

Fire-Loosened Sediment Menaces the City¹

Arthur E. Bruington²

Sediment is a resource. It forms the soil upon which we live and within which we grow our food. Sediment is also a problem endured by people in some variety wherever they live.

In Southern California a special sediment problem arises as the result of the high ranges of mountains lying parallel to and relatively close to the ocean, creating a steep gradient for streamflow. The steep gradients, the earthquake fractured mountains, the recurring, massive wildfires in the chaparral-type mountain ground cover and the occasional occurrences of torrential rainfall work together to cause catastrophic movement of sediment out of the mountain valleys onto the coastal plain where people live. In Los Angeles County the San Gabriel Mountains average 27 miles from the ocean and the ridgeline elevation ranges from 2,000 feet to over 10,000 feet in elevation. The mountains are mostly granitics. The sediment is formed by wintertime freezing and thawing action acting on the fractures and shattering caused by earthquakes as well as the usual decomposition processes.

Rainfall in Southern California is relatively sparse, but occasionally warm storms from the Pacific Ocean at mid latitudes cause very intense rainfall. Typically, these storms consist of a series of disturbances moving fairly rapidly along a west-to-east path, sometimes carrying copious quantities of moisture. The final disturbance in the series is usually the most severe because it is associated with the high winds which cause the breakdown of the storm system, but also add intensity to the rainfall. Thus, the heaviest rainfall intensities usually occur on a saturated watershed, the best case for a high runoff condition.

On March 2, 1938, an average of 1.4 inches per hour of rainfall occurred for a period of 5 hours at Clear Creek, a mountain station located at 3,100 feet elevation. On April 5, 1926, at a mountain station of about 4,400 feet elevation, a rain gauge registered 1 inch in 1 minute. At a nearby location in January 1943,

Abstract: Sediment management is an absolute requirement, but an expensive problem for the residents of the coastal strips between the mountains and the ocean in Southern California. The combination of earthquake fractured mountains, frequent freezing and thawing action in the winter-time, occasional torrential rainfall and explosive wildfires leads to a dangerous and destructive condition. Records of the Los Angeles County Flood Control District are used to cite data on high intensity rainfall and massive sediment movement together with examples of the effects on the communities lying near the mountains. The high costs of managing sediment are highlighted by a description of the sediment situation at San Gabriel Dam and Reservoir since its construction in the mid 1930's.

26 inches of rain fell in 24 hours. In 1969, there were 2 major rain storms 1 month apart, the first in January caused 45 inches of rain over a period of 9 days at Hi Hill, a mountain station near Mt. Wilson. In February, 21 more inches of rainfall occurred in 3 days. Each of the storms was flood producing. In February 1978 at a rainfall station located in northern San Fernando Valley at an elevation of 3,500 feet, a fairly typical flood producing rainfall pattern occurred. By 3:00 p.m. on February 9 precedent rainfall for the season had been 29.2 inches and over the last 22 hours, 5.3 inches. During the following 7 hour period 2.2 inches of rain occurred. From 10:00 p.m. until 1:05 a.m. another 2.0 inches of rain occurred, an intensity of more than 0.6 inches per hour, significant in any situation. Between 1:05 a.m. and 1:30 a.m. a deluge of 1.4 inches occurred, of which 0.4 inches fell in 5 minutes (equivalent to 4.8 inches per hour). This was the shortest interval registered by the rain gauge. These rainfall intensities occurred during the passage of a very intense cold front. Later I will relate these latter rainfall records to downstream sediment movement.

In Southern California production of sediment occurs more rapidly than runoff can carry it away. As a result alluvial valleys have been formed at the foot of the mountains. In their natural condition all of the valley streams are in an aggrading condition. Aggrading streams change course. When the velocity of the stream slows down, the heavier sediment particles settle out and raise the streambed. This causes the stream to become higher than the surrounding ground so the stream breaks out to another course having a naturally steeper gradient. Changes caused by sediment deposition generally occur very slowly, but, during, a few hours of a major storm event, major movement and deposition can cause severe damage and/or greatly change the land configuration.

Let's look at some of the historical occurrences. During the 1880's there were a number of major floods in Southern California. These caused damage to roads and railroads and water

systems, but there had been relatively little development along rivers so the hazard to people and property was relatively small. During the following period until 1914 no major storms occurred. Many people moved into the area. Development encroached into the flood plain of the Los Angeles River and other natural water-courses. A major flood occurred in 1914 with loss of life and considerable property damage. The community response in Los Angeles County resulted in the formation of the Los Angeles County Flood Control District in 1915.

The first attempts by the District were to define stream courses and to confine streamflows to those stream courses. While that approach was successful for small storms it could not succeed in controlling major flood flows carrying large amounts of sediment. Efforts were then centered on providing regional flood control protection with reservoirs and major channel improvements. This was followed beginning in the 1950's with various approaches to the management of the production, movement and deposition of sediment. Managing the sediment capable of being produced by the San Gabriel Mountains is important to the safety of the residents of the District, but frankly it is like trying to hold back the storm tides of the ocean.

Let's look at what has happened in the largest mountainous watershed in Los Angeles County. San Gabriel Dam was constructed during the 1930's to form a flood control reservoir. The dam is located about 5 miles upstream of the mouth of the mountain canyon. The reservoir has a tributary, uncontrolled mountain watershed of 160 square miles. The dam began blocking streamflow and disrupting the natural downstream movement of sediment in the summer of 1936. The original reservoir capacity at spillway elevation was 53,000 acre feet. From 1936 to the summer of 1980 the reservoir had collected sediment in the amount of 26,000 acre feet or 43 million cubic yards. From time to time sediment was moved through the dam by the process of sluicing. Sluicing consisted of using streamflow to dig sediment out of the reservoir bed and carry it through the dam in a low-level tunnel. Sluicing could occur only when there had been a large snowpack developed in the tributary area and when it was feasible to empty the reservoir before the runoff from the melting snowpack had receded below an efficient carrying capacity. During those 45 years, sediment was removed by the process of sluicing in the approximate amount of 10 million cubic yards. The cost of this process was 10 cents per cubic yard adjusted to 1981 prices.

