

FINAL
Drainage Feasibility Study
Volume I (Hydrology & Hydraulics
Component)

Community of Rimforest
County of San Bernardino, CA

Prepared For:



San Bernardino County Department of Public Works
Flood Control District
825 East Third Street
San Bernardino, CA 92415
Phone: (909) 387-7918
Fax: (909) 387-8130

November 8, 2010



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JOSEPH E.
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November 8, 2010





November 8, 2010

Re: Rimforest Drainage Feasibility Study

Executive Summary

Over the last several decades, the southern portion of the community of Rimforest has experienced significant erosion of property that has been a substantial concern to the community. The County of San Bernardino engaged the services of our firm through a Request for Proposal (RFP) to examine the erosion and discuss potential remedies to the problem.

Our study confirms that the erosion is the result of several contributing factors. Amongst them are the geology of the mountains, earthquakes, surface waters, and subsurface waters. The study also revealed a previously unknown, potentially active earthquake fault.

Similar to all earthquake faults, the extent of movement along the fault and onset of quake activity is almost totally unpredictable with the science and instruments currently available to us. Also, without further studies, it is not known if there is any reasonable measure that could be taken to decrease the amount of subsurface water in the area. It is possible that these contributing factors could cause further erosion even in the absence of surface water.

Based on past topographic maps, there was a drainage area that historically flowed southerly near the current alignment of Blackfoot Trail West. During development of the Rimforest community, two storm drain catch basins and pipes were installed on Apache Trail to direct that surface water off the road and over the cliff.

The proposed plan of action addresses the possibility of minimizing the amount of surface water reaching the southern portion of Rimforest. The potential action is to install a trench, pipes and a lift station (indicated as Option 1 in the study) to intercept the majority of the surface water, thereby diverting such water away from the southern portion of the community. This plan would require the expenditure of substantial funds and have to meet environmental and jurisdictional reviews. While we believe that the plan will help slow the rate of failure along the cliff, it will not stop every eventual failure.

Sincerely,

Joseph E. Bonadiman & Associates, Inc.

Joseph S.C. Bonadiman, P.E.
C.E.O.



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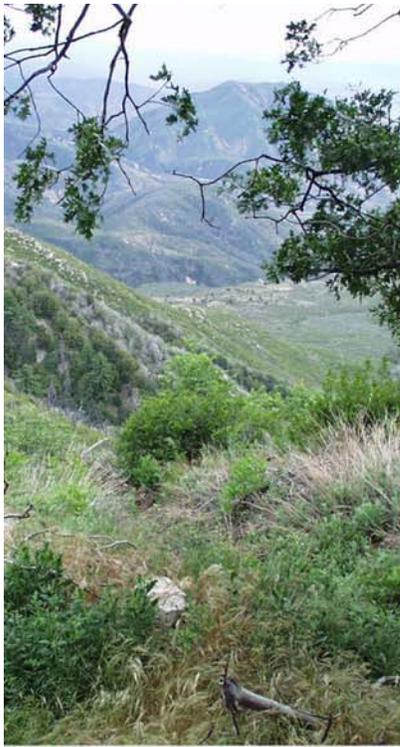
III. ATTACHMENTS

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Exhibits

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Project Watershed – USGS Quadrangle Map	"A"
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Applicable Isohyetal Maps	"C"
Applicable Soils Groups Map	"D"
Watershed Division Exhibit	"E"
Hydrology/Hydraulics Study Map – Proposed Options 1 & 2	"F"
Water Surface Pressure Gradient (WSPG) Analysis Exhibits	"G"





Attachments

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FINAL Rimforest Drainage Feasibility Study

1.1 Summary

Drainage Options

The village of Rimforest has eroding cliff-side property and bluff retreat in the Southern part of the village. This problem is primarily caused by storm runoff from either rainstorms or snowmelt after winter storms. The runoff flows to the south side of Rimforest and is discharged over the cliff at two principal locations. This study report evaluated a number of options to re-direct the majority of the runoff to other discharge locations for the purpose of reducing and mostly eliminating the cliff-side erosion. Two options presented in this study appear to be feasible if new conventional storm drain systems are installed.

The improved drainage options only differ in the runoff discharge locations:

Option Number 1 would divert the runoff into Little Bear Creek, which flows through Blue Jay and into Lake Arrowhead (Mojave Watershed).

