

ATTACHMENT C

Design Concepts and Hydrologic Analysis
Chatsworth Reservoir Wetland/Riparian Mitigation

**DESIGN CONCEPTS AND HYDROLOGIC ANALYSIS:
CHATSWORTH RESERVOIR WETLAND/RIPARIAN MITIGATION**

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The following analyzes the hydrologic feasibility of wetlands and riparian creation at the Chatsworth Reservoir site in support of the BFI, Inc. mitigation plan. The site is owned by the City of Los Angeles Department of Water and Power (LADWP) but is no longer used as a reservoir and has been designated a nature preserve by the City.

Design Features

The plan has two principal goals; creation of an expanded seasonal wetland surrounding an existing wetland, and the creation of additional riparian wetland areas. Expansion of the seasonal wetland would be accomplished by excavating to elevations similar to the existing wetland. New riparian wetland areas would be created through removal of approximately 500 feet of existing concrete channel and the expansion of stream zone below the confluence of Woolsey and Box Canyon creeks (see Plate 1 of mitigation plan) as described below. Riparian wetlands would also be expanded by increasing the width of Woolsey Canyon Creek and Box Canyon Creek at their confluence through selective grading along the streambanks. As will be described, the feasibility of wetlands creation is based on the existence of a shallow aquifer which responds seasonally to direct precipitation and runoff to bring the water table within the rooting zone of the target wetland and riparian species which are already found elsewhere on the site.

Expansion of the riparian area below the confluence would be accomplished by removing approximately 460 feet of existing levee which will connect the existing main drainage channel to the wetland basin immediately to the west. This main drainage is the last segment of a stormwater bypass system prior to the point where it enters a tunnel. This connection will allow the combined flows from Woolsey, Box, and the existing concrete channel entering from the east to split between the existing channel and a new, wide channel leading into the wetland basin. Grade control sills will be set at the existing channel bottom elevation on the existing channel, and at 0.3 feet higher on the new “overflow” channel. Thus, low flows will continue down the existing channel, but, once the depth of flow exceeds 0.3 feet, flows will begin to split between the two channels.

The creation of this riparian wash, which exceeds 300 feet wide at its maximum, is a particularly appealing aspect of the project since it conforms to the overall geomorphic setting of the landscape. The sandstone bedrock, often exposed in the watershed, largely degrades directly to sand, such that the alluvium at the base of the hills is extremely permeable. Both Woolsey and Box Canyon Creeks appear to be rapidly “losing” streams as they enter onto the property, indicating that surface runoff is infiltrating through the streambed. Evidence for this trend is the development of riparian vegetation on the lower banks and sometimes on the channel bottom itself.

The above condition gives rise to channels which tend to be aggradational and migrate laterally as they no longer have the energy sufficient to continue to transport their sediment load as flows diminish in a downstream direction. On larger systems, these creeks would tend to have a braided channel form. Here, because flows are ephemeral, the channels will tend to migrate laterally in a discontinuous fashion in response to major floods. Although it may be counter-intuitive, the tendency of the channels to migrate at what might be described as the geomorphic equivalent of the terminal end of an alluvial fan provides for a condition under which riparian vegetation can not only establish through plantings, but also can sustain itself in the future as the channels create local scour and deposition, resulting in new surfaces which can be naturally colonized by riparian vegetation. In essence, the proposed concept is a restoration of not just riparian habitat, but also a restoration of geomorphic processes which will allow for sufficient dynamism to sustain and revitalize it in perpetuity.

As can be seen on Plate 1, the grading will consist of very gentle, but varying gradients so as both to mimic the existing topography and to provide a range of soil moisture gradients. In most cases, the created slopes range from 5:1-7:1 around the periphery of the created wetlands. In some cases they are steeper where they converge onto existing steeper topography, or where they were steepened up to a maximum of 4:1 in order to maximize the width of channel bottom created through removal of the existing concrete channel.

