APPENDIX HYD-2

UPPER WESTSIDE FLOOD INUNDATION PROPAGATION PROCEDURAL/TECHNICAL MEMORANDUM

Department of Water Resources
Matt Satow
Director

Divisions
Water Supply
Drainage
Administrative Services/Finance

County of Sacramento

Date: **07/01/2024**

To: **Emma Patten**
Todd Smith
County PER

Subject: Upper Westside Specific Plan (PLNP2018-00284) – County DWR Comments on the Flood Inundation Propagation Procedural Memorandum Dated 05/31/2024.

County DWR has no further comments on the subject procedural memorandum. Review by County DWR was limited to the overall content of the procedural memorandum and did not include technical review of the modeling used for the inundation analysis, emergency and evacuation procedures, or the criteria used to deem flooding as "not to be material from a public safety or flood damages perspective." A technical review of the flood inundation analysis was conducted by GEI and any comments from their review should be addressed.

Please feel free to call if you have any questions.

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Cc
Michael Durkee, P.E.
County DWR
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GEI

MACKAY & SOMPS
ENGINEERS PLANNERS SURVEYORS

UPPER WESTSIDE
FLOOD INUNDATION PROPAGATION
Procedural/Technical Memorandum

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MAY 31, 2024

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PROCEDURAL/TECHNICAL MEMORANDUM

To: Nick Avdis

From: Ken Giberson

Cc: Todd Taylor – Sacramento County Planning Dept.

Date: May 31, 2024

Job No.: 27035.000

Subject: Upper Westside – Flood Inundation Propagation

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1. INTRODUCTION

Sacramento County Planning and Environmental Review Department requested Upper Westside (Project) prepare a Procedural/Technical Memorandum (PM) and supporting maps that show the cumulative inundation propagation in the Natomas Basin (Basin) in the event of a Natomas Basin levee failure. **Exhibit 1** shows the location of Upper Westside within the Basin. Staff requested the Procedural/Technical Memorandum include the depth of potential flooding, timing of potential flooding and flow direction.

Specifically, on September 15, 2020, Staff requested the Applicant to provide, among other items, the following information to support Staff's analysis of the project:

> *"Technical memorandum and supporting maps that show the cumulative inundation propagation in the Natomas Basin in the event of Sacramento River failure or NEMDC levee failure. This should include the depth of potential flooding, timing of potential flooding, and flow direction. Cumulative development assumptions should include Sutter Point [sic], Grandpark, Metro Air Park, Sacramento International Airport, and City of Sacramento development."*

This PM is being submitted to Sacramento County Office of Planning and Environmental Review in response to this request.

The intent of these requests was to determine whether development of the Upper Westside Specific Plan would trigger a need to update the "2015 City/County of Sacramento Flood Evacuation Plan for the Natomas Study Area" (2015 City/County Evacuation Plan) or the County of Sacramento, Sacramento County Multi-jurisdictional

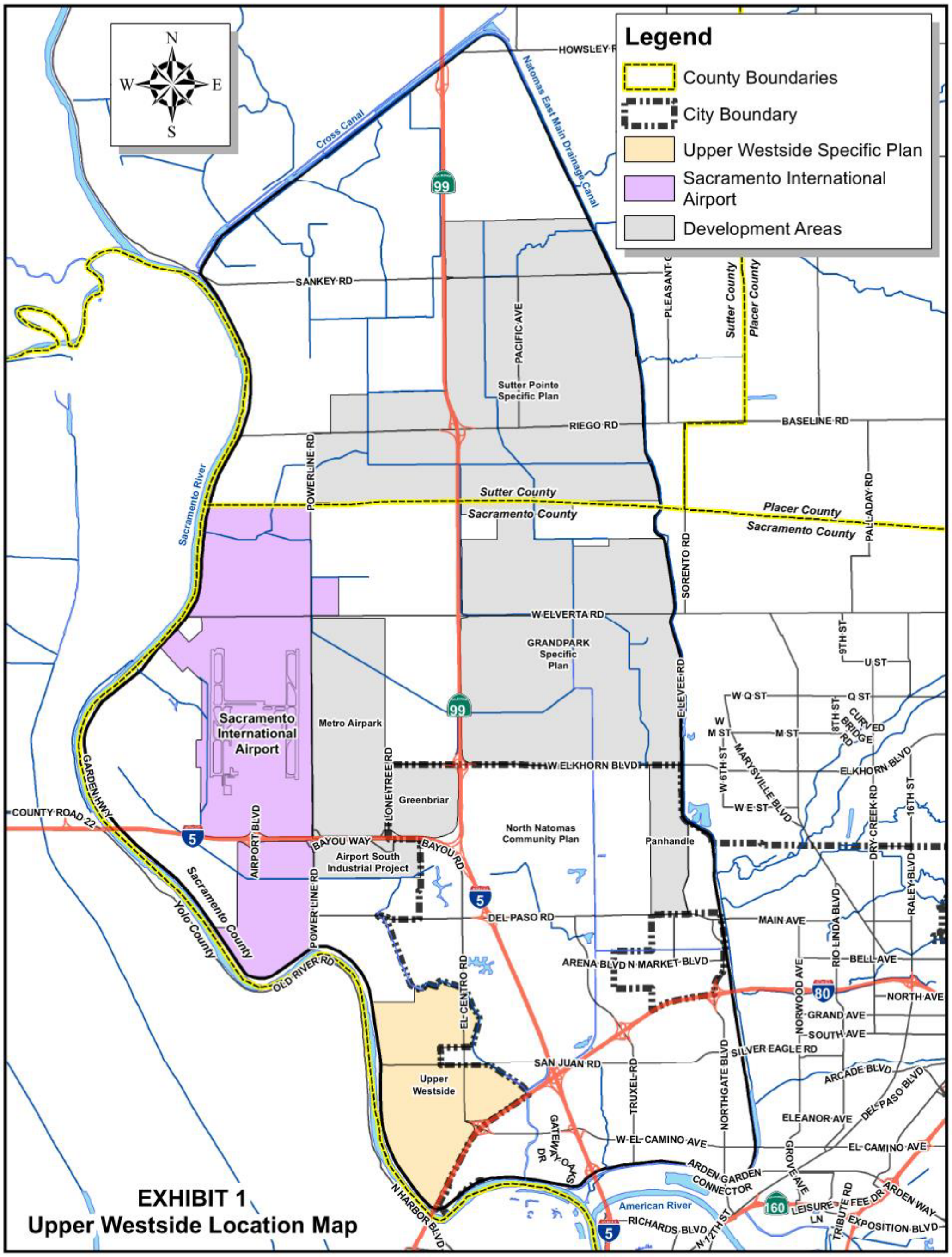

Exhibit 1
Upper Westside Location Within Natomas Basin

Local Hazard Mitigation Plan Updated in 2021 (2021 LHMP).[1] Any changes that may be needed in the 2015 City/County Evacuation Plan or the 2021 LHMP resulting from the development of Upper Westside will be identified in this PM.

Therefore, this PM was prepared in response to the Staff's request for technical information that would be needed to update the County's evacuation planning documents. These documents would need to be updated to reflect emergency response operational and/or tactical changes that may be needed over time as Upper Westside is developed.

Accordingly, this PM is a planning level study to assist County flood management emergency response professionals to plan for and evaluate the flooding affects within the Basin for Cumulative Plus Project Conditions (C+P). The cumulative conditions are more particularly described in Section 5 of this PM.

The analysis and modeling prepared to support this PM did not create the levee breach modeling that was used during the preparation of the 2015 City/County Evacuation Plan. Rather, the analysis and modeling prepared for this PM merely updated the 2015 modeling (e.g., updating the breach modeling using the current modeling software and correcting minor modeling errors) along with using the best available topographic mapping information. The 2015 modeling incorporated basic assumptions (e.g., levee breach formation assumptions) from an earlier prepared model of the Sacramento and American River systems that included predetermined river stage/flow assumptions.

Levees can fail in a number of ways. The most frequent and dangerous form of levee failure is a breach. A levee breach is when part of the levee actually breaks away, leaving a large opening for water to flood the land protected by the levee.

A levee breach can be a sudden or gradual failure that is caused either by overtopping from excessive flows and wave actions in the adjoining rivers and canals, or by a subsurface failure of the levee. Either mode of failure can quickly lead to incipient instability and rapid rupture of a levee.

Failure of a levee can result in catastrophic consequences within a relatively brief period of time after initiation of the breach – perhaps suddenly or within a small number of hours. In compliance with the requirements of the State of California's ULOP (Urban Level of

[1] The 2015 City/County Evacuation Plan includes a series of flood evacuation route maps which deal with potential levee breach scenarios. These maps are meant to assist emergency officials, first responders and the general public on how to evacuate from the Basin in the event of a flood emergency. Emergency officials, first responders and the general public should not assume that the evacuation routes shown on the maps will necessarily be the best way to evacuate from the community during a flood event. These evacuation routes could be affected by localized flooding, traffic accidents, and different flooding situations occurring at the same time. Emergency officials should monitor roadway conditions and advise the public through radio stations and other media if alternate routes should be taken. This caution applies equally to the various maps and exhibits presented in this PM.

Flood Protection) and ULDC (Urban Levee Design Criteria), SAFCA and the U.S. Army Corps of Engineers, though their joint Natomas Levee Improvement Project (NLIP), have designed and are continuing to strengthen the levee system surrounding the Basin to address the potential for levee failure from both overtopping and subsurface failure.

The design and construction of the levee system surrounding the Basin includes measures that are intended to prevent failure of the levee in the event of overtopping and subsurface failure. Notwithstanding the design and construction of this levee system to withstand these forces resulting in a levee breach, it is theoretically possible for a breach to occur.

Accordingly, this PM summarizes the results of rigorous technical analysis of the effects of flooding within the Basin should a levee breach actually occur in the levee system surrounding the Basin. Based on the above-mentioned analysis, with a few very minor exceptions, the analysis performed for this PM indicate that the development of Upper Westside will not have a material effect on either:

1. The time to inundation of 1-foot depth of flooding over critical roadway locations along the regional evacuation routes within the Basin during a catastrophic levee breach, or
2. The maximum depth of flooding within the Basin during a catastrophic flooding event.

The very minor exceptions noted in this Procedural Memorandum are neither individually nor cumulatively remarkable, and therefore not particularly notable. As they are de minimis in nature, they are deemed not material for the purposes of this PM.

Further, based on the analysis provided in this PM, the 2015 City/County Evacuation Plan will require only nominal changes resulting from development of Upper Westside, and the 2021 LHMP will not require any changes resulting from development of Upper Westside.

2. UPDATE OF 2015 GEI FLOOD MAPPING

This evaluation is based upon the 2015 GEI levee breach analyses of the Natomas Basin as a part of the 2015 City/County Evacuation Plan. The 2015 City/County Evacuation Plan identified seven (7) hypothetical locations around the Basin where levee failures might potentially occur. These locations are typified by significant differences in the water surface elevations in the adjoining river or stream during peak flood events and the elevation of the existing ground at the landside toe of the levee at that location. Under these conditions, the hydrostatic pressure on the levee is relatively high when compared with other locations around the levee system where the elevation of the ground at the landside toe of the levee is higher (e.g., along the levee on the east side of the Basin northerly of Del Paso Road).

It is these locations, where the hydrostatic pressures on the levees are relatively high, where levee failures are more likely to occur, and if they were to fail, they would likely result in the potential for catastrophic flooding of the Basin. These seven (7) locations were evaluated in the 2015 City/County Evacuation Plan for their potential to flood the Basin in the event of a levee breach.

The 2015 GEI levee breach analysis upon which the 2015 City/County Evacuation Plan was modeled utilized HEC-RAS Version 4.1.3 – which was then state-of-the-art flood plain modeling software. The 2015 modeling was updated for this PM in 2022 using the following newer state-of-the-art version of the HEC-RAS (Version 6.2) hydraulic modeling software utilizing Two-Dimensional (2D) terrain modeling techniques. This version of the updated modeling software allows for a more advanced and better analysis of the duration of time for the levee breach flood wave to propagate across terrain.[2]

While the previous levee breach analysis utilized modeling software that was state-of-the-art at the time, the newer version of the modeling software includes several enhanced modeling techniques that do a superior job of estimating overland flow rates and durations utilizing two-dimensional algorithms. This enhanced technology was not available in the earlier version of the software. Therefore, the engineering community widely uses the updated software because it produces more accurate and reliable results.

This updated analysis also improves and/or corrects several mapping and modeling deficiencies that existed in the previous modeling. As such, this analysis provides a current and more accurate estimate of the potential flooding conditions that could have occurred in 2015 and that could occur with implementation of the Upper Westside Specific Plan and the other reasonably foreseeable projects (i.e., under cumulative conditions) in comparison to earlier analyses.

3. NATOMAS BASIN FLOOD SETTING

The Basin is surrounded by 42± miles of flood control levees. This levee system protects the Basin from flooding from the Sacramento and American Rivers, the Natomas Cross Canal, and the North East Main Drainage Channel (NEMDC).

The Basin encompasses 55,000± acres of urban and agricultural land uses. The Basin is crossed by two (2) interstate freeways (I-80 and I-5), State Route 99, and several major arterials and throughfares. One of the Sacramento region’s most important transportation assets, the Sacramento International Airport, is located within the Basin.

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[2] This version of HEC-RAS utilizes the Shallow Water Equation to solve two-dimensional flow problems.

The exact location of future potential levee failures cannot be predicted with certainty. However, the location of potential failures could hypothetically include the Cross Canal Levee, the Sacramento River Levee, the American River Levee, and the NEMDC Levee.

In 2015, at the request of the City of Sacramento and the County of Sacramento, GEI Consultants, Inc., (GEI) performed levee breach (levee failure) analyses for seven (7) hypothetical locations along different reaches of the Natomas Basin Levee System that have the hydrostatic condition described above. These locations are shown on **Exhibit 2** as well as listed below:

1. **Breach 1**: Natomas Cross Canal at River Mile 1.35 (approximately 1.3± miles east of the confluence with the Sacramento River)
2. **Breach 2**: Sacramento River at River Mile 77.584 (approximately 0.8± miles north of the Riego Road/Garden Highway Intersection)
3. **Breach 3**: Sacramento River at River Mile 74.0 (approximately 0.8± miles south of the Elkhorn Blvd./Garden Highway Intersection)
4. **Breach 4**: Sacramento River at River Mile 66.924 (approximately 0.1± miles east of the Power Line Road/Garden Highway Intersection)
5. **Breach 5:** Sacramento River at River Mile 64.104 (approximately 0.5± miles north of the Sacramento Weir)
6. **Breach 6:** American River at I-5 Bridge (approximately 0.2± miles east of the confluence with the Sacramento River)
7. **Breach 7:** NEMDC at I-80 Bridge (approximately 0.2± miles south of the I-80 Bridge)

In the event of a levee failure, flood waters will enter the Basin and flow to the lowest points within the Basin. Over time, as these flood waters continue to fill the Basin, evacuations will likely occur to allow people in the most vulnerable locations to move to high ground and/or leave the Basin by one of many evacuation routes. With regard to evacuations, the most critical measure of safety is the duration of time for the flood waters to fill the lowest locations along the evacuation routes.[3]

In addition to a potential levee failure, the Basin is susceptible to flooding from the "Sankey Gap." The Sankey Gap is a low point in the Basin's east levee where Sankey Road crosses

[3] When considering the rapidity of flooding, the concept of "duration of time" is sometimes incorrectly referred to as "velocity". For example, when someone asks, "How fast does the flooding occur?", they are concerned about the duration of time until flooding occurs, and not necessarily the velocity at which the flood waters travel across the ground.

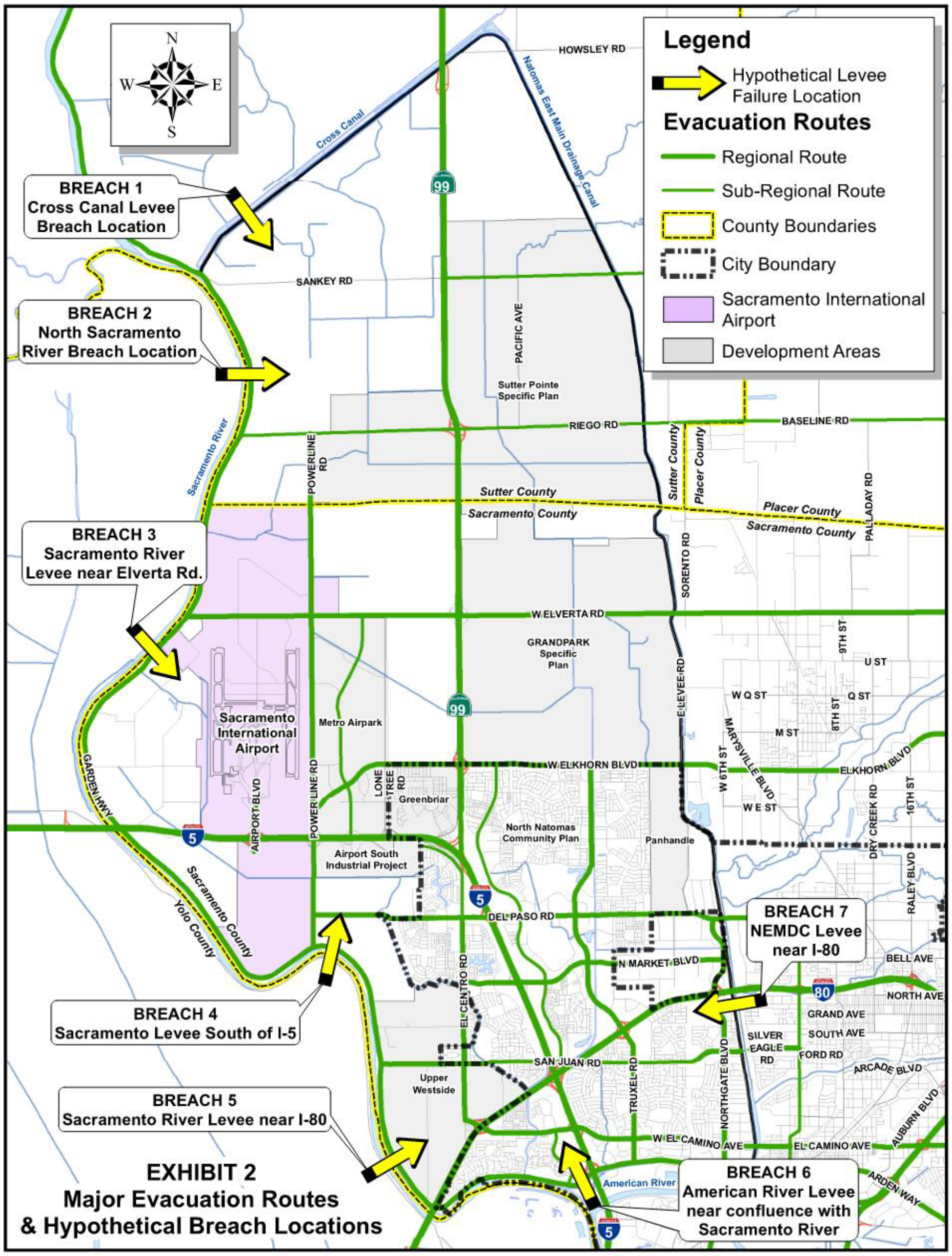

Exhibit 2
Major Evacuation Routes & Hypothetical Levee Breach Locations

the levee.[4] During periods of high flows in the Sacramento River, the runoff from eastern Sutter County and western Placer County back up in the Natomas Cross Canal and NEMDC (a.k.a., Steelhead Creek).

In the absence of future flood protection improvements along the Sacramento River upstream of the Natomas Cross Canal (e.g., widening of the Fremont Wier), the peak water surface elevations in the Sacramento River will create high stages in the Natomas Cross Canal and Steelhead Creek during peak flood events, and as a result, flood waters may spill through the Sankey Gap and enter the Basin.

The levee system protecting the Natomas Basin is being strengthened and improved by the Sacramento Area Flood Control Agency (SAFCA) to meet 200-year levels of flood protection.[5] SAFCA has a stated goal to improve the overall level of flood protection for the greater Sacramento metropolitan area, including the Basin, beyond the 200-year levels, with a longer-term goal of achieving 500-year level of flood protection for the region.

In summary, SAFCA has a stated goal to get the region to the highest level of flood protection possible. Of course, in order for SAFCA to meet the goal of 500-year level of flood protection, formal approval of additional flood protection improvements by the SAFCA Board of Directors will be required.

In improving the levee system, SAFCA and its partners are required to comply with local, State and Federal design standards and requirements that ensure the levee system can withstand a wide range of design events. Included in these design standards is a requirement that the levees do not experience a catastrophic failure when overtopped by flood events that exceed their nominal design capability. In essence, these design standards and requirements result in levee systems, that once certified, are unlikely to fail even if overtopped.[6]

In conjunction with this anti-catastrophic design standard, SAFCA has developed and implemented several levee operation and maintenance programs and associated long-term financing vehicles that are designed to prevent flooding of the Basin. These programs and financing vehicles provide for the long-term operation and maintenance of the levee system and the ability to meet these types of standards as they evolve over time.

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[4] This low point is a legacy feature left over from the earliest days of reclamation of the Basin. The "gap" protected upstream lands within eastern Sutter County and western Placer County from additional flooding than would have otherwise occurred after construction of the levee system around the Basin in the early decades of the twentieth century but for the creation of a "gap" in the levee.

[5] SAFCA has several local, State, and Federal partners that are working together to protect the Sacramento region from flooding.

[6] Overtopping of a levee, while a serious event in itself, results in significantly less flood water volumes entering the Basin when compared to a structural failure and washout of a levee as analyzed in this PM.

Nonetheless, it is theoretically possible that the levee system could experience a catastrophic failure. However, the design standards and requirements described above, along with (1) the continuing efforts of SAFCA to reach its long-term goal to get the region to the highest level of flood protection possible, and (2) the long-term operation and maintenance programs being used by SAFCA, effectively reduce the probability of a catastrophic levee failure for the Basin to an extremely low level.

4. EVACUATION ROUTES

The principle of evacuation is to move citizens from a place of relative danger to a place of relative safety via a route that does not pose significant danger. There are ten (10) major roadways within the Basin that can be considered regional evacuation routes in the event of a flood. There are several other sub-regional evacuation routes that are available to the driving public during a flooding event.

Several of these roadways have more than one low point that could potentially pose a significant barrier to the driving public if a regional evacuation route were flooded.

In total, there are eighteen (18) critical locations along the ten (10) regional evacuation routes where flooding of these evacuation routes should be considered to pose an evacuation limitation for the driving public if flooding were more than one (1) foot in depth.[7] These critical locations are shown graphically on **Exhibit 3**.

These eighteen (18) critical locations are summarized as follows:

1. Del Paso Road
    a. Del Paso Road approximately 0.1± miles east of Natomas Road
2. El Camino Avenue
    a. El Camino Avenue approximately 0.1± miles east of Truxel Road
3. Elkhorn Boulevard
    a. Elkhorn Boulevard approximately 1.0± miles west of Natomas Road
    b. Elkhorn Boulevard West approximately 0.8± miles east of Power Line Road
4. Elverta Road
    a. Elverta Road approximately 1.8± miles east of State Route 99
    b. Elverta Road West approximately 0.5± miles east of Power Line Road

[7] This standard was established in the 2015 GEI levee breach analysis for the Natomas Basin as a part of the City/County of Sacramento Flood Emergency Evacuation Plan for the Natomas Study Area (dated December 2015).

5. Interstate 5 (I-5)
    a. I-5 Central approximately 0.6± miles south of Del Paso Road
    b. I-5 Junction approximately 1.2± miles east of Power Line Road
    c. I-5 West approximately 0.6± miles west of Airport Boulevard
6. Interstate 80 (I-80)
    a. I-80 Central approximately 0.8± miles west of Interstate 5 (I-5)
    b. I-80 East approximately 0.4± miles east of Truxel Road
    c. I-80 West approximately 1.0± miles east of the Sacramento River Bridge
7. Natomas Road
    a. Natomas Road approximately 0.4± miles south of Elkhorn Boulevard
    b. Power Line Road approximately 0.5± miles south of Elverta Road
8. San Juan Road
    a. San Juan Road approximately 0.5± miles east of Truxel Road
9. State Route 99 (SR-99)
    a. SR-99 approximately 1.0± miles north of Elverta Road
    b. SR-99 North approximately 0.1± miles south of Sankey Road
    c. SR-99 South approximately 0.7± miles south of Elkhorn Boulevard
10. Power Line Road
    a. Power Line Road approximately 0.2± miles south of Elverta Road

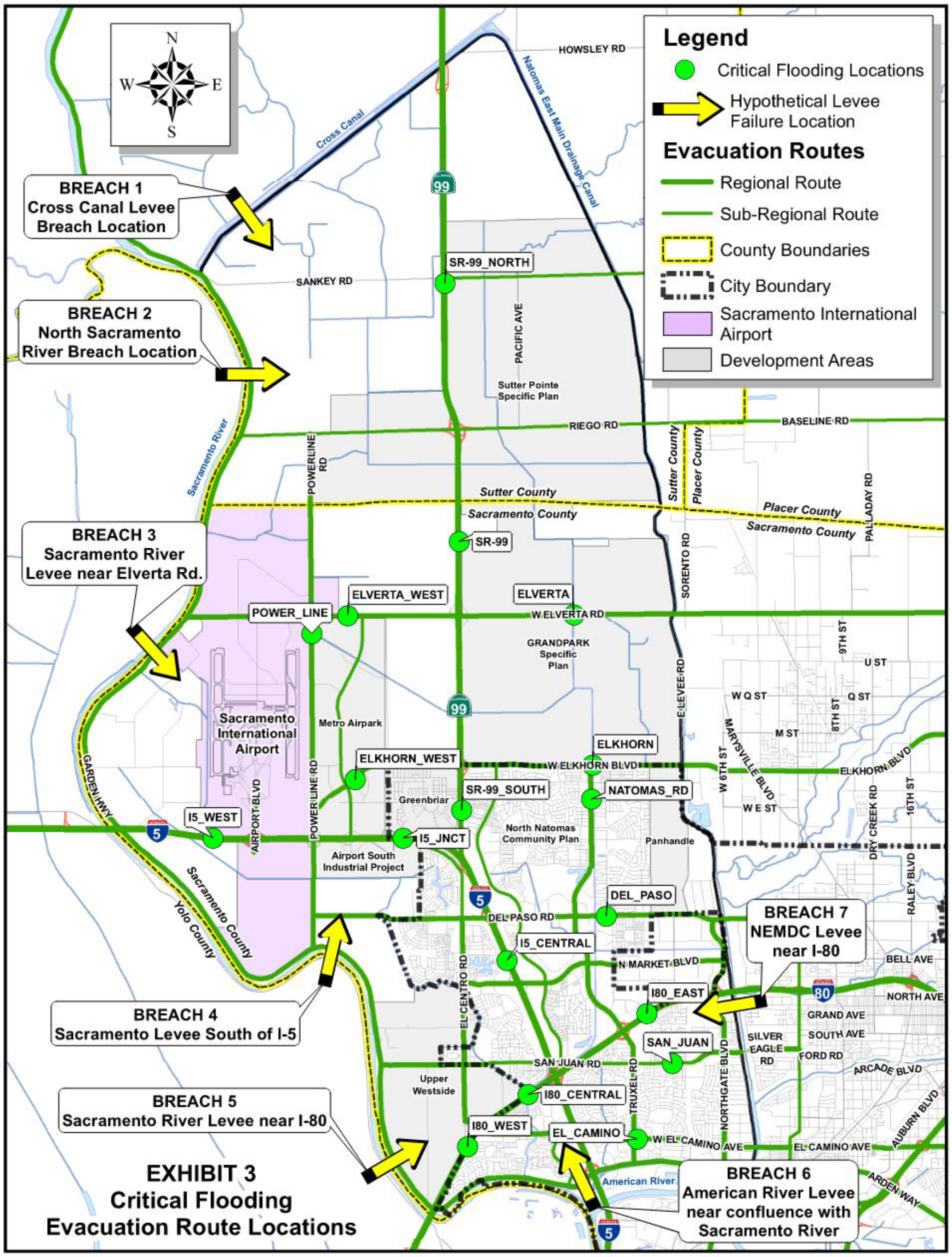

Exhibit 3
Critical Flooding Evacuation Route Locations

5. METHODOLOGY

The 2015 levee breach HEC-RAS hydraulic models and analysis were obtained from GEI by Civil Engineering Solutions, Inc. (CESI). The 2015 levee breach modeling evaluated levee breaches at the seven (7) theoretical locations described above and shown on Exhibit 2. CESI updated these models as described below to better estimate the projected rate of inundation and the maximum depth of flooding within the Basin post development of Upper Westside.[8] CESI coordinated its modeling effort with GEI to ensure the updated modeling was performed correctly and that the resulting output of the updated modeling yielded comparable results to the 2015 GEI models.[9]

The 2015 levee breach model was updated as follows:

1. **Updated HEC-RAS Software**. CESI updated the 2015 GEI flood modeling to HEC-RAS Version 6.2 (One-Dimensional (1D)) modeling from HEC-RAS Version 4.1.3 (1D) modeling. GEI used HEC-RAS Version 4.1.3 (1D) in the preparation of the 2015 mapping effort. Once the conversion was complete, CESI checked for error messages. The newer version of the software detected several errors in the geometry file that were not evident in the previous version of the software (e.g., a Htab parameter error in the geometric files in the HEC-RAS model noted a point where the starting elevation of a water surface is set lower than the invert of a channel). CESI corrected the errors by making modifications in the geometry file.
2. **Verification**. Prior to making any adjustments to the model to reflect the best available topographic and development information, CESI ran the updated HEC-RAS Version 6.2 1D models for each breach scenario to determine if it produced results that were generally consistent with the 2015 GEI models. In each case, CESI found the results from the HEC-RAS Version 6.2 (1D) modeling was similar to the published HEC-RAS Version 4.1.3 (1D) modeling results of the 2015 GEI models for both durations in time to 1-foot depth of inundation at the critical locations along regional evacuation routes and for the maximum depth of flooding

[8] The results of the CESI modeling were reported in CESI's Technical Memorandum No. 0040 which are included in Appendix B of this PM.

[9] The GEI models were based upon river modeling of the Sacramento and American Rivers prepared by SAFCA and/or the California State Department of Water Resources (or by consultants working for one of both of these agencies). In 2015, GEI further developed these HEC-RAS 1D models for the Natomas Basin Levee Breach analysis. That analysis resulted in the flood maps contained in the 2015 City/County Evacuation Plan. For the 2015 analysis, the City & County of Sacramento determined the locations of the seven (7) perimeter levee breach locations. The 2015 GEI models do not include allowances for the effects of climate change. Nonetheless, the rate of flood inundation propagation of the Basin during a climate change influenced catastrophic levee breach would not measurably differ from the results shown in this PM.

within the Basin. [10] This comparison of the time to inundation of 1-foot depth of flooding over the critical roadway locations and the maximum depth of flooding within the Basin verified that the updated model was sufficiently accurate to provide dependable and reliable results during the subsequent model runs.

Upon completion of this effort, CESI consulted with GEI wherein GEI and CESI mutually agreed that the updated modeling provided comparable results to the 2015 GEI modeling when utilizing similar assumption sets. In essence, this consultation process provided a form of peer review of the updated modeling effort.

3. **Updated Terrain Modeling**. CESI updated the terrain modeling to 2-Dimensional terrain modeling (2D Modeling) from the 1D terrain modeling (1D Modeling) used in the 2015 modeling effort. The HEC-RAS Version 6.2 2D modeling algorithms are superior to HEC-RAS Version 4.1.3 1D modeling algorithms when evaluating flood storage volumes and duration of time for flooding to occur. The HEC-RAS Version 6.2 is recognized by the engineering community for its superior capabilities to analyze flooding using 2D terrain surfaces more accurately as compared to HEC-RAS Version 4.1.3 that only utilized 1D terrain models.

   Since no terrain model was available from the previous modeling effort, CESI produced a current existing conditions topographic model that was used to produce a current digital terrain model for all 2D modeling analyses. It should be noted that Staff from the County Department of Water Resources requested the updated terrain model include an assumption of a fully developed grading plan for Metro Air Park for the existing conditions terrain model. This was added to all models.

4. **Breach Depth Correction**. The updated software detected errors not evident in the previous modeling relating to the depth of the breach at some locations. The previous model included adjacent ground elevations at some breach locations where the specified minimum elevation of the breach was below the adjacent ground elevations within the Basin at the landside toe of the levee (e.g., inaccurate spot elevations representing channel elevations near the levee). Specifically, this situation was observed for Breach 6, and to a lesser degree for Breach 3.

   In these cases, the lower ground elevations resulted in more excessive breach depths and formation size than were reasonable given the adjacent levee toe elevations. CESI noticed that HEC-RAS Version 6.2 automatically made the necessary corrections thereby eliminating the prediction of greater flood volumes surging through the breach than could be reasonably anticipated. Also, this

[10] The durations of time to 1- foot depth of flooding reported in this PM represents the times at the respective data points that were reported throughout the duration of the modeling period.

correction affected the timing and ability of flood waters to move through the breach, and therefore throughout the Basin.

These corrections allowed for a better estimate of flood water volumes entering the Basin. When these changes were made, CESI found that the updated models projected a lower rate of flow being conveyed through the affected breaches (i.e., through Breach 6 and to a lesser degree through Breach 3), and into the Basin. CESI found that this change resulted in a lower total volume of flood water entering the Basin (and the aerial extent of flooding).[11] Additionally, the smaller breach sizes resulted in a longer duration of time until 1-foot depth of flooding occurred at the critical locations along the evacuation routes.

5. **In-Situ Storage Correction**. The updated HEC-RAS Version 6.2 software utilizes 2D Modeling to estimate overland flow storage volumes and durations of time while transmitting the flows to downstream conveyance facilities and storage areas. The previous model did not have this capability. Typically, this change increases the accuracy of the modeling effort and results in better estimations of duration of flooding until critical flood levels are achieved (e.g., at critical locations along regional evacuation routes). This correction in the models was an automatic result of CESI's decision to convert the modeling from HEC-RAS Version 4.1.3 (1D) to HEC-RAS Version 6.2 (2D).

6. LEVEE BREACH & RIVER STAGE ASSUMPTIONS

The 2015 GEI modeling included a number of preset levee breach and river stage assumptions. A review of these preset assumptions provides insight into the level of accuracy and precision that should rightfully be implied when reviewing and interpreting the modeling results presented in this PM.

1. Levee Breach Assumptions

The 2015 GEI modeling contained preset assumptions regarding the mode of levee breach failures that might be expected to occur on the levee system protecting the Basin. California DWR originally developed these theoretical assumptions from generalizations based on historical levee breaches, These

[11] The elevation of natural ground on the inland side of a breach has a significant effect on the rapidity and total volume of flow passing through the breach. While a scour hole at the breach location can occur, for the purposes of this modeling exercise, scour was not assumed to occur. This assumption is consistent with the assumption used in the 2015 breach analysis.

assumptions, which relate to the size, shape, width, and timing of formation of levee breaches, were not changed in the modeling performed for this PM.

However, in all probability, if one of the Basin's levees were ever breached, the actual size, shape, width, and timing of formation will likely deviate from the theoretical assumptions included in the models – perhaps unpredictably. That is, in the unlikely event of a levee breach, the rapidity of failure and the resulting rate of inundation propagation will likely vary from the results projected by the modeling prepared to support this PM.[12]

This is important from a flood evacuation planning perspective. The durations of time to 1-foot depth of flooding at the eighteen (18) critical locations along the regional evacuation routes predicted in this PM may seem readily predictable. However, given the inherent uncertainties in the predictability of the variability and mode of levee failures, these durations of time should be considered a guide rather than a certitude from an evacuation planning perspective.

2. **River Stage Assumptions**

Similar to the levee breach assumptions mentioned above, the 2015 GEI model included preset assumptions regarding the flood flows and stages (the water level in the river) of the surrounding rivers and canals, and the timing of a breach occurrence. These assumptions were not changed in the modeling performed for this PM.

The stage of the river directly affects the rate of flow through a levee breach, and the resulting rapidity of flooding and the maximum depth of flooding behind the levee. Since the stage of the river varies over time during a flood event, the timing of a breach vis-à-vis the river stage at the moment of breach occurrence will determine the rate and depth of flooding behind the levee.

Accordingly, like the levee breach assumptions, in all probability, the actual timing of levee failure will deviate from the theoretical assumptions included in the models – perhaps unpredictably. That is, in the unlikely event of a levee breach, the rapidity of failure and the resulting rate of inundation propagation will likely vary from the results projected by the modeling prepared to support this PM.

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[12] Typically, when a levee breaches, the breach opens relatively slowly at first. Then, as the breach widens and deepens, flood flows from the breach will radically increase within a brief time period after initiation of the breach event. This phenomenon, breach initiation to full breach conditions, can occur within a matter of a few hours.

Again, this is important from a flood evacuation planning perspective. The actual durations of time to 1-foot depth of flooding at the eighteen (18) critical locations along the regional evacuation routes identified in this PM will likely deviate from those values reported due to the uncertainties associated with river stages at the time of breach occurrence. The uncertainty of the stage of the surrounding rivers and canals surrounding the Basin's levees needs to be taken into consideration. The durations of time reported in this PM should be used as a guide rather than a certitude from an evacuation planning perspective.

7. FLOOD MODELING

A. Existing Conditions

Substantial urbanization exists with the southern and southeastern portions of Basin. These existing urbanized areas are generally described as follows:

1. City of Sacramento

a. **I-80/I-5 Northeast Quadrant** – Generally bounded by Elkhorn Blvd. on the north, the NEMDC on the east, I-80 on the south, and the I-5/SR-99 corridor on the west.

b. **I-80/I-5 Southeast Quadrant** – Generally bounded by I-80 on the north, the NEMDC on the east, the American River on the south, and the I-5/SR-99 corridor on the west.

c. **I-80/I-5 Southwest Quadrant** - Generally bounded by I-80 on the north, the I-5/SR-99 corridor on the east, the American River on the south, and the Sacramento River on the west.

d. **I-80/I-5 Northwest Quadrant** – Generally bounded by Arena Blvd. on the north, the I-5/SR-99 corridor on the east, I-80 on the south, and El Centro Road on the west.

e. **I-5/SR-99 Southwest Quadrant** – Generally bounded by I-5 on the north, the I-5/SR-99 corridor on the east, Arena Blvd. on the south, and Fisherman's Lake on the west.

f. **I-5/SR-99 Northwest Quadrant** – Generally bounded by Elkhorn Blvd. on the north, the I-5/SR-99 corridor on the east, I-5 on the south, and Metro Air Park on the west.

2. **Sacramento County**
    a. **Sacramento International Airport** – Generally bounded by Pritchard Lake on the north, Power Line Road on the east, I-5 on the south, and the Teal Bend agricultural area on the west.
    b. **Metro Air Park** – Generally bounded by Elverta Road on the north, Lone Tree Rad on the east, I-5 on the south, and Power Line Road and the Sacramento International Airport on the west
    c. **Teal Bend Golf Club** – Generally located on the east side of the Garden Highway southerly of Reservoir Road and westerly of the Sacramento International Airport.
    d. **Garden Highway River Frontage** – Generally consisting of rural residential estate properties along the east and west side of the Garden Highway as it parallels the Sacramento River south of the Sacramento/Sutter County line to I-80.
3. **Sutter County**
    a. **Pacific Avenue Industrial Area** – Generally bounded by Pacific Avenue on the west, and between Sankey Road on the north, agricultural lands on the east, and Riego Road on the south.
    b. **Garden Highway River Frontage** – Generally consisting of rural residential estate properties along the east and west side of the Garden Highway as it parallels the Sacramento River north of the Sacramento/Sutter County line to the Natomas Cross Canal.

The above-described urbanized areas, plus the assumption of full buildout of Metro Air Park, constitute the "existing conditions" assumption for the purposes of this PM.

Cumulative Conditions

There are several other Natomas Basin development projects that are reasonably foreseeable to occur in the future. These future projects, when combined with existing conditions represent the cumulative scenario for purposes of this PM. The Upper Westside land use plan is shown in **Exhibit 4**.

In addition to Upper Westside, the reasonably foreseeable projects that make up the cumulative scenario are as follows:

1. Grandpark (north of Elkhorn Blvd, east of SR-99, south of the Sacramento/Sutter County line, and west of the NEMDC)
2. Northlake (Greenbriar) (Northwest quadrant of I-5/SR-99 Interchange)

3. Panhandle (South of Elkhorn Blvd. at NEMDC)
4. Sacramento International Airport (Runway Expansion)
5. SAFCA "Preferred Alternative Plan" for Storage of Sankey Gap Spills"[13]
6. Sutter Pointe (Sutter County just north of Sacramento County line)
7. Airport South Industrial Project (South of I-5 opposite Metro Air Park and Greenbriar)

Except for the Airport South Industrial Project, the preliminary grading plans reflecting developed conditions for each of these future projects were obtained and added to the existing conditions terrain model utilized in the updated HEC-RAS model to create a cumulative conditions terrain model for the C+P analysis. The Airport South Industrial Project is a relatively new land use entitlement application pending review by the City of Sacramento.

At this time there is no readily available engineering information for the Airport South Industrial Project. For the purposes of this PM, it has been assumed that developed conditions grading of this project will closely resemble the existing terrain on the project site. Based on this assumption, the Airport South Industrial Project will have neither a substantive effect on the results of the flood inundation and propagation modeling nor on the depth of flooding results reported in this PM.

However, the Airport South Industrial Project may be located within a local floodplain and may require significant grading to allow for future development. As such grading of the site may impact the flood inundation propagation and depth of flooding beyond that analyzed in this Procedural Memorandum.

It is important to note that the developed conditions grading for the cumulative conditions analysis represented finish grade surface only and did not include any fences or structures which will be built within the cumulative conditions. These future condition items cannot be included in the current modeling as their locations and makeup are still unknown.

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[13] SAFCA does not intend to close the "Sankey Gap" until the Fremont Weir is widened sometime in the future. Extension of the weir will result in lower stages in the Sacramento River during major flooding events which in turn will lower the depth of flooding in the Natomas Cross Canal and for areas upstream of the Sankey Gap. Rather, SAFCA Staff reports that SAFCA is currently focusing on implementing the "Preferred Alternative Plan" as described in the May 22, 2018 "Sankey Road Gap Closure Project Basis of Design Report" (personal conversation with Gary Bardini, Director of Planning at SAFCA on July 21, 2022). This project will store the flood flows that pass through the "Sankey Gap", enter the Natomas Basin and be stored in detention basins to be located interior to the Natomas Basin. These flood waters will flow into two (2) large detention basins (one (1) located on the north side of Sankey Road at the east levee of the Basin, and another located west of SR-99 south of Sankey Road). These two (2) basins will be connected by an open channel and culvert system. Each basin will be surrounded by earthen embankments to contain the flood waters. These detention basins are planned to be located within the interior flood plain of the Natomas Basin. Their embankments will therefore usurp a portion of the storage capacity of the interior flood plain.

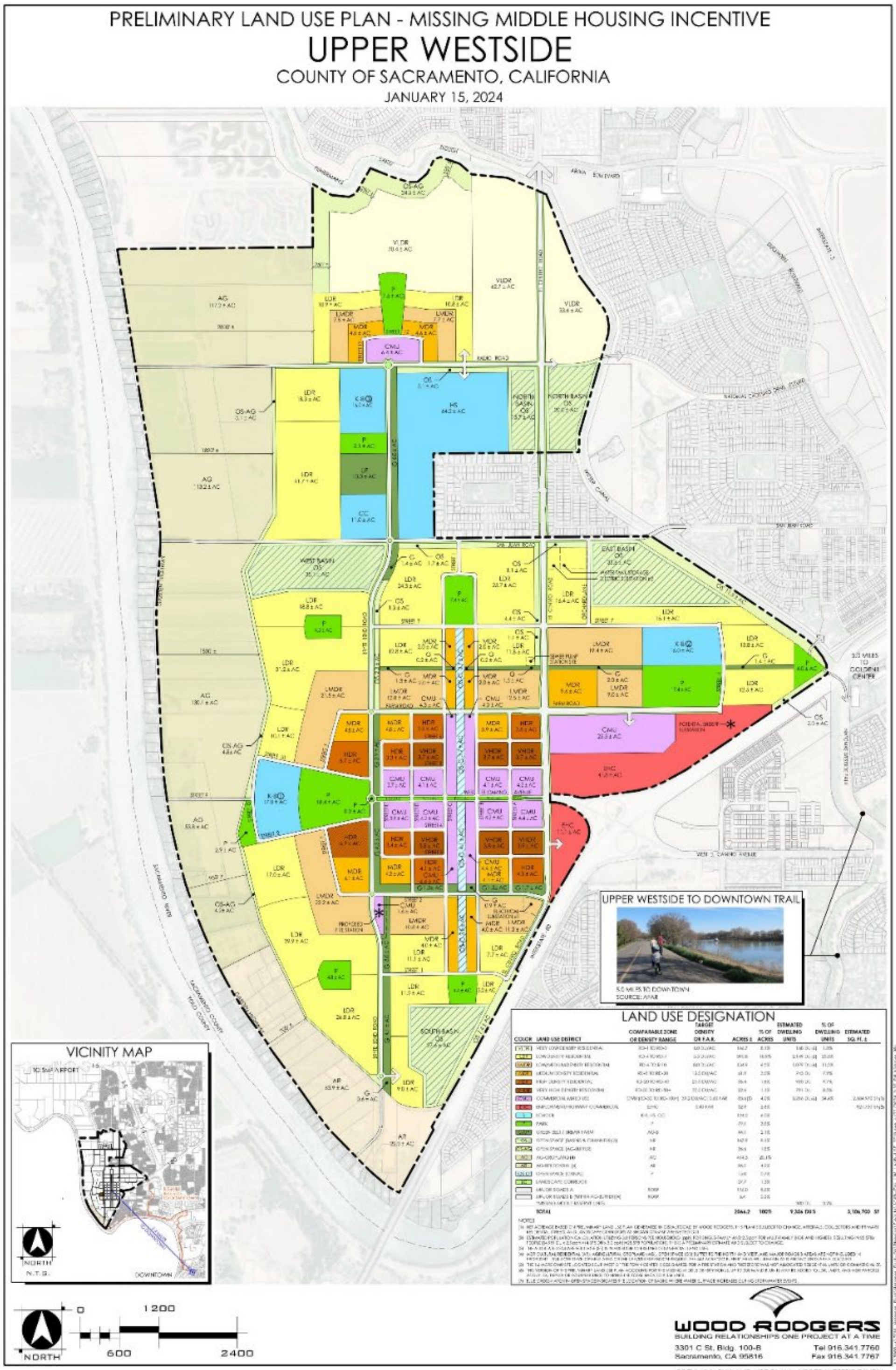


Exhibit 4
Upper Westside Land Use Plan

Additionally, adjustment for resistance to flood flows that may occur post development from these fences and structures (increases in Manning's "n" friction values) were not included in the analysis performed for this analysis.

Accordingly, the results reported in this PM are somewhat conservative in nature. That is to say that the durations in time to 1-foot depth of flooding at the critical locations along the regional evacuation routes in the Basin may be marginally shorter in duration than may actually occur during a flooding event as a result of flood flows being retarded by future fences and structures.

Except for updating the terrain model to simulate cumulative conditions for all of the above-described future projects (excluding the Airport South Industrial Project), the C+P modeling exercise utilized the same assumptions as the existing conditions modeling.

When Upper Westside is added to the above-described cumulative scenario, the resulting combined scenario represents the Cumulative Conditions Plus Project scenario, the C+P Scenario.

Cumulative Conditions + Project (C+P) Flood Modeling

In terms of model runs, three (3) separate model runs each were performed for the seven (7) levee breach locations. For each breach location, the eighteen (18) roadway locations listed above were evaluated in each modeling run for the duration of time until a flooding depth of one (1) foot was reached.

The three (3) modeling runs are briefly described below:

1. **Existing Conditions (1D Analysis)**. After adjustments to the model were complete, CESI updated and ran the models to compare the results of the updated model run as a 1D model to those found in the 2015 1D model runs to determine the time to inundation of 1-foot depth of flooding over the critical roadway locations under existing conditions. This comparison allowed for verification that the updated model provided comparable results to the prior modeling notwithstanding the use of the updated HEC-RAS Software (Version 6.2 v Version 4.1.3).
2. **Existing Conditions (2D Analysis)**. CESI then ran the updated models as 2D models to determine the time to inundation of 1-foot depth of flooding over the critical roadway locations under existing conditions. CESI used these modeling results to establish the baseline that was used for comparison to the C+P modeling analysis.
3. **Cumulative Plus Project Conditions (2D Analysis)**. CESI then ran the updated 2D model to determine the time to inundation of 1-foot depth of flooding over the critical roadway locations under C+P Conditions. CESI used these modeling results

to estimate the effects of developing Upper Westside along with the other reasonably foreseeable projects within the Basin in the "Cumulative Plus Project" Conditions (C+P).

The projected changes in hours until critical depths occurred along the regional evacuation routes were then calculated by CESI, comparing Cumulative Plus Project Conditions (C+P) to Existing Conditions (EC). The differences, plus or minus, were measured in terms of the number of hours of change in time until a 1-foot depth of flooding over the critical roadway locations under C+P Conditions was reached.

8. <u>LEVEL OF CONSEQUENCE</u>

There does not appear to be a set of objective standards for the definition of material effects as it relates to flooding. A survey of local public agencies in the greater Sacramento region did not reveal the existence of these types of objective standards.

Such standards, if they exist at all, will likely vary widely depending upon local conditions and the specifics of the flooding event. To establish an objective standard, consideration should include:

- Substantial technical analysis,
- Careful and objective evaluation of the effects that flooding may have:
  - In the Basin,
  - On the safety of the general public and,
  - On surrounding properties within the Basin.
- The exercise of substantial professional judgement and experience.

Upon review of the above considerations, we developed a working definition of flooding effects that are deemed not to be material for the purposes of this PM.

In the case of critical locations along regional evacuation routes that may be susceptible to rapid inundation, alternative local evacuation routes will be essential for the safe evacuation of the public from these local areas. Because these local areas will not contain a sizable number of people, these alternative local evacuation routes will not require large capacity roadways to safely accommodate their evacuation needs. Based on our experience and professional judgment, it is reasonable that a minimum of six (6) alternative local evacuation routes should be sufficient to facilitate a safe and orderly evacuation from areas subject to rapid evacuation.

For purposes of illustration, and without limitation, the following flooding effects were deemed not to be material from a public safety or flood damages perspective:

1. A reduction in the duration of time after a catastrophic levee breach occurs until a particular evacuation route is no longer safe for the general public to travel when at least six (6) alternative local evacuation routes from the same general area are available and those alternative routes offer adequate time for the safe evacuation of the affected area,
2. An increase in the depth or rapidity of catastrophic flooding when that effect does not impose substantial additional flood hazards on the general public, public or private properties, or environmental resources in the area,
3. An increase in the depth or rapidity of catastrophic flooding that is not great enough in magnitude to be noticeable or merit considering (e.g., a “de minimis” increase in the depth of flooding), and
4. Development of future growth areas within the Basin where balanced on-site earthwork can be reasonably anticipated to occur and, as a result, have negligible or de minimis consequences on the duration of time until evacuation routes are adversely affected and/or on the depth or rapidity of flooding during a catastrophic levee breach scenario.

Any flood effects that exceed the above-described level of consequences were deemed material and are reported as such in this PM.

9. EVACUATION ROUTE FLOOD MODELING RESULTS

Cumulative + Project Conditions Results

The results of the C+P modeling runs described above are summarized in **Tables 1 through 7**. Again, it should be noted that all adverse changes of less than 1-hour change in time to a 1-foot depth of flooding at the critical locations along the evacuation routes are less than the accuracy of the model. Accordingly, only changes in time to the critical depth of flooding greater than one (1) hour were deemed a material change.

A review of **Tables 1 through 7** reveals those evacuation route locations where the time until flooding to critical depth (one (1) foot depth of flooding) is affected for each breach scenario under C+P Conditions. **Table 8** is a summary of the locations where the duration in time is materially changed under C+P Conditions.

10. ANALYSIS OF EVACUATION ROUTE FLOOD MODELING RESULTS

Analysis of the modeling results has been grouped into two (2) categories: General Observations and Specific Observations. These observations are described below:

a. General Observations

Generally, the C+P evacuation flood modeling results from the conversion of HEC-RAS Version 4.1.3 to Version 6.2 indicate there are nominal changes in the average duration of time until a 1-foot depth of flooding occurs at the critical evacuation route locations under all seven (7) levee breach scenarios on a basin-wide basis. These changes are summarized as follows:

Modeling Scenario	Average Change
Existing Conditions (EC)	+8 Hours
Cumulative + Project Conditions (C+P)	+3 Hours

While the magnitude of these changes varies by location and levee breach scenario, the magnitude of these changes generally indicates that the public has the same amount of time, or more, to evacuate as originally projected in the 2015 GEI modeling effort.

The movement of citizens from a place of relative danger to a place of relative safety can be realized by traveling various evacuation routes. Since there are no locations within the Basin that cannot be evacuated by more than one (1) evacuation route, the flooding of an individual location is not deemed to be crucial for the safe evacuation of citizens to a place of relative safety. Accordingly, while some of the locations on the evacuation routes may flood relatively quickly, there are alternative routes that offer sufficient time for an orderly evacuation to occur.

b. Specific Observations

There are a number of instances where the duration of time to 1-foot depth of flooding at the critical locations along the regional evacuation routes is reduced from the times indicated in the 2015 GEI modeling.[14] The most notable of those are discussed below:

[14] The change in modeling software, from HEC-RAS Version 4.1.3 to Version 6.2, resulted in a greater level of accuracy in terms of the duration of time until a 1-foot depth of flooding over the critical evacuation routes occurs. In particular, newer versions of HEC-RAS utilize the Shallow Water Equation to solve two-dimensional flow problems across broad and shallow flood storage areas such as across the farm fields and rice checks that cover so much of the Basin. These notable changes are reasonable when one considers the fact that the lag time due to in-situ storage of flood flows across farmland is included in the newer versions of HEC-RAS, which the earlier version of the software did not calculate.

1. **Immaterial Reductions in Duration of Time.**

   Seemingly material changes in the duration of time to 1-foot depth of flooding under Cumulative Plus Project (C+P) Conditions were observed for several of the levee breach scenarios. These changes are summarized in **Table 8** for C+P Conditions.

   While measurable, the majority of these changes are not deemed material because of the amount of time remaining that is projected to be available to the public to evacuate. The movement of citizens from a place of relative danger to a place of relative safety can be realized by traveling various evacuation routes.

   Since there are no locations within the Basin that cannot be evacuated by more than one (1) route, and often by several different routes, the flooding of an individual location is not deemed to be crucial for the safe evacuation of citizens to a place of relative safety. Accordingly, while some of the locations on the evacuation routes may flood relatively quickly, there are alternative routes that offer sufficient time for an orderly evacuation to occur.

2. **Rapid Inundation of Regional Evacuation Routes.**

   Existing Conditions

   The 2015 GEI 1D modeling identified several critical locations where rapid inundation of the evacuation routes within the Basin were projected to occur in the event of a levee breach. The duration of time to 1-foot depth of flooding at these critical locations of less than twelve (12) hours duration after occurrence of a breach are of particular importance.

   The rapid durations of time at these locations should not be interpreted literally. Rather, these brief time frames should be considered in the context of the limitations of the modeling given the theoretical assumption sets relating to levee breach formation and river stages contained in the 2015 GEI modeling.

   Good evacuation planning dictates that the identified “rapid duration” locations should be closed to public traffic prior to or contemporaneously with the occurrence of a levee breach. Because of the uncertainties in the modeling, this planning principle is true whether the estimated duration of time to 1-foot depth of flooding is one (1) hour or ten (10) hours.

   From a practicable perspective, the logistics associated with the closing of a roadway (including the response time to make the decision to close a roadway, and the amount of time required by first responders to sign, barricade, and close an evacuation route to public traffic) can take several hours to accomplish. This fact, in and of itself, indicates that evacuation routes subject to rapid inundation should be closed as soon as practical after a levee breach occurs.

Proposed Conditions

Generally, the updated 2D modeling prepared for this PM identified the same locations where rapid inundation of the evacuation routes were projected to occur in the 2015 GEI 1D modeling. These rapid inundation locations for Existing Conditions and under C+P Conditions in Tables 1 through 7 (under the Updated 2D Model columns). It should be noted that the rapid inundation locations are projected to occur in relatively the same time frames under Existing Conditions (2D) and C+P Conditions (2D) modeling. That is to say, the development of Upper Westside does not adversely affect the rapidity of flooding of these critical locations.

Associated with four (4) of the levee breach locations, there are a total of nine (9) locations that are prone to rapid inundation during a levee breach. They are summarized in the table below.

Logically, the public will want to evacuate away from a levee breach instead of trying to use evacuation routes that lead towards a breach. Further, it is reasonable to assume that first responders will direct the public away from areas of concern and towards areas of relative safety.

However, when one or more locations along the regional evacuation routes identified above (e.g., El Camino Avenue, I-5, or I-80) are unsafe for travel by the general public due to rapid inundation, alternative evacuation routes to move people from areas of concern and toward areas of safety need to be identified. **Exhibit 5** depicts four (4) areas of concern where it is highly likely that rapid inundation is projected to occur during the first twelve (12) hours after a levee breach. breach – see the dashed colored lines surrounding areas where rapid inundation is likely to occur.

Breach No.	**Breach Description**	**Critical Locations**
1	Natomas Cross Canal Levee	None
2	North Sacramento River Levee	None
3	Sacramento River Levee Near Elverta Road	Elkhorn West I-5 West Powerline
4	Sacramento River Levee South of I-5	Elkhorn West I-5 Junction I-5 West
5	Sacramento River Levee Near I-80	I-80 Central I-80 West
6	American River Near Confluence with Sacramento River	None
7	NEMDC Levee Near I-80	El Camino Avenue I-80 East San Juan Avenue

Each of these four (4) areas of concern are associated with a nearby hypothetical levee breach location. (i.e., one area of concern each near Breach Nos. 3, 4, 5, and 7). Depending upon the location of an actual breach, the affected roadways should be closed to the traveling public prior to or immediately following the occurrence of a levee breach.

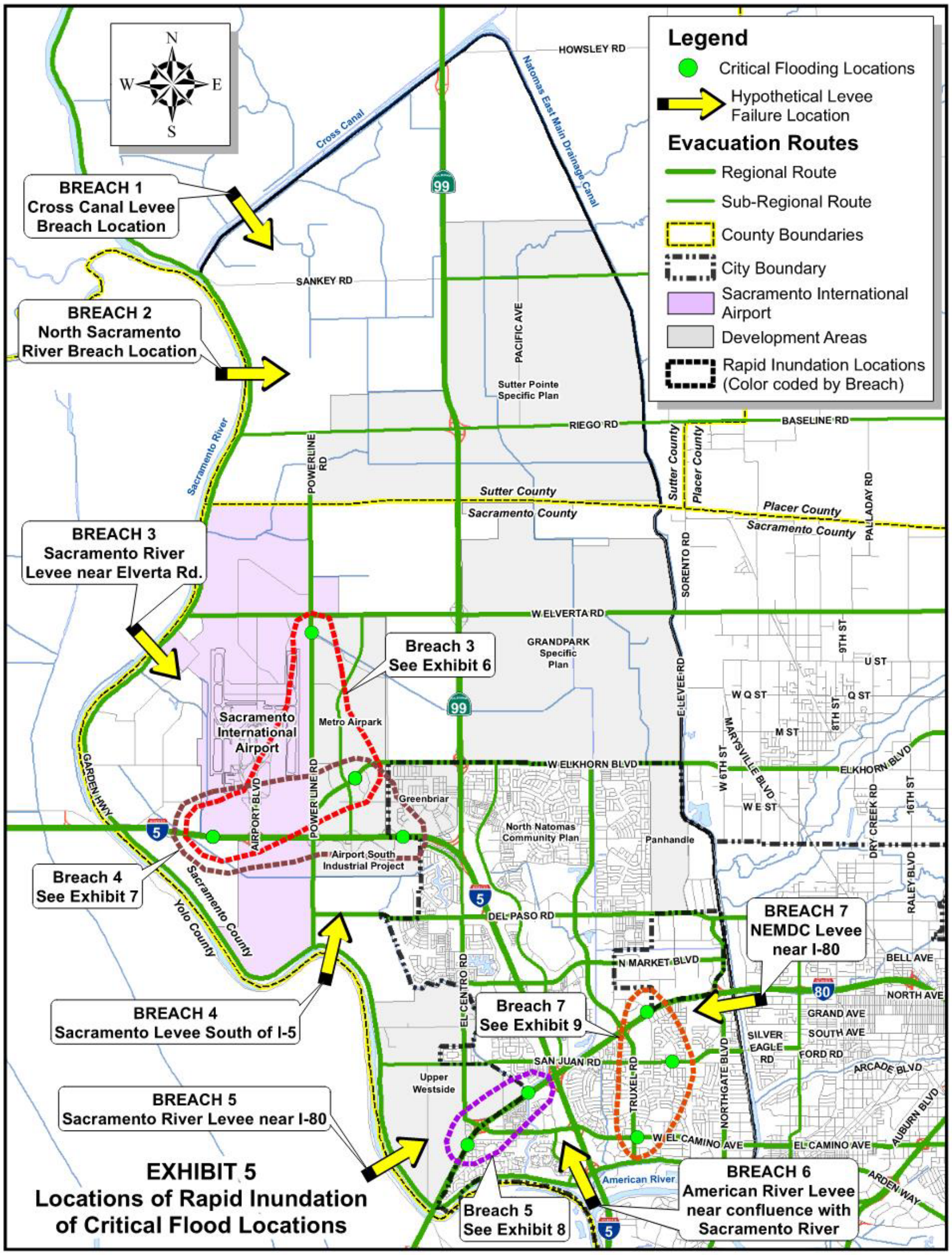


Exhibit 5
Locations of Rapid Inundation of Critical Flood Locations

Exhibits 6, 7, 8 and 9 each depict in greater detail the four (4) areas of concern for rapid inundation of regional evacuation routes during a levee breach in the vicinity of Breach 3, Breach 4, Breach 5, and Breach 7, respectively. In total, there are nine (9) locations in these four (4) areas of concern that are subject to rapid inundation. These exhibits show alternative local evacuation routes that are available for evacuation during the first few hours after a breach occurrence.

In each of the four (4) areas of concern, there are at least nine (9) alternative routes that are available for evacuation during the early hours of a catastrophic flood resulting from the respective levee breach locations. Accordingly, safe evacuation of the public from areas of rapid flooding can still occur using the alternative routes identified in Exhibits 6, 7, 8, and 9.

Additionally, during periods of high river stages, the entities responsible for flood watch patrols should be able to identify seeps and sand boils on the land side of the levees and the loss of freeboard on the water side of the levees that are typically precursors to potential levee failures. Once these precursors are spotted, the flood watch patrol officials should notify the appropriate public safety and evacuation entities who should then initiate pre-planned flood evacuation procedures, including the closure of roadways, including roadways that may be in threat of rapid inundation during a catastrophic levee failure, prior to or immediately after the occurrence of a levee breach.

