 100-year Rational Method hydrology. The rational method estimates required pipe sizes using normal depth calculations. Manning's "n" values for reinforced concrete pipe (RCP) used in the analysis was 0.013. Pipe sizes ranged from 18" to 66" RCP. Figure 3.1 shows the approximate locations and sizes of the proposed drainage system. The sizes shown are for master planning purposes only, additional hydraulic calculations must be performed before final design of the storm drain system.

7.1.1 Canyon Diversion

Development of EOPC AreasEast Orange Area 2 & 3 and proposed storm drainage facilities will divert a portion of the runoff that currently flows from existing canyons into underground conduit. One concern is the natural irrigation of certain native oaks and other vegetation in four main canyons located along the southerly portion of the project. In order to maintain a water source to the native vegetation, a series of canyon diversion pipes is proposed to runoff dry weather and low flows to these areas, see Figure 7.1, Conceptual Canyon Diversion Plan.

Case 1: That portion of the runoff lost to development will be replaced with flows diverted from a natural area approximately equal in size.

Case 2: That portion of the runoff lost to development which is will not able to be replaced by runoff from a natural area will be replaced by a developed area approximately 0.70 (70%) in size as the area it is replacing. This factor is based on empirical and calculated dry weather and low flows over urbanized areas. Pre-treatment of these flows is required, such as an additional water quality basin or other BMP.

Additionally, that portion of the runoff lost to development that cannot be replaced with runoff from the areas described in Cases 1 or 2 will have an efficient watering system installed to maintain flows to the native oaks and other vegetation.

Figure 7.2, Canyon Diversion Area Table, summarizes watershed areas being diverted from and diverted to these canyons by tributary area.

Because low- and dry-weather flows will now be diverted into these canyon areas, there may be a potential for erosion. Project design features to be included as a part of the storm drain improvements plans to decrease the possibility of erosion or scour may include:

- Extending the outlet pipes directly into the stream bed,
- Construction of energy dissipators,
- Placing a hard bottom at the outlet,
- Placing rock or rip-rap at the outlet, and/or
- Installing slope protection.

The precise erosion control project design feature or features will be determined at the time of final engineering.

The above Conceptual Canyon Diversion Plan is proposed as a possible project design feature. Further research should be done to determine whether these low- and dry-weather flows should be diverted into the canyons. Other measures to address irrigation of the native habitat within these canyons should also be considered once a more thorough research and investigation is performed, and the actual watering requirements of the habitat are known.

7.2 IRVINE LAKE (SANTIAGO RESERVOIR)/SANTIAGO DAM

According to Orange County Hydrology Report No. E08-2A, the 100-year expected value peak runoff inflow at the Irvine Lake is 19,900 cfs (rounded), with ana design outflow of 12,600 cfs at the Santiago Dam. As shown in Section 6, the increases in post-development peak expected value peak flows and volumes as Limestone Creek enters100-year post-development inflow at Irvine Lake are negligible, and peak flows in Santiago Creek areis 19,833 cfs, the design outflow is not expected to change. Therefore, the impact from the proposed development has an insignificant effect regarding the 100-year runoff from on-site flows. Differences between the existing condition and the proposed condition will have an insignificant impact on the volumes and water surface elevations in Irvine Lake and Limestone Creek. Since lake levels are practically unchanged, storage is also expected to be unaffected. For an analysis of potential combined impacts in Irvine Lake relating to the proposed SHII/EO1 development, see Section 6.5 of the Santiago Hills II/EOPC Area 1 ROMP, Volume 1, Storm Water Hydrology.

SECTION 8 – DEBRIS AND SEDIMENT YIELD/TRANSPORT

The alluvium located within the drainage areas generally consists of coarse-grained material of pebble/cobble to boulder-sized material with a sandy matrix that has been transported from upstream. Currently the project area is contributing sediment to the drainage areas through typical surficial erosion that occurs during the rainy season. Per Preliminary Geotechnical Analysis of Lake Village Concept Stormwater Mitigation Management Plan, City of Orange, County of Orange, by GeoSoils, Inc., dated April 2002, the proposed development would decrease the amount of sediment currently being transported into the Irvine Lake.

