North Carolina Department of Transportation

Manual for Construction Layout

Acknowledgements

Revised 8/15/2011

In order to establish minimum standards for construction layout and uniformity in staking procedures, the North Carolina Department of Transportation developed this Construction Layout Manual.

The Department would like to thank the many people who participated in the development of this document. A special thank you is extended to all Division Construction offices that assisted with the reviewing and editing process, and to the Location and Surveys Unit that provided information concerning the Global Positioning System (GPS).

The Manual for Construction Layout was edited and published by the North Carolina Department of Transportation, Construction Unit. If you have any comments or questions regarding this Manual, contact the Construction Unit.

Corrections Sheet

By using the corrections sheet you will help NCDOT improve future instructional material. Please read the following instructions before going any further.

INSTRUCTIONS:

1. As you use these guidelines, record mistakes and/or printing errors when you encounter them.
2. Once you have recorded any mistakes and/or printing errors, return this sheet to the address at the bottom of the page.
3. Do not use this sheet for asking questions or making comments that require a reply; please write a separate letter for such questions or comments.

I have noted the following mistakes and/or printing errors:

Page Paragraph Remarks

Use the opposite side of this page if necessary.

Please mail this sheet to:

North Carolina Department of Transportation
Construction Unit
Roadway Estimates & Claims Engineer
1543 Mail Service Center Raleigh, NC 27699-1543

Preface

Contract Surveyors play an important role in constructing safe, efficient, economical and durable transportation facilities. The North Carolina Department of Transportation (NCDOT) believes the current trend of providing Prime Contractors the responsibility of surveying their own projects, will continue well into the future. By developing a standard Manual for Construction Layout, NCDOT establishes consistency in construction layout and staking procedures to be used by all department contractors. The use of these uniform procedures will result in fewer construction stakeout errors and problems resulting from such errors.

These standards and procedures were established by a technical advisory committee consisting of NCDOT and contractor personnel.

You, the Contract Surveyor, are expected to review these guidelines, consider them in the compilation of your bid and apply them to your daily surveying operations.

Introduction

The purpose of the Manual for Construction Layout is to familiarize Contract Surveyors with the standards and procedures required to survey and stake a NCDOT project. The majority of construction layout procedures encountered during a typical project are detailed within this manual. If an item is not included, contact the Resident Engineer administering the project for the appropriate procedure.

Construction Surveying is essential to completing a high quality and economical project. The Contract Surveyor is involved in construction layout at all stages of the project, from verifying initial control points through project completion. By knowing and understanding the standards and procedures for construction layout, the Contract Surveyor helps to improve the overall quality, productivity and profitability of the project.

In any successful partnership, effective communication is vital. The partnership between the Contract Surveyor and the Resident Engineer's surveying staff is no different. Everyone involved with the project must communicate effectively to increase overall understanding of both the information being established in the field and submitted for review.

NCDOT realizes that the effectiveness of this manual is an important element in the construction layout of a project. If, while surveying a department project, you develop a more efficient procedure, please submit it to the Construction Unit. The Construction Unit will evaluate its viability for inclusion in the next revision of this manual. Please note that written approval should be provided by the Resident Engineer if a deviation from this manual is proposed.

Reference Materials

In addition to the Manual for Construction Layout, you should have access to the following:

- Standard Specifications for Roads and Structures
- Roadway Standard Drawings
- Project contract and plans
- Any and all revisions for the project

Table of Contents

Chapter 1
General Information

1.1 General Information

Perform all construction layouts in accordance with this manual, the current edition of the Standard Specifications for Roads and Structures (Section 801), and the project Contract (unless otherwise approved or directed).

Set all types of stakes at intervals of 50 feet (20 meters) unless otherwise detailed or directed. Intervals may be adjusted by the Engineer to properly construct the project.

Reference all elevations to the finished grade.

Accuracy is a degree of conformity with a standard or accepted value. According to *Definitions of Surveying and Associated Terms*, accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result is obtained. The accuracy ratio shall not exceed an error of closure of 1 foot per 20,000 feet (1 meter per 20,000 meters) of perimeter for all control and structure surveys and 1 foot per 10,000 feet (1 meter per 10,000 meters) of perimeter for all other horizontal surveys. The accuracy for vertical surveys shall not exceed

$$0.05ft.\sqrt{(x)miles} \quad (15.24mm\sqrt{0.62137(x)km}$$

for control and structure surveys, and

$$0.10ft.\sqrt{(x)miles} \quad (30.48\text{mm}\sqrt{0.62137(x)km})$$

for all other vertical surveys. The precision for surveying each operation is detailed within this manual.

1.2 Safety

The number one concern in construction stakeout is ensuring that all work is conducted in a safe manner. Proficiency, accuracy and timeliness should never take precedence over safety of the crew and/or public. The consequences of any accident, no matter how minor, cannot be justified by the desire to complete work within a given schedule. Remember, when operating in a hazardous area, the top priority is the safety of each individual, equipment is secondary.

The stakeout crew is exposed constantly to moving vehicles and equipment on the construction site. Earthmoving equipment can dwarf a survey crew member, making it difficult for the equipment operator to see the individual standing on the ground. Therefore, one should always notify the Contractor of his/her

intended area of operation and the expected time period of occupancy. Crew members should be alert for backing equipment. When one is setting stakes, it is recommended to have a standing person close by to make the operation more visible and act as the eyes of the stake driver. If working beneath a construction operation, each crew member should wear an approved safety helmet. In some cases, the Prime Contractor may require the use of safety helmets while performing work within the project limits.

When stakeout is required adjacent to active travel lanes, extreme caution should be taken to protect the crew from oncoming traffic. Each member of the crew should stay alert and watch for potential hazardous situations. In addition, the appropriate traffic control measures should be installed.
The stakeout crew will be exposed to the elements, insects and some poisonous plants. Therefore, the appropriate clothing should always be worn.

1.3 Required Submittals

Submit the following information to the Engineer for review and approval.

- A printout of horizontal verification, as well as coordinates, differences and error of closure.
- A printout of vertical control verification, with benchmark location elevations, and differences from plan elevations.
- Sketch of location of newly referenced horizontal control, with text printout of coordinates, method of reference and field notes associated with referencing control.
- Description of newly established benchmarks with location, elevation and closed loop survey field notes.
- The proposed method for recording information in field books to ensure clarity and adequacy.
- All updated electronic and manuscript survey records on a monthly basis.
- Two (2) copies of layout drawings for all utility construction systems.
- Two (2) copies of layout drawings for all drainage systems.
- Layout drawing for each structure and culvert.
- Computations for buildups over beams, screed grades and overhang form elevations.
- Sign S-Dimension information on an 11 ½ inch x 17 inch drawing depicting the theoretical finished section at each proposed overhead sign assembly location.
- Coordinate data showing differences between supplied baseline coordinates and field obtained GPS coordinates, including report detailing preliminary input data.
- Any proposed plan alteration to rectify a construction stakeout error, including design calculations, narrative and sealed drawings.
- Validation of right-of-way marker locations.
- Alignment of baseline for each borrow pit location.
- Detailed sketch of proposed overhead and Type A and B ground mounted sign locations along with any obstructions that may interfere with installation.
- Digital Terrain Model
- AMG Work Plan

Chapter 2
Staking Control Points

2.1 General Information

The initial control is the foundation from which the entire project will be surveyed. Therefore, it is critical to establish accurate control. The Department strives to provide accurate baseline control. The expectation is that the Contract Surveyor will easily be able to verify the Department's control within the specified accuracy, and will preserve such accuracy in referencing the control outside the project limits.

2.2 Verifying Control Points

Horizontal Control

Verify the Department's horizontal control by performing a closed traverse of the baseline control points. All baseline control points should be occupied. Notify the Engineer in writing of any discrepancies in the horizontal control. The Engineer should provide written direction before control points, which do not validate within the specified accuracy, are utilized.

Submit to the Engineer a printout of the control verification, as well as coordinates, differences and error of closure.

Vertical Control

Verify the Department's vertical control by performing a closed loop survey utilizing differential leveling. Notify the Engineer, in writing, of any discrepancies in the vertical control.

Submit to the Engineer a printout of all benchmarks with locations, elevations and differences from plan elevations.

2.3 Referencing Control Points

Horizontal Control

Approved methods for referencing horizontal control points shall include a minimum of three (3) points and one (1) angle. An offset baseline traverse is an approved method for referencing horizontal control. (See *Figure 2.1*.)

Submit to the Engineer a sketch showing location of new control, a text printout of coordinates, the method of reference and the field notes associated with referencing control.

Vertical Control

An approved method for referencing vertical control is to establish a new benchmark by performing a closed loop survey utilizing differential leveling.

Submit to the Engineer a description of the new benchmark, location, elevation and closed loop survey field notes. (See *Figure 2.2*.)

2.4 Type of Stakes

Recommended Stake Size: 60D nail or 18" #5 rebar for horizontal control point ¾" x 1 ¾" x 36" for guard stake. Railroad spikes may be used for vertical control or other approved points. A paint mark will not be acceptable. A ¾" x 1 ¾" x 18" stake should accompany the benchmark with the elevation information legibly written upon it.

2.5 Staking Accuracy

Horizontal Control

The accuracy ratio shall not exceed an error of closure of 1 foot per 20,000 feet (1 meter per 20,000 meters) of perimeter (1:20,000).

Vertical Control

The error of closure shall not exceed $0.05\text{ft.}\sqrt{(x)miles}$ $(15.24mm\sqrt{0.62137(x)km})$

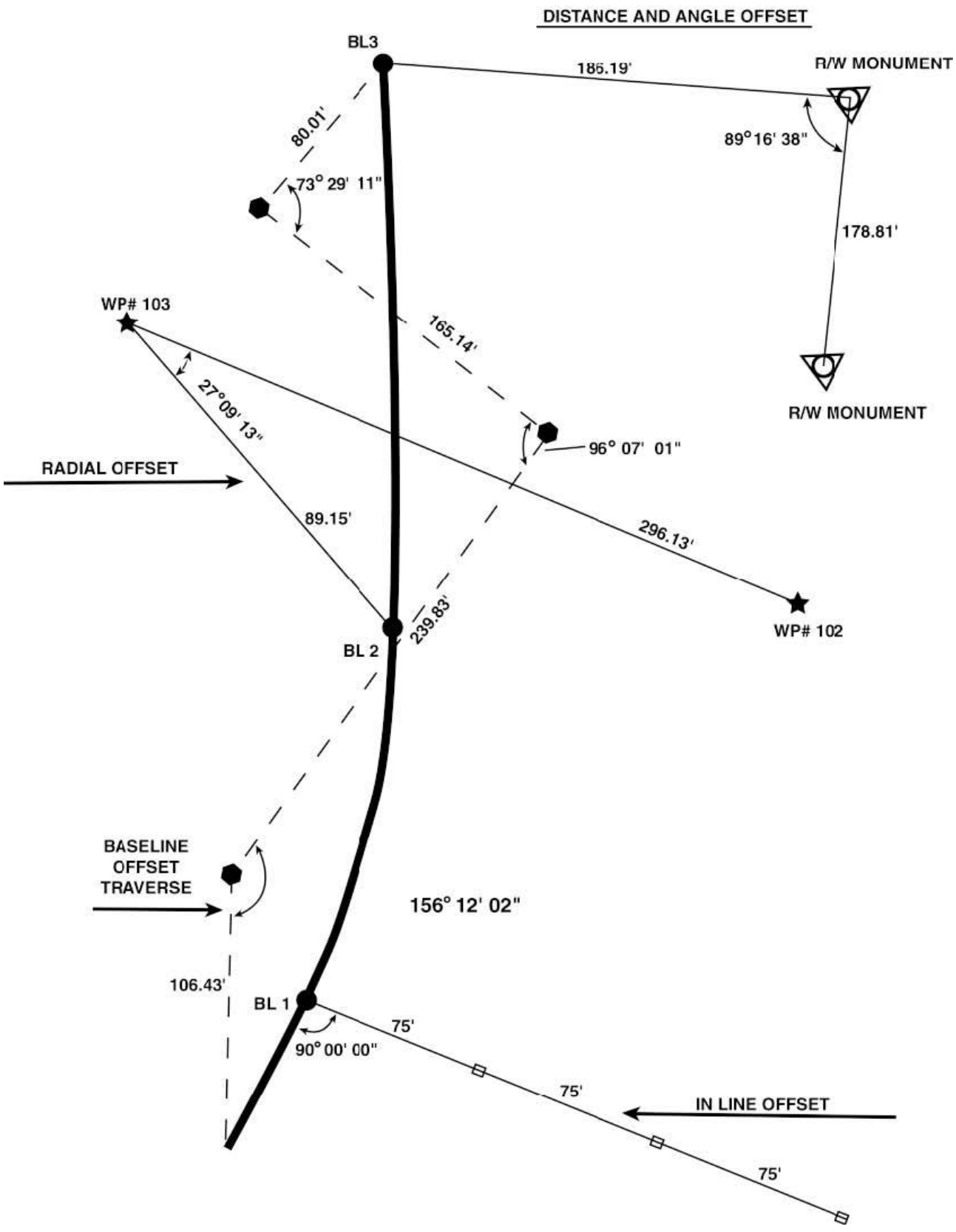

METHODS OF REFERENCING HORIZONTAL CONTROL
DISTANCE AND ANGLE OFFSET
BL3
186.19'
R/W MONUMENT
80.01'
89° 16' 38"
73° 29' 11"
178.81'
WP# 103
165.14'
R/W MONUMENT
27° 09' 13"
96° 07' 01"
RADIAL OFFSET
89.15'
296.13'
239.83'
WP# 102
BL 2
BASELINE
OFFSET
TRAVERSE
156° 12' 02"
106.43'
BL 1
75'
90° 00' 00"
75'
IN LINE OFFSET
75'

Figure 2.1

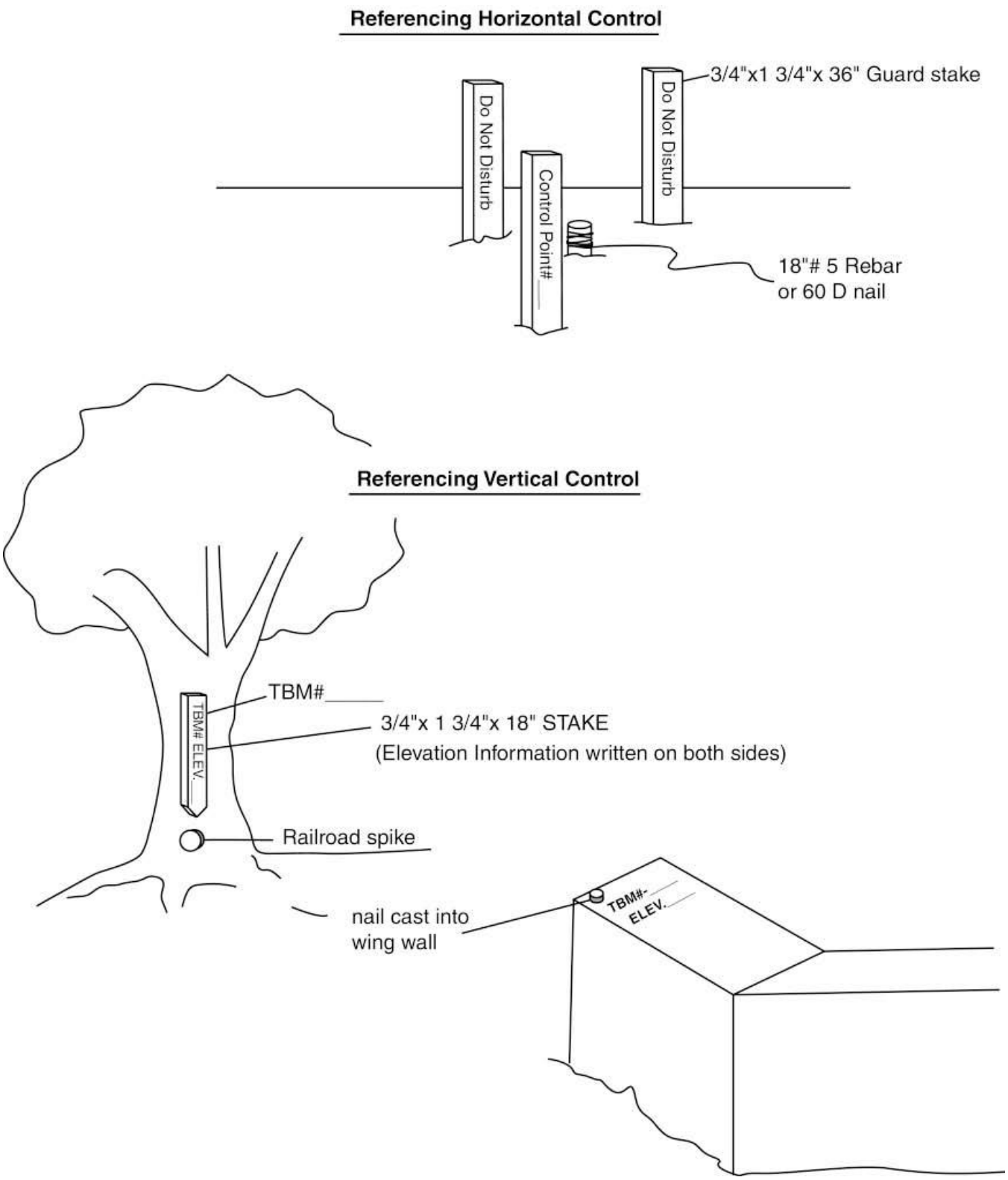

Referencing Horizontal Control
3/4"x1 3/4"x 36" Guard stake
Do Not Disturb
Control Point#___
Do Not Disturb
18"# 5 Rebar
or 60 D nail
Referencing Vertical Control
TBM#_____
TBM# ELEV.___
3/4"x 1 3/4"x 18" STAKE
(Elevation Information written on both sides)
Railroad spike
nail cast into
wing wall
TBM#-
ELEV.

Figure 2.2

Chapter 3
Centerline Stakes

3.1 General Information

With today's technology and the use of baseline surveys, the need to install centerline stakes has diminished. However, there are different types of projects across North Carolina which, for various reasons, may require the installation of centerline stakes. If the centerline is inaccessible, an offset line may be required.

3.2 Guideline Information

Set centerline stakes at 50 foot (20 meter) intervals, including all cardinal points (TS, SC, CS, SC, equalities, etc.)

3.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Precision: Horz. 0.1'
Stake Use: Location and Information

3.4 Stake Information

The information described below is detailed in *Figure 3.1*.

1. Station number
2. Offset (if necessary)
3. Designation of alignment

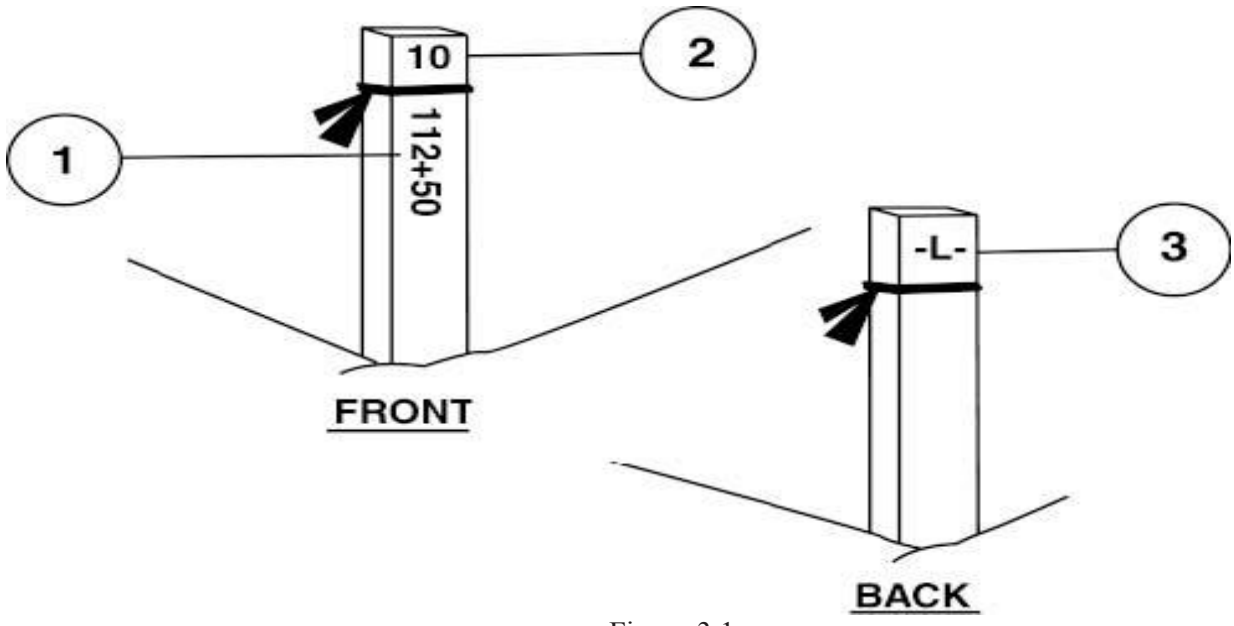


Figure 3.1

Chapter 4
Orange Safety Fence

4.1 General Information

Provide construction stakes to establish the locations of the safety fence along the outside riparian buffer, wetland, water boundary or other boundaries located within the construction corridor as shown on the permit drawings. Coordinates for the limits of the permitted area can be obtained from the Engineer.

