California High-Speed Train Project

Request for Proposal for Design-Build Services

RFP No.: HSR 11-16
Stormwater Management Report
Veterans Blvd to South of E. American Ave

Prepared for
CALIFORNIA
High-Speed Rail Authority

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CALIFORNIA HIGH-SPEED TRAIN

Engineering Report

DRAFT 30% DESIGN SUBMISSION

Fresno to Bakersfield

Sierra Subdivision
Procurement Package 1
Stormwater Management Report

April 2012

06/29/2012 ADDENDUM 3 - RFP HSR 11-16

CALIFORNIA
High-Speed Rail Authority

<u>CALIFORNIA HIGH-SPEED TRAIN PROJECT</u>

<u>ENGINEERING REPORT</u>

Draft 30% Design Submission

Sierra Subdivision
Procurement Package 1
Stormwater Management Report

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April 27, 2012

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Abbreviations

ARRA	American Recovery and Reinvestment Act
BMP	best management practice
BNSF	Burlington Northern Santa Fe
Caltrans	California Department of Transportation
CRWQCBCVR	California Regional Water Quality Control Board Central Valley Region
CVFPB	Central Valley Flood Protection Board
DWR	Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
F-B	Fresno to Bakersfield
FEMA	Federal Emergency Management Agency
FID	Fresno Irrigation District
FMFCD	Fresno Metropolitan Flood Control District
HDM	*Highway Design Manual*
HSG	Hydrologic Soil Group
HST	high-speed train
ICS	Initial Construction Section
IFB	infiltration basin
M-F	Merced to Fresno
mph	miles per hour
PPDG	Project Planning and Design Guide
RWQCB	Regional Water Quality Control Board
SR 99	California State Highway Route 99
SWMR	Stormwater Management Report
SWRCB	State Water Resources Control Board
TDC	Targeted Design Constituent
TM	Technical Memorandum
TMDL	Total Maximum Daly Load
USEPA	U.S. Environmental Protection Agency
WQF	water quality flow
WQV	water quality volume

1.0 Introduction

1.1 Purpose

This Stormwater Management Report (SWMR) was prepared for the proposed preliminary design for the segment located between Herndon Avenue and E American Avenue in Fresno, CA. The purpose of this SWMR is to:

- Summarize the regulatory framework pertaining to stormwater management
- Summarize hydrologic and hydraulic design requirements for stormwater management facilities
- Describe conceptual-level drainage and stormwater management designs
- Summarize preliminary hydrologic and hydraulic data and analyses that support conceptual-level water-crossing designs; and
- Identify additional analyses and permits that will be needed as design progresses

The main body of the SWMR summarizes a plan for stormwater management for the high-speed train (HST) consistent with the preliminary design discussing the general hydrologic setting, drainage conditions, and stormwater treatment measures. Appendixes A and B discuss the specific hydraulic and hydrology analysis and stormwater management within the project site, including facilities owned and maintained by the City of Fresno, the Fresno Metropolitan Flood Control District (FMFCD), Fresno Irrigation District (FID), and the California Department of Transportation (Caltrans).

1.2 Project Description

1.2.1 California High Speed Train Project

The California HST Project will provide intercity, high-speed service on more than 800 miles of tracks throughout California, connecting the major population centers of Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, the Inland Empire, Orange County, and San Diego. The HST System is envisioned as a state-of-the-art, electrically powered, high-speed, steel-wheel-on-steel-rail technology that will include contemporary safety, signaling, and automated train-control systems. The trains will be capable of operating at speeds of up to 220 miles per hour (mph) over a dedicated track alignment.

To maintain these speeds, and a comfortable ride, horizontal and vertical curves must be gradual. The guideway must also be isolated from animals, pedestrians, and vehicles to avoid collisions. There must be a grade separation from intersecting roads, railroads, walkways, trails, and throughways. Limitations on at-grade crossings and curve radii prevent the horizontal and vertical alignments from being constructed exactly parallel to existing transportation features at some locations, and may also constrain the angle and location at which floodplains and water bodies are crossed.

1.2.2 Construction Package 1

The planning and design for the HST Project in the Central Valley is performed in separate sections, each with its own design team and procurement schedule. As part of the American Recovery and Reinvestment Act (ARRA), funding was obtained to begin early construction of an Initial Construction Section (ICS) that covers a contiguous portion of the Merced to Fresno (M-F) and the Fresno to Bakersfield (F-B) segments. The ICS limits and alignment are currently being defined; therefore, the ICS was subdivided into two phases with the first phase, Construction Package 1 (the Project), consisting of a settled alignment extending from roughly Herndon Avenue in the north to E American Avenue within the City of Fresno. The design is being developed by two separate Joint Venture Engineering teams. The M-F Team, consisting of AECOM and CH2M HILL, is developing the design north of W Clinton Avenue to Herndon Avenue. The F-B Team, consisting of URS, Hatch Mott MacDonald, and Arup, is developing the design from W Clinton Avenue south to E American Avenue (see Figure 1-1). This Project is slated to begin construction in 2012.

Appendix A and B provide a summary of the hydraulic and hydrology analysis carried out for the M-F and F-B portions of Construction Package 1 respectively.

1.2.3 Design Components

1.2.3.1 High-speed Train Improvements

In the M-F section, the majority of the HST track will be constructed at-grade. This section of track will be approximately 5.5 miles with few locations with fill, retained fill, cut or retained cut sections. A summary of the general project description is provided below. From the Veterans Boulevard grade separation to W Richert Avenue, the rail will be above the existing ground elevation. Fill depth will vary from zero to 8 feet and retaining walls may be required in certain areas to retain fill. From Richert Avenue to north of W Clinton Avenue, the rail will be either at-grade or in cut condition, with cut depths as much as 4 feet. From north of W Clinton Avenue to the section limit at W Clinton Avenue, the rail will be above the existing ground elevation, with fill depths up to 8 feet.

In the F-B section, the HST will run at grade and parallel to the existing Union Pacific Railroad (UPRR) alignments between W Clinton Avenue and W Olive Avenue. South of W Olive Avenue the HST alignment runs parallel to the UPRR alignment and descends below grade to pass beneath Dry Creek Canal and State Route 180, rising back to grade near Stanislaus Street. The alignment remains at-grade, running parallel to UPRR between Stanislaus Street and E Florence Avenue. South of E Florence Avenue the alignment descends below grade to pass beneath the East Jensen Bypass. East Jensen Bypass represents the low point, south of which the alignment begins to rise above grade and on to a viaduct structure that clears SR 99, returning to grade at E Central Avenue. From Central Avenue to south of E American Avenue it remains at grade, running parallel to the existing BNSF alignment.

In the City of Fresno, existing streets are laid out in a north-south/east-west grid pattern. The UPPR/SR 99 transportation corridors cut across this pattern at a roughly 45-degree angle, running northwest and southeast. To accommodate these angled railroad and state highway embankments, portions of the adjacent road network have been similarly angled to parallel the railroad and highway as frontage roads, or to approach them orthogonally as intersections or dead ends. N Golden State Boulevard serves as a frontage road on the northeastern side of SR 99. The following local roadway improvements are part of the Project and are presented in the project plans.

In the M-F Segment the HST alignment requires the following local road grade separations over the HST alignment north of W Clinton Avenue:

- Veterans Boulevard
- Shaw Avenue
- Ashlan Avenue
- Clinton Avenue

Additional local road realignments, widening, or other improvements will be required for the following streets in the M-F Segment:

- Golden State Boulevard
- Kathryn Way
- W. Barstow Avenue
- Carnegie Avenue
- N Market Street
- N State Street
- N Cornelia Avenue
- W Santa Ana Avenue
- W Richert Avenue
- W Swift Avenue
- N Parkway Drive
- Pleasant Avenue
- Vassar Avenue
- Shields Avenue
- Marks Avenue
- Courtland Avenue
- Valentine Avenue
- Dakota Avenue
- Motel Drive
- Marty Avenue
- Jennifer Avenue

In the F-B Segment the HST alignment requires the following local road grade separations crossing the HST alignment south of W Clinton Avenue:

- W McKinley Avenue
- W Olive Avenue
- W Belmont Avenue
- Stanislaus Street
- Tuolumne Street
- Fresno Street (to be completed by others)
- Tulare Street
- Ventura Street
- E Church Avenue
- E Central Avenue
- E American Avenue

Additional local road realignments, widening, or other improvements will be required for the following streets in the F-B Segment:

- McKinley Avenue Connector
- N Weber Avenue
- N West Avenue
- N Golden State Boulevard
- N H Street/N Weber Avenue
- Wesley Avenue
- N Throne Avenue
- G Street
- S Cedar Avenue
- S Sunland Avenue

1.2.3.2 State Route 99 Improvements

The existing SR 99 mainline facility between Clinton Avenue and Ashlan Avenue is a north-south, six-lane highway adjacent to the west side of the UPRR rail yard with southbound on- and off-ramps at Shields Avenue, and on-ramps at Dakota Avenue and Princeton Avenue. In order to facilitate the proposed HST alignment, SR 99 would be realigned and shifted approximately 80 feet to the west between Clinton Avenue and Ashlan Avenue. The proposed SR 99 mainline would maintain six mixed flow-through lanes with the addition of one auxiliary lane in each direction between Clinton Avenue and Ashlan Avenue. The SR 99 Interchange at Clinton Avenue would be modified and the Clinton Avenue Bridge overcrossings at SR 99 and UPRR would be replaced to accommodate the HST aerial structure alignment and facilitate its construction. The northbound off-ramp and southbound on-ramp at Ashlan Avenue Interchange would be reconstructed. Modifications to local roads would also be required to accommodate the realigned freeway.

1.3 Regulatory Setting

The regulatory setting for the HST Project includes federal, state, and local regulations and guidelines applicable to the Project Site. The most relevant stormwater regulations are promulgated by agencies such as the Regional Water Quality Control Board (RWQCB), the Fresno Metropolitan Flood Control District (FMFCD), the Central Valley Flood Protection Board (CVFPB), the Fresno Irrigation District (FID), and Caltrans. These regulations and guidelines are summarized in detail in the Project Environmental Impact Report/Environmental Impact Statement (EIR/EIS), and are incorporated by reference.

Within the City of Fresno, stormwater is managed by both the FMFCD and the City Department of Public Works. For local developments, the City reviews and permits grading and drainage improvements to ensure that private drainage systems are designed to minimize impacts to regional flood control objectives. For regional drainage facilities, the FMFCD is responsible for operations and maintenance. These facilities include pipes, channels, and detention facilities. The FMFCD has developed a storm drainage and flood control master plan that delineates the stormwater management watershed areas within the FMFCD jurisdiction. A portion of that master plan including the watersheds affected by the Project is presented in Figure 1-2. Any modification to the existing stormwater system is subject to authorization by the FMFCD.

Conventional train braking systems have been shown to be a source of metal pollutants. The HST Project would use electrically powered trains that have a regenerative braking system; this type of braking system would result in only minor physical brake wear. For stormwater purposes, electrically powered trains used in other cities have been determined to be non-polluting sources. These include the Metropolitan Transit System in San Diego and the Metro System in Los Angeles, as well as the light rail systems serving Seattle, Washington. Therefore, the HST linear features (rail line, at-grade embankment fill, and elevated structures) are assumed to be non-pollutant-generating surfaces. At this time we believe that the HST linear features would not require additional water quality treatment. However, as the project moves forward, additional measures required by the applicable agencies would be incorporated into the project design.

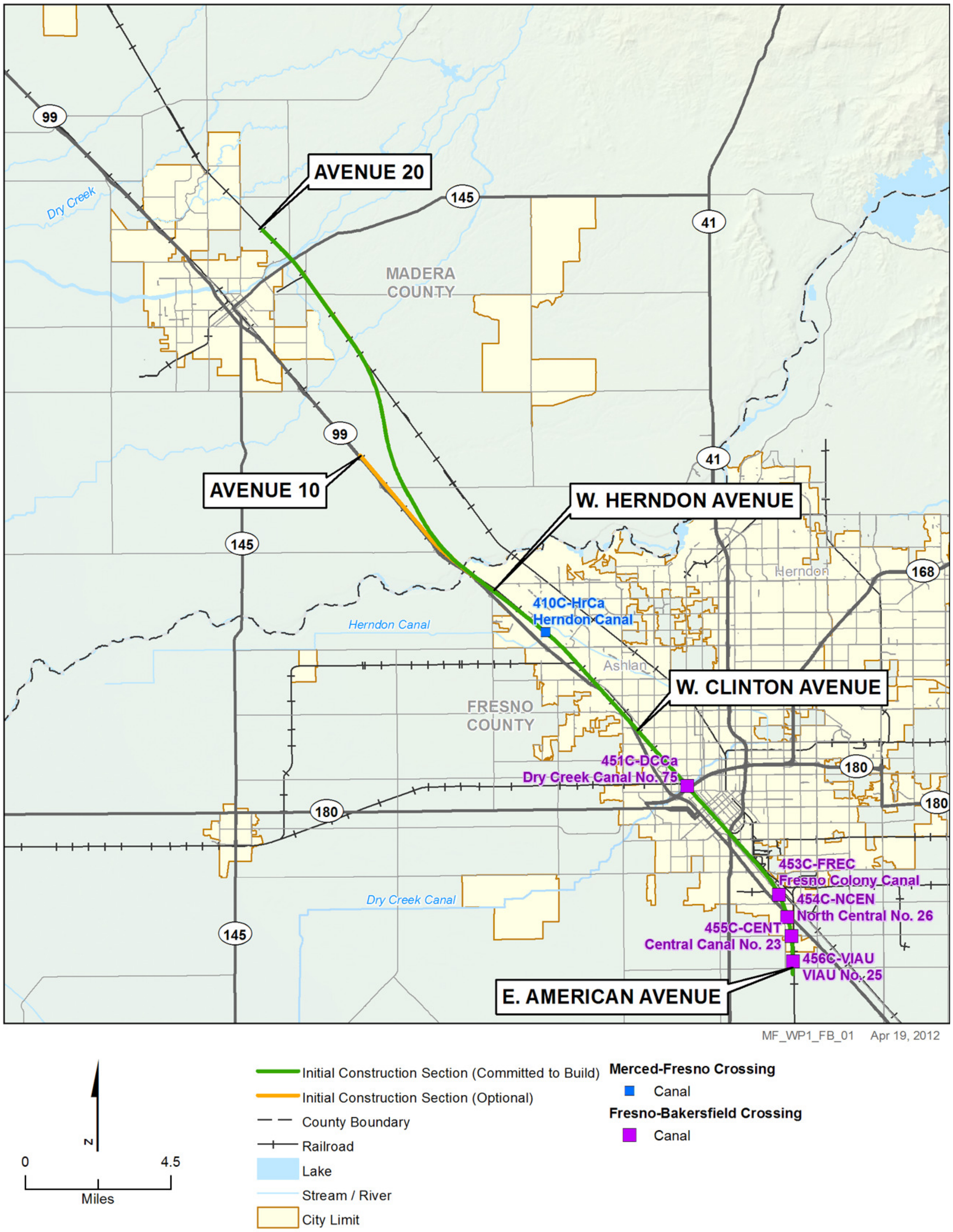

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Figure 1-1
Initial Construction Section Limits and Alignments

