Infiltration Trench

Design Guidance

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California Department of Transportation
HQ Division of Design

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ac-ft	acre foot/feet
AASHTO	American Association of State Highway Transportation Officials
ASTM	American Society of Testing and Materials
BEES	Basic Engineering Estimating System
BMP	Best Management Practice
CRZ	Clear Recovery Zone, (AASHTO Clear Zone)
CDA	contributing drainage area
CF	cubic foot
cfs	cubic feet per second
CY	cubic yard
DPP	Design Pollution Prevention
DPPIA	Design Pollution Prevention Infiltration Area
EPA	Environmental Protection Agency
ft	foot/feet
FHWA	Federal Highway Administration
FP	Federal Project
ft/s	foot/feet per second
HQ	Headquarters
HDM	Highway Design Manual
H:V	Horizontal:Vertical
hr	hour
HRT	Hydraulic Residence Time
HSG	Hydrologic Soil Group
in	inch
in/hr	inches per hour
LID	Low Impact Development
max	maximum
MSL	Mean Sea Level
min	minimum
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
nSSP	non-Standard Special Provision
OHSD	Office of Hydraulics and Stormwater Design
PA/ED	Project Approval/Environmental Document
PDT	Project Development Team
PE	Project Engineer
PECE	Preliminary Engineer's Cost Estimate
PID	Project Initiation Document
PPCE	Project Planning Cost Estimate
PPDG	Project Planning and Design Guide – Stormwater Quality Handbook
PS&E	Plans, Specifications and Estimate
RWQCB	Regional Water Quality Control Board
sec	second
SQFT	square feet
SQYD	square yard
SSP	Standard Special Provision
SWDR	Stormwater Data Report
SWRCB	State Water Resources Control Board
TBMP	Treatment Best Management Practice
USCS	Unified soil classification system
USDA	United States Department of Agriculture
WQF	Water Quality Flow
WQV	Water Quality Volume

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Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating Infiltration Trench Treatment Best Management Practices (TBMPs) into projects during the planning and design phases of Caltrans highways and facilities. An Infiltration Trench is a narrow excavation backfilled with a high porosity material that has no outlet and is designed to create storage of highway drainage that treats runoff through infiltration. An Infiltration Trench may also be known as a water quality exfiltration trench. The primary functions of this document are to:

1. Describe an Infiltration Trench
2. Provide design guidance
3. Review the required elements for implementing an Infiltration Trench into Plans, Specifications, and Estimates (PS&E) packages
4. Provide a design example

It is assumed that the need for post construction TBMPs has already been determined in accordance with the guidelines and procedures presented in the Project Planning and Design Guide (PPDG; Caltrans 2019b).

The following guidance is provided based on Caltrans pilot studies and professional design experience. Designers may utilize alternatives to the calculation methodologies presented in this guidance. Alternative calculations and design decisions must be documented in the project Stormwater Data Report (SWDR) and the Project File. The SWDR template can be found in the PPDG.

1.1 Design Responsibility

The Project Engineer (PE) is responsible for the design of Infiltration Trench hydrology, hydraulics, grading, and traffic because they are part of the highway drainage system. The designer must consider the highway grading plans and the impacts stormwater infiltration may have on the roadway especially in consideration of the Clear Recovery Zone (CRZ). Coordinate with other functional experts to implement successful and functioning Infiltration Trenches.

Refer to Chapter 800 of the Highway Design Manual (HDM), the Headquarters (HQ) Office of Hydraulics and Stormwater Design (OHSD), and District Hydraulics for project drainage requirements. To achieve sustainability requirements, the Project Development Team (PDT) is encouraged to use native and climate appropriate vegetation that does not require irrigation and requires the least amount of maintenance.

1.2 Infiltration Trenches

Infiltration Trenches utilize relatively narrow excavations backfilled with gravel or other high porosity materials to create subsurface storage for runoff that will infiltrate into the surrounding soils over a design period. Infiltration Trenches are considered an LID BMP because of their flow attenuation capabilities.

Infiltration Trenches are sized to treat the WQV. This BMP is highly effective at removing sediments, nutrients, pesticides, full trash capture, metals, pathogens and bacteria, oil and grease, organics, turbidity, temperature, and mercury as noted in the PPDG and TC-10 of the California Stormwater Quality Association (CASQA) manual (CASQA 2003). Due to the effectiveness of treatment, consider infiltration first when selecting a TBMP for a Caltrans project.

An Infiltration Trench may be configured in any shape, although ease of construction should always be considered. In a typical configuration, the trench is formed against bare earth with a filter-fabric used as a separator rather than concrete walls, and with a curb or dike at its perimeter at the ground surface. The filter fabric is placed between the rock and the native ground to prevent soil from migrating into the void space.

An Infiltration Trench cross-section is shown in Figure 1-1. Because an A-1 curb is called for in the notes, this configuration would be appropriate for a parking lot, a low speed highway, or for placement outside of the CRZ. The WQV is stored in the void spaces of the Surface Gravel Layer and Trench Filler Material. The Surface Gravel Layer has an additional function of capturing sediments near the ground surface, with the result that maintenance may easily remove these sediments. Filter fabric is used to separate the Surface Gravel Layer and Trench Filler Material. Curbs are placed to limit damage to the device from errant wheel loads in accordance with HDM Topic 303 criteria, or curbs may be omitted where sheet flow to the device is acceptable. Consult with Geotechnical Design to determine if existing soil conditions require a filter fabric separation between native soil and Trench Filler Material. Consult with Geotechnical Design, Hydraulics, and Traffic Safety if within the CRZ.

Monitor the performance of the Infiltration Trench by using an observation well placed within the Infiltration Trench. This observation well can also be used to access the trench if maintenance is required (e.g. using a hose and pump to remove standing water). Monitoring well access should be placed at grade of the Surface Gravel Layer.

The calculations in this guidance assume instantaneous runoff to the BMP (i.e., 'slug-flow') which is likely conservative. Alternative sizing calculations, like unsteady-flow storage routing, may be used to refine the BMP size. When installed in a Type A or Type B soil, an increase in the WQV treated can be expected. See Section 3.1.

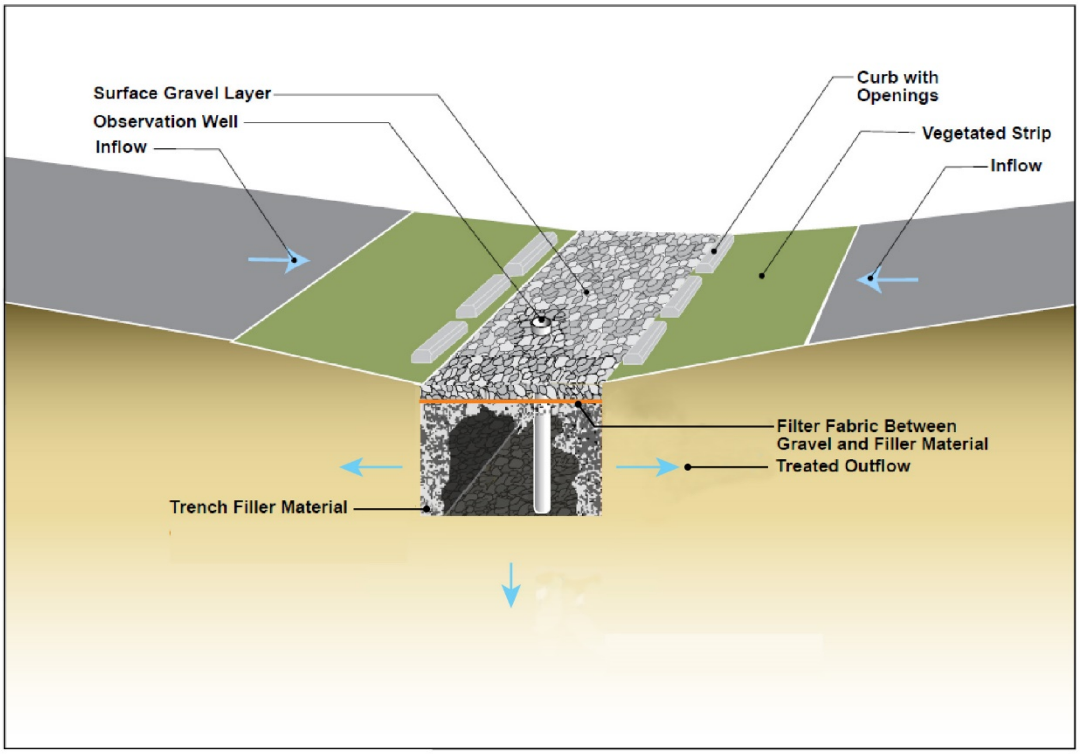

Figure 1-1. Typical Cross-Section of an Infiltration Trench[1]

[1] The bottom of the trench shall have a 0% slope in longitudinal and transverse directions.