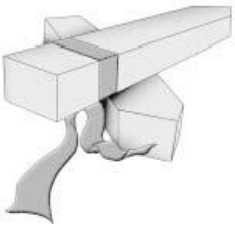
Provide wooden stakes on 25 foot maximum intervals with flagging attached to delineate the interior boundaries of all jurisdictional areas. Interior boundaries may be staked on a tangent that runs parallel to the buffer but must not encroach on the buffer at any location. Interior boundaries of hand clearing areas shall be identified with a different colored flagging to distinguish it from mechanized clearing.

4.2 Guideline Information

Utilize Contract Permit Drawings, Permit Stakeout Drawings (see Appendix), Erosion Control Plans, Standard Drawings, Roadway Plans, Utility Construction Plans and Project Cross-Sections in establishing the location of the Orange Safety Fence.

4.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 48"
Recommended Flagging: Orange
Precision: Horz. 0.1ft.
Stake Use: Location



Chapter 5
Clearing Limits

5.1 General Information

One of the initial operations on a new project is to establish the limits for clearing and grubbing, which prepares the project for grading within the construction limits.

5.2 Guideline Information

Utilize Erosion Control Plans, Utility Construction Plans, Contract Permit Drawings, Roadway Plans, Standard Drawings, and Project Cross-Sections in establishing clearing limits. In critical areas such as wetlands, condemned parcels and any other areas deemed necessary by the Engineer, install slope stakes prior to establishing clearing limits. Flagging tape may be tied on stable trees to supplement the clearing stakes. Retain the clearing stakes throughout the clearing and grubbing operation.

5.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue and White Striped
Precision: Horz. 1.0 unless slope staking is required, then Horz. 0.1'
Stake Use: Location

5.4 Stake Information

The information described below is detailed in *Figure 5.1*.

1. Denotes type of stake (clearing limits)
2. Station

CLEARING LIMITS

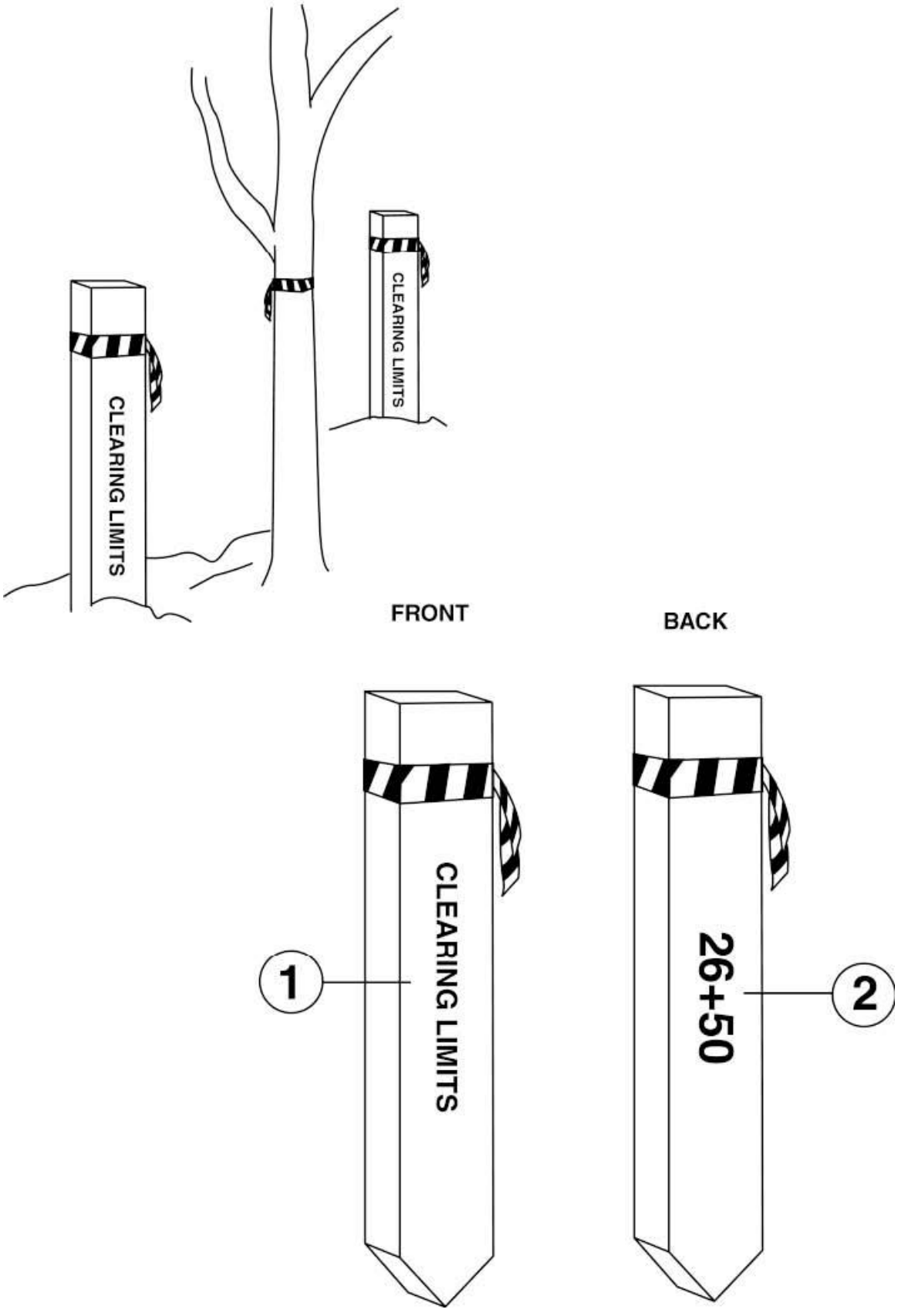
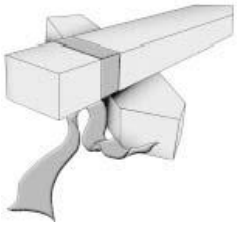


Figure 5.1



Chapter 6
Slope Stakes

6.1 General Information

Before beginning earthwork construction, the limits of the cuts and fills must be identified for equipment operators. Slope stakes establish the intersection of either the top of cut or the toe of fill with the natural ground. They also reference the centerline location and quantify the depth of material to be excavated or placed. Slope stakes should remain in place until the slopes are completed, inspected and permanently seeded.

6.2 Guideline Information

Install slope stakes with a minimum offset distance of 10 feet (3 meters). Slope stakes shall not be scaled from the plans or determined from plan cross sections. Instead, they should be determined mathematically in the field prior to grading operations.

If a hinge point is detailed, set the slope stake to the hinge point. Otherwise, set the slope stake to the shoulder point or ditchline.

6.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Precision: Horz. 0.1', Vert. 0.1'
Stake Use: Information and Location

6.4 Stake Information

The information described below is detailed in *Figure 6.1*.

1. Offset distance (horizontal distance between catch point and slope stake)
2. Total fill or cut from the base point to intercept point with natural ground
3. Total horizontal distance of slope
4. Rate of slope
5. Total distance from centerline to intercept point
6. Offset difference (±)
(vertical difference between intercept point and offset stake point) + offset stake point higher than intercept point -offset stake point lower than intercept point
7. Station number
8. Superelevation

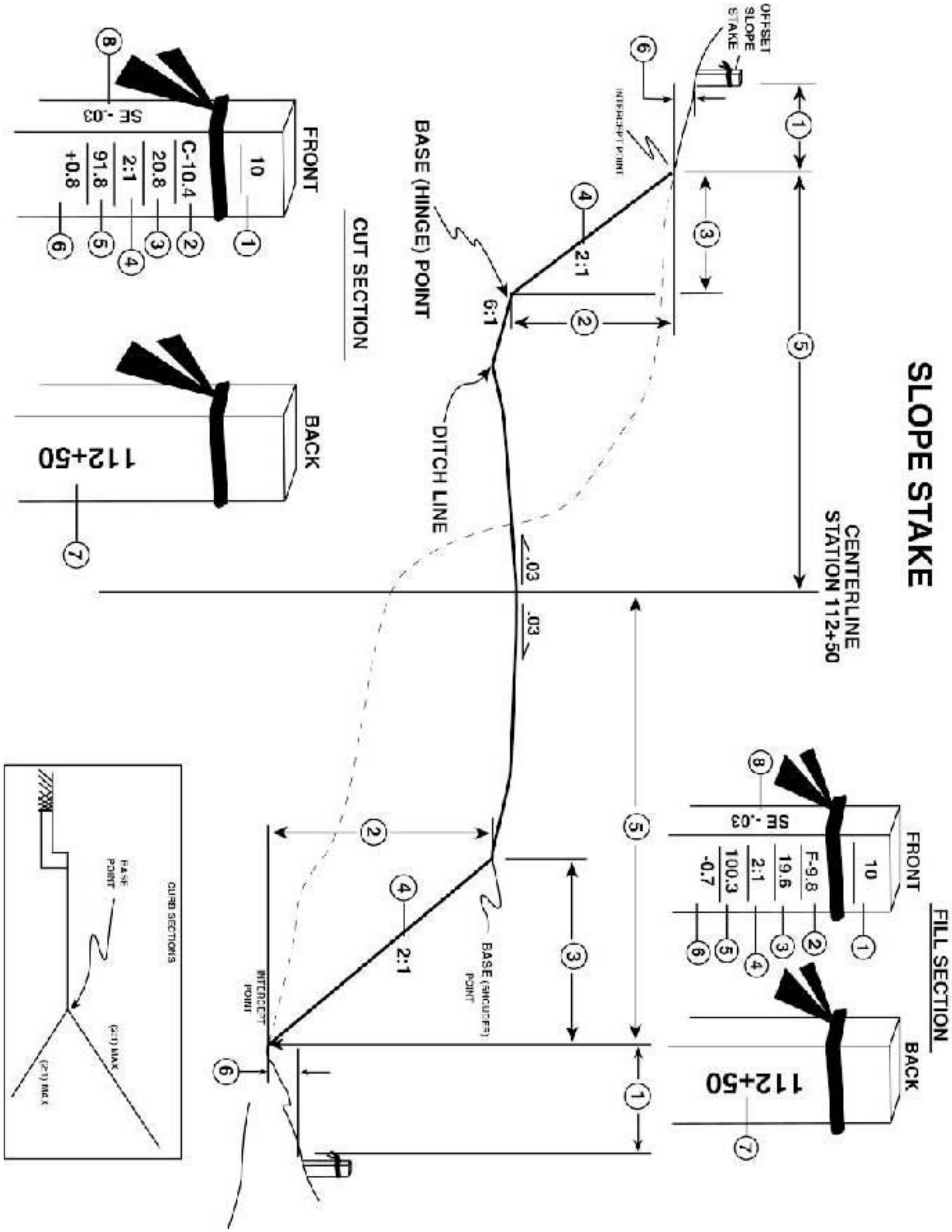
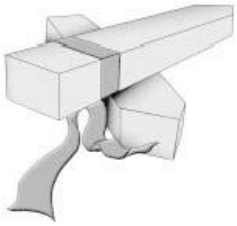

SLOPE STAKE
CENTERLINE
STATION 112+50
OFFSET
SLOPE
STAKE
INTERCEPT POINT
BASE (HINGE) POINT
DITCH LINE
2:1
6:1
.03
.03
BASE (SHOULDER) POINT
INTERCEPT POINT
2:1
CUT SECTION
FRONT
10
C-10.4
20.8
2:1
91.8
+0.8
SE -.03
BACK
112+50
FILL SECTION
FRONT
10
F-9.8
19.6
2:1
100.3
-0.7
SE -.03
BACK
112+50
CURB SECTIONS
BASE POINT

Figure 6.1



Chapter 7
Ditch Stakes

7.1 General Information

Drainage ditches typically are located at the toe of fill sections to provide a controlled channel to carry storm water. Ditch stakes provide the location, depth and width of such channels.

7.2 Guideline Information

Utilize Roadway Plans, Project Cross-Sections, slope stake information and drainage ditch details when establishing the location and depth of a drainage ditch. Ditch stake elevations should be established from the profile plan sheets. The ditch typical section will override profile grades in order to achieve minimum depths. The ditch depth should be measured either to the top of the ditch lining or to the flow line of the ditch (if no lining is specified).

7.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Blue
Precision: Horz. 0.1', Vert. 0.1'
Stake Use: Information and Location

7.4 Stake Information

The information described below is detailed in *Figure 7.1*.

1. Offset distance to intercept point of back slope with natural ground
2. Cut to bottom of ditch from stake
3. Back slope of ditch
4. Base width
5. Ditch typical from plans
6. Offset difference (±)
   (vertical difference between intercept point and offset ditch stake point)
   + offset ditch stake point higher than intercept point
   - offset ditch stake point lower than intercept point
7. Station

DITCH STAKES

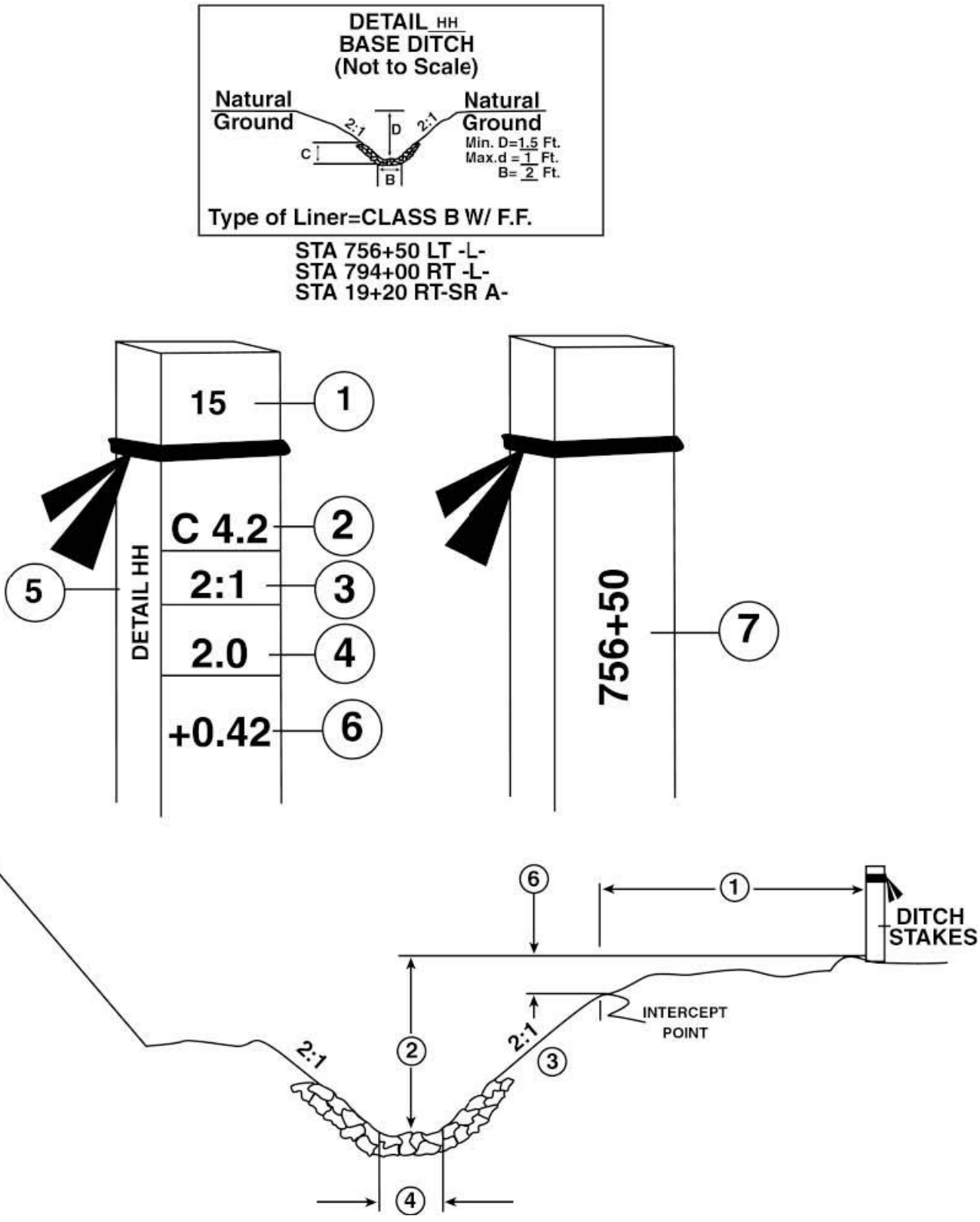


Figure 7.1

Chapter 8
Pipe Stakes

8.1 General Information

A critical task, on any project, is to construct the drainage so that it effectively collects and distributes storm water. During construction stakeout, the survey crew should identify potential drainage problems and make recommendations for correction to the Engineer. It is the responsibility of the construction stakeout crew to ensure that the drainage systems detailed in the plans will function properly as staked. If a concern exists that the drainage system may be inadequate, based upon field observations, it also should be addressed with the Engineer.

8.2 Guideline Information

Prior to calculating and staking the drainage system detailed in the plans, perform a field investigation of the proposed area. Consider the locations and elevations of all existing and proposed utilities, proposed utility construction, and existing and proposed drainage systems in the layout of the drainage system. A layout drawing of the drainage system must be submitted to the Engineer for review and approval (See Appendix.) However, before submitting the drawing, verify that all the required information is included by referring to the *Checklist for Drainage Layout Submittal* (See Appendix.) In addition, unless otherwise instructed, calculate the entire network before submitting any portion of the network for approval.

Establish pipe lengths from the drainage structure locations and/or actual location of the slope intercept with existing streams, natural ground or proposed drainage ditches as measured during the field investigation and/or layout. In order to ensure the clear zone recovery requirements are met, when staking crossline pipes notify the Engineer if the pipe length is less than the plan length. Use 12” hubs for referencing the pipe’s line and flowline elevation. Pipelines greater than 200 feet will require intermediate hubs set on 100 foot intervals or on smaller intervals as deemed necessary by the Engineer. The intermediate hubs shall contain cuts or fills relative to the pipes invert elevations directly adjacent to the intermediate hubs’ location. Stationing of the pipe shall begin with 0+00 at the outlet end of the pipe and advance to the inlet end. Provide one reference line, consisting of two hubs with corresponding reference stakes, for the inlet and outlet of the pipeline. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub.

8.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

8.4 Stake Information

Reference stakes will be used in conjunction with hubs to provide the required information as detailed below and depicted in *Figure 8.1*.

