CHAPTER 3

IMPACT ON SEWER SYSTEM IN AN EARTHQUAKE

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Introduction

The establishment of wastewater treatment plants in the East Bay has greatly improved the water environment in the Bay. The Bay can even be opened for recreational fishing purposes soon. However, the question posed to us now is whether the facilities will be safe in case of some natural disaster such as an earthquake. Most sewage treatment plants in the East Bay were built during the 1950's under the outdated building regulations which were invalidated after the review of observations from the San Fernando earthquake in 1971. Thus, it is worthwhile to examine whether or not the East Bay Municipal Utilities District and the City of Berkeley have done anything to correct the sewage plants and pipelines in preparation for an earthquake in the City of Berkeley.

It is almost impossible to measure how many preparations are needed to prevent a major disaster in case of an earthquake in the City of Berkeley. However, the use of a projection of an earthquake on the Richter Scale of seven along the Hayward fault not only tells us how well both the EBMUD and City of Berkeley have prepared for a major earthquake, but it also tells us what is needed to be done. Will the wastewater treatment plants withstand such an earthquake as that described above? Should sewer operations cease after destruction of the sewers, what will be the damages to our health and the marine life in the Bay? To answer all these questions, we must first understand the whole sewer service system, system components, and then state their performance in the projected earthquake.

Sewer Service System

The water-borne wastes (called sanitary sewage) are generally transported from the curb line at the property of origin through the City-owned sewer pipes to the receiving interceptor (main collector) sewer. The sewage treatment plants and interceptor sewer are owned, operated and maintained by the EBMUD's Special District one. The interceptor traverses Berkeley from Albany to Emeryville near the east side of the Eastshore Freeway. The interceptor exists into Emeryville and ultimately joins the sewage treatment plant on the south side of the Bay Bridge toll plaza[9] (FIGURE 1).

Berkeley has thirteen trunk sewers which carry waste to the interceptor, and two of these trunks serve the hills of North Berkeley by transporting sewage through Albany[1] (FIGURE 1).

Special District One (SDO) serves the area which includes the cities of Alameda, Albany, Berkeley, Emeryville, Oakland, Piedmont, and Stege Sanitary District, which includes El Cerrito, Kensington and part of Richmond. The SDO is serving an approximate population of 580,000, and its revenues come from a flat rate charge to all living units which are within the District. Generators of industrial and commercial waste water are charged in accordance with liquid volume, weight of solids, and biological oxygen demand of the sewage generated.[9] In 1979, single family

