2017 Lower American River Streambank Erosion Monitoring Report

April 2018

Prepared for:
American River Flood Control District
&
Sacramento Area Flood Control Agency

Prepared by
MBK ENGINEERS
455 University Avenue, Suite 100
Sacramento, CA 95825
916/456-4400
916/456-0253 (fax)

MBK ENGINEERS

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Prepared under the direction of:

Nathan J. Hershey, P.E.

Brian E. Janowiak, P.E.

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Background

The Lower American River (LAR) is a 30-mile long watercourse that conveys regulated stormwater and snowmelt runoff within the American River Basin via Folsom Dam to its confluence with the Sacramento River. The American River Parkway is located along the LAR and provides recreational opportunities such as biking, rafting, and multi-use trails, in balance with providing valuable habitat for a wide variety of wildlife and vegetation. During a high-water event, the first line of defense in providing flood protection for the residents of Sacramento is by regulating water releases from Folsom Dam that will control the resulting increase in water surface elevations and flow velocities within the channel of the LAR. Additional flood control measures to protect the residents of Sacramento are provided by the levees that flank the LAR. Levees exists on both the north (right) and south (left) banks of the American River from its confluence with the Sacramento River upstream to across from Riverbend Park on the right bank and Larchmont on the left bank.

In the leveed sections of river, channel migration and erosion can create problems to flood control officials and Parkway managers. Due to the river's erosive forces, the structural integrity of levees and loss of parkway space can be threatened. Although a waterside bench is present along the majority of the levees to provide additional stability and increase the active riparian zone footprint within the Parkway, bank erosion has the potential to migrate into the structural section of a levee and become a major hazard to the levee system during a high flow, if not monitored and controlled properly. As the erosion encroaches in the structural section, the undermining effects could cause structural instability which may result in levee failure. In addition, loss of levee section could accelerate seepage through the levee to the point where levee failure may occur due to soil piping.

After the 1986 flood, several sites along the levees had experienced varying degrees of erosion. A bank protection program, developed by the Sacramento Area Flood Control Agency's (SAFCA) Lower American River Task Force, was implemented to provide embankment protection along these erosion sites between 1986 and 2004. In 2004, Ayers Associates submitted the report titled "Lower American River, Erosion Susceptibility Analysis for Infrequent Flood Events" in response to the damages sustained along the levees during the 1986 event and to support the certification efforts for FEMA accreditation. In July 2004, MBK Engineers had participated in the original waterside field investigation for the entire river reach with Ayers Associates to review additional locations along the levee where the hydraulic modeling had predicted high velocities and shear stresses. The field investigation and predictive modeling efforts in computing water flow velocities had resulted in the identification of twelve (12) sites as possible locations where potential erosion would cause significant damage to the levee.

Since 2005, the erosion evaluation for the LAR levees has been conducted on an annual basis by MBK, along with staff members from SAFCA and the local maintaining agency, the American River Flood Control District (ARFCD). Due to embankment protection measures implemented after the 1986 flood and the time elapsed without a major high water event, many of the original twelve sites during the initial study in 2004 have been re-evaluated over time and are no longer considered to be active erosion sites. SAFCA continues to lead the development of bank

protection on the American River through the LAR Task Force and its Bank Protection Working Group. This group consists of approximately 15 stakeholder organizations representing flood control agencies, natural resource management agencies, environmental groups, and other local agencies and partnerships. A primary goal of the BPWG is to support federal, state, and local efforts to provide the highest level of flood protection for the surrounding community and the conservation of irreplaceable natural resources along the American River Parkway. This report serves as an annual record of the changing condition of the LAR and over the past several years, new erosion sites have been detected and subsequently repaired based on their potential impact to levee integrity while other non-severe sites are monitored regularly.

Purpose

In order to observe changes indicative of active erosion and a possible problem while the problem is in its infancy rather than when the structural section of the levee is affected, a prudent levee maintenance program that includes annual monitoring of existing bank erosion should be implemented. As problems are identified, solutions can be developed in a collaborative fashion to allow the input of interested parties in levee protection. One of the tools used to evaluate erosion potential include the assessment estimated flow velocities from the most recent hydraulic model in relation to the soil material type along the bankline.

The scope of this effort is to conduct an annual inspection of the Lower American River (LAR) Federal Project levees where existing erosion had been identified in previous years and detect locations where newly formed erosion sites may have developed. One of the objectives of this erosion monitoring report is to supplement American River Flood Control District's (ARFCD) operation and maintenance plan to address erosion to ensure that the levees meet 44 CFR 65.10, paragraph (d) requirements for maintenance of certified levees. This section states:

> "*Maintenance plans and criteria.* For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedures that ensure that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance."