At First Reference Hub

1. Offset to the reference point of pipe
2. Station of the point referenced with respect to the pipe line
3. Cut or fill from hub to invert
4. Length size and type of pipe
5. Grade of pipe in percent with either inlet or outlet defined
6. Structure number

At Second Reference Hub (Reference location of pipe by alignment with first hub)

1. Offset to the reference point of pipe
2. Station of the point referenced with respect to the pipe line
4. Length size and type of pipe
6. Structure number

At Intermediate Hubs

1. Offset to the pipe
2. Station with respect to the pipe line
3. Cut or fill from hub to invert

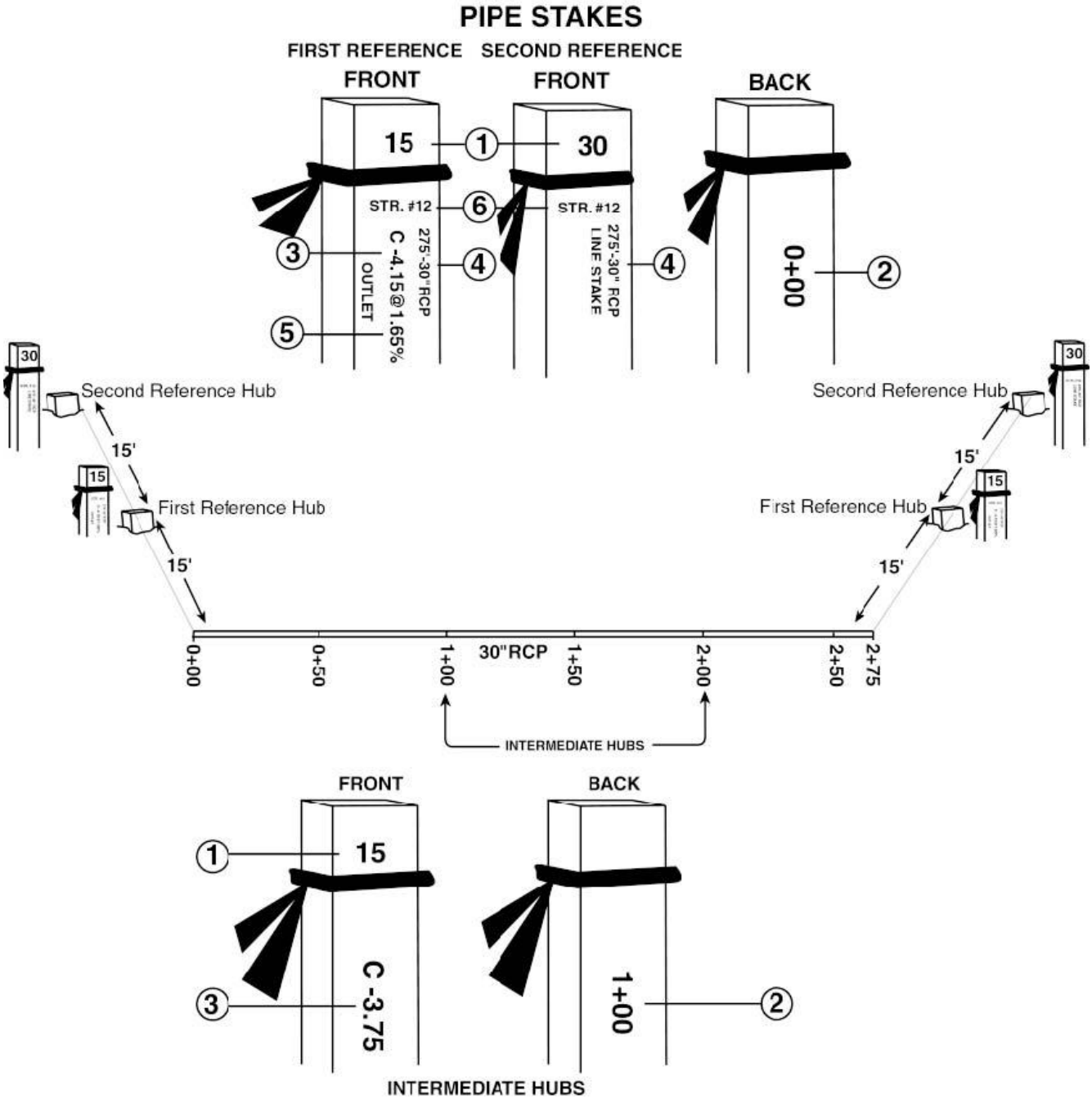

PIPE STAKES
FIRST REFERENCE
SECOND REFERENCE
FRONT
FRONT
BACK
15
30
STR. #12
STR. #12
C -4.15@1.65%
275'-30" RCP
OUTLET
275'-30" RCP
LINE STAKE
0+00
Second Reference Hub
Second Reference Hub
First Reference Hub
First Reference Hub
15'
15'
15'
15'
0+00
0+50
1+00
30"RCP
1+50
2+00
2+50
2+75
INTERMEDIATE HUBS
FRONT
BACK
15
C -3.75
1+00
INTERMEDIATE HUBS

Figure 8.1

Chapter 9
Minor Structure Stakes

9.1 General Information

During construction stakeout, the survey crew should identify potential drainage problems in the field and make recommendations for correction to the Engineer. It is the responsibility of the construction stakeout crew to ensure that the drainage systems detailed in the plans will function properly as staked. Verify the location of all drainage structures within sag vertical curves and reposition as necessary to assure the structure is located at the lowest point. Superelevations at both the roadway and shoulder should be considered in establishing the lowest point. If a concern exists that the drainage system may be inadequate based upon field observations, it should be addressed with the Engineer.

9.2 Guideline Information

Stake each drainage structure independently of each pipeline. Each structure will require a reference line for alignment and grade, consisting of at least one hub on opposite sides of the drainage structure. The hubs should have equal offsets and be a minimum of 10 feet (3 meters) from the reference point. The reference line should mark the centerline of junction boxes and drop inlets, and the inside back wall of catch basins. Grades should be set and referenced from the hubs to top of structure for junction boxes and catch basins, and flow line of grate for drop inlets. Refer to the Standard Drawings for the grate and frame dimensions.

Prior to submitting a drainage system layout drawing, refer to the *Checklist for Drainage Layout Submittal* (See Appendix) to verify that all of the required information is included. Unless otherwise approved, calculate the entire network before submitting any portion of the network.

9.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Information

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub with tack
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

9.4 Stake Information

The information described below is detailed in *Figure 9.1*.

1. Offset to the center of the structure
2. Reference line of hubs with respect to drainage structure
3. Cut or fill from hub to invert and top of structure for drop inlets and junction boxes, top of grate for catch basins.
4. Structure number

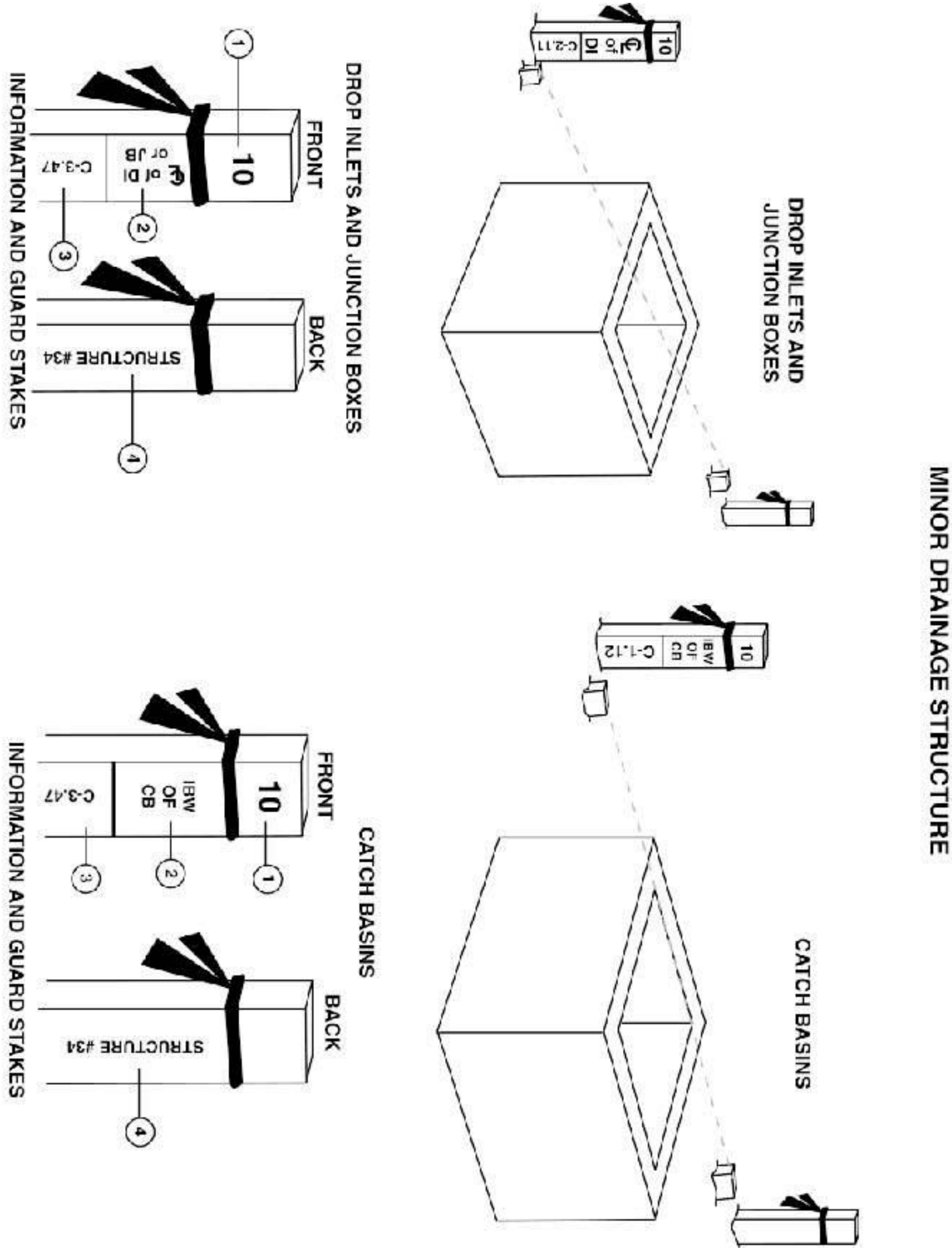

MINOR DRAINAGE STRUCTURE
DROP INLETS AND JUNCTION BOXES
10
℄ of DI
C-2.11
CATCH BASINS
10
IBW OF CB
C-1.12
DROP INLETS AND JUNCTION BOXES
FRONT
10
℄ of DI or JB
C-3.47
BACK
STRUCTURE #34
1
2
3
4
INFORMATION AND GUARD STAKES
CATCH BASINS
FRONT
10
IBW OF CB
C-3.47
BACK
STRUCTURE #34
1
2
3
4
INFORMATION AND GUARD STAKES

Figure 9.1

Chapter 10
Endwall Stakes

10.1 General Information

Endwalls assist in channeling water into the pipe network, minimizing erosion of the stream channel and retaining the embankment above the pipe. Prior to staking the endwall, you must know the limits of your embankment and pipe.

10.2 Guideline Information

Prior to staking the endwall, set slope stakes to establish the limits of the embankment. Stake endwalls perpendicular to the pipe. Adjust the slope and pipe length to accommodate the endwall. Endwalls require one reference line with a hub on each side of the proposed structure. The line should be referenced to the outside face of the endwall. Grades should be set and referenced from the hubs to a known or calculated elevation on the proposed structure. (See *Figure 10.1*.) When locating the endwall, the fill slope should be projected to intersect with the inside wall of the endwall.

10.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 36"
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Information

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub with tack
Recommended Flagging: Blue
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

10.4 Stake Information

The information described below is detailed in *Figure 10.2*.

1. Offset to the center, outside face of endwall
2. Cut or fill from hub to reference point on endwall (typically top of wall)

ENDWALL REFERENCING

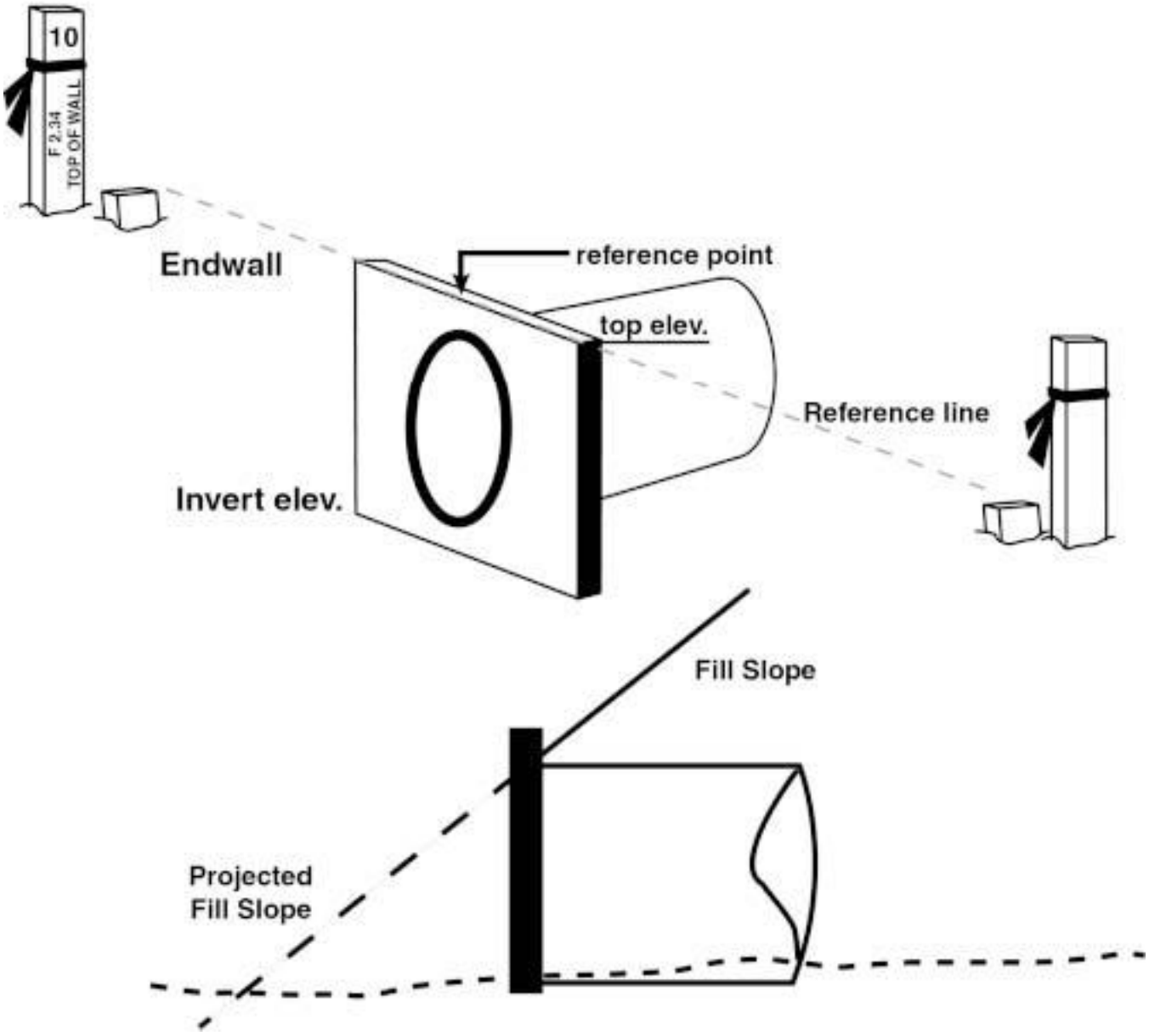


Figure 10.1

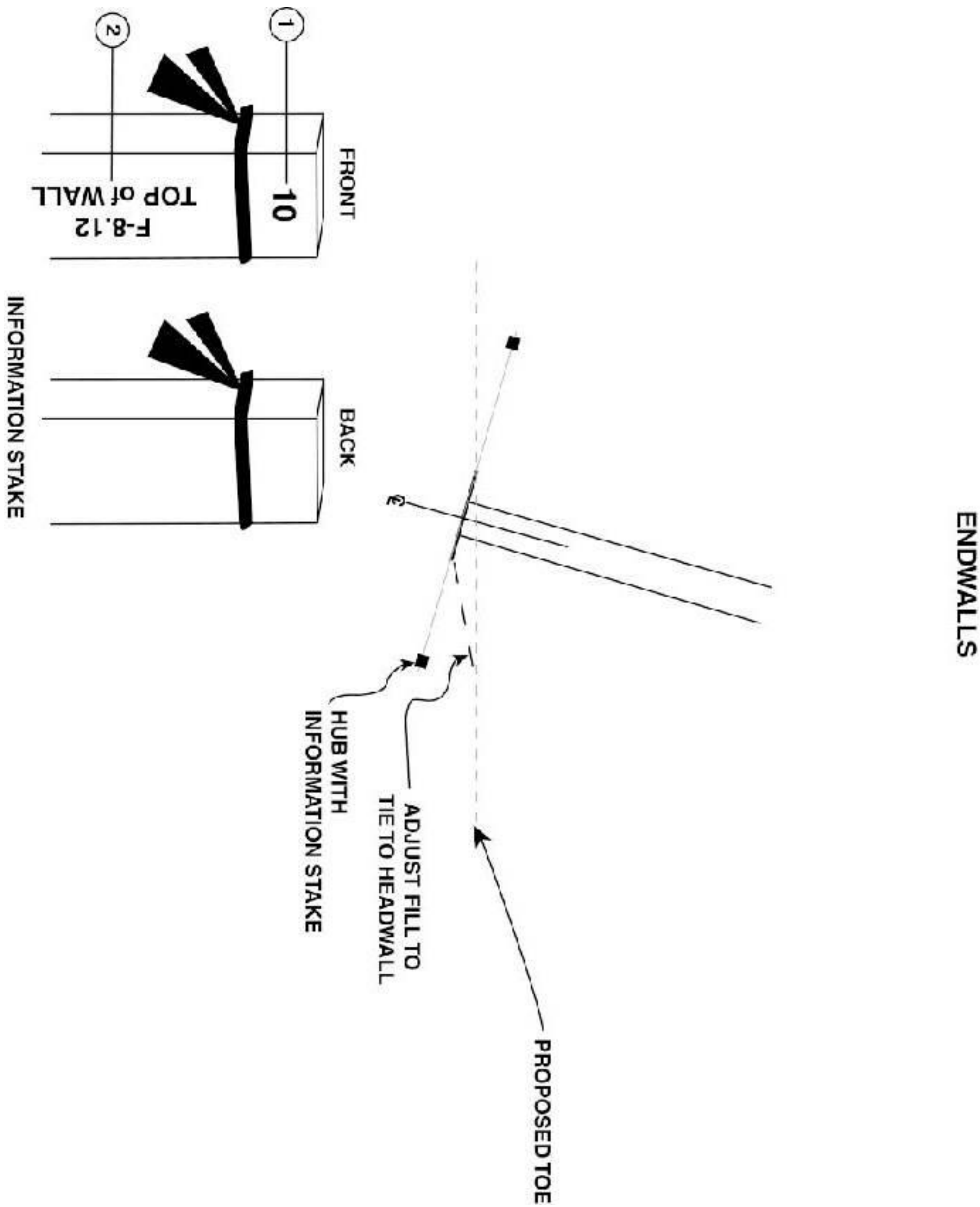
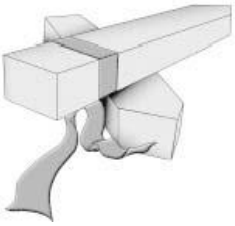

ENDWALLS
FRONT
BACK
10
TOP of WALL
F-8.12
1
2
INFORMATION STAKE
HUB WITH
INFORMATION STAKE
ADJUST FILL TO
TIE TO HEADWALL
PROPOSED TOE

Figure 10.2



Chapter 11
Intermediate Grade Stakes

11.1 General Information

Intermediate grade stakes typically are set after slope stakes and before fine grade stakes. Although the information contained on intermediate grade stakes may be obtained from the slope stakes, intermediate grade stake installation often expedites grading operations by providing the equipment operators a reference to the finished grade location.

11.2 Guideline Information

Set intermediate grade stakes on the centerline or a designated offset line (grade or crown point). On each stake, provide the difference in elevation from finished grade to the top of the stake. Mark the top of the stake with an X to designate the elevation reference.

11.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Precision: Horz. 0.1', Vert. 0.01'
Stake Use: Grade and Alignment

11.4 Stake Information

The information described below is detailed in *Figure 11.1*.

1. Station Number
2. Superelevation
3. Alignment designation
4. Cut or Fill to proposed finish grade

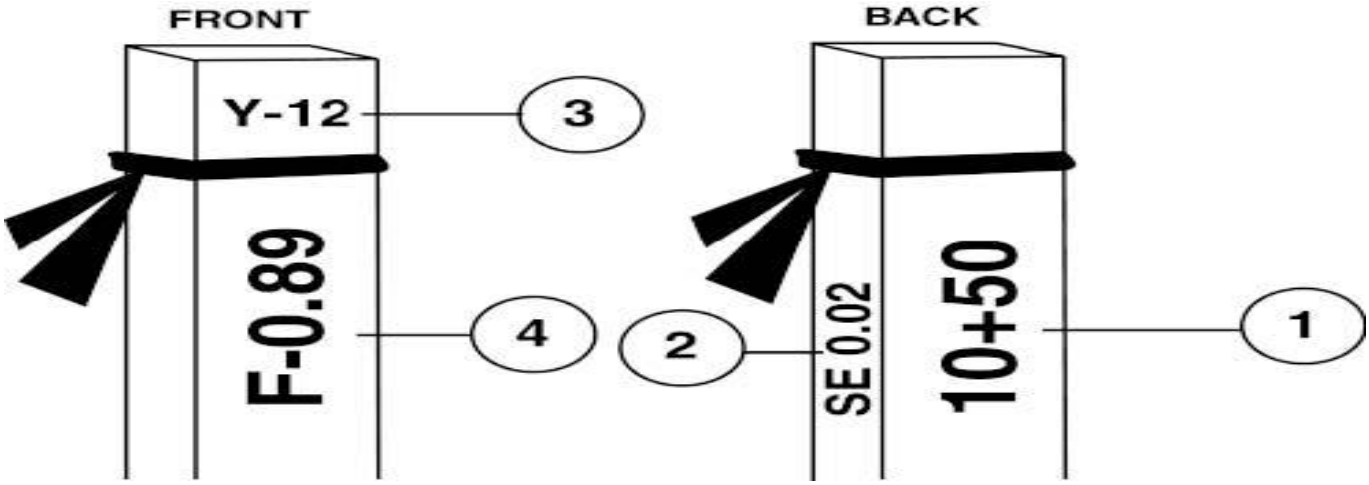


Figure 11.1

Chapter 12
Curb Stakes

12.1 General Information

Various types of curb are specified within NCDOT projects to assist in collecting and distributing storm water to a controlled outlet. Although several types of curbs or curb and gutters may be specified, they should be staked uniformly as detailed below.

