

**TO:** James L. App, City Manager  
**FROM:** Meg Williamson, Interim Director of Public Works  
**SUBJECT:** Golden Hill Road Reservoirs Earthquake Repairs  
**DATE:** March 2, 2004

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**NEEDS:** For the City Council to direct staff to prepare bid documents to repair the Golden Hill Road Reservoirs which were damaged as a result of the San Simeon earthquake.

**FACTS:**

1. The City's two 4-million gallon steel reservoirs located at Golden Hill Road were operating at near full capacity at the time of the San Simeon earthquake, which occurred on December 22, 2003. Each sustained damage.
2. Reservoir No. 1, constructed in 1972, sustained more damage than did Reservoir No. 2, which was constructed in 2001. Connecting inlet/outlet piping to both reservoirs was damaged. The control valving for Reservoir No. 2 could be operated following the earthquake, therefore allowing it to be isolated from Reservoir No. 1 and maintained in operation. Reservoir No. 1 was drained and taken out of service due to sustained damage.

Following site observations and engineering analysis, it may be concluded that each Reservoir performed well relative to no catastrophic failure and within the capacity of their original design. Engineering analysis indicates both reservoirs were subjected to high stress.

3. Reservoir No. 1 sustained substantial damage to the bottom sketch plate (floor plate immediately inside the perimeter shell plate) as determined by observations and engineering analysis. Reservoir No. 1 also suffered substantial damage to roof purlins (rotation and displacement), purlin rod ties and column (twisting out of vertical alignment).
4. Reservoir No. 2 sustained minimal damage to roof purlins, roof purlin connections near the top of the perimeter shell plate, and floor plate. The inlet/outlet piping of both reservoirs received substantial damage due to differential movement between the tank and adjacent foundations.
5. Details of the damage to each tank and appurtenant structures are outlined in the attached report.

**ANALYSIS  
AND**

**CONCLUSION:** Both tanks were evaluated based on engineering calculations and data obtained in the field (soils bearing testing, diver inspection, and survey).

The following summarizes the conclusions of the analysis and recommended repairs. The attached report has further details and calculations.

Reservoir No. 1

The tank was analyzed using Boyle Engineering's in-house computer program, which is based upon AWWA D100-96 criteria. The basic tank shell material was assumed to be ASTM A 283-C which has a yield stress of 30,000 pounds per square inch (psi). The allowable stress for static design was set at 15,000 psi with AWWA D100-67, Appendix C, allowable increase in shell plate stress equal to 19,400 psi. The analysis indicated the tank is adequate for static loads with shell stresses somewhat high for combined static and earthquake dynamic loads. The maximum shell stresses for static and dynamic loads reached 26,670 psi, which indicated that the critical yield stress of 30,000 psi was not exceeded.

Hand calculations were used to check the computer analysis and were likely similar to those used in the original tank design. These calculations included seismic loads per AWWA D100-67 and which would have been similar to design criteria contained in 1970 UBC.

The bottom sketch plate, bottom floor plate adjacent to the perimeter shell, was evaluated for what was observed to be a reasonable vertical (upward) or downward deflection of approximately 1.5 to 2.0 inches. This analysis was performed to determine if the sketch plate had exceeded a 30,000-psi yield stress. Analysis based upon probable deflections indicated that sketch plate had yielded. Vertical shell plate deflections were confirmed by using a support computer program, STADD; a well-known engineering analysis program.

An analysis of the welds between the bottom of the perimeter shell plate and sketch plate indicated that the stresses in these welds were well within allowable limits. No failure of these welds was detected by field testing.

The results of the engineering analysis indicate that the tank shell plates may have experienced some high levels of stress but not beyond yield. However, analysis indicates the sketch plate exceeded yield strength, has deflected, and should be replaced.

It is estimated that the construction cost to repair the reservoir is \$635,570. Attached is a detailed cost estimate which includes contingencies and design service costs for a total cost estimated to be \$986,670.

#### Reservoir No. 2

The procedures used to evaluate Reservoir No. 2 were similar to those used for Reservoir No. 1, except for using design criteria contained in AWWA D100-96. Analysis indicates that Reservoir No. 2 was not subjected to overstress loadings other than the second course of shell plate above the bottom (approximately 12 to 16 feet). The analysis indicates a stress level for the second course shell plate to be above 19,300 psi, yet well below the 42,000 psi yield strength of ASTM A 573-70 steel plate. At this time, only minor repair is anticipated for this reservoir.