Finally, the identification of those critical locations along regional evacuation routes that are prone to early inundation should provide evacuation planners with a clearer picture of which of the regional evacuation routes are not prone to early inundation. This finding should allow evacuation planners to prioritize their roadway closures plans to allow for early evacuations from the Basin regardless of the location of a levee breach.

Therefore, notwithstanding the rapid inundation of these four (4) critical flooding locations during the first twelve (12) hours post-occurrence of their respective levee breaches, the alternative evacuation routes presented in Exhibits 6 through 9 show that the public can evacuate from these critical flooding locations by a minimum of nine (9) different evacuation routes. In our professional opinion, the existence of such a large number of alternative evacuation routes indicates that early evacuation of these areas can safely occur notwithstanding the rapid inundation of the critical locations.

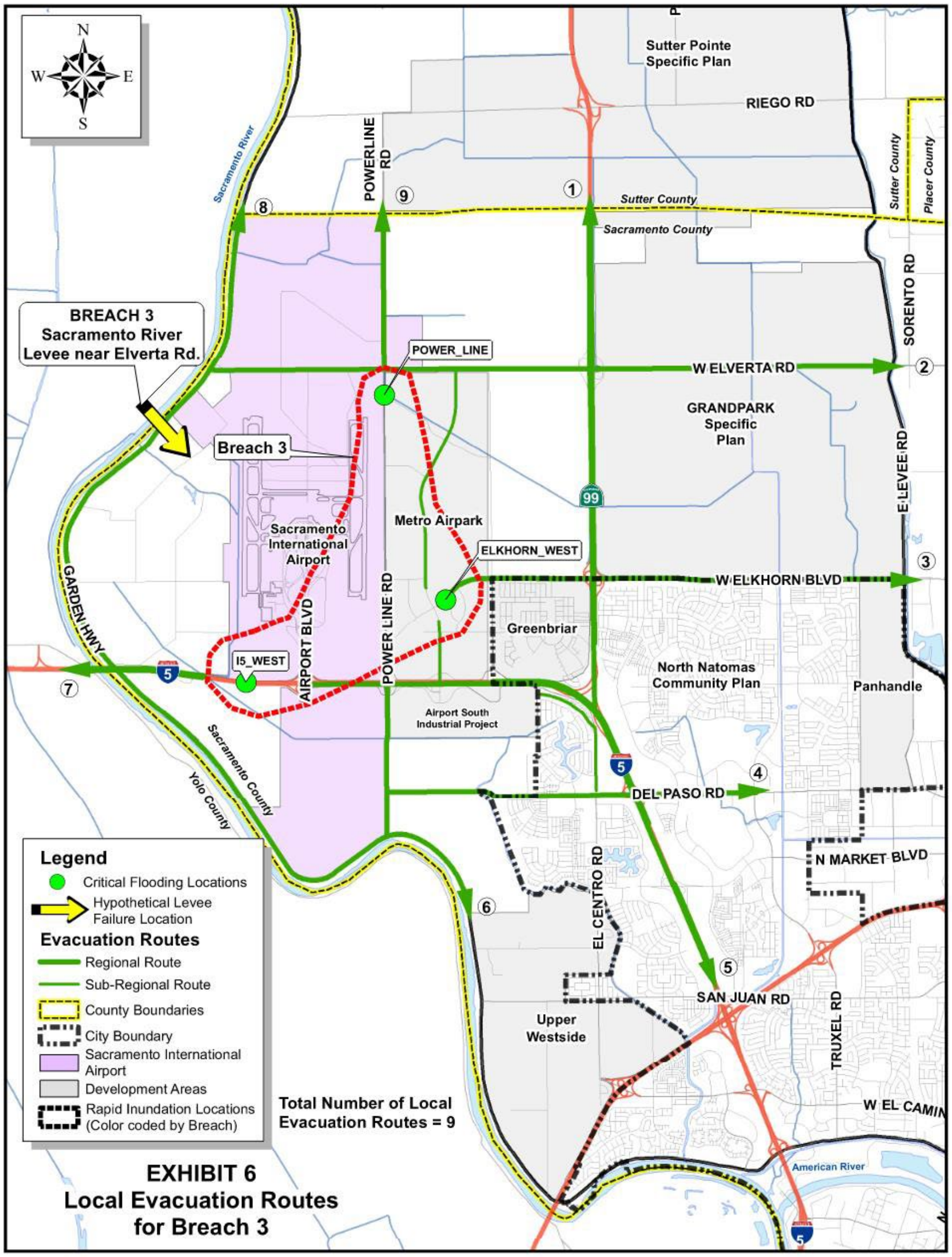


Exhibit 6
Local Evacuation Routes for Breach 3

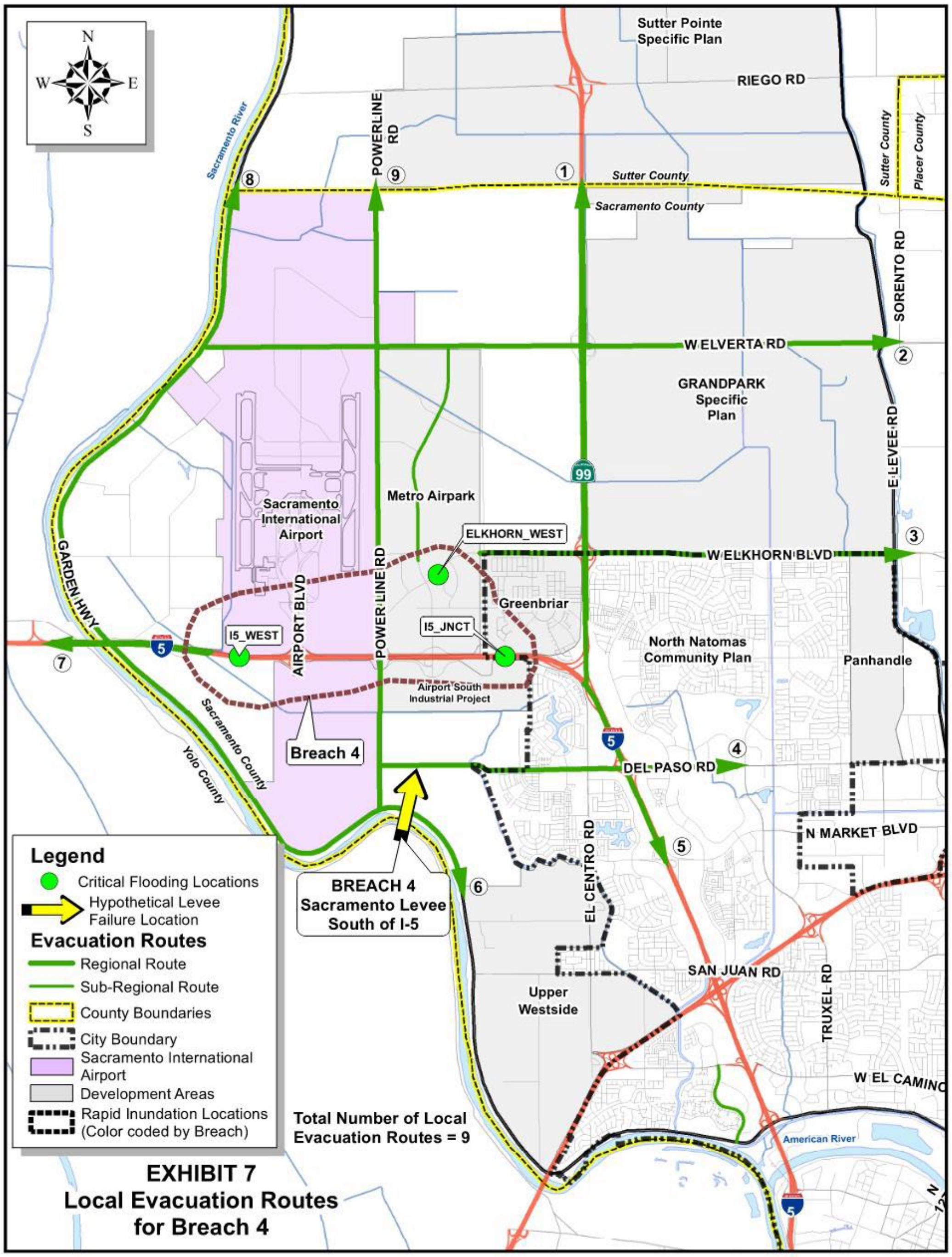


Exhibit 7
Local Evacuation Routes for Breach 4

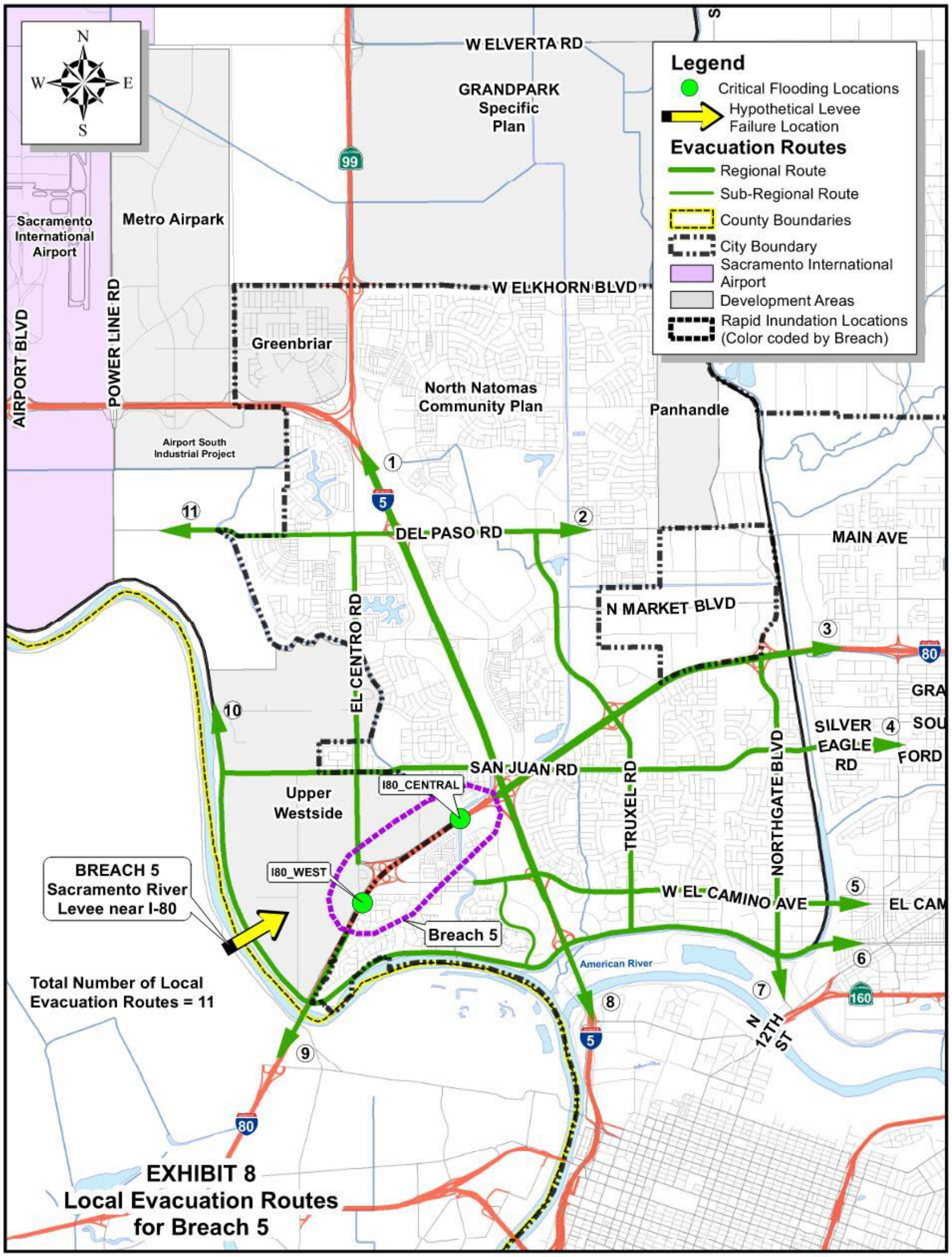


Exhibit 8
Local Evacuation Routes for Breach 5

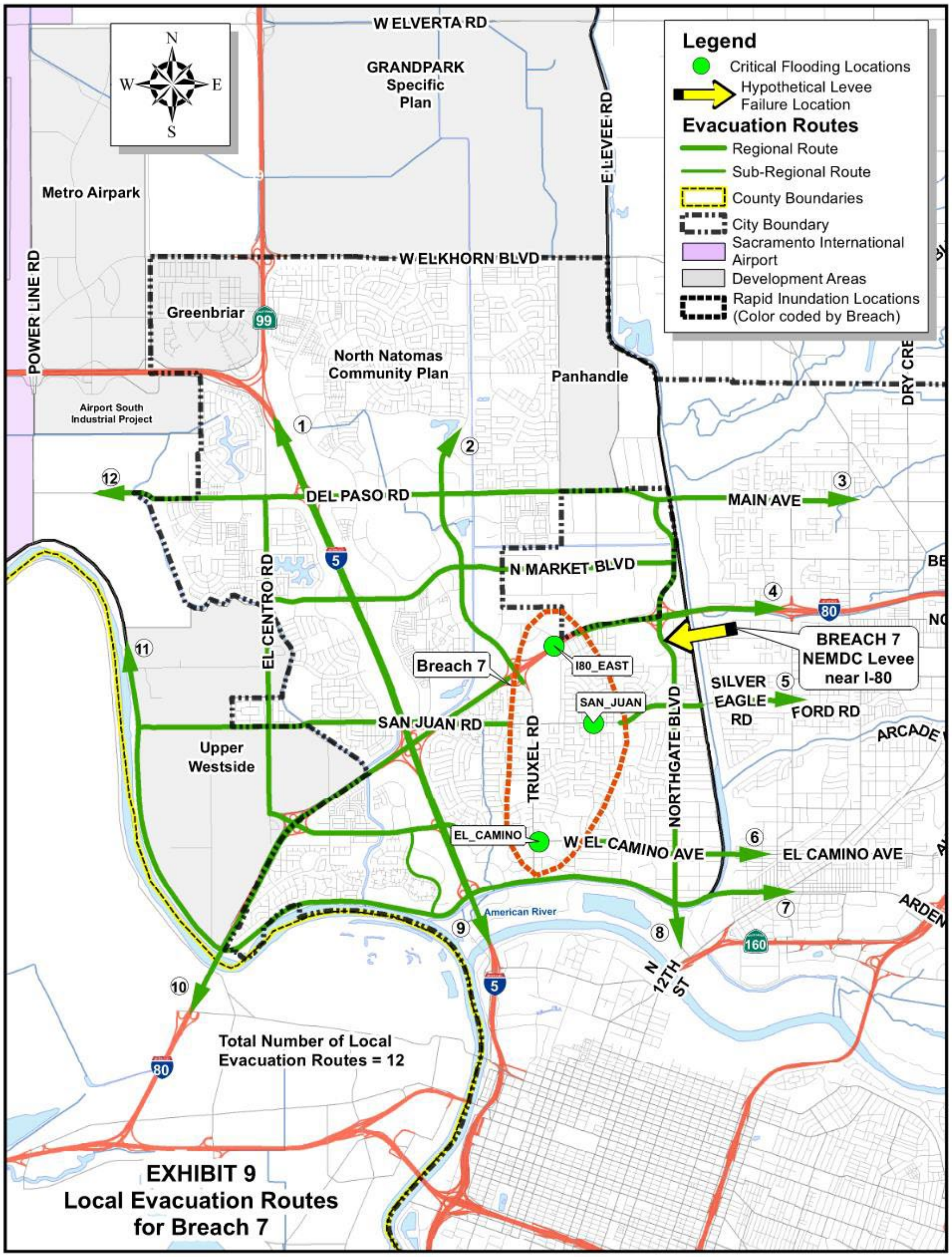


Exhibit 9
Local Evacuation Routes for Breach 7

3. Numerically Large Reductions in Duration of Time

The modeling revealed a small number of instances under C+P Conditions where numerically large reductions in the duration of time to 1-foot depth of flooding were observed. While numerically large, these reductions of time were not deemed material from an evacuation perspective. These instances and the reasoning for them being immaterial are explained below:

A. Cumulative Plus Project Conditions

In five (5) cases, the total duration of time to 1-foot depth of flooding of a regional evacuation route under C+P Conditions were found to have decreased by a large number of hours when compared to existing conditions:

Breach	Location	Reduction	Remaining Time
1	SR-99	-31 Hours	62 Hours
1	SR-99 North	-59 Hours	39 Hours
2	Elkhorn West	-16 Hours	36 Hours
2	Elverta West	-19 Hours	14 Hours
7	Power Line	-13 Hours	123 Hours

Similarly, in these limited number of cases, there either remains adequate time to evacuate and/or several other alternative evacuation routes are available for the public to utilize to reach a location of relative safety. Accordingly, these decreases in evacuation time do not appear to be material from a safety perspective.

11. MAXIMUM DEPTH OF FLOODING MODEL RESULTS

Methodology

The 2015 GEI modeling also evaluated the maximum depth of flooding within the Basin that would likely result from a levee breach at each of the seven (7) levee breach locations under existing conditions. Based on this analysis, a series of “maximum flood depth maps” were prepared for the 2015 City/County Evacuation Plan.

The 2015 mapping effort depicted the aerial extent of maximum flooding in 4-foot increments projected to occur within seven (7) days post levee breach. This mapping was prepared to a level of accuracy that was deemed appropriate by the City and County for flood evacuation planning.

The updated levee breach modeling performed for this PM provided sufficient data to allow updating of those 2015 maximum flood depth maps. For purposes of evaluating the resulting material changes related to development of Upper Westside under cumulative conditions, the 2015 maps were updated utilizing the new modeling results.

Similar to the evacuation route analysis described above, analysis of the maximum depth of flooding was performed for the following scenarios:

1. Existing Conditions (1D Analysis).
2. Existing Conditions (2D Analysis).
3. Cumulative Plus Project Conditions (2D Analysis).

The results of these analyses were then plotted in aerial view over the HEC-RAS 6.2 Terrain Model prepared by CESI for Existing Conditions and for Cumulative Plus Project Conditions. The results of this exercise were then compared side-by-side to provide a visual comparison of the maximum flooding depths projected to occur under Existing Conditions and C+P Conditions as a result of the seven (7) different levee breach scenarios. The resulting series of maximum depth of flooding maps for Existing Conditions (1D), Existing Conditions (2D), and Cumulative Plus Project Conditions (2D), all utilizing the latest HEC-RAS software, are included in **Appendix A**.

Maximum Depth of Flooding

By visual inspection of the maximum flood depth maps in **Appendix A**, it is evident that for all breach locations (Breaches 1-7), the results of the updated mapping effort for C+P Conditions are similar to the updated 2D Existing Conditions (EC) maximum depth of flooding maps.

The following observations are self-evident after visually inspecting the updated maximum depth of flooding maps.

1. A comparison of the results from the 1D and 2D modeling for C+P scenarios indicate a high degree of consistency between the 2015 depth of flooding maps and the updated depth of flooding maps.
2. The Sankey Gap spill path is not apparent in the Existing Conditions 1D Analysis.
3. The estimated maximum depth of flooding resulting from the new 2D Analysis is less than that based on the 1D Analysis.
4. The aerial extent of the maximum depths of flooding from the new 2D Analysis is less than that based on the previous 1D Analysis. This is especially evident for Breach 6, and to a lesser degree for Breach 3.

5. Grading within the reasonably foreseeable projects under C+P Conditions shows some nominal differences in the maximum depths of flooding. However, the lower depths occur where embankments are proposed, and the greater depths occur at the locations where detention basins are proposed. These differences were not deemed material.

A comparison of Maximum Flooding Water Surface Elevations for Upper Westside under C+P Conditions for each breach scenario is shown in **Table 10**. The point of reference for this comparison is the north-south mid-point within the Upper Westside Project.

Therefore, the differences in maximum water surface elevations between the Existing Conditions (2D) analysis and the Cumulative Plus Project Conditions (2D) analysis are deemed nominal and not material from a flooding perspective. The maximum depth of flooding under Existing Conditions 2D as compared with the Existing Conditions Plus Upper Westside 2D would be nearly identical to the water surface elevations and changes thereto shown in Table 17 (the C+P results).

This conclusion can be easily reached when one considers that, for all intents and purposes, rough grading of all urban and non-urban sites within the Natomas Basin is accomplished on a "net-zero" basis. That is to say, rough grading of nearly all sites within the Natomas basin have been and will continue to be the result of "balanced" on-site grading plans – with little or no import or export of dirt from or into the Basin.[15]

Generally, the Basin will fill to a single-pool elevation under each breach scenario. The maximum depth of flooding under each scenario, the single-pool elevation, is a function of the water surface elevation in the river at the time equilibrium is reached with the water surface elevation within the Basin.

Accordingly, flood storage volumes and their aerial distribution within the Natomas Basin have and will remain relatively unchanged over time. While localized, minor changes in

[15] SAFCA has imported fill material and may continue to import fill material as a part of the levee improvement project to protect the Natomas Basin from the threat of external flooding. The volumes of import material used to strengthen the levee system and to create the future detention basin to capture Sankey Gap spills (the SAFCA "Preferred Alternative Plan for Storage of Sankey Gap Spills") are relatively minor and should be considered de minimis when compared to the overall flood storage volume within the Natomas Basin. Accordingly, the volume of fill material imported into the Natomas Basin for flood protection purposes is not deemed material during a catastrophic flooding event.

the aerial extent of catastrophic flooding may occur on a project-by-project basis, the distribution of flooding on a basin-wide basis will not vary measurably over time.[16]

12. CITY/COUNTY EVACUATION PLANS

Sacramento County Office of Emergency Services [17]

The Sacramento County Office of Emergency Services (SacOES) coordinates the overall Sacramento Countywide response to large scale incidents and disasters. SacOES is responsible for alerting and notifying appropriate agencies when disaster strikes; coordinating all agencies that respond, ensuring resources are available and mobilized in times of disaster; developing plans and procedures in response to and recovery from disasters; and developing and providing preparedness materials for the public.

SacOES staffs the Operational Area Emergency Operations Center (EOC), a central facility responsible for carrying out the principles of emergency preparedness and emergency management, or disaster management functions at a strategic level in an emergency situation and ensuring the continuity of operation in the County. The EOC is responsible for the strategic overview, or "big picture," of the disaster, and does not normally directly control field assets, instead making operational decisions and leaving tactical decisions to lower commands. These commands include various County departments, cities, schools and special districts, business and industry, volunteer organizations, individuals, and state and federal government agencies.

Emergency plans and associated functional annexes are developed and maintained by SacOES. These plans address extraordinary emergency situations associated with human-caused disasters, natural disasters, technological incidents and/or emergencies, and national security incidents and/or emergencies affecting or within Sacramento County. Responding agencies may include public and non-government organizations.

In the event of an emergency that requires citizens to evacuate to a safe area, SacOES has developed a set of agreed-upon strategies and responses already in place to ensure the evacuation process is managed as smoothly and effectively as possible. This set of agreed-upon strategies and responses also accounts for the many people with disabilities, the elderly, and others with access and functional needs who may need additional support in an evacuation.

The tactical commands for flood related emergencies within the Sacramento County portions of the Basin are the City of Sacramento, Reclamation District No. 1000 (RD 1000),

[16] The maximum depth of flooding may be different than those shown in the PM when the effects of climate change are considered.

[17] Much of the text of this section of the PM was obtained from the SacOES website on September 9, 2022.

and the County Departments of Water Resources (County DWR) and Transportation (County DOT). The County of Sutter is responsible for the development of tactical commands for flood related emergencies in the Sutter County portion of the Basin. These tactical commands are responsible for the development of operational evacuation plans in their respective portions of the Basin. These operational evacuation plans provide a framework to guide a local government response during times of emergency.[18]

Based on a review of the SacOES emergency response plans relating to flooding and the analysis contained in this PM, the development of Upper Westside does not trigger the need for any modifications to the various SacOES emergency planning documents mentioned in this PM. Similarly, based on the same document review and the analysis contained in this PM, the development of Upper Westside does not require any modifications to the operational evacuation plans of the various tactical commands mentioned above.

2015 City/County Evacuation Plan

Based on a review of the 2015 City/County Evacuation Plan and the analysis contained in this PM, only minor changes are required to modify the 2015 City/County Evacuation Plan to address the effects of developing Upper Westside. These changes_will be required to reflect the current estimated durations of time until the critical locations along the regional evacuation routes studied in this PM are inundated to a 1-foot depth within 1-hour after a catastrophic levee breach.[19]

2021 Local Hazard Mitigation Plan

SacOES partnered with the Cities of Sacramento, Citrus Heights, Elk Grove, Folsom, Galt, Isleton, Rancho Cordova, and several special districts to update their countywide 2016 Local Hazard Mitigation Plan (2016 LHMP). The 2016 LHMP was approved by FEMA. FEMA requires a LHMP to be updated every five (5) years to incorporate any changes in local conditions and requirements.

While natural hazards such as flooding cannot be prevented, a LHMP forms the foundation for a community's long-term strategy to reduce disaster losses. Communities with a FEMA-

[18] It is recommended that these operational evacuation plans identify the roadways that are prone to rapid inundation in the event of a levee breach. This should allow evacuation planners to identify alternative local evacuation routes and to prioritize their roadway closure plans to allow for early evacuations from the Basin regardless of the location of a levee breach. To hasten the roadway closure response time, it is recommended these plans include pre-event stockpiling of roadway closure materials (e.g., barricades, traffic control and detour signs, traffic cones, flares, and warning lights) at strategic locations near those areas prone to rapid inundation.

[19] These changes are highlighted in the Technical Memorandum included in Appendix C of this PM.

approved LHMP are eligible for FEMA pre- and post-disaster grant funding and for lower costs of flood insurance to residents through the National Flood Insurance Program's (NFIP) Community Rating System (CRS).

The 2021 Local Hazard Mitigation Plan (2021 LHMP) served to update the 2016 FEMA approved 2016 LHMP. The purpose of hazard mitigation is to reduce or eliminate long-term risk to people and property from hazards. Sacramento County, along with 31 incorporated communities and special districts within the County, prepared the 2021 LHMP in order to make the County and its residents less vulnerable to future hazard events, including flood events. Based on a review of the 2021 LHMP and the analysis contained in this PM, the development of Upper Westside does not require any modifications to the 2021 LHMP.

13. SUPPLEMENTAL MODELING ANALYSIS

A. GEI Peer Review

During the County's review of an earlier draft of this Procedural Memorandum, the County retained GEI Consultants to perform a peer review of the flood modeling portions of the technical analyses contained therein. Specifically, the County asked GEI to review the modeling changes described in Appendices C & D – the 2022 levee breach analyses prepared by CESI – to independently determine whether the 2015 City/County Evacuation Plan and the 2021 LHMP needed to be updated as a result of the development of Grandpark and Upper Westside.

The comments received from GEI's peer review were mostly confirmational and advisory in nature with regards to the modeling changes that were prepared by CESI with one minor exception. The exception related to the difference between the assumption sets for breach length and scour pit formation in GEI's 2015 modeling effort and CESI's 2022 modeling effort. GEI suggested that it would be interesting to determine what differences in modeling results would occur if the two sets of analyses used the same breach and scour pit assumptions.

Even though GEI did not identify any meaningful issues with the 2022 modeling effort, as their findings indicated the 2022 modeling effort was technically adequate, the difference in breach length and scour pit formation assumption sets were deemed to be interesting enough to warrant further investigation.

Accordingly, in response to the comment regarding breach lengths and scour pits formation, the applicants directed CESI to perform a supplemental analysis using the updated 2022 modeling work with the 2015 breach and scour pit assumption set to facilitate identification of material differences in modeling results between 2015 and the 2022 modeling effort, if any.

B. Supplemental Analysis Results

The results of this supplemental analyses are presented in Appendix E (CESI Technical Memorandum 0040A). The general finding of the supplemental analysis brings about consistency in levee breach assumptions when using the improved modeling software. This modeling effort demonstrated slightly greater elapsed times to one foot of flooding at a majority of critical locations along the evacuation routes identified earlier in this Procedural Memorandum. In general, the 2024 supplemental analysis found that the resulting timing for flood inundation propagation from each of the seven breach locations were relatively consistent with those found in the 2015 flood mapping analysis.

Specifically, the key observations from this supplemental analysis are listed below:

1. The 2015 assumption set for breach length and scour pit formation allowed the levee breaches and scour pits to form to the full depth and height in all seven simulated locations regardless of the landside toe elevations. However, this change in the modeling assumption did not increase the amount of flow significantly to the interior of the basin.

2. The landside elevations that the breaches could flow to as an exit from the breach weir location did contribute to some higher flow rates into the Natomas Basin in a few of the analyses.

3. However, the addition of a full depth scour pit delayed some flow delivery and reduced overall peak flows. This is likely due to the fact that during the breach formation, the scour pit operated at a water surface elevation below the exterior river water surface elevation as there are head losses for the flow passing through the breach. The lower water surface elevation of the scour pit delivering water to the landside terrain therefore had less potential energy to drive the flood waters to spill over the terrain. Also, because the scour pit flood elevation is above the terrain elevations, the head to drive flood waters through which the breach operates was less when the near submergence.

4. The changes in breach length and scour pit formation assumptions generally resulted in less flooding depths and longer flood timings for all seven breach locations studied. This suggests that for total flow and timing, the importance of the breach formation depths was not as significant as the elevations of the

landside terrain the flood waters eventually must pass over after passing through the breach and scour pit.

5. Finally, the changes in timings in the two 2D models (Existing Conditions and Cumulative Conditions) stayed similar to the previous analysis and was not sensitive to the issues raised in the GEI Comments.

C. Additional Findings

There were several additional findings from the supplemental analysis that are worth noting:

1. Breach 6

   Based on the results of the supplement analysis contained in TM 0040A, Breach 6 is another place where rapid inundation is possible. The three locations where rapid inundation is possible for Breach 6 are (a) Elkhorn, (b) I-80 Central, and (c) I-80 West.

   Two of these three locations were previously identified as rapid inundation locations: (b) I-80 Central, and (c) I-80 West. These two locations are subject to rapid inundation and should be treated as such in any emergency planning activities.

   However, while the Elkhorn location was identified as a possible rapid inundation location, inspection of the developed conditions topographic mapping used in the supplemental analysis reveals that the roadway in this vicinity was incorrectly mapped at its existing elevation in the cumulative analysis. In reality, the conceptual rough grading plan for this roadway is shown to be raised to elevation 21.5 feet – well above the developed conditions 200-year flood plain – and significantly above the elevation that will be subject to rapid inundation. Accordingly, this location can be eliminated from the list of rapid inundation locations.

   The table on Page 27 is hereby amended to show Breach 6 (American River Near Confluence with Sacramento River) with two critical locations: (1) I-80 Central, and (2) I-80 West. A new table of critical locations along major evacuation routes where rapid inundation is projected to occur is presented below:

Breach No.	**Breach Description**	**Critical Locations**
1	Natomas Cross Canal Levee	None
2	North Sacramento River Levee	None
3	Sacramento River Levee Near Elverta Road	Elkhorn West I-5 West Powerline
4	Sacramento River Levee South of I-5	Elkhorn West I-5 Junction I-5 West
5	Sacramento River Levee Near I-80	I-80 Central I-80 West
6	American River Near Confluence with Sacramento River	I-80 Central I-80 West
7	NEMDC Levee Near I-80	El Camino Avenue I-80 East San Juan Avenue

Further, Exhibit 10 shows the location of the two rapid inundation locations associated with Breach 6 and hereby replaces Exhibit 5 above for the purposes of the 2024 analyses. Finally, Exhibit 11 shows the two locations of rapid inundation for Breach 6. Exhibits 10 and 11 are shown below.

2. Immaterial Reduction in Duration of Time

   Similar to the results of the 2022 analyses, the results of the 2024 analyses revealed several locations where insignificant reductions in duration of time to 1-foot depth of flooding at critical locations along evacuation routes occur. For the same reasons as explained earlier in this Procedural Memorandum, these reductions were deemed immaterial in the supplemental analysis.

3. Numerically Large Reductions in Duration of Time

   Again, similarly to the results of the 2022 analyses, the results of the 2024 analyses revealed several locations where numerically large reductions in duration of time to 1-foot depth of flooding at critical locations along evacuation routes occur. For the same reasons as explained earlier in this Procedural Memorandum, these large reductions were deemed immaterial in the supplemental analysis.

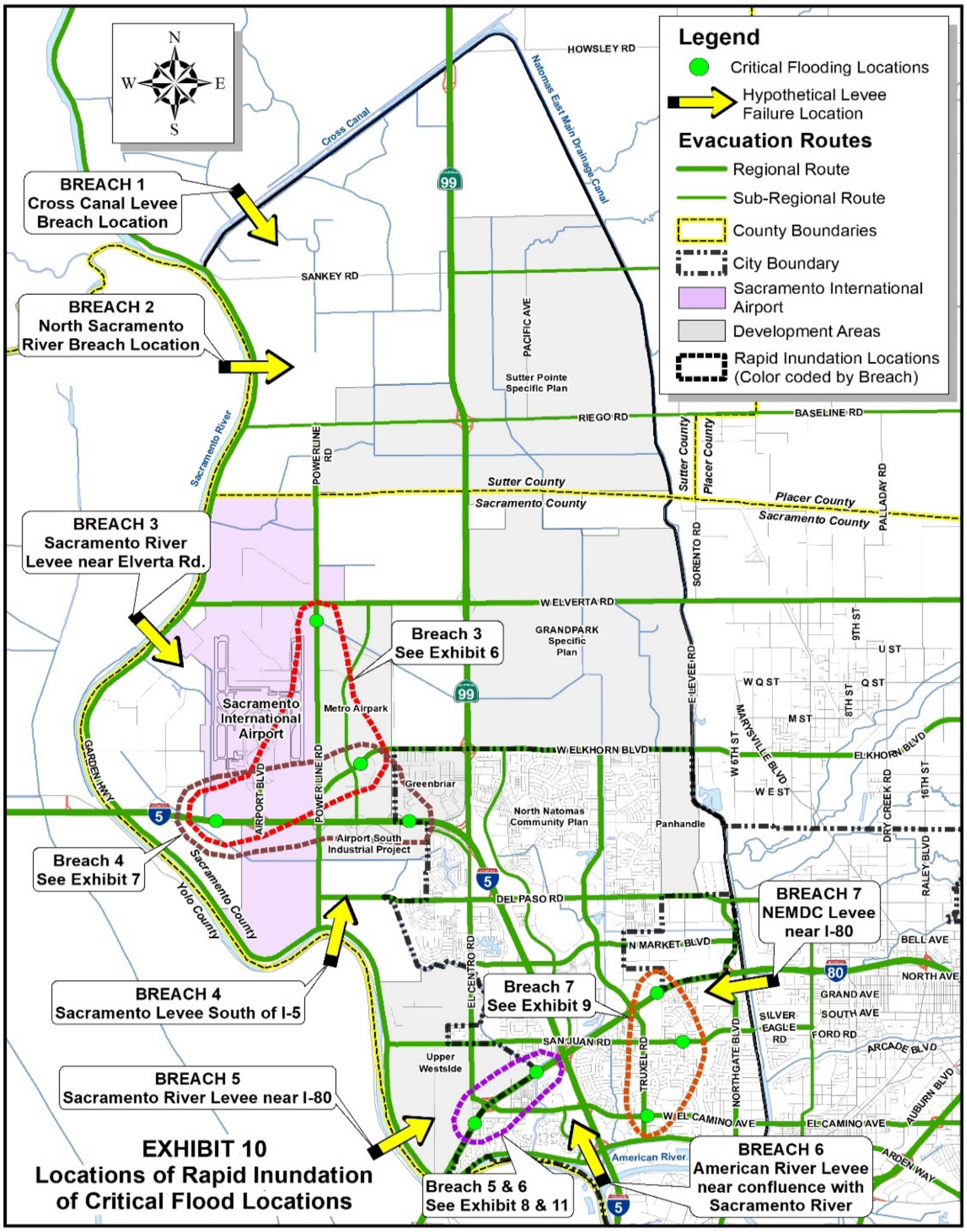


Exhibit 10
Locations of Rapid Inundation of Regional Evacuation Routes

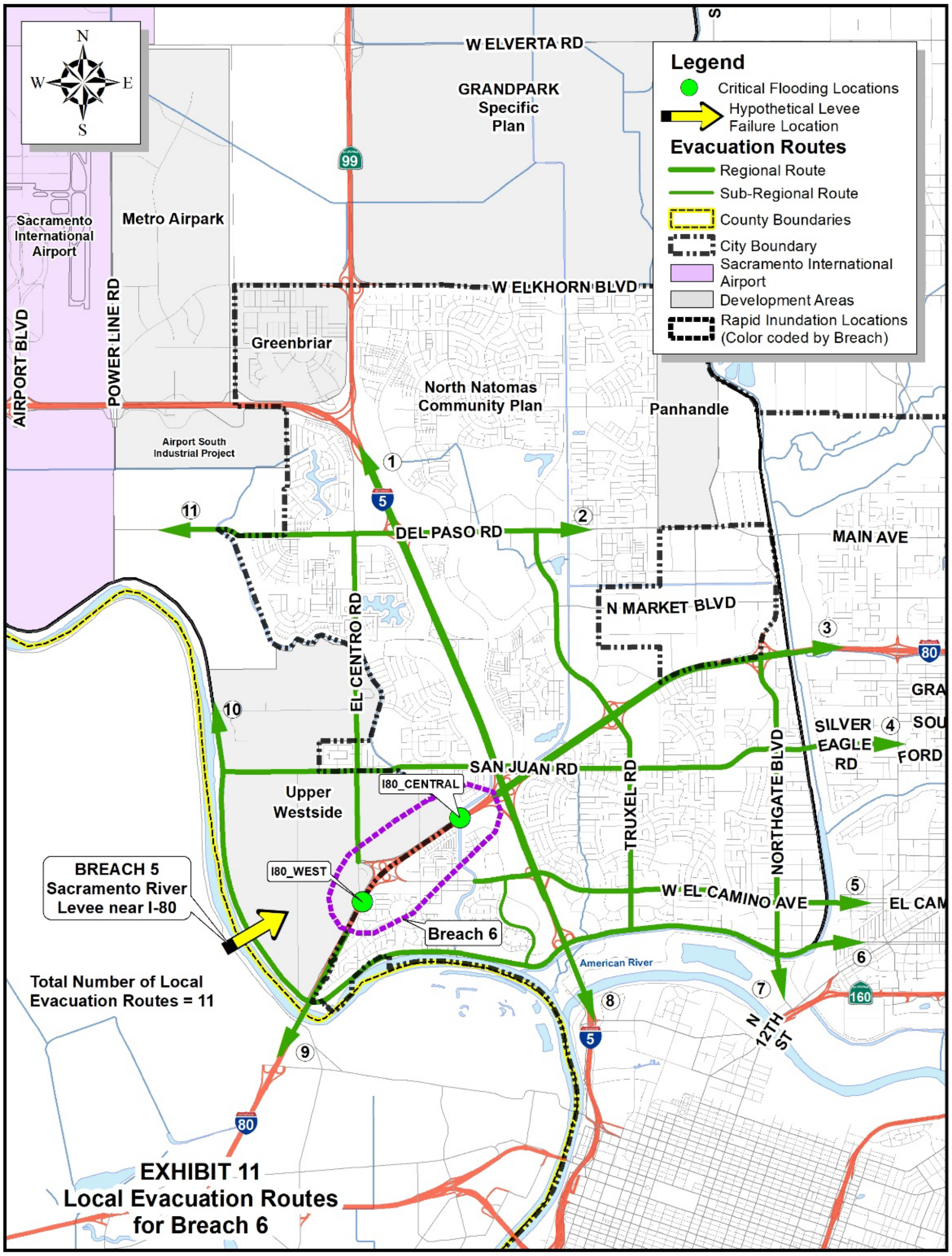


Exhibit 11
Local Evacuation Routes for Breach 6

4. Time to 1-Foot Depth of Flooding

   Inspection of the results of the supplemental analysis contained in Appendix C reveals that the duration of time to 1-foot of flooding depth at the critical locations along the major evacuation routes has generally increased. In addition to the decrease volumes of flow passing through the theoretical breach locations as a result of the use of the 2015 breach formation assumptions, the decrease in the durations of time to 1-foot of flooding depth is a result of the way the newer version of the HEC-RAS software calculates the overland flow time.

   The 2015 version of the HEC-RAS software used a “basin” approach that did not include overland flow durations. In reality, water does not instantaneously flow from one location to another as was calculated in the 2015 version of HEC--RAS. Rather, it takes time for flows spilling through a breach to reach distant locations with the Natomas Basin. It is primarily for this reason that the duration of time to 1-foot of flooding depth at the critical locations generally increases at the critical locations along the major evacuation routes.

5. Maximum Depth of Flooding

   The table below indicates the maximum flooding water surface elevations under Existing and under Cumulative Plus Project Conditions (C+P) for each of the seven breach locations. Generally, the supplemental analysis revealed that the maximum water surface elevation of flooding within the Natomas Basin is projected to be lower than that shown on the 2015 City/County Evacuation Plan.

   The reasoning behind this finding is principally the result of two differences between the modeling performed in 2015 and 2024:

   a. Lower rates and volumes of flood waters entering the Natomas Basin as revealed by the 2024 modeling, and

   b. The longer period of time required to reach stabilized levels of flooding with the external rivers and streams. As more time passes, the external rivers and streams are experiencing a falling of flood stages.

Notes:

Supplemental Analysis
Maximum Flooding Water Surface Elevations
(Existing and C+P Conditions)

Breach Scenario	GEI 1D Existing	UWS Existing	UWS Cumulative	Grandpark Existing	Grandpark Cumulative	Approximate WSE Change
1 Natomas Cross Canal	37.56’	31.66’	31.66’	31.66’	31.66’	<6.0 Feet>
2 Sac. River North	31.80’	23.81’	23.84’	23.81’	23.84’	<8.0 Feet>
3 Sac River North (Central)	29.19’	24.95’	24.96’	24.95’	24.96’	<4.2 Feet>
4 Sac River Central	32.28’	29.60’	29.61’	29.60’	29.61’	<2.7 Feet>
5 Sac River South	26.29’	20.64’	20.91’	20.61’	20.91’	<5.4 Feet>
6 American River	27.06’	18.21’	18.38’	18.21’	18.38’	<8.7 Feet>
7 NEMDC	23.16’	23.29’	23.31’	23.29’	23.31’	+0.1 Feet

1. All elevations are based on the North American Vertical Datum of 1988 (NAVD 88). Horizontal Datum is CA State Plane Zone II Projection.
2. The Approximate Water Surface Elevation (WSE) Change reflects differences between the results of the GEI 1D Existing Conditions modeling performed in 2015 and the Cumulative Conditions modeling completed in 2024 supplemental analysis by CESI.
3. This table supersedes Table 17 mentioned above for the results of the supplemental analysis.

D. Summary

In summary, with the exception of longer durations of time to 1-feet depth of flooding and a lower depth of maximum flooding, a review of Technical Memorandum 0040A (Appendix C) indicates that the findings of this supplemental analysis are generally consistent with both the 2015 City/County Evacuation Plan, and the analysis and findings of the 2022 modeling results presented earlier in this Procedural Memorandum. The longer durations of time and the lower maximum depths of flooding are positive findings that resulted from the use of the newer version of HEC-RAS flood modeling software and better topographic mapping.

Therefore, it is evident that neither the 2015 City/County Evacuation Plan nor the 2021 LHMP will require any changes as a result of the development of Upper Westside. That is, the supplemental analysis did not result in a finding that flooding in the Natomas Basin as a result of a catastrophic levee breach is projected to be an adverse impact from the development of Upper Westside.

14. REGIONAL FLOOD PROTECTION IMPROVEMENTS AND CLIMATE CHANGE[20]

There have been several changed conditions in the regional flood protection system since the City/County Evacuation Plan was prepared in 2015. The following narrative provides a layperson's explanation of these changed conditions that are intended to help the reader understand the conservative nature of the analysis contained in this Procedural Memorandum.

There are eight (8) principal changes in circumstances that one can logically reason that the analysis used to prepare the 2015 City/County Evacuation Plan and the analyses presented in this Procedural Memoranda is conservative in nature. These changes in circumstances are as follows:

1. **Improved Natomas Basin Levees**. The 2015 levee breach analysis was prepared based on the assumption that the condition of the levees in the modeling reflected the physical state of the levees as they existed in 2015. Since that time, many of the most critically weak levees have been improved (e.g., slurry walls, raising of the top heights, sub-excavated out sand lenses, reconstructed the levees as engineered structures, and/or buttressed). Accordingly, the 2015 modeling assumed weak levees that were susceptible to rapid failure, wide and deep breaches, and large volumes of water entering the Natomas Basin.

[20] The text for this section of the PM was developed from the content of a personal conservation between Ken Giberson (MacKay & Somps) and Chris Ferrari (GEI Consultants) on August 10, 2023.

Neither the 2024 analysis nor the supplemental analyses prepared for this Procedural Memorandum reflected the ongoing improvements to the Natomas Basin. These improvements, both those completed to date and those projected to be completed in the next few years, has, and will continue to significantly strengthen these levees over the levels that existed in 2015 when the City/County flood mapping exercise was completed. Today's levees are now much stronger and less susceptible to rapid failure and very wide levee breaches than they were in 2015.

Because of these improvements, significantly lower volumes of water could enter the Natomas Basin than suspected in 2015. Additionally, longer durations of time for the flood waters to reach the critical depth flooding threshold of one foot of depth at critical locations along the major evacuation routes with the Natomas Basin are reasonably anticipated to occur. Therefore, intuitively, it can be concluded that evacuation times would be longer than those predicted in this Procedural Memorandum.

2. **Better Weather Forecasting**. Today's weather forecasting models are highly accurate in their ability to provide advanced weather forecasts 7-10 days in advance of a storm event; much more advanced and accurate than the models that were available in 2015. These weather forecasting tools provide valuable information to the operators of the valley's reservoirs and rivers to aid in long-term flood forecasting – as much as 10-15 days advanced warning.
3. **Better River Flow Forecasting**. Current river forecasting models are much better today than existed in 2015. Additionally, these models have been calibrated to a degree of accuracy that they closely mimic real time river flows such as occurred during the storms of the winter of 2022/2023. Therefore, together with the better weather forecasting tools, today's river forecasting models provide more reliable flood forecasts.
4. **Better Operation of Reservoirs and Rivers**. These modern weather and flood forecasting tools allow the operators of the valley's reservoirs and streams to anticipate reservoir inflows and water levels a week or more in advance of the occurrence of major storms. This allows more time for the operators to plan for the impending flood flows and to release stored water in the reservoirs far in advance of a major storm event. This allows the reservoir system to create more flood storage

and the river system to convey those initial release flows to safely flow through the river system and out to the ocean. [21]

5. **Improved Bypass Facilities**. Currently underway are various efforts to widen local weirs and bypasses to convey a larger portion of the flood flows than historically possible. These weirs and bypass improvements will lessen the flows and water surface elevations in the Sacramento and American Rivers and lessen the pressure on the levee system protecting the Natomas Basin.

   There are efforts underway at this time with the construction work to widen the Sacramento Weir and Bypass, and the planning work that should lead to the widening of the Fremont Weir and the Yolo Bypass. The net effect of these improvements would be to lower the maximum stage in the Sacramento and American Rivers along the length of the Natomas Basin by about 1-foot.

   This lowering in river stages will reduce the pressures on the Natomas Levee system and reduce the potential for a levee breach. With lower stages in the river, not as much water will flow through a breach if it were to occur, and the time to critical depth of flooding of evacuation routes within the basin will increase.

6. **Additional Storage at and Upstream of Folsom Dam**. SAFCA and its flood protection partners have provided and are planning to provide additional storage in the American River watershed over time. These storage projects include:

   a. The recent construction of the auxiliary spillway which allows early and greater lowering of storage levels in the reservoir in anticipation of receiving peak inflows from the American River watershed during peak storm events,

   b. The on-going effort to increase in the height of Folsom Dam,

   c. The reoperation of Folsom Lake to create more storage for winter-time storm events (see Item 4 above), and

   d. The possibility of creating more flood storage farther up in the Folsom Reservoir watershed.

   These improvements will increase the level of flood protection for the Natomas Basin through lowering the maximum river stage in the Sacramento and American Rivers

[21] Advanced reservoir operations forecasting is referred to as Forecast Informed Reservoir Operations (FIRO). FIRO is a reservoir operations strategy that better informs decisions to retain or release water stored in the reservoir by integrating additional flexibility in operation policies and rules with enhanced monitoring and improvement weather and runoff forecasts. Source: American Meteorological Society; 2020).

during major flood events. This will help to reduce the pressure on the Natomas Bain levee system and decrease the potential for, and the severity of, flooding within the basin during a levee breach, thereby increasing the time to critical depth of flooding and increasing the evacuation time within the basin.

7. **Prior Lack of Evacuation Planning.** The 2015 modeling effort focused on time to critical depth of flooding of evacuation routes, not on emergency planning in the event of a levee breach. While some discussion about emergency planning occurred in 2015, it was not a major emphasis of the 2015 City/County Evacuation Plan.

   Additionally, the lack of definitive plans for evacuation of the Natomas Basin have not been prepared by the responsible emergency agencies and first responders. The suggestion in the Memoranda that emergency response agencies and first responders should formerly plan for immediate response to the threat of a levee breach (e.g., first responders focusing on the areas of early and rapid flooding, the pre-staging of evacuation route management[22]) will increase the safety of the general public during a flooding event.

8. **Effects of Climate Change**. Regional flood protection experts believe that current climate change modeling suggests that the resulting increase of peak flows in the river system from climate change will result in about a 1-foot increase in the maximum stage of the Sacramento River near the Natomas Basin. This, however, does not consider the reductions in the maximum river stage because of the current and future flood control and management improvements discussed above (e.g., improved levees, increased bypass capacities, storm and river forecasting leading to improved operations of reservoirs and river flows, etc.).

   When these two sets of factors are considered together, one can reasonably conclude that the effects of climate change, in and of itself, will not significantly increase the likelihood of levee breach occurrences of the Natomas Basin levee system. To a large degree, and perhaps totally, the effects of climate change will be offset by the benefits that will result from weather and river forecasting, reservoir system reoperations (FIRO), and the construction of additional flood control improvements (e.g., Natomas Basin levee, Folsom Dam improvements, and flood bypass improvements).

[22] For example, portable road barricades, warning lights and signs, and detour signs could be stored at staging areas near the critical locations along regional evacuation routes.

13. FINDINGS & CONCLUSIONS

A major finding of the analysis presented in this PM is that the improved modeling capabilities of the newer versions of HEC-RAS resulted in a more accurate analysis of the effects of catastrophic flooding that might occur within the Basin in the event of a levee breach. The use of newer HEC-RAS modeling software allowed for the development of a more accurate representation of the projected effects of a catastrophic levee breach in terms of flood evacuation planning and in terms of the maximum depth of flooding during a catastrophic levee breach.

Under C+P Conditions, the duration of time to 1-foot depth of flooding at critical locations along the regional evacuation routes within the Basin were generally found to be longer than projected in the 2015 GEI analysis under existing conditions.

Another major finding of this PM is that the development of Upper Westside will not have a material effect on the existing rate of flood inundation propagation or the maximum depth of flooding within the Basin in the hypothetical event of a levee breach. This finding applies to C+P Conditions.

The 2022 modeling effort identified nine (9) locations where rapid inundation of a regional evacuation route is projected to occur under one (1) or more of the hypothetical levee breach scenarios. For example, under the Breach No. 3 scenario, there are three (3) locations where rapid inundation is projected to occur. Breach No. 4 has three (3) locations, Breach No. 5 has two (2) locations, and Breach No. 7 has three (3) locations. Breach Nos. 3 and 4 both affect two (2) common locations out of the three (3) locations mentioned above.

In addition to the same nine (9) locations where rapid inundation of regional evacuation routes were identified in the 2022 flood modeling, the 2024 supplemental analysis revealed that Breach 6 has the same type of rapid inundation effects as mentioned above for Breach 5. Both Breach 5 and 6 affect two (2) common locations: (I-80 Central and I-80 West).

Due to the modeling limitations explained earlier in this PM, any rapid inundation time frames under twelve (12) hours are deemed to occur “immediately”, or nearly so after a levee breach. Rapid inundation of these critical locations is projected to occur in the same relative time frames under Existing Conditions and C+P Conditions regardless of the levee breach assumption set used in the flood modeling analysis. That is to say, the development of Upper Westside does not adversely affect the rapidity of flooding of these critical locations.

Depending upon the location of an actual breach, the affected roadways should be closed to the traveling public prior to or immediately following the occurrence of a levee breach in their respective locations. The affected roadways most prone to rapid inundation are located in the vicinity of Breach Nos. 3, 4, 5, 6, and 7, respectively.

Further, the identification of the roadways that are prone to rapid inundation in the event of a levee breach provides evacuation planners with a clear picture of which evacuation routes are not prone to rapid inundation. This finding should allow evacuation planners to prioritize their roadway closure plans to allow for early evacuations from the Basin regardless of the location of a levee breach, including the use of alternative local routes (as necessary). Accordingly, it is concluded that post development of Upper Westside, there will be adequate time to allow movement of citizens to a place of relative safety via a route that does not pose significant danger. Further, it is concluded that the maximum depth of flooding within the Basin in the event of a levee breach is not materially changed from existing conditions under C+P Conditions.

Further, using the 2022 breach assumption set it is concluded that the maximum depth of flooding within the Basin in the event of a levee breach is not materially changed from existing conditions under both E and C+P Conditions. However, when using the 2015 breach assumption set it is concluded that the maximum depth of flooding within the Basin is significantly reduced under C+P Conditions as compared to the depths of flooding determined in the 2015 flood modeling effort that supported the 2015 City/County Evacuation Plan. This difference indicates that the depth of flooding from a levee breach is somewhat variable, and it will depend on the location, the length of the levee breach, and the depth of scour pits that are really formed during an actual levee breach scenario.

Finally, based on the findings of the analysis presented in this PM, it is evident that the development of Upper Westside will not require any changes to the SacOES plans and the 2021 LHMP. A few minor changes in the 2015 City/County Evacuation Plan may be advisable to reflect the different durations of time until the critical locations along the regional evacuation routes studied in this PM are inundated to a 1-foot depth within 1-hour after a catastrophic levee breach.

14. LIMITATIONS

This PM, prepared in support of the Upper Westside project, was prepared to the best of our knowledge and judgement to satisfy our understanding of its intended purposes. It was prepared in a manner consistent with that level of care and skill ordinarily exercised by other members of MacKay & Somps' profession practicing in the same locality, under similar conditions, and on the date the services are provided. The conclusions, opinions, and recommendations contained within this PM are based on our professional judgement and experience in the general geographic area in which the project is located. Some data may have been prepared using information from outside sources that have varying degrees of reliability.

The use or misuse of this information contained in this PM, other than for its intended purposes, as noted, is at the sole risk of the party using the information. MacKay & Somps makes no other representations, guarantees, or warranties, express or implied, regarding its instruments of professional services, communications (oral or written), estimates or reports, and/or opinions contained herein.

This report presents the results of an engineering analysis relating to the duration of time to 1-foot depth of flooding at critical locations along regional evacuation routes and the maximum depth of flooding within the Basin in the event of a catastrophic breach of the levee system protecting the Basin. It is possible that conditions could vary between the location, mode, and rapidity of an actual levee breach as compared to the assumptions contained in this PM. Accordingly, the effect that these changes may result in the need for different evacuation responses than those described in this PM.

This report is based on upon technical analysis by CESI wherein CESI updated the 2015 GEI modeling that was used for the 2015 City/County Evacuation Plan. With the exception of the changes described in this PM, the assumption sets contained in the 2015 GEI models were not changed. The idealized analytical models developed for this PM are based on considerable engineering and hydraulic judgement and experience, and they are intended to be reasonable representations of the conditions and anticipated performance of the levee breach scenarios envisioned herein.

This is particularly true as it relates to the assumption sets contained in the 2015 GEI models as they relate to assumptions on the modes of levee failures and the stages and timing of river flows in the rivers and streams in the vicinity of the Basin. Any errors contained in the 2015 GEI models are the responsibility of others.

If changes occur in these assumption sets, the findings and recommendations contained in this PM should be reviewed and MacKay & Somps should be provided an opportunity to provide additional recommendations and/or to modify the recommendations contained herein, as appropriate. The conclusions and recommendations contained in this report are solely professional opinions and they are subject to potential revision from changes in available data and applicable regulatory criteria. No warranty is expressed or implied.

15. REFERENCES

The analysis upon which this Procedural/Technical Memorandum is based, and upon which the reported findings and conclusions are reached, is predicated upon the following:

1. *Bardini, Gary, Director of Planning, Sacramento Area Flood Control Agency (SAFCA – Personal Conversation, July 21, 2022.)*
2. *City/County of Sacramento Flood Emergency Evacuation Plan – Natomas Study Area* (December 2015).

3. County of Sacramento, *2016 Sacramento Countywide Local Hazard Mitigation Plan Update*, prepared by Foster Morrison Consulting, LLC, December 2016.
4. County of Sacramento, *2021 Sacramento County Multi-jurisdictional Local Hazard Mitigation Plan Update*, September 2021.
5. County of Sacramento, Email Correspondence from Todd Smith, Principal Planner (now the County's Planning Director), to Mike Motroni, et.al, at Wood Rodgers, Inc., dated September 15, 2020, requesting submittal of a Flood Inundation Propagation Procedural/Technical Memorandum.
6. County of Sacramento, Office of Emergency Services (SacOES), *Evacuation Functional Annex*, August 2021.
7. County of Sacramento, Office of Emergency Services (SacOES), *Evacuation Operations Plan – Version 1.0*, April 2017,
8. County of Sacramento, Office of Emergency Services (SacOES), *Operational Area Plan*, March 2019.
9. County of Sacramento, Office of Emergency Services (SacOES), *Sacramento County Recovery Plan*, December 2020.
10. Ferrari, Chris, Project Engineer, GEI Consultants – Personal Communication, June 14, 2022, and August 10, 2022.
11. Flynn-Nevins, Mary Jo, Chief of Emergency Services, Sacramento County Office of Emergency Services (SacOES) – Personal Conversation, September 9, 2022.
12. Plummer, Thomas, Principal, Civil Engineering Solutions, Inc. (CESI) – Personal Communications, various dates.
13. "Sankey Road Gap Closure Project Basis of Design Report," SAFCA (May 22, 2018).
14. "Technical Memorandum No. 0040, Grandpark Flood Control and Storm Drainage Master Plan – Levee Breach Analysis – Cumulative Analysis", Civil Engineering Solutions, Inc., (CESI), November 7, 2022. See **Appendix B**.
15. "Technical Memorandum No. 0040A, Grandpark Flood Control and Storm Drainage Master Plan – Levee Breach Analysis – Cumulative Analysis", Civil Engineering Solutions, Inc., (CESI), May 3, 2024. See **Appendix C**.

Table 1

**Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 1: Natomas Cross Canal Levee**

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Decreased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	22	39	50	+11 Hours
El Camino Ave.	36	52	63	+11 Hours
Elkhorn	38	39	50	+11 Hours
Elkhorn West	73	96	104	+8 Hours
Elverta	47	42	49	+7 Hours
Elverta West	106	116	111	-5 Hours
I-5 Central	106	125	128	+3 Hours
I-5 Junction	79	79	111	+32 Hours
I-5 West	73	96	104	+8 Hours
I-80 Central	58	73	74	+1 Hour
I-80 East	31	46	63	+17 Hours
I-80 West	63	80	79	-1 Hour
Natomas Road	28	36	47	+11 Hours
Power Line	92	116	124	+8 Hours
San Juan Ave.	36	52	62	+10 Hours
SR-99	89	93	62	-31 Hours
SR-99 North	98	98	39	-59 Hours
SR-99 South	135	145	147	+2 Hours
Averages	67	79	82	+3 Hours

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 2

Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 2: North Sacramento River Levee

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	14	22	26	+4 Hours
El Camino Ave.	22	29	33	+4 Hours
Elkhorn	20	20	24	+4 Hours
Elkhorn West	45	52	36	-16 Hours
Elverta	25	18	21	+3 Hours
Elverta West	43	33	14	-19 Hours
I-5 Central	53	56	57	+1 Hour
I-5 Junction	47	55	58	+3 Hours
I-5 West	44	52	55	+3 Hours
I-80 Central	34	39	38	-1 Hour
I-80 East	18	25	32	+7 Hours
I-80 West	32	39	40	+1 Hour
Natomas Road	17	20	24	+4 Hours
Power Line	55	53	65	+12 Hours
San Juan Ave.	22	28	32	+4 Hours
SR-99	35	22	19	-3 Hours
SR-99 North	12	15	14	-1 Hour
SR-99 South	87	88	88	0 Hours
Averages	35	37	38	+1 Hour

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 3

Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 3: Sacramento River Levee Near Elverta Road

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	33	37	37	0 Hours
El Camino Ave.	30	36	36	0 Hours
Elkhorn	43	48	46	-2 Hours
Elkhorn West	4	9	9	0 Hours
Elverta	47	53	61	+8 Hours
Elverta West	79	82	81	-1 Hour
I-5 Central	67	48	46	-2 Hours
I-5 Junction	10	13	13	0 Hours
I-5 West	9	7	6	-1 Hour
I-80 Central	17	24	25	+1 Hour
I-80 East	40	40	37	**-3 Hours**
I-80 West	23	28	27	-1 Hour
Natomas Road	38	44	44	0 Hours
Power Line	17	6	5	-1 Hour
San Juan Ave.	30	36	36	0 Hours
SR-99	66	71	73	+2 Hours
SR-99 North	75	80	84	+4 Hours
SR-99 South	129	127	125	-2 Hours
Averages	42	44	44	0 Hours

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 4

Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 4: Sacramento River Levee South of I-5

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	38	38	37	-1 Hour
El Camino Ave.	33	37	37	0 Hours
Elkhorn	47	51	49	-2 Hours
Elkhorn West	9	8	8	0 Hours
Elverta	52	56	65	+9 Hours
Elverta West	80	78	77	-1 Hour
I-5 Central	69	55	53	-2 Hours
I-5 Junction	9	8	8	0 Hours
I-5 West	6	6	6	0 Hours
I-80 Central	18	23	24	+1 Hour
I-80 East	44	42	39	-3 Hours
I-80 West	24	28	26	-2 Hours
Natomas Road	42	46	47	+1 Hour
Power Line	21	19	19	0 Hours
San Juan Ave.	33	37	37	0 Hours
SR-99	70	75	78	+3 Hours
SR-99 North	78	83	85	+2 Hours
SR-99 South	101	99	97	-2 Hours
Averages	43	44	44	0 Hours

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 5

Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 5: Sacramento River Levee Near I-80

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	21	19	18	-1 Hour
El Camino Ave.	19	18	16	-2 Hours
Elkhorn	39	36	30	-6 Hours
Elkhorn West	57	25	26	+1 Hour
Elverta	50	46	60	+14 Hours
Elverta West	112	110	113	+3 Hours
I-5 Central	100	96	90	-6 Hours
I-5 Junction	27	30	34	+4 Hours
I-5 West	19	23	25	+2 Hours
I-80 Central	9	8	6	-2 Hours
I-80 East	21	19	18	-1 Hour
I-80 West	9	6	3	-3 Hours
Natomas Road	30	29	27	-2 Hours
Power Line	46	51	55	+4 Hours
San Juan Ave.	19	18	16	-2 Hours
SR-99	84	83	83	0 Hours
SR-99 North	22	98	102	+4 Hours
SR-99 South	99	99	97	-2 Hours
Averages	44	45	46	+1 Hour

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., "-1 hour") is considered "no change" in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 6

**Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 6: American River Levee Near Confluence with Sacramento River**

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	10	76	118	+42 Hours
El Camino Ave.	4	31	32	+1 Hour
Elkhorn	21	No Flooding	No Flooding	No Flooding
Elkhorn West	14	No Flooding	No Flooding	No Flooding
Elverta	29	No Flooding	No Flooding	No Flooding
Elverta West	65	No Flooding	No Flooding	No Flooding
I-5 Central	57	No Flooding	No Flooding	No Flooding
I-5 Junction	17	No Flooding	No Flooding	No Flooding
I-5 West	11	No Flooding	No Flooding	No Flooding
I-80 Central	137	143	156	+13 Hours
I-80 East	6	40	42	+2 Hours
I-80 West	141	148	162	+14 Hours
Natomas Road	16	No Flooding	No Flooding	No Flooding
Power Line	31	No Flooding	No Flooding	No Flooding
San Juan Ave.	4	30	31	+1 Hour
SR-99	53	No Flooding	No Flooding	No Flooding
SR-99 North	61	No Flooding	No Flooding	No Flooding
SR-99 South	133	No Flooding	No Flooding	No Flooding
Averages	45	78	90	+12 Hours

Note: A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 7

Effects at Critical Evacuation Route Locations (C+P Conditions)
Breach Location 7: NEMDC Levee Near I-80

Evacuation Route Critical Location	Time to 1-Foot Depth Using Previous 1D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Existing Conditions) In Hours	Time to 1-Foot Depth Using Updated 2D Model (Cumulative + Project (C+P) Conditions) In Hours	Improvement (Increased Delay) in Time to 1-Foot Depth of Flooding In Hours
Del Paso Road	14	15	15	0 Hours
El Camino Ave.	5	6	6	0 Hours
Elkhorn	29	30	25	-5 Hours
Elkhorn West	80	84	76	-8 Hours
Elverta	56	57	159	+102 Hours
Elverta West	No Flooding	No Flooding	No Flooding	No Flooding
I-5 Central	No Flooding	No Flooding	No Flooding	No Flooding
I-5 Junction	88	93	90	-3 Hours
I-5 West	82	86	80	-6 Hours
I-80 Central	26	37	30	-7 Hours
I-80 East	6	2	3	+1 Hour
I-80 West	27	48	39	-9 Hours
Natomas Road	20	22	22	0 Hours
Power Line	140	136	123	-13 Hours
San Juan Ave.	4	4	3	-1 Hour
SR-99	No Flooding	No Flooding	No Flooding	No Flooding
SR-99 North	No Flooding	No Flooding	No Flooding	No Flooding
SR-99 South	No Flooding	No Flooding	No Flooding	No Flooding
Averages	44	48	52	+4 Hours

Note: The locations where the duration in time under E+P Conditions was found to be equal to or greater than under Existing Conditions are highlighted in light green. The locations where the duration in time was found to be less than under Existing Conditions are shown in light yellow highlighting**.** A decrease in time to 1-foot depth of flooding, in hours, of negative 1 hour (i.e., “-1 hour”) is considered “no change” in duration of time due to rounding estimates and/or the inherent accuracy of the modeling software. Hours may not add due to rounding.