12.2 Guideline Information

Stake curb and gutter on 50 foot (20 meter) or smaller intervals in sharp radii, tapers and along flat grades as deemed necessary. Intervals may be adjusted by the Engineer to properly construct the project. Stake curb and gutter with a minimum 3 foot (0.9 meters) and maximum 6 foot (1.8 meter) offset. Set hubs with tacks on the offset line used for horizontal and vertical control. Reference grades to the top of the curb and the offset to the back of the curb. Reference will be taken from the tack in the hub.

When staking radii, stake and mark the curve radius point along with the PC point, the PT point and one or more points equally distributed throughout the curve. When staking radii for -Y- lines, the grades along -L- should override those of the -Y- line to facilitate rideability of the -L- line. Adjust the -Y- lines accordingly.

Consult the Standard Drawings for *Curb Slopes for Variable Superelevations.*

12.3 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Orange
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" with tack
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and Alignment

12.4 Stake Information

The information described below is detailed in *Figure 12.1*

1. Offset to back of curb
2. Cut or fill to top of curb
3. Gutter slope
4. Super elevation of pavement
5. Station number

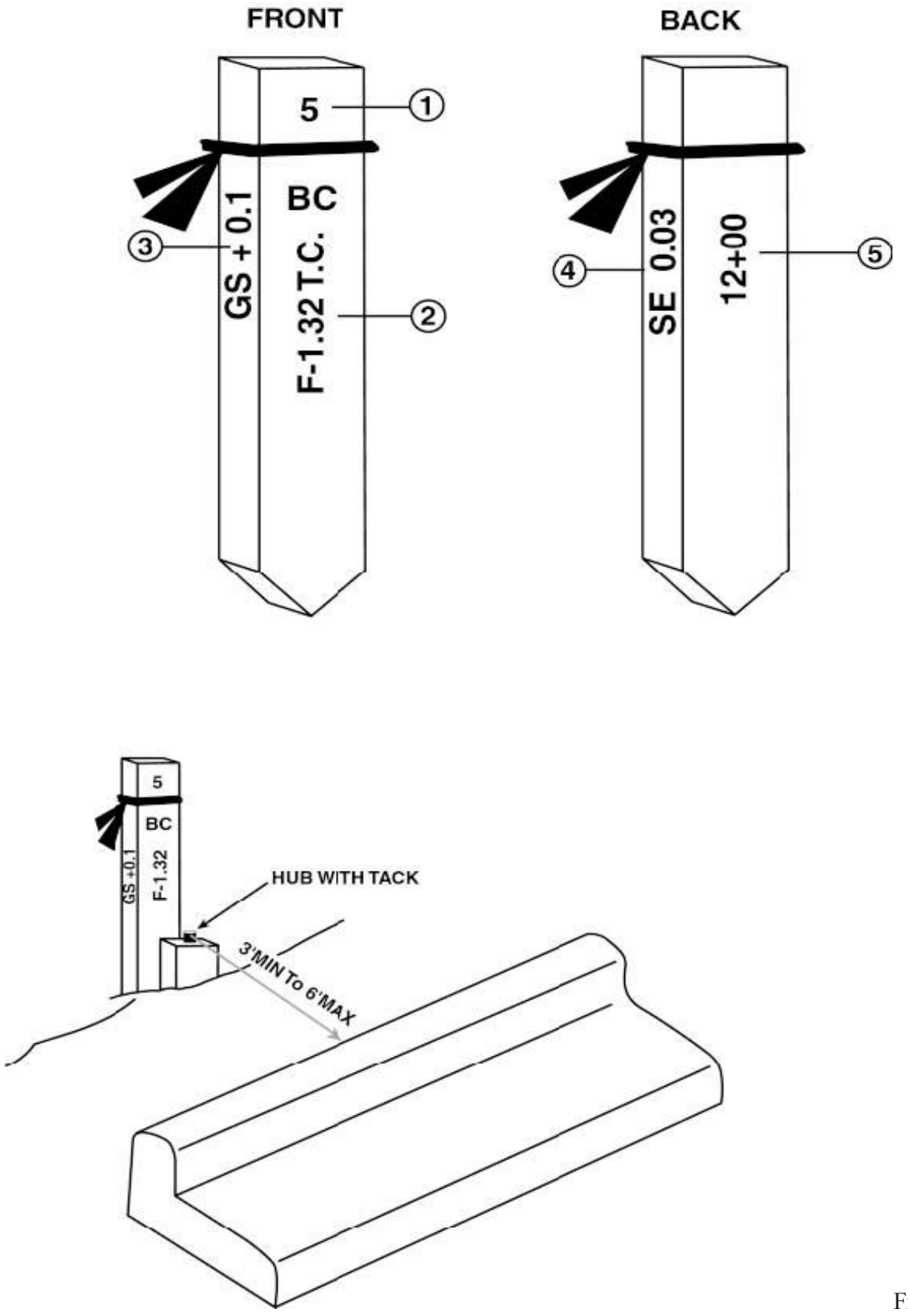

FRONT
BACK
5
1
BC
GS + 0.1
3
F-1.32 T.C.
2
SE 0.03
4
12+00
5
5
BC
GS +0.1
F-1.32
HUB WITH TACK
3'MIN To 6'MAX

Figure 12.1

Chapter 13
Fence Line Stakes

13.1 General Information

The majority of fence on projects will be control of access fence. However, different fences may be specified for Right-of-Way or safety considerations.

13.2 Guideline Information

Set fence stakes at the intervals required by field conditions, not to exceed 100 feet (30 meters). If the control of access and Right of Way lines differ, set stakes on the control of access line. Otherwise set stakes on the right of way line. Establish the Department's Right-of-Way or controlled access line by using the plans and/or any applicable revisions.

Stake other fences along the alignment detailed in the Plans.

13.3 Type of Stake

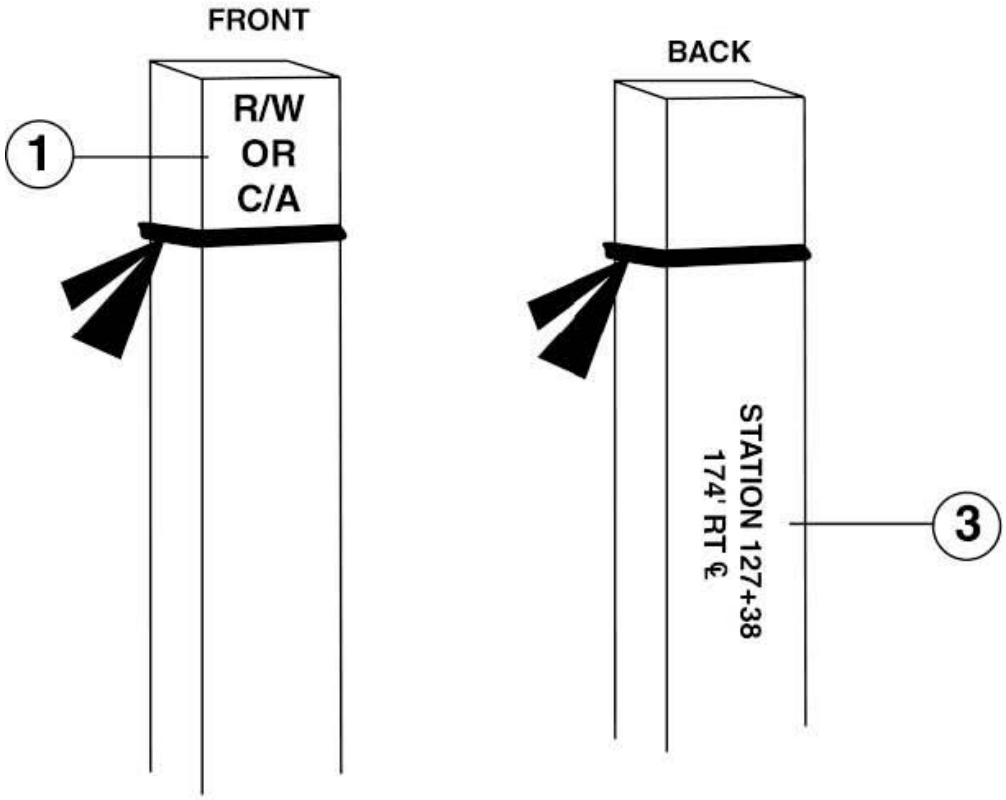
Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: White
Precision: Horz. 0.1'
Stake Use: Alignment

13.4 Stake Information

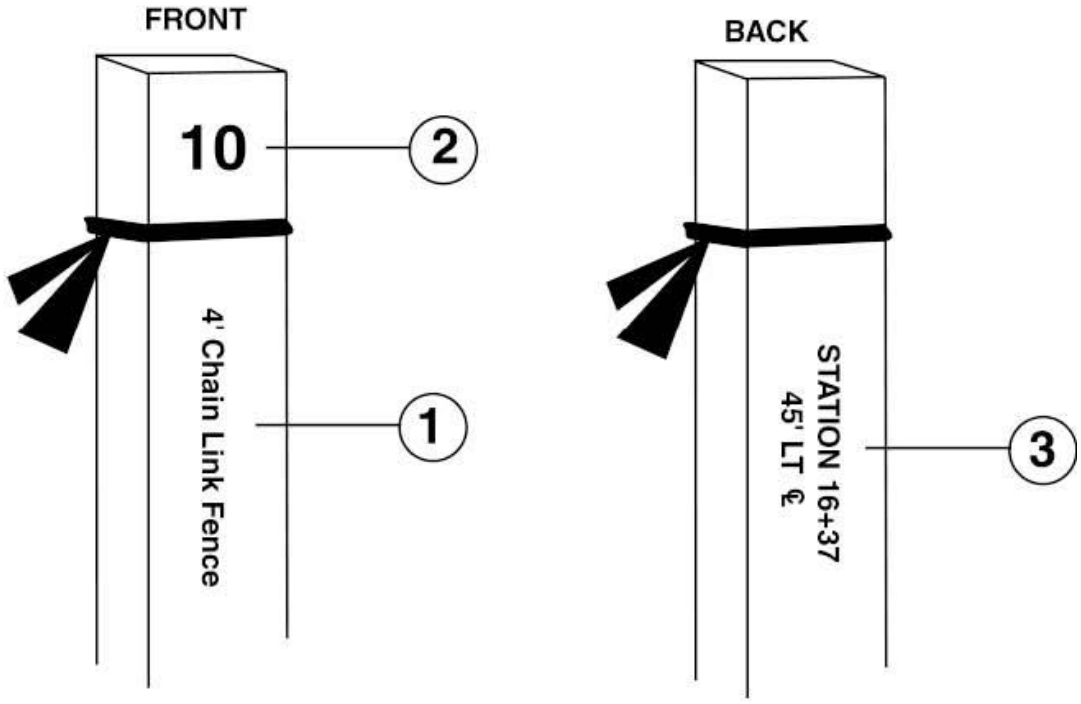
The information described below is detailed in *Figure 13.1*.

1. Denotes type of fence
2. Offset
3. Station and distance from centerline

FENCE STAKES



Control of Access Fence



Other Fences

Figure 13.1

Chapter 14
Fine Grade Hubs

14.1 General Information

Fine grade hubs reference the proposed finish elevation. They are used to establish and check the elevation of all layers of the pavement schedule up to the final layer of surface. Typically set upon completion of rough grading, fine grade hubs provide reference for the elevation of all layers of the pavement, including subgrade, base and pavement.

14.2 Guideline Information

Install and reference all fine grade hubs to finish grade. Set fine grade hubs at a maximum 50 foot (20 meter) interval. A smaller interval may be necessary for gores, tapers, and sharp horizontal and vertical curves or superelevation transitions. Set fine grade hubs on a suitable offset from the edge of paved shoulder, but no less than 5 feet (1.5 meters). (See *Figure 14.1* and *14.2*.) Set an intermediate stake at the centerline if the fine grade hubs span more than 60 feet (20 meters) of proposed pavement. Reestablish this intermediate stake after each layer of pavement structure, excluding the final layer of surface course.

Retain and, if necessary, reinstall all fine grade hubs until the completion of the first layer of surface course.

14.3 Type of Stake

Recommended Stake Size: 1 ¾" x 1 ¾" x 12"-24" hub
¾" x 1 ¾" x 18" reference stake
Recommended Flagging: Orange
Precision: Horz. 0.1', Vert. 0.01'
Stake Use: Alignment, Finished Grade and Pavement Slope

14.4 Stake Information

The information described below is detailed in *Figure 14.3*.

1. Offset
2. Cut or fill from reference hub to the proposed projected finished grade, excluding Case III B (cut or fill to proposed grade or crown point elevation)
3. Superelevation
4. Station number
5. Distance to Grade Point or Crown Point
6. Build up (Optional - Case III A)

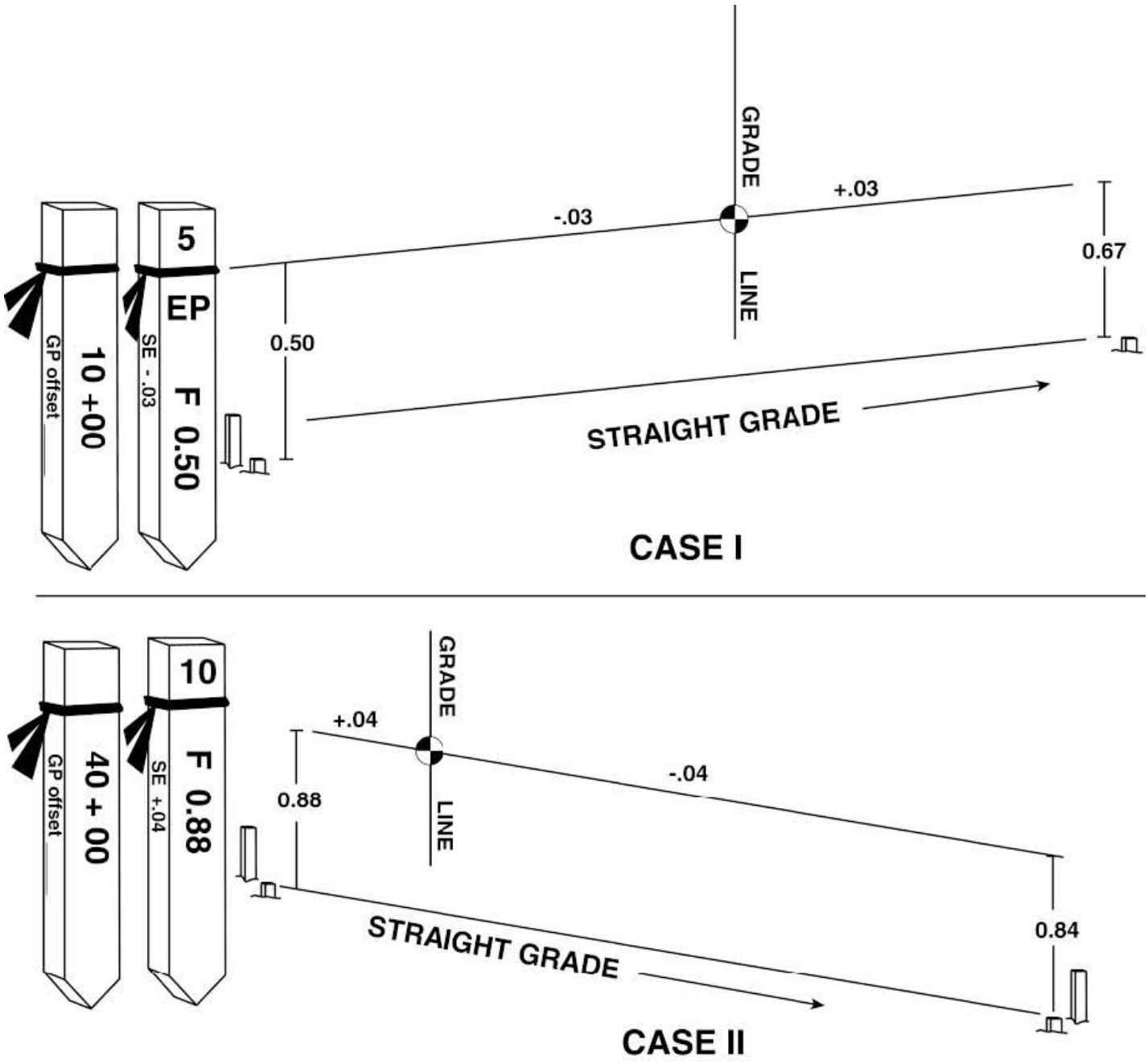
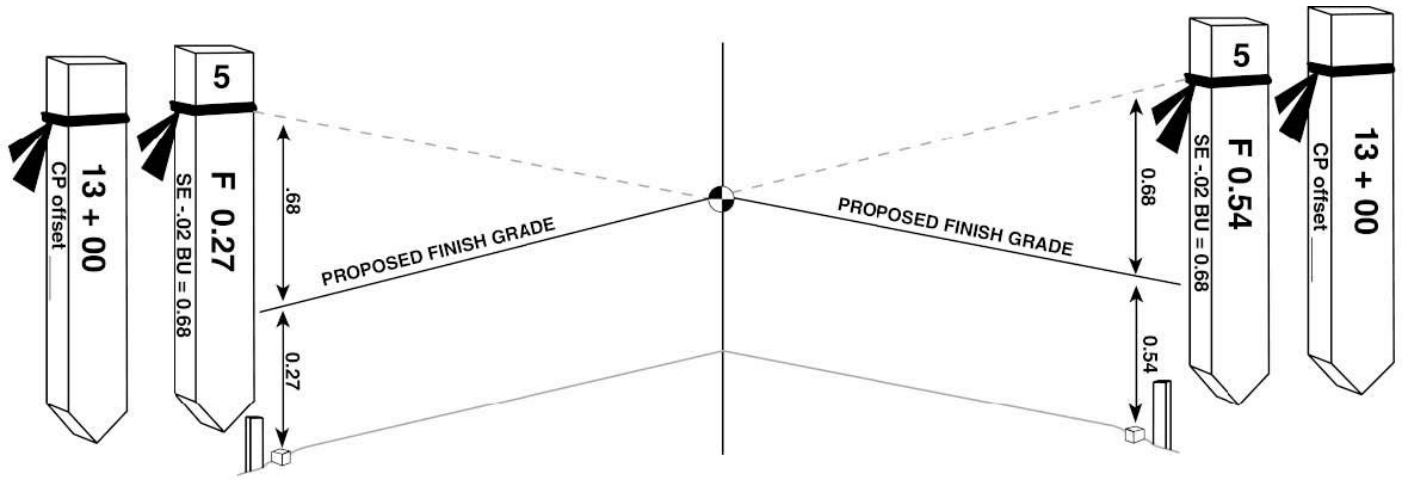
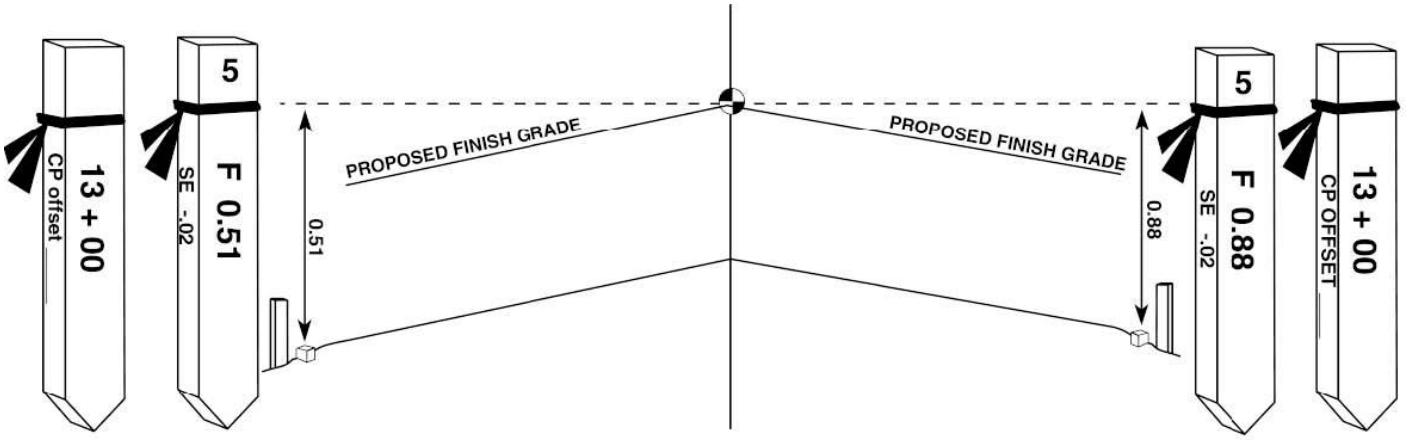