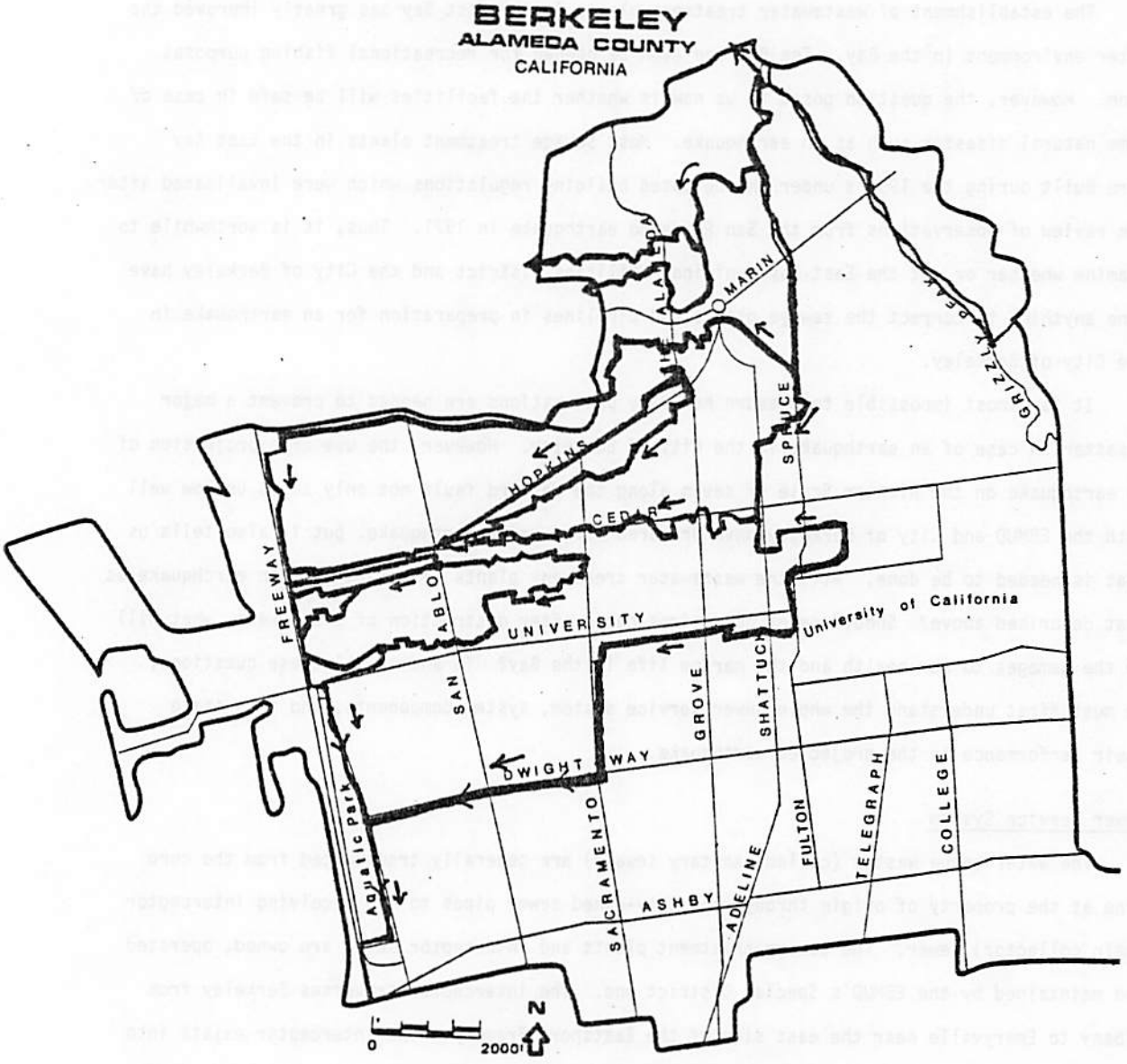

FIGURE 1. Location of the Trunk Sewers
SOURCE: Public Works Department, Berkeley, 1979;
Map from Berkeley Planning Department.

residences are charged $3.80 per month for sewage treatment. In addition, the City of Berkeley is presently charging single family residences $2.00 per month for transportation of sewage to the District's interceptor.[1]

Sanitary Sewer System Components

The City of Berkeley has approximately 350 miles of sanitary sewer mains and trunks and about 190 miles of house laterals (sewer lines which connect to the trunk sewers from all living units) to be maintained by the Sewer Maintenance Department.[1] The wastewater treatment plant is composed of pipes ranging in size from 6 inches to 45 inches in diameter (mostly in metal). The house laterals are 4 inches to 6 inches in diameter, and most of them were constructed with metal before 1900.[1] Most of the sanitary mains are composed of various kinds of pipelines, such as clay and reinforced concrete.

The reinforced concrete pipe intercepting sewers range from 12 to 108 inches in diameter and are 21.6 miles in length. Eleven pumping stations lift wastewater in to the interceptors from the cities of Alameda, Albany, Oakland, and the Stege Sanitary District system; then a bigger pumping station relifts the flow in the East Oakland section of the south interceptor into the wastewater treatment plant.[9]

Causes of Damages to the Sanitary Sewer System Components

The complete shutdown of the wastewater treatment plant due to electric power loss or earthquake damages has never occurred since its operation started in 1951.[9] The sanitary sewer plant has two power sources - one from San Francisco and the other from Oakland. In the past, they have had numerous breakdowns on the pumping stations due to the blockage of pumps by accumulation of waste materials. However, EBMUD feels such a problem could be resolved quickly without a major cutdown on the plant's service.[9]

The 21.6 mile long interceptor was built with reinforced concrete, and EBMUD expects such design of the intercepting sewers to withstand an earthquake of 6.5 on the Richter Scale.[9] This hypothesis, however, has never been tested. Because of the location of the interceptor, which is buried under filled bay mud,[9] I would say liquefaction after an earthquake could have much impact upon the system.