Table 8

Reduction in Duration of Time Until Critical Flooding Depth Occurs (Cumulative Plus Project vs. Existing Conditions)

Breach Location (Table No.)	Critical Evacuation Route Location	Reduction in Time (Hours)	Remaining Evacuation Time (Hours)	Comment (See Note 1)
1 (Table 1)	Elverta West	-5 Hours	111 Hours	Adequate Evacuation Time
	SR-99	-31 Hours	62 Hours	Adequate Evacuation Time
	SR-99 North	-59 Hours	39 Hours	Adequate Evacuation Time
2 (Table 2)	Elkhorn West	-16 Hours	36 Hours	Adequate Evacuation Time
	Elverta West	-19 Hours	14 Hours	Adequate Evacuation Time
	SR-99	-3 Hours	19 Hours	Adequate Evacuation Time
3 (Table 113)	Elkhorn	-2 Hours	46 Hours	Adequate Evacuation Time
	I-5 Central	-2 Hours	46 Hours	Adequate Evacuation Time
	I-80 East	-3 Hours	37 Hours	Adequate Evacuation Time
	SR-99 South	-2 Hours	125 Hours	Adequate Evacuation Time
4 (Table 4)	Elkhorn	-2 Hours	49 Hours	Adequate Evacuation Time
	I-5 Central	-2 Hours	53 Hours	Adequate Evacuation Time
	I-80 East	-3 Hours	39 Hours	Adequate Evacuation Time
	I-80 West	-2 Hours	26 Hours	Adequate Evacuation Time
	SR-99 South	-2 Hours	97 Hours	Adequate Evacuation Time
5 (Table 5)	El Camino Ave.	-2 Hours	16 Hours	Adequate Evacuation Time
	Elkhorn	-6 Hours	30 Hours	Adequate Evacuation Time
	I-5 Central	-6 Hours	90 Hours	Adequate Evacuation Time
	I-80 Central	-2 Hours	6 Hours	Rapid Inundation (See Note 2)
	I-80 West	-3 Hours	3 Hours	Rapid Inundation (See Note 2)
	Natomas Road	-2 Hours	27 Hours	Adequate Evacuation Time
	San Juan Ave.	-2 Hours	16 Hours	Adequate Evacuation Time
	SR-99 South	-2 Hours	97 Hours	Adequate Evacuation Time

Breach Location (Table No.)	Critical Evacuation Route Location	Reduction in Time (Hours)	Remaining Evacuation Time (Hours)	Comment (See Note 1)
6 (Table 6)	None	N/A	N/A	N/A
7 (Table 7)	Elkhorn	-5 Hours	25 Hours	Adequate Evacuation Time
	Elkhorn West	-8 Hours	76 Hours	Adequate Evacuation Time
	I-5 Junction	-3 Hours	90 Hours	Adequate Evacuation Time
	I-5 West	-6 Hours	80 Hours	Adequate Evacuation Time
	I-80 Central	-7 Hours	30 Hours	Adequate Evacuation Time
	I-80 West	-9 Hours	39 Hours	Adequate Evacuation Time
	Power Line	-13 Hours	123 Hours	Adequate Evacuation Time

Note:

1. The findings in the Comment column denoted “Adequate Evacuation Time” indicate that the remaining evacuation time (in hours) is significantly greater than a reasonable evacuation time allowance in the event of a levee breach. Additionally, this finding also recognizes that for each location shown there are numerous additional alternative evacuation routes available to the driving public during a flood emergency.
2. While this location is subject to rapid inundation, there are several alternative evacuation routes available to the driving public to relocate from areas of relative danger to areas of relative safety.

Table 9

Upper Westside Maximum Flooding Water Surface Elevations Under C+P Conditions

Breach Location	Existing Conditions (2D)	Cumulative Plus Project Conditions (2D)	Difference in Flooding Elevations	Comment
1	36.85 Feet	36.76 Feet	-0.09 Feet	Slight Decrease In Flooding
2	31.77 Feet	31.78 Feet	+0.01 Feet	Slight Increase In Flooding
3	29.22 Feet	29.23 Feet	+0.01 Feet	Slight Increase In Flooding
4	32.23 Feet	32.24 Feet	+0.01 Feet	Slight Increase In Flooding
5	25.15 Feet	25.14 Feet	-0.01 Feet	Slight Decrease In Flooding
6	16.15 Feet	15.82 Feet	-0.33 Feet	Slight Decrease In Flooding
7	23.23 Feet	23.28 Feet	+0.05 Feet	Slight Increase In Flooding

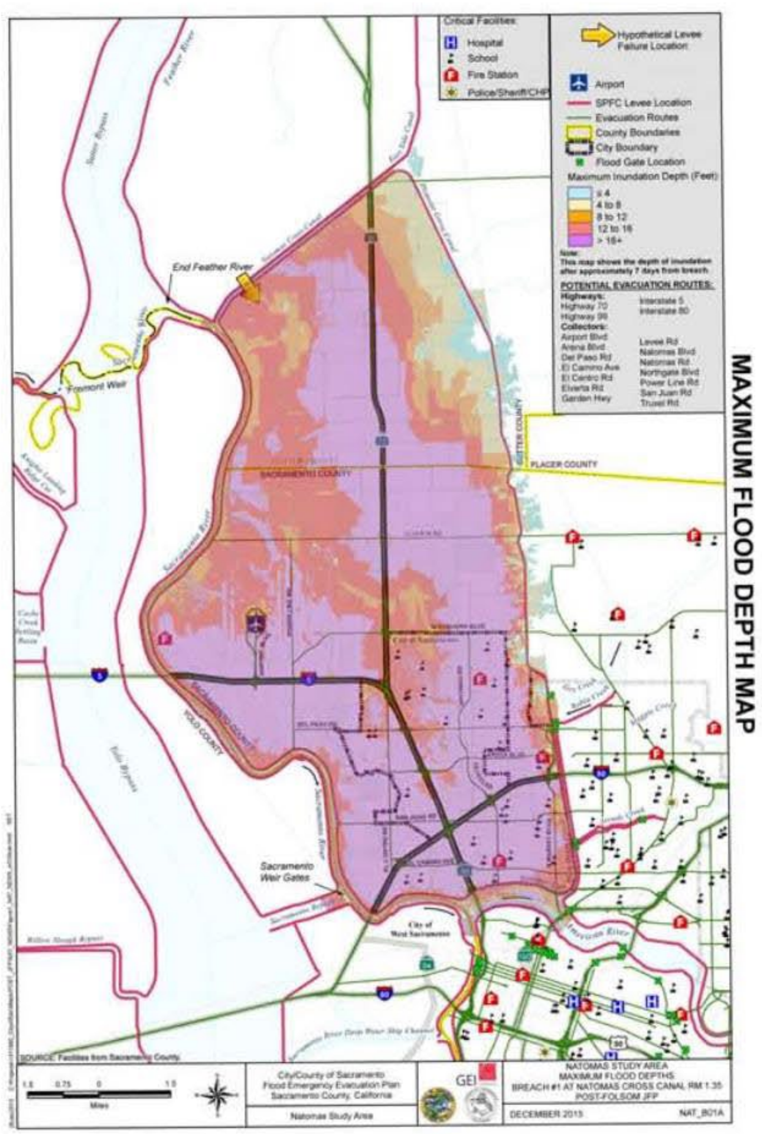
Note: All elevations shown are related to the NAVD 88 Datum. These differences in flooding depth are within the inherent accuracy of the model. Therefore, they are not considered material for the purposes of this PM.

APPENDIX A

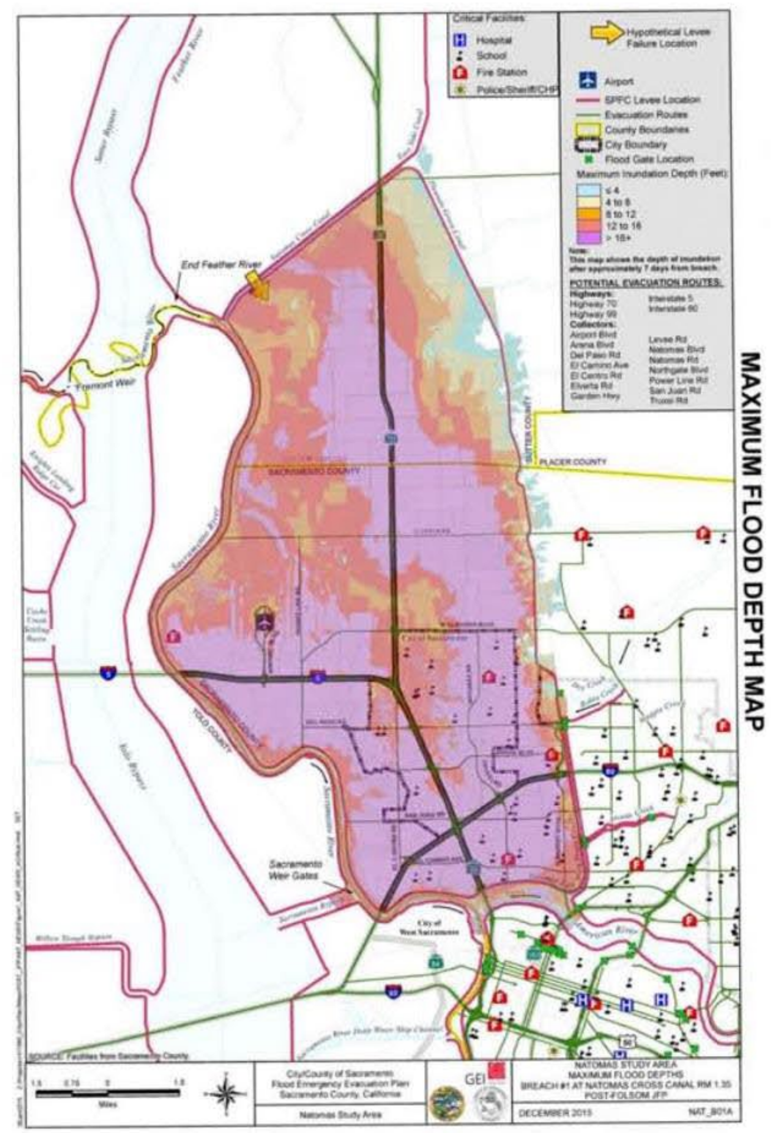
Maximum Depth of Flooding Exhibits

Under Cumulative + Project Conditions (C+P)

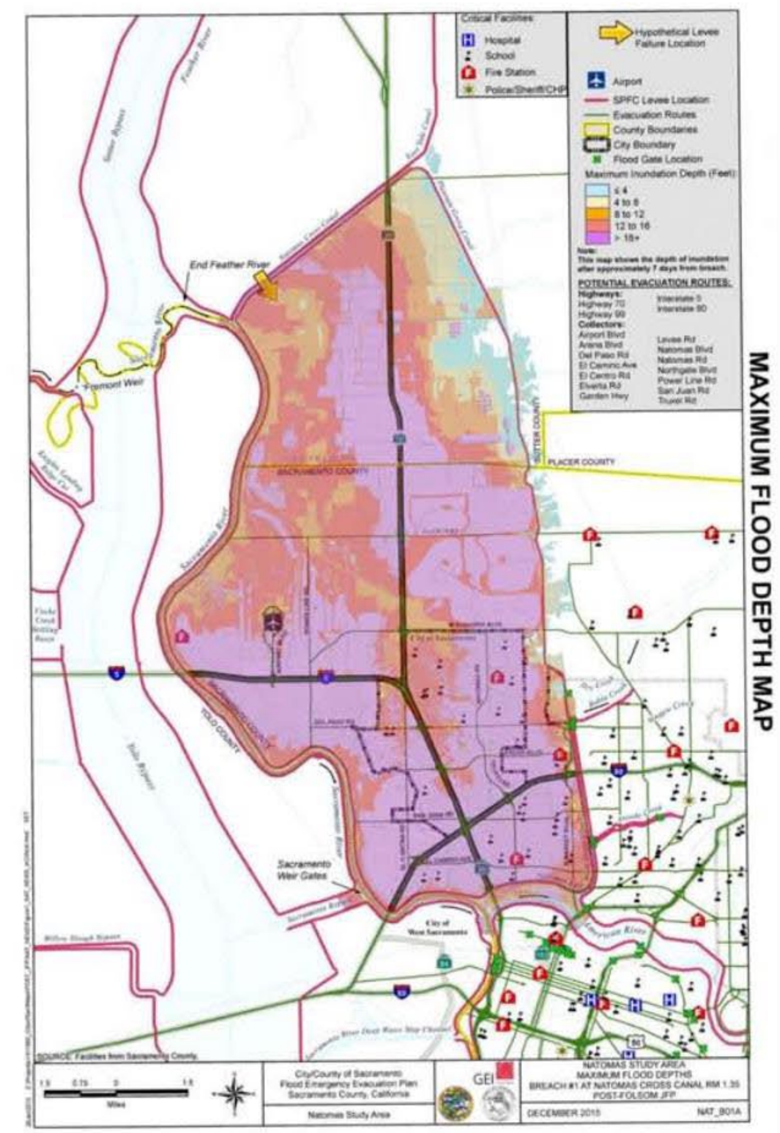
BREACH 1 AT NATOMAS CROSS CANAL
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 1-
1D GEI EXISTING ALTERNATIVE

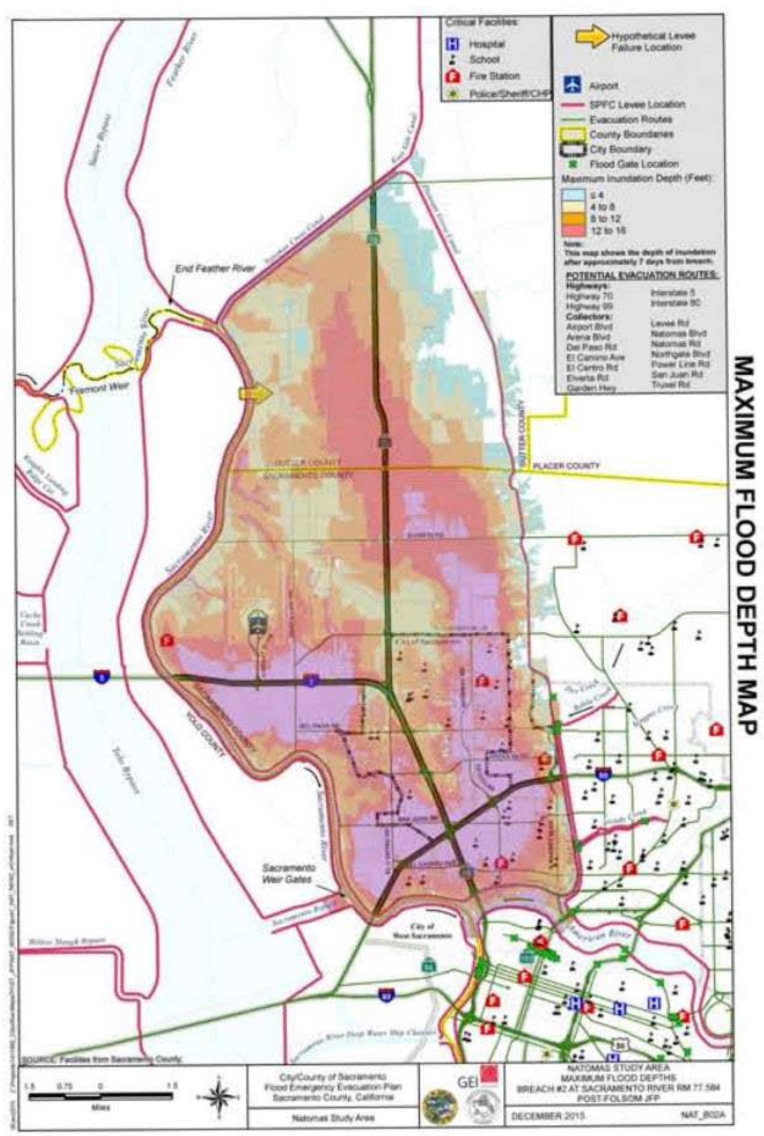


GRANDPARK ANALYSIS - BREACH 1-
2D EXISTING ALTERNATIVE

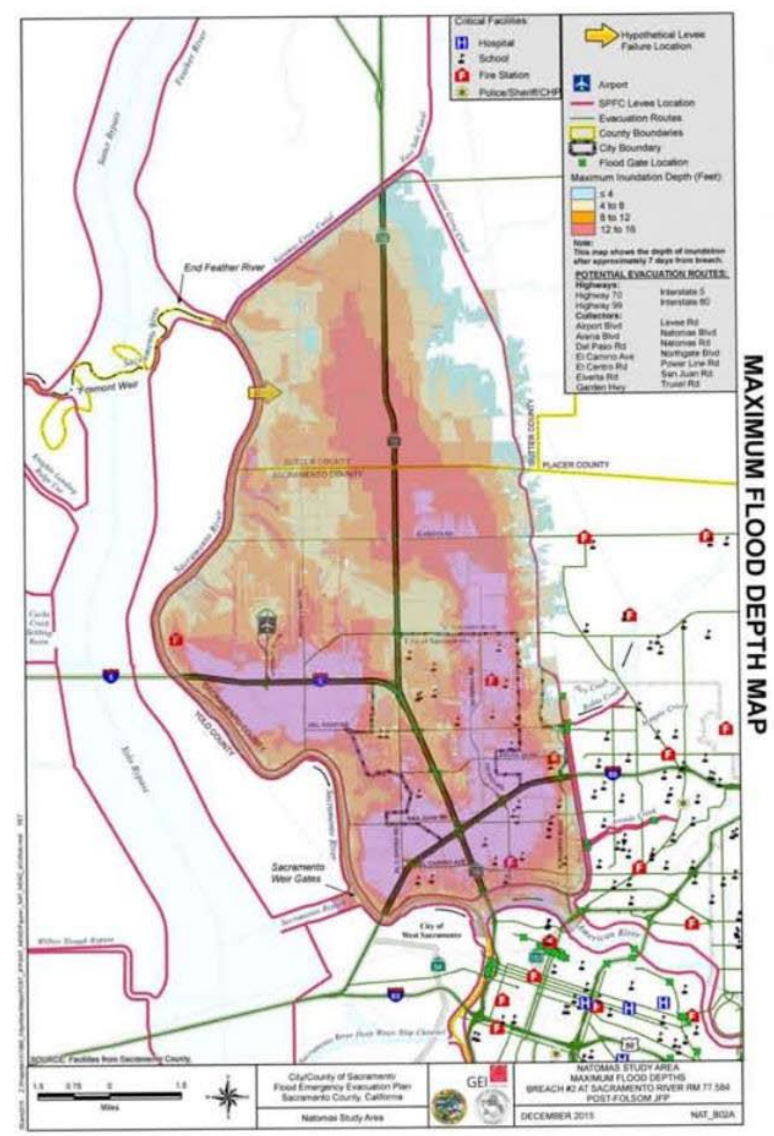


GRANDPARK ANALYSIS - BREACH 1-
2D CUMULATIVE ALTERNATIVE

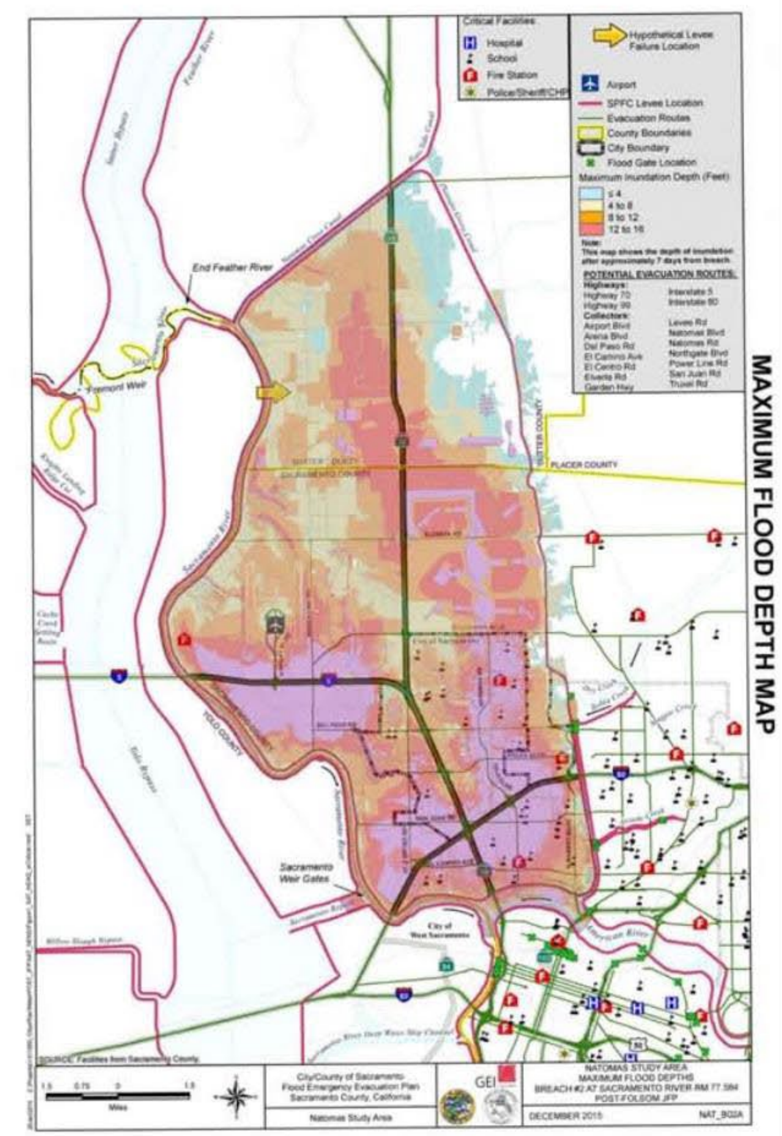
BREACH 2 AT NORTH SACRAMENTO RIVER BREACH
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 2-
1D GEI EXISTING ALTERNATIVE

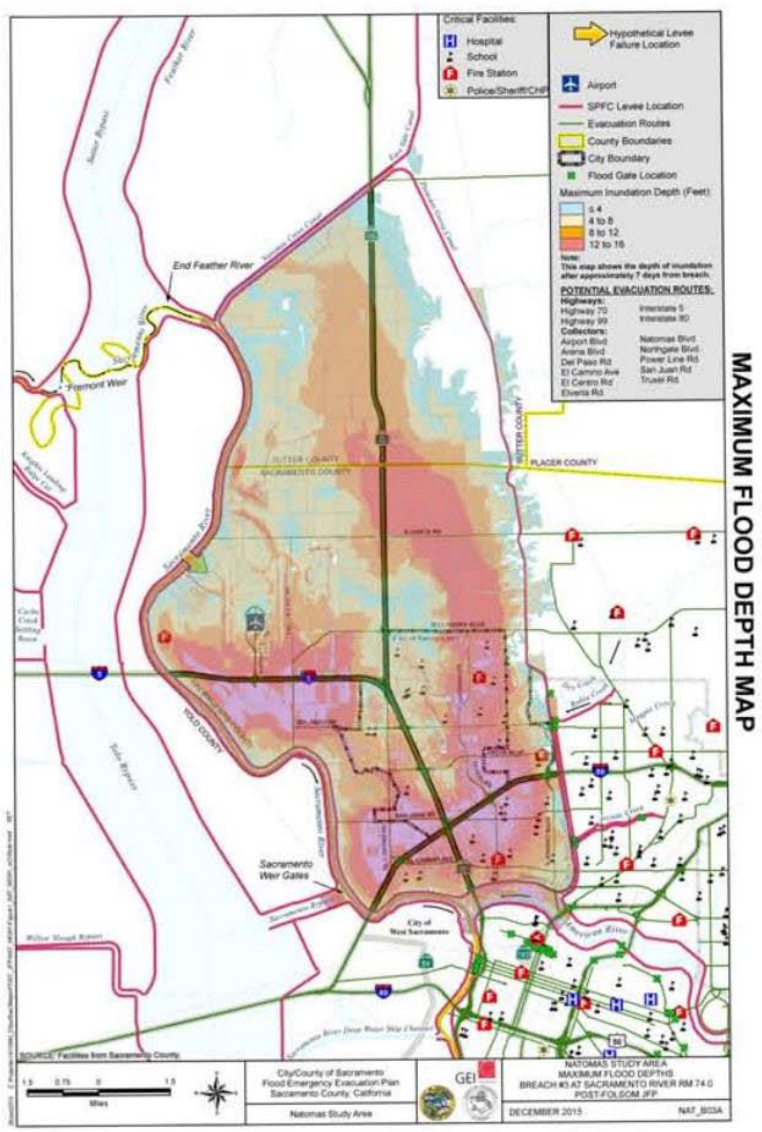


GRANDPARK ANALYSIS - BREACH 2-
2D EXISTING ALTERNATIVE

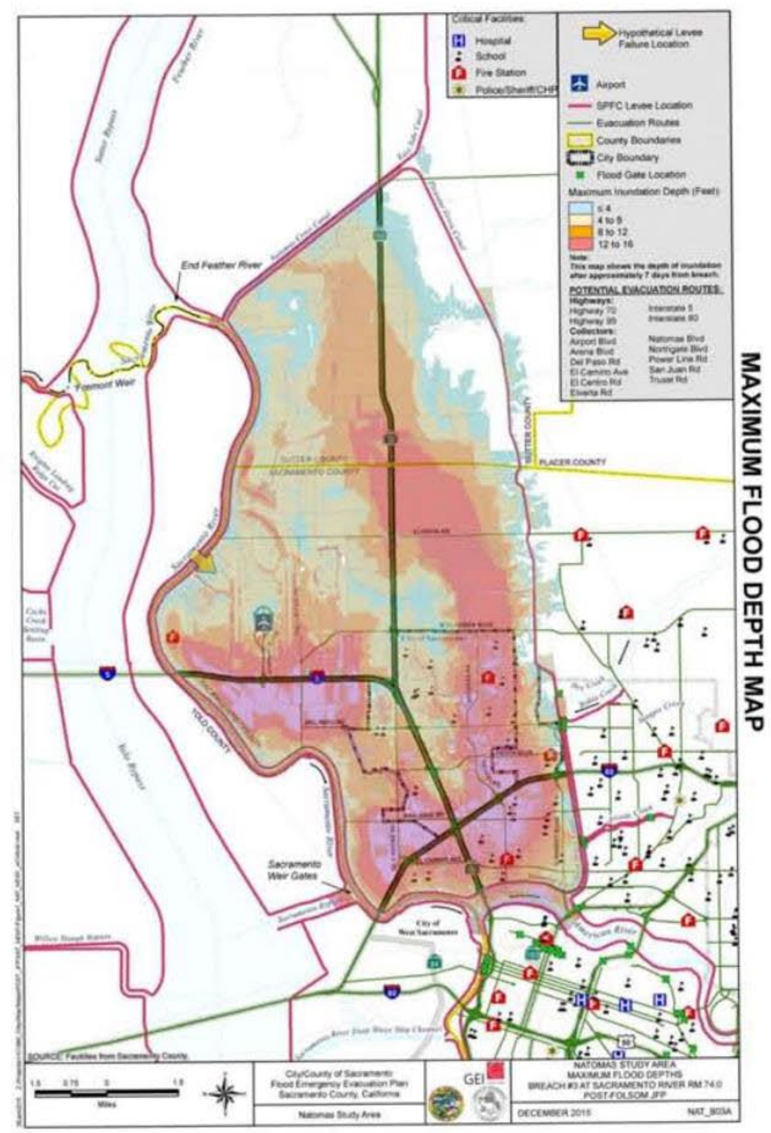


GRANDPARK ANALYSIS - BREACH 2-
2D CUMULATIVE ALTERNATIVE

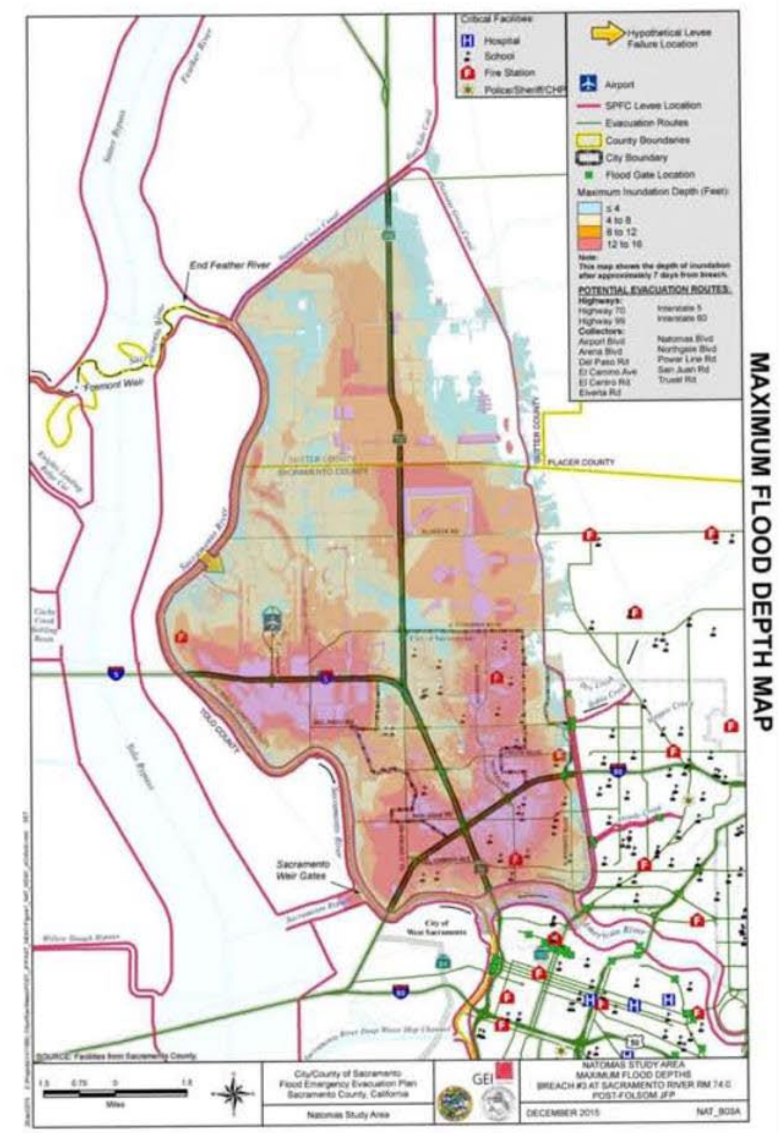
BREACH 3 AT SACRAMENTO RIVER LEVEE NEAR ELVERTA ROAD
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 3-
1D GEI EXISTING ALTERNATIVE

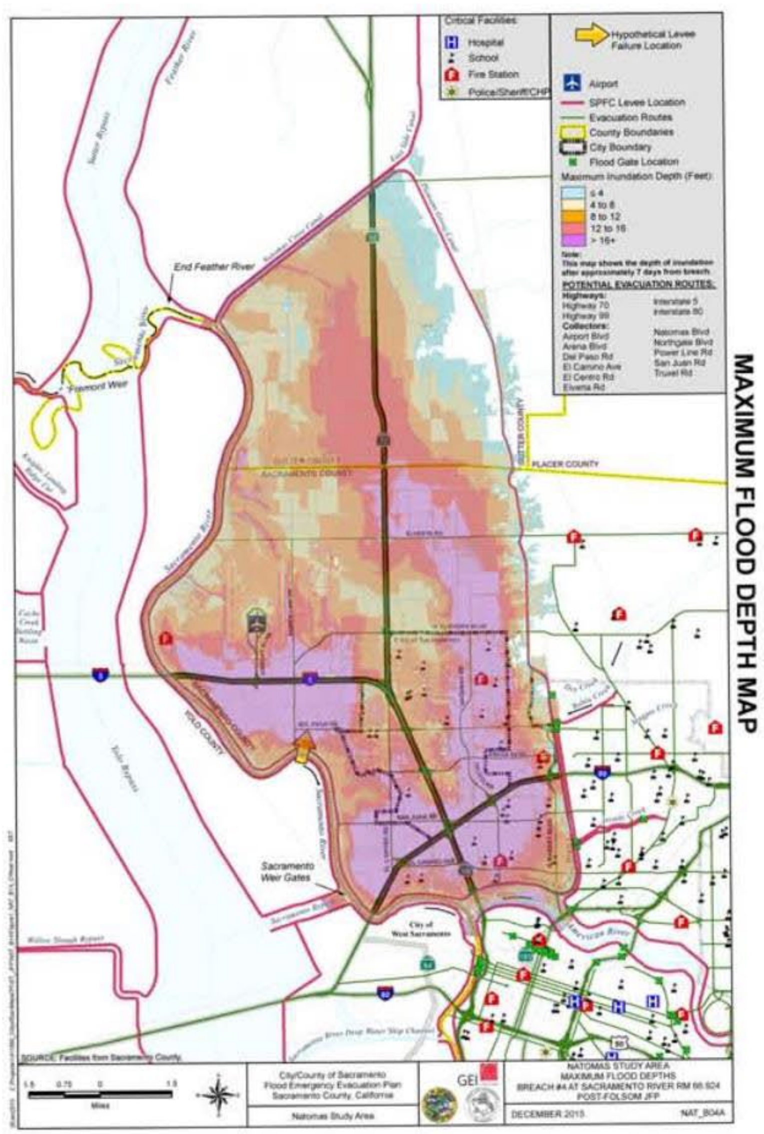


GRANDPARK ANALYSIS - BREACH 3-
2D EXISTING ALTERNATIVE

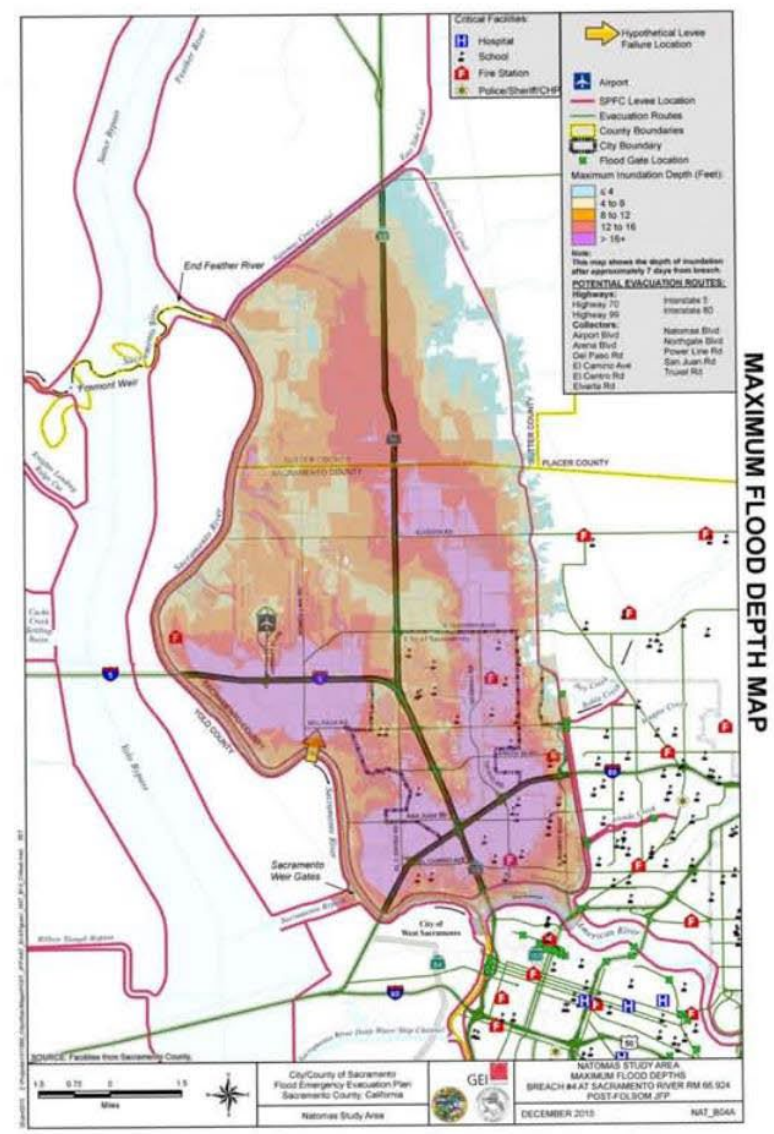


GRANDPARK ANALYSIS - BREACH 3-
2D CUMULATIVE ALTERNATIVE

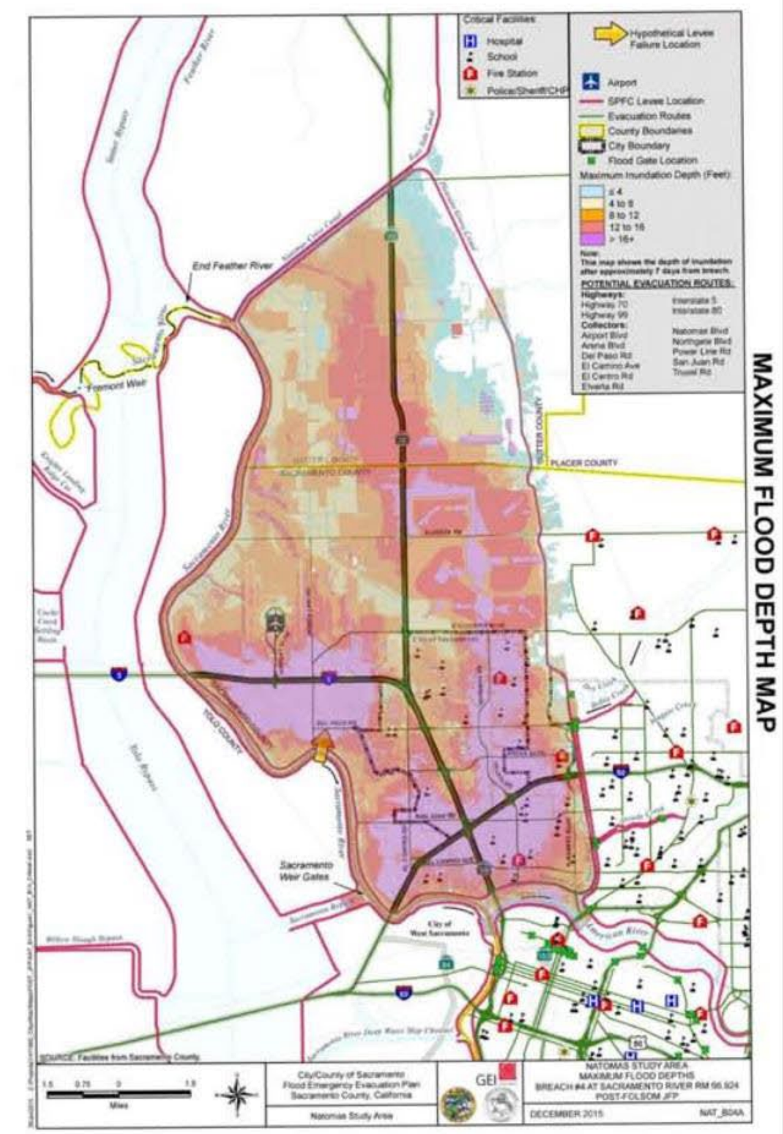
BREACH 4 AT SACRAMENTO RIVER LEVEE SOUTH OF I-5
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 4-
1D GEI EXISTING ALTERNATIVE

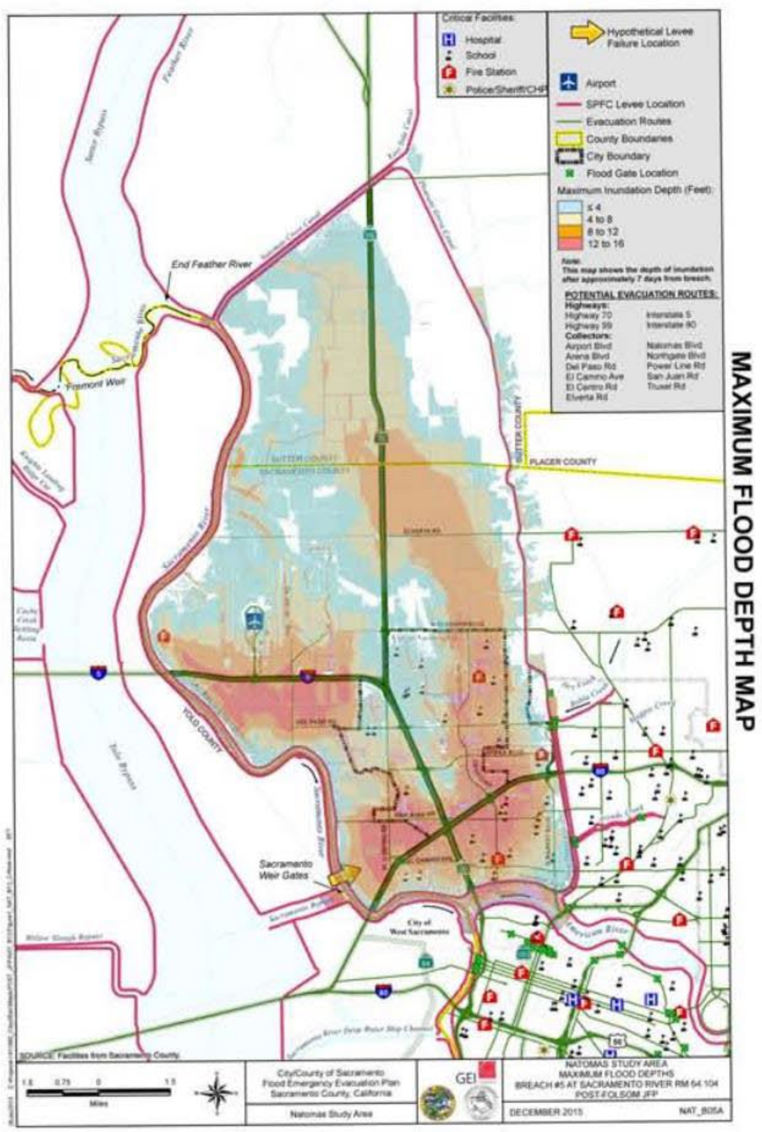


GRANDPARK ANALYSIS - BREACH 4-
2D EXISTING ALTERNATIVE

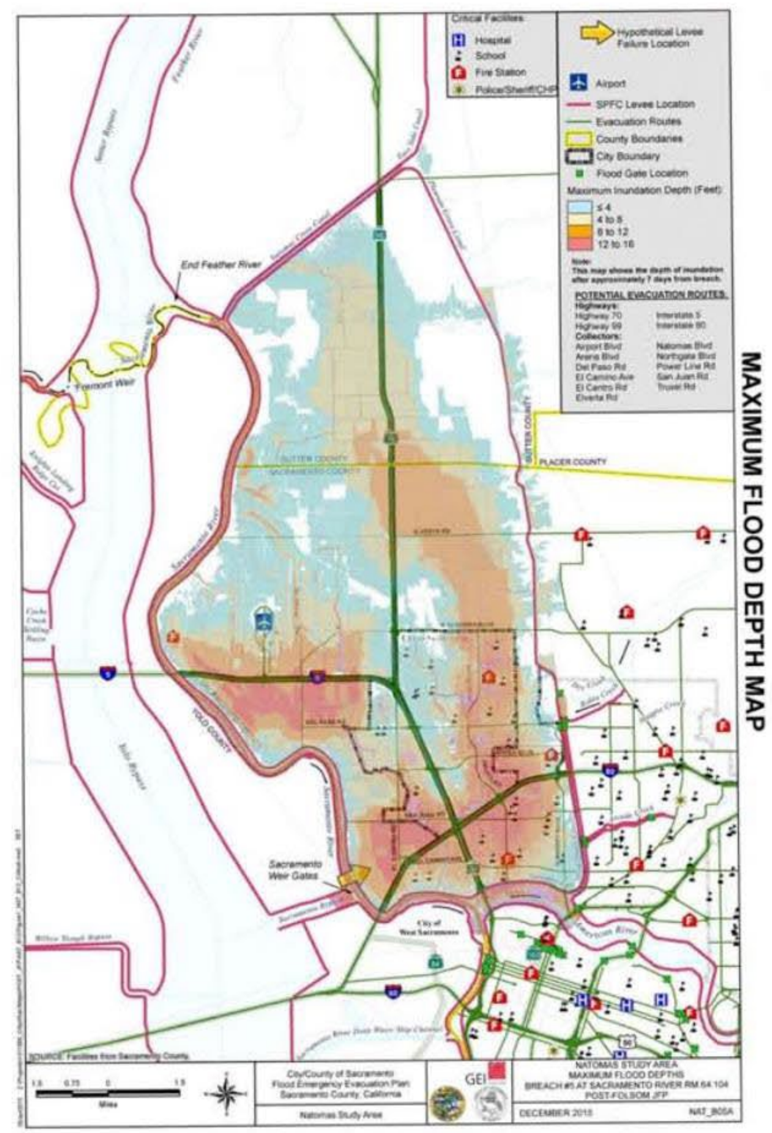


GRANDPARK ANALYSIS - BREACH 4-
2D CUMULATIVE ALTERNATIVE

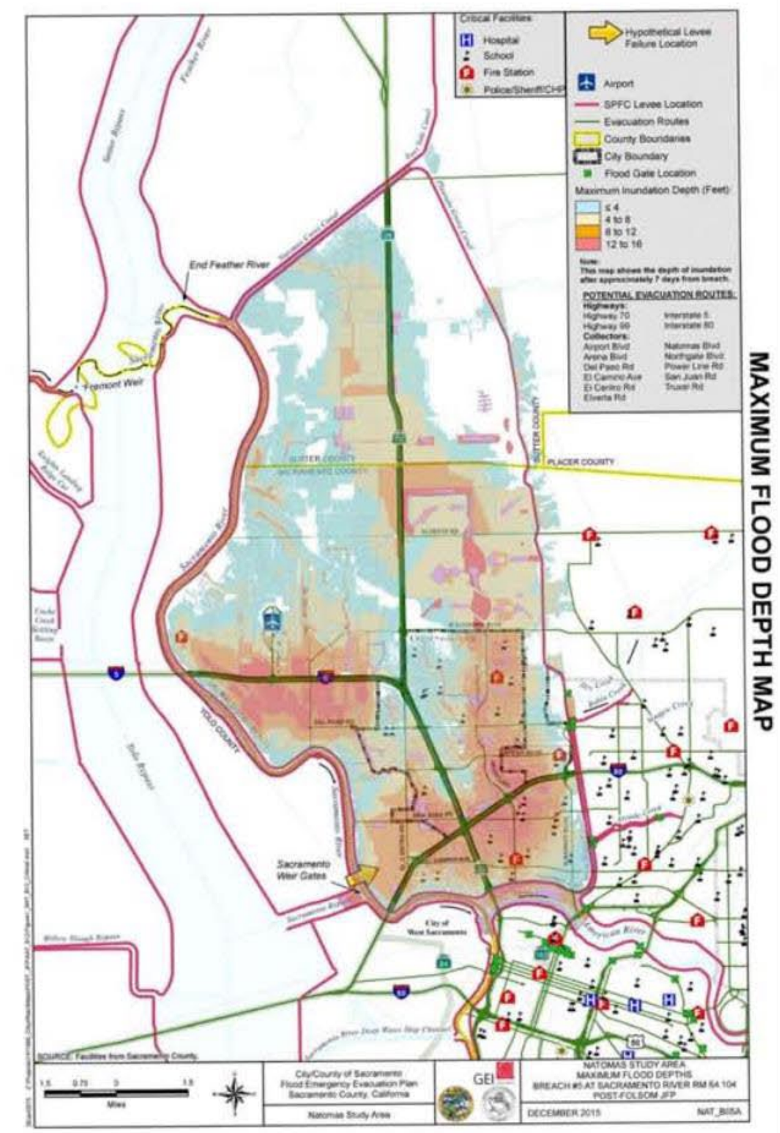
BREACH 5 AT SACRAMENTO RIVER LEVEE NEAR 1-80
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 5-
1D GEI EXISTING ALTERNATIVE

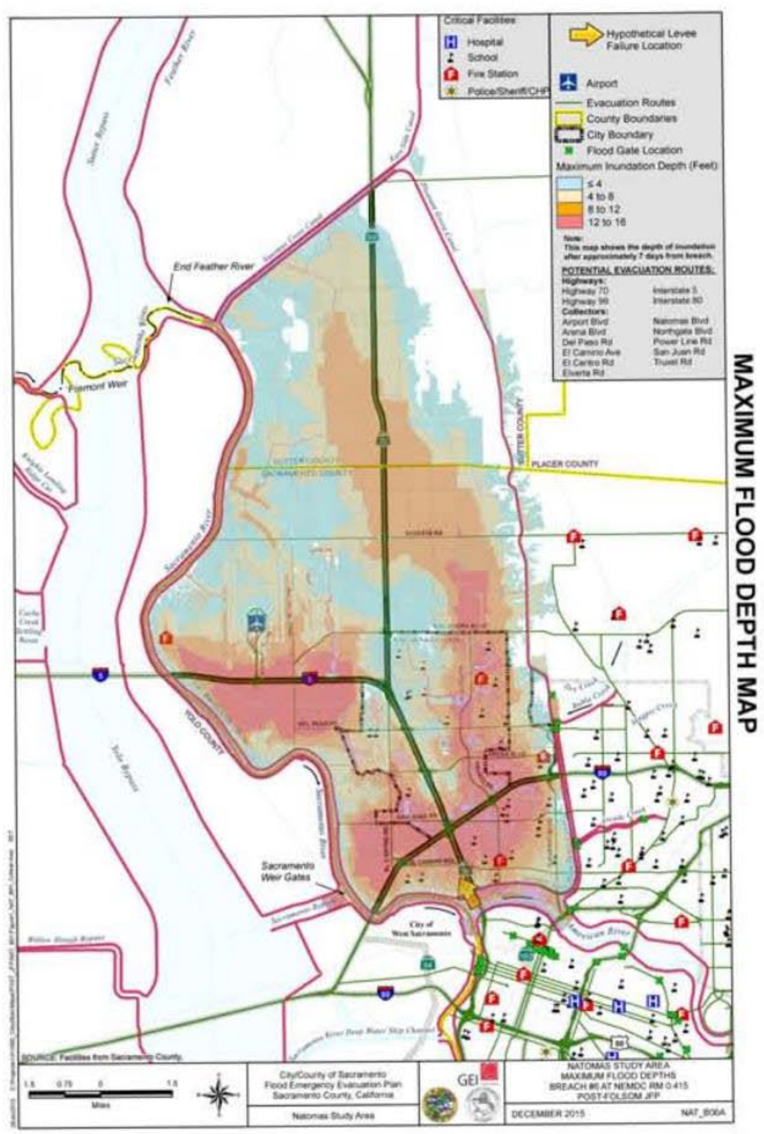


GRANDPARK ANALYSIS - BREACH 5-
2D EXISTING ALTERNATIVE

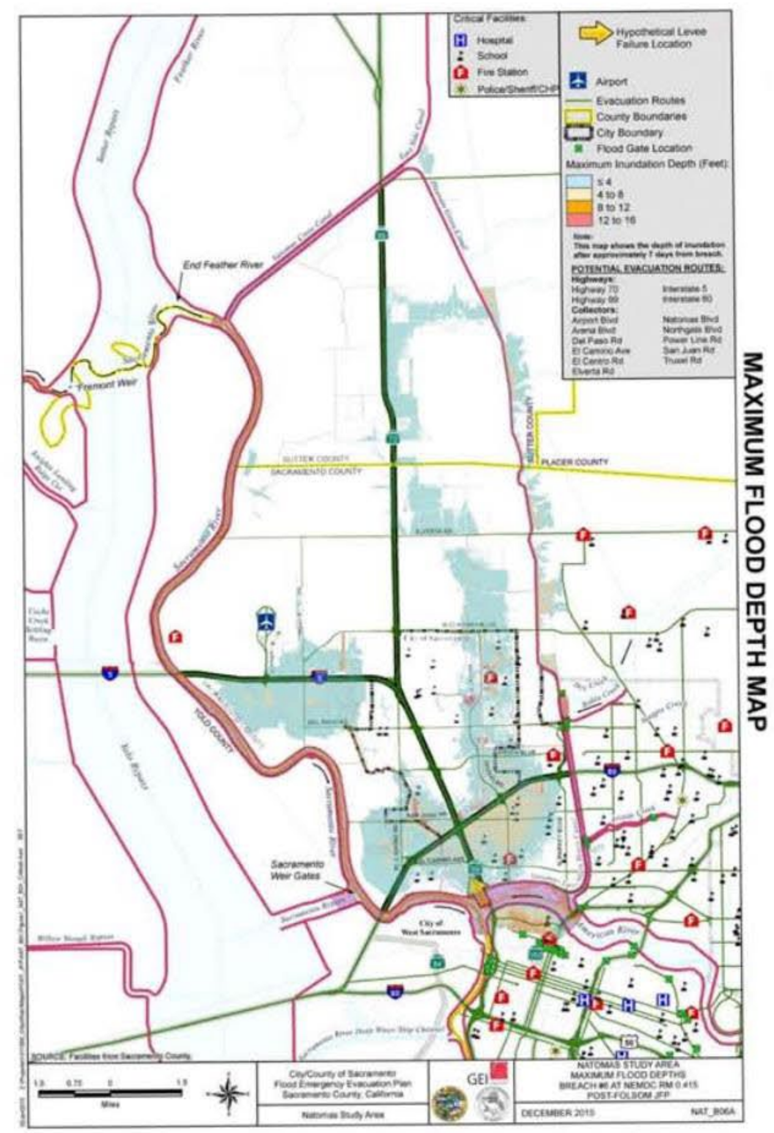


GRANDPARK ANALYSIS - BREACH 5-
2D CUMULATIVE ALTERNATIVE

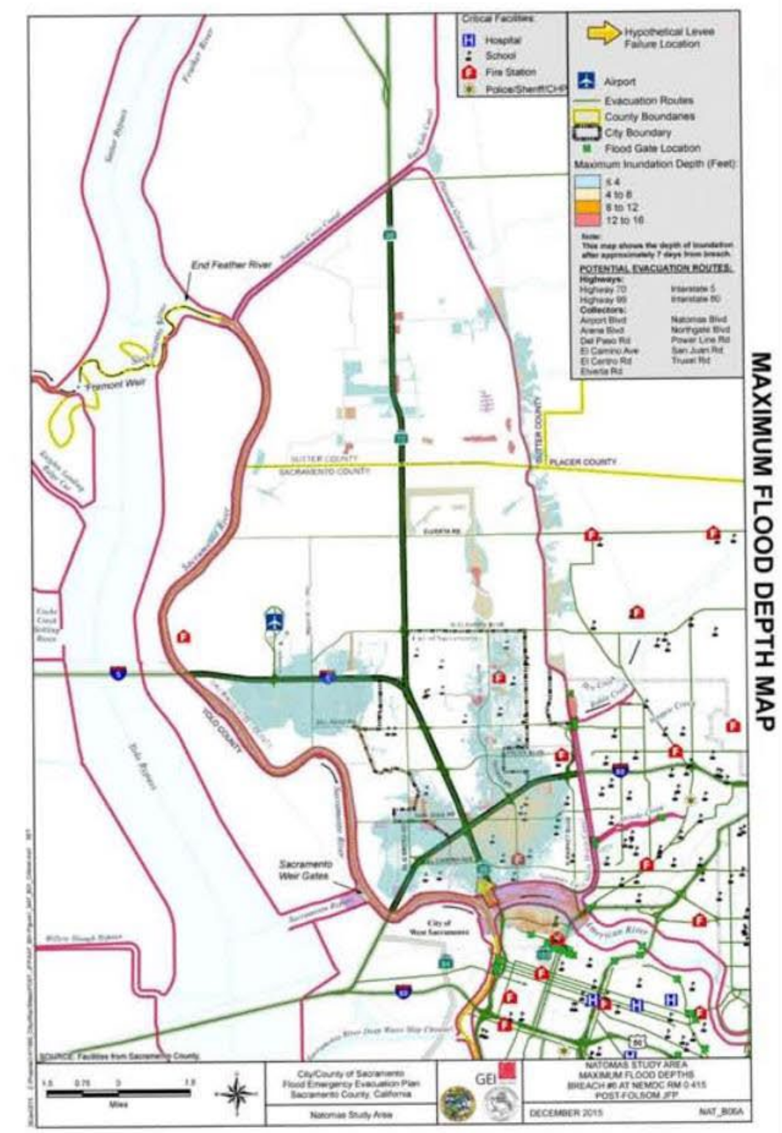
BREACH 6 AT AMERICAN RIVER LEVEE NEAR CONFLUENCE WITH SACRAMENTO RIVER
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 6-
1D GEI EXISTING ALTERNATIVE

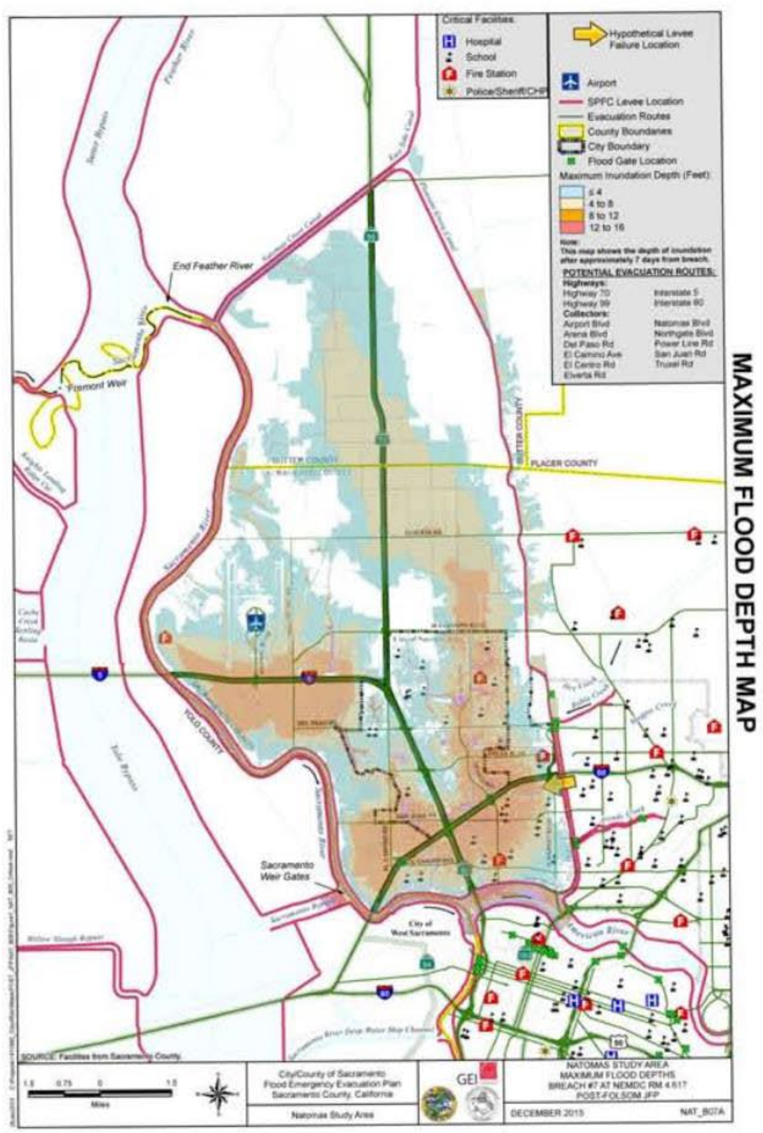


GRANDPARK ANALYSIS - BREACH 6-
2D EXISTING ALTERNATIVE

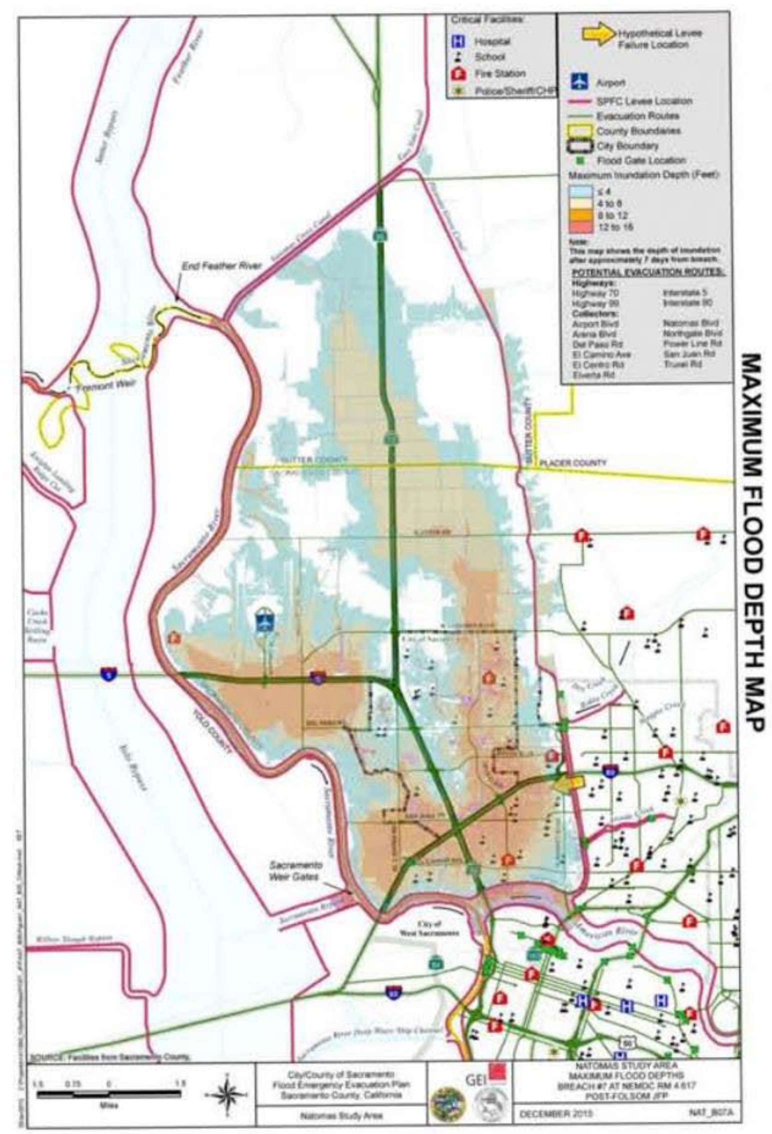


GRANDPARK ANALYSIS - BREACH 6-
2D CUMULATIVE ALTERNATIVE

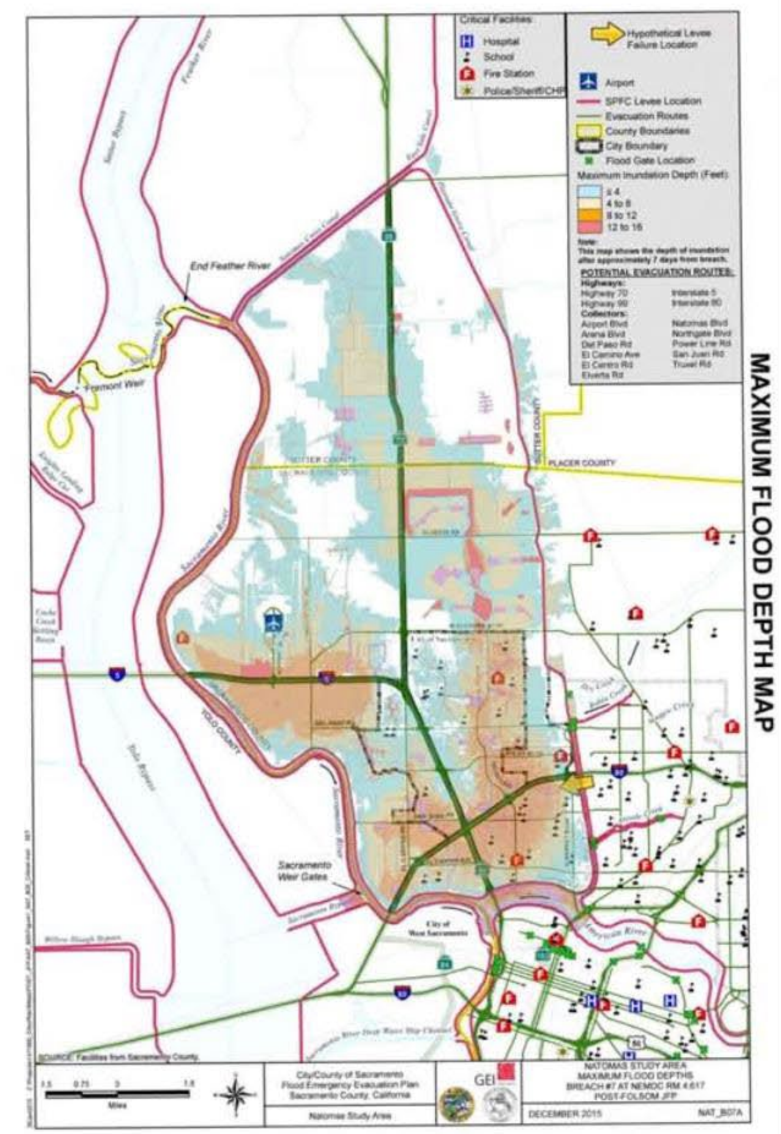
BREACH 7 AT NEMDC LEVEE NEAR 1-80
CUMULATIVE PLUS PROJECT ANALYSIS



GRANDPARK ANALYSIS - BREACH 7-
1D GEI EXISTING ALTERNATIVE



GRANDPARK ANALYSIS - BREACH 7-
2D EXISTING ALTERNATIVE



GRANDPARK ANALYSIS - BREACH 7-
2D CUMULATIVE ALTERNATIVE

APPENDIX B

CESI Technical Memorandum No. 0040

Levee Breach Analysis – Cumulative Plus Project Analysis

MacKay & Somps
ENGINEERS PLANNERS SURVEYORS

CIVIL ENGINEERING SOLUTIONS, INC.