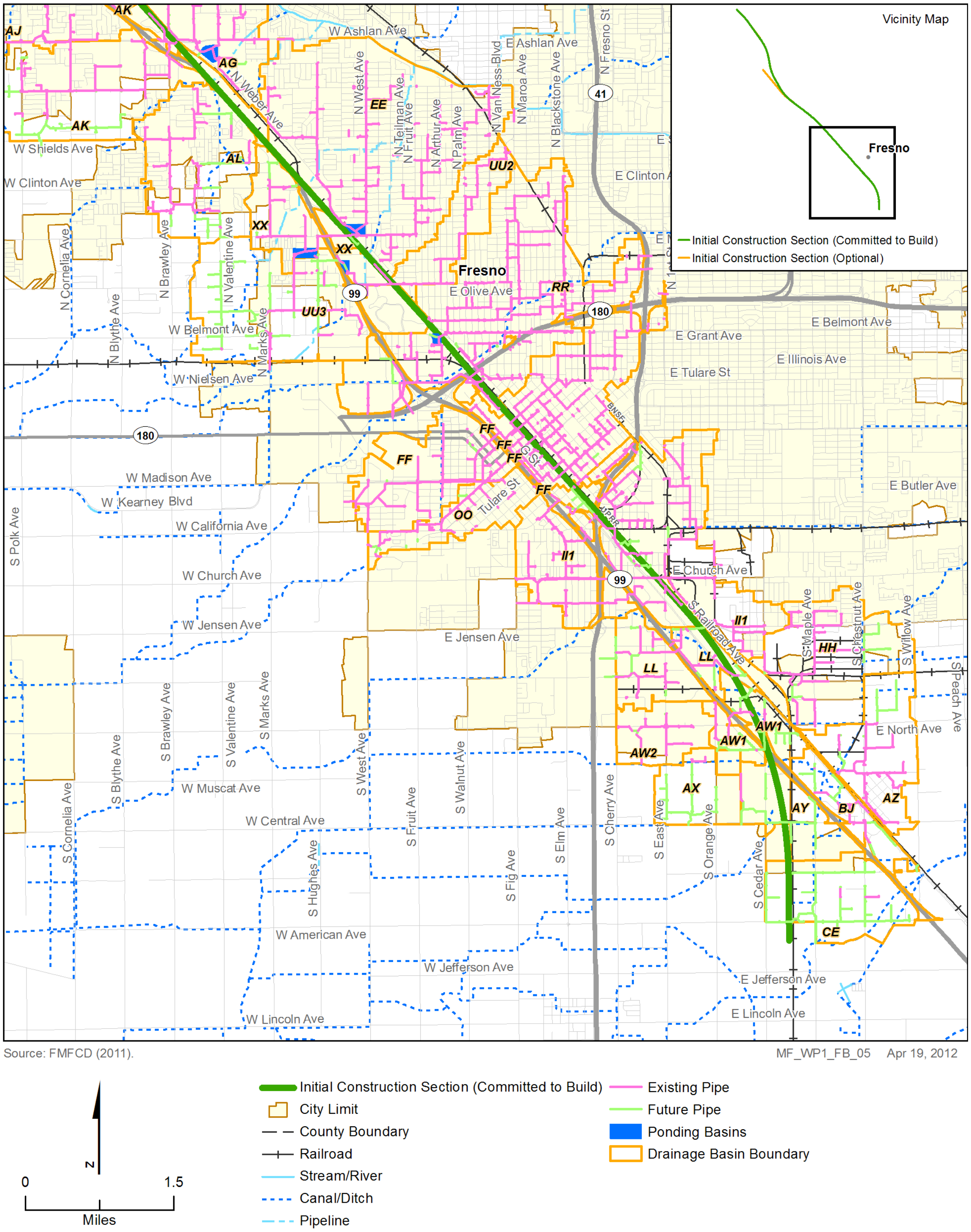

Figure 1-2
FMFCD Master Plan Basins and Watershed Boundaries

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2.0 Hydrologic Setting

Along the HST corridor, the climate is Mediterranean, characterized by long, dry summers and mild, moderately wet winters. The average annual precipitation is about 11 inches, with typically less than 10 percent of that total falling during the 5-month period from May to September. Because of the generally low rainfall in this portion of the Central Valley, agriculture is heavily dependent on irrigation. A vast network of irrigation canals crisscrosses the valley floor. Both irrigation flows and stormwater are conveyed through the irrigation network, as well as by natural streams. All of the streams along the Project are ultimately tributary to the San Joaquin River or to Tulare Lake. The Project is located within the urbanized Fresno Metropolitan area, which is moderately to densely urbanized. Land uses near the project include a mixture of agricultural, open space, residential, commercial, industrial, railroad, highway, and flood control uses.

2.1 Natural Hydrologic Features

Hydrologic considerations for the M-F and F-B Segments of the HST Project are described in considerable detail in California High-Speed Rail Authority and the Federal Rail Authority documents *Record Set 15% Design Submission, the Fresno to Bakersfield Hydrology, Hydraulics*, and *Drainage Report and the Hydraulics and Floodplain Report – Merced to Fresno Section Project EIR/EIS* (Authority and FRA 2011c and 2011e respectively). These reports identify and characterize the water body crossings (natural and manmade) along both the UPRR/SR 99 and Burlington Northern Santa Fe (BNSF) alignment corridors. These reports also summarize relevant hydraulic and hydrologic regulations, floodplain issues, hydraulic design requirements and considerations, design flows for crossings, and plans for completing hydraulic modeling and permitting requirements.

The watershed traversed by the Project is the San Joaquin River watershed and its tributaries within the City of Fresno. The San Joaquin River flows northeast to southwest from the Sierra Nevada foothills through the northern edge of the City of Fresno. The project vicinity generally has low gradients, typically less than 1 percent. Regional drainage includes tributaries and constructed flood control channels that drain generally from east to west toward the San Joaquin River. Within the City of Fresno, an extensive flood control system managed by the FMFCD captures and conveys storm runoff to regional detention basins.

2.2 Receiving Water Bodies

The Project will cross several flood control channels and irrigation canals and ditches, each a part of a master plan of flood control within the City of Fresno. These flood control facilities ultimately discharge to the San Joaquin River or Tulare Lake.

2.3 Soil Types and Infiltration Rates

Soil groups within the Project have been mapped and classified according to criteria determined by the U.S. Department of Agriculture Natural Resources Conservation Service (formerly known as the Soil Conservation Survey). Based on these criteria, soils are further classified into four hydrological soil groups: A, B, C, and D, where Group A soils have relatively high infiltration rates (and low runoff potential; that is, sand and gravel), and Group D soils have very low infiltration rates (and high runoff potential: for example, clay soils or soils with a shallow water table).

Representative boring logs were collected within and adjacent to the American Recovery and Reinvestment Act (ARRA) Phase 1 Project. Information in these boring logs indicates that subsurface soils generally consist of layered loose or soft to very dense or hard clay, silt, and sand of varying contents. Thicknesses and depths of loose/soft soils, medium dense/stiff soils, and dense/hard soils vary throughout the study area. Although all four soil types are present within the Project area, the predominant soil types in the Project vicinity are largely Class D with some Class B and C soils (see Figure 2-1).

2.4 Groundwater

The aquifer system underlying the Project Site is the Fresno Groundwater Basin. This aquifer system is confined by beds and lenses of fine-grained silts and Corcoran clay that impede the vertical flow of water. Corcoran clay is a low-permeability, aerially extensive, lacustrine deposit that extends throughout much of the Central Valley and divides the basins into an upper semi-confined zone and a lower confined zone. These low-permeable barriers hinder vertical flow and create significant hydraulic gradients with depth.

Throughout much of Fresno County, the groundwater basin is overdrawn (Fresno County 2000), with notable groundwater depressions near the Fresno and Clovis urban areas (California Department of Water Resources [DWR] 2006). Downtown Fresno is highly urbanized and the accompanying increase in impervious surfaces, such as parking lots and buildings, has reduced the potential for groundwater recharge at the Downtown Fresno Station study area. Groundwater depths along the HST alignment vary between 50 feet to 150 feet below ground in Fresno County. To mitigate aquifer depletion resulting from pumping, the FMFCD has combined its flood control and urban drainage programs with groundwater recharge. Flood control reservoirs and infiltration basins serve dual purposes to reduce peak flows and recharge groundwater in the Fresno basin. The District’s facilities provide approximately 17,000 acre-feet of annual stormwater recharge, infiltrating more than 80 percent of stormwater runoff (FMFCD 2009).

Groundwater in the study area tends to be high in sodium bicarbonate, with associated low total dissolved solids, hardness, iron, and manganese; however, there are localized areas of high hardness, iron, nitrate, and chloride in the subbasins (DWR 2006). Septic disposal systems and leach fields, fertilizers, animal manures, geologic sources, and plant residues are potential sources of nitrate contamination.

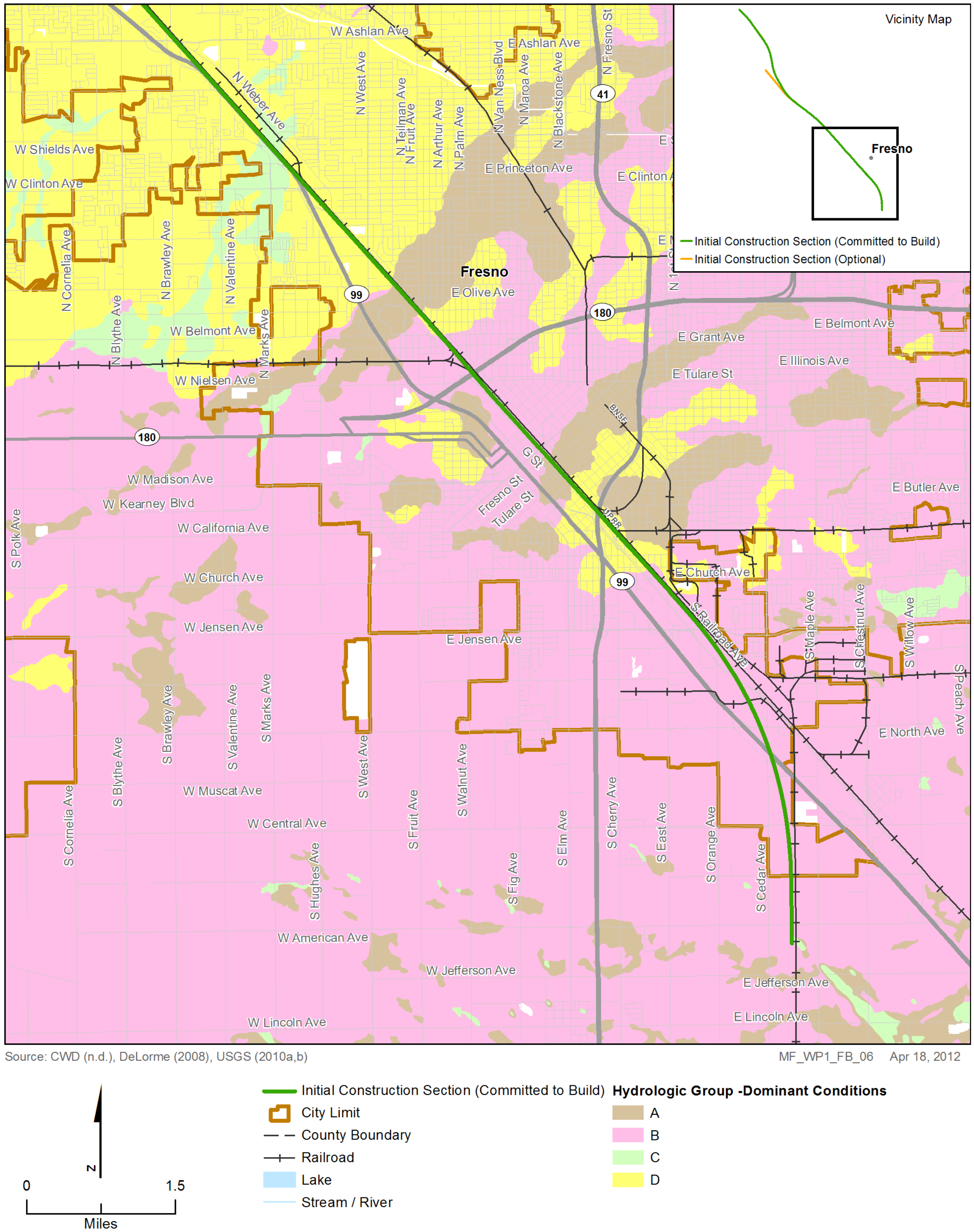

Figure 2-1
Hydrologic Soil Groups

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3.0 Drainage Conditions

Existing and proposed drainage conditions in the HST Project area are described in this section.

