Mitchell M. Tsai

From: Medak, Christine <christine_medak@fws.gov>
Sent: Wednesday, September 14, 2016 1:17 PM
To: GYU@dpw.lacounty.gov
Cc: Rogers, Bonnie L SPL; Mari (Schroeder) Quillman; Vargas, Jessica M SPL; Chirdon, Matthew@Wildlife; Jonathan Snyder
Subject: Review of On-Site Mitigation Hydrology Justification
Attachments: Appendix_D_hydrology-report_small.pdf

Hi Grace,

As we discussed over the phone on August 9, 2016, it is my understanding that the County is preparing a habitat restoration and management plan for impacts associated with the Devil's Gate Sediment Removal Plan. We are concerned that the proposed sediment removal will alter the hydrology in the reservoir in a manner that may impede restoration of riparian habitat outside the project footprint. I have reviewed the information provided by the County (Veronica Mardis) on April 20, 2016 (*Devil's Gate Sediment Removal and Management Plan On-Site Mitigation Hydrology Justification*, Justification) in support of establishing riparian vegetation on the west side of the reservoir (attached). This message is to request clarification regarding the information provided and to recommend that specific information is included as part of the restoration and management plan to ensure habitat created for the vireo will be viable over the long term.

1) The information provided in the Justification does not take into consideration the proposed increase in diversion of flows from the Arroyo Seco as part of the City of Pasadena's Arroyo Seco Canyon Project. The diversion project is currently undergoing review by the CDFW and Corps. The diversion will change the hydrology in Devil's Gate Reservoir by eliminating surface flows except during large storm events. It will also redistribute flows from the west side of the basin into the spreading basins located on the east side of the basin (away from the majority of proposed habitat restoration). While the diversion will increase the amount of water spread on the east side of the reservoir, the purpose of the project is to allow increased groundwater pumping by the City of Pasadena. How will this diversion affect the long-term viability of riparian habitat for the vireo, outside the proposed sediment removal project?

2) Information provided in Attachments 5 and 6 of the Justification compares groundwater elevations over time and at various sediment levels within the reservoir. What is the source of the data provided in these graphs? Monitoring wells located on the east side of the reservoir are depicted in Attachment 4 but it is not clear if these wells were used to generate the graphs in Attachments 5 and 6. Is it possible that wells located on the east side of the spreading basins record artificially high groundwater levels due to the adjacent City of Pasadena spreading basins that are located above the elevation of the reservoir? If so, these wells may not detect changes in groundwater levels compared to sediment levels in the Reservoir. It appears the spreading basins are regularly maintained so the elevation of adjacent groundwater should be fairly stable.

3) In Attachment 6, the graph displays reservoir capacity below 1054'; however, the spillway was lowered to 1040.5' in 1997. What is the source of the data? Does this graph include data prior to 1997 (i.e., when more water could be held)? What is the relevance of capacity above the spillway elevation?

4) Table 1 includes the number of days water is present "in the pool". What is the elevation of water when a day is counted as having water present in the pool? The number of days water is present in the pool is affected by both inflows and reservoir capacity. What is the respective reservoir capacity (i.e., water/sediment) below the spillway for each water year displayed in the table? Given the known inflow, how many days would water have been in the pool (at the same elevation) with the proposed project in place?

5) Based on updated vegetation mapping completed by ECORP, the quality of habitat for the vireo has been declining over the last several years. Black willows are sensitive to long periods of inundation. How has the increased number of inundation days associated with reduced reservoir capacity affected the quality and extent of riparian vegetation within the reservoir? How will hydrological conditions change so that riparian vegetation will be supported in the proposed restoration areas?

5) In attachment 7, what is the relevance of the 2009 water capacity? How does this compare with the current condition?

6) According to the Justification, the greater reservoir capacity will result in more water permeating into the side slopes of the reservoir. What is the reduction in surface flows downstream from Devil's Gate Dam as a result of percolation into the basin bottom and side slopes upstream from Devil's Gate Dam? How will the reduction in flows affect habitat restoration completed downstream in Arroyo Seco?

7) Given the anticipated increase in percolation, how much additional groundwater pumping will be enabled by the proposed project? Does the County have authority over the amount of water that is pumped from surrounding wells? How will the additional groundwater pumping affect the availability of water for remaining habitat for the vireo in the reservoir?

8) Attachments 8 and 9 of the Justification compare a modeled 2-year event with an actual event in January 2008. In the modeled event, the peak inflow is 3691.7 cfs and in the actual event, the peak inflow is 5720.4 cfs. Clarify if the actual event is a 2 year or 5 year event. Both events anticipate flows reaching about 1040' elevation. Clarify if this elevation is reached as a result of water backing up behind the dam or if surface flows sufficient to cause scour and deposition of sediment will occur at this elevation. If no scouring flows are anticipated during a 5720.4 cfs event, what level of flows will be required to cause scour and deposition within the remaining riparian habitat, outside the permanent impact footprint?

9) Attachments 10 and 11 compare the 2009 topography with the proposed project. How does the proposed project compare with the current topography? The approved project (attachment 11) appears to include changes in topography west of the proposed project footprint. Was the modelling based on this topography? Is the additional grading (beyond the proposed project footprint) required? Are the grading limits for the proposed project based on current topography?

10) Attachment 12 compares the slope of the low flow channel over time with the proposed project. While the streambed elevation increased between 2009 and 2014, the slope appears to remain about the same. The proposed project will increase the slope substantially relative to the 2009/2014 slope. Will this cause a headcut upstream? How far upstream do you anticipate the headcut to extend as a result of increasing the gradient of the streambed? Does the proposed annual maintenance account for erosion of the bed and banks associated with the headcut?

11) Attachments 15 and 17 compare cross sectional profiles in 2009 and with the proposed project. While the 1040' elevation contours appear similar, there is substantially more capacity below 1020' elevation with the proposed project. We are concerned the increase in capacity and confinement of flows within the permanent impact footprint will decrease the frequency of surface flows reaching remaining habitat. Riparian vegetation suitable for vireo breeding, feeding and sheltering consists of a complex structure of understory, midstory and canopy vegetation that is maintained by natural processes. Restoration conducted in areas that will be isolated from natural processes will need to be managed in a way that not only provides adequate soil moisture but also maintains the structural diversity necessary to support the species. The management actions necessary to maintain habitat for the vireo over the long term should be included as part of the proposed habitat restoration and management plan.

We look forward to the opportunity to review the proposed habitat restoration plan. Should you have any questions regarding this message, please feel free to contact me.

Christine L. Medak

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"I'd like to offer a plug for actually having the natural processes instead of having to simulate them."
— Nadav Nur, PRBO Conservation Science

Groundwater

The project area overlies the Raymond Groundwater Basin (Raymond Basin), which is located within the Los Angeles-San Gabriel Hydrologic Unit. Raymond Basin's average annual precipitation is approximately 21 inches; and groundwater recharge is possible through the penetration of rain falling on alluvial surfaces, returns from irrigation water, and infiltration of stream flow, primarily from the San Gabriel Mountains. Stream flows that collect in Devil's Gate Reservoir and also flows that are diverted to the adjacent City of Pasadena's Arroyo Seco Spreading Grounds contribute to groundwater recharge of the Ramond Basin.

According to available monitoring well data from the adjacent Jet Propulsion Laboratory (JPL) site, see Attachment 1, water level elevations measured at MW-3 in 2012 ranged from 973 feet to 1004 feet amsl. During a site investigation in 2011, groundwater was encountered at soil borings B-3, B-4, and B-9 (Attachment 2) at a depth of 22 to 25 feet below ground surface (approximate elevations of 1022, 1019, and 1010 feet, respectively). The water encountered in the three borings indicates the presence of a perched aquifer at those locations, see Attachment 3.

LACFCD has several groundwater monitoring wells adjacent to Devil's Gate Reservoir, which have data dating back to the 1920s, approximate locations of these wells are shown in Attachment 4. Attachment 5 is a graph showing the historic groundwater elevations from a monitoring well on the east side of the reservoir. The groundwater levels in Devil's Gate Reservoir have been fairly consistent over the life of the dam. The groundwater levels do fluctuate over time, but typically keep within the 900 to 1,000-foot amsl. This is consistent with the dynamics of a reservoir system, as the amount of rainfall received and water impounded in the reservoir can affect the level of the groundwater table. For example, water impounded in the reservoir will permeate into the ground, thus raising the groundwater table in the surrounding area. Similarly, when little rainfall is received, and water is still being extracted from the groundwater table, the elevation of the groundwater over the entire basin will drop.

Attachment 6 is a graph showing the groundwater levels at various reservoir capacities. A decrease in reservoir capacity represents an increase in sediment levels. As can be seen from Attachment 6, the historic groundwater levels in the reservoir show no correlation between sediment levels and groundwater elevation. Rather, the correlation between rainfall received, water entering the reservoir, and groundwater levels indicates that water within the reservoir dictates the groundwater elevations.

Water Held behind Devil's Gate Dam

Table 1 shows information regarding the water held behind Devil's Gate Dam since the spillway elevation change in 1997. The retrofit of Devil's Gate Dam in 1997 lowered the elevation of the spillway to 1040.5', and thereby reduced the amount of reservoir capacity below the spillway. The table shows the total amount of days that water was held behind the dam and the maximum elevation that the water level reached each water year.

Table 1 – Water Levels at Devil's Gate Reservoir

Water Year	Days Water Pool Present	Max. Water Elevation (ft amsl)
1998/1999	35	1,009.1
1999/2000	24	1,007.3
2000/2001	28	1,007
2002/2003	115	1,029.6
2003/2004	50	1,028.6
2004/2005	201	1,045.4
2005/2006	118	1,008.8
2007/2008	28	1,033.1
2008/2009	7	1,000
2009/2010	119	1,036.8
2010/2011	124	1,039.9
2011/2012	122	1,030.9
2012/2013	120	1,018.2
2013/2014	87	1,034.5
2014/2015	134	1,028

After the sediment cleanout project, any water held above the 1,020-foot contour will continue to inundate the west side of the reservoir, as it currently does. Attachment 7 shows the capacity of the reservoir in 2009 and after project implementation, respectively. After project implementation, there will be more capacity within the permanent maintenance area to hold water. This will increase the amount of water allowed to permeate the side slopes and provide soil moisture to the mitigation areas.

Table 2 shows the yearly inflow into Devil's Gate Reservoir over the past 15 years. Excluding the water year 2004/2005, the average yearly inflow into Devil's Gate Reservoir is approximately 8,400 acre-ft. Inflows to Devil's Gate eventually flows downstream, and any downstream mitigation areas will not be affected by the Project.

Attachments 8 and 9 show the results of a hydrological analysis of Devil's Gate Reservoir after the Approved Project. Attachment 8 models the storage and flow of 2-year frequency design storm with the Approved Project cut plan. From the summary results shown in Attachment 8, its can be seen that with the Approved Project cut plan and the current operation plan, the peak storage and elevation within the reservoir would have been 1829 acre-ft. and 1042.4 ft., respectively. This model shows that under the 2-year frequency design storm the reservoir will be filled to spillway elevation. Attachment 9 models the storage and flow of an actual storm that occurred in the watershed of Devil's Gate Reservoir in 2008 under the Approved Project cut plan. The 2007/2008 water year was chosen to model for being an average water year in terms of rainfall. The January 4 – 8 storm represents a 2-5 year frequency storm that occurred within the 2007/2008 water year. From the summary results shown in Attachment 9, its can be seen that with the Approved Project cut plan, the peak storage and elevation within the reservoir

would have been 1580.1 acre-ft. and 1039.8 ft., respectively. From the two different scenarios modeled for the Approved Project cut plan, it can be concluded that the western portion of the reservoir will be inundated regularly.

Table 2 – Total Yearly Inflow to Devil's Gate Reservoir

Water Year	Total Inflow (acre-ft.)
1999/2000	15,792
2000/2001	12,259
2001/2002	1,731
2002/2003	3,137
2003/2004	2,071
2004/2005	134,360
2005/2006	6,573
2006/2007	4,717
2007/2008	13,962
2008/2009	2,579
2009/2010	19,143
2010/2011	33,340
2011/2012	2,298
2012/2013	513

Flow Paths

Attachment 10 shows the contours and estimated flow path of Devil's Gate Reservoir in January 2009, pre-Station Fire. Pre-Station Fire conditions show water flowing from the north end of the reservoir towards the face of the dam through channels that were cut by storm flows. The contours in Attachment 10 show several braided channels within the north end of the reservoir that converge into one main channel that flows toward the dam, all within the proposed project boundary. Attachment 11 shows the proposed configuration post-project. After the completion of the Devil's Gate Sediment Removal Project, the water will flow through a path similar to the pre-Station Fire. Even though the reservoir will be evenly graded during construction within the project boundary, the water flowing into the permanent maintenance area will continue to meander and braid through the sediment deposited during storms.

Reservoir Profile

Attachment 12 shows Devil's Gate Reservoir Profile before the Station Fire (2009), after the Station Fire (2011, 2012, and 2014), and after the project. The vertical scale has been exaggerated in relation to the horizontal scale to view the profiles. The unevenness of the 2009 sediment profile is the result of long-term deposition of sediment and erosion from periodic storm flows. The 2011 sediment profile shows the large influx of sediment resulting from the Station Fire and, other than the interim cleanout of

sediment right behind the dam, the large amount of sediment continued to persist into 2014. The elevation of the sediment will be lowered within the project boundary, but the slope will still remain gradual, with an average slope of approximately 1.7 percent.

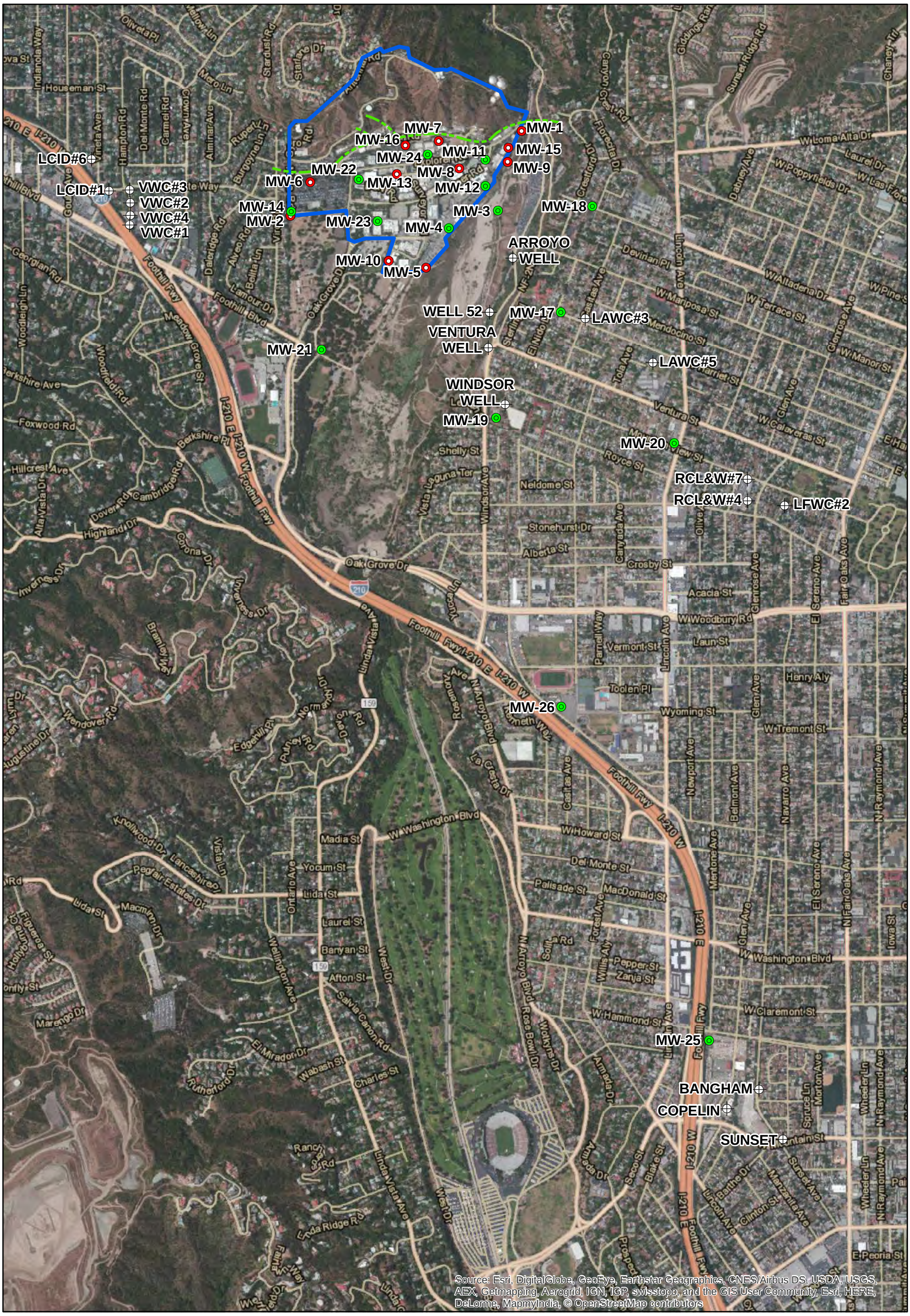
Riparian Vegetation

Attachment 13 shows the tributary drainage areas west of Devil's Gate Reservoir that drain into the reservoir. This attachment also shows the calculated flow and volume from each area into the reservoir for various storm return intervals. From the table shown on Attachment 13, a total of 33 acre-ft. of storm flows enter the reservoir from the western tributaries during a 2-year frequency storm. The volume of flows from the western tributaries can reach up to 89 acre-ft. during a 50-year frequency storm.

Attachment 14 is an aerial of Devil's Gate Reservoir in June 2009, before the Station Fire. This is following the 2008 – 2009 storm season, in which water was not held behind the dam at a high elevation or for very long, as shown in Table 1. Even so, the aerial shows persistent vegetation established throughout the reservoir. Cross sections across the reservoir in 2009 are shown in Attachment 15. Comparing the riparian vegetation in the aerial (Attachment 14) and the cross sections in Attachment 15, it can be seen that riparian vegetation is abundant above the 1,020-ft elevation.

In addition, riparian vegetation has persisted throughout the reservoir, even after several drought years.

With the combination of the western tributary flows, previously existing vegetation, historic groundwater elevations, and water levels behind Devil's Gate Dam, riparian vegetation will be able to establish on the west side of the reservoir. Attachment 16 shows the proposed contours of the project over the proposed mitigation plan. All proposed mitigation under the 1,040-ft contour will be below spillway, and therefore subject to inundation. Attachment 17 shows cross sections similar to those in Attachment 15, but for the post-project reservoir configuration. The relationship between the 1,020-ft contour and the proposed mitigation area is similar to that in 2009. When water is held in the reservoir, the water will permeate into the side slopes, providing adequate soil moisture for the vegetation.