Option Number 2 would divert the runoff southerly into a canyon east of Rimforest and south of Highway 18. This is shown on the USGS map as the blue line stream immediately east of a trail marked Daley Road, which joins City Creek two miles south of Highway 18. The blue line stream will be referred to as is named "West Fork City Creek" in the remainder of this report.

Both options consist of **3 phases** of construction:

Phase 1 would be to intercept the largest part of the runoff from north of Highway 18 of 51 Acres (64% Reduction)

Phase 2 would be to drain runoff from 16 acres of the interior part of Rimforest (30% Reduction).

Phase 3 would be to install a lift pump station to drain an additional 4 acres nearby the southern most discharge point at Apache Trail and Blackfoot Trail West (5% Reduction).

Both options require construction of storm drain systems along Highway 18 and inside the village of Rimforest. Option 1 would require construction of retarding basin(s) to avert runoff damage to Blue Jay and structures along Little Bear Creek. Option 2 would discharge runoff through a weir outlet structure into West Fork City Creek and require permission from the U.S. Forest Service. Option 2 would cause erosion at and below the discharge point, however no structures would be affected. The flow would cross the existing Daley trail approximately 1,000 feet below the discharge point.

Option 1 would divert approximately 47 Acre-Feet per year from the Santa Ana River watershed to the Mojave basin watershed, requiring some negotiation on water rights issues. Option 2 would divert runoff from the Strawberry Creek watershed into the West Fork City Creek watershed. It appears that water rights would not be an issue with Option 2 since both creeks ultimately lead to the Santa Ana River, where all



water rights are claimed by the San Bernardino Valley Municipal Water District.

Options	Estimated Cost	Percent Runoff Reduction
Option 1 – Drain into Little Bear Creek -Phase 1	\$2,836,199	64%
Option 1 – Phase 2	\$908,822	30%
Option 1 – Phase 3	\$241,643	5%
Option 1 Total	\$3,986,664	99%
Option 2 – Drain to West Fork City Creek Phase 1	\$2,424,556	64%
Option 2 – Phase 2 (Same Scope as Option 1 – Phase 2)	\$908,822	30%
Option 2 – Phase 3 (Same Scope as Option 1 – Phase 3)	\$241,643	5%
Option 2 Total	\$3,575,021	99%

Geological/Geotechnical Summary:

The Report of Geological Investigation and Feasibility Evaluation of Proposed Mitigation Procedures (Geological Report) revised January 2010 and prepared by Hilltop Geotechnical, Inc. makes the following recommendations with respect to the aforementioned Options 1 and 2:

Option 1

Page 56 of the Geological Report states “From a geotechnical / geologic stand point, construction of the proposed three (3) basins should not present any adverse condition on the Church of the Woods and/or the adjoining properties. However, additional geotechnical / geologic studies should be performed on the Church of the Woods property to properly design the retention basin facilities. Additionally, as part of the future investigation, more information with respect to actual groundwater depths, groundwater flow direction, and groundwater gradient should be determined to further evaluate the potential impact of developing the basin system with respect to slope conditions south and east of the town of Rimforest. At this time, it is assumed that the groundwater gradient follows existing drainage and is towards the north. However, prior to development of this property, this condition should be verified by future studies.”

Option 2

Page 58 of the Geological Report states that “Because of the high probability that runoff redirected to flow along the base of the subject slope would destabilize the slope, and because of the potentially serious consequences of triggering a new retrogressing landslide area, Option 2 is not considered to be feasible from a geotechnical standpoint.”

Therefore, pursuant to the Geological Report, only Option 1 is found to be viable from a geotechnical standpoint.



Environmental Summary:

The Environmental Determination found in Section 3 of the Drainage Feasibility Study (Environmental Report) revised January 2010 and prepared by Michael Brandman Associates states the following regarding Options 1 and 2:

“Development of **Option 2** will create significant impacts associated with erosion at the toe of slope immediately east of Rimforest. Because of the high probability that runoff redirected to flow along the base of the subject slope would destabilize the slope, and because of the potentially serious consequences of triggering a new retrogressing landslide area, Option 2 is not considered to be feasible from a geotechnical standpoint. Thus, pursuance of Option 2 may potentially elicit analysis of the potentially significant impacts within an Environmental Impact Analysis (EIR).”