The scope does not include the LAR right bank levee downstream of the Natomas East Main Drainage Canal, as this levee is maintained by RD 1000. ARFCD inspects the actual levees for stability, seepage, encroachments, and erosion. The scope of this effort includes inspection of the top of the berm and levee face if the previous flood season had flood stages above the berm. The geographic limits of the inspection are from LAR River Mile (RM) 12.0 to the confluence of

the LAR and the Sacramento River as well as the Sacramento River left bank from RM 60.5 to 60.0. The Federal Project levee extends upstream of LAR RM 12.0 on the right bank to approximately RM 14.0, but is located away from the low flow channel and is not threatened by streambank erosion. In addition, the levee along the right bank between RM 2.0 and RM 5.3 is a significant distance from the low flow channel (approximately 1800 lineal feet). Erosion in the low flow channel poses no threat to the levee in this reach. However, this reach of levee was included in the inspection due to the high-water events experienced during the 2016-2017 water year (October 2016 – September 2017).

The findings contained in this report are the result of visual inspection of the levees and review of two-dimensional hydraulic modeling results. This report is the eleventh annual inspection report. The 2016 report serves as the baseline for this evaluation. Figure 1 shows the extent of the inspection and those areas not inspected.

Flow History for the 2016-2017 Flood Season

Figure 2 shows the mean daily flows for the American River from October 14, 2016 through October 31, 2017. This year's inspection occurred on October 17, 2017. The maximum peak flow since the previous inspection date (October 13, 2016) was 82,400 cfs, occurring February 10, 2017. The peak flow of 82,400 cfs is significantly greater than the previous inspection year's peak flow of 20,200 cfs, occurring March 13-15, 2016.

Process

Site Visit

The LAR Inspection Team conducted a site inspection by boat on October 17, 2017. The inspection team consisted of Tim Kerr (ARFCD), Ross Kawamura (ARFCD), Bill Pavao (ARFCD), Dan Tibbitts (SAFCA), KC Sorgen (SAFCA), Ray Costa (Consultant), Steve Chainey (GEI), Chuck Watson (WRC Environmental), Tom Smith (RiverSmith Engineering), Brian Wardman (Northwest Hydraulic Consultants) Mike Kynett (MBK), Brian Janowiak (MBK), Matt Bachman (MBK), and Andrew Reece (MBK). The monitoring process included both visual observations of the water side banks along the American River downstream of RM 12 and the Sacramento River left bank from RM 60.5L to 60.0L, as well as a review of two-dimensional hydraulic modeling results. During the inspection, the team stopped at the accessible sites to take a closer look at the existing conditions. The flow in the river on the date of inspection was approximately 2,090 cfs.

The results of the field review are summarized in Table 3. Photo documentation of the site visit is attached as Appendix A. The purpose of the field visit was to locate areas where erosion is visible due to loss of vegetation, apparent unstable bank lines, bare unconsolidated soil, and/or human activity. The boat survey began at approximately RM 12.0 (Gristmill Park) and proceeded downstream to the confluence with the Sacramento River. Due to the relatively low flows in the river, the inspection was performed by drift boats as well as a 10-foot aluminum jon

boat. The jon boat, deployed by MBK, and one of the drift boats were both equipped with a small outboard motor and were used to inspect sites that required upstream navigation. These sites included RM 10.8R on the American River, as well as RM 60.3L and RM 60.1L on the Sacramento River. No new erosion sites were identified during the inspection. The locations of the sites inspected are shown on Figure 1.

Due to the high-water events experienced during the 2016-2017 water year, Mike Kynett (MBK) also inspected the right bank of the American River from RM 2.0 to 5.3 via car and on foot on March 15, 2018. No erosion sites were identified during the right bank inspection.

Review of 2-D Hydraulic Modeling

The second task in the process was to review two-dimensional hydraulic analyses at flows of 115,000 cfs and 145,000 cfs. One hundred fifteen thousand (115,000) cfs is the objective release from Folsom Dam and 145,000 cfs is the FEMA "Base Flood" flow (1/100 Annual Exceedence Probability flood event). The "Lower American River, Erosion Susceptibility Analysis for Infrequent Flood Events" (Ayres, July 9, 2004) was reviewed to identify additional reaches that may be of concern that were not obvious during the site visit. The 115,000 cfs and 145,000 cfs velocity contour plates are included as Appendix B. Velocities at the sites observed during the site visit are shown in Table 3.

Velocity information from the 2-D model has been evaluated for the following reaches that were defined by floodway width to evaluate the potential for systemic erosion problems. The following table provides a summary of the modeled velocities for each reach.

Table 1 – Lower American River Modeled Velocity Summary

Reach	**Flow = 115,000 cfs**			**Flow = 145,000 cfs**		
	Velocity (Main Channel)	Velocity (Streambank)	Velocity (Levee)	Velocity (Main Channel)	Velocity (Streambank)	Velocity (Levee)
LAR RM 0 to 6	5-8 fps	1-5 fps	1-4 fps	7.5-9 fps	4-7.5 fps	1-5 fps
LAR RM 6 to 11	6-10 fps	4-6 fps	1-6 fps	7.5-12 fps	5-7.5 fps	1-7 fps
LAR RM 11 to 14	5-7.5 fps	3-5 fps	1-5 fps	5-8 fps	3-5 fps	1-6 fps

LAR RM 0 to RM 6

The reach downstream of LAR RM 6 is generally characterized by a wide berm on the right bank and a narrow or no berm on the left bank. As discussed above, erosion in the active river channel is not a threat to the right bank levee between RM 2.0 and RM 5.3. For a flow of 115,000 cfs, velocities are generally 5-8 fps in the main channel, 1-5 fps at the streambanks, and 1-4 fps at the levee. Velocities on the left bank for a flow of 115,000 cfs tend to be greater than bare soil or vegetation can handle without experiencing erosion. The following table summarizes suggested maximum permissible mean channel velocities.