N
W E
S

0 490 980 1,470
Feet

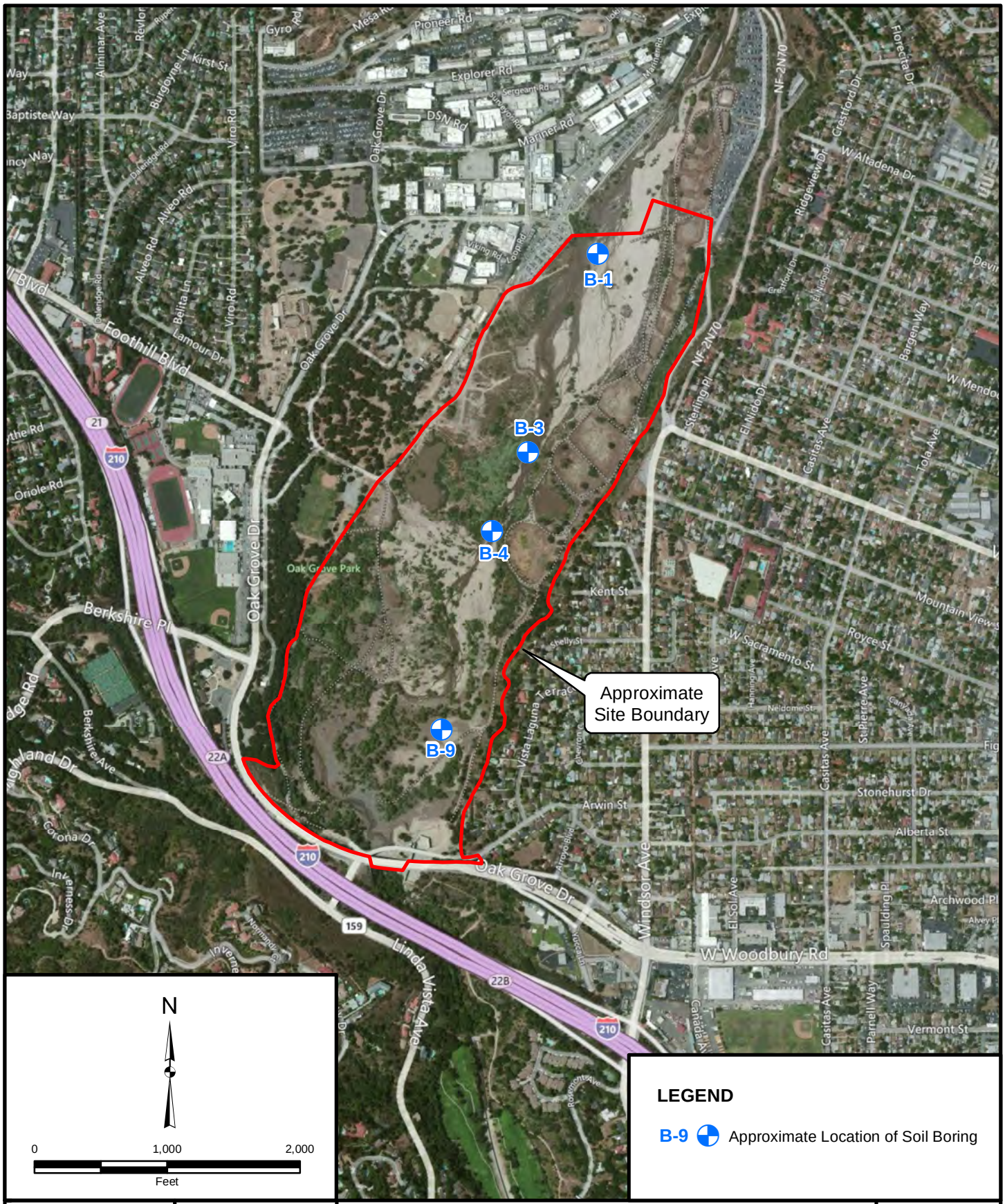
Legend

- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well

TIDEWATER INC
ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

Locations of JPL Groundwater Monitoring Wells and Nearby Municipal Production Wells

DESIGNED BY JHG DRAWN BY JHG CHECKED BY DC	JPL - Pasadena, CA Contract No: W912PL-13-D-0018 TO 001	Figure 1 June 2015



Project: 603211-001	Eng/Geol: VPI/RML
Scale: 1 " = 1,000 '	Date: October 2011

Base Map: ESRI Resource Center, 2010
Thematic Info: Leighton
Author: (cgiovando)

BORING LOCATION MAP

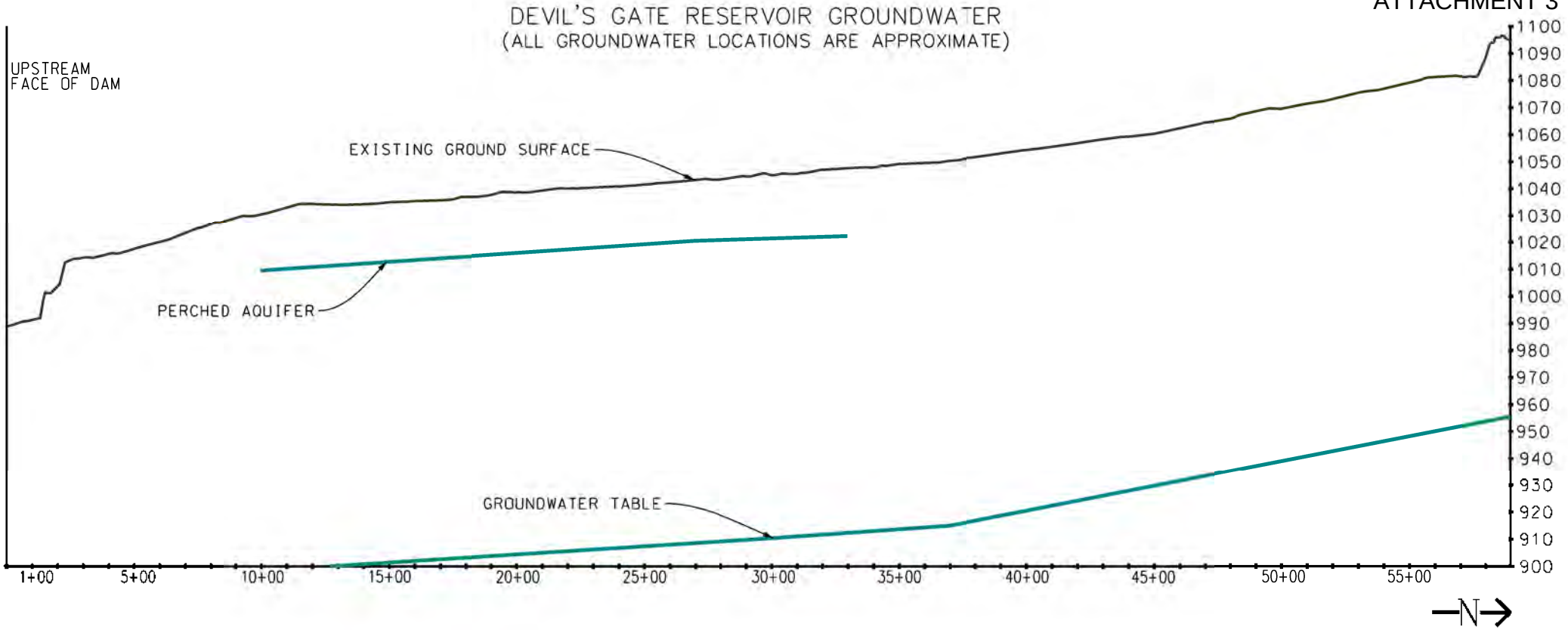
Devil's Gate Reservoir
Pasadena, California

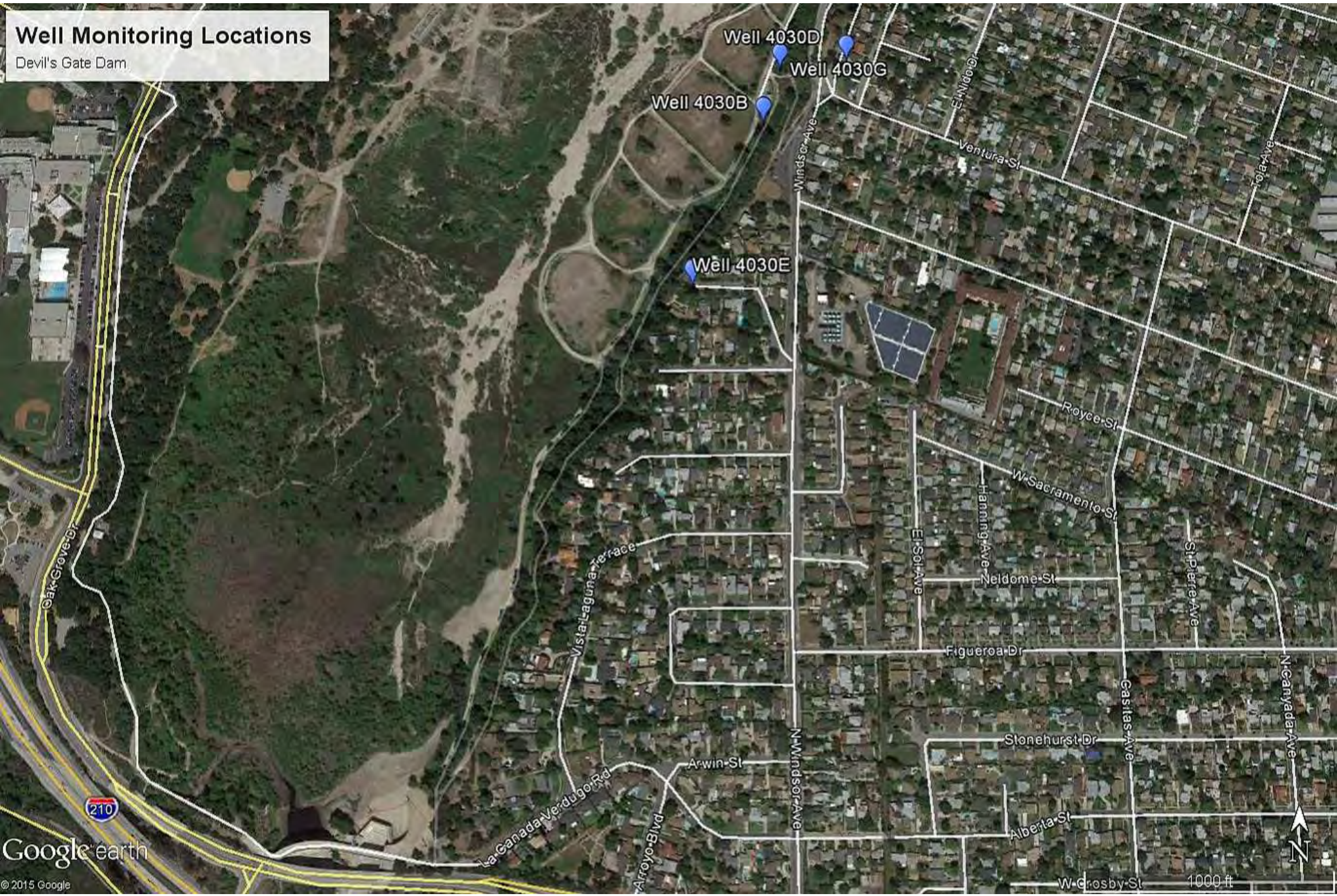
Figure 2

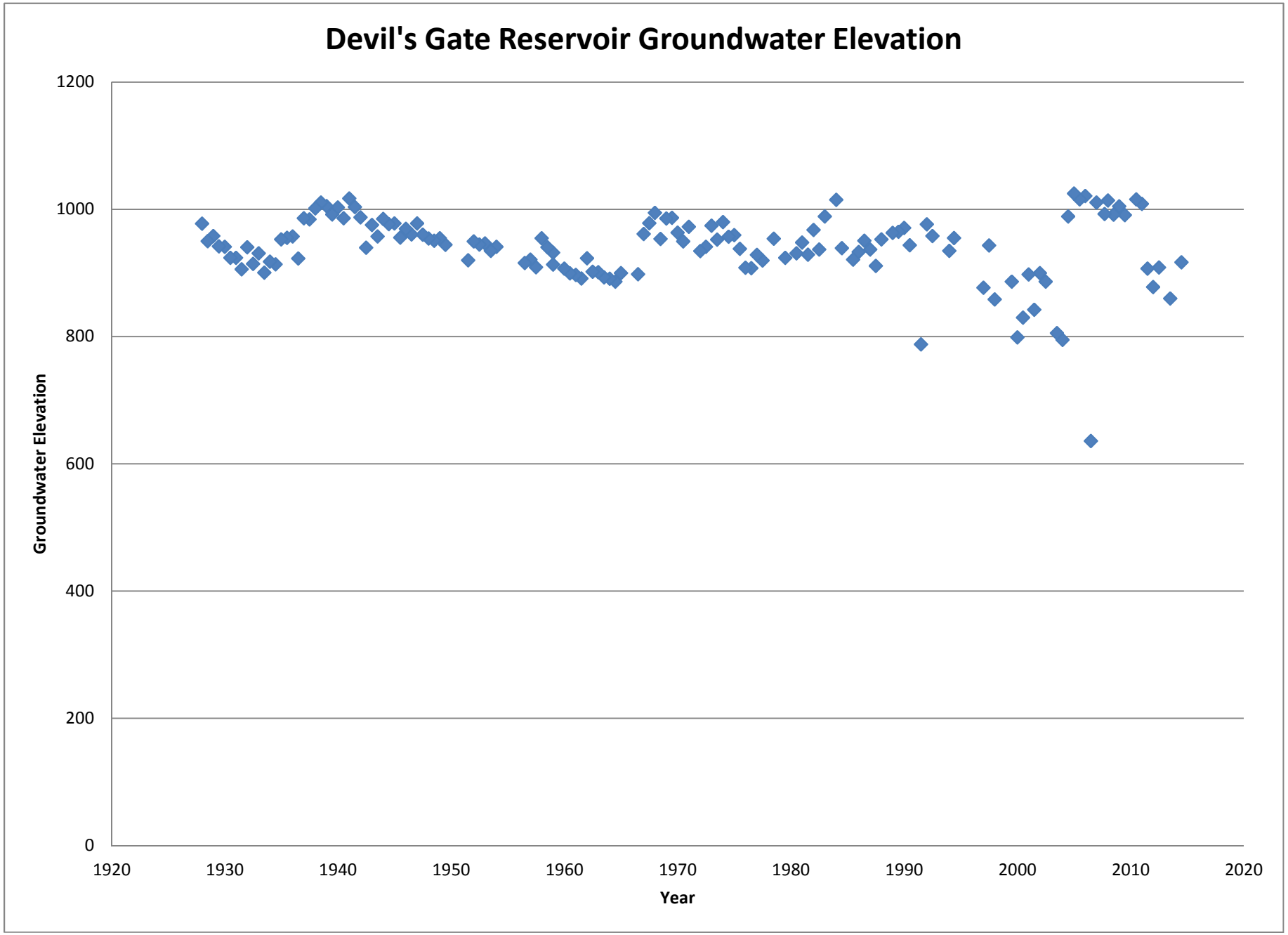
Leighton

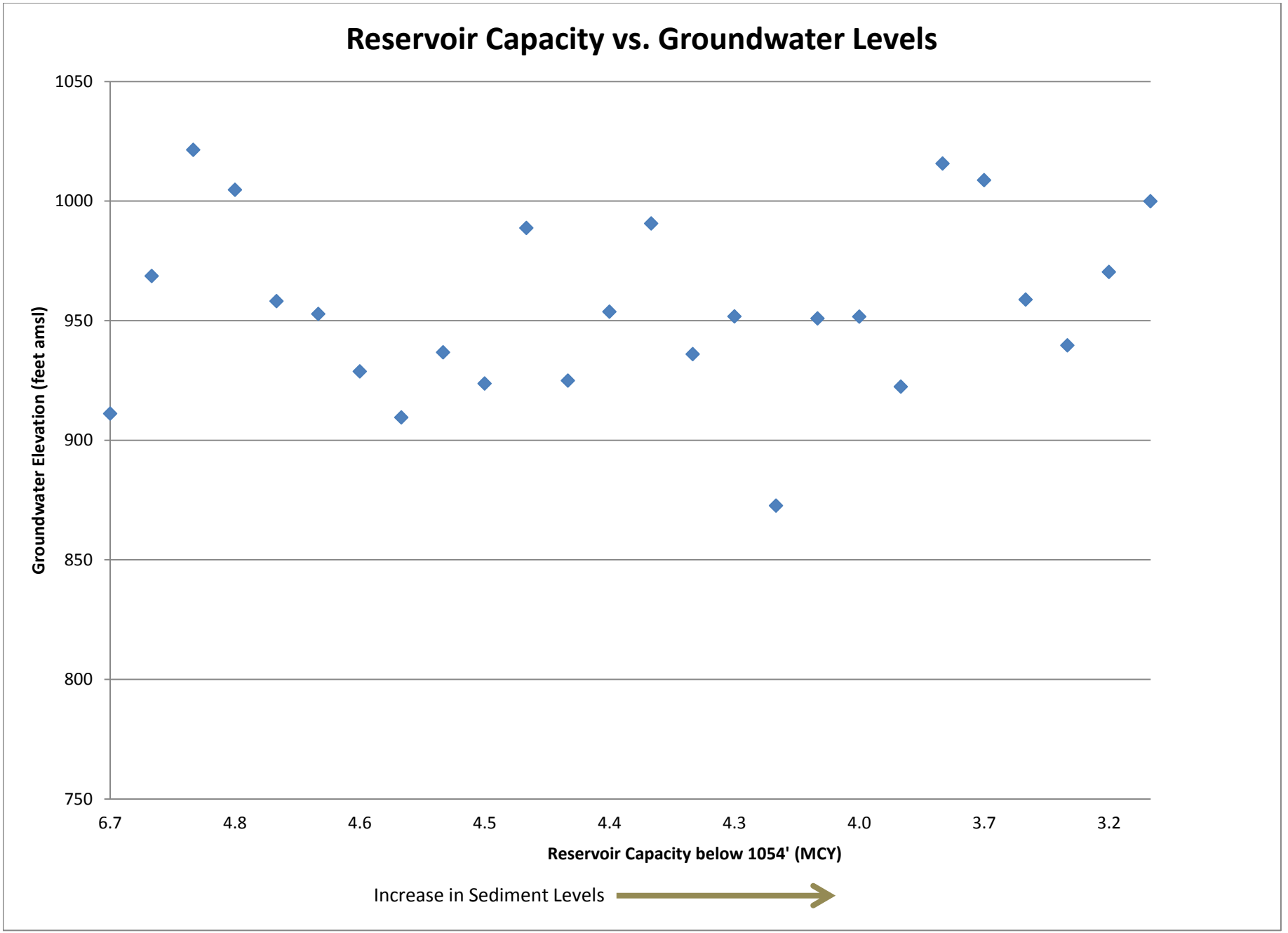
Map Saved as V:\drafting\603211\001\Maps\P603211-001_F02_BoringLocationMap_GIS_2013-01-23.mxd on 1/23/2013 3:36:43 PM

ATTACHMENT 3




Well Monitoring Locations
Devil's Gate Dam
Well 4030D
Well 4030G
Well 4030B
Well 4030E
Windsor Ave
Ventura St
Royce St
W Sacramento St
Hanning Ave
El Sol Ave
Neldome St
St Pierre Ave
Figueroa Dr
Casitas Ave
N Canyada Ave
Stonehurst Dr
Alberta St
W Crosby St
Oak Grove Dr
Vista Laguna Terrace
Arwin St
La Canada Verdugo Rd
Arroyo Blvd
N Windsor Ave
210
Google earth
© 2015 Google
1000 ft
N

