Attachment 7

Stormwater Flood Management Grant Proposal
Littlerock Reservoir Sediment Removal Project
Technical Justification

Attachment 7 consists of the following items:

- ✓ **Technical Justification.** Attachment 7 provides the technical justification for the proposed project.
- ✓ **Supporting Documentation.** Technical reports, feasibility studies, and other documents justifying the claimed physical benefits are included in this attachment.

Project Overview

The LRSR Project proposes to restore the capacity of the reservoir to 3,325 AF through removal of 900,000 net cubic yards (equivalent to 560 AF) of accumulated sediment behind the Littlerock Dam. In addition, the LRSR Project proposes to construct a grade control structure that will prevent sediment loss and headcutting upstream of the Reservoir beyond Rocky Point to protect and preserve habitat for the federally endangered arroyo toad. Water quality, energy, and climate change benefits are also provided by the Project.

Project Physical Benefits

The following physical benefits are claimed for the LRSR Project. These physical benefits are further summarized in Table 7-1.

- Water Supply
  - Increased Reservoir volume of 900,000 net cubic yards enables PWD to provide an additional 560 AF of local surface water supply to customers each year; the total cumulative volume is 28,000 AF over the 50-year lifespan of the Project
  - Increased water supply reliability for PWD during times of drought experienced by the SWP by offsetting less reliable imported water with more reliable local surface water
- Reduced Delta demands to help address Bay-Delta environmental goals
- Flood Protection
  - Increased Reservoir volume of 900,000 net cubic yards enables PWD to provide an additional 560 AF of flood protection each year
- Habitat Protection (included in non-monetized benefits discussion)
  - Avoidance of “take” of federally endangered species
  - Preservation of habitat acres for federally endangered species
- Water Quality
  - Avoidance of 4,835 metric tons of salts imported from outside the Region over the 50-year lifespan of the Project
  - Avoidance of 14,450 pounds of bromide imported from outside the Region over the 50-year lifespan of the Project
  - Reduced disinfection byproducts (DBPs) in product water
- Energy Conservation
  - Reduction of 84 million kWh over the 50-year lifespan of the Project

- Greenhouse Gas Reduction
  - Avoidance of 27,600 metric tons of CO_2 equivalents emitted over the 50-year lifespan of the Project

Table 7-1: Summary of Physical Benefits

Physical Benefit	Unit	Technical Justification
Water Supply - increased Reservoir volume	cubic yards (and acre-feet)	*Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report*, June 2005. Note: Excavated volume of 540,000 cubic yards in report was increased to approximately 900,000 net cubic yards based on seven additional years of sedimentation at 54,000 cubic yards per year on average. See Appendix A.
Water Supply - increased reliability	Qualitative	California Department of Water Resources (DWR). *The 2011 State Water Project Final Delivery Reliability Report.* Bay-Delta Office. June 2012.
Delta Demands - decreased	Qualitative	California Department of Water Resources (DWR). *The 2011 State Water Project Final Delivery Reliability Report.* Bay-Delta Office. June 2012.
Flood Protection - reduced flow over Littlerock Dam during storm events	cubic yards (and acre-feet)	*Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report*, June 2005. See Appendix A. Flood Insurance Rate Maps (FIRM), Community: Palmdale, City/Los Angeles CO, Panel #'s: 06037C0694F, 06037C0711F, 06037C0442F, and 06037C0450F. Effective Date: September 26, 2008. See Appendix E. Aerial photos – GoogleEarth – 8/25/2012 Flood Insurance Study – Los Angeles County, CA. September 26, 2008. See Appendix E. USDA/NRCS - National Geospatial Management Center. National Elevation Data 10 meter or better. Process Date: 09/2011. Hydrologic Units (USGS HUCS/Watersheds) - USDA/NRCS - National Geospatial Management Center. 10 Digit Watershed Boundary Dataset in HUC8. Publication Date: 2012. (Shapefiles not included) Anaverde Flood Hydrograph – Upper Anaverde Watershed Detention Storage Alternatives, City of Palmdale, prepared by URS, 2002 Summary of LACDPW Observed Flooding Location in the Antelope Valley, compiled by LACDPW, January 2013. Placed at the end of Attachment 7.

Physical Benefit	Unit	Technical Justification
Habitat Protection	qualitative	*Littlerock Reservoir Sediment Removal Project Draft Biological Resources Technical Report,* October 2012. Qualitative - see discussion
Water Quality - avoidance of salts imported from outside Region	AFY of supply milligrams per liter of (mg/L) of TDS	AVEK 2011 Annual Water Quality Report - Los Angeles County System; average TDS for Acton, Eastside, Quartz Hill, and Raw Influent sources. Water Quality Table. See Appendix F. http://www.avek.org/2011%20LA%20County%20AWQR.pdf
Water Quality - reduced bromide concentrations:	AFY of supply mg/L of bromide	Tech. Memo No. 1 - *Development, Evaluation, and Selection of Treatment Train Alternatives for the Eastside Water Treatment Plant*, Carollo Engineers, February 2007. See Appendix G.
Energy Conservation - reduced energy from offset of SWP water	kWh	*Analysis of the Energy Intensity of Water Supplies for West Basin Municipal Water District*, WBMWD, March 2007, p. 4. See Appendix H. http://www.westbasin.org/files/general-pdfs/Energy--UCSB-energy-study.pdf
Greenhouse Gas Reduction - reduced emissions	Tons of CO_2 equivalents	Climate Action Registry, General Reporting Protocol http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html

Narrative Description of Without-Project Baseline

Sediment is expected to accumulate at an average rate of 34 AF/year. If the LRSR Project is not implemented, the Reservoir will continue to lose water supply storage capability from the current capacity of roughly 2,765 AF. In addition to diminishing water supply for consumption, the reduced capacity of the reservoir will result in continuing vulnerability of downstream areas to flooding. Finally, without the grade control structure included in the LRSR project, sediment loss will result in degradation of the natural habitat for the arroyo toad.

Lost water supply capability due to increasing sediment deposits will have additional damages related to alternative water options. By not increasing the supply of water, PWD will have to rely on additional SWP imports, which are less reliable compared to local water from Littlerock Creek. SWP imports include TDS and bromide loadings, and will require additional monitoring and treatment. SWP imports to the region will also continue to increase energy consumptions and carbon dioxide emissions.

