Devil's Gate and Eaton Stormwater Flood Management Project

Project Physical Benefits

The physical benefits that the Devil's Gate and Eaton Stormwater Flood Management Project will provide include:

- Flood damage reduction
- Increased local water supply
- Water quality improvements
- Enhanced ecosystem habitat

This attachment provides a description of the physical benefits, a summary of the technical analysis that determined the physical benefits, and the references for the technical background documentation.

Flood Damage Reduction

Dam and Reservoir Safety Requirements

Devil's Gate and Eaton Wash Dams and Reservoirs are under the jurisdiction of the State Department of Water Resources Division of Safety of Dams (DSOD) and are maintained according to District Standards. Safety standard that are required by DSOD and/or the District are not met by the facilities in their current conditions as described further in this attachment.

Phase II-Eaton Wash Dam Rehabilitation Project

Technical Justification

There is a need to rehabilitate the dams outlet works, improve downstream embankment erosion, and construct a new toe drain in order to improve the dams performance, seismic safety, and ability to conjunctively manage captured stormwater.

Eaton Wash Dam is required by DSOD to withstand a Maximum Credible Earthquake (MCE). The seismic faults that could impact the dam are listed in the following table. In 1998, the District performed a seismic analysis of the Eaton Wash Dam. The analysis indicated that the dam embankment will not catastrophically fail when subjected to a significant earthquake, but the dam's outlet tower, which houses the dam's four outlet gates, will experience significant damage. The seismic analysis is attached in **Appendix 3-A.**

The outlet tower at Eaton Wash Dam is a reinforced concrete structure with a total height of 73 feet. In the analysis, the tower was modeled as a 3D-frame consisting of beams and calumny. The earthquake input included 3-component acceleration response spectra, representing the

Fault Name	Maximum Earthquake Magnitude	Fault Type	Closest Distance to Site	Range of Slip Rate	Peak Horizontal Ground Acceleration at Soil Surface	
	Mw		(km)	(mm/yr)	Mediam (g)	84th Percentile
Sierra Madre	7.3	Reverse/thrust	2	4+-2	0.72	1.1
Raymond	6.75	Strike Slip/Reverse	4.5	0.5+-0.3	0.42	0.65
San Andreas	8	Strike-Slip	37	27+-3	0.2	0.25

84th percentile ground motion for a magnitude 7.3 MCE on the Sierra Madre Fault at 2 km from the dam site. The peak ground acceleration was estimated to be 1.1g.

The results of linear analysis showed that the tower will be exposed to very large cross section forces during the postulated MCE ground motion. These forces are far beyond the yield lines of the corresponding bending moment-axial force interaction diagrams. The demand/capacity or required/design strength ratios reached values above 10 in many column and beam sections. This indicates that the steel yielding and concrete crushing will be extensive during the MCE shaking.

The maximum tower displacements computed by the linear structural model with the effective section properties (cracked section), exceeded values of 20 inches in the longitudinal and 18 inches in the transverse directions. With such large displacements of the tower, the access bridge is likely to be torn off of its supports and the hydro-mechanical equipment that controls the outlet gates will be damaged and put out of operation.

The outlet gates perform a vital function for the safety of the dam since they provide a way to draw down the reservoir for repair, inspection, or during emergencies such as major seismic events. A major seismic event will not cause the dam embankment to immediately fail, but it may cause less significant damage such as initiating seepage. The potential damage during a major seismic event and the inability to dewater the reservoir will impose additional hydrostatic and seepage forces that could lead to embankment failure. Since this is a concern that this phase of the Project will eliminate (as described in Attachment 3), the inundation area for Eaton Wash Dam and the affected parcels are included in **Appendix 7-A.**

The following table summarizes the physical benefits that this phase of the Project will provide.