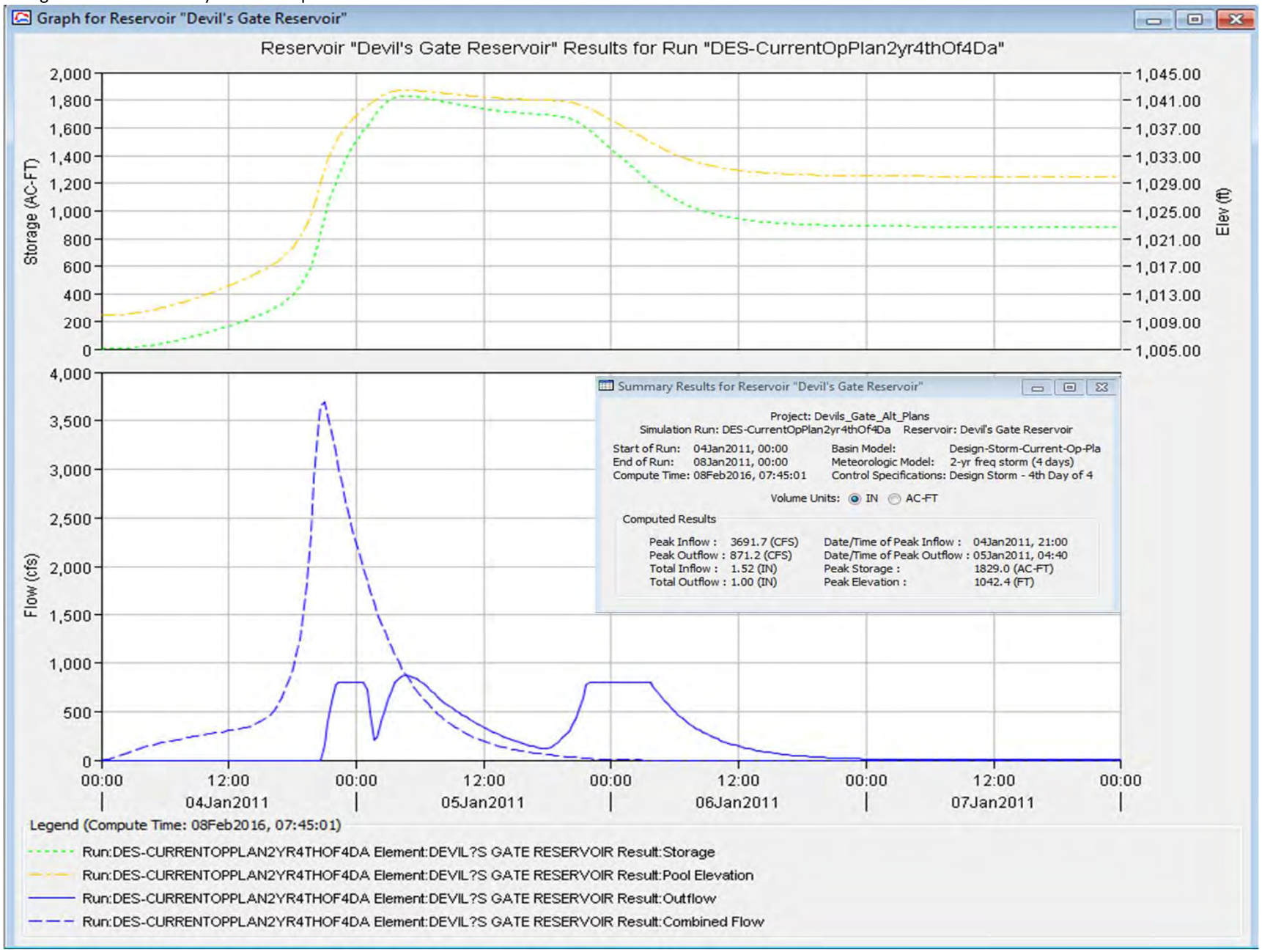

Devil's Gate Reservoir Groundwater Elevation
Groundwater Elevation
1200
1000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year


Reservoir Capacity vs. Groundwater Levels
Groundwater Elevation (feet amsl)
1050
1000
950
900
850
800
750
6.7
4.8
4.6
4.5
4.4
4.3
4.0
3.7
3.2
Reservoir Capacity below 1054' (MCY)
Increase in Sediment Levels

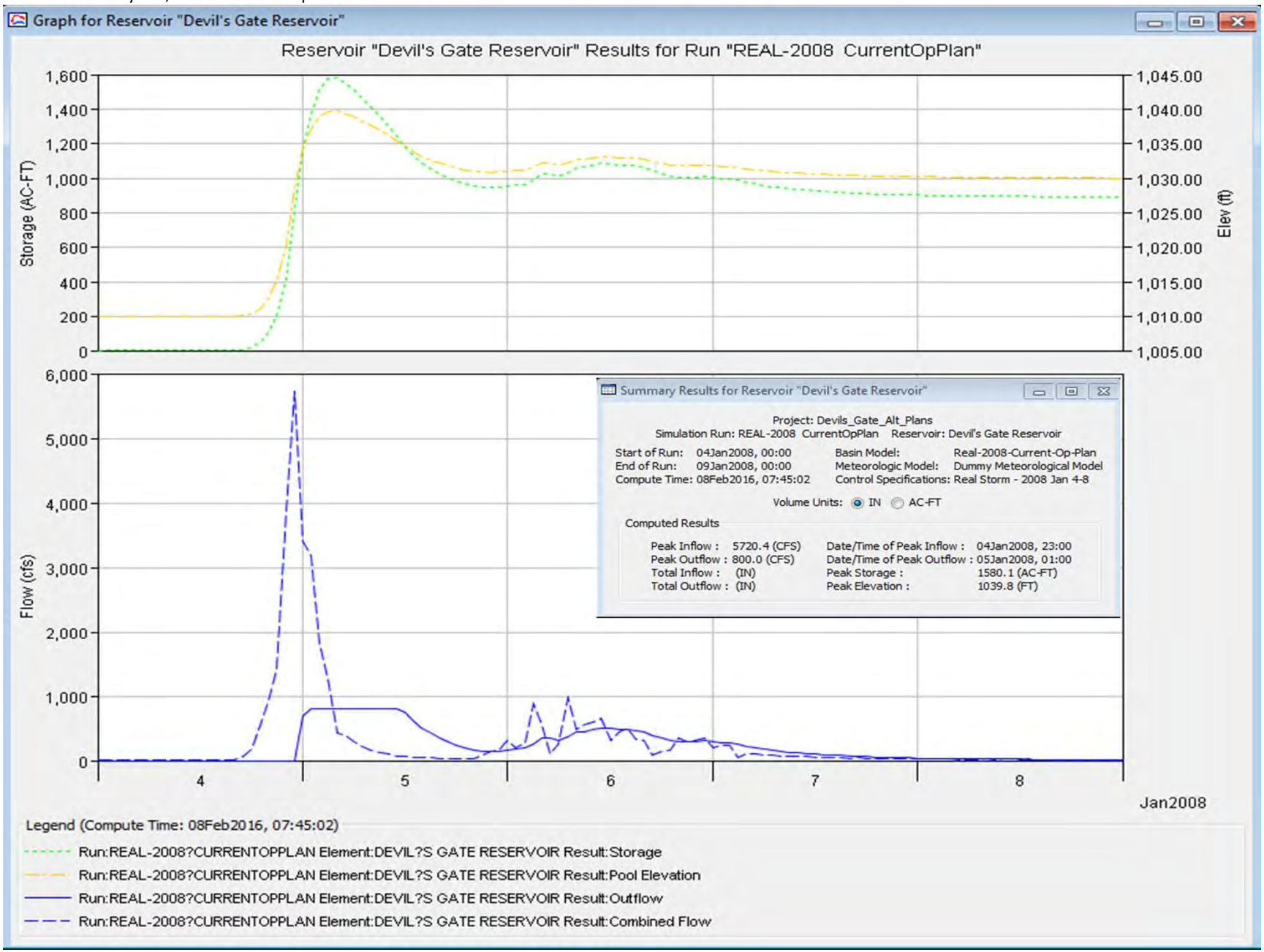
DEVIL'S GATE DAM RESERVOIR
DEVIL'S GATE RESERVOIR SEDIMENT REMOVAL PROJECT

Contour	Accum. Volume (acre-ft)	
	2009	Post-Project
985	0	4.74
990	0	50.07
995	0.15	138.88
1000	4.72	268.19
1005	26.36	429.08
1010	68.60	611.70
1015	139.10	808.26
1020	244.67	1015.97
1025	396.19	1237.81
1030	613.21	1499.64
1035	932.35	1816.75
1040	1349.59	2210.66
1040.5	1396.02	2255.74

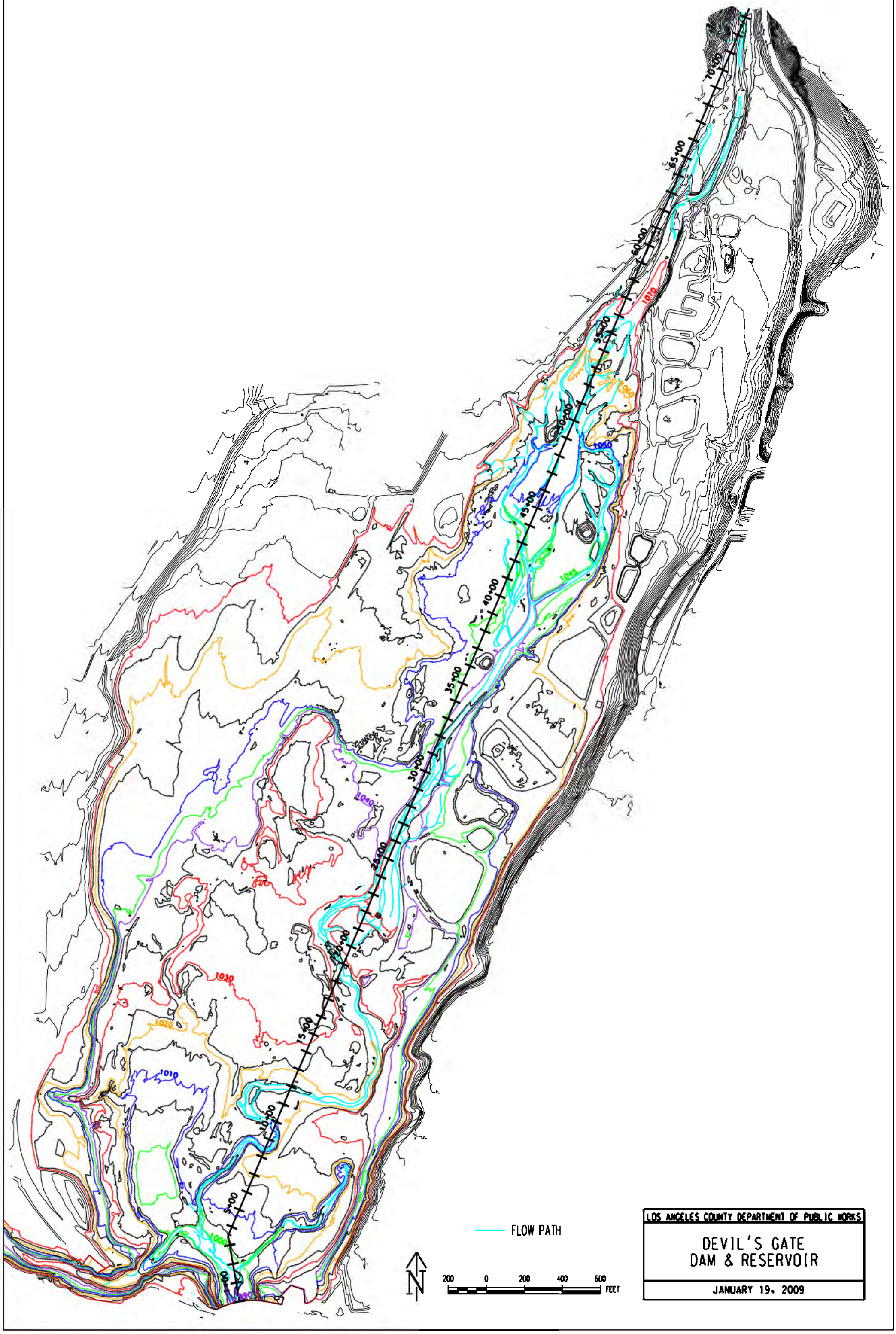
Design Storm - 2Yr 4th Day <Current Op Plan>



Storm of January 4-8, 2008 <Current Op Plan>



ATTACHMENT 10

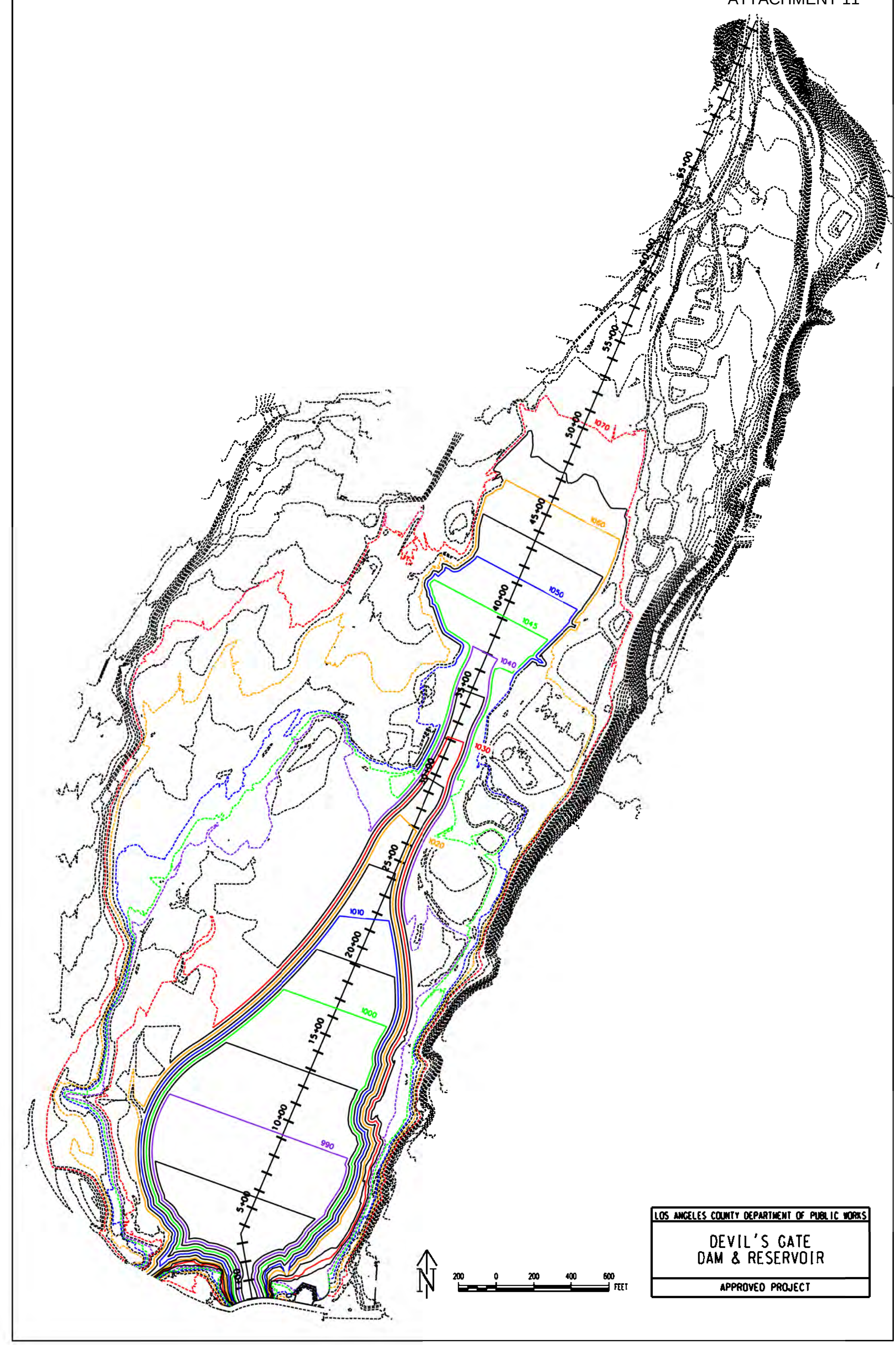


LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE DAM & RESERVOIR

JANUARY 19, 2009

ATTACHMENT 11



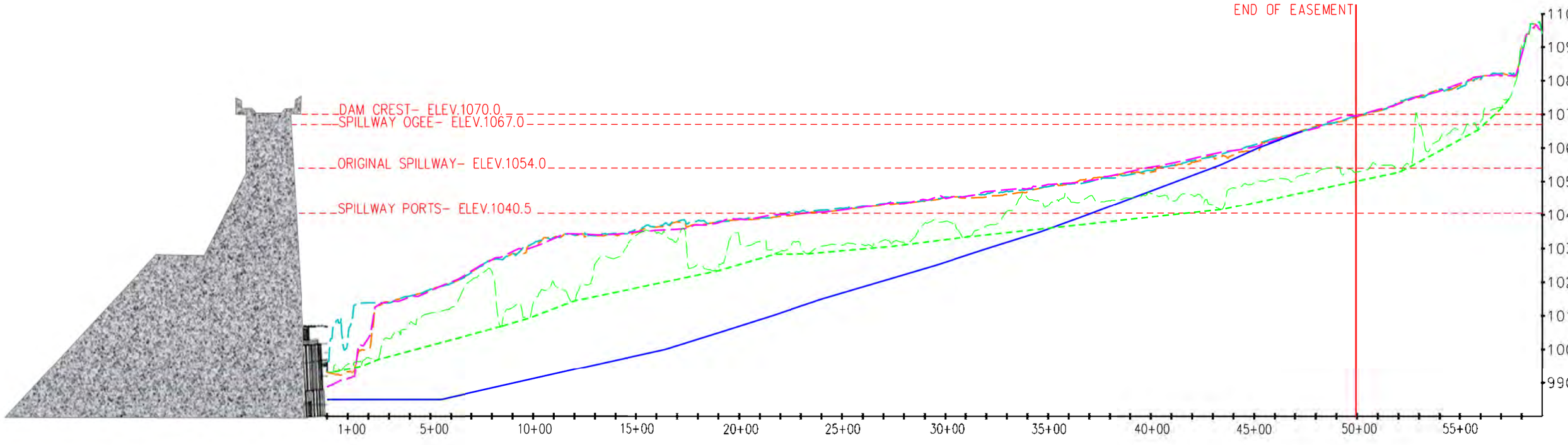
LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE DAM & RESERVOIR

