3.9 Hydrology and Floodplains

This section addresses issues related to hydrology and floodplains in the corridor and vicinity. The information below is summarized from the Location Hydraulic Study (LHS), including the Floodplain Evaluation Report Summary (FERS; appended to the LHS), and the Hydrology and Water Quality Technical Report prepared for the project.

3.9.1 Regulatory Setting

Executive Order 11988 (Floodplain Management) directs all federal agencies to refrain from conducting, supporting, or allowing actions in floodplains unless it is the only practicable alternative. FHWA requirements for compliance are outlined in 23 CFR 650 Subpart A. In order to comply, the following must be analyzed:

- The practicability of alternatives to any longitudinal encroachments;
- Risks of the action;
- Impacts on natural and beneficial floodplain values;
- Support of incompatible floodplain development; and
- Measures to minimize floodplain impacts and to preserve/restore any beneficial floodplain values impacted by the project.

The base floodplain is defined as "the area subject to flooding by the flood or tide having a one percent chance of being exceeded in any given year." An encroachment is defined as "an action within the limits of the base floodplain."

Executive Order 11988 guidelines for assessing potential floodplain impacts include an eight-step process that agencies should carry out as part of their decision-making process on projects that have potential impacts to or within the floodplain.

- Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).
- Conduct early public review, including public notice.
- Identify and evaluate practicable alternatives to locating in the base floodplain, including alterative sites outside of the floodplain.
- Identify impacts of the proposed action.
- If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.
- Reevaluate alternatives.
- Present the findings and a public explanation.
- Implement the action.

Among a number of things, the Interagency Task Force on Floodplain Management clarified the Executive Order with respect to development in floodplains, emphasizing the requirement for agencies to select alternative sites for projects outside the floodplains, if practicable, and to develop measures to mitigate unavoidable impacts.

The Caltrans environmental review process, including preparation of Location Hydraulics Studies, Summary Floodplain Encroachment Reports, and environmental review document, is used to determine compliance with Executive Order 11988; the environmental review process follows the Executive Order 11988 guidelines.

The following federal, State, and local plans and regulations are applicable to hydrology and floodplains in the corridor.

Federal Regulations

Federal Flood Insurance Program

The National Flood Insurance Act of 1968 and Flood Disaster Protection Act of 1973 were enacted to reduce the need for large, publicly-funded flood control structures and disaster relief. The approach of these acts is to restrict development on floodplains. The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP) to provide subsidized flood insurance to communities that comply with FEMA regulations limiting development on floodplains. FEMA issues Flood Insurance Rate Maps (FIRMs) for communities participating in the NFIP. These maps delineate flood hazard zones in the community.

State Regulations

California Reclamation Board

The California Reclamation Board cooperates with various agencies of the federal, State, and local governments in establishing, planning, constructing, operating, and maintaining flood control works. The board also maintains the integrity of the existing flood control system and designated floodways through its regulatory authority by issuing permits for encroachments.

Local Regulations

Solano County Code[1]

Chapter 9 Drainage and Land Leveling. This chapter discusses permit requirements for interference with public drainage and control facilities including conformance with grading and erosion control standards.

[1] County of Solano, California. 2006. Solano County Code. <http://www.co.solano.ca.us/countycode.asp> Accessed April 23, 2007.

Chapter 12.2 Flood Damage Prevention. The purpose of this ordinance is to promote public health, safety, and general welfare; and to minimize public and private losses due to flood conditions in specific areas by provisions designed: (a) to protect human life and health; (b) to minimize expenditure of public money for costly flood control projects; (c) to minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public; (d) to minimize prolonged business interruptions; (e) to minimize damage to public facilities and utilities such as water and gas mains; electric, telephone and sewer lines; streets and bridges located in areas of special flood hazard; and others.

Section 12.2-13. Methods of Reducing Flood Losses. In order to accomplish its purposes, this ordinance includes methods and provisions for:

(a) Restricting or prohibiting uses which are dangerous to health, safety, and property due to water hazards, or which result in damaging increases in flood heights or velocities;

(b) Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;

(c) Controlling the alteration of natural floodplains, stream channels, and natural protective barriers which help accommodate or channel flood waters;

(d) Controlling filling, grading, dredging, and other development which may increase flood damage; and

(e) Preventing or regulating the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards in other areas.

Chapter 13 Grading and Erosion Control. The purpose of this chapter, in conjunction with Uniform Building Code as adopted, is to provide the means for controlling soil erosion, sedimentation, increased rates of water runoff and related environmental damage by establishing minimum standards and providing regulations for the construction and maintenance of fills, excavations, cuts and clearing of vegetation, revegetation of cleared areas, drainage control, and the protection of exposed soil surfaces in order to protect downstream waterways and wetlands and to promote the safety, public health, convenience and general welfare of the community.

