Map MODERNIZATION

Federal Emergency Management Agency

FEMA's Flood Hazard Mapping Program

Guidelines and Specifications *for* Flood Hazard Mapping Partners

Appendix N: Data Capture Guidelines

FEDERAL EMERGENCY MANAGEMENT AGENCY

www.fema.gov/fhm/dl_cgs.shtm

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Data Capture Guidelines

N.1 Data Capture Guidelines Overview

The open stormwater system is made up of bridges, culverts, dams and stream cross sections. Surveying this system consists of initial field reconnaissance and field surveys for hydraulic structure geometry and immediate overbank cross section data. The field survey includes obtaining channel and floodplain cross sections, identifying or establishing elevation reference marks (ERMs) (following guidance in FEMA's *Flood Insurance Study Guidelines and Specifications for Study Contractors (FEMA 37)),* obtaining the physical dimensions of hydraulic and flood control structures, and taking photographs at each hydraulic structure and at the location of cross sections to determine Manning's roughness coefficient. A flowchart for the field survey is shown.

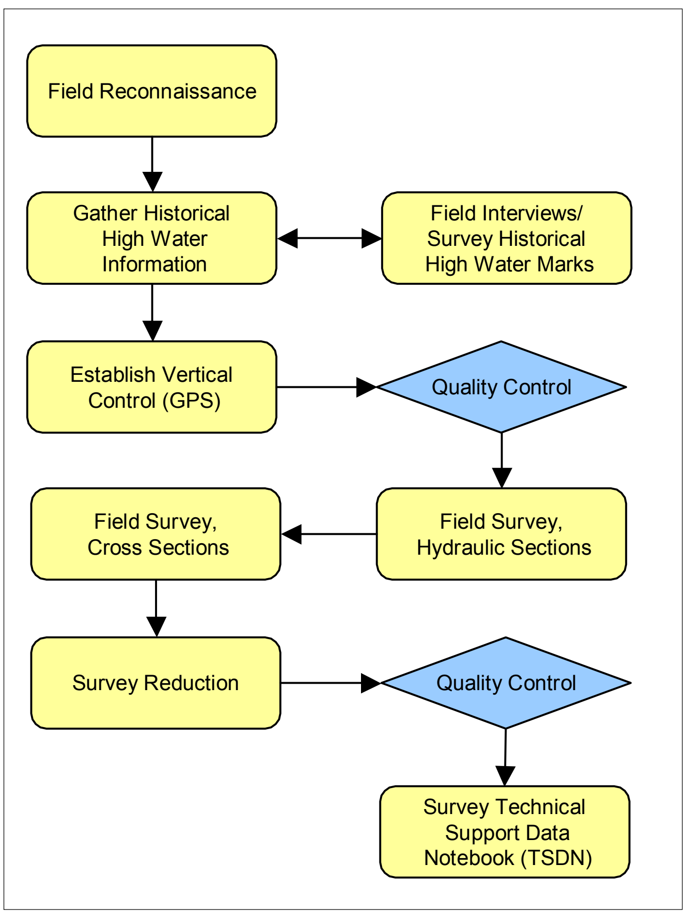


Figure 1. Field Survey Flow Chart

First, a field reconnaissance is conducted. The purpose of the field reconnaissance is to drive (and walk, if necessary) each stream to ensure that all structures are accounted for in the modeling. The reconnaissance will also identify any hydraulic structures on private property that will require property owner coordination and permission.

Historical flooding information is researched and compiled (published and non-published) from available sources including FEMA, US Army Corps of Engineers, USGS, NCDOT, municipalities and other agencies and consulting firms.

In general, the structure surveys obtain the structure geometry and the natural ground at a hydraulic structure. Each hydraulic structure is represented with a combination of the natural ground at the upstream face of the structure and the roadway profile along the centerline or crown of the roadway (highest profile.

The surveyors will set an Elevation Reference Mark (ERM) at each structure. During the survey of the structure, the ERM will be shot to give the benchmark an elevation and location (X,Y). An ERM normally will be a chiseled square at the upstream left face of the structure in the head wall or wing wall. If a structure does not have a headwall, then a large spike in a telephone pole, top of manhole, chiseled square on top of pipe of structure, or on a stable structure will be used.

For bridge surveys, the roadway profile is defined as the highest-grade line of the road along the structure. The survey of the top of road begins, at a minimum, 200 feet down-station from the beginning of the structure and ends, at a minimum, 200 feet up-station of the end of the structure. The ground points represent the natural ground geometry at the bottom of the fill at the upstream face of the structure.

The survey of a culvert is similar to that of the bridge. The top of road sections and natural ground sections are collected in a similar manner as the bridge survey. The upstream and downstream inverts of each culvert barrel(s) are also collected, as well as the shape, material, dimensions and entrance and exit types (headwalls and wingwalls).

Three cross sections are surveyed for a dam: an upstream ground (underwater) section of the pond or lake, a section across the top of dam, and section downstream of the dam embankment. If a spillway is present, elevation points are obtained at the top of dam, top of spillway, and bottom of spillway. The upstream and downstream side slope of the dam as well as the top width are measured and documented in the survey sketch. If a riser is present, elevations are obtained for the top of the riser, the invert of the riser, the inverts of the barrel or outlet works, and any obstruction on the riser, such as a metal grate or cover will be noted. The downstream natural ground section is obtained off of the fill or bottom of the slope of the dam and surveyed similar to upstream section of a bridge or culvert.

At least four digital photographs are taken at each hydraulic structure. In addition, a detailed sketch is made of the structure and vicinity. Sketches for structures include the structure, channel banks, edge of water, channel, direction of flow, rails, benchmark location, structure dimensions and any historical high water marks and references collected during the survey.

Hydraulic cross sections are surveyed and included in the hydraulic model. Because of the accurate terrain information for the floodplains, only the main channel portions (bank to bank) and immediate floodplain areas are field surveyed. This channel geometry information is then propagated upstream and downstream in the reaches between bridges. A minimum of two digital photographs are taken at each cross section.

Attempts to obtain historical high water marks are made on every detailed studied stream. In some cases, no historical high water information can be obtained for a stream. Information acquired from witnesses is: name of the witness, witness's address, length of residency, type, date and frequency of any high water events. Also included is the interviewer's name, photograph, date of interview, and stream location. Permission is obtained from property owners prior to any required survey. The high water mark is surveyed and used in later model calibration and verification for detailed study streams.

If this guidance document has been followed, then WISE can be used to import and store survey data (locations of the structures, cross sections, photographs, and ERMs) in a database format, when the survey is completed. This format enables the user to manually change numbers if required. The survey coordinator or field manager can review the data for accuracy. This quality control review consists of reviewing the importing of the raw ASCII (text) files into the WISE Open Inventory Module. This feature gives the survey leader(s) the ability to instantly view the survey as the hydraulic engineers and the hydraulic computer model will view the data. Errors and/or missing data can be detected. In addition, digital pictures are imported into WISE and linked to the structure database, serving as another quality control check.

After the office quality control checks, the structure and cross section survey data is ready for incorporation into the hydraulic models by the engineering team.

N.2 Basic Survey

N.2.1 General Survey Requirements

It is the surveyor's job to determine what will hinder or obstruct the flow of water. Bridges, culverts, dams and cross sections alter and restrict the flow of water and shall be recorded in survey notes, sketches and shots.

N.2.1.1 Survey Sketches

The structure survey sketch shall include notes representing the structural geometry and the natural ground using standard survey codes. The survey notes shall represent the hydraulic opening of each structure as well as surveying the top of road (the highest point) in order to determine how high the water must rise to proceed over the road. For a bridge, the survey must locate the trapezoidal opening as well as its hydraulic width. In addition, piers restrict the flow of water and need to be part of the survey. For a culvert, the hydraulic opening is determined by the shape, size, number, and hydraulic widths of the culverts. For a dam, the survey must define the height of the dam, the width of the spillway opening, the size and depth of risers, and the hydraulic width of the pipe from the riser to the downstream outlet. The survey requirements for each structure will be described in detail in this chapter.

The structure survey sketches will provide a planimetric and profile view of the structure. The orientation for sketches should be looking at the upstream face of the structure. A template for the structure drawings will be provided. The sketches shall show the structure, piers, channelbanks, channel, direction of flow, rails, deck, footings, abutments, culvert inverts, shape and size of opening, benchmark location, other dimensions, and other details of the structure.

N.2.1.2 Survey Coordinates

The survey needs to be performed in real world coordinates. Two alignment points need to be shot and coded, **ALPT1** and **ALPT2,** to define the alignment. These shots will create a new baseline that is perpendicular to the creek. For more information on this, refer to the State Plane Coordinates section in "Overview and Problem Surveys".

N.2.2 Starting the Survey

The method of starting the survey follows. Steps 4 and 5 are **only used** when using the CMT MC-V data collector. Other data collectors could use a different set up.

1. Take the 4 pictures required for the bridge, culvert or dam, the 2 pictures required for a levee or channel, or the 2 pictures for a cross section.
2. Set an elevation reference mark (**ERM**) in the headwall of the structure.
3. Provide a sketch of a planimetric and a profile view of the structure and other requested structure information on the given template.
4. Set up the total station on either side of the structure or stream that allows seeing all the necessary shots. Give the occupying point a Northing of 1000 and an Easting of 500, or use state plane coordinates. The downstream side of a structure is preferred to allow for a better angle into the vegetation on the upstream side.
5. The first shot and last shot of the survey should be the benchmark (**ERM**). This is to give the benchmark a true or assumed elevation and to check the elevation after the survey. If the elevation is not known, then give the benchmark an assumed elevation of 100 and adjust at a later date.
6. The second shot is the backsight. When using assumed data, this shot does not need a specific coordinate, but needs to be perpendicular to the structure. Looking downstream, if the total station is set up on the left side of the structure, the backsight should be facing right, over the stream. If the total station is set up on the right side of the structure, the backsight should be facing right, away from the stream. The northings need to increase left to right when looking downstream.

N.2.3 Setting Elevation Reference Marks (ERM)

Surveyors must set an Elevation Reference Mark on the upstream left headwall of each structure. This could be either a chiseled square or a chiseled X. If there is a chiseled square on one of the headwalls, check with any old Flood Insurance Rate Maps to see if this is an old ERM. If so, do not create a new ERM. Use the existing one.

Follow this order of where to set the ERMs. If the first location is unattainable, use the second, and so on.