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Section 2

Basis of Infiltration Trench Design

Infiltration Trenches may be considered for sites determined to be suitable for infiltration, sites with soils that meet infiltration requirements or can be amended to enhance infiltration, sites where safety criteria are met, and where flow velocities can be mitigated to prevent scour. The site should have sufficient area for pretreatment BMPs upstream of the trench.

Checklist T-1, Part 2 in the PPDG, assists in evaluating the initial feasibility of Infiltration Trenches for a project. The checklist identifies design elements that should be considered during the design of Infiltration Trenches. Once the feasibility of the device has been confirmed using Checklist T-1, Part 2 in the PPDG, use the following subsections to further understand the design elements of an Infiltration Trench for a given site.

The basis of design criteria and concepts for the Infiltration Trench described below have been determined to meet Caltrans' goals and objectives:

1. The Infiltration Trench must be able to retain the WQV, or portion thereof, in the void spaces within the Trench Filler Material.
2. Pretreatment to capture sediment in the runoff is required upstream of the Infiltration Trench to increase longevity of the system by using vegetation, forebay, sand trap, flow splitter with sump, etc. Pretreatment will also prolong the life of the BMP and maximize the period between heavy maintenance.
3. Curbs should be used to protect the trench from vehicles and designed in accordance with HDM Topic 303 criteria. The appropriate type of curb will depend on highway type and speeds. If the water enters the BMP as sheet flow then a curb would not be appropriate.
4. An observation well must be incorporated into the Infiltration Trench to monitor performance.
5. The trench geometric configuration must be sized to allow the runoff to drain within 96 hours. Required drain time may be more stringent based on District-specific or local vector requirements.
6. If placed inline, the upstream and downstream conveyance of the Infiltration Trench must be able to convey peak design flows from the contributing drainage area (CDA) that were used in the drainage system design for that roadway section[2].

[2] For convenience in this document, this Design Storm flow will be referred to as Q25, although other recurrence intervals may be used, as described in HDM Chapter 830, Transportation Facility Drainage. Confer with District Hydraulics.

2.1 Preliminary Design Criteria

Infiltration Trenches must meet certain design criteria to perform as an effective TBMP. The primary factors to be incorporated into the design are found below in Table 2-1.

Table 2-1. Infiltration Trench Design Criteria

Parameter	Minimum Value	Maximum Value
Runoff Volume[1]	For water quality treatment: WQV, or portion thereof	None, as long as other site conditions and requirements are met
Design Volume of Trench[2]	2.85 times design volume	2.85 times design volume
Total Depth of Trench (includes Surface Gravel Layer and Trench Filler Material)	3 ft	13 ft[3]
Surface Gravel Layer Thickness	0.5 ft	0.5 ft
Filter Fabric Flow Rate	95 gal/min/SQFT	95 gal/min/SQFT
Slope at Bottom of Trench (in both longitudinal and transverse directions)	0%	0%
Width	3 ft	25 ft suggested[3, 4,5]
Drawdown Time	12hr	96 hr[6]
In-Situ Infiltration Rate (Hydrologic Soil Groups [HSG] A, B, and C)	0.5 in/hr	2.5 in/hr[7]
Perimeter Curb Height	Varies[8]	Varies[8]
Observation Well	4-in diameter minimum, use weatherproof cap	4-in diameter minimum, use weatherproof cap

1. *Consult with the District/Regional NPDES Coordinator for feasibility analysis for WQVs less than 0.1 ac-ft.*
2. *With the porosity of the Trench Filler Material at 0.35. Alternative filler materials having higher porosities are currently being studied, which would reduce the volume. Consult with the District/Regional Design Stormwater Coordinator and OHSD. This will require a special design for structural design calculations to support maintenance vehicles.*
3. *To avoid classification as a Class V stormwater drainage well (underground injection well), the trench depth must not be greater than the largest surface dimension (Environmental Protection Agency (EPA) 2018).*
4. *Based on constructability.*
5. *Maximum width is dependent on stability of Trench Filler Material. For larger trenches, concurrence by Geotechnical Design, District/Regional Design Stormwater Coordinator, and District Maintenance Stormwater Coordinator is recommended.*
6. *The drawdown time may be as high as 96 hours. The recommended design drainage time is between 40 and 48 hours. Drawdown times longer than 96 hours may be allowable if vector controls meeting California Department of Public Health requirements are implemented. Coordinate with District/Regional Design Stormwater Coordinator.*
7. *If the measured infiltration rate is significantly higher, consider the impacts to groundwater quality based on depth to seasonally high groundwater. Coordinate with Geotechnical Design to discuss methods to mitigate high infiltration rates. Contact the District/Regional NPDES Coordinator prior to PS&E submittal to determine if consultation with the RWQCB is needed.*
8. *Design curb height in accordance with HDM Topic 303.*

2.2 Site Soils and Infiltration

When infiltrative type BMPs are proposed, infiltration testing and depth to seasonal high groundwater may be needed for the project. At the PID phase, use historic soil information or previous geotechnical reports from projects within the area to determine existing soil types and infiltration rates. Designers can use the Digital Archive of Geotechnical Data, (GeoDOG) to search archived geotechnical information at this location; https://geodog.dot.ca.gov/

The minimum effort required to determine infiltration rates may be obtained using Caltrans Water Quality Planning Tool (http://svctenvims.dot.ca.gov/wqpt/wqpt.aspx) using the NRCS maps layer (use the Soil Details layer under the Risk Level Determination subsection) to determine the Hydrologic Group at the location of the Treatment BMP. The Hydrologic Group can be input into Caltrans Infiltration Tool IT4 and the tool defaults to typical infiltration rates for each type of soil (A, B, C or D), bulk density, specific gravity and void ratios. Note this methodology is less desirable because soils most likely have been disturbed within the highway prism. It is up to the PE to determine the level of effort (including cost, schedule and scope issues) to determine the inputs into the Caltrans Infiltration Tool or other infiltration calculation methodology.

Coordination of geotechnical tests required for inputs to the Caltrans Infiltration Tool IT4 are recommended to be requested at the 0 phase while other soil testing is normally being conducted. Caltrans Infiltration Tool IT4 can be used to model the infiltration trench performance for the water quality storm event. Grain size curves will help determine the suitability of an area for infiltration. Locations that contain large fractions of silt and clay where the $D_{10} > 0.02$mm and $D_{20} > 0.06$mm may indicate slow infiltration rates.

At the PA/ED phase, preliminary geotechnical or site investigation studies are typically prepared and are used to further develop the discussion of the geotechnical features within the project. Well records can provide information regarding the depth from surface to seasonal high groundwater.