TECHNICAL MEMORANDUM No. 0040

GRANDPARK
Flood Control & Storm Drainage Master Plan
Sacramento County, California

To: Todd Smith, Sacramento County

Mike Johnson, County DWR

From: Thomas S. Plummer P.E., CFM

Date: October 31, 2022

Subject: LEVEE BREACH ANALYSIS – CUMULATIVE ANALYSIS

REGISTERED PROFESSIONAL ENGINEER
THOMAS S. PLUMMER
No. C49582
EXP. 9/30/24
STATE OF CALIFORNIA

Sacramento DWR:

By: ____________________

Date: ____________________

- ☐ Acknowledged
- ☐ Approved
- ☐ Other: ____________

ELEVATION DATUM

All Elevations shown in this TM are in NAVD 88 Vertical Datum.

USE OF "SACRAMENTO-COMBINED" HEC-RAS MODEL FROM GEI

GEI provided CESI the 2015 HEC-RAS One-Dimensional (1D) modeling that the existing Natomas Basin Levee Breach analysis was performed with for the seven (7) perimeter levee breach locations previously chosen by the City and County of Sacramento for the GEI analysis in 2015. The updated modeling is run for the same total duration of analysis as the original GEI model. This modeling was used for this analysis except for changes described below.

The results of the previous Breach Analysis are posted at the following link:

https://waterresources.saccounty.net/stormready/Pages/Natomas-Area-Flood-Map.aspx

The results presented in this Technical Memorandum focus on two analyses:

1. Time to Fill to 1-foot of depth at Evacuation Route locations, and
2. Maximum Depth of Inundation measured in the modeling.

The previous Breach Analysis Maps were published by the County at the link above to present the results of the GEI modeling.

The original model was performed in HEC-RAS version 4.1.3. In consultation with Chris Ferrari of GEI Consultants, CESI updated the 2015 modeling. Specifically, CESI updated the model to HEC-RAS 6.2 and further modified the model as described below. This required modification for errors in the geometry file detected by the current version of HEC-RAS that were not evident in the previous version. Typically, these errors occurred where HTAB table definitions started below the invert of a channel, or storage area starting elevations below the lowest elevation in the storage area.

Version 6.2 of HEC-RAS generates a warning at some breach locations that the specified minimum elevation of the breach is below the adjacent ground elevations. When this occurs, HEC-RAS Version 6.2 will limit the breach weir formation elevation to the adjacent lowest ground elevation.

The original model analyzed flood distribution within the basin by including a set of storage areas connected by weirs and culverts. This method discounts the impact of local ground features and the time it takes for flood waters to cross the storage areas, as HEC-RAS views a storage area as equally distributing the inflow to the entirety of the storage area instantaneously.

CESI decided for the current analysis, it would be better to analyze the breach flooding over Two Dimensional (2D) surfaces using the Version 6.2 capabilities of HEC-RAS. Digital terrain models (topographic models) of the Natomas Basin were not provided by GEI when the original model was transferred to CESI.

Accordingly, CESI generated a cumulative conditions topographic model for the Natomas Basin and utilized HEC-RAS Version 6.2 to generate a digital terrain model surface for the existing conditions. CESI then developed digital terrain models based on the current land use plans and drainage plan documents (where available – See TM 0039) and then added these terrain models for the reasonably foreseeable development projects for the Cumulative Conditions modeling.[1]

The following development areas were included in the Cumulative Conditions:

- GRANDPARK (Conceptual Grading Plan – April 20, 2022).[2]
- SUTTER POINTE (Appendix E Drainage Master Plan and Appendix B Land Use and Development Code).
- SAFCA "Sankey Road Gap Closure Project Basis of Design Report".
- GREENBRIAR (used land use plan and documentation from the January 5, 2017, Environmental Checklist (online version)).
- PANHANDLE (Preliminary Grading Plan by MacKay & Somps).
- UPPER WESTSIDE (land use plan from Staff Presentation February 2022).
- SACRAMENTO INTERNATIONAL AIRPORT (Master Plan January 2017), including Airport South Industrial project (using the layout included in the Airport Master Plan)

It should be noted that the ultimate buildout of Metro Airpark is included in the Existing Conditions terrain models.

It's important to note that the grading input for all of the projects added in the Cumulative conditions models is for the finished grade surfaces only and does not include any structures which will be built.

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[1] For this analysis, a version 6.05 terrain surface was created for the Cumulative development scenario. The 6.04 and 6.05 Terrains were based on 2 feet by 2 feet pixel size, and, at locations where the terrain did not include hydraulic reinforced data (invert data at bridge and culvert crossings, this data was added by interpolating a section from upstream grades to downstream grades in the LiDAR data set).

[2] The 2022 Grandpark Conceptual Grading Plan was used in this analysis. This conceptual grading plan is an update of the conceptual grading plan used in TM 0007 (Grandpark Land Use Plan 08F) as it reflects the elimination of the "Lennar" parcels as a development site and instead leaves this property as an undeveloped open space parcel. Additionally, the 2022 Conceptual Grading Plan reconfigured the Grand Parkway from a water feature intensive open space plan into a more natural floodplain with a central drainage channel and overbank flood storage areas without significant water features. Lastly, the 2022 Conceptual Grading Plan redistributed the required flood storage volumes within the Grand Parkway in order to (1) meet County design standards relating to avoiding water surface level impacts to upstream and downstream properties, (2) achieve a condition where post development peak flow rates do not exceed predevelopment levels upstream and downstream of Grandpark, and (3) achieve an equitable allocation of flood storage volumes between the various property owners within the area of the Grandpark Specific Plan.

Additionally the friction is not adjusted at these locations for the resistance to flows that may occur post development from fences and structures.

CESI then prepared 4 different analyses for each breach location as follows:

- **GEI Existing Conditions 1D Analysis.** The GEI existing conditions 1-dimensional (1D) storage-area based analysis was re-run in HEC-RAS 6.2.[3] Based on a visual comparison of the results from this re-run of the GEI existing conditions 1D in 2D analysis with the GEI published 1D results, the two sets of results were found to be similar.

  Upon completion of this modeling exercise, CESI again consulted with GEI to report on the efforts to update the 2015 model and the results from this modeling existing conditions analysis when using the newer HEC-RAS software. During this consultation, both GEI and CESI agreed the updated model was producing results similar to those obtained from the 2015 model in terms of the duration of time to 1-foot depth of flooding over the critical locations along the major evacuation routes, and the maximum depth of flooding within the Basin.

- **Existing Conditions Analysis with Storage Areas Converted to 2D**. HEC-RAS limited the breach weir formation elevations to the lowest grade in the adjacent 2D mesh elements. As a result, where higher ground was adjacent to the weir location, less flow was transmitted through the breach. This is a better solution than the original analysis, as it considers the local ground elevations. In particular, this applies to Breach 3 and Breach 6, where changes to the amount and timing of inflows are noted.

  Compared to the GEI 1D modeling which fills each storage area with flood volumes from the lowest elevation upward regardless of the distance, terrain and flow impediments within the storage area, the 2D analysis models the water flowing from the breach location through overland paths before entering into the main system of canals.

- **"With Grandpark" Analysis (also using 2D)**. This alternative is discussed in TM 0039.

- **Cumulative Conditions Analysis (also using 2D)**. This alternative is discussed in this TM 0040.

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[3] The HEC-RAS Version 6.2 is recognized by the engineering community for its superior capabilities to more accurately analyze flooding using 2D terrain surfaces as compared to HEC-RAS Version 4.1.3 that only utilized 1D terrain models.

TIME TO FILL TO 1-FOOT DEPTH AT EVACUATION ROUTE LOCATIONS:

Oversized exhibits are included at the end of this technical memorandum which present the results of these analyses for each of the 4 alternatives studies for each breach location. They are plotted on top of the original GEI exhibits from the original Study.

For each Evacuation Route location identified in the original mapping, CESI identified the location where the depth would reach 1 foot of inundation depth earliest (the lowest point of the roadway stretch) and retrieved the time to 1-foot of inundation depth for each scenario and breach in hours. The results are summarized in the following tables (Tables 1 through 7) for each of the seven breach locations. These results are also shown on the oversized exhibits included with this TM (Note: On the oversized exhibits, if flooding to a depth of 1 foot over the roadway was not demonstrated in the analysis, the point was removed from the exhibit).

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BREACH 1

The results of the modeling exercise for Breach 1 are summarized in Table 1 and the text following the table.

Table 1
BREACH 1: (Natomas Cross Canal Levee Breach Location)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	89	93	62	-31
ELVERTA	47	42	49	+7
ELKHORN	38	39	50	+11
DEL PASO	22	39	50	+11
I-80 EAST	31	46	63	+17
I-5 CENTRAL	106	125	128	+3
I-5 JUNCTION	79	79	111	+32
I-5 WEST	73	96	104	+8
I-80 WEST	63	80	79	-1
ELKHORN WEST	73	96	104	+8
SR-99 NORTH	98	98	39	-59
SR-99 SOUTH	135	145	147	+2
POWER LINE	92	116	124	+8
ELVERTA WEST	106	116	111	-5
SAN JUAN	36	52	62	+10
EL CAMINO	36	52	63	+11
I-80 CENTRAL	58	73	74	+1
NATOMAS RD	28	36	47	+11

1D to 2D model:

In general the change from 1D to 2D modeling had little effect on the result of the flood depth timing to 1 foot, and for most of the points reviewed there was an increase in the time to the flood depth. The ELVERTA location shows a reduction in time to 1 foot depth as a result of the 2D model predicting increased overland and system flows at this location in the 1st 48 hours of the event.

2D to 2D Cumulative Model Changes:

In general, most of the data points show that there is an increased delay in the propagation of the breach flood wave timing as a result of the Cumulative Conditions improvements in the Natomas Basin for Breach 1.

The following four points identify reductions in timing to the depth of 1 foot:

1. SR-99: SR-99 is located near a low point in SR-99 near the northern boundary of the proposed Grandpark project. A reduction in flood depth timing at this location of 31 hours is identified in the modeling (93 hours to 62 hours). The reduction in flood time results from the reduced flood volumes in the northern part of the basin due to the embankments placed for the Sankey Gap storage basin proposed by SAFCA to be constructed with the Sutter Pointe project.

   Also, the proposed culvert crossings within the Grandpark development under Elverta Road restrict how fast flows lower than the street overtopping levels can progress from north of the Grandpark project to south of the project. These culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year, 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

2. I-80 WEST: A 1 hour reduction is shown, but this is within the rounding estimates of the model results. We would not expect any changes in this area of the basin for this breach location.

3. SR-99 NORTH: A reduction in 1 foot flood depth timing at this location of 59 hours is identified in the modeling (98 hours to 39 hours). This roadway low point is at a slightly lower elevation than surrounding data points, so it sees flooding sooner in the Cumulative Event analysis as a result of the Sankey Gap Storage Facility Embankments and Grandpark proposed project culverts under Elverta Road at its crossing of the East Drainage Canal.

4. ELVERTA WEST. A reduction in 1 foot flood depth timing at this location of 5 hours is identified in the modeling (116 hours to 111 hours). This data point is affected by the Sankey Gap storage facility embankments.

The three data points noting a meaningful change in 1 foot flood depth arrival time are in the Northwest quadrant of the basin, where the breach occurs.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

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BREACH 2

The results of the modeling exercise for Breach 2 are summarized in Table 2 and the text following the table.

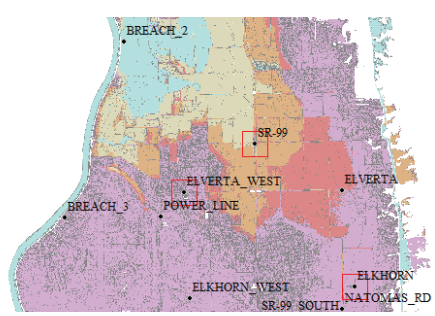
Table 2

BREACH 2 (North Sacramento River Breach Location)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	35	22	19	-3
ELVERTA	25	18	21	+3
ELKHORN	20	20	24	+4
DEL PASO	14	22	26	+4
I-80 EAST	18	25	32	+7
I-5 CENTRAL	53	56	57	+1
I-5 JUNCTION	47	55	58	+3
I-5 WEST	44	52	55	+3
I-80 WEST	32	39	40	+1
ELKHORN WEST	45	52	36	-16
SR-99 NORTH	12	15	14	-1
SR-99 SOUTH	87	88	88	0
POWER LINE	55	63	65	+2
ELVERTA WEST	43	33	14	-19
SAN JUAN	22	28	32	+4
EL CAMINO	22	29	33	+4
I-80 CENTRAL	34	39	38	-1
NATOMAS RD	17	20	24	+4

1D to 2D model:

In general the change from 1D to 2D modeling had little effect on the result of the flood depth timing to 1 foot, and for most of the points reviewed there was an increase in the time to the flood depth.



Three locations show a reduction in flood depth response timing, SR-99, ELKHORN and ELVERTA WEST. For these three locations the flood waters passing through the breach area conveyed overland before they enter the system, in the direction of these locations, and the flood waters have not yet fully filled some of the storage downstream of these locations. As a result the 2D model more accurately predicts that there is potential for these locations to become overtopped to a depth of 1 foot in a shorter duration of the time than the 1D model predicts.

2D to 2D Cumulative Model Changes:

This breach analysis identifies 3 locations where moderate adverse changes to the timing of 1 foot inundation of the evacuation routes would occur at: SR-99, ELKHORN WEST, and ELVERTA WEST.

The breach location is similar to the location of Breach 1, discharging into the Northwest Quadrant of the basin. As a result, the Sankey Gap storage area reduces available storage in this area below the embankment overtopping elevations. Proposed project culverts in Grandpark also slow the progression of the initial flood wave below Elverta Road overtopping elevations, resulting in a modest acceleration of the flood timing within the northwest quadrant. These culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year, 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

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BREACH 3

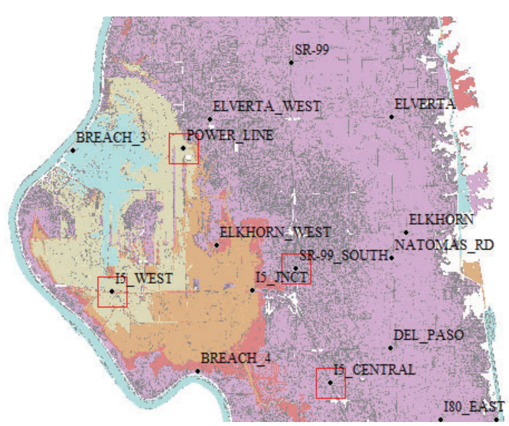
The results of the modeling exercise for Breach 3 are summarized in Table 3 and the text following the table.

Table 3
BREACH 3(Sacramento River Levee Near Elverta Road)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	66	71	73	+2
ELVERTA	47	53	61	+8
ELKHORN	43	48	46	-2
DEL PASO	33	37	37	0
I-80 EAST	40	40	37	-3
I-5 CENTRAL	67	48	46	-2
I-5 JUNCTION	10	13	13	0
I-5 WEST	9	7	6	-1
I-80 WEST	23	28	27	-1
ELKHORN WEST	4	9	9	0
SR-99 NORTH	75	80	84	+4
SR-99 SOUTH	129	127	125	-2
POWER LINE	17	6	5	-1
ELVERTA WEST	79	82	81	-1
SAN JUAN	30	36	36	0
EL CAMINO	30	36	36	0
I-80 CENTRAL	17	24	25	+1
NATOMAS RD	38	44	44	0

<u>1D to 2D model:</u>

In general the change from 1D to 2D modeling had little effect on the result of the flood depth timing to 1 foot, and for most of the points reviewed there was an increase in the time to the flood depth.



Four locations show a reduction in flood depth response timing, I-5 CENTRAL, I-5 WEST, SR-99 SOUTH and POWER LINE. The four locations are highlighted on the figure to the right. For these locations, in the 2D model, a greater portion of the breach flood waters stay in the west side of the basin and flow easterly and southerly overland as compared to the 1D model. The POWERLINE location is near the breach and receives overland flow earlier than it would fill from the system flows. I-5 WEST is the next point in the flood propagation which gets overtopped as a result of this overland flow path of the flood waters in a southerly direction. The changes at I-5 CENTRAL and SR-99 SOUTH are small changes which occur much later in the event, as these points are higher in elevation. Similarly though these changes result from differences in how the 2D model fills the overland areas by filling areas connected by terrain, and not filling areas that are separated by terrain for given flood elevations, which the 1D model cannot handle

2D to 2D Cumulative Model Changes:

For this breach location scenario, the Cumulative Condition produces similar results to the Existing Conditions model at all locations. The largest reduction in time to flood 1 foot is at I-80 EAST where a 3-hour reduction occurs (40 to 37 hours). This is in an area near the breach location, in which flood storage volumes are reduced by the Sankey Gap storage area embankments.

All other minor changes noted by the analysis are less than 1 hour, which is approximately the rounding error in the results.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

BREACH 4

The results of the modeling exercise for Breach 4 are summarized in Table 4 and the text following the table.

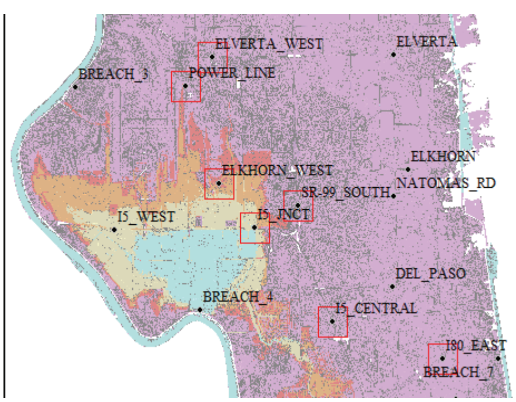
Table 4
BREACH 4 (Sacramento River Levee South of I-5)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	70	75	78	+3
ELVERTA	52	56	65	+9
ELKHORN	47	51	49	-2
DEL PASO	38	38	37	-1
I-80 EAST	44	42	39	-3
I-5 CENTRAL	69	55	53	-2
I-5 JUNCTION	9	8	8	0
I-5 WEST	6	6	6	0
I-80 WEST	24	28	26	-2
ELKHORN WEST	9	8	8	0
SR-99 NORTH	78	83	85	+2
SR-99 SOUTH	101	99	97	-2
POWER LINE	21	19	19	0
ELVERTA WEST	80	78	77	-1
SAN JUAN	33	37	37	0
EL CAMINO	33	37	37	0
I-80 CENTRAL	18	23	24	+1
NATOMAS RD	42	46	47	+1

1D to 2D model:

In general the change from 1D to 2D modeling had little effect on the result of the flood depth timing to 1 foot, and for most of the points reviewed there was an increase in the time to the flood depth.

Seven locations show a reduction in flood depth response timing, ELVERTA WEST, POWERLINE, ELKHORN WEST, SR-99 SOUTH, I-5 JNCT, I-5 CENTRAL and I80 EAST.



The I-5 JNCT and ELKHORN WEST locations show in the 2D model a larger overland flow component fanning out to the north than the 1-D model shows. This overland flow reaches these sites before the in system flow would overtop them, and as a result a reduction in timing to a depth of 1 foot is reported. Similarly the POWERLINE location is also impacted by the 2D models identification of the overland flow to the north. These three locations show an impact early in the event.

Later in the event, The ELVERTA WEST, SR-99 SOUTH, I5 CENTRAL, and I-80 EAST locations show a reduction resulting from differences in how the 2D model fills the overland areas by filling areas connected by terrain, and not filling areas that are separated by terrain for given flood elevations, which the 1D model cannot handle

<u>2D to 2D Cumulative Model Changes:</u>

For this breach location scenario, the Cumulative Conditions produce similar results to the Existing Conditions model at all locations. The largest reduction in time to flood 1 foot is at I-80 EAST where a 3-hour reduction occurs (42 to 39 hours). This is in an area near the breach location, in which flood storage volumes are reduced by the Sankey Gap storage area embankments.

All other minor changes noted by the analysis are less than 1 hour, which is approximately the rounding error in the results.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

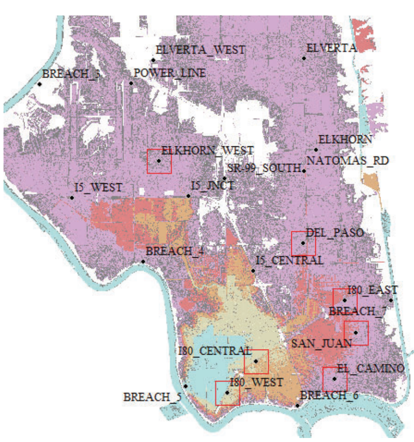
BREACH 5

The results of the modeling exercise for Breach 5 are summarized in Table 5 and the text following the table.

Table 5
BREACH 5 (Sacramento River Levee Near I-80)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	84	83	83	0
ELVERTA	50	46	60	+14
ELKHORN	39	36	30	-6
DEL PASO	21	19	18	-1
I-80 EAST	21	19	18	-1
I-5 CENTRAL	100	96	90	-6
I-5 JUNCTION	27	30	34	+4
I-5 WEST	19	23	25	+2
I-80 WEST	9	6	3	-3
ELKHORN WEST	57	25	26	+1
SR-99 NORTH	22	98	102	+4
SR-99 SOUTH	99	99	97	-2
POWER LINE	46	51	55	+4
ELVERTA WEST	112	110	113	+3
SAN JUAN	19	18	16	-2
EL CAMINO	19	18	16	-2
I-80 CENTRAL	9	8	6	-2
NATOMAS RD	30	29	27	-2

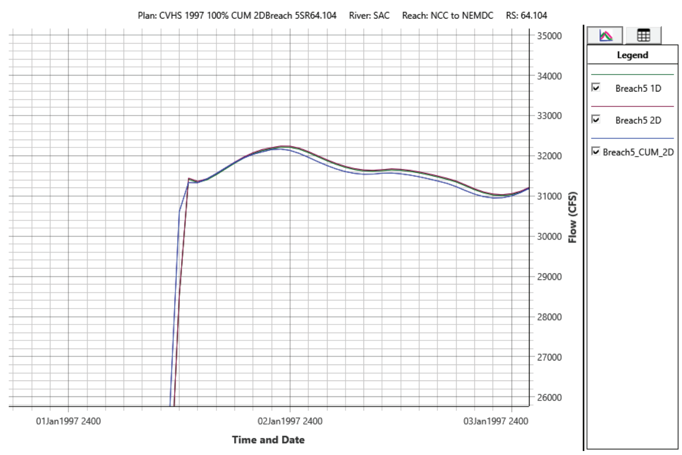
<ins>1D to 2D model:</ins>



For Breach 5 a number of locations show a reduction in timing to 1 foot depth. For this Breach location, the 2D model allows higher flow rates through the breach due to the low ground elevations adjacent to the breach. As a result we would highlight the changes at the point identified in the image to the right. For the 1st impacted points of the I-80 WEST and I-80 CENTRAL locations the increased breach flows and overland flooding paths which are computed in the 2D model show these points to be at risk of flooding even sooner than the 1D model. Other points which are shown to be closed early in the event Such as the EL CAMINO, SAN JUAN, I-80 EAST and DEL PASO points, an increase in flows early in the event through the eastern flow paths accounts for the roughly 2 hours of reduced timing between the 2D and 1D models.

2D to 2D Cumulative Model Changes:

The Breach location near the I-80 crossing of the Sacramento River generally shows a small reduction in response time to a 1-foot depth along the I-80 corridor within the southern areas of the basin (Data Points: ELKHORN, DEL PASO, I-80 EAST, I-5 CENTRAL, I-80 WEST, SR-99 SOUTH, SAN JUAN, EL CAMINO, I-80 CENTRAL and NATOMAS RD).



Of note would be the low points in Interstate 80 at I-80 WEST, and I-80 central where the response time to flood 1 foot reduces from 6-hours to a 3-hours, and 8 hours to 6-hours respectively, between the 1D and 2D models. The models show there are 2 reasons for the reduction in timing. The most important is that for the 2D Cumulative Condition, the model shows the full breach formation 1 hour and 10 minutes sooner than in the 1D and 2D conditions per the graph to the right. This generally affects all points and accounts for the general reduction between 1 and 2 hours seen in many of the data point locations.

The second portion which additionally affects the 2 I-80 points nearest the breach appears to result from the proposed grading at the Upper Westside project. The breach flows would spread out from the breach through the generally flat grades proposed and through the streets which are at lower grades. The result is an overland flooding path to these locations sooner in the event. The Breach 5 location just happens to be directly adjacent to the southern end of the Upper Westside project. The 2D Cumulative Models do not account for the resistance to the flow spreading effect that would occur due to the construction of buildings, fences and the planting of vegetation and trees. An average friction value is applied over the surface. These future condition items cannot be included in the current modeling as they are still unknown. It is likely that if structures, fences and vegetation are built similar to other developments, they would slow the spread effect.

BREACH 6

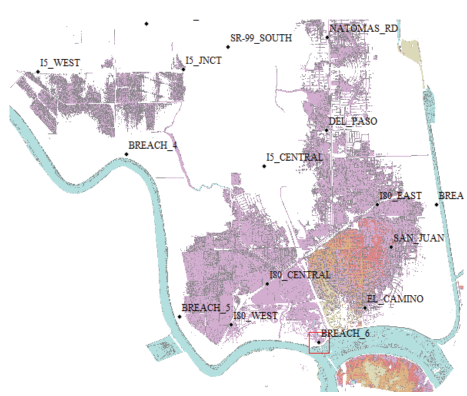
The results of the modeling exercise for Breach 6 are summarized in Table 6 and the text following the table.

Table 6

BREACH 6 (American River Levee Near Confluence With Sacramento River)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	53	No Flood	No Flood	No Flood
ELVERTA	29	No Flood	No Flood	No Flood
ELKHORN	21	No Flood	No Flood	No Flood
DEL PASO	10	76	118	+42
I-80 EAST	6	40	42	+2
I-5 CENTRAL	57	No Flood	No Flood	No Flood
I-5 JUNCTION	17	No Flood	No Flood	No Flood
I-5 WEST	11	No Flood	No Flood	No Flood
I-80 WEST	141	148	162	+14
ELKHORN WEST	14	No Flood	No Flood	No Flood
SR-99 NORTH	61	No Flood	No Flood	No Flood
SR-99 SOUTH	133	No Flood	No Flood	No Flood
POWER LINE	31	No Flood	No Flood	No Flood
ELVERTA WEST	65	No Flood	No Flood	No Flood
SAN JUAN	4	30	31	+1
EL CAMINO	4	31	32	+1
I-80 CENTRAL	137	143	156	+13
NATOMAS RD	16	No Flood	No Flood	No Flood

Note: "No Flood" means that the breach event did not report flooding in excess of 1 foot at the data point throughout the model event duration (typical for all Tables).



<u>1D to 2D model:</u>

For Breach 6, in the 2D versions of the model, flooding will not reach the 1-foot depth for the duration of the model. This results from the fact that the ground elevations directly downstream of the breach location are higher ground, and as a result flows passing through the breach are significantly limited in quantity passing beyond this high ground.

<u>2D to 2D Cumulative Model Changes:</u>

No reductions in flood response time to 1 foot depth were noted for this analysis.

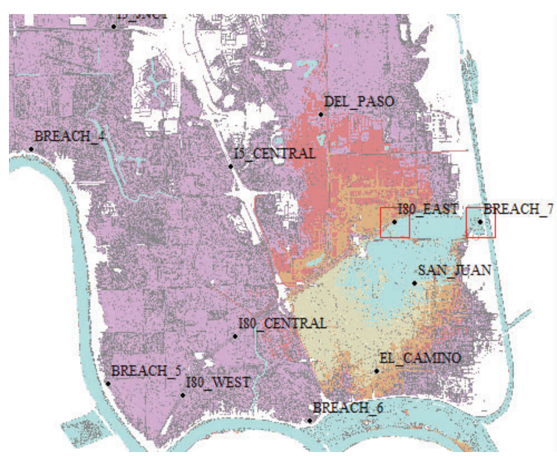
BREACH 7

The results of the modeling exercise for Breach 7 are summarized in Table 7 and the text following the table.

Table 7
BREACH 7 (NEMDC Levee Near I-80)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
ELVERTA	56	57	159	+102
ELKHORN	29	30	25	-5
DEL PASO	14	15	15	0
I-80 EAST	6	2	3	+1
I-5 JUNCTION	88	93	90	-3
I-5 WEST	82	86	80	-6
I-80 WEST	27	48	39	-9
ELKHORN WEST	80	84	76	-8
POWER LINE	140	136	123	-13
SAN JUAN	4	4	3	-1
EL CAMINO	5	6	6	0
I-80 CENTRAL	26	37	30	-7
NATOMAS RD	20	22	22	0

1D to 2D model:



For Breach 7, most points report similar or delayed timing. However, the data point for I-80 West shows a reduction from 6 hours to 2 hours. The figure to the right shows that the I-80 WEST point is directly downstream of the Breach 7 location, and how the overland flow path of the waters passing through the breach would be directed at this location before they could reach any main system conveyance paths. The 1D model simply models the area downstream of this breach as a storage area with 1 set of stage-storage values for the whole area which simply fills from the lowest elevation upwards. The 2D model allows the flood waters to spill over the terrain, and be redirected by high and low terrain. The 1D model could not accurately model the timing of flooding of this data point location.

2D to 2D Cumulative Model Changes:

This beach location is located along the Natomas East Main Drainage Canal Levee, north of the American River.

In general, the Cumulative analysis shows a reduction in flood response timing to a depth of 1 foot in the southern areas of the basin. Along the I-80 corridor, for example, reductions of 86 to 80 hours (I-5 West), 48 to 39 hours (I-80 WEST) and 37 to 30 hours(I-80 CENTRAL) are estimated by the modeling.

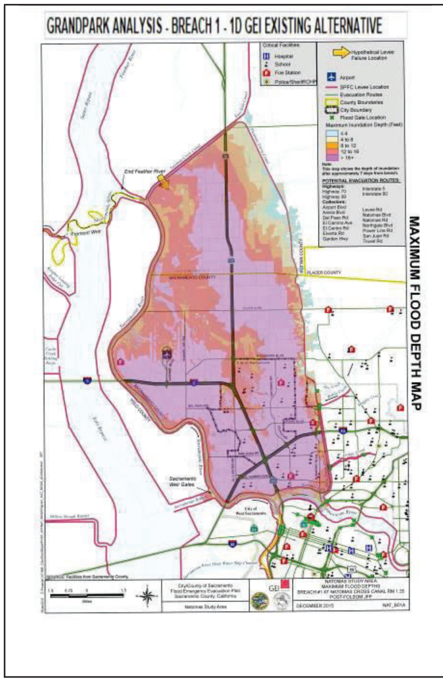
These changes result from the proposed Grandpark project culverts under Elverta Road restricting low flows below their roadway overtopping elevations along the East Drainage Canal in a South to North direction These culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year, 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

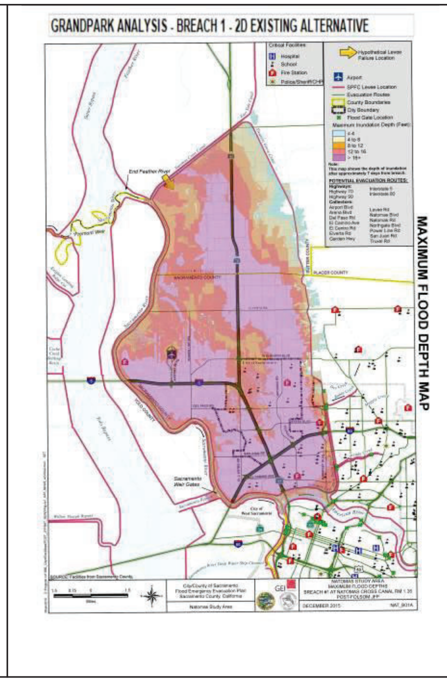
Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

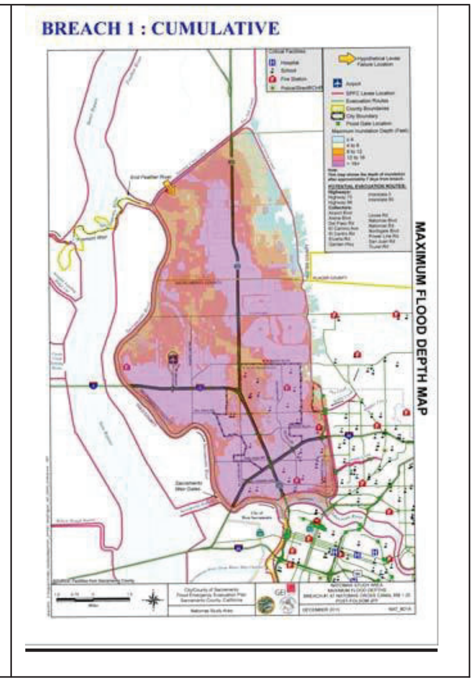
MAXIMUM INUNDATION DEPTH:

Following is a comparison of the Maximum Inundation Depth computed for each breach scenario under each analysis. Oversized versions of these exhibits are presented at the end of this Technical Memorandum.

BREACH 1: (Cross Canal Levee Breach Location)



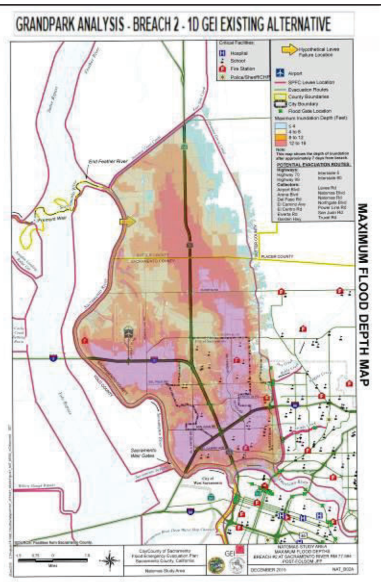


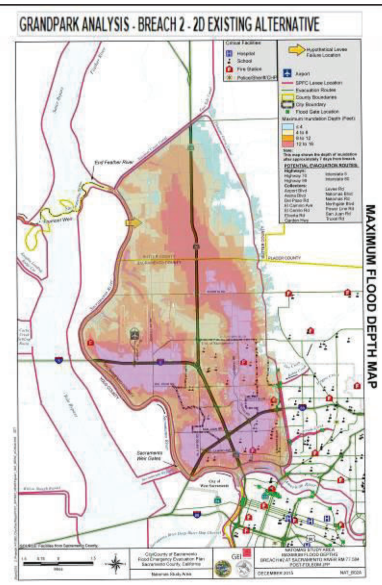


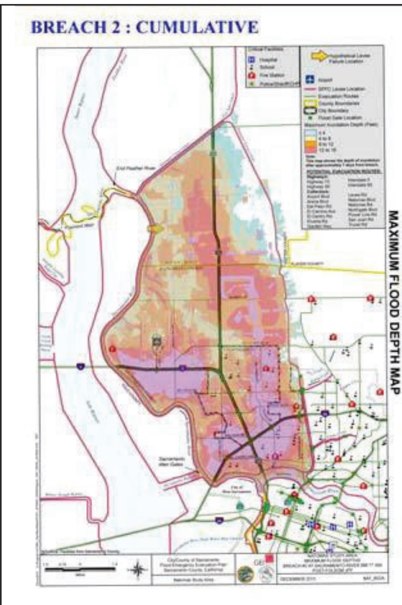
For the Breach 1 scenario, the results are similar except as follows:

- The 1D analysis floods to a greater depth than the 2D analysis.
- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

BREACH 2: (North Sacramento River Breach Location)







For the Breach 2 scenario, all results report a similar final flooding depth with the exception of:

- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.

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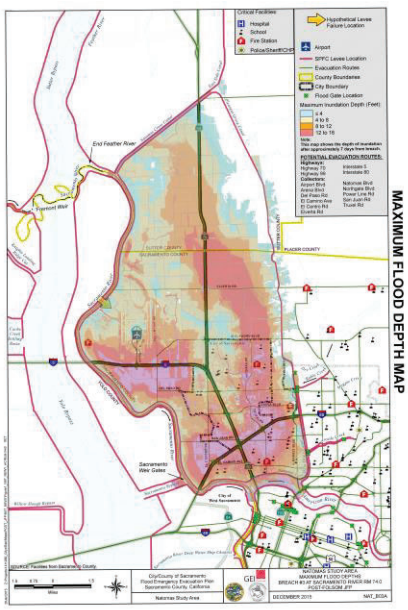
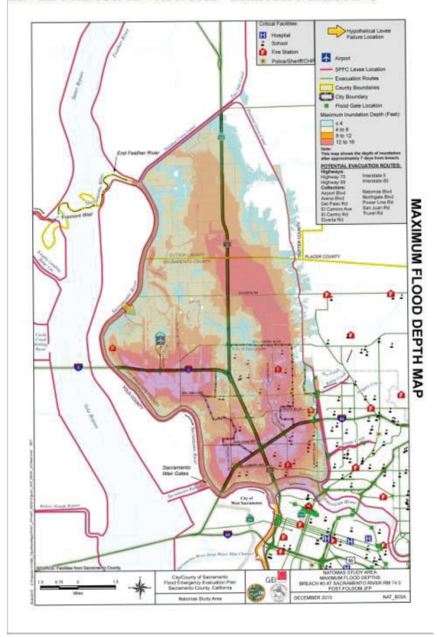
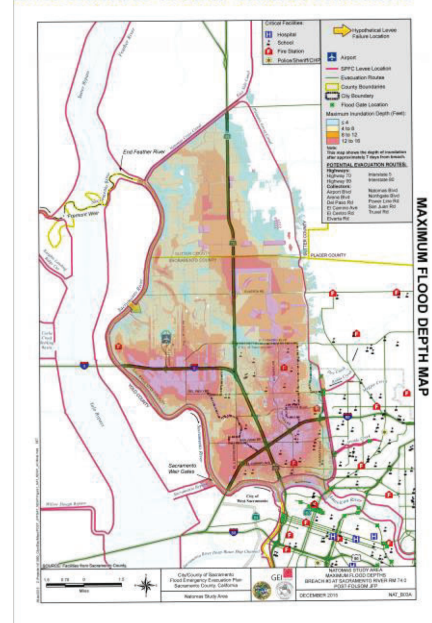
BREACH 3: (Sacramento River Levee Near Elverta Road)



LEVEE BREACH 2D - APR 2022 - BREACH 3 EXISTING



LEVEE BREACH 2D - APR 2022 - BREACH 3 CUMULATIVE



For the Breach 3 scenario, all results report a similar final flooding depth with the exception of:

- The existing conditions 1D analysis showed a much higher maximum flooding depth than the 2D analysis: This is result of greater breach flows being allowed in this model resulting from the differences between storage areas and 2D analysis.

- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.

- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.

- Grading within the Cumulative Developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.

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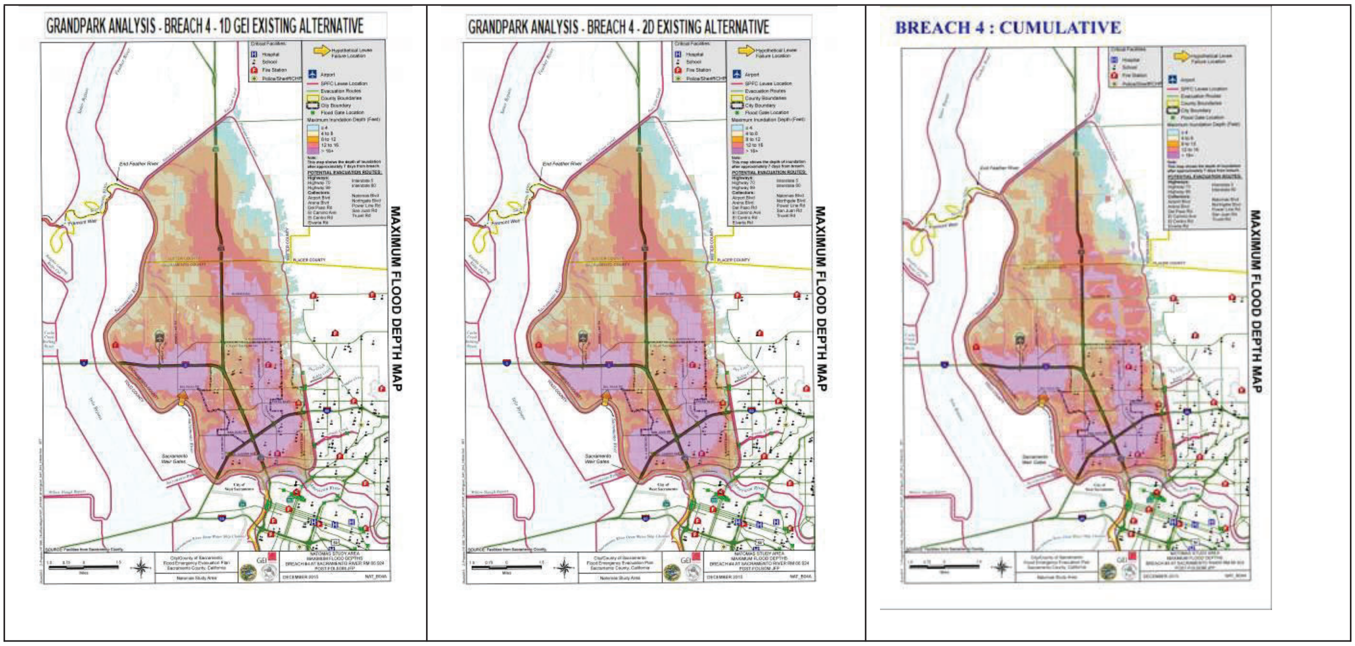
BREACH 4: (Sacramento River Levee South of I-5)



For the Breach 4 scenario, all results report a similar final flooding depth with the exception of:

- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.

- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.

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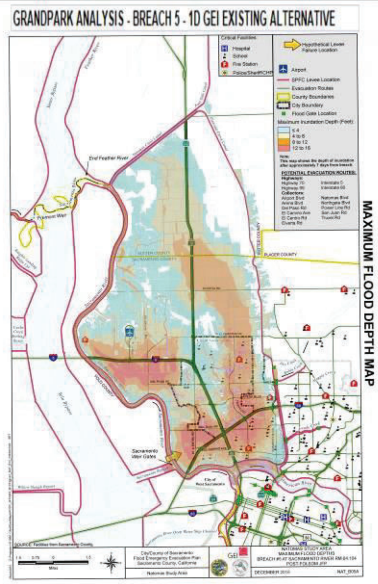
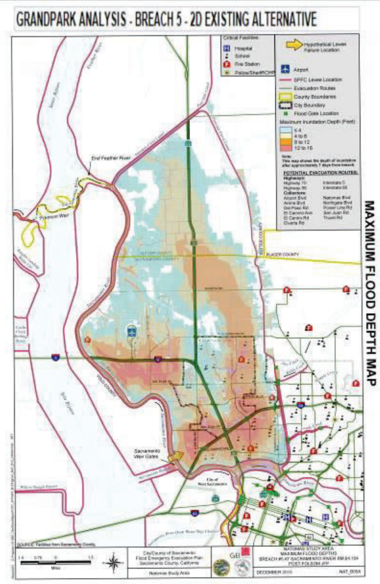
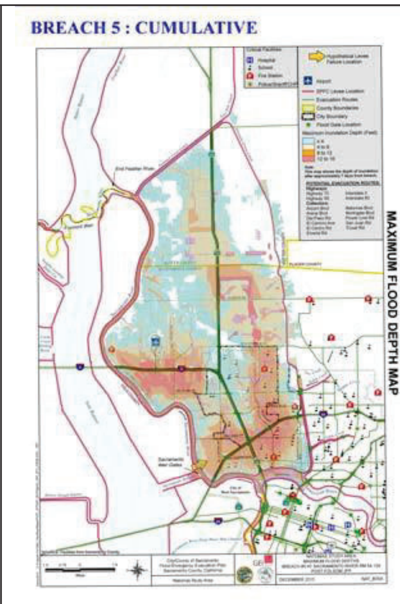
BREACH 5: (Sacramento River Levee Near I-80)







For the Breach 5 scenario, all results report a similar final flooding depth with the exception of:

- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.

- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.

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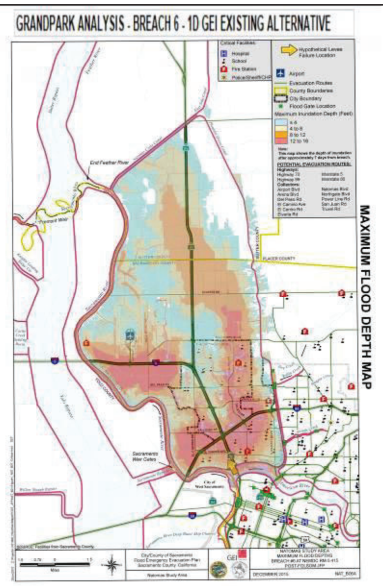
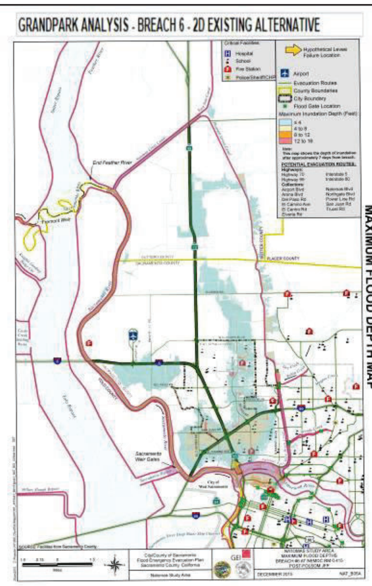
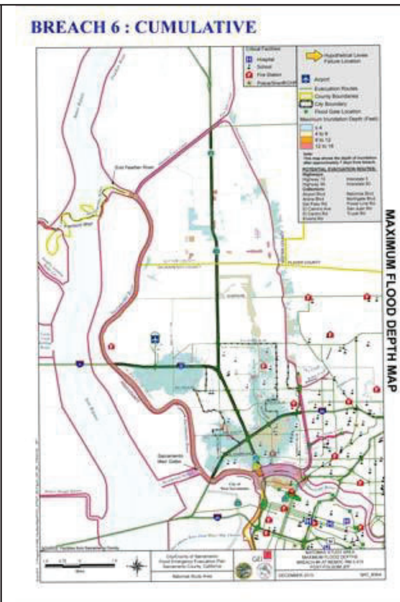
BREACH 6 (American River Levee Near Confluence With Sacramento River):







For the Breach 6 scenario, for the 2D analyses report a similar final flooding depth. However:

- The existing conditions 1D analysis showed a much higher maximum flooding depth than the 2D analysis. This is result of greater breach flows being allowed in this model resulting from the differences between storage areas and 2D analysis.
- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.
- Due to available flood capacity within the Grand Parkway, lower maximum flood depths occur within the southwestern areas and areas north of Elkhorn Blvd.

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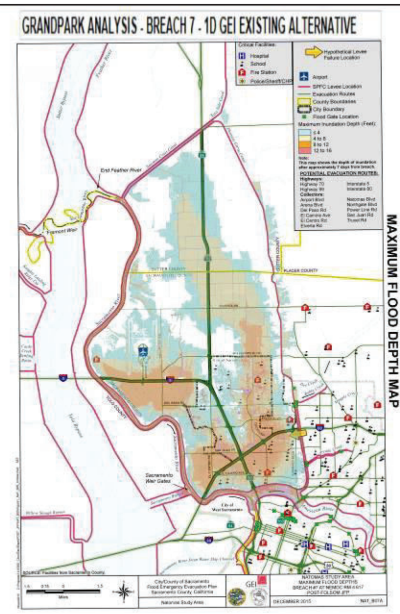
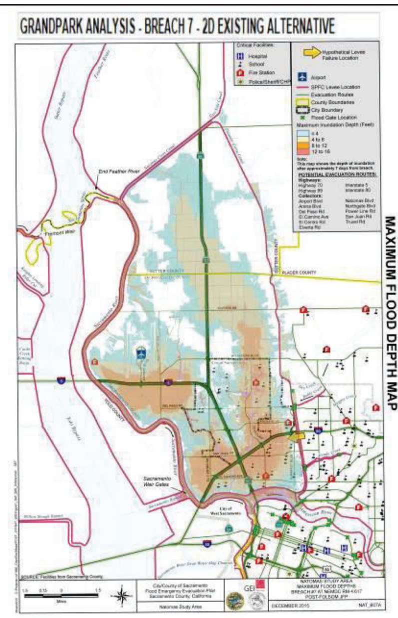
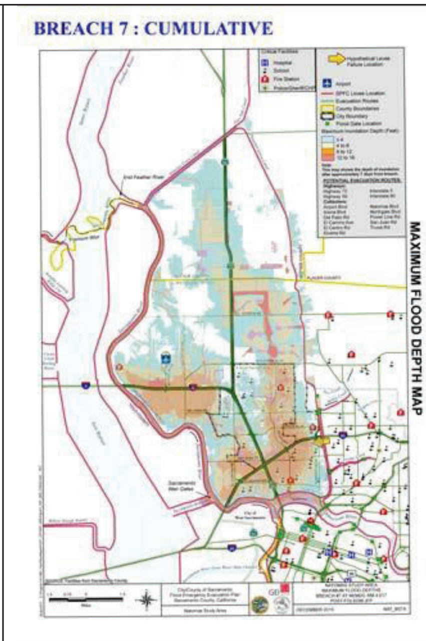
BREACH 7 (NEMDC Levee Near I-80)







For the Breach 7 scenario, all results report a similar final flooding depth with the exception of:

- The existing conditions 1D analysis does not show the Sankey gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at detention basins.

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MAXIMUM DEPTH OF FLOODING COMPARISON

A comparison of Maximum Flooding Water Surface Elevations for the Grandpark and Upper Westside Development Areas, by breach scenario is shown in Table 8. For this table the location of the East Drainage Canal Crossing of Elverta Road was selected for the Grandpark project, and a central point within the Upper Westside project was selected.

TABLE 8
Maximum Flooding Water Surface Elevations
(Existing v. Cumulative Conditions)

BREACH SCENARIO	UWS Existing	UWS Cumulative	Grandpark Existing	Grandpark Cumulative
1 – Natomas Cross Canal	36.85	36.76	36.85	36.76
2 – Sac. River North	31.77	31.78	31.77	31.79
3 – Sac River Northcentral	29.22	29.23	29.22	29.23
4 – Sac River Central.	32.23	32.24	32.23	32.24
5 – Sac River South	25.15	25.14	25.15	25.14
6 – American River	16.15	15.82	15.86	15.51
7 – NEMDC	23.23	23.28	23.23	23.28

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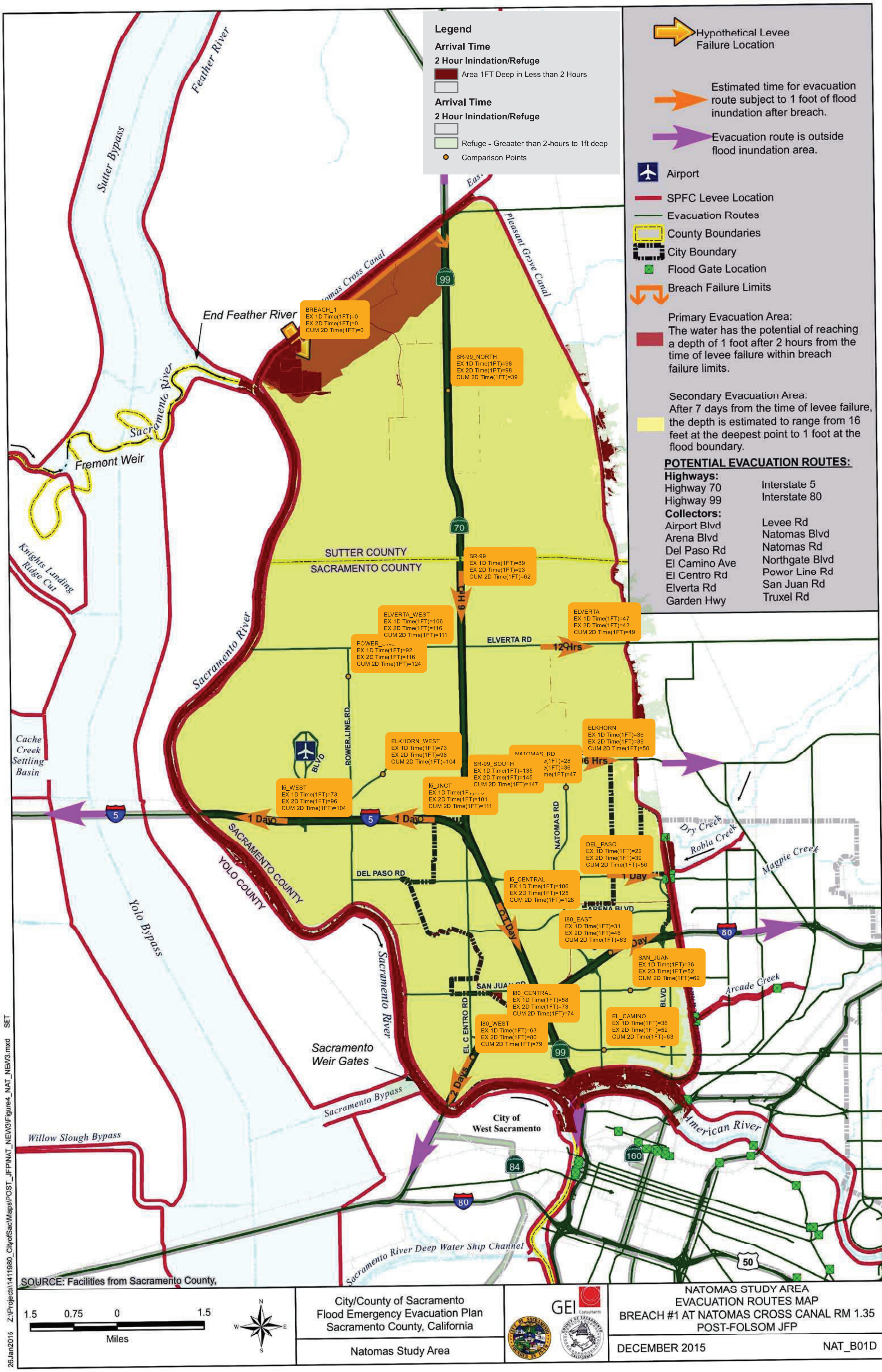
MACKAY & SOMPS
ENGINEERING PLANNING SURVEYING

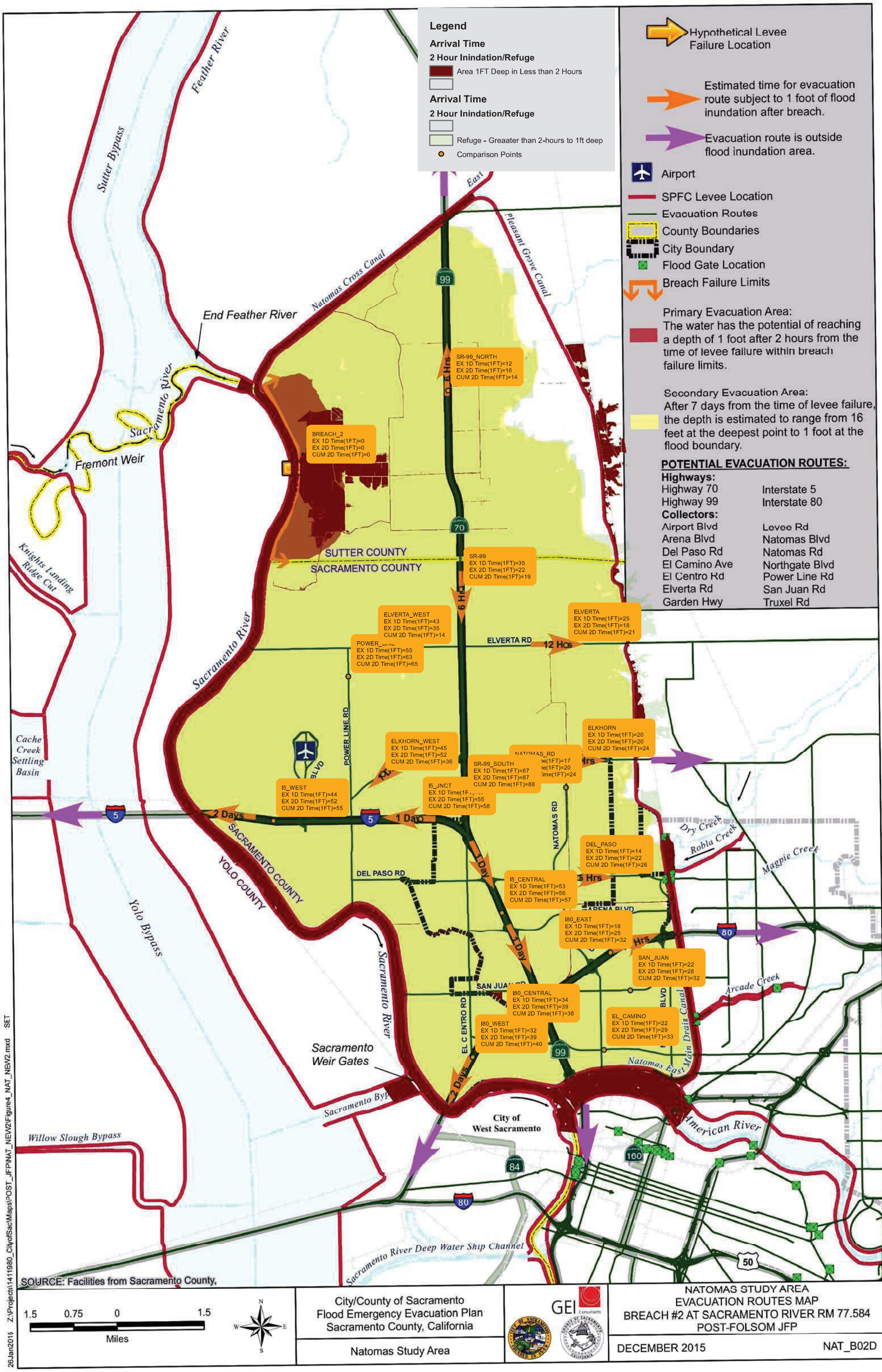
CIVIL ENGINEERING
SOLUTIONS, INC.