3.9.2 Affected Environment

The Hydrology and Water Quality Technical Report describes the environmental and regulatory setting of the corridor, the environmental consequences of the alternatives as they pertain to hydrology and water quality, and measures to minimize impacts of the proposed action on hydrology and water quality. The bridges spanning Old Ulatis Creek, New Ulatis Creek, and Horse Creek were widened as separate projects. According to the City of Vacaville and studies for this project, the base floodplain is contained at these locations.

Surface Water Resources

The Jepson Parkway corridor includes two major hydrologic units (Lower Sacramento and Suisun Bay) that contain several smaller watersheds. Portions of the corridor, primarily in Fairfield and Suisun City, are connected to Suisun Slough, which drains to Suisun Bay via seasonal and perennial streams in the area. Area streams have been used primarily for fish and wildlife habitat, groundwater recharge, conveyance, and agricultural water supply. The streams in this area crossed by all of the project alignments are Alamo Creek and McCoy Creek. Leisure Town Road crosses Horse Creek, Old Ulatis Creek, New Ulatis Creek, Alamo Creek, and New Alamo Creek. Vanden Road crosses Union Creek. Peabody Road crosses Alamo Creek, Union Creek, the Putah South Canal, and McCoy Creek and the McCoy Detention Basin. The Putah South Canal flows through the corridor from northeast to southwest, delivering water from Lake Berryessa for agricultural and municipal purposes. Cement Hill Road and the proposed Walters Road Extension cross McCoy Creek. Figure 3.9-1 shows the named streams and creeks within the study area and their mapped floodplains.

Base Floodplain

FEMA provides information on flood hazard and frequency for cities and counties on its FIRMs. FEMA identifies designated zones to indicate flood hazard potential. The 100-year floodplain is defined as "the area subject to flooding by the flood or tide having a 1 percent chance of being exceeded in any given year." An encroachment is defined as "an action within the limits of the 100-year floodplain." Changes to the floodplain will require concurrence from the FEMA.

In general, flooding occurs along waterways, with infrequent localized flooding also occurring because of constrictions of storm drain systems or surface water ponding. As part of preparation of the LHS, FEMA 100-year base floodplain limits were mapped onto design drawings for the build alternatives. Figure 3.9-1 shows the streams and their associated 100-year base floodplains. The base floodplain limits for each action alternative are shown on Figures 3.9-2 to 3.9-7.

3.9.3 Impacts (including Permanent, Temporary, Direct, Indirect, and Cumulative)

Methodology

The assessment of impacts on hydrology and floodplains is based on the findings of the LHS, including the FERS, an appendix to the LHS, as well as a review of agency and statutory requirements relevant to the proposed action and corridor.

Summary of Impacts to Hydrology and Floodplains

Table 3.9-1 summarizes the potential for each alternative to affect hydrology and floodplains. As shown, each of the build alternatives would alter drainage conditions in the corridor. Each build alternative also crosses mapped and unmapped areas of the floodplain. A detailed description of hydrology and floodplain impacts for each alternative is presented below.