At the PS&E phase, the locations and details of the TBMPs are known and the project-specific Geotechnical Design Report is typically finalized. The Geotechnical Design Report should generally describe features that relate to stormwater quality design (e.g., types of soils, groundwater depth and conditions) and may include infiltration rates and the detailed soil testing performed at proposed stormwater TBMP locations. The findings of the report are used to update the BMP design assumptions.

Specific soils testing to be reported in the Geotechnical Design Report must be carefully considered. Soil testing, including determining the infiltration rate of site soils, should be completed as part of the Geotechnical request. The infiltration and soil property tests that may be considered for inclusion in the Geotechnical request are listed in Tables 2-2 and 2-3.

Table 2-2. Infiltration and Soil Properties Testing Table for Input into the Caltrans Infiltration Tool

Parameter	Test method(s)
Infiltration Rate, in/hr	CTM 750 (modified for shallow depth) ASTM D5126 (Single-Ring/Infiltrometer) ASTM D3385 (Double-Ring/Infiltrometer) ASTM D8152-18 (Modified Philip Dunne/Infiltrometer) CTM 220
Bulk Density, Dry Density, Water Content	ASTM D7263-09 ASTM D1557 CTM 216 – compaction behavior
Specific Gravity	CTM 209 – specific gravity of the soil ASTM D1557 ASTM D854
Void Ratio	ASTM D1556

Table 2-3. Other Possible Soil Tests

Parameter	Test method(s)
Hydraulic Conductivity, Saturated	ASTM D5856
Soil Classification	AASHTO M145 ASTM D2487
Particle Size Distribution	CTM 202 - sieve analysis CTM 203 - hydrometer
Remolded Moisture Curve	ASTM D698 ASTM D1557

In addition to the soil tests listed above there may be additional effort to ensure the effectiveness of the infiltration areas:

- Which project phase the tests are completed in, as some preliminary information may be needed prior to PS&E
- The number of tests needed and spacing of the tests (i.e., if the BMP is 50 ft long vs. 0.25 mile long) to adequately categorize conditions
- Shallow depth of geotechnical tests to estimate infiltration rates

2.3 Safety Considerations

Infiltration Trench BMPs should be located using the general roadway drainage considerations for safety and CRZ concept in the AASHTO manual (AASHTO 2011). Traffic safety is an important part of highway drainage facility design. The

Infiltration Trench should provide a traversable section for errant traffic leaving the traveled way within the CRZ (HDM Topics 304, 309, and 861.4).

Consult with District Traffic Operations for all proposed BMP placements to determine if guard railing is required. Infiltration Trenches should have detailing such as fences, that preclude ready access by the public. Consider installing warning signs.

Coordinate with other functional experts such as District Traffic Operations, District Maintenance, District Hydraulics, Geotechnical Design, and Traffic Safety, as applicable.

2.4 Alternative Trench Filler Materials

Typical trench filler material consists of permeable material with a specified mix of rock and gravel gradations that provide pore space for runoff to be stored until it is infiltrated into the surrounding soil. The sizing of an Infiltration Trench is controlled in part by the porosity available within the permeable material to store the WQV. Alternative materials for use as trench filler material that have been studied by Caltrans include sand and media filter drain mixture. Both materials can be used to increase storage capacity of the BMP and to allow for filtration of runoff. The type of sand and use is the same as other approved Caltrans treatment devices (i.e., media filters). The media filter drain media is a mixture of perlite, dolomite, gypsum, and crushed rock. The design of the media must be coordinated with the District/Regional Design Stormwater Coordinator. In addition to providing an increased storage capacity, the mixture provides treatment via filtering, adsorption, and ion exchange.

Infiltration Trenches can be designed using high-void-space materials, or storage cell media, which are proprietary modular systems that provide storage of water within the BMP. The storage cell media typically consists of a network of hard-perforated mats or cells that interconnect to form a box structure encased in geotextile filter fabric. As runoff enters the storage cell media, the water filters through the geotextile fabric and infiltrates into the native soil. Using storage cell media can make the BMP smaller because the void space within the storage cell is larger than that of soil and therefore, less volume of space is needed to contain the WQV. The use of storage cell media within an Infiltration Trench must be approved by the District/Regional Design Stormwater Coordinator. Other functional unit coordination can include Geotechnical Design, Traffic Safety, and District Maintenance Stormwater Coordinator.

2.5 Litter and Trash Considerations

Caltrans has developed a Statewide Trash Implementation Plan (Plan; Caltrans 2019c) to prevent the discharge of trash to surface waters through stormwater discharges. The Plan identifies statewide Significant Trash Generating Areas (STGAs) requiring consideration of full trash capture BMPs.

Full trash capture should be included in the design of an Infiltration Trench within a watershed where any of the following exists:

1. A Total Maximum Daily Load (TMDL) restriction for trash
2. Discharges to a 303(d) listed waterway for trash
3. Has been identified as an STGA
4. Required by a Regional Basin Plan

The Infiltration Trench is a Caltrans approved treatment device that can be certified as a multi benefit full trash capture BMP. The full-capture volume is calculated using the 1-year, 1-hour storm event depth. Refer to the Multi Benefit Treatment BMP Trash Full Capture Requirements Design Guide (Caltrans 2018) for specifics on design details.

Additionally, the PE may include a pretreatment device to capture the gross solids (e.g., paper, plastics, glass) and naturally occurring debris that may be conveyed by stormwater to the Infiltration Trench. The device should be designed to remove all litter and solids 5 mm and larger. This pretreatment can be provided by the Caltrans approved Gross Solids Removal Devices (GSRDs) TBMP or other devices that meet the requirements for full trash capture.

Use of other devices requires a detailed design by the PE and must be coordinated with the District/Regional Design Stormwater Coordinator, District Hydraulics, Traffic Safety, District Maintenance Stormwater Coordinator, and OHSD, as appropriate. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required. Design decisions and coordination on the trash device must be documented in the SWDR.

2.6 Restrictions/Coordination

Successful implementation and utilization of the Infiltration Trench as a TBMP will require proper siting by the PDT with coordination of District Hydraulics, District Maintenance, District Traffic Operations, District Landscape Architecture, Geotechnical Design, and Traffic Safety, as applicable per site design. Infiltration Trench design decisions and coordination must be documented in the SWDR and the project file.

Additional design criteria applicable to the use of the Infiltration Trench TBMP are as follows:

- Infiltration Trenches are not considered suitable in close proximity to a Drinking Water Reservoir or a Recharge Facility due to the difficulty in cleaning in the event of a spill[3].
- Infiltration Trenches should not be installed where there is inadequate soil infiltration rate (less than 0.5 in/hr and/or HSG Type D soils). Note that constructed embankments used to support highways are highly disturbed areas, and it is most likely that the infiltration rate will be degraded compared to that of native soils. These sites should not be considered without consultation with Geotechnical Design and other data sources.
- There may be locations, especially in an urban environment, where infiltration is not allowed. Coordinate with the District Hazardous Waste Coordinator and District/Regional NPDES Coordinator if Infiltration Trenches are proposed at locations having a previously identified contaminated groundwater plume below or near the proposed site. Coordinate with the Regional Water Quality Control Board (RWQCB) to discuss feasibility and design options in these locations.
- Protect groundwater and consider consultation with RWQCB if less than 5 ft separation from invert.
- Infiltration Devices must not present a potential hazard to building or bridge foundations, and therefore should not be used within 10 ft down gradient or 100 ft up gradient of building or bridge foundations. A project Geotechnical Design Report and approval are required if outside these criteria.
- In order to prevent gross slope instability, Infiltration Trenches are not considered appropriate when slopes are steeper than 15% (3.75H:1V). If trenches are proposed in steeper locations, a project Geotechnical Design Report and approval are required.
- Infiltration Trenches should not be located within 100 ft of a private well, septic tank, or drain field due to potential groundwater contamination concerns.
- Consideration of placement within a highway median should be done with the concurrence of District Traffic Operations and the District Maintenance Stormwater Coordinator.
- Areas contributing runoff directly into the Infiltration Trench should be stabilized and not be a source of sediments.