Narrative Description of Physical Benefits (with Project)

A. Water Supply

Increase Use of Local Surface Water

Littlerock Reservoir is a critical water supply asset for PWD. Approximately 60 percent of potable water supply for PWD's customers comes from imported and local surface water. These supplies are primarily made up of State Water Project (SWP) and are supplemented with local surface water from the Reservoir. Surface water from the Reservoir is conveyed through an 8.5-mile ditch to Palmdale Lake and eventually treated at PWD's 15-mgd water treatment plant for potable use. However, with the increasing variability of SWP deliveries, PWD has been relying more on the Reservoir to supplement water demands. This Project will offset imported water supplies from the SWP.

The water supply benefit claimed is for 560 additional AFY of local surface water supply that will replace 560 AFY of water imported from the SWP. The LRSR Project removes approximately 900,000 net cubic yards of sediment. This volume is based on the 2005 *Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report*[1] which developed an alternative proposing to remove 540,000 cubic yards of sediment, followed by removal of an additional 270,000 cubic yards every five years thereafter. The alternative developed in the 2005 report assumed that 540,000 cubic yards represented a 10-year period of sediment deposition from 1995 to 2005, based on a 1991 sediment flow analysis[2] that estimated 54,000 cubic yards of deposition per year, on average.

The Project submitted in this application builds upon that 2005 project alternative and assumes that 54,000 cubic yards of sediment deposition has continued to occur for each of the seven years between 2005 and 2012. This accumulated sediment amounts to approximately 900,000 net cubic yards for the full seventeen-year period from 1995 to 2012. Once the sediment is removed, this volume would allow for approximately 560 AF of additional Reservoir capacity.

In the 2005 Report, the Reservoir storage capacity was reported as 3,000 AF. Assuming the ongoing deposition mentioned above, the 2012 capacity of the Reservoir may be approximated by subtracting the volume of the additional seven years of sediment, 378,000 cubic yards (235 AF), from the 2005 Reservoir volume. Using this method, the 2012 Reservoir capacity is estimated as 2,765 AF. The Project would increase the total storage capacity of the Reservoir from 2,765 AF to 3,325 AF; therefore these volumes represent the with- and without-Project conditions, respectively.

The 2005 Report estimated the time to fill the Reservoir, assuming full capacity was available at the beginning of the runoff season and that the 1995 topography was adjusted for 10 years of sediment deposition to represent 2005 conditions. Using historical runoff data, it was estimated that the median year inflow would fill the Reservoir by March 2. The 2005 Report also described USGS records indicating that the annual runoff volume exceeds 2005 Reservoir capacity 80 percent of the time. Using these estimates, and with the understanding that even less storage volume is available in 2012 after seven additional years of sediment deposition, this Project assumes that the Reservoir, under typical operating conditions, is filled to capacity early in the

[1] Aspen Environmental Group, 2005. *Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report.* June 2005.
[2] Woodward-Clyde Consultants, 1991. *Littlerock Dam Reservoir Restoration Project. Evaluation of Aggregates for RCC Construction*.

year. Thus, additional storage capacity in the Reservoir will capture additional stormwater runoff during the rainy season months of December through May; and depending on water use patterns by PWD, could capture additional surface runoff that occurs outside the rainy season months if the Reservoir is drawn down prior to storm events. These high-inflow years would be offset occasionally by dry years where the total additional captured flow would be less than the total storage capacity of the Reservoir.

Once sediment removal takes place, no additional facilities are needed to provide water supply benefits since Littlerock Dam and the associated water conveyance system already has capacity to store and deliver the additional 560 AFY.

The documented information described above validates the water supply benefit claim that the Project will provide an additional 560 AFY of local surface water supply to the Region.

Increase Supply Reliability

The reliability of a water supply refers to the ability to consistently meet water demands, even in times of drought or other constraints on source water availability. The Project would help increase the reliability of water use by PWD by substituting local surface water from Littlerock Reservoir for SWP supplies. The SWP Delivery Reliability Report for 2011[3] shows that the long-term reliability of SWP supplies is 60% of the total demand for SWP Table A water, with deliveries during multiple dry year periods averaging 32% to 38% of total demand. In comparison, PWD's 2010 Strategic Water Resources Plan[4] includes a record of Littlerock Creek runoff by year that indicates a reliability of 100% of PWD's 5,500 AFY diversion right during an average year.

Reduce Demands on California Delta

The Antelope Valley Region has made it a priority to reduce dependence on imported water supplies received from the Sacramento-San Joaquin Delta (Delta), a priority that is reflected in the Region's 2007 IRWMP Plan. Diversion of water from the Delta to southern California has caused damage to the Bay Delta's ecosystem due to SWP and Central Valley Project operations. In particular, infrastructure used to divert water to southern California directly impacts species (such as the entrainment of aquatic species in pumps) and damages habitats, while operations that reverse river flows impact ecosystems activity. By reducing the Region's reliance on the Bay Delta, diversions will be reduced, thus reducing operations that impact native species and habitats. This reduction in operations will help to meet Bay Delta environmental goals to restore tidal marshes and floodplains, and restore fish and wildlife species.

B. Flood Protection

The Project will restore the level of debris control and flood peak attenuation provided by Littlerock Dam and Reservoir by removing 900,000 net cubic yards of sediment to achieve a capacity of 3,325 AF, as established in the Water Supply section above. Estimates show that approximately 54,000 cubic yards of sediment are deposited into the Reservoir annually from seasonal inflow. The project would remove a

[3] California Department of Water Resources (DWR). *The 2011 State Water Project Final Delivery Reliability Report.* Bay-Delta Office. June 2012.
[4] 2010 Palmdale Water District Strategic Water Resources Program: Options Report, RMC, March 2010.

minimum of 900,000 cubic yards of sediment during a 5-year closure of the Reservoir. The LRSR Project would increase the flood control capacity at the Reservoir by a minimum of 560 AF on average.

Flood damage from Little Rock Creek downstream of Little Rock Dam occurs primarily through flooding of roadway crossings and potential flooding of homes and other structures in the floodplain. The proposed excavation will create additional storage within the reservoir such that the magnitude and frequency of floods exiting the reservoir are potentially reduced.

The purpose of this analysis is to provide a rough characterization of potential flood damages prevented by the LRSR Project.

Reservoir Operations and Hydrology

Under current conditions Littlerock reservoir has a storage capacity of 2,765 acre feet. After project implementation, the capacity will be approximately 3,345 acre feet. The excavation of an additional 560 acre feet of volume within the reservoir will provide additional capacity for attenuating flood flows.

Flows entering Littlerock Reservoir during the annual winter flood season, which extends roughly from November to May, are held in the reservoir until the reservoir water level reaches the spillway crest. Before the water level reaches the dam spillway crest, all flood flows entering the reservoir are attenuated completely. No discharges except for water supply withdrawals by PWD are allowed to exit the reservoir. Project-related attenuation of flows will not occur at water levels exceeding the spillway crest.