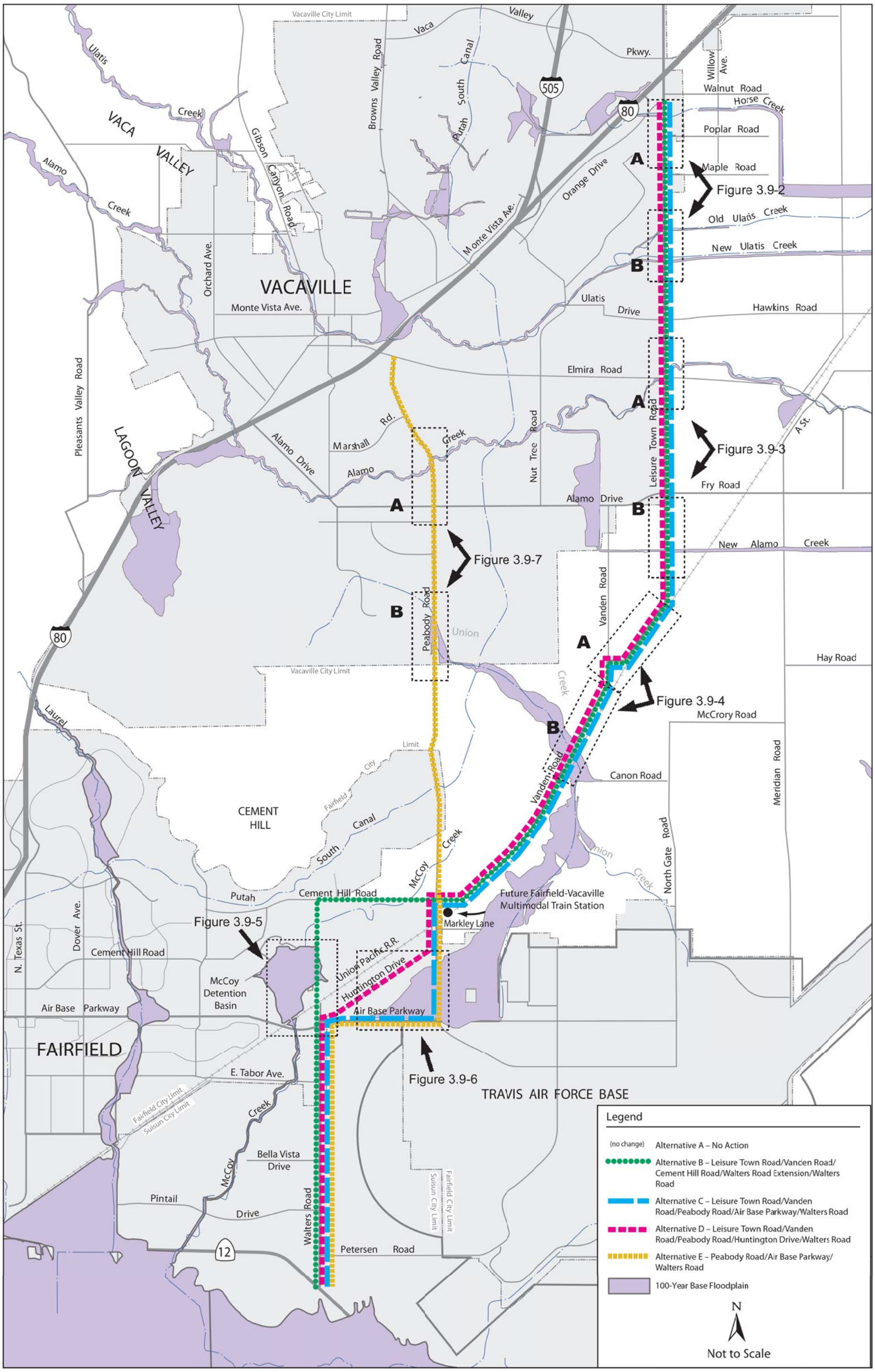

Figure 3-9.1
Base 100-Year Floodplain Overview

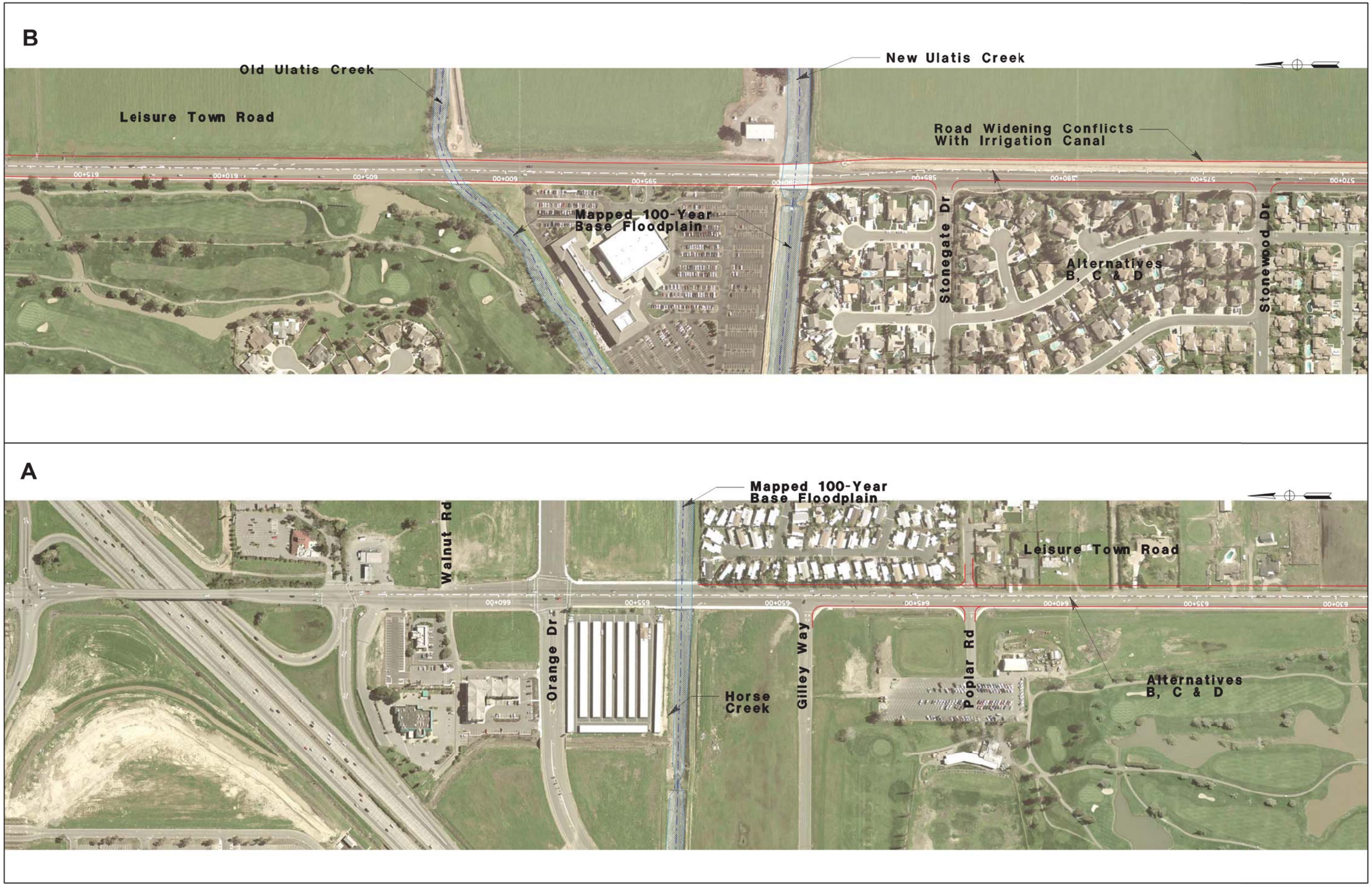

Figure 3.9-2
Leisure Town Road 100-Year Base Floodplain

Figure 3.9-3
Leisure Town Road 100-Year Base Floodplain

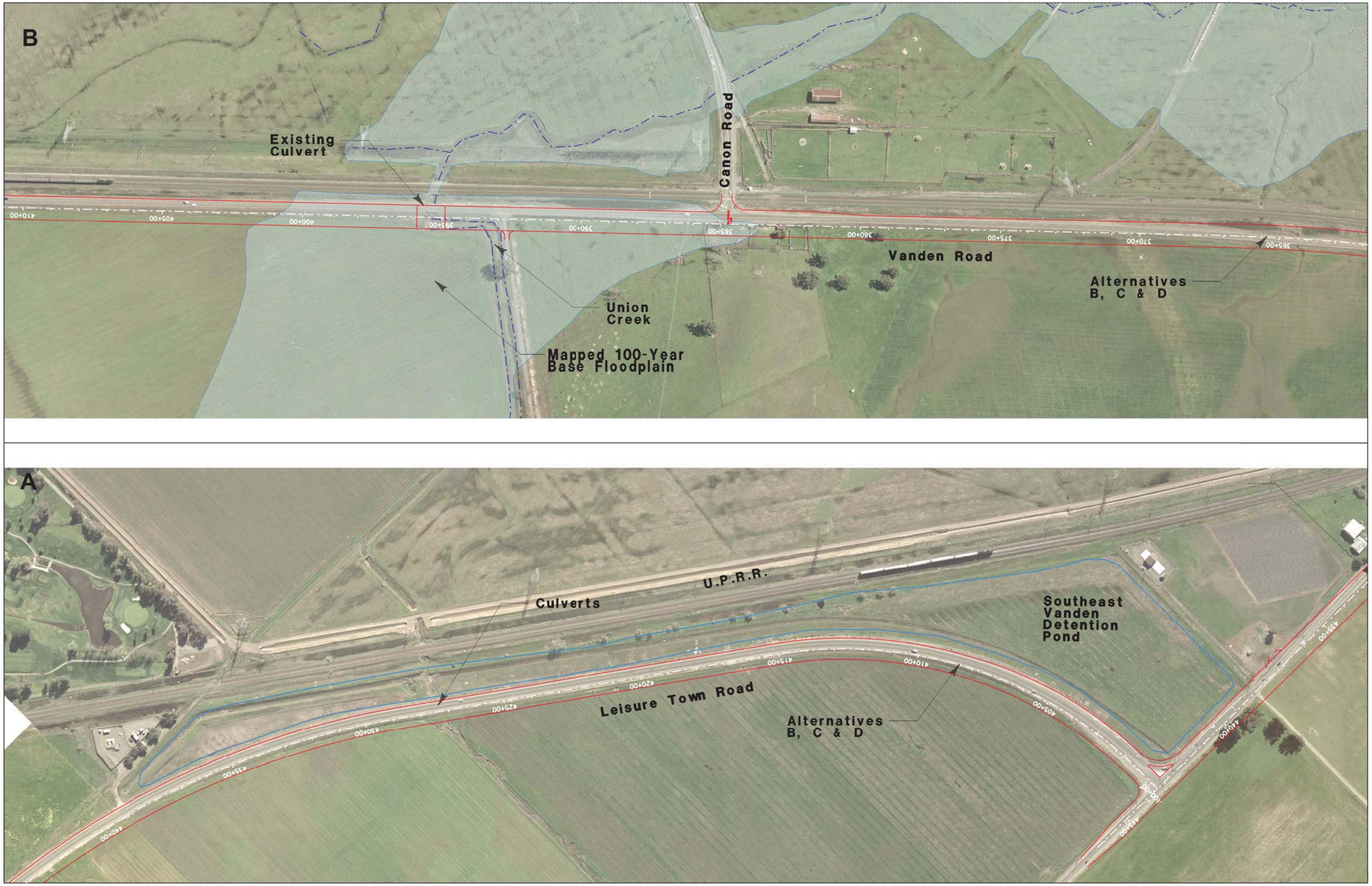

Figure 3.9-4
Leisure Town and Vanden Road 100-Year Base Floodplain

Figure 3.9-5
Walters Road Extension 100-Year Base Floodplain

Figure 3.9-6
Peabody Road and Air Base Pkwy 100-Year Base Floodplain

Figure 3.9-7
Peabody Road 100-Year Base Floodplain

3-9-11

Table 3.9-1
Summary of Impacts to Hydrology and Floodplains

Impact	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Permanently change local stormwater drainage patterns or volumes	No	Yes	Yes	Yes	Yes
Encroach into the FEMA-mapped 100-year floodplain	No	Yes	Yes	Yes	Yes
Potentially encroach into floodplains not mapped by FEMA	No	Yes	Yes	Yes	Yes

Impact HYD-1: Would the Alternatives Permanently Change Local Stormwater Drainage Patterns or Volumes?

Alternative A. Under Alternative A, the proposed roadway improvements and widening would not be constructed. Ongoing maintenance of existing roads and facilities would continue. However, improvements to existing stormwater drainage and conveyance infrastructure pursuant to implementation of the build alternatives would not occur.

Alternative B. Under Alternative B, the introduction of new impervious surfaces caused by roadway widening and the construction of new roadway surface for the Walters Road Extension would result in an incremental reduction in the amount of natural soil surfaces available for infiltration of rainfall and runoff, potentially generating additional runoff during storm events. This additional runoff could contribute to the flood potential of natural stream channels and accelerate soil erosion and stream channel scour.