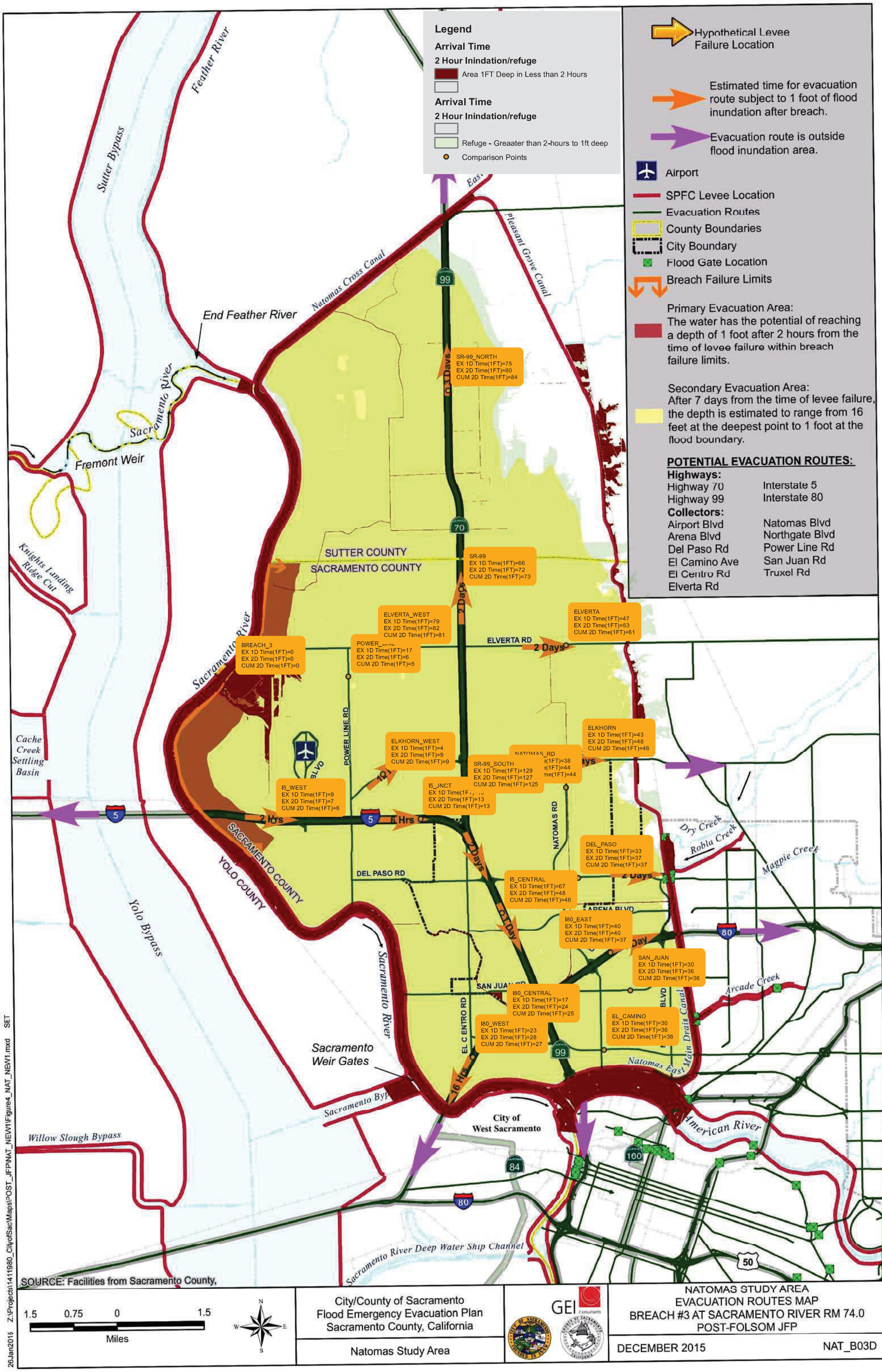
OVERSIZED EXHIBITS



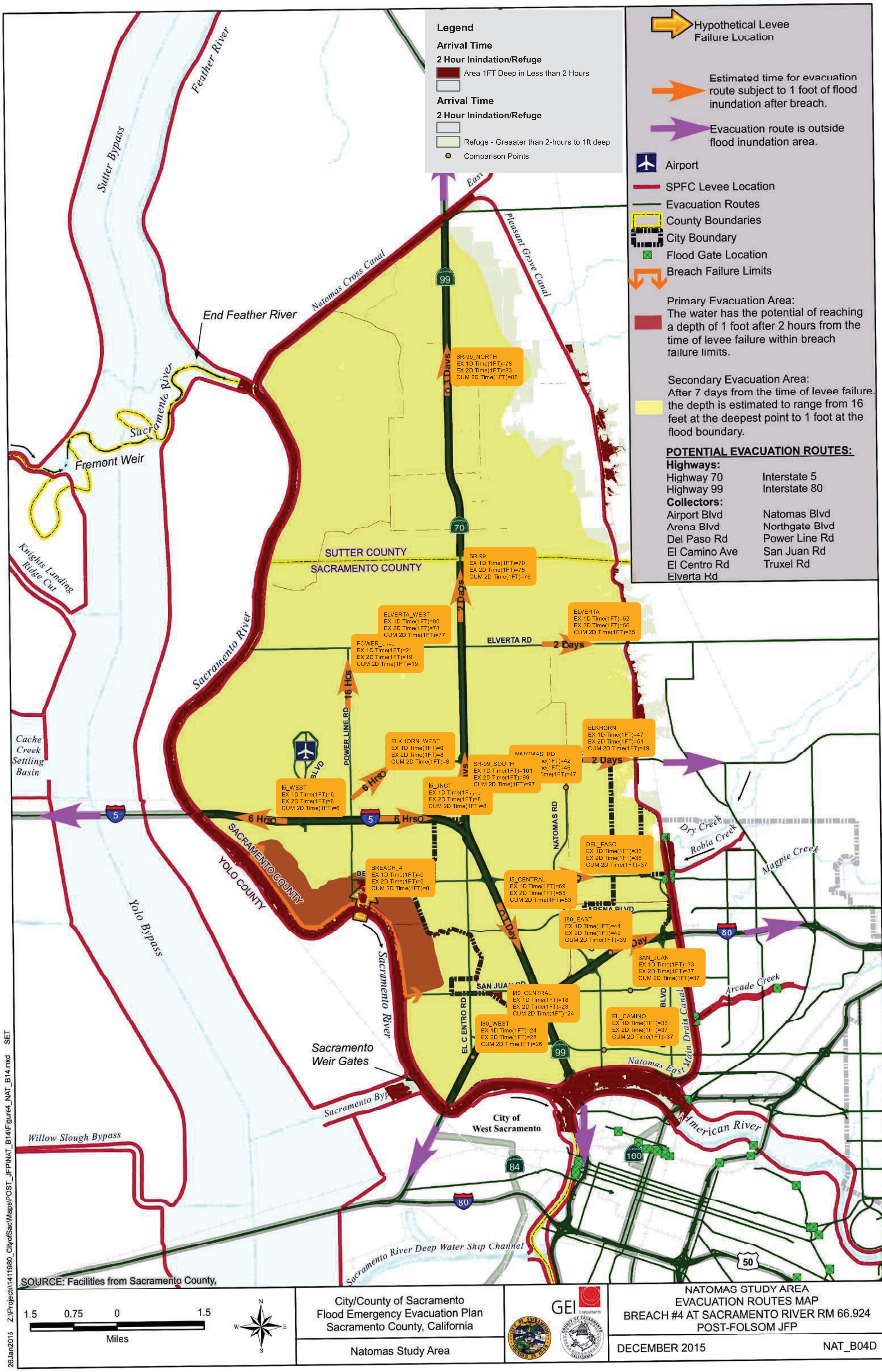
RECOMMENDED EVACUATION ROUTES

RECOMMENDED EVACUATION ROUTES

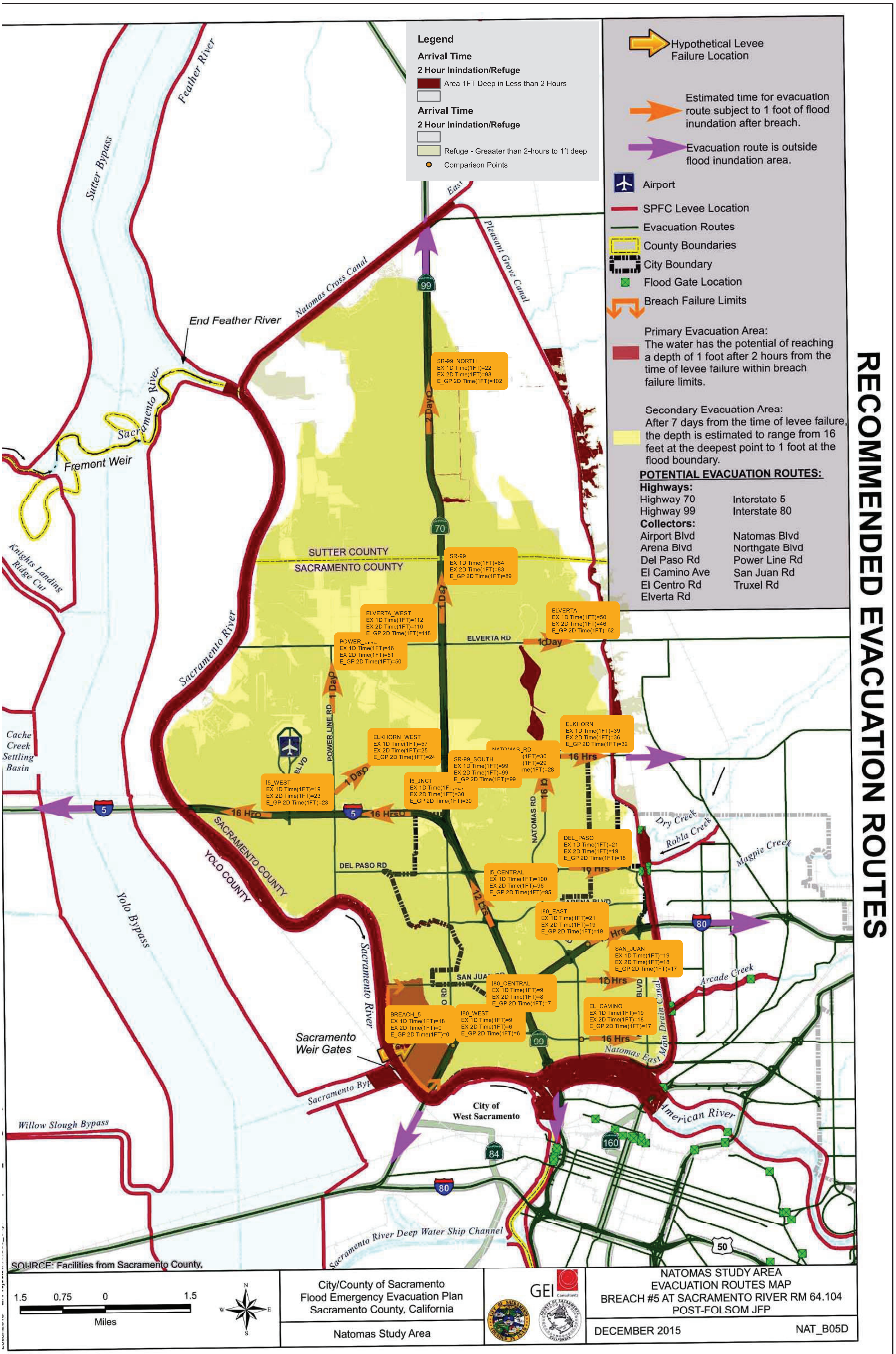




RECOMMENDED EVACUATION ROUTES



RECOMMENDED EVACUATION ROUTES
Legend
Arrival Time
2 Hour Inindation/Refuge
Area 1FT Deep in Less than 2 Hours
Arrival Time
2 Hour Inindation/Refuge
Refuge - Greaater than 2-hours to 1ft deep
Comparison Points
Hypothetical Levee Failure Location
Estimated time for evacuation route subject to 1 foot of flood inundation after breach.
Evacuation route is outside flood inundation area.
Airport
SPFC Levee Location
Evacuation Routes
County Boundaries
City Boundary
Flood Gate Location
Breach Failure Limits
Primary Evacuation Area: The water has the potential of reaching a depth of 1 foot after 2 hours from the time of levee failure within breach failure limits.
Secondary Evacuation Area: After 7 days from the time of levee failure the depth is estimated to range from 16 feet at the deepest point to 1 foot at the flood boundary.
POTENTIAL EVACUATION ROUTES:
Highways:
Highway 70
Highway 99
Interstate 5
Interstate 80
Collectors:
Airport Blvd
Arena Blvd
Del Paso Rd
El Camino Ave
El Centro Rd
Elverta Rd
Natomas Blvd
Northgate Blvd
Power Line Rd
San Juan Rd
Truxel Rd
Feather River
Sutter Bypass
Natomas Cross Canal
Pleasant Grove Canal
End Feather River
Sacramento River
Fremont Weir
Knights Landing Ridge Cut
SUTTER COUNTY
SACRAMENTO COUNTY
YOLO COUNTY
Cache Creek Settling Basin
Yolo Bypass
Sacramento Weir Gates
Sacramento Bypass
Willow Slough Bypass
City of West Sacramento
American River
Natomas East Main Drain Canal
Dry Creek
Robla Creek
Magpie Creek
Arcade Creek
Sacramento River Deep Water Ship Channel
ELVERTA RD
NATOMAS RD
POWER LINE RD
EL C ENTRO RD
ARENA BLVD
SAN JUAN RD
0.3 Days
2 Days
16 Hrs
6 Hrs
0.1 Day
SR-99_NORTH
EX 1D Time(1FT)=78
EX 2D Time(1FT)=83
CUM 2D Time(1FT)=85
SR-99
EX 1D Time(1FT)=70
EX 2D Time(1FT)=75
CUM 2D Time(1FT)=76
ELVERTA_WEST
EX 1D Time(1FT)=80
EX 2D Time(1FT)=78
CUM 2D Time(1FT)=77
ELVERTA
EX 1D Time(1FT)=52
EX 2D Time(1FT)=56
CUM 2D Time(1FT)=65
EX 1D Time(1FT)=21
EX 2D Time(1FT)=19
CUM 2D Time(1FT)=19
ELKHORN_WEST
EX 1D Time(1FT)=9
EX 2D Time(1FT)=8
CUM 2D Time(1FT)=8
ELKHORN
EX 1D Time(1FT)=47
EX 2D Time(1FT)=51
CUM 2D Time(1FT)=49
SR-99_SOUTH
EX 1D Time(1FT)=101
EX 2D Time(1FT)=99
CUM 2D Time(1FT)=97
I5_WEST
EX 1D Time(1FT)=6
EX 2D Time(1FT)=6
CUM 2D Time(1FT)=6
I5_JNCT
EX 2D Time(1FT)=8
CUM 2D Time(1FT)=8
BREACH_4
EX 1D Time(1FT)=0
EX 2D Time(1FT)=0
CUM 2D Time(1FT)=0
DEL_PASO
EX 1D Time(1FT)=36
EX 2D Time(1FT)=38
CUM 2D Time(1FT)=37
I5_CENTRAL
EX 1D Time(1FT)=69
EX 2D Time(1FT)=55
CUM 2D Time(1FT)=53
I80_EAST
EX 1D Time(1FT)=44
EX 2D Time(1FT)=42
CUM 2D Time(1FT)=39
SAN_JUAN
EX 1D Time(1FT)=33
EX 2D Time(1FT)=37
CUM 2D Time(1FT)=37
I80_CENTRAL
EX 1D Time(1FT)=18
EX 2D Time(1FT)=23
CUM 2D Time(1FT)=24
I80_WEST
EX 1D Time(1FT)=24
EX 2D Time(1FT)=28
CUM 2D Time(1FT)=26
EL_CAMINO
EX 1D Time(1FT)=33
EX 2D Time(1FT)=37
CUM 2D Time(1FT)=37
SOURCE: Facilities from Sacramento County,
1.5 0.75 0 1.5
Miles
City/County of Sacramento
Flood Emergency Evacuation Plan
Sacramento County, California
Natomas Study Area
GEI Consultants
NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #4 AT SACRAMENTO RIVER RM 66.924
POST-FOLSOM JFP
DECEMBER 2015
NAT_B04D
26Jan2016 Z:\Projects\1411980_CityofSacMaps\POST_JFP\NAT_B14\Figure4_NAT_B14.mxd SET


RECOMMENDED EVACUATION ROUTES
Legend
Arrival Time
2 Hour Inindation/Refuge
Area 1FT Deep in Less than 2 Hours
Arrival Time
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Hypothetical Levee Failure Location
Estimated time for evacuation route subject to 1 foot of flood inundation after breach.
Evacuation route is outside flood inundation area.
Airport
SPFC Levee Location
Evacuation Routes
County Boundaries
City Boundary
Flood Gate Location
Breach Failure Limits
Primary Evacuation Area: The water has the potential of reaching a depth of 1 foot after 2 hours from the time of levee failure within breach failure limits.
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POTENTIAL EVACUATION ROUTES:
Highways:
Highway 70
Highway 99
Interstate 5
Interstate 80
Collectors:
Airport Blvd
Arena Blvd
Del Paso Rd
El Camino Ave
El Centro Rd
Elverta Rd
Natomas Blvd
Northgate Blvd
Power Line Rd
San Juan Rd
Truxel Rd
Feather River
Sutter Bypass
Natomas Cross Canal
Pleasant Grove Canal
End Feather River
Sacramento River
Fremont Weir
Knights Landing Ridge Cut
SUTTER COUNTY
SACRAMENTO COUNTY
YOLO COUNTY
Cache Creek Settling Basin
Yolo Bypass
Sacramento Weir Gates
Sacramento Bypass
Willow Slough Bypass
City of West Sacramento
American River
Natomas East Main Drain Canal
Dry Creek
Robla Creek
Magpie Creek
Arcade Creek
Sacramento River Deep Water Ship Channel
ELVERTA RD
POWER LINE RD
NATOMAS RD
DEL PASO RD
SAN JUAN RD
SR-99_NORTH
EX 1D Time(1FT)=22
EX 2D Time(1FT)=98
E_GP 2D Time(1FT)=102
SR-99
EX 1D Time(1FT)=84
EX 2D Time(1FT)=83
E_GP 2D Time(1FT)=89
ELVERTA_WEST
EX 1D Time(1FT)=112
EX 2D Time(1FT)=110
E_GP 2D Time(1FT)=118
EX 1D Time(1FT)=46
EX 2D Time(1FT)=51
E_GP 2D Time(1FT)=50
ELVERTA
EX 1D Time(1FT)=50
EX 2D Time(1FT)=46
E_GP 2D Time(1FT)=62
ELKHORN_WEST
EX 1D Time(1FT)=57
EX 2D Time(1FT)=25
E_GP 2D Time(1FT)=24
ELKHORN
EX 1D Time(1FT)=39
EX 2D Time(1FT)=36
E_GP 2D Time(1FT)=32
SR-99_SOUTH
EX 1D Time(1FT)=99
EX 2D Time(1FT)=99
E_GP 2D Time(1FT)=99
I5_WEST
EX 1D Time(1FT)=19
EX 2D Time(1FT)=23
E_GP 2D Time(1FT)=23
I5_JNCT
EX 2D Time(1FT)=30
E_GP 2D Time(1FT)=30
DEL_PASO
EX 1D Time(1FT)=21
EX 2D Time(1FT)=19
E_GP 2D Time(1FT)=18
I5_CENTRAL
EX 1D Time(1FT)=100
EX 2D Time(1FT)=96
E_GP 2D Time(1FT)=95
I80_EAST
EX 1D Time(1FT)=21
EX 2D Time(1FT)=19
E_GP 2D Time(1FT)=19
SAN_JUAN
EX 1D Time(1FT)=19
EX 2D Time(1FT)=18
E_GP 2D Time(1FT)=17
I80_CENTRAL
EX 1D Time(1FT)=9
EX 2D Time(1FT)=8
E_GP 2D Time(1FT)=7
BREACH_5
EX 1D Time(1FT)=18
EX 2D Time(1FT)=0
E_GP 2D Time(1FT)=0
I80_WEST
EX 1D Time(1FT)=9
EX 2D Time(1FT)=6
E_GP 2D Time(1FT)=6
EL_CAMINO
EX 1D Time(1FT)=19
EX 2D Time(1FT)=18
E_GP 2D Time(1FT)=17
2 Days
1 Day
16 Hrs
12 Hrs
SOURCE: Facilities from Sacramento County.
1.5 0.75 0 1.5
Miles
City/County of Sacramento
Flood Emergency Evacuation Plan
Sacramento County, California
Natomas Study Area
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NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #5 AT SACRAMENTO RIVER RM 64.104
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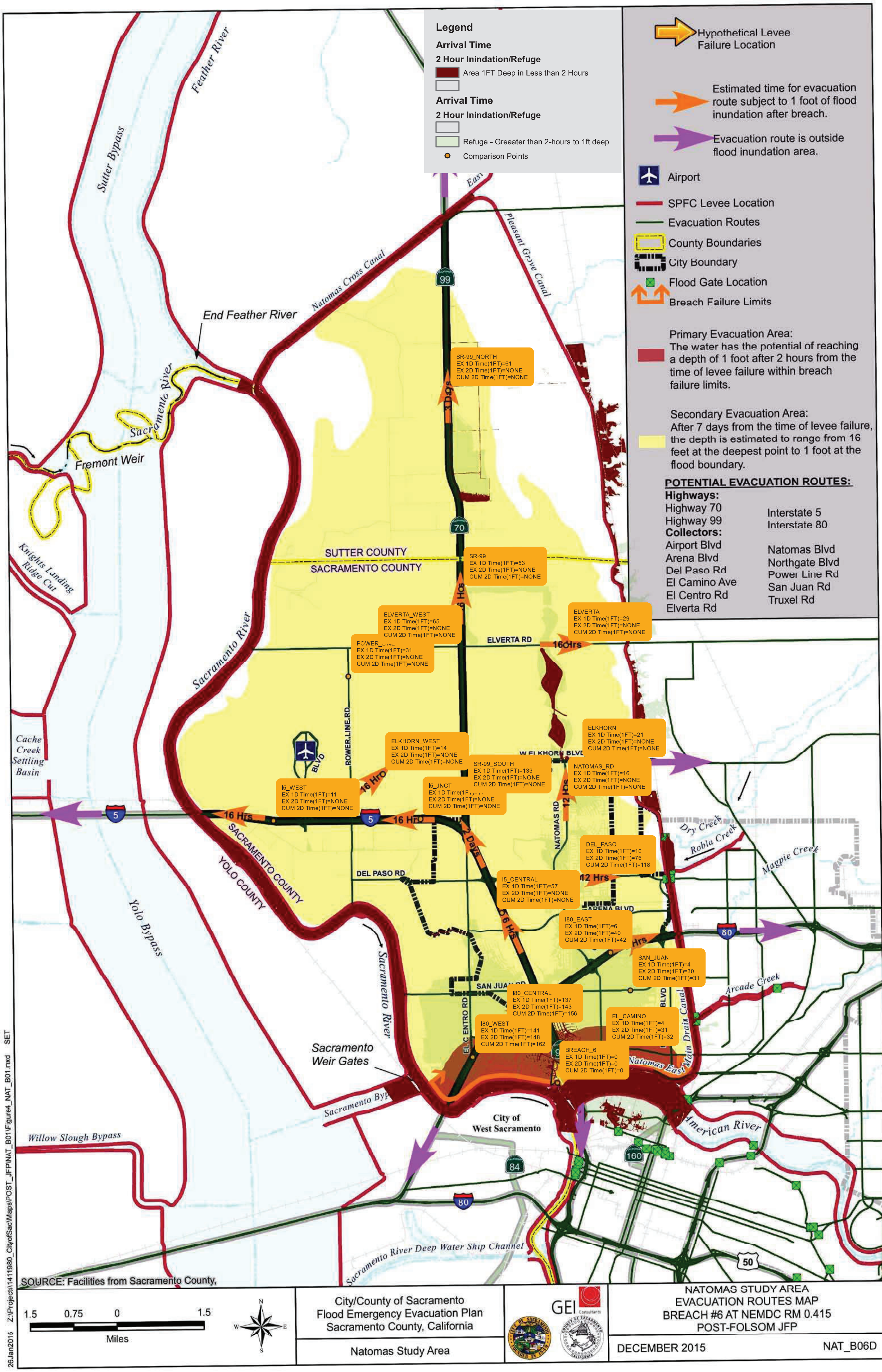
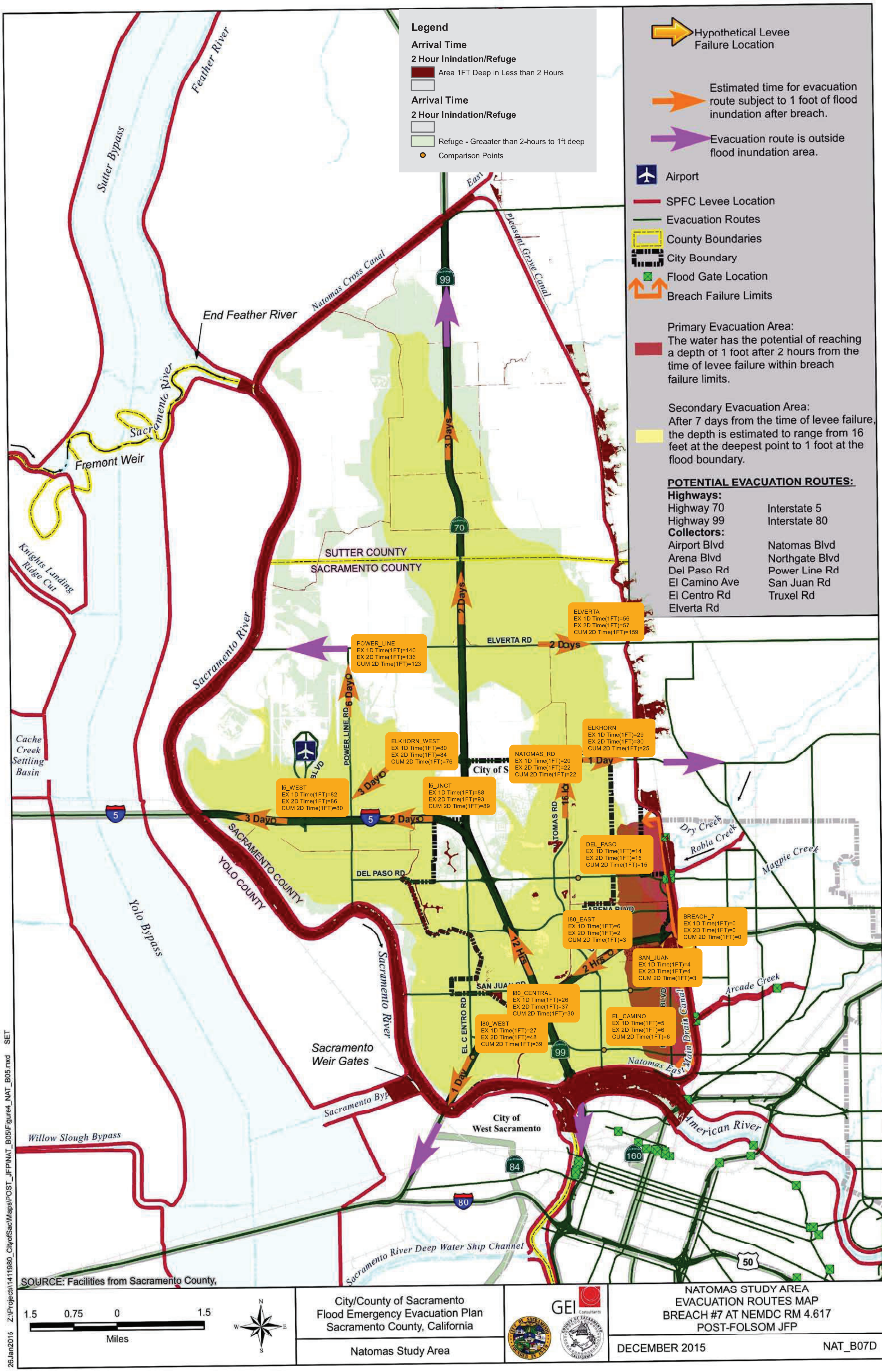
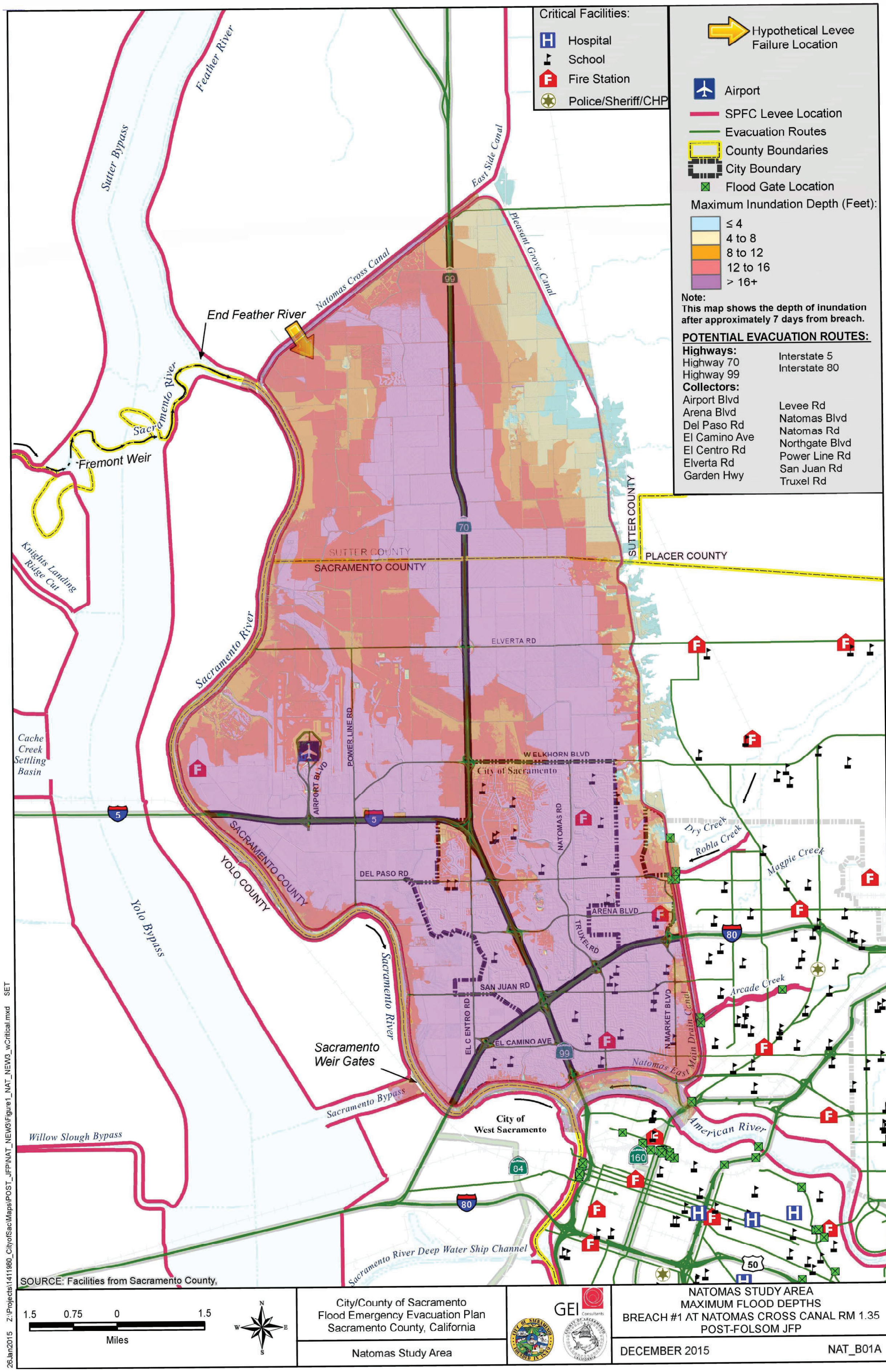
DECEMBER 2015
NAT_B05D



RECOMMENDED EVACUATION ROUTES

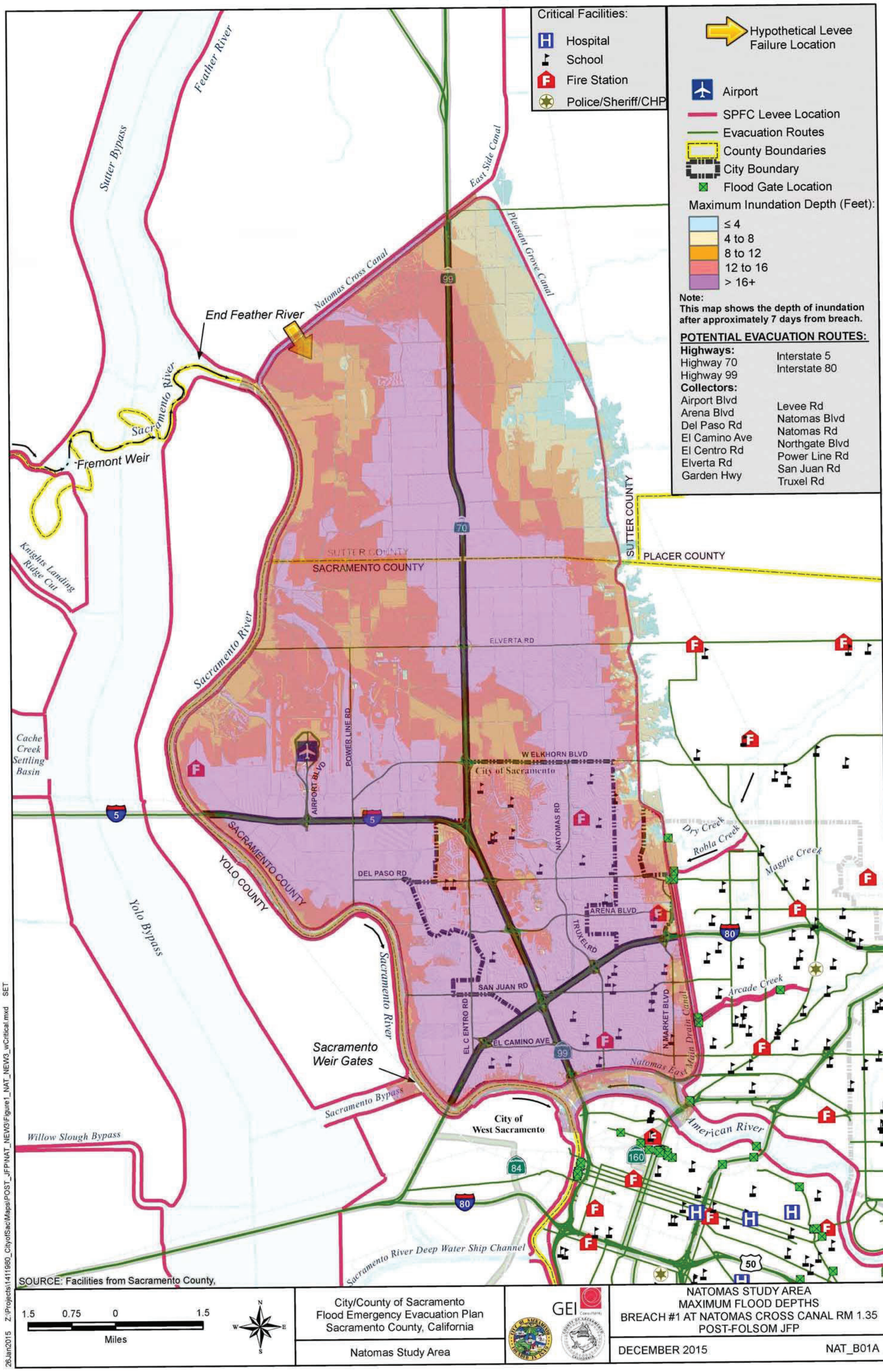
RECOMMENDED EVACUATION ROUTES



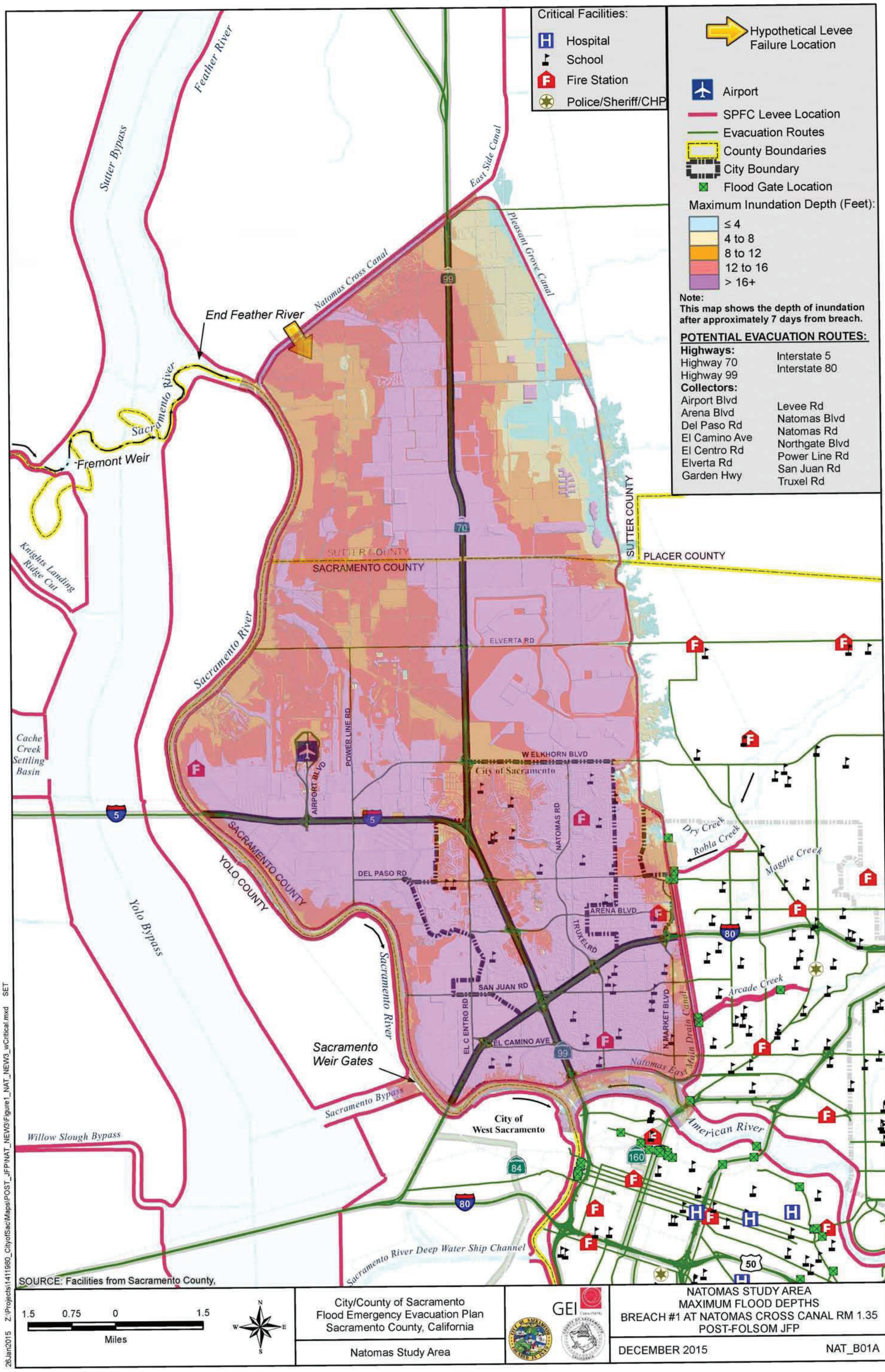


MAXIMUM FLOOD DEPTH MAP

LEVEE BREACH 2D - APR 2022 - BREACH 1 EXISTING

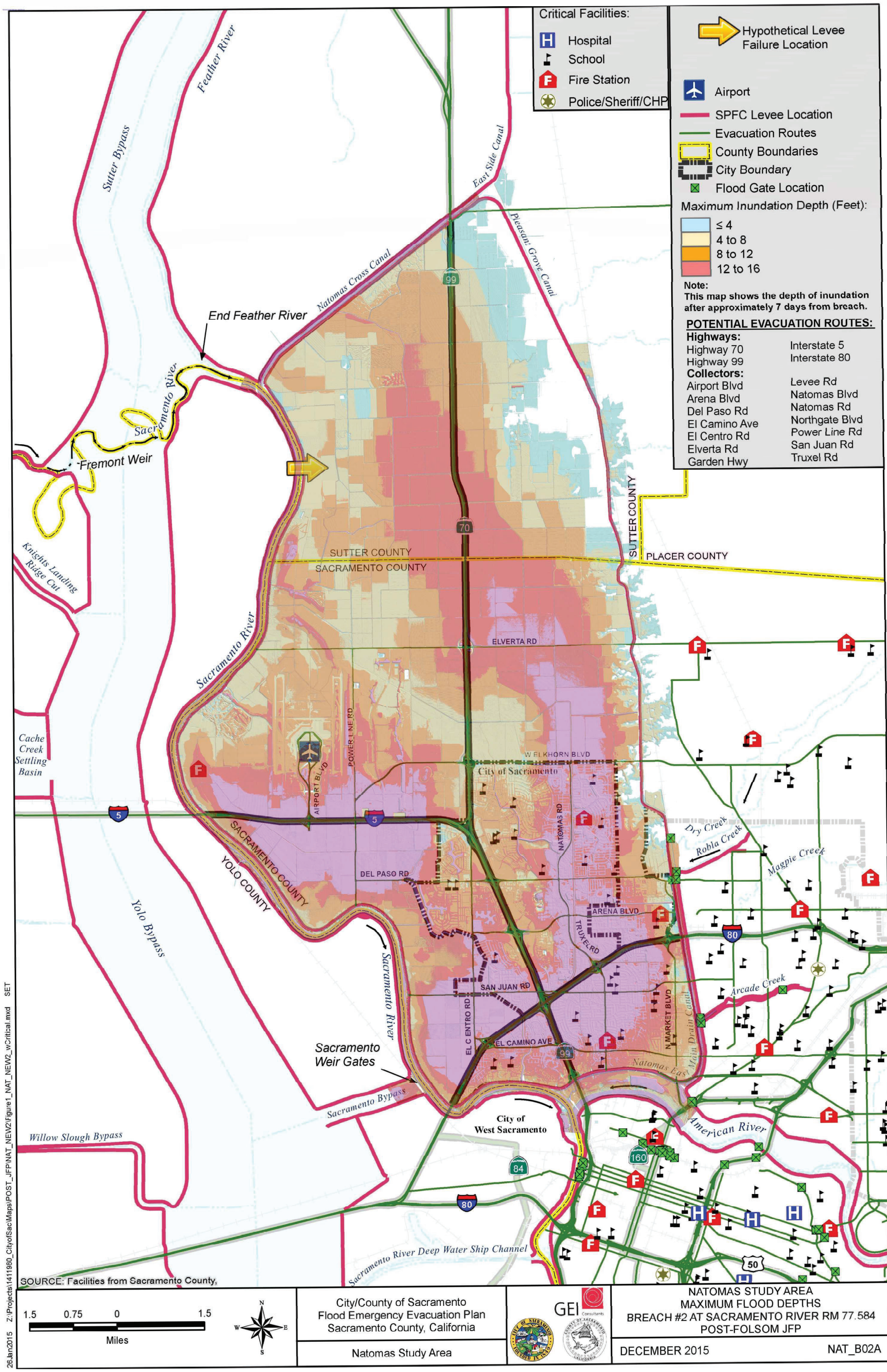


LEVEE BREACH 2D - APR 2022 - BREACH 1 CUMULATIVE

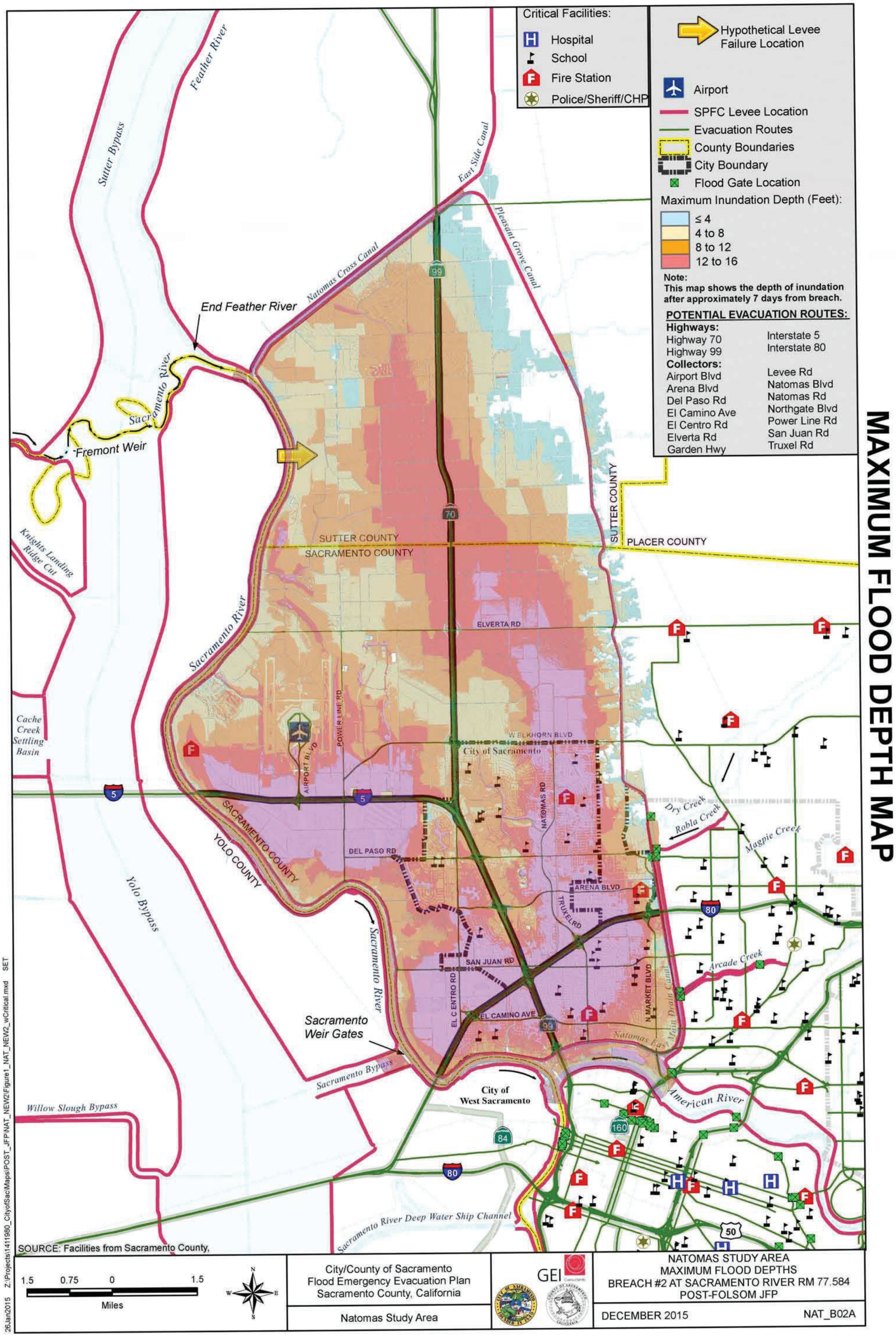


MAXIMUM FLOOD DEPTH MAP

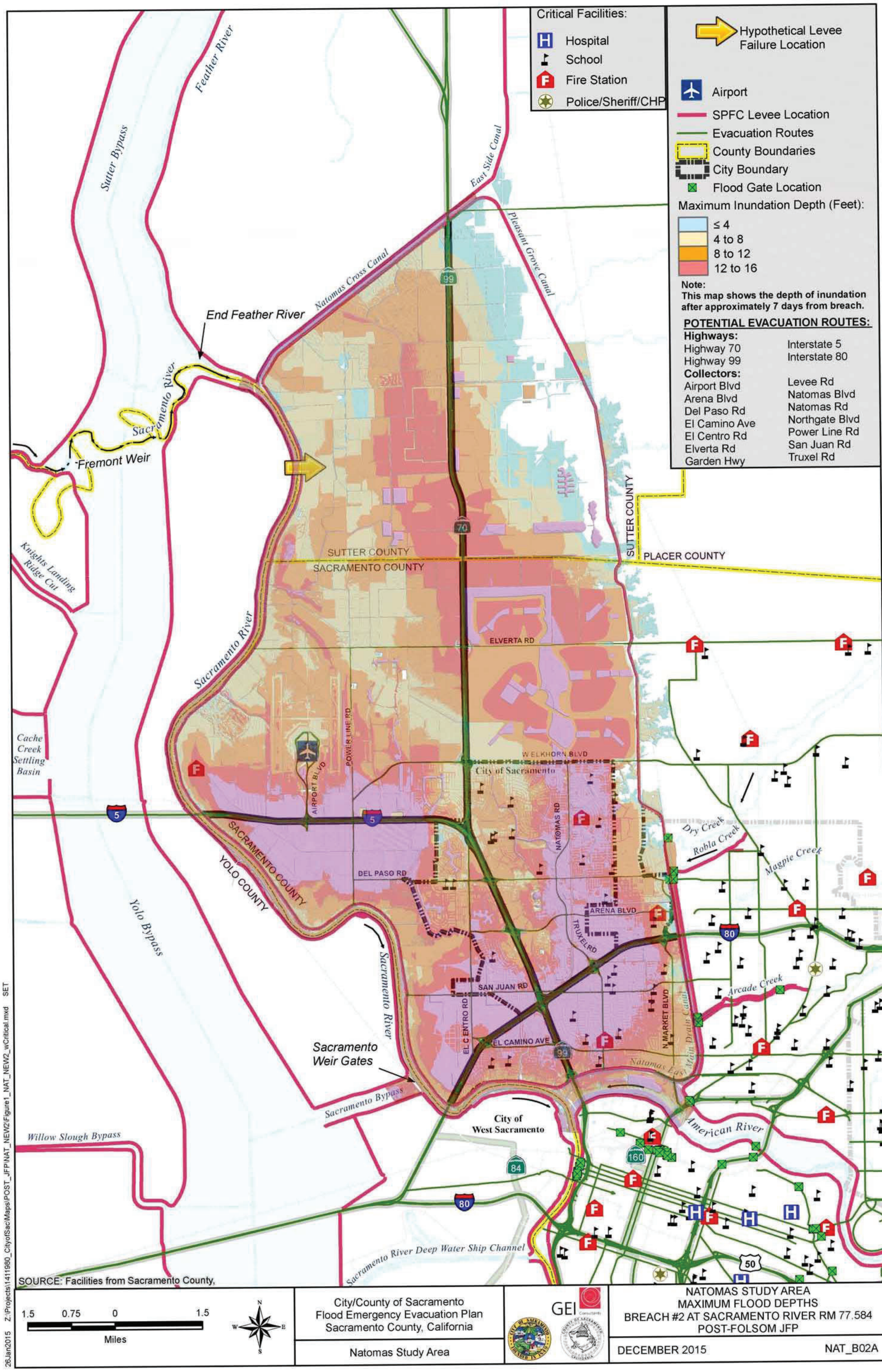
MAXIMUM FLOOD DEPTH MAP



LEVEE BREACH 2D - APR 2022 - BREACH 2 EXISTING

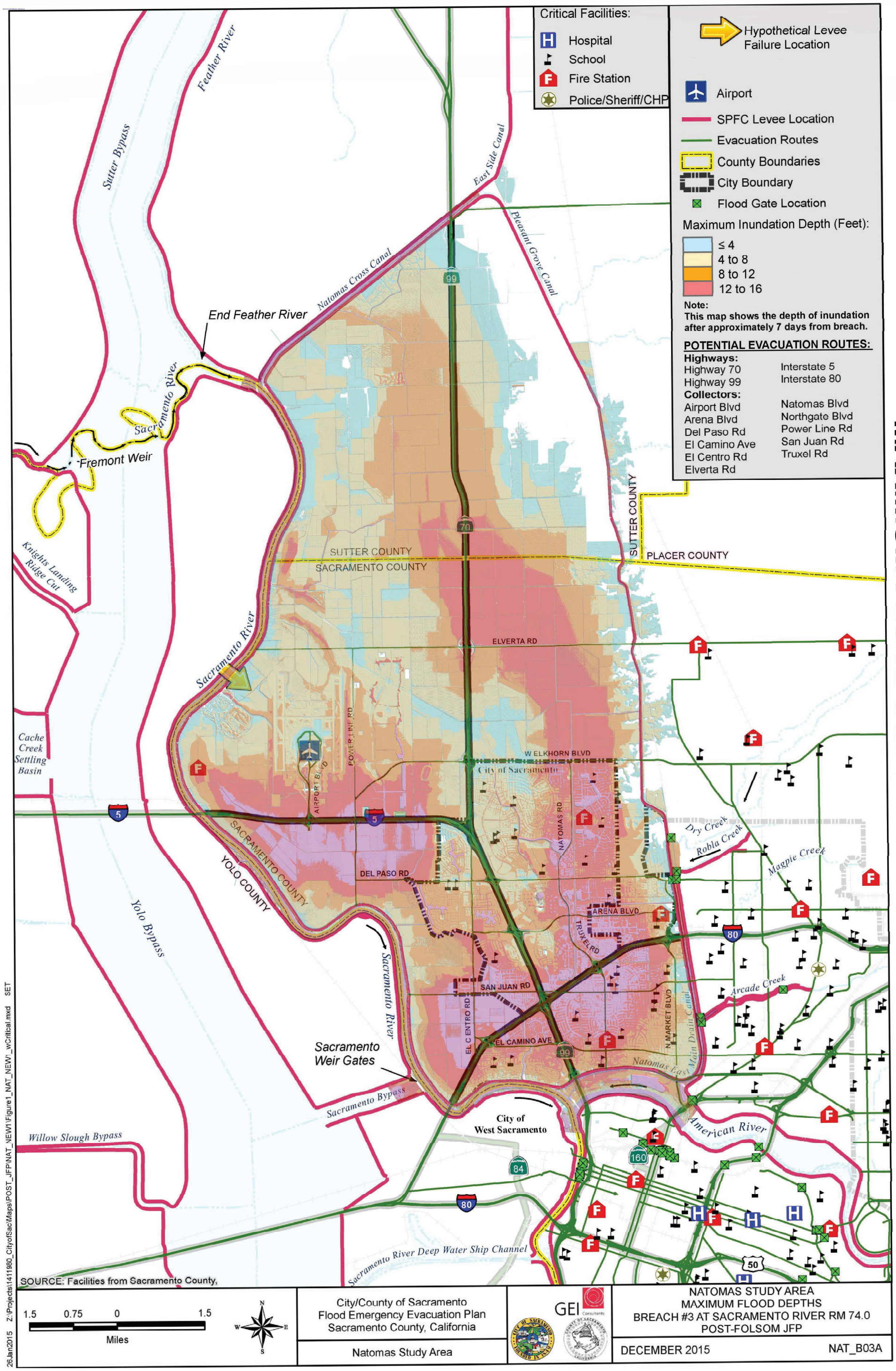


LEVEE BREACH 2D - APR 2022 - BREACH 2 CUMULATIVE



MAXIMUM FLOOD DEPTH MAP

MAXIMUM FLOOD DEPTH MAP



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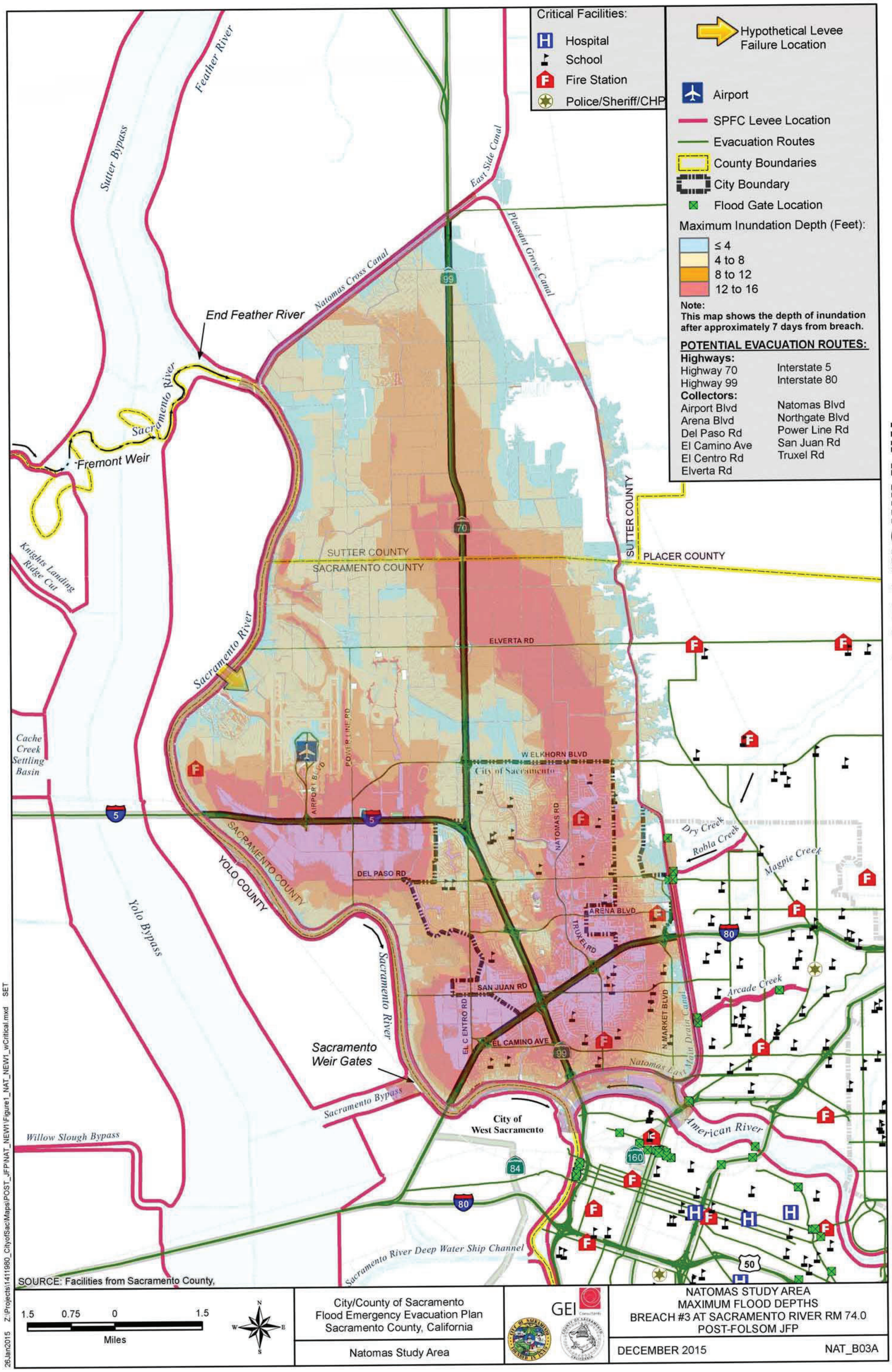

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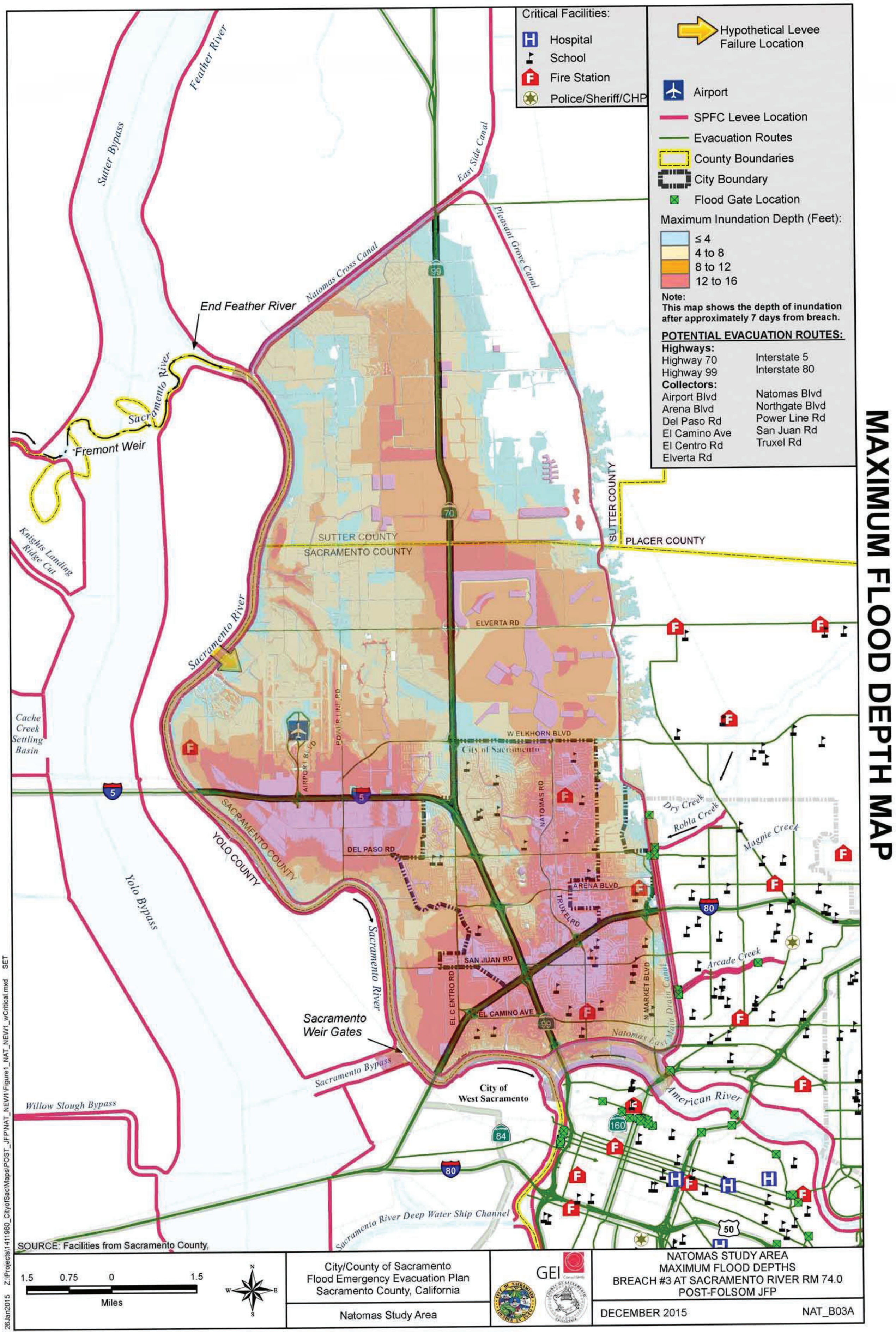