“However, the slope stability evaluations for **Option 1**, from both a soil and rock perspective, indicated that nearly all of the analyses show current conditions below today’s standards (>1.1 F.S.) and with implementation of the Geotechnical Report’s recommendations, impacts are reduced to less than significant levels. Thus, pursuance of Option 1 may potentially elicit analysis of the potentially significant impacts within an Initial Study Mitigated Negative Declaration (IS/MND). Consequently, based on this feasibility study prepared for the proposed project, Option 1 is the preferred alternative.”

Therefore, pursuant to the Environmental Report, Option 1 is the preferred alternative from an environmental impact standpoint.



1.2 References

The following documents have been made a part of this Study by reference:

Report of Geological Investigation & Feasibility Evaluation of Proposed Mitigation Procedures for Active Landslide Community of Rimforest, revised January 2010, prepared by Hilltop Geotechnical, Inc.

Drainage Feasibility Study, revised January 2010, prepared by Michael Brandman Associates.



1.3 Overview

The purpose of the following Drainage Feasibility Study is to investigate storm drain improvements with the potential to stop or significantly reduce runoff over the cliff(s) in the south side of Rimforest village. This will assist in reducing the slow erosion of the cliffs, which has caused the loss of property in the past. In addition, reduction of runoff will lessen infiltration into the underlying soil of Rimforest and thereby reduce soil saturation and pore pressure, which may contribute to the erosion and loss of cliff side property. Refer to Exhibit "A" for a USGS Quadrangle of the project watershed location; refer to Exhibit "B" for an Aerial Orthophoto/Site Photos for the project. The following view shows the existing cliff erosion problem:

Photo No. 1 – Aerial View of Rimforest Community (Source: Google Earth)





1.4 Discussion - Existing Drainage Conditions

Currently, runoff from 51 acres of the area north of Highway 18 crosses the highway and enters Rimforest Village. The largest crossing point with approximately 30 acres of offsite runoff is shown in the following picture:

Photo No. 2 – State Highway 18 Crossing Location (Source: Field Investigation)



The runoff of the property flows into a Nursery south of Highway 18, then south to Pine Avenue, then easterly to a low point on Pine Avenue (see next page):



Photo No. 3 – Highway 18 Crossing Point (Source: Field Investigation)



Photo No. 4 – Existing Nursery & Pipe (Source: Field Investigation)





Three additional culverts direct the runoff from north of Highway 18 under the road and into Rimforest village. The following picture shows the westerly crossing where a “mountain inlet” is installed to capture runoff for a crossing pipe into Rimforest Village:

Photo No. 5 – Westerly Crossing/“Mountain Inlet” (Source: Field Investigation)



Most of the off-site runoff and some of the on-site runoff flows to the easterly portion of Pine Avenue and Blackfoot Trail:

Photo No. 6 – Pine Avenue & Blackfoot Trail (Source: Field Investigation)





At the intersection of Pine Street and Blackfoot Trail, a drainage ditch, street inlet, and parking lot drain pipe have been installed to carry the flow to the main drainage ditch and discharge point into Strawberry Creek. According to the San Bernardino County Flood Control Hydrology Report, the peak flow rate at this intersection for a 100-year storm event is 265 CFS. The following pictures show the drainage pipes are woefully undersized. In talking to Mr. Butch Baumann, owner of the Lumber Yard on Pine Street, the ponding depth at this intersection is 3 – 4 feet during heavy rainstorms.

Photos No. 7 & 8 – Pine Avenue & Blackfoot Trail Drainage Pipes (Source: Field Investigation)





The following pictures show the largest drainage channel outlet from Rimforest into the headwater of Strawberry Creek. Approximately 68 acres are tributary to this outlet.

Photo No. 9 – Drainage Channel Outlet to Strawberry Creek (Source: Field Investigation)





View over the cliff from channel:

Photo No. 10 – Drainage Channel Outlet to Strawberry Creek – Cliff View (Source: Field Investigation)



Looking at the residence immediately west of this outlet:

Photo No. 11 – Cliff View of Residence West of Outlet (Source: Field Investigation)





This is the smaller channel outlet from a drainage area of approximately 9 acres from the western part of Rimforest at the intersection of Apache Trail and Blackfoot Trail West.

