Traction Sand Traps

Design Guidance

December 2020

California Department of Transportation
HQ Division of Design

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
BEES	Basic Engineering Estimate System
BMP	Best Management Practice
CDA	contributing drainage area
CF	cubic feet
CF/yr	cubic feet per year
CIP	Cast-in-Place
CMP	Corrugated Metal Pipe
CRZ	Clear Recovery Zone, (AASHTO Clear Zone)
CY	cubic yard
DPPIA	Design Pollution Prevention Infiltration Area
ft	foot/feet
H:V	Horizontal:Vertical
HDM	Highway Design Manual
HQ	Headquarters
in	inch/inches
lbs	pounds
lbs/cf	pounds per cubic feet
NPDES	National Pollutant Discharge Elimination System
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
RTL	Ready to List
sec	Second
SQFT	square feet
SQYD	square yard
SSHM	Small Storm Hydrology Method
SSP	Standard Special Provision
SWDR	Stormwater Data Report
TBMP	Treatment Best Management Practice
TST	Traction Sand Trap
WQF	Water Quality Flow
WQV	Water Quality Volume

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Section 1

Introduction

This document provides guidance to Caltrans Designers for incorporating Traction Sand Traps (TSTs) Treatment Best Management Practices (TBMPs) and Detail Drawings into projects during the planning and design phases of Caltrans highways and facilities. TSTs are Caltrans-Approved Treatment Best Management Practices (TBMPs). The primary functions of this document are to:

1. Describe a TST
2. Provide design guidance
3. Review the required elements for implementing a TST 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 2019a).

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 TST 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 treatment may have on the roadway especially in consideration of the clear recovery zone (CRZ). Coordinate with other functional experts to implement successful and functioning TSTs.

Refer to Chapter 800 of the Highway Design Manual, 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 Traction Sand Traps

TSTs are devices that are used to capture sand from stormwater runoff and should be used at sites where traction sand or abrasives are applied to the roadway at least twice a year. When it snows, abrasives are commonly applied to the roadway for traction. As the snow melts, or during subsequent storm events, the stormwater has the potential to transport sand to the storm drain system and ultimately to a receiving water body. This can result in sediment and other pollutants entering the stormwater. TSTs are deployed to collect the sand and prevent sediment discharges while decreasing the potential for clogging. A typical TST is a sedimentation device that temporarily detains runoff and allows traction sand to settle out, while accommodating peak hydraulic flows. TSTs are recommended for the following pollutants of concern:

- Traction Sand
- Cinders

1.3 Types of Traction Sand Traps

There are four basic types of TSTs:

1. Modified Pipe Inlet: Corrugated Metal Pipe (CMP), Reinforced Concrete Pipe (RCP), and Cast-in-Place (CIP) types
2. Loading Docks: CIP and K-rail types
3. Earthen Berm
4. Sand Vault.

Each type is suitable for a specific range of conditions. The following guidance will aid in determining the most appropriate type of TST to use for a specific site. Sample plans developed by OHSD for the Modified Pipe Inlet, Loading Dock and Earthen Berm, and Concrete Sand Vault type TSTs are available by request. Consult with Geotechnical Design, Hydraulics, Maintenance, and Traffic Safety if within the CRZ.

1.3.1 Modified Pipe Inlet

The Modified Pipe Inlet TSTs name is derived from a Caltrans standard detail and can be made of CMP, RCP, or CIP concrete. The CMP and RCP types are below-grade structures that use commercially available CMP or RCP pipe placed vertically with an outflow pipe offset from the invert of the trap to capture sand and sediment. CMP and RCP type TSTs can be used in either a single- or double-barrel configuration (See Figure 1-1). CIP type TSTs function in a manner similar to the CMP and RCP types, but also function as a standard catch basin and are comparable in the way they are constructed and placed (See Figure 1-2). Sites that have small traction sand volumes and/or limited space are the most suitable for modified

CMP, RCP, and CIP traps. Weepholes are also used to eliminate standing water but do have a tendency to clog over time.

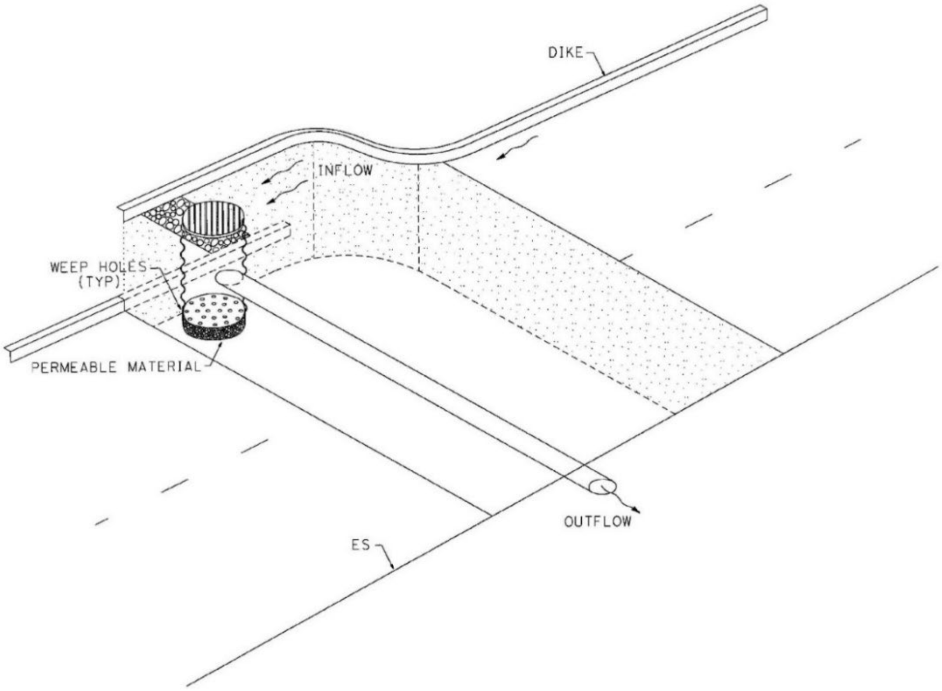

Figure 1-1. CMP Grate Inlet
A curb opening inlet can also be used for Figure 1-1.

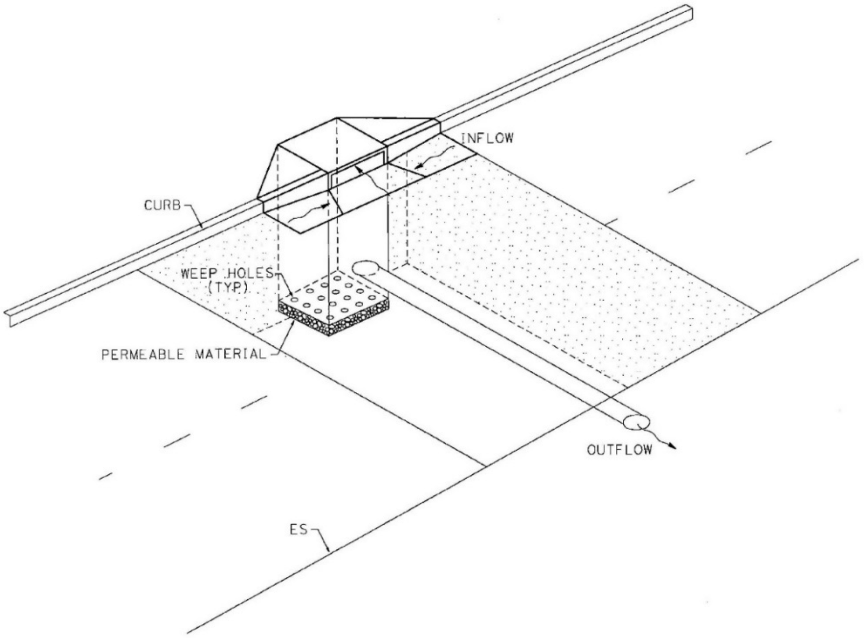

Figure 1-2. CIP Curb Inlet
A grate opening inlet can also be used for Figure 1.2.

1.3.2 Loading Dock

The Loading Dock TST, sometimes called a Snow Go, is designed as a sedimentation basin used to settle and store the anticipated traction sand volume. The sedimentation basin is sized to retain the traction sand volume and the sediment load associated with site conditions as calculated in Section 3. There are two varieties of Loading Dock TSTs: CIP and K-rail (See Figures 1-3 and 1-4, respectively). A Loading Dock TST is most appropriate when a large amount of recovered traction sand is estimated and right of way and visual impacts are not a concern. A Loading Dock TST may also be used as a sediment forebay for other TBMPs, such as Infiltration Devices or Media Filters. Use filter fabric in front of the gabion wall (See Figure 1-3) to increase the amount of captured sand in the CIP loading dock. Consult with the District Maintenance Stormwater Coordinator.

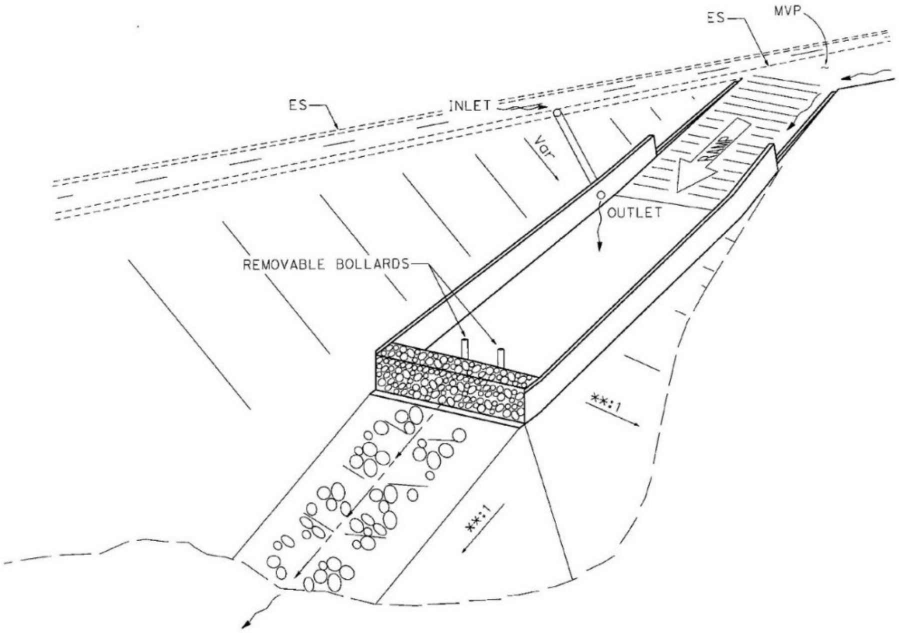

Figure 1-3. CIP Loading Dock

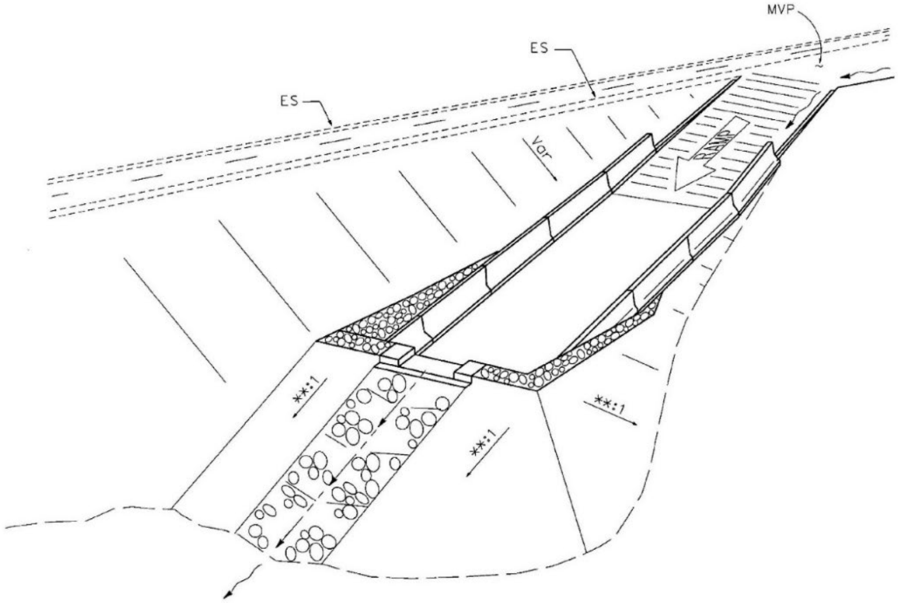

Figure 1-4. K-rail Loading Dock

1.3.3 Earthen Berm

The Earthen Berm type TST is similar to the Loading Dock type TST but does not use CIP concrete or Temporary Railing (Type-K) to stabilize the basin walls. The Earthen Berm type TST may be used in series with Infiltration Devices or other TBMPs as a pre-treatment device. In this configuration, the Earthen Berm type TST acts as a sedimentation basin and is separated from the Infiltration or other TBMP by a partially buried Temporary Railing (Type-K) that acts as a sediment weir. The traction sand settles in the Earthen Berm type TST and the water flows over the sediment weir into the Infiltration Device or other TBMP (See Figure 1-5). This type of TST is most appropriate when a large amount of recovered traction sand is estimated, visual impacts are a concern, and right of way is not limited. Consult with the District Maintenance Stormwater Coordinator.