3.1 Existing Drainage Conditions

Existing drainage in the Project Site consists of overland sheet flow and concentrated flow in swales, ditches, irrigation canals (many confined by elevated embankments/levees), and natural channels, including levees, embankments and diversions primarily managed by FMFCD. FMFCD is legally mandated to manage stormwater within the Fresno-Clovis metropolitan area, including the area of the subject project. The community has developed and adopted a Storm Drainage and Flood Control Master Plan (FMFCD Master Plan). Within the metropolitan area storm runoff produced by land development is controlled through a system of pipelines and storm drainage retention basins. The FMFCD Master Plan also details locations for the expansion of future FMFCD facilities. The subject project lies within several individual drainage areas of the locally adopted Master Plan (see Figure 1-2). Details of the specific existing drainage conditions are provided in the Composite Utility and Drainage and Grading Drawings.

3.2 Proposed Drainage Conditions

The HST alignment generally will produce the amount of stormwater runoff at or near those reflected in the FMFCD Master Plan. The FMFCD will require that the HST coordinate drainage from frequent storms (2-year Master Plan design) into the planned drainage system.

FMFCD also requires that the HST consider mitigating impacts from major storms (those that overwhelm the FMFCD Master Plan design). Generally, FMFCD will manage the disposal of stormwater within the project area although the HST may need to provide some attenuation storage as specific locations wherein the HST needs additional flood protection and/or is adding water to certain FMFCD systems differently than planned.

Development of the HST will require the construction of facilities planned by the FMFCD Master Plan and lying within or across the HST right-of-way. Construction of these facilities must precede pipelines that may be located within any new or reconstructed local streets.

The design approach for proposed drainage condition is generally discussed below with detailed hydraulic analysis is provided in the Appendixes.

3.2.1 Offsite Drainage

Runoff generated up gradient (uphill) of the HST alignment will be allowed to pass the intercepting sections of project embankment, retained fill, or retained cut. The Authority has agreed to follow the Caltrans *Highway Design Manual* (HDM), with few exceptions, and has summarized design guidelines in *Technical Memorandum [TM] 2.6.5: Hydraulics and Hydrology Design Guidelines* (Parsons-Brinckerhoff 2011).

In general, culverts are used to provide conveyance of flow under at-grade track segments and associated new roads. These culverts are designed to capture and convey runoff to existing storm drains or to existing detention basins. During the 30 percent design, no hydraulic analysis was provided to size any cross culverts. However, cross culverts will be needed in several locations along the HST route. These locations are presented in the preliminary design grading and drainage plans. During the final design, hydraulic analysis will be required to ensure the design of culverts and other stormwater crossings is adequate.

Final design should include design flow rate, required freeboard/clearance, and backwater depths and distances. Energy dissipation and erosion control at outlets should be provided.

3.2.2 Onsite Drainage

At-grade Track Segments: The "at-grade" track will rest on ballast fill. Depending on local topographic slopes, the ballast will be placed in the form of an embankment, typically about 4 to 10 feet high. Rainfall will percolate through the rail ballast but would be unlikely to infiltrate readily into the underlying ground because of compaction, and will flow laterally out from the ballast. If the soils in the adjacent right-of-way are Hydrologic Soil Group (HSG) A or B soils, the runoff volumes will be evaluated for their potential to infiltrate onsite. For slowly infiltrating soils (HSG C and D), runoff will be collected in track-side ditches and conveyed to nearby storm drains.

Below Grade Track Segments: The below grade track segments will consist of track on concrete slab, with a single central drain between the rails. Stormwater would drain by gravity within the slab drains to the low point of the below grade track segment and flow into a pump station with a detention basin and wet well. Stormwater would be pumped to an at-grade detention basin and discharged to the FMFCD storm drain system at a controlled rate.

Above Grade Track Segments: Elevated sections drain water to channels on either the outside edges of the viaduct or a single central drain between the rails. Stormwater is directed into drain inlets located intermittently along the channel and piped through down spouts at the viaducts structural columns to grade. At-grade, stormwater is directed into a trench drain or swale that runs beneath and parallel to the rail alignment. The trench drain/swale conveys water towards points of connection with the existing FMFCD storm drain lines, while storing the volumetric difference between the 2-year event and 50-year event.

Variations to this approach will occur where the elevated section is a steel truss. In these sections, stormwater will be collected and conveyed through pipes in the structure towards a drain inlet located at the low point of the steel truss. The stormwater will then be conveyed down to grade and into trench drains/swales through a similar approach as described above.

State Highways: The HST Project will require the relocation of more than 2 miles of SR 99 within the City of Fresno. The highway will be relocated approximately 80 feet to the west to allow room for elevated tracks. The HST Project will maintain six through lanes and add one auxiliary lane in each direction. The Clinton Avenue Bridge will be replaced and the Ashlan Avenue interchange will be reconstructed. An existing highway drainage system provides stormwater collection and the runoff is generally captured within the state right-of-way and allowed to percolate into existing well drains. During extreme events, overflows from these infiltration basins are captured by the city's drainage system, which flows to detention and infiltration basins operated by the FMFCD. Discharges from Caltrans right-of-way will be subject to Caltrans' National Pollution Discharge Elimination System requirements.

Local Roadway Improvements: The HST Project will require modification of existing intersections where the HST is at grade or in spatial conflict with existing overpasses. Runoff from the new and replaced roadway pavement will not require stormwater treatment as long as it is discharged in accordance with the current FMFCD Master Plan (see Section 4 below). Local flow paths and discharge points will not be modified substantially.

Train Station: The Fresno train station will not be constructed as part of Package 1; however temporary in-line detention basins will be required as part of the Project Site to manage storm drainage generated within the project right-of-way. When the train station is constructed the temporary basins can be removed and the stormwater generated within the project right-of-way can be managed in a more appropriate, long-term manner.

4.0 Stormwater Management Measures

Major drainage design concepts for the HST Project are described in this section. Where feasible and practical, the drainage design will do the following:

- Maintain existing drainage flow patterns.
- Incorporate existing drainage systems.
- Disperse onsite runoff to encourage local infiltration.
- Improve existing drainage capacity if the HST Project exacerbates existing drainage problems or flooding at a location where the existing system is known to be undersized.
- Provide appropriate best management practices (BMPs) to meet water quality objectives and water quality standards set forth by the Central Valley RWQCB.

The following sections describe the design criteria and water quality BMPs proposed for the Project.

4.1 Design Criteria

Program-wide design criteria are issued in TM 2.6.5, *Hydraulics and Hydrology Design Guidelines* (Parsons-Brinckerhoff 2010). These criteria provide the foundation for drainage design for the entire program. Where local drainage requirements differ, the local drainage requirements will take precedence.

4.1.1 Hydrology

The hydrologic analysis is based on the design criteria outlined in TM 2.6.5, *Hydraulics and Hydrology Design Guidelines* (Parsons-Brinckerhoff 2011), Caltrans' HDM, and Caltrans Hydraulics Design Criteria (Central Region). The most pertinent design criteria are summarized as follows:

- Drainage areas in the project vicinity are small (less than 320 acres). For these areas, the Rational Method is used to determine all onsite design discharges.
- Rainfall intensities for Caltrans facilities are determined using Caltrans' IDF-2000 program for onsite drainage areas. For local roadway improvements and HST right-of-way, FMFCD criteria are used (FMFCD, 2010).
- For SR 99, local streets, and other paved areas, in accordance with Caltrans' HDM a minimum time of concentration of 5 minutes is used for onsite drainage calculations.
- For impervious areas, a runoff coefficient of 1.0 is used. For pervious areas, the runoff coefficient varies based on the surface type (Caltrans HDM).
- Flow diversions across FMFCD-owned basin watershed boundary lines require approval by FMFCD prior to final design (see Figure 1-2 for FMFCD watershed boundary map).
- Retention basins in urban areas are sized to contain the runoff generated by two 10-year frequency storms of 24-hours duration (Caltrans, 2011).

Design storm frequencies for the project are summarized in Table 4-1.

Table 4-1
Urban Design Storm Frequencies

Storm Facility	Design Frequency (Rural/Urban)
Drainage facilities crossing the HST track (i.e., culverts)	2% (50-yr) / 1% (100-yr)
Drainage facilities not crossing the HST track (i.e., parking lots, station drainage facilities)	10% (10-yr) / 2% (50-yr)
Ditches/storm drainage systems adjacent to the HST track	4% (25-yr) / 2% (50-yr)
Freeways—Minor Ramps and Frontage Roads Conventional Highways—High volume, multilane or urban with speeds of 45 mph and under.	10% (10-yr)
Freeways—Through traffic lanes, branch connections, and other major ramp connections Conventional Highways—High volume, multilane or low volume, rural with speeds over 45 mph	4% (25-yr)
Drainage systems crossing under bridge structure and on the right-of-way	2% (50-yr) / 1% (100-yr)
Local Streets and storm drains	50% (2-yr)[1]
Critical facilities (electrical, vents, communication buildings, etc.)	Min. 1% (100-yr)
Note: Local criteria provided by FMFCD.	

4.1.2 Hydraulics

Program-wide hydraulic design criteria are issued in TM 2.6.5, *Hydraulics and Hydrology Design Guidelines* (Parsons-Brinckerhoff 2011). For HST drainage systems the hydraulic design of storm conveyance facilities will generally conform to Metrolink's *Design Criteria Manual* (Metrolink 2003) for optimum efficiency and economy. For Caltrans facilities, drainage design must comply with the HDM. For local storm drains, hydraulic design complies with FMFCD design criteria. The most relevant design criteria are summarized as follows:

- For direct connections to existing FMFCD storm drains, flow control and detention are required to mitigate flows into the existing storm drain to those allowable by FMFCD (the pre-project 2-year discharge)
- For direct connections to existing FMFCD storm drainage system, no detention is required

4.1.3 Stormwater Quality

Program-wide stormwater quality design guidelines are included in TM 2.6.5, *Hydraulics and Hydrology Design Guidelines* (Parsons-Brinckerhoff 2011). These criteria provide the foundation for stormwater treatment and compliance with permitting requirements for the HST project without identifying individual stormwater quality requirements imposed by local agencies. Generally, stormwater management will be provided in accordance with Caltrans' Project Planning Design Guide (PPDG) for the HST project. However, where these guidelines conflict with, or do not meet, local agencies' stormwater requirements, the local agencies' stormwater requirements should be applied.

Where required, pollutant removal will be accomplished using treatment BMPs, which are measures designed to remove pollutants from stormwater runoff prior to discharging (directly or indirectly) to receiving waters. The PPDG emphasizes treatment for "targeted design constituents" (TDCs), which are pollutants assumed to be present in runoff from the Project Site. Specific TDCs include phosphorus, nitrogen, total and dissolved copper, total and dissolved zinc, total and dissolved lead, and sediments. TDCs also include a category known as general metals, which includes cadmium, nickel, chromium, and other trace constituents such as selenium and arsenic. In accordance with the PPDG, the Project must implement permanent treatment BMPs to the maximum extent practicable.

Table 4-2 is a list of impaired water bodies downstream of the Project. The San Joaquin River (Friant Dam to Mendota Pool) is impaired for exotic species and the Mendota Pool is impaired for selenium. Because selenium qualifies as a targeted design constituent, where treatment BMPs may be implemented, emphasis will be given to treatment for general metals.

Table 4-2
Section 303(d) List of Impaired Waters in the Study Area

Water Body	Impairment	Source of Impairment	TMDL Completion Date
2006 Section 303(d) Listings			
San Joaquin River (Friant Dam to Mendota Pool)	Exotic species	Unknown	2019
Mendota Pool	Selenium	Agricultural Return Flows, Agriculture, Ground Water Withdrawal, Other	2019
Source: Central Valley RWQCB (2006); Central Valley RWQCB (2008).			

Generally, the Project must implement Caltrans-approved treatment BMPs in accordance with the PPDG. These BMPs include biofiltration swales, biofiltration strips, infiltration devices, detention devices, media filters, multi-chambered treatment trains, wet basins, dry weather diversion, and gross solids removal devices. With the exception of gross solids removal devices, all of these BMPs are considered effective in removing turbidity, total suspended solids, and particulate metals (Caltrans 2010). With the exception of gross solids removal and detention devices, these BMPs are also considered effective in removing dissolved metals. Note that traction sand traps are not considered appropriate for the study area because of the area's relatively warm winter weather and the rarity with which traction sand is ever applied in the region. Other BMPs may also be considered, if demonstrated to be appropriate.

For this Project, the presence of the FMFCD regional flood control system has had a significant influence on the drainage and stormwater BMP design. Because detention and retention are provided on a regional level, according to the County of Fresno MS4 permit information sheet, "It would be inefficient to require individual developments to do the same thing... This regional system is more protective of water quality because it provides mitigation measures for all existing as well as new development" (RWQCB, 2001). With the exception of Caltrans' right-of-way, all runoff from the project limits is captured and treated by the FMFCD basins prior to discharging to downstream water bodies. Therefore no additional treatment BMPs are required within the Project area. This also requires that all stormwater is coordinated by FMFCD and should not be discharged directly to canals or other Fresno Irrigation District or private facilities within Fresno.