PWD currently has the right to withdraw up to 5,500 acre feet of water per year from Littlerock Reservoir. The reservoir is normally drained by the end of December. Withdrawals can occur after the fall runoff inflow and occur throughout the year. Assuming a 10-month withdrawal period (i.e., end of November to end of September), average water supply withdrawal discharge is 9.1 cfs.

An estimate of the time to fill for the Littlerock Reservoir to the level of the spillway crest was made by subtracting the average supply withdrawal of 9.1 cfs from average inflows recorded by the United States Geological Survey (USGS).[5] Withdrawals were assumed to begin December 13, which is the day average inflow begins to exceed 9.1 cfs. This analysis showed that net inflow volume reaches 2,765 acre feet on February 4 each year, on average. After February 4, inflows pass over the spillway crest and are not attenuated. The same analysis showed that with the with-project volume of 3,325 acre feet, net inflow would be reached on February 11, providing an average of seven additional days per year when no flood flows would pass over Littlerock Dam. In other words, without the excavation project, Littlerock Reservoir has the potential for attenuation of floods that occur before February 4 each year on average. With the project the potential for attenuation is extended to February 11. After those dates no flood attenuation can be expected.

A review of USGS annual peak flow records[6] over a period of 51 years shows the following frequency of flood occurrences by month:

[5] Hydrologic Units (USGS HUCS/Watersheds) - USDA/NRCS - National Geospatial Management Center. 10 Digit Watershed Boundary Dataset in HUC8. Publication Date: 2012.

[6] Hydrologic Units (USGS HUCS/Watersheds) - USDA/NRCS - National Geospatial Management Center. 10 Digit Watershed Boundary Dataset in HUC8. Publication Date: 2012.

Month	Number of Annual Peak Flow Occurrences
September	1
October	0
November	5
December	7
January	10
February	15
March	5
April	6
May	2
Total	51

The table above shows that roughly half of the peak flows on Littlerock Creek occur in or before February and have the potential to be attenuated by Littlerock Reservoir.

According to the FEMA flood insurance study for Littlerock Creek[7], the 100-year discharge at Littlerock Dam is 20,000 cfs. A 100-year flood hydrograph was developed for Littlerock Creek using the hydrograph shape from the nearby Anaverde Creek adjusted to conform to the peak discharge of Littlerock Creek.[8] This hydrograph gave a 100-year, 24-hour volume of 5,500 acre feet. An approximation of the potential of Littlerock Reservoir to attenuate this peak was made using the following assumptions:

- The flood occurs when the reservoir is initially empty.
- Reservoir storage volume is equal to cumulative hydrograph inflow minus cumulative reservoir outflow.
- Reservoir outflow is 9.1 cfs (same as the average PWD maximum delivery allocation).
- No flood attenuation occurs after the maximum reservoir volume below the spillway crest is reached.

The analysis showed that under current conditions the maximum reservoir capacity of 2,675 acre feet would be reached before the peak inflow occurs, resulting in no attenuation of the 100-year peak. Under with-project conditions the peak inflow at the time maximum capacity is reached would be approximately 19,625 cfs, meaning the 100-year peak would be reduced by approximately 2%. If the flood occurs after the end of November, with associated previous inflow to the reservoir, there would be no reduction in the flood peak. Therefore, for the excavation project to have an effect on the 100-year flood, the flood must occur in or before the month of November. Based on the flood peak frequency table above, roughly one in ten floods occur in or before November.

[7] Floodplain information - Flood Insurance Rate Maps (FIRM), Community: Palmdale, City/Los Angeles CO, Panel #'s: 06037C0694F, 06037C0711F, 06037C0442F, and 06037C0450F. Effective Date: September 26, 2008.

[8] Anaverde Flood Hydrograph – Upper Anaverde Watershed Detention Storage Alternatives, City of Palmdale, prepared by URS, 2002

A 50-year flood analysis showed that if the flood occurs before the end of November, there is a potential for a reduction in flood peak of approximately 4,400 cfs, but if the flood occurs after the end of December the project-related flood peak reduction is extremely low. Based on the seasonal frequency of flood peaks given above, the chance a 50-year flood will occur before the end of November is approximately 12%. Approximately one in eight 50-year floods that enter Littlerock Reservoir have the potential to be reduced by Project-related excavation.

The 25-year flood exhibits shows that if the flood occurs when the reservoir is initially empty, the reservoir has capacity for the entire flood under existing and with-Project conditions, meaning there would be no project-related flood-control benefit. If the flood occurs at the end of November, the Project-related reduction in flood peak would be approximately 1,800 cfs. If the flood occurs at the end of December, the Project-related reduction in flood peak would be approximately 4,600 cfs. Based on the seasonal frequency of flood peaks given above, the chance a 25-year flood will occur during the month of December, the window of primary opportunity for 25-year flood-control benefit, is approximately 14%. Approximately one in seven 25-year floods that enter Littlerock Reservoir have the potential to be reduced by Project-related excavation.

Summary of Approximate Potential Flood Peak Reductions by Little Rock Dam

Flood Return Period	Discharge in cfs[1]	Project-related peak reduction, in cfs[2]	With Project peak flow, in cfs	With Project peak percent of without Project peak	Seasonal window of opportunity for this peak reduction[3]	Likelihood the peak will be reduced in a given flood season[4]
100 Year	20,000	0	20,000	100%	Not applicable. no peak reduction.	0
50 Year	13,000	4,400	8,600	66%	September to end of November	12%
25 Year	9,000	4,600	4,400	49%	December	14%

1 100-Year is from the FEMA study. The others are by ratio from the Anaverde Wash study.
2 Computed by approximate routing analysis described in the text.
3 Due to annual filling of the reservoir, the flood must occur within this period for any flood peak reduction to occur.
4 Based on observed distribution of annual peak flow events from USGS records.

Roadway Damages Prevented

Based on information from the Los Angeles County Department of Public Works,[9] roadway flooding has occurred at the following roadways:

- 70th Street East
- Avenue N
- Avenue I
- Avenue H
- 50th Street East
- Avenue G

70th Street, at a distance of approximately 10 miles downstream of Little Rock Reservoir, is the nearest crossing.

Benefits of the Littlerock Reservoir excavation project to the roadway crossings would be:

- 5 additional days per year when there is no flow over Littlerock Dam.
- Reduced frequency and magnitude of flood peaks for floods of 50-year magnitude or smaller from Littlerock Dam, if the floods occur early in the flood season.