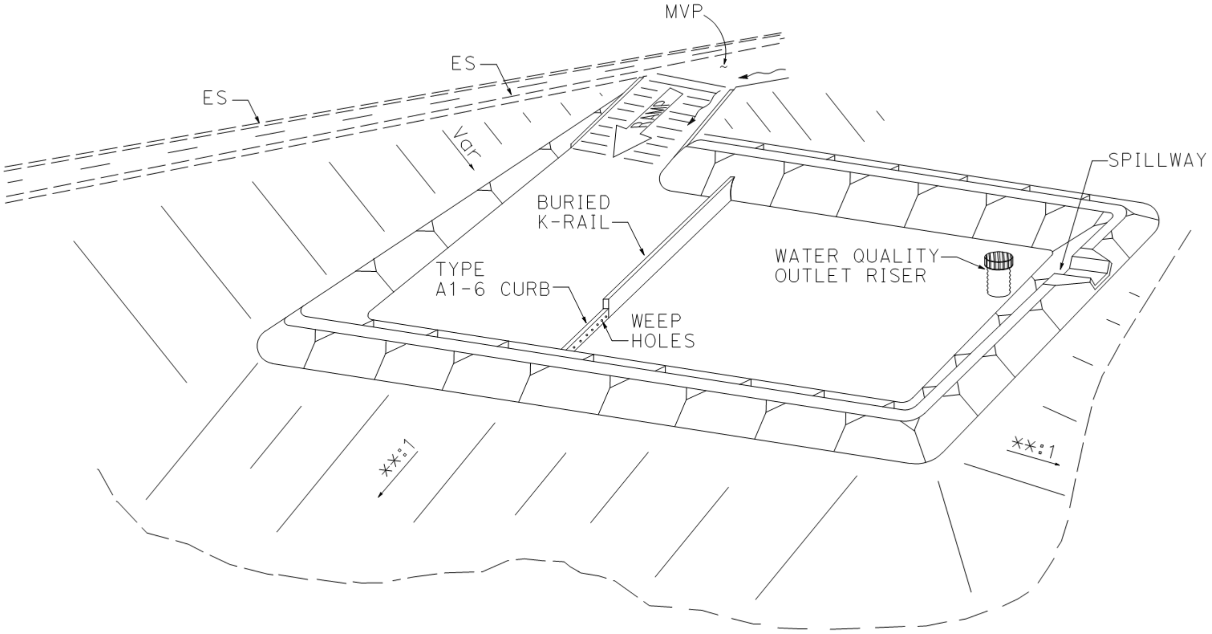

Figure 1-5. Earthen Berm

1.3.4 Sand Vault (In-Line and Side-by-Side)

The Sand Vault TST consists of one or more underground structures placed in-line or side-by-side within storm drain systems to capture traction sand. The vault has a sedimentation chamber to slow flow velocities and settle sand (See Figure 1-6). This type of TST is most appropriate when a large amount of recovered traction sand is estimated and limited right of way is a concern. Maintenance of this type of TST must be considered during design. Since this is an enclosed space the access hatch should be of sufficient size to allow all areas of sand storage to be access by a vacuum truck without the necessity of Maintenance personnel having to enter the TST. Consult with the District Maintenance Stormwater Coordinator.

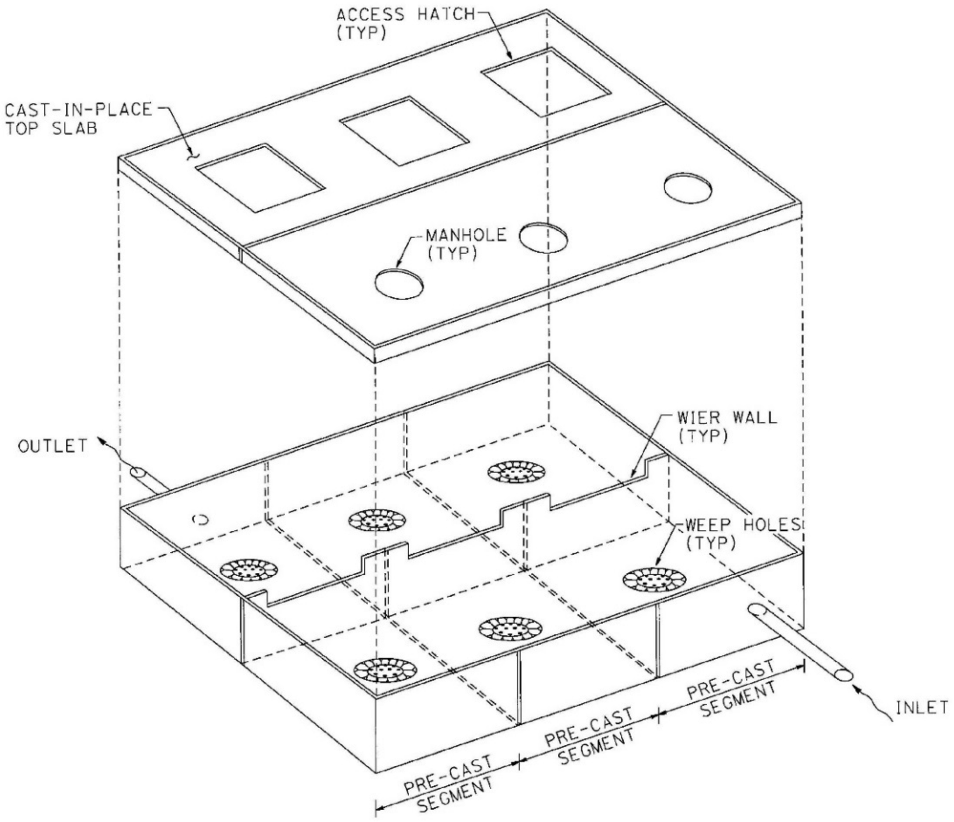

Figure 1-6. Sand Vault

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Section 2

Basis of TBMP Design Considerations

TSTs are TBMPs which temporarily detain runoff to allow traction sand or abrasives to settle prior to the runoff being discharged. The parameters for selecting the most appropriate type of TST for a specific location include the tributary area contributing traction sand to the sand trap, the contributing drainage area (CDA) to determine Design Storm flow rates for sizing, the surrounding physical terrain, and the available right of way. The estimated volume of sand recovered in the sand trap determines the minimum storage required in the proposed sand trap. After the storage volume is known, the site restrictions should be considered.

2.1 Selection Criteria

TSTs should be sized so that they have sufficient volume to store captured sand through the winter season. The designer should consider incoming flow conditions when selecting the type of TST. For a Modified Pipe Inlet TST or Vault type TST, flow will be turbulent in the chamber due to its confined space. A Loading Dock TST should be designed to minimize re-suspension of solids by placing the inflow point (i.e., the outlet end of a drainage pipe, reference Figure 1-3) at the upstream end of the storage area. It is preferred to separate the roadway pavement drainage from the adjacent slope drainage by utilizing a curb or a dike to direct only runoff from the roadway into a TST. Maintenance effort and safety concerns should also be considered during siting of the TST, see Section 2.5. Table 2-1 summarizes the siting criteria for the various types of TSTs. Consult with District Maintenance Stormwater Coordinator.

Table 2-1. Summary of Selection Criteria

TST Type	Footprint	Storage Capacity	Access
Modified Pipe Inlet	Small	Small	Vehicle Pullout[1]
Loading Dock	Large	Large	Access Road may be required depending on siting
Earthen Berm	Large	Large	Access Road may be required depending on siting
Sand Vault	Large	Large	Vehicle Pullout[1]

1. *For definition of vehicle pullout, see Section 6.2.2*

2.2 Modified Pipe Inlet

Modified Pipe Inlet TSTs are relatively small in footprint and sediment storage capacity. These TSTs are good for limited right of way and are relatively easy to maintain with a vacuum truck. The Modified Pipe Inlet is an underground structure and is easy to install. Modified Pipe Inlets function by intercepting runoff and detaining it long enough such that the detained traction sand settles out in the device prior to the runoff being discharged. The capacity of the TST is based on the elevation difference of its invert and six inches below the invert of the outlet pipe, or the trap. Short road segments with low net traction sand volumes are most suitable for Modified Pipe Inlet TSTs. The Engineer should refer to HDM Topic 829.2(4) for pipe cover requirements. A schematic is shown in Figure 2-1.

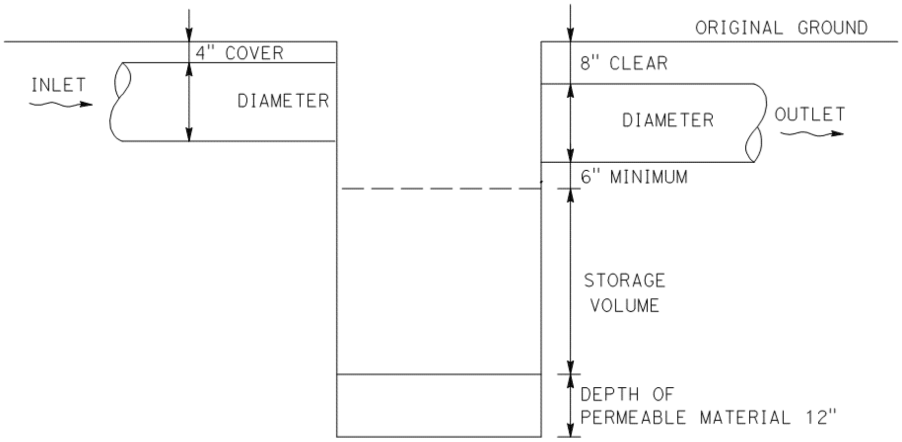

Figure 2-1. Modified Pipe Inlet TST – Available Storage

2.2.1 Type Selection

There are two typical configurations for a Modified Pipe Inlet TST. The first type uses commercially available CMP or RCP. The pipe is placed vertically and typically ranges from 5 to 10 feet (ft) in depth. To capture sand, the outflow pipe invert is offset from the invert of the vertical riser, creating a sump or trap. A common variation of this type of TST is the Double Barrel Sand Trap. A curb inlet is recommended as it does not easily clog; however, a pipe inlet or side inlet is preferred. At the invert of the Modified Pipe Inlet TST, a layer of permeable material is placed to allow infiltration in the native ground. Weepholes are sometimes drilled into the bottom of the CMP or RCP to drain the TST.

The second typical configuration is a CIP inlet. Its physical characteristics are similar to CIP catch basins. Similar to the CMP and RCP configurations, the outflow pipe is raised above the invert to create a trap and weepholes are provided at the bottom to drain. Its inlet can be a grate or a curb opening type; a curb opening inlet is preferred.

2.2.2 Maintenance

Rocks and/or other permeable materials are placed at the TST invert to allow percolation. This material must be removed, and the TST must be periodically cleaned out to remove trapped sediment. To reduce maintenance effort, a layer of geotextile can be placed between the permeable material and the bottom of the TST. Weepholes are utilized to drain the TST and avoid vector issues. A vehicle pullout shall also be provided for routine maintenance to eliminate the need for a lane closure. For the CMP type of Modified Pipe Inlet, the connection pipe should be a minimum diameter of 12 inches and a maximum diameter of 24 inches.

2.2.3 Siting Criteria

Modified Pipe Inlet TSTs should be designed to capture the estimated traction sand volumes calculated in Section 3.2 and applied within the designated tributary area. The device should be placed to minimize negative upstream or downstream effects when the trap exceeds treatment capacity. The safety of Maintenance personnel must be taken into account. Finally, siting criteria should be closely followed to increase effectiveness of the TST and minimize issues during maintenance.

General recommended design criteria for the Modified Pipe Inlet are shown in Table 2-2.

