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### CALLEGUAS CREEK: PROBLEMS AND SOLUTIONS Prepared by Howard H. Chang, Ph.D., P.E. May 2006

#### I. OVERVIEW

A study has been made to assess the problems for Calleguas Creek and to developed solutions for the problems. Channel reaches covered in the study are as follows:

- (1) Calleguas Creek and Arroyo Simi from the Pacific Ocean to Madera Road,
- (2) Conejo Creek from the Calleguas Creek Confluence to Santa Rosa Creek, and
- (3) Revolon Slough from PCH to Laguna Road.

These stream channels have undergone substantial changes in recent decades. Such changes are related to major storms as well as human activities, such as channelization, grade control structures, sediment basins, sand and gravel mining, etc. The streambeds have undergone significant degradation along certain reaches and aggradation along other reaches. Corrections for certain problems have resulted in large expenditures. In order to maintain stream channel stability, the gradient problem needs to be checked and countermeasures are needed for channel stabilization. In addition to channel instability, these stream channels do not have the capacity for the 100-yr flood along several reaches. Large areas adjacent to such stream reaches may be subject to flooding. Several infrastructures, such as bridges and grade control structures, are inadequate to pass the 100-yr flood. Major existing problems that require solutions are summarized below:

- (1) Inadequate channel capacity for the 100-yr flood: Certain large areas are subject to flooding.
- (2) Channel instability: Stream channel changes including erosion and sedimentation, and aggradation and degradation of the channel bed.
- (3) Inadequate infrastructure: Several bridges are subject to overtopping, certain grade control structures are subject to outflanking.
- (4) Maintenance dredging for lower Calleguas Creek and Mugu Lagoon preservation.

Because of the above problems, a comprehensive study has been made to develop plan for channel improvement, flood control, and environmental enhancement. Since these stream channels are affected by natural and human activities in its drainage basin, the study covered the overall fluvial system that supplies sediment and water to the streams.

The purpose of the study was to identify existing problems and to develop solutions. An analysis of the fluvial system of Calleguas Creek was made followed by detailed modeling of the stream channels. The scope of work consisted of the following major tasks: (1) review and comment on existing reports, (2) analysis of fluvial geomorphology of the fluvial system, (3) assessment of sediment yields of the drainage basin and sediment inflows to the stream channels, (4) sediment modeling of the stream channels for the existing conditions, (5) channel improvements for flood control and environmental enhancement, (6) sediment modeling for channel stabilization, and (7) sediment control for lower Calleguas Creek and Mugu Lagoon. The study findings and proposed improvements are described below.

## II. INADEQUATE CHANNEL CAPACITY

One of the existing problems is inadequate channel capacity. As a result, large areas outside the channel are subject to flooding for the design flood or base flood. Such areas have been identified in a comprehensive floodplain mapping study recently completed by Nolte Associates. As long as the floodplain extends outside the channel, the main channel does not have sufficient capacity for the base flood. Many existing buildings and other improvements are within the floodplain along several channel reaches. Such channel reaches need to be improved to provide flood free conditions for these areas and improvements.

Areas subject to flooding will be shown graphically in the FIRMs (Flood Insurance Rate Maps). Nolte Associates has completed the study and produced floodplain maps. This study is currently in the public review period and the FIRMs have not yet been published. Dewberry & Davis will be preparing the final FIRMs once all public review comments have been addressed. The estimate is that preliminary FIRMs will be released in about 6 months.

## III. CHANNEL INSTABILITY

Channel reaches that have undergone significant changes are considered unstable. Generally speaking, the upper portions of the channel system have been undergoing erosion and channel bed degradation while the opposites have occurred along the lower channel reaches. As a result of channel-bed degradation, many grade control structures have been built along these channel reaches in order to stabilize the channel bed. Substantial deposition and channel bed aggradation have occurred along Calleguas Creek below the Upland Road Bridge and downstream of the Conejo Creek confluence.

Calleguas Creek is an alluvial stream; its natural geometry was formed in geological times, measured in millions of years. A natural alluvial stream exists in a state of equilibrium, with its geometry delicately adjusted in response to the flow and sediment supplied from its watershed. If the water or sediment inflow is altered, then the stream channel will respond by making changes.