These benefits should be considered in the context of the overall watershed. The figure below shows the watersheds contributing runoff at the approximate location of the road crossings listed above. In addition to the Littlerock Creek watershed, there is a substantial watershed referred to as Town of Pearblossom, entering between the dam and the road crossings. At Avenue K, which is at approximately the midpoint of these road crossings, the total watershed area is 184 square miles, compared to 64 square miles at Littlerock Dam. With 120 square miles of watershed area contributing downstream of the dam, nearly twice the watershed of the dam, the effect of the dam on flood peaks and duration at the location of the road crossings will be substantially reduced. A rough approximation of flood depth reductions at the road crossings can be found in the analysis described below.

Structure Damages Prevented

A review of aerial photographs indicates 77 structures in the FEMA floodplain. Based on our interpretation of aerial photographs there are 40 residential structures, 20 warehouse structures, 9 commercial outbuildings, 6 industrial buildings, and 2 garages. The watershed figure above shows the location of these structures. All but 2 are more than 15 miles downstream of the dam.

According to FEMA maps, all but two of the 77 structures referred to above are in a Zone A, defined as having undetermined 100-year flow depths. The FEMA study has no discharges for Littlerock Wash at the location of the flooded structures (approximately at Avenue K). The floodplain in this area is delineated by approximate methods. For purposes of this analysis, the peak 100-year discharge at that location is estimated at 57,500 cfs by area ratio using the following method:

- Watershed area at Littlerock Dam = 64 Square Miles
- Watershed Area at Avenue K = 184 Square Miles

[9] *Summary of LACDPW Observed Flooding Location in the Antelope Valley*, compiled by LACDPW, January 2013.

- 100-Year Peak Flow at Littlerock Dam = 20,000 cfs
- 20,000 cfs/64 Square Miles * 184 Square Miles = 57,500 cfs

Without-project 50-year and 25-year discharges are estimated by ratio as 37,375 cfs and 25,875 cfs, respectively. With-project 50-year and 25-year discharges are estimated by subtracting the with-project peak reductions given above and are 32,975 cfs and 21,275 cfs, respectively.

Flow depths at the location of the flooded structures are approximated by normal depth calculations using the assumption of a flat-bottomed cross section:

- Floodplain Width = 2 miles (measured as typical at most floodplain structures)
- Ground Slope = 0.004 Feet per Foot
- Roughness Coefficient = 0.05 (for cultivated areas)

Without and with-project flow depths in the Zone A structures affected by flooding are as shown in the following table:

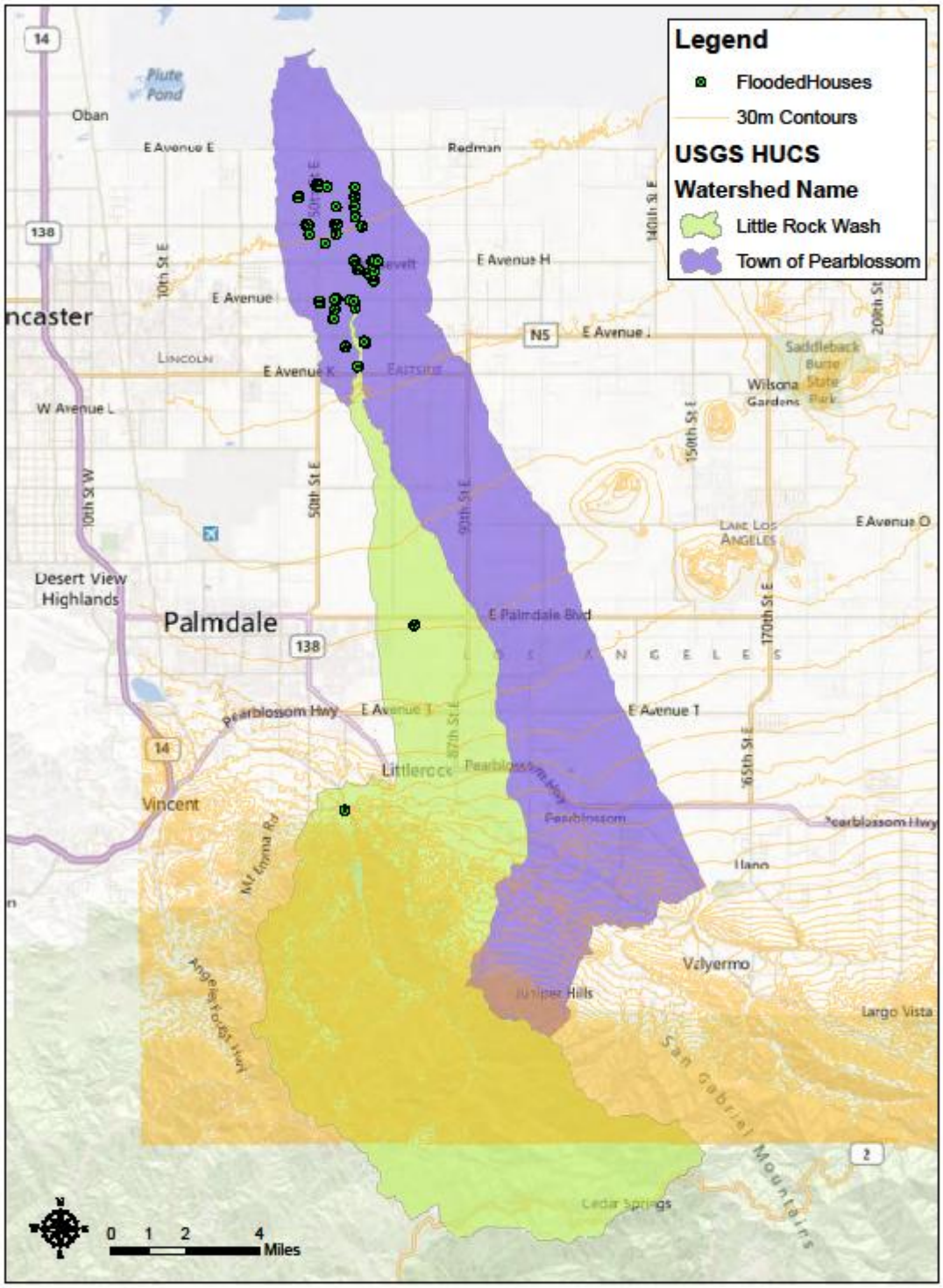
Approximate With and Without Project Flood Depths at Zone A Flooded Structures in Littlerock Wash Floodplain		
Flood Return Period	Without-Project Flood Depth, in Feet	With-Project Flood Depth, in Feet
100-Years	1.89	1.89
50 Years	1.46	1.36
25-Years	1.17	1.04

No information is available on finished floor elevations. In the absence of this information an assumption of 6 inches above surrounding grade is used. The table below gives flood depths above and below finished floors at the floodplain structures.