Table 7- Annual Project Physical Benefits from Flood Damage Reduction

Project Name: **Phase II-Eaton Wash Dam Rehabilitation Project**			
Measure of Benefit Claimed (Name of Units): Multiple as shown below			
Additional Information About this Measure:			
(a)	(b)	(c)	(d)
Measure of Benefit Claimed	Physical Benefits		
	Without Project	With Project	Change Resulting from Project (b) – (c)
Area flooded, acres	828.34	-	828.34
Parcels flooded	1791	-	1791
Residential	1477	-	1,477
Commercial	190	-	190
Industrial	34	-	34
Recreational	6	-	6
Govt., Misc.	84	-	84
Units flooded	2,398	-	2,398
Square footage of structures flooded	8,774,691	-	8,774,691
210 Freeway, miles	1.05	-	1.05

The flood damage costs associated with the potential failure are described and included in Attachment 8.

Devil's Gate and Eaton Stormwater Flood Management Project

Phase V- Devil's Gate Reservoir Sediment Removal and Management

Historical Flooding along the Arroyo Seco Wash

The Arroyo Seco has a long history of flooding that, over the past century, has caused loss of life and severe damage to structures and infrastructure . The Devil's Gate Dam was constructed in 1920 to protect the downstream communities from the unpredictable winter storms. Most of the Arroyo Seco downstream of the dam was channelized between 1934 and 1947. The combined flood control facilities alleviated major flooding concerns and continue to protect the downstream areas.

Figure 7.1- Arroyo Seco at confluence of the LA River below N. Figueroa St., 1912

Technical Justification

There is a need to remove sediment from the Devil's Gate Reservoir in order to increase reservoir capacity and reduce the flood damage risk to the communities along the Arroyo Seco Channel. The resulting new reservoir configuration will result in the ability to impound stormwater to be conveyed via the new pipeline to Eaton Wash spreading Grounds for conservation

The reservoir was designed to capture storm water, sediment and debris during storm events and to prevent high flow rates or sediment laden flows from overwhelming the downstream flood control channel. The outflow from the reservoir is controlled by three outlet corridors; a low level gate, the outlet valve, and the outlet tunnel gates. The outlets allow the dam to discharge up to 5,500 cfs. Controlled releases are made through the outlet valve and tunnel gates after the reservoir has impounded storm water. During major storm events that exceed the capacity of the valves and gates, the dam is designed such that the reservoir level rises until flow discharges, uncontrolled thru the spillway ports (openings in the spillway structure) and then over the spillway.

The need for a sediment removal project is determined based on the amount of sediment behind the dam. Too much sediment accumulation can affect the ability of the outlet works (valves, gates and spillway) to function correctly or reduce available reservoir capacity below that necessary for flood control storage or to safety contain future sediment inflow including the Design Debris Event (DDE). The DDE is the predicted amount of sediment that will flow into

the reservoir after the undeveloped portion of the tributary watershed is completely burned and a 50-year design storm event (Capital Storm) occurs after four years of watershed recovery. The 50-year design storm and the DDE are defined by the Los Angeles County Department of Public Works Hydrology and Sedimentation Manuals respectively. The DDE for the Devil's Gate Reservoir is approximately 2,000,000 cubic yards.

The storms that occurred in the two wet seasons after the 2009 Station Fire increased sediment accumulation in the reservoir by approximately 1,300,000 cubic yards reducing the available capacity to less than one DDE. In October 2010, the California DSOD recommended the removal of sediment build-up behind the dam as well as the removal of vegetation growth.

In March 2011, the Los Angeles County Board of Supervisors (Board) directed the District to complete an Environmental Impact Report (EIR) to assess the impacts associated with removing sediment from the project site. Since the EIR would take considerable time to complete, the District was also directed to complete interim measures to project the dam structure and outlet works and to perform a risk assessment for the downstream areas. Interim protection measures included modifying and extending the height of the existing trash rack to keep debris out, installing new catwalks to allow maintenance crews to remove debris during storm events, installing new boom logs to hold back floating debris, and clearing out sediment from immediately in from of the dam face. While these protective measures have improved the situation by providing limited protection to the valves and gates of the dam during typically annual storm events, the major sediment removal activity is still required for downstream flood protection during larger storm events.