Photo No. 12 – Smaller Channel Outlet (Source: Field Investigation)



A mountain type inlet collects runoff for this pipe outlet:

Photo No. 13 – Small Drainage Channel Inlet (Source: Field Investigation)





Noting the lack of vegetation the smaller drainage area appears to be causing greater damage to the cliff side property:

Photos No. 14 & 15 – Drainage Discharge Location (Source: Field Investigation)





1.5 Discussion – Drainage Mitigation Options

To reduce the runoff over the cliff(s), the runoff must be diverted to another path. This new path could be either to the Santa Ana watershed by construction of a channel to carry the runoff to the east of Rimforest and then southerly to West Fork City creek, or, construct drainage channel(s) to divert the runoff into Little Bear Creek. This diversion of flow has two major impacting factors to be considered. The first consideration is that the increased runoff and greater flow rate will affect the new downstream channels. The second is the diversion will change Water Rights to the existing runoff pattern.

The increased flow rate impact to Little Bear Creek cannot be handled by the existing Little Bear Creek drainage system. This could be alleviated by either the installation of a retarding basin system, or enlargement of the Little Bear Creek storm drain system. The increased flow rate impact to West Fork City Creek would cause increased erosion at the discharge point with unknown effect. This could be reduced by selection of the discharge point and outlet structure.

If the Little Bear Creek diversion option is selected, the 100-Year storm event peak flow rate will increase from the existing 167 CFS to 470 CFS. The existing downstream channel system is inadequate. As shown in the following pictures, the first storm drain below Rimforest in Little Bear Creek is the San Bernardino County Blue Jay maintenance yard where a three-foot diameter pipe is expected to carry all of the flow. A Jersey barrier and dirt mound helps control the existing flow:

Photo No. 16 – Jersey Barrier & Dirt Mound (Source: Field Investigation)





Photo No. 17 – San Bernardino County Blue Jay Maintenance Yard (Source: Field Investigation)



Flow in excess of channel capacity will drain through the maintenance yard and flood existing streets. There are numerous cabins and structures downstream of this yard and nearby Little Bear Creek.

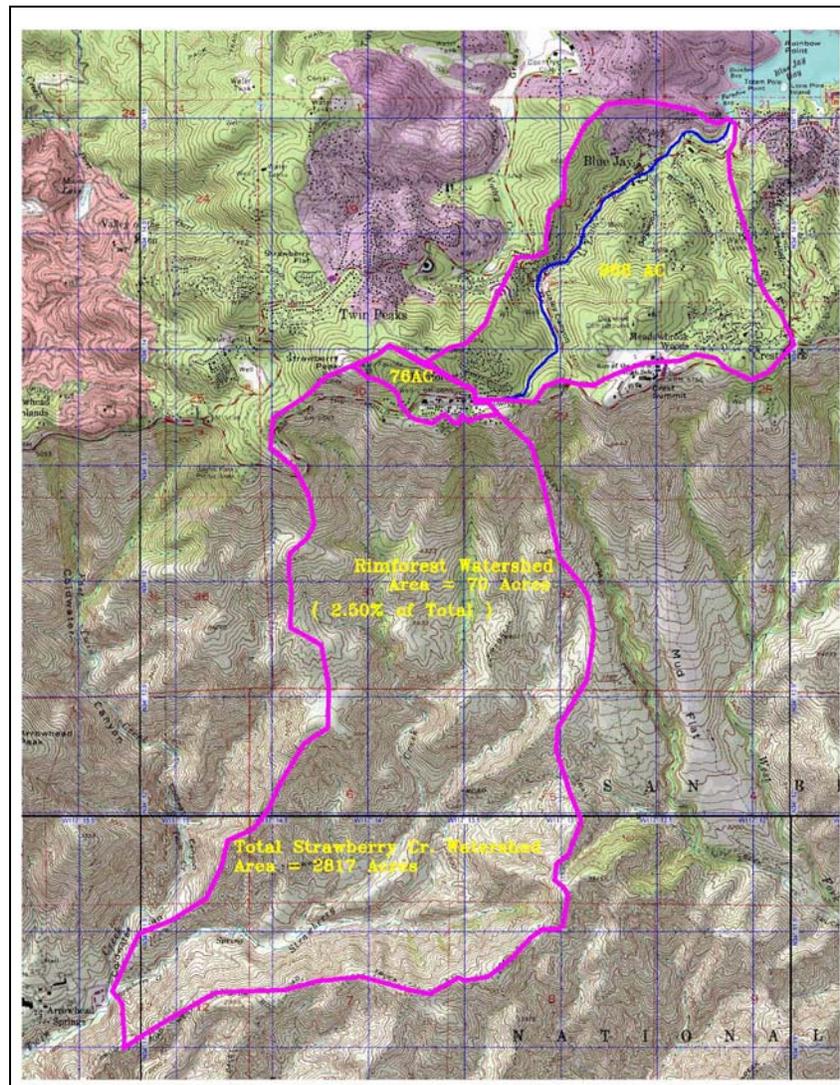
Photo No. 18 – San Bernardino County Blue Jay Maintenance Yard (Source: Field Investigation)