Flood Depths Above and Below Finished Floors at the Floodplain Structures		
Flood Return Period	Without Project Flood Depth, in Inches	With Project Flood Depth, in Inches
100-Years	16.7	16.7
50 Years	11.5	10.3
25-Years	8.0	6.5

Miles of Inundated Roads, With and Without Project, by Road Category and Return Period (i.e., Flood Frequency)			
	Major Roads (mi)		
	With Project	Without Project	Change
25-Year	0.54	0.65	0.11
50-Year	0.8	0.9	0.1
100-Year	1.5	1.5	0

Source: CDM-Smith modeling analysis


Legend
FloodedHouses
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USGS HUCS
Watershed Name
Little Rock Wash
Town of Pearblossom
Oban
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Eastside
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Saddleback Butte State Park
Lake Los Angeles
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Palmdale
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Vincent
Llano
Valyermo
Juniper Hills
Largo Vista
San Gabriel Mountains
Cedar Springs
0 1 2 4 Miles

Summary and Conclusion

This analysis shows that the flood-control benefit of the sediment removal project is likely to occur in the early stages of the flood season when the reservoir is empty or near empty. The potential for flood benefits is reduced substantially as the runoff season progresses. No benefit is expected for floods that occur after mid-February. Benefits are negligible for the 100-year flood. Nearly all potential benefits are 15 miles or more downstream of the dam and for the 50-year and smaller discharges. Because of the complexities involved, it is possible a more detailed analysis would show benefits to be less than those presented here.

Limitations

The analysis presented here is an approximate analysis using simplifying assumptions that could have implications regarding the accuracy of the results. The primary intent is to determine whether it is possible there be flood benefits from the excavation at Littlerock Reservoir, and to make an approximation of the probable magnitude of these benefits in terms of flood frequency and flood depth at flood-prone structures. Major limitations to this study are listed below:

- The flood hydrograph used was based on the shape of a hydrograph developed by another study for a nearby watercourse (Anaverde Creek), with ordinates adjusted by ratio of the Littlerock 100-year peak to the Anaverde 100-year peak. It is likely a detailed analysis of Littlerock hydrology will result in a different hydrograph with larger runoff volumes at Littlerock Dam, resulting less flood peak attenuation than presented here. Peak discharge rates at the location of the flooded homes are likely less than represented here due to channel attenuation, area rainfall reduction, timing of converging peaks, and watershed topography.

- The reservoir routing analysis used an approximation rather than the standard storage indication method normally used in reservoir routing.

- The reservoir inflow scenario and assumption of available reservoir storage capacity at the initiation of the flood season is simplified and should be revisited with more inflow scenarios in a more detailed analysis.

- Flood depths at the location of the flooded properties are assumed by normal depth calculations, not by step backwater analysis.

- Finished floor elevations are assumed to be 6 inches. No on-site information is available.

C. Habitat Protection (also discussed in Attachment 8)

Littlerock Creek, which feeds the Reservoir, provides habitat for the federally endangered arroyo toad (*Bufo californicus*). Previous plans for sediment removal from the Reservoir posed potential risks for “take” of arroyo toad and degradation of arroyo toad habitat upstream of the Reservoir beyond the Rocky Point area. The LRSR project proposes to construct a soil cement grade control structure at Rocky Point to prevent sediment loss and headcutting of the stream channel upstream of Rocky Point. This grade control structure will minimize the degradation of critical habitat for and incidental “take” of the federally-endangered arroyo toad. In addition, the grade control structure would act as a barrier between human activities (i.e., recreation activities, sediment removal activities, etc.) within the Reservoir and the arroyo

toad's habitat upstream of Rocky Point. Protection of the arroyo toad is consistent with USFS Strategy WL 1 (Threatened, Endangered, Proposed, Candidate, and Sensitive Species Management).

The grade control structure design would consist of a permanent structure of soil cement and would be constructed as a cascading (i.e., stair-step) structure with a series of steep drops of approximately 4-feet each with 15-foot horizontal aprons downstream of each drop, extending to a total depth of up to 70 feet below the existing ground surface. The structure would be constructed below grade, and once backfilled, only the top or upper lip of the structure would be visible when the Reservoir water level is lowered. When the Reservoir is full it would contain water beyond the Rocky Point area and any portion of the grade control structure at the Reservoir bottom grade would be submerged and not visible.

The number of federally endangered species and acres of protected habitat will be further evaluated and determined in subsequent phases of the *Littlerock Reservoir Sediment Removal Project Biological Resources Technical Report* that will be completed in a final version in late 2013.

D. Water Quality

Total Dissolved Solids

State Water Project (SWP) water contains total dissolved solids (TDS) or salts. A typical value for TDS in SWP water is 140 mg/l, based on the Antelope Valley East Kern Water Agency 2011 Annual Water Quality Report.[10] Since this water is imported from outside of the Antelope Valley basin, it represents a net increase in loading of salts to the basin. Efforts such as the ongoing Antelope Valley Salt and Nutrient Management Plan have increased awareness of salt balance in the Region and have increased concern for identifying and reducing salt inflows. SWP water is the largest inflow of TDS to the Region and this is of particular concern in the Antelope Valley because the groundwater basin and subbasins are closed (i.e., no outlet to the ocean).

Assuming an average SWP TDS concentration of 140 mg/L, and assuming that TDS loadings that originate from local surface water are already contained within the Antelope Valley Region (and therefore do not represent salt inflows), 560 AFY of offset imported SWP water represents approximately 97 metric tons per year of salts that would no longer be imported. Over the lifespan of the Project, this amounts to approximately 4,835 metric tons of TDS that will not be introduced to the Antelope Valley as a salt input.

Bromide

SWP water supplies also contain higher levels of bromide, which is a concern in drinking water. Bromide combines with chemicals used in the water treatment process to form disinfection byproducts (DBPs) such as trihalomethanes (THMs) that are strictly regulated under the Federal Safe Drinking Water Act. PWD treats all water to meet stringent state and federal drinking water standards before delivering it to customers. However, source water of poorer quality will make it increasingly expensive and difficult to meet such standards. Increased levels of constituents that could aid in the formation of THMs can mean more time spent monitoring treated water in the distribution systems and may lead to the use of increased proportions of groundwater in the blend water supplies in order to control THMs. The LRSR Project would offset the need for SWP Imported water with local surface water supply that contains less bromide and has less propensity to form DBPs.