From a geotechnical standpoint, materials encountered during grading in all development areas will be compacted to meet project compaction requirements. This will help minimize the potential for erosion and the addition of sediment to the existing Santiago Creek and Limestone Creek drainage areas.

Currently the project area is contributing sediment to the drainage areas through typical surficial erosion that occurs during the rainy season. Development would tend to minimize this process by decreasing the area exposed to surficial erosion. However, the

The drainage areas receive their sediment from a large area of which the proposed project development is only a small part. The developed area within the Limestone Creek tributary will only constitute 413 acres of the 3,528 acre Limestone Creek watershed, or approximately 5%.

Section 6 shows that post-development flows have a minor contribution to Limestone Creek at various outlets along the project. At these outlets, minor increases in flows, volumes and associated velocities will have a negligible impact on sediment transport compared to the flows, volumes and associated velocities already within the creek during storm events. As previously discussed, potential increases in erosion will be addressed through the use of one or more erosion control project design features.

Changes to the stability of the creek due to development, if any, will be restricted by control structures, namely, Irvine Lake (the ultimate receiver of sediment within Limestone Creek), the proposed triple box culvert crossing at the entrance of the proposed development, and the existing double box culvert. The lake and the structures impede the transportation of sediment within these reaches. These control structures are at the most downstream reach of Limestone Creek and impacts due to a decreased sediment supply, if any, will have a negligible impact on the entire reach.

The change in the runoff (and associated sediment transport) that will occur as a result of the proposed project and its impact on Limestone Creek and Irvine Lake is expected to be insignificant due to the difference in the relative size of the project site compared to the overall tributary watershed.

From a geotechnical standpoint, materials encountered during grading in all development areas will be compacted to meet project compaction requirements. This, combined with the addition of some impervious surfaces and landscaping associated with development, will help minimize the potential for erosion and the addition of sediment to the existing Santiago Creek and Limestone Creek drainage areas. The alluvium located within the drainage areas generally consists of coarse-grained material of pebble/cobble to boulder-sized material with a sandy matrix that has been transported from upstream.

Scouring that may occur due to increased, more concentrated flows at outlet points would be limited to the upper 1 to 2 feet in the drainage areas and would be limited to the sandy material. The underlying pebble/cobble to boulder sized material would tend to remain in place due to the size and density and energy level required to transport such material. Also, due to the closeness in elevation of the outlet points with the active stream channel, the amount of scouring due to possible increased flows would be minor.

The general drainage areas show that the majority of the sediment located in and being transported along the major drainages is from off-site sources as the flows and velocities required to transport the larger sized material would come from along the main drainage channels. The materials being transported from on-site are very limited in extent in size and quantity.

The change in the runoff (and associated sediment transport) that will occur as a result of the proposed project and its impact on Santiago Creek, Limestone Creek and Irvine Lake is expected to be insignificant due to the difference in the relative size of the project site compared to the overall tributary watershed.

In light of the absence of tentative tract map level information, a limited geotechnical analysis has been performed by GeoSoils Inc. and has been referenced in Section 16 of this report. In addition, a menu of potential project design features to protect outfall areas from potential scour/erosion impacts can be found in Sections 6.2, 7.1.1, 10.4 and 11.6. A quantitative analysis of potential erosion and scour expected to result in natural channels downstream of outfalls will be prepared at the storm drain improvement design stage, at which time the precise erosion control project design features will be selected.

SECTION 9 – RUNOFF WATER QUALITY ASSESSMENT

On January 18, 2002, the Santa Ana Regional Water Quality Control Board issued a municipal storm water National Pollutant DischargeRunoff Elimination System (NPDES) permit to the County of Orange and the 25 incorporated citiescitied within the Santa Ana region (Order No. R8-2002-0010 NPDES Permit No. CAS618030).

The 1987 amendments to the Clean Water Act (CWA) added section 402(p) establishing a framework for regulating municipal and industrial (including construction) stormwater runoffs under NPDES permits including stormwater runoffs from municipal separate storm sewer systems (MS4) as well as other designated storm water runoffs that are considered significant contributors of pollutants to the waters of the United States.