Figure 7.2- Debris impacting Devil's Gate valves before interim measures

As part of the risk assessment, the District's consultant performed hydrologic and hydraulic analyses for the existing sediment impacted reservoir. The goal of the analysis was to determine hydraulic characteristics and potential areas of flooding during the anticipated peak Capital Storm event based upon the impacted condition of the Devils Gate Dam. Through the analysis, several areas of potential flooding were identified and, the District subsequently prepared a Flood Hazard and Warning Contingency Plan, which is included in **Appendix 3-A**. In addition, the District has been coordinating with local Cities and Emergency Management Personnel to prepare for potential flooding events.

The proposed Devil's Gate Reservoir Sediment Removal and Management project will restore the flood protection to the downstream communities. The following table summarizes the physical benefits of the flood reduction that the Project will provide. A list of the parcels potentially affected by flooding is included in **Appendix 7-A.** The flood damage costs associated with the potential failure are described and included in Attachment 8.

Table 7- Annual Project Physical Benefits from Flood Damage

Project Name: **Phase V- Devil's Gate Reservoir Sediment Removal and Management**			
Measure of Benefit Claimed (Name of Units): Multiple as shown below			
Additional Information About this Measure: 1 in 50 year event beginning in 2013			
(a)	(b)	(c)	(d)
Measure of Benefit Claimed	Physical Benefits		
	Without Project	With Project	Change Resulting from Project (b) – (c)
Area flooded, acres	165.16	-	165.16
Parcels flooded	650	-	650
Residential	561	-	561
Commercial	0	-	-
Industrial	14	-	14
Recreational	2	-	2
Govt., Misc.	73		

Project Name: **Phase V- Devil's Gate Reservoir Sediment Removal and Management**			
		-	73
Units flooded	1,437	-	1,437
Square footage of structures flooded	1,247,309	-	1,247,309
110 Freeway, miles	3.44	-	3.44

Diverting Potential Flood Waters

The remaining three phases of the Project divert water from the flood control channels to groundwater recharge facilities. This protects the downstream areas by preserving capacity within the flood control system during potential flood conditions. The following tables list the amount of water that each phase will divert during a high-rainfall year. This was determined by modeling each component's proposed attributes with historical stream flow/dam release data. The stream flow data is in **Appendix 7-B**. These diversions are recognized to reduce downstream flooding during highly intense local storm events, however the extent of flooding and the flood damage reduction resulting from these diversions was not quantified (nor were any benefits claimed) for this aspect of the project.

Table 7- Annual Project Physical Benefits from Flood Damage

Project Name: **Phase I- Eaton Wash Spreading Grounds Improvements**			
Measure of Benefit Claimed (Name of Units): Acre-Foot Per Year			
Additional Information About this Measure: Flows are based on a high-rainfall year expected to occur 1 in 10 years			
(a)	(b)	(c)	(d)
	Physical Benefits		
Measure of Benefit Claimed	Without Project	With Project	Change Resulting from Project (b) – (c)
Flow in Eaton Wash Flood Control Channel	6965	5893	1072

Project Name: **Phase III-Eaton Wash Spreading Grounds Intake Improvement and Basin Enlargement**			
Measure of Benefit Claimed (Name of Units): Acre-Foot Per Year			
Additional Information About this Measure: Flows are based on a high-rainfall year expected to occur 1 in 10 years			
(a)	(b)	(c)	(d)
	Physical Benefits		
Measure of Benefit Claimed	Without Project	With Project	Change Resulting from Project (b) – (c)
Flow in Eaton Wash Flood Control Channel	5893	5793	100