[3] Consult District/Regional NPDES Coordinator if an Infiltration Trench is being considered adjacent to a Drinking Water Reservoir or Recharge Facility.

- The BMP geometry and location design should consider future impacts. Assure that the BMP as designed (geometry and location), is maintainable and shown on project plans.
- Velocity of sheet flow onto the BMP must not cause erosion.
- Whenever possible provide some type of full trash capture, at the best available location within the trench, to create a multi benefit TBMP that has a full trash capture feature.

Because an Infiltration Trench relies on flow through a filter fabric, the device is prone to clogging if excessive sediment loads enter the device. Pretreatment to capture sediment in the runoff is required upstream of the Infiltration Trench to increase longevity of the system by using vegetation, forebay, sand trap, flow splitter with sump, etc. To further minimize the clogging potential, the design includes a Surface Gravel Layer underlain by filter fabric that acts as an initial filter and can be periodically removed and replaced as conditions warrant, rather than removing the entire rock volume.

Section 3
Getting Started

Evaluate site conditions to obtain and assess the design parameters that will be used to determine if an Infiltration Trench is suitable based on the Feasibility Criteria described in Section 2 and in the PPDG. An extensive geotechnical investigation is required for Infiltration Trenches, see the Infiltration Basins Design Guidance (Caltrans 2020b) for more information. This section provides the calculations that are used to verify BMP feasibility. Calculations for CDA length, longitudinal slope, and length of flow path can be obtained from the project design information, and therefore, an example of these calculations is not provided.

3.1 Preliminary Design Parameters

The calculations in this guidance assume instantaneous runoff to the BMP (i.e., 'slug-flow') which does not consider active treatment during the event, leading to conservative sizing designs. A sizing alternative to account for timing of runoff is to perform rainfall-runoff and unsteady-flow storage routing computations for the BMP. When the runoff is distributed over the duration of an event, early-event runoff can be treated and released before the peak runoff arrives. Using these calculations, the BMP does not need to be sized to store the entire runoff volume at once (i.e., 'slug-flow'), leading to smaller designs. By accounting for active treatment occurring during the event, an increase in the WQV treated by an Infiltration Trench can be expected. Details of this methodology and findings are discussed in the Review of Design Guidance for Sizing Media Filters for Stormwater Quality Treatment (Caltrans 2019e).

Additionally, when an infiltrative BMP is installed in a Type A or Type B soil the BMP footprint can be reduced while treating the same WQV. The following figure shows an example of how accounting for active treatment and native soil type using the Caltrans Infiltration Tool IT4 tool impacts BMP size. The example shows that in a Type A soil a BMP can be 60% smaller than if it were installed in Type C or Type D soils.

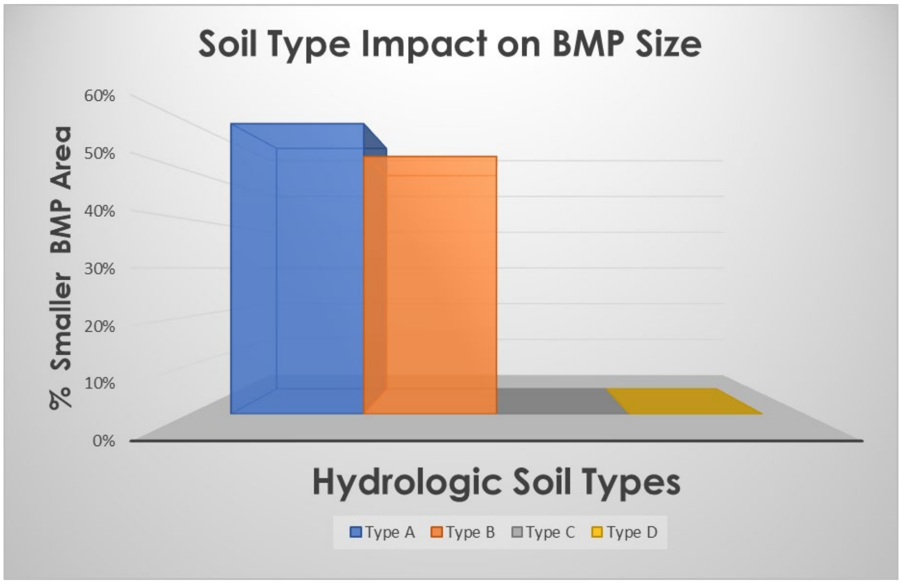

Figure 3-1. BMP Size Reduction Based on Soil Type

Alternative calculations may be used by the PE for a specific project and must be developed by a qualified professional in consultation with the District/Regional Design Stormwater Coordinator and documented in the SWDR. Consult with DEA and OHSD for design approval or to determine if a Special Design or pilot is required.

3.1.1 Contributing Drainage Area and WQV

The WQV generated by the BMP CDA is calculated using the Small Storm Hydrology Method (PPDG Section 5.3). The Caltrans Infiltration Tool IT4 can also be used when this BMP is modeled as an infiltration basin. An explanation of CDA delineation and WQV calculation and example can be found in Section 3 of the DPPIA Design Guidance (Caltrans 2019a).

3.1.2 Design Storm Event

When placed in an inline configuration, the Design Storm event will typically govern the Infiltration Trench design regarding shear stress and erosion. When placed inline, the BMP Surface Gravel Layer must be designed to convey peak drainage from the roadway in accordance with HDM Topic 831. Continue to use the runoff coefficients in HDM Topic 819.2 and the total BMP CDA for drainage design and flood flows. The permissible velocity and permissible shear stress of the Surface Gravel Layer during the Design Storm must be evaluated when sheet flows are expected to concentrate, see HDM Chapter 860 and Table 865.2.

3.2 Calculations

3.2.1 Geometric Requirements: Infiltration Trench with Vertical Sides

The geometric requirements of the Infiltration Trench are based on the WQV, the in-situ infiltration rate, and void space available in the trench. Note that the invert area of an Infiltration Trench having vertical sides is identical to the surface area.

To determine the invert area dimensions of an Infiltration Trench follow the steps below.

Step 1: Calculate the depth, D, as follows:

$$D = (k \times t)/(C \times SF \times 0.35) \qquad \text{(Eq. 1)}$$

Where:

D = depth of the Infiltration Trench (ft)

k = estimated soil permeability from Table 3-1 or from the Geotechnical Report[4] (in/hr)

t = drawdown time, 48 hr recommended

C = conversion factor (12 to convert from in to ft)

SF = safety factor of 2.0 for offline placement

0.35 = porosity of trench material (value for rock); value may change if other material is used

Note: in the calculations that follow, the elevation of the invert of the Infiltration Trench should be the highest of:

- that elevation associated with the depth calculated above
- the invert elevation should be no greater than 5 ft, unless shoring is used during construction. It can be up to 13 ft max below the original ground
- that elevation that provides the required minimum separation of the invert from the groundwater table

Step 2: Calculate the required excavated volume for the Infiltration Trench:

$$EV = WQV / 0.35 \qquad \text{(Eq. 2)}$$

Where:

EV = Excavated volume (CF)

WQV = Water Quality Volume or assigned volume for the project (CF)

[4] During the early phases of a project, if the soil permeability is not known the lowest acceptable permeability (0.5 in/hr) should be used, so that the maximum invert area is calculated. Once the in-situ soil permeability is determined, the depth and all subsequent calculations should be revised using the new value of permeability.