Sections of the alignment would encroach on FEMA 100-year floodplains (Impact HYD-2). Encroachment into the floodplain from road widening and bridge crossings, and the resulting changes in impervious surfaces, could cause direct and indirect changes in local stormwater drainage patterns. Direct changes could occur from road widening by slightly reducing floodplain storage capacity because it would take up slightly more space in some of the floodplain. Bridges could directly reduce hydraulic capacity of channels by placing pilings or other structures in the channels that could restrict flow. Indirectly, increased impervious areas could contribute more runoff, and therefore, more flood flows.

Many of the existing drainage facilities in the rural sections of Alternative B are undersized or full of sediment. Most facilities would be replaced or upgraded to meet design standards or inadequate capacity. Within the urban areas of Leisure Town Road, Cement Hill Road, and Walters Road, existing storm drain facilities would be used or upgraded. Upgrades would be completed to meet design standards and improve capacity. Alternative B would also lengthen the culvert on Alamo Creek (Figure 3.9-3). Lengthening the culvert may affect creek hydraulics. A detailed hydraulics analysis would be performed to determine whether the existing culvert can be lengthened or should be replaced with a larger culvert or series of culverts that has better hydraulic conveyance (Mitigation Measures

HYD-1 and HYD-2). Alternative B would not adversely alter drainage patterns and would improve existing conditions by reducing the potential for localized flooding due to the current lack of storm drainage facilities.

Alternative C. The impact under Alternative C would be similar to Alternative B; although less new impervious surface would be created under Alternative C. Alternative C would require expansion of road crossings for Alamo Creek, New Alamo Creek, and Union Creek. Alternative C would follow Alternative B south as far as the