1. Upstream left headwall
2. Upstream right headwall.
3. Downstream left headwall.

4. Downstream right headwall.
5. Spike in a nearby power pole set towards the road and 0.5 feet above the ground.
6. Top of the rim of a Manhole (not in road).
7. Flange bolt of a fire hydrant (not on top).
8. Spike in a nearby tree set towards the road or creek and 0.5 feet above the ground.

All ERMs must have a full description of the location in relation to the structure and road.

N.2.4 Naming Structures and Cross Sections

All structures and cross sections shall have a unique ID. A structure name should have the stream name or the abbreviated name followed by the number of the structure on that stream. All numbers start from the downstream limit and increase upstream.

There are many ways to create a naming scheme for a project. One common method is to abbreviate the stream name. For example, **SC3** is the third structure from the downstream limit on **S**wift **C**reek. **S**wift **C**reek would be **SC**. If there is another stream in the project with a **SC** (**S**wan **C**reek), then change **S**wif**t** **C**reek to **STC** and **S**wa**n** **C**reek to **SNC**.

Another example of naming files is to just use the first name of the stream. For example, **Swift** Creek would be **Swift** and **Swan** Creek would be **Swan**. This could be a problem if there are streams with long names or if the project has many names with Tributary in them.

Before surveying, review all the stream names to determine the best way to name the files and streams. Create a list of all the streams that are to be surveyed and find all the crossing and street names of that stream. This way a structure ID will already be assigned where the stream crosses the road.

Once in the field, there may be a time when a new road is built and is not on the current map or the bridge is in a park or private property. These will need to be surveyed as all structures need to be surveyed that cross the stream within the study limits. If all the IDs are assigned, use the letter A at the end of the ID. For example, SC3 would represent the third structure and SC3A would represent the fourth structure upstream.

N.2.5 Format of Survey Text Files

For quality control, the surveyors are usually directed to take the first two shots in the field as the occupying point (OCC) and the back sight (BS) and to describe them as control points. These two shots should remain in the survey, but two additional shots to describe the structure need to be added above these shots. To save the OCC and BS points, copy shots 1 and 2, the OCC and the BS, and paste them at the top of the survey. Now there should be two OCC and two BS points. The first two descriptions can be changed to describe the structure, but the OCC and BS descriptions will remain in the survey.

Figure 2. Formatting Text Files

```
data collector
1,13878618.350,3023941.825,121.122,GPS_H_LAN_11B
2,13878984.000,3023921.366,118.635,GPS_H_LAN_11A
3,13878308.673,3023976.571,118.083,ALPT2
4,13878304.382,3023963.576,118.419,OPEN
5,13878351.112,3023944.586,118.516,GR
6,13879068.480,3023995.192,119.164,TR

First 2 shots copied and replaced with appropriate
Descriptions and header included.
U00-10
1,13878618.350,3023941.825,121.122,BR U00-10 92 1.9
2,13878984.000,3023921.366,118.635,QUEENSTON DRIVE
1,13878618.350,3023941.825,121.122,GPS_H_LAN_11B
2,13878984.000,3023921.366,118.635,GPS_H_LAN_11A
3,13878308.673,3023976.571,118.083,ALPT2
4,13878304.382,3023963.576,118.419,OPEN
5,13878351.112,3023944.586,118.516,GR
6,13879068.480,3023995.192,119.164,TR
```

The first two shots are changed later in the office. The first two descriptions are changed to define the structure and some of its measurements.

For a bridge, the code should read **BR SC3 46 2.2**. This code means **BR** for bridge, **SC3** is the ERM ID, **46** is the width of bridge, and **2.2** is the deck thickness.

A culvert's first code is as follows: **CUL SC2 78**. The **CUL** represents culvert, **SC2** is the ERM ID, and **78** is the hydraulic width of the culvert.

A dam's first code is as follows: **DAM SC4 22 1.8**. The **DAM** represents a dam, **SC4** is the ERM ID, **22** is the width of the top of dam, and 1.8 is the embankment side slope.

The first shot for a cross section only needs **XS**, for cross section, and the ERM ID. The second shot's code is the street name in which the stream crosses.

Survey text files should be comma-delimited (text only). The first field shall be the shot number follow by the northing field, easting field, elevation field, and description field. Finally, a header needs to be inserted in the first line of the text file. The header will be the same as the structure name. All structure names must be unique. There cannot be a duplicate name in the project. Below is an example of a typical survey file.

Figure 3. Sample Survey Shots for a Bridge

```
WK_BGBR11
   1,764213.544,2111149.97,286.890,CUL WK_BGBR11 98
   2,764213.544,2111149.97,286.890,MILLBROOK ROAD
   0624,764213.544,2111149.97,286.890,W BIB 9A
   0625,764248.160,2110789.62,319.450,W BIB 9B
   1035,764248.463,2111423.05,275.042,ERM
   1009,765047.017,2111729.83,283.641,TR
   1010,765067.885,2111740.81,287.721,GR
   1014,765097.525,2111650.99,283.330,CB
   1015,765096.980,2111645.21,277.763,TE
   1016,765093.222,2111640.97,277.676,H2O
   1017,765093.734,2111639.07,277.697,UIB1 7 10
   1018,765094.884,2111636.03,277.653,H2O
   1019,765096.338,2111632.30,277.678,H2O
   1020,765097.258,2111629.27,277.663,UIB2 7 10
   1021,765099.064,2111624.86,277.725,H2O
   1022,765099.514,2111623.31,277.751,TE
   1025,765108.556,2111614.26,282.566,CB
   1030,765039.783,2111581.57,286.862,ALPT2
   1031,765010.312,2111670.01,283.829,ALPT1
   1032,764995.459,2111643.25,271.066,DS IN
   1033,764995.300,2111643.31,274.050,DIB1 7 10
   1034,764999.754,2111632.38,274.163,DIB2 7 10
```

It is assumed that a survey code is upstream (US) unless it is identified as downstream.

To identify a downstream shot, the surveyor must add DS after the survey code, such as GR DS or CB DS.

N.2.6 Naming Digital Photographs

Every structure and cross section will have a unique identification name. The photos taken at the structure or cross section will share that same identification name.

Four digital photos will be taken for each structure and two digital photos taken for each cross section. Each digital photo will be named using the identification name followed by an underscore and the picture number. For example, if the structure identification name is **E_BEB3**, picture 1 (US face) would be called **E_BEB3_USF.PNG**, picture 2 (US channel) would be called **E_BEB3_USC.PNG**.

- E-BEB3_USF.PNG – Upstream face
- E-BEB3_USC.PNG – Upstream channel
- E-BEB3_DSC.PNG – Downstream channel
- E-BEB3_DSF.PNG – Downstream face

Figure 4. Examples of Digital Photographs

N.3 Bridge Survey

The Merriam-Webster definition of a bridge is "a structure carrying a pathway or roadway over a depression or obstacle." Unlike a culvert, a bridge has an earthed floor underneath rather than a cement bottom.[1]

N.3.1 Bridge Sketch

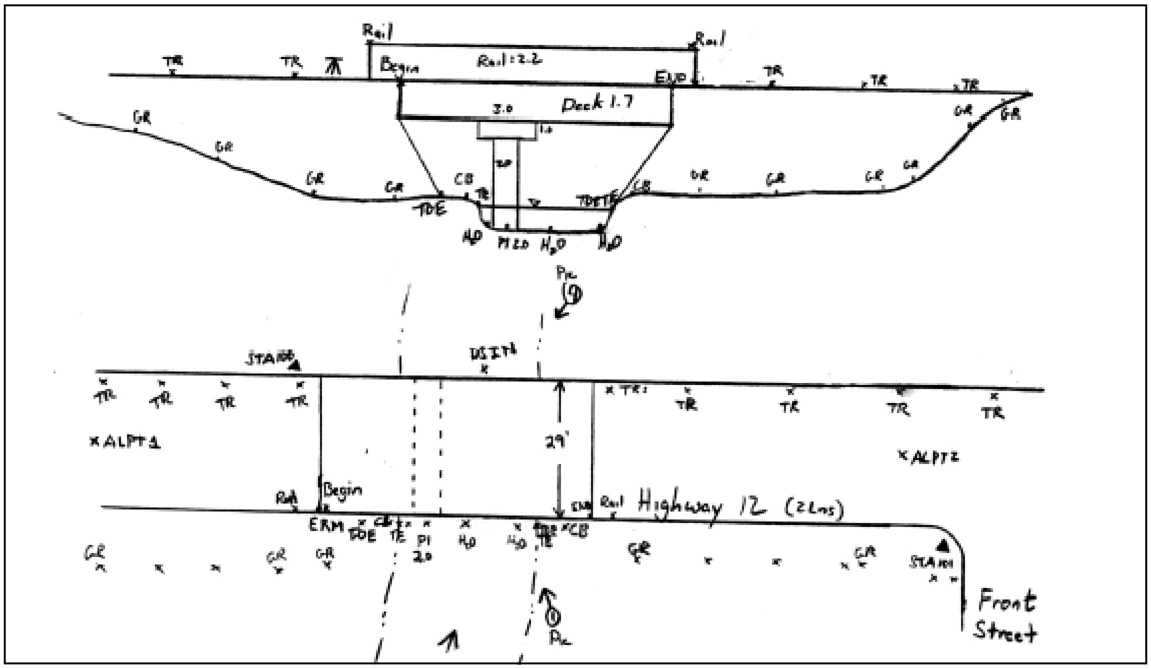
Each sketch for a bridge shall include the following: (use the template if provided):

- Project Name – Name of project or the area being studied.
- Stream Name – Name of the studied stream.
- Location – Road name that crosses the stream.
- Date of survey
- FEMA Contract number
- Filename – Survey filename in the data collector.
- Surveyors – Names of those surveying, listed as last name, comma, first initial.
- ERM ID – Specific location and type of benchmark (i.e. USGS benchmark disk on the upstream left headwall.)
- Elevation – Elevation of the ERM in the correct datum.
- Bridge hydraulic width – The distance that the stream flows through the structure. For example, a bridge whose roadway is 20' wide, but whose rails, piers, or sidewalk extends out one foot on each side of the structure would be 22' wide.
- Rail height – Distance from the road to the top of the rail.
- Deck thickness – Distance from top of road to low chord (top of opening of bridge).
- Pier dimensions
- North Arrow
- Direction of stream flow
- Photo IDs and Location – location and direction of where the photo was taken. Place the circled photograph number where the picture was taken and an arrow in the direction the photograph was taken.