Current requirements of the California Regional Water Quality Control Board – Santa Ana Region and City of Orange Local Implementation Plan, and the local Orange County Drainage Area Management Plan (DAMP), 2003, require implementation of water quality for flows from new development control measures. Recommendations regarding the selection of structural and non-structural control measures will be developed specific to the watershed to comply with these requirements. This study is intended to be a portion of a conceptual planning level WQMP. A detailed water quality assessment has been performedwill be addressed by GeoSyntec Consultants. See EOPC Areas 2 and 3 ROMP, Volume 2, Surface Water Qualityothers.

SECTION 10 – DESIGN CONSIDERATIONS

10.1 AGENCY AGREEMENTS AND APPROVALS

This study is subject to the review and approval of the City of Orange and the County of Orange. All flood protection (storm drain) facilities shall be designed in accordance with the County of Orange standards and City of Orange policies and requirements where they are more stringent than the County of Orange.

10.2 GEOTECHNICAL

A preliminary geotechnical analysis of various locations at the site was performed by GeoSoils, Inc. on March 2002. Soil samples were taken from the preliminary locations of the proposed water quality basins and laboratory tests were performed. Laboratory test results can be found in the report, Preliminary Geotechnical Analysis of Lake Village Concept Stormwater Mitigation Management Plan, City of Orange, County of Orange, by GeoSoils, Inc., dated April 2002. In addition, GeoSoils performed a study, Limited Geotechnical Analysis of Existing Drainage Facilities, East Orange 2 & 3, City of Orange, County of Orange, dated November 2003, which qualitatively assessed the existing condition of the streambed in Limestone Creek and potential for erosion and scouring.

10.3 ENVIRONMENTAL CONSTRAINTS

The City of Orange is currently in the process of preparing an Environmental Impact Report to address impacts and, if necessary, appropriate mitigation for implementation of this Planning Level Hydrology Analysis.

10.4 ULTIMATE DEVELOPMENT REQUIREMENTS

The specific runoff mitigation techniques employed in this planning level hydrology analysis are based on the most current Best Management Practices (BMPs) contained in the WQMP, the DAMP, and the EIR, and are as follows:

- Drainage improvements: A combination of improvements to natural stream courses and low-flow/high-flow storm drain systems will be incorporated, such as rip-rap, energy dissipators, slope stabilizers or other similar structures, to minimize the potential for channel erosion and accompanying sediment deposition.

- Extended Detention Basins: Proposed to accept low storm flows and dry weather flows at various locations within the site. The purpose of these basins is to reduce pollutants of concern in the storm water flows to the maximum extent practicable through the incorporation and implementation of treatment control BMPs.

The extended detention basins will be designed with outlets that detain the runoff volume from the water quality design storm (the 85th percentile 24-hour event) for 36 hours to allow particles and associated pollutants to settle out. The water quality basins will also incorporate wetland vegetation in a low flow channel in the bottom of the basin for the treatment of dry weather flows and small storm events.

Per the MS4 permit, the extended detention basins within the proposed Project will be designed to contain a "water quality pool" sized to meet the maximized storm water capture volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87 (1998). Rainfall events with depths equal to or less than 0.10 inches tend to produce little if any runoff. The mean depth of storms greater than or equal to 0.1 inches depth (a 6 hour dry period is used to define storms) used to size the detention facilities is 0.73 inches.

The position and alignment of these basins shall be based on the most practical locations which minimize impacts within the site and are dependent upon grading and as field conditions allow, see Figures 10.1 & 10.2 for preliminary locations and basin sizing.

The outlet pipes of these basins may have the potential for scour/erosion of the surrounding area. Flows from the basins will be released in a non-erosive manner. Design features that will be implemented in the storm drain improvement plans to decrease the possibility of erosion or scour may include:

- Extending the outlet pipes directly into the stream bed,
- Construction of energy dissipators,
- Placing a hard bottom at the outlet,
- Placing rock or rip-rap at the outlet, and/or
- Installing slope protection.

The precise design feature or features will be selected at the time of final engineering.

- Other water quality features: The proposed Project includes small pockets of disconnected development (herein referred to as "other development areas") outside of Areas 2 and 3 and the Golf Course such as a fire station, pump lift station, two commercial/

recreational areas, and a proposed reservoir. Runoff generated from these areas will not drain to any of the proposed water quality basins. Therefore, bioswales are proposed for treatment of wet and dry-weather runoff from the other development areas. A more detailed discussion of these BMP project design features can be found in the report, East Orange Planned Community Areas 2 and 3 Surface Water Quality Report by GeoSyntec Consultants.