APPROVED PROJECT

ATTACHMENT 12

DEVIL'S GATE RESERVOIR PROFILE



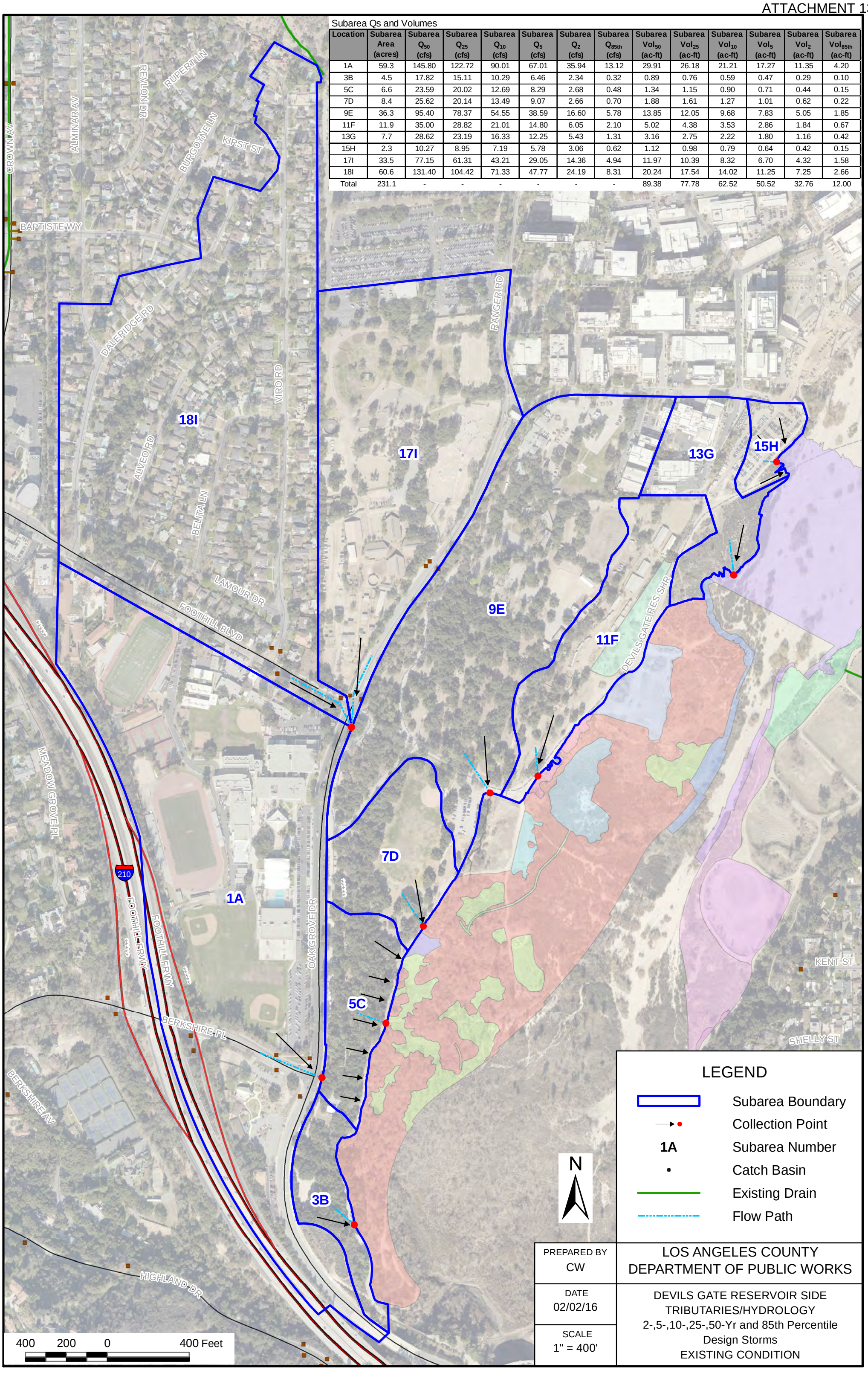
LEGEND

- JANUARY 2009
- JAN. 2009 APPROX. FLOW PATH
- MARCH 2011
- MARCH 2012
- MAY 2014
- APPROVED PROJECT

N

Subarea Qs and Volumes

Location	Subarea Area (acres)	Subarea Q_{50} (cfs)	Subarea Q_{25} (cfs)	Subarea Q_{10} (cfs)	Subarea Q_{5} (cfs)	Subarea Q_{2} (cfs)	Subarea Q_{85th} (cfs)	Subarea Vol_{50} (ac-ft)	Subarea Vol_{25} (ac-ft)	Subarea Vol_{10} (ac-ft)	Subarea Vol_{5} (ac-ft)	Subarea Vol_{2} (ac-ft)	Subarea Vol_{85th} (ac-ft)
1A	59.3	145.80	122.72	90.01	67.01	35.94	13.12	29.91	26.18	21.21	17.27	11.35	4.20
3B	4.5	17.82	15.11	10.29	6.46	2.34	0.32	0.89	0.76	0.59	0.47	0.29	0.10
5C	6.6	23.59	20.02	12.69	8.29	2.68	0.48	1.34	1.15	0.90	0.71	0.44	0.15
7D	8.4	25.62	20.14	13.49	9.07	2.66	0.70	1.88	1.61	1.27	1.01	0.62	0.22
9E	36.3	95.40	78.37	54.55	38.59	16.60	5.78	13.85	12.05	9.68	7.83	5.05	1.85
11F	11.9	35.00	28.82	21.01	14.80	6.05	2.10	5.02	4.38	3.53	2.86	1.84	0.67
13G	7.7	28.62	23.19	16.33	12.25	5.43	1.31	3.16	2.75	2.22	1.80	1.16	0.42
15H	2.3	10.27	8.95	7.19	5.78	3.06	0.62	1.12	0.98	0.79	0.64	0.42	0.15
17I	33.5	77.15	61.31	43.21	29.05	14.36	4.94	11.97	10.39	8.32	6.70	4.32	1.58
18I	60.6	131.40	104.42	71.33	47.77	24.19	8.31	20.24	17.54	14.02	11.25	7.25	2.66
Total	231.1	-	-	-	-	-	-	89.38	77.78	62.52	50.52	32.76	12.00

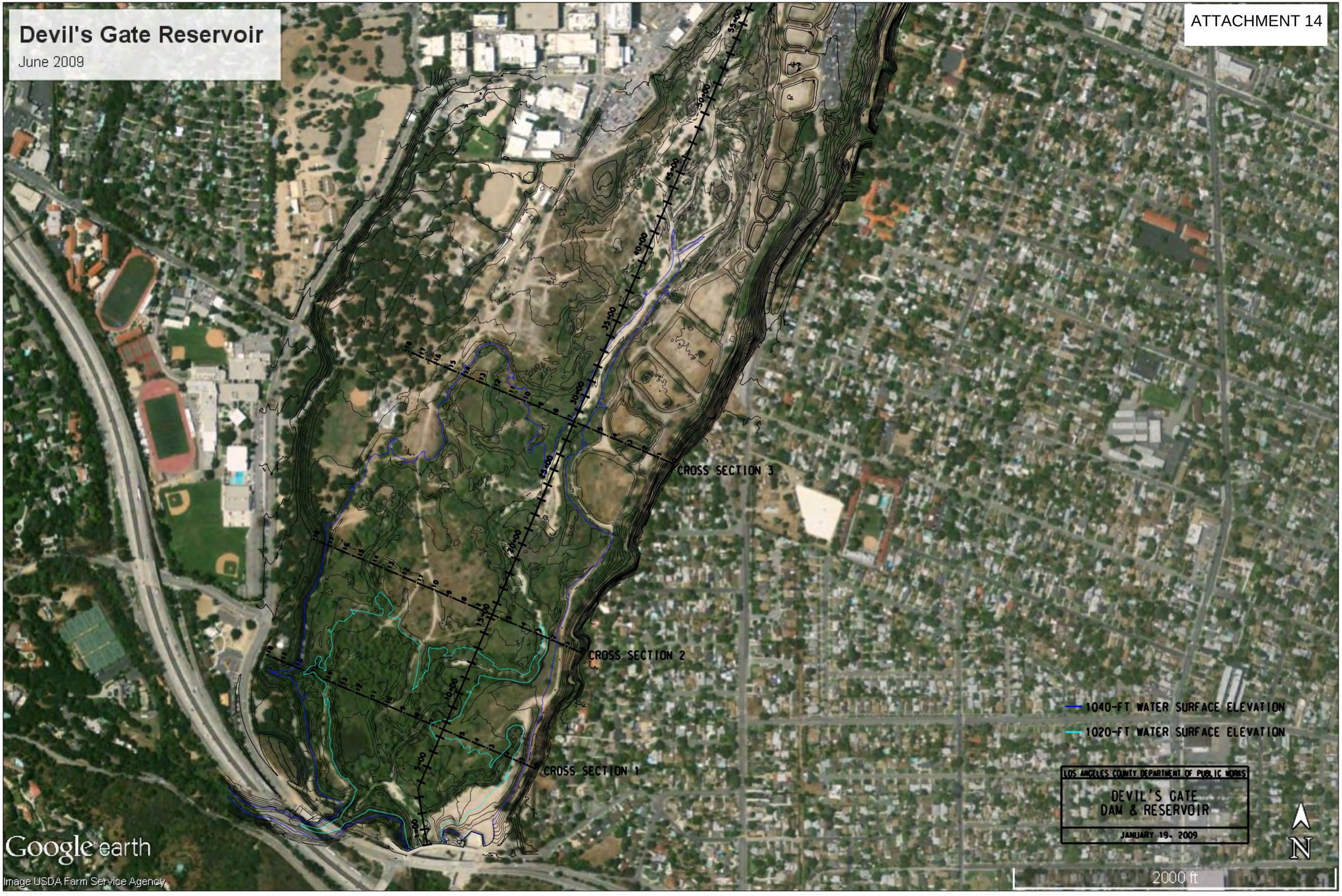


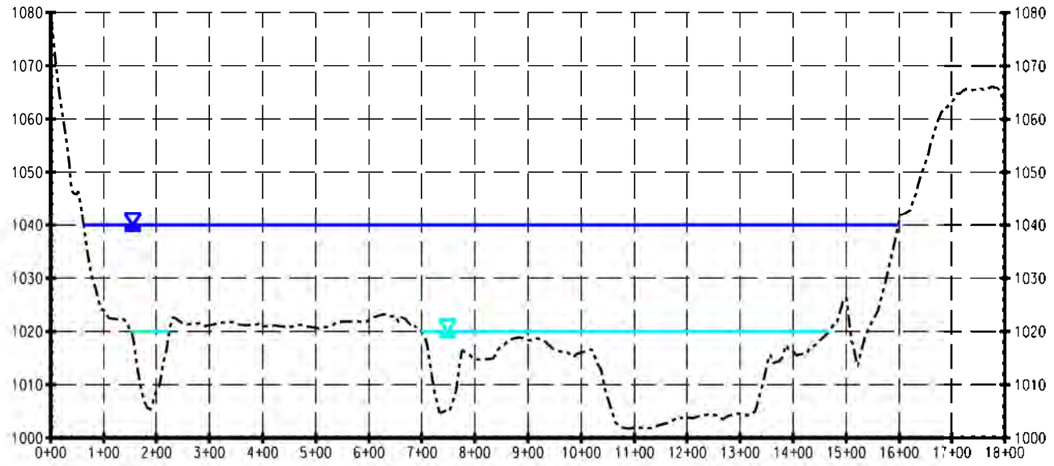
PREPARED BY CW	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 02/02/16	DEVILS GATE RESERVOIR SIDE TRIBUTARIES/HYDROLOGY 2-,5-,10-,25-,50-Yr and 85th Percentile Design Storms EXISTING CONDITION
SCALE 1" = 400'	

ATTACHMENT 14

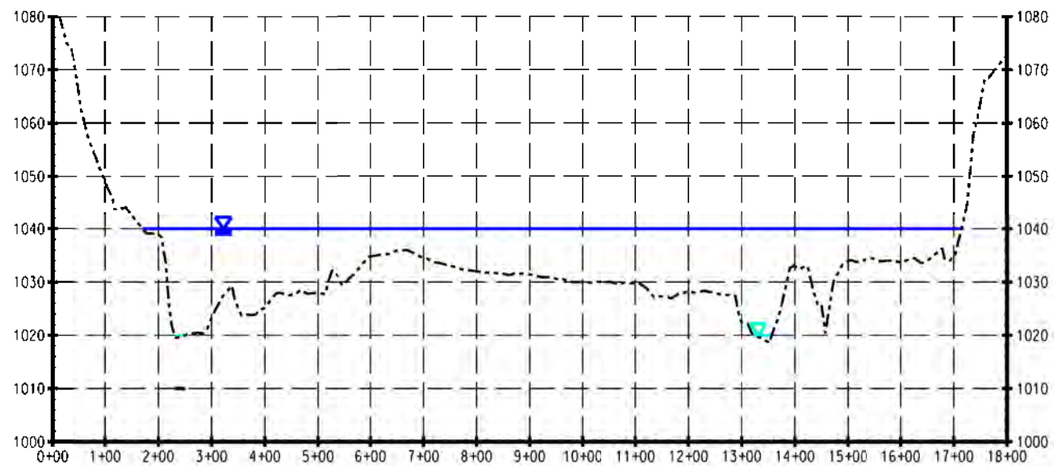
Devil's Gate Reservoir

June 2009





CROSS SECTION 1



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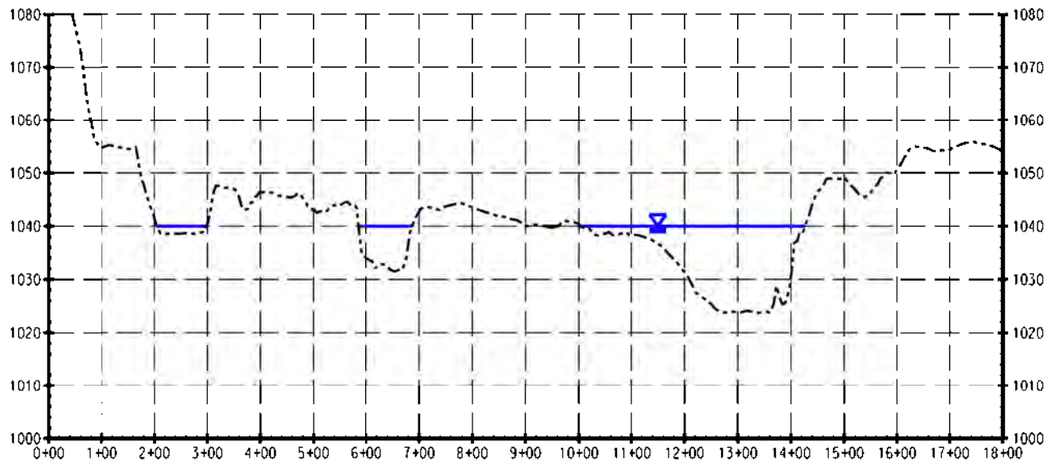


CROSS SECTION 3

1040-FT WATER SURFACE ELEVATION

1020-FT WATER SUFACE ELEVATION

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE
DAM & RESERVOIR

JANUARY 19, 2009

Devil's Gate Mitigation Areas

Map Features

Initial Project Footprint [1]

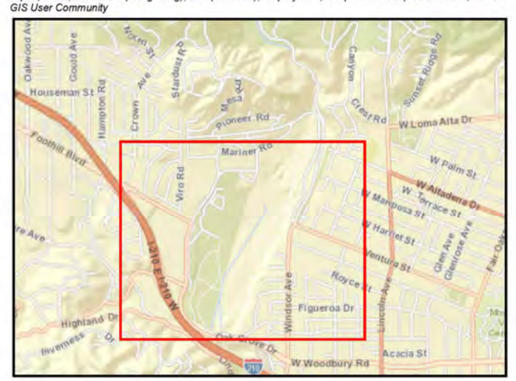
Annual Maintenance Footprint [1]

Waters of the U.S.[2]

- Non-wetland Waters of the U.S.
- Wetland Waters of the U.S.

Mitigation Areas

- DG-1 (5.90 acres)
- DG-2 (5.15 acres)
- DG-2A (0.10 acres)
- DG-2B (0.38 acres)
- DG-3A (1.13 acres)
- DG-3B (Alta Dena) (0.62 acres)
- DG-4 (30.59 acres)
- DG-4A (5.59 acres)
- DG-4B (0.54 acres)
- DG-4C (0.45 acres)
- DG-4D (2.32 acres)
- DG-5 (0.26 acres)
- DG-6 (1.46 acres)
- DG-7 (Temp Impacts) (1.41 acres)
- DG-8 (Temp Impacts) (0.87 acres)
- DG-9 (Temp Impacts) (14.12 acres)
- DG-Park (1.64 acres)
- DG-SF-1 (0.06 acres)
- DG-SF-2 (0.03 acres)
- DG-W-1 (3.44 acres)
- DG-W-2 (2.13 acres)
- DG-W-2 (Outlet) (0.13 acres)



ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

Location: N:\2014\2014-003.008 Devils Gate Mitigation Plan\MAPS\Mitigation_Plan\HMMP\Devils_Gate_v1\DG_Mitigation_Areas_20151028.mxd (JDS)-JSwager 10/28/2015

2014-003.008 Devils Gate Mitigation Plan

Scale in Feet: 0 300 600

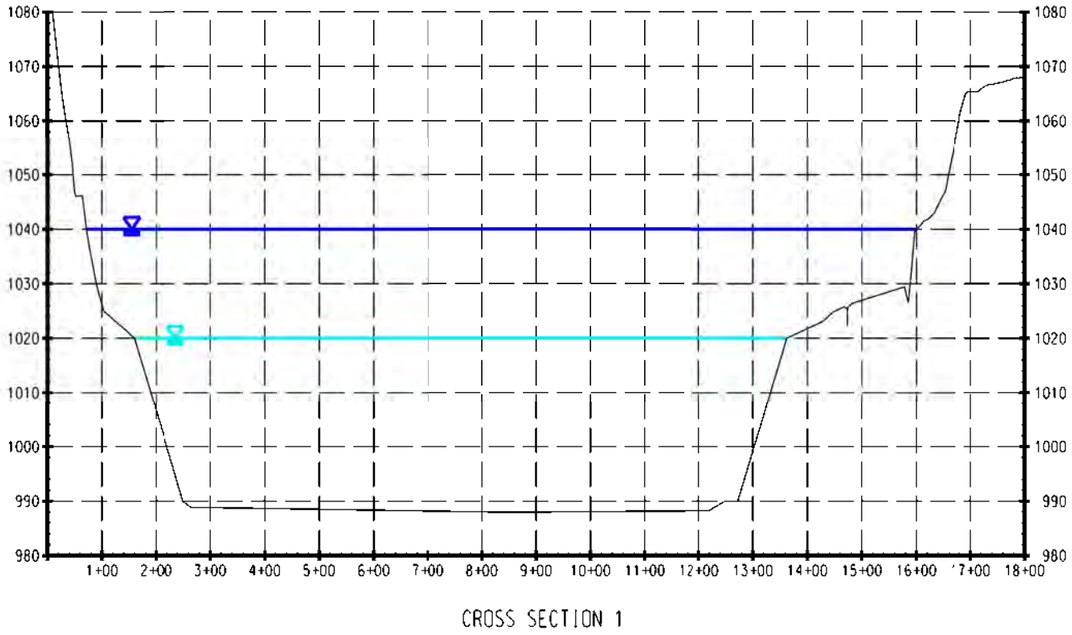
1040-FT WATER SURFACE ELEVATION

1020-FT WATER SURFACE ELEVATION

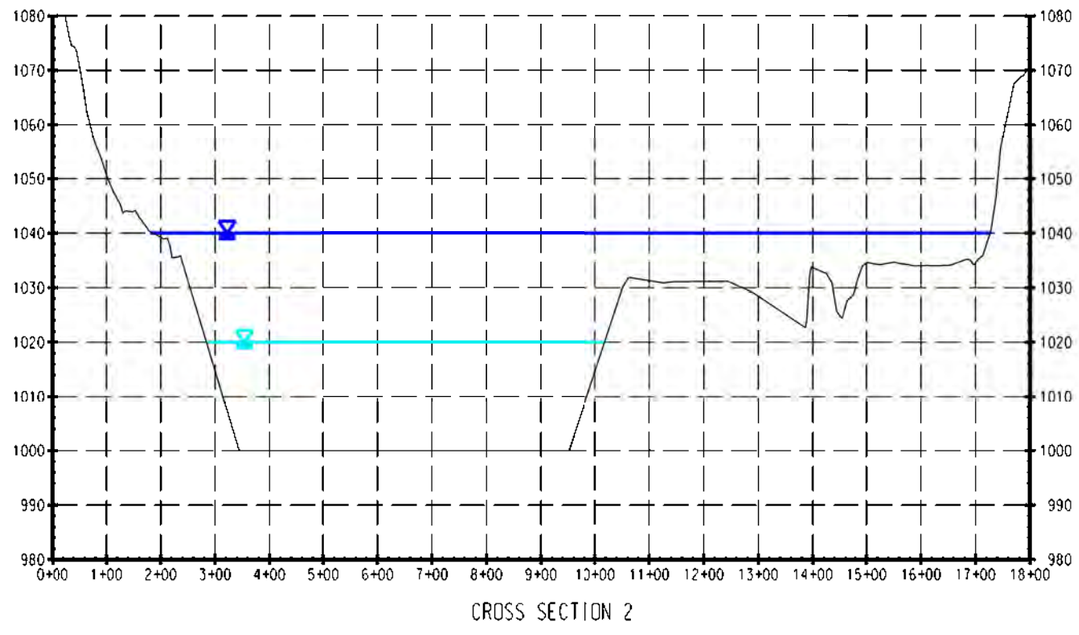
Photo Source: NAIP 2014
[1] LADPW
[2] ECORP and Chambers