Table 2 – Suggested Maximum Channel Water Velocities[1]

Channel Material	Mean Channel Velocity (fps)
Fine Sand	2
Course Sand	4
Sandy Silt	2
Silt Clay	3.5
Clay	6
Soils with good vegetative cover	6-7
Poor rock (usually sedimentary)	10
Good rock (usually igneous or hard metamorphic)	20

Velocities above these ranges for the identified material would be expected to result in erosion. For a flow of 145,000 cfs, velocities are 7.5-9 fps in the main channel, 4-7.5 fps at the streambanks, and 1-5 fps at the levee. Most of the left bank in this reach has been revetted, portions of which are non-engineered and may sustain damage during high flow events.

LAR RM 6 to RM 11

This reach has a narrow floodway when compared to the up and downstream reaches. For a flow of 115,000 cfs, velocities are 6-10 fps in the main channel, 4-6 fps at the streambanks, and 1-6 fps at the levee. For a flow of 145,000 cfs, velocities are 7.5-12 fps in the main channel, 5-7.5 fps at the streambanks, and 1-7 fps at the levee. The rate of streambank erosion could be slowed by maintaining a dense cover of vegetation along the streambank. However, erosion will be an ongoing problem in this reach due to the high velocities and will eventually require structural measures. If vegetation is added to this reach, hydraulic modeling should be conducted to analyze the potential impact on water surface elevations.

LAR RM 11 to RM 14

This reach has a wide floodplain and the levees are relatively small and located away from the main channel. For a flow of 115,000 cfs, velocities are 5-7.5 fps in the main channel, 3-5 fps at the streambanks, and 1-5 fps at the levee. For a flow of 145,000 cfs, velocities are 5-8 fps in the main channel, 3-5 fps at the streambanks, and 1-6 fps at the levee. The 2-D model upstream boundary is approximately RM 14.

Sacramento River RM 60.0 to RM 60.5

This reach has a wide river channel with a floodplain on the right bank. The left bank levee is maintained by ARFCD and transitions to the streambank with little to no berm. Velocities along the left bank levee are generally less than 3 fps (with the Sacramento Weir open). The 2-D

[1] Modified from U.S. Army Corps of Engineers EM 1110-2-1601, page 2-16.

model downstream boundary is RM 59.4.

Conclusions

The site inspection observed nine sites (Table 3) that are actively eroding or show signs of past erosion within the jurisdiction of the ARFCD. Three of these nine sites, RM 10.5L (downstream portion of site), RM 9.8L (upstream portion of the site), and RM 2.7L have been either partially or fully repaired. One of these sites, Sacramento River RM 60.1L, has been fully repaired by the District. Discussion of site specific details involving the repairs for the individual sites is summarized below. Based on visual observations during the inspection, it appears that erosion has not advanced into the 3:1 waterside levee cross section. All sites will be continually monitored by ARFCD. Other parkway interests can use this information to decide if there are partnering opportunities to address erosion at an early stage to prevent the risk of erosion progressing into the standard levee section and preserving limited parkway lands. Additional potential erosion sites were not identified as a result of the review of the 2-D hydraulic model results at a flow of 115,000 cfs or 145,000 cfs.

The following is a summary of the sites and a description of potential actions that could be taken:

LAR RM 10.9 Left – Erosion at this site does not threaten the integrity of the levee due to the width of the berm. Planting woody vegetation on the bank would reduce the rate of erosion. However, recreational use at the site may dictate a more structural fix. Minor erosion was noted in 2010 in a confined area along the channel bank, likely due to animal activity and surface drainage. This erosion does not appear to have progressed significantly. Cross section surveys are an option that would enable the district to monitor the progression of the erosion at this site.

LAR RM 10.8 Right – Erosion at this site does not threaten the integrity of the levee due to the width of the berm. Planting woody vegetation on the bank would reduce the rate of erosion. However, recreational use at the site may dictate a more structural fix. Observed site characteristics are comparable to the 2016 inspection.

LAR RM 10.5 Left – Erosion at this site does not appear to threaten the integrity of the levee due to the width of the berm. However, the soils at the site appear to be non-cohesive soils that would likely erode rapidly during a high water event, especially if the vegetative cover continues to degrade due to high recreational use. Planting woody vegetation on the bank would reduce the rate of erosion. Recreational use at the site may dictate a more structural fix. Erosion at the upstream portion of the site does not appear to have progressed significantly since the 2016 inspection. A 20 foot section along the downstream end of the site continues to show signs of minor erosion. Since the 2016 inspection, fewer rodent burrows were observed along the steep middle and upper bank. If erosion continues to progress at the site, a more structural fix will be required. Repair of the site will need to accommodate intense recreational use.