HST and Authority Right-of-way. As stated in Section 1.3, the HST rail alignment (track, ballast-embankment, and elevated sections) are not anticipated to contribute significant stormwater pollutants. Treatment of stormwater runoff from the rail alignment is therefore not necessary unless this runoff is co-mingled with runoff from HST-constructed roads. For HST storm systems constructed within the City of Fresno, direct connections to the FMFCD's storm drains are encouraged by FMFCD.

State Highways. The HST Project will require the relocation of 2 miles of SR 99 in Fresno and the modification of several interchanges. Because SR 99 is a high-traffic volume highway, water quality treatment for turbidity, total suspended solids, and metals will need to be provided. Stormwater treatment BMPs are incorporated for the freeway modifications of SR 99 according to the PPDG. These stormwater facilities will be located within the new Caltrans right-of-way limits. A separate Stormwater Data Report will be prepared to present this portion of the HST Project in detail.

Local Roadway Improvements. All relocated roads, such as Golden State Boulevard, and grade separations of the local road system will result in new or replaced paved road surfaces that are anticipated to contribute total suspended solids and turbidity to runoff. For storm drain connections within the City of Fresno, direct connections to the FMFCD's storm drains are encouraged by FMFCD.

"No Service" Areas. The HST alignment traverses some areas for "no-service" to FMFCD. These are generally areas of Caltrans or City right-of-way wherein those agencies are responsible for drainage facilities. These areas will be designed to meet the "Post-Construction Standards" specified in Section XIII of the NPDES General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities, Order No. 2009-0009-DWQ. Section XIII, in general terms, requires that projects outside the MS4 boundary be designed such that post-project stormwater runoff generated by a site is equal to or less than pre-project runoff.

4.2 Stormwater Treatment BMPs

BMP design depends on the volume and rate of runoff expected, which is affected by the drainage area and configuration, land use, topography, soil characteristics, impervious area, and storm intensity and duration. BMP design is based on a specific design storm and the constituents of concern to be removed. In general, treatment BMPs are designed to treat the flow of smaller, more frequent storm events rather than rare, high-flow events. Treatment BMPs are designed by one of two methods:

Water Quality Volume (WQV). WQV is defined in the PPDG as the active storage capacity of stormwater treatment BMPs and is required in order to size volume-based BMP treatment systems. The WQV for treatment BMPs is determined by applying a water quality depth to the tributary area for the BMP. It is intended to provide the level of protection specified by the greater of: regional water quality control board numeric sizing criteria for treatment BMPs, or local government guidelines for sizing stormwater treatment BMPs. The State Water Resources Control Board (SWRCB) recommends using the calculating tool known as BasinSizer to evaluate the water quality volume (Woody 2010, personal communication). For the Project Site, the BasinSizer program prescribes a water quality depth of 0.57-inch.

Water Quality Flow (WQF). The WQF has been negotiated between the SWRCB and the Central Valley RWQCB, and is used as the basis for designing the approved filtration-type treatment BMPs. For the Project Site, the WQF will be calculated using the Rational Method and a precipitation rate of 0.20-inch/hour. This rate is designated in the PPDG for the Central Valley RWQCB.

To manage high-flow events, flow splitters are often used. The major purpose for a flow splitter is to direct WQFs to an off-channel location for stormwater treatment, while allowing peak flows to remain, untreated, in the channel. Caltrans has drafted design guidelines for flow splitters that direct WQFs and/or WQVs to BMPs while allowing higher flows to bypass (Caltrans 2007a). These guidelines will be followed when designing flow splitters for the HST Project.

4.3 Proposed BMPs

BMPs are designed and implemented to reduce the discharge of pollutants from onsite stormwater. Incorporation of BMPs into the onsite drainage system will result in an improvement in water quality from onsite runoff before it enters receiving water bodies. Constraints that were evaluated during BMP selection and design include the following:

- Land use (for example, BMPs for culturally and biologically sensitive sites will be managed to reduce impacts)
- Storm drain conveyance viability (for example, the feasibility of draining by gravity to existing local stormwater infrastructure was evaluated)
- Right-of-way and topographic constraints (for example, certain BMPs are preferred because of space limitations, or accommodated through onsite grading)
- Outlet locations (for example, releasing directly to major streams would reduce potential downstream channel erosion attributable to the discharge)

Infiltration/Evaporation Basins: An infiltration basin (IFB) is designed to remove pollutants from surface discharges by retaining stormwater runoff and infiltrating it directly into the soil or evaporating it without release to surface waters. The feasibility criteria for IFBs require a design WQV that exceeds 0.1 acre-foot, sufficient soil infiltration rates, sufficiently low water table (generally greater than 10 feet below the bottom of the basin), and no threat to local groundwater quality. IFBs are a good choice for surface water protection where permeable soils support their use and there is sufficient area or right-of-way.

Soils along the Project route are highly variable. Generally, soils falling under HSGs A and B are suitable for infiltration. HSG C soils may also be suitable if local studies confirm suitable infiltration capability. HSG D soils are generally unsuitable for infiltration because of either poorly infiltrating soils or shallow depth to bedrock or the water table. Although HSG C and D soils are prevalent, several infiltration wells are installed within and near the Project Site, including many within the SR 99 right-of-way. Because of their historic use, IFBs are considered feasible for this Project in the preliminary design. Permeability testing will be required prior to final design of new IFBs. The proposed IFBs are summarized in Table 4-3 and presented in Figure 4-1.

Detention Devices: A detention basin is a permanent device that temporarily detains stormwater runoff under calm, non-turbulent conditions such that sediment and particulates are able to settle before the runoff is discharged. They are also used to attenuate peak flows. A portion of the detained water is also lost through infiltration (if the basin is unlined) and evaporation. Detention basins remove litter, settleable solids (debris), total suspended solids, and pollutants that are attached (adsorbed) to the settled particulate matter. Detention basins are primarily suited for sites where the water quality volume is at least 0.1 acre-foot, where the seasonal high groundwater is below the bottom of the basin, and where an elevation difference is available so that water stored in the basin does not cause objectionable backwater conditions in the storm drain systems. In accordance with the Caltrans Treatment BMP Technology Report (Caltrans 2007b), detention basins have good removal efficiencies for total metals (mainly those in particulate form) and suspended solids, which are pollutants of concern for portions of this Project.

Table 4-3
Stormwater Best Management Practices (BMPs)

BMP	Tributary Drainage Area [ac]	Water Quality Volume/Flow [ft^3/cfs]
Infiltration Basins		
IFB 101L	3.91	5,574
IFB 115L	7.29	10,535
IFB 130L	1.95	2,729
IFB 132R	14.98	19,629
IFB 141L	2.53	2,884
IFB 157L	23.86	38,318
IFB 205L	16.36	24,770
IFB 208L	1.54	2,442
IFB 213L	1.20	1,862
IFB 233L	3.54	4,151
IFB 239L	4.43	5,942
Biofiltration Swales		
BSW 20L	3.58	0.36
Note: While IFB 130L, 208L and 213L would not meet PPDG requirements for minimum water quality volume, these basins will be provided.		

Alternative BMPs: If infiltration is deemed infeasible during final design at the proposed IFB locations (shown in Table 4-3), alternative BMPs must be considered according to Caltrans PPDG. The feasibility for implementation must be determined during final design.

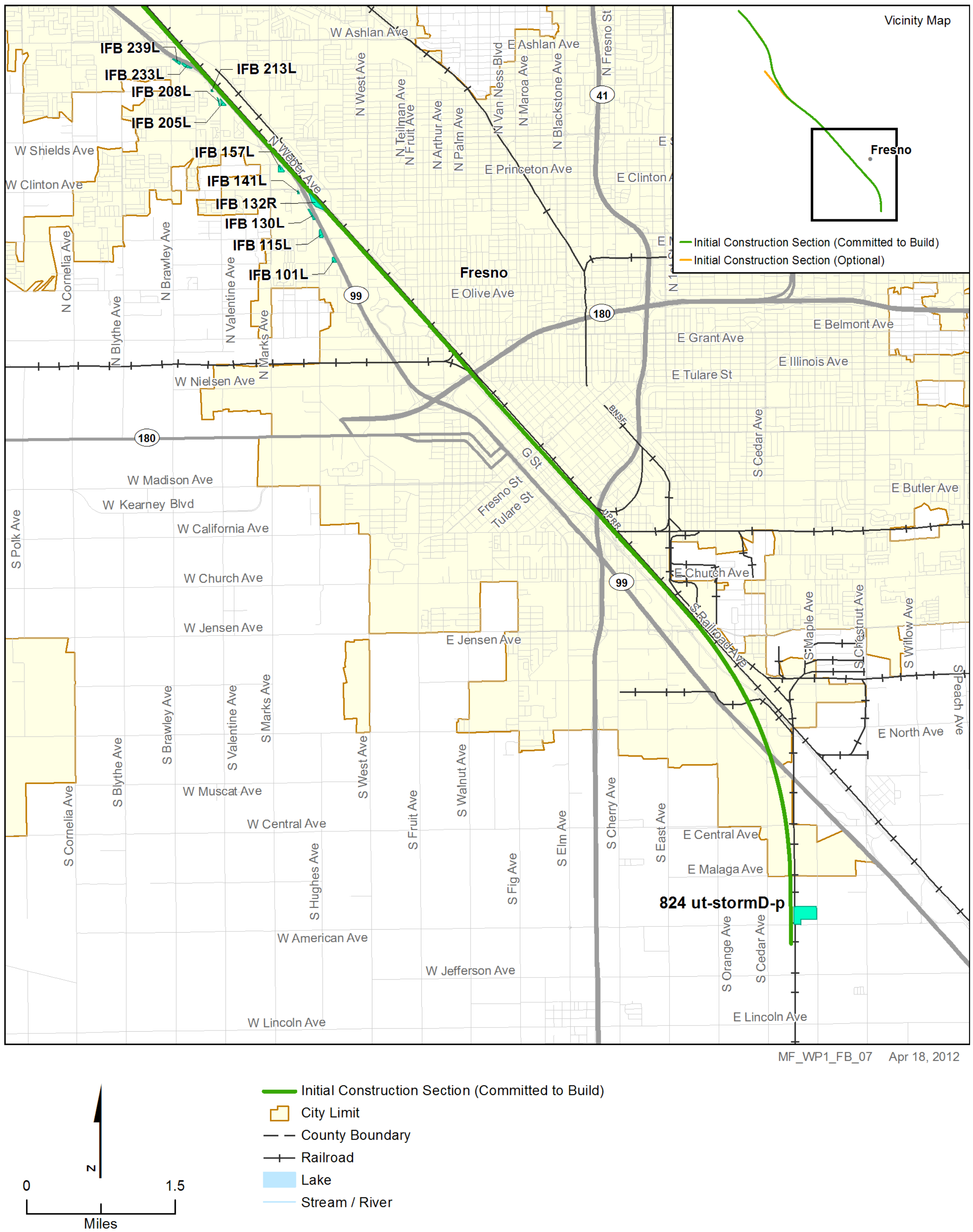

Figure 4-1
Proposed Infiltration Basins, North of Clinton Avenue

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APPENDIX A
Summary of Stormwater Management Strategy (Merced to Fresno Section)

A1. Existing FMFCD System

The northernmost portion of Procurement Package #1 (Merced to Fresno [M-F] Segment) extends between Herndon Avenue and W Clinton Avenue to the south. The general topography around the high-speed train (HST) right-of-way is gently sloping northeast-southwest. Currently, a well-defined storm drainage system does not exist within or around the HST right-of-way. The stormwater run-on or run-off from the right-of-way sheet-flows into the adjacent properties. Further, the runoff from these areas finds its way to the local Fresno Metropolitan Flood Control District (FMFCD) storm drain system and infiltration and/or detention basins (hereafter referred to as basins). In addition to providing infiltration and storage, the basins serve as best management practices (BMPs) for treating the FMFCD's stormwater. Several private developments along the alignment also have owner-operated detention and infiltration facilities. The majority of the segment is on the downstream of the existing Union Pacific Railroad (UPRR) right-of-way, and the overland flow further east of the UPRR will not enter the HST right-of-way. However, the areas southwest of the UPRR will drain to the HST right-of-way.

The FMFCD storm drain system throughout the Fresno area is generally sized to convey the 2-year storm event to basins. When Fresno experiences an event larger than the 2-year storm, stormwater collects in the streets until the system clears. The basins are sized to manage larger storm events and are often connected in series, with storm volumes managed between basins. When stormwater volumes exceed the basin capacities, water is pumped to one of the many canals that traverse the Fresno metropolitan area.

A2. Drainage Strategy

Grading and drainage for the Project improvements were discussed with FMFCD and the City of Fresno on September 1, 2011. Preliminary design concepts were presented and the general approach for stormwater management, including treatment, was discussed. Based on that meeting, we understood the general design principles for drainage within the FMFCD jurisdiction. While the 30% design has not been reviewed by the City or FMFCD, these principles became the basis of the stormwater management approach. They include the following:

- The FMFCD has performed extensive hydrologic and hydraulic analysis of their flood control system. The Project must preserve the existing flow patterns as much as possible. Where this is not feasible, coordination with FMFCD will be required and mitigation of peak flows will be mandatory.
- The MS4 Permit allows discharges from developments directly to the FMFCD regional flood control system.
- While FMFCD encourages direct discharges to their flood control system, runoff from HST storm drains should be distributed purposefully to minimize diversions across watershed boundaries.
- For direct connections to FMFCD storm drains, peak flows must be mitigated to allowable values (provided by FMFCD). For direct connections to detention basins, no peak attenuation is required. For sheet flows off the roadways, track, no detention is required.
- Caltrans' runoff is not incorporated into the FMFCD master plan—they currently infiltrate their runoff onsite.
- Stormwater runoff discharges to Herndon Canal are not permitted
- Where it is feasible, FMFCD encourages portions of the planned FMFCD storm drains which are planned to cross the HST right-of-way to be constructed as part of this project,

especially where construction of those facilities would mitigate construction impacts to the transportation facilities later.