Project Name: **Phase IV- Devil's Gate Water Conservation**			
Measure of Benefit Claimed (Name of Units): Acre-Foot Per Year			
Additional Information About this Measure: Flows are based on an average rainfall year			
(a)	(b)	(c)	(d)
	Physical Benefits		
Measure of Benefit Claimed	Without Project	With Project	Change Resulting from Project (b) – (c)
Flow in Arroyo Seco Flood Control Channel	6900	2400	4500

Water Supply

The Project will maximize conservation of local ground water resources. In addition to providing a local sustainable groundwater supply, this will generate cost savings through avoided purchase of imported water. Attachment 8 has additional information regarding the cost savings. The following table lists the quantity of additional groundwater the Project can supply on a yearly average basis. The following tables list the quantity of additional groundwater that each phase will conserve during an average rainfall year. This was determined by modeling each component's proposed attributes with historical stream flow/dam release data. The stream flow data is in **Appendix 7-B**.

Table 7- Annual Project Physical Benefits from Water Supply

Project Name: **Phase I- Eaton Wash Spreading Grounds Improvements**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply based on 10 year average of historical stream flow data and spreading grounds recharge data			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
Available stormwater that is not recharged to the Groundwater	1003	655	348

Project Name: **Phase II-Eaton Wash Dam Rehabilitation Project**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply based on the amount of water that is was recharged into the Eaton Wash Spreading Grounds during a year with average rainfall. This does not include the benefits from Phase I and Phase III			
(a)	(b)	(c)	(d)
Measure of Benefit Claimed	Physical Benefits		
	Without Project	With Project	Change Resulting from Project (b) – (c)
Available water that would pass through spillway and not be recharged to the Groundwater	1,244	-	1,244

Project Name: **Phase III-Eaton Wash Spreading Grounds Intake Improvement and Basin Enlargement**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply Based on 10 year average historical stream flow data and spreading grounds recharge data			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project

Project Name: **Phase III-Eaton Wash Spreading Grounds Intake Improvement and Basin Enlargement**			
			(b) – (c)
Available stormwater that is not recharged to the Groundwater	655	644	11

Project Name: **Phase IV- Devil's Gate Water Conservation**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply Based on 10 year average of historical stream flow data			
(a)	(b)	(c)	(d)
	Physical Benefits		Change Resulting from Project
Year	Without Project	With Project	(b) – (c)
Available stormwater that is not recharged to the Groundwater (Assuming PhI and PhIII are implemented)	6900	2400	4500
Available stormwater that is not recharged to the Groundwater (Assuming PhI and PhIII do not exist)	6900	4336	2564

Water Quality

This Project will increase stormwater capture and groundwater recharge to the Raymond Basin. The groundwater recharge occurs by percolation of that captured stormwater through the pervious soils underlying the spreading grounds. This process effectively filters the stormwater resulting in high quality water added to the groundwater basin. This recharge of percolated stormwater is considered higher quality than the existing water in the Raymond Basin. It is noted that the water purveyors from the Raymond Basin have experienced water quality concerns in some wells. The new stormwater recharge effectively dilutes the lower quality existing water in the basin. A copy of the draft Raymond Basin Groundwater Recharge Technical Analysis Stormwater Capture Program January 26, 2011 report prepared for the Raymond Basin Management Board by Geoscience Support Services, Inc. is attached as

Appendix 7-C. Preliminary results of the model demonstrate that increased stormwater capture has beneficial improvements to the overall water quality of the Basin. The following tables list the quantity of additional groundwater treated through recharge during an average rainfall year.

Additionally, surface water quality along the Arroyo Seco is improved by the proposed project. Currently, the high volume of sediment in the Devil's Gate Reservoir results in the flows being released from the dam to be highly turbid. As a result, the sediment settles out along the flatter, natural sections of the Arroyo Seco. The sediment has also affected two diversions structures which direct flow to native stream habitat restoration areas that are located alongside channelized portions of the Arroyo Seco. The project will significantly remove the sediment impacts from dam releases and result in enhanced habitat function for these natural and restored areas downstream. This benefit is not quantified (nor were any benefits claimed) for this aspect of the project.