The downstream portion of the site has been repaired by the US Army Corps of Engineers as part of the Sacramento River Bank Protection Program. Repairs included placing riprap along the bank as well as planting vegetation.

LAR RM 9.8 Left – This site has been repaired by the US Army Corps of Engineers as part of the Sacramento River Bank Protection Program. Construction activities included repairing the eroded sections of the site by placing riprap along the bank as well as planting vegetation.

The west end of this site (downstream, formerly known as Site 10.0L) was previously repaired and woody vegetation was planted on the waterside edge of the berm. This planting appears to have reduced the rate of erosion as it has not progressed significantly since 2016. Observations indicate the cobble and the finer particles on the surface of the berm continue to erode, exposing some of the underlying riprap. At the downstream end of the site, some of the larger rocks delineating the pedestrian access ramp have been displaced and settled on the lower bank. This appears to be the result from primarily pedestrian and recreational activity. However, this condition is largely aesthetic and the structural component appears to be intact. The repair appears to be holding up relatively well, however it is highly correlated to the amount of pedestrian use at the site. The District has historically performed minor maintenance in the area to stabilize the pedestrian path.

LAR RM 8.8 Right – This site was previously studied by the Sacramento River Bank Protection Project as the "Site 5 extension" (Lower American River – Site 5 Extension, US Army Corps of Engineers, prepared by HDR, March 2002). Consideration should be given to repairing the scalloping at this site to reduce the rate of erosion. Consideration should also be given to taking action over the entire reach to preserve the berm, equestrian trail, and existing mature vegetation. No visible progression of erosion or undercutting on vertical banks was observed during the inspection, and it should be noted that the vegetative cover appears to be similar to the 2016 inspection. Due to the high level of recreational activity at this site, a cross section survey of the entire reach was performed by MBK in March 2013. Subsequent surveys could be performed as needed to monitor the rate of erosion and degradation of the bank.

LAR RM 7.5 Right – Erosion at this site does not threaten the integrity of the levee due to the width of the berm. Planting woody vegetation on the bank may reduce the rate of erosion and should be considered. The width of the berm is substantial (greater than 100 feet) at this site. However, the apparent erodability of the exposed soils could lead to significant erosion during a high flow event, although it is not anticipated to erode the entire berm in one flood event. Armoring the bank with biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings) should be considered to preserve the berm and bike trail. Erosion at this site does not appear to have progressed since the 2016 inspection. Vegetative cover also appears to be similar to 2016.

LAR RM 2.7 Left – This site has been partially repaired by the Army Corps of Engineers under the Sacramento River Bank Protection Program. As previously noted, it was observed that the repair efforts do not appear to encompass the entire area experiencing erosion, specifically the upstream portion of the site. Erosion at the upstream end of the site threatens the integrity of the floodwall because the streambank is steeper than 3:1. This floodwall has been previously studied by MBK (Alternatives Analysis for Replacement of the Existing Floodwall at Lower American River, River Mile 2.7, March 2007). This report concluded that a failure of the wall at or below flows of 160,000 cfs would lead to localized flooding, as shown in Figure 3, because flooding would be contained by high ground that surrounds the wall. However, so long as this

floodwall is an element of the Sacramento River Flood Control Project, the integrity of the floodwall should be maintained. This site does not appear to represent an immediate threat to public safety because of high ground located behind the levee and floodwall; however, a more detailed site analysis could be performed to determine if corrective action is required.

Sacramento River RM 60.3 Left – Recreational use is frequent at this site, contributing to the degradation of the embankment. Vegetative cover observed along the lower bank in 2016 is no longer present. Most of the trees along the levee slope have exposed roots. In 2013, one of the larger trees caught fire and fell over. The tree is no longer on the bank, but the void created by the uprooted portion of the tree is on the upper bank and the area should still be monitored to identify additional erosion or degradation, especially during and after rainfall. Overall, fill with vegetation on the upper bank is a possible solution to stabilize the bank. This site does not appear to represent an immediate threat to the levee based on the low velocities that characterize the reach; however, a more detailed site analysis could reveal that corrective action is required. The District has historically performed minor maintenance in the area to address erosion at the top of the slope. This site should continue to be monitored and maintained.

Sacramento River RM 60.1 Left – This site was repaired in October 2011. The site repair included a riprap bench established at the waterline to protect the bank from wind generated waves and boat wakes. Fill material was placed above the riprap to repair the eroded embankment. The site was hydroseeded in an effort to minimize future erosion. The willow trees that were planted in 2013 along the rebuilt slope remain intact. The original riprap and embankment repair appears to be holding up well and no further repairs are necessary at this time.