Two sediment removal contracts were awarded by the Flood Control District. Sediment was removed by mechanical means and disposed in an upstream canyon about 1 mile away. The configuration of the disposal area was designed to assure that runoff would not bring the sediment back to the reservoir. The first of these

contracts was awarded in 1968. It involved the removal of about 14 million cubic yards at 70 cents per cubic yard. Typical of the problems with occasional intense rainfall and large sediment movement, the contractor lost a great deal of equipment in the reservoir when it was buried by sediment during the floods of winter 1969. Later he was able to complete his contract. A second contract was awarded in 1978 following floods and additional sediment deposition that occurred the previous winter. The second contract was for 5 million cubic yards at \$2.00 per cubic yard. Thus, after 45 years of operation of San Gabriel Reservoir and the expenditure of approximately \$20 million for sediment removal the reservoir capacity remains impaired by sediment to the extent of 14 million cubic yards, 16 percent of the original capacity. Through the District, the residents are battling, but sediment is still winning.

Now let's look at the effect of fires in the watershed. When high temperatures, extremely dry air and strong winds combine, the high fuel content of the chaparral cover can explode into uncontrollable wildfires that may extend over thousands of acres before control is gained. Then the stage is set for catastrophic sediment movement. Records have been obtained in more than 37 controlled watersheds in Los Angeles County for periods greater than 25 years. This data demonstrates that up to a 40 fold increase in sediment production can occur during the first storm season following a watershed fire if high intensity rainfall occurs. Under normal conditions a period of brush regrowth of 10 years is needed to return to a baseline sediment production situation. Where less than an entire watershed is burned, outflow of sediment is often reduced to the extent that natural storage of sediment occurs within the watershed. Where the entire watershed is burned, severe storms have resulted in the movement of soil, rocks and boulders equivalent in volume to the removal of the top 2 or 3 inches of soil covering an entire watershed. Controlled burning of small areas, as proposed for brush management, reduces the probability of catastrophic events, but sediment production will be increased in direct proportion to the size of the burned watershed area and according to the coincidence of the occurrence of major storms. Thus, the obvious conclusion is that controlled burning should be done only in those years in which heavy rainfall will not occur in the following storm season.

Having now made my mark on posterity with that profound statement let me continue with another contribution to folklore. It has been observed in the Los Angeles County situation that the highest rainfall intensities in a given storm system always occur upon the most recently burned watershed. No scientific explanation has been developed for this phenomenon although possible, but unlikely, explanations include increased

availability of raindrop nuclei from ash particles or differences in heat reflection from the burned area.

Following are some examples of major sediment events. In the New Year's Day flood of 1934 there were large but unmeasured sediment flows onto the partially developed alluvial fan area of La Crescenta. The streams carried and deposited boulders of up to 20 feet in their largest dimension.

During the March 2, 1938 flood all 10 mountain reservoirs owned by the Flood Control District were rendered inoperable by sediment plugging of their outlet works. Sediment inflow into West Ravine Debris Basin amounted to 120,000 cubic yards per square mile on a 0.25 square mile watershed which had been burned in 1933. Most major highway and railroad routes out of Southern California were blocked by sediment deposits, flooding or flood washouts.

During the major storms of January and February 1969, sediment inflow to Hook East Debris Basin amounted to 223,000 cubic yards per square mile on a 0.30 square mile watershed, which had burned in the Fall of 1968. This fire had covered a very large area of the frontal slopes of the San Gabriel Mountains lying upstream of the City of Glendora. Numerous canyons within the City carried heavy sediment flows and created problems for residents within and below the canyons. In one nearby canyon, stream-deposited sediment covered a one-story house up to the eaves of the roof. A 7 foot by 6 foot concrete box storm drain below Hook Canyon was blocked by a boulder of about the same dimension at a location about 1/2 mile downstream of the storm drain inlet. The portion of

the storm drain upstream of the boulder was filled completely with sediment. It was cleared with a piece of mining equipment designed for working in a small cross-sectional area.

On February 10, 1978, sediment inflow to Zachau Debris Basin in the Sunland area was estimated to be at least 100,000 cubic yards per square mile on a 0.35-square-mile watershed which had burned in the Fall of 1975. Sediment overflowed the structure and spread over an area of about 1/2 square mile of densely populated area downstream. Streets were blocked, houses filled with sediment, and considerable damage was done to landscaping, parking lots and other outdoor facilities. A sediment-blocked storm drain in Shields Canyon in La Crescenta caused sediment-laden storm flow from the mountain canyon with a 2-year-old burn to be diverted onto a residential street. Several homes were severely damaged before the flow found its way back into the defined watercourse. Sediment and flood flows from a 2-square-mile mountain canyon contributed to the destruction of many buildings in a small mountain community killing 11 people. These events occurred as a result of the intense rainfall described earlier in the paper.

Well then, what is the outlook? In my opinion there is little likelihood of totally controlling sediment production or movement. Sediment management will continue to be directed at protecting people and lowering costs. Avoiding catastrophic events will lower the risk to people. It is likely that costs will continue to be high. However, for people to live and work safely in the communities at the base of the San Gabriel Mountains, sediment management is an absolute necessity.