Table 2-2. Modified Pipe Inlet Design Criteria

Parameter	Min. Value	Max. Value
Total Depth (Measured from Base of Permeable Material to FG of Roadway)	5 ft	10 ft
Diameter (CMP and RCP only)	36 in	36 in
Storage Volume Depth	1.5 ft	7.0 ft
Depth of Permeable Material	12 in	20 in

The recommendations for design are the following:

- Standardize sizing where possible
- Consider appropriately sized tributary areas, see Section 3.2
- Incorporate maintenance vehicle pullout to eliminate lane closures where feasible (if maintenance vehicle pullout is not feasible, obtain Maintenance approval)
- Consider silting in cut slope areas, see Section 3.2.6
- Encase structure in permeable material
- Verify required minimum separation between invert and seasonally high groundwater is met
- Add weepholes

2.3 Loading Dock

There are three types of Loading Dock TSTs: CIP, K-rail, and Earthen Berm. Their main advantage is that traction sand can easily be removed with a loader. They have large footprints as well as large sediment storage capacities which require adequate right of way, and an access road for routine maintenance with safe ingress and egress onto a highway. The Loading Dock TST includes an overflow spillway as an alternative outlet for flows generated by large storm events. The spillway also prevents the overtopping of Loading Dock walls. Energy dissipation, such as riprap, may be necessary at the discharge point or outlet pipe if the velocities exceed values presented in HDM Tables 862.2 and 873.3E.

CIP Loading Dock TSTs require additional considerations such as formwork and have a longer construction duration. A schematic is shown in Figure 2-2.

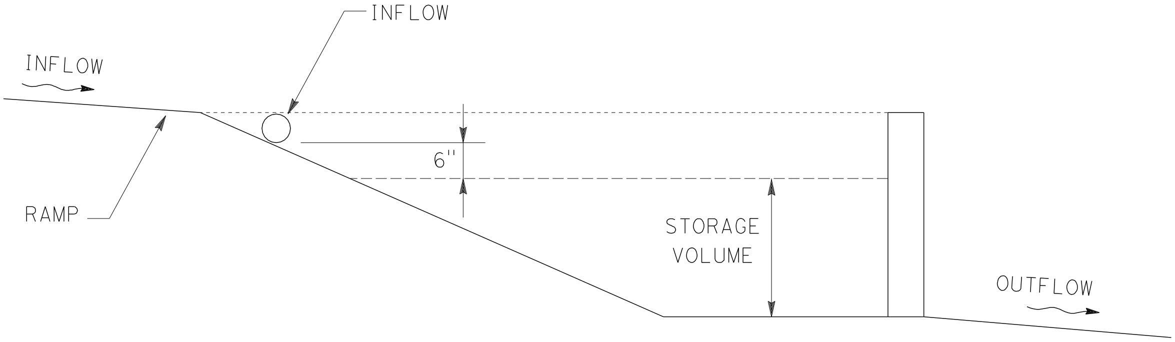

Figure 2-2. Loading Dock TST – Available Storage

2.3.1 CIP Loading Dock

The CIP Loading Dock incorporates CIP concrete retaining walls and floors. Stormwater runoff can flow directly into the Loading Dock or can be intercepted by a drain inlet and conveyed via a pipe to the Loading Dock. The floor of the Loading Dock is designed to produce low velocity flows which allows traction sand to settle. Water is discharged via gabion walls and low flow outlets. Energy dissipation and overflow spillways are used similarly as discussed previously.

2.3.2 K-Rail Loading Dock

The K-rail Loading Dock utilizes both K-rail and CIP concrete retaining walls to store traction sand. K-rail is generally used along the sides of the Loading Dock while the CIP concrete retaining wall is used at the downstream end. Stormwater runoff sheet flows directly into the Loading Dock or can be conveyed by a curb or dike into the area. Energy dissipation and overflow spillways are used similarly as discussed previously. K-rail type TSTs are relatively quick to construct. For low flow conditions, a water quality outlet riser should be installed with a drain time of no more than 96 hours. Details of water quality outlet risers can be found in Section 9 of the Supplemental Details Design Guidance (Caltrans 2020b).

2.3.3 Earthen Berm

Earthen Berms form the perimeter of the TST to retain traction sand. Earthen floors are preferred, although concrete may be used for the invert. Stormwater runoff can flow directly into the Earthen Berm type TST or can be intercepted by a drain inlet and conveyed to the basin by means of a storm drain. For low flow conditions, a water quality outlet riser should be installed with a drain time of no more than 96 hours. Energy dissipation and overflow spillways are used similarly as discussed for Loading Docks. Earthen Berms are easier to construct than the CIP or K-rail type Loading Docks, but still require an access road for routine maintenance.

2.3.4 Siting Criteria

General recommended design criteria for the Loading Dock TST are as presented in Table 2-3.

Table 2-3. Loading Dock Design Criteria

Parameter	Min. Value	Max. Value
Design Flow	NA	HDM
Sand Retention Volume	Up to 100%	Up to 100%
Side Slope, H:V	4:1	Vertical (For Earthen Berm use 3:1)
Invert Slope	1%	16%
Length	10 ft	40 ft
Width	12 ft	20 ft
Depth (Cable safety railing or fence required if depth is over 4 ft)	4 ft	4 ft

The recommendations for design are the following:

- Consider appropriate tributary area, see Section 3.2
- Consider silting in cut slope areas, see Section 3.2.6
- Provide access road
- Discharge treated water via gabion walls and/or low flow outlets
- Discharge flows generated by large storm events via overflow spillway
- Provide flared end section at inlet to TST
- Incorporate concrete retaining walls or K-rail, excluding Earthen Berm
- Provide energy dissipaters if flows exceed recommended values in HDM Chapter 830
- Provide concrete floor (CIP type only)
- Provide Water Quality Outlet
- Consult with the District Maintenance Stormwater Coordinator.

2.4 Sand Vault (In-Line and Side-by-Side)

There are two types of configurations for Sand Vault TSTs, in-line and side-by-side. In-line or side-by-side placement is in respect to the adjacent road. There is no operational benefit to choosing one type over the other. The criterion for choosing one configuration over another is dictated by the terrain geometry of the location where the Sand Vault TSTs are sited. Sand Vault TSTs have large capacities and large footprints, but are below-grade structures. The Sand Vault TSTs are typically sited outside the shoulder and do not allow for traffic loading on the roof. They do, however, allow for typical traffic surcharge on the side walls. If infrequent traffic loads are allowed on the roof, modify design for expected loading. Low flow drainage conditions will be handled by the weepholes beneath the vaults. Sand Vault TSTs are made of pre-cast material which allows for fairly quick installation.

The Sand Vault TST is a TBMP primarily designed to intercept traction sand from stormwater runoff and may also provide an effective means to capture other solids such as litter. In addition, this device has the ability to effectively intercept fines.[1] The Sand Vault TSTs are a two-chambered pre-cast structure, but it can also be custom designed. The first chamber is utilized for sedimentation with the base being internally sloped to allow for water to drain out. The second chamber also holds collected materials but may be retrofitted as a filtration chamber to satisfy future treatment requirements.[2] In the filtration chamber, filtration devices can be installed in various layouts. The base of the filtration chamber contains weepholes to drain standing water. In its fully improved stage, stormwater would be directed into the first (sedimentation) chamber where the larger sediments, including traction sand and particulates, settle out. Subsequently, the partially treated stormwater is conveyed into the second (filtration) chamber to be filtered through a filter media.

Sand Vault TSTs are enclosed structures. A drainage inlet is utilized to intercept roadway flow and convey runoff into the vault. Sand Vault TSTs are constructed at grade. The vault top has a level cross slope and a variable longitudinal slope to match the grade of the adjacent road. They can also be placed in-line within storm drain systems; however, a consideration must be given to the depth of the incoming and outgoing drainage system connection elevations. In some cases, they may be too low to achieve sizeable storage volume.

Sand Vault TSTs are always confined spaces and should be limited in size such that confined space entry issues are minimized. A schematic is shown in Figure 2-3. Refer to HDM Topic 829.2(4) for pipe cover requirements.

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[1] Sand Vault TSTs were found to be effective at reducing TSS concentrations to levels meeting surface discharge limits up to 90% of the time in Tahoe Pilot Studies (Caltrans 2006).

[2] Use of the second chamber as a filtration chamber requires prior approval from OHSD.

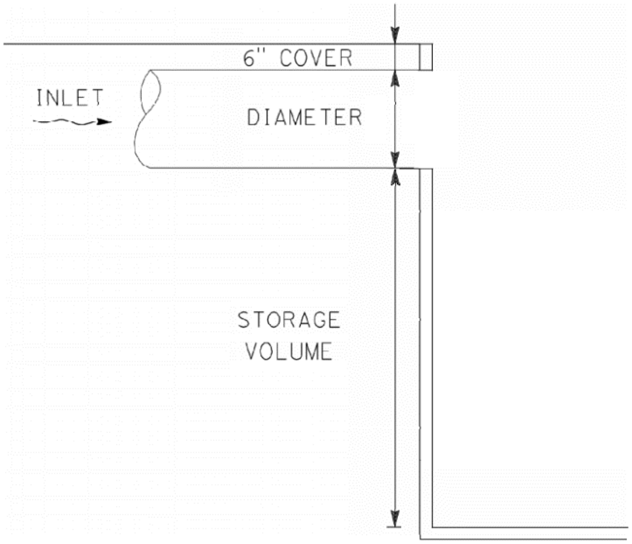

Figure 2-3. Sand Vault TST – Available Storage

2.4.1 Maintenance

A vehicle pullout for routine maintenance must be provided to access the vaults without a lane closure. At-grade vaults contain hinged lids for access. When open, a hinged lid exposes a larger area of the Sand Vault, thereby facilitating maintenance and access. Wherever possible, hinged lids should be utilized.

2.4.2 Siting Criteria

General recommended design criteria for the Sand Vault are shown in Table 2-4.

Table 2-4. Pre-cast Concrete Sand Vault Design Criteria

Parameter[1]	Min. Value	Max. Value
Surcharge Load (Traffic Load)	2 ft	2 ft
Invert Slope (parallel to flow)	0.5%	0.5%
Invert Slope (perpendicular to flow)	2%	2%
Length	6 ft	20 ft
Width (assume both chambers have the same width)	8 ft	16 ft
Storage Volume Depth	4 ft	6 ft
Depth of Permeable Backfill	Per Structural Requirements	Per Structural Requirements

[1] *Dimensions are inside dimensions*

The recommendations for design are the following:

- Establish minimum/maximum tributary area/segment length, see Section 3.2
- Incorporate a manhole or drainage grate when access is within travel way or shoulder or at locations that cannot be protected from snowplows
- Hinged lids recommended when access is outside travel way or shoulder and can be protected from snowplows. Hinged lids shall be utilized wherever possible
- Incorporate maintenance vehicle pullout to eliminate lane closure where feasible (if maintenance vehicle pullout is not feasible, obtain Maintenance approval)
- Consider silting in cut slope areas, see Section 3.2.6
- Place invert 3 to 6 ft above seasonal high groundwater
- Add weepholes
- Consult with the District Maintenance Stormwater Coordinator.

2.5 Safety Considerations

TSTs 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 TST section should provide a traversable section for errant traffic leaving the traveled way within the CRZ (HDM Topics 304, 309, and 861.4). Coordinate with other functional experts such as District Traffic Operations, District Maintenance, District Hydraulics, Geotechnical Design, Structure Design, and Traffic Safety, as applicable.

Consult with District Traffic Operations for all proposed placements to determine if guard railing is required. TSTs should have detailing, such as fences, that preclude ready access by the public as applicable.

2.6 Restrictions/Coordination

Successful implementation and utilization of TSTs will depend on proper siting of the devices. TSTs should generally be sited in an unobstructed location that can be easily accessed by maintenance vehicles and large equipment. The footprints of the approved TSTs are discussed in Section 2; however, the following major restrictions should be considered during the TST selection, siting, and sizing process.

2.6.1 Groundwater Restrictions

The invert of the TST must be a minimum of 3 to 6 ft above the seasonal high groundwater table to allow for drainage. For higher groundwater conditions, a specially designed TST should be used. Weepholes should be provided as TSTs that do not drain may create vector problems in the spring.

2.6.2 Soil Restrictions

Soil conditions should be determined through a geotechnical site investigation, and restrictions should be set based on the results of the investigation, such as excessively high or low infiltration rates, depth to bedrock, or presence of a high water table.

2.6.3 Self-Cleaning Velocities in Pipes

TSTs should also have sufficient hydraulic head for gravity flow in the pipes to achieve self-cleaning velocities. A velocity of greater than 3 fps for the inlet and outlet pipes of the TST should be obtained. The inlets and outlets should be arranged as far apart as possible, or baffled, to minimize short circuiting of the flow and to maximize particle settling. Provide if possible, at least 0.5’ between top of captured sand and outlet pipe. See Topic 838.4 and Table 838.4 of the HDM for minimum pipe diameters.