Peabody Road/Cement Hill Road intersection, with the same changes in impervious surfaces resulting from the widening of the Leisure Town Road from two lanes to four lanes. Alternative C would also widen sections of Peabody Road from Cement Hill Road to Air Base Parkway and from Air Base Parkway to Walters Road from four lanes to six lanes, thereby increasing the impervious surfaces in these areas. Along Air Base Parkway the existing conveyance ditch on the north side of the road would be encroached on, requiring a realignment of the ditch and requiring extending and possibly enlarging the double culvert crossing at Walters Road. A detailed hydraulics analysis would be performed to determine whether the existing culverts can be lengthened or should be replaced with larger culverts. Encroachment into the floodplain from road widening and bridge crossings, and the resulting changes in impervious surfaces, could cause direct and indirect changes in local stormwater drainage patterns, as described above. Mitigation has been identified for this effect (Mitigation Measures HYD-1 and HYD-2).

Alternative D. The impact under Alternative D would be similar to Alternative B and would increase impervious surface area, potentially increasing stormwater runoff volumes. Like Alternative C, Alternative D would also require expansion of road crossings for Alamo Creek, New Alamo Creek, and Union Creek. Alternative D would follow Alternative C south to Huntington Drive, which would be widened from two lanes to four lanes to the Air Base Parkway/Walters Road intersection, increasing the impervious surfaces along this alignment. Encroachment into the floodplain from road widening and bridge crossings, and the resulting changes in impervious surfaces, could cause direct and indirect changes in local stormwater drainage patterns, as described above. Mitigation has been identified for this effect (Mitigation Measures HYD-1 and HYD-2).