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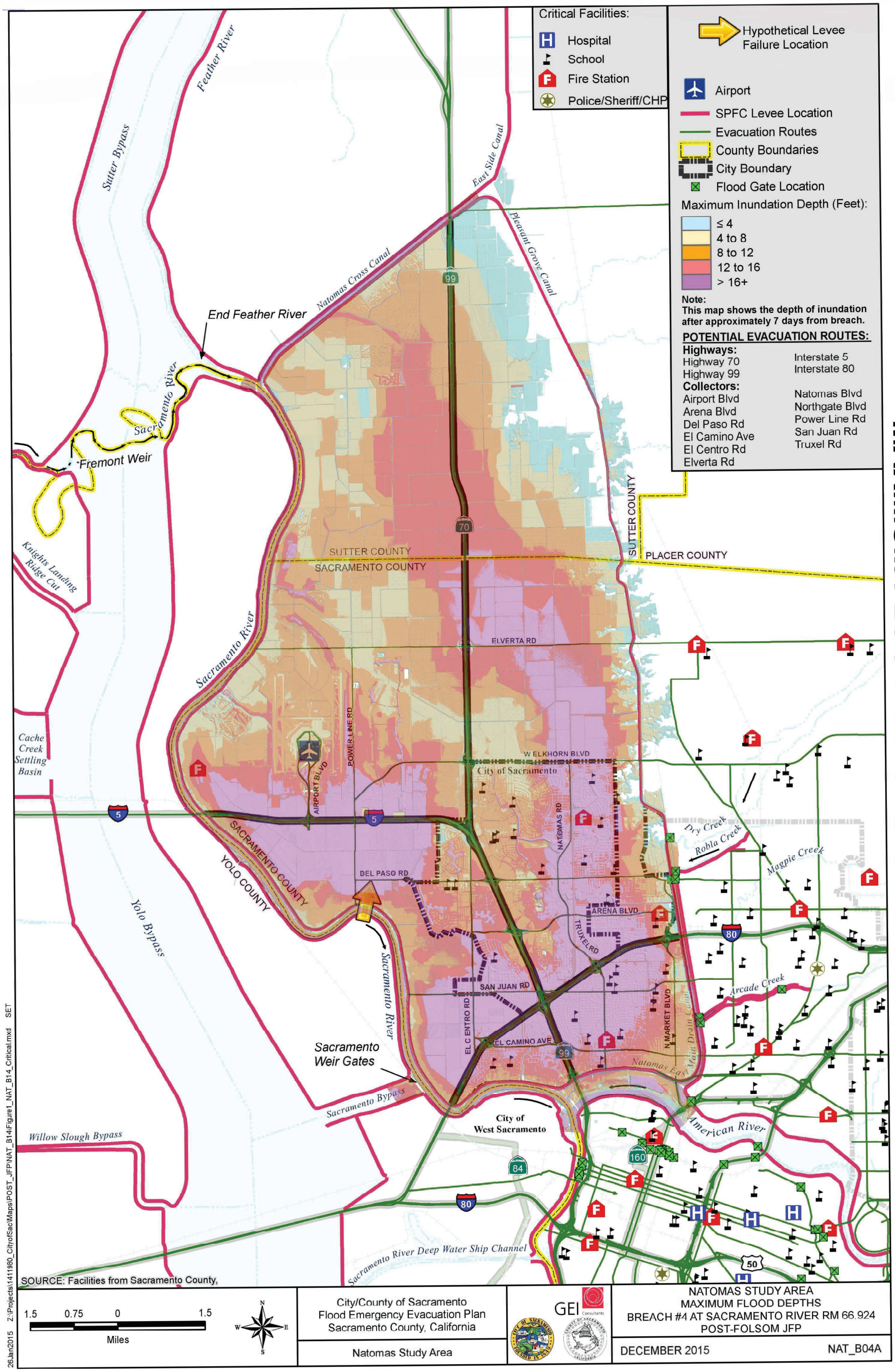

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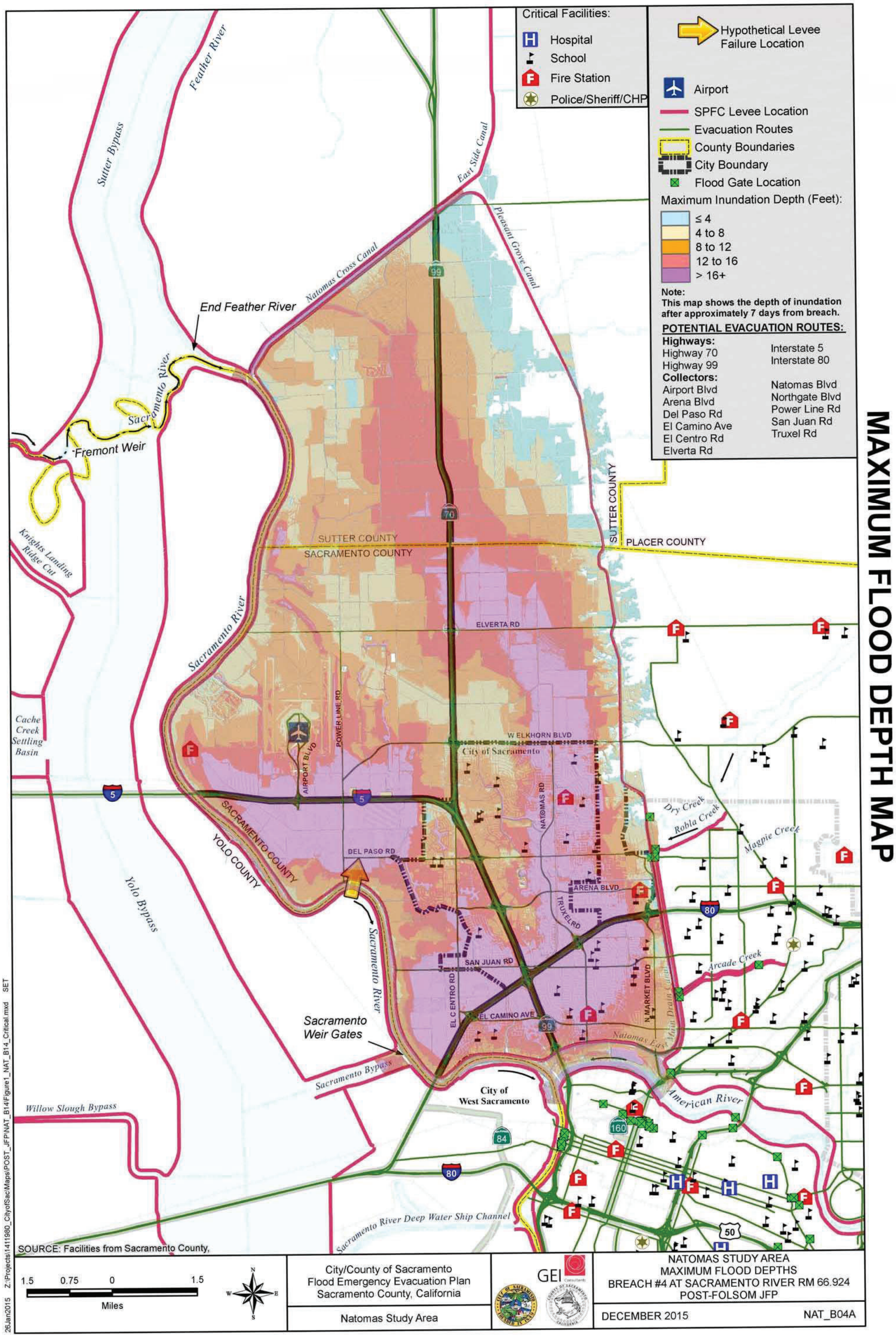

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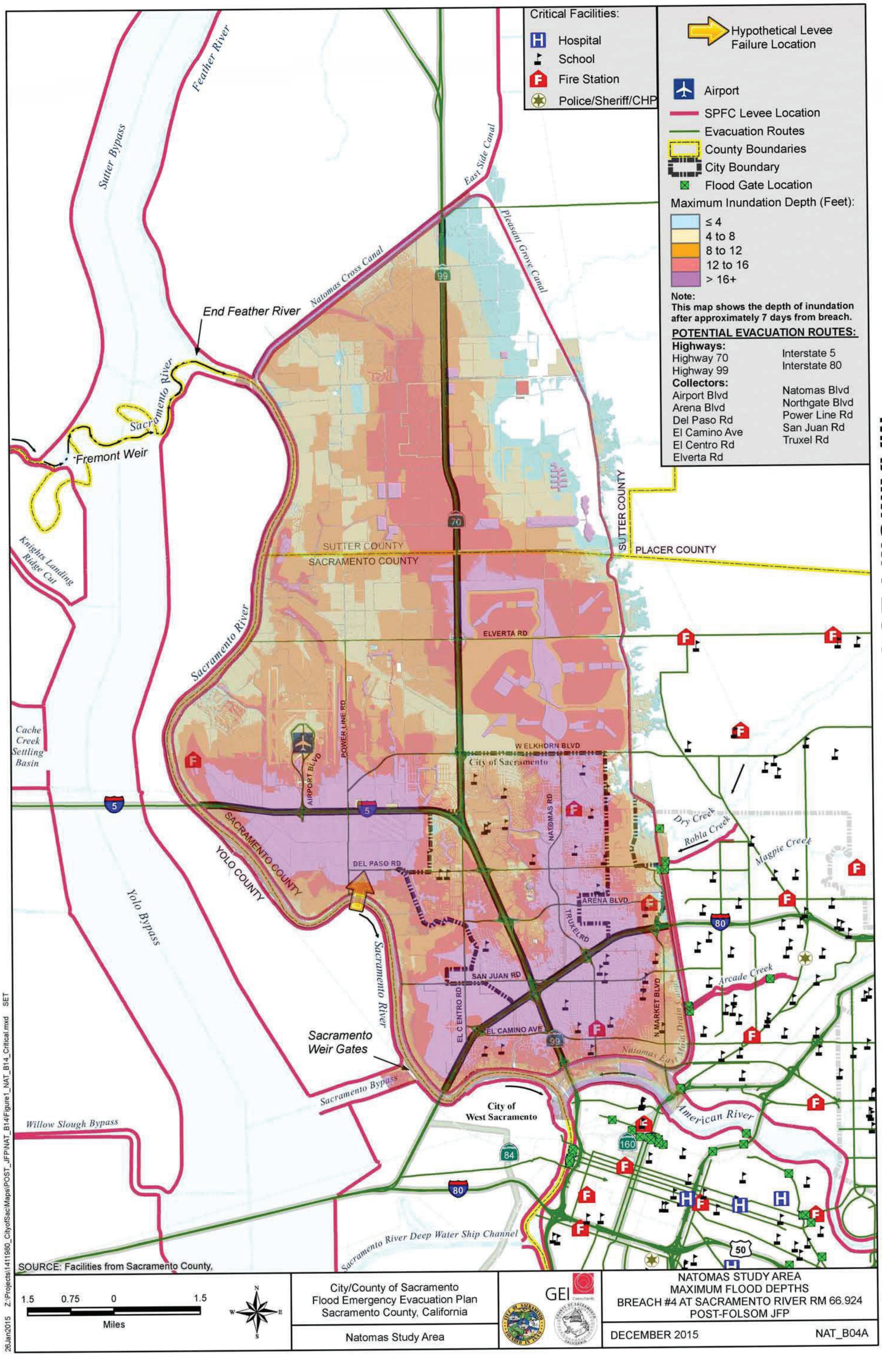
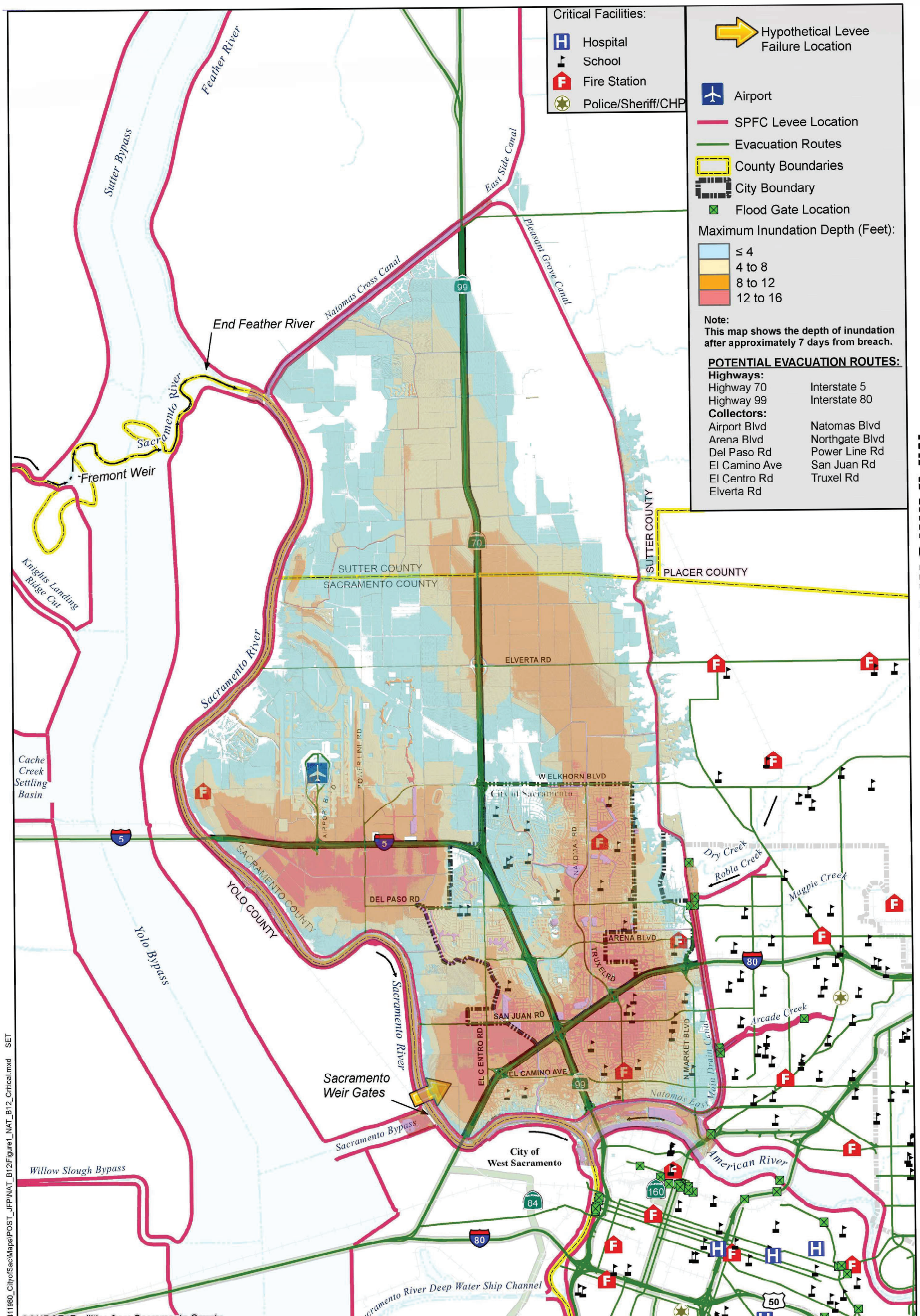


MAXIMUM FLOOD DEPTH MAP



City/County of Sacramento
Flood Emergency Evacuation Plan
Sacramento County, California

Natomas Study Area

GEI Consultants

NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #5 AT SACRAMENTO RIVER RM 64.104
POST-FOLSOM JFP

DECEMBER 2015 NAT_B05A

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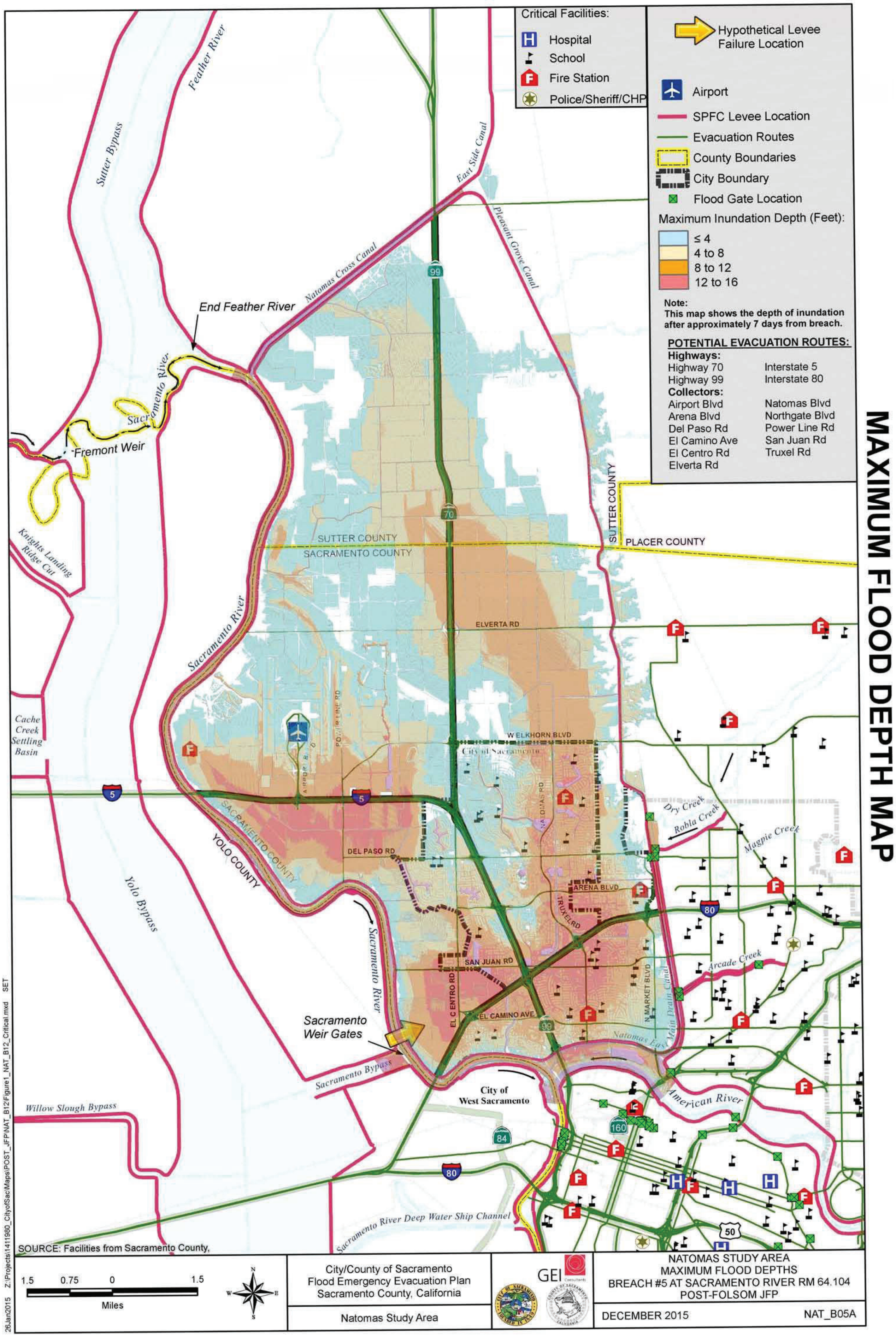

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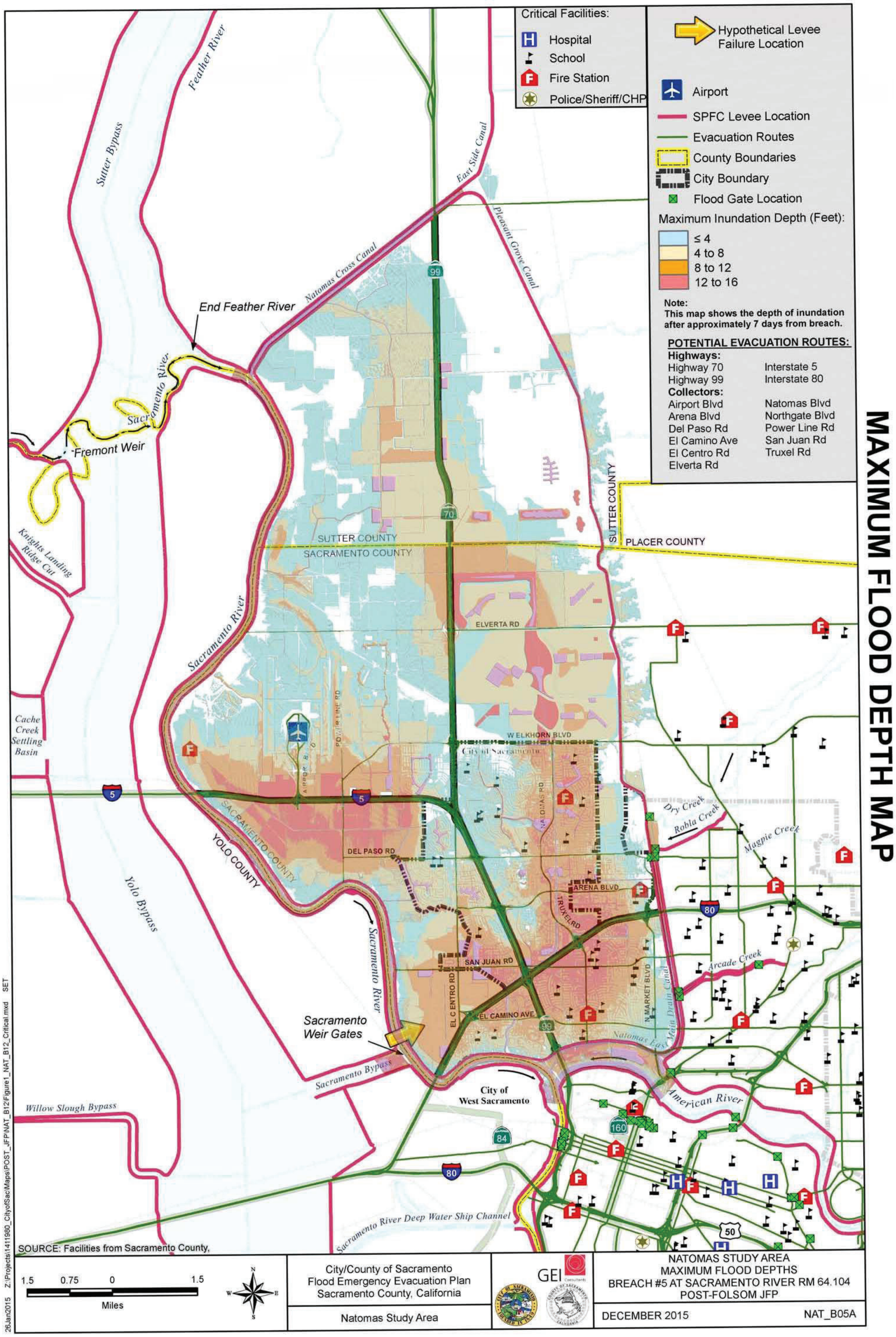

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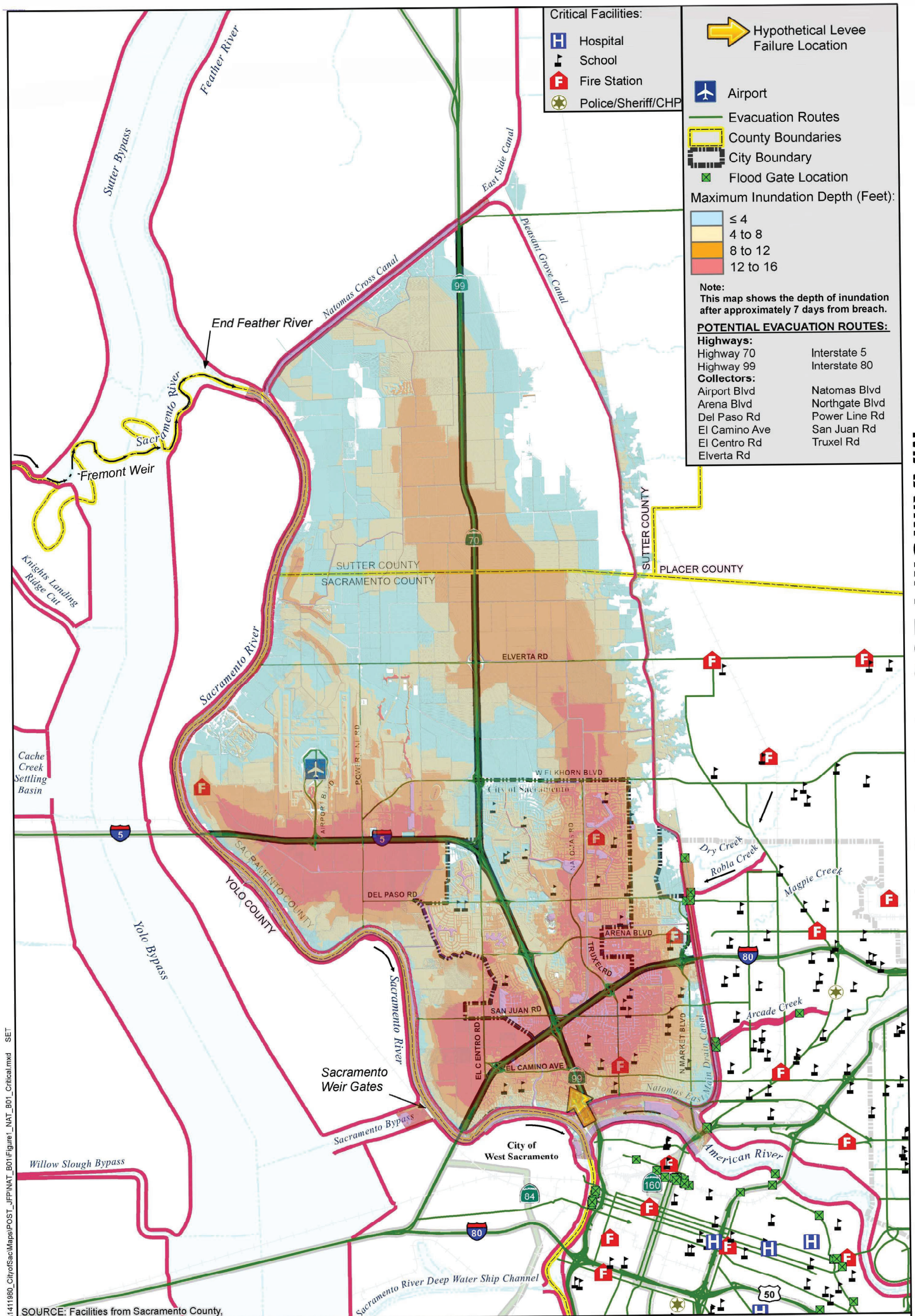

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City/County of Sacramento
Flood Emergency Evacuation Plan
Sacramento County, California

Natomas Study Area

GEI Consultants

NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #6 AT NEMDC RM 0.415
POST-FOLSOM JFP

DECEMBER 2015 NAT_B06A

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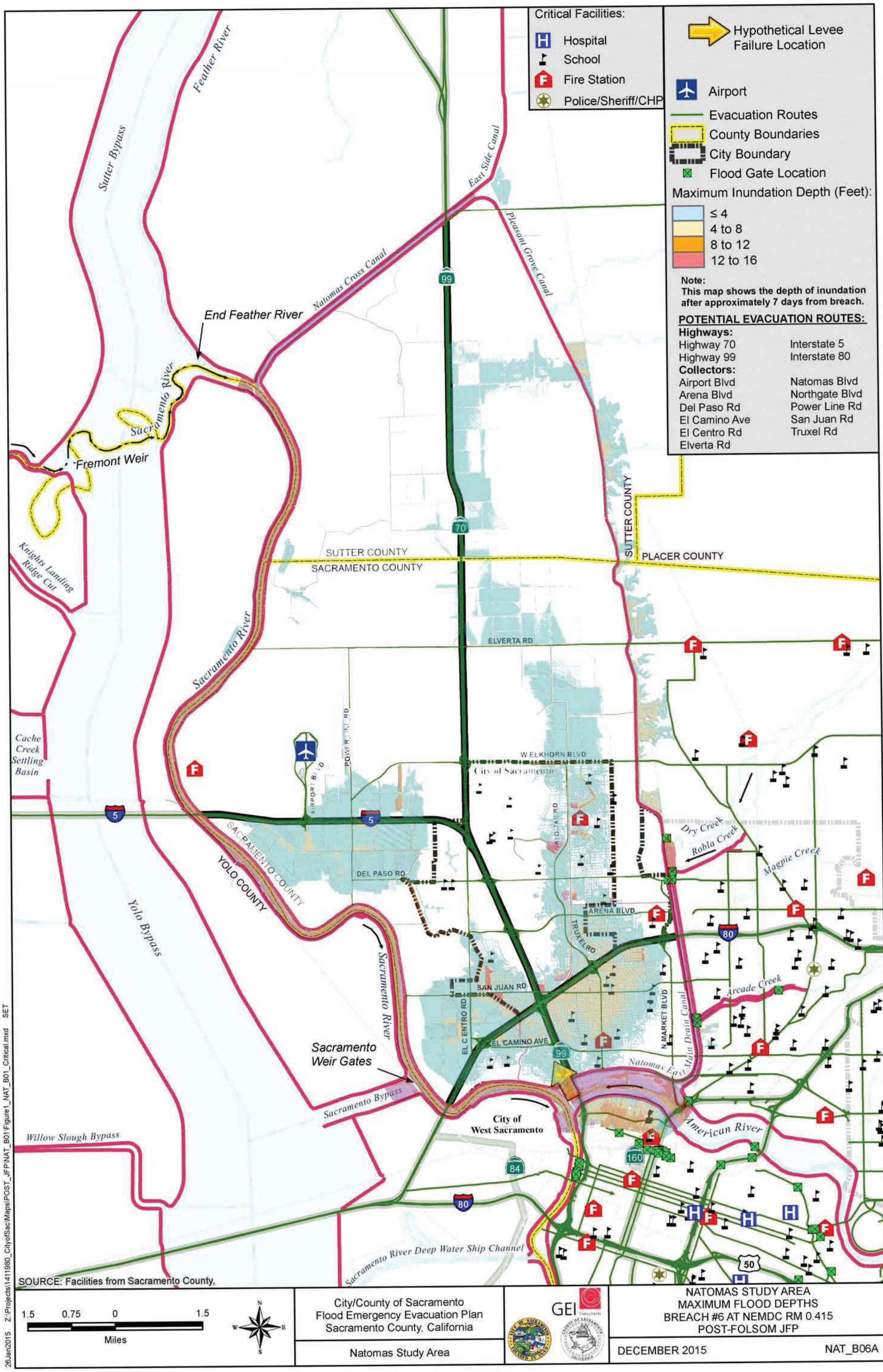
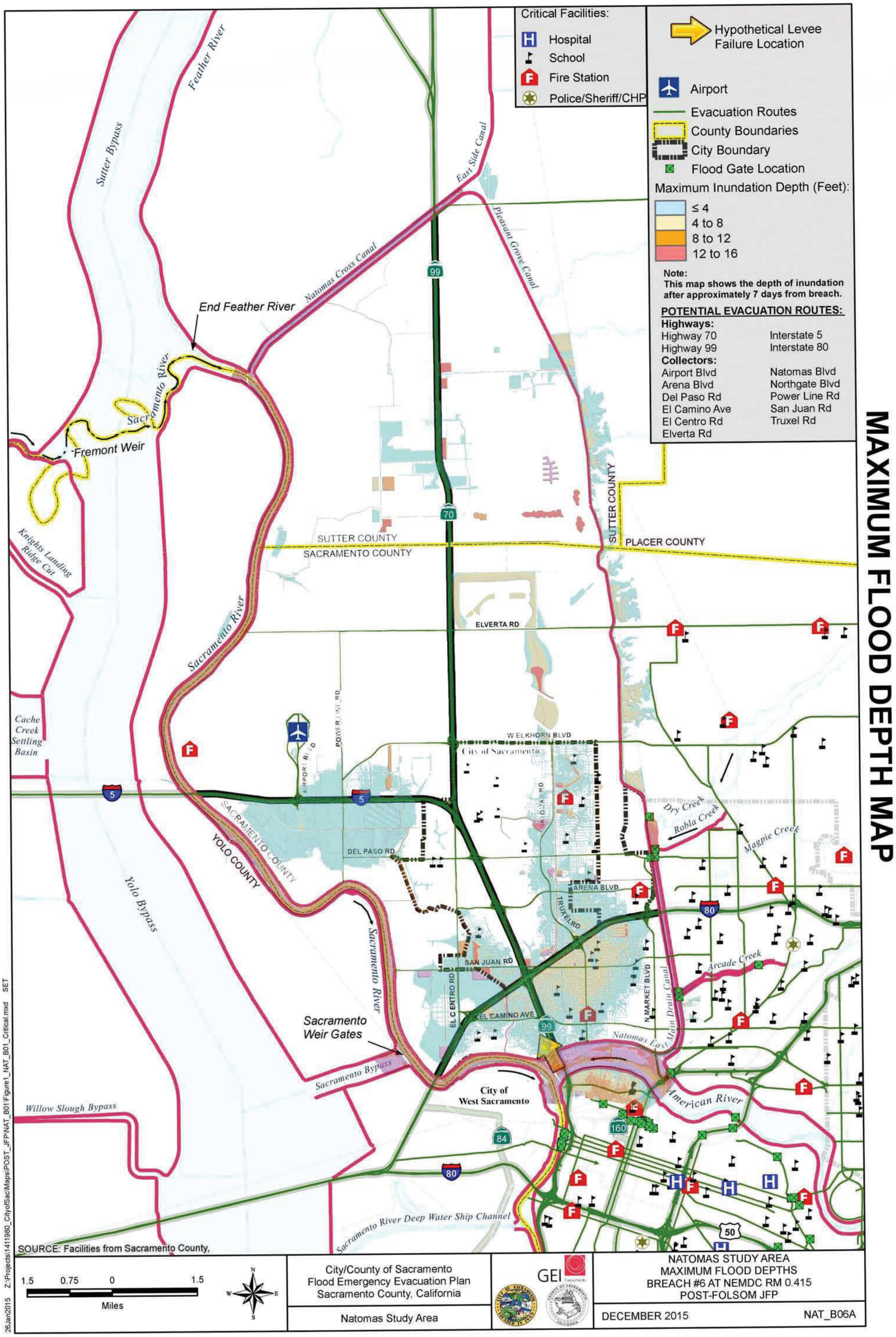
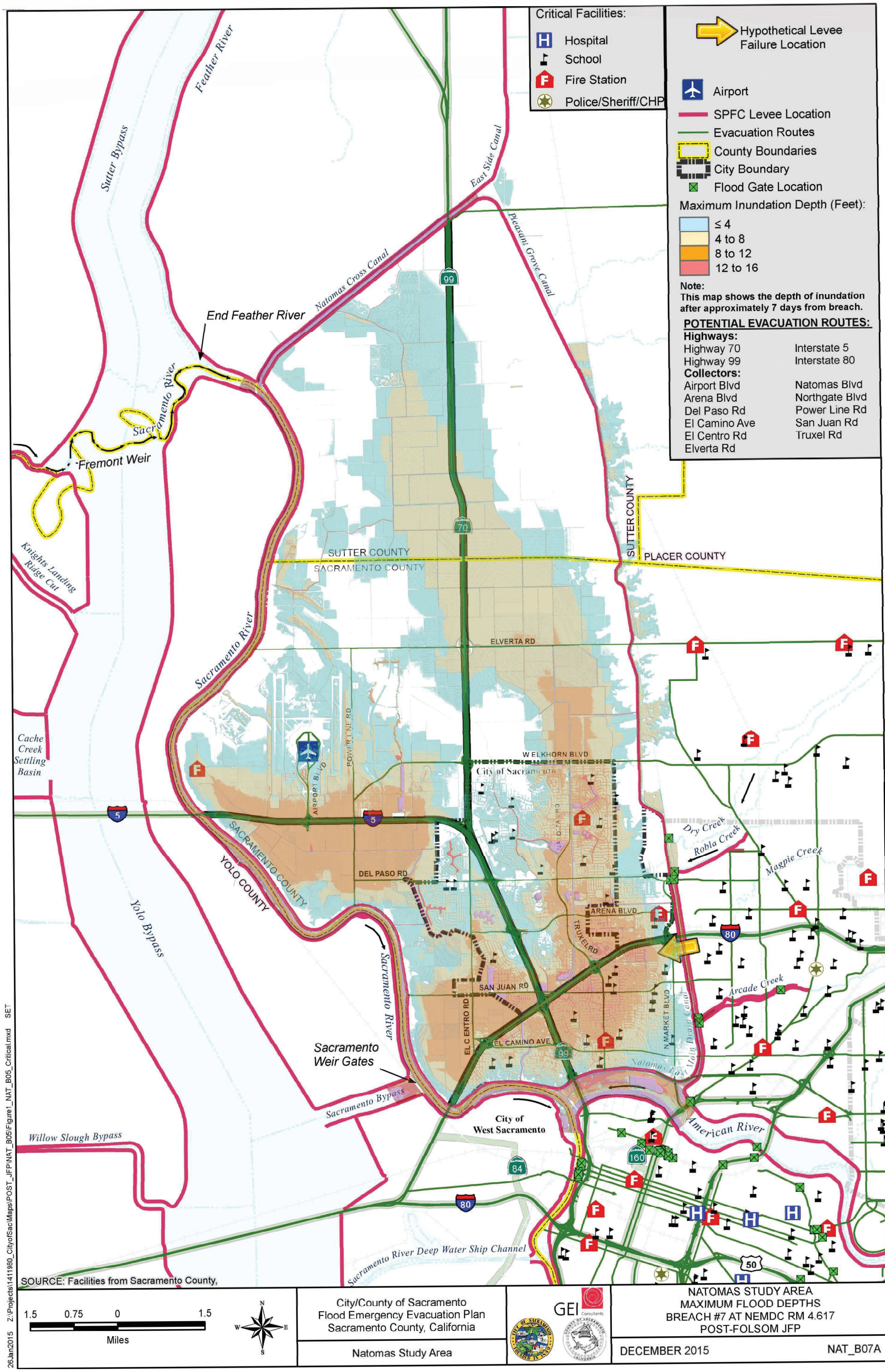


MAXIMUM FLOOD DEPTH MAP

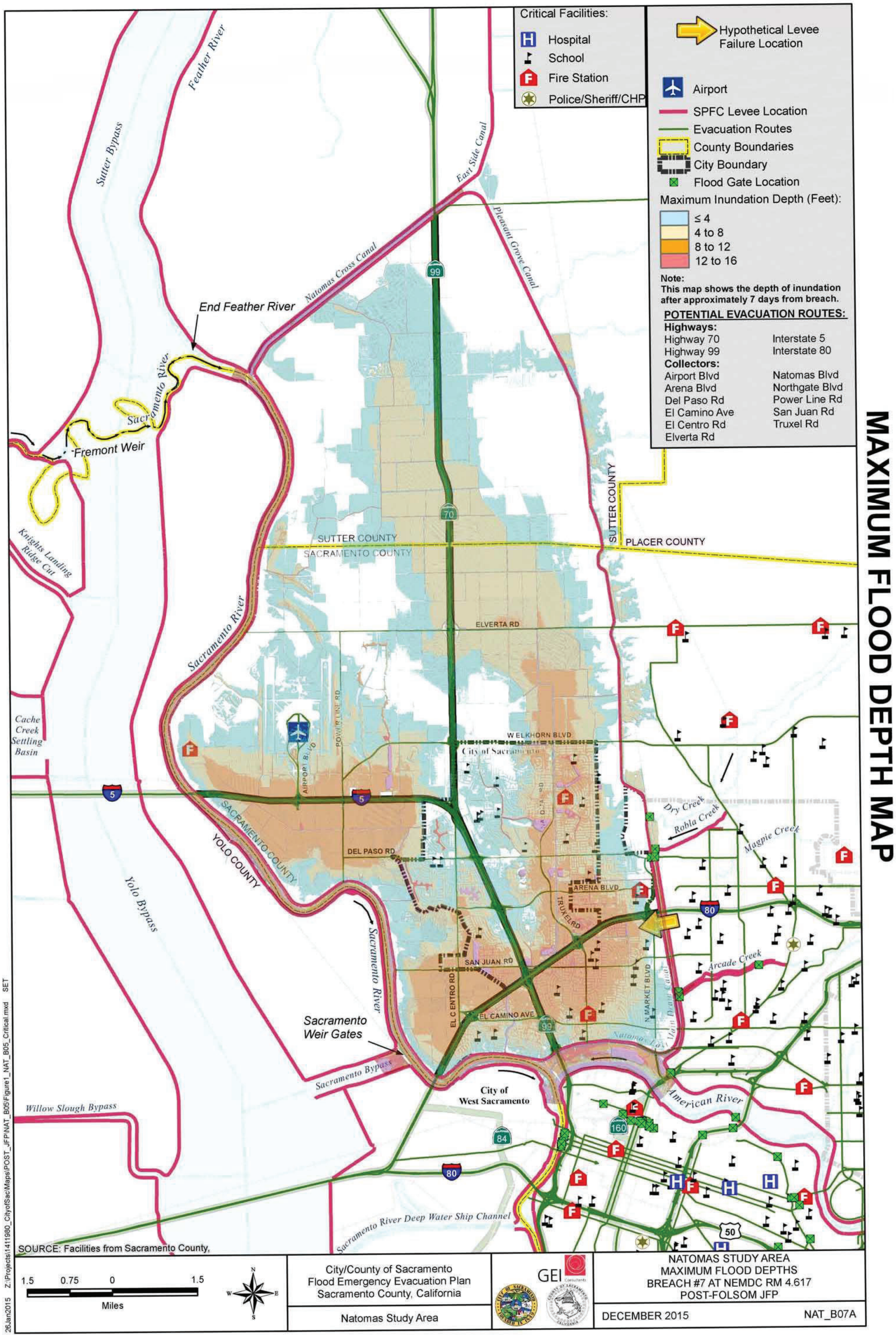
LEVEE BREACH 2D - APR 2022 - BREACH 6 CUMULATIVE



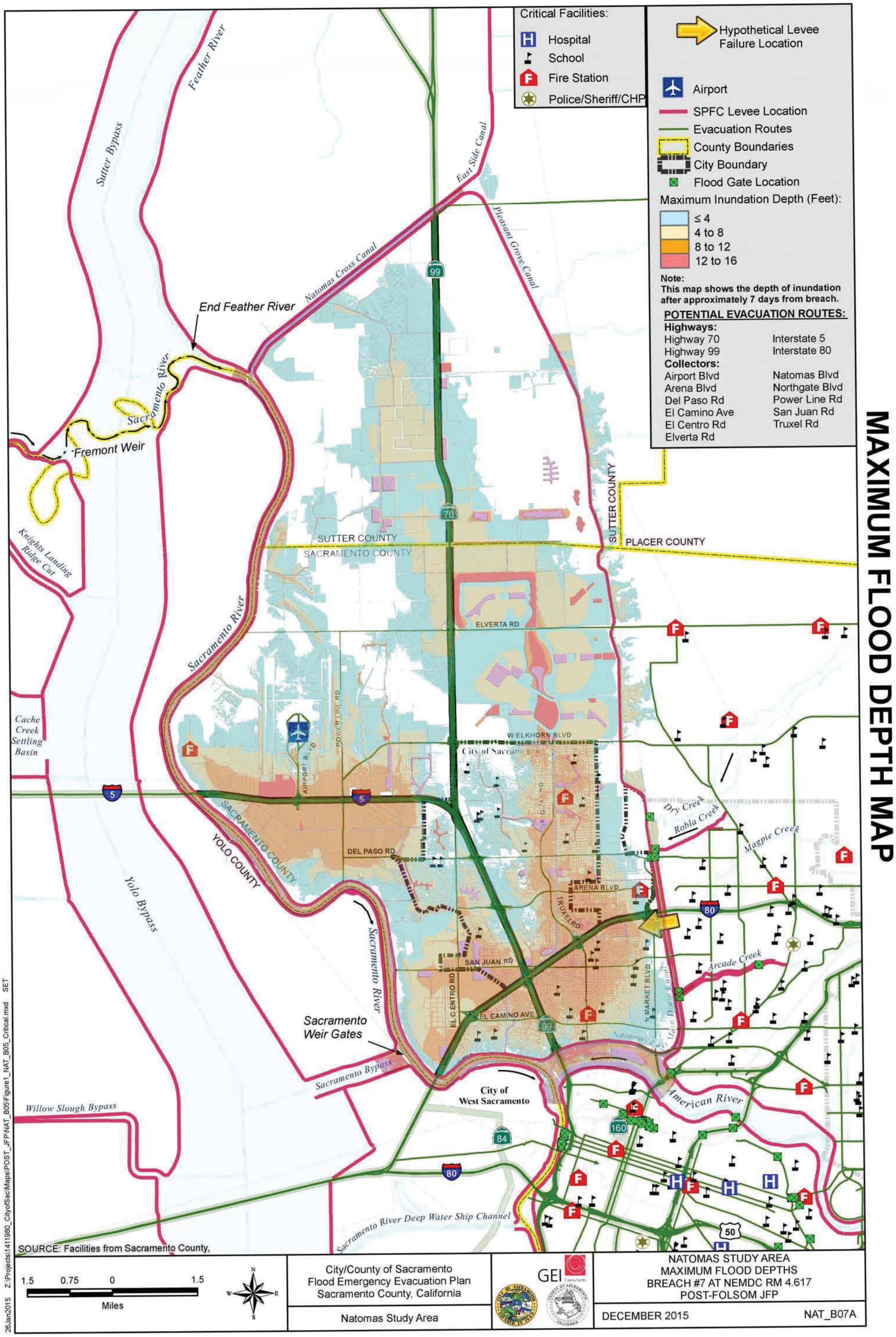
MAXIMUM FLOOD DEPTH MAP



LEVEE BREACH 2D - APR 2022 - BREACH 7 EXISTING



LEVEE BREACH 2D - APR 2022 - BREACH 7 CUMULATIVE



APPENDIX C

Supplemental Analysis

CESI Technical Memorandum No. 0040A
Levee Breach Analysis – Cumulative Plus Project Analysis

MACKAY & SOMPS
ENGINEERS PLANNERS SURVEYORS

CIVIL ENGINEERING SOLUTIONS, INC.

TECHNICAL MEMORANDUM No. 0040A

SUPPLEMENTAL ANALYSIS AND
RESULTS IN RESPONSE TO COMMENTS

GRANDPARK & UPPER WESTSIDE

Flood Inundation Propagation
Procedural Memorandum

Sacramento County, California

To: **Todd Smith, Sacramento County**

From: **Thomas S. Plummer P.E., CFM**

Date: **May 3, 2024**

Subject: **LEVEE BREACH ANALYSIS – CUMULATIVE ANALYSIS**

REGISTERED PROFESSIONAL ENGINEER
THOMAS S. PLUMMER
No. C49582
EXP. 9/30/24
STATE OF CALIFORNIA

Sacramento DWR:

By: ____________________

Date: ____________________

☐ Acknowledged

☐ Approved

☐ Other: ____________

MACKAY & SOMPS
ENGINEERING PLANNING SURVEYORS

CIVIL ENGINEERING SOLUTIONS, INC.

EXECUTIVE SUMMARY

Background

This supplemental analysis was prepared to respond to the County's November 2, 2023 comments on the following Procedural Memoranda:

- *Grandpark Flood Inundation Propagation Procedural/Technical Memorandum* prepared by MacKay & Somps (dated November 10, 2022), and
- *Upper Westside Flood Inundation Propagation Procedural/Technical Memorandum* prepared by MacKay & Somps (dated November 10, 2022).

These Procedural Memoranda were prepared based on the flood modeling technical work prepared by CESI in 2022. This technical work included HEC-RAS modeling of the same seven (7) theoretical levee breach locations that the City of Sacramento selected for modeling by GEI Consultants in preparation of the 2015 City/County Evacuation Plan (2015 Evacuation Plan), and the 2021 Sacramento County Multi-Jurisdictional Local Hazard Mitigation Plan (2021 LHMP).
As explained below, the technical analysis prepared for the Procedural Memoranda utilized a newer version of HEC-RAS modeling software (ver. 6.2) than the modeling performed in 2015. This newer work effort took into consideration three principal considerations:

1. Better and more accurate topographic mapping,
2. Two Dimensional (2D) Flood Hydraulic Analysis Landside of the Breach Formation
3. More realistic breach formation determinations (within HEC-RAS) based on the more accurate landside topographic mapping.

County Comments

The County's comments on the two Procedural/Technical Memoranda mentioned above did not require formal responses as they were advisory in nature. However, the County's comments suggested that it would be appropriate to review modeling results that used modeling assumptions that were identical in nature to those used for the 2015 Evacuation Plan to facilitate identification of material differences in modeling results between 2015 and the current modeling effort. Notwithstanding the technical adequacy of the prior modeling effort and the conclusions contained in the 2022 Procedural Memoranda, it was for this reason that Grandpark and Upper Westside chose to update the modeling performed for the 2022 Procedural/Technical Memoranda using the same set of modeling assumptions that were used in the 2015 modeling effort. The differences in modeling assumptions are summarized in this Technical Memorandum.

Findings of TM 0040A

Bringing about consistency in levee breach assumptions when using the improved modeling software resulted in slightly greater elapsed time to one-foot of flooding at critical locations along the evacuation routes. Basically, the 2024 modeling analysis performed for this Technical Memorandum found that the resulting timing for flood inundation propagation from each of the seven breach locations were relatively consistent with those found in the 2015 flood mapping analysis.

Specifically, the key findings of this supplemental analysis are listed below:

1. The addition of a scour pit allowed the levee breach to form to the full depth and height in all simulated locations. However, this change in the modeling assumption did not increase the amount of flow significantly to the interior of the basin.

2. The review of landside nearby lowest elevations that the breach could flow to as an exit from the weir location did contribute to some higher flow rates in a few of the analysis.

3. The addition of a scour pit delayed some flow delivery and reduced overall peak flows. This is likely because during the breach formation, the scour pit would form at a water surface below the exterior river water surface as there are head losses for the flow passing through the breach. The lower water surface elevation of the scour pit delivering water to the landside terrain would have less potential energy to drive the flood waters to spill over the terrain. Also, because the scour pit flood elevation is above the terrain elevations, the head to drive flood waters through which the breach operates was less when the breach is near submergence.

4. The changes to the model generally resulted in less flooding depths and longer flood timings for all breach locations studied. This suggests that for total flow and timing, the importance of the breach formation depths was not as significant as the elevations of the landside terrain the flood waters eventually must pass over after passing through a breach and scour pit.

5. Finally, the changes in timings in the two 2D models (Existing Conditions and Cumulative Conditions) stayed similar to the previous analysis and was not sensitive the issues raised in the GEI Comments.

RESPONDING TO:

GEI Consultants prepared a review of Technical Memorandum's 39 and 40 for the Grandpark and Upper Westside projects on November 2, 2023. The purpose of their review was "to provide a third party review of the reports regarding inundation floodplain mapping from hypothetical levee failures in the Natomas Basin". These Technical Memorandum's included analysis for 7 levee breach locations along the Natomas levee protection system, under different project circumstances.

GEI Concluded:

> *1) The full Sacramento River system model geometry and hydrology used for the GP/UWS evaluation is acceptable. The water levels in the surrounding river system (Sacramento River, American River, Cross Canal, NEMDC) are acceptable and do not need adjusting for the levee failure evaluation.* ***Figure 1*** *shows the full system model and* ***Figure 2*** *shows the proposed Natomas basin breach locations for this evaluation.*
>
> *2) A notable change between the 2015 GEI hypothetical levee breach openings and the 2022 GP/UWS hypothetical levee breach opening was assuming if scour would occur for longer duration flood events. For the 27 levee failure maps dated 2015, the city and county requested each of the levee failures to*

assume an extra scour hole depth below the levee toe of approximately 10-20 feet because of unknown soil conditions. The deeper scour hole depth assumption causes a wider opening which increases the breach flow entering into the Natomas Basin. The breach open criteria (Width = 50 x Distance from water level to land toe) is based on recommendations from the Corps of Engineers and the State of California Department of Water Resources (CADWR).
Because there have been no actual levee failures in the Sacramento River levee systems, the breach opening assumptions provided by the GP and UWS evaluations are not unreasonable.

3) Breach 6 showed a significantly reduced floodplain in the Natomas basin for both the GP and UWS evaluation compared to the 2015 city inundation maps. The GP/UWS maps are reasonable, but the 2015 maps are more conservative because the evaluation assumed a deep scour hole could form which would increase breach flows. The scour hole assumption was based on a request from the City.

4) The inundation mapping dated 2015 does not include flows from the Sankey Gap. This was discussed with the City and County of Sacramento but was decided only to include breach flows from the adjacent streams.

5) A significant change between the 2015 and the 2022 analysis was the new Corps of Engineers Hydraulics Program (HEC-RAS) version 6.0 which includes a new approach for routing overland flows.

a. The new program improves the overland flow routing by using two-dimensional grids which uses the physical terrain as opposed to storage areas which occurred with the previous program developing the 2015 maps. Storage areas in the hydraulic model are lake like regions which fill as a bowl.

b. As shown in the GP and UWS TMs, the updated 1D/2D HEC-RAS program showed there was not a significant change in the travel time between the two model program approaches. However, using the updated 1D/2D HEC-RAS program is recommended.

PURPOSE OF RESPONSE

The purpose of this Technical Memorandum is to respond to GEI's conclusions numbers 2 and 3 with additional technical analysis. In this technical memorandum we have revised the technical analysis for all 7 breach locations to include a scour pit formation to occur adjacent to the existing levee where the breach would form. This would allow the full breach shape to form, rather than only the partial breach depth formed in a few locations in our previous analysis. In addition, we re-assessed land side elevations of the weir connection from the scour pit to the 2D model areas inside the basin.

By performing this additional investigation, we intend to address any concerns that different conclusions might occur if these modeling changes were performed.

DESCRIPTION OF MODELING CHANGES:

At each breach location, a storage area was added to represent a scour pit formation on the land side of the levee breach location. The flows entering the breach would spill into the scour pit, and have to fill it before these flows would connect to the 2D flood areas. The scour pit was set to be 16 feet deep, and roughly 6 acres at the landside ground level[1]. The scour pit depth allows the full formation in depth and width of each levee breach[2]. Previously, the scour pit depth of formation was limited to the landside existing ground elevations directly adjacent to the levee breach.

Connecting each scour pit to the 2D Natomas floodplain is a lateral weir set based on the landside existing ground elevations near the levee breach. These were re-evaluated with this analysis to try and find the lowest near adjacent grades, to permit the maximum flood flow exchange.

All other model development assumptions remain the same as described in the applicable sections of TM 0039 and TM 0040. Some instabilities did occur when attempting to run this version of the models, which were addressed by adding a 10 cfs base flow in the NEMDC, which was consistently added in all of the analysis.

ELEVATION DATUM

All Elevations shown in this TM are in NAVD 88 Vertical Datum.

USE OF "SACRAMENTO-COMBINED" HEC-RAS MODEL FROM GEI

GEI provided CESI the 2015 HEC-RAS One-Dimensional (1D) modeling that the existing Natomas Basin Levee Breach analysis was performed with for the seven (7) perimeter levee breach locations previously chosen by the City and County of Sacramento for the GEI analysis in 2015. The updated modeling is run for the same total duration of analysis as the original GEI model. This modeling was used for this analysis except for changes described below.

The results of the previous Breach Analysis are posted at the following link:

https://waterresources.saccounty.net/stormready/Pages/Natomas-Area-Flood-Map.aspx

The results presented in this Technical Memorandum focus on two analyses:

1. Time to Fill to 1-foot of depth at Evacuation Route locations, and
2. Maximum Depth of Inundation measured in the modeling.

The previous Breach Analysis Maps were published by the County at the link above to present the results of the GEI modeling.

The original model was performed in HEC-RAS version 4.1.3. In consultation with Chris Ferrari of GEI Consultants, CESI updated the 2015 modeling. Specifically, CESI updated the model to HEC-RAS 6.2 and further modified the model as described below. This required

[1] These dimensions are based on State DWR analyses of empirical data from several historical levee breach events in the Sacramento-San Joaquin Delta. Based on DWR analysis, these dimensions appear to be typical of the levee breaches that would form within the vicinity of the Natomas Basin. Scour Pits are typically 6 acres in surface area and 16-feet deep. Levee breach widths are typically 50 times the distance from the water level in the external river to the land side toe elevation.

[2] Full formation of breach size (width and height) as defined in the original 2016 analysis for each formation location.

modification for errors in the geometry file detected by the current version of HEC-RAS that were not evident in the previous version. Typically, these errors occurred where HTAB table definitions started below the invert of a channel, or storage area starting elevations below the lowest elevation in the storage area.

Version 6.2 of HEC-RAS generates a warning at some breach locations that the specified minimum elevation of the breach is below the adjacent ground elevations. When this occurs, HEC-RAS Version 6.2 will limit the breach weir formation elevation to the adjacent lowest ground elevation.

The original model analyzed flood distribution within the basin by including a set of storage areas connected by weirs and culverts. This method discounts the impact of local ground features and the time it takes for flood waters to cross the storage areas, as HEC-RAS views a storage area as equally distributing the inflow to the entirety of the storage area instantaneously.

CESI decided for the current analysis, it would be better to analyze the breach flooding over Two Dimensional (2D) surfaces using the Version 6.2 capabilities of HEC-RAS. Digital terrain models (topographic models) of the Natomas Basin were not provided by GEI when the original model was transferred to CESI.

Accordingly, CESI generated a cumulative conditions topographic model for the Natomas Basin and utilized HEC-RAS Version 6.2 to generate a digital terrain model surface for the existing conditions. CESI then developed digital terrain models based on the current land use plans and drainage plan documents (where available – See TM 0039) and then added these terrain models for the reasonably foreseeable development projects for the Cumulative Conditions modeling.[3]

The following development areas were included in the Cumulative Conditions:

- GRANDPARK (Conceptual Grading Plan – April 20, 2022).[4]

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[3] For this analysis, a version 6.05 terrain surface was created for the Cumulative development scenario. The 6.04 and 6.05 Terrains were based on 2 feet by 2 feet pixel size, and, at locations where the terrain did not include hydraulic reinforced data (invert data at bridge and culvert crossings, this data was added by interpolating a section from upstream grades to downstream grades in the LiDAR data set).

[4] The 2022 Grandpark Conceptual Grading Plan was used in this analysis. This conceptual grading plan is an update of the conceptual grading plan used in TM 0007 (Grandpark Land Use Plan 08F) as it reflects the elimination of the "Lennar" parcels as a development site and instead leaves this property as an undeveloped open space parcel. Additionally, the 2022 Conceptual Grading Plan reconfigured the Grand Parkway from a water feature intensive open space plan into a more natural floodplain with a central drainage channel and overbank flood storage areas without significant water features. Lastly, the 2022 Conceptual Grading Plan redistributed the required flood storage volumes within the Grand Parkway in order to (1) meet County design standards relating to avoiding water surface level impacts to upstream and downstream properties, (2) achieve a condition where post development peak flow rates do not exceed predevelopment levels upstream and downstream of Grandpark, and (3) achieve an equitable allocation of flood storage volumes between the various property owners within the area of the Grandpark Specific Plan.

- SUTTER POINTE (Appendix E Drainage Master Plan and Appendix B Land Use and Development Code).
- SAFCA "Sankey Road Gap Closure Project Basis of Design Report".
- GREENBRIAR (used land use plan and documentation from the January 5, 2017, Environmental Checklist (online version)).
- PANHANDLE (Preliminary Grading Plan by MacKay & Somps).
- UPPER WESTSIDE (land use plan from Staff Presentation February 2022).
- SACRAMENTO INTERNATIONAL AIRPORT (Master Plan January 2017), including Airport South Industrial project (using the layout included in the Airport Master Plan)

It should be noted that the ultimate buildout of Metro Airpark is included in the Existing Conditions terrain models per the request of Sacramento County DWR Staff.

It's important to note that the grading input for all of the projects added in the Cumulative conditions models is for the finished grade surfaces only and does not include any structures which will be built. Additionally, the friction is not adjusted at these locations for the resistance to flows that may occur post development from fences and structures.

CESI then prepared 4 different analyses for each breach location as follows:

- **GEI Existing Conditions 1D Analysis.** The GEI existing conditions 1-dimensional (1D) storage-area based analysis was re-run in HEC-RAS 6.2.[5] Based on a visual comparison of the results from this re-run of the GEI existing conditions 1D in 2D analysis with the GEI published 1D results, the two sets of results were found to be similar.

  Upon completion of this modeling exercise, CESI again consulted with GEI to report on the efforts to update the 2015 model and the results from this modeling existing conditions analysis when using the newer HEC-RAS software. During this consultation, both GEI and CESI agreed the updated model was producing results similar to those obtained from the 2015 model in terms of the duration of time to 1-foot depth of flooding over the critical locations along the major evacuation routes, and the maximum depth of flooding within the Basin.

- **Existing Conditions Analysis with Storage Areas Converted to 2D**. The addition of a scour pit landside of the levee allowed the full formation of the breach width and depth to match the specifications of the original GEI analysis. From the scour pit flows are spread over the existing ground grades and dispersed into the 2D domains for the interior areas of the Natomas Basin.

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[5] The HEC-RAS Version 6.2 is recognized by the engineering community for its superior capabilities to more accurately analyze flooding using 2D terrain surfaces as compared to HEC-RAS Version 4.1.3 that only utilized 1D terrain models.

Compared to the GEI 1D modeling which fills each storage area with flood volumes from the lowest elevation upward regardless of the distance, terrain and flow impediments within the storage area, the 2D analysis models the water flowing from the breach location through overland paths before entering into the main system of canals.

- “**With Grandpark” Analysis (also using 2D)**. This alternative is discussed in TM 0039 and is specific to the Grandpark project, and not part of this Cumulative Analysis.
- **Cumulative Conditions Analysis (also using 2D)**. Similar to the Existing Conditions 2D analysis: The addition of a scour pit landside of the levee allowed the full formation of the breach width and depth to match the specifications of the original GEI analysis. From the scour pit flows are spread over the existing ground grades and dispersed into the 2D domains for the interior areas of the Natomas Basin.