The community of Rimforest, is situated in the vicinity of the headwaters of Strawberry Creek. Strawberry Creek eventually runs into City Creek, which in turn outlets into the Santa Ana River. (See figure 1). Strawberry Creek watershed is a totally of 2817 acres. The runoff that affects Rimforest is about 77 acres. This drainage area is part of the overall watershed of the Santa Ana River, which is considered the safe yield of the San Bernardino Municipal Water District (SBVMWD).

Figure 1 – Watershed Division (See Exhibit “E”)



There does not appear to be any appropriate water rights appurtenant to Strawberry Creek itself, however there well could be some rights riparian and over lying rights.

The water runoff from the 77 acres has caused the loss of property, structures, roadways, and utilities in the past and those losses will continue into the future if not mitigated. Also there is a real possibility of



the loss of life if there isn't a solution to the drainage. It would appear that the best solution to protect Rimforest would be to divert the flow from the 77 acres away from Strawberry Creek and into Little Bear Creek. Even though this appears to be the best solution many problems would be encountered.

First and maybe the most difficult would be the diversion of water from the Santa Ana River basin into the Mohave River basin. This would need to be approved by the State Water Resources Control Board as well as SBVMWD and possibly additional minor water rights claimants. However if these problems could be solved would benefit to the community of Rimforest as well as the community of Lake Arrowhead.

Presently the water supplier for Lake Arrowhead is the Lake Arrowhead Community Services District (LACSD). LACSD is presently purchasing Feather River water from the SBVMWD, which is then wheeled through Crestline Lake Arrowhead Water Agency (CLAWA). The cost of this water to LACSD is approximately \$2500 per acre-foot which cost includes treatment. Based upon conversations between engineers of our firm and some of the potential interested parties there appears to be a real possibility of an economic and physical agreement of being reached.

The average annual volume runoff water diversion is calculated to be 47 acre-feet (refer to Attachment No. 14 of this report.



Option 1 is to divert runoff to Little Bear Creek. The proposal is to accomplish this in three phases:

Phase 1 (Reduce Runoff Tributary Area by 64% - 50.35 AC)

- Construct an improved channel, approximately 2,700 feet long, on the north side of Highway 18 to transport mountainside runoff from an additional 51 acres to Little Bear Creek. The upper western part of the channel would be designed to intercept the mountainside runoff and at the same time filter any debris into the street. Then, a 5 to 6 foot RCP would be connected to carry the runoff to Little Bear Creek. The current runoff into this creek is from a tract north of Highway 18 from an area of approximately 41 acres, with a 100-year flow rate of approximately 167 CFS. The added flow rate from 51 acres north of Highway 18 would be 225 CFS for a total flow rate of 393 CFS. The channel size and shape have been completely evaluated; a 4-foot wide, 6-foot high rectangular channel is adequate for the upper 1060 feet of the channel, with numerous grate inlets to filter debris from the channel and onto Highway 18. The lower 1615 feet of the channel would be either 5 or 6-foot diameter concrete pipe, with street inlets.
- Construct retarding basin (2) as part of the proposed Church of the Woods development. Preliminary analysis shows a single 10 Acre-Foot basin with 2 – 24” discharge pipes will reduce the peak outflow to 139 CFS, less than the existing 100-year flow rate of 167 CFS. Because of the inadequate drainage structures in Little Bear Creek, it may be desirable to install larger basin(s), to alleviate future flooding problems. The hydrology study map of this report show the area covered by three interconnected basins immediately northwest of the Church of the Woods proposed development.

The following picture shows a portion of the existing Church of the Woods proposed site:

Photo No. 19 – Proposed Church of the Woods Site – Existing Conditions (Source: Field Investigation)





Phase 2 (Reduce Runoff Tributary Area by 30% - 23.79 AC)

Install a 48” RCP storm drain from Pine Avenue under Highway 18 to Little Bear Creek. This will require a trench with depths up to 22 feet over a total distance of 1,176 feet. The added flow rate from 24 Acres of onsite area would be 106 CFS from the pipe. After a confluence with the Phase 1 flow the peak 100-year flow of 454 CFS, if the Phase 3 option described on the following page is included, then the peak flow rate would be 470 CFS.