- Landscaping: Hillside developments typically require cut and fill slopes which are susceptible to erosion. All manufactured slopes will be landscaped and maintained by the community association. Slopes will also be protected during construction with conventional erosion control measures.

- Edge/slope stabilization: Since development of the site may narrow portions of Santiago Creek along its southerly banks due to the proposed golf course, velocities may increase in the creek during large storm events. Examples of possible erosion protection to be implemented as a project design feature along the golf course edge/slope include: planting of dense vegetation, placing of a layered geo-grid matrix, an interlocking wall system and rip-rap. In addition, similar control measures along the banks of Santiago Creek opposite the golf course may be necessary.

- Erosion/Scour: As discussed in previous sections, this project may introduce the potential for scour and/or erosion. This would typically occur at the outlets of pipes, and locations where flows have increased or velocities are higher. Flows from the basins should be released in a manner similar to an existing condition, or at least to a non-erosive manner. Design features that will be incorporated into the storm drain improvement plans to decrease the possibility of erosion or scour may include:

  - Extending the outlet pipes directly into the stream bed,
  - Construction energy dissipators,
  - Placing a hard bottom at the outlet,
  - Placing rock or rip-rap at the outlet, and/or
  - Installing slope protection.

  The precise design feature or features will be selected at the time of final engineering.

  A limited geotechnical analysis of the project site was performed by GeoSoils, Inc. (see Appendix B). Most of the existing drainage facilities showed only minor erosion at the outlet areas of Limestone Creek. The majority of the drainage facilities had rip-rap or some other erosion protection device at the outlet area. The soils exposed at the outlet consist of coarse-grained material generally consisting of gravel to cobble sized materials with a sandy matrix. It does not appear that this material is susceptible to scouring. If scouring were to take place due to increased volumes of runoff, it would most likely affect only the upper 1 to 2 feet of material in the drainage channels due to the nature of the materials. It also appears that the drainages at the outlet end are not susceptible to major down cutting as the stream channel elevation is close to the outlet elevations for the most part. Any additional erosion due to increased volumes in runoff would most likely result in minor, insignificant widening of the drainage channel in this area.

SECTION 11 – PROPOSED DRAINAGE FACILITIES

11.1 GENERAL

All flood protection (stormStorm drain) facilities shall be designed in accordance with the County of Orange Standards and City of Orange policiespolicy and requirements where they are more stringent than the County of Orange. Conceptual alignment and locations have been identified, however, final drainage facility design and locations will be reviewed as part of the final engineering and grading plans. All on-site storm drain facilities shall be designed to convey flows from the minimum City criteria design storm with additional design factors of safety and freeboard to provide a 100-year level of protection to all proposed structures. Storm drain facilities for Limestone Creek shall be designed to safely convey 100-year flows across Santiago Canyon Road and maintain at least one clear lane during this event.

11.2 FACILITY ALIGNMENT

The alignment of the proposed storm drain system is based on a preliminary assessment of drainage requirements and flood protection goals associated with the site. Constraints for the site include location of existing drainage facilities, construction phasing issues, and achievement of water quality goals. The storm drain facility alignments are shown in Figure 3.1.

11.3 RIGHT-OF-WAY

Right-of-way issues at the project interfaces with the surrounding areas such as Santiago Canyon Road and Irvine Lake will be resolved as the project is formalized, and will be consistent with the proposed City of Orange annexation agreement.

11.4 WATER QUALITY FEATURES/MAINTENANCE

As stated in Section 10.4, a number of extended detention basins are proposed to accept low flows at various locations within the site. The purpose of these water quality basins is to infiltrate, filter and treat initial storm water runoff and low flows.