All of the area within the wetland basin will have topsoil salvaged to a depth of three inches. Topsoil will be stockpiled and then reapplied so as to more closely replicate a natural soil profile. This is particularly important within the transition between the existing uplands and created wetlands, where the intent is to fully reestablish the existing upland vegetation.

In addition to the flow split described above, there are two other design features which are important to the function of the wetland. Below the area of levee removal, a 120 foot wide channel will be created to convey runoff into the wetland basin. The channel gradient is .022, which is relatively steep, although steeper gradients exist currently in Box Canyon Creek within the project area. As a safeguard against incision, the new channel will have a series of 5 loose rock grade control sills. The sills will be covered with up to 0.5 feet of soil such that they will be not be visible. However, should very high flows be experienced prior to the channel being colonized by woody riparian vegetation, the sills will resist incision, but at the same time, should some incision occur, they will tend to armor the channel surface downstream with cobbles and rocks eroded out of the sills. As a result, any incision response becomes self-limiting.

Another important feature is the grade control established within the wetland basin. Currently, runoff entering from the basin enters two 36-inch culverts which convey this runoff into the forebay of the drainage tunnel at the terminus of the existing main drainage channel. These culverts were set substantially below the existing grade, and there has been a minor headcutting response. With the potential addition of substantial additional runoff, there will be more events which could further gully development into the wetland basin, potentially threatening both the existing and created wetlands. A berm and overflow apron will be installed to prevent any further headcutting. The elevation of the top of this grade control will be set at elevation 870.7. This elevation will cause inundation of all areas within the basin which are lower than this elevation. Although the hydrologic justification for

wetlands creation is based on a near-surface water table, allowing runoff from the watersheds to the north, bringing a total of 2,089 acres of additional drainage area, could potentially result in routine, reliable inundation as long as flow depths in excess of 0.3 feet deep in the existing channel occur sporadically each year. It is also possible that more routine and extensive inundation will result through installation of the grade control simply because runoff generated in the wetland basin's watershed will no longer be able to freely drain out of the basin.

The height of the grade control berm can also be easily adjusted by several inches if monitoring indicates that such an adjustment would increase habitat values.

Hydrologic Setting

Bedrock exposures are common both along the southern edge of the Chatsworth reservoir site, and in the hills to the north, where the exposures predominate the landscape. The geomorphic setting can be described as a depressional area formed through faulting between two sets of ridges, with the northerly ridge being of far greater height. The created basin then filled with alluvium. Overall, the depth of alluvium is shallow, and, at its maximum is described as 120 feet thick (LADWP, Chatsworth Reservoir and Dams Geologic Report, undated). There appear to be limited opportunities for groundwater to exit this basin at depth, via seepage through the faults or other bedrock cracks. This condition has given rise to a relatively shallow, persistent water table over much of the site as documented through geologic and groundwater investigations (LADWP 1969, Essentia 2004).

Because of the highly permeable sandy soils, runoff can occur as overland flow or flow within a stream channel, or, more commonly, it can be in the form of water which leaves a given site by percolating vertically to a water table or flowing laterally under the surface along bedrock contacts (a sloped water table). These latter two processes predominate during dry years and during the fall and winter of normal and dry years. However, as seasonal recharge of the shallow aquifer continues, the water table rises, and the water table hydraulic gradients toward low points in the landscape, i.e., the drainages, increases. As this process continues, at some point, the water table rises to intersect the surface within the drainage bottoms, and the watershed becomes ever more efficient at converting rainfall to surface runoff as available storage within the alluvium is exhausted.

This geologic setting provides for a much dampened hydrologic response to storms, in spite of its appearance from the visible rock exposures on the hillslopes. Intense storms, particularly early in the rainy season generate little or no surface runoff on the site, and even though the rocky hills to the north may produce overland flow on the rock itself, the runoff is rapidly infiltrated into the highly permeable alluvium at the base of the slopes and within the drainage channels. Thus, despite the initial appearance of being a flashy watershed, the highly permeable alluvium greatly dampens streamflow response to storms.