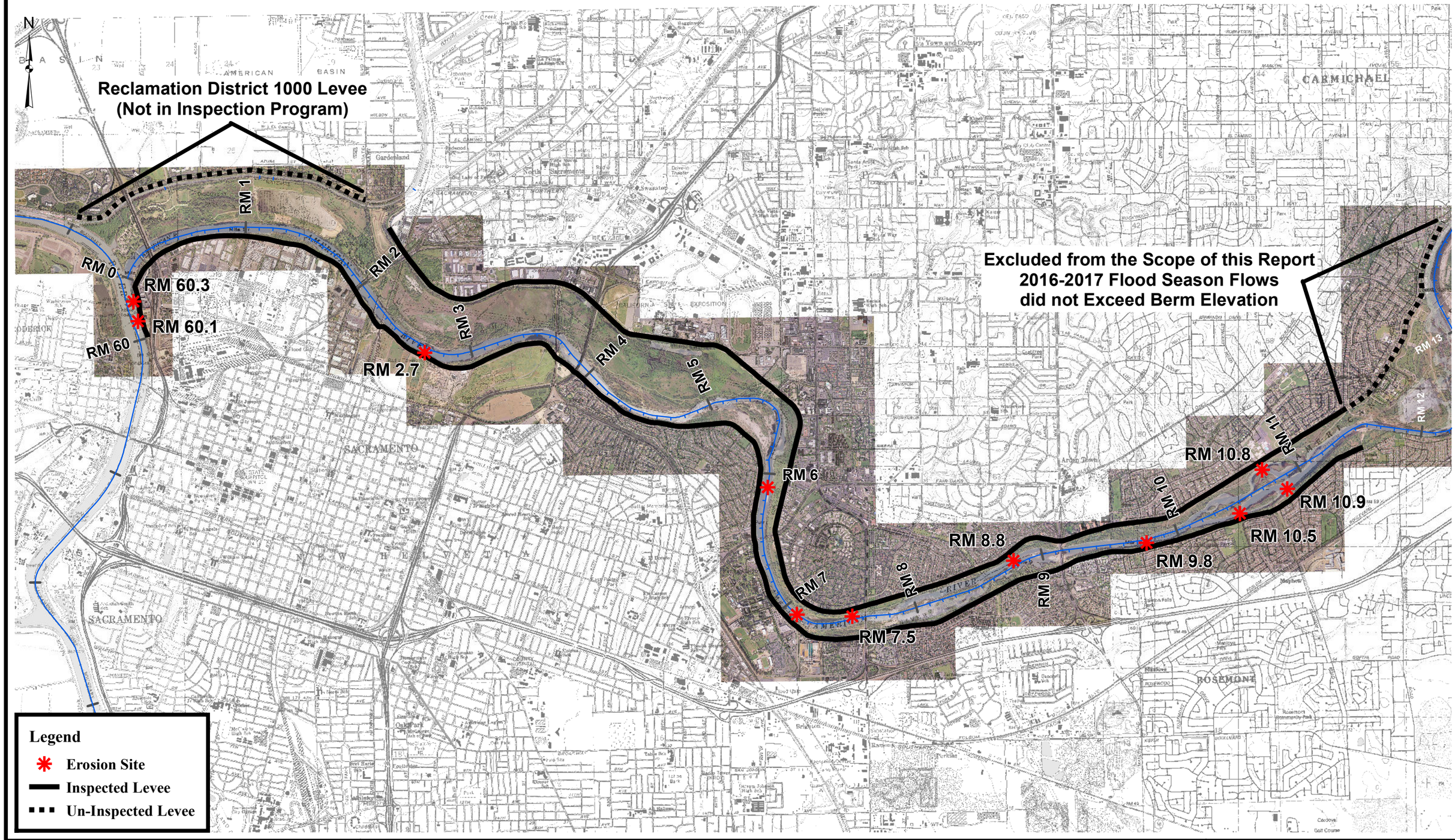
In summary, based on the annual field investigations and regular visual observations by the ARFCD staff, the primary reason for their current state of erosion can be attributed to high pedestrian traffic and steep and poorly vegetated bank slopes in areas of non-cohesive soils. We observed higher than average flows since the last inspection (5 days total above 60,000 cfs and 22 days total above 30,000 cfs), but these flows did not appear to contribute to further erosion at pre-identified sites or reveal new and detectable erosion sites. Boat traffic along the American River is limited due to shallow water depths and enforced speed limits (5 miles per hour) which minimize boat wake effects as being a possible contributor to the erosion activity. Transient camps continue to be observed at various locations along the American River. These camps are generally flat areas that are cut into the bank, which can compromise bank stability. Future erosion monitoring surveys should include the monitoring of transient camps and any other semi-permanent encroachments that could pose a risk to the stability of the river bank.

Recommendations

It is recommended that the District continue to monitor the sites identified in Table 3. As site specific changes in conditions are observed, they should be documented and reported for further investigation. Inspections should continue to be performed after high water events and on an as-needed basis.