Each sketch shall include both planimetric and profile view. The profile view should be oriented looking downstream at the upstream face of the structure. The sketches shall show the structure, piers, channel banks, channel, direction of flow, rails, deck, footings, abutments, ERM location, other dimensions, etc. A typical sketch is shown.

[1] *Merriam-Webster Dictionary*, 10 ed., s.v. "bridge."

Figure 5. Typical Bridge Sketches



N.3.2 Bridge Survey Text File

See the end of this section for an example of a Survey Text File for a Bridge. A header or a structure name is needed above the first shot of that text file. Each text file should have a unique header.

After the header, two shots or entries that provide the program with a useful description of the structure must follow the header. Shot number one provides the type of structure, the ERM for the structure, bridge width, and the deck thickness.

For example, **BR SF4 24 3.0** identifies the structure as a bridge (**BR**), the ERM ID is **SF4**, the bridge width is 24 feet, and the deck thickness is 3.0 feet. The second shot provides the street name of the bridge. The street name for this bridge is Stanley-Spencer Mountain Road.

N.3.3 Bridge Photographs

A minimum of four digital photographs will be submitted for each bridge. The required aspects or view of the photographs include:

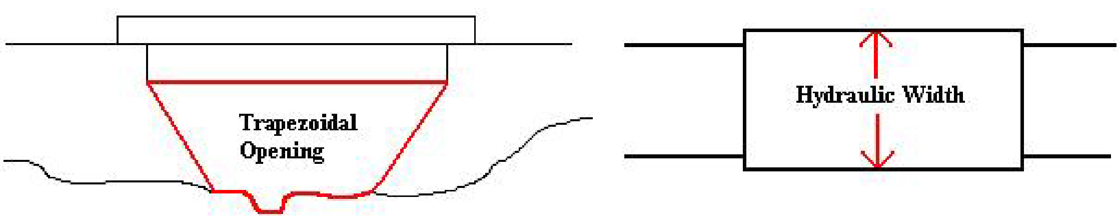
- SOMEWHERE_RD_USF. Standing upstream of structure, looking downstream at the structure
- SOMEWHERE_RD_USC. Standing on or below the structure, looking upstream at the channel
- SOMEWHERE_RD_DSC. Standing on or below the structure, looking downstream at the channel
- SOMEWHERE_RD_DSF. Standing downstream of structure, looking upstream at the structure

Figure 6. Examples of Bridge Photographs

N.3.4 Bridge Survey

It is the surveyors' responsibility to identify what will interfere or obstruct the flow of water. The survey should represent the hydraulic opening of all structures as well as surveying the top of road (the highest point to determine how high the water must rise to proceed over the road). With a bridge, the survey must locate the trapezoidal opening as well as its hydraulic width. Piers also restrict the flow of water and need to be part of the survey.

Figure 7. Trapezoidal Opening for Bridge



There are a variety of shots and codes that are needed to represent a bridge. A bridge requires structure data and two cross sections to be surveyed, a top of road section (**TR**) and a ground section (**GR**). The following shots are descriptions used in the survey: top of road data (**TR, BEGIN, END, RAIL)**, the structure data (**P1 1.0, TOE, DS IN**), and the ground section (**GR, CB, TE, H2O**). The table at the end of this section lists more in detail the valid codes required for a bridge survey.

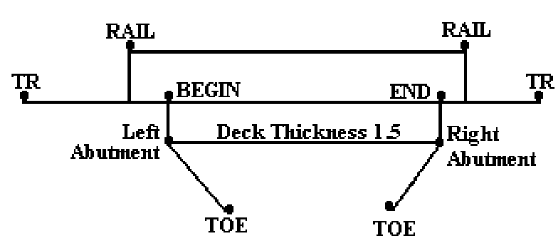
The ground (**GR**) section shall represent the natural ground at the bottom of the fill. The survey of the ground shall extend 200 feet from each channel bank running perpendicular to the creek. The ground section should represent where the water will go once the water goes outside the channel. The stream channel is defined as the water being contained in the channel at normal levels. The stream channel should be surveyed at the upstream face of the bridge.

A common method of surveying the stream channel is to take the channel shots from the top of the upstream side of the bridge. The survey codes for the stream channel are **CB** (channelbank), **TE** (top and edge), and **H2O** (water). All bridges must have two **CB**s, two **TE**s, and adequate number of **H2O** shots. Channelbank (**CB**) is defined as the top of the stream channel. Top and edge (**TE**) of water is defined as the top of the water in the streambed and where the water meets the land or the side of the channel. The number of water shots taken depends on the size of the channel. Water shots should be taken where there is a break in elevation in the channel. If the water is not clear, then probe the water to find any change in depth. There should be a minimum of three **H2O** shots. Two of those shots are at the bottom of the slope of the creek bed. If there is only one H2O shot in the middle of the creek, the representation of the channel would look like a "V".

N.3.4.1 Top of Road

The top of road (**TR**) points defines the highest-grade line of the road along the structure. The survey of the top of road shall begin, at a minimum, 200 feet down-station from the beginning of the structure and end, at a minimum, 200 feet up-station of the end of the structure. The beginning (**BEGIN**) and end (**END**) of bridge is defined as the top of road where the abutment begins. The **BEGIN** is the start of the left abutment and the **END** is the start of the right abutment. The top of the abutment is calculated by taking the top of road elevation (coded **BEGIN** and **END**) and subtracting the deck thickness. The deck thickness is coded within the first shot of the surveyed text file. (See the Code List at the end of this section). If the top of road is earthen and not asphalt or concrete, the **TR** is still used as a code even if it appears to be ground. A footbridge is an example of having an earthen top of road.

Figure 8. Bridge Shots

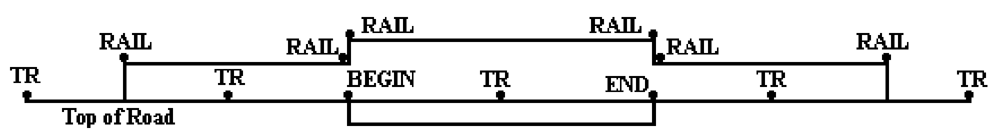


N.3.4.2 Rail

If there is a rail on the bridge, use a **RAIL** shot. The RAIL shot will be taken on top of the rail where the rail begins and ends. If the rail appears to change heights, survey a RAIL shot where there is a significant change in elevation. See example below (Figure 18). There should be a minimum of two rail shots for each set of rail heights that will be averaged for the rail height.

Figure 9. Example of One Rail Height

Figure 10. Example of Multiple Rail Heights



N.3.4.3 Other Codes

Other codes need to be in the survey (**P**iers, **TOE, DS IN, ERM**, and alignment points (**ALPT**)), but not all bridges will have **P**iers or **TOE**s.

TOEs are only needed if the abutment is on an angle (not straight down). In some of the older bridges, the abutments are at a 90-degree angle (straight down). In these cases, a **TOE** code is not needed. The **BEGIN** and **END** codes will still be taken on the top of the road at the abutment stationing. The **TOE**s will be generated automatically by drawing a line from the top of the abutments, created by the **BEGIN** and **END**, to the natural ground created by the **GR** section. Footbridges are built directly over a channel and will not have an abutment (**TOE** shot) as shown in Figure 18.

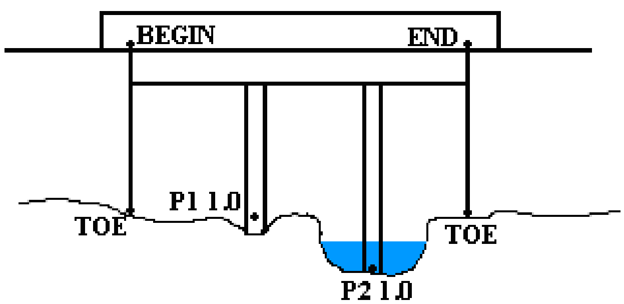
N.3.4.4 Piers

The pier shots (**P2 1.0**) have to be taken on the upstream face of the bridge and at its base. Piers will be coded as one continuous solid pier. Piers are also coded within the field data. Do not shoot another GR of H2O at the piers. If a pier is in a scour hole, survey the pier base as if it were filled in. In order to compensate, either raise the rod directly in front of the pier over the scour hole at the normal ground or extend the rod out in front of the pier until the normal ground is represented. Do not survey anything in a scour hole. If there is a footing or a cap, write the measurements (height and width) in the additional comments section of the drawing template.

The pier description must be followed by a pier number and its thickness (**P1 1.5**). The Piers are numbered from left to right. The piers are coded as part of the ground section. If there is a pier in the water, that pier will also be a water (**H2O**) shot.

Below is an example of where to take the shot with a pier in a scour hole, and also to survey pier 2 as a water shot. Other shots were omitted to avoid clutter.

Figure 11. Bridge Pier Shots



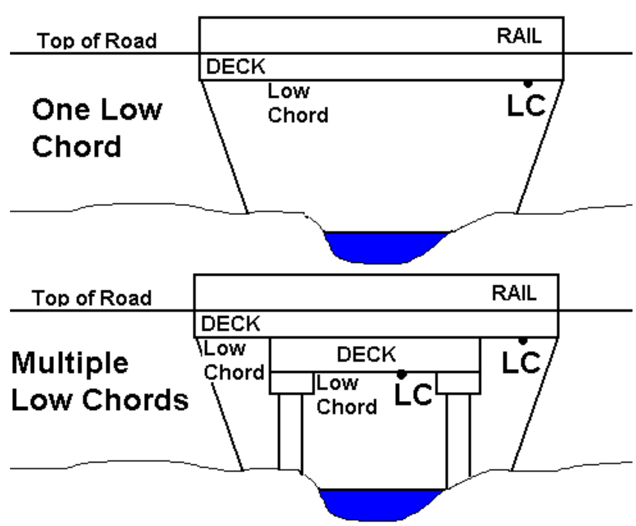
In the example above, the **TOE** shots were taken but not needed. This is a surveyor's option. Survey the **TOE** shots on a vertical abutment if there was a change in elevation.

N.3.4.5 Low Chord (LC)

The surveyor must supply either the deck thickness or one or more low chords. The deck thickness is defined as the distance between the top of road elevation and the bottom of the bridge deck or low chord.

Figure 12. Examples of Low Chords

If the surveyor provides low chords without a deck thickness, an average deck thickness is calculated based on the low chords. If only one low chord is provided without a deck thickness, the deck thickness is calculated and stored, based on the low chord, as well as the actual elevation. If both a deck thickness and low chords are provided, both are stored but the LC code is used to calculate the deck thickness. LC codes are used if the actual deck thickness measurement is hard to obtain or if there is a super elevated turn. Shoot two LCs if there are multiple low chords.