Routine operation and maintenance (O&M) activities for the extended detention basins would include the following:

- Site Inspections
- Trash & Debris Removal
- Minor Vegetation Removal/Thinning
- Snag Removal
- Integrated Pest/Plan Management
- Bti (bio-chemical pesticide) Application
- Intermittent Flooding/Drying

The extended detention basins will periodically require major maintenance and possibly repairs to ensure that the PDFs operate at their maximum efficiency and treatment capacity. Major activities include:

- Structural Modifications / Repairs
- Major Vegetation Removal & Planting
- Major Sediment Removal

O&M activities that could harm sensitive species or disturb avian species during nesting season will be avoided. No significant flooding/drying, sediment or vegetation removal, or major construction activities will be performed during the breeding and nesting season.

While vector control of other pests is important, such as for flies, rodents and over-abundant waterfowl, the potential for public health effects from these pests is generally regarded to be low. Controlling these pests is relatively easy and the likelihood of vector-borne outbreaks associated with these pests is considered minimal.

A more comprehensive discussion of the maintenance of water quality features can be found in Section 17 – Technical Appendix A, OPERATION

AND MAINTENANCE SPECIAL STRUCTURAL WATER QUALITY BMPS, and in EOPC Areas 2 and 3 ROMP, Volume 2, Surface Water Quality. Additionally, the Serrano Water District and the City of Orange will have the right to inspect and maintain the proposed extended detention basins and charge the HOA.

11.5 GOLF COURSE

The proposed golf course will have its own local area drainage system, independent of the storm drain system for the proposed EOPC Area 2 & 3 project site. Development shall include, but not be limited to: low-flow (dry-weather) flows returned to irrigation reservoirs and interceptor drains to capture non-storm runoff and divert to sump areas or other water quality features.

Permanent structures associated with the golf course (i.e. clubhouse, lodge, pro shop, maintenance buildings, etc.) shall be placed at an elevation in accordance with the County of Orange 100-year flood protection guidelines as shown in Section 13 – Development of Drainage Design Guidelines.

Except as shown on the hydrology map, storm flows tributary to the proposed development are to be conveyed via conduit through the golf course and into Santiago Creek where it ultimately flows to the Irvine Lake. The paths for the natural storm flows are shown on previous Figure 3.1 – Conceptual Drainage System, and Exhibit F – Conceptual Golf Course Site. These storm flows will not be impeded and will not be increased or decreased appreciably by the project. For flows on the golf course itself, fairways, ponds and other topographic features may act as a retarding basin during smaller storm events (i.e.: 1- or 2-year events), while protecting greens and tees.

The golf course design shall include a design feature incorporating retention of the 85th percentile/first flush for water quality purposes. Low-flow (dry-weather) flows and irrigation runoff from fairways and golf ground drainage would be conveyed via grassy swales and/or berms to these collection/extended detention basins with precise areas determined in the final grading plans as well as the method to deliver the water to these water quality structures/features. A more detailed discussion of these BMP project design features can be found in the report, East Orange Planned Communities Areas 2 and 3 Surface Water Quality Report, by GeoSyntec Consultants. Installation of any water quality feature should be designed to incorporate an equivalent 36-hour detention time as stated in Section 10.4. Runoff is routed to golf design features (ponds, lakes, water hazards) and/or diverted for biological treatment or irrigation reuse. Turf grass and native grasses provide a substantial filter of stormwater and, with the natural landscape, traps sediment and reduces erosion before pollutants enter waterways. The outlet pipes of these water quality features may have the potential for scour/erosion of the surrounding area. Flows will be released in a non-erosive manner. Possible design features that will be implemented to in the area storm drain improvement plans to decrease the possibility of erosion or scour may include:

- Extending the outlet pipes directly into the stream bed,
- Construction energy dissipators,
- Placing a hard bottom at the outlet,
- Placing rock or rip-rap at the outlet, and/or
- Installing slope protection.

The precise project design feature or features will be selected at the time of final engineering.

Currently, the conceptual golf course plan shows an estimated available retention volume of about 8.13 acre-feet above and beyond its current capability to retain an initial storm event. Swaled fairways may be an incorporated project design feature to provide some additional retention capacity within the golf course. Also, additional grading of the proposed golf course may be required in order to attain retention beyond the initial storm event. Calculations of estimated golf course storm retention can be found in Section 17 – Technical Appendix.