2.6.4 Bedrock and Boulders

Structural type TSTs should avoid being placed in locations were bedrock or boulders are present due to difficultly in excavation and potential need for blasting.

Section 3

Getting Started

This section presents the design parameters used in selecting, sizing, and laying out the appropriate TST, and a list of calculations that need to be performed to support the TST selection process.

3.1 Preliminary Design Parameters

The key design parameters for a TST are as follows:

- Tributary Area: The tributary area contributing to the TST is critical for determining the amount of traction sand directed towards the TST. It should be noted that the volume of traction sand is a function of the amount of paved surface tributary area to the TST and the traction sand application rate, and the entire CDA that drains towards the TST must be considered when determining Design Storm flow rates. The tributary areas for traction sand should be determined by using the methodology in the following sections.
- CDA: The CDA of the TST is critical for determining the Design Storm flows directed towards the TST. The Design Storm runoff should be calculated by using the methodology in HDM Chapter 830, Transportation Facility Drainage.
- Roadway Alignment: Roadway characteristics, such as horizontal and vertical alignments, and amount of traction sand applied defines the necessary size of the TST. The traction sand volume is estimated by applying Equation 1 below and K factors listed in this document.
- Sand Application Rate and Sweeping: District Maintenance should be consulted to determine the sand application rate and the frequency of roadway sweeping. For example, typical application rates for traction sand in the Tahoe Basin range from 600 to 1,000 lbs/lane/mile/year. Exposure may affect traction sand application volume since roadways on north facing slopes generally require more traction sand than similar south facing slopes. Also consider roadway grade as steeper grades generally require more traction sand. In most areas of the Tahoe Basin, the application rate is 600 lb/lane/mile/year.

3.2 Preliminary Calculations

The process for sizing (and therefore selecting) the TST depends on obtaining an accurate tributary area along with a traction sand application rate, and then calculating the losses or gains that will occur within that area, to obtain the volume of recovered traction sand. The following steps will help to obtain factors for miscellaneous losses and accumulations. This factor will be called “L” and will be used in the following equation to calculate the estimated volume of recovered traction sand. A detailed flowchart can be referenced in Appendix A. Equation 1 is presented here:

$$V = \frac{(S \times R \times L \times E)}{F} \qquad \text{(Eq. 1)}$$

where:

V = The total volume of traction sand that must be stored (CF)
S = The estimated volume of sand applied (CF/yr)
R = A factor to account for sand recovered by roadway sweeping
L = A factor to account for other miscellaneous losses/accumulations
E = A factor to account for recovery efficiency
F = The number of times the trap will be cleaned (times/yr)

3.2.1 Determine Profile Grade Factor (K1)

To determine the profile grade factor "K1", begin by dividing the roadway into multiple segments; those where the profile grade is greater than 5 percent and those where the profile grade is less than 5 percent. More traction sand is applied where the profile is steep and less where the profile is flat. For segments that have a profile grade greater than 5 percent, apply a "K1" factor of 2.0, and for segments that have a grade less than 5 percent, apply a "K1" factor of 1.0 as shown in Table 3-1 below.

Table 3-1. Profile Grade Factor, K1

	Less than 5%	More than 5%
Profile Grade	K1=1.0	K1=2.0

3.2.2 Determine Segment Alignment Factor (K2)

To determine the segment alignment factor "K2", further divide the profile segments into sub-sections where the roadway is on a curve or superelevated, and where the roadway is on a tangent or crowned. Please note that segments that are superelevated and on a tangent, or are within the superelevation runout distance, should be included in the curved roadway segment since superelevated segments will receive more traction sand. For segments that are on a curve, apply a "K2" factor of 2.0, and for segments that are on a tangent, apply a "K2" factor of 1.0 as shown in Table 3-2 below.

Table 3-2. Segment Alignment Factor, K2

	Segment on Curve (Superelevated)	Segment on Tangent (Crowned)
Segment Alignment	K2=2.0	K2=1.0

3.2.3 Pick Starting Factor (K3)

The starting factor "K3" is equal to the larger of the two factors "K1" and "K2" obtained from above. Since the roadway should be broken into segments (profile grade segments and alignment segments), a "K3" value must be selected for each sub-section of the roadway. For example, if the roadway segment has a profile grade of more than 5 percent, twice as much traction sand will be applied, if the segment is on a curve or superelevated, the segment will also receive twice as much traction sand. But if the segment has a profile grade of more than 5 percent and is also on a curve, four times the amount of traction sand will not be applied, only twice the amount. Therefore, only the larger of the "K1" and "K2" factors will be used to estimate the amount of recovered traction sand. Note that the two values of "K1" and "K2" are not multiplied or added together.

3.2.4 Determine Cross-Section

Determine if the section is in cut, fill, or a combination of cut and fill. Divide the roadway segments already defined into sub-subsections, depending on their respective cross-sections:

- Looking at the criteria presented previously, the roadway should now be divided into tributary areas, with the corresponding Starting Factor "K3" known for each sub-section.
- The CDA for Design Storm drainage requirements calculated pursuant to the HDM will be different than the tributary area for traction sand calculated in this guidance. These two areas are different since the tributary area for the traction sand is broken into sections based on profile grade, while the CDA area is not.

3.2.5 Determine Roadway Classification and Number of Lanes Factor (K4)

A roadway is classified as an interstate, freeway, highway, or local road. The Number of Lanes Factor "K4" is a function of the roadway classification and the number of lanes, and may be determined as follows (this is a typical approach, but should be verified with the approach of local District Maintenance):

- For an interstate or freeway classification:
  - The road will remain open at all times and each lane will receive traction sand;
  - The Number of Lanes Factor "K4" will be equal to the total number of lanes for each direction as shown in Table 3-3 below.

Table 3-3. Interstate and Freeway Number of Lanes Factor, K4

	2 Lanes Each Direction	3 Lanes Each Direction	4 Lanes Each Direction
Interstate or Freeway	K4 = 2.0	K4 = 3.0	K4 = 4.0

- For a highway or local road classification:
  - Typically, only one lane will remain open in each direction and receive traction sand. This is independent of the number of existing lanes;
  - The Number of Lanes Factor "K4" is dependent on if the section is in cut or fill, and the overall width of the roadway.
    - Both sides of the roadway are in cut:
      - No sand will be lost over the side;
      - The width of the roadway will not determine the factor "K4";
      - The value of "K4" will be equal to 1.0.
    - One or both sides of the roadway are in fill:
      - The factor "K4" is dependent on the width of the road and the cross-section as shown in Table 3-4 below.

Table 3-4. Highway and Local Road Number of Lanes Factor, K4

	Both Sides in Fill	One Side Fill, One Side Cut	Both Sides in Cut
1 Lane Each Direction or Equivalent Width	K4 = 0.5	K4 = 0.75	K4 = 1.0
2 Lanes Each Direction or Equivalent Width	K4 = 0.8	K4 = 0.95	K4 = 1.0

3.2.6 Determine Silting Factor (K5)

If the roadway is adjacent to a cut slope, then more material will reach the TST. This is due to the fact that a cut slope prevents traction sand from migrating off-site, and due to an additional amount of material that may be received from erosion of the cut slope. This silting factor must be included since this affects the volume of material that will eventually be captured in the TST. The Silting Factor "K5" is determined by the steepness of the cut slope (Table 3-5). Therefore, if both sides of the roadway are in fill, this factor will be 1.0. To determine the silting factor, the designer must consider drainage. For example, if the roadway is crowned, then it must be divided down the center, and the slope adjacent to each side will be used to determine the silting factor for each sub-section. If the roadway is superelevated, then the road will all drain to one side, and the slopes adjacent to both sides will determine the silting factor for the sub-section. Note that if the roadway is superelevated, then an average of both slopes should be used. Engineering judgment is required for this factor. The overall surface type should be determined (e.g., vegetation, rock) and the factor adjusted accordingly.

Table 3-5. Silting Factors, K5

H:V	Both Sides in Cut	One Side Fill, One Side Cut
4:1 Slope	K5 = 1.0	K5 = 1.0
3:1 Slope	K5 = 1.2	K5 = 1.1
2:1 Slope	K5 = 1.4	K5 = 1.2
1:1 Slope	K5 = 1.6	K5 = 1.3

Note: For a section with both sides in fill, the Silting Factor "K5" equals 1.0.

3.2.7 Determine Shade Factor (K6)

If the roadway is in a location that receives sun, the snow will melt more rapidly and less traction sand will be needed. However, if the roadway is in the shade, the snow will remain longer and more traction sand must be applied. This condition occurs when the road is in a cut condition or has vegetation or other obstructions that could potentially shade the roadway from the sun and requires a Shade Factor "K6" to be applied. Therefore, this factor will not be used when the roadway has a fill slope on both sides of the road.

One way to determine how much sun a roadway segment receives is what direction the slope is facing. For example, a south facing slope is expected to see more intense sun than a north facing slope, and an east facing slope will receive more intense sun than a west facing slope as shown in Table 3-6 below.

Table 3-6. Shade Factor, K6

Full Sun	Half Sun	No Sun
K6 = 0.8	K6 = 1.0	K6 = 1.5

Note: For both sides in fill section, the Shade Factor "K6" equals 1.0.

3.2.8 Determine Average Number of Snowdays per Year (K7)

The amount of traction sand that is applied is also dependent on the number of days it snows for a specified location. For each snowstorm, traction sand will be applied to the roadway. The Average Number of Snowdays per Year Factor "K7" will equal the average number of snowdays a year for a specific area and elevation. Such historical information can be obtained from a variety of websites, some of which charge for information such as www.weather-source.com, or a free website such as http://cdec.water.ca.gov, which only lists precipitation and temperature. District Maintenance Stormwater Coordinator may also have information on the average number of snowdays for a specific location.

3.2.9 Determine Values Used in Equation 1

Once the factors "K1" through "K7" are known, the values used in Equation 1 may be determined. The annual volume of traction sand applied "S" may be determined by the following equation:

$$S = \text{Amount of traction sand applied per snow day} * K3 * K4 * K6 * K7$$

The factor to account for sand recovered by roadway sweeping "R" may be estimated based upon the frequency of highway sweeping for the specific segment. A value for "R" between 1.0 (no roadway sweeping) and 0.6 (aggressive winter roadway sweeping) should be selected based on interviews with local District Maintenance staff. If actual sweeping records are available, these may provide a more accurate estimate.

The miscellaneous losses and accumulations factor "L" may be determined by setting "L" equal to K5.

The efficiency factor "E" accounts for traction sand that passes through the TST without settling out. The efficiency factor "E" is actually a function of particle size, specific gravity, and other factors. Absent empirical information obtained from pilot studies, a value of 1.0 should be used for this factor.

The cleaning frequency factor "F" accounts for the number of times the TST will be cleaned each year. Usually, the value for "F" is 1.0 as most basins are cleaned once per year, usually in the summer. If obtaining the required storage volume is difficult, it may be possible to implement mid-season cleaning (F greater than 1), but District Maintenance staff should be consulted to make sure this is practicable. Mid-season cleaning requirements will also likely affect trap design, as maintenance equipment will have to access the trap under wet or snowy conditions.

3.2.10 Calculate Estimated Recovered Volume of Sand

Now that the factors "S", "R", "L", "E", and "F" are known, use Equation 1 and the corresponding methodology in this section to calculate the total volume of sand recovered by the TST.

Section 4

TBMP Selection

The process for selecting the most appropriate TST size and configuration for a given site will depend on the recovered volume of traction sand and available right of way for a given site. The selection of TSTs is therefore governed by site characteristics. Figure 4-1 presents a flowchart for selecting the proper TST for specific site conditions. Where site conditions allow, TSTs are to be selected in the order of preference as follows:

1. Loading Dock or Earthen Berm;
2. Concrete Sand Vault;
3. Modified Pipe Inlet.

Use Figure 4-1 and the guidelines in Section 2 to determine the most appropriate type of TST to use.

4.1 Check TST Footprint

The footprint of the TST should be kept inside the existing right of way and away from trees and utilities. The footprint should be checked versus the site plan to verify that the size and placement is feasible.