- Extension of existing FMFCD facilities is feasible.
- FMFCD is willing to negotiate an agreement to cover design, construction and operations issues, e.g. construction or modification of existing FMFCD facilities, design analysis, available borrow locations, encroachments, future discharges, etc.

Additionally, the following basic premises were considered for the hydraulic analysis as governing the design of the Project drainage:

- The drainage system should be capable of carrying the 50-year design flow (design flow) safely within the project right-of-way.
- The drainage facilities should not exacerbate flooding or flow conditions upstream and downstream of the CHST right-of-way.
- The drainage system should be consistent with design requirements of the local agencies' storm drain systems, and should integrate measures within the CHST right-of-way as necessary. That is, wherever the local agency system is designed for a smaller storm event, based on the CHST design criteria, flow attenuation facilities should be introduced into the system.

Conceptual Drainage Design Criteria: The following general criteria are adopted for drainage design. This criteria originates from the Caltrans HDM and Caltrans PPDG.

Drainage Swales

Side Slope	2:1
Minimum swale bottom width	2 ft
Minimum swale depth	1.5 ft
Minimum freeboard	0.75 ft
Maximum design flow velocity	4 ft/sec

Storm Drains or Underdrain System

Minimum drain pipe diameter	18 in
Minimum pipe cover	1 ft
Cleanout of catch basin spacing	48 in below the top of rail
Minimum drainage slope	Slope to maintain 3 ft/s velocity at half full pipe

The Draft 30 Percent Grading and Drainage Plans illustrate this approach across the M-F Segment of Procurement Package #1. A summary of how this strategy is applied to the 5 miles of trackway between Herndon Avenue and W Clinton Avenue is discussed below.

A2.1. HST Track

The FMFCD storm drain system is sized for the 2-year event, which is inadequate for the 50-year design storm that the CHST in urban areas is obligated to manage under TM 2.6.5. To meet both requirements the volumetric difference between the 2-year and 50-year storms will need to be contained within the CHST right-of-way. Stormwater generated from storms greater than the 50-year event will be conveyed to the streets of Fresno to be managed within the larger FMFCD system. This approach is in accord with FMFCD in principle, recognizing that specific locations of points of connection may change as the design develops.

A2.1.1. At-grade Section (right-of-way 100 feet)

In locations where the right-of-way is wider, drainage swales will be used to collect, convey, and store stormwater on either side of the alignment (see Figure A-1).

The swales are positioned to collect runoff from the rail embankment and from any areas outside of the right-of-way that drain toward the alignment. The swales run parallel to the alignment toward connection points with the existing FMFCD storm drain lines and detention basins, and the detention basins to be developed as part of the CHST Project.

In general, the drainage swales will be located along the trackway side, leaving space along the property line for maintenance road, fence line, and for any utilities associated with the CHST Project. The longitudinal slope of the swales will follow, in most cases, the existing ground slope.

Based on the preliminary design, most of the drainage swales are designed to have a 2-foot bottom width and be less than 2 feet deep. The maximum top width is estimated to be about 8 feet.

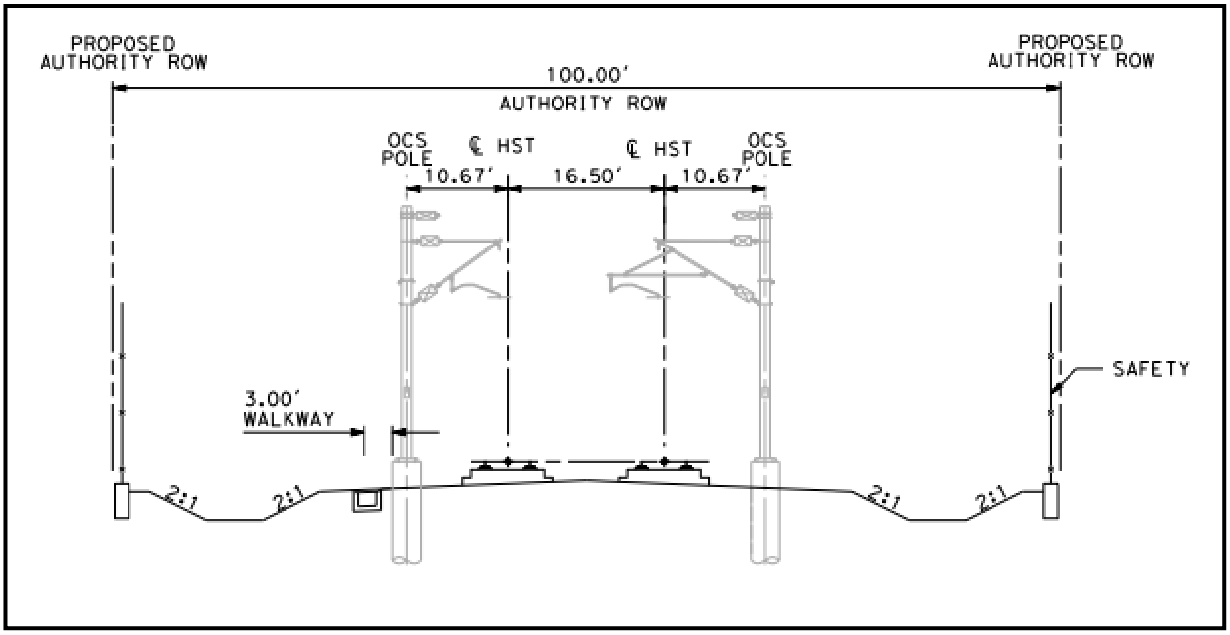

Figure A-1
At-grade Alignment (Typical Section)

A2.1.2. At-grade Section (right-of-way<60 feet)

In narrow portions (60-foot right-of-way) of the alignment, stormwater will be collected, conveyed, and stored within trench drains located on either side of the alignment (see Figure A-2). The typical trench drain is 3 feet wide, and of variable depth, lined with a geotextile filter fabric, with a perforated pipe (of variable diameter) at the bottom of the trench and backfilled with drain rock. Minimum pipe diameter will be 1 foot. The trench drains are positioned to collect runoff from the rail embankment and any areas outside of the right-of-way that drain toward the alignment. The trench drains run parallel to the alignment toward connection points with the existing FMFCD storm drain lines.

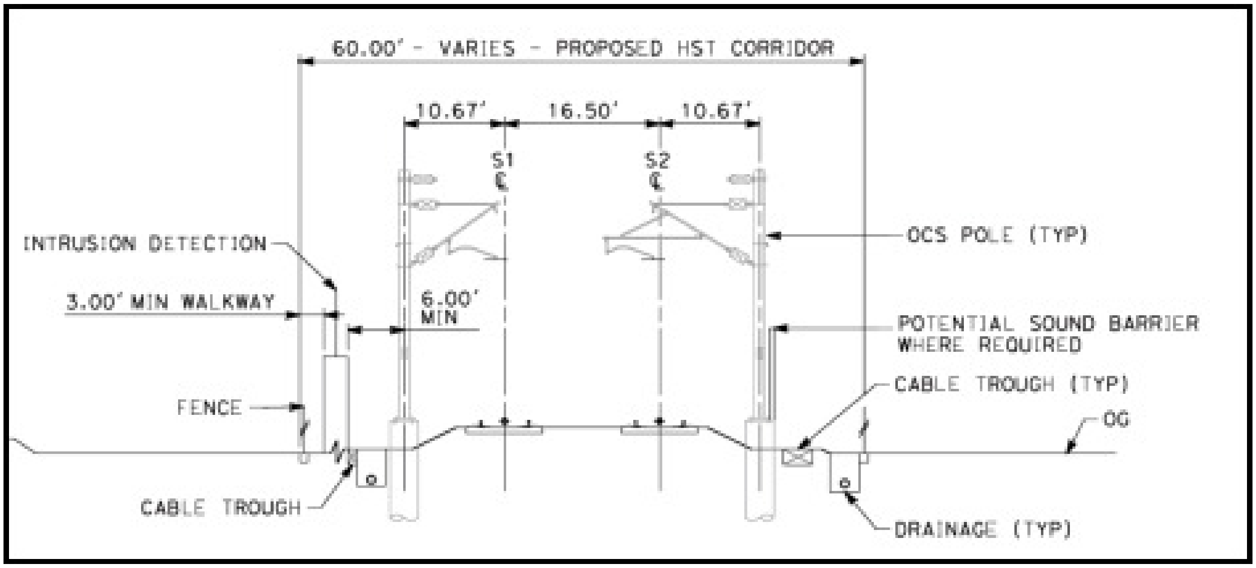

Figure A-2
Typical Narrow, At-grade Alignment Section

A2.1.3. Railway Drainage Strategy Summary

Table A-1 summarizes the lengths where each typical section is planned along the CHST alignment, and the potential point of connection of the CHST storm drain system to the existing FMFCD system.

Table A-1
Summary of Section Type Along the M-F Procurement Package #1 Alignment

Drainage Area Location	Drainage Type	Approximate Point of Connection	Notes
S10535+00 to S10580+00	Drainage swale	North of Station S10535+00	Connect swales to east (E) FMFCD detention basin on south of Herndon Avenue. The drainage swales will be extended along the CHST right-of-way (either side). Additional detention is not proposed for this drainage area.
S10580+00 to S10592+00	Drainage swale	S10592+00	Connect swales to (E) storm drain system on the north of Herndon Canal. Onsite earthen detention basin is proposed for this drainage area for runoff attenuation.
S10592+00 to S10617+00	Drainage swale	S10617+00	Connect swales to north (N) storm drain system. New storm drain will connect to (E) detention basin on the NE side of the CHST alignment. The (E) detention basin property is proposed to be acquired by the Authority. Onsite detention is not proposed.
S10617+00 to S10648+00	Drainage swale on SW and storm drain on NE of right-of-way	S10617+00	Connect swale and storm drain to (E) storm drain system to the SE. Onsite detention is needed at this location. New storm drain will connect to (E) detention basin on the NE side of the CHST alignment. The (E) detention basin property is proposed to be acquired by the Authority. Onsite detention system is not proposed.
S10648+00 to S10661+00	Drainage swale on SW and storm drain on NE side of right-of-way	S10648+00	Connect swale and storm drain to (E) storm drain system. Onsite detention basins (earthen and concrete) are proposed for this drainage area to attenuate runoff.
S10661+00 to S10701+00	Drainage swale on SW and storm drain on NE of right-of-way	S10681+00 and S10701+00	Connect NE storm drain to a (N) storm drain at S10701+00. The (N) storm drain will ultimately drain to FMFCD detention basin on south of W Ashlan Avenue, NE of the CHST right-of-way. Connect the SW swale to (E) storm drain system at S10681+00. Onsite detention basins (earthen) are proposed for swale drainage area to attenuate runoff.
S10701+00 to S10744+00	storm drain system	S10701+00	Connect the storm drains to a (N) proposed storm drain at S10701+00. The (N) storm drain will ultimately drain to FMFCD detention basin on south of W Ashlan Avenue, NE of the CHST right-of-way. Onsite detention is not proposed for this drainage area.
S10744+00 to S10805+00	storm drain system	S10805+00	Connect the storm drains to the Fresno to Bakersfield proposed SD system draining SE.

A2.2. Roadway

The CHST project encompasses multiple roadway re-alignments and improvements throughout the proposed corridor. Local agencies as well as state agencies have standards that deviate from the general design criteria outlined above for CHST drainage design. The proposed roadway structure types are summarized in Table A-2.

Conceptual Drainage Design Criteria: Conceptual design criteria for the proposed roadway improvements are shown below. This criteria originates from the Caltrans HDM and the Caltrans PPDG.

Drainage Swales

Side Slope	4:1
Minimum swale bottom width	2 ft
Minimum swale depth	1.5 ft
Minimum freeboard	0.75 ft
Maximum design flow velocity	4 ft/sec

Storm Drains or Under Drains System

Minimum drain pipe diameter	18 in
Minimum under drain pipe diameter	8 in
Minimum pipe cover	24 in below the top of roadway grade

The design storm for sizing of proposed basins within Caltrans right-of-way is a 10-year, 24-hour event. This standard was implemented for local basins and surface streets as well.

Table A-2
Roadway Structure Type

Roadway	Design Type
Golden State Boulevard and various Local Street Intersections	Re-Aligned, At-Grade
N. Cornelia Ave	Re-Aligned, At-Grade
Shaw Avenue, and intersections with N. Jennifer Ave and W. Mission St	Retained Earth Overpass
W. Santa Ana Ave	Re-Aligned, At-Grade
SR-99	Re-Aligned, At-Grade
SR-99 Interchange @ McKinley Ave	Retained Earth Overpass
N Parkway Drive	Re-Aligned, At-Grade
Pleasant Ave	Re-Aligned, At-Grade
SR-99 Interchange @ Clinton Ave	Retained Earth Overpass
Vassar Ave	Re-Aligned, At-Grade
N Motel Dr	Re-Aligned, At-Grade
N Marks Ave	Re-Aligned, At-Grade
Shields Ave	Re-Aligned, At-Grade
Valentine Ave	Re-Aligned, At-Grade
Dakota Ave	Re-Aligned, At-Grade
N Weber Ave	Re-Aligned, At-Grade
Ashlan Ave, and intersections with Marty Ave	Retained Earth Overpass
SR-99 ramps @ Herndon Ave	Re-Aligned, At-Grade

A2.2.1. Watershed Hydrology

The FMFCD has delineated regional watersheds for each of their flood control facilities. To preserve the serviceability of the FMFCD facilities, FMFCD has requested that the Project approach for stormwater management minimizes diversions across these watershed boundaries. Where this is not feasible, FMFCD will require flow attenuation to match pre-project peak flows, as determined and provided by FMFCD. Such mitigation would be costly, and may require additional right-of-way. Therefore the stormwater management approach for this project is to maintain existing flow paths wherever feasible.