This option also requires additional storm drains inside the Rimforest Village to intercept the flow along Pine Avenue with street inlets and a smaller drain from the southwest through the Lumber Yard to the Pine Avenue main pipe. (See Exhibit “F” for pipe and inlet locations). The following picture shows where some of the additional street inlets are proposed to divert flow away from the western Rimforest cliff discharge point. Grate inlets would also be installed in the Lumber Yard off of Pine Avenue.

Photo No. 20 – Location of Proposed Additional Street Inlets (Source: Field Investigation)





Phase 3 (Reduce Runoff Tributary Area by 5% - 3.99 AC)

Install a lift/pump station at the intersection of Apache Trail and Blackfoot Trail West to divert flow to the Phase 2 proposed 30-inch drain pipe through the Lumber Yard. This would add approximately 16 CFS during a 100-Year storm event to the Phase 2 pipe. Phase 3 may be necessary regardless of any other options to divert this flow away from this cliff area of Rimforest where the most severe landslide damage is taking place. The runoff could be pumped to the existing primary discharge channel south of Pine Street. This would require a combination lift pump for low flow rates, and a 30 horsepower turbine pump when the peak flow rate occurs. A 24" PVC pipe approximately 405 feet long is required to transport peak flow rate to the proposed 30" storm drain. The following picture shows the location of the proposed lift pump system:

Photo No. 21 – Location of Proposed Lift Pump System (Source: Field Investigation)

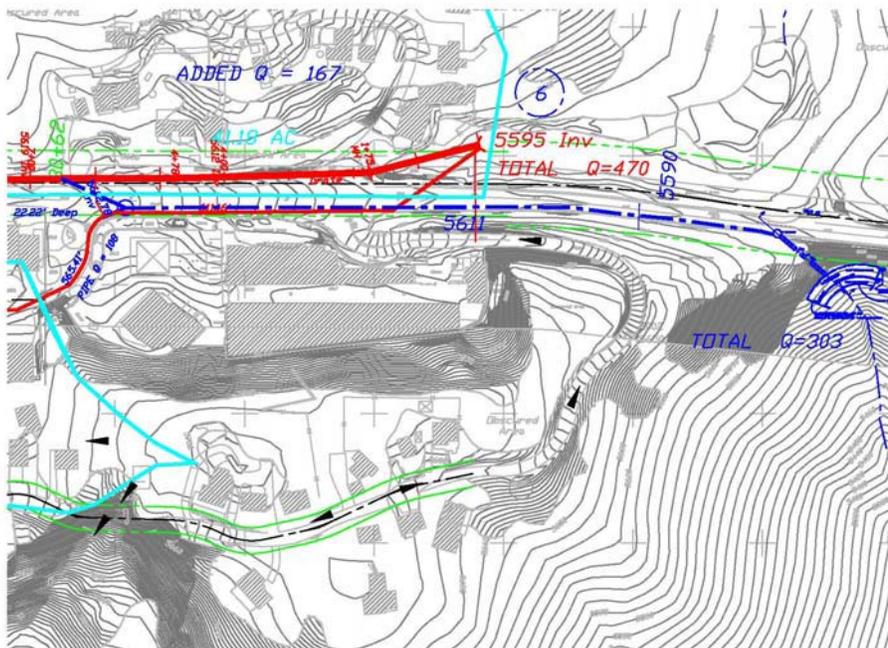




Option 2 is to divert runoff to the West Fork City Creek watershed. This option would divert the same area flows in three phases as Option 1. The existing Tract runoff from North of Highway 18 would remain draining into Little Bear Creek (167 CFS from 41 Acres). The diverted flow rate of 303 CFS from the Village of Rim Forest, including the 51 Acres north of Highway 18, (which currently flows into the village), would be routed to an existing valley location immediately south of Highway 18, which connects to West Fork City Creek. Refer to Exhibit “F” for the Option 2 Study Map.

The below drawing, not to scale, shows proposed Option 1 discharge point in RED, and the Option 2 outlet point in BLUE.