0.35 = porosity of trench material (value for rock); value may change if other material is used

Step 3: Once D and EV are obtained, calculate the invert area of the Infiltration Trench[5]:

$$A = EV / D \qquad \text{(Eq. 3)}$$

Where:

A = estimated or calculated area of invert of Infiltration Trench (SQFT)

EV = excavated volume (CF), as calculated in Eq. 2

D = Depth, as calculated in Eq. 1

Step 4: Calculate the invert dimensions for the Infiltration Trench:

$$A = L \times W \qquad \text{(Eq. 4)}$$

Where:

A = estimated or calculated area of invert of Infiltration Trench (SQFT), from Eq. 3

L = length of Infiltration Trench (ft)

W = width of Infiltration Trench (ft)

Adjust length and width to meet site constraints. Note: To avoid classification as a Class V stormwater drainage well (underground injection well), the trench depth must not be greater than the largest surface dimension (EPA 2018).

[5] The Infiltration Trench runoff is assumed to infiltrate vertically through the invert, and not horizontally through the sidewalls.

Table 3-1. Typical Infiltration Rates for Natural Resources Conservation Service (NRCS) Type, HSG, and Untied States Classification System (USCS) Classifications[1]			
NRCS Soil Type	HSG Classification	USCS Classifications	Typical Infiltration Rates (inches/hour)[2,3,4]
Sand	A	SP, SW, or SM	8
Loamy Sand	A	SM, ML	2
Sandy Loam	A	SM, SC	1
Loam	B	ML, CL	0.3
Silt Loam and Silt	B	ML, CL	0.25
Sandy Clay Loam	C	CL, CH, ML, MH	0.15
Clay Loam, Silty Clay Loam, Sandy Clay, and Silty Clay	D	CL, CH, ML, MH	< 0.05
Clay	D	CLM CH, MH	< 0.05

1. *USCS classifications are shown as approximation to the NRCS classifications. Note that the NRCS textural classification does not include gravel, while the USCS does. Note also that the gradation criteria (particle diameter) for the three soil types as used in the NRCS and the USCS, while agreeing in large part, are not congruent. Dual classifications in the USCS omitted. Infiltration estimates for USCS found in standard geotechnical references may vary from those shown for NRCS classifications, especially if significant gravel is present.*
2. *Infiltration Trench should be placed at locations with soils classified as HSG A, B, or C soils if geotechnical investigations demonstrate minimum infiltration rate of 0.5 in/hr. Maximum infiltration rate allowed for any Infiltration Device is 2.5 in/hr unless ground water protection is evaluated; RWQCB concurrence recommended.*
3. *When estimating the invert area for Infiltration Trenches placed in HSG Group B and C soils using the equations above, use the minimum infiltration rate of 0.5 in/hr to size the Infiltration Device until geotechnical investigation provides a field rate for the proposed location.*
4. *For Particle/Grain Size Distribution as it relates to typical infiltration rates, refer to https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba*

3.2.2 Geometric Requirements: Infiltration Trench with Sloped Sides

The procedure used above to calculate an Infiltration Trench having vertical sides can be modified to calculate the dimensions of one having sloping sides. This may be recommended by Geotechnical Services in locations where the soils are unlikely to stand vertically during construction.

To calculate the dimensions of an Infiltration Trench having sloping sides:

- Calculate D, EV, and A as shown in Steps 1 through 4 above.
- While holding the L and W as the invert dimensions, calculate the depth and surface dimensions for the site (the shape will define a trapezoid if all four sides slope at the same angle).

The final step is to verify that the excavated volumes (EVs) are equal for both Infiltration Trenches (i.e., vertical sides and sloping interior sides).

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Section 4

BMP Layout

This section discusses various detailing needed to place an Infiltration Trench within the project, including inline versus offline placement, pretreatment under either sheet flow or concentrated flow, and detailing of the conveyances carrying runoff into and away from the devices.

As part of BMP placement, the Design Storm that was used for the design of the roadway drainage system must be considered to verify adequate capacity for the overflow unless offline placement of the Infiltration Trench is made. Follow the requirements of Chapter 800 of the HDM.

Safety of the traveling public is paramount. Placement of this or any other TBMP must not cause objectionable headwater or violate requirements of Chapter 800 of the HDM. Specific consideration of the overall placement within a particular drainage system is beyond the scope of this document and should be coordinated with District Hydraulics.

4.1 Inline vs. Offline Placement

An Infiltration Trench can be placed in an inline or offline configuration; the offline configuration is preferred.

4.1.1 Inline Placement

An Infiltration Trench is placed in an inline configuration when the overflow events can only flow through the device (see Figure 4-1). Often this placement cannot be avoided due to space restrictions. Discussion of issues involved when inline placement is made is found in Section 4.3.

4.1.2 Offline Placement

Offline placement is provided when runoff in excess of the WQV is diverted around the Infiltration Trench by means of an upstream flow splitter. One benefit of flow splitting is to direct peak flows around the Infiltration Trench, especially if the peak flows are considered to be more likely to carry heavy sediments. Diverting peak flows will thus increase the time period between major maintenance efforts, but this benefit must be considered against the initial costs of the flow splitter itself. The procedures for design of flow diversion structures may be found in the Vault Flow Splitters Design Guidance (Caltrans 2020c).