[10] AVEK 2011 Annual Water Quality Report - Los Angeles County System; average TDS for Acton, Eastside, Quartz Hill, and Raw Influent sources.

A 2007 water quality report for AVEK[11] reported an average bromide value of 0.19 mg/L for SWP water and a value of "non-detect" for surface water in the Littlerock Reservoir. Assuming this average concentration of 0.19 mg/L, 560 AFY of offset imported SWP water represents approximately 289 pounds per year of bromide that would no longer be imported. Over the lifespan of the Project, this amounts to approximately 14,450 pounds of bromide that will not be introduced to the Antelope Valley; moreover, this reduced bromide will reduce the propensity for DBP formation in potable drinking supplies.

E. Energy Conservation

The long-distance transport of water in conveyance systems consumes a significant portion of California's total electricity demand. The SWP, is the largest consumer of electrical energy in the California, requiring an average of 5,000 GWh per year, and contributes 0.6% of California's total GHG emissions.

The energy required to convey surface water from the Reservoir to PWD's 35-mgd water treatment plant is essentially zero. For imported supplies, West Basin Municipal Water District (WBMWD) has estimated that approximately 3,000 kilowatt-hours (kWh) per AF of energy is required for conveyance and pumping to Southern California SWP contracting agencies.[12] Assuming 3,000 kWh/AF and an average annual imported water offset of 560 AF, approximately 1,680,000 kWh per year of energy will be saved by implementing the Project. Over the 50-year lifespan of the Project, this totals 84 million kWh of conserved energy.

F. Greenhouse Gas Reduction

The proposed project would avoid greenhouse gas (GHG) emissions generated by the additional energy needed to transport imported SWP water for the Region. This value may be calculated by applying a factor of 0.724 lbs. of CO_2 equivalents per kWh and converting to total tons of CO_2 equivalents, based on the California Action Registry, General Reporting Protocol.[13] By offsetting the demand of 560 AF of imported SWP water, the proposed Project will avoid GHG emissions of 552 metric tons per year of CO_2 equivalents per year. Over the 50-year lifespan of the Project, this totals 27,600 metric tons of avoided carbon emissions.

[11] Tech. Memo No. 1 - *Development, Evaluation, and Selection of Treatment Train Alternatives for the Eastside Water Treatment Plant*, Carollo Engineers, February 2007.
[12] *Analysis of the Energy Intensity of Water Supplies for West Basin Municipal Water District*, WBMWD, March 2007.
[13] Climate Action Registry, General Reporting Protocol http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html

Annual Project Physical Benefits

The following tables present the physically quantifiable benefits for the project. One table is completed for each physically quantifiable benefit.

Benefit #1 - Water Supply

The table below provides information regarding Reservoir capacity for local surface water, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: increased Reservoir capacity for local surface water supply			
Measure of Benefit Claimed (Name of Units): AF			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	2,765	2,765	0
2013	2,765	2,765	0
2014	2,765	2,765	0
2015	2,765	2,765	0
2016	2,765	2,765	0
2017	2,765	2,765	0
2018	2,765	2,765	0
2019	2,765	2,765	0
2020	2,765	3,325	560
2021	2,765	3,325	560
2022	2,765	3,325	560
2023-2069	2,765	3,325	560
References: *Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report*, June 2005. Note: Excavated volume of 540,000 cubic yards in report was increased to approximately 900,000 net cubic yards based on seven additional years of sedimentation at 54,000 cubic yards per year on average.			

Benefit #2 - Flood Protection

The table below provides information regarding the degree of flood protection, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: increased Reservoir capacity for flood protection			
Measure of Benefit Claimed (Name of Units): AF			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	2,765	2,765	0
2013	2,765	2,765	0
2014	2,765	2,765	0
2015	2,765	2,765	0
2016	2,765	2,765	0
2017	2,765	2,765	0
2018	2,765	2,765	0
2019	2,765	2,765	0
2020	2,765	3,325	560
2021	2,765	3,325	560
2022	2,765	3,325	560
2023-2069	2,765	3,325	560
References: *Littlerock Reservoir Hydrologic and Sediment Transport Analysis Technical Report*, June 2005. Note: Excavated volume of 540,000 cubic yards in report was increased to approximately 900,000 cubic yards based on seven additional years of sedimentation at 54,000 cubic yards per year on average.			

Benefit #3 - Water Quality, Total Dissolved Solids (TDS)

The table below provides information regarding the amount of TDS imported to the Region, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: avoided imported TDS			
Measure of Benefit Claimed (Name of Units): metric tons			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	97	97	0
2013	97	97	0
2014	97	97	0
2015	97	97	0
2016	97	97	0
2017	97	97	0
2018	97	97	0
2019	97	97	0
2020	97	0	-97
2021	97	0	-97
2022	97	0	-97
2023-2069	97	0	-97
References: AVEK 2011 Annual Water Quality Report - Los Angeles County System; average TDS for Acton, Eastside, Quartz Hill, and Raw Influent sources. Water Quality Table.			

Benefit #4 - Water Quality, bromide

The table below provides information regarding the amount of bromide imported to the Region, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: avoided imported bromide			
Measure of Benefit Claimed (Name of Units): pounds			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	289	289	0
2013	289	289	0
2014	289	289	0
2015	289	289	0
2016	289	289	0
2017	289	289	0
2018	289	289	0
2019	289	289	0
2020	289	0	-289
2021	289	0	-289
2022	289	0	-289
2023-2069	289	0	-289
References: Tech. Memo No. 1 - *Development, Evaluation, and Selection of Treatment Train Alternatives for the Eastside Water Treatment Plant*, Carollo Engineers, February 2007.			

Benefit #5 - Energy Conservation

The table below provides information regarding energy consumption for conveyance of SWP imported water, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: energy consumed			
Measure of Benefit Claimed (Name of Units): kilowatt-hours (kWh)			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	1,680,000	1,680,000	0
2013	1,680,000	1,680,000	0
2014	1,680,000	1,680,000	0
2015	1,680,000	1,680,000	0
2016	1,680,000	1,680,000	0
2017	1,680,000	1,680,000	0
2018	1,680,000	1,680,000	0
2019	1,680,000	1,680,000	0
2020	1,680,000	0	-1,680,000
2021	1,680,000	0	-1,680,000
2022	1,680,000	0	-1,680,000
2023-2069	1,680,000	0	-1,680,000
References: *Analysis of the Energy Intensity of Water Supplies for West Basin Municipal Water District*, WBMWD, March 2007, p. 4.			

Benefit #6 - Greenhouse Gas (GHG) Emissions

The table below provides information regarding GHG emissions for conveyance of SWP imported water, with and without the Project.