As the water table rises in response to incident rainfall and groundwater recharge from the adjacent hills, the system becomes more reactive to rainfall, but it nonetheless tends to respond with a sizeable portion of the streamflow appearing as "baseflow" as water exfiltrates into the channels at the base of the northern hills. Overall, peak flows from the

watersheds entering the project area are greatly diminished over what would typically occur, and all three of the unlined channels entering the site get progressively smaller as they move away from the rocky foothills and streamflow originating there infiltrates the alluvium. The lack of well developed alluvial fans exiting the hills from Woolsey and Box Canyons attests to the facts that these watersheds do not produce large peak flows and that the sediment is largely easily transported sand, as opposed to larger materials which would tend to rapidly deposit as the drainage exits the hills.

While the above description is accurate overall, it greatly simplifies the geologic history of deposition in the project area. Weathering of the original bedrock has resulted in silts and clays at depth, and the age of the basin, along with shifting patterns of deposition has led to complex associations of newer alluvium eroding into older weathered deposits of silts and clays. In general, finer textured materials are more apt to be found in locations more isolated from geologically modern deposition, i.e., generally more prevalent along the southern edge of the site and away from the predominant drainages. More recent, coarser alluvium will tend to be found farther to the north, closer to the hills and at locations nearer the drainages exiting from them.

Seasonal Wetland Creation Feasibility

The existing seasonal wetlands within the basin currently receive no hydrologic support from Woolsey Canyon Creek, Box Canyon Creek or the perimeter drain which extends eastward. Instead, they are supported by incident precipitation and runoff from an approximately 192-acre watershed. The area has a shallow water table which then rises in response to precipitation during the winter, providing sufficient saturation to support seasonal wetland vegetation. A small drainage enters from the west and terminates within the area proposed for wetland expansion. A sizeable portion of this drainage is urbanized, such that some inputs from landscape irrigation runoff provide an additional hydrologic input. Because of the prevalent sandy surface soils surrounding the area, it is expected that much of the water yielded from the watershed is transported to the wetland via subsurface lateral flow, rather than sheet flow or surface flows in the channel. Certainly, however, during large storms, runoff is delivered via the channel. The following discussion examines the three sources for hydrologic support of created wetlands; direct precipitation, runoff, and groundwater.

Direct Precipitation

Table 1 shows the on-site monthly water balance based on mean monthly precipitation from the Chatsworth FC24F weather station, located approximately 2-3 miles northeast of the site (National Oceanic and Atmospheric Administration Database). The Chatsworth station has 40 years of available data, but was discontinued in 1988. The average annual precipitation there is 15.4 inches. Potential Evapotranspiration (PET), which is the amount of water which can be either evaporated from a lake or pond, or transpired by vegetation when there is no restriction in soil moisture, is based on values published for San Fernando (University of California, 1987).

Table 1. Seasonal Water Balance.

Month	Precipitation (inches)	PET (inches)	Balance (inches)
November	2.39	2.60	-0.61
December	2.13	2.1.95	+0.18
January	3.12	1.95	+1.17
February	2.85	2.62	+0.20
March	2.61	3.54	-0.93
April	1.21	4.61	-3.40

Table 1 shows that rainfall exceeds the maximum amount of water use by vegetation only during the months of December through February, on average. The cumulative total water balance is 1.55 inches. This is the amount of water in excess of that needed to support unrestricted transpiration. That water is first used to replenish soil moisture lost over the previous summer and fall. Once the amount of water in the rooting zone exceeds the maximum amount capable of being held by capillary forces (field capacity), then the water can percolate downward. In rare instances during heavy storms, particularly where the soils are shallow over bedrock or over a shallow water table, the soil profile may become saturated to the surface, thereby resulting in overland flow.

From a monthly water balance perspective, the 1.55 inches of seasonal water “excess” would be exhausted replenishing soil moisture. Since the surface soils are sandy, the 1.55 inches would raise the soil water content from the wilting point to field capacity for a 22 inch thick soil column, which is the approximate depth of seasonal soil drying. Additional water would be needed to completely saturate the soil to the surface. In practice, rainfall is not uniformly distributed, such that individual storms can replenish soil moisture and allow for some percolation or runoff. Nonetheless, the water balance indicates that direct precipitation is generally insufficient to create wetlands, except in a vernal pool type of setting where there is a thin layer of soil overlying an essentially impermeable hardpan or claypan.