Compared to the GEI 1D modeling which fills each storage area with flood volumes from the lowest elevation upward regardless of the distance, terrain and flow impediments within the storage area, the 2D analysis models the water flowing from the breach location through overland paths before entering into the main system of canals.

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TIME TO FILL TO 1-FOOT DEPTH AT EVACUATION ROUTE LOCATIONS:

As explained in TM 0039 and TM 0040, the duration of time to inundation of 1-foot of flooding over critical roadway locations along the regional evacuation routes within the Natomas Basin during a catastrophic levee breach is analyzed in each breach model. The criteria of 1-foot of inundation is considered the critical factor in moving the public from places of relative danger to locations of relative safety during a flooding event. Using the 2015 assumption set for levee breach formation, this analysis reevaluated the timing to 1-foot of inundation at the eighteen (18) critical evacuation routes within the Natomas Basin that were evaluated in TMs 0039 and 0040.

Oversized exhibits are included at the end of this technical memorandum which present the results of these analyses for each of the 4 alternatives studies for each breach location. They are plotted on top of the original GEI exhibits from the original Study.

For each Evacuation Route location identified in the original mapping, CESI identified the location where the depth would reach 1 foot of inundation depth earliest (the lowest point of the roadway stretch) and retrieved the time to 1-foot of inundation depth for each scenario and breach in hours. The results are summarized in the following tables (Tables 1 through 7) for each of the seven breach locations. These results are also shown on the oversized exhibits included with this TM (Note: On the oversized exhibits, if flooding to a depth of 1 foot over the roadway was not demonstrated in the analysis, the point was removed from the exhibit).

LEVEE BREACH ANALYSIS RESULTS

In general, the change from 1D to 2D modeling was to provide a more accurate estimate of the timing and depths of flows arriving. The 2D modeling requires the flood flows to travel overland spatially in order to move throughout the basin, whereas the storage area based previous models do not physically model the movement of the flood, except through the connections of the storage areas.

Below are the individual results for the levee breach analyses using the same breach and scour pit assumptions used in the preparation of the 2015 City/county Evacuation Plan.

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<u>BREACH 1</u>

The results of the modeling exercise for Breach 1 are summarized in Table 1 and the text following the table.

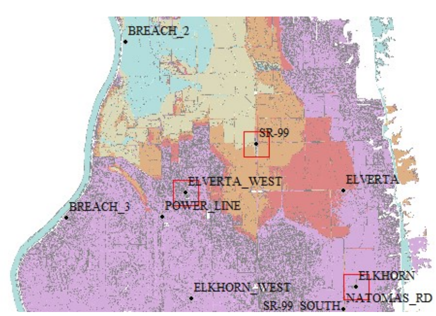
<u>Table 1</u>

<u>BREACH 1: (Natomas Cross Canal Levee Breach Location – C+P Conditions)</u>

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	89	140	127	-13
ELVERTA	47	99	121	+22
ELKHORN	38	74	90	+16
DEL PASO	22	60	69	+9
I-80 EAST	31	82	99	+17
I-5 CENTRAL	106	170	172	+2
I-5 JUNCTION	79	147	155	+8
I-5 WEST	73	141	149	+8
I-80 WEST	63	112	123	+11
ELKHORN WEST	73	139	147	+8
SR-99 NORTH	98	138	115	-23
SR-99 SOUTH	135	208	209	+1
POWER LINE	92	161	167	+6
ELVERTA WEST	106	157	149	-8
SAN JUAN	36	80	115	+35
EL CAMINO	36	81	97	+16
I-80 CENTRAL	58	103	115	+12
NATOMAS RD	28	55	67	+12

<u>1D to 2D model:</u>

For all of the points reviewed there was an increase in the time to the flood depth of 1 foot. The addition of storage contained within the “Scour Pit” directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pits act to dampen the flow propagation from the levee breach to the land side terrain.



<u>2D to 2D Cumulative Model Changes:</u>

In general, most of the data points show that there is an increased delay in the propagation of the breach flood wave timing as a result of the Cumulative Conditions improvements in the Natomas Basin for Breach 1.

The following three points identify reductions in timing to the depth of 1 foot:

1. SR-99: SR-99 is located near a low point in SR-99 near the northern boundary of the proposed Grandpark project. A reduction in flood depth timing at this location of 13 hours is identified in the modeling (140 hours to 127 hours). The reduction in flood time results from the reduced flood volumes in the northern part of the basin due to the embankments placed for the Sankey Gap storage basin proposed by SAFCA to be constructed with the Sutter Pointe project.

   Also, the proposed culvert crossings within the Grandpark development under Elverta Road restrict how fast flows lower than the street overtopping levels can progress from north of the Grandpark project to south of the project. These culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year and 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

2. SR-99 NORTH: A reduction in 1 foot flood depth timing at this location of 23 hours is identified in the modeling (138 hours to 115 hours). This roadway low point is at a slightly lower elevation than surrounding data points, so it sees flooding sooner in the Cumulative Event analysis as a result of the Sankey Gap Storage Facility Embankments and Grandpark proposed project culverts under Elverta Road at its crossing of the East Drainage Canal.

3. ELVERTA WEST. A reduction in 1 foot flood depth timing at this location of 8 hours is identified in the modeling (157 hours to 149 hours). This data point is affected by the Sankey Gap storage facility embankments.

The three data points noting a meaningful change in 1 foot flood depth arrival time are in the Northwest quadrant of the basin, where the breach occurs.

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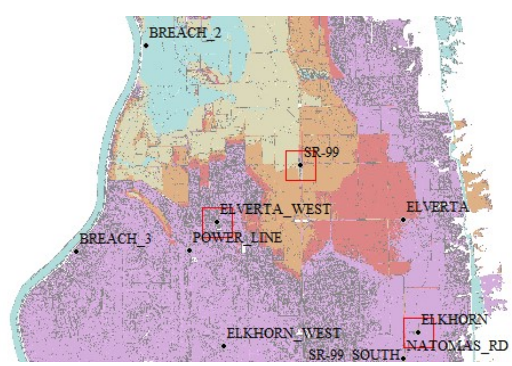
BREACH 2

The results of the modeling exercise for Breach 2 are summarized in Table 2 and the text following the table.

Table 2
BREACH 2 (North Sacramento River Breach Location C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	3	169	65	-104
ELVERTA	2	39	45	+6
ELKHORN	2	36	46	+10
DEL PASO	1	37	47	+10
I-80 EAST	1	50	59	+9
I-5 CENTRAL	5	166	166	0
I-5 JUNCTION	4	99	111	+12
I-5 WEST	4	93	102	+9
I-80 WEST	3	66	75	+9
ELKHORN WEST	4	91	98	+7
SR-99 NORTH	1	41	41	0
SR-99 SOUTH	8	70	70	0
POWER LINE	5	124	136	+12
ELVERTA WEST	4	187	187	0
SAN JUAN	2	49	58	+9
EL CAMINO	2	49	59	+10
I-80 CENTRAL	3	61	59	-2
NATOMAS RD	1	33	49	+16

1D to 2D model:
For all of the points reviewed there was an increase in the time to the flood depth of 1 foot The addition of storage contained within the "Scour Pit" directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.



2D to 2D Cumulative Model Changes:

This breach analysis identifies 2 locations where moderate adverse changes to the timing of 1 foot inundation of the evacuation routes would occur at: SR-99 and I-80 CENTRAL.

The breach location is similar to the location of Breach 1, discharging into the Northwest Quadrant of the basin. As a result, the future Sankey Gap storage area reduces available storage in this area below the embankment overtopping elevations. This is demonstrated in the "SR-99" reduced timing to 1 foot of depth. Proposed project culverts in Grandpark also slow the progression of the initial flood wave below Elverta Road overtopping elevations, resulting in a modest acceleration of the flood timing within the northwest quadrant. This is demonstrated in the "I-80 Central" reduced timing to 1ft of depth. The proposed Grandpark project culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year and 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

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BREACH 3

The results of the modeling exercise for Breach 3 are summarized in Table 3 and the text following the table.

Table 3
BREACH 3(Sacramento River Levee Near Elverta Road – C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	66	137	137	0
ELVERTA	47	78	105	27
ELKHORN	43	72	70	-2
DEL PASO	33	51	53	+2
I-80 EAST	40	82	83	+1
I-5 CENTRAL	67	170	170	0
I-5 JUNCTION	10	19	19	0
I-5 WEST	9	9	9	0
I-80 WEST	23	37	40	3
ELKHORN WEST	4	12	12	0
SR-99 NORTH	75	169	167	-2
SR-99 SOUTH	129	74	74	0
POWER LINE	17	7	7	0
ELVERTA WEST	79	191	194	+3
SAN JUAN	30	36	54	+18
EL CAMINO	30	53	54	+1
I-80 CENTRAL	17	36	36	0
NATOMAS RD	38	64	65	+1

1D to 2D model:

POWERLINE And SR-99 SOUTH are the only 2 points with reductions in time to 1 foot for the change from the original 1-D modeling of the existing conditions, to using a 2-D model. These reductions result from flow from the scour location traveling faster to these points than the 1D model showed it took for the storage areas at these locations to fill to above the elevations near these locations.

For all of the remaining points reviewed there was an increase or no change in the time to the flood depth. The addition of storage contained within the "Scour Pit" directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.

2D to 2D Cumulative Model Changes:

For this breach location scenario, the Cumulative Condition produces similar results to the Existing Conditions model at all locations. The largest reduction in time to flood 1 foot is at ELKHORN and SR-99 NORTH where a 2-hour reduction occurs (72 to 70 hours, and 169 to 167 respectively).

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

BREACH 4

The results of the modeling exercise for Breach 4 are summarized in Table 4 and the text following the table.

Table 4

BREACH 4 (Sacramento River Levee South of I-5- C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	7	102	102	0
ELVERTA	5	75	88	+13
ELKHORN	4	66	65	-1
DEL PASO	3	46	48	+2
I-80 EAST	4	49	51	+2
I-5 CENTRAL	6	93	88	-5
I-5 JUNCTION	9	13	14	+1
I-5 WEST	6	8	8	0
I-80 WEST	2	32	34	+2
ELKHORN WEST	9	11	10	-1
SR-99 NORTH	7	110	115	+5
SR-99 SOUTH	1	144	143	-1
POWER LINE	2	29	28	-1
ELVERTA WEST	8	112	112	0
SAN JUAN	3	31	30	-1
EL CAMINO	3	47	49	+2
I-80 CENTRAL	1	31	30	-1
NATOMAS RD	4	58	60	+2

1D to 2D model:

For all of the points reviewed there was an increase in the time to the flood depth from the original 1D based analysis to the 2-D based analysis. The increase in timing is the result of the flow having to travel overland to fill areas, as opposed to instantly filling storage areas. The addition of storage contained within the "Scour Pit" directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.

2D to 2D Cumulative Model Changes:

For this breach location scenario, the Cumulative Conditions produce similar results to the Existing Conditions model at all locations. The largest reduction in time to flood 1 foot is at I-5 CENTRAL where a 5-hour reduction occurs (93 to 88 hours). This is in an area near the breach location, in which flood storage volumes are reduced by the Sankey Gap storage area embankments.

All other minor changes noted by the analysis are less than 1 hour, which is approximately the rounding error in the results. Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

BREACH 5

The results of the modeling exercise for Breach 5 are summarized in Table 5 and the text following the table.

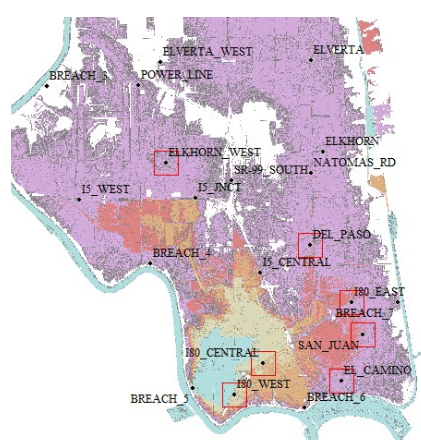
Table 5
BREACH 5 (Sacramento River Levee Near I-80 – C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	84	282	282	0
ELVERTA	50	123	147	+24
ELKHORN	39	81	67	-14
DEL PASO	21	32	30	-2
I-80 EAST	21	43	39	-4
I-5 CENTRAL	100	N/A	N/A	N/A
I-5 JUNCTION	27	57	67	+10
I-5 WEST	19	47	53	+6
I-80 WEST	9	12	5	-7
ELKHORN WEST	57	42	45	+3
SR-99 NORTH	22	N/A	N/A	N/A
SR-99 SOUTH	99	N/A	N/A	N/A
POWER LINE	46	111	111	0
ELVERTA WEST	112	N/A	N/A	N/A
SAN JUAN	19	34	34	0
EL CAMINO	19	39	34	-5
I-80 CENTRAL	9	12	11	-1
NATOMAS RD	30	55	51	-4

N/A= These points do not flood to a depth of 1 foot within the model analysis duration.

1D to 2D model:

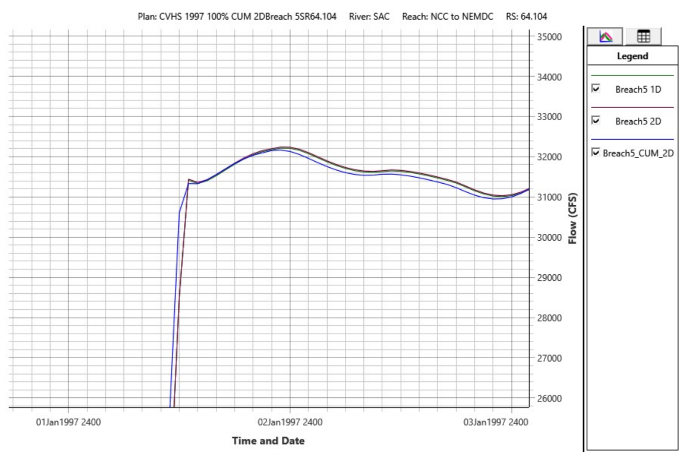
For the location of "ELKHORN WEST", the difference in timing of the 1 foot of depth was from 57 hours in the original 1-D analysis to 42 hours in the 2-D analysis. The reduction results from the proximity of the breach to this location, and that flows overland reach this point before all areas within the storage area/2D domain are filled to the elevation that produces 1 foot of depth at this location.



For all of the remaining points reviewed there was an increase in the time to the flood depth. The addition of storage contained within the "Scour Pit" directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.

2D to 2D Cumulative Model Changes:

The Breach location near the I-80 crossing of the Sacramento River generally shows a small reduction in response time to a 1-foot depth along the I-80 corridor within the southern areas of the basin (Data Points: ELKHORN, DEL PASO, I-80 EAST, I-80 WEST, EL CAMINO, I-80 CENTRAL and NATOMAS RD).



Of note would be the low points in Interstate 80 at I-80 WEST, and I-80 CENTRAL where the response time to flood 1 foot reduces from 12-hours to a 5-hours, and 12 hours to 11-hours respectively, between the 2D Existing and 2D Cumulative Conditions models. The models show there are 2 reasons for the reduction in timing. The most important is that for the 2D Cumulative Condition, the model shows the full breach formation 1 hour and 10 minutes sooner than in the 2D Existing and the 2D Cumulative Conditions per the graph to the right. This generally affects all points and accounts for the general reduction between 1 and 2 hours seen in many of the data point locations.

The second reason which additionally affects the 2 I-80 points nearest the breach (I-80 EAST and I-80 CENTRAL) appears to result from the proposed grading at the Upper Westside project. The breach flows would spread out from the breach through the generally flat grades proposed and through the streets which are at lower grades. The result is an overland flooding path to these locations sooner in the event. The Breach 5 location just happens to be directly adjacent to the southern end of the Upper Westside project.

The 2D Cumulative Models do not account for the resistance to the flow spreading effect that would occur due to the construction of buildings, fences and the planting of vegetation and trees. An average friction value is applied over the surface. These future condition items cannot be included in the current modeling as they are still unknown. It is likely that if structures, fences and vegetation are built similar to other developments, they would slow the spread effect.

BREACH 6

The results of the modeling exercise for Breach 6 are summarized in Table 6 and the text following the table.

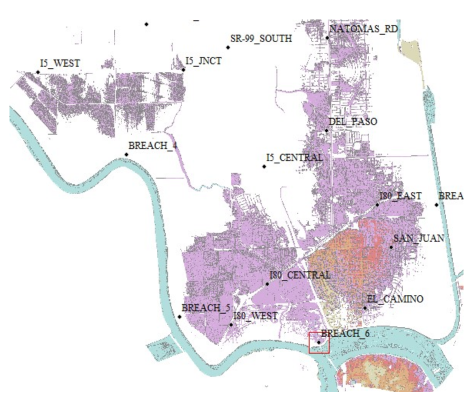
Table 6

BREACH 6 (American River Levee Near Confluence With Sacramento River- C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	53	279	279	0
ELVERTA	29	144	144	0
ELKHORN	21	9	9	0
DEL PASO	10	53	50	-3
I-80 EAST	6	72	64	-8
I-5 CENTRAL	57	N/A	N/A	N/A
I-5 JUNCTION	17	110	110	0
I-5 WEST	11	76	86	+10
I-80 WEST	141	8	8	0
ELKHORN WEST	14	67	68	+1
SR-99 NORTH	61	N/A	N/A	N/A
SR-99 SOUTH	133	N/A	N/A	N/A
POWER LINE	31	108	108	0
ELVERTA WEST	65	N/A	N/A	N/A
SAN JUAN	4	55	51	-4
EL CAMINO	4	57	52	-5
I-80 CENTRAL	137	5	4	-1
NATOMAS RD	16	100	88	-12

Note: "N/A" means that the breach event did not report flooding in excess of 1 foot at the data point throughout the model event duration (typical for all Tables).

1D to 2D model:



Three points show reduced timing changes in model for the time to the 1 foot depth. ELKHORN[6] from 21 hours to 9 hours, I-80 WEST from 141 hours to 8 hours, and I-80 CENTRAL from 137 hours to 5 hours. The proximity of the breach location to these locations shows that flooding to a depth of 1 foot would occur due to flood waters propagating to these locations overland before the volumes of the entire storage area/2-D domain fill to the required

[6] ELKHORN as a critical evacuation route appears to have a significantly shorter time to 1 foot than previously analyzed by GEI, Note that this is based on the existing conditions roadway elevations low point. The Grandpark project intends to raise the elevation of this roadway with the project construction such that it would continue to provide adequate evacuation timing.

depth as was analyzed in the original 1-D analysis.

For all of the remaining points reviewed there was an increase in the time to the flood depth. The addition of storage contained within the “Scour Pit” directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.

<u>2D Existing to 2D Cumulative Model Changes:</u>

For this breach location scenario, the Cumulative Conditions produce similar results to the Existing Conditions model at all locations. The largest reduction in time to flood 1 foot is at NATOMAS ROAD where a 12-hour reduction occurs (100 to 88 hours). This is in an area near to and north of the breach location. All points which show reductions in timing to 1 foot depth are in the south area of the basin, and near where the breach location overland flooding controls the timing to the 1 foot depth instead of the timing to fill all of the storage area/2-D area up to the elevation.

All other minor changes noted by the analysis are less than 1 hour, which is approximately the rounding error in the results.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

BREACH 7

The results of the modeling exercise for Breach 7 are summarized in Table 7 and the text following the table.

Table 7
BREACH 7 (NEMDC Levee Near I-80 – C+P Conditions)

Evacuation Route Location:	Time to 1ft for 1D GEI Exist Cond. Model (hrs)	Time to 1 ft for 2D Existing Cond. Model (hrs)	Time to 1ft for 2D Cumulative Model (hrs)	Improvement in Timing of 1ft Depth (hrs)
SR-99	53	280	295	+15
ELVERTA	29	57	160	+103
ELKHORN	21	30	25	-5
DEL PASO	10	15	15	0
I-80 EAST	6	3	3	0
I-5 CENTRAL	57	31	N/A	N/A
I-5 JUNCTION	17	93	89	-4
I-5 WEST	11	86	80	-6
I-80 WEST	141	48	40	-8
ELKHORN WEST	14	83	76	-7
SR-99 NORTH	61	58	N/A	N/A
SR-99 SOUTH	133	86	N/A	N/A
POWER LINE	31	134	124	-10
ELVERTA WEST	65	55	N/A	N/A
SAN JUAN	4	4	3	-1
EL CAMINO	4	6	6	0
I-80 CENTRAL	137	36	30	-6
NATOMAS RD	16	22	22	0

Note: "N/A" means that the breach event did not report flooding in excess of 1 foot at the data point throughout the model event duration (typical for all Tables).

This beach location is located along the Natomas East Main Drainage Canal Levee, north of the American River.

1D to 2D model:

Seven points show reduced timing changes in model for the time to the 1 foot depth. I-80 EAST (6 to 3 hours), I-5 CENTRAL(57 to 31 hours), I-80 WEST(141 to 48 hours), SR-99 NORTH(61 to 58 hours), SR-99 SOUTH (133 to 86 hours), ELVERTA WEST(65 to 55 hours), and I-80 CENTRAL(137 to 36 hours).

The I-80 EAST location is close to the model breach location and the difference can be explained by the previous use of storage areas methodology compared to the overland 2D flooding methodology. In the previous methodology all of the above ground storage within a storage area has to be filled by the breach flows to a certain elevation. In the 2D model, the flood propagates overland, and the flood flows themselves have depth as the flood wave is spread throughout the basin. In this case the breach flows themselves achieve the 1 foot depth at these locations well before low areas in this quadrant are filled.

The other locations are similarly showing changes as a result of improved flow path analysis of the 2D model v. the storage fills from the bottom up previous methodology.

For all of the remaining points reviewed there was an increase in the time to the flood depth. The addition of storage contained within the “Scour Pit” directly adjacent to the breach location alters some timing as the scour pit needs to be filled before flooding of the remainder of the Natomas Basin will occur. This filling of the scour pit acts to dampen the flow propagation from the levee breach to the land side terrain.

2D to 2D Cumulative Model Changes:

In general, the Cumulative analysis shows a reduction in flood response timing to a depth of 1 foot in the southern areas of the basin. Along the I-80 corridor, for example, reductions of 86 to 80 hours (I-5 WEST), 48 to 40 hours (I-80 WEST) and 36 to 30 hours(I-80 CENTRAL) are estimated by the modeling. Later in the event, points ELKHORN, I-5 JCNT, ELKHORN WEST, POWER LINE and SAN JUAN ROAD show similar reductions in timing.

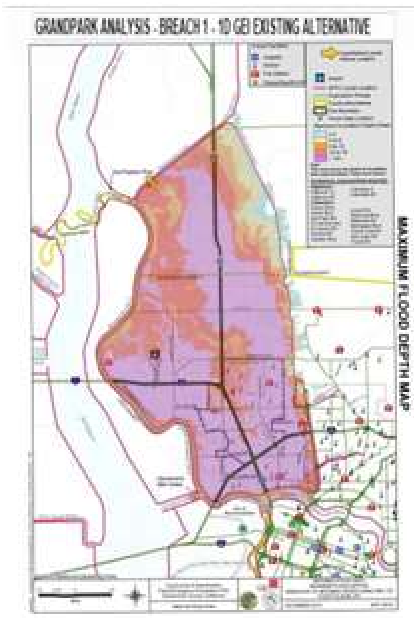
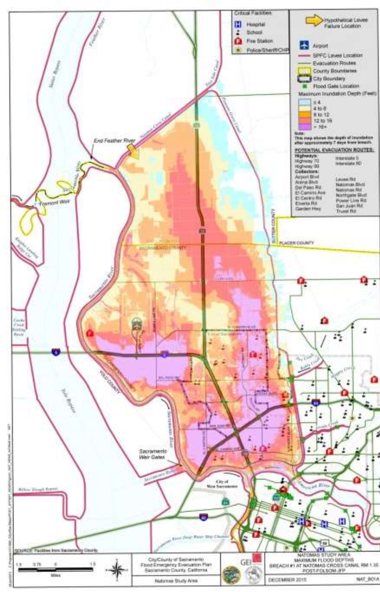
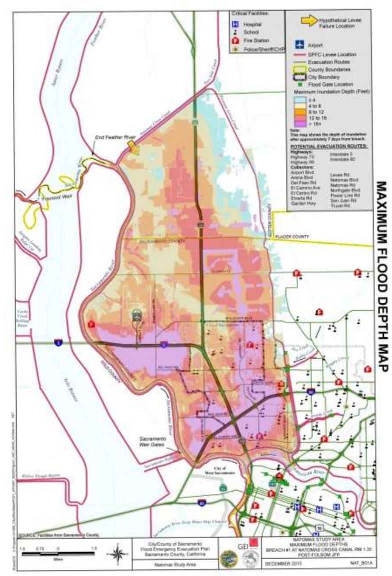
These changes result from the proposed Grandpark project culverts under Elverta Road restricting low flows below their roadway overtopping elevations along the East Drainage Canal in a South to North direction These culverts are sized for properly reducing potential flooding changes both downstream and upstream of the Grandpark project in the 100-year, 200-year design storms with and without Climate Change being factored, in order to meet Sacramento County and RD-1000 peak flood mitigation requirements.

Also, adverse timing of 1-hour (-1 hour) is less than the accuracy of this model and, therefore, this reduction in timing to 1-feet depth of flooding is not considered material.

MAXIMUM INUNDATION DEPTH:

Following is a comparison of the Maximum Inundation Depth computed for each breach scenario under each analysis. Oversized versions of these exhibits are presented at the end of this Technical Memorandum.

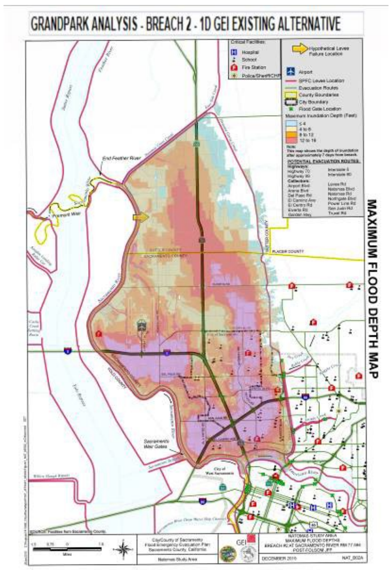
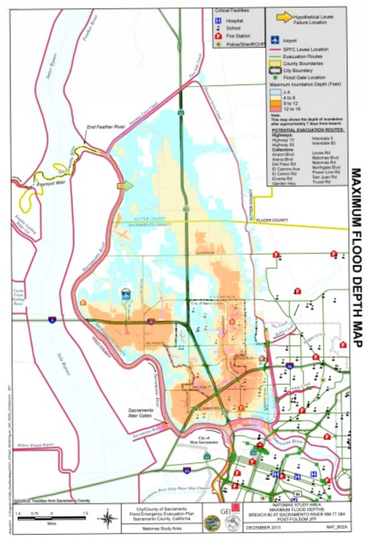
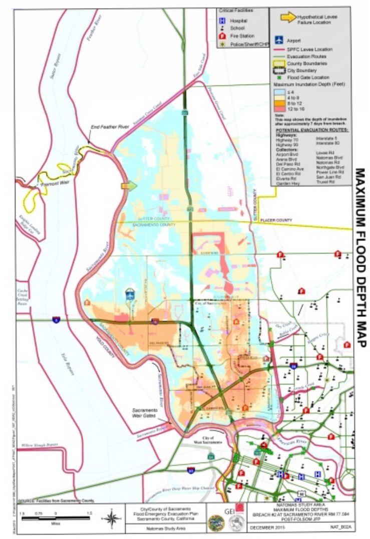
BREACH 1: (Cross Canal Levee Breach Location- C+P Conditions)

 BREACH 1 – 1D EX MAX DEPTH	 BREACH 1 – 2D EX MAX DEPTH	 BREACH 1 – 2D CUMUL MAX DEPTH

For the Breach 1 scenario, the results are similar except as follows:

- The 1D analysis floods to a greater depth than the 2D analysis.
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

BREACH 2: (North Sacramento River Breach Location- C+P Conditions)

 BREACH 2 – 1D EX MAX DEPTH	 BREACH 2 – 2D EX MAX DEPTH	 BREACH 2 – 2D CUMUL MAX DEPTH

For the Breach 2 scenario, all results report a similar final flooding depth with the exception of:

- The 1D analysis floods to a greater depth than the 2D analysis
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

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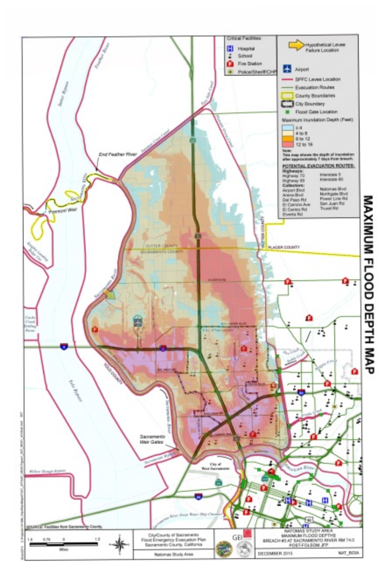
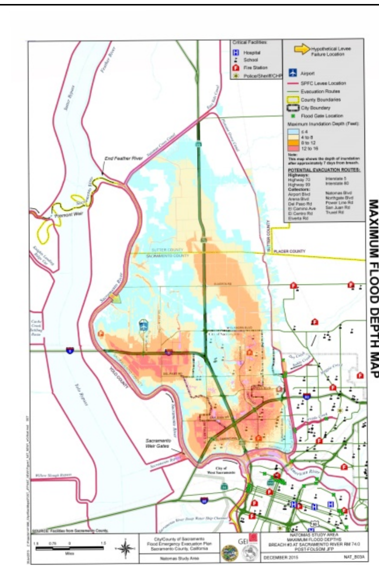
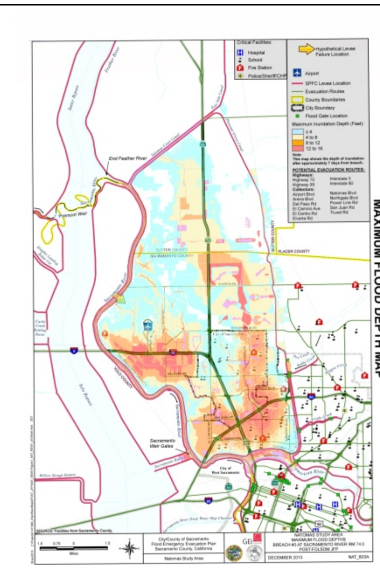
BREACH 3: (Sacramento River Levee Near Elverta Road- C+P Conditions)



BREACH 3 – 1D EX MAX DEPTH



BREACH 3 – 2D EX MAX DEPTH

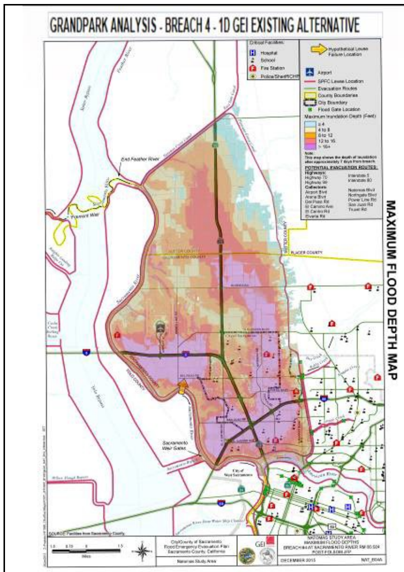
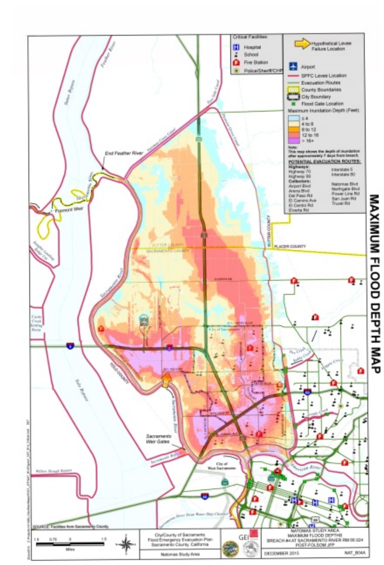
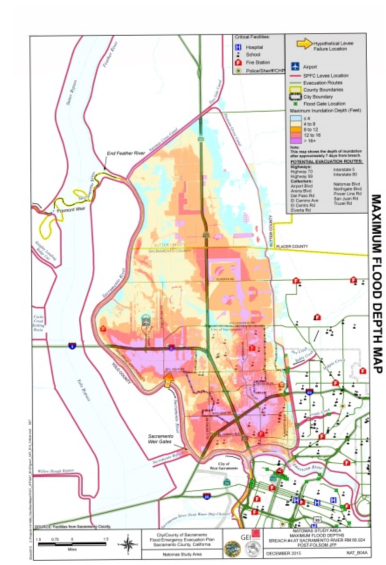


BREACH 3 – 2D CUMUL MAX DEPTH

For the Breach 3 scenario, all results report a similar final flooding depth with the exception of:

- The 1D analysis floods to a greater depth than the 2D analysis.
- The existing conditions 2D analysis showed similar maximum flooding depth as shown in the 1D analysis. Since the depth of the breach in the 2D analysis is somewhat less than that shown in the 1D analysis, the resulting breach flows are not materially less than those shown in the 2D analysis, and the resulting maximum depth of flooding is relatively unchanged from the 1D to the 2D analysis.
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading for the embankments at the Sankey Gap flood storage facility block the flood progression until the embankments are overtopped. This causes the northwest quadrant to have less flood volume initially than the existing conditions analysis.
- Grading within the Cumulative Developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

BREACH 4: (Sacramento River Levee South of I-5- C+P Conditions)

 BREACH 4 – 1D EX MAX DEPTH	 BREACH 4 – 2D EX MAX DEPTH	 BREACH 4 – 2D CUMUL MAX DEPTH

For the Breach 4 scenario, all results report a similar final flooding depth with the exception of:

- The 1D analysis floods to a greater depth than the 2D analysis.
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

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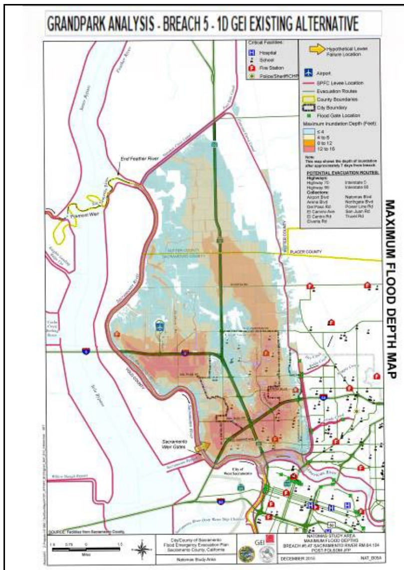
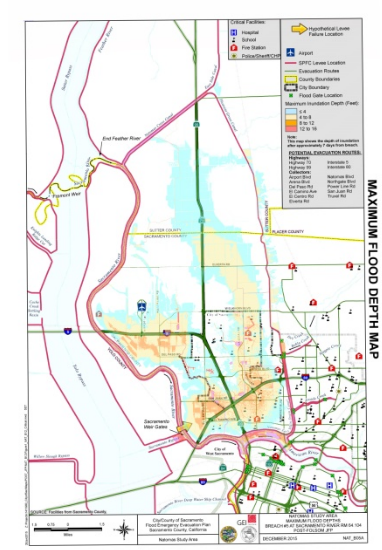
ENGINEERS PLANNERS SURVEYORS

CIVIL ENGINEERING SOLUTIONS, INC.

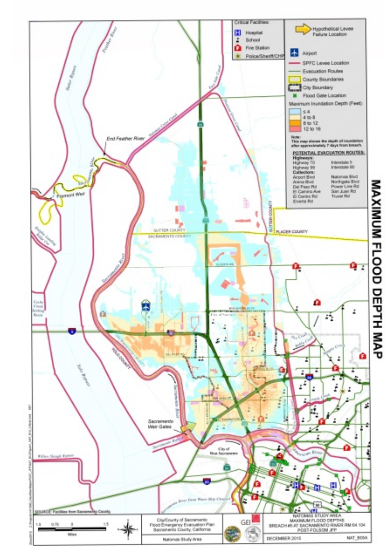
<u>BREACH 5: (Sacramento River Levee Near I-80 - C+P Conditions)</u>



BREACH 5 – 1D EX MAX DEPTH



BREACH 5 – 2D EX MAX DEPTH



BREACH 5 – 2D CUMUL MAX DEPTH

For the Breach 5 scenario, all results report a similar final flooding depth with the exception of:

- The 1D analysis floods to a greater depth than the 2D analysis
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

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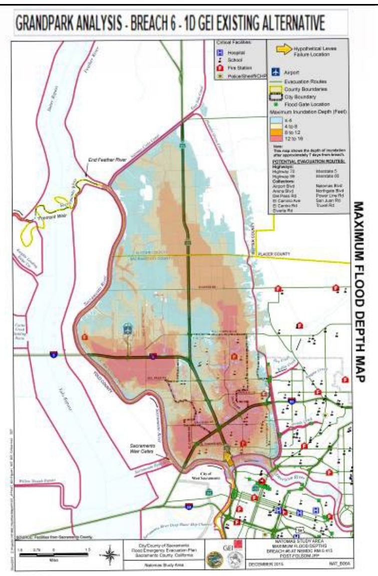
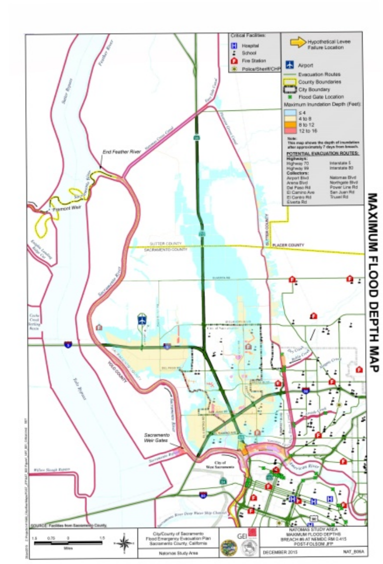
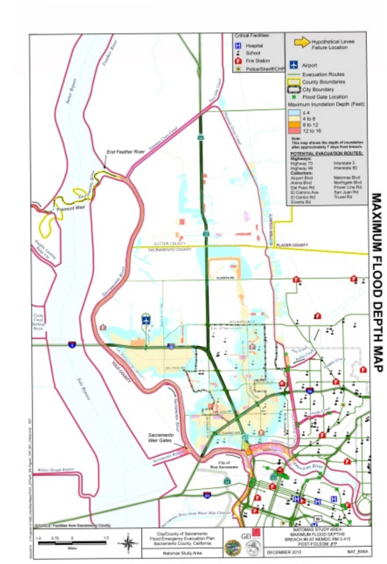
BREACH 6 (American River Levee Near Confluence With Sacramento River – C+P Conditions):



BREACH 6 – 1D EX MAX DEPTH



BREACH 6 – 2D EX MAX DEPTH



BREACH 6 – 2D CUMUL MAX DEPTH

For the Breach 6 scenario, for the 2D analyses report a similar final flooding depth. However:

- The 1D analysis floods to a greater depth than the 2D analysis.
- The existing conditions 1D analysis showed a much higher maximum flooding depth than the 2D analysis. This is result of greater breach flows being allowed through a deeper breach in the 1D model as compared to the 2D model resulting in the reduced maximum depth of flooding from the 2D analysis.
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.
- Due to available flood capacity within the Grand Parkway, lower maximum flood depths occur within the southwestern areas and areas north of Elkhorn Blvd.

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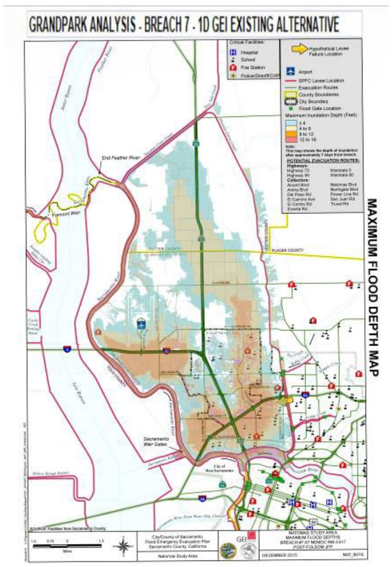
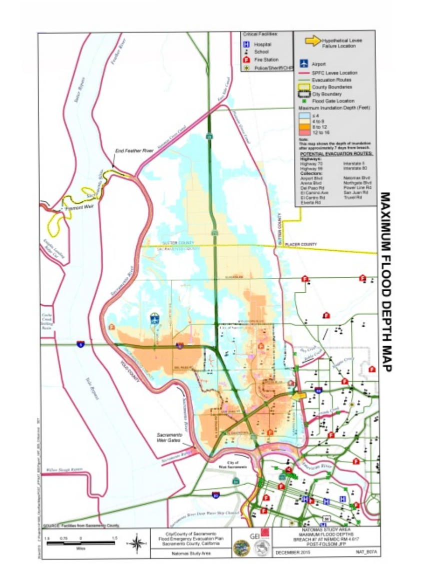
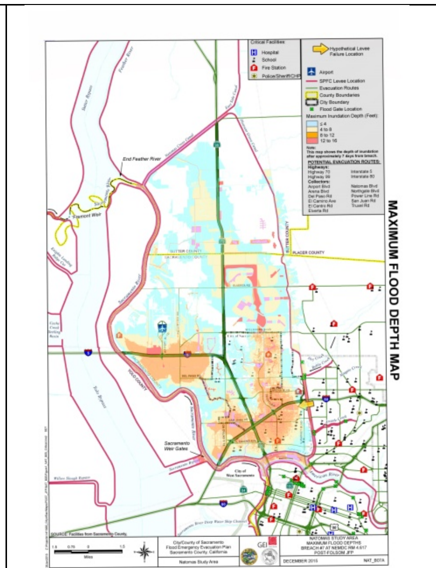
BREACH 7 (NEMDC Levee Near I-80 – C+P Conditions)



BREACH 7 – 1D EX MAX DEPTH



BREACH 7 – 2D EX MAX DEPTH



BREACH 7 – 2D CUMUL MAX DEPTH

For the Breach 7 scenario, all results report a similar final flooding depth with the exception of:

- The 2D analysis floods to a slightly greater depth than the 1D Analysis (0.10 feet to 0.15 feet greater depth depending upon location within the Natomas Basin. This slight increase is within modeling tolerances and is not deemed material for purposes of this analysis).
- The existing conditions 1D analysis does not show the Sankey Gap spill path. This is because of how storage areas are represented in the 1D model.
- Grading within the Cumulative developments shows some differences, such as lower depths where embankments are proposed and higher depths at proposed detention basins.

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MAXIMUM STAGE OF FLOODING COMPARISON

A comparison of Maximum Flooding Water Surface Elevations for the Grandpark and Upper Westside Development Areas, by breach scenario is shown in Table 8. For this table the location of the East Drainage Canal Crossing of Elverta Road was selected for the Grandpark project, and a central point within the Upper Westside project was selected.

TABLE 8
Maximum Flooding Water Surface Elevations
(Existing v. Cumulative Conditions)

BREACH SCENARIO	GEI 1D Existing	UWS Existing	UWS Cumulative	Grandpark Existing	Grandpark Cumulative
1 – Natomas Cross Canal	37.56	31.66	31.66	31.66	31.66
2 – Sac. River North	31.80	23.81	23.84	23.81	23.84
3 – Sac River North Central	29.19	24.95	24.96	24.95	24.96
4 – Sac River Central.	32.28	29.60	29.61	29.60	29.61
5 – Sac River South	26.29	20.64	20.91	20.64	20.91
6 – American River	27.06	18.21	18.38	18.21	18.38
7 – NEMDC	23.16	23.29	23.31	23.29	23.31

As shown in Table 8, one can easily conclude that, for all intents and purposes, grading of the Upper Westside and Grandpark projects (and other Cumulative projects included in the analysis) is generally accomplished on a "net-zero" impact basis to total potential flooding in a levee breach. That is to say, grading of the project will result in "balanced" on-site grading plans – with little or no import or export of dirt from or into the Natomas Basin thus having minimal adverse effect on the maximum flood stage within the Natomas Basin.

Accordingly, flood storage volumes and their aerial distribution within the Natomas Basin have and will remain relatively unchanged over time. While localized, minor changes in the aerial extent of catastrophic flooding may occur on a project-by-project basis, the distribution of maximum depth of flooding on a basin-wide basis will not vary measurably over time.

The peak timing of the maximum depth of flooding within the basin will sometimes occur at a time closer to the peak timing of the flood outside the basin. Sometimes, these two peaks will occur at times more distant. The peak flooding of the all breach scenarios occurs after the peak flooding in the exterior river system in all breach scenarios studied herein. Thus when the timing becomes shorter, a higher peak stage in the basin will occur and when the peak timing within the basin is more delayed the peak stage inside the basin at equilibrium with the exterior rivers will show as being reduced.

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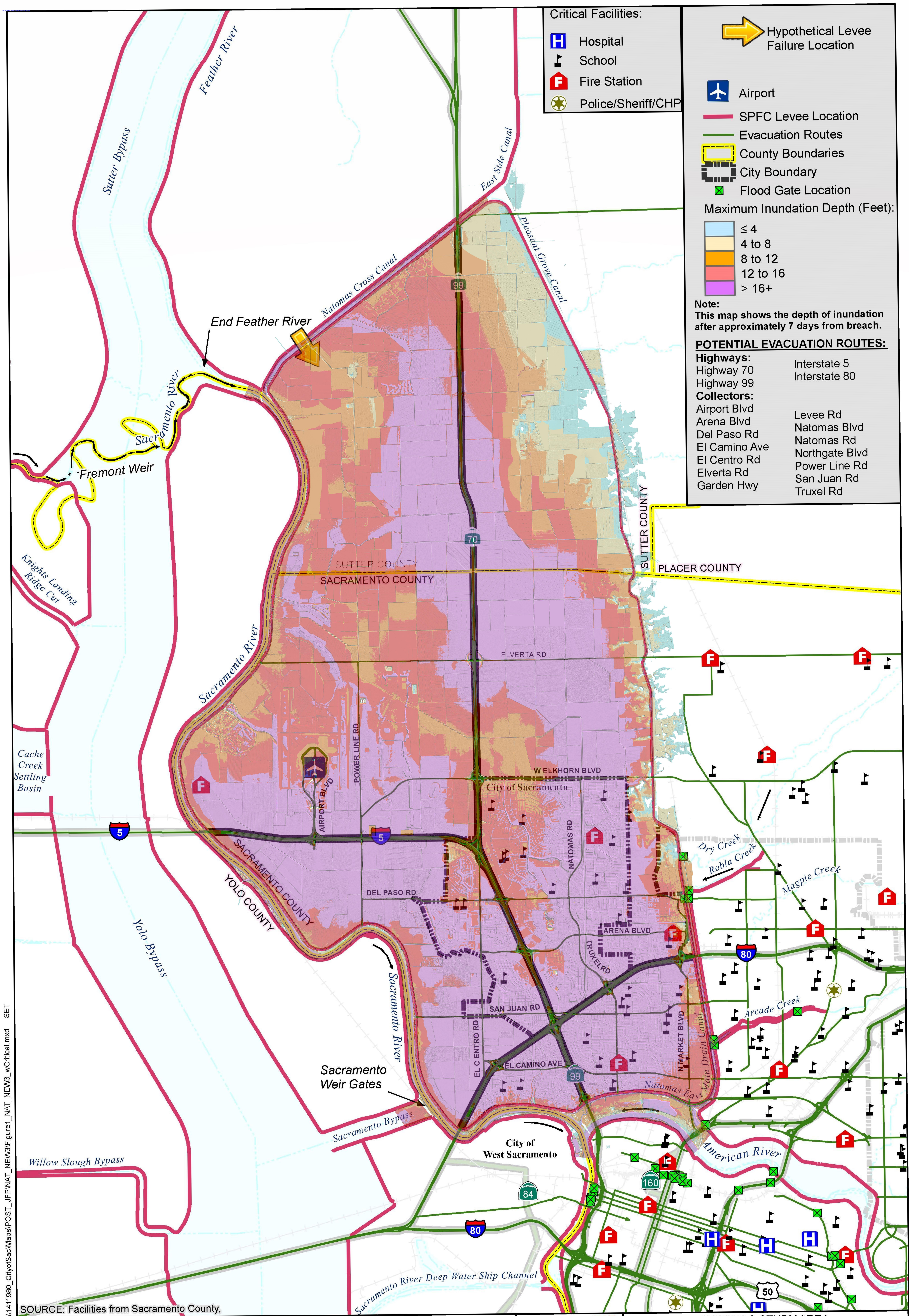
CONCLUSIONS:

1. The addition of a scour pit did allow the levee breach to form to the full depth and height. However, this change in the model did not increase the amount of flow significantly to the interior of the basin.
2. The review of landside nearby lowest elevations that the breach could flow to as an exit from the weir location did contribute to some higher flow rates in a few areas.
3. The addition of a scour pit delayed some flow delivery and reduced overall peak flows. This is likely because during the breach formation, the scour pit would form at a water surface below the exterior river water surface as there are head losses for the flow passing through the breach. The lower water surface elevation of the scour pit delivering water to the landside terrain therefore had less potential energy to drive the flood waters to spill over the terrain. Also because the scour pit flood elevation is above the adjacent terrain elevations, the head differential from outside the basin to the inside basin (at the Scour Pit) is reduced (less than the difference from the outside water surface to the lowest elevation in the storage area. Also, because the scour pit flood elevation is above the terrain elevations, the head to drive flood waters through which the breach operates was less than when near submergence was modeled
4. The changes to the model generally resulted in less flooding depths and longer flood timings for all breach locations studied. This suggests that for total flow and timing, the importance of the breach formation depths was not as significant as the elevations of the landside terrain the flood waters eventually have to pass over after passing through a breach and scour pit.
5. Finally the changes in timing in the two 2D models, Existing Conditions and Cumulative Conditions stayed similar to the previous analysis and was not sensitive the issues raised in the GEI Comments.

OVERSIZED EXHIBITS

BREACH 1 - 1D - EXISTING



1.5 0.75 0 1.5
Miles

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #1 AT NATOMAS CROSS CANAL RM 1.35
POST-FOLSOM JFP

DECEMBER 2015 NAT_B01A

MAXIMUM FLOOD DEPTH MAP

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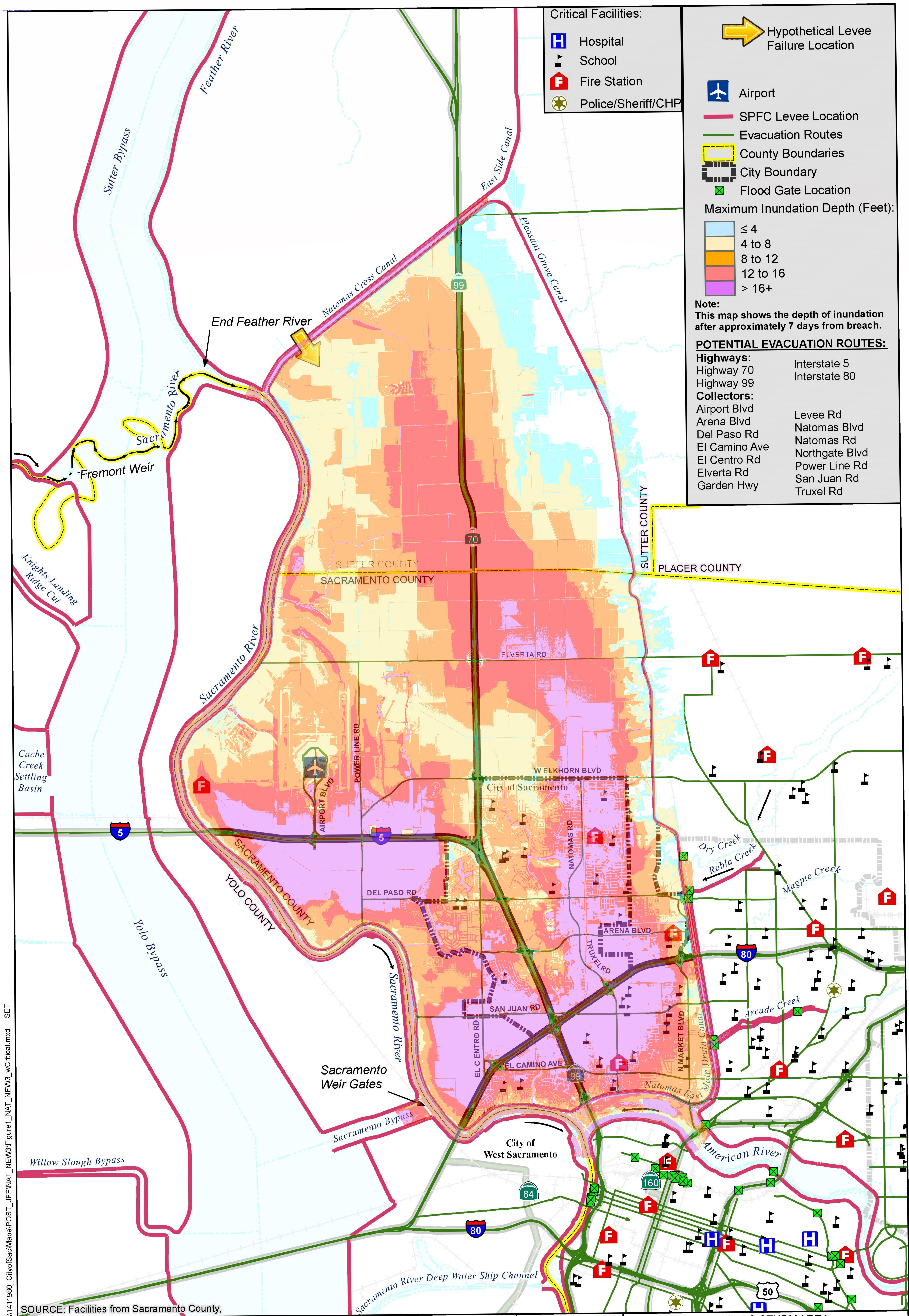
BREACH 1 - 2D - EXISTING



MAXIMUM FLOOD DEPTH MAP

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Miles

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BREACH #1 AT NATOMAS CROSS CANAL RM 1.35
POST-FOLSOM JFP

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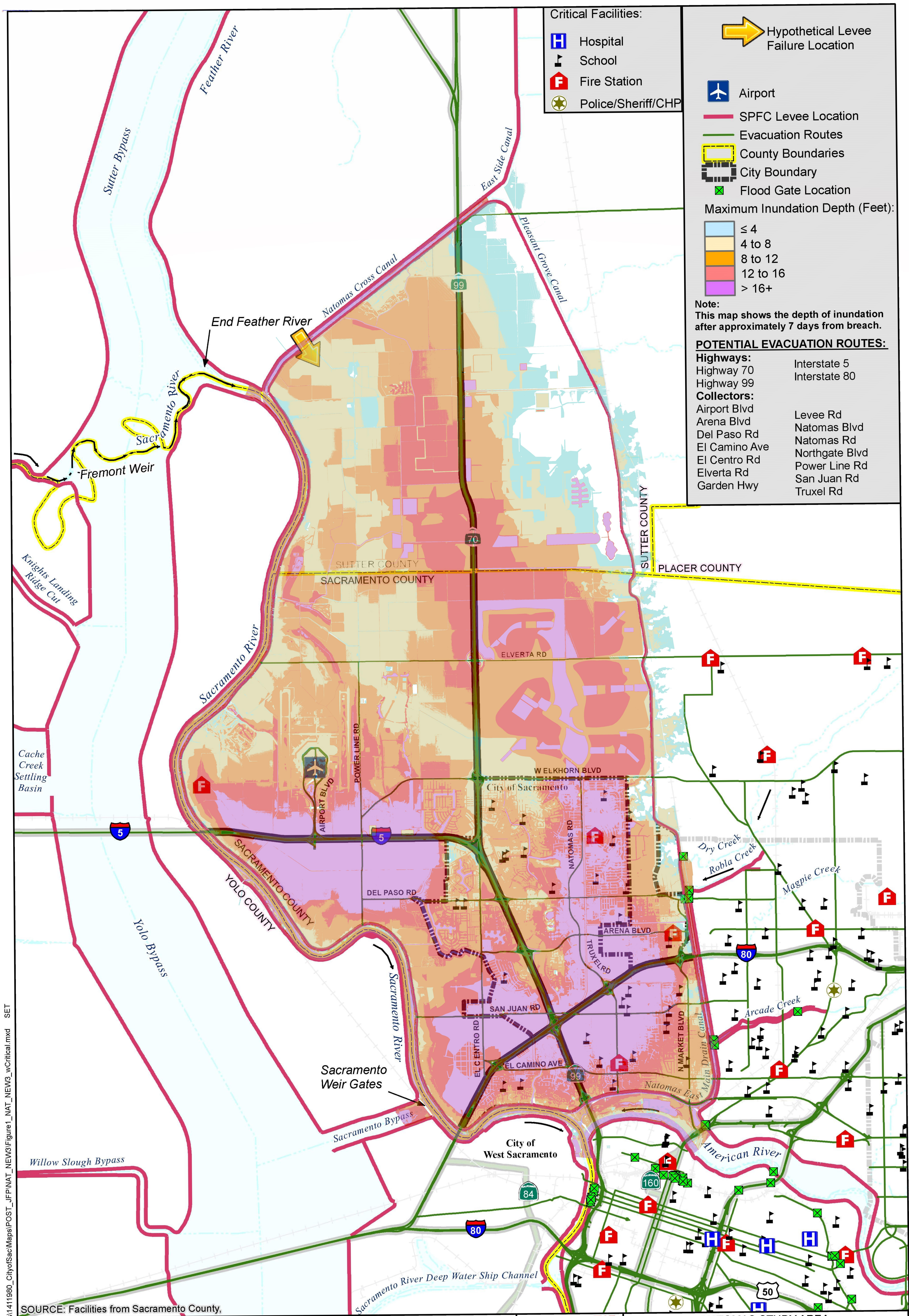
BREACH 1 - 2D - CUMULATIVE



MAXIMUM FLOOD DEPTH MAP

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Miles

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MAXIMUM FLOOD DEPTHS
BREACH #1 AT NATOMAS CROSS CANAL RM 1.35
POST-FOLSOM JFP

DECEMBER 2015

NAT_B01A

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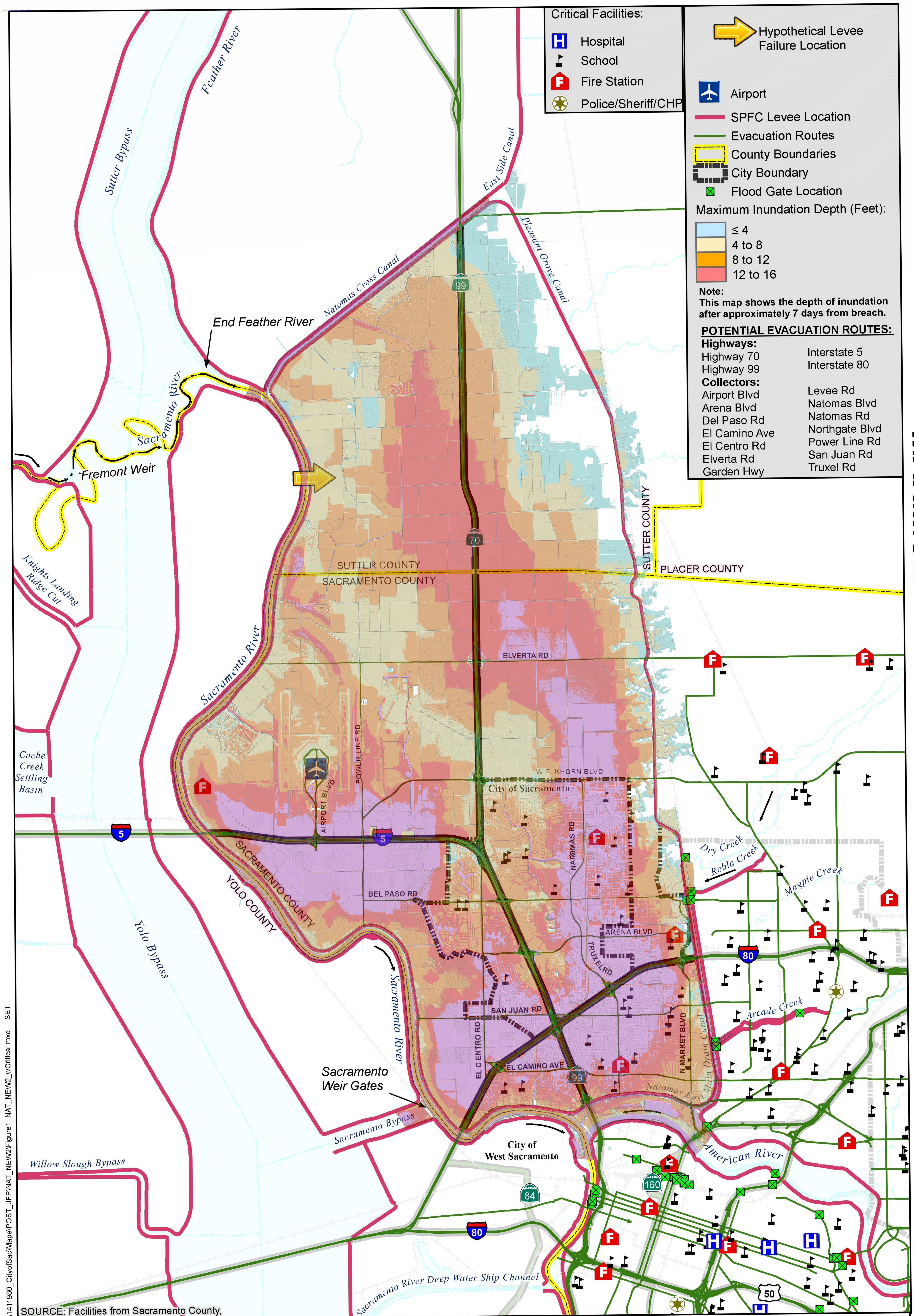

MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5
Miles

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MAXIMUM FLOOD DEPTHS
BREACH #2 AT SACRAMENTO RIVER RM 77.584
POST-FOLSOM JFP