GRADE
LINE
-.03
+.03
0.67
0.50
5
EP
F 0.50
SE -.03
10 +00
GP offset
STRAIGHT GRADE
CASE I
GRADE
LINE
+.04
-.04
0.88
0.84
10
F 0.88
SE +.04
40 + 00
GP offset
STRAIGHT GRADE
CASE II

Figure 14.1



CASE III A



CASE III B

Figure 14.2

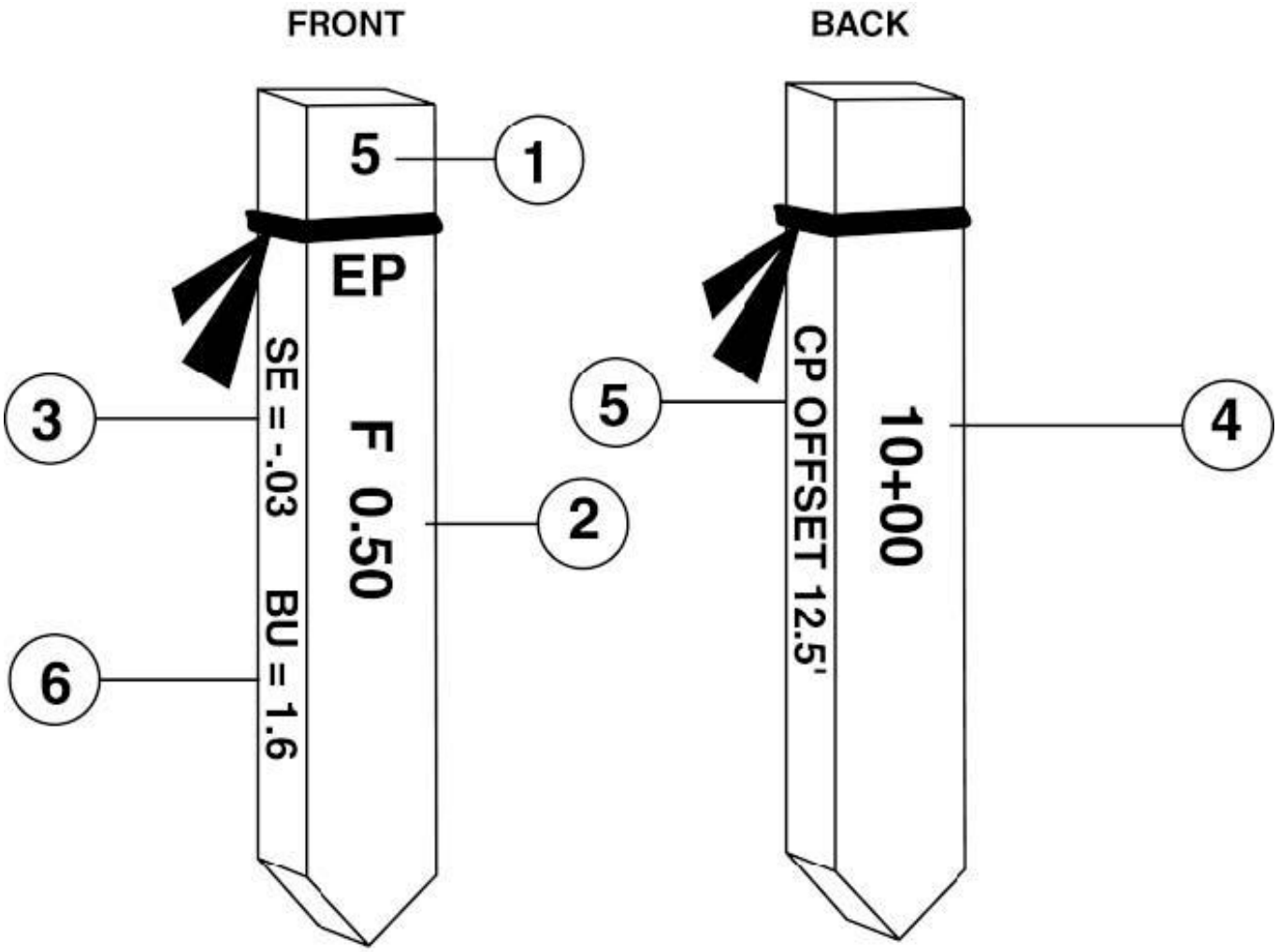


Figure 14.3

Chapter 15
Right-of-Way Markers

15.1 Guideline Information

Reference the location of all proposed Right-of-Way monuments within the construction limits. Submit reference information to the Engineer for review. Submit any Right-of-Way discrepancies between the roadway plans, including any applicable revisions, and the location established by the Department.

Unless concrete Right-of-Way markers are specified in the Contract, install a Right-of-Way monument cap and a carsonite witness stake at each proposed location. Mount the monument cap on an 18" long #5 reinforcing bar, which has been driven flush with the top of the ground. Using a hammer, snugly secure the monument cap to the top of the bar. Install a carsonite witness stake adjacent to the Right-of-Way monument, and drive it approximately 12 inches (30 centimeters) into the ground. Avoid damaging the top of the monument cap or witness stake. The Department will provide both the Right-of-Way monument cap and witness stake.

If concrete monuments are specified, install a 60D nail or hub with tack at the proposed monument locations. The Contractor should install additional reference line stakes on opposing sides of the proposed monument location to reference this location during concrete monument installation.

15.2 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: White
Stake Use: Information and Guard

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" with tack or 60D Nail
Recommended Flagging: White
Precision: Horz. 0.01'
Stake Use: Location

15.3 Stake Information

The information described below is detailed in *Figure 15.1*.

1. Denotes type of stake (Right-of-Way)
2. Alignment
3. Offset from survey line
4. Station
5. Monument cap
6. 18" long #5 reinforcing bar
7. Carsonite witness stake

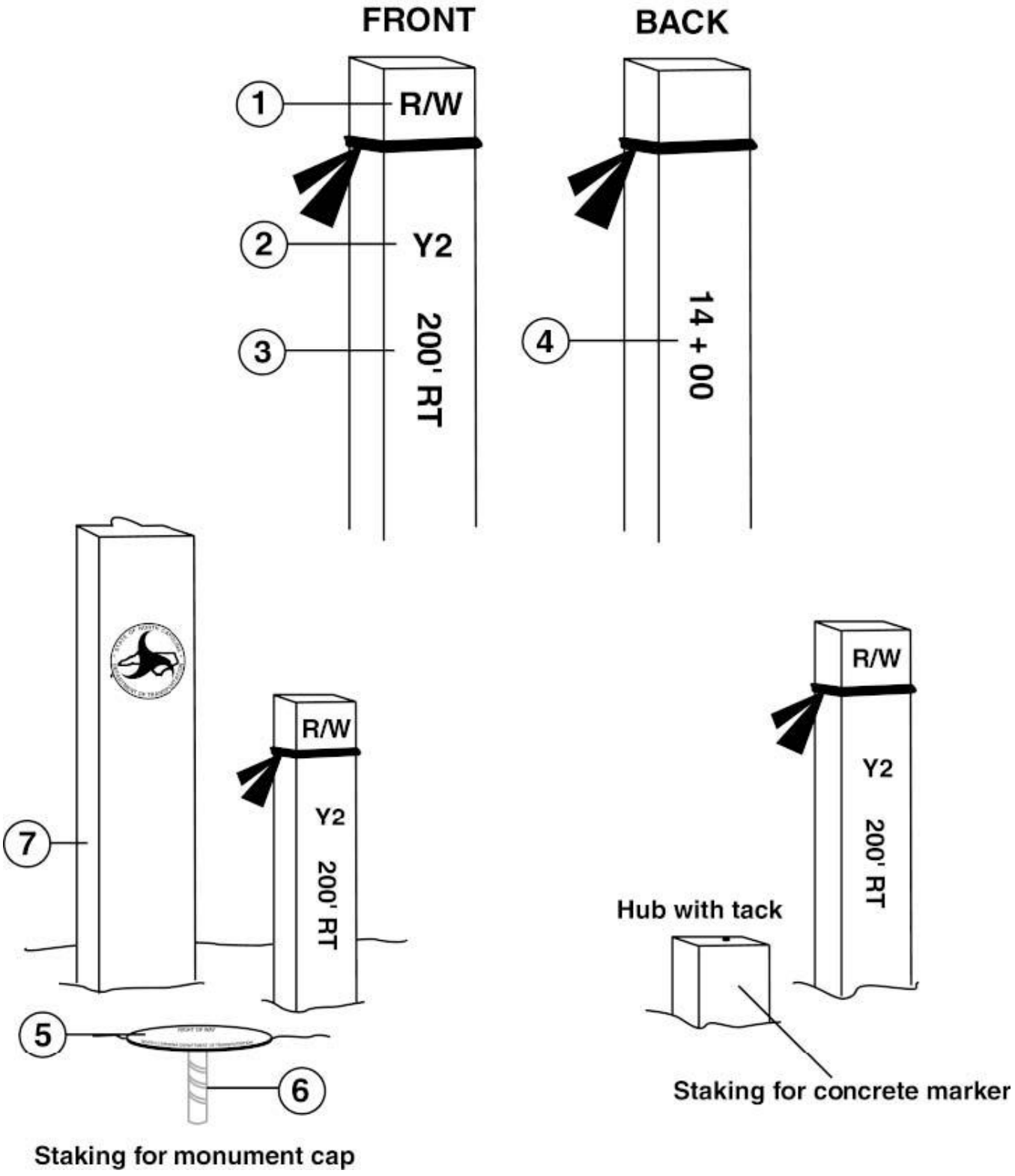

FRONT
BACK
1
R/W
2
Y2
3
200' RT
4
14 + 00
R/W
Y2
200' RT
7
5
6
Staking for monument cap
R/W
Y2
200' RT
Hub with tack
Staking for concrete marker

Figure 15.1

Chapter 16
Signs

16.1 General Information

The s-dimensions and support lengths detailed in the plans are used for estimating purposes only and are not intended for fabricating supports. Prior to sign support fabrication, the s-dimensions should be verified by either theoretical calculation or field measurement and should be submitted to Traffic Engineering for review. Once verified by the Contractor and reviewed by the Department, sign plan revisions will be provided to the Contractor for the fabrication of ground mounted supports and design of overhead sign structures.

16.2 Guideline Information

Prior to establishing the s-dimensions, stake the horizontal location of the proposed signs for the Engineer's review. Perform a thorough investigation of the proposed sign locations, or revised locations established during the Engineer's review. Identify any obstruction, either existing or proposed, which may interfere with the proposed sign installation. Such items may include, but are not limited to, existing or proposed drainage systems, underground and/or aboveground utilities, and drainage ditches. If adjustments in the sign locations are warranted to avoid obstacles, advise the Engineer in writing. Include a detailed sketch of the proposed sign location, the obstruction and the new location recommended to avoid the obstruction. Do not revise any sign locations without the written direction of the Engineer.

Once proposed overhead sign locations are confirmed, use the roadway plans to calculate the theoretical finished elevations at that station. Consider the following in calculating the theoretical finished section:

- Proposed lane and shoulder widths, including any tapers or widening for guardrail roadway
- Superelevations
- Shoulder rollovers
- Side ditches
- Barrier rail sections
- Slope gradients
- Any other items which may affect the span length or elevation of the proposed sign

16.3 Overhead Sign Assemblies

The s-dimension for overhead sign assemblies is the difference in elevation between the highest point of the roadway section, including the paved shoulder, and the ground at the proposed center of the overhead sign footing location. (See *Figure 16.1*.)

Submit an 11 1/2" x 17" cross-section drawing of the proposed overhead sign locations detailing the following:

- Roadway, shoulder and slope gradients
- Edge of pavement elevations
- Elevation of each lane line
- Elevation of the ground at each sign footing location
- Location of any monolithic islands
- Calculated s-dimension

Unless grading work is not anticipated at the proposed sign location, calculate and install a slope stake at each proposed sign location to ensure the Contractor constructs the slopes to the gradient utilized in calculating the theoretical finished section.

Layout the overhead sign assemblies as detailed in the Contractor's approved shop drawings. Provide reference line for the footings, which consists of a minimum of two hubs with corresponding reference stakes. Reference the center of the sign footing. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub. Grades should be set and referenced from the hubs to a known or calculated elevation of the proposed footing. (See *Figure 16.3*)

16.4 Ground Mounted Signs (Type A and B)

The s-dimension for ground mounted signs represents an increase (+) or decrease (-) in support length relative to the elevation of the edge of the outside travel lane, not the outside edge of the paved shoulder. (See *Figure 16.2*) Reference the *Typical Elevation Ground Mounted Sign* detail located within the project Signing Plans.

Submit to the Engineer, in tabular format, the s-dimensions for each support within the proposed Type A and B ground mounted signs.

Provide reference line for the footings, which consists of a minimum of two hubs with corresponding reference stakes. Reference the center of the sign footing. The first reference hub shall be a minimum of 10 feet (3 meters) from the reference point with the second hub installed at an equal distance from the first hub. Grade information is typically not required. (See *Figure 16.4*.)

16.5 Ground Mounted Signs (Type D, E and F)

S-dimensions are not required for Type D, E and F Ground Mounted Signs.

Provide location of ground mounted signs. Install an information stake at the proposed sign location. (See *Figure 16.5*.)

16.6 Type of Stake

Recommended Stake Size: 1 ¾" x 1 ¾" x 12" hub
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Grade and/or Alignment

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Pink
Stake Use: Information and Location

16.7 Stake Information

The information described below is detailed in *Figure 16.6*.

1. Offset to center of footing
2. Grade to known or calculated elevation of footing (typically not required for ground mounted signs)
3. Distance to centerline
4. Station
5. Alignment

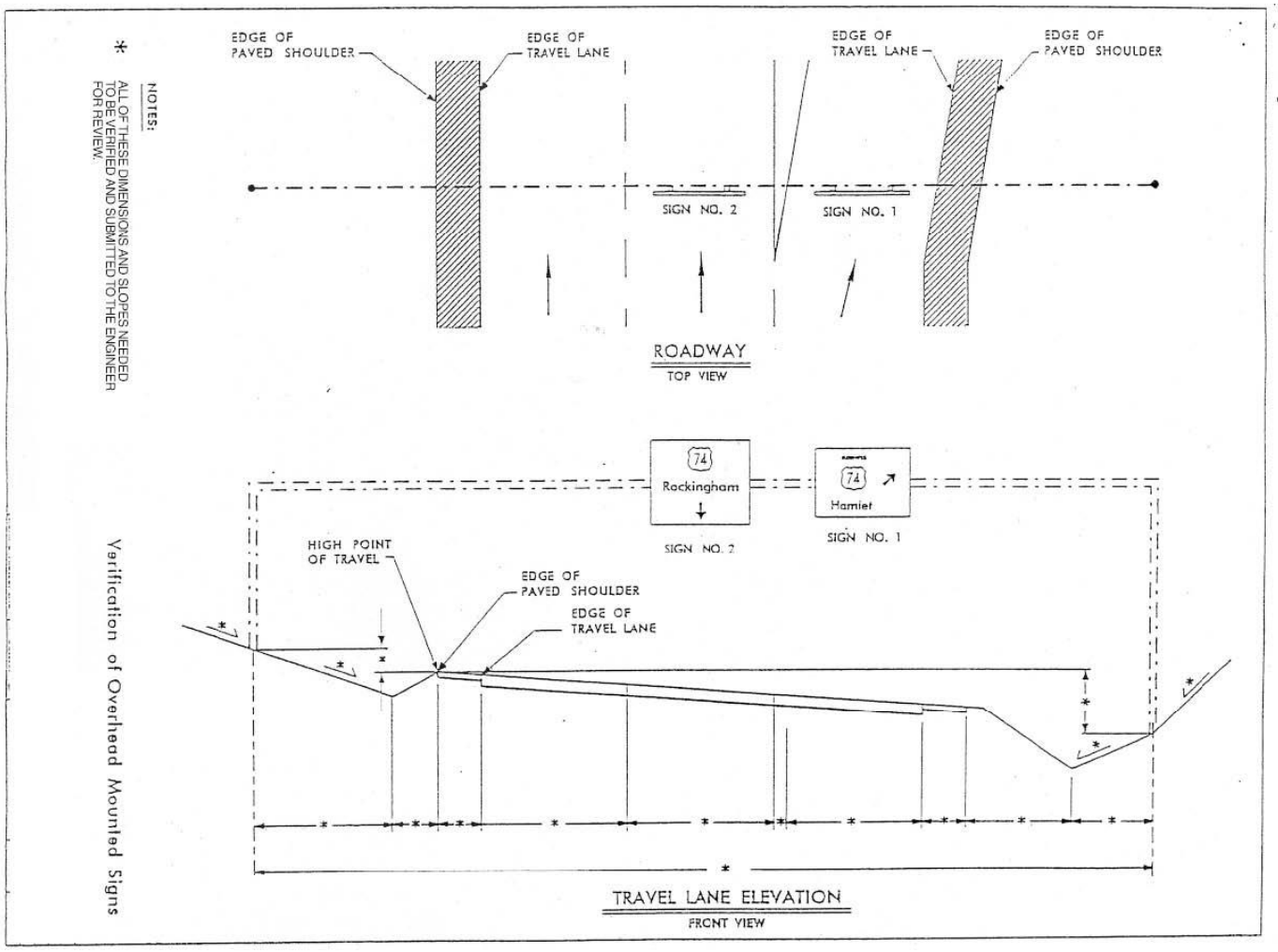

NOTES:
* ALL OF THESE DIMENSIONS AND SLOPES NEEDED TO BE VERIFIED AND SUBMITTED TO THE ENGINEER FOR REVIEW.
Verification of Overhead Mounted Signs
EDGE OF PAVED SHOULDER
EDGE OF TRAVEL LANE
EDGE OF TRAVEL LANE
EDGE OF PAVED SHOULDER
SIGN NO. 2
SIGN NO. 1
ROADWAY
TOP VIEW
74
Rockingham
74
Hamlet
SIGN NO. 2
SIGN NO. 1
HIGH POINT OF TRAVEL
EDGE OF PAVED SHOULDER
EDGE OF TRAVEL LANE
TRAVEL LANE ELEVATION
FRONT VIEW