It is estimated that the construction cost to repair this reservoir is \$76,300. Attached is a detailed cost estimate which includes contingencies and design service costs for a total cost estimated to be \$123,000.

#### **POLICY**

**REFERENCE:** Water Operations and Maintenance.

#### **FISCAL**

**IMPACT:** Staff will pursue FEMA reimbursement for the costs (construction and design) to repair both tanks.

#### **OPTIONS:**

- A.** For the City Council to direct staff to initiate the repairs to both reservoirs by authorizing the City Manager to engage the services of Boyle Engineering to prepare the construction documents for bids to be advertised for the repairs of both tanks for a not-to-exceed fee of \$90,200.
- B.** Amend, modify, or reject the above option.

Attachments:

Cost Estimates (2)

Report Prepared By:

Ditas Esperanza, P.E.

Capital Projects Engineer

# IV. Earthquake Damage Repairs

The estimated costs for the repair of earthquake damage sustained by Reservoirs No. 1 and No. 2 are based upon field observations and engineering analysis. The estimated costs represent the engineer's opinion for costs associated with similar structural work. It is noted that the costs presented may be revised following the development of final detailed engineering plans and specifications necessary for construction bid for the repair or replacement work identified.

## A. Reservoir No. 1

Repair Cost Estimate for Earthquake Damage - Golden Hills Reservoir No. 1					
Item	Description	Unit	Quantity	Price/Unit	Total Price
1.	Mobilization	L.S.	1	\$10,000	\$10,000
2.	Plata/Access Shell	L.S.	1	\$24,560	\$24,560
3.	Scaffolding	L.S.	1	\$4,000	\$4,000
4.	Lift Equipment	M.O.	3	\$5,400	\$16,200
5.	Clean Joist	S.F.	5,720	\$4	\$22,880
6.	Clean Beams	S.F.	400	\$4	\$1,600
7.	Clean Roof	S.F.	5,720	\$4	\$22,880
8.	Straighten Joist	L.S.	1	\$69,000	\$69,000
9.	Straighten Column	L.S.	1	\$23,000	\$23,000
10.	Paint Joist/Beam/Roof	S.F.	11,840	\$4	\$47,360
11.	Replace Outlet/Floor	L.S.	1	\$36,100	\$36,100
12.	Replace Interior/Equipment Piping	L.S.	1	\$10,800	\$10,800
13.	Grout Voids	L.S.	1	\$8,000	\$8,000
14.	Repaint Floor	S.F.	13,000	\$2	\$26,000
15.	Replace Access	L.S.	1	\$55,790	\$55,790
16.	Sketch Plate	L.S.	1	\$162,000	\$162,000
17.	Ringwall Concrete	L.S.	1	\$70,000	\$70,000
18.	Yard Piping	L.S.	1	\$17,000	\$17,000
19.	Repave	S.Y.	280	\$30	\$8,400
Total					\$635,570
Contingencies at 15%					\$95,400
Contractors at 20%					\$146,200
Subtotal					\$877,170
Test and Inspection					\$34,300
Engineering and Geotechnical					\$75,200
<b>Grand Total</b>					<b>\$986,670</b>

## B. Reservoir No. 2

Repair Cost Estimate for Earthquak Damage - Golden Hills Reservoir No. 2					
Item	Description	Unit	Quantity	Price/Unit	Total Price
1.	Mobilization	L.S.	1	\$5,000	\$5,000
2.	Scaffolding	L.S.	1	\$4,000	\$4,000
3.	Check Connections and Repair	EA	66	\$75	\$4,950
4.	Connections/Paint	EA	66	\$75	\$4,950
5.	Clean Floor	L.S.	1	\$2,000	\$2,000
6.	Straighten Joist	L.S.	1	\$5,000	\$5,000
7.	Replace Outlet*	L.S.	1	\$18,600	\$18,600
8.	Yard Piping	L.S.	1	\$29,700	\$29,700
9.	Repave	S.Y.	70	\$30	\$2,100
Total					\$76,300
Contingencies at 15%					\$11,450
Contractors at 20%					\$17,600
Subtotal					\$105,350
Test and Inspection					\$2,650
Engineering and Geotechnical					\$15,000
<b>Grand Total</b>					<b>\$123,000</b>
*Assume same repair as Tank No. 1.					