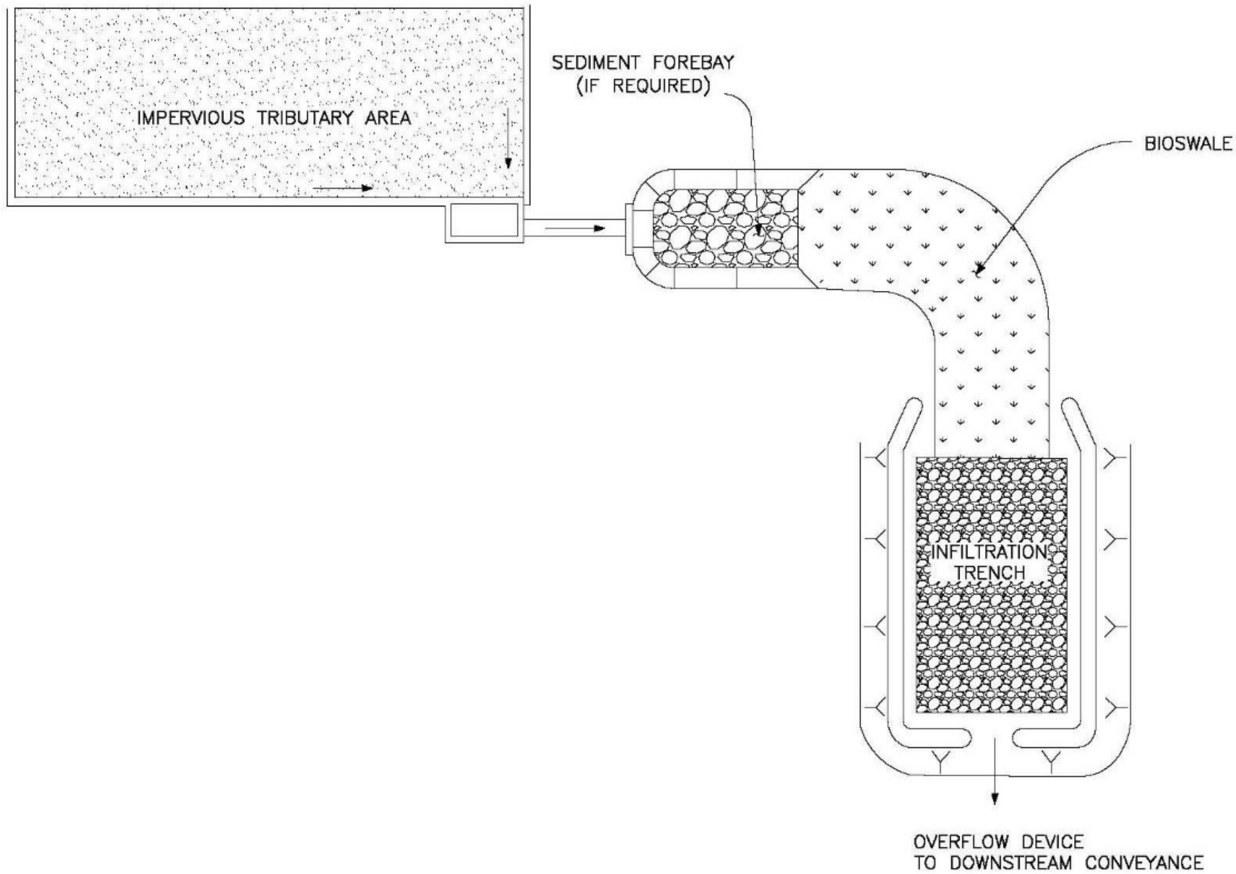

Figure 4-1. Schematic of an Inline Infiltration Trench

Receiving concentrated runoff from an open channel

4.2 Pretreatment of Runoff

This section addresses the pretreatment options required before the runoff enters the Infiltration Trench. This runoff should be pretreated in order to minimize the build-up of sediments in the device, which will ultimately impair performance.

4.2.1 Concentrated Flow into an Infiltration Trench

Stormwater runoff that is directed to an Infiltration Trench would usually be in a concentrated flow regime. Under those conditions, a vegetated swale should be the first choice for pretreatment. The swale could be either a Biofiltration Swale TBMP (having a minimum 5-minute Hydraulic Residence Time [HRT]) or a vegetated DPPIA if the HRT were less than 5 minutes. However, an HRT minimum of 2-minutes should be sought for pretreatment purposes. If a minimum 2-minute HRT cannot be provided by the upstream vegetated swale or vegetated DPPIA, then a Sediment Forebay should be placed immediately upstream of the Infiltration Trench.

4.2.2 Sheet Flow into an Infiltration Trench

Stormwater runoff entering under sheet flow conditions may be directed into an Infiltration Trench (e.g., from parking lots or roadways), if pretreatment is first provided. The sheet flow should be directed through a vegetated area or buffer strip adjacent to the Infiltration Trench (see Figure 4-2). When possible, the vegetated area should be designed to meet the requirements for a Biofiltration Strip. If site conditions do not fully meet the requirements for a Biofiltration Strip, a vegetated DPPIA can be used. However, it should be noted that use of sheet flow exclusively to fill an Infiltration Trench with the WQV will result in a long device.

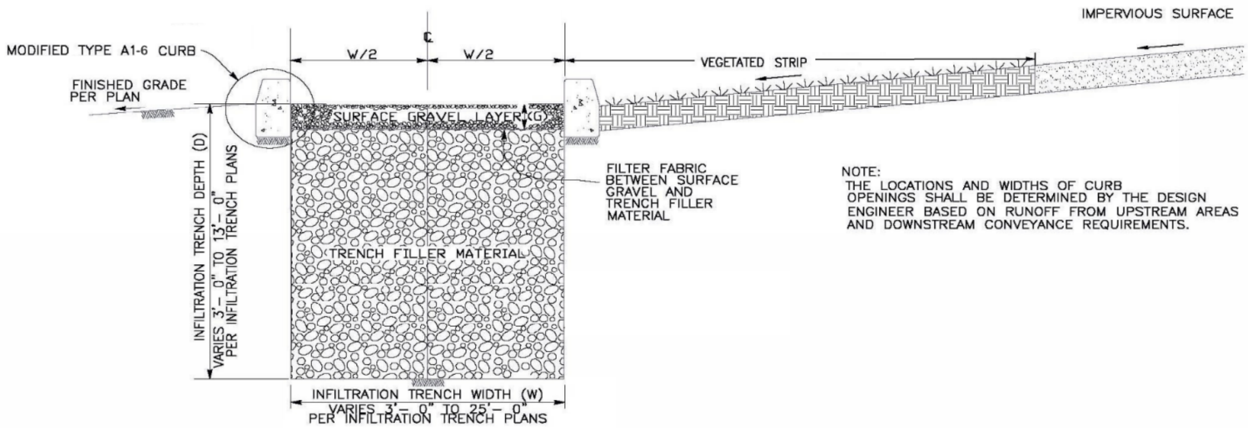

Figure 4-2. Vegetated Strip as a Pretreatment BMP for Infiltration Trench

4.3 Design Storm Used for Drainage Off The Roadway Highway Facility

WQV-based TBMPs that are designed for inline placement must also safely pass those events that are larger than the Water Quality Event. The design of the overflow event must be consistent with the intensity, duration, and frequency of the rainfall event used in the roadway drainage design for the CDA generating runoff to the TBMP, as discussed in HDM – Topic 831. While most TBMPs have a specific overflow device the Infiltration Trench does not because the overflow will simply pass over the top of the Infiltration Trench. Downstream of the Infiltration Trench, overflow must continue in a surface or subsurface conveyance. Consider erosion downstream of these BMPs during overflow events if surface conveyance is employed. Downstream conveyance design is beyond the scope of this document.

4.3.1 Detailing the Upstream End of the Infiltration Trench

Calculate the velocity of flow entering the Infiltration Trench particularly during the overflow event to determine if scour protection of the Surface Gravel Layer is required. If the velocity entering the proposed Infiltration Trench exceeds 3.7 fps, an energy dissipator will be required (HDM Table 865.2). Coordinate the design of an energy dissipator with District Hydraulics.

4.4 Space Considerations

4.4.1 Horizontal Clearances

Locate the Infiltration Trench outside of the CRZ (see HDM Topic 309). If this is not possible, consult with District Traffic Operations and Traffic Safety on design criteria.

4.4.2 Maintenance

Infiltration Trenches require sufficient access for maintenance and inspection. Locate the Infiltration Trench where adequate access is available for maintenance activities without requiring lane or shoulder closures. A space of six ft should be maintained whenever possible between moving traffic and the work area. Include nine ft for parking width for maintenance vehicle. The proposed location must be discussed with District Maintenance Stormwater Coordinator.

4.5 Perimeter Curbs

Perimeter curbs can help protect the trench surface from vehicles driving onto it, which can lead to breakage of the filter fabric or crushing of the interior rock. Curbs must be designed to allow inflow by sheet or concentrated flow and must accommodate the larger flows for drainage design. Curb openings can be designed to adequately convey the peak design storm runoff to the trench surface. When used, the perimeter curb should be in accordance with HDM Topic 303 - Curbs, Dikes, and Side Gutters.

Section 5

PS&E Preparation

This section provides guidance for incorporating Infiltration Trenches into the PS&E package, discusses the typical specifications that may be required, and presents information about estimating construction costs.

While every effort has been made to provide accurate information here, the PE is responsible for incorporating all design aspects of Infiltration Trenches into the PS&E in accordance with the requirements of Section 2 of the Construction Contract Development Guide (Caltrans 2019d).