Figure 16.1

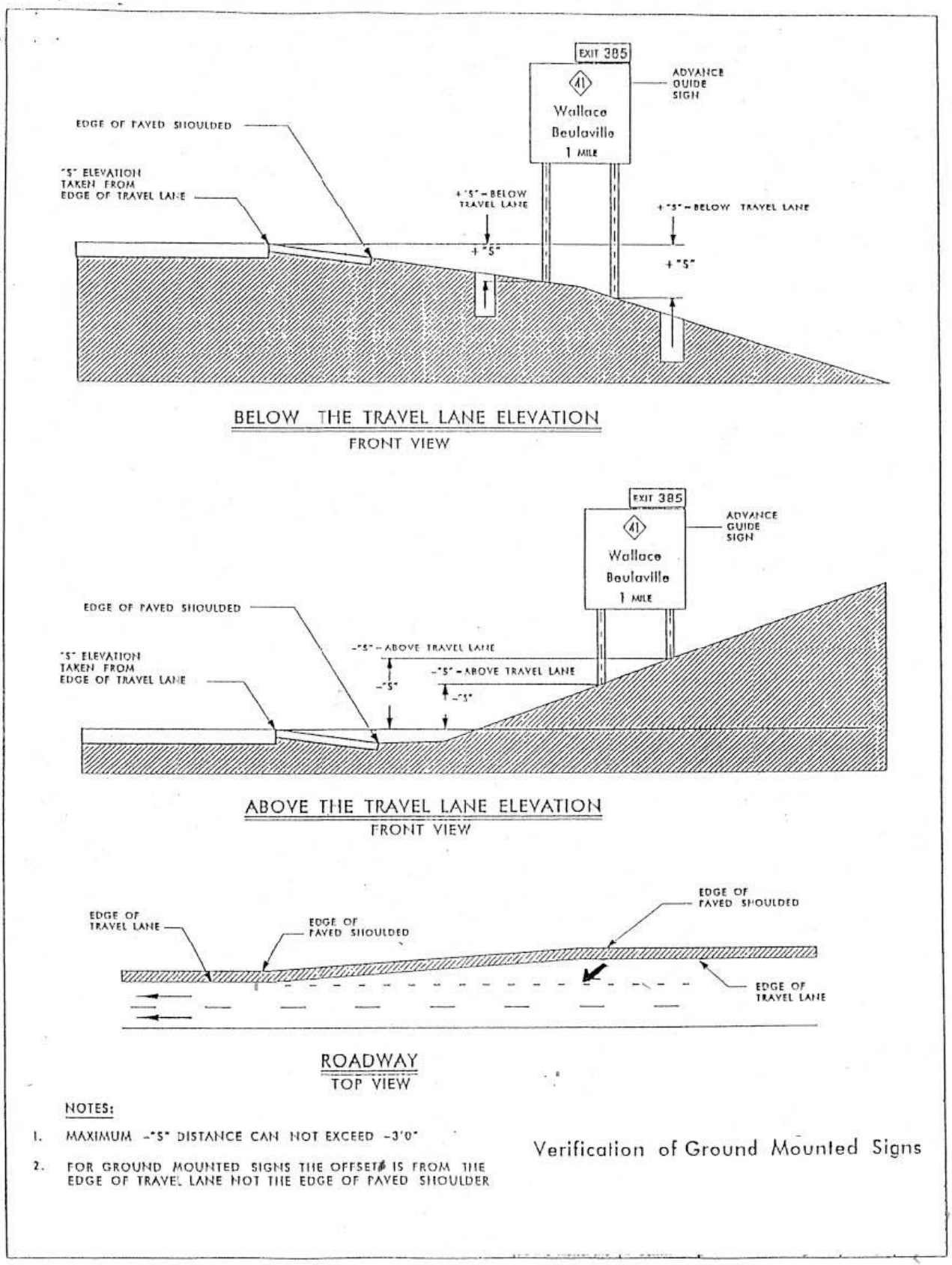

EXIT 385
41
Wallace
Beulaville
1 MILE
ADVANCE GUIDE SIGN
EDGE OF PAVED SHOULDED
"S" ELEVATION TAKEN FROM EDGE OF TRAVEL LANE
+"S" - BELOW TRAVEL LANE
+"S"
+"S" - BELOW TRAVEL LANE
+"S"
BELOW THE TRAVEL LANE ELEVATION
FRONT VIEW
EXIT 385
41
Wallace
Beulaville
1 MILE
ADVANCE GUIDE SIGN
EDGE OF PAVED SHOULDED
"S" ELEVATION TAKEN FROM EDGE OF TRAVEL LANE
-"S" - ABOVE TRAVEL LANE
-"S" - ABOVE TRAVEL LANE
-"S"
-"S"
ABOVE THE TRAVEL LANE ELEVATION
FRONT VIEW
EDGE OF TRAVEL LANE
EDGE OF PAVED SHOULDED
EDGE OF PAVED SHOULDED
EDGE OF TRAVEL LANE
ROADWAY
TOP VIEW
NOTES:
1. MAXIMUM -"S" DISTANCE CAN NOT EXCEED -3'0"
2. FOR GROUND MOUNTED SIGNS THE OFFSET IS FROM THE EDGE OF TRAVEL LANE NOT THE EDGE OF PAVED SHOULDER
Verification of Ground Mounted Signs

Figure 16.2

Overhead Signs

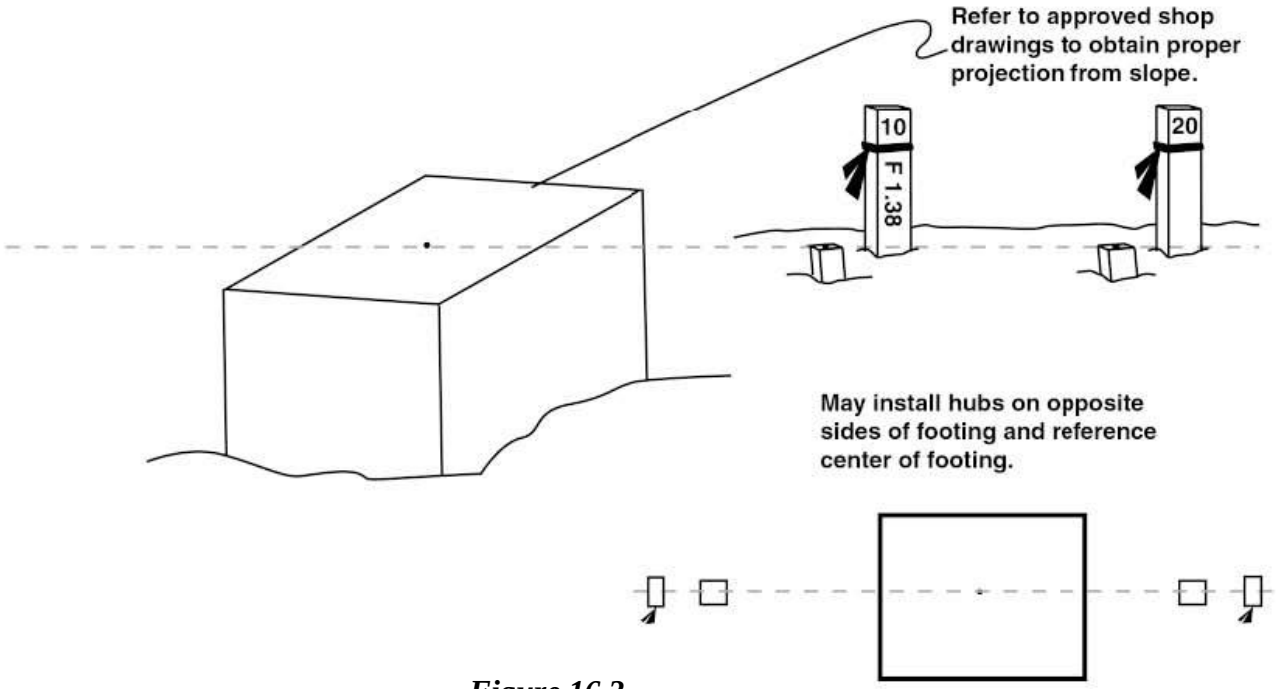


Figure 16.3

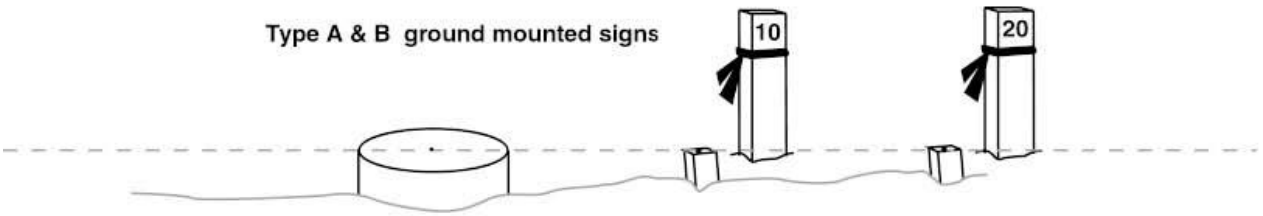


Figure 16.4

Typically grade information is not required for ground mounted signs.

Type D, E and F Ground mounted signs

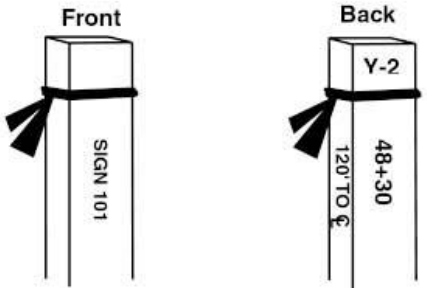


Figure 16.5

Sign Stakes

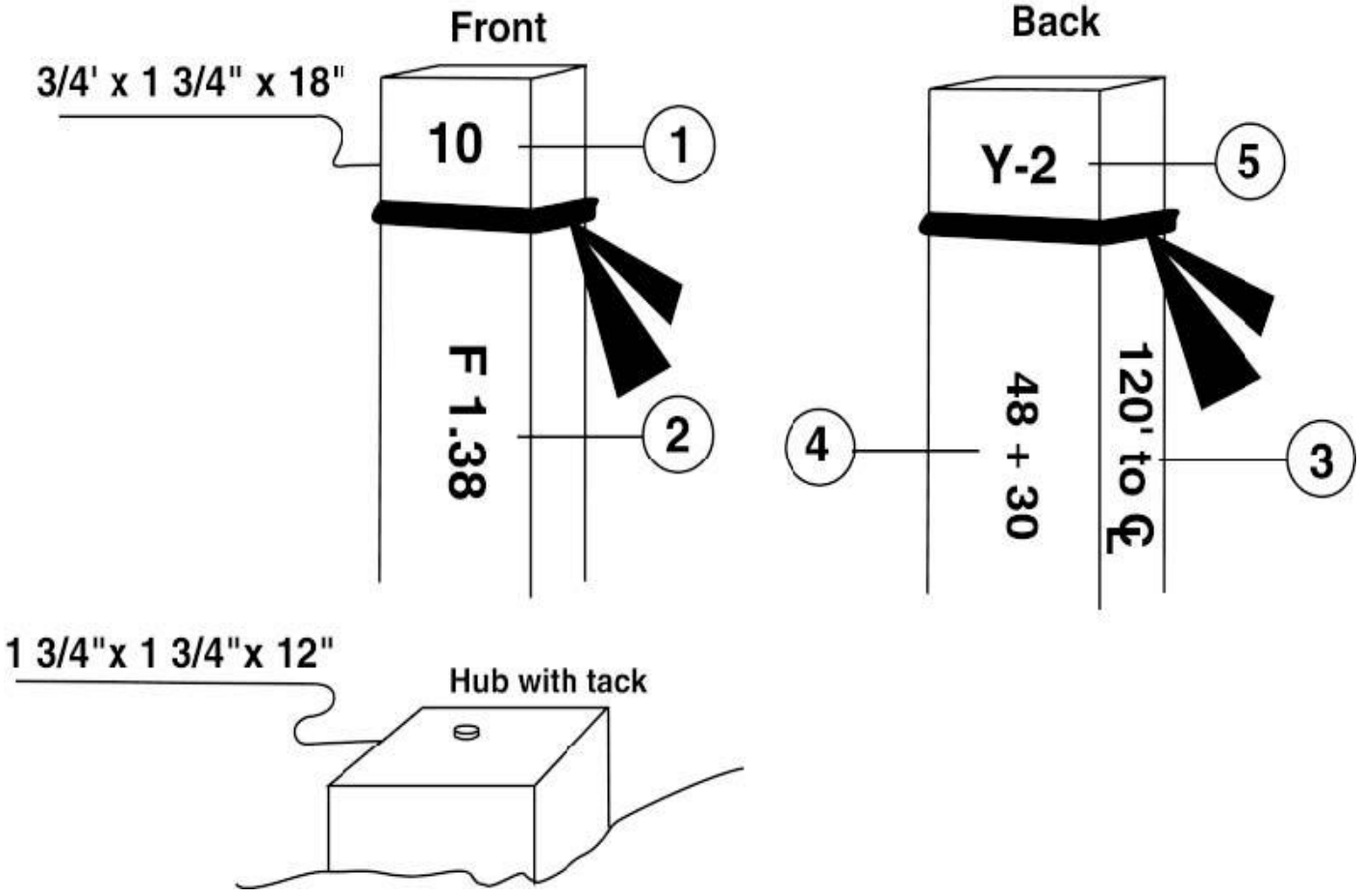


Figure 16.6

Chapter 17
Major structure Stakes

17.1 Guideline Information

All major structures will be staked with reference lines which contain at least three (3) reference hubs on each side with tacks. These hubs should be spaced equally apart at adequate intervals. Reference hubs shall be checked for accuracy after sitting all winter. If two structures are side by side, then the reference hubs for each bridge should be color coordinated to eliminate confusion.

Bridge Stake Out

Bridge stake out will contain two reference lines for each end bent, interior bent, and the long chord line. (See *Figures 17.1a* and *17.1b*.) Set a minimum of two (2) temporary benchmarks to remain in place throughout the entire bridge construction. One benchmark is to be used for substructure and one for superstructure. On grade separation structures, a point of minimum vertical clearance may be shown on the general drawing. If shown on the plans, the elevation of this point shall be verified at the time of bridge layout.

Construction elevations are furnished from Structure Design for all bridges except cored slabs and should be used as follows:

Bottom of slab grades will be used to determine build ups at tenth points along each girder of each span. (For longer spans 20^{th} or 30^{th} points may be require; this will be given in the construction elevation printouts.) After camber has been checked, necessary corrections made and diaphragm connection bolts tightened, elevations should be determined on top of girders at each tenth point and are used in computing build-up heights. The effect of the sun can significantly change girder camber. Levels should be run either early in the morning or on a completely overcast morning. Deflections shown in the deflections tables are used in the required computations. Build-up height at a tenth point is computed as follows:

+ final bottom of slab elevation
+ deflection due to weight of slab
+ deflections due to weight of parapet, rail, and F.W.S.
- top of girder elevation (determined in field)

The algebraic sum of these values equals the height of build-up above the top of girder. In some cases, this value will be minus indicating the girder flange projects into the slab.

The build-up heights for the entire bridge can be computed and listed in a field book well in advance of any forming operation. These heights can be marked on the top of girder at the proper tenth point.

The Contractor should be made aware that the computed height is at the centerline of girder and will vary at each side of the build-up depending on the crown slope and flange width.

Overhang grades are given for every 4' interval along the lower outer most point of the proposed overhang. (See *Figure 17.2*.) These grades are given in respect to centerline stations. In order to correctly locate these overhang locations, a reference point on each of the proposed overhangs must be determined according to centerline station, from which the other overhang points can be laid off. These grades are provided only to check the overhangs which have been set in accordance with the construction manual.

Header grades are given along the skew of the proposed header, to the finished top of slab grade. (See *Figure 17.2*.) These elevations can be used as listed when grading headers located over the bearing points. However, when a header is located on a span, movement of the header will occur as the beams deflect during the deck casting operation. This type of header is known as a "floating" header. Floating headers are best graded by measuring up the deck thickness for the bottom of slab elevation at each point the header crossed a beam. When the header does not cross a beam at a previously calculated build-up, interpolation should be used. The header must reflect many changes in the transverse slope of the deck which may occur between beams.

Drilled shafts should be staked only after bridge stake out is complete. Each drilled shaft should be referenced individually so that casing and reinforcing steel alignment can be checked during drilling and casting operations. Each drilled shaft stakeout will contain two reference lines with two reference points on either side. If field conditions do not permit this type of referencing, then the Contractor should consult the Resident Engineer with a proposed method of referencing and receive approval.

Approach slab grades also are given to the finished slab grade. (See *Figure 17.3*.) It is important to check a point on the actual deck, at either end of the structure, which is relative to a given approach slab elevation in order to determine any necessary minor adjustment to the approach slab. Grades should be checked utilizing a stringline off deck.

Culvert Stake Out

The grade that is provided on the structural plans is referenced to the centerline invert of the culvert. The length of the culvert should be checked to ensure that it intercepts the roadway slope properly. Culvert stake out will contain a reference line for the centerline of barrel and for each culvert headwall face. Each reference point should refer to the intersection point of the centerline of the barrel reference line and the face of the culvert headwall reference line. Grades set on the hubs referencing the face of the culvert headwall will be set in reference to the top of the headwall or curtain wall. Intermediate hubs for culverts over 100' in length will be set at even intervals no greater than 50'+/- apart or at the construction joints. (See *Figure 17.4*.) Grades set on the centerline offset hubs shall reference the proposed elevation of the culvert invert. Plan inverts should not be adjusted without consulting the Engineer due to environmental permit requirements.

Wall Stake Out

Noise walls, reinforced earth walls and retaining walls will be staked with a reference line to the face of the wall or as noted in the structure plans or as otherwise needed for construction. Existing ground elevations shown in the plans shall be verified for accuracy. For pile/panel type walls three (3) offsets shall be provided for each pile. All critical elevations shall be referenced, including, but not limited to, top of wall/ coping, bottom of shaft/pile, etc.

17.2 Type of Stake

Recommended Stake Size: ¾" x 1 ¾" x 18"
Recommended Flagging: Color Coordinated
Stake Use: Information

Recommended Stake Size: 1 ¾" x 1 ¾" x 12"
Recommended Flagging: Color Coordinated
Precision: Horz. 0.01', Vert. 0.01'
Stake Use: Alignment and Grade

Recommended Stake Size: ¾" x 1 ¾" x 48"
Recommended Flagging: Color Coordinated
Stake Use: Guard