Table 3
Lower American River Erosion Monitoring
Erosion Sites Identified as a Concern
March 2018

Site	Length	Year Identified	Conditions	Modeled Velocity	Modeled Velocity	Recreational Setting	Potential Action
River Mile				115,000 CFS	145,000 CFS		
10.9L	150 feet	2005	Poorly vegetated bank with 280 feet from channel to levee. Some minor erosion was first noted in 2010 in a confined area along the channel bank, likely a combination of animal activity and surface drainage. This erosion does not appear to have progressed significantly over the past several years. Site characteristics appear to be comparable to 2016 inspection.	1-3 fps	3-4 fps	Self-maintained walking trails at top of bank.	Establish woody vegetation thicket on bank or other biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings), especially along waterside toe.
10.8R	120 feet	2005	Site characteristics are comparable to 2016 based on field inspection. Poorly vegetated, undercut bank with 175-foot berm to levee. Signs of recreational use are apparent at the site.	1-3 fps	1-3 fps	50 feet to Equestrian Trail and 85 feet to Bike Trail.	Establish woody vegetation thicket on bank or other biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings), especially along waterside toe.
10.5L	150 feet	2006	Poorly vegetated bank with non-cohesive soils and heavy recreational use. Upstream portion of site has not degraded significantly since 2016 inspection. Small section (20 feet) along downstream end of site continues to show signs of minor erosion. Fewer rodent burrows were observed in the steep upper and middle bank as compared to 2016. Downstream reach has been repaired by the Army Corps of Engineers under the Sacramento River Bank Protection Program.	1-3 fps	2-4 fps	Adjacent to Equestrian Trail and foot path.	Repair of the site will need to integrate recreational use. Due to the challenges with repairs at RM 10.0 (see 2006 report), vegetation is not likely to be successful due to the intense recreational use. Cobbles with vegetation or other biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings) are a possible solution. The downstream reach has been repaired as part of the Sacramento River Bank Protection Project, also known as the Sac Bank Program.
9.8L	1150 feet	2005	Erosion has historically occurred due to high pedestrian access / recreational use, however it does not appear to have progressed significantly since 2016 aside from the displacement of some of the larger rocks that delineate the pedestrian access ramp. The upstream reach has been repaired by the Army Corps of Engineers under the Sacramento River Bank Protection Program.	4-6 fps	5-7 fps	65 feet to levee maintenance road	The upstream reach has been repaired as part of the Sacramento River Bank Protection Project, also known as the Sac Bank Program. The downstream reach was previously repaired and appears to be holding up relatively well.
8.8R	280 feet	2005	Undercut, vertical bank sloughing into river, 100 foot berm to levee. Vegetative cover is similar to 2016. Undercutting along vertical banks does not extend below water level.	3-5 fps	4-6 fps	Adjacent to Equestrian Trail ; 60 feet to Bike Trail.	Armor bank at and below low flow shoreline with rock and treat upper bank with biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings). Cross section survey was performed by MBK in March 2013 to monitor erosion and degradation of bank.
7.5R	820 feet	2005	No visible progression of erosion compared to 2016 field inspection. Undercut, vertical bank sloughing into river, 150 foot berm to levee. Vegetative cover is similar to 2016.	3-6 fps	5-6 fps	40 feet to Equestrian Trail; 80 feet to Bike Trail.	Restore slope and armor bank.
2.7L	700 feet	2006	Site has been partially repaired by the Army Corps of Engineers under the Sacramento River Bank Protection Program. Repair efforts do not appear to encompass all areas experiencing erosion, specifically the upstream end of the site.	1-3 fps	2-4 fps	Private property, limited public access.	Extend the repair efforts further upstream to include the erosion near the existing floodwall (approximately 350 feet).
Sac River 60.3L	330 feet	2006	Site is north of the old water intake facility. Streambank above waterline is over steepened with poorly vegetated bank and non-cohesive soils. Erosion historically has migrated toward the access road on the bench. The District has historically performed minor maintenance in the area to address erosion at the top of the slope. Most trees along levee slope have exposed roots. The large tree on the upper slope that caught fire and fell towards the river in 2013 is no longer on the bank, but the void from the root wad remains on the upper bank. Vegetative cover along the lower bank observed in 2016 is no longer present.	>3 fps	>3 fps	Bike trail at top of bank. High recreational use.	Fill with vegetation or biotechnical measures such as brush mattress, willow waddles or brush boxes (all supplemented with plantings). Site (including void created by uprooted portion of tree) should continue to be monitored and maintained, especially during and after rainfall.
Sac River 60.1L	100 feet	2006	Site is between the old water intake facility and the new intake facility. Site was repaired in October 2011. Repaired levee appears to be in good condition.	>3 fps	>3 fps	Bike trail at top of bank. High recreational use.	In October 2011, a riprap bench was established at the waterline to protect the bank from wind generated waves and boat wakes. Fill material was placed above the riprap to repair the eroded embankment. The site was hydroseeded in an effort to minimize future erosion. Willows were planted above the riprap in 2013. Repair efforts have been successful and levee appears to be in good condition.