5.1 PS&E Drawings

This section provides guidance for incorporating the Infiltration Trench TBMP into the contract plans. This TBMP does not include standard drawings or details except for two sheets, a cross section and a detail for an observation well. When an Infiltration Trench is included in project PS&E drawings may include the following:

- Layout(s): Show location(s) of the Infiltration Trench. This will aid in recognizing, both within and outside Caltrans, that Infiltration Trenches were placed within the project limits.
- Grading or Contour Grading(s): Associated grading surrounding the Infiltration Trench should be shown on these sheet(s).
- Drainage Plan(s), Profiles, Details, and Quantities:
  - The Drainage Plan sheets should show the Infiltration Trench in plan view. Other existing or proposed drainage conveyance devices that direct the runoff into the device should also be shown.
  - The Drainage Profile sheets should show the Infiltration Trench in profile within the drainage conveyance system. These sheets should also call out the specific inlet and outlet flow line (surface) elevations, as well as the trench invert elevation.
  - The Drainage Detail sheets should show detailing needed for the construction of the Infiltration Trench (e.g., curbing, inflow and outflow detailing). A cross section of an Infiltration Trench and an observation well detail are available from OHSD and could be included on these sheets.
  - The Drainage Quantity sheets should include all pay and non-pay items associated with the construction of the Infiltration Trench, except for those items that will be placed on the Summary of Quantities sheets.

- Temporary Water Pollution Control Plans: These sheets are used to show the temporary BMPs used to establish the Infiltration Trench BMPs and compliance with the Construction General Permit.

5.2 Specifications

Contract specifications for projects that include Infiltration Trenches will include Standard Specifications, Standard Special Provisions (SSPs), and non-Standard Special Provisions (nSSPs). In some cases, specific nSSPs have been developed by OHSD.

The special provisions needed for the various items of work to construct the Infiltration Trench could be organized under a blanket heading of 'Infiltration Trench' with some or all the required items listed as subheadings. Payment would be made for 'each' Infiltration Trench.

Optionally, separate listings could be made for each contract item of work, with separate measurements and payments. The PE and the District Office Engineer should consider which method would better serve the project.

5.2.1 Standard Specifications

Standard Specifications are to be used for a project that constructs an Infiltration Trench BMP. Consider the construction of the Infiltration Trench in the context of the entire project to determine what Standard Specifications are applicable. Within the Standard Specifications, these are the sections that will typically be applicable:

13 Water Pollution Control

17 General (Earthwork and Landscape)

19 Earthwork

64 Plastic Pipe

68 Subsurface Drains

70 Miscellaneous Drainage Facility

71 Existing Drainage Facilities

72 Slope Protection

73 Concrete Curbs

96 Geosynthetics

5.2.2 Standard Special Provisions

SSPs may be included for a project that constructs an Infiltration Trench TBMP. Additional SSPs may be required depending on the types of appurtenant facilities and materials proposed for the project. Consult the current index of SSPs available on the Office of Construction Contract Standards section of the

Caltrans website. Consider the construction of the Infiltration Trench in the context of the entire project to determine if other SSPs may be required.

5.2.3 Non-Standard Special Provisions

Below is an nSSP that may be applicable to Infiltration Trench TBMPs. It is possible that this nSSP will not apply to all situations. Ensure that the selected nSSPs are relevant when incorporated in the Contract Special Provisions. This nSSP can be obtained from OHSD:

- Trench Filler Material (Permeable Material Class 6)

Other nSSPs may be necessary for the project, including for alternative trench filler material (i.e., high-void-space materials) and special design considerations. Coordination with OHSD or other appropriate office may be necessary.

Infiltration Trench nSSPs are recommended, so the costs and location of Infiltration Trench can be captured and tracked for compliance with the NPDES permit.

5.3 Project Cost Estimates

Project Cost Estimates are required at every phase of the project – Project Initiation Document (PID), Project Approval/Environmental Document (PA/ED), and PS&E. The Caltrans Division of Design, Office of Project Support has developed the following website to assist in the development of cost estimates:

http://www.dot.ca.gov/hq/oppd/costest/costest.htm

This website includes links to Chapter 20 Project Development Cost Estimates of the Project Development Procedures Manual and Caltrans Cost Estimating Guidelines. In addition to Chapter 20, this website includes other useful cost estimating information on project cost escalation, contingency and supplemental work, and cost estimating templates for the planning and design phases of the project. These templates may be used to track estimates relating to costs for incorporating TBMPs.

5.3.1 PID and PA/ED Phases

A preliminary cost estimate, Project Planning Cost Estimate (PPCE), is required as an attachment of the SWDR during the PID phase of the project. A refined version of the PPCE is developed in PA/ED phase. For details on what needs to be included in PPCE, refer to Section 6.4.9 and Appendix F of the PPDG.

At the PID phase of the project, the construction cost for Infiltration Trenches could be estimated based on the findings of the BMP Retrofit Pilot Program Final

Report, which was $34/CF of WQV treated[6]. To determine an initial cost estimate using this value simply use the following equation:

Initial construction cost = ($34/CF) x WQV

This estimate will need to be modified as the project progresses. If some design is conducted during the PA/ED phase of the project, it is possible that a refined estimate could be made using the methods in Section 5.3.2. A cost escalation should be added for projects that are anticipated to advertise more than a year after the date of the estimate.

5.3.2 PS&E Phase

Preliminary Engineer's Cost Estimates (PECE) are initiated at the beginning of PS&E and are updated until the completion of PS&E. PECEs focus on the construction costs of the project and the stormwater BMPs, and are inputs to the Basic Engineering Estimating System (BEES). Verify the quantities for inclusion in the project cost estimate to identify which should be considered Final Pay items, and to determine appropriate unit prices for each. Develop all necessary earthwork quantities for each specific Infiltration Trench location, and determine limits of excavation and backfill.

5.4 Developing Infiltration Trench Cost Estimates

Develop a quantity-based cost estimate, regardless of availability of specific unit cost or quantity data. As the design process proceeds, the project cost estimate should be updated as new data becomes available. Identify contract items required to construct the Infiltration Trench. A challenging aspect of developing a cost estimate is determining the BMP limits of work. Only costs for work exclusively used to construct the TBMP should be included in the estimate.

Additionally, it may not be necessary to include costs for items that support the TBMP. For example, utility relocation, maintenance vehicle pullouts, traffic safety items, drainage systems, or other site design elements that are required for the project even if the TBMP was not needed. Include the costs for these items when they are exclusively required for the TBMP.

Table 5-1 includes typical contract items that may be included in the unit cost (CY and FT) estimate if they are required for Infiltration Trenches. Table 5-1 is not a complete list and must be modified on a project-specific basis to accommodate all aspects of design.

[6] In 2021 dollars inflated from 1999; contact District Office Engineer for appropriate run-up factors based on local experience. The initial cost included with pretreatment Biofiltration Strip, but this should be considered as a minor component of the cost.

Table 5-1. Example Infiltration Trench Estimate					
Contract Item	Type	Unit	Quantity	Price	Amount
Clearing and Grubbing		LS			
Excavation		CY			
Sand Bedding		CY			
Structure Backfill		CY			
Class 1 Permeable Material (Surface Gravel Layer)		CY			
Class 6 Permeable Material (Trench Filler Material)		CY			
Class D Filter Fabric		SQYD			
Observation Well		EA			
Minor Concrete		CY			
Erosion Control		SQFT			

When developing costs based on unit quantities, the unit costs should be based upon the most recent Caltrans Contract Cost Data Book, and recent District 8 Cost Data Base for current similar projects.

https://sv08data.dot.ca.gov/contractcost/

Use the project specifications, SSPs, and nSSPs to develop a list of items for which unit costs should be supplied. Carefully check that all items of work are accounted for either as pay or non-pay items.

Watch for the costs associated with permeable material for each specific Infiltration Trench location, because that item of work could have the most variable costs for this TBMP. For earthwork exclusive to Infiltration Trenches, use Section 19-2 Roadway Excavation or Section 19-3 Structure Excavation and Backfill of the Standard Specifications. Add the location and unit quantity of each Infiltration Trench to the quantity sheet for the Excavation line item. Consider the need for shoring to protect an existing highway feature when determining earthwork costs for the Infiltration Trench.[7]

Estimate the total cost of each Infiltration Trench used on the project for tracking TBMP costs at PS&E. Document all BMP costs in the project SWDR at PS&E.