The proposed East Orange Golf Course drainage is composed of two components:

- The first component is the existing overland drainage courses that flow generally to the north across the proposed golf course to Santiago Creek. These flows will be allowed to cross the course within a defined channel that will be created to convey a 100-year storm event. These channels will be incorporated into the design of the course by the golf course architect. The channel edges will be graded and bermed so that any onsite flows will be directed away from the channel. It should be noted that the flows within these channels drain from natural undeveloped areas and as such, this water will not be treated prior to runoff into Santiago Creek.

- The second component is the on-course drainage itself. Non-storm flows on the course will be eliminated through the use of an efficient irrigation management plan. The implementation of such a plan will ensure that irrigation runoff from the golf course to waterways is eliminated. Any irrigation runoff will either infiltrate into the course or will be conveyed either through an open or closed conveyance device to an irrigation pond for future irrigation use.

The proposed golf course and facilities associated with its development (clubhouse, maintenance, lodge, pro shop, etc.) shall also be in accordance with the objectives outlined in Section 1.2 as it pertains to drainage and water quality.

11.6 Santiago Canyon Road

There are a number of existing culverts, pipes and drainage facilities on Santiago Canyon Road, which borders most of the southerly portion of the site and roughly parallels Limestone Creek. Descriptions of these existing features can be found in Section 4.1, Existing Culverts and Storm Drain Facilities, and are shown on Figure 4.1, Existing Drainage Structures.

A limited geotechnical analysis of the existing drainage facilities along Limestone Creek within the project site was performed by GeoSoils, Inc.[20] With the exception of one culvert in this reach, all existing drainage facilities showed only minor erosion at the outlet areas of Limestone Creek. The majority of the drainage facilities had rip-rap or some other erosion protection device at the outlet area. The soils exposed at the outlet consist of coarse-grained material generally consisting of gravel to cobble sized materials with a sandy matrix. It does not appear that this material is susceptible to scouring. If scouring were to take place due to increased volumes of runoff, it would most likely affect only the upper 1 to 2 feet of materials in the drainage channels due to the nature of the materials. It also appears that the drainages at the outlet end are not susceptible to major down cutting as the stream channel elevation is close to the outlet elevations for the most part. The one culvert mentioned previously, which is located directly to the east of the Santiago Creek Bridge crossing over Limestone Creek, is comprised of relatively fined grained material that has been subject to erosion in the form of down cutting to reach the active stream channel. However, it appears that in this area that the majority of down cutting has occurred since the outlet has reached the approximate elevation of the active stream channel. Any additional erosion due to increased volumes in runoff would most likely result in minor, insignificant widening of the drainage channel in this area.

Per Sections 5 and 6, results of the unit hydrograph analysis indicate only about a an approximate maximum of 1.54% increase in runoff for a 100-

[20] Per Limited Geotechnical Analysis of Existing Drainage Facilities, East Orange – Area 2/3, City of Orange, County off Orange, California, by GeoSoils, Inc. (November 2003), see Appendix B.

year EVexpected value storm event. Minor, if any, additional scour or erosion in the form of down cutting may be likely to be expected.

100-year rational hydrology analysis indicates that the storm flows may not be able to be conveyed by the existing pipes and culverts along the easterly portion of the site. As shown on the Area 2 Existing Condition 100-year Hydrology Map and Figure 4.1, Existing Drainage Structures, there are a number of pipe culverts, east of the Santiago Creek Bridge, which convey flows from the site, beneath Santiago Canyon Road, and runoff to Limestone Creek. These pipes range in size from 18” to 48”. Exhibit E, Limestone Creek Drainage, shows 100-year flows from developed Areas 2, 3 and the canyon areas. Proposed hydrologic areas “E”, “F”, and “G” will have flows that may not be conveyed adequately by the smaller pipe culverts (18” and 24”).

As part of a project design feature at the time storm drain improvements are prepared, additional parallel and/or larger pipe culverts will need to be placed along Santiago Canyon Road in order to convey the larger event storm flows from these areas to Limestone Creek. If these additional culverts are to be constructed, they will be placed at locations and elevations approximate to the existing active stream channels in order to minimize the effects, if any, of scour or erosion. In addition, rip-rap or similar other erosion protection device may be installed to reduce scour, erosion or downcutting. Ultimate locations and elevations of these culverts will be determined once final engineering and locations of the water quality basin outlets are known.