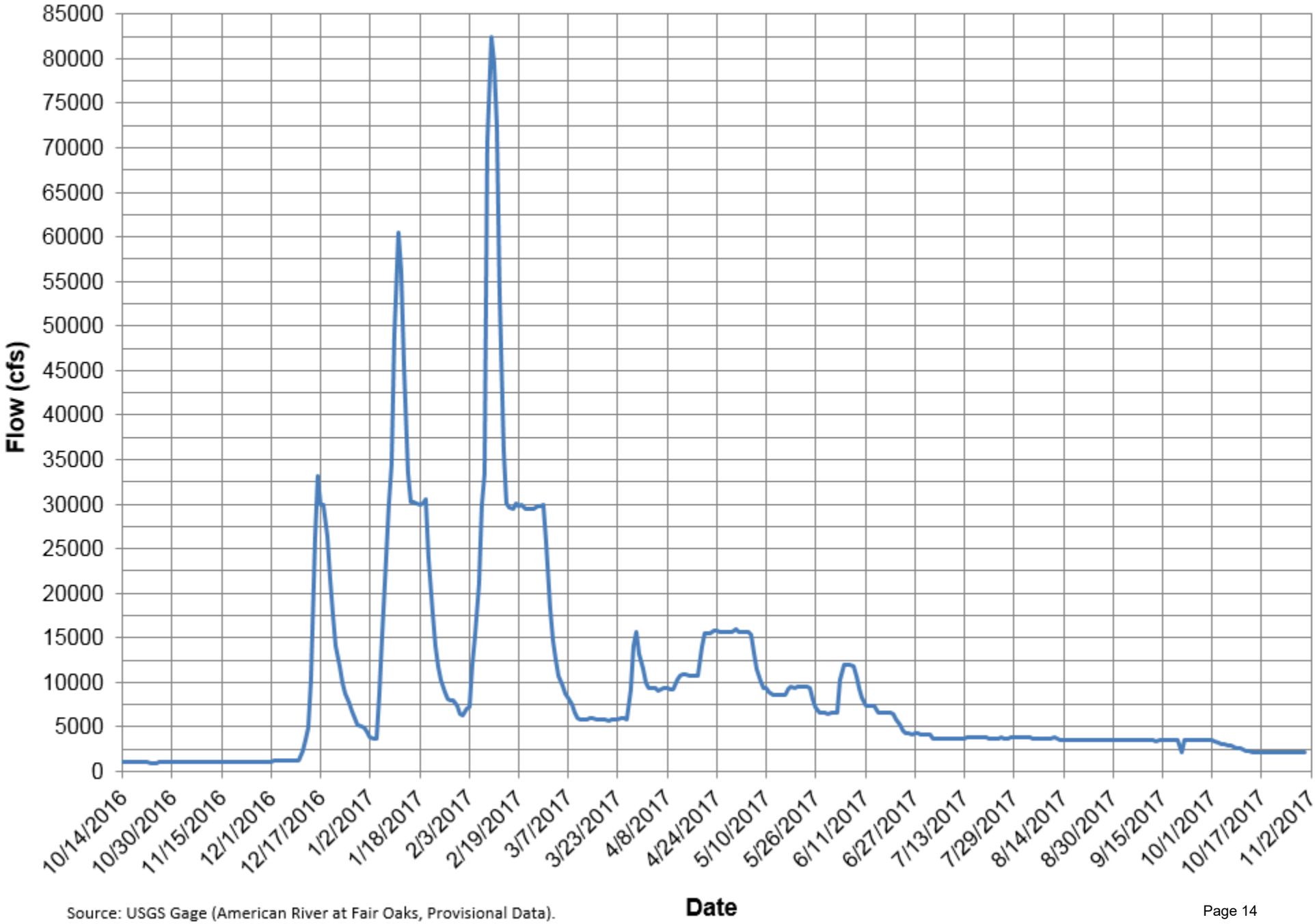
MBK ENGINEERS
455 University Avenue, Suite 100
Sacramento, California 95825-6579
(916) 456-4400