To understand the impacts of the proposed drainage design, the watersheds affected by the project site were evaluated to identify drainage diversions from one watershed to another. Existing watersheds were delineated based on existing flow patterns per the FMFCD master plan. Proposed roadway drainage watersheds were developed based on project conditions. Changes in land use result in an increase in paved areas that will likely discharge additional runoff to the regional facilities. The regional facilities' watershed boundaries have remained intact. FMFCD's master plan of drainage accounts for future development of the Project site, therefore the additional flows resulting from the project are not anticipated to create adverse impacts to the serviceability of the FMFCD regional systems.

Table A-3 below summarizes the individual roadway drainage watershed areas. Existing and Proposed watersheds are provided, with impervious and pervious areas identified. Watersheds were named according to the relevant FMFCD facility that was impacted.

Caltrans roadway drainage is not incorporated in the FMFCD master plan. The roadway drainage within Caltrans right of way is currently infiltrated on site with a few exceptions. These exceptions include:

- Pump stations that divert roadway drainage to an FMFCD facility.
- Pump stations that divert roadway drainage to a Caltrans facility.
- Roadway drainage that discharges to the San Joaquin River.

The proposed Caltrans roadway drainage continues this pattern with proposed infiltration within the proposed Caltrans right of way and the continuation of the current drainage patterns regarding exceptions to infiltration. Three existing pump stations will be impacted by the roadway improvements. The existing and proposed watershed areas that drain to these pump stations were evaluated and efforts to mitigate any proposed watershed area increases were completed such that these pump stations do not need to be upgraded. The table below outlines the individual Caltrans roadway drainage watershed areas for the pump stations and the San Joaquin River discharge and is broken down by impervious areas and pervious areas for the existing conditions and the proposed conditions.

Table A-3
Watersheds (Ac) Affected by Roadway Improvements

Location	Existing Conditions (Ac)		Proposed Conditions (Ac)	
	Impervious	Pervious	Impervious	Pervious
Watershed EH				
EH-1	3.61	0.72	3.97	0.30
EH-2	6.31	1.56	12.17	6.40
EH-3	0.00	1.21	1.21	0.00
EH-4	0.00	7.46	7.46	0.00
Other Areas (1)	125.95	758.98	124.44	749.85
Totals	135.87	769.93	149.25	756.55
Watershed EL				
EL-1	2.67	0.23	3.03	1.25
Other Areas (1)	68.10	37.88	67.22	37.38
Totals	70.77	38.11	70.25	38.63

Location	Existing Conditions (Ac)		Proposed Conditions (Ac)	
	Impervious	Pervious	Impervious	Pervious
Watershed AH1				
AH1-1	4.96	1.41	6.16	3.18
AH1-2	3.81	0.85	5.25	2.79
AH1-3	5.00	0.00	8.45	0.06
AH1-4	2.48	0.00	3.47	0.00
Other Areas (1)	338.55	288.03	332.69	283.04
Totals	354.80	290.29	356.02	289.07
Watershed AK				
AK-1	4.42	0.00	4.63	0.30
AK-2	0.28	0.00	0.66	0.20
AK-3	0.43	0.00	0.38	0.00
AK-11	4.42	0.00	4.63	0.30
AK-12	0.28	0.00	0.66	0.20
Other Areas (1)	32.61	26.55	32.10	26.14
Totals	39.82	26.55	39.73	26.64
Watershed EE				
EE-1	2.20	0.00	2.51	0.00
Other Areas (1)	703.65	1646.97	703.55	1646.75
Totals	705.85	1646.97	706.06	1646.76
Watershed XX				
XX-1	2.39	0.00	2.11	0.00
Other Areas (1)	216.92	146.21	217.09	146.32
Totals	219.31	146.21	219.20	146.32
Watershed AG				
AG-1	4.10	0.00	4.20	0.00
Other Areas (1)	214.99	511.22	214.96	511.15
Totals	219.09	511.22	219.16	511.15
San Joaquin River				
H1-1	0.97	1.60	1.75	2.23
H1-2	1.64	2.98	0.60	0.30
(1) These watershed areas are outside the Project limits.				

A2.2.2. Pump Stations

Olive Avenue Pump Station. The Olive Ave pump station is located beneath the Olive Ave overcrossing. A comparison of the pre-project and post-project watersheds is presented in Table A-4 below. The tributary area draining towards the Olive Ave pump station has been reduced by approximately 0.19 ac. This reduction is a result of a proposed infiltration basin near the upstream portion of the Olive Ave pump station watershed. Proposed drainage inlets divert roadway drainage toward "IFB 101L" prior to reaching the Olive Ave pump station. This was done to mitigate the additional impervious area created with the proposed auxiliary lane along the SR-99 alignment. As a result of the reduction of tributary area to the Olive Avenue Pump Station, without physical modifications which would affect the structure, replacement of the pump station is not required due to the SR 99 improvements.

Ashlan Avenue Pump Station. The Ashlan Ave pump station is located beneath the Ashlan Ave overpass over the SR-99 alignment. A comparison of the pre-project and post-project watersheds is presented in Table A-4 below. The tributary area draining towards the Ashlan Ave Pump Station has been reduced by approximately 0.08 ac. This reduction is a result of the re-alignment of SR-99 and the re-location of drainage inlets near the top of the Ashlan Ave pump station watershed. These proposed drainage inlets divert roadway drainage toward the proposed infiltration basin "IFB 233L". As a result of the reduction of tributary area to the Ashlan Avenue Pump Station, without physical modifications which would affect the structure, replacement of the pump station is not required due to the SR 99 improvements.

Clinton Avenue Pump Station. The Clinton Ave pump station is located beneath the SR-99 alignment on the SB SR-99 off ramp to Motel Dr. The portion of roadway that houses this pump station is proposed to be left in place. Further upstream within the pump station watershed there will be significant alterations in the roadway geometry which will affect the post-project watershed. For example, the SB off ramp will be re-aligned horizontally and vertically.

A comparison of the pre-project and post-project watersheds is presented in Table A-4 below. The tributary area draining towards the Clinton Ave pump station has been reduced by approximately 1.01 ac. This reduction is a result of the modifications to the SB SR 99 off ramp and other roadway modifications. Those roadway modifications have also resulted in a local diversion of some of the former pump station watershed to IFB 132R. As a result of the reduction of tributary area to the Clinton Avenue Pump Station, without physical modifications which would affect the structure, replacement of the pump station is not required due to the SR 99 improvements. Figure A-3 shows the locations of the proposed pump stations.

Table A-4
Pump Station Watersheds

Location	Existing Conditions		Proposed Conditions	
	Impervious	Pervious	Impervious	Pervious
Olive Pump Station				
95R	1.70	0.00	1.51	0.00
Ashlan Pump Station				
250L	3.02	0.00	2.94	0.00
Clinton Pump Station				
132R	1.48	3.72	1.47	2.72

Infiltration Basins. Proposed drainage for the new Caltrans right-of-way will provide retention of runoff similarly to the existing condition. Infiltration basins are proposed to capture two 10-year storms, in accordance with the Caltrans' standard hydraulic design criteria for the Central Region Districts (5, 6, & 10). They will also provide stormwater treatment and are proposed as treatment BMPs. Surface streets that had roadway improvements with drainage that did not discharge into a FMFCD facility also had proposed infiltration basins for final discharge. Table A-5 below summarizes the watershed areas tributary to each basin.

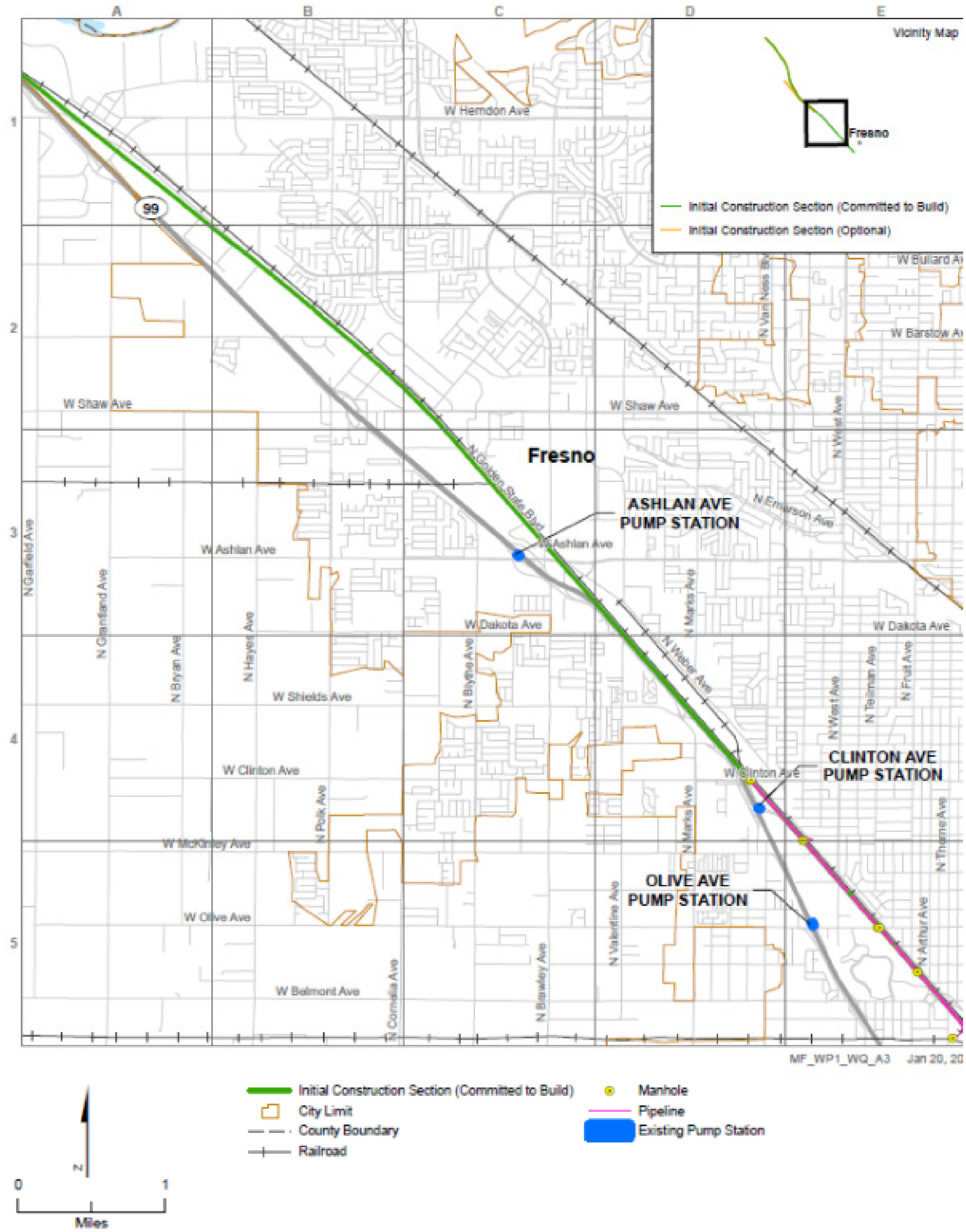

Figure A-3
Proposed Pump Stations, North of Clinton Avenue

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Table A-5
Proposed Caltrans Infiltration Basins

Watershed	Proposed Conditions	
	Impervious	**Pervious**
101L	2.08	1.83
115L	4.02	3.27
130L	0.98	0.96
132R	6.10	8.89
141L	0.57	1.97
157L	17.30	6.56
205L	10.24	6.11
208L	1.08	0.47
213L	0.80	0.39
233L	0.92	2.62
239L	1.95	2.49
FMFCD Basin		
208L	1.08	0.47
130L	0.98	0.96
213L	0.80	0.39

APPENDIX B
Summary of Stormwater Management Strategy (Fresno to Bakersfield Section)

B1. Existing FMFCD System

The general topography around the HST right-of-way is gently sloping northeast-southwest. The stormwater run-on and run-off from the right-of-way sheet-flows into the adjacent properties. Further, the runoff from these areas finds its way to the local Fresno Metropolitan Flood Control District (FMFCD) storm drain system and infiltration and/or detention basins (hereafter referred to as basins). In addition to providing infiltration and storage, the basins serve as best management practices (BMPs) for treating the FMFCD's stormwater. Several private developments along the alignment also have owner-operated detention and infiltration facilities in areas where FMFCD facilities have not yet been built.

In the southern portion of Procurement Package #1, between W Clinton Avenue and just south of E American Avenue, the general approach is to use the HST right of way to collect and convey stormwater to the existing FMFCD stormwater collection system. As discussed above the existing FMFCD system consists of a number of discrete watersheds across the entire Procurement Package #1 area. The FMFCD pipes throughout Fresno are generally sized to convey the 2-year storm event to basins. When Fresno experiences an event larger than the 2-year storm, stormwater collects in the streets until the system clears. The basins are sized to manage larger storm events and are often connected in series, with storm volumes managed between basins. When stormwater volumes exceed the basin capacities, water is pumped to one of the many canals that traverse Fresno. The FMFCD watersheds are provided in Figure 1-2 with proposed points of CHST connection to the FMFCD system identified in the proposed preliminary design drainage and grading plans.