N.3.4.6 Upstream and Downstream Faces of Structure

The USSTRUCT and DSSTRUCT codes are required as they measure the hydraulic width of the structure. The shots are to be taken on top of the bridge at the upstream (USSTRUCT) and downstream (DSSTRUCT) face of the structure over the stream. Using these codes will overwrite the existing hydraulic width value found in the first shot.

N.3.4.7 Elevation Reference Mark and Downstream Invert

All bridges and culverts need an ERM and a DS IN. The **ERM**, or **E**levation **R**eference **M**ark, must be set and surveyed at each structure. The ERM is a temporary benchmark to be referenced later. The **DS IN**, or **D**own**S**tream **IN**vert, is the deepest water shot taken on the **downstream** side on the bridge. Avoid taking a DS IN in a scour hole. If the downstream channel has a rocky bottom due to the construction of the bridge, probe through the rocks to find the stream bottom, otherwise move a little downstream where the streambed is attainable.

N.3.5 Close Interstate or Highway Structures

For bridges only, there are cases when two bridges are close enough to be modeled as one structure. Bridges are only to be modeled as one structure when two bridges are less than 50 feet from one another and they share the same shape. For example, the two bridges have the same deck thickness, rails, abutments, and number and shape of piers. These close structures are commonly found on major highways and interstates and were built using the same plans.

The ground section will be surveyed on the upstream side of the upstream structure and the downstream invert will be taken on the downstream side of the downstream structure. The top of road section will be taken at the highest elevated road. The low cord or the deck thickness will be measured between the highest elevated road and the lowest deck.

For example, if the highest elevated road is at an elevation of 100 feet and the lowest elevated road is at 96 feet with a deck of 2 feet. The deck thickness will be calculated to the difference between the two road elevations (4 feet) and adding the deck (2 feet), which makes the deck 6 feet. An LC shot can be shot in lieu of measuring a deck thickness. The hydraulic width of the bridge will be the sum of the two widths of each bridge and the distance separating the two bridges. If the two bridges were 42 feet wide with a distance of 26 feet in between them, the width of the bridge would be 110 feet.

Figure 13. Close Bridges

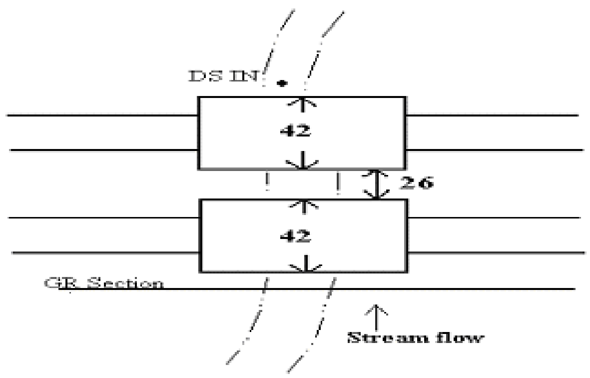


Figure 14. Deck Thickness versus LOW CHORD Shots

Table 1. Survey Codes for a Bridge

Valid Codes	Example	Notes for use
HEADER		
Structure Type ERM Hydraulic width Deck	BR SF4 24 3.0	Shot 1 only. Bridge with ERM ID, Hydraulic width and Deck Thickness. If Deck Thickness is supplied, it is not necessary to use LOW CHORD
Road Name	Mountain Road, Interstate 85	Shot 2 only.
FIELD SHOTS (Bridge)		
ERM	ERM SF4, ERM N_TAR-4	Elevation reference mark
TR	TR	Top of Crown Data
BEGIN	BEGIN	Top of Crown at Begin Abutment
END	END	Top of Crown at End Abutment
RAIL	RAIL	Top of Rail. Must be inside TR.
GR	GR	Ground Field Data
CB	CB	Channelbank
P? Width	P1 3.0, P4 2.3	Pier #1 and Width
TOE	TOE	Toe of Fill Station
TOE TE	TOE TE	Toe of Fill Station and Edge H2O
TE	TE	Edge H2O
H2O	H2O	Underwater Field Data Shot
HIS	HIS	Historical Shot
DS IN	DS IN	Downstream Invert for Bridge
OPEN	OPEN	Open Area Field Shot
BRUSH	BRUSH	High Brush Field Shot
WOOD	WOOD	Wooded Canopy Field Shot
ALPT	ALPT1, ALPT2	Alignment points (left, right)
LC or LOW CHORD	LC	Bottom of suspension structure. Must be inside of Begin and End. If LC is used, it is not necessary to supply Deck Thickness.

Figure 15. Survey Codes for a Bridge

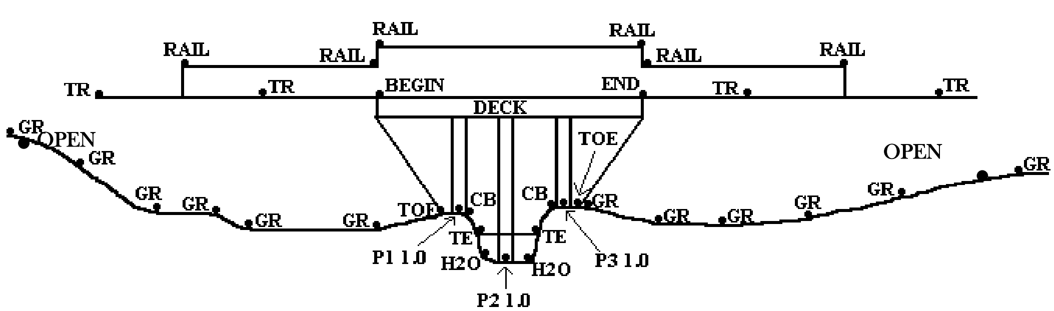


Figure 16. Sample Survey Text File using LOW CHORD for a Bridge

```
U20-2
1,13878649.380,3019506.624,120.841,BR U20-2 76.0
2,13879384.780,3019487.254,122.978,BARKER CYPRESS
1,13878649.380,3019506.624,120.841,H_DIN_1
2,13879384.780,3019487.254,122.978,H_LAN_12
3,13878581.860,3019520.325,104.740,H2O
4,13878582.852,3019519.517,104.808,H2O
5,13878585.552,3019518.683,105.680,TE
6,13878605.509,3019519.738,110.907,P1 1.4
7,13878638.154,3019516.560,119.458,GR
8,13878650.431,3019515.926,121.042,GR
9,13878660.838,3019517.306,121.266,TOE
10,13878661.048,3019517.407,122.532,LC
11,13878657.988,3019498.682,122.015,CB
12,13878742.104,3019509.338,122.306,GR
13,13878801.661,3019506.965,121.947,GR
14,13878859.131,3019506.000,122.218,GR
15,13878896.482,3019504.989,122.124,GR
16,13878896.515,3019504.989,122.124,OPEN
17,13878899.260,3019527.576,123.943,ALPT1
18,13878899.977,3019539.121,124.101,TR
19,13878842.998,3019541.268,124.470,TR
20,13878786.292,3019543.254,124.859,TR
21,13878731.543,3019545.490,125.232,TR
23,13878696.666,3019548.514,129.085,RAIL
24,13878669.845,3019535.840,125.154,BEGIN
25,13878619.904,3019549.086,125.230,TR
27,13878502.279,3019541.545,125.157,END
28,13878504.890,3019552.787,125.252,TR
30,13878463.567,3019559.801,126.589,RAIL
31,13878449.010,3019554.153,125.832,TR
32,13878384.540,3019556.611,126.009,TR
33,13878328.447,3019559.033,126.086,TR
34,13878273.629,3019560.861,126.214,TR
35,13878273.511,3019549.542,126.083,ALPT2
36,13878270.766,3019519.814,124.902,OPEN
37,13878270.719,3019519.815,124.901,GR
38,13878337.985,3019517.340,123.184,GR
39,13878400.862,3019511.553,122.275,GR
40,13878463.913,3019509.565,122.225,GR
41,13878496.103,3019513.638,122.083,CB
42,13878503.521,3019522.387,122.134,TOE
43,13878503.468,3019522.142,122.653,LC
44,13878512.950,3019521.211,119.852,GR
45,13878548.091,3019521.401,110.564,P2 1.4
46,13878565.061,3019518.663,105.694,TE
47,13878567.956,3019518.266,104.878,H2O
48,13878577.880,3019520.488,125.466,ERM UC
49,13878663.015,3019517.676,125.513,USSTRUCT
50,13878676.048,3019592.510,125.520,DSSTRUCT
51,13878615.852,3019595.333,105.260,DS IN
52,13879384.780,3019487.265,122.958,H_LAN_12
```

N.4 Culvert Survey

The definition of a culvert is a prefabricated structure carrying a pathway or roadway over a depression or obstacle. Unlike a bridge, a culvert has a concrete or metal bottom.

N.4.1 Culvert Sketch

Each sketch for a culvert shall include the following (use the template if provided):

- Project Name – Name of project or the area being studied
- Stream Name – Name of the studied stream
- Location – Road name that crosses the stream
- Date of survey
- FEMA Contract number
- Filename – Survey filename in the data collector
- Surveyors – Names of those surveying, listed as last name, comma, first initial
- ERM ID – Specific location and type of benchmark (i.e. USGS benchmark disk on the downstream left headwall, chiseled square on the upstream left headwall.)
- Elevation – Elevation of the ERM in the correct datum
- Culvert length – The distance that the stream flows through the structure. If the culvert has a bend, this needs to be factored into the culvert hydraulic width
- Type – The type of culvert (i.e. concrete box, circular concrete pipe, elliptical metal pipe, etc)
- Number – Number of openings
- Rail height - Distance from top of road to top of rail. (If any)
- North Arrow
- Direction of stream flow
- Photo IDs and Location – location and direction of where the photograph was taken. Place the circled photograph number where the picture was taken and an arrow in the direction the photograph was taken.

Each sketch shall include both planimetric and profile view. The profile view should be oriented looking at the upstream face of structure. The sketches shall show the shape of the structure, culvert inverts, number and size of opening, channelbanks, channel, direction of flow, rails, ERM location, dimensions, etc. A typical sketch for a culvert is shown.