Littlerock Reservoir Sediment Removal Project			
Physical Benefit: CO_2 equivalents emitted			
Measure of Benefit Claimed (Name of Units): metric tons			
Additional Information about this Measure:			
Year	**Physical Benefits**		
	Without Project	**With Project**	**Change Resulting from Project**
2012	552	552	0
2013	552	552	0
2014	552	552	0
2015	552	552	0
2016	552	552	0
2017	552	552	0
2018	552	552	0
2019	552	552	0
2020	552	0	-582
2021	552	0	-582
2022	552	0	-582
2023-2069	552	0	-582
References: Climate Action Registry, General Reporting Protocol http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html			

Strategic Water Resources Program: Options Report

Prepared by:

RMC
Water and Environment

In Association with:

A&N Technical Services

Wildermuth Environmental

March 2010

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Appendices

Appendix A Demand and Conservation Model Analysis

3.7 Littlerock Reservoir

PWD uses Littlerock Creek as a local surface water supply source. The watershed is approximately a 90 square mile area and has tributary flows that feed Littlerock Reservoir from Littlerock Creek and Santiago Creek. From Littlerock Reservoir, the Palmdale Ditch flows to Lake Palmdale prior to treatment and distribution. The current Littlerock Reservoir capacity is 3,000 af. In normal years, Littlerock Reservoir overflows its capacity in wet months and water is released to Littlerock Creek.

The original design of Littlerock Reservoir allowed for a maximum storage capacity of 4,300 af. Due to sediment build-up, the storage capacity was substantially reduced to 1,600 af by 1991. In 1992, PWD raised the height of the dam and the storage capacity increased to 3,300 af but did not remove any sediment. If all sediment were removed given the current dam height, the maximum storage capacity of Littlerock Reservoir could be 6,000 af.

In preparing this section, the following materials were reviewed:

- *Alternatives for Proposed Rocky Point Grade Control Structure*, URS Corporation. June 2008.
- *Preliminary Dredging/Slurry Feasibility Analysis for Excavation of Littlerock Reservoir*, Aspen Consulting Engineers, September 2007.
- *Environmental Impact Report/Environmental Impact Statement, Littlerock Reservoir Sediment Removal Project*, Aspen Environmental Group. April 2007.
- *Hydropower Program: Hydrofacts*, Idaho National Laboratory. July 2005.
- *Estimation of Economic Parameters of U.S. Hydropower Resources*, Idaho National Laboratory and Environmental Laboratory. June 2003.
- *Hydropower Resource Economics Database*, Idaho National Laboratory. April 2003.

3.7.1 Existing Supply

In a normal year, PWD takes about 4,400 af from Littlerock Reservoir, as shown in **Table 3-27**, from January through June – which is about 150% of the storage capacity of 3,000 af. **Figure 3-35** provides a graphic summary of the annual deliveries to Littlerock Reservoir from Littlerock Creek. As shown in **Table 3-28** the average yearly supply from Littlerock Creek is 18,950 afy and that supplies are almost non-existent in summer months. At present, Littlerock Reservoir is losing roughly 30-40 af of storage capacity each year due to ongoing sediment build-up. PWD is not currently removing sediment from Littlerock Reservoir to maintain its storage capacity and so it is anticipated that potential supplies will continue to decrease over time. **Figure 3-36** provides this rate of storage capacity loss. Assuming the current trend of storage capacity being lost and PWD's current use of about 150% of storage capacity, **Figure 3-37** shows graphically the cumulative costs PWD will incur to purchase imported water to counterbalance storage losses at Littlerock Reservoir.

Table 3-27: PWD Historical Production from Littlerock Reservoir

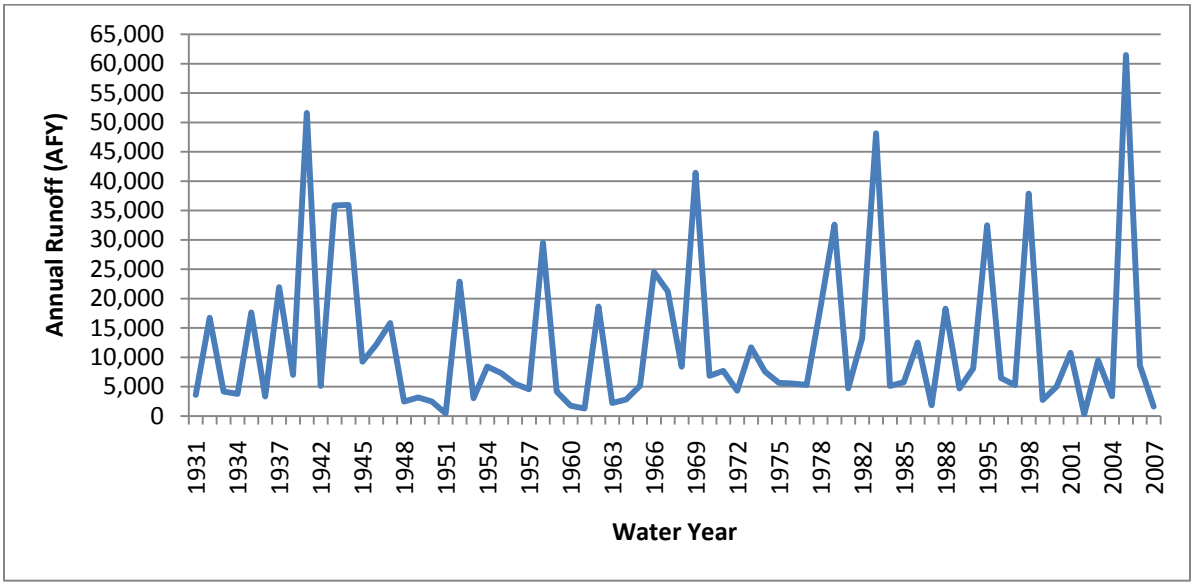
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
PWD Take (AFY)	3,771	2,409	3,595	5,040	3,050	6,501	6,852	-	3,499	3,660	6,900	4,173	-	3,045	4,400

Table 3-28: Littlerock Creek Runoff by Monthly Average

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Mean (CFS)	113.61	59.51	49.42	38.71	31.62	7.46	2.19	1.10	0.94	3.63	1.68	8.60	318.47
Mean (AF/month)	6,760	3,541	2,941	2,303	1,882	444	130	65	56	216	100	512	18,950