B2. Alignment Drainage Strategies

Grading and drainage for the project improvements were discussed with FMFCD on September 14, 2011. Preliminary design concepts were presented and the general approach for stormwater management, including treatment, was discussed. Based on that meeting general design principles were agreed for drainage within the FMFCD jurisdiction. While the 30% design has not been reviewed by the City or FMFCD, these principles became the basis of the stormwater management approach. They include the following:

- The FMFCD has performed extensive hydrologic and hydraulic analysis of their flood control system. The Project must preserve the existing flow patterns as much as possible. Where this is not feasible, coordination with FMFCD will be required and mitigation of peak flows will be mandatory.
- The FMFCD MS4 Permit allows discharges from developments directly to the FMFCD regional flood control system.
- While FMFCD encourages direct discharges to their flood control system, runoff from HST storm drains should be distributed purposefully to minimize diversions across watershed boundaries.
- For direct connections to the FMFCD storm drain system, peak flows must be mitigated to allowable values (provided by FMFCD). For direct connections to detention basins, no peak attenuation is required. For sheet flows off the roadways, track, no detention is required.
- In some instances the HST may desire to increase the size of proposed FMFCD storm drainage pipelines and/or construct parallel storm drainage specifically for HST needs to an FMFCD stormwater management basin. Increasing the diameter of planned facilities could convey an increased flow generated by the HST and this option should be

considered in the design of the stormwater conveyance system. The cost for such revisions to the Master Plan would be borne by the HST and not be eligible for fee credit.

- The construction of an overpass at W McKinley Avenue adjoins FMFCD Basin "EE". The HST must not allow any runoff from the HST right-of-way to surface flow into the basins as it would cause severe and unacceptable erosion.
- FMFCD cannot accept a reduction in the capacity of basin "RR2" at Belmont Avenue. FMFCD recommends expansion of the basin beneath Belmont Avenue and expansion into what is currently the Belmont Circle. FMFCD will need access beneath Belmont Avenue so that maintenance does not require external travel between the two sides of Belmont Avenue. Basin side slope must be no steeper than 4:1. No additional HST drainage will be accepted into this basin. HST shall be required to provide access and maintenance roads that will meet all weather access requirements for operations and maintenance of Basin "RR2" for any proposed mitigation.
- Caltrans' runoff is not incorporated into the FMFCD master plan—they currently infiltrate their runoff within the Caltrans right-of-way.
- Stormwater runoff discharges to FID facilities are not permitted.
- Where it is feasible, FMFCD encourages portions of the planned FMFCD storm drains which are planned to cross the HST right-of-way to be constructed as part of this project, especially where construction of those facilities would mitigate construction impacts to the transportation facilities later.
- Extension of existing FMFCD facilities is feasible.
- FMFCD is willing to negotiate an agreement to cover design, construction and operations issues, e.g. construction or modification of existing FMFCD facilities, design analysis, available borrow locations, encroachments, future discharges, etc.

Additionally, the following basic premises were considered for the hydraulic analysis as governing the design of the Project drainage:

- The drainage system should be capable of attenuating and conveying the 50-year design flow (design flow) safely within the project right-of-way.
- The drainage facilities should not exacerbate flooding or flow conditions upstream and downstream of the CHST right-of-way.
- The drainage system should be consistent with design requirements of the local agencies' storm drain systems, and should integrate measures within the CHST right-of-way as necessary. That is, wherever the local agency system is designed for a smaller storm event, based on the CHST design criteria, flow attenuation facilities should be introduced into the system.

The proposed preliminary design grading and drainage plans illustrate this approach across the F-B JV portion of Procurement Package 1. A summary of how this strategy is applied across five typical alignment types (Constrained, At-Grade Section: 2-Track; Constrained, At-Grade Section: 4-Track or More; Railway Grade Separation: Below Grade; Railway Grade Separation: Above Grade; and Unconstrained, At-Grade Section), is provided below.

B2.1. Constrained, At-Grade Section: 2-Track (right-of-way<100 ft)

In narrow portions of the alignment (right-of-way <100 feet) stormwater will be collected, stored, and conveyed within trench drains or swales located on either side of the alignment (see Figures B-1). The typical trench drain is three feet wide, and of variable depth, lined with a geotextile filter fabric, with a perforated pipe (of variable diameter) at the bottom of the trench. The trench drain is backfilled with drain rock. The trench drains are positioned to collect runoff from the rail embankment and any areas outside of the right of way that drain towards the alignment. The trench drains run parallel to the alignment towards intermittent connection points with the existing FMFCD storm drain lines.

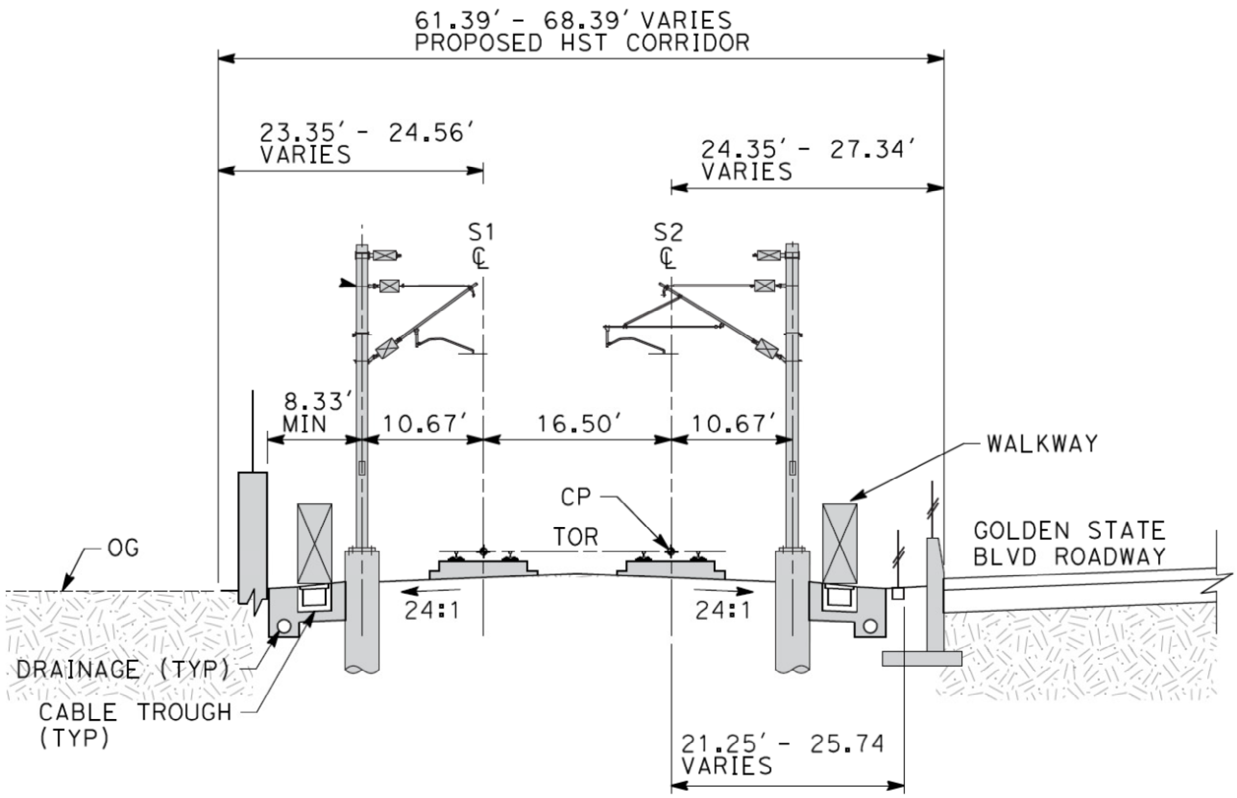

Figure B-1
Typical Constrained, At-grade Alignment: 2-Track Section

B2.2. Constrained, At-Grade Section: 4-Track or More

Portions of the alignment that are stations or approaching stations up to six parallel tracks will be required to collect and convey stormwater with trench drains placed strategically across the section (see Figure B-2). The typical trench drain is three feet wide, and of variable depth, lined with a geotextile filter fabric, with a perforated pipe (of variable diameter) at the bottom of the trench. The trench drain is backfilled with drain rock. The trench drains are positioned to collect runoff from the rail embankment and any areas outside of the right of way that drain towards the alignment. The trench drains run parallel to the alignment towards intermittent connection points with the existing FMFCD storm drain lines.

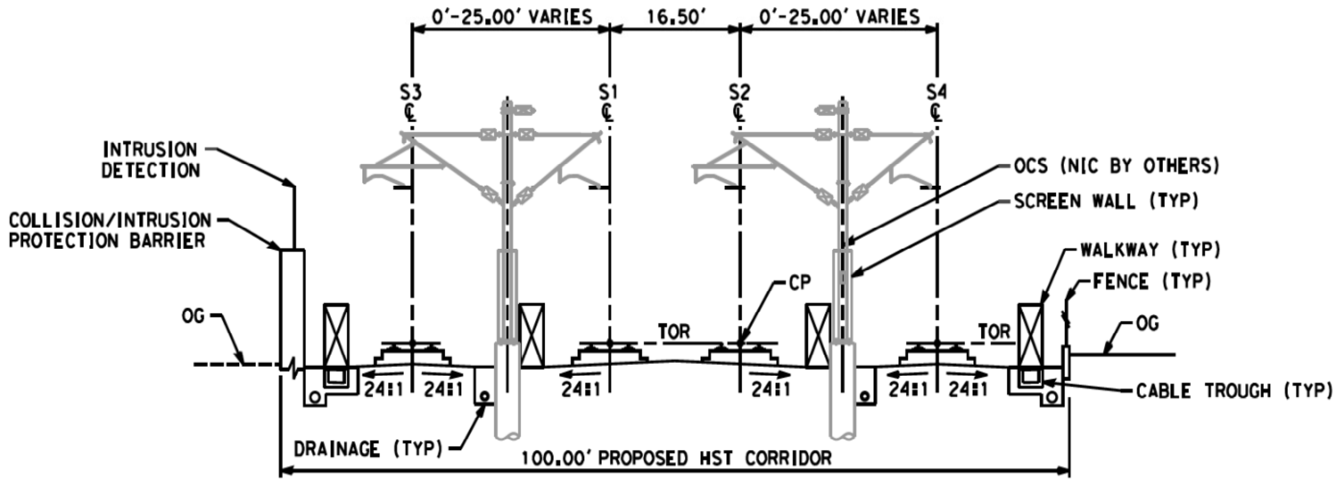

Figure B-2
Typical Constrained, At-grade Alignment: 4-Track or More Section

B2.3. Railway Grade Separation: Below Grade

Below grade separation sections typically have three drains that run parallel to the alignment (see Figure B-3). Two drains are at-grade on either side of the grade separation to collect runoff from any areas outside of the right of way that drain towards the alignment. These at-grade drains are either concrete lined channels of variable depths or earthen swales. The at-grade drainage lines collect and convey stormwater flowing towards the alignment from outside the HST right-of-way to intermittent FMFCD points of connection. Stormwater volumes in excess of the 2-year stormwater event will be attenuated within the at-grade drainage facilities. The primary function of the at-grade drainage lines is to avoid ponding next to the Fresno grade separation walls and to provide a route for surface water that would previously have flowed overland across the HST right-of-way. It is recommended that UPRR be consulted on drainage issues in this area.

Drains within the grade separation are located between the rails and serve to collect and convey stormwater to the low point of the trench. At the low point of the grade separation, the stormwater is diverted into a wet well and then pumped to an at-grade detention basin. The detention basin is sized to contain the 50-year storm event volume collected from the grade separation and will be pumped to the existing FMFCD storm drain facilities at the 2-year event flow rate.

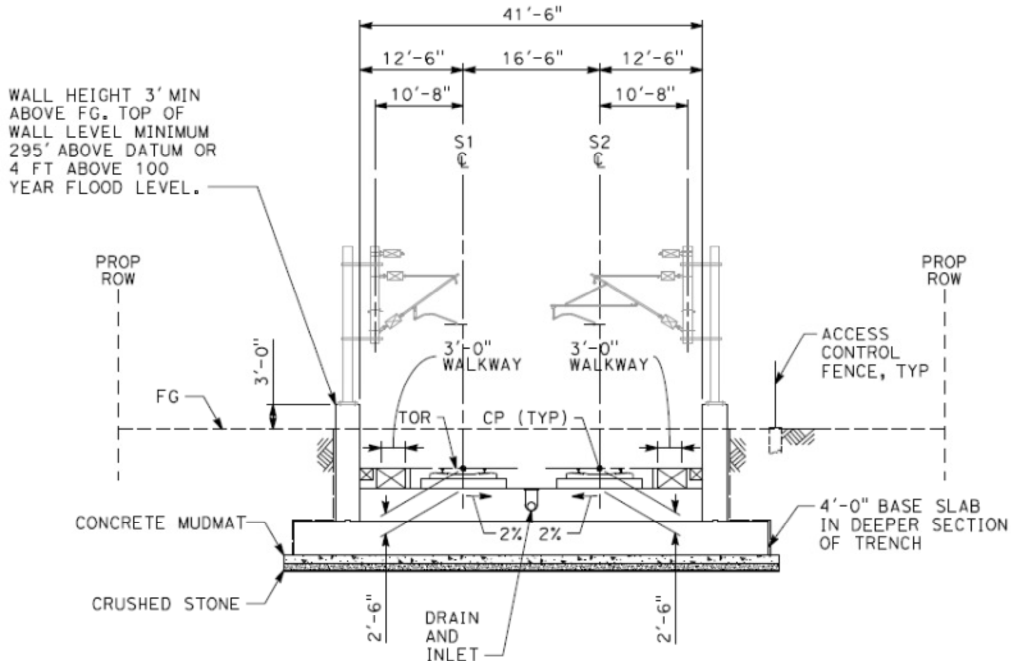

Figure B-3
Typical Rail Grade Separation: Below Grade Section

B2.4. Railway Grade Separation: Above Grade

Elevated sections drain water to channels on either the outside edges of the viaduct (see Figure B-4) or a single central drain between the rails. Stormwater is directed into drain inlets located intermittently along the channel and piped through down spouts at the viaducts structural columns to grade. At-grade, stormwater is directed into a trench drain or swale that runs beneath and parallel to the rail alignment. The trench drain/swale conveys water towards points of connection with the existing FMFCD storm drain lines, while storing the volumetric difference between the 2-year event and 50-year event.