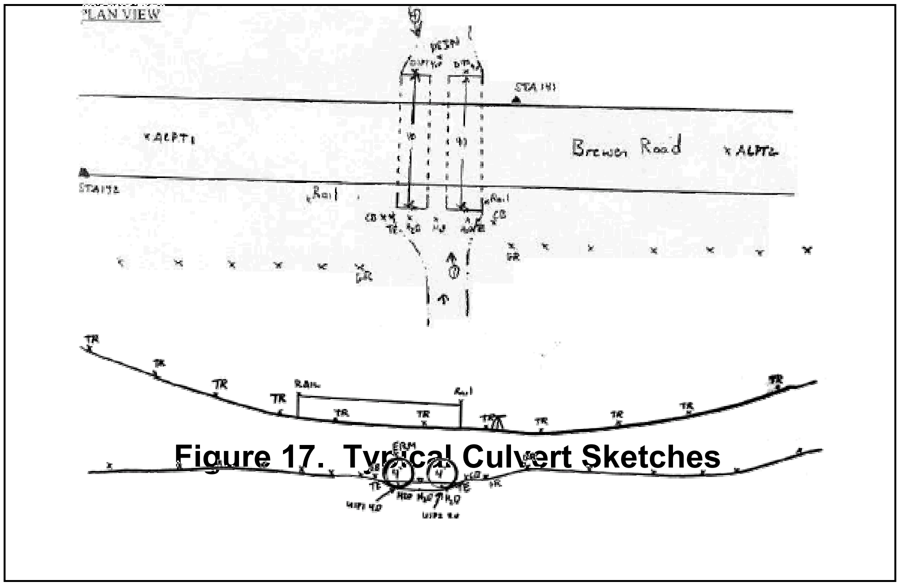


Figure 17. Typical Culvert Sketches

N.4.2 Culvert Survey Text File

The text file must begin with two shots or entries that provide the program with a useful description of the structure. Shot number one provides the type of structure, the abbreviated name, and the culvert hydraulic width. For example, **CUL AC2 99** identifies the structure as a culvert (**CUL**), the identification of the culvert is **AC2**, and the culvert hydraulic width is 99 feet. The second shot provides the street name of the culvert. The end of this section shows an example of a survey text file for a culvert. A header or a structure ID is needed above the first shot of that text file. Each text file should have a unique header.

N.4.3 Culvert Photographs

A minimum of four digital photographs will be submitted for each culvert. The required aspects or view of the photographs include:

- SOMEWHERE_RD_USF. Standing upstream of structure, looking downstream at the structure.
- SOMEWHERE_RD_USC. Standing on the structure, looking upstream at the channel.

- SOMEWHERE_RD_DSC. Standing on the structure, looking downstream at the channel.
- SOMEWHERE_RD_DSF. Standing downstream of structure, looking upstream at the structure.

Figure 18. Examples of Culvert Photographs

N.4.4 Culvert Survey

It's the surveyor's job to see what will interfere with or obstruct the flow of water. The survey should represent the hydraulic opening of all structures as well as surveying the top of road (the highest point to determine how high the water must rise to proceed over the road.) With a culvert, the survey must locate the opening of the culvert(s) as well as its hydraulic width. The culvert headwalls and columns do not need to be surveyed. The three types of culvert are Circular Pipe (**P**), Elliptical (**E**), and Box (**B**).

N.4.4.1 Top of Road

The following shots are descriptions used in the survey: top of road data (**TR, TR RAIL 2.0**), the structure data (**UIB1 7.0 7.0, DIB2 7.0 7.0, DS IN**), and the ground section (**GR**, **CB**, **TE**, **H2O**). See the code list at the end of this culvert section for the first two shots description and the following field shots.

The top of road (**TR**) points define the highest-grade line of the road along the structure. The survey of the top of road shall begin, at a minimum, 200 feet down-station from the beginning of the structure and end, at a minimum, 200 feet up-station of the end of the structure.

If there is a rail near the culvert, use a **RAIL** shot. The RAIL shot will be taken on top of the rail where the rail begins and ends. If the rail appears to change heights, survey a RAIL shot where there is a significant change in elevation. There should be a minimum of two rail shots for each set of rail heights.

N.4.4.2 Ground Section

The ground (**GR**) points shall represent the natural ground at the bottom of the fill. The survey of the ground shall extend 200 feet from each channel bank running perpendicular to the creek. The ground section should represent where the water will go once the water goes outside the channel.

The stream channel is defined as the stream water being contained in the channel at normal levels. The stream channel should be surveyed at the upstream face of the culvert.

The survey codes for the stream channel are **CB** (channelbank), **TE** (top and edge), and **H2O** (water). All culverts must have two **CB**s, two **TE**s, and adequate number of **H2O** shots. Channelbank (**CB**) is defined as the top of the stream channel. Top and edge (**TE**) of water is defined as the top of the water in the streambed and where the water meets the land or the side of the channel. Water (**H2O**) is defined as the shots in the water at the bottom of the streambed.

The number of water shots taken depends on the size of the channel. Water shots should be taken where there is a break in elevation in the channel. If the water is not clear, then probe the water to find any change in depth. There should be a minimum of three **H2O** shots. Two of those shots are at the bottom of the slope of the creek bed. If there is only one H2O shot in the middle of the creek, the representation of the channel would look like a "V".

N.4.4.3 Culvert Shots

All culvert shots must be in the center of openings (inverts). The following descriptions are examples of three 10' high and 8' wide box culverts with a 2' thickness. The sketches that follow the description explain the three *different* ways to obtain the shots for these boxes. **Use only <u>one</u> method for each box**.

- **Recommended Method**
  The first box is given a code of UIB1 10 8. This means Upstream Invert of Box 1 with a height of 10 and a width of 8.
  OR
- **Method Two**
  The second shot is taken at the top of the opening of box 2 given a code of UTB2 10.0 8.0 0.0. This means Upstream Top of Box 2 with a height of 10, a width of 8, and a thickness of 0.
  OR

- **Method Three**
  The third shot is taken at the top of the structure of box 3 given a code of UTB3 10.0 8.0 2.0. This means Upstream Top of Box 3 with a height of 10, a width of 8, and a thickness of 2.

A pipe culvert is done the same way except "P" (pipe) is used rather than "B" (box). In the example below, UIP4 3.5 is used. This means Upstream Invert of Pipe 4 (fourth culvert) with a 3.5 diameter opening.

For all culverts, you must survey **the downstream inverts of each culvert opening** as well as 1 downstream channel invert shot**.**

Figure 19. Profile View of a Culvert

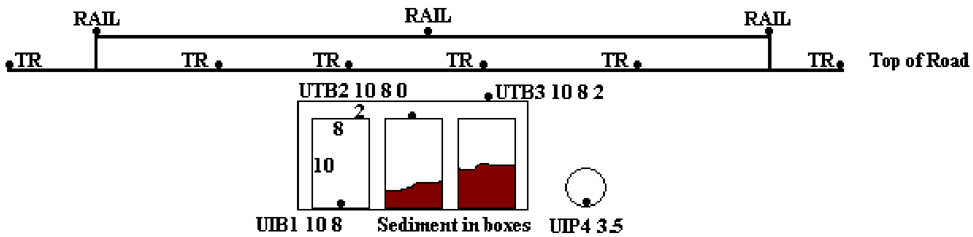
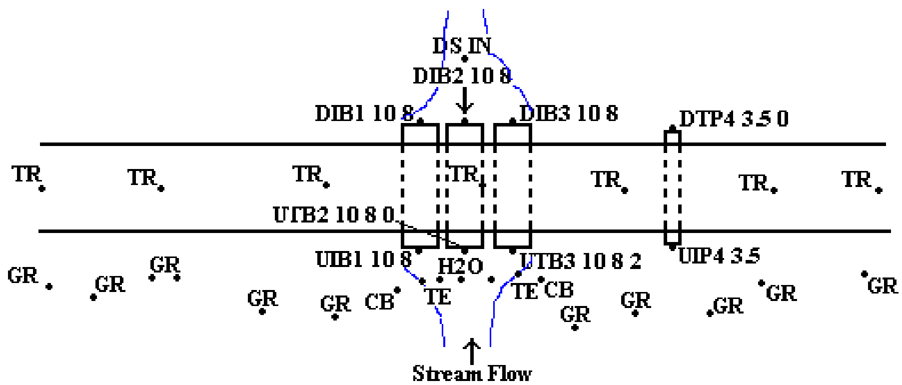


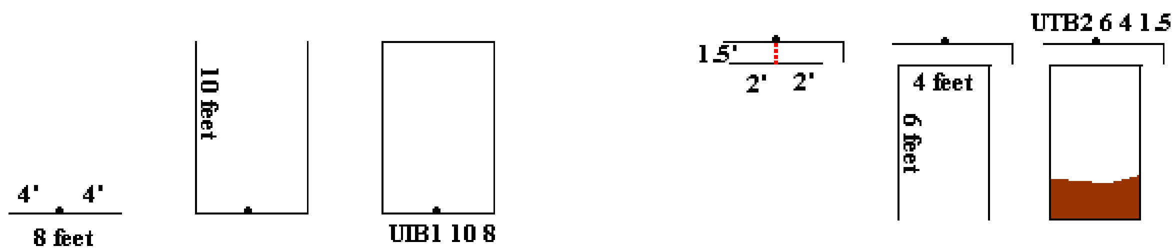
Figure 20. Planimetric View of a Culvert



Any of the above methods of coding a culvert can be used. There can be any number of reasons to use these assortments of shots. There will be times when the shots need to be at the top of the culvert. Some of these examples are rod height restrictions, undercut pipes, and sediment in the culvert. Only **one** of these types of shots needs to be taken for each culvert. The recommended method is surveying the invert of the culvert.

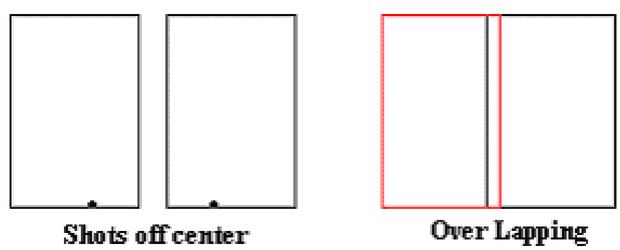
These shots are interpreted by taking the location and elevation of that surveyed shot and drawing a box, circle, or an elliptical pipe. At a surveyed point coded **UIB1 10 8**, a line 4 feet from either side of that point (8' wide) is drawn, the line is extended up to 10 feet in height, and then the rectangle is closed. If the shot was **UTB2 6 4 1.5**, a value of 1.5 is subtracted to find the top of the box opening, then draw a line 2 feet from either side (4' wide), subtract the height (6') to find the invert, and then close the rectangle. If the shot was surveyed at the top of the opening of the culvert, the thickness would be zero.