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DEVIL'S GATE DAM & RESERVOIR
APPROVED PROJECT

Map Date: 10/28/2015



CROSS SECTION 1



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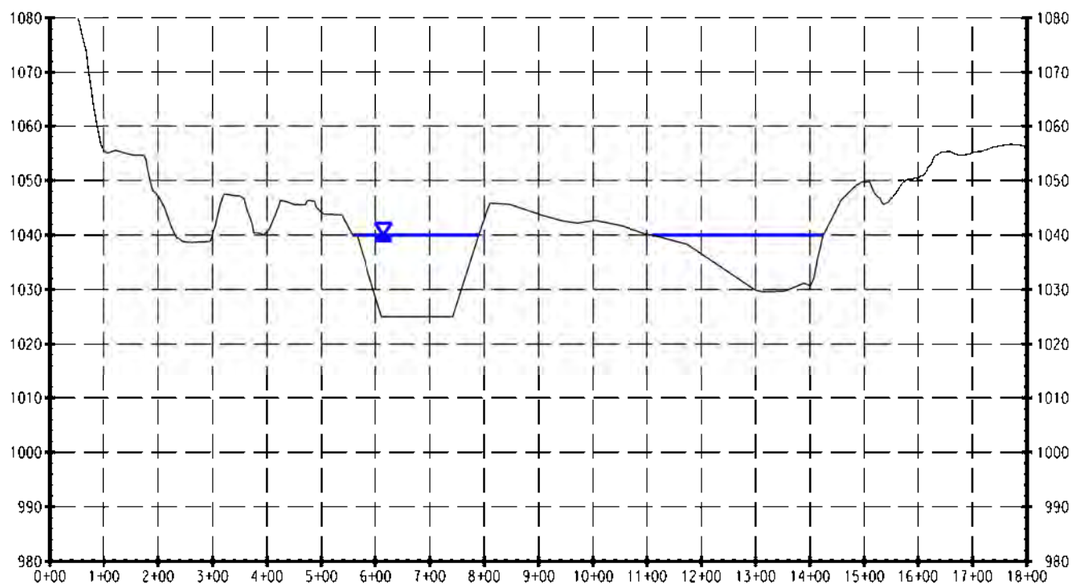


CROSS SECTION 3

1040-FT WATER SURFACE ELEVATION

1020-FT WATER SUFACE ELEVATION

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE
DAM & RESERVOIR

APPROVED PROJECT

APPENDIX E

COMPENSATORY MITIGATION
CHECKLISTS

Groundwater

The project area overlies the Raymond Groundwater Basin (Raymond Basin), which is located within the Los Angeles-San Gabriel Hydrologic Unit. Raymond Basin's average annual precipitation is approximately 21 inches; and groundwater recharge is possible through the penetration of rain falling on alluvial surfaces, returns from irrigation water, and infiltration of stream flow, primarily from the San Gabriel Mountains. Stream flows that collect in Devil's Gate Reservoir and also flows that are diverted to the adjacent City of Pasadena's Arroyo Seco Spreading Grounds contribute to groundwater recharge of the Ramond Basin.

According to available monitoring well data from the adjacent Jet Propulsion Laboratory (JPL) site, see Attachment 1, water level elevations measured at MW-3 in 2012 ranged from 973 feet to 1004 feet amsl. During a site investigation in 2011, groundwater was encountered at soil borings B-3, B-4, and B-9 (Attachment 2) at a depth of 22 to 25 feet below ground surface (approximate elevations of 1022, 1019, and 1010 feet, respectively). The water encountered in the three borings indicates the presence of a perched aquifer at those locations, see Attachment 3.

LACFCD has several groundwater monitoring wells adjacent to Devil's Gate Reservoir, which have data dating back to the 1920s, approximate locations of these wells are shown in Attachment 4. Attachment 5 is a graph showing the historic groundwater elevations from a monitoring well on the east side of the reservoir. The groundwater levels in Devil's Gate Reservoir have been fairly consistent over the life of the dam. The groundwater levels do fluctuate over time, but typically keep within the 900 to 1,000-foot amsl. This is consistent with the dynamics of a reservoir system, as the amount of rainfall received and water impounded in the reservoir can affect the level of the groundwater table. For example, water impounded in the reservoir will permeate into the ground, thus raising the groundwater table in the surrounding area. Similarly, when little rainfall is received, and water is still being extracted from the groundwater table, the elevation of the groundwater over the entire basin will drop.

Attachment 6 is a graph showing the groundwater levels at various reservoir capacities. A decrease in reservoir capacity represents an increase in sediment levels. As can be seen from Attachment 6, the historic groundwater levels in the reservoir show no correlation between sediment levels and groundwater elevation. Rather, the correlation between rainfall received, water entering the reservoir, and groundwater levels indicates that water within the reservoir dictates the groundwater elevations.

Water Held behind Devil's Gate Dam

Table 1 shows information regarding the water held behind Devil's Gate Dam since the spillway elevation change in 1997. The retrofit of Devil's Gate Dam in 1997 lowered the elevation of the spillway to 1040.5', and thereby reduced the amount of reservoir capacity below the spillway. The table shows the total amount of days that water was held behind the dam and the maximum elevation that the water level reached each water year.

Table 1 – Water Levels at Devil's Gate Reservoir

Water Year	Days Water Pool Present	Max. Water Elevation (ft amsl)
1998/1999	35	1,009.1
1999/2000	24	1,007.3
2000/2001	28	1,007
2002/2003	115	1,029.6
2003/2004	50	1,028.6
2004/2005	201	1,045.4
2005/2006	118	1,008.8
2007/2008	28	1,033.1
2008/2009	7	1,000
2009/2010	119	1,036.8
2010/2011	124	1,039.9
2011/2012	122	1,030.9
2012/2013	120	1,018.2
2013/2014	87	1,034.5
2014/2015	134	1,028

After the sediment cleanout project, any water held above the 1,020-foot contour will continue to inundate the west side of the reservoir, as it currently does. Attachment 7 shows the capacity of the reservoir in 2009 and after project implementation, respectively. After project implementation, there will be more capacity within the permanent maintenance area to hold water. This will increase the amount of water allowed to permeate the side slopes and provide soil moisture to the mitigation areas.

Table 2 shows the yearly inflow into Devil's Gate Reservoir over the past 15 years. Excluding the water year 2004/2005, the average yearly inflow into Devil's Gate Reservoir is approximately 8,400 acre-ft. Inflows to Devil's Gate eventually flows downstream, and any downstream mitigation areas will not be affected by the Project.

Attachments 8 and 9 show the results of a hydrological analysis of Devil's Gate Reservoir after the Approved Project. Attachment 8 models the storage and flow of 2-year frequency design storm with the Approved Project cut plan. From the summary results shown in Attachment 8, its can be seen that with the Approved Project cut plan and the current operation plan, the peak storage and elevation within the reservoir would have been 1829 acre-ft. and 1042.4 ft., respectively. This model shows that under the 2-year frequency design storm the reservoir will be filled to spillway elevation. Attachment 9 models the storage and flow of an actual storm that occurred in the watershed of Devil's Gate Reservoir in 2008 under the Approved Project cut plan. The 2007/2008 water year was chosen to model for being an average water year in terms of rainfall. The January 4 – 8 storm represents a 2-5 year frequency storm that occurred within the 2007/2008 water year. From the summary results shown in Attachment 9, its can be seen that with the Approved Project cut plan, the peak storage and elevation within the reservoir

would have been 1580.1 acre-ft. and 1039.8 ft., respectively. From the two different scenarios modeled for the Approved Project cut plan, it can be concluded that the western portion of the reservoir will be inundated regularly.

Table 2 – Total Yearly Inflow to Devil's Gate Reservoir

Water Year	Total Inflow (acre-ft.)
1999/2000	15,792
2000/2001	12,259
2001/2002	1,731
2002/2003	3,137
2003/2004	2,071
2004/2005	134,360
2005/2006	6,573
2006/2007	4,717
2007/2008	13,962
2008/2009	2,579
2009/2010	19,143
2010/2011	33,340
2011/2012	2,298
2012/2013	513

Flow Paths

Attachment 10 shows the contours and estimated flow path of Devil's Gate Reservoir in January 2009, pre-Station Fire. Pre-Station Fire conditions show water flowing from the north end of the reservoir towards the face of the dam through channels that were cut by storm flows. The contours in Attachment 10 show several braided channels within the north end of the reservoir that converge into one main channel that flows toward the dam, all within the proposed project boundary. Attachment 11 shows the proposed configuration post-project. After the completion of the Devil's Gate Sediment Removal Project, the water will flow through a path similar to the pre-Station Fire. Even though the reservoir will be evenly graded during construction within the project boundary, the water flowing into the permanent maintenance area will continue to meander and braid through the sediment deposited during storms.

Reservoir Profile

Attachment 12 shows Devil's Gate Reservoir Profile before the Station Fire (2009), after the Station Fire (2011, 2012, and 2014), and after the project. The vertical scale has been exaggerated in relation to the horizontal scale to view the profiles. The unevenness of the 2009 sediment profile is the result of long-term deposition of sediment and erosion from periodic storm flows. The 2011 sediment profile shows the large influx of sediment resulting from the Station Fire and, other than the interim cleanout of

sediment right behind the dam, the large amount of sediment continued to persist into 2014. The elevation of the sediment will be lowered within the project boundary, but the slope will still remain gradual, with an average slope of approximately 1.7 percent.

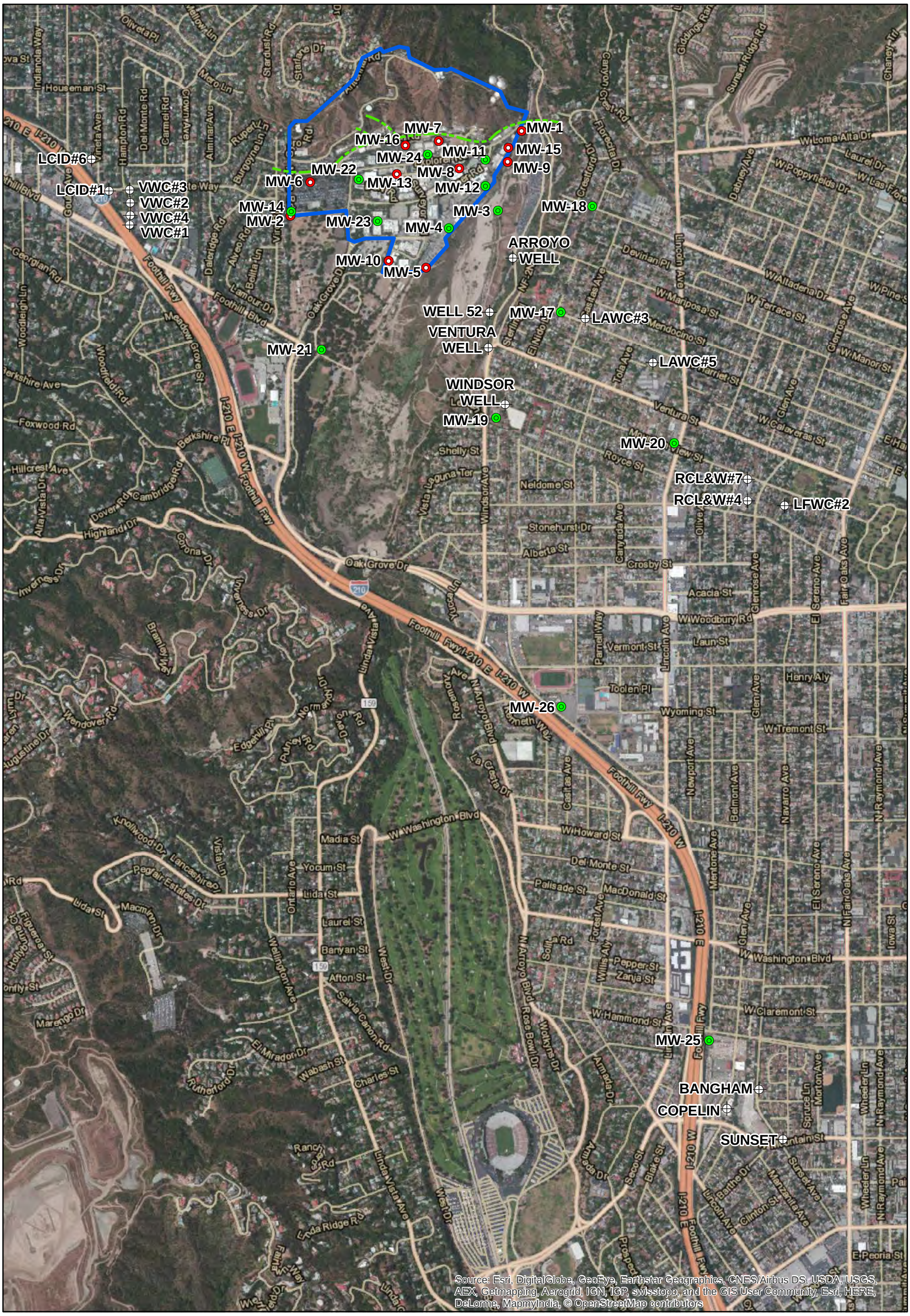
Riparian Vegetation

Attachment 13 shows the tributary drainage areas west of Devil's Gate Reservoir that drain into the reservoir. This attachment also shows the calculated flow and volume from each area into the reservoir for various storm return intervals. From the table shown on Attachment 13, a total of 33 acre-ft. of storm flows enter the reservoir from the western tributaries during a 2-year frequency storm. The volume of flows from the western tributaries can reach up to 89 acre-ft. during a 50-year frequency storm.

Attachment 14 is an aerial of Devil's Gate Reservoir in June 2009, before the Station Fire. This is following the 2008 – 2009 storm season, in which water was not held behind the dam at a high elevation or for very long, as shown in Table 1. Even so, the aerial shows persistent vegetation established throughout the reservoir. Cross sections across the reservoir in 2009 are shown in Attachment 15. Comparing the riparian vegetation in the aerial (Attachment 14) and the cross sections in Attachment 15, it can be seen that riparian vegetation is abundant above the 1,020-ft elevation.

In addition, riparian vegetation has persisted throughout the reservoir, even after several drought years.

With the combination of the western tributary flows, previously existing vegetation, historic groundwater elevations, and water levels behind Devil's Gate Dam, riparian vegetation will be able to establish on the west side of the reservoir. Attachment 16 shows the proposed contours of the project over the proposed mitigation plan. All proposed mitigation under the 1,040-ft contour will be below spillway, and therefore subject to inundation. Attachment 17 shows cross sections similar to those in Attachment 15, but for the post-project reservoir configuration. The relationship between the 1,020-ft contour and the proposed mitigation area is similar to that in 2009. When water is held in the reservoir, the water will permeate into the side slopes, providing adequate soil moisture for the vegetation.



N
W E
S

0 490 980 1,470
Feet

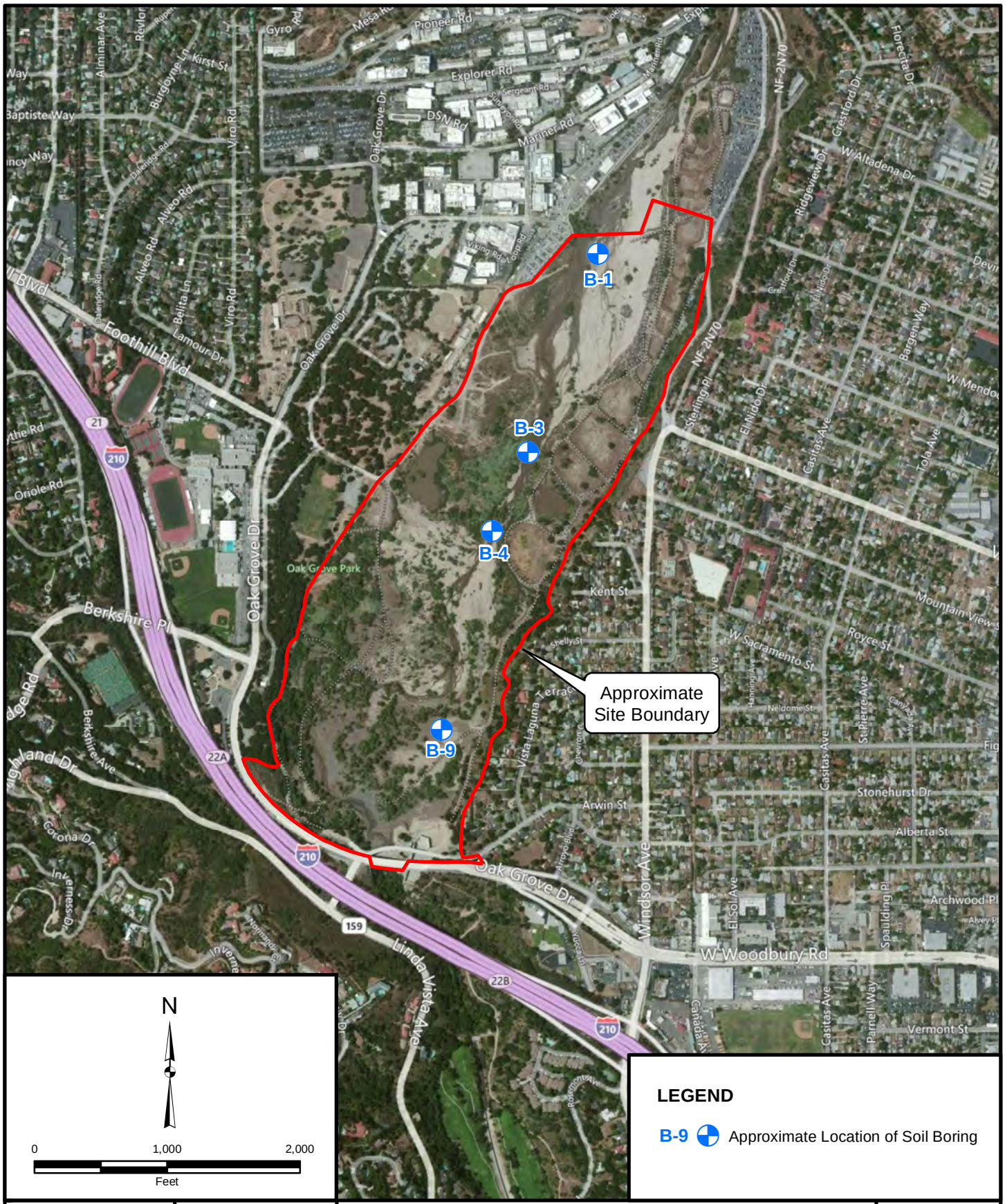
Legend

- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well

TIDEWATER INC
ENGINEERS / SCIENTISTS / PROGRAM MANAGERS

Locations of JPL Groundwater Monitoring Wells and Nearby Municipal Production Wells