The mains still in service in the City of Berkeley were constructed of various materials just around the turn of the century. The speed of replacing the wearing pipes is limited by the funds available to the City. Thus, numerous old sewers have cracks which have resulted in a total collapse and have brought a number of damage claims. The number of claims by private citizens in recent years has gradually increased as shown in FIGURE 2.[1] And since the City is self-insured, the value of settled claims has also increased parallel to the number of damage claims filed.

Fiscal Year	No. of Claims	Value of Claims	Number Settled	Value Paid
1972–73	2	$ 1,050	2	$1,150
1973–74	2	97	1	20
1974–75	3	32,219	3	1,219
1975–76	13	5,366	6	3,286
1976–to (3–22–77)	9	2,261	9	1,200

FIGURE 2. Damage Claims
SOURCE: Public Works Department, Report to City Council, Berkeley, 1977.

The joints between each pipe segment were made of one of the following materials: cement mortar, sulfur and sand, asphalt and tar, and several compounds containing linseed oil.[1] All of these joint materials are susceptible to attack by the constituents of sewage. When a joint fails, the annular space between pipe segments becomes a place for entrapment of waste materials, thus causing a blockage.[7] Furthermore, a failed joint becomes a point of access for infiltrating ground water and for tree roots, which ultimately cause the failure of the pipe.

Damage Caused by Past Earthquakes and Preparations Made by EBMUD and the City of Berkeley

In the San Fernando earthquake in 1971, most piping systems survived the earthquake with only minor damage; it was reported that out of the broad areas affected by the earthquake, only a small area would need a complete reconstruction of the sewer system.[8] Many instances were reported where pipes remained unbroken. However, the most failures reported occurred at the joints. In general, pipes in the ground are subjected to compression and expansion.[5] The measure of the force is Ec, where E is Young's modulus for the

material of the pipe and c is the unit of compression and expansion per unit length of the pipe that is measured. It will generally require tons of force to crush the existing pipe line, whereas at the joints the pipes are weaker and thus problems often occur there.[5]

It is to nobody's surprise that the sanitary sewer mains in Berkeley are not specifically designed for major earthquakes. However, flexibility of movement in the pipes and joints has recently been emphasized seriously by the City of Berkeley. Installation of plastic pipes to replace the old pipes is gradually in process. Plastic pipes cost less and provide better flexibility to bend and stretch in case of any earth movement.[1] But how strong an earth movement they can withstand has never been tested. "Should they rupture in a major earthquake, we have to just let the sewage flow on the streets for a couple days," said one source in the City Engineering Office.

Although the intercepting sewers are built to withstand an earthquake of Richter magnitude 6.5 to 7, the interceptor is susceptible to another source of natural disaster -- that is liquefaction of the filled bay mud. One way to prevent such an occurrence is to move the interceptor system inland. However, it will be very uneconomical to provide the labor cost for relocation and to purchase more pumps to lift the constituent, which is normally lifted by gravity. Another way that seems to be more feasible is to compact the soil underneath the interceptor so that a chance of liquefaction would not be likely to occur there.

Since there is no limit on how safe is considered safe, I think the City and the EBMUD have put out every effort to improve the sewer system within their limited resources. In some areas, however, improvements are needed with immediate attention. FIGURE 3 shows the number of service calls and repairs in Berkeley. The annual number of service calls has steadily risen from 1,418 calls in 1970 to 2,058 in 1976 for an average annual increase of 106 calls (about 6.5%) per year. Repairs to mains and laterals have increased from 513 in 1970 to 681 in 1976 for an average annual increase in serious repair of 5% per year.[1] This implies that the sewer net is deteriorating faster than it can be replaced and that the Sewer Maintenance Department is gradually changing from a prevention maintenance program to one of correction maintenance. Unless more funding is available to replace the old failing sewers and laterals now, the next earthquake may result in a more severe disaster to our health by totally destroying the old sewers and thus causing the overflow of sewage onto the street.