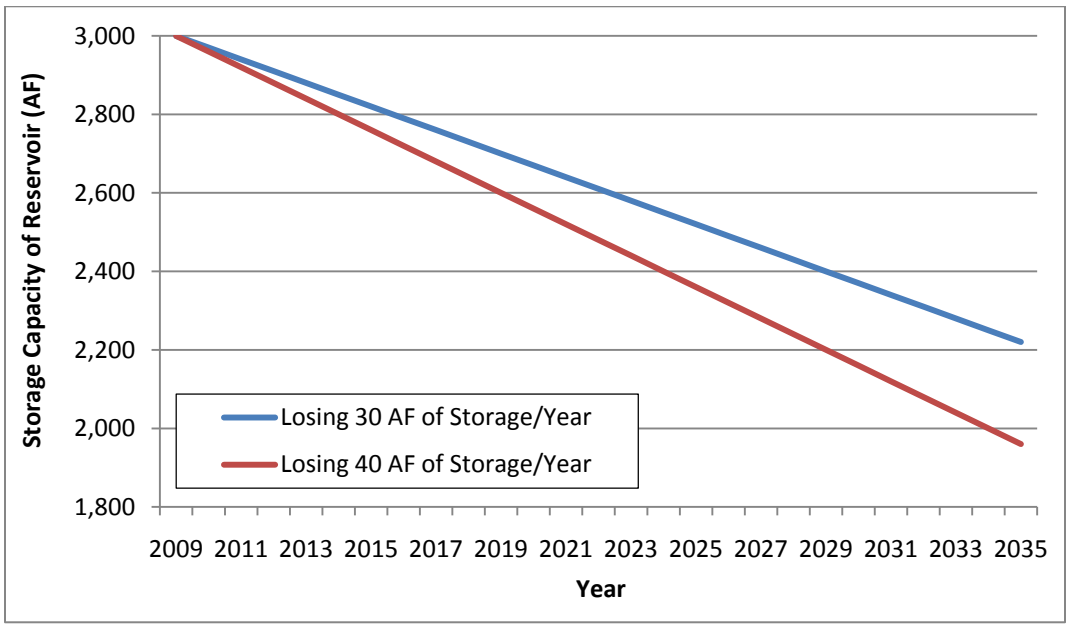
Source: http://www.ladpw.org/wrd/report/0607/runoff/discharge.cfm

Figure 3-35: Littlerock Creek Runoff by Year



Source: http://www.ladpw.org/wrd/report/0607/runoff/discharge.cfm

Figure 3-36: Littlerock Reservoir Projected Loss of Storage Capacity



Summary of LACDPW Observed Flooding Locations in the Antelope Valley

Information provided by: Youssef Chebabi, Dale Brown, Bob Holmes, and Thomas Ashton, LA County Department of Public Works

Summarized by: Brian Dietrick, P.E., RMC Water and Environment

Date: 1/26/2013

1. **<u>Flood Frequency - all storms</u>**:
    a. 240th St. East at Avenue P
    b. Avenue O west of 240th St. East
    c. 180th St. East at Avenue O
    d. Avenue P at 170th St. East
    e. Avenue Q4 at 160th St. East
    f. Avenue Q4 at 155th St. East
    g. Avenue L8 at 170th ST. East
    h. Avenue M8 at 155th St. East
    i. Avenue M12 at 155th St. East
    j. 165th St. East at Avenue N
    k. Cool Water St. at 167th St. East
    l. Avenue N at 160th St. East
    m. Avenue N at 155th St. East
    n. 50th St. East and Avenue J (south side is City)
    o. Avenue H east of Division St.
    p. Avenue P8 at 90th St. East
    q. Avenue M east of 150th St. East
    r. Avenue G east of Division St.
    s. Avenue F east of 10th St. East
    t. Avenue G6 at Division St.
    u. Avenue M12 at 157th St. East
    v. Frontier Circus St. from Stagecoach to Avenue P8
    w. Avenue J at 100th St. East
2. **<u>Flood Frequency - medium and high storm events:</u>**

    Big Rock Creek
    a. Avenue Q at 145th St. East
    b. Avenue Q west of 140th St. East
    c. 140th St. East south of Avenue Q
    d. 145th St. East north of Avenue Q
    e. 150th St. East at Palmdale Blvd. to Avenue Q4 (very high storm events)
    f. Avenue O at 140th St. East
    g. 150th St. East at Avenue M8
    h. 150th St. East at Avenue M4

i. 110th St. East from Avenue K8 to Avenue I (down middle of street for 2 miles)
j. Avenue I west of 110th St. East
k. Avenue H at 100th to 105th St. East

Littlerock Creek

a. 70th St. East +/- Avenue M
b. Avenue N west of 70th St. East
c. Avenue I west of 60th St. East
d. Avenue H at 55th St. East
e. Avenue H (3/4 of the water travels west on Avenue H to 50th St. East)
f. 50th St. East (3/4 of water flows down from Avenue H to Avenue D (to AF Base), water travels down street for 4 miles)
g. Avenue G at 55th St. East (1/4 of water flows down on Avenue G)

3. Other Areas

a. Hasley Canyon Road and Del Valle Road: Hasley Cyn area
b. Lincoln approximately 200 feet south of Chiquito Canyon Road: Val Verde area
c. Lincoln and Taylor: Val Verde area
d. Kenningston Road at Arlington St.: Val Verde area
e. 20th St. West from Ave. E to Ave. F
f. 60th St. West from Ave. A to Ave. E
g. 70th St. West from Ave. A to Ave. E
h. 90th St. West from Ave. A to Ave. G8
i. 110th St. West from Ave. A to Ave. K
j. Lancaster Road from 70th St. West to 245th St. West
k. La Petite Ave. from Ave. B8 to Ave. D
l. Ave. A from 100th St. West to 170th St. West
m. 170th St. West from Ave. A to Lancaster Road
n. 190th St. West from Ave. B to Ave. D
o. Elizabeth Lake Road from Godde Hill Road and Lake Hughes Road
p. Bouquet Canyon Road from Elizabeth Lake Road to M.M. 8.01 (end of district)
q. San Francisquito Canyon Rd. from Elizabeth Lake Road and Pelton Road (end of district)
r. Johnson Hill Road from 110th St. West to Elizabeth Lake Road
s. Munz Ranch Road from Lancaster Road to Elizabeth Lake Road
t. 45th St. West from Quartz Hill Road to Ave. M4
u. Ave. N west of 50th St. West - for dip
v. Ave. M east and west of 51st St. West
w. Ave. L east and west of 52nd St. West
x. Ave. L8 from 42nd to 45th St. West - at dip
y. Ave. K east of 45th St. West on south side - where water comes from field
z. Ave. K east and west of 52nd St. West
aa. Quartz Hill Road and Ave. M from 40th St. West to 50th St. West