DESIGNED BY JHG DRAWN BY JHG CHECKED BY DC	JPL - Pasadena, CA Contract No: W912PL-13-D-0018 TO 001	Figure 1 June 2015



Project: 603211-001	Eng/Geol: VPI/RML
Scale: 1 " = 1,000 '	Date: October 2011

Base Map: ESRI Resource Center, 2010
Thematic Info: Leighton
Author: (cgiovando)

BORING LOCATION MAP

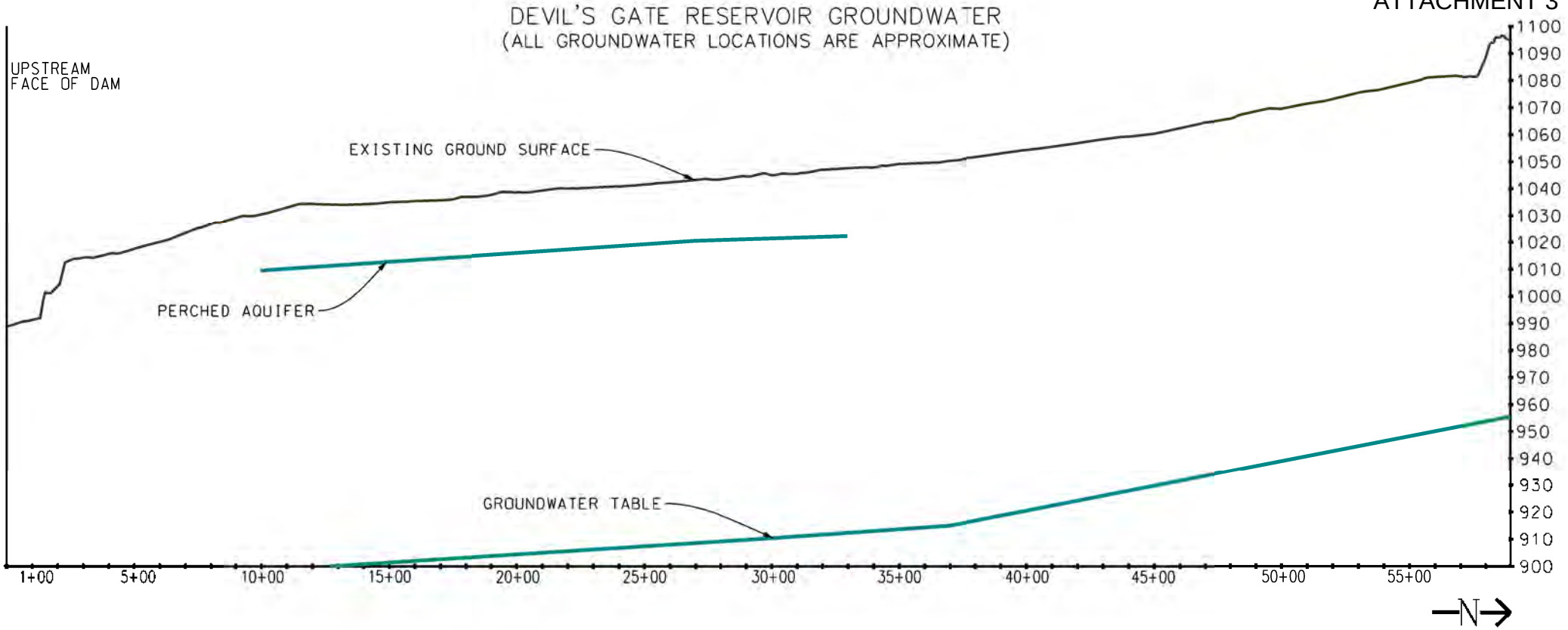
Devil's Gate Reservoir
Pasadena, California

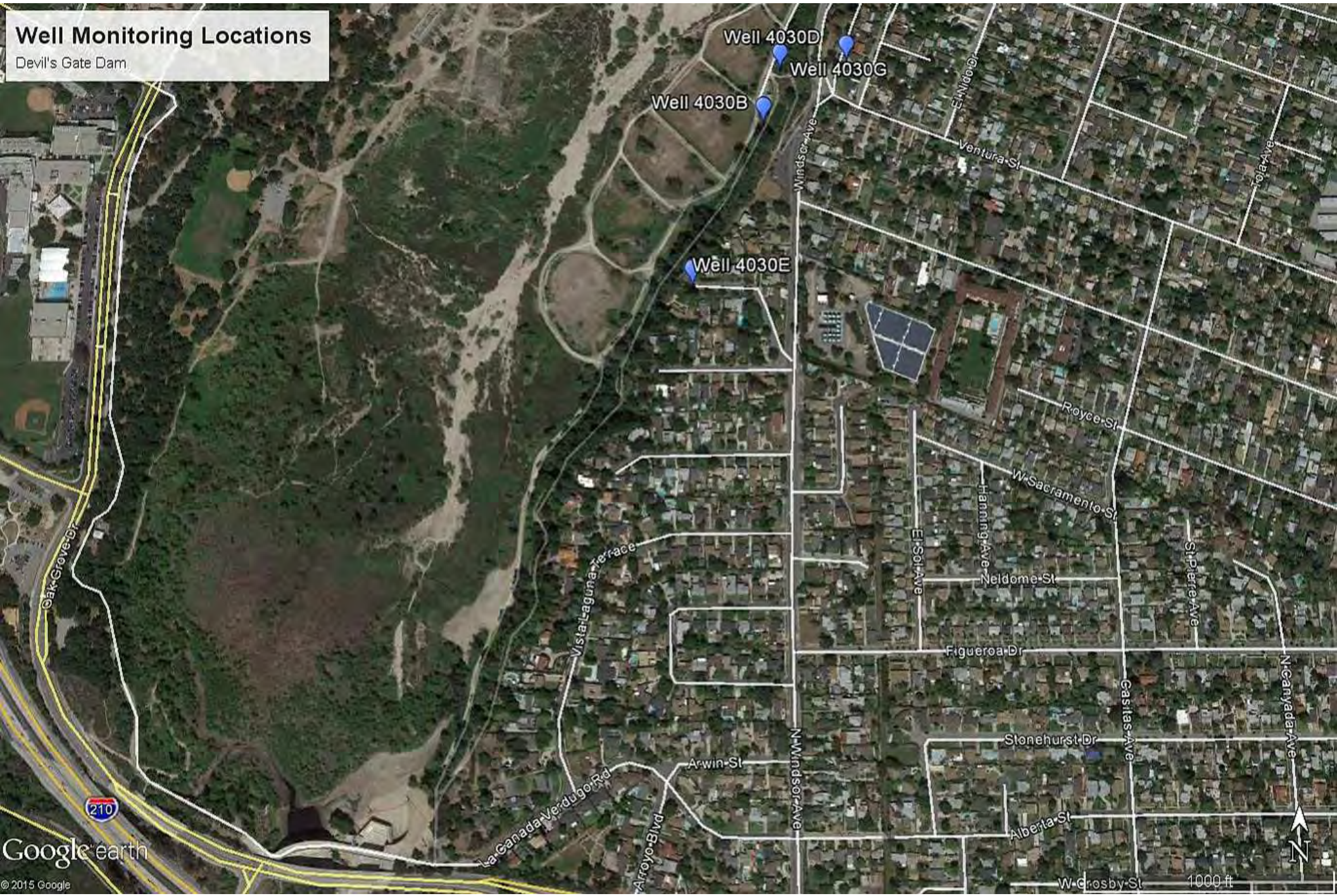
Figure 2

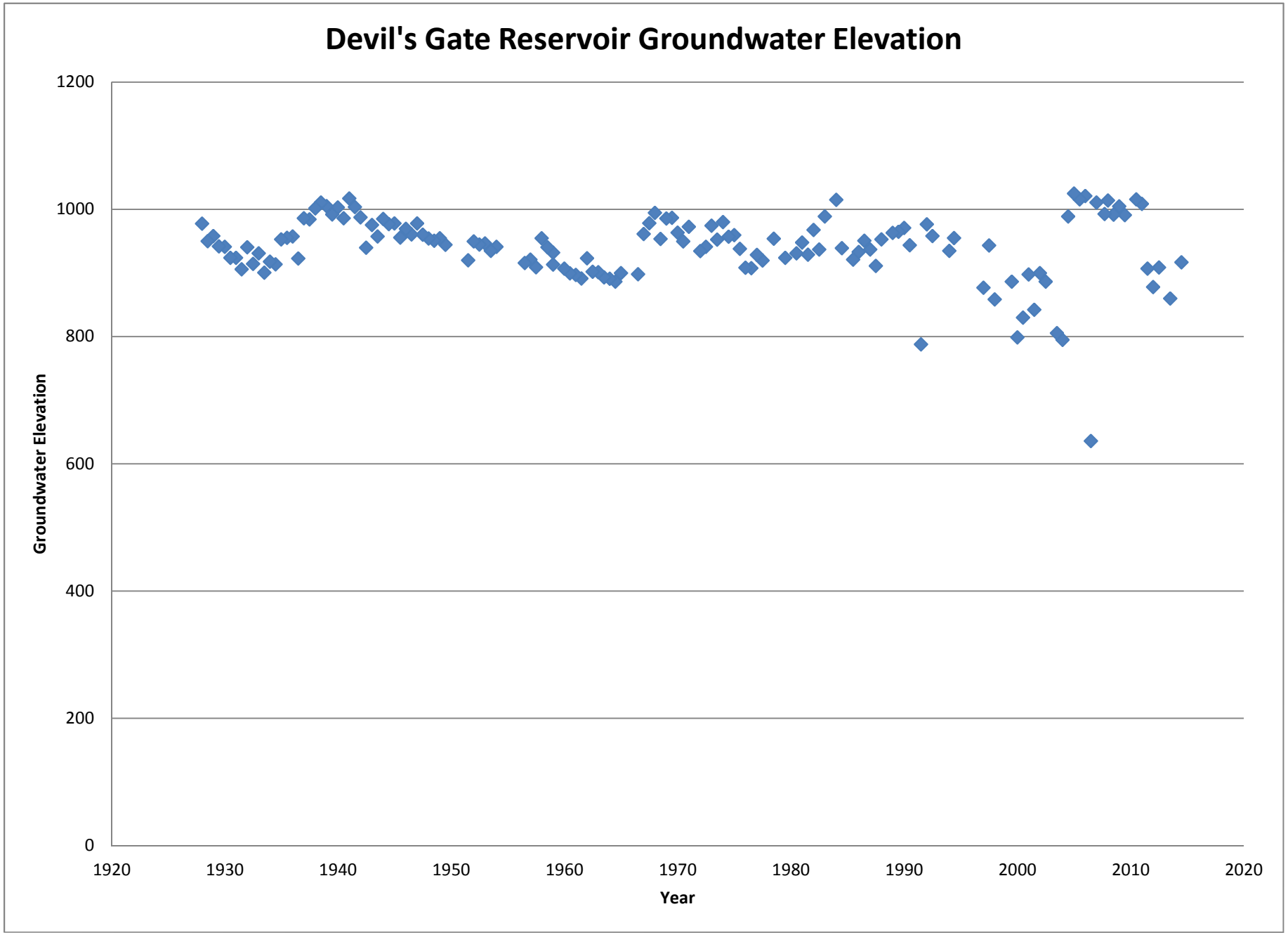
Leighton

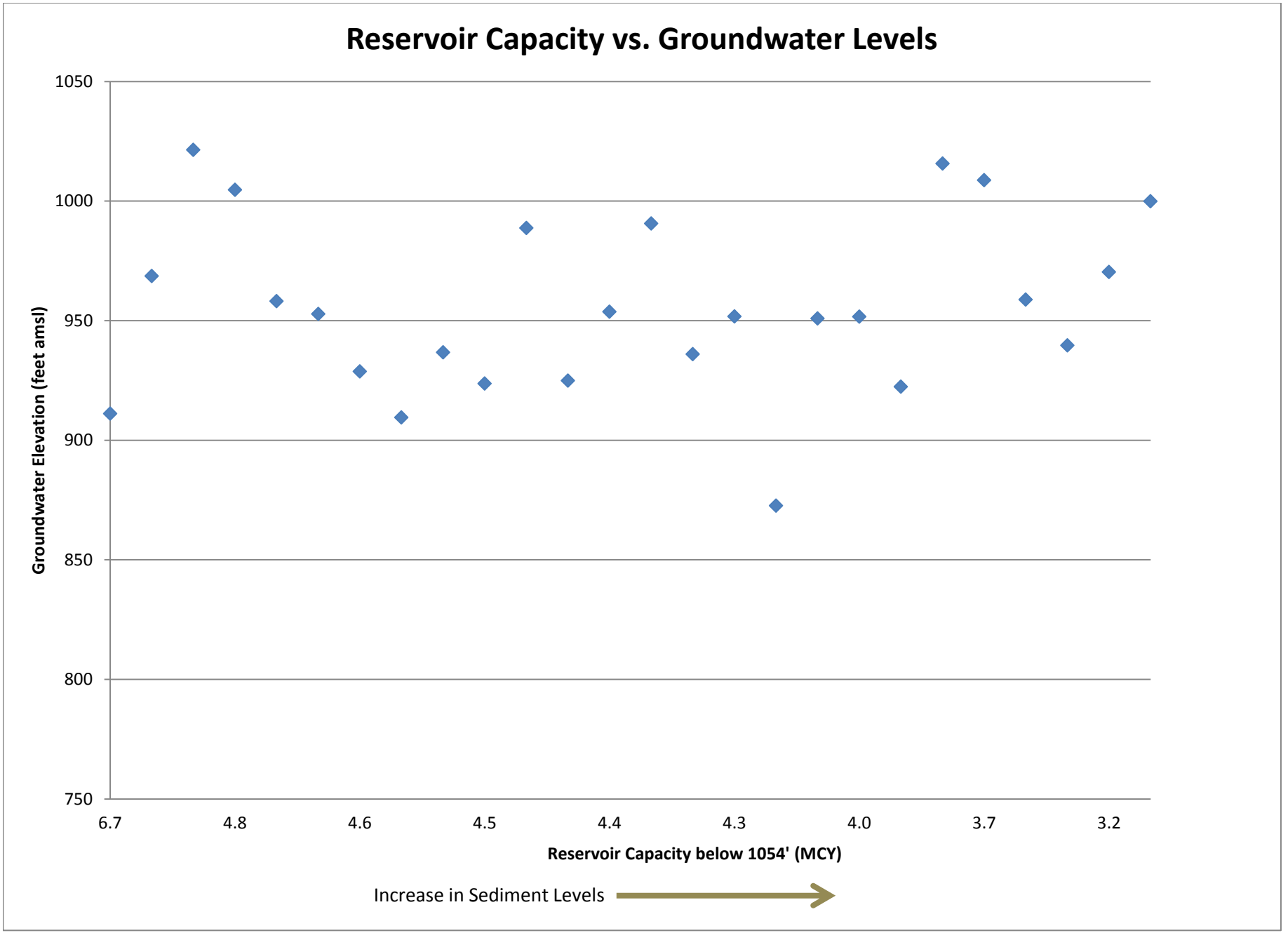
Map Saved as V:\drafting\603211\001\Maps\P603211-001_F02_BoringLocationMap_GIS_2013-01-23.mxd on 1/23/2013 3:36:43 PM

ATTACHMENT 3




Well Monitoring Locations
Devil's Gate Dam
Well 4030D
Well 4030G
Well 4030B
Well 4030E
Windsor Ave
Ventura St
Royce St
W Sacramento St
Hanning Ave
El Sol Ave
Neldome St
St Pierre Ave
Figueroa Dr
Casitas Ave
N Canyada Ave
Stonehurst Dr
Alberta St
W Crosby St
Oak Grove Dr
Vista Laguna Terrace
Arwin St
La Canada Verdugo Rd
Arroyo Blvd
N Windsor Ave
210
Google earth
© 2015 Google
1000 ft
N

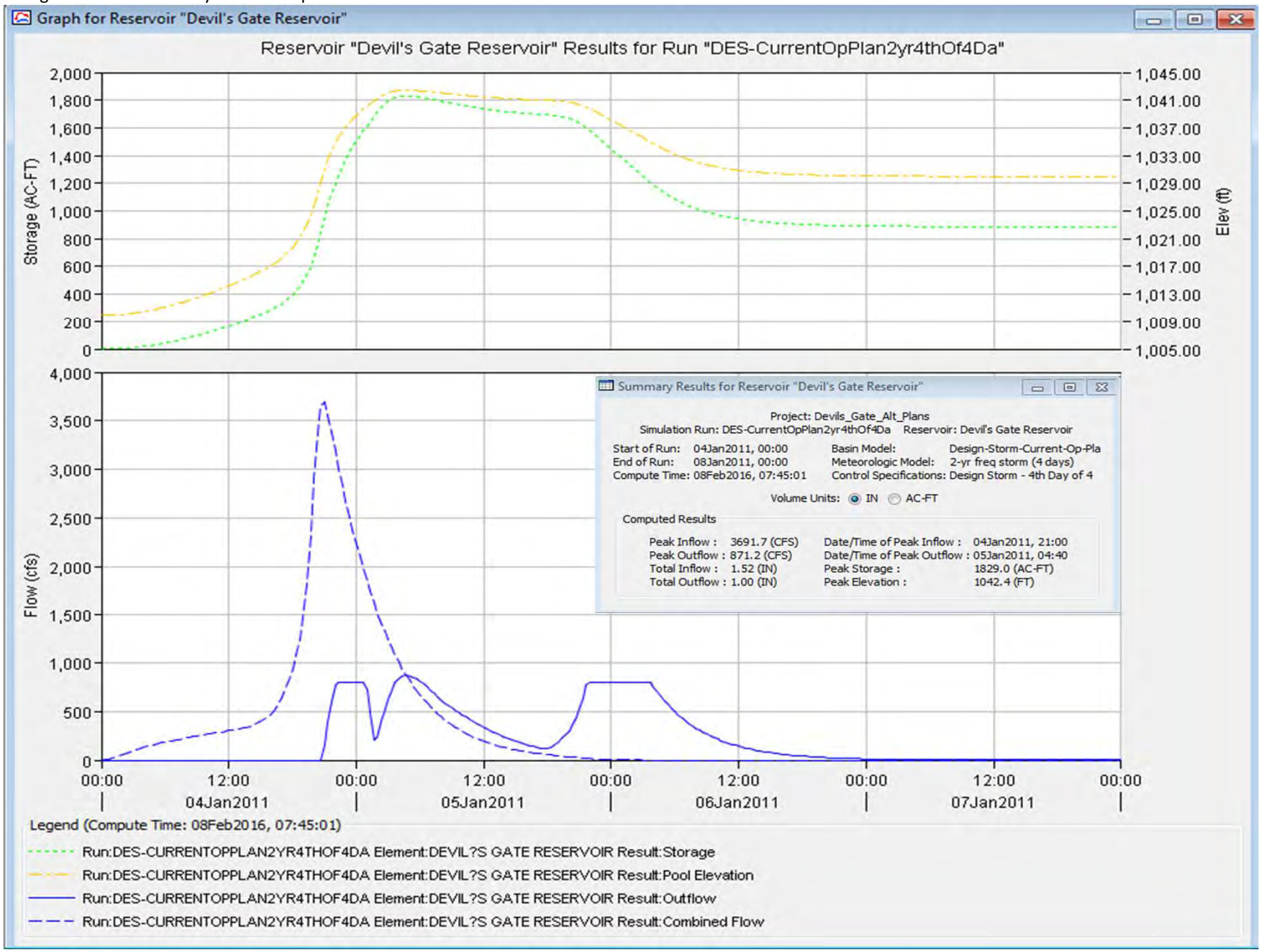

Devil's Gate Reservoir Groundwater Elevation
Groundwater Elevation
1200
1000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year