Figure 21. Interpretation of Culvert



If the surveyed inverts are not in the center of the culvert, there will be an overlap with the boxes. See the following example. There are two boxes at 10 feet wide with a 1-foot divider. If the inverts are taken 1 foot towards that divider for each culvert, the divider will not be drawn and the culverts will merge into one. The divider will be calculated by culvert shots. The exact size of the divider is not important. If the divider is 1 foot and the survey only measures the distance between the culverts at 0.7 that is fine. The main concern is the size of the boxes and the inverts of the culverts in the center of the boxes.

Figure 22. Overlapping Box Culverts

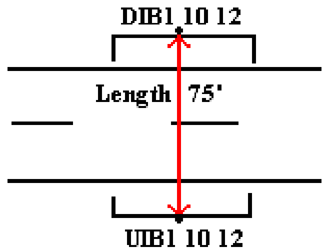


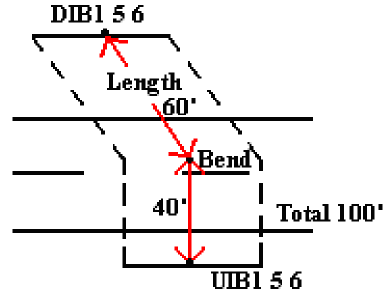
N.4.4.4 Hydraulic Width

There are a few ways to measure the hydraulic width of the culvert. The first method is to find the distance between the upstream and downstream inverts of each culvert. Many data collectors can determine the distance automatically between two points. The distance between **UIB1** and **DIB1** should be measured to get the hydraulic width of box 1.

Another method is to use a tape measure. This measurement must be made inside the culvert. Measuring the culvert from the top of the road may create a bend in the tape. When there is a bend in the culvert, survey on top of the road where that bend is located underground. Use that shot to help determine the true hydraulic width with the bend.

Figure 23. Hydraulic Width of Culverts





N.4.4.5 Upstream and Downstream Faces of Structures

The USSTRUCT / DSSTRUCT codes are required as they measure the hydraulic width of the structure. The shots are to be taken on top of the middle culvert at the upstream (USSTRUCT) and downstream (DSSTRUCT) face of the structure. Using these codes will over-write the existing hydraulic width value found in the first shot. Do not use these shots if there is a bend in the culvert.

N.4.4.6 Flared or Skewed Culverts

Flared culverts or cut to fill culverts are usually elliptical and will be coded with an **E** for the third letter of the code. The measurements, culvert width, and the invert shots are to be taken where the entire culvert is enclosed, as shown in the photograph.

There is a common problem with measuring skewed box culverts. Measuring the face will not give the correct measurement of the box. The correct way to measure the width of this type is to measure the inside of the box at a 90-degree angle. Below is an example of a skewed culvert. The height shouldn't need any correction.

Figure 24. Skewed Culverts

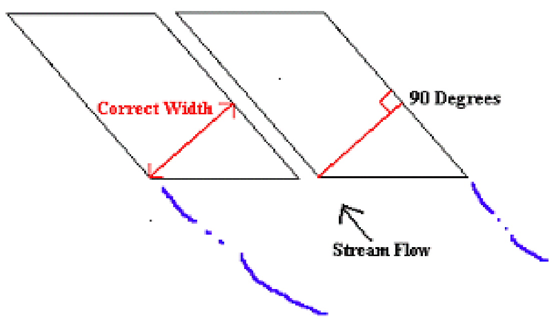


Table 2. Survey Codes for a Culvert

Valid Codes	Example	Notes for use
HEADER		
Structure Type BM Hydraulic width	CUL AC2 99	Shot 1 only. Culvert with Benchmark and Hydraulic width of the Culvert.
Road Name	Garrison Boulevard	Shot 2 only.
FIELD SHOTS (Culvert)		
ERM	ERM AC2, ERM N_TAR-4	Elevation reference mark
TR	TR	Top of Crown Data
RAIL	RAIL	Top of Rail
GR	GR	Ground Field Data
TE	TE	Edge H2O
H2O	H2O	Underwater Field Data Shot
CB	CB	Channelbank
DS IN	DS IN	Downstream Invert for Culvert
OPEN	OPEN	Open Area Field Shot
BRUSH	BRUSH	High Brush Field Shot
WOOD	WOOD	Wooded Canopy Field Shot
ALPT	ALPT1, ALPT2	Alignment points (left, right)
UIB# Height Width	UIB2 10.1 10.8	Upstream Invert Box 2
DTE# Height Width Thick	DTE3 5.6 7.9 0.5	DS Top Ellipse 3
DTP# DIA Thick	DTP1 7.0 0.3	DS Top Pipe 1
DS = Downstream **US = Upstream**	**I = Culvert Invert @ Centerline** **T = Top of Culvert @ Centerline**	**B = Box, P = Pipe** **E = Elliptical Culvert**

Figure 25. Sample Survey Text File for a Culvert

```
U20-10
1,13884469.810,3007486.297,138.149,CUL U20-10 103
2,13884259.280,3007429.304,137.770,FRY ROAD
1,13884469.810,3007486.297,138.149,H_DIN_5A
2,13884259.280,3007429.304,137.770,H_DIN_5B
3,13884460.767,3007487.914,138.641,ERM UL
5,13884463.554,3007489.669,140.164,RAIL
9,13884334.867,3007352.793,140.282,RAIL
10,13884369.190,3007388.005,136.927,CB
11,13884382.836,3007402.634,130.055,GR
12,13884389.167,3007409.621,126.388,TE
13,13884392.584,3007413.345,125.198,H2O
14,13884401.096,3007421.951,125.312,H2O
15,13884409.258,3007430.658,125.251,H2O
16,13884412.533,3007433.970,126.452,TE
17,13884419.368,3007441.749,130.167,GR
19,13884405.138,3007426.358,125.136,UIB1 10 12
20,13884396.147,3007416.877,124.957,UIB2 10 12
21,13884320.947,3007487.795,124.456,DIB2 10 12
22,13884330.293,3007496.827,124.476,DIB1 10 12
23,13884323.690,3007491.363,124.790,DS IN
24,13884324.557,3007491.103,140.702,DSSTRUCT
25,13884400.790,3007422.646,140.634,USSTRUCT
26,13884371.046,3007443.994,139.591,TR
27,13884411.521,3007486.597,138.645,TR
28,13884454.685,3007532.734,137.048,TR
29,13884493.927,3007575.721,136.904,TR
32,13884585.876,3007672.269,137.000,ALPT1
33,13884622.115,3007634.222,138.055,BRUSH
34,13884622.143,3007634.198,138.056,GR
35,13884575.007,3007595.595,137.593,GR
36,13884534.003,3007552.524,137.808,GR
37,13884490.380,3007505.049,137.749,GR
38,13884453.493,3007468.610,137.905,CB
39,13884357.223,3007373.035,136.691,GR
40,13884313.299,3007325.663,136.863,GR
43,13884233.382,3007238.533,137.281,BRUSH
44,13884202.589,3007265.291,136.857,TR
45,13884241.347,3007306.893,137.137,TR
46,13884283.134,3007351.250,137.190,TR
48,13884320.543,3007390.211,137.992,ALPT2
50,13884259.280,3007429.306,137.693,H_DIN_5B
```

Except for the first two shots or entries, these shots can be in random order and do not need to follow this pattern as long as valid codes are used. A header or a structure ID is needed above the first shot.

N.5 Dam Survey

The Encyclopedia Britannica definition of a dam is "structure built across a stream, river, or estuary to retain water. Its purposes are to meet demands for water for human consumption, irrigation, or industry; and to reduce peak discharge of floodwater."[2]


N.5.1 Dam Sketch

Each sketch for a dam shall include the following:

- Project Name – Name of project or the area being studied.
- Stream Name – Name of the studied stream.
- Location – Road name that crosses the stream.
- Date of survey
- FEMA Contract Number
- Filename – Survey filename in the data collector.
- Surveyors – Names of those surveying, listed as last name, comma, first Initial. For example: Smith, J
- ERM ID – Specific location and type of benchmark (i.e. USGS benchmark disk on the upstream left headwall.)
- Elevation – Elevation of the ERM in the correct datum.
- North Arrow
- Direction of flow
- Top Width – Width of the top of dam
- Side Slope – Embankment side slope of dam
- Riser – size and material
- Culvert Type – The type of culvert (i.e. concrete box, circular concrete pipe, elliptical metal pipe,)

[2] *Encyclopædia Brittanica 2003*, s.v. "dam (engin.)."

- Number – Number of openings
- Culvert hydraulic width – The distance that the stream flows through the bottom of the riser to the outlet pipe. If the culvert has a bend, this needs to be factored into the culvert hydraulic width
- Spillway – Height and Width
- Weir – Thickness of the weir where the water runs over
- Photo IDs and Location – Location and direction of where the photograph was taken. Place the circled photograph number where the picture was taken and an arrow in the direction the photograph was taken.

Each sketch shall include both planimetric and profile view. The profile view should be oriented looking downstream at the structure. The sketches shall show the structure, channelbanks, channel, direction of flow, benchmark location, north arrow, dimensions, etc. A typical sketch is shown.