Runoff

In addition to the 192 watershed which currently supports the basin, a portion of stormflows from Woolsey, Box Canyon, and other drainages to the east, totaling approximately 2,090 acres, will now be tributary to the proposed expanded wetland.

Table 2 below gives a range of water yield estimates from gauged basins with periods of record in excess of 20 years which are believed to bracket the actual water yield from the contributing watershed. The watershed extends from 870 feet in the existing wetland to 2,314 feet on Chatsworth Peak. Rainfall increases with elevation due to orographic influences. For example, the mean annual precipitation at Big Tujunga Dam, at elevation 2,317 feet, based on 52 years of record, is 25.86 inches. It is reasonable to assume that rainfall at the top of the watershed approximates this amount, such that it ranges from 15.4 to 25 inches.

Table 2. Annual Water Yield From Representative Gauged Basins.

Stream	Mean Annual Water Yield (Area-inches)
Castaic Creek Above Fish Creek Near Castaic	1.46
Pacoima Creek Near San Fernando	1.37
Little Tujunga Creek Near San Fernando	0.83
Rio Hondo Near Montebello	0.015

The true average annual water yield from the tributary watershed area is unknown. However, it is conservatively estimated to be 0.5 area-inches/year. Given that the total area which will be made tributary to the expanded wetland area is approximately 2,200 acres, the average water yield based on 0.5 area-inches would be equivalent to 92 acre feet of water. As was described in the hydrologic setting, most of this water reaches the site in the form of migrating groundwater. A water yield of 92 acre feet would be sufficient to support a 21 acre perennial marsh. Of course, water yield exhibits large year-to-year variation. Nonetheless, the water yield from the concrete lined perimeter drain entering from the east,, Box Canyon and Woolsey Canyon is far more than is required to support the ** new acres of wetland proposed to be created.

An additional, and probably increasing source, of inflow to the site comes in the form of landscape irrigation runoff. Most of the residences within the watershed have at least some level of landscaping which requires irrigation. It is reasonable to expect that the sandy surface soils readily percolate irrigation water, which then, in turn, percolates downslope along bedrock contacts, discharging into stream channels or into the alluvium at the base of the hills. Water was present in the upper portion of Box Canyon Creek on the site on February 16, 2006, in spite of the fact that there had been no rainfall for weeks prior to that date. During a site visit in October, 2005, there was landscape irrigation runoff flowing a short distance onto the site in the western-most drainage, which terminates in the expanded wetland area.

Although some of the water yield exits the site as streamflow, this only tends to occur once seasonal recharge of the water table is complete.

Groundwater

Rainfall is obviously the ultimate source of groundwater on the site, with most of the groundwater being generated in the adjacent rocky hills to the north and then either migrating along sloping bedrock contracts to the site, or being carried to the site as streamflow and then infiltrating into the alluvium until the alluvium is saturated to the elevation of the channel bottom, at which point further runoff entering the site simply runs through it.

Table 3 below gives the depth of water below the surface for shallow monitoring wells installed within the mitigation planning area in late September 2005 (see Plate *). Water levels were noted at the time of installation and then routine weekly monitoring was initiated on February 22, 2006.

Table 3: Chatsworth Groundwater Levels (feet below ground surface).