Table 7- Annual Project Physical Benefits from Water Quality

Project Name: **Phase I- Eaton Wash Spreading Grounds Improvements**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply based on 10 year average of historical stream flow data and spreading grounds recharge data			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (b) – (c)
Available stormwater that is not treated through infiltration	1003	655	348

Project Name: **Phase II-Eaton Wash Dam Rehabilitation Project**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply based on the amount of water that is was recharged into the Eaton Wash Spreading Grounds during a year with average rainfall. This does not include the benefits from Phase I and Phase III			
(a)	(b)	(c)	(d)
Measure of Benefit Claimed	Physical Benefits		
	Without Project	With Project	Change Resulting from Project
			(b) – (c)

Project Name: **Phase II-Eaton Wash Dam Rehabilitation Project**			
Available water that would pass through spillway and not be treated through infiltration	1244	-	1,244

Project Name: **Phase III-Eaton Wash Spreading Grounds Intake Improvement and Basin Enlargement**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply Based on 10 year average historical stream flow data and spreading grounds recharge data			
(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project
			(b) – (c)
Available stormwater that is not treated through infiltration	655	644	11

Project Name: **Phase IV- Devil's Gate Water Conservation**			
Measure of Benefit Claimed (Name of Units): Acre-Foot per Year			
Additional Information About this Measure: Water Supply Based on 10 year average of historical stream flow data			
(a)	(b)	(c)	(d)
	Physical Benefits		Change Resulting from Project
Year	Without Project	With Project	(b) – (c)
Available stormwater that is not treated through infiltration (Assuming PhI and PhIII are implemented)	6900	2400	4500

Project Name: **Phase IV- Devil's Gate Water Conservation**			
Available stormwater that is not treated through infiltration (Assuming PhI and PhIII do not exist)	6900	4336	2564