Biological Hazards and Emergency Service in an Earthquake

If a leak or blockage occurs in a sanitary sewer under any house, the wastewater then saturates the ground gradually. When the water supply pipe is also leaking in a state of lowered pressure due to the enormous water output by a fire engine to fight fires, the contaminated

Calendar Year	Service Calls	Annual Increase Service Calls	Repairs to Mains & Laterals	Ann. Increase Reps.
1970	1418		513	
		136		49
1971	1554		562	
		29		7
1972	1583		569	
		25		40
1973	1608		609	
		77		-47
1974	1685		562	
		199		56
1975	1884		618	
		174		63
1976	2058		681	

FIGURE 3: Sanitary Sewer Service Calls and Repairs to Mains and Laterals
SOURCE: Public Works Department, Report to City Council, Berkeley, 1977.

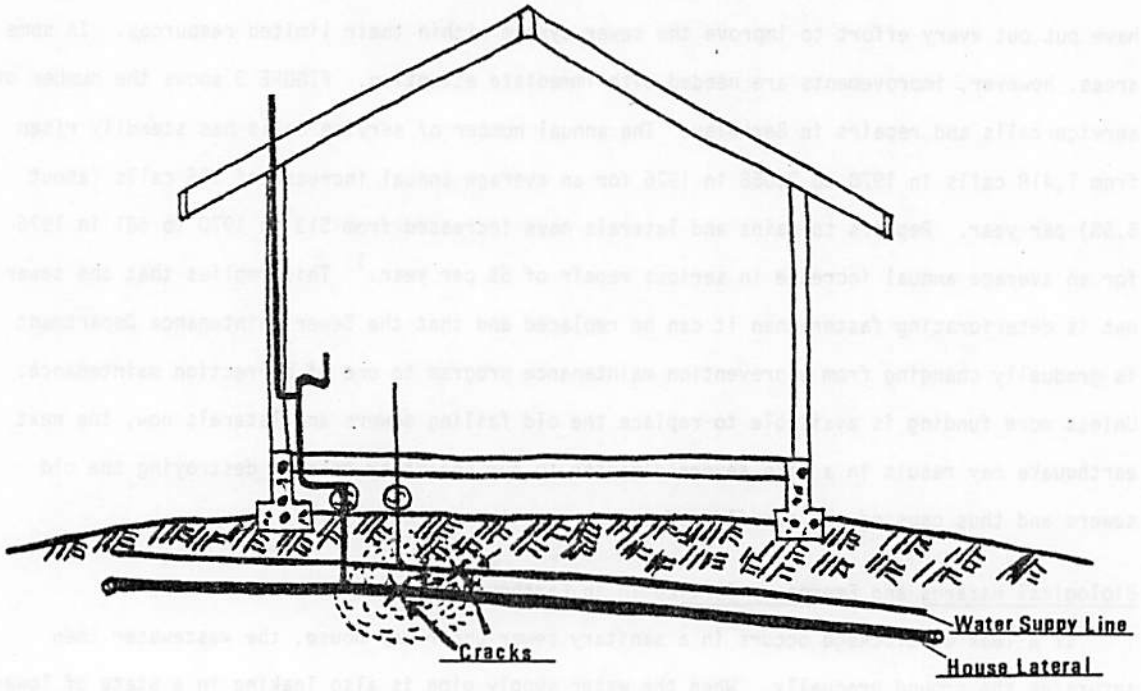

FIGURE 4. Cross-Connection of the Water Supply Line and the Sewer (House Lateral).

wastewater that saturated the ground may get into the water supply pipe as a result (FIGURE 4).[2] Such an occurrence is called the "cross connection." Cholera, amebiasis, and ascariasis are diseases which occur in areas where there are improper sanitary disposal of human feces.[10] Cross connection in sewer and water supply pipe lines and overflow sewage due to the breakdown of sewers by an earthquake are two possible situations which pose such health hazards to the public.