Figure No. 2 – Option 1 vs. Option 2 Discharge Locations





The proposed Option 2 discharge point is shown in the following pictures looking southeast from Highway 18:

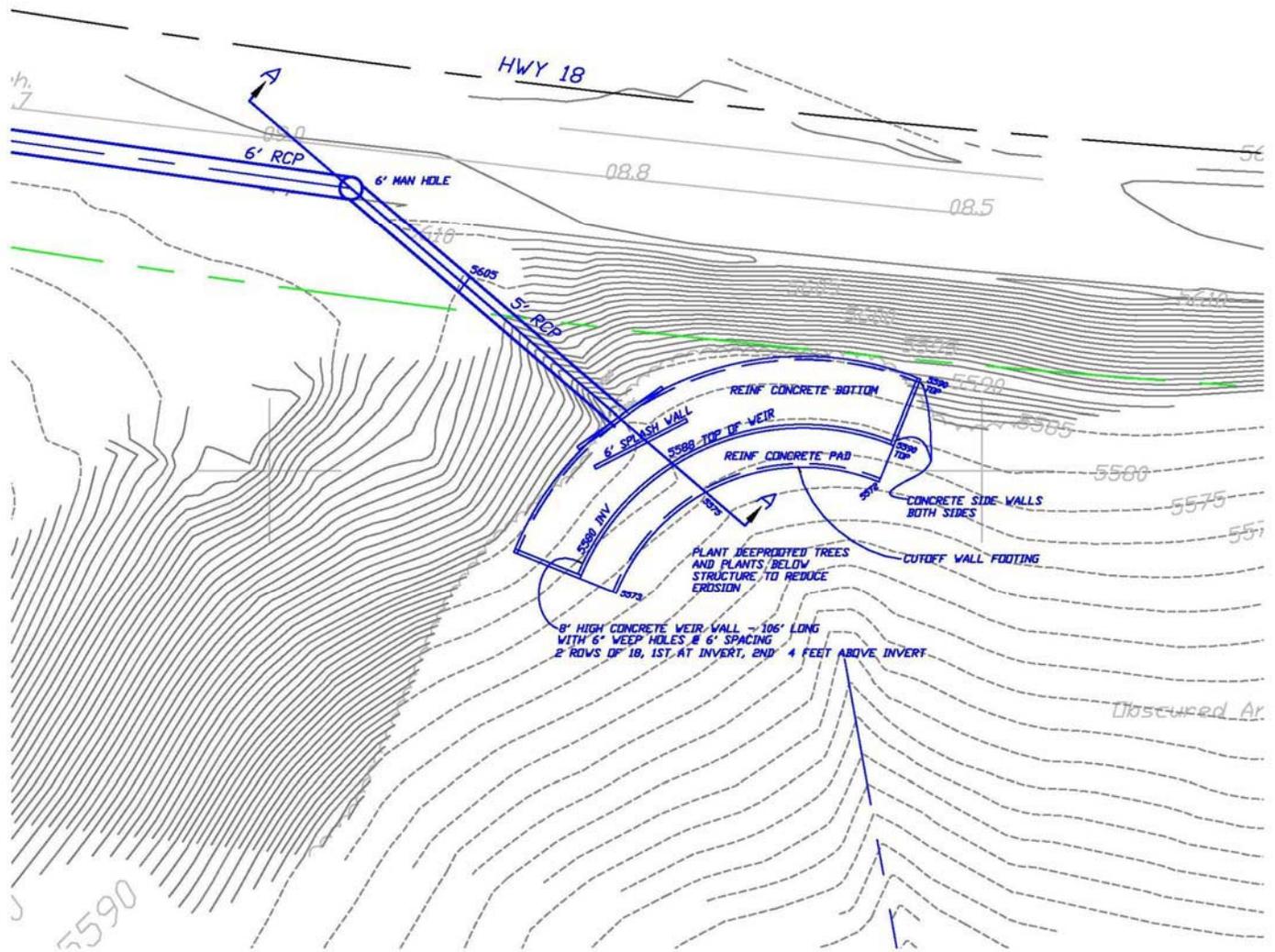
Photos No. 22 & 23 – Location of Proposed Option 2 Discharge Point (Source: Field Investigation)





The following drawing shows a possible outlet structure and location for Option 2 Phase 1. Depending on the nature of the soil at the site, the structure would be anchored to the hillside with either deep cutoff walls or pilings if necessary. See Soils/Geotechnical report.