TYPICAL BRIDGE - TANGENT SURVEY LAYOUT

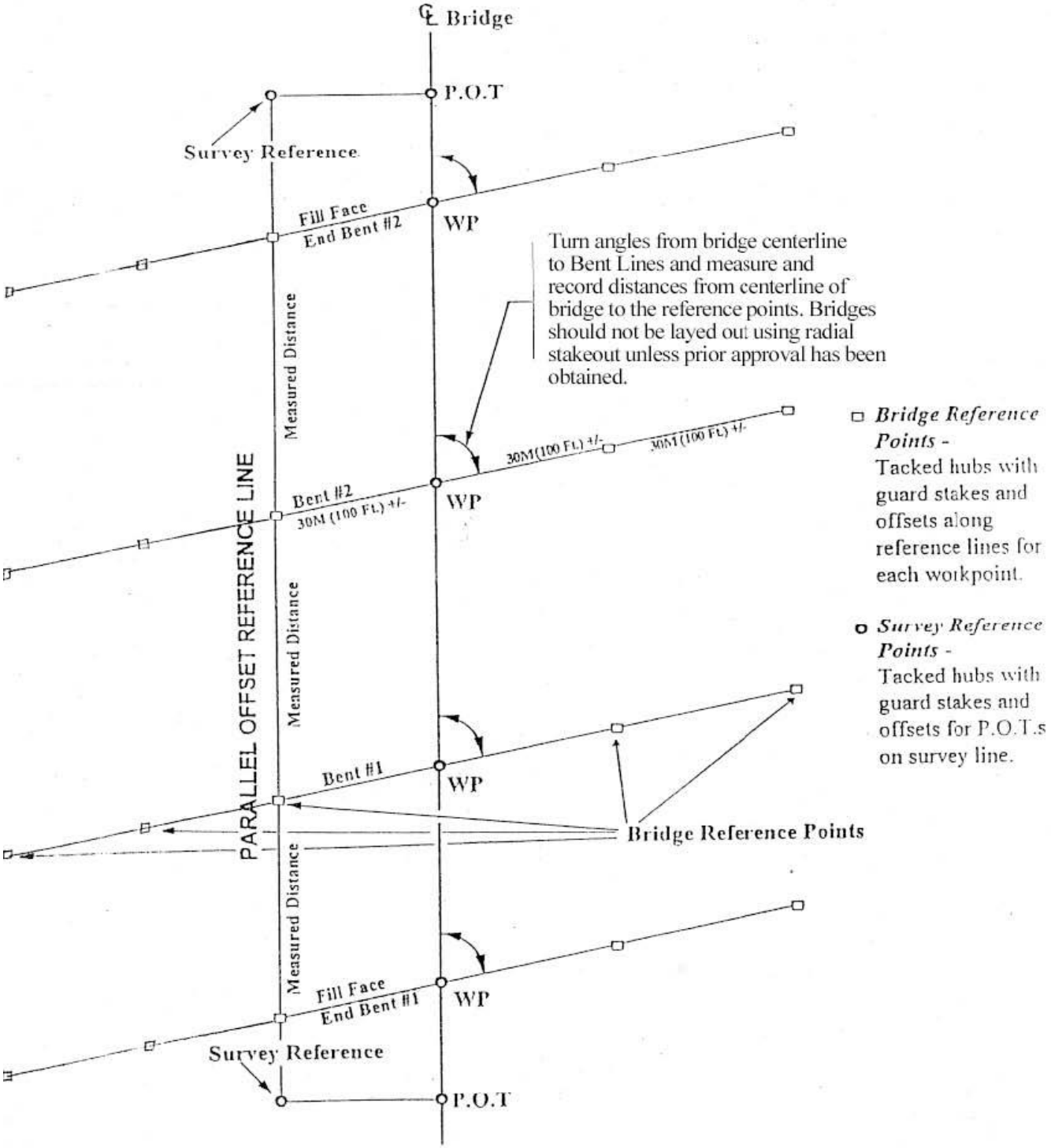


Figure 17.1a

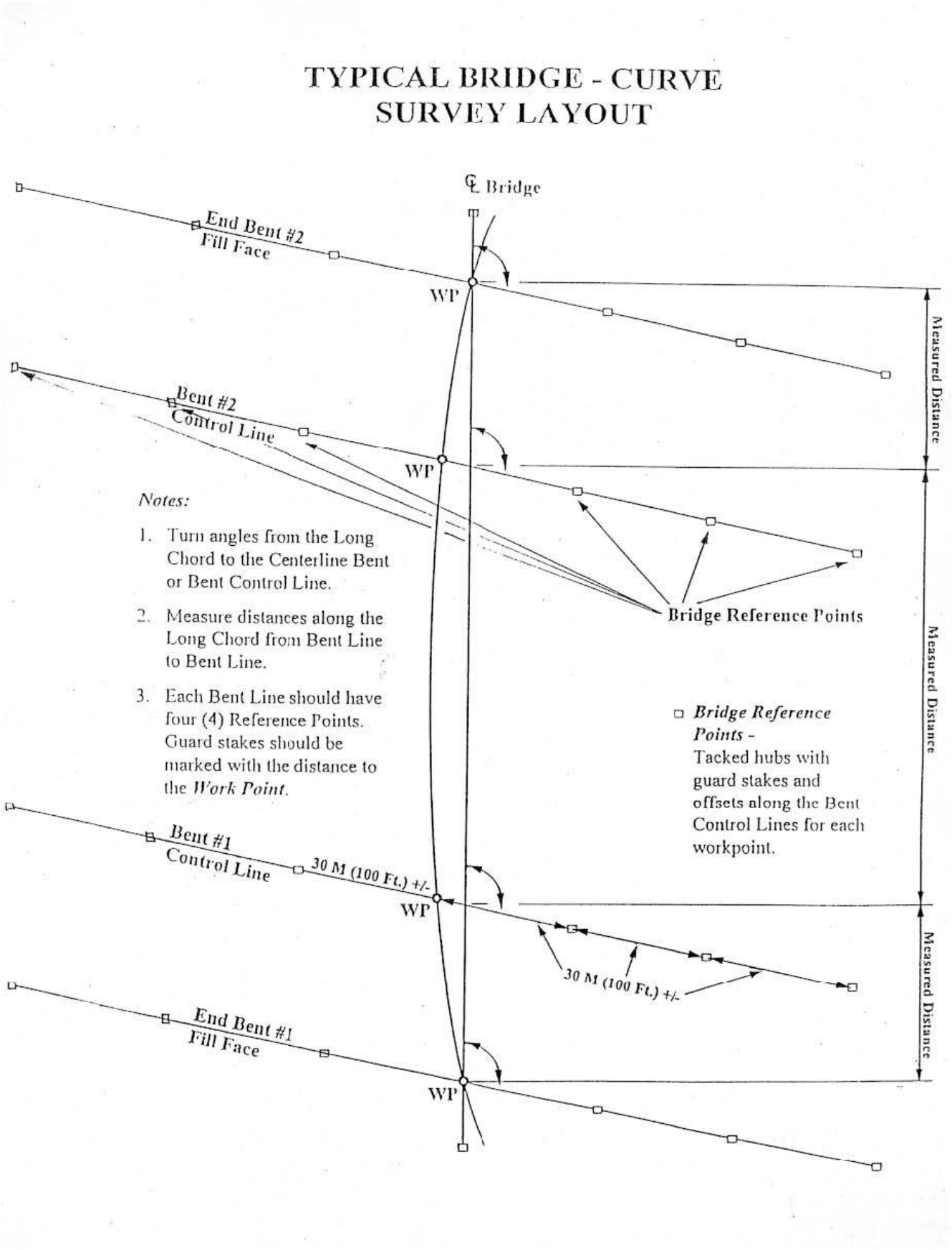

TYPICAL BRIDGE - CURVE
SURVEY LAYOUT
℄ Bridge
End Bent #2
Fill Face
WP
Measured Distance
Bent #2
Control Line
WP
Notes:
1. Turn angles from the Long Chord to the Centerline Bent or Bent Control Line.
2. Measure distances along the Long Chord from Bent Line to Bent Line.
3. Each Bent Line should have four (4) Reference Points. Guard stakes should be marked with the distance to the Work Point.
Bridge Reference Points
Measured Distance
□ Bridge Reference Points - Tacked hubs with guard stakes and offsets along the Bent Control Lines for each workpoint.
Bent #1
Control Line
30 M (100 Ft.) +/-
WP
30 M (100 Ft.) +/-
Measured Distance
End Bent #1
Fill Face
WP

Figure 17.1b

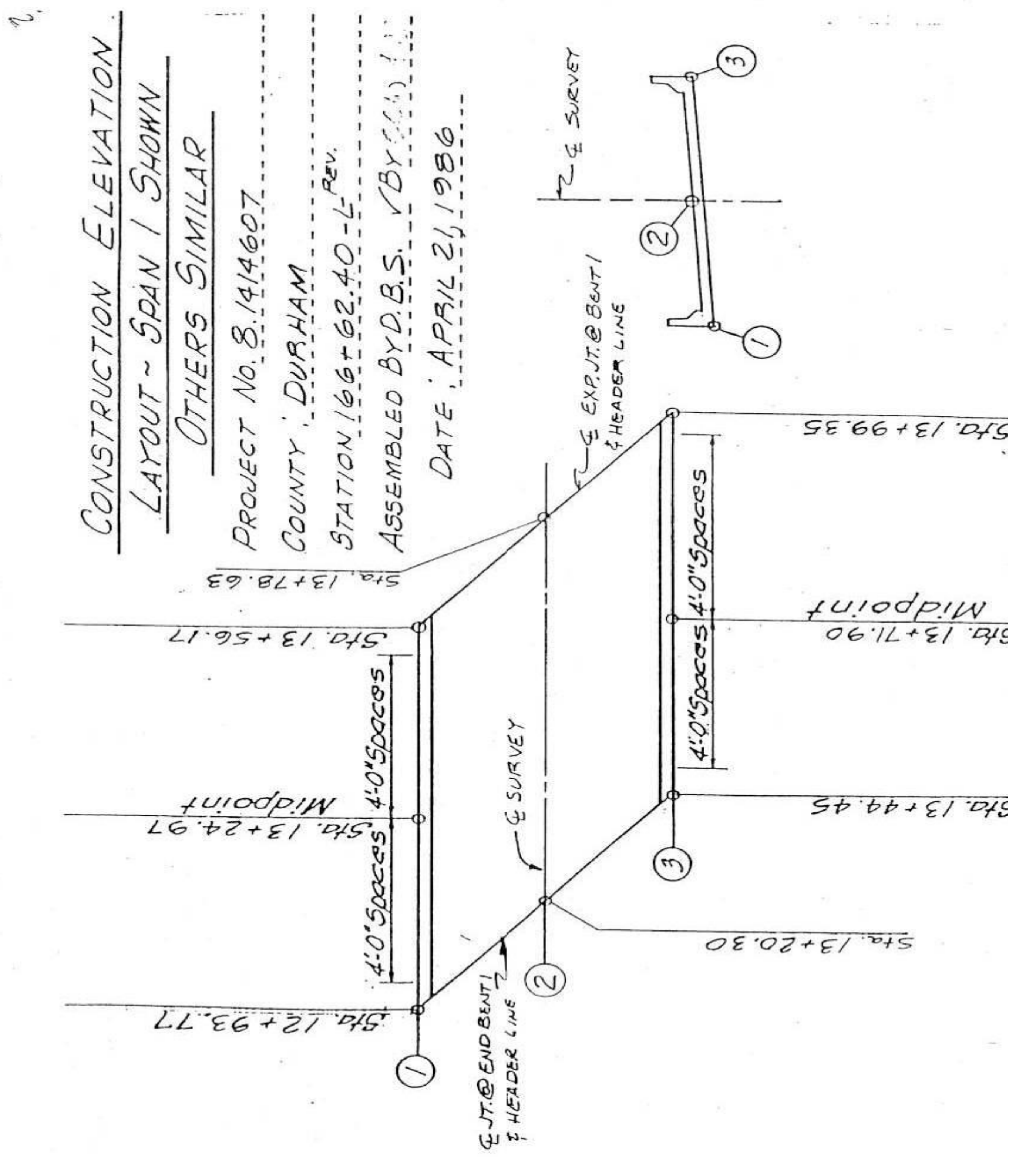
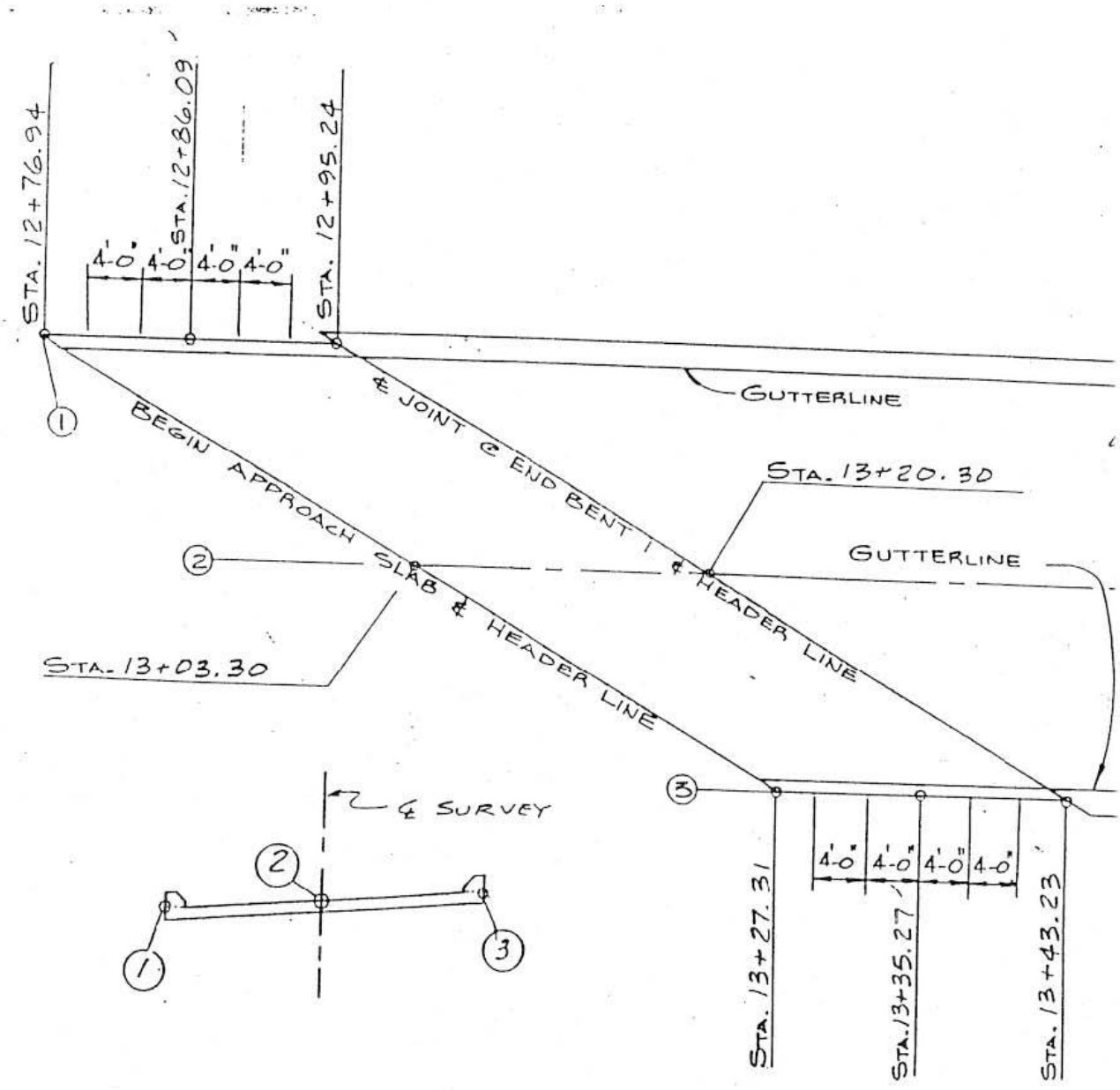

CONSTRUCTION ELEVATION
LAYOUT ~ SPAN 1 SHOWN
OTHERS SIMILAR
PROJECT No. 8.1414607
COUNTY: DURHAM
STATION 166+62.40-L- REV.
ASSEMBLED BY D.B.S.
DATE: APRIL 21, 1986
℄ SURVEY
℄ EXP. JT. @ BENT 1 & HEADER LINE
℄ JT. @ END BENT 1 & HEADER LINE
Sta. 12+93.77
Sta. 13+24.97 Midpoint
Sta. 13+56.17
Sta. 13+78.63
Sta. 13+20.30
Sta. 13+49.45
Sta. 13+71.90 Midpoint
Sta. 13+99.35
4'-0" Spaces
1
2
3

Figure 17.2



CONSTRUCTION ELEVATION LAYOUT

APPROACH SLAB AT BEGINNING OF BRIDGE

(END OF BRIDGE SIMILAR)

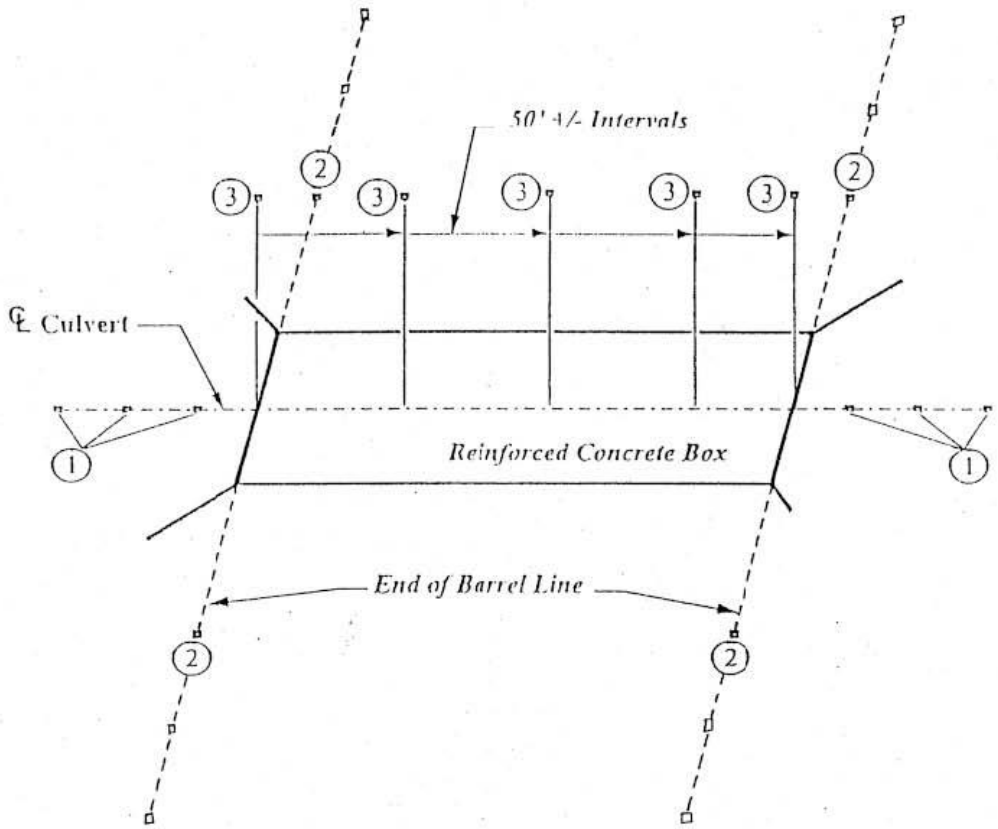
PROJECT No.: B-1414607 COUNTY: DURHAM

STA.: 166+62.40-L-REV ASSEMBLED BY: D.B. SIMPSON, JR.

DATE: APRIL 21, 1986 CHECKED BY:

Figure 17.3

TYPICAL REINFORCED CONCRETE BOX CULVERT SURVEY LAYOUT



(1) Tacked hubs along centerline of culvert.

(2) Tacked hubs along end of barrel with distance marked to centerline of culvert and cut/fill to top of bottom slab on guard stakes.

(3) Hubs with marked guard stakes giving offset and cut/fill to top of bottom of slab - including camber.

Figure 17.4

Chapter 18
Cross-sections for Earthwork Quantities

18.1 General Information

The Engineer may elect to obtain cross-sections or Digital Terrain Models (DTM) by using either hand or aerial methods depending on the typography, vegetative cover, and size of the project or borrow sites. The Department often utilizes aerial photography to obtain cross-sections for calculation of earthwork quantities. Aerial photography requires the installation of photogrammetric control panels. Once panels are installed, the Photogrammetry Unit can orient the film both horizontally and vertically and obtain a correct scale.

18.2 Guideline Information

If the Engineer elects to hand section the project, set centerline stakes for all alignments on 50 foot (20 meter) intervals as detailed in Chapter 3. Offset alignments also may be required.

If the Engineer elects to obtain cross-sections by aerial methods, the Engineer will provide the photogrammetric panel locations. The staking of the survey line is typically not required when setting photogrammetric panels at the predetermined locations. Set panels at the locations shown in the panel plan, and provide a panel book detailing the panel coordinates. Install photogrammetric panels as detailed below:

Photogrammetric Control Panels

Install photogrammetric panels on 5 foot x 5 foot sheets of black plastic or paint them on the roadway surface. An oil based exterior paint is recommended to mark the panel arrows. Panel arrows should have legs approximately 5 feet in length and six inches in width. (See *Figure 18.1*.) The point of the arrow represents the photogrammetric control point.

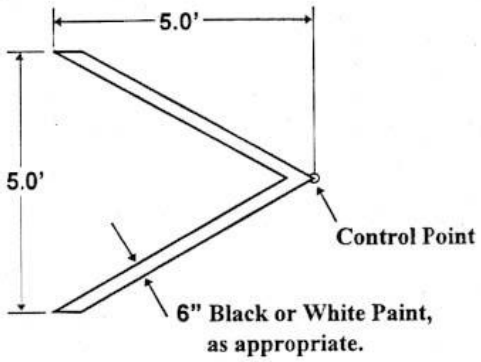
The Engineer will obtain the vertical elevations for each panel.

Maintain the photogrammetric panels until a successful aerial photograph has been obtained. Photogrammetric panels must be clearly visible on the scheduled flight day.

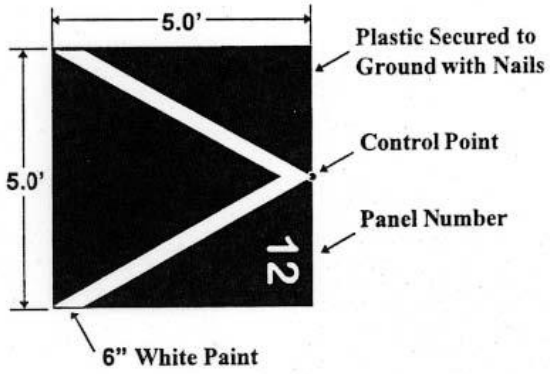
18.3 Type of Stake

Panel Size: 60" x 60" sheet of black plastic with arrow
Precision: Horz. 0.01'
Stake Use: Location

AERIAL FLIGHT PANEL CONFIGURATION



Typical configuration for asphalt or concrete surfaces.



Typical configuration for earth or other surfaces.

Figure 18.1

Chapter 19
Automated Machine Guidance

19.1 General Information

If the Contractor elects to use Global Positioning System (GPS) machine control grading it shall be used in conjunction with Section 801 of the Standard Specifications for Roads and Structures. The use of this technology is referenced as Automated Machine Guidance (AMG). All equipment using AMG shall be able to generate end results that meet the Standard Specifications. Perform test sections for each type of work to be completed with AMG to demonstrate that the system has the capability to achieve acceptable results. If acceptable results cannot be achieved, conform to the requirements for conventional stakeout.
The Contractor shall be responsible for all errors resulting from the use of AMG and shall correct deficiencies to the satisfaction of the Engineer at no cost to the Department.

SUBGRADE AND BASE CONTROLS

If the Contractor elects to use AMG for fine grading and placement of base or other roadway materials, the GPS shall be supplemented with a laser or robotic total station. Include details of the proposed system in the AMG work plan. In addition, the following requirements apply for the use of AMG for subgrade and base construction.

1. Provide control points at intervals along the project not to exceed 1000 feet. The horizontal position of these points shall be determined by static GPS sessions or by traverse connection from the original base line control points. The elevation of these control points shall be established using differential leveling from project benchmarks, forming closed loops where practical. A copy of all new control point information shall be provided to the Engineer prior to construction activities.

2. Provide conventional survey grade stakes at 500’ intervals and at critical points such as, but not limited to, PCs, PTs, superelevation transition points, and other critical points as requested by the Engineer.

3. Provide hubs at the top of the finished subgrade at all hinge points on the cross section at 500 foot intervals. These hubs shall be established using conventional survey methods for use by the Engineer to check the accuracy of construction.

19.2 Submittals

If the Contractor elects to use AMG, a Digital Terrain Model (DTM) of the design surface and all intermediate surfaces shall be developed and submitted to the Engineer for review. At least 90 days prior to beginning grading operations, the Contractor shall submit to the Engineer an AMG work plan to include, but not limited to, proposed equipment, control software manufacturer and version, types of work to be completed using AMG, project site calibration report, repetitive calibration methods for construction equipment and rover units to be used for the duration of the project, and local GPS base station to be used for broadcasting differential correction data to rover units (this may include the NC Network RTK). All surveys must be tied to existing project control as established by NCDOT.