Degradation of the channel bed and erosion of the channel boundary along the upper channel reaches are caused a reduction of sediment supply from the watershed. Among the many factors, sediment basins should be the primary factor. Fig. 1 is a sediment basin on a tributary in Simi Valley. Sediment basins have trapped large amounts of sediment, preventing it from reaching Calleguas Creek. Channel bed degradation developed in responds to the deficit in sediment supply. In order to check channel bed degradation, a series of drop structures have been constructed along the channel. Degradation has continued, notably just below the drop structure below Hitch Boulevard.



Fig. 1. View of a sediment basin on a tributary of Arroyo Simi

Now, causes for channel bed aggradation along the lower reaches of Calleguas Creek are analyzed. The channel reach just upstream from Adolpho Road has experienced channel bed aggradation. The deposited sediment has been dredged to maintain the channel capacity. This development is caused by the grade control structure at Adolpho Road. The structure has a high crest elevation and it has thus reduced channel bed slope on its upstream side. The channel reach with its slope reduced by the drop structure does not have the capability to move the sediment supply from upstream; sediment deposition occurred as a consequence. While the grade control structure at Adolpho Road detains sediment on its upstream side, it also causes a deficit in sediment supply to its downstream channel, where major degradation has occurred just below Pleasant Valley Road.

The lower reach of Calleguas Creek is in a broad floodplain, which has formed under the natural fluvial processes of Calleguas Creek over geological

times measured in millions of years. The floodplain was under ocean water in ancient times. The alluvial plain has formed by sediment deposits from Calleguas Creek. Mugu Lagoon is a remaining area not yet silted above the ocean level. The upper watershed is the sediment producing area and the lower alluvial plain is the sediment deposition area. These processes are still going on but they are also affected by human activities.

Now the lower Calleguas Creek has been channelized, natural sediment brought in by Calleguas Creek can no longer spread out to the alluvial plain. Most of the flood events are now confined to the channel and so is sediment deposition. Sediment may still deposit in the floodplain if breakout occurs. The existing longitudinal channel bed profile of Calleguas Creek has a concave profile with the slope decreasing toward downstream. Sediment settles in the channel as the velocity slows down with the decreasing slope. There is no question that preservation of the lower Calleguas Creek channel and Mugu Lagoon requires maintenance dredging.

An alluvial channel reach in sediment equilibrium, i.e, non-silting and non-eroding, is a channel with uniformity in sediment delivery. Because of the physical conditions, it is not possible to achieve sediment equilibrium along the lower channel reach. The natural processes of sediment deposition will continue. In order to maintain channel capacity, it is necessary to carry out maintenance dredging in the channel unless the channel is restored to the natural floodplain.

#### IV. STUDIES FOR CHANNEL STABILIZATION AND IMPROVEMENTS

Hydraulic and sediment modeling studies for the channel system have been made to identify the existing problems and to develop improvement plans. The study results show that the channel under existing conditions does not have adequate capacity for the 100-yr flood along several reaches and many reaches do not have sediment equilibrium. Therefore, channel improvements are needed for flood control, stream channel stability, and environmental enhancement.

The channel improvement plans for Calleguas Creek, Conejo Creek and Revolon Slough have been developed to accomplish the two following objectives:

- (1) Channel improvements to convey the design flood - The purpose of this measure is to provide flood free and flood safe conditions for adjacent land areas and improvements.
- (2) Channel improvements to achieve long-term channel stabilization - In order to avoid future channel bed changes due to aggradation or degradation, it is important to maintain an approximate sediment balance. In other words, the sediment transport capacity for each channel reach should be compatible with the sediment supply to the channel reach to maintain a balance in long-term sediment delivery thereby avoiding major erosion and deposition in the channel. To avoid adverse bank erosion,

bank protection shall be installed at critical areas.

Details of the channel improvement plan are described in the study reports. The proposed channel improvements are summarized in the following:

- (1) Modifications of channel geometry—The cross-sectional geometries for certain reaches will be modified by dredging, widening, and adjustments of longitudinal channel slope. Such modifications will lower the flood level. It is also desirable to lower the flood level such that the 100-yr flood will pass through the bridges to avoid large expenditures for bridge modification or even reconstruction.
- (2) Raising the top of levee—Certain existing levees need to be raised in order to contain the 100-yr flood within the channel. The top of levee will be raised and maintained at a level that is 3 feet above the 100-yr flood level.
- (3) Wetland creation.
- (4) Raising roadway elevation at bridge crossings - In order to maintain the three-foot-freeboard for the channel, each bridge roadway at the bank location need to be raised such that the top of roadway is three feet above the 100-yr water surface.
- (5) Bridge replacement – Some of the existing bridges will be replaced if they can not pass the design flood by modifications of the channel or the bridge.
- (6) Modifications of grade control structures- Certain grade control structures will be modified or removed and new one may also be added to maintain channel capacity and stability.