In light of the foregoing discussion, it is important to check any breakage in both the water supply line and sewers with water sampling techniques and available tools after an earthquake. Immediate use of water after an earthquake is not recommended. Furthermore, do not flush toilets if sewer lines are broken. If water is off, emergency water may be obtained from the water heater, melted ice cubes and toilet tanks.

In the San Fernando earthquake, the damages to sewer lines were only limited to certain areas. Thus, the temporary sharing of toilets in areas where no damage occurred is encouraged even though it may cause inconvenience to the public.

In the event of total destruction of the sewer lines and system, mobile toilets would be made available to the public by the fire department. However, it is doubtful that such mobile toilets would reach the disaster area quickly, as the roads would probably be made unavailable for transportation by the earthquake. A more reliable method is to store a portable emergency toilet in each house all the time. Such portable toilets not only come in handy in case of an emergency, but they can also be used on a camping trip where no public toilet is available to the public.

In addition to the health hazards to the people from the possible rupture of sewer lines in an earthquake, numerous adverse ecological effects will also be imposed on the marine life in the Bay by the untreated sewage dumped into the Bay. Contamination of shellfish and elimination of a number of species of fish which can only survive in a higher oxygen water environment are foreseeable.[3] Thus the disappearance of fish would not only be an economic loss of a food stock to the whole community, but would also serve as the major cause to upset the ecological balance of the aquatic community of the Bay.

Conclusion

It is extremely difficult to determine what structures are considered completely safe or not safe in case of an earthquake. On the other hand, to completely change or upgrade any long existent structure is quite unfeasible economically. Therefore, the trade-off between money and safety is often a hectic debate politically. Any improvement on earthquake safety measurement of various structures is vastly dependent on how much funds the citizens are willing to give up in the trade-off between various public services that they may get and the amount of taxes that they are required to pay.

In the City of Berkeley, a rather interesting trend on how to allocate the limited funds to various public projects has increasingly dominated the funding procedures in recent years; funds for maintenance of the already existing structures has first priority on available funds, and then the replacement of any parts of the troublesome structures. The sanitary sewer maintenance and construction funding in the City of Berkeley is a good example of such a trend (FIGURE 5).[1] What is bad is that it will shift all the preventative programs (in case of earthquake, the installation of new sewer lines in replacing all old ones) to the corrective programs, which mainly spend money for fixing the endless problems arising in time.

In order to minimize the damages in case of an earthquake in the City of Berkeley, we have to have a more comprehensive and preventative program on the whole sewer system. Replacement or rehabilitation is urgently needed for the 27,000 linear feet of sanitary sewer which have been identified as high maintenance cost and environmentally deficient by the Public Works Maintenance Superintendent. Because the new sewers require little or no maintenance and can withstand earthquakes better as experience indicates, replacement of sanitary sewers in the City of Berkeley will result in the decrease of maintenance demands, the chances of cross-connection with the

Fiscal Year	New Funds Received	Funds Spent Maintenance	Funds For Replacement
1971–72	621,005	367,432	253,573
1972–73	626,092	367,453	258,639
1973–74	618,730	448,349	170,381
1974–75	632,667	414,575	218,092
1975–76	624,365	463,568	160,797

FIGURE 5. Income, Maintenance Expenditures and Sewer Replacement Trends
SOURCE: Public Works Department, Berkeley, 1977.

water supply lines, and the number of ruptures on the sewer lines during the earthquake.

With the present political structure in our government, opinions and support from the public are very important in public policy making processes. Public awareness on various issues is a crucial need in getting an adequate and rational opinion from the general public. Therefore, constantly providing earthquake information and education to the public through periodical journals and television is most recommended.

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