Alternative E. The impact under Alternative E would be similar to Alternative B, although Alternative E would increase the impervious surface area along Peabody Road from Elmira Road to the Vacaville city limits by widening this portion of Peabody Road from four lanes to six lanes. Alternative E would also require expansion of Peabody Road crossings at Alamo Creek, Union Creek, and McCoy Creek, and the Putah South Canal. Encroachment into the floodplain from road widening and bridge crossings, and the resulting changes in impervious surfaces, could cause direct and indirect changes in local stormwater drainage patterns, as described above. Mitigation has been identified for this effect (Mitigation Measures HYD-1 and HYD-2).

Impact HYD-2: Would the Alternatives Encroach into the FEMA-Mapped 100-Year Floodplain?

Alternative A. Alternative A would not encroach into the mapped 100-year floodplain because the proposed roadway improvements and widening would not be constructed.

Alternative B. Alternative B would encroach on the mapped 100-year floodplain of Alamo Creek, Union Creek, and McCoy Creek, increasing the potential for flooding. The fill proposed for the widening of the section of Leisure Town Road at Elmira Road would result in blockage of the Alamo Creek channel (Figure 3.9-3), which would require either a culvert to convey the water or construction of a new channel farther east of Leisure Town Road. At this time, Alternative B includes plans for a culvert. A hydraulics analysis would be performed to determine whether the existing culvert can be lengthened or should be replaced with a larger culvert or series of culverts that has better hydraulic conveyance (Mitigation Measures HYD-1 and HYD-2). The FERS identified a longitudinal encroachment of the base floodplain at this location. The roadway would encroach on approximately 0.2 acres of the mapped 100-year floodplain.

Floodplain mapping indicates that the portion Vanden Road in the vicinity of Union Creek (Figure 3.9-4) is overtopped with flow during the 100-year flood. The proposed roadway would encroach on approximately 5.3 acres of the mapped 100-year floodplain. Encroachment would occur in an area where the FEMA floodplain was mapped using "approximate methods"[2] instead of a detailed study. A detailed hydraulic analysis will be conducted to accurately determine the flood elevation, location of the floodplain boundaries, and amount of floodplain encroachment. The existing crossing for Union Creek is comprised of two undersized pipe culverts, and the roadway is about five feet lower than the adjacent UPRR tracks. Alternative B includes raising the roadway in this area two feet to four feet and replacing the undersized culverts with a series of box culverts or a small bridge. The combination of raising the roadway and increasing the crossing size would eliminate the roadway over topping in the 100-year flood. A detailed hydraulic analysis would be completed to determine the appropriate sized crossing (Mitigation Measures HYD-1 and HYD-2).

Alternative B would require the creation of a new road crossing at McCoy Creek (Figure 3.9-5). Encroachment would occur in an area where the FEMA floodplain was mapped using "approximate methods"[2] instead of a detailed study. A detailed hydraulic analysis will be conducted to accurately determine the flood elevation, location of the floodplain boundaries, and amount of floodplain encroachment. The upstream drainage area of this area is relatively small, so a culvert would likely provide sufficient conveyance of flow under the roadway; however, a small bridge is planned for this crossing of McCoy Creek. Mitigation is available for this impact (Mitigation Measure HYD-1).

Alternative C. Similar to Alternative B, Alternative C would encroach on the mapped 100-year floodplain of Alamo Creek and Union Creek, increasing the potential for flooding. The impact on the Alamo Creek and the Union Creek floodplains would be the same as described for Alternative B.

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[2] FEMA flood zones mapped using "approximate methods" include flood data and floodplain information from a variety of sources — such as soils mapping, actual high water profiles, aerial photographs of previous floods, and topographic maps —to overlay the approximate outline of the base floodplain for specific stream reaches on available community maps, usually U.S. Geological Survey topographic quadrangle maps. In addition, many flooding sources have been studied by other federal, State, or local agencies. Some of these studies do not meet the NFIP standards for a Flood Insurance Study, but often contain valuable flood hazard information, which may be incorporated into the NFIP maps as approximate studies. Those types of studies typically cover developed or developing areas. They often contain flood elevation profiles that can be used as "best available data" for floodplain management purposes. Approximate methods do not allow for determination of Base Flood Elevations.

Alternative C would encroach on the area of Peabody Road and Air Base Parkway where the FEMA floodplain for Union Creek was mapped using "approximate methods" instead of a detailed study. A detailed hydraulic analysis would be conducted to accurately determine the flood elevation, location of the floodplain boundaries, and amount of floodplain encroachment. Recent drainage improvements in the area and site topography indicates that actual floodplain is not as large as shown and existing roadside ditches and cross culverts convey storm runoff adequately. There is no history of roadway overtopping or property flooding damage in this area. The flyover ramp in this area would raise the elevation of northbound Peabody Road in this area. If required, additional cross culverts could be placed under Peabody Road to accommodate flood flows. Mitigation is available for this impact (Mitigation Measures HYD-1 and HYD-2).