Lower American River 2017 Bank Erosion Survey

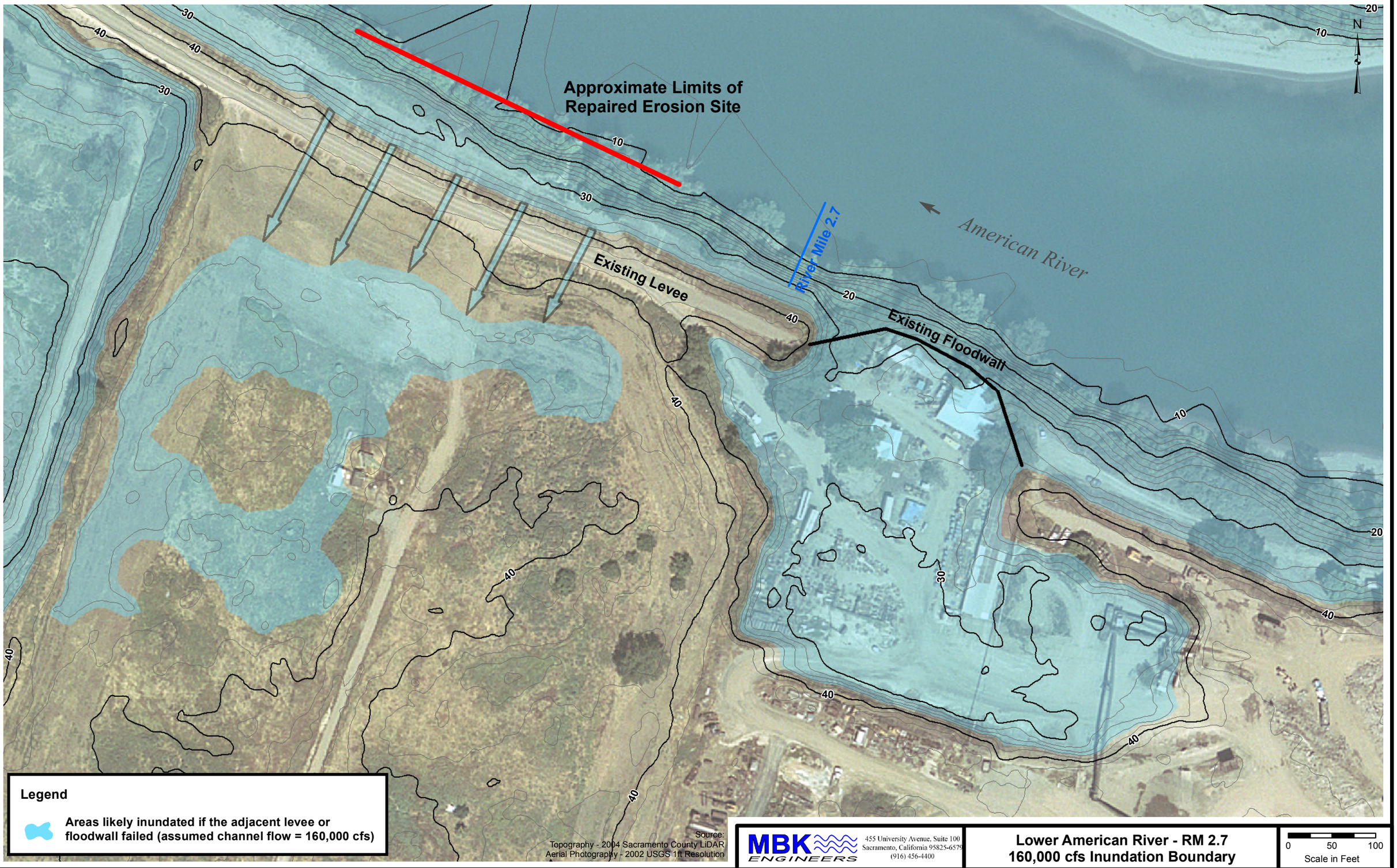
0 1,750 3,500 7,000
Scale in Feet

Figure 1

Figure 2 - Mean Daily Flows on the American River



Source: USGS Gage (American River at Fair Oaks, Provisional Data).



MBK ENGINEERS
455 University Avenue, Suite 100
Sacramento, California 95825-6579
(916) 456-4400

Lower American River - RM 2.7
160,000 cfs Inundation Boundary

0 50 100
Scale in Feet

Date Saved: 2/2/2015 11:33:14 AM
Path: R:\1479.00 ARFCD\2013-10 LAR Erosion Monitoring Report\ArcMap\Sutters Landing with 160 kcfs Inundation Boundary.mxd

Figure 3

Appendix A
Photos

Photograph 1 – LAR RM 10.9L (1)

Photograph 2 – LAR RM 10.9L (2)

Photograph 3 – LAR RM 10.9L (3)

Photograph 4 – LAR RM 10.9L (4)

Photograph 5 – LAR RM 10.8R

Photograph 6 – LAR RM 10.5L (1)

Photograph 7 – LAR RM 10.5L (2)

Photograph 8 – LAR RM 10.5L (3)

Photograph 9 – LAR RM 10.5L (4)

Photograph 10 – LAR RM 10.5L (5)

Photograph 11 – LAR RM 9.8L (1)

Photograph 12 – LAR RM 9.8L (2)

Photograph 13 – LAR RM 9.8L (3)

Photograph 14 – LAR RM 8.8R (1)

Photograph 15 – LAR RM 8.8R (2)

Photograph 16 - LAR RM 7.5R (1)

Photograph 17 - LAR RM 7.5R (2)

Photograph 18 - LAR RM 7.5R (3)

Photograph 19 - LAR RM 7.5R (4)

Photograph 20 - AR RM 3.7R (1)

Photograph 21 - AR RM 3.4R (1)

Photograph 22 – LAR RM 2.7L (1), upstream of repair site

Photograph 23 - LAR RM 2.7L (2), repair site

Photograph 24 - SR RM 60.3L (1)

Photograph 25 - SR RM 60.3L (2)

Photograph 26 - SR RM 60.3L (3)

Photograph 27 - SR RM 60.3L (4)

Photograph 28 - SR RM 60.1L (1)

Photograph 29 - SR RM 60.1L (2)

Photograph 30 - SR RM 60.1L (3)

Appendix B
Velocity Contours