Well #	Monitoring Date						
	Sept 28 2005	Feb 22,2006	Mar 27 2006	Apr 10 2006	Apr 24 2006	May 15 2006	May 29 2006
1	4.00	3.25	2.84	2.02	2.47	2.77	3.12
2	3.62	2.63	2.40	1.70	2.00	2.40	2.20
3	Dry	4.01	3.15	1.53	2.93	3.73	3.73
4	5.25	2.99	1.43	0.44	1.64	2.59	1.70
5	4.17	2.56	2.02	0.67	1.92	2.62	2.52
6	Dry	2.63	1.89	0.35	1.60	2.55	2.65
7	Dry	4.91	4.05	1.35	3.35	4.50	4.90
8	Dry	4.19	2.02	0.03	1.77	2.47	2.57
9	4.17	2.36	1.86	0.21	1.76	2.31	2.41
10	7.17	2.86	1.17	0.10	1.96	2.60	2.60
11	2.33	1.44	0.80	0.16	0.76	1.61	1.21
12	4.00	2.47	1.72	0.07	1.62	2.22	2.22
13	3.50	2.48	1.82	0.07	1.68	2.43	2.28
14	Dry	2.80	1.50	0.30	2.20	2.85	2.25
15	4.00	2.38	1.98	0.59	1.89	2.54	2.45
16	6.75	3.11	2.86	1.05	2.42	2.82	3.17
17	3.25	1.83	0.19	0.10	0.65	1.60	2.05
18	Dry	Dry	Dry	4.55	5.40	Dry	Dry
19	Dry	3.82	3.67	2.40	3.05	3.40	3.40
28	Dry	6.05	5.03	3.09	3.44	3.99	4.10

Precipitation over the 2006 rainy season has been drier than normal. From Table 1, the normal precipitation at Chatsworth from November through March is 14.31 inches. Although the Chatsworth weather station was discontinued in 1988, the Susana Knolls fire station on Valley Circle Boulevard, adjacent to the site, has initiated precipitation measurements. Total precipitation from November, 2005 through March, 2006 (the latest data available) is 10.32 inches. Precipitation data for April was available from Pierce College, approximately 5 miles south of the site. April precipitation there was 2.48 inches, bringing the estimated November-April total to 12.8 inches, compared to the assumed normal for the site of 14.31 inches. Overall, rainfall was slightly drier than normal during the 2006 rainy season.

As shown on Table 3, groundwater levels rose from what was probably their seasonal low in September, 2005 to a high on April 10, 2006. This correlates with the occurrence of the last significant storm of the season on April 3-6. Since that date, groundwater levels have been dropping, in response to a lack of additional rainfall, and removal from the soil by vegetation. Water levels will continue to drop in response to further transpirational demand and through discharge out of the aquifer through seepage through bedrock cracks and

migration through the alluvium downslope in locations where the bedrock on the southern edge of the site does not extend to the same elevation as the water table. Because most of the vegetation on the site consists of annuals, transpirational demand tends to approach zero past June, and water tables below depths of about four feet are no longer subject to seasonal drawdown. Transpiration by deeper rooted trees, and discharge out of the aquifer account for lowering of the water table during the summer and fall.

It is not known to what degree the water table fluctuates in response to multi-year wet and dry cycles. The September, 2005 readings clearly show the presence of a near-surface water table, yet a series of drier years could conceivably result in lowered water tables that could affect wetland performance. However, the presence of long-established wetlands within the lowest elevations of the basin indicates otherwise. The presence of existing wetlands is the strongest evidence that the site fully supports wetlands which can persist through dry cycles.

Normally, the expectation is that conversion from upland to wetland would require additional water for transpiration by wetland vegetation. In this case, however, the transpirational demand is expected to be approximately the same as the annual grasses which currently occupy the site. In general, the annual wetland species on the site produce about the same, and, in many cases less, biomass than the annual upland grasses, such that total transpirational demand with respect to annual upland versus annual wetlands species is not expected to increase significantly and may, in fact be slightly less.

However, the creation plan does call for planting woody riparian species which will increase consumptive use to some degree. This use cannot directly affect the annuals, since most of their transpiration occurs during February and March, prior to the onset of significant water use by woody riparian species, which occurs later in the season. Additional water use by trees could indirectly affect seasonal wetland vegetation by lowering the water table during the summer, resulting in a lower antecedent water level in the fall, thereby affecting next season's seasonal high water table. If all of the riparian plantings yielded a 100 percent canopy cover over 4 acres (representing approximately 20 percent of the area within the wetland basin, they would consume an additional 10 acre feet of water through transpiration during from April through September. This represents 11 percent of the average 92 acre feet of water yield from the watershed, which, as stated above, would support a 21 acre perennial marsh.