These improvements were determined based on the results of hydraulic and sediment modeling in many trial runs. The future 100-yr flood will be contained within the channel with a freeboard of three feet. At the bridge crossings, the roadway surfaces will stay above the 100-yr flood.

## V. MAINTENANCE REQUIREMENTS FOR CALLEGUAS CREEK

Sediment deposits in the lower reach of Calleguas Creek as well as Mugu Lagoon. Deposited sediment in the channel consists primarily of sand but deposits in the lagoon are mostly fines of silt and clay. Under the present practice by VCWSPD, the lower reach of Calleguas Creek from PCH to Hueneme Road is maintained by periodical dredging. The requirements for maintenance dredging have been estimated in the study and compared with actual dredging records. In the study, the reduction in sediment delivery from Hueneme Road to PCH is the sediment storage that is also the amount of sediment removal required to maintain the design channel-bed level.

According to County's records, the mean annual dredging removal is 84,900 tons. The study results and the county records are listed in Table 1 for comparison. The required dredging removal obtained in the modeling study of 82,100 tons per year is similar to the County dredging records of 84,900 tons

per year. This check also provides confidence on the sediment modeling study for the river channel.

Table 1. Comparison of maintenance dredging requirements for channel

Methods for estimation	Mean annual dredging tons/yr
Based on County 67-yr flow records	82,100
Based on County dredging records	84,900

In view of sediment deposition, the VCWSPD has devised sediment basins along the lower reach of Calleguas Creek, located just upstream from PCH. With these sediment basins, maintenance dredging will be limited primarily to the sediment basins.

## VI. MAINTENANCE FOR MUGU LAGOON AND LAGOON SEDIMENT CONTROL

Calleguas Creek and Revolon Slough are primary suppliers of sediment for Mugu Lagoon. Sediment settles in the lagoon as the stream flows slow down. After sediment basins in Calleguas Creek are constructed, there will be less sediment deposition in Mugu Lagoon but most of the fines will still reach the lagoon.

Because of sediment deposition in the lagoon, preservation of Mugu Lagoon requires maintenance dredging. Mean annual coarse sediment supply from Calleguas Creek and Revolon Slough has been determined based on sediment modeling study and dredging records. Coarse sediment supply from Calleguas Creek and Revolon Slough is estimated to be 25,200 tons/yr from the modeling study under existing conditions.

Now, the coarse sediment inflow to the lagoon is compared with the annual sediment deposition in Mugu Lagoon, which is about 350,000 tons per year according to the Corps dredging records. It can be seen that bed material load of coarse sediment from these streams contributes to a small portion of the total sediment deposition in the lagoon. Most of the deposited sediment in the lagoon consists of fines in the wash load size range. In fact, dredging records of Mugu Lagoon by the Corps show that sediment deposits in Mugu Lagoon consist mostly of clay and fine silt that belong to the wash-load size range. A sediment transport model only computes bed material load but not wash load. The transport of wash load is not correlated with stream flow characteristics but controlled by the supply from the watershed. Since the fines constituting the wash load do not settle in the river channel in large quantities, the transport of wash load is not correlated with the channel flow characterizes. Wash load, however, does settle in the lagoon. Sediment control for Mugu Lagoon depends on the control of soil loss from the watershed. Instream sediment basins that induce the deposition of bed material load in Calleguas Creek only have limited

effects in reducing sediment flow to the Lagoon. Sediment control by sediment basins in the watershed has caused channel bed degradation in the upper reaches of Calleguas Creek.

An alternative way for sediment control of Mugu Lagoon is the construction of a bypass channel to convey the sediment flow of these streams directly into the ocean. The bypass channel can be constructed by extending the levees of Calleguas Creek and Revolon Slough through the mud flat to the beach. Such a channel will separate the stream flow and sediment flow from the lagoon; it will convey the bed material load as well as the wash load directly into the ocean. Littoral drift along the beach is toward the south and it sends sediment flow toward south away from the lagoon entrance. Thus, sediment reaching the ocean does not usually find its way back into the lagoon.