Figure 26. Typical Earthen Dam Sketches

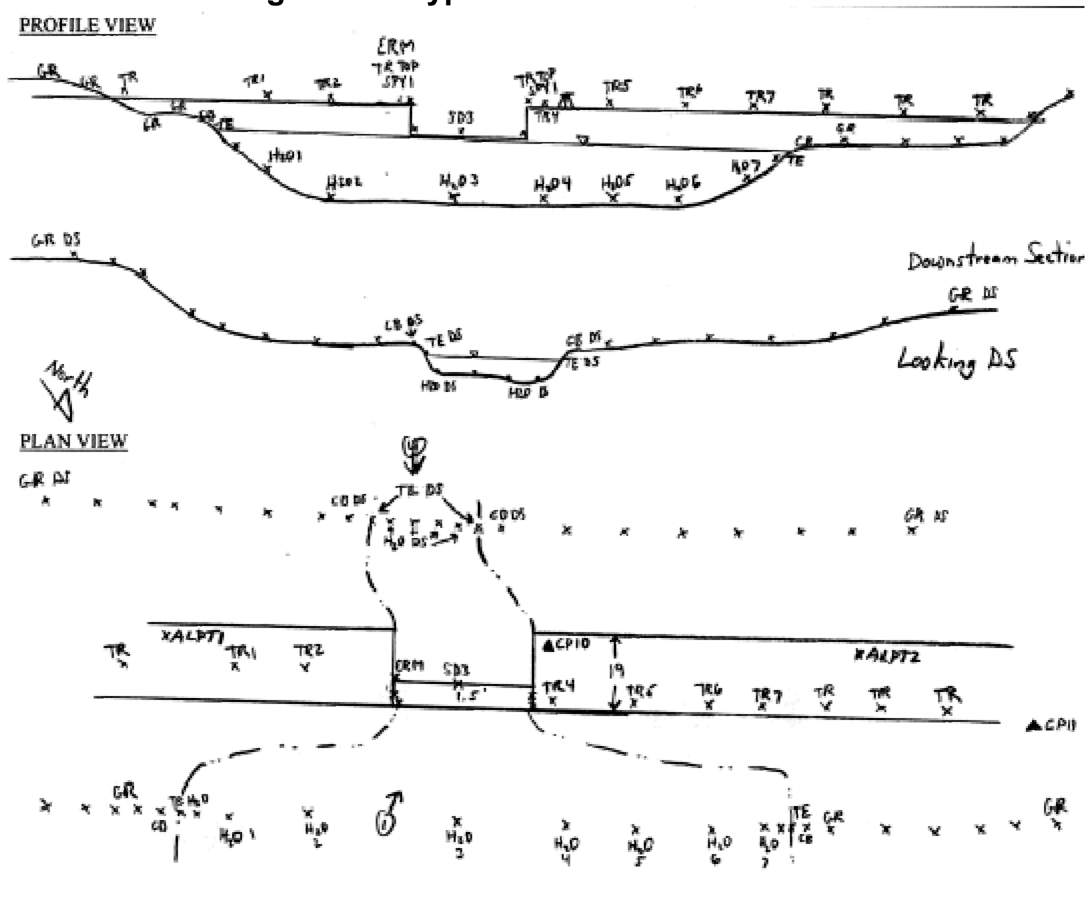
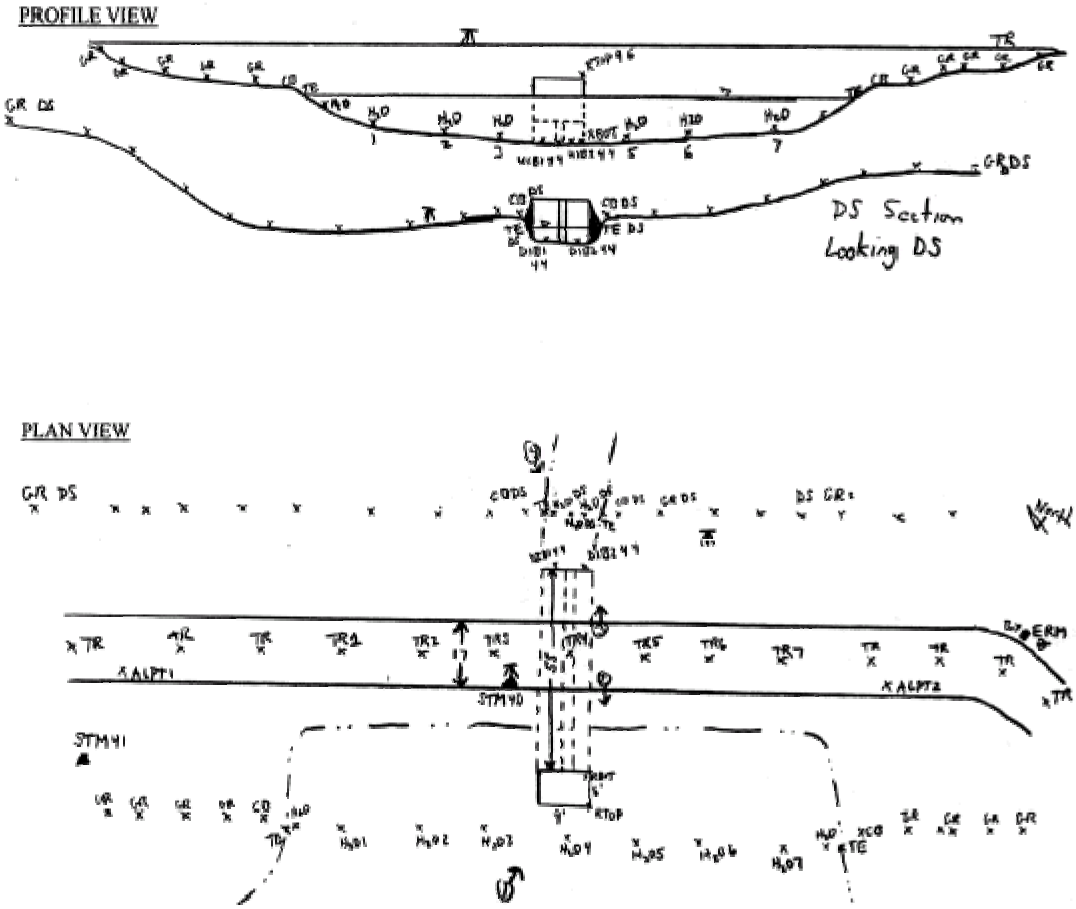


Figure 27. Typical Dam with Riser Sketches



N.5.2 Dam Survey Text File

The text file must begin with two shots or entries that provide the program with a useful description of the structure. Shot number one provides that the type of structure, the abbreviated structure name, top width of the dam, and the side slope of the dam. For example, **DAM DC3 14 2.5** identifies the structure as dam (**DAM**) with the benchmark identification as **DC3**, the top width of the dam is **14**, and the upstream side slope is **2.5**. The second shot provides the name of the crossing road.

N.5.3 Dam Photographs

A minimum of four digital photographs will be submitted for each dam. The required aspects or view of the photographs include:

- SOMEWHERE _USF. Standing upstream of structure, looking downstream at the structure.
- SOMEWHERE _USC. Standing on the structure, looking upstream at the pond or lake.
- SOMEWHERE_DSC. Standing on the structure, looking downstream at the channel.
- SOMEWHERE_DSF. Standing downstream of structure, looking upstream at the structure.

Figure 28. Examples of Dam Photographs

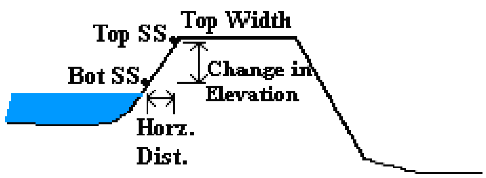
N.5.4 Dam Survey

It is the surveyor's responsibility to identify what will interfere with or obstruct the flow of water. The survey should represent the hydraulic opening of all structures as well as surveying the top of road (the highest point to determine how high the water must rise to proceed over the road.) With a dam, the survey must locate the spillway and/or the opening of the riser as well as the pipes that go under the dam. **The survey shall also include a downstream and upstream ground cross sections**.

N.5.4.1 Embankment and Top of Dam

The embankment side slope is measured by taking the inverse of the rise/run. These are not required codes in the survey. Take two shots, one on top of the embankment and the other near the bottom perpendicular to the top of dam. Find the change in elevation and divide it by the horizontal distance, and then take the inverse. For example, if the change in elevation is 8 and the horizontal distance is 20 (8/21), the slope would be 0.4 and the inverse of the slope (1/x) would be 2.5.

Figure 29. Embankment and Top of Dam Shots



The top of dam (**TR**) points defines the highest-grade line of the dam along the structure and the over banks. The survey of the top of dam shall begin, at a minimum, 100 feet down-station from the beginning of the dam and end, at a minimum, 100 feet up-station of the end of the dam, using the code **TR**. When going beyond the dam, the top of road survey must show how high the water must get to go over the extended road. The top of dam will not always be concrete or asphalt. Most dams will consist of vegetation or will be earthen. Shots shall be taken at breaks in elevation or at maximum 25-foot intervals.

N.5.4.2 Ground Sections

The upstream ground (**GR**) points shall represent the natural ground section as well as the water inverts of the pond or lake just off the dam. The ground section shall begin with the same station as the top of dam survey. The survey codes for the pond are **GR** (ground), **CB** (channelbank), **TE** (top and edge), and **H2O** (water). All dams must have two **CB**s, two **TE**s, and adequate number of **H2O** shots. The cross section across the pond should be surveyed at the bottom of fill of the dam and extend 100 feet beyond the channelbanks. The Channelbank (**CB**) is defined as the top of the pond's bank. Top and edge (**TE**) of water is defined as the top of the water in the pond and where the water meets the land or the side of the channel. Water (**H2O**) is defined as the shots at the bottom of the streambed in the water. The amount of water shots taken depends on the size of the pond.

N.5.4.3 Water Shots

Surveying the water shots in the pond can be challenging. Most likely you will need a boat to take the water shots. For a successful shot, the pond needs to be very still as well as the boat.

One method of surveying in the water is to take soundings. The first step is to mark off and number the stations on top of the dam. A minimum of 5 stations is recommended or every 50 feet, and the spacing between stations should be no greater than 100 feet apart. Starting from the left at the **TE** looking downstream, mark off the first 50 feet with the number 1, the next 50 feet with a number 2, and so forth until it ends up near the right edge of pond (**TE**).

Once all the stations are set, one surveyor walks on the top of the dam while two others survey the soundings in the boat. The surveyor on top of the dam will stand on the first station marked number 1, while the boat takes a sounding in line with that station. The person(s) in the boat would extend the rod to the bottom of the pond and read the number where the rod meets the surface of the water. The surveyor on the dam will write those numbers in the notes and later subtract them from the elevation of the **TE**.

If the pond is shallow, walking across with the rod is an option but beware of soft sediment. After acquiring the **TE** shot, extend the rod into the pond for a water shot.

In the office, download the survey file and copy all the **TR**s with the numbers at the end and paste them at the end of the survey. Rename all the **TR**s with **H2O**s. Change the elevation of these shots to match the elevation in the notes.

The following example shows sketches of the dam shots and a portion of a text format.