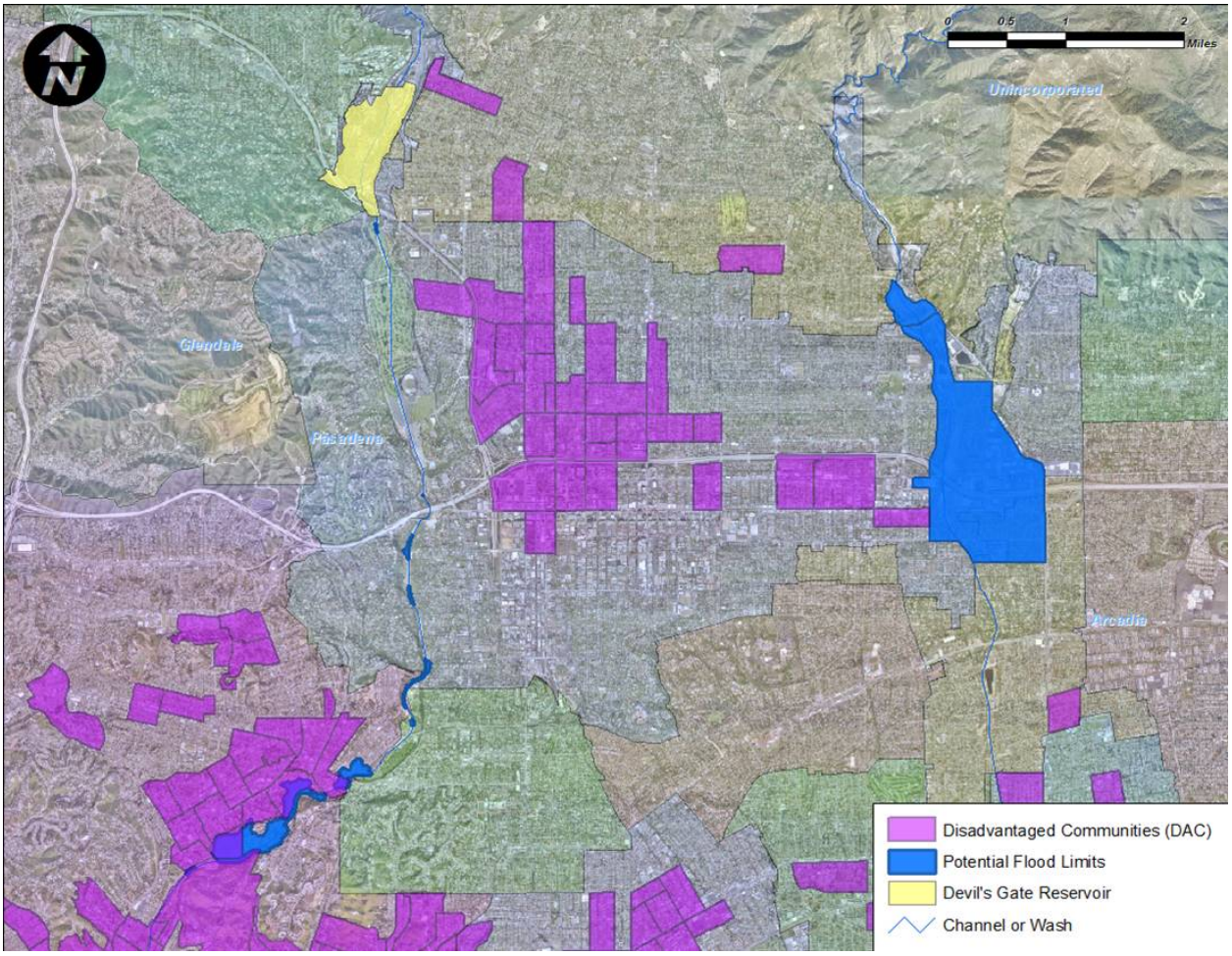
Enhance Ecosystem

The Bay-Delta ecosystem is sensitive to water levels and pumping activities associated with water exports for the State Water Project and Central Valley Project. As the Project reduces demand for Metropolitan Water District of Southern California (MWD) water supplies, it indirectly decreases demand for Bay-Delta exports, assuming all demands on other water users is unchanged. Reduced water exports from the Bay-Delta may increase habitat quality and associated services provided by the ecosystem, such as recreational opportunities. Additionally there are significant environmental impacts associated with generation and use of the required power to transport water from the Bay-Delta area to Los Angeles County. Prior studies have monetized these services as well as willingness-to-pay for general improvements in habitat (non-use values). Also, as noted under the Water Quality Section, above, the project will significantly remove the sediment impacts from Devil's Gate Dam releases and result in enhanced habitat function for the natural and restored areas downstream along the Arroyo Seco. Data limitation and Project budget constraints prevent monetization of these benefits.

Other

The Project will improve the social benefits and recreation in the region. Phase III will provide landscaping amenities including shrubs, trees, and decorative fencing. It will include construction of a decomposed granite walking path that will provide an extension to a nearby existing pathway. Additionally, Phases II and V will promote social health and safety by reducing the need for critical emergency services following seismic and flooding events.

The Project will protect a national historic resource. Phases IV and V will provide significant flood protection to the 110 freeway. The 110 freeway, Arroyo Parkway, connects the City of Pasadena to downtown Los Angeles and has significant historical value. The freeway was listed in the National Register of Historic Places in February 2011, designated a National Scenic Byway by the U.S. Secretary of Transportation in 2002, and designated a National Historic Civil Engineering Landmark in 1999 by the American Society of Civil Engineers.

Disadvantaged Communities (DAC) will benefit from the increased flood protection that the Project will provide. The major flooding concerns along the Arroyo Seco impact several DACs

as shown in the following map. This benefit is not quantified (nor were any benefits claimed) for this aspect of the project.