In addition to the minor increase in water use brought about through an increase in riparian vegetation, the overall hydrologic behavior of the site suggests that the alluvium is recharged to capacity reliably each year. During an April 11, 2006 site visit, there was approximately 0.5-1.0 cubic feet/second of streamflow exiting the site through the drainage tunnel. There was also some discharge through the culverts draining the basin. This flow occurred six days after the last storm and there was no apparent diminishment in flow between the confluence of Woolsey and Box Canyon Creeks, and the tunnel forebay. Thus, even during a year of slightly less than normal rainfall, the alluvium's storage capacity was at a maximum. This suggests that the water yield from the watershed exceeds the capability of the alluvium to store it, a further indication that the hydrology of the site can support the proposed wetland expansion.

Shallow excavation of the area surrounding the existing wetlands will allow for replication of the groundwater conditions that support them. The depth of excavation will generally range from 0-1.5 feet. Some deeper areas will have depths of excavation up to two feet. The water table tends to be parallel to the ground surface, which slopes gently toward the east. This condition allows for shallower excavation on the west side of the wetland than would be the case if the water table were horizontal and also indicates the tendency for groundwater to exfiltrate into the main channel on the eastern edge of the basin. For example, on April 10, 2006, the water level in Well 5, at the southwest corner of the wetland creation area, was at an elevation of 872.64 feet. In contrast, in Well 1, next to the drainage channel, the water table elevation was 869.39 feet. This sloping water table indicates a slow migration of groundwater from west to east across the site and accounts for the fact that there was a small amount of surface runoff exiting the basin in the southeast corner, despite the fact that there was no streamflow entering the site.

New Riparian/Woodland Creation Feasibility

Most of the discussion above is also pertinent to the new riparian wetlands proposed to be created through expansion of the riparian corridor along Woolsey and Box Canyon Creeks, along that portion of the eastern perimeter drain where the concrete lining will be removed, and in the new channel leading into the wetland basin.

The preceding section demonstrated that there is more than sufficient water yield from the watersheds to support deep rooted riparian species, and that such support may be enhanced to some degree by landscape irrigation in the surrounding hills, which may increase in the future.

Wells 18, 19, and 28, which are along the northern edge of the site all had water, albeit generally at increased depths than occurred in the wetland basin. Yet these water levels are extremely well suited for species such as willows, sycamores and oaks. These observations document the presence of groundwater in the northern portion of the project site, and the previous hydrologic analysis demonstrates there is more than adequate hydrologic support of additional riparian habitat.

The density of existing riparian habitat on the site is presently largely a function of channel morphology and a lack of frequency of large floods sufficient to result in channel avulsion which can create germination sites. Shallow excavation to expand the width of the lower end of Woolsey Canyon Creek, and the creation of broad new “wash” surfaces downstream will allow for a large increase in the area exposed to streamflow, and will also decrease the depth to the water table to mimic the conditions that currently exist in the main drainage channel below the confluence of Woolsey and Box Canyon Creeks. The combination of a decreased distance to the water table and exposure to scour and deposition processes will make for a site which fully replicates the natural geomorphic and hydrologic setting which woody riparian and riparian wetland species exploit.

Modifications in Flood Flow Routing

The principal wetland creation site was originally known as Detention Basin #1, when LADWP originally designed the stormwater bypass system to isolate the reservoir from

runoff (Chatsworth Reservoir Improvement Plans, Drawing Number D, April, 1969). The bypass system was designed for a 50-year recurrence interval storm. Detention Basin #1 served to reduce flow in the drainage channel from 4,200 cubic feet/second (cfs) to 3,000 cfs, in order to meet the constrained capacity of the Chatsworth Creek flood control channel, which had a capacity of 3,475 cfs at Roscoe Boulevard.