[7] Note that if a sloping excavation cannot be allowed at the site or any portion of the site, the Contract Special Provisions must clearly indicate this requirement and shoring must be required, usually as a separate pay item.

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Section 6

Design Example

This section presents an example on how to implement the procedure presented in Section 3. The site chosen for this example is a proposed bridge expansion at Sea World Drive, District 7, located at Route 5. An aerial photograph of the site is provided in Figure 6-1.

Figure 6-1. Aerial Photograph of Sea World Drive, Route 5

Location of the proposed Infiltration Trench is circled.

Givens:

- Soil permeability (K_{est}) as 1.50 in/hr
- Precipitation depth (P) as 0.6 in
- Contributing drainage area (A) as 1.54 ac, 100 percent impervious
- Drawdown time (T) as 48 hr
- Trench length must be twice the width
- Ground surface elevation at proposed Infiltration Trench: 100 ft Mean Sea Level (MSL)
- Groundwater elevation below proposed Infiltration Trench: 75 ft MSL
- No Water Quality siting restrictions apply
- Calculate two alternatives for the trench filler material, use rock (porosity = 0.35) and use storage cell media (porosity = 0.80)

For Alternative A, trench filler material is rock where porosity = 0.35

Step 1A: Determine the WQV:

$WQV = R_v (P/12) A$

Where:

WQV	=	Runoff volume generated by the 85th percentile 24-hr storm event (CF)
R_v	=	Volumetric Runoff Coefficient, 0.89 – from PPDG Section 5.3 for 100 percent impervious drainage area
P	=	Precipitation Depth, 0.6 in
A	=	Contributing Drainage Area, 1.54 ac = 67,082 SQFT

WQV = 0.89 x 0.60 in (1 in /12 ft) x 67,082 SQFT = 2,985 CF

Step 2A: Next, calculate the required depth of the Infiltration Trench (D), as follows:

$D = (k_{est} \times t)/(C \times SF \times 0.35)$

Where:

D	=	depth of the Infiltration Trench (ft)
k_{est}	=	estimated soil permeability, 1.5 in/hr
t	=	drawdown time, 48 hr
C	=	conversion factor (12 to convert from in to ft)
SF	=	safety factor of 2.0
0.35	=	porosity of void material (value for rock shown)

D = (1.5 in/hr x 48 hr)/(12 in/ft x 2.0 x 0.35) = 8.57 ft, for an elevation of 91.42 ft MSL

Check: the elevation of the invert of the Infiltration Trench should be the highest of:

i) that elevation associated with the depth calculated above, 91.42 ft MSL

ii) no greater than 13 ft below the original ground surface, 87.00 ft MSL

iii) minimum separation of the invert from the groundwater (10 ft), 85.00 ft MSL

91.42 ft MSL controls depth

Step 3A: Next, calculate the required excavated volume for the Infiltration Trench:

EV = WQV / 0.35

Where:

EV	=	excavated volume (CF)
WQV	=	Water Quality Volume (CF)
0.35	=	porosity of void material (value for rock shown)

EV = 2,985 CF / 0.35 = 8,529 CF

Step 4A: Once the depth and excavated volume are obtained then calculate the invert area of the Infiltration Trench:

A = EV / D

Where:

A	=	estimated or calculated area of invert of Infiltration Trench (SQFT)
EV	=	excavated volume (CF)
D	=	depth of the trench (≤13 ft)

A = 8,529 CF / 8.57 ft = 995 SQFT

Step 5A: The final step is to calculate the invert dimensions for the Infiltration Trench:

A = L x W

Where:

A	=	estimated or calculated area of invert of Infiltration Trench (SQFT)
L	=	length of Infiltration Trench (ft)
W	=	width of Infiltration Trench (ft)

Adjust length and width to meet site constraints. Per the problem statement, length must be twice the width at this location, giving:

A = 2W x W, then 995SQFT = $2W^2$ giving W = 22.30 ft, and L = 44.60 ft

For Alternative B, use storage cell media as the trench material where porosity = 0.80

Step 1B: Determine the WQV:

$WQV = R_v\ (P/12)\ A$

Where:

WQV = Runoff volume generated by the 85th percentile 24-hour storm event (CF)

R_v = Volumetric Runoff Coefficient, 0.89 – from PPDG Section 5.3 for 100 percent impervious drainage area

P = Precipitation Depth, 0.6 in

A = Contributing Drainage Area, 1.54 ac = 67,082 SQFT

WQV = 0.89 x 0.60 in (1 in /12 ft) x 67,082 SQFT = 2,985 CF

Step 2B: Next, calculate the required depth of the Infiltration Trench (D), as follows:

$D = (k_{est} \times t)/(C \times SF \times 0.80)$

Where:

D = depth of the Infiltration Trench (ft)

k_{est} = estimated soil permeability, 1.5 in/hr

t = drawdown time, 48 hr

C = conversion factor (12 to convert from in to ft)

SF = safety factor of 2.0

0.80 = porosity of void material (value for storage cell media shown)

D = (1.5 in/hr x 48 hr)/(12 in/ft x 2.0 x 0.80) = 3.75 ft, for an elevation of 96.25 ft MSL

Check: the elevation of the invert of the Infiltration Trench should be the highest of:

i) that elevation associated with the depth calculated above, 96.25 ft MSL

ii) no greater than 13 ft below the original ground surface, 87.00 ft MSL

iii) minimum separation of the invert from the groundwater (10 ft), 85.00 ft MSL

96.25 ft MSL controls depth

Step 3B: Next, calculate the required excavated volume for the Infiltration Trench:

EV = WQV / 0.80

Where:

EV = excavated volume (CF)

WQV = Water Quality Volume (CF)

0.80 = porosity of void material (value for storage cell media shown)

WQV = (DWQ) x (C) x (A)

EV = 2,985 CF / 0.80 = 3,731 CF

Step 4B: Once the depth and excavated volume are obtained then calculate the invert area of the Infiltration Trench:

A = EV / D

Where:

A = estimated or calculated area of invert of Infiltration Trench (SQFT)

EV = excavated volume (CF)

D = depth of the trench (≤13 ft)

A = 3,731 CF / 3.75 ft = 995 SQFT

Step 5B: The final step is to calculate the invert dimensions for the Infiltration Trench:

A = L x W

Where:

A = estimated or calculated area of invert of Infiltration Trench (SQFT)

L = length of Infiltration Trench (ft)

W = width of Infiltration Trench (ft)

Adjust length and width to meet site constraints. Per the problem statement, length must be twice the width at this location, giving:

A = 2W x W, then 995 SQFT = $2W^2$ giving W = 22.30 ft, and L = 44.60 ft

Step 6: Determine if the project site will allow the calculated width and length. If the site cannot accommodate the area, a new width and length must be calculated using up to the maximum trench depth allowed, which is 13 ft. For this example, the above dimensions calculated will fit and no further design is required.

Additional steps:

- Final concurrence of the design location and size must be obtained from District Maintenance Stormwater Coordinator. If access is not already present, consider a gravel or paved access.
- A complete geotechnical study appropriate for the final design should be conducted at the site.
- Energy dissipator should be considered upstream and downstream of the Infiltration Trench, if the expected shear stress may cause erosion of the rock or soil.
- Overtopping the perimeter curbs or Infiltration Trench during the Q_{25} event should be considered for erosion of the slope or drainage system (HDM Chapter 860).
- Pretreatment recommendations using a DPPIA , Biofiltration Swale, Biofiltration Strip, and/or a Sediment Forebay must be analyzed and placed into the contract plans when required.
- Briefly document the Infiltration Trench design in the SWDR.

Section 7

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