Figure No. 3 – Proposed Option 2 Outlet Structure





Other Options Considered

Several other options were looked at but were considered impractical because of cost and maintenance problems:

1.) Drain Runoff To The West of Rimforest by Boring Underground Pipe

The collection point for most of the runoff under concern is near the east end of Pine Avenue at an elevation of 5610 (invert of storm drain). To direct this flow in a conduit to the west, an elevation of 5680 along the Highway 18 would be encountered, making it nearly impossible to trench and bury a pipe. The option of boring to install the pipe was also looked at, but the length of the bore would have to be over 2,500 feet long. Construction and ongoing maintenance of such an option would be impractical. As no storm drain manholes are installed for in a boxed pipe system for maintenance, an extensive filtering system would be required before the pipe inlet(s).

According to a reference sources, the maximum Horizontal Auger Boring (HAB) Method for gravity flow RCP or Steel pipe is 1500 feet. Horizontal Directional Drilling (HDD) with 24"-48" steel pipe is possible up to 6000 feet, however, this is only recommended for pressure pipe.

2.) Install Containment / Retarding Basins

The original proposal envisioned the possibility of installing retarding basins to reduce the peak flow rates and serve as an impervious storage location to prevent infiltration. However, it does not appear that the small drainage area is contributing to any substantial percolation.

Option 1 of this study recommends retarding basin(s) after discharge into Little Bear Creek which are necessary to reduce the peak flow rates into an already undersized storm drain system.

3.) Install Impervious Cover On Hillsides To Prevent Infiltration

The hillside Soil Group is "D", resulting in rapid rainfall runoff on relatively steep slopes and little infiltration. There may be greater infiltration under snow melt conditions. As stated in the previous comments, the benefit of the installation of an impervious soil cover such as soil cement, is questionable (See Soils Report).



4.) Drain Runoff In A Bypass Pipe to Strawberry Creek

To drain the runoff into Strawberry Creek, at a discharge point, where further erosion would not cause problems, would require a pipe installed approximately 1900 feet south of Highway 18. If a pipe were installed to this drainage point, the cost of construction would be significant. With an elevation drop of 800 feet, the average pipe slope would be 42%, and, in some places the slope is 100 % or a 45-degree downward angle.

If reinforced concrete pipe were installed, velocity control rings would be required at each 8-foot interval to keep maximum velocity within acceptable limits. In addition, the pipe would require soil anchors at frequent intervals to stabilize the installation. Because pipe freezing would be a consideration during cold temperatures, the pipe should be installed underground. To trench and install such a storm drain system would probably be cost prohibitive. The following drawing shows a north/south blue line where the least expensive drain to a canyon leading to Strawberry Creek could be installed:

Figure No. 4 – Drain to Strawberry Creek (in Blue)





1.6 Discussion – Early-Warning System Implementation

The County of San Bernardino could consider the implementation of an early-warning system in the area of the Rimforest Community under the most immediate threat of catastrophic landslides, to protect the lives and property most at risk. One possible scenario would be the installation of ultrasonic vibration or radar sensors in a stable location aimed at target(s) located in the slide area. This would allow for the tracking of any ground movement. In the event that this movement increases to a predetermined rate threshold, an alarm and/or reverse 9-1-1 emergency call could be implemented to warn the residents within the slide zones to leave their homes immediately.

HydroLynx Systems, Inc. is a real-time data telemetry equipment manufacturer based in Sacramento, CA. Their equipment, software and services may be suitable for the scenario described above.

Refer to *Attachment 15* for documentation and specifications for early-warning system sensors and management software provided by HydroLynx Systems, Inc.

1.7 Information on Historic Drainage Patterns

As discussed in *Attachment 13*, historic topographic maps dated prior to the construction of Highway 18 (Rim of the World Highway) indicate that a sizable portion of the Rimforest area north of what is now the Highway and east of Strawberry Peak followed a drainage course that flowed in a southeasterly (near the current alignment of Blackfoot Trail West) and then curved in a northeasterly direction within the Mojave Watershed (towards Lake Arrowhead). The maps (also included in *Attachment 13*) examined were:

- 1939 U.S. Department of the Interior Redlands Quadrangle (reprint of the August 1901 edition)*.
- 1905 Hydrologic Map of San Bernardino, Redlands, & Vicinity*.
- 1929 California Department of Transportation As-Built Plans (Document No. 80000357).

During the development of the Rimforest community, two storm drain catch basins and pipes were installed on Apache Trail to direct surface water off the road and over the cliff.

(End)

* Note that these maps appear to have identical topographic data.