The future ownership of Santiago Canyon Road to the east of the centerline of SR 241 has not yet been determined. The City does not intend to take over from the County ownership of Santiago Canyon Road east of SR 241 as part of its annexation request, though the ultimate boundaries of the City will be determined by LAFCO during the annexation process. If the County continues to own the road segment after annexation, it will continue to be responsible for the ownership and maintenance of all existing storm drains, culverts, and related appurtenances, and will take ownership and maintenance responsibility for any future improvements therein or new facilities constructed in parallel. Should the eastern segment of Santiago Canyon Road ultimately be included in the annexation agreement, then the City will own and maintain all new or existing storm drain infrastructure in Santiago Canyon Road.

SECTION 12 – ESTIMATED CONSTRUCTION COSTS

A preliminary estimate of cost has been prepared for this preliminary hydrology analysis and water quality analysis. A summary of the estimated cost is included in Table 12.1, Estimated Engineering and Construction Costs. These costs include water quality basins, pipe drainage systems and manhole structures.

The number of extended detention basins was based on current preliminary configurations. The sizes and configurations for the basins may vary.

The pipe sizes for the storm drainage system were taken from the hydrology analyses. The pipe sizes in the hydrology analyses are calculated to determine travel times and times of concentration. Once the conceptual alignments and drainage concepts are approved, the pipe sizes and associated cost can be refined.

The number of manhole structures assumed was based on typical manhole spacing (about 300 continuous linear feet of conduit) and pipe junctions.

Table 12.1 – Estimated Engineering and Construction Costs[21]
EAST ORANGE AREA 2 & 3

DESCRIPTION	QUANTITY[22]	UNIT	UNIT COST[23]	COST
Extended Detention Basin	11	EA	$50,000	$550,000
Manhole	110	EA	$4,500	$495,000
18" RCP	4,300	LF	$55	$236,500
24" RCP	7,920	LF	$61	$483,120
30" RCP	5,370	LF	$68	$365,160
36" RCP	4,190	LF	$110	$460,900
42" RCP	7,970	LF	$120	$956,400
48" RCP	5,300	LF	$140	$742,000
54" RCP	2,700	LF	$150	$405,000
60" RCP	1,460	LF	$158	$230,680
66" RCP	1,460	LF	$187	$273,020
			Subtotal	$5,197,780
			25% Contingency	$1,299,445
			Total	$6,497,225

SECTION 13 – DEVELOPMENT OF DRAINAGE DESIGN GUIDELINES

[21] Estimate does not include catch basins/inlets.
[22] All quantities are approximate.
[23] Unit costs based on current available data

13.1 LOCAL DRAINAGE FACILITIES

To provide the required level of flood protection and reduce potential public safety hazards, an underground drainage system shall be provided to intercept and convey the stormwater flow generated by the project or off-site tributary flows to the project. Storm drain criteria will be as outlined in Section 3.2 – Hydraulic Design.

13.2 DESIGN STANDARDS

The design of the extended detention basins and additional BMPs will be required to conform to the Drainage Area Management Plans (DAMP) adopted for Orange County, and the Local Implementation Plan adopted by the City of Orange pursuant to its DAMP obligations. In addition, BMPs designed for East Orange will be required to be consistent with the recommendations set forth in the water quality section of this study.

All flood protection (~~The~~ storm drain) facilities shall ~~system will~~ be designed in accordance with the County of Orange standards and ~~per~~ City of Orange policies and requirements where they are more stringent than the County of Orange.~~Standards and Criteria.~~ The design of portions of the storm drain system will need to be coordinated with the County of Orange where the proposed systems interface with County facilities.

SECTION 14 – EROSION CONTROL/CONSTRUCTION ACTIVITIES

In accordance with local and state regulations, a Storm Water Pollution Prevention Plan (SWPPP) will be developed for the project site during construction. The SWPPP will identify site-specific erosion and sediment control measures such as debris basins, straw wattles, sand bags, check dams, catch basin inlet protection, slope protection, etc. to minimize the transport and runoff of sediment laden storm water. The Project Superintendent along with other designated personnel will be responsible for the maintenance and upkeep of the sediment and erosion control measures on-site to reduce sediments from discharging from the site during construction.