Variations to this approach will occur where the elevated section is a steel truss. In these sections, stormwater will be collected and conveyed through pipes in the structure towards a drain inlet located at the low point of the steel truss. The stormwater will then be conveyed down to grade and into trench drains/swales through a similar approach as described above.

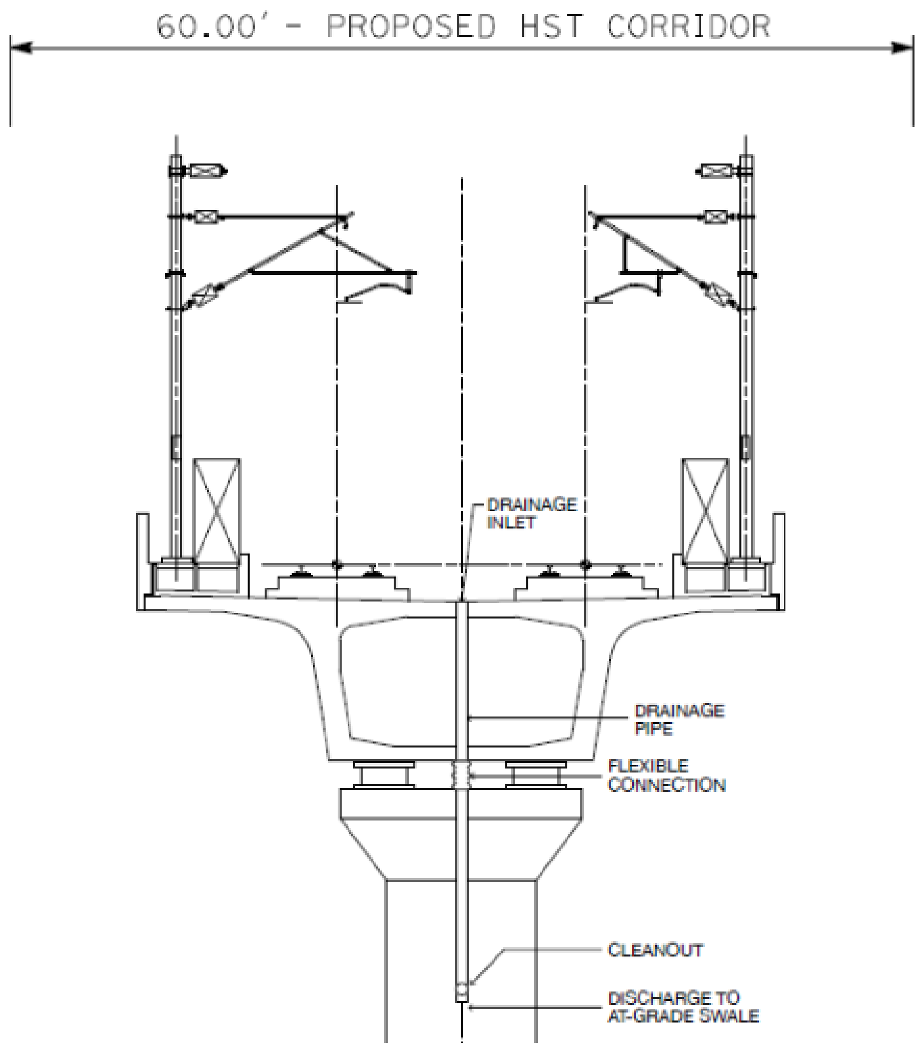

Figure B-4
Typical Rail Grade Separation: Above Grade Section

B2.5. Unconstrained, At-Grade Section (right-of-way≥100 ft)

In locations where the right of way is wider, swales will be utilized to collect, convey, and store stormwater on either side of the alignment (see Figure B-5). The swales are positioned to collect runoff from the rail embankment and any areas outside of the right of way that drain towards the alignment. The swales run parallel to the alignment towards connection points with the existing FMFCD storm drain lines.

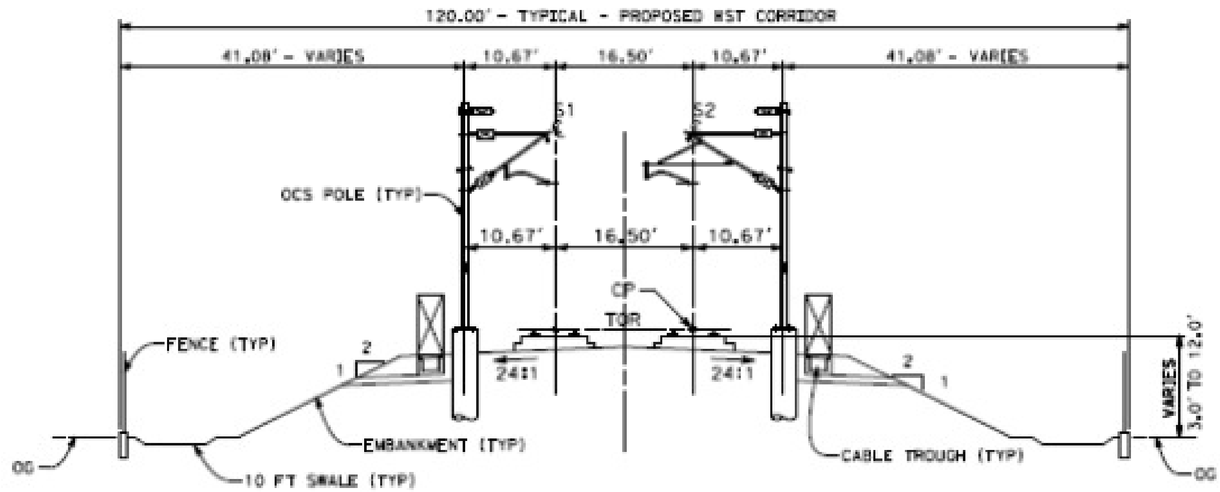

Figure B-5
Typical Unconstrained, At-Grade Section

B2.6. Railway Drainage Strategy Summary

Table B-1 below summarizes the lengths where each typical section is planned along the CHST alignment and the potential point of connection of the CHST storm drain system to the existing FMFCD system.

Table B-1
Summary of Section Type Along the F-B Procurement Package #1 Alignment

Drainage Area	Approximate Range	Drainage Type	Approximate Point of Connection	Notes
1	S10805+75 – S10840+80	Constrained, At-Grade: 2-Track	S10833+59	Drainage in this area will be collected at a point of connection with the FMFCD system at approximately S10833+59. When stormwater flows exceed the 2-year storm flow rate, the HST storm drain facilities will back up and serve as in-line storage eventually backing up to a larger in-line detention basin located between Golden State Blvd. and SR 99.

Drainage Area	Approximate Range	Drainage Type	Approximate Point of Connection	Notes
2	S10841+58–S10853+68	Constrained, At-Grade: 2-Track	S10846+96	
3	S10854+68–S10865+40	Constrained, At-Grade: 2-Track	S10861+05	
4	S10866+50 – S10884+00	Constrained, At-Grade: 2-Track	S10875+54	
5	S10885+00 – S10975+00	Below Grade	S10935+00	The at-grade drainage points of connection to the FMFCD system are located approximately at: S10897+56 S10948+55 S10953+83 S10962+64 S10972+50 The low point of the below grade alignment is at approximately S10926+93. From this location the stormwater is pumped up to a detention basin and then discharged to a FMFCD point of connection at approximately S1093+00.
6	S10976+00 – S10991+65	Constrained, At-Grade: 4-Track or More	S10986+75	
7	S10992+81 – S11030+00	Constrained, At-Grade: 4-Track or More	S11011+17	Temporary in-line detention basins are provided in the station area to manage drainage storm flows in excess of the 2-year storm flow rate for the station area prior to station construction.
8	S11030+00 – S11035+00	Unconstrained, At-Grade	S11037+00	
9	S11035+00 – S11052+00	Unconstrained, At-Grade	S11050+00	
10	S11052+00 – S11069+40	Unconstrained, At-Grade	S11060+75	
11	S11069+40 – S11140+00	Below Grade	S11119+50	The at-grade drainage points of connection to the FMFCD system are located approximately at: S11072+00 S11086+00 S11122+00 S11134+00 The low point of the below grade alignment is at approximately S11119+50. From this location the stormwater is pumped up to a detention basin and then discharged to a FMFCD point of connection at approximately S11134+00.

Drainage Area	Approximate Range	Drainage Type	Approximate Point of Connection	Notes
12	S11140+00 – S11230+00	Above Grade		The at-grade drainage points of connection to the FMFCD system are located approximately at: S11155+50 S11165+50 S11174+50 S11186+50 S11210+50 S11217+50 S11224+00 S11236+50 Points of connection to the existing Caltrans detention basin at ST 99 are located approximately at: S11200+00 S11201+00
13	S11230+00 – S11236+50	At-Grade	S11236+50	
14	S11236+50 – S11263+75	At-Grade	S11263+75	
15	S11263+75 – S11276+95	At-Grade	S11276+95	
16	S11276+95 – S11300+00	At-Grade	S11290+00	

B3. Roadway

The CHST project encompasses multiple roadway re-alignments and improvements throughout the proposed corridor.

The FMFCD has delineated regional watersheds for each of their flood control facilities. To preserve the serviceability of the FMFCD facilities, FMFCD has requested that the Project approach for stormwater management minimizes diversions across these watershed boundaries. Where this is not feasible, FMFCD will require flow attenuation to match pre-project peak flows, as determined and provided by FMFCD. Such mitigations would be costly, and may require additional right-of-way. Therefore the stormwater management approach for this project is to maintain existing flow paths wherever feasible.

To understand the impacts of the proposed drainage design, the watersheds affected by the project site were evaluated to identify drainage diversions from one watershed to another. Existing watersheds were delineated based on existing flow patterns per the FMFCD master plan. Proposed roadway drainage watersheds were developed based on project conditions. Changes in land use result in an increase in paved areas that will likely discharge additional runoff to the regional facilities. FMFCD's master plan of drainage accounts for future development of the Project site, therefore the additional flows resulting from the project are not anticipated to create adverse impacts to the serviceability of the FMFCD regional systems.

Drainage for new or realigned roadways resulting from this project is being designed to be integrated into the existing FMFCD system. Generally, there are three types of roadway design that are being completed for this project and each has a slightly different approach for managing stormwater. Each of the three stormwater management strategies is discussed below, while Table B-2 provides a summary of the drainage strategy applied at each proposed roadway improvement.

B3.1. At-Grade Streets

New or realigned streets will be integrated in to the FMFCD stormwater system. Drain inlets will be replaced or relocated to match the FMFCD requirements and will connect to new or relocated FMFCD stormwater pipes. The new drain inlets and pipes resulting from the new or realigned streets will be sized to collect and convey the 2-year storm flow, unless agreed otherwise with FMFCD.

A number of existing street crossings will be closed as a result of this project. As such, existing surface drainage patterns that utilize streets must be carefully reviewed with an aim of maintaining existing drainage patterns with cross drains or other approved conveyance systems, including provisions for any major storm flows across the HST. The change in street improvements in the vicinity of the HST must be similarly mitigated with respect to drainage impacts. To assist HST, FMFCD has identified the following roadways from Clinton Avenue south, where major storm surface flows must cross the HST alignment:

- McKinley Avenue
- Divisadero Street
- S Van Ness Avenue
- S East Avenue
- S Orange Avenue
- E Central Avenue
- E Malaga Avenue

B3.2. Roadway Overpasses

There are numerous roadway relocations required as part of this project that will divert existing at-grade roadways over the proposed rail alignment. These grade separations take several different forms depending on the space constraints, but all bridge over the rail alignment with a concrete bridge span. Stormwater will be collected in curb and gutters at the outside edges of the grade separation structures which will convey stormwater towards drain inlets at the at-grade base of the structure. The new drain inlets and pipes resulting from the new or realigned grade separated streets will be sized to collect and convey the 2-year storm flow.

B3.3. Roadway Underpasses

Where roadways are proposed to be relocated under the HST alignment stormwater will be collected in curb and gutters at the outside edges of the underpass which will convey stormwater towards intermittent drain inlets as the water flows to the low point. The drain inlets will convey stormwater to pipes and eventually into a wet well. From the wet well, stormwater will be pumped to an at-grade storage area designed to contain the 50-year storm event volume. The storage area will discharge, utilizing gravity, to the existing FMFCD storm drain lines at the 2-year event flow rate.

Table B-2
Roadway Structure Type

Roadway	Design Type
W McKinley Avenue	Retained Earth Overpass
McKinley Avenue Connector	New, At-Grade
N Weber Avenue	Re-Aligned, At-Grade
N West Avenue	Re-Aligned, At-Grade
N Golden State Blvd.	Re-Aligned, At-Grade
W Oliver Avenue	Retained Earth Overpass
W Belmont Avenue	Retained Earth Overpass
N H Street/N Weber Avenue	Re-Aligned, At-Grade
Wesley Avenue	Re-Aligned, At-Grade
N Thorne Avenue	Re-Aligned, At-Grade
Stanislaus Street	Retained Earth Overpass
Fresno Street	To be completed by others
G Street	Re-aligned, Overpass
Tulare Street	Underpass
Ventura Street	Underpass
E Church Avenue	Retained Earth Overpass
E Central Avenue	Retained Earth Overpass
E American Avenue	Embanked Earth Overpass