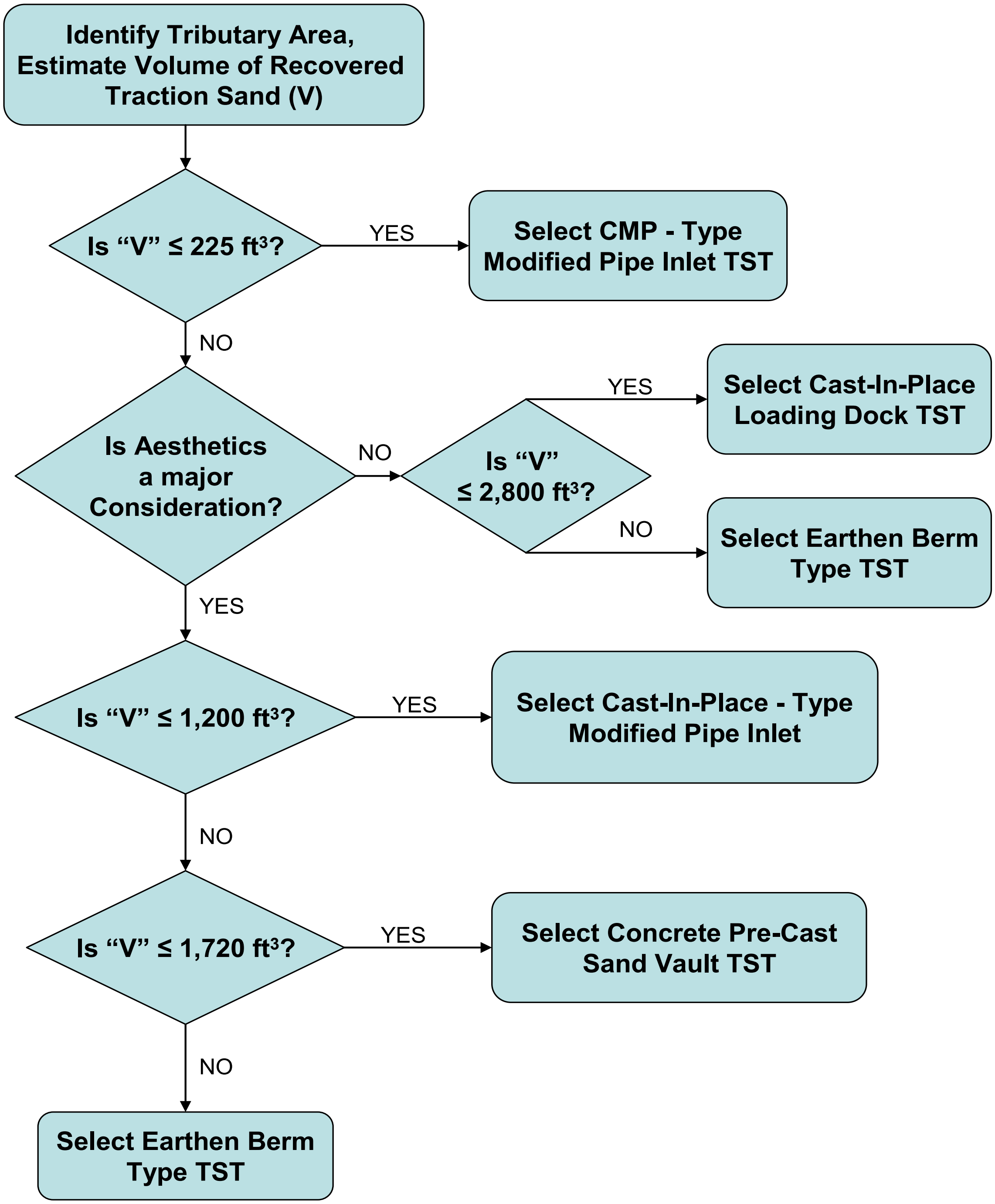

Figure 4-1. Selection Flowchart for Traction Sand Traps

Section 5

Design Elements

Certain supplemental structures and devices may be required in the construction of TSTs. These supplemental design elements are discussed in detail in the Supplemental Details Design Guidance.

5.1 Optional Elements

The following optional design elements may be required in the construction of TSTs.

5.1.1 Overflow Spillway

Specific types of TSTs, such as Loading Docks and Earthen Berms, should be equipped with an overflow spillway designed to safely handle flows associated with the Design Storm flow in the event that the outlet pipe becomes clogged or cannot handle the additional flow. Overflow spillways are intended to control the location where the flows would overtop the loading dock perimeter in order to avoid structural damage to the embankment, and then direct the flows into the downstream conveyance system or other applicable discharge point. Minimum spillway length is 3 ft and is measured perpendicular to flow. Details of overflow spillways and their design parameters can be found in Section 5 of the Supplemental Details Design Guidance.

5.1.2 Vehicle Pullouts

Vehicle pullouts should be provided on the shoulder to provide safe access to a Modified Pipe Inlet or Sand Vault TST for yearly maintenance by a vacuum truck. Pullouts may also be required to provide access to other types of TSTs as discussed in Section 2.2. The vehicle pullout should be wide enough to accommodate all sizes of vehicles that need to access the TST while being completely clear of all traffic lanes. A minimum distance of 14 ft from the edge of shoulder to the edge of traveled way is preferred however, physical constraints sometimes prohibit construction of a full pullout. The vehicle pullout should also be placed in close proximity to the TST to allow easy access for the vacuum truck to perform maintenance and inspections.

5.1.3 Maintenance Access Ramp

A maintenance access ramp is typically required around Loading Dock and Earthen Berm TSTs to adequately and safely allow access to the TST for maintenance by a vacuum truck or other equipment as discussed in Section 2.2. Maintenance access ramps should be located within areas owned by Caltrans or located within a maintenance easement. Maintenance access ramps must be able to accommodate all anticipated equipment or vehicles used for routine inspections or for trash and debris removal. Details of maintenance access ramps can be found in Section 10 of the Supplemental Details Design Guidance. Consult with the District Maintenance Stormwater Coordinator.

Maintenance access should be used with off-the-roadway TBMPs such as Earthen Berm and Loading Dock type TSTs.

5.1.4 Weepholes

Most TSTs should be equipped with weepholes designed to drain standing water and to avoid vector issues. The Modified Pipe Inlet type includes an outflow pipe that is raised above the invert of the TST to create a trap for the sand and weepholes are provided at the bottom to drain the TBMP. Similarly, weepholes should be designed for the bottom of the Sand Vault TST to manage low flow drainage conditions. Details and design parameters of weepholes can be found in Section 12 of the Supplemental Details Design Guidance.

Section 6

PS&E Preparation

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

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

6.1 Plans

TSTs do not have standard drawings but there are several sheets that should be placed in the PS&E package. The PS&E drawings for most projects having TSTs may include:

- Layout(s): Show the location(s) of the TST and call out TST type. This will aid in recognizing, both within and outside Caltrans, that TSTs were placed within the project limits.
- Grading Plan(s): Show the TST on this sheet for clarity and associated grading surrounding the TST should be shown on these sheet(s).

Drainage Plan(s), Profiles, Details, and Quantities:

  - Drainage Plan sheets should show each TST in plan view, along with other existing and proposed drainage conveyance devices that direct the runoff into the device and overflow from the device.
  - Drainage Profile sheets should show the TST in profile within the drainage conveyance system. These sheets should also call out the specific TST inlet and outlet flow line (surface) elevations and invert elevation.
  - Drainage Detail sheets should show the details as needed to construct or clarify TST interface points.
  - Drainage Quantity sheets should include a summary of quantities table with station, offset, and dimensions of the TSTs and should include all pay and non-pay items associated with the construction of the TST.

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

6.2 Specifications

Contract specifications for TST projects will include a combination of Standard Specifications, Standard Special Provisions (SSPs), and may include non-Standard Special Provisions (nSSPs).

Special provisions for the various items of work needed to construct the TST could be organized under an umbrella ‘TST’ nSSP with the required items listed as subheadings. Payment would be made for by ‘each’ TST. 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.

6.2.1 Standard Specifications

Listed below are Standard Specifications that would typically be used for a project that constructs a TST. Consider the construction of the TST in the context of the entire project to determine if other Standard Specifications may be required.

13 Water Pollution Control
15 Existing Facilities
17 General (Earthwork and Landscape)
19 Earthwork
20 Landscape
21 Erosion Control
26 Aggregate Bases
39 Asphalt Concrete
40 Concrete Pavement
51 Concrete Structures
52 Reinforcement
61 Drainage Facilities- General
64 Plastic Pipe
65 Concrete Pipe
66 Corrugated Metal Pipe
68 Subsurface Drains
70 Miscellaneous Drainage Facilities
71 Existing Drainage Facilities
72 Slope Protection
73 Concrete Curbs and Sidewalks

80 Fences

96 Geosynthetics

6.2.2 Standard Special Provisions

SSPs may be included for a project that constructs a TST. Additional SSPs may be required depending on the types of appurtenant facilities and materials proposed for the project. The listed SSP section numbers are presented to assist in preparing the Contract Special Provisions. Consult the current index of SSPs available on the Office of Construction Contract Standards section of the Caltrans website. Each SSP topic should be examined in the context of the entire project to determine if other SSPs may be required.

39-2.01C(10) Roadside Paving (Maintenance Vehicle Pullout)

6.2.3 Non-Standard Special Provisions

A project that constructs a TST may require nSSPs so the PE can assure the design assumptions are constructed properly in the drainage system. The PE and PDT should decide the most appropriate specifications for the site-specific conditions to meet other goals in the HDM for safety. OHSD can provide nSSPs to support the design. nSSPs may be required when standard specifications are insufficient to address all the design and construction needs for the project. At this time, there are no nSSPs for this TBMP.

Below is a list of nSSPs that may be applicable to TSTs. It is possible that not every nSSP listed below will apply to all situations or that additional nSSPs are applicable to the project. Ensure that the included nSSPs are relevant when incorporated into the Contract Special Provisions. Other nSSPs may be necessary for the project. Coordination with OHSD or other appropriate office may be necessary.

- Concrete Structures
- Miscellaneous Metal

6.3 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/design/pjs/index.html

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.

6.3.1 PID and PA/ED Phases

A preliminary cost estimate, Project Planning Cost Estimate (PPCE), is required as an attachment of the SWDR during 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. 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 more refined estimate could be made using the methods in Section 6.3.2. A cost escalation should be added for projects that are anticipated to advertise more than a year after the date of the estimate.

6.3.2 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 phase of the project. PECEs focus on the construction costs of the project and the permanent TBMPs 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 TST location.

6.4 Developing TST Cost Estimates

Develop a quantity-based cost estimate. As the design process proceeds, the project cost estimate should be updated as new data becomes available. Identify contract items required to construct the TST. 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.

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

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

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

6.5 Plan Sheet Approval

The TST Detail Drawings may be used when standard sized vaults are incorporated. A set of pdf drawings can be requested from OHSD. At the PS&E phase, the PE must request an electronic copy of drawings that will be incorporated into the PS&E package to be submitted to the District Office Engineer. Prior to submitting the plans to DES Office Engineer, the PE is responsible to request the latest plans available to see if revisions have been made. If so, the new set of plans must be incorporated into the project.

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Section 7

TST Selection Example

This section presents an example on how to implement the procedure presented in Section 2 for TST design. The example layout and cross-sections shown in Figures 7-1 and 7-2, respectively, apply to the calculations presented in this section.