Reservoir Capacity vs. Groundwater Levels
Groundwater Elevation (feet amsl)
1050
1000
950
900
850
800
750
6.7
4.8
4.6
4.5
4.4
4.3
4.0
3.7
3.2
Reservoir Capacity below 1054' (MCY)
Increase in Sediment Levels

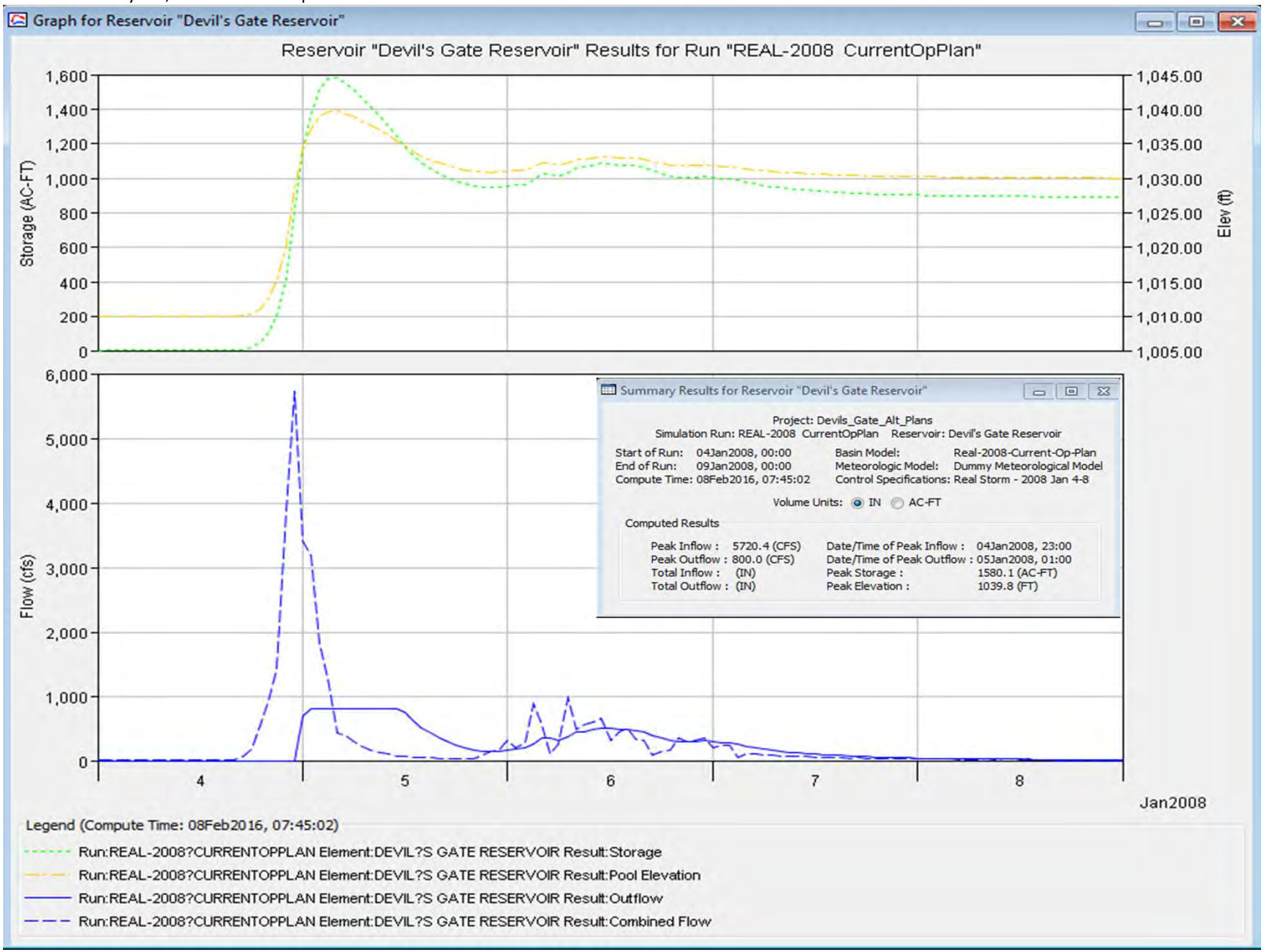
DEVIL'S GATE DAM RESERVOIR
DEVIL'S GATE RESERVOIR SEDIMENT REMOVAL PROJECT

Contour	Accum. Volume (acre-ft)	
	2009	Post-Project
985	0	4.74
990	0	50.07
995	0.15	138.88
1000	4.72	268.19
1005	26.36	429.08
1010	68.60	611.70
1015	139.10	808.26
1020	244.67	1015.97
1025	396.19	1237.81
1030	613.21	1499.64
1035	932.35	1816.75
1040	1349.59	2210.66
1040.5	1396.02	2255.74

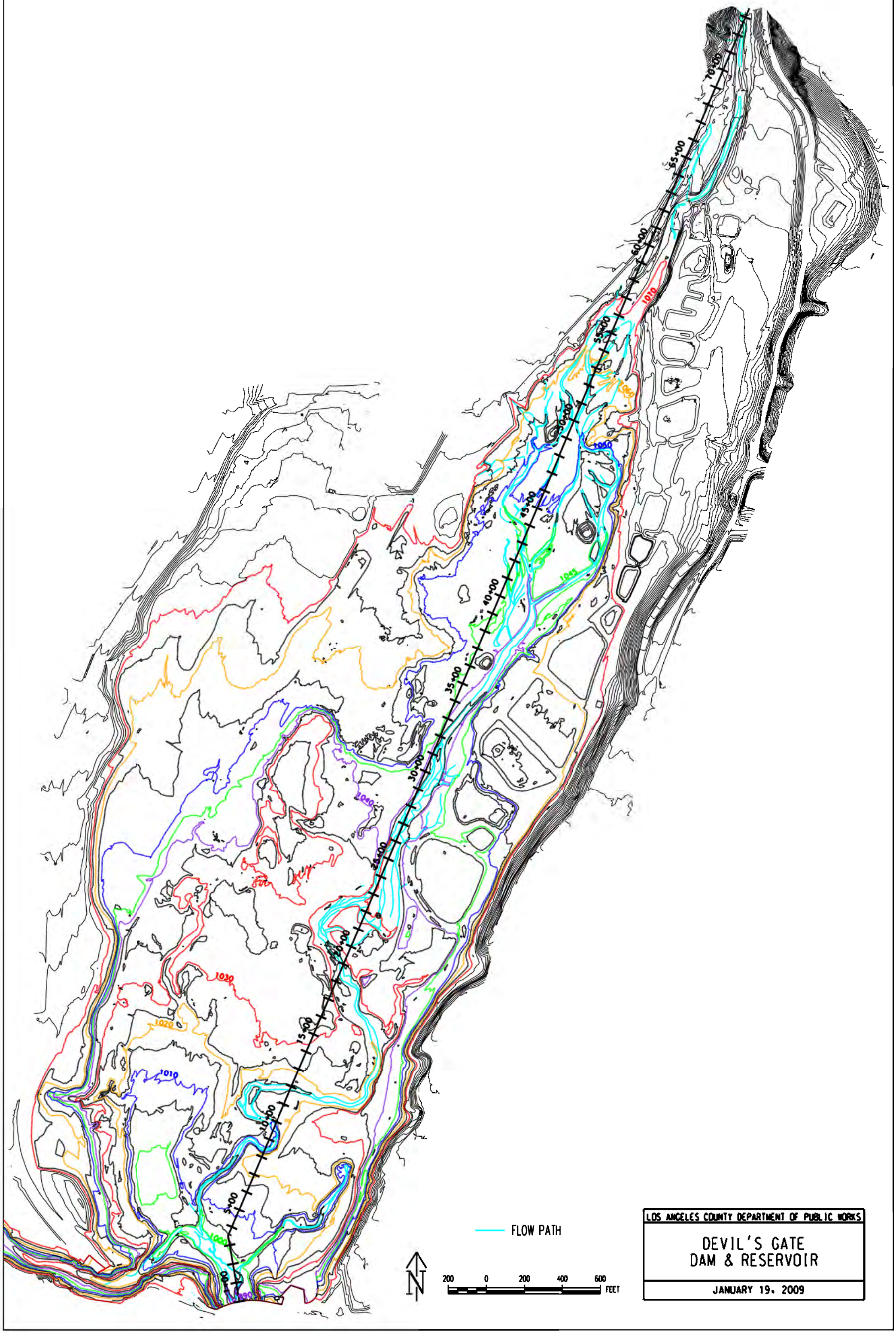
Design Storm - 2Yr 4th Day <Current Op Plan>



Storm of January 4-8, 2008 <Current Op Plan>



ATTACHMENT 10

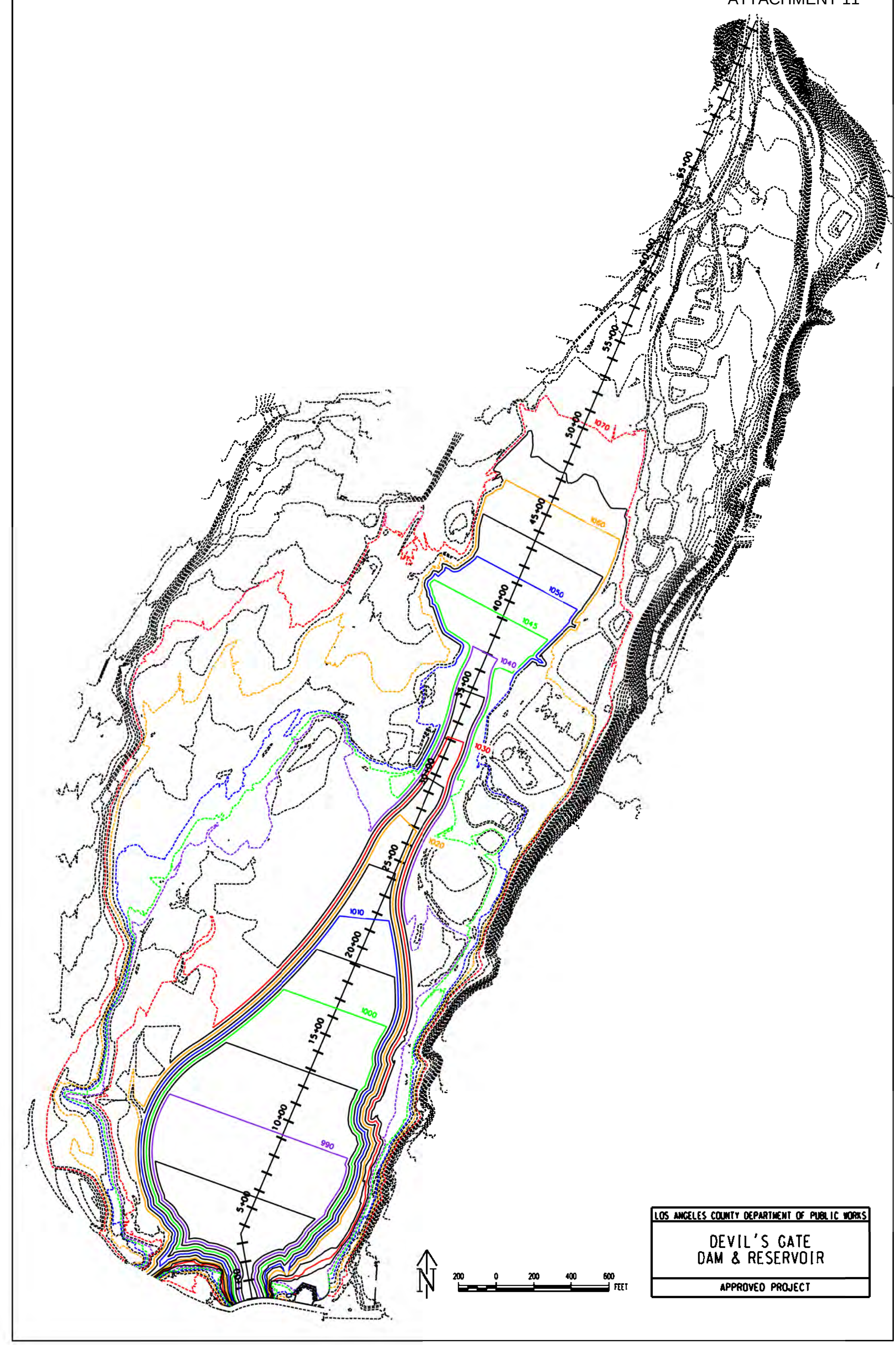


LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE DAM & RESERVOIR

JANUARY 19, 2009

ATTACHMENT 11



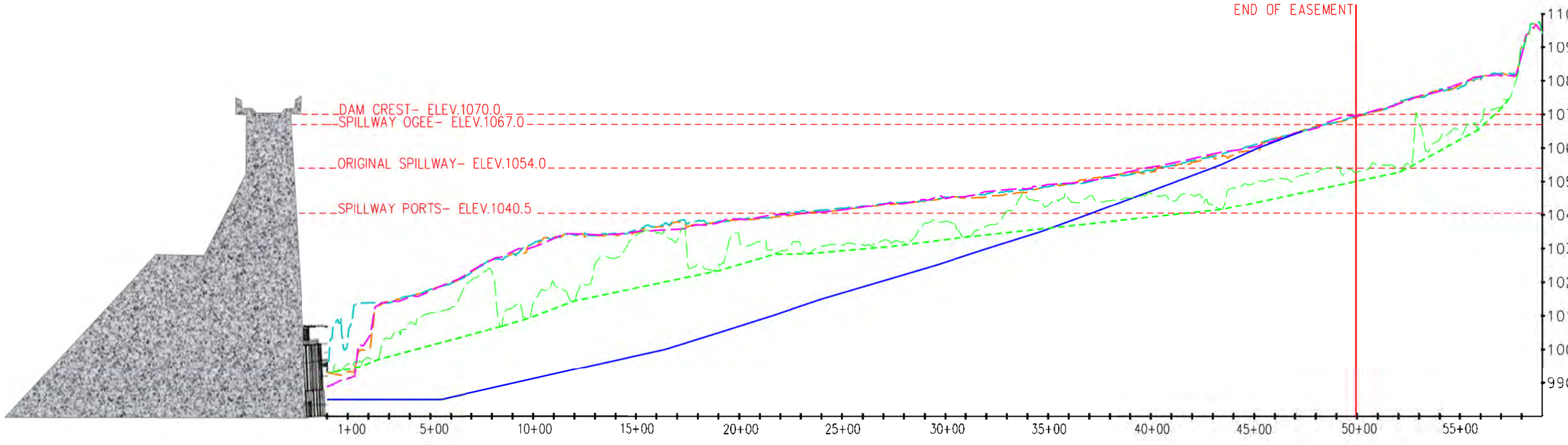
LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE DAM & RESERVOIR

APPROVED PROJECT

ATTACHMENT 12

DEVIL'S GATE RESERVOIR PROFILE



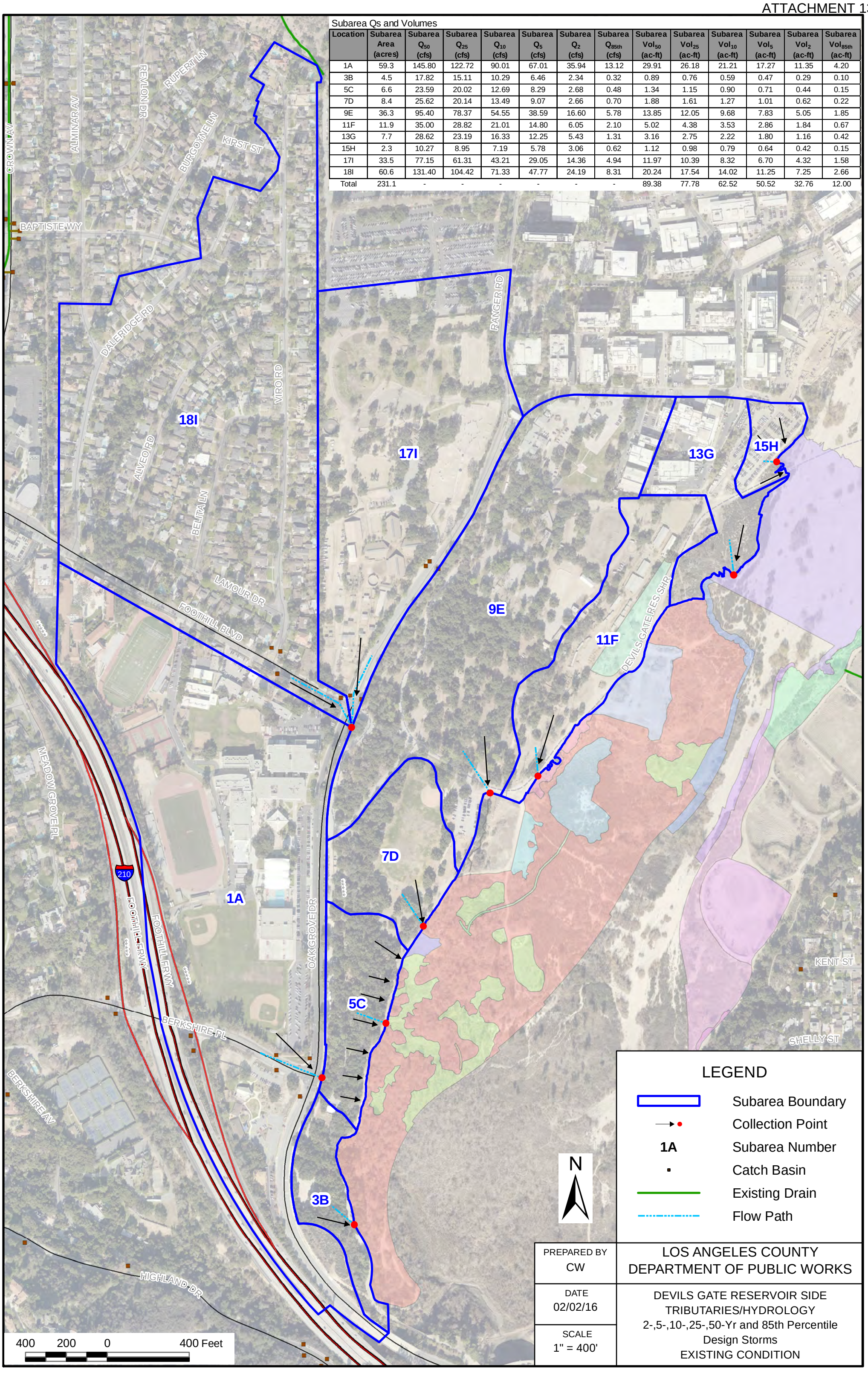
LEGEND

- JANUARY 2009
- JAN. 2009 APPROX. FLOW PATH
- MARCH 2011
- MARCH 2012
- MAY 2014
- APPROVED PROJECT

N

Subarea Qs and Volumes

Location	Subarea Area (acres)	Subarea Q_{50} (cfs)	Subarea Q_{25} (cfs)	Subarea Q_{10} (cfs)	Subarea Q_{5} (cfs)	Subarea Q_{2} (cfs)	Subarea Q_{85th} (cfs)	Subarea Vol_{50} (ac-ft)	Subarea Vol_{25} (ac-ft)	Subarea Vol_{10} (ac-ft)	Subarea Vol_{5} (ac-ft)	Subarea Vol_{2} (ac-ft)	Subarea Vol_{85th} (ac-ft)
1A	59.3	145.80	122.72	90.01	67.01	35.94	13.12	29.91	26.18	21.21	17.27	11.35	4.20
3B	4.5	17.82	15.11	10.29	6.46	2.34	0.32	0.89	0.76	0.59	0.47	0.29	0.10
5C	6.6	23.59	20.02	12.69	8.29	2.68	0.48	1.34	1.15	0.90	0.71	0.44	0.15
7D	8.4	25.62	20.14	13.49	9.07	2.66	0.70	1.88	1.61	1.27	1.01	0.62	0.22
9E	36.3	95.40	78.37	54.55	38.59	16.60	5.78	13.85	12.05	9.68	7.83	5.05	1.85
11F	11.9	35.00	28.82	21.01	14.80	6.05	2.10	5.02	4.38	3.53	2.86	1.84	0.67
13G	7.7	28.62	23.19	16.33	12.25	5.43	1.31	3.16	2.75	2.22	1.80	1.16	0.42
15H	2.3	10.27	8.95	7.19	5.78	3.06	0.62	1.12	0.98	0.79	0.64	0.42	0.15
17I	33.5	77.15	61.31	43.21	29.05	14.36	4.94	11.97	10.39	8.32	6.70	4.32	1.58
18I	60.6	131.40	104.42	71.33	47.77	24.19	8.31	20.24	17.54	14.02	11.25	7.25	2.66
Total	231.1	-	-	-	-	-	-	89.38	77.78	62.52	50.52	32.76	12.00