In addition, the SWPPP will address the construction and post-construction BMPs that will be implemented for the project. In conformance with the State's General Permit, BMPs will also be identified in the SWPPP for implementation during construction.

Improper handling of construction materials and/or equipment could result in accidental spills that could affect surface water quality. Specific BMPs will be included to minimize the potential for construction material-related pollutants to runoff from the site. Construction material pollutant BMPs are usually related to housekeeping, storage and handling of sensitive construction materials. Non-structural items such as employee training, and storm water information dissemination also will be included in the SWPPP. The SWPPP will identify proper housekeeping practices for sensitive material, spill containment procedures, proper disposal procedures, etc. and required frequencies for training sessions. In addition, the SWPPP will comply with the Construction General Storm Water Permit by including a sampling and analysis plan for non-visible pollutants. The Project Superintendent will be responsible for implementing the proper BMPs to control construction material pollutants from discharging from the project site and prevent causing or contributing to excursions of water quality standards.

To minimize the impacts of construction operation with respect to sedimentation, erosion control measures during and immediately following grading operation will be necessary. Soil loss may occur due to sheet erosion and channel erosion, therefore, these two processes must be properly controlled. Most serious erosion occurs along slopes; therefore, soil on steep slopes must be preserved by planting to reduce this potential. During the interim period before groundcover becomes established, bonded fiber matrix, rolled erosion control material, straw, wood chips, plastic (visqueen), and other equivalent measures will be used as stabilizing agents. Overland flow will be prevented running uncontrolled over slopes. The top of slopes will be bermed or otherwise protected to prevent overflow. Due to the steep terrain in the watershed, the overland flows will probably have high erosive velocities and will be slowed to tolerance limits. Possible solutions include gravel bag dams placed perpendicular to the flow or to direct the overland flow into temporary gravel bottom channels. In addition, energy dissipation devices will be provided as necessary to prevent erosion of the natural channel bed directly downstream of the high-velocity storm drain outlets. In general, the basic principles involved in effectively controlling erosion and sedimentation include the following:

1. Leaving the soil exposed for the shortest time possible.
2. Providing protective cover for the soil utilizing mulch or vegetation.
3. Reducing the velocity and controlling the flow runoff.
4. Detaining runoff on-site to trap sediment.
5. Releasing runoff safely to downstream areas.

Grading and excavation activities at the westerly portions of the project area and within Irvine Lake will be at low lake levels.

Sediment and erosion control structures will be provided where construction has created an artificial erosion potential.

SECTION 15 – FACILITIES MAINTENANCE

Maintenance of the planned local storm drain facilities described in this report will be provided by either the City of Orange, County of Orange or by the Homeowner's Association (HOA).community association. Maintenance of all publicly owned master planned (MPD) or local storm drain systems will be assumed by the developer prior to acceptance of the facilities and thereafter maintenance will occur as specified through an agreement with the City of Orange.

The HOA will be responsible for maintaining all extended detention basins, vegetated swales, and CDS units. They will also own and maintain any culverts, storm drains, and related appurtenances that are not in existing or future public streets. The City of Orange will own and maintain storm drain facilities in any future public streets falling outside the control of the HOA. The revetment and slope stabilization in Santiago Creek, and all other storm drain facilities related to the golf course development will be owned and maintained by the eventual golf course owner/operator.

The County of Orange'sFlood Control District's involvement in maintaining facilities will be limited to continuing to maintain continue maintaining the existing portions of facilities, if any, along Santiago Canyon Road, Santiago Creek and Limestone Creek, and areas where the County District has and will continue to have right-of-way, if any. No new drainage features within the project boundaries are proposed to be owned or maintained by the County of Orange, with the exception of any improvements, or structures constructed in parallel, to the existing drainage structures in Santiago Canyon Road, as necessary to transport the 100-year storm (See Section 11.6 above).

Additional discussion of maintenance issues can be found in Section 17 – Technical Appendix A, OPERATION AND MAINTENANCE SPECIAL STRUCTURAL WATER QUALITY BMPS, and in EOPC Areas 2 and 3 ROMP, Volume 2, Surface Water Quality. Additionally, the Serrano Water District and the City of Orange will have the right, although they willit is not be obligated, to inspect and maintain the proposed extended detention basins and charge the HOA.