The design parameters for this example are as follows:

- Estimated recovery efficiency of traction sand is 100 percent
- Average grade is 6.75 percent
- Sand trap will be cleaned once a year
- Application Rate = 750 lb/lane/mile per snow day (mixture of sand and salt)
  - 80 percent traction sand and 20 percent salt is used (by weight)
- No roadway sweeping
- One traveled lane in each direction
- An average of 26 snowstorms a year
- Adjacent slope is facing south

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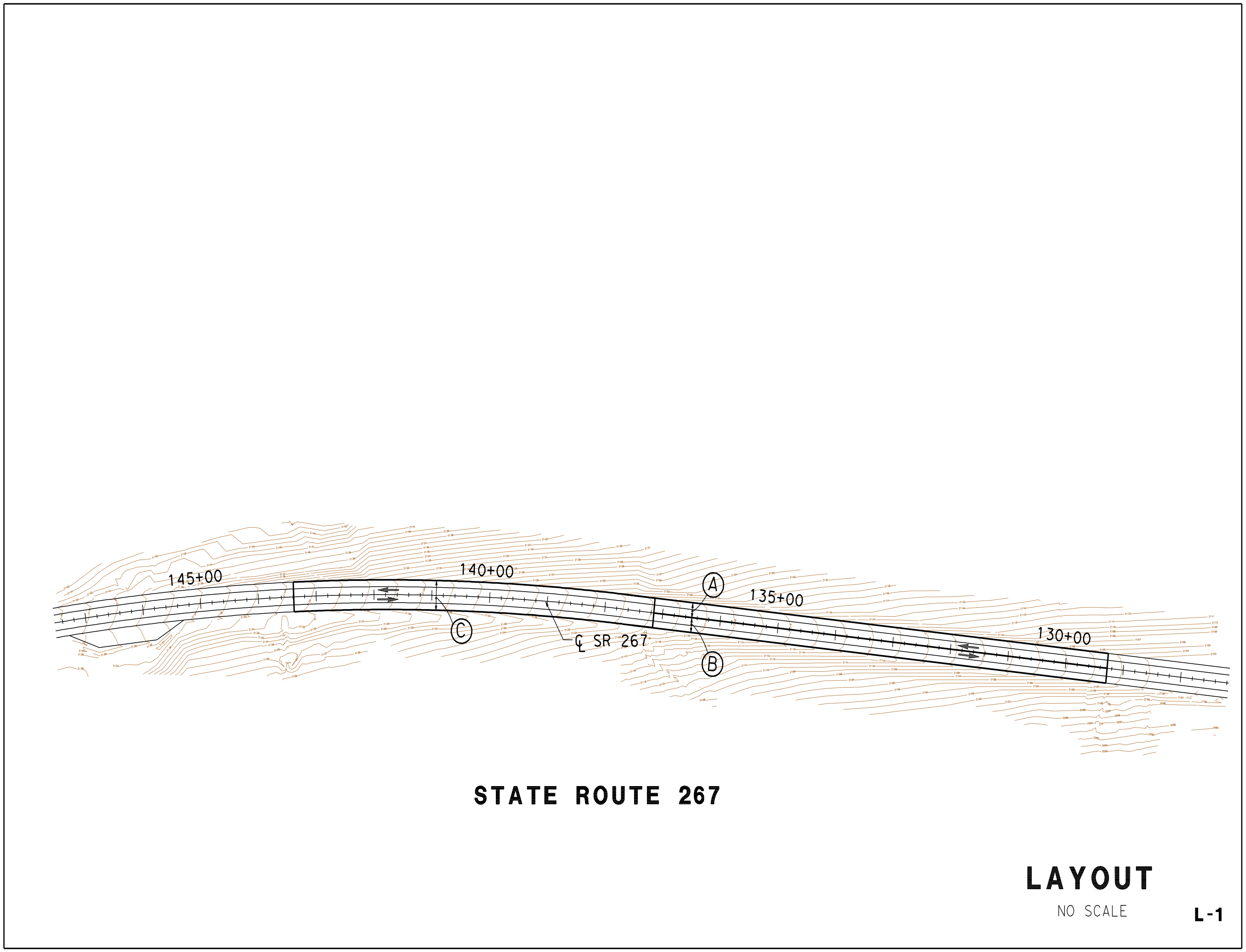

Figure 7-1. Layout

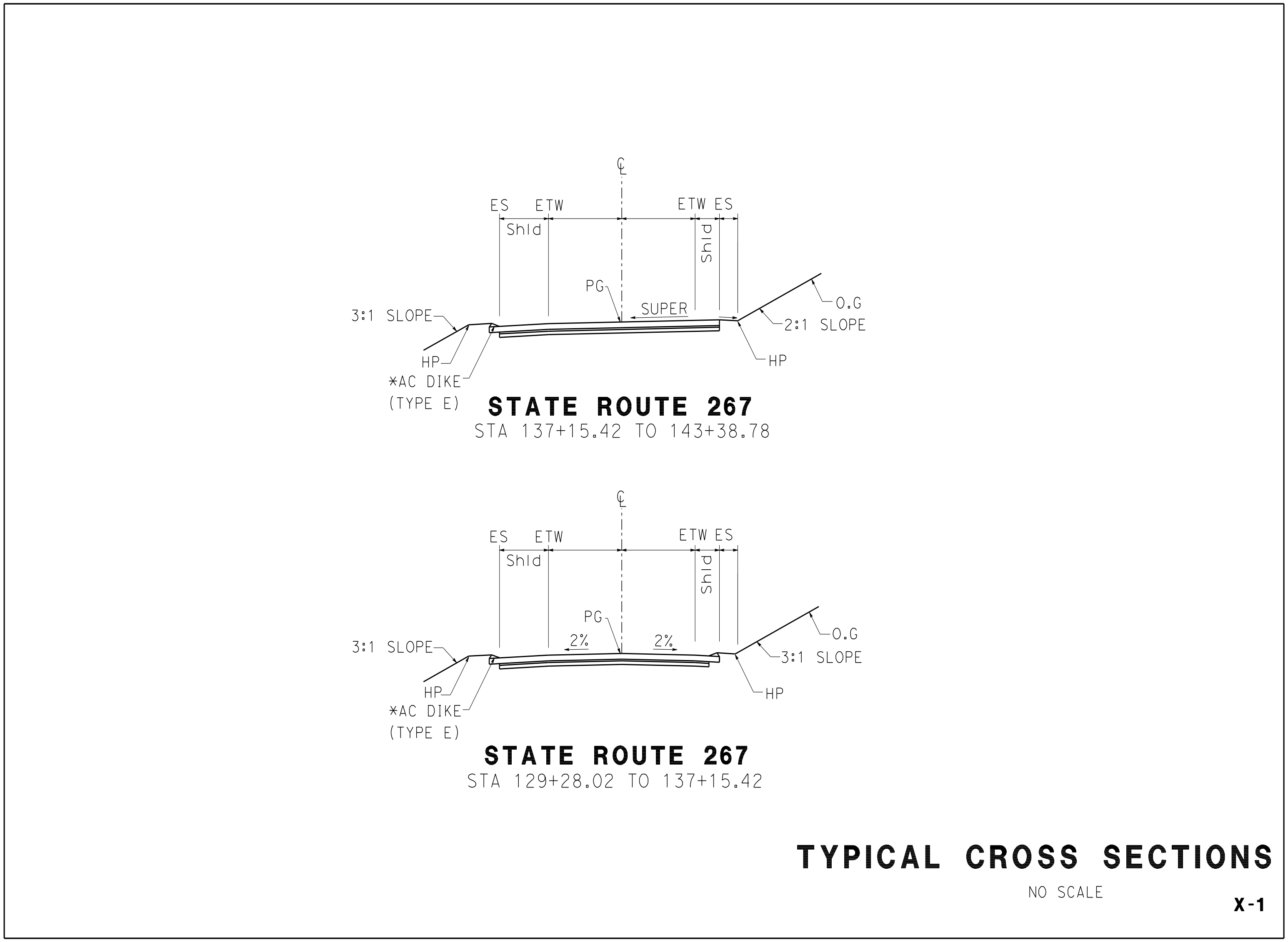

Figure 7-2. Typical Cross Sections

Step 1: Determine Profile Grade Factor, "K1"

Average grade of roadway is 6.75 percent from Station 129+28.02 to 143+38.78 (Figure 7-1)

Therefore K1 = 2.0

Step 2: Determine Segment Alignment Factor, "K2"

Station 129+28.02 to 137+15.42

On tangent; therefore, K2 = 1.0

Station 137+15.42 to 143+38.78

On curve; therefore, K2 = 2.0

Step 3: Pick Starting Factor, "K3"

The segments need to be looked at independently since they have different factors for K2.

For Station 129+28.02 to 137+15.42

K1 = 2.0 and K2 = 1.0; therefore, use a starting factor K3 of 2.0

For Station 137+15.42 to 143+38.78

K1 = 2.0 and K2 = 2.0; therefore, use a starting factor K3 of 2.0

Step 4: Determine Cross-Section

For Station 129+28.02 to 143+38.78, the section is in fill on one side and cut on the other. For this example, split the roadway into three segments:

1. Station 129+28.02 to 137+15.42, North Side
2. Station 129+28.02 to 137+15.42, South Side
3. Station 137+15.42 to 143+38.78, Both Sides

Step 5: Determine Roadway Classification and Number of Lanes Factor, "K4"

For Stations 129+28.02 to 137+15.42 and 137+15.42 to 143+38.78

The roadway classification is a State Route Highway; therefore, only one lane will remain open in each direction (verify with local District Maintenance for difference in approach).

Fill slope on one side and a cut slope on the other

One lane in each direction existing

Using table 3.2 from Section 3 for the above requirements, K4 = 0.75

Step 6: Determine Silting Factor, "K5"

For Station 129+28.02 to 137+15.42

The roadway section is crowned and the silting factor will only need to be applied to the northern side of the road since there is an adjacent cut slope on the that side. For the southern side of the road, there is a fill slope adjacent; therefore, use a value of K5 = 1.0 since no silting will occur.

For the north side of the road, the cut slope is at 3:1; therefore, K5 = 1.1

For Station 137+15.42 to 143+38.78

The section is super elevated and the silting factor will need to be applied to both sides of the road; consider drainage.

The cut slope is at 2:1; therefore, K5 = 1.2

Step 7: Determine Shade Factor, “K6”

For Station 129+28.02 to 137+15.42

Slope facing south; therefore, since it will receive full sun, K6 = 0.8

For Station 137+15.42 to 143+38.78

Slope facing south; therefore, since it will receive full sun, K6 = 0.8

Step 8: Determine Average Number of Snowdays per Year, “K7”

For Stations 129+28.02 to 143+38.78,

The average number of snowdays a year for this area and elevation equals 26 days.

Therefore, K7 = 26.0

Step 9: Determine Values Used in Equation #1

S = Amount of traction sand applied per snow day * K3 * K4 * K6 * K7

Per District Maintenance, application rate is 750 lbs/lane/mile/snow day, with 80 percent sand and 20 percent salt.

Please note that salt cannot be recovered since it dissolves into the water and runs off.

K3 = 2.0, K4 = 0.75, K6 = 0.8, K7 = 26

<u>For Station 129+28.02 to 137+15.42 (North Side)</u>:

Distance = 13715.42– 12928.02 = 787 ft = 0.149 miles

Density of Sand = 120 lbs/CF

Number of Lanes = 1

S = (750 * 0.8) * 0.149 * 1.0 * 2.0 * 0.75 * 0.8 * 26 = (2,789 lbs/yr) / (120 lbs/cf)

= 23.2 CF/year

<u>For Station 129+28.02 to 137+15.42 (South Side)</u>:

Distance = 13715.42 – 12928.02 = 787 ft = 0.149 miles

Density of Sand = 120 lbs/CF

Number of Lanes = 1

S = (750 * 0.8) * 0.149 * 1.0 * 2.0 * 0.75 * 0.8 * 26 = (2,789 lbs/yr) / (120 lbs/cf)
= 23.2 CF/year

<u>For Station 137+15.42 to 143+38.78</u>:

Distance = 14338.78 – 13715.42 = 623 ft = 0.118 miles

Density of Sand = 120 lbs/CF

Number of Lanes = 2

S = (750 * 0.8) * 0.118 * 2.0 * 2.0 * 0.75 * 0.8 * 26 = (4,418 lbs/yr) / (120 lbs/cf)
= 36.8 CF/year

Per District Maintenance, R = 1.0 (No roadway sweeping)

L = K5

<u>For Station 129+28.02 to 137+15.42, North Side</u>

L = 1.1

<u>For Station 129+28.02 to 137+15.42, South Side</u>

L = 1.0

<u>For Station 137+15.42 to 143+38.78</u>

L = 1.2

Assume E = 1.0 (No specific data provided by Pilot Project)

Per District Maintenance, F = 1.0 (Cleaning once per year)

Step 10: Calculate Estimated Recovered Volume of Sand

Use Equation 1 and the corresponding methodology in Section 3 to calculate the total volume of sand recovered by the TST.

V = (S x R x L x E) / F

Where,

S = Estimated volume of sand applied (CF/year)

R = A reduction factor to account for sand recovered by roadway sweeping

E = Estimated recovery efficiency (Use E = 1.0)

F = Number of times trap will be cleaned per year

For Station 129+28.02 to 137+15.42, North Side

$V = (S \times R \times L \times E) / F$

$= (23.2 \times 1.0 \times 1.1 \times 1.0) / 1.0 = 25.5 \text{ ft}^3$

For Station 129+28.02 to 137+15.42, South Side

$V = (S \times R \times L \times E) / F$

$= (23.2 \times 1.0 \times 1.0 \times 1.0) / 1.0 = 23.2 \text{ ft}^3$

For Station 137+15.42 to 143+38.78

$V = (S \times R \times L \times E) / F$

$= (36.8 \times 1.0 \times 1.2 \times 1.0) / 1.0 = 44.2 \text{ ft}^3$

These calculations are summarized in Table 7-1 below.