Alternative D. Similar to Alternative B, Alternative C would encroach on the mapped 100-year floodplain of Alamo Creek and Union Creek, increasing the potential for flooding. The impact on the Alamo Creek and the Union Creek floodplains would be the same as described for Alternative B. Mitigation is available for this impact (Mitigation Measures HYD-1 and HYD-2).

Alternative E. Alternative E would encroach on the mapped 100-year floodplain of Alamo Creek and Union Creek, increasing the potential for flooding. Peabody Road crosses the mapped floodplain of Alamo Creek with a bridge (Figure 3.9-7A). Alternative E would widen the existing bridge. The bridge would encroach on less than 0.1 acres of the mapped 100-year floodplain.

Peabody Road passes through the mapped floodplain of Union Creek (Figure 3.9-7B). Floodplain mapping indicates that the existing roadway is overtopped with flow during the 100-year flood. The road would encroach on approximately 1.8 acres of the mapped 100-year floodplain. Encroachment would occur in an area where the FEMA floodplain was mapped using "approximate methods" instead of a detailed study. A detailed hydraulic analysis will be conducted to accurately determine the flood elevation, location of the floodplain boundaries, and amount of floodplain encroachment. The existing culvert would be replaced with a larger culvert. A detailed hydraulic analysis will be completed to determine the appropriate sized crossing. Mitigation is available for this impact (Mitigation Measures HYD-1 and HYD-2).

Impact HYD-3: Would the Alternatives Potentially Encroach into Floodplains Not Mapped by FEMA?

Alternative A. Alternative A would not encroach into floodplains not mapped by FEMA because the proposed roadway improvements would not be constructed.

Alternative B. Alternative B would cross and possibly affect several irrigation canals, existing culverts, and several drainages in areas where FEMA floodplain studies have not been performed, increasing the potential for flooding. Irrigation canals along Leisure Town Road would be impacted by road construction and would require extensions or reconstruction. A detailed hydraulics analysis is necessary to determine whether extending culverts would provide adequate hydraulic conveyance. Based on warning signs on Cement Hill Road that indicate that the road is subject to flooding, the area around McCoy Creek may be within the 100-year floodplain. A detailed hydraulics analysis is necessary to

establish the limits of the floodplain, determine future road surface elevation to prevent flow from overtopping the road during a 100-year event, and provide adequate hydraulic conveyance under the road at each drainage channel crossing to prevent flooding north of the road. Mitigation is available for this impact (Mitigation Measure HYD-1).

Alternative C. Similar to Alternative B, Alternative C would cross and possibly affect several irrigation canals and existing culverts, increasing the potential for flooding. Irrigation canals along Leisure Town Road would be impacted by road construction and would require extensions or reconstruction. Mitigation is available for this impact (Mitigation Measure HYD-1).

Alternative D. Similar to Alternatives B and C, Alternative D would cross and possibly affect several irrigation canals and existing culverts, increasing the potential for flooding. Irrigation canals along Leisure Town Road would be impacted by road construction and would require extensions or reconstruction. Mitigation is available for this impact (Mitigation Measure HYD-1).

Alternative E. Similar to Alternatives B, C, and D, Alternative E would cross and possibly affect drainages in areas where FEMA floodplain studies have not been performed, increasing the potential for flooding. Peabody Road passes through an area just north of the Peabody Road and Cement Hill Road/Vanden Road intersection where no detailed FEMA study has been performed to delineate floodplain boundaries. The existing road may be within the 100-year floodplain and may be inundated during a 100-year flood event. The FERS identified a longitudinal encroachment of the base floodplain at this location. A detailed hydraulics analysis is necessary to establish the limits of the floodplain, determine future road surface elevation to prevent flow from overtopping the road during a 100-year event, and provide adequate hydraulic conveyance under the road at each drainage channel crossing to prevent flooding north of the road. Mitigation is available for this impact (Mitigation Measure HYD-1).

Impact HYD-4: Would the Alternatives, in Combination with Other Development, Result in Cumulative Effects to Hydrology and Floodplains?

The proposed project would introduce new impervious surfaces that would result in an incremental reduction in the amount of natural soil surfaces available for infiltration of rainfall and runoff, potentially generating additional runoff during storm events. Additional runoff can contribute to the flood potential of natural stream channels, and accelerate soil erosion and stream channel scour. Addition development in the vicinity of the corridor would also increase impervious surfaces and associated runoff. Implementation of Mitigation Measures HYD-1 and HYD-2 would ensure that the proposed project would not make a cumulatively considerable contribution to regional increases in runoff volumes and flooding.

3.9.4 Avoidance, Minimization, and/or Mitigation Measures

In addition to the measures below, each build alternative design includes improvements to drainage crossings, storm sewer systems, culverts, and irrigation facilities to collect and convey stormwater drainage and floodwaters.