The original 1969 plans were not constructed as designed. Most notably, the terminus of the drainage channel empties into a tunnel, which conveys the flows through a bedrock hill to daylight on the south side of the hill, where a concrete channel conveys the flows to the property boundary. These modifications are shown on plans dated October, 1970 (Drawing number D4070-X-2). Originally, the drainage channel was designed to continue as an open channel by skirting around the western edge of the hill. On both sets of plans, a portion of the levee between the basin and the drainage channel is shown as an “overflow spillway” which would reduce the design peak flow in the channel from 4,200 cfs to 3,000 cfs.

The hydrologic design (LADWP, 1969) was exceptionally conservative in that it was based on the rationale formula where the watershed was subdivided into a very large number of small subbasins with short times of concentrations. This results in high precipitation intensities. The “c” factors used were also uniformly high, commonly 0.93 and higher. This treatment produces very high peak flows, and while the peak flows are routed through the channel system the methodology essentially assumes that the peak storm intensity of the storm occurs simultaneously throughout the entire 2,200 acre watershed. The advent of computer simulation models in the 1970s has since allowed for more realistic treatments wherein a hydrograph is generated on each land unit over the entire storm (as opposed to only calculation of the peak flow, and flows enter and are routed through the channel system using very small time steps.

The levee spillway shown on the plans which allowed water to overflow the levee separating the drainage channel from the basin was never constructed. The top of the levee is at an elevation of approximately 888 feet over nearly its entire length, except for final 300 feet, which is much lower, at an elevation of 876 feet. This elevation is only about 2.5 feet higher than the grade control sill at the tunnel forebay. Using WINXSPRO (U.S. Forest Service 2005) Manning’s equation at a cross-section was solve, with a roughness coefficient of 0.047 gives a flow rate of 195 cfs. As a result, rather than spilling over the levee at the stage where flows in the channel would be approaching 3,000 cfs, flows from the channel spill into the basin once the flow rate exceeds approximately 200 cfs. Flows would continue to flow into the basin until water filled the basin to the height of the lowered section of the levee, at which point approximately 170 acre feet of water would be in the basin. After that point the water surface in the creek and in the basin coalesce, and the hydraulics more closely resemble routing flows through a reservoir.

As proposed, removal of a portion of the levee above the northern end of the basin would allow higher flows to split between the existing main drainage channel and the new channel conveying flows into the wetland basin. Once the wetland basin fills to the same elevation as the lower portion of the levee, at 876 feet, then, if water in the channel is lower than 2.5 feet, water from the basin will flow over the low portion of the levee back into the main drainage channel. If flows in the main channel are higher than approximately 2.5 feet deep,

then channel flow will continue to pass over the levee, again until the water surfaces equalize.

During large floods assuming that flows in the drainage channel are in excess of approximately 3.5 feet deep, then the depth of water in the basin will continue to rise to an elevation of 877 feet. At that point the water surface in the basin will have risen to the point to submerge the entrance to the new channel at the northern end of the basin, such that there is no longer active “spilling” into the basin. Instead flow routing is performed as through a reservoir in which case the hydrograph is dampened through the storage effects of the basin. Thus, as the system currently operates, there will be no difference in peak flow rates entering the tunnel forebay during major floods when the depth of water in the basin would exceed approximately six feet.

It is not known why the original levee overflow weir was not constructed, but it may have been in recognition that peak flows are probably far less than were originally computed. For example, rather than the confluence of Woolsey and Box Canyon creeks merging into the 70-foot wide main drainage channel, instead, a service road crosses the confluence which is equipped with a 48-inch diameter smooth steel pipe. The pipe appears to have been in place for decades, perhaps, even shortly after completion of the bypass system. The 50-year design flow at this location was computed to be 3,200 cfs. However, with two feet of head over the top of the pipe (equivalent to the road surface), the pipe has a flow capacity of approximately 120 cfs.