Table 7-1. Summary of Example Calculations

	Station 129+28.02 to 137+15.42: Northbound	Station 129+28.02 to 137+15.42: Southbound	Station 137+15.42 to 143+38.78: Northbound & Southbound	Units
S:	23.2	23.2	36.8	CF/year
R:	1.0	1.0	1.0	
L:	1.1	1.0	1.2	
E:	1.00	1.00	1.0	
F:	1.00	1.00	1.0	Per year
V:	25.5	23.2	44.2	CF

Step 11: Pick Most Appropriate Traction Sand Trap (Reference Figure 3-1)

For Station 129+28.02 to 137+15.42, North side

Estimated Volume = 25.5 CF

Since the estimated volume of traction sand is small, a Modified Pipe Inlet type of TST should be used.

Assuming a 36" diameter riser, the area of a Modified Pipe Inlet = 7.06 SQFT

25.5 / 7.06 = 3.61 ft; Required storage depth

Assume:

Inlet pipe is 15" with 4" of cover

Invert of outlet pipe is 4" below invert of inlet pipe

Minimum clearance between top of sand storage and invert of outlet pipe is 6”

Depth of permeable material on bottom of barrel is 12”

Therefore, the added depth required = 15”+4”+4”+6”+12” = 41 inches or 3.42 ft

- Minimum required depth is 3.61 ft + 3.42 ft = 7.03 ft
- Maximum depth of riser is 10 ft
- Check for drainage capacity
- Check for inlet interception
- Check minimum required depth against depth of seasonally high groundwater to ensure minimum separation is provided

Note that a larger inlet diameter might be needed to accommodate peak drainage flows.

Use 1-each Modified Pipe Inlet type TST.

For Station 129+28.02 to 137+15.42, South side

Estimated Volume = 23.2 CF

Since the estimated volume of traction sand is small, a Modified Pipe Inlet type of TST should be used.

Area of 36” diameter Modified Pipe Inlet = 7.06 SQFT

23.2 / 7.06 = 3.29 ft; Required storage depth

Assume:

Inlet pipe is 15” with 4” of cover

Invert of outlet pipe is 4” below invert of inlet pipe

Minimum clearance between top of sand storage and invert of outlet pipe is 6”

Depth of permeable material on bottom of barrel is 12”

Therefore, the added depth required = 15”+4”+4”+6”+12” = 41 inches or 3.42 ft

- Minimum required depth is 3.29 ft + 3.42 ft = 6.71 ft
- Maximum depth of riser is 10 ft
- Check for drainage capacity
- Check for inlet interception
- Check minimum required depth against depth of seasonally high groundwater to ensure minimum separation is provided

Note that a larger inlet diameter might be needed to accommodate peak drainage flows.

Use 1-each Modified Pipe Inlet type TST.

For Station 137+15.42 to 143+38.78

Estimated Volume = 44.2 CF

Since the estimated volume of traction sand is small, a Modified Pipe Inlet type of TST should be used.

Area of 36" diameter Modified Pipe Inlet = 7.06 SQFT

44.2 / 7.06 = 6.26 ft; Required storage depth

Assume:

Inlet pipe is 15" with 4" of cover

Invert of outlet pipe is 4" below invert of inlet pipe

Minimum clearance between top of sand storage and invert of outlet pipe is 6"

Depth of permeable material on bottom of barrel is 12"

Therefore, the added depth required = 15"+4"+4"+6"+12" = 41 inches or 3.42 ft

- Minimum required depth is 6.26 ft + 3.42 ft = 9.68 ft
- Maximum depth of riser is 10 ft
- Check for drainage capacity
- Check for inlet interception
- Check minimum required depth against depth of seasonally high groundwater to ensure minimum separation is provided

Note that a larger inlet diameter might be needed to accommodate peak drainage flows.

Use 1-each Modified Pipe Inlet type TST.

Section 8

References

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California State Water Resources Control Board ORDER 2012-0011-DWQ, NPDES NO. CAS000003 for State of California Department of Transportation Statewide Storm Water Permit, referred to as "NPDES Permit"

California Department of Transportation (Caltrans), 2006. Caltrans Tahoe Basin Highway 267 Sand Trap with Filter Fabric Pilot Study, Monitoring Season 2005-2006, August 2006

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Appendix A:

Calculation Flowchart for Estimated Volume of Traction Sand

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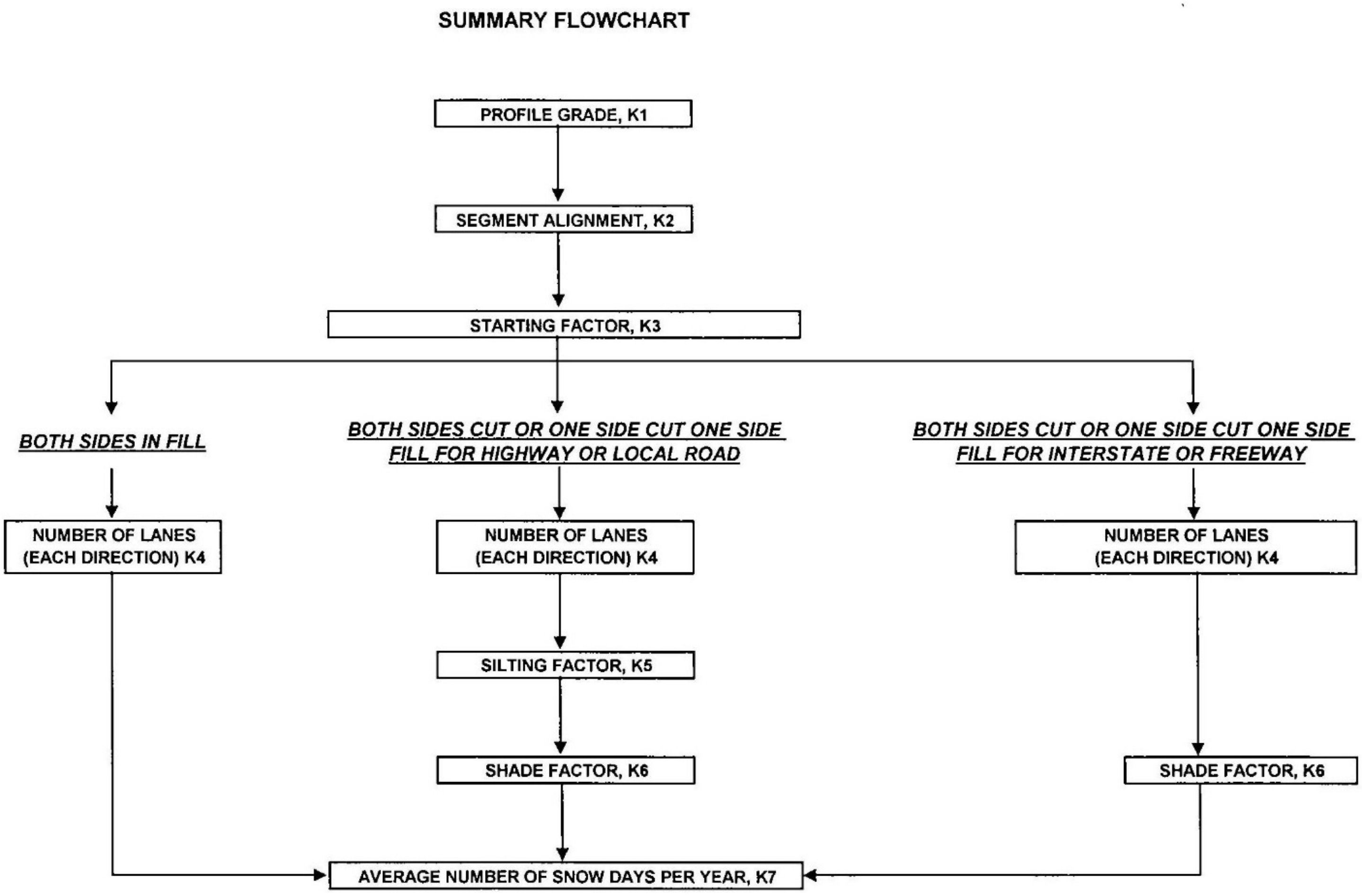