Mitigation Measure HYD-1: Prepare Detailed Master Drainage Plan (MDP) and Implement Plan Requirements. In coordination with the Cities of Fairfield, Vacaville, and Suisun City, STA shall prepare a detailed drainage report (also called a master drainage plan or runoff design report) for the entire construction area. This MDP shall include detailed hydrology and hydraulics for the chosen alternative's affected creek encroachment areas, bridges, culverts, and associated floodplain areas. This MDP shall be reviewed and approved by the Solano County Water Agency (SCWA), Solano County, and STA, and reviewed by the Cities of Fairfield, Suisun, and Vacaville. STA shall include in the project design, drawings, and plans the flow and drainage control requirements identified in the MDP in order to prevent flood and flood flow impacts. The drainage system will be designed in accordance with the flood control design criteria of Solano County and SCWA. The MDP shall ensure that project design and drainage plans comply with Executive Order 11988, Sections 3.b and 4.c. The MDP will be coordinated with any required mitigation measures associated with work in the creeks and streams that require a 404 or 401 permit.

The MDP shall be prepared by a registered water resources civil engineer before site development begins and shall include:

- An accurate calculation of pre- and post- project runoff conditions using standards specified in the Solano County Hydrology Manual. These conditions shall be determined at all water crossings along the project corridor and at intermediate locations necessary to obtain an accurate determination of flood potentials. Post-project runoff conditions shall include any detention structures incorporated into the site design.

  If post-project runoff rate and volume exceed existing conditions for the design storm event, the MDP shall include calculations of the amount of detention required to reduce stormwater runoff to pre-project levels.

- A detailed hydraulic analysis. An accurate determination of base (e.g., irrigation ditch areas) and post-project flood elevation levels and hydraulic conditions using standard hydraulics engineering methods (e.g., Hydrologic Engineering Centers River Analysis System) shall be prepared. These techniques shall be used to accurately evaluate potential changes in design storm flood elevations and flow erosive potential for the design of flow conveyance or control features. Additional topography surveying may be required to accurately describe the existing floodplain within areas not mapped by FEMA (e.g., irrigation/drainage channels adjacent to roads).

  If post-project conditions exceed drainage design standards as specified in the Solano County Hydrology Manual or if they otherwise contribute to adverse hydraulic impacts in the drainage system, the proposed drainage system structures shall be redesigned to minimize impacts. For example, if the proposed box culvert for Alamo Creek is found to create adverse hydraulic impacts in Alamo Creek (e.g., back up of flood flows, concentrated high velocity flow, and others), according to this detailed hydraulic analysis, then other designs shall be assessed (e.g., bridge). One or more system designs shall be prepared to mitigate potential project impacts and to minimize changes from the original plan while mitigating adverse impacts.

  The standards for proposed drainage systems shall be evaluated on an alternative-specific basis.

- An inventory and assessment of any existing drainage facilities within the corridor including any necessary upgrades, replacements, redesigns, and rehabilitation.
- Proposed storm drainage systems will be designed to convey both on-site and off-site stormwater runoff to regional streams and creeks. Storm drainage systems will use existing facilities within the corridor as available and upgrade undersized facilities as needed.
- Proposed design measures to remove structures from 100-year floodplain areas. Where structures are below the post-project 100-year flood elevation level, design measures shall be developed and implemented to remove these structures from the floodplain. Any substantial removal or import of fill material, placement or removal of barriers, or placement or removal of drainage systems to remove structures from floodplain shall be included in all hydraulic analyses.
- A description of the proposed maintenance program for the on-site drainage system(s).

Mitigation Measure HYD-2: Improve Under Capacity Culverts. Many of the existing drainage facilities in the rural areas are undersized and full of sediment. Consistent with Mitigation Measure HYD-1, a detailed hydraulic analysis will be completed for the project to identify the appropriate culvert size.

For Alternatives B, C, and D the existing culverts under Vanden Road at Union Creek shall be replaced with a bridge or series of box culverts sufficient for adequate hydraulic capacity during a 100-year flood event. A detailed hydraulic analysis (see Mitigation Measure HYD-1) of the design configurations shall be conducted to determine sizing and efficacy of both the bridge and large culvert structures for mitigating flood conditions. The roadway shall also be raised in this area by approximately two feet to four feet above the existing road elevation to be higher than the elevation of the mapped floodplain.

For Alternatives C and E the existing culverts under Walters Road on the north side of Air Base Parkway shall be extended and possibly upsized to account for the loss of the roadside ditch from the widening of Air Base Parkway. A detailed hydraulic analysis (see Mitigation Measure HYD-1) of the crossing shall be conducted to determine sizing and efficacy. These improvements shall be included in all hydrologic and hydraulic analysis specified in Mitigation Measure HYD-1 and will be designed in accordance with Executive Order 11988, Sections 3.b and 4.c.