The floods of the 2005 water year provided realistic estimates of the flood generating capability of the watersheds. Unfortunately, the lack of available 15-minute precipitation data prevented a rigorous approach in attempting to classify the storms with respect to their recurrence interval. However, two other methods were used to place the original design flow estimates into context.

Daily precipitation records were available from both the Susana Knolls fire station on Valley Circle Boulevard adjacent to the site, and at Sage Ranch station near the top of Woolsey Canyon. For the 2005 water year, both stations had recorded nearly the same amount, 42.71 inches for Sage Ranch, and 42.61 at Susana Knolls. Although the Chatsworth precipitation gauge was discontinued in 1988, 42.61 inches exceeds the maximum yearly total ever recorded there over the 40 years it was in operation. During the 2005 water year several major storms occurred and, of course, daily precipitation records do not adequately represent the duration and intensity of the storms. Table 4 shows the three highest daily totals.

Table 4: Daily Total Precipitation Extremes, 2005 Water Year.

Date	Daily Total Precipitation (inches)	
	Susana Knolls	Sage Ranch
December 28, 2004	3.81	3.87
January 10, 2005	2.65	3.03
February 21, 2005	3.60	2.91

A reconnaissance was performed of the channels during October, 2005 prior to the fire which burned much of the site. High water marks consisting of debris lines and flood formed bars were observed in all four channels (Woolsey Canyon, Box Canyon, the concrete lined eastern bypass channel, and the channel entering from the west that empties into the wetland basin). Cross sections and high water marks were flagged in preparation for surveys. Unfortunately, the fire entered the site at the end of the same day, which eliminated most of the debris lines. Nonetheless, based on recollections of the initial reconnaissance, the sites were reflagged and surveyed. For both Woolsey Canyon and the concrete portion of the bypass channel, 2005 high water marks were still available. For the remaining channels the high water mark was estimated based on examination of scour lines and deposition.

Most peak flow estimates were made using WINXSPRO (U.S. Forest Service 2005) which solves Manning's equation at a cross-section. The terminus of Woolsey Canyon channel is equipped with a 3-foot diameter culvert. Peak flow there was estimated using a standard culvert formula along with an observation of the high water mark upstream of the culvert. Table 5 gives the results of the analysis. In some cases, more than one peak flow estimate per channel was computed.

Table 5: Peak Flow Estimates, 2005 Water Year.

Location	Discharge (cubic feet/second)
Woolsey Canyon, Site 1	26
Woolsey Canyon @ Culvert	46
Box Canyon, Site 1	34
Box Canyon, Site 2	30
Eastern Concrete Bypass	9
Wetlands Basin Tributary, Site 1	18
Wetlands Basin Tributary, Site 2	5

Using the highest flow estimate for each channel, the total flow converging into the main drainage channel is 89 cfs. While the recurrence interval of the storms listed above is not known, it appears that, in any case, the 2005 water year was one of the wettest within the last 50 years. The computed 50-year flood estimate in the main drainage channel was 4,200 cfs. The very large difference between the 2005 peak and the 4,200 cfs design flow suggests that the channel design was indeed very conservative.

Another comparison is available using the U.S. Geological Survey regional equations, developed using flood frequency analysis on hundreds of gauging stations and crest stage gauges throughout California (U.S. Geological Survey, 1977). Using the equation developed for the south coastal region, the estimated 50-year flood is 1,000 cfs based on an assumed annual mean basin precipitation of 20 inches. Although the regional equation does not

specifically account for the effects of residential development in the watershed, neither does it exclude such effects since gauged basins in the vicinity had various levels of urbanization.

All of the above discussion points to the fact that while there will be some modification in the routing of high flows, that; 1) actual flood flows appear to be far less than originally estimated and, 2) flow routing differences are limited to smaller flood peaks where the total depth of water in the basin is less than approximately 6 feet deep. During larger floods, when the depth of water in the basin is greater (the water surface elevation exceeds 877 feet) the existing lowered portion of the levee allows for equalized water surface elevations in the basin and the main drainage channel, which, in turn, leads to backwater at the head of the proposed new channel leading into the wetland basin.

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