DECEMBER 2015

NAT_B02A

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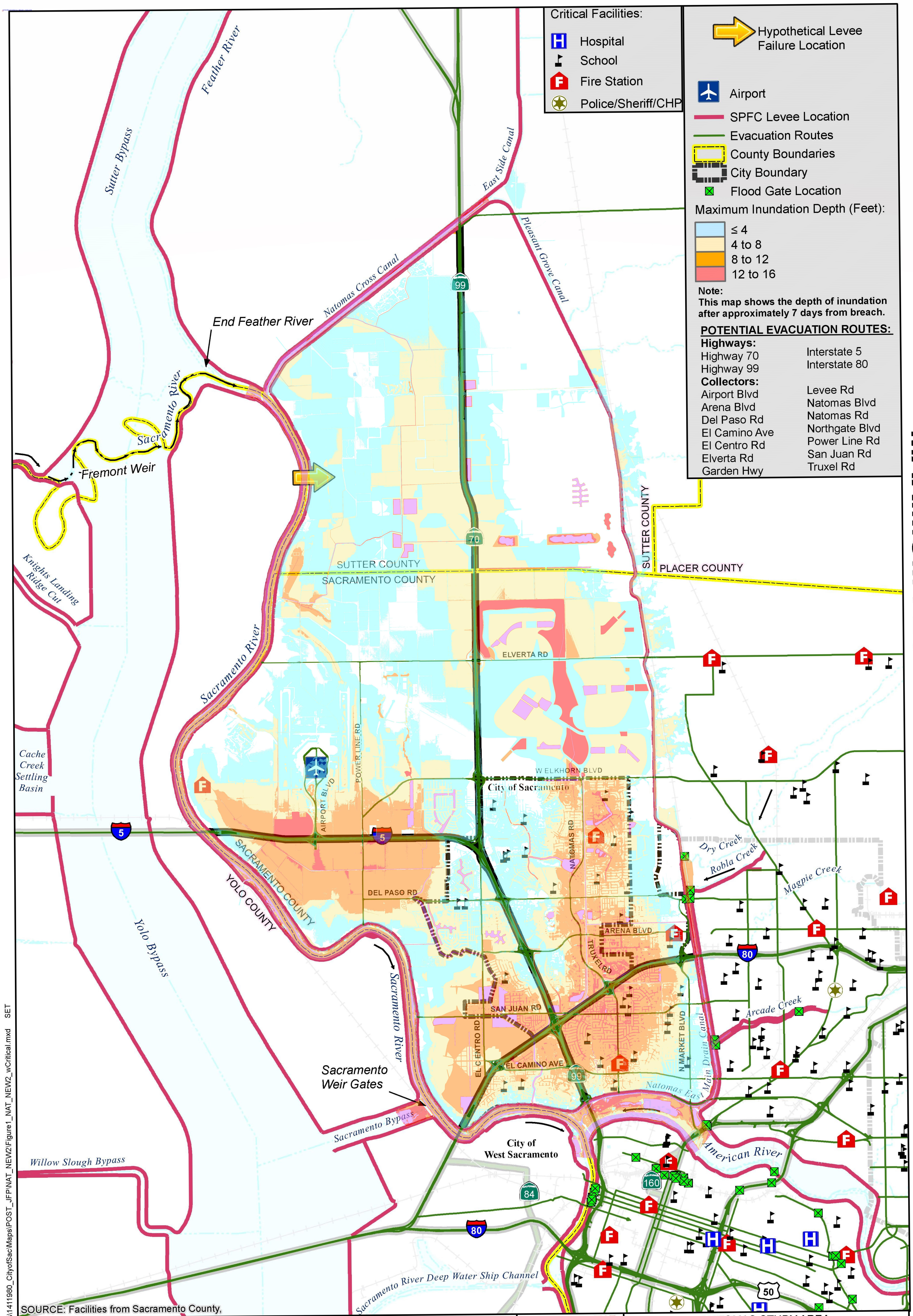
BREACH 2 - 2D - EXISTING

BREACH 2 - 2D - CUMULATIVE



MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5

Miles

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MAXIMUM FLOOD DEPTHS
BREACH #2 AT SACRAMENTO RIVER RM 77.584
POST-FOLSOM JFP

DECEMBER 2015

NAT_B02A

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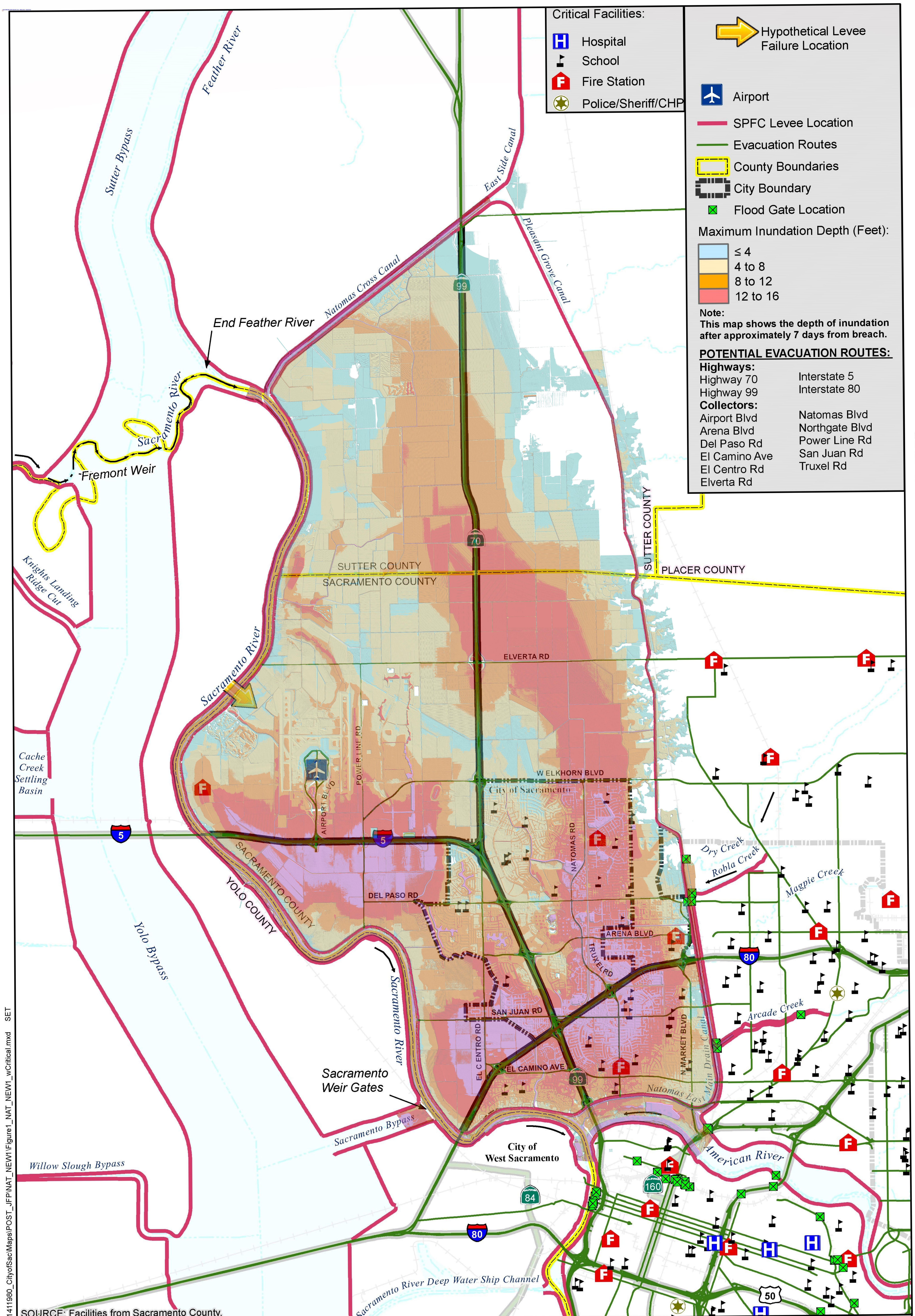

MAXIMUM FLOOD DEPTH MAP

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Sacramento County, California

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #3 AT SACRAMENTO RIVER RM 74.0
POST-FOLSOM JFP

DECEMBER 2015 NAT_B03A

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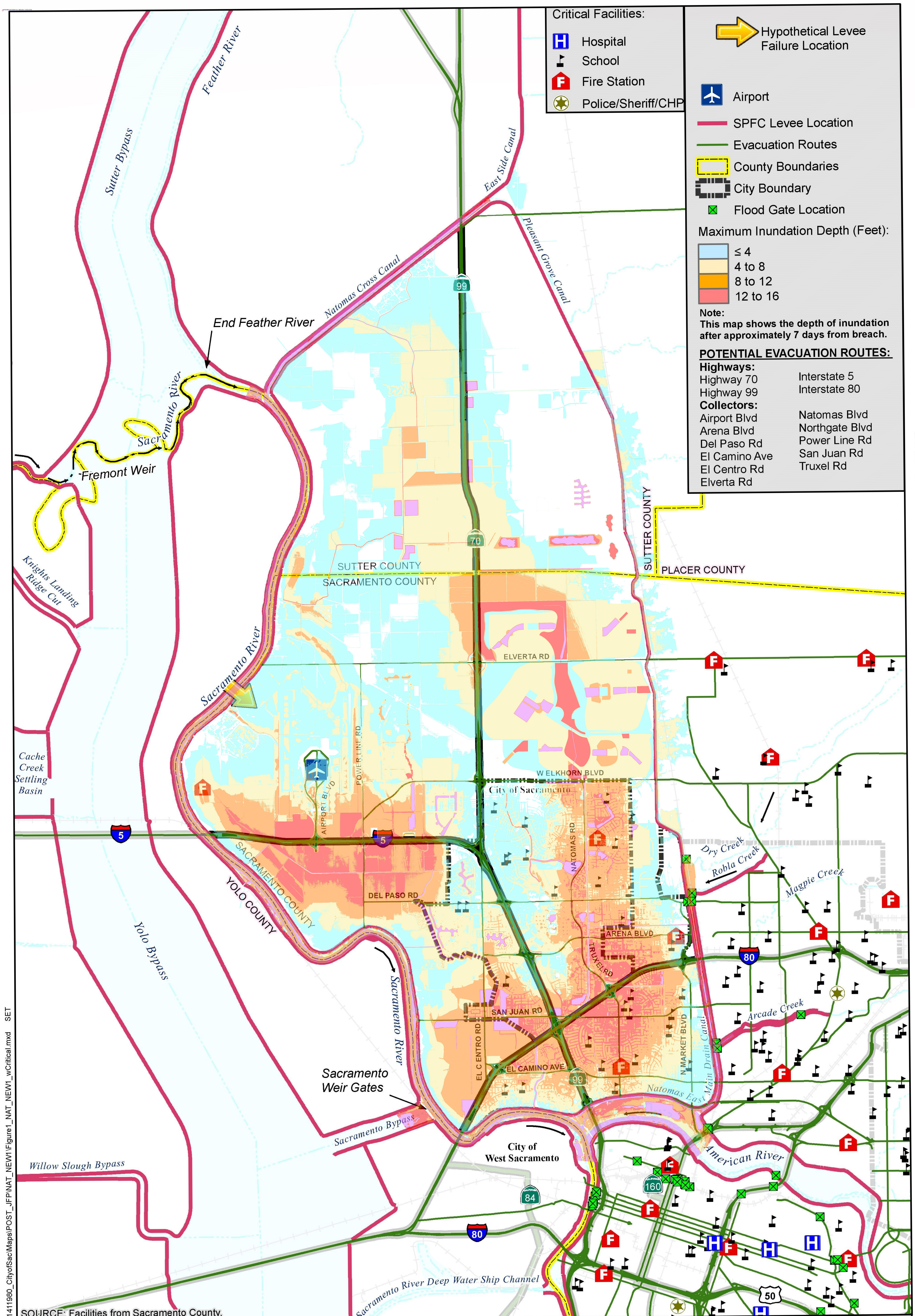
BREACH 3 - 2D - EXISTING

BREACH 3 - 2D - CUMULATIVE

MAXIMUM FLOOD DEPTH MAP



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Miles

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #3 AT SACRAMENTO RIVER RM 74.0
POST-FOLSOM JFP

DECEMBER 2015 NAT_B03A

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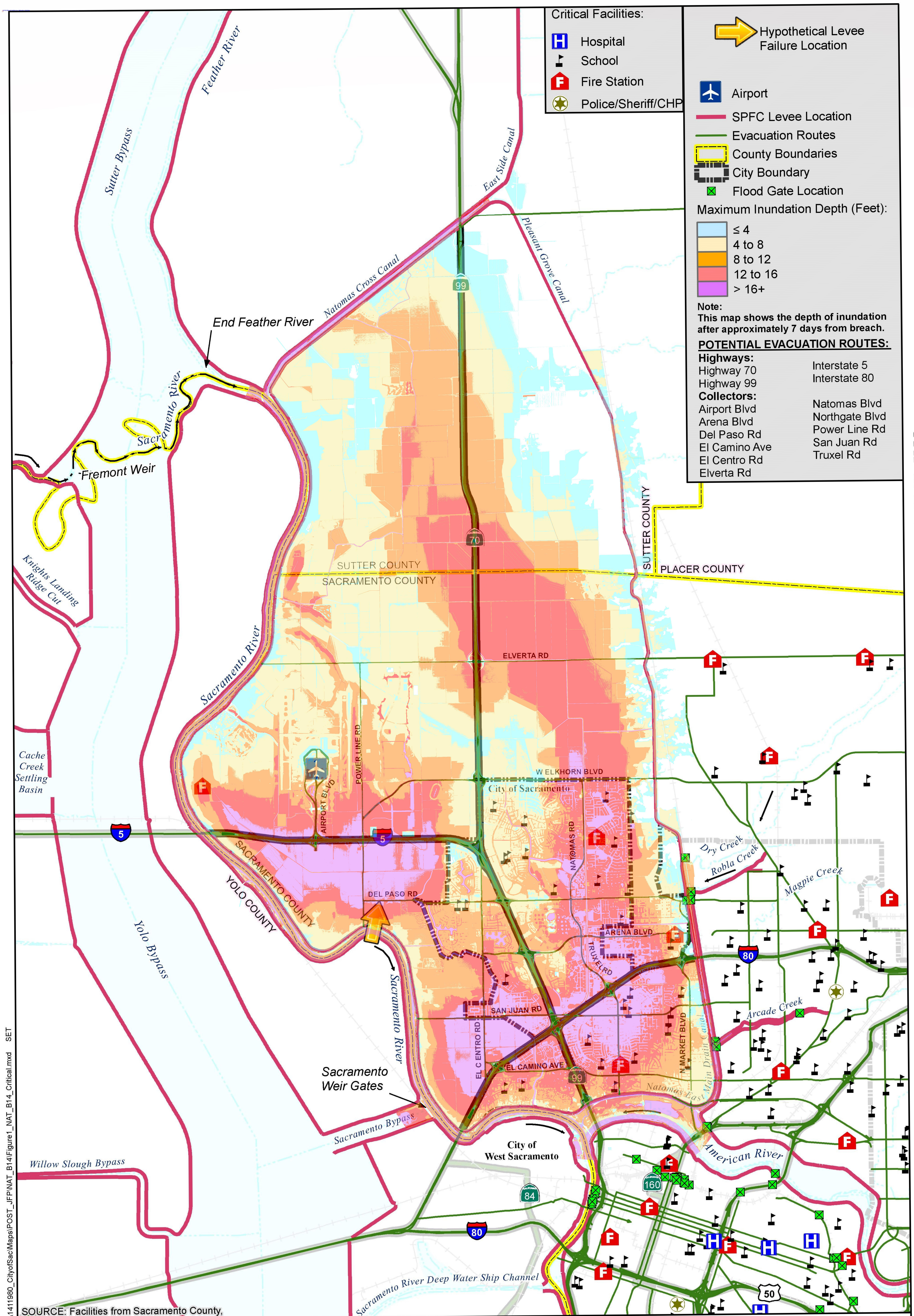
BREACH 4 - 1D - EXISTING

MAXIMUM FLOOD DEPTH MAP

BREACH 4 - 2D - EXISTING



MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5
Miles

N S E W

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Sacramento County, California

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #4 AT SACRAMENTO RIVER RM 66.924
POST-FOLSOM JFP

DECEMBER 2015

NAT_B04A

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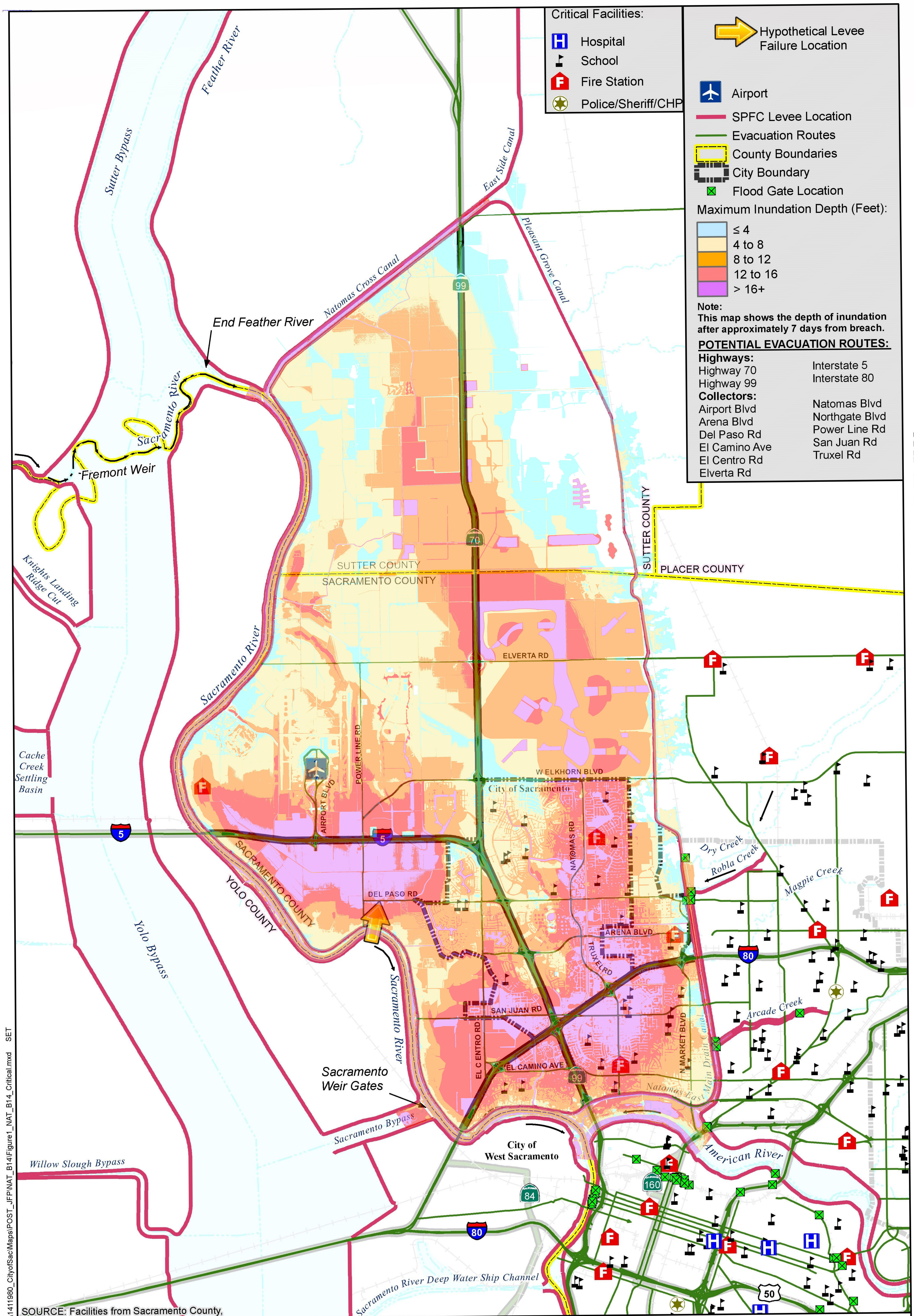

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Miles

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Sacramento County, California

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #4 AT SACRAMENTO RIVER RM 66.924
POST-FOLSOM JFP

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BREACH 5 - 1D - EXISTING

BREACH 5 - 2D - EXISTING

BREACH 5 - 2D - CUMULATIVE

MAXIMUM FLOOD DEPTH MAP

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BREACH 6 - 1D - EXISTING

MAXIMUM FLOOD DEPTH MAP

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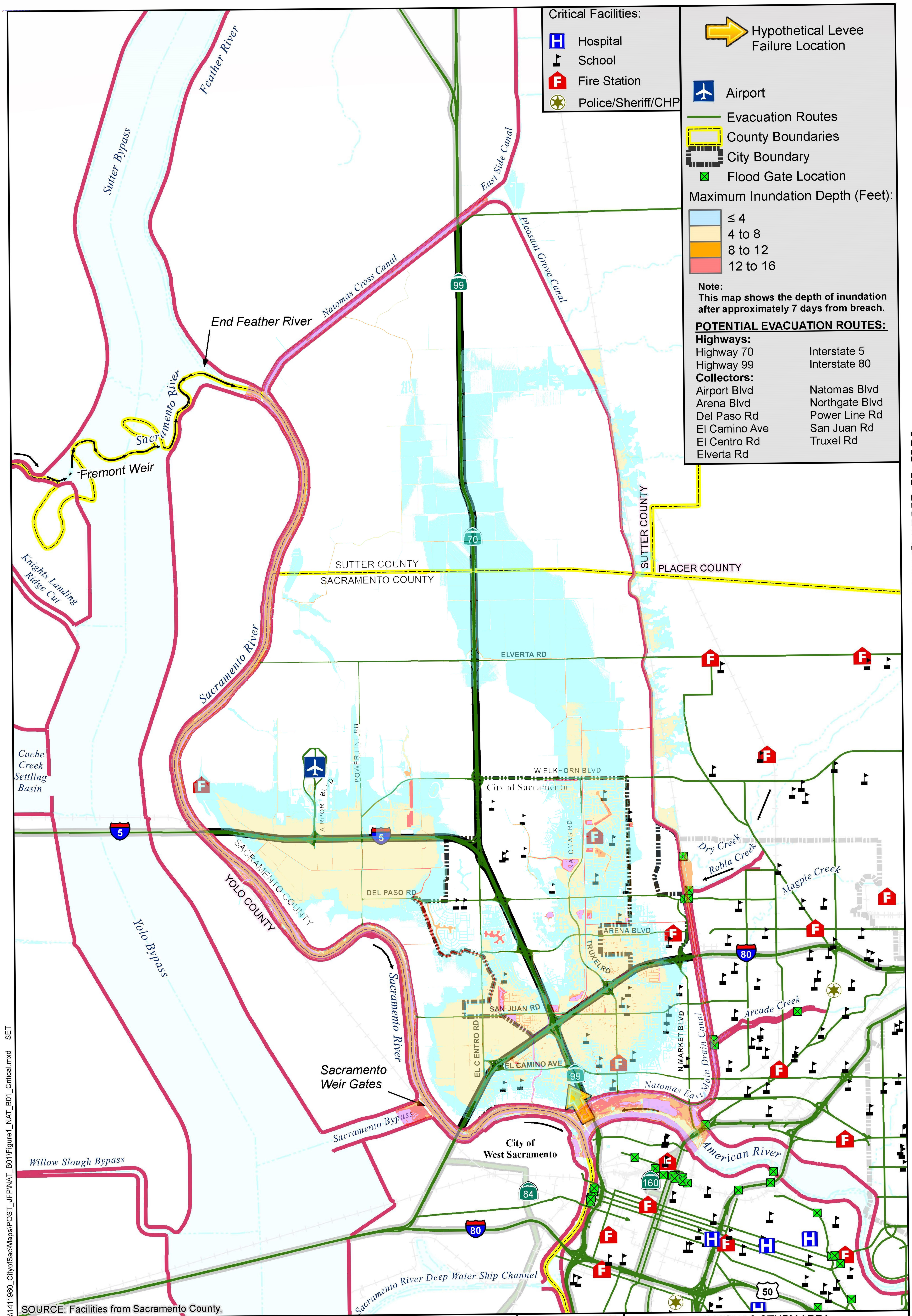

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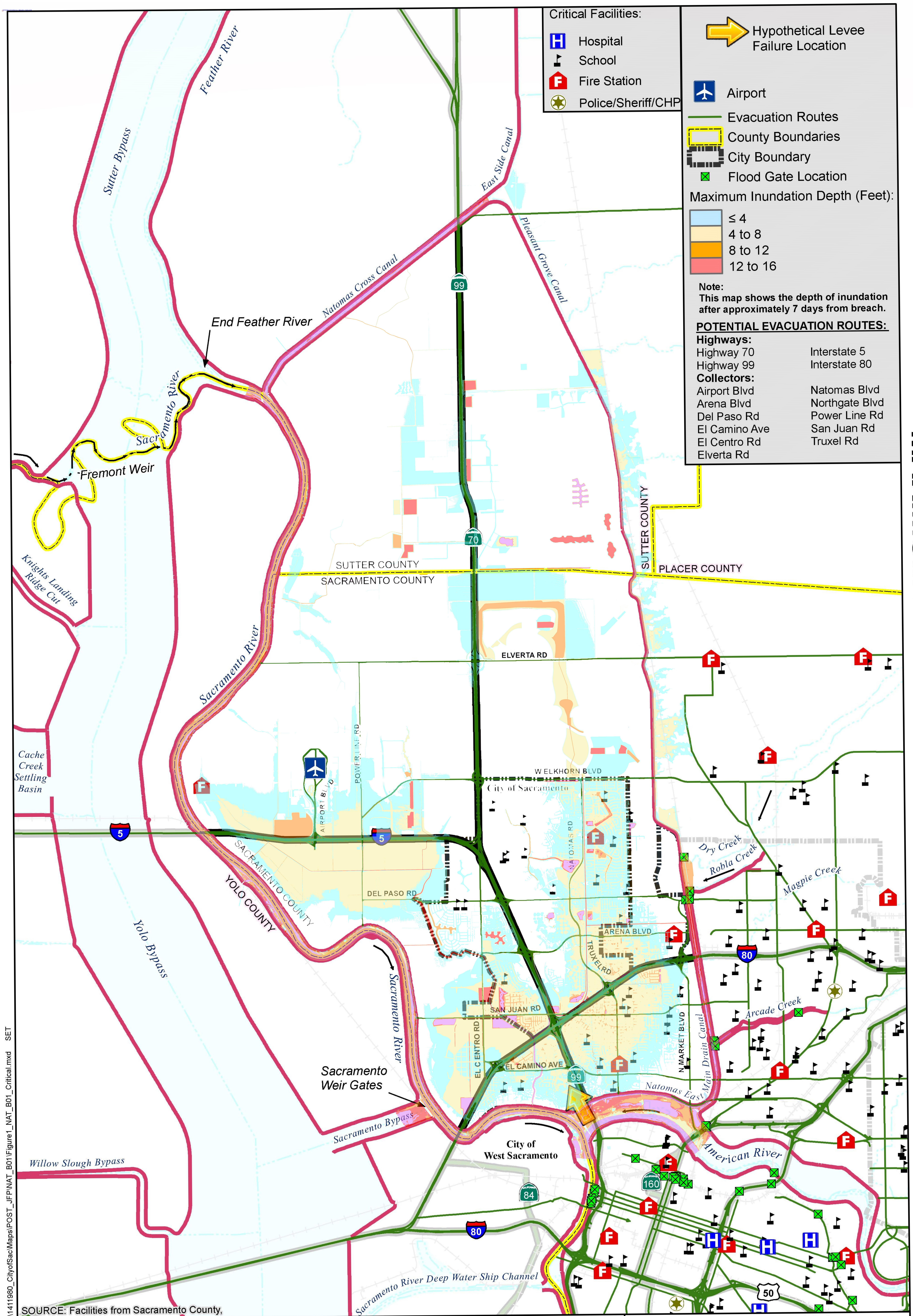
NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #6 AT NEMDC RM 0.415
POST-FOLSOM JFP

DECEMBER 2015

NAT_B06A

BREACH 6 - 2D - CUMULATIVE



MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5

Miles

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #6 AT NEMDC RM 0.415
POST-FOLSOM JFP

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NAT_B06A

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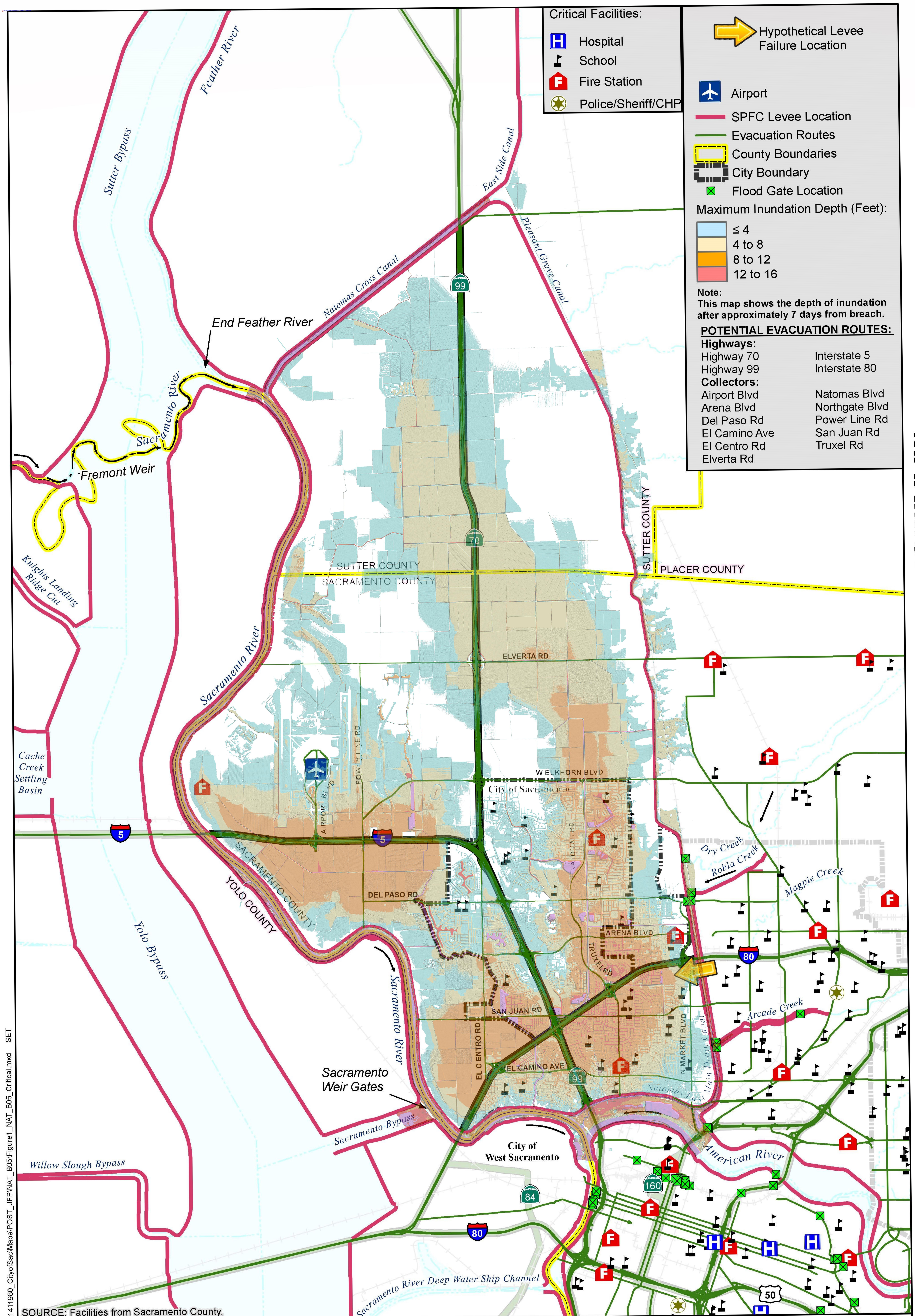

1.5 0.75 0 1.5
Miles

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Sacramento County, California

Natomas Study Area

NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #7 AT NEMDC RM 4.617
POST-FOLSOM JFP

DECEMBER 2015

NAT_B07A

MAXIMUM FLOOD DEPTH MAP

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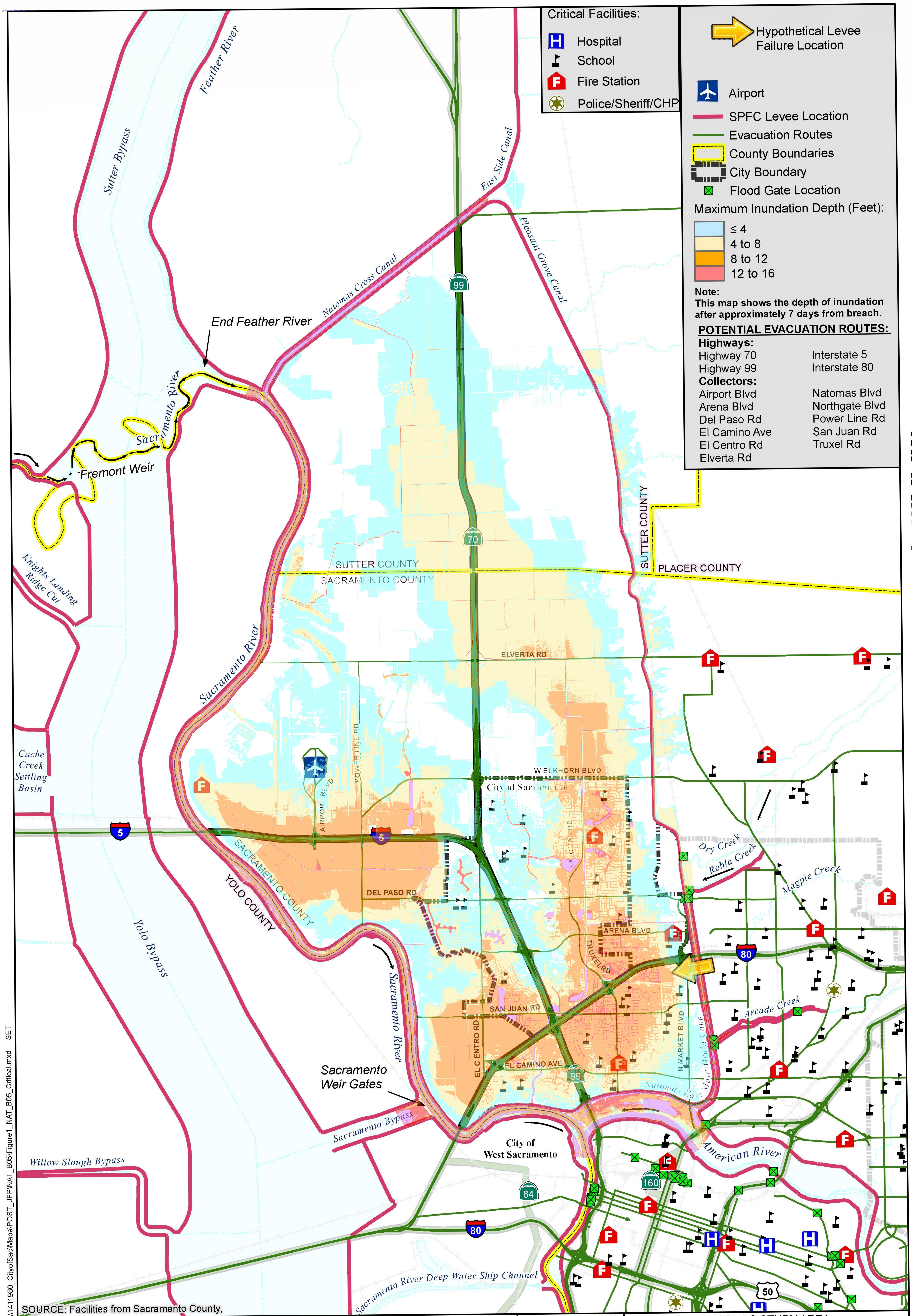

MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5
Miles

City/County of Sacramento
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Sacramento County, California

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #7 AT NEMDC RM 4.617
POST-FOLSOM JFP

DECEMBER 2015

NAT_B07A

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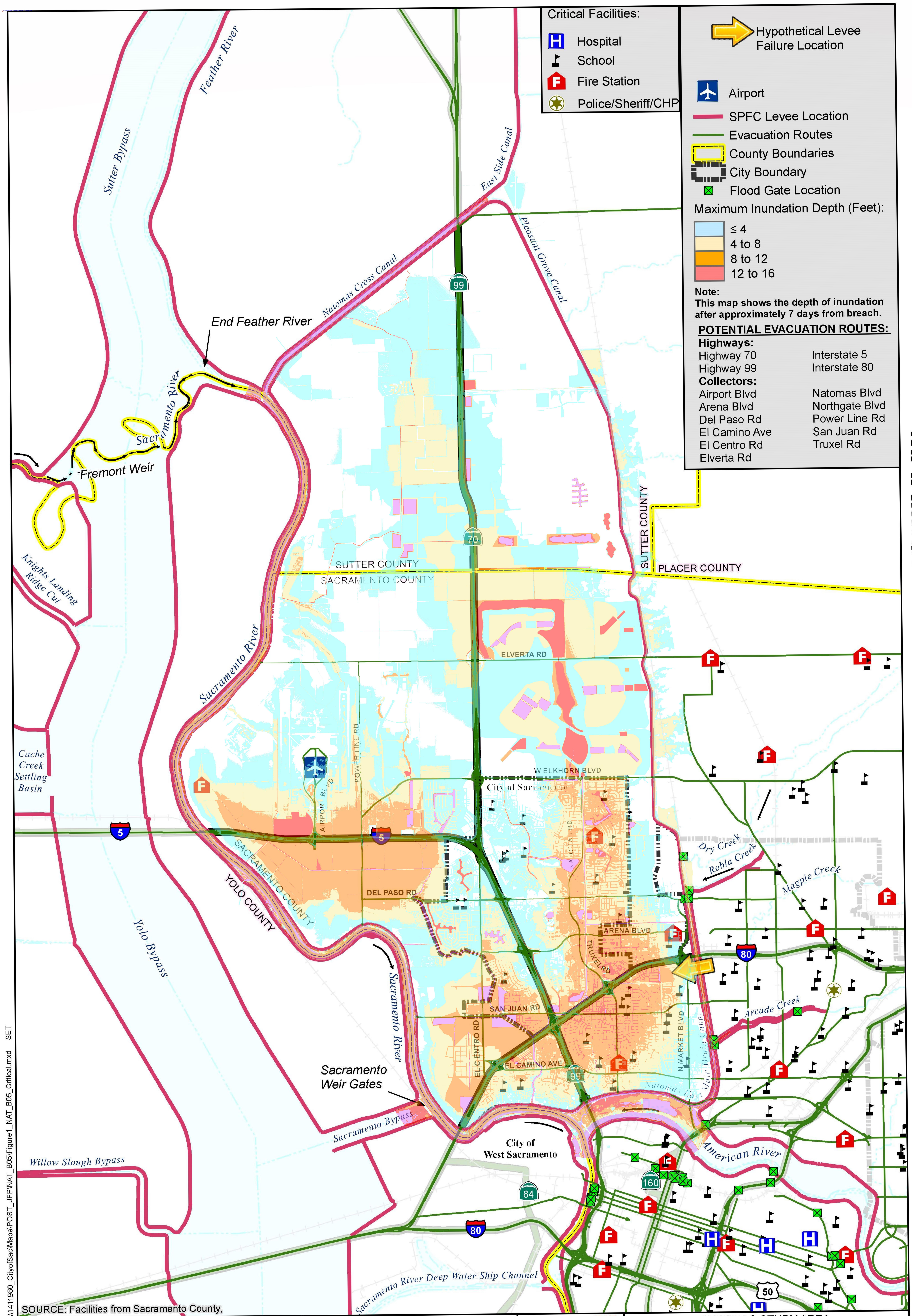

MAXIMUM FLOOD DEPTH MAP

1.5 0.75 0 1.5
Miles

City/County of Sacramento
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Sacramento County, California

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NATOMAS STUDY AREA
MAXIMUM FLOOD DEPTHS
BREACH #7 AT NEMDC RM 4.617
POST-FOLSOM JFP

DECEMBER 2015

NAT_B07A

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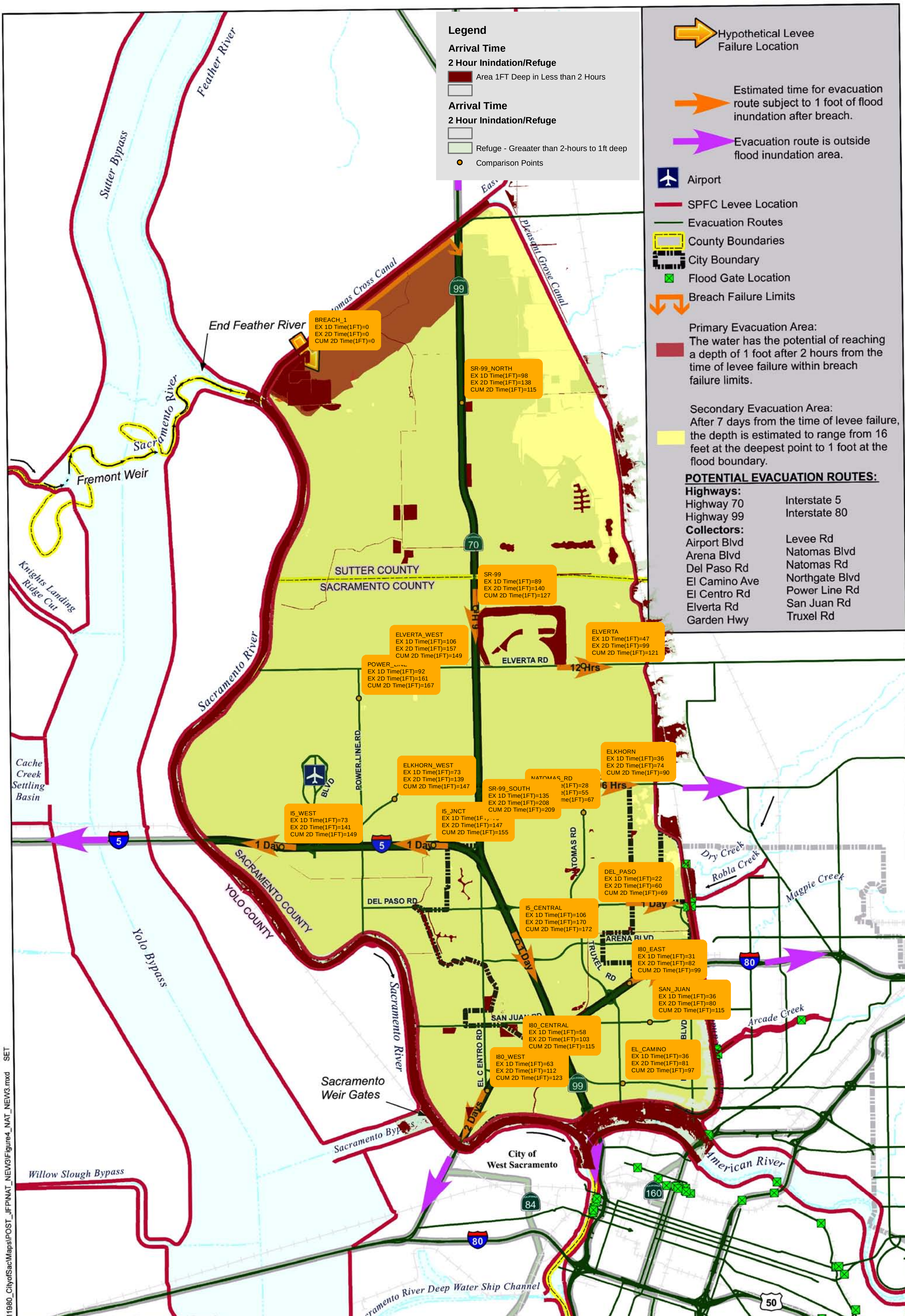
RECOMMENDED EVACUATION ROUTES



1.5 0.75 0 1.5
Miles

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Sacramento County, California

Natomas Study Area

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NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #1 AT NATOMAS CROSS CANAL RM 1.35
POST-FOLSOM JFP

DECEMBER 2015

NAT_B01D

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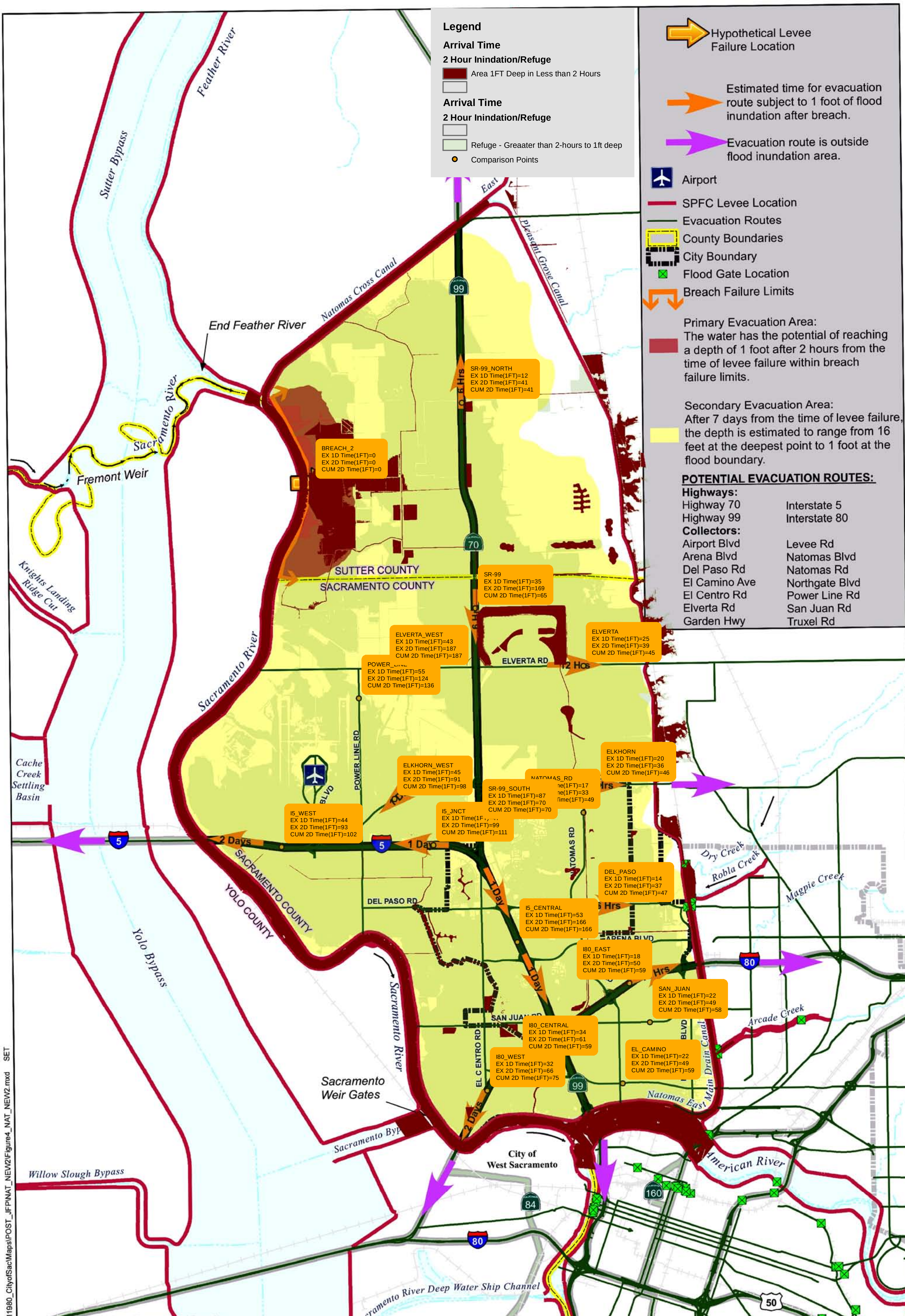

1.5 0.75 0 1.5
Miles

City/County of Sacramento
Flood Emergency Evacuation Plan
Sacramento County, California

Natomas Study Area

NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #2 AT SACRAMENTO RIVER RM 77.584
POST-FOLSOM JFP

DECEMBER 2015

NAT_B02D

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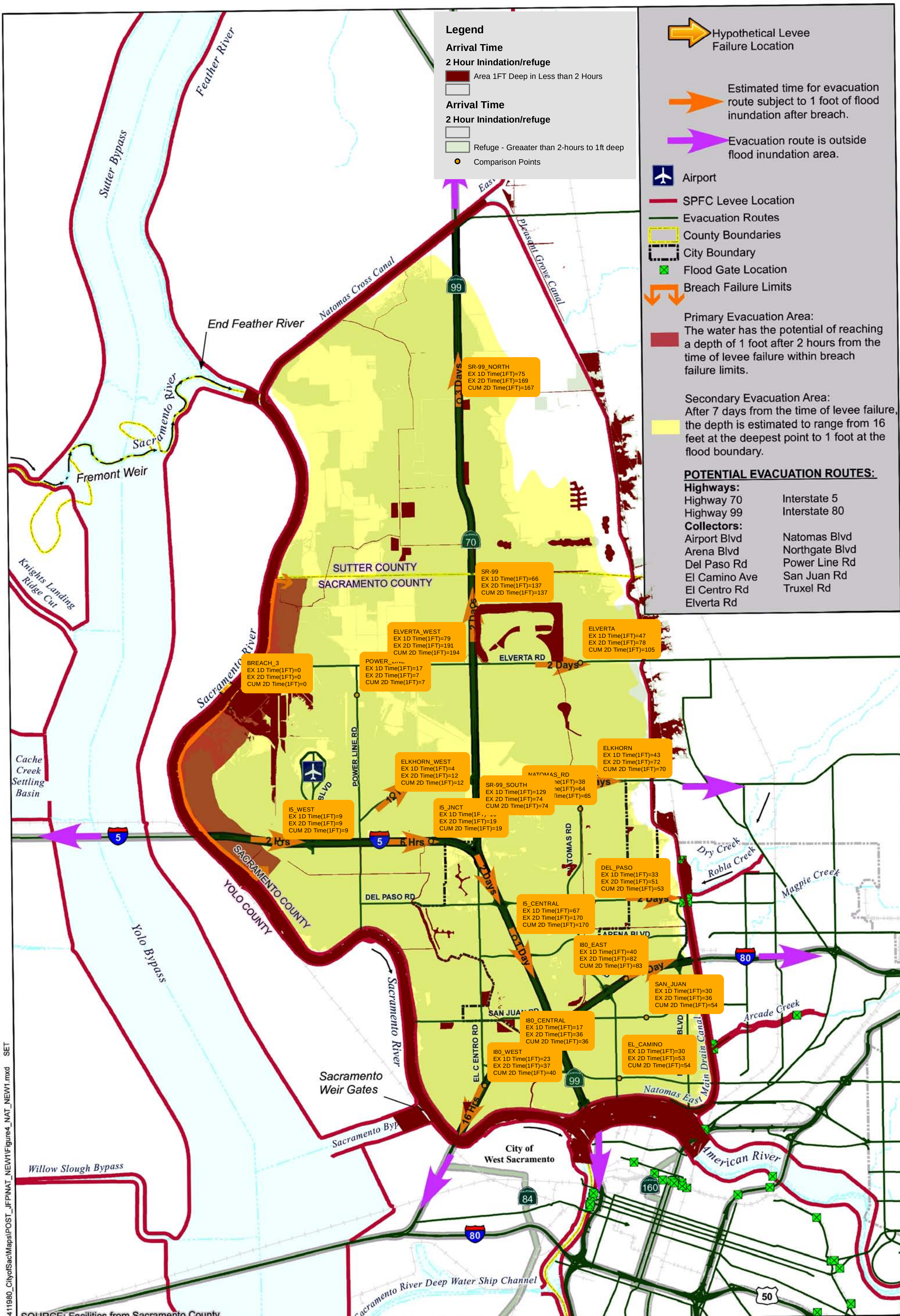

RECOMMENDED EVACUATION ROUTES

1.5 0.75 0 1.5
Miles

City/County of Sacramento
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Sacramento County, California

Natomas Study Area

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NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #3 AT SACRAMENTO RIVER RM 74.0
POST-FOLSOM JFP

DECEMBER 2015

NAT_B03D

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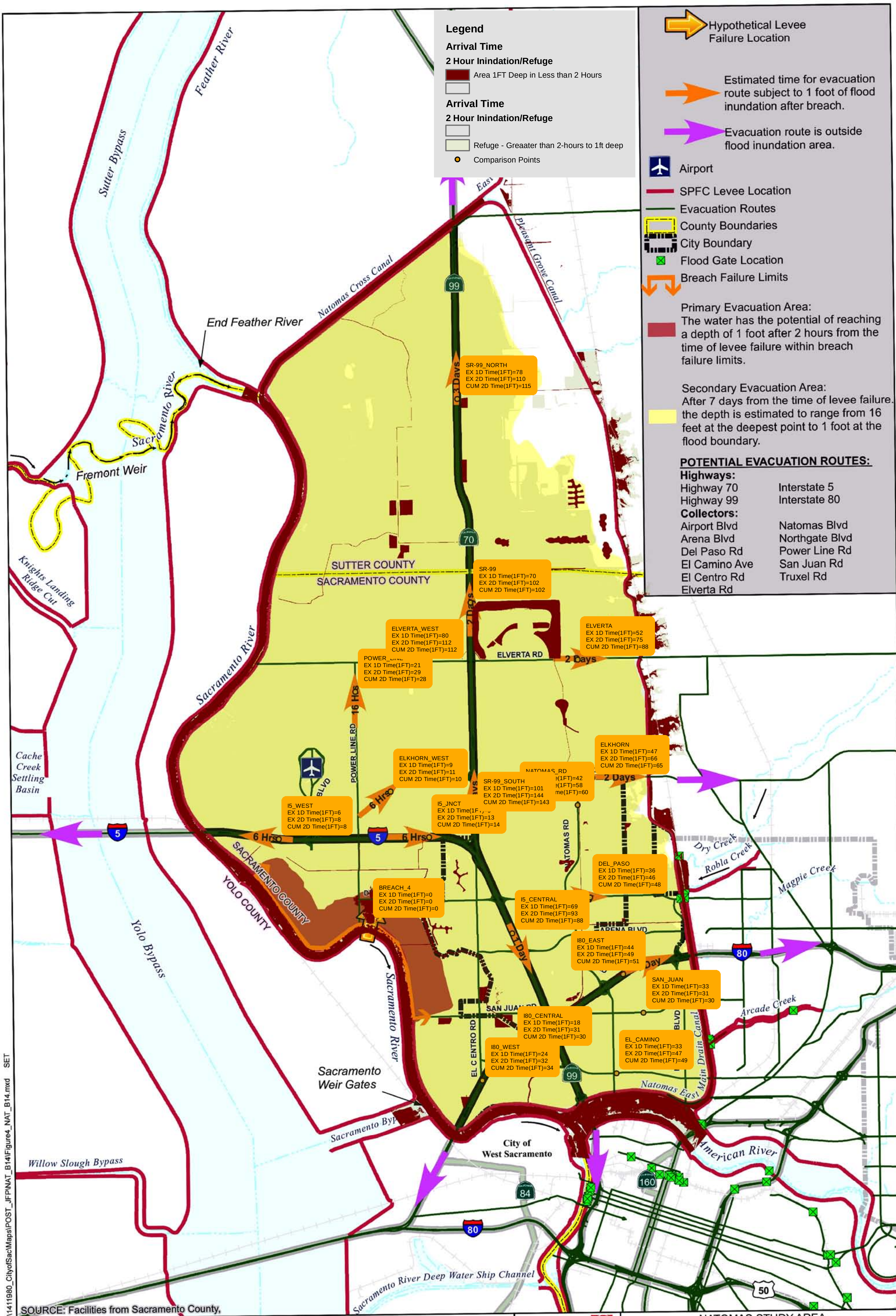
RECOMMENDED EVACUATION ROUTES



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Miles

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Sacramento County, California

Natomas Study Area

GEI Consultants

NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #4 AT SACRAMENTO RIVER RM 66.924
POST-FOLSOM JFP

DECEMBER 2015 NAT_B04D

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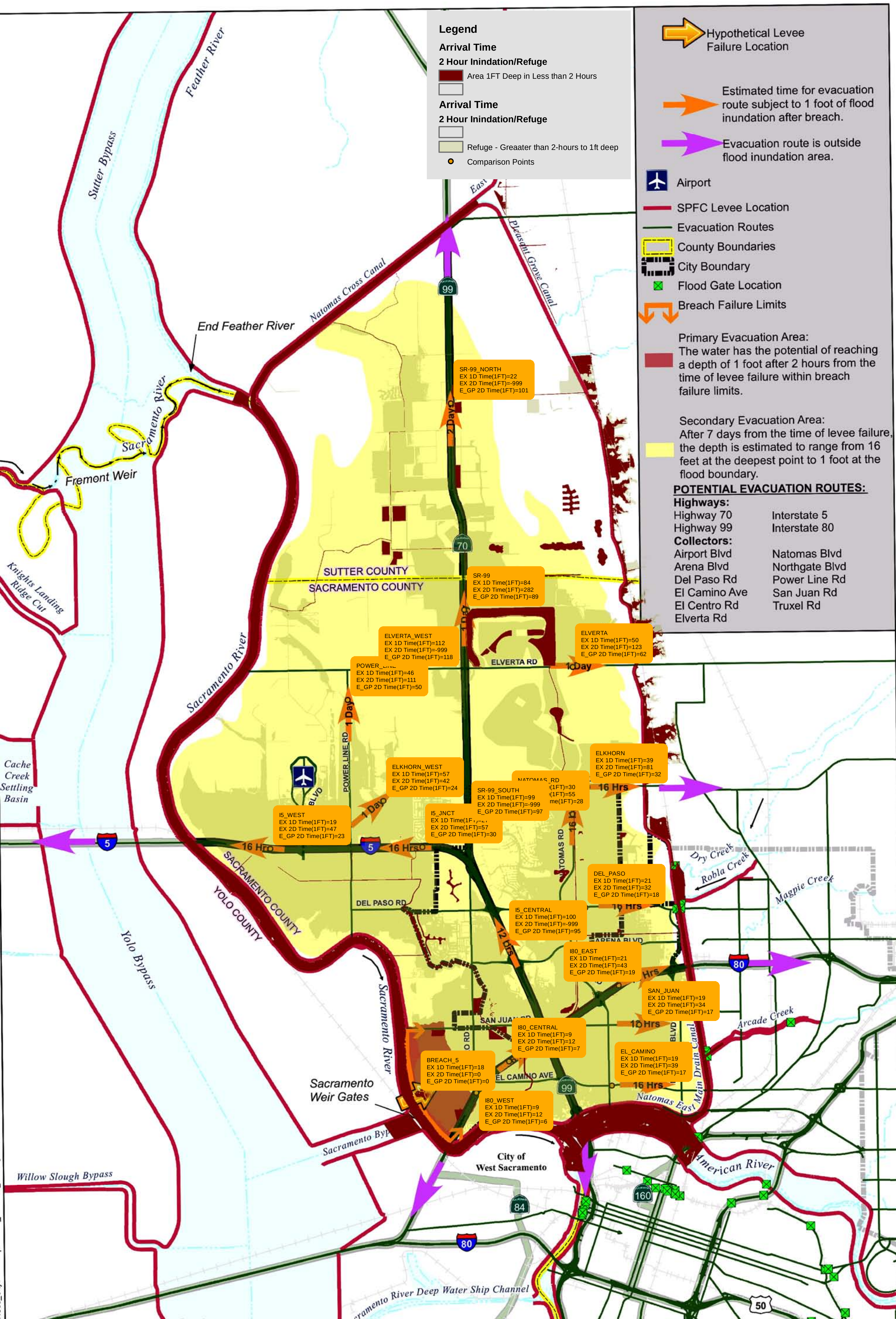

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Sacramento County, California

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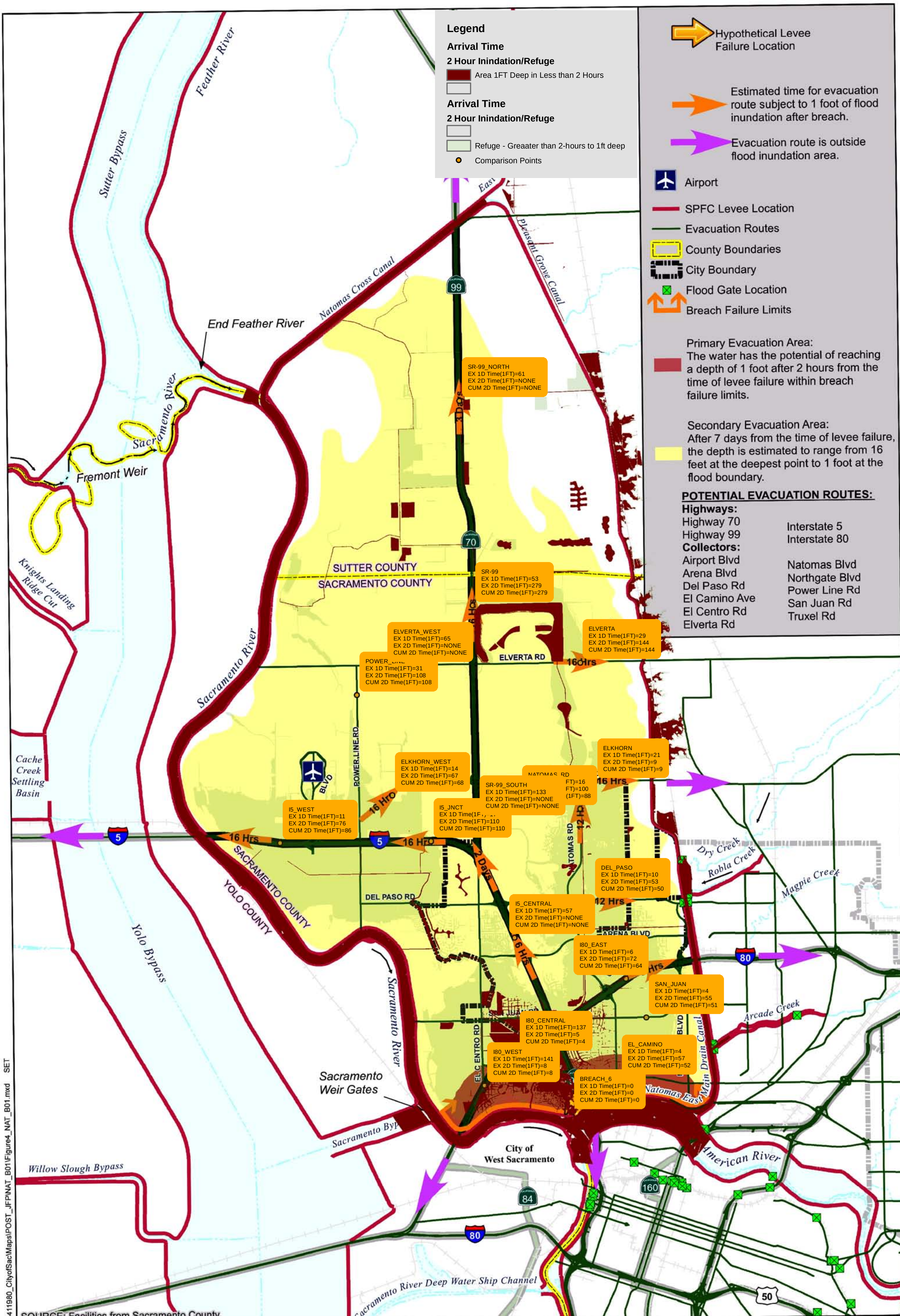
NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #5 AT SACRAMENTO RIVER RM 64.104
POST-FOLSOM JFP

DECEMBER 2015

NAT_B05D



RECOMMENDED EVACUATION ROUTES

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NATOMAS STUDY AREA
EVACUATION ROUTES MAP
BREACH #6 AT NEMDC RM 0.415
POST-FOLSOM JFP

DECEMBER 2015 NAT_B06D

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