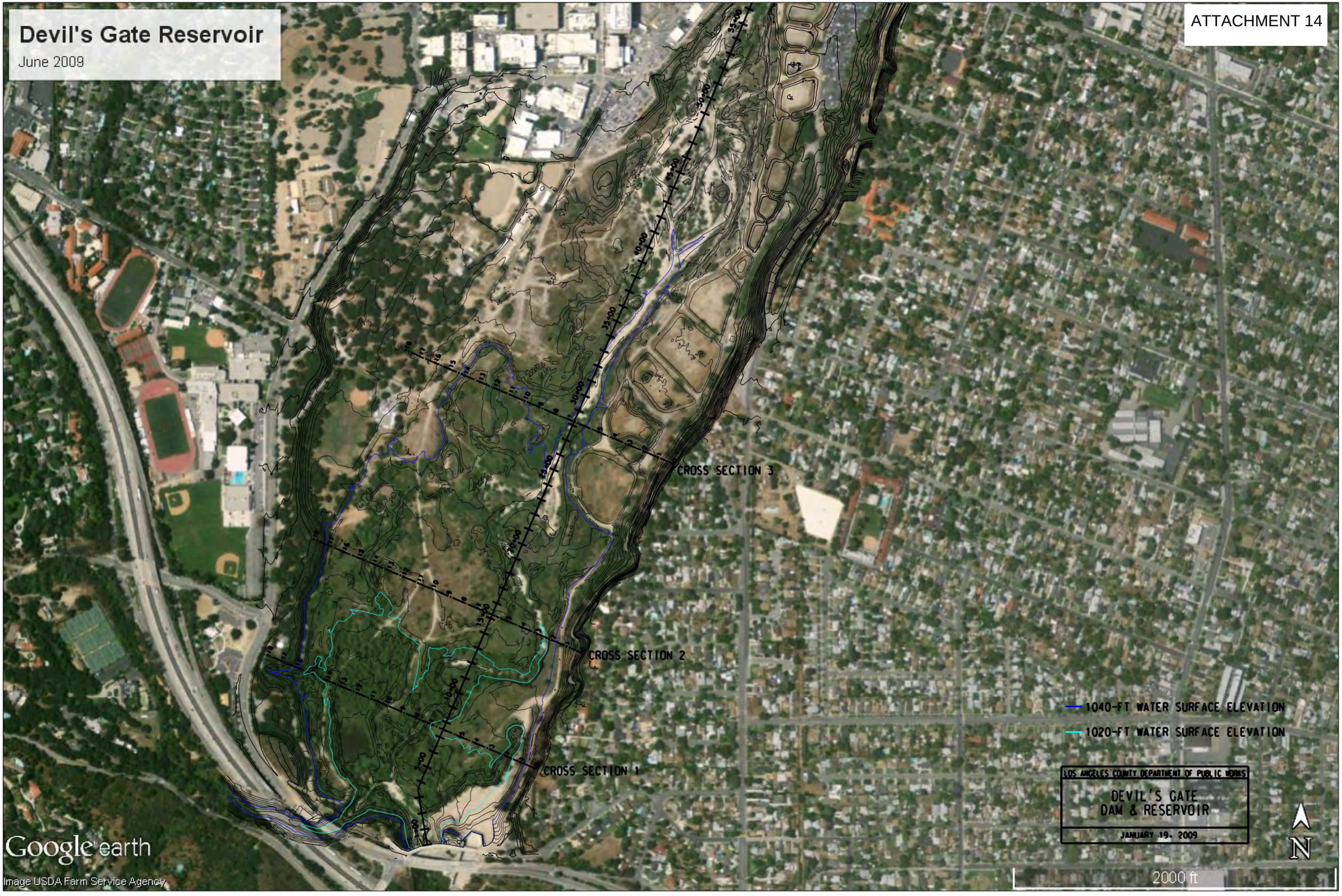


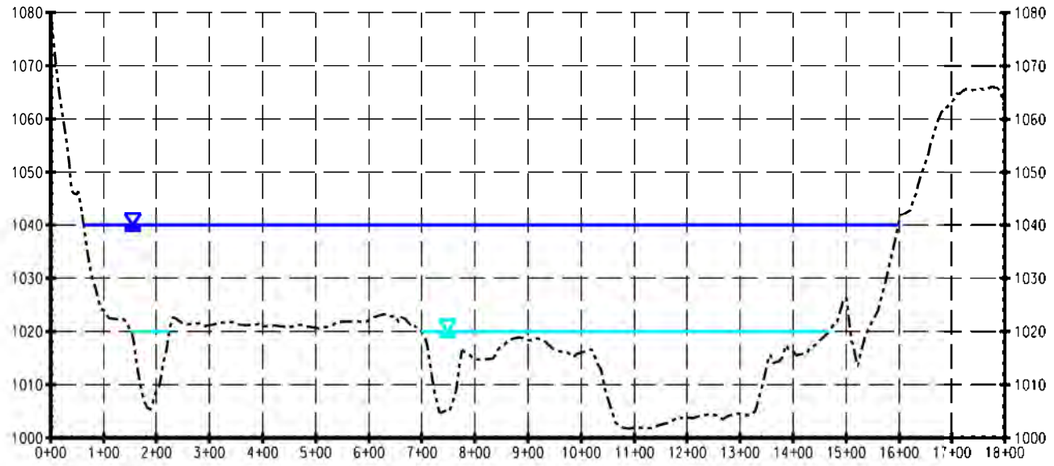
PREPARED BY CW	LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DATE 02/02/16	DEVILS GATE RESERVOIR SIDE TRIBUTARIES/HYDROLOGY 2-,5-,10-,25-,50-Yr and 85th Percentile Design Storms EXISTING CONDITION
SCALE 1" = 400'	

ATTACHMENT 14

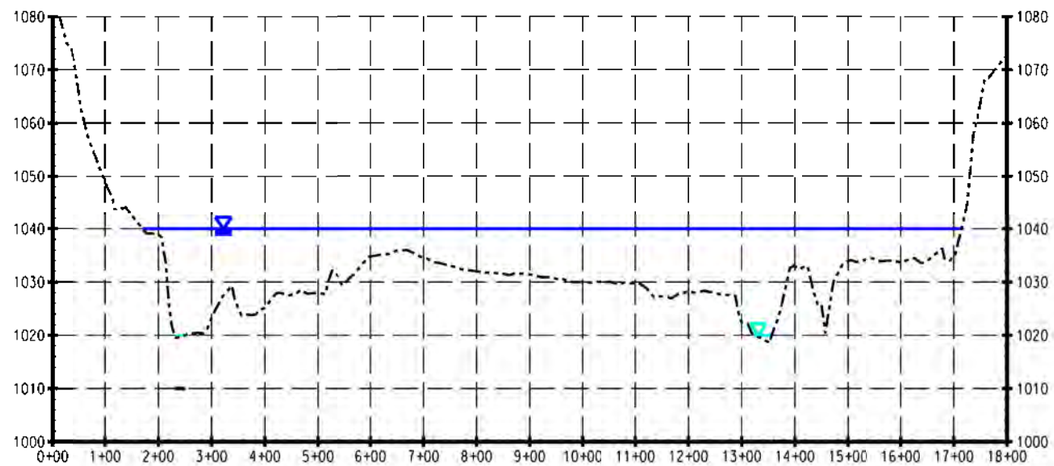
Devil's Gate Reservoir

June 2009





CROSS SECTION 1



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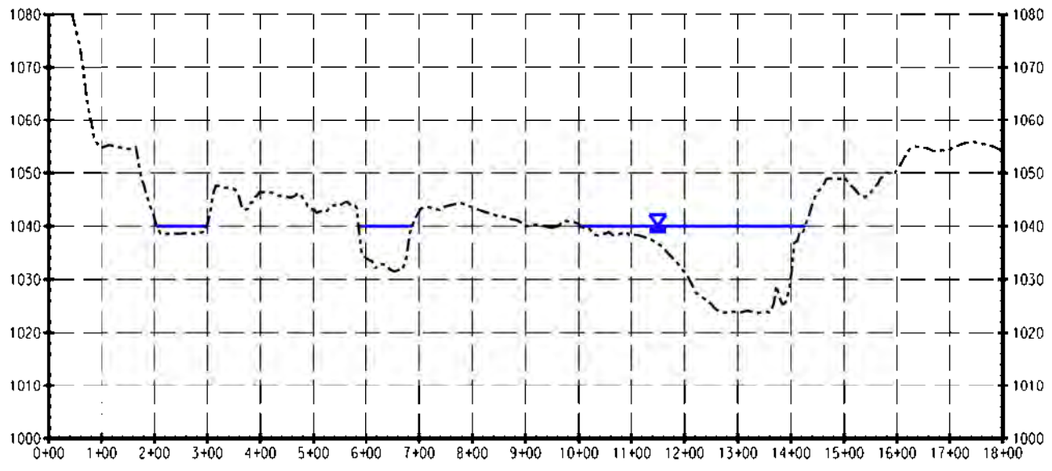

CROSS SECTION 3

1040-FT WATER SURFACE ELEVATION

1020-FT WATER SUFACE ELEVATION

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE
DAM & RESERVOIR

JANUARY 19, 2009

Devil's Gate Mitigation Areas

Map Features

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Annual Maintenance Footprint [1]

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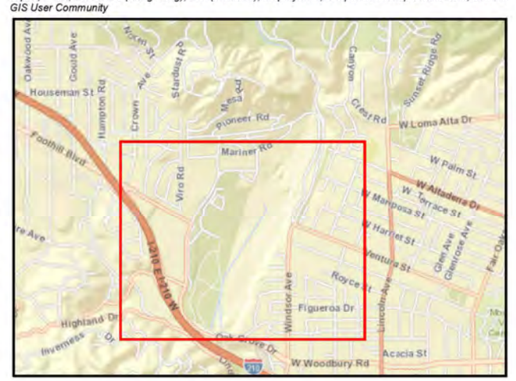


ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

Location: N:\2014\2014-003.008 Devils Gate Mitigation Plan\MAPS\Mitigation_Plan\HMMP\Devils_Gate_v1\DG_Mitigation_Areas_20151028.mxd (JDS)-JSwager 10/28/2015

2014-003.008 Devils Gate Mitigation Plan

Scale in Feet: 0 300 600

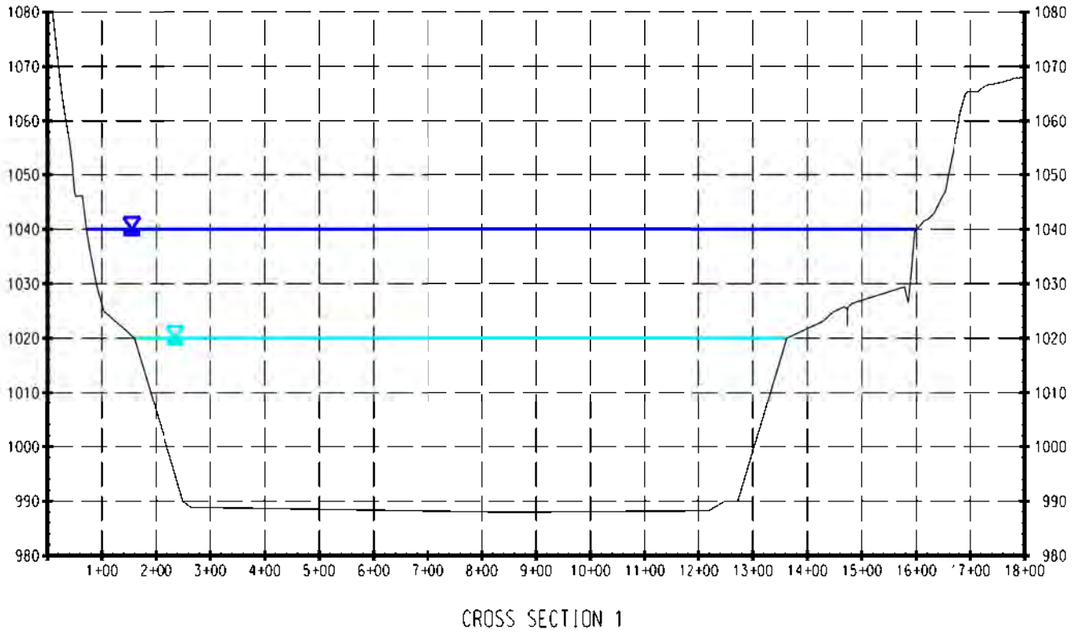
1040-FT WATER SURFACE ELEVATION

1020-FT WATER SURFACE ELEVATION

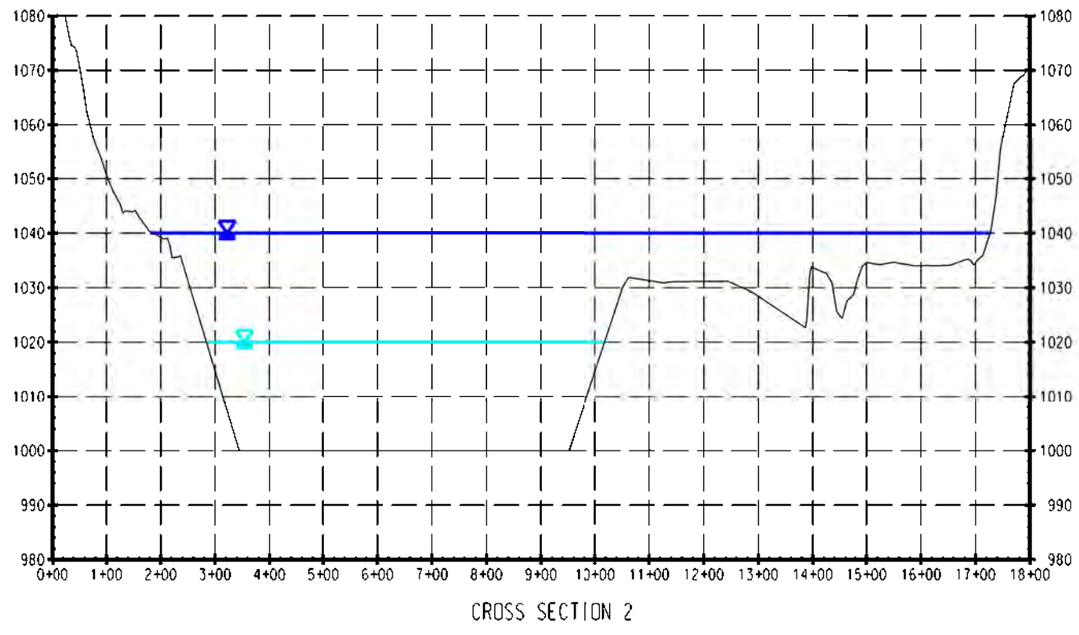
Photo Source: NAIP 2014
[1] LADPW
[2] ECORP and Chambers

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
DEVIL'S GATE DAM & RESERVOIR
APPROVED PROJECT

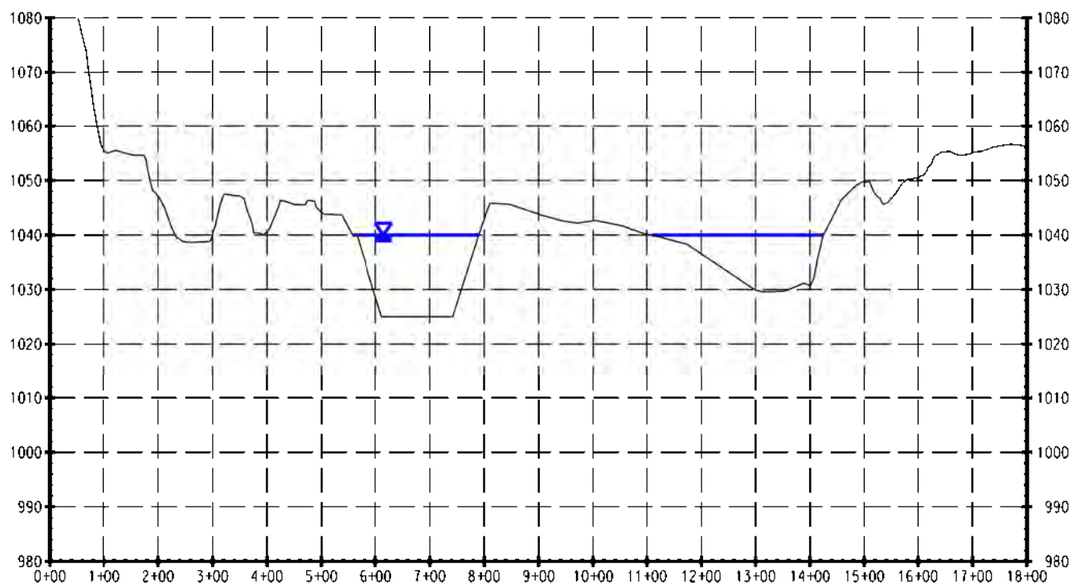
Map Date: 10/28/2015



CROSS SECTION 1



CROSS SECTION 2



CROSS SECTION 3

1040-FT WATER SURFACE ELEVATION

1020-FT WATER SUFACE ELEVATION

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS

DEVIL'S GATE
DAM & RESERVOIR

APPROVED PROJECT

APPENDIX E

COMPENSATORY MITIGATION
CHECKLISTS