Figure A-1. Estimated Volume of Traction Sand, Summary Flowchart

TST FLOW CHART

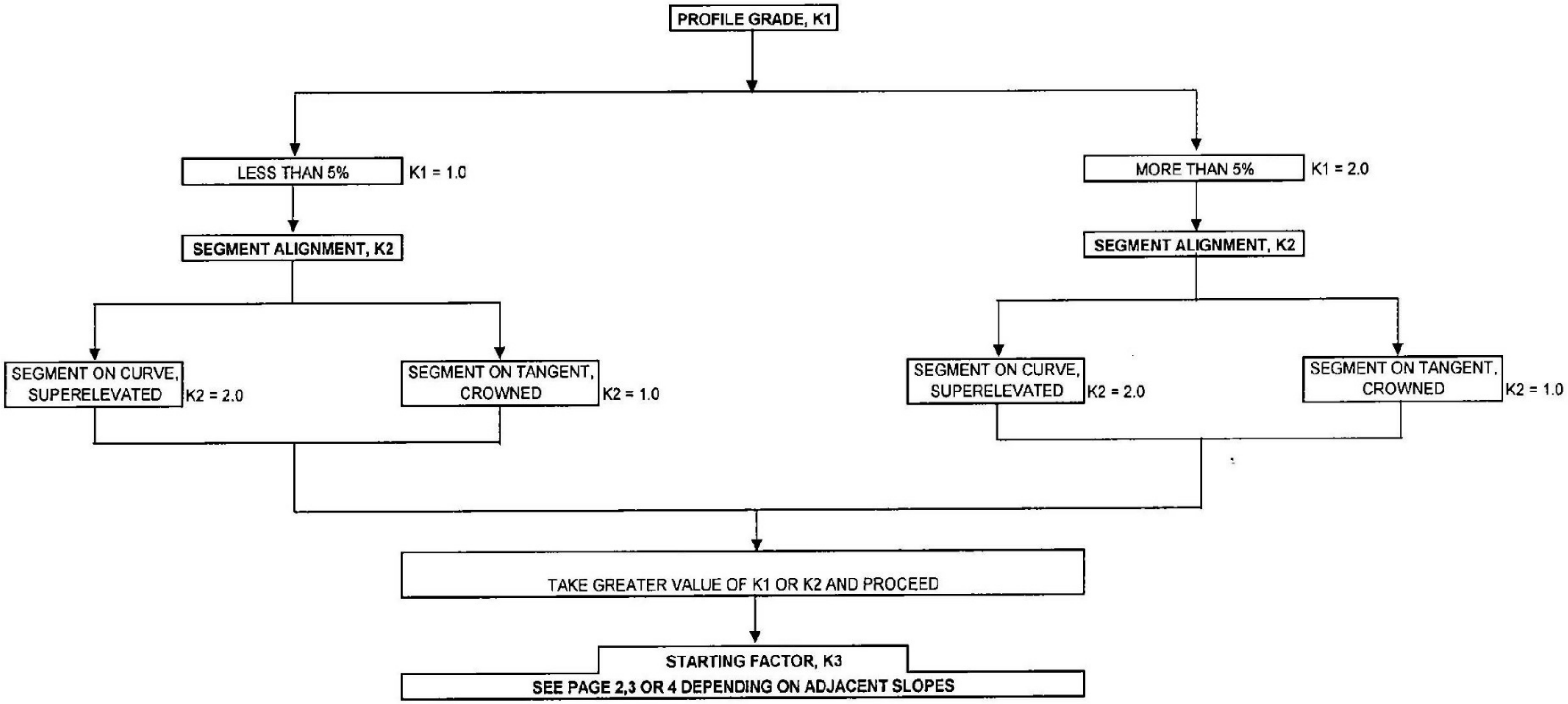

Figure A-2. TST K1

TST FLOW CHART

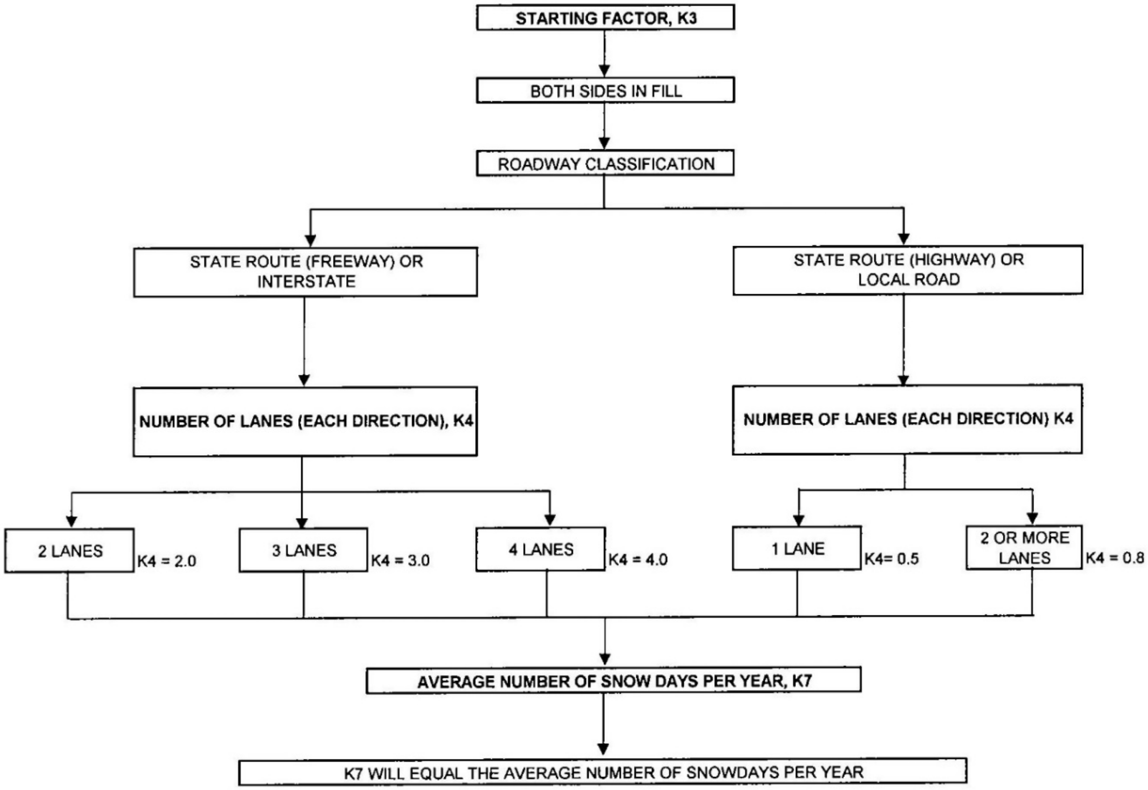

Figure A-3. TST K3, Both Sides in Fill

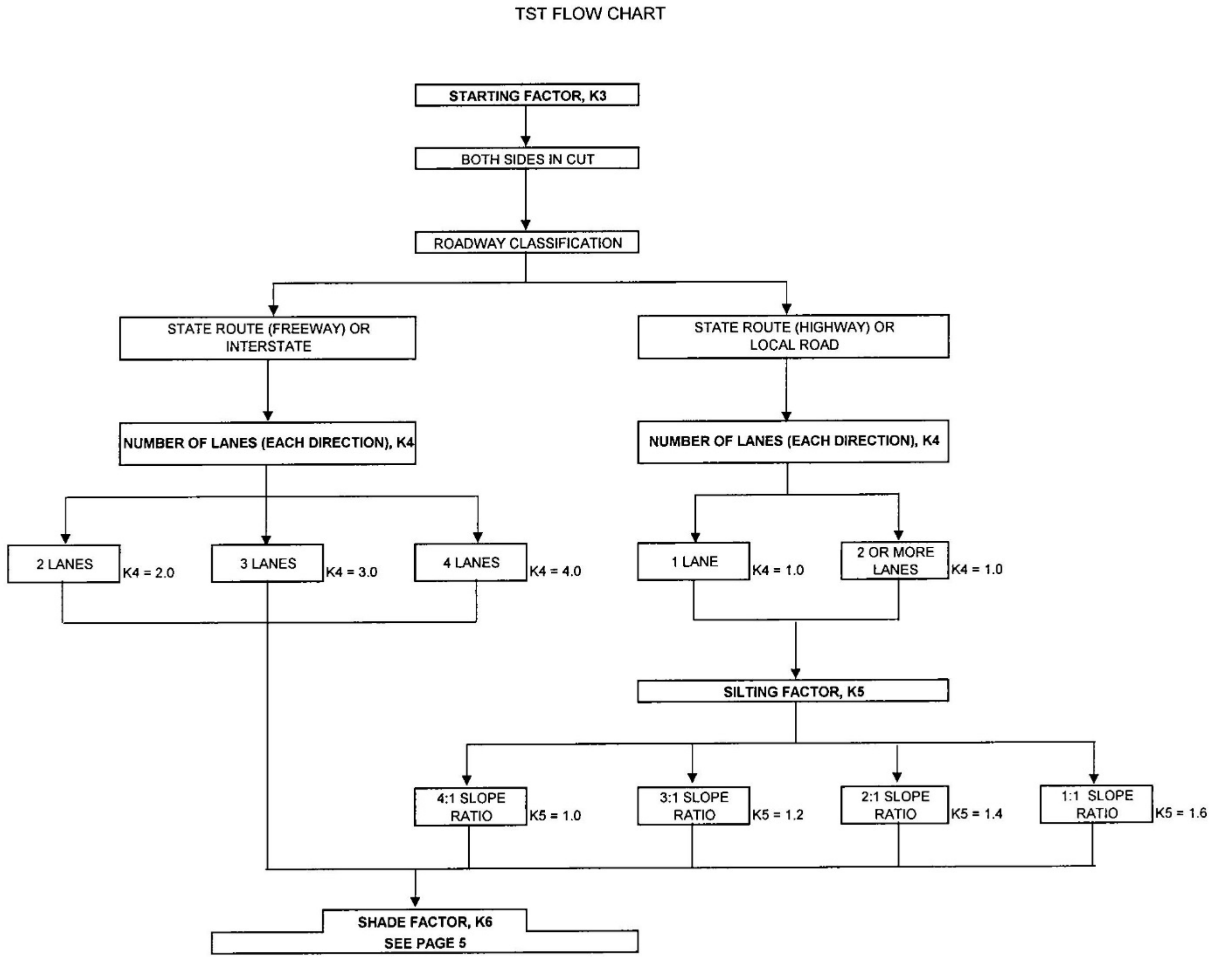

Figure A-4. TST K3, Both Sides in Cut

TST FLOW CHART

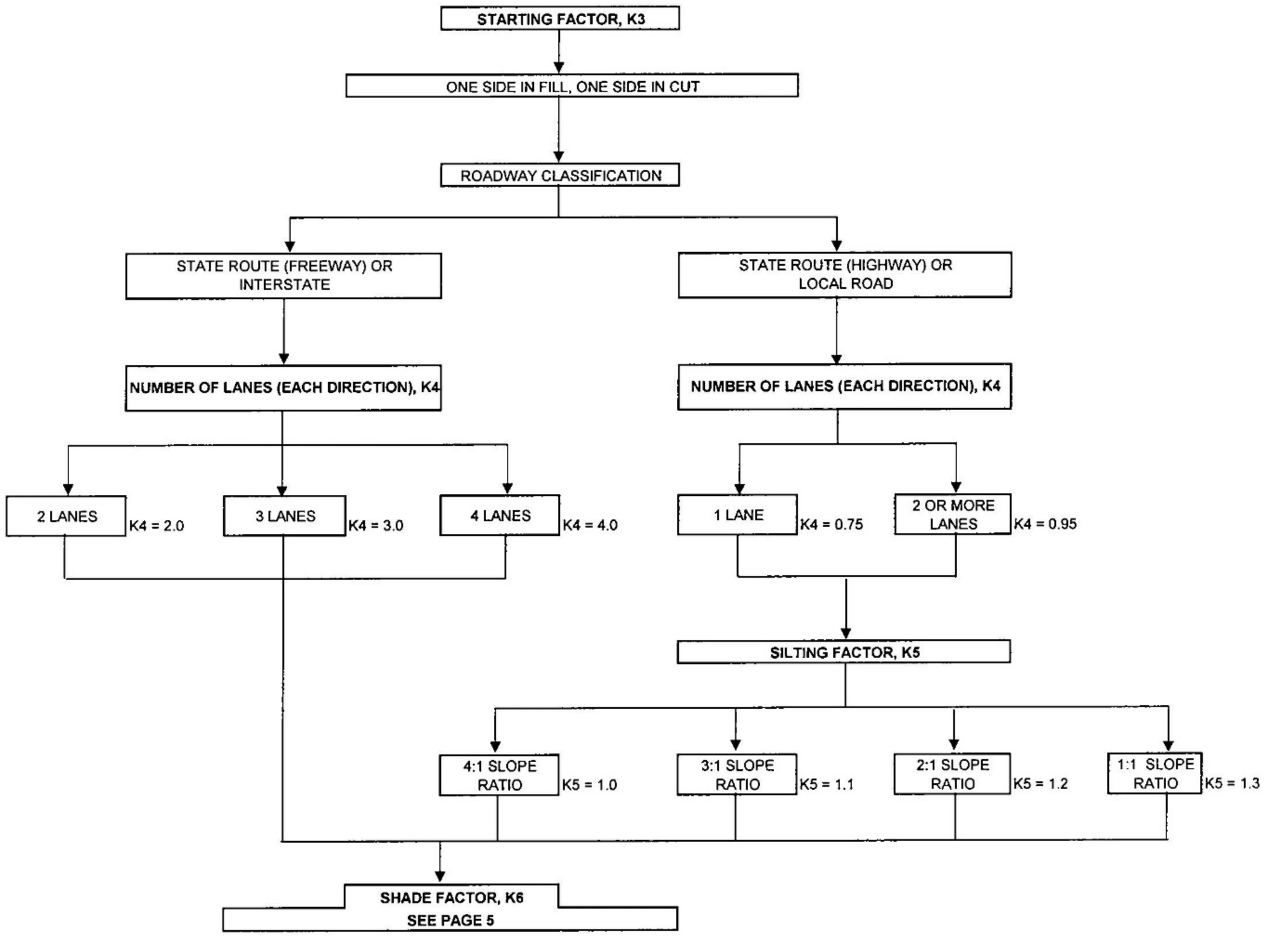

Figure A-5. TST K3, One Side in Fill and One Side in Cut

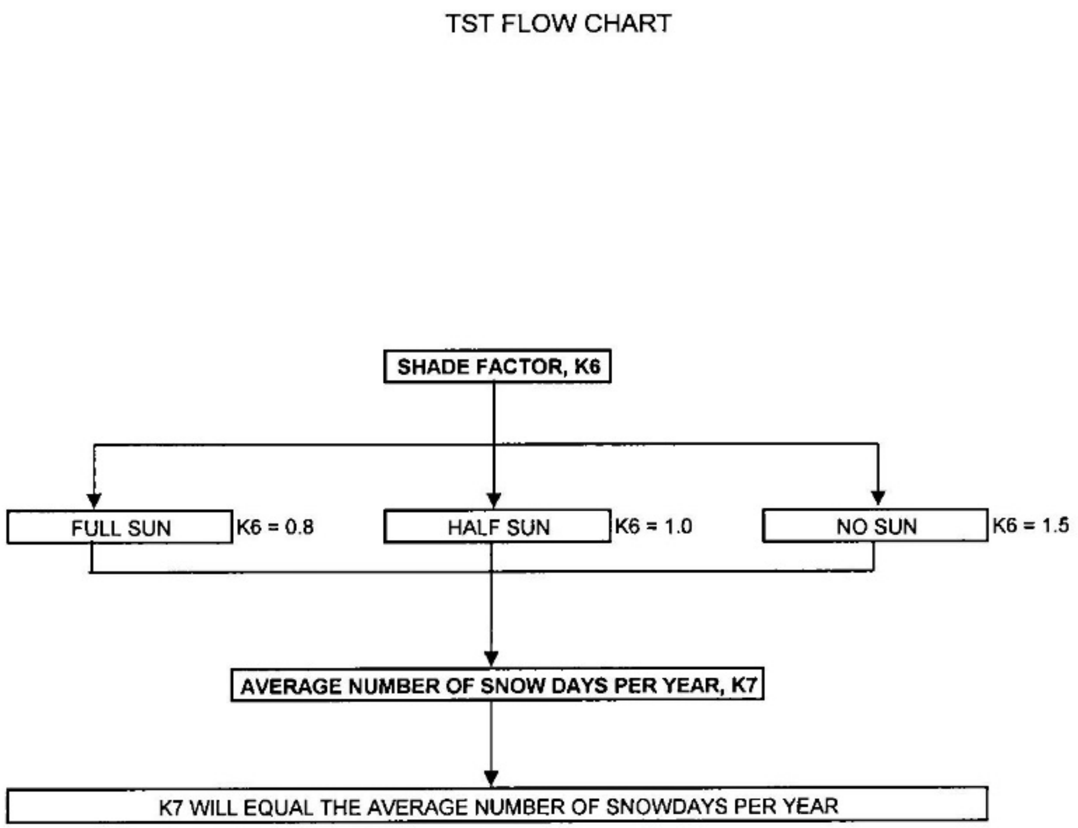

Figure A-6. TST K6