Chapter 20
GPS

20.1 General Information

The Contractor may elect to utilize Global Positioning System (GPS) surveying, either static or kinematic. Perform GPS surveys with same or higher order of accuracy as conventional surveys. NCDOT projects utilize a localized coordinate system developed by the Location and Surveys Unit specifically for each individual project. Using the Survey Control Sheet located in the plans, obtain the control information that the Location and Surveys Unit utilized in establishing the localized coordinate system, specifically the Rotation, Scaling, Translation and coordinates for the azimuth pairs. This will aid in the comparison of actual results.

If no site calibration is provided in the plans, perform a site calibration and include the results in the required horizontal and vertical control verification submittal for approval.

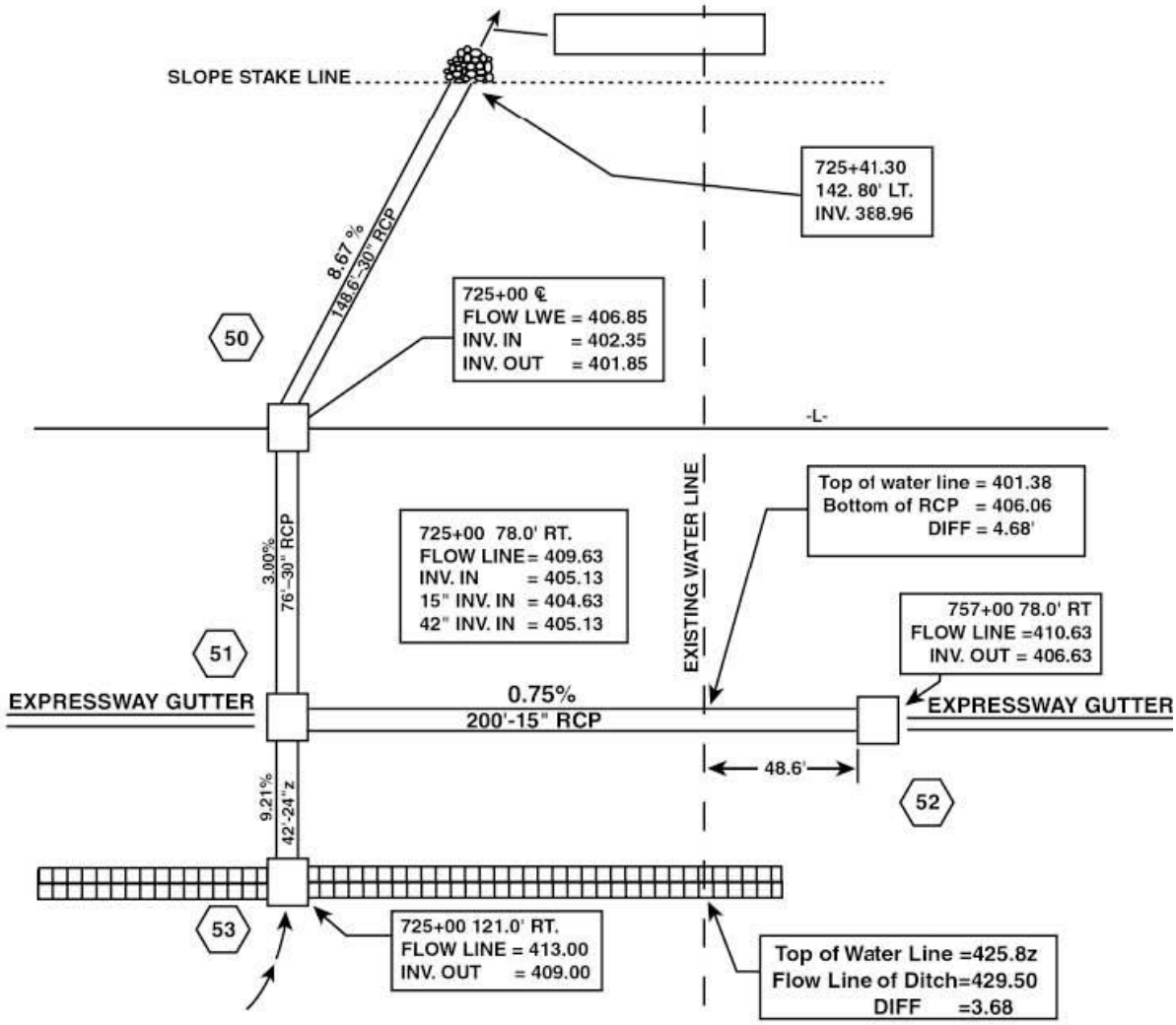
Newly developed GPS procedures and techniques that do not conform to the Specifications in this section may be used if approved by the Engineer.

For additional guidance in performing GPS, see the GPS Survey Guidelines in the NCDOT Location and Surveys Manual. The link to the manual is below.

http://www.ncdot.org/doh/preconstruct/highway/location/support/Support_Files/Documents/Manuals/LocationGPS0210.pdf

Appendix

TYPICAL DRAINAGE SUBMITTAL



OUTLET PIPE

EXISTING STREAM = 388.46
+0.50
INV. OUT = 388.96

142.80' LT. SLOPE STAKE
INTERCEPT POINT

STR# 51

GRADE POINT GRADE = 410.35
12' x .021 = +0.24
410.59
26' x .021 = -0.54
410.05
10' x .042 = -0.42
FLOW LINE OF GRATE = 409.63
-5.00
INV. OUT = 404.63
+0.50
INV. IN = 405.13

STR# 52

GRADE POINT GRADE = 411.35
12' x 0.21 = +0.24
411.59
26' x .021 = -0.54
411.05
10' x .042 = -0.42
FLOW LINE OF GRATE = 410.63
-4.00
INV. OUT = 406.63

STR# 50

GRADE POINT GRADE = 410.35
TYPICAL 12' x .042 = -0.50
409.85
18' x 0.167 = -3.00
FLOW LINE OF GRATE = 406.85
HEIGHT OF BOX = -5.00
INV. OUT = 401.85
+0.50
INV. IN = 402.35

STR# 53

Flow line of ditch elevation
from cross sections at
STA. 725 + 00 121' RT.
is 413.00 after setting slope
stake using ditch detail "Q"
this elevation checks.

Flow line of grade = 413.00
-4.00
INV. OUT = 409.00

CHECKLIST FOR PIPE LAYOUT DRAWING SUBMITTALS

VERIFY THE FOLLOWING IS CONTAINED WITHIN YOUR LAYOUT DRAWING SUBMITTAL:

STRUCTURE NUMBER _____ STATION AND DISTANCE FROM CENTERLINE _____ SIZE OF PIPE _____ PLAN INVERTS (IF PROVIDED) _____ PROPOSED INVERT _____ FLOW LINE AT GRATE _____ ELBOW _____ COLLAR _____ % GRADE OF PIPE _____

EXPLANATION IF LENGTH OF PIPE VARIES FROM THE PLAN QUANTITY _____

IS THERE A DITCH AT THE BEGINNING OR END OF PIPE? _____ FIELD VERIFICATION OF DITCH LOCATION AND ELEVATION _____ OR EXISTING DITCH LOCATION AND ELEVATION _____

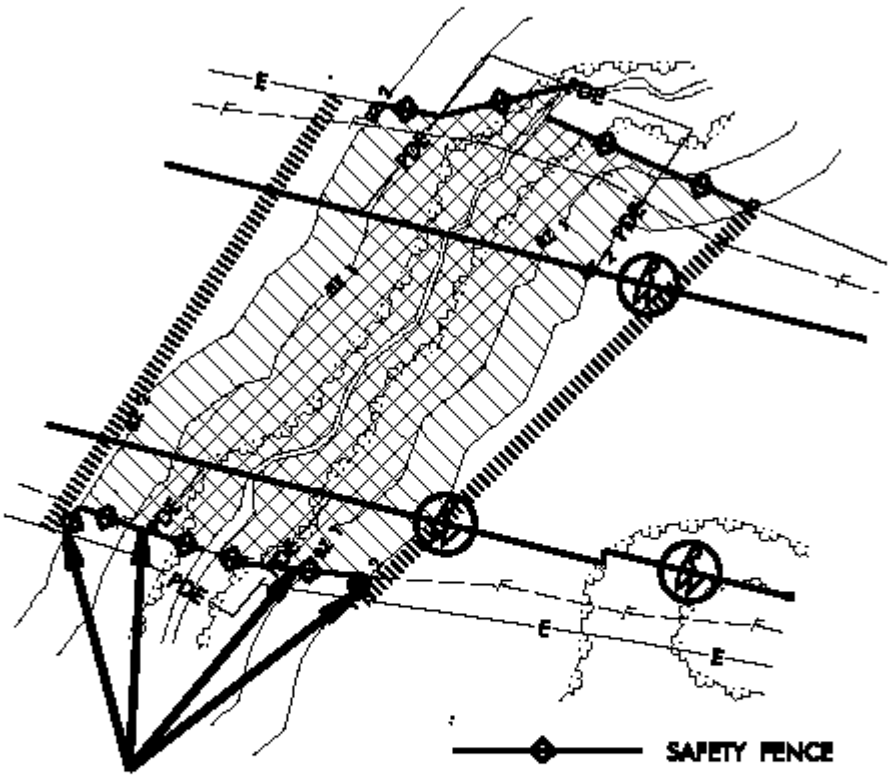
DOES PIPE EMPTY INTO CREEK? _____ ELEVATION OF SHOT TAKEN IN EXISTING CREEK AT INTERVALS TO ENSURE DRAINAGE _____ WAS THE TOE OF FILL AT THE CREEK INVESTIGATED? _____

EXTRA DEPTH BOXES _____ DETAIL THE EXTRA DEPTH DRAINAGE STRUCTURE SPECIFIED IN PLANS _____ IF A DRAINAGE STRUCTURE IS NOT SHOWN ON PLANS, REASON FOR EXTRA DEPTH _____

IS THERE A HEADWALL? _____

PROVIDE DETAIL DRAWING NUMBER _____ TOP OF HEADWALL ELEVATION _____ INVERT ELEVTION _____ SHOULDER ELEVATION _____ SHOW SLOPE CONNECTION TO BACK OF HEADWALL _____ DISTANCE FROM DIRT SHOULDER TO BACK OF HEADWALL _____

JURISDICTIONAL STREAM – RIPARIAN BUFFER ZONE*



SAFETY FENCE

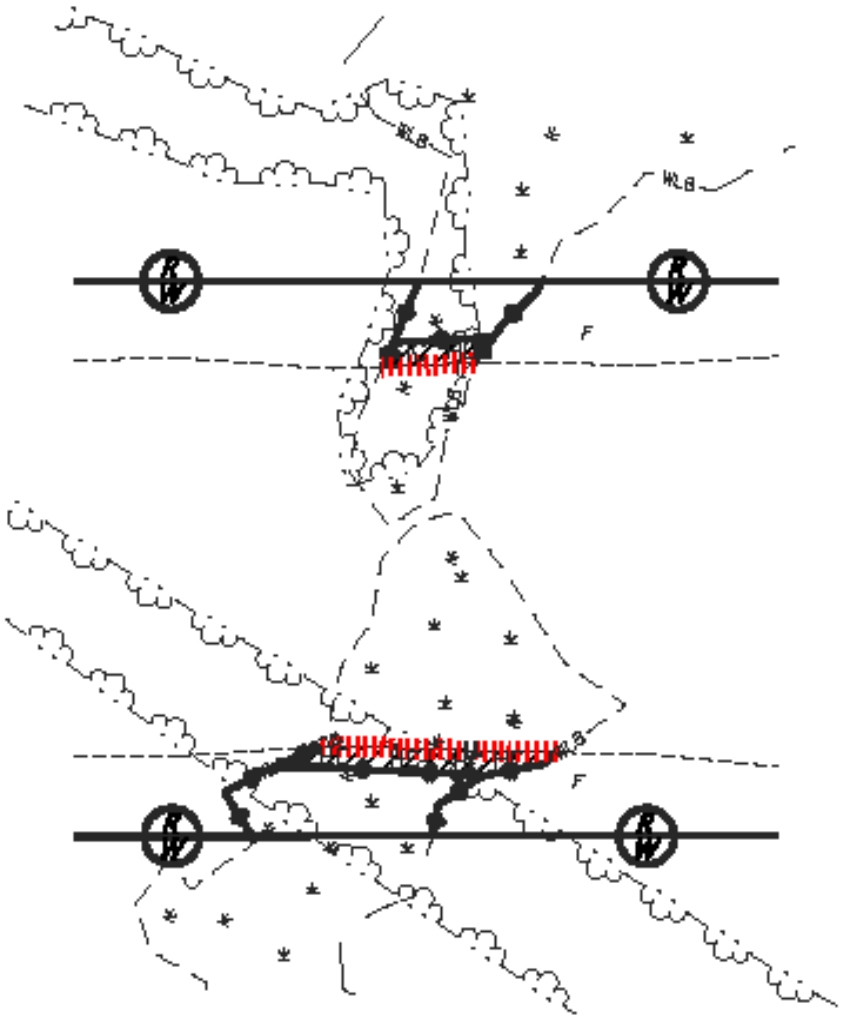
FLAGGING

ALLOWABLE IMPACTS ZONE 1

ALLOWABLE IMPACTS ZONE 2

* – REFER TO PERMIT DRAWINGS FOR JURISDICTIONAL BOUNDARIES AND BUFFER ZONE IMPACTS

WETLAND – HAND CLEARING*



* – REFER TO PERMIT DRAWINGS FOR JURISDICTIONAL BOUNDARIES

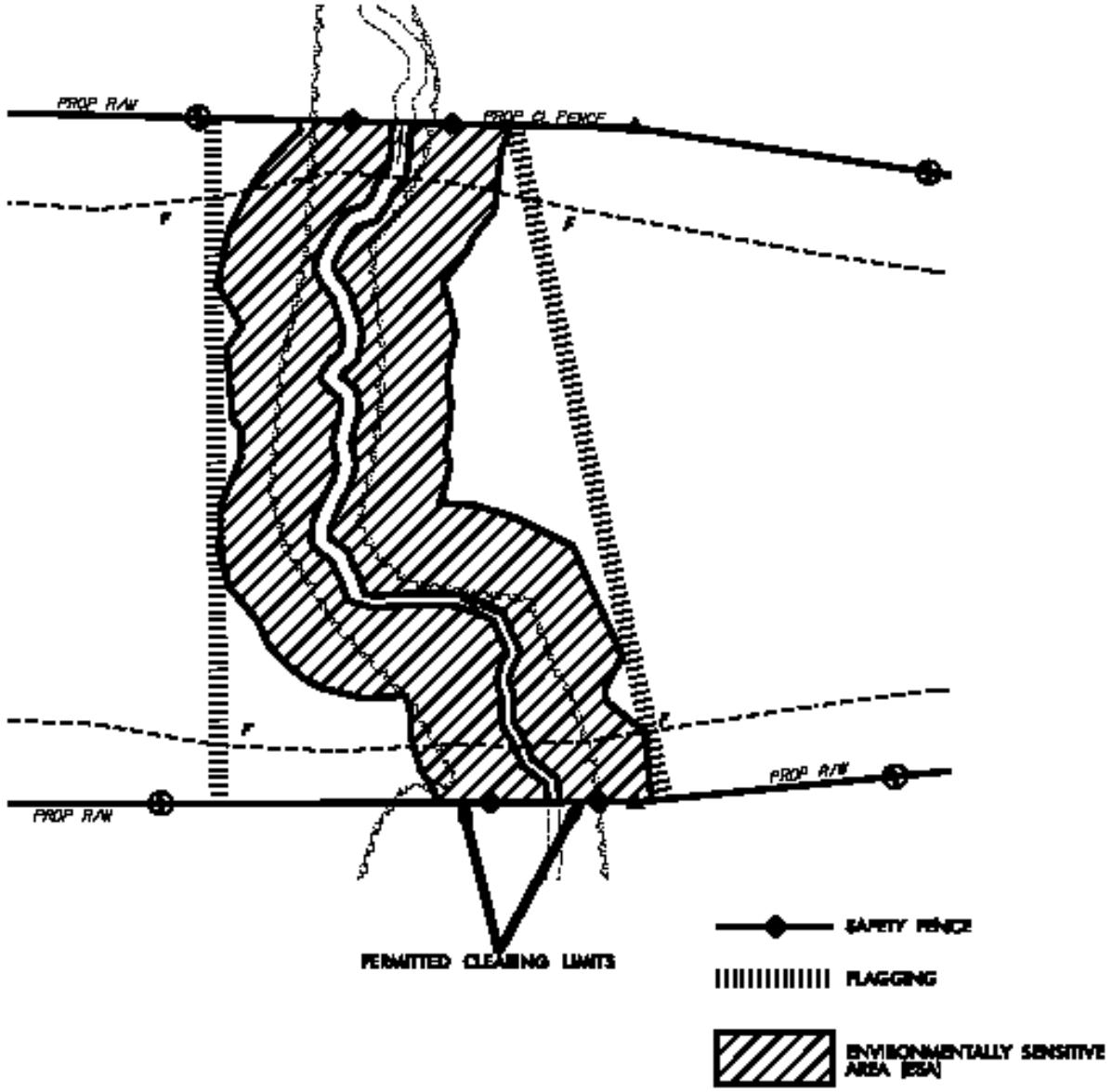
** – FLAGGING COLOR DOES NOT HAVE TO BE RED, BUT MUST BE A DIFFERENT COLOR THAN FLAGGING FOR INTERIOR BOUNDARIES OF MECHANIZED CLEARING PERMITTED AREAS

HC HC HAND CLEARING

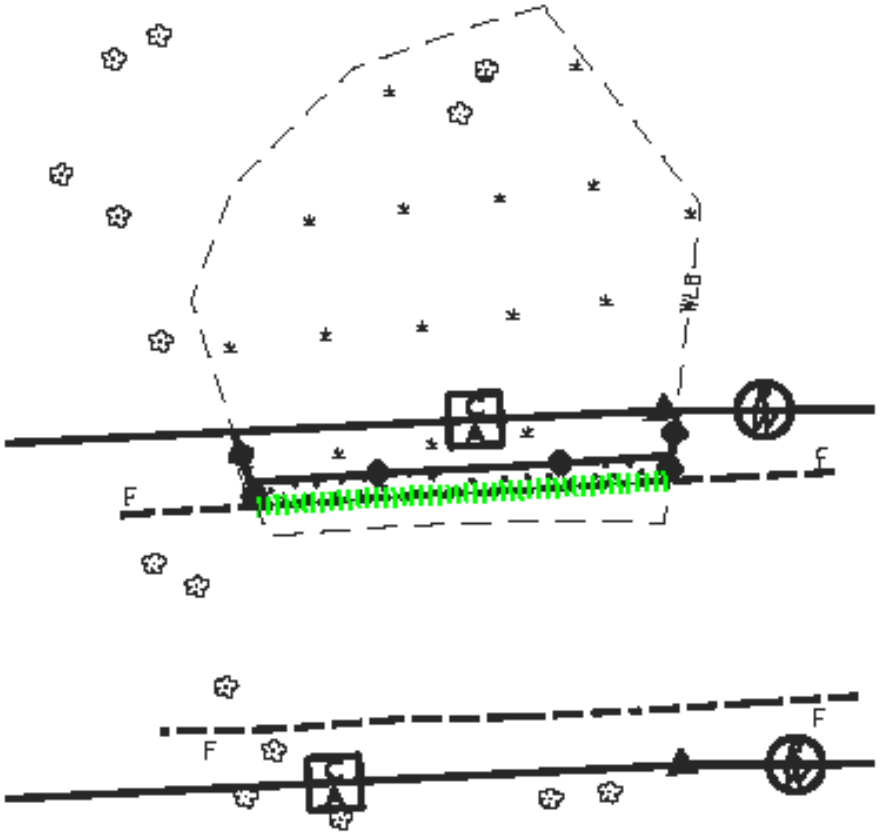
SAFETY FENCE

FLAGGING**

JURISDICTIONAL STREAM – ENVIRONMENTALLY SENSITIVE AREA (ESA) WITHOUT RIPARIAN BUFFERS



WETLAND – MECHANIZED CLEARING*



* – REFER TO PERMIT DRAWINGS FOR JURISDICTIONAL BOUNDARIES

** – FLAGGING COLOR DOES NOT HAVE TO BE GREEN, BUT MUST BE A DIFFERENT COLOR THAN FLAGGING FOR INTERIOR BOUNDARIES OF HAND CLEARING PERMITTED AREAS

MECHANIZED CLEARING

SAFETY FENCE

FLAGGING**

JURISDICTIONAL STREAM – NO HQW / NO BUFFER