Figure 30. Dam and Water Shots

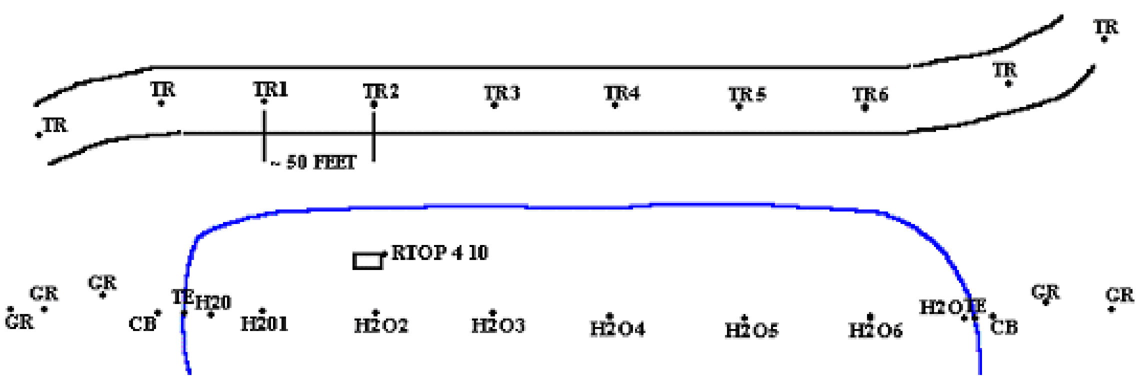


Figure 31. Portion of Text for Dam Shots

```
4,919.3279,576.0364, 91.2530,TE
19,928.7958,498.5637, 96.4390,TR 1 2.8
20,992.8429,492.7395, 96.5600,TR 2 6.6
21,1056.8358,493.0522, 95.6460,TR 3 5.8
22,1122.2576,492.3201, 95.4070,TR 4 6.1
23,1179.8873,494.5825, 95.3710,TR 5 6.6
24,1267.0692,493.9005, 93.2310,TR 6 4.6
25,1365.9968,496.0914, 91.2140,TE
32,1379.4407,545.2858, 90.9540,H2O
19,928.7958,498.5637, 88.4590,H2O 1
20,992.8429,492.7395, 84.6300,H2O 2
21,1056.8358,493.0522, 85.4560,H2O 3
22,1122.2576,492.3201, 85.1570,H2O 4
23,1179.8873,494.5825, 84.6510,H2O 5
24,1267.0692,493.9005, 84.6510,H2O 6
```

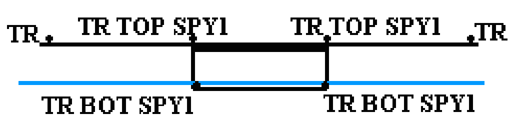
N.5.4.4 Downstream Sections

The downstream natural ground section should be taken off of the fill or bottom of the slope of the dam and surveyed like an upstream section of a bridge or culvert. The codes for the downstream section of a dam are **GR DS**, **CB DS**, **TE DS**, and **H2O DS**. The **DS** codes the shots to be part of the downstream section of the survey. Omitting the **DS** would place those shots with the upstream ground section.

N.5.4.5 Spillways

If spillway is present, obtain elevation points of the top of dam (**TR**), top of spillway (**TR TOP SPY1**), bottom of spillway (**TR BOT SPY1**). If two spillways are present, spillway 1 would be on the left side of the dam while spillway 2 would be on the right. Each spillway will have two **TR TOP SPY#** and two **TR BOT SPY#**. The example shown has a bridge that will not be surveyed.

Figure 32. Spillway Shots

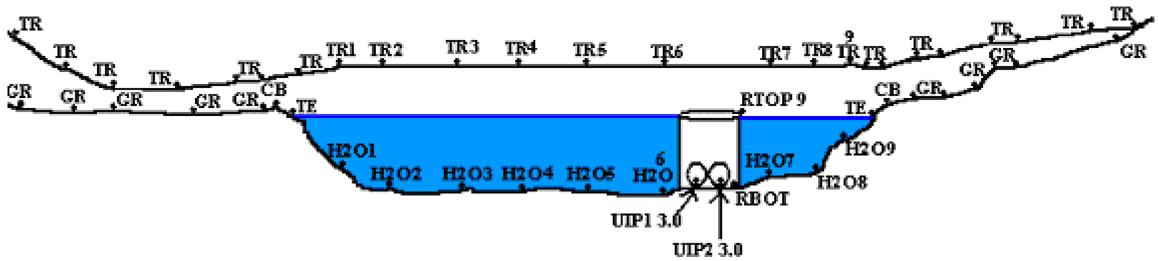


N.5.4.6 Risers

If a riser is present, obtain a surveyed shot at the top of the riser (**RTOP 5 8**). This shot is taken where the water goes over into the vertical pipe or box that allows the water to travel under the dam. The numbers following the shot are the dimensions of the top of the riser. These dimensions can be in any order (width, length). A circular pipe requires only one dimension. The bottom of the riser is coded **RBOT**.

At the bottom of the riser there will be outlet pipes. These are coded the same way a culvert is coded. For example, if there are two circular pipes measuring 3 feet at the bottom of the riser, they would be coded from left to right **UIP1 3** and **UIP2 3**. The downstream outlet pipes also must be surveyed and given a code beginning with **D** (**DIP1 3, DIP2 3)**. There will not be any downstream invert (**DS IN**) shot because of the downstream cross section.

Figure 33. Shots Downstream of Dam



There are other codes for the different types of risers. Some risers have orifices, which are small openings around the riser. These are to be surveyed if water would pass through these openings. These will be coded **ORIF 2 1** along with the size of the opening (Height (**2**) and width (**1**), or the diameter). Each orifice along the riser must be shot and coded. Some risers will have a trash rack. A trash rack is a frame on top of a riser to prevent debris from entering the pipe. The shot shall be taken at the top of the trash rack and coded **TRK 5 8 2.5** (width, length, height). A drainage valve needs to be shot and located within the survey. This code is **VALVE** and need to be surveyed on top of the valve. Not all dams have orifices, trash racks, or valves. The picture shown is of a trash rack and a valve.

See codes for a dam on the following page.

[April 2004]

Table 3. Survey Codes for a Dam

Valid Codes	Example	Note
HEADER		
DAM ERM Top width SS	DAM SC-3 20.0 2.5	Shot 1 only. Dam with ERM ID, Top Width and embankment side slope (x.x: 1)
Road Name	SR 2210, US220, Main Street	Shot 2 only.
FIELD SHOTS (Dam)		
ERM	SF4, N_TAR-4	Elevation reference mark
TR	TR	Top of Dam
GR [DS]	GR, GR DS	Ground Field Data
TE [DS]	TE, TE DS	Edge H2O
H2O [DS]	H2O, H2O DS	Underwater Field Data Shot
CB [DS]	CB, CB DS	Channel bank
OPEN	OPEN	Open Area Field Shot
BRUSH	BRUSH	High Brush Field Shot
WOOD	WOOD	Wooded Canopy Field Shot
ALPT	ALPT1, ALPT2	Alignment points (left, right)
FIELD SHOTS (Spillway)		
TR TOP SPY#	TR TOP SPY1	Top of Spillway 1 (2 shots req.)
TR BOT SPY#	TR BOT SPY2	Bottom of Spillway 2 (2 shot min.)
FIELD SHOTS (Outlet Pipes)		
UIB# Height Width	UIB2 10.1 10.8	Upstream Invert Box 2
DTE# Height Width Thick	DTE3 5.6 7.9 0.5	D/S Top Ellipse 3
DTP# DIA Thick	DTP1 7.0 0.3	D/S Top Pipe 1
D = Downstream **U = Upstream**	**I = Culvert Invert @ Centerline** **T = Top of Culvert @ Centerline**	**B = Box, P = Pipe** **E = Elliptical Culvert**
FIELD SHOTS (Riser Barrel)		
RTOP DIA/Width [Length]	RTOP 2.5, RTOP 3.7 6.1	Top of Riser Barrel (not trash rack)
RBOT	RBOT	Bottom of riser
ORIF DIA/Height Width	ORIF 0.7 2.0, ORIF 0.5 0.0	Centerline elevation of orifice
TRK DIA/Width Length Height	TRK 5.1 8.1 2.0, TRK 4.5 0.0 1.5	Top of Trash Rack
VALVE	VALVE	Location of drainage valve

Codes having parameters with [ ] around them indicate that the parameter is not essential and can be left blank. However, leaving a parameter blank has implications. For example, the code **RTOP 2.5** implies that **2.5** is a diameter of a riser barrel, therefore a length is not needed. The code GR in a dam survey implies that it is a ground shot on the upstream side of the dam, whereas **GR DS** shots apply to the downstream cross section.

Figure 34. Sample Survey Text File for a Dam

```
D_ERT8A
1,854226.635,2014210.168,538.110,DAM D_ERT8A 7 1.6
2,854541.701,2014220.953,548.130,RUSSELL RD
1001,854359.127,2013917.497,528.773,GR
1002,854221.540,2013873.437,522.515,CB
1003,854220.552,2013870.516,521.802,TE
1004,854220.384,2013866.536,520.580,H2O
1005,854221.212,2013863.021,518.909,H2O
1006,854185.928,2013955.814,531.619,ALPT1
1007,854183.787,2013950.116,531.408,TR
1008,854170.179,2013920.233,529.331,TR
1009,854166.790,2013904.698,521.478,TR
1011,854135.941,2013826.498,523.818,TR
1012,854121.788,2013809.822,521.702,TOP SS DS
1013,854116.681,2013811.141,518.344,BOT SS DS
1014,854137.223,2013819.301,523.211,TOP SS US
1015,854139.662,2013818.914,521.994,BOT SS US
1016,854122.593,2013775.640,523.685,TR
1018,854097.596,2013669.724,523.609,TR
1019,854088.427,2013624.651,523.605,TR
1020,854086.453,2013614.915,523.010,TR TOP SPY1
1021,854086.507,2013603.826,521.129,TR BOT SPY1
1022,854085.908,2013599.391,521.153,TR BOT SPY1
1023,854081.928,2013583.791,524.772,TR TOP SPY1
1024,854068.253,2013531.177,526.146,TR
1025,854059.871,2013486.784,528.146,TR
1026,854059.631,2013485.519,528.578,ALPT2
1027,854176.943,2013516.239,528.734,GR
1028,854174.097,2013549.132,528.594,GR
1029,854172.376,2013560.044,527.215,GR
1030,854168.601,2013591.414,522.457,CB
1031,854168.034,2013593.584,521.828,TE
1032,854166.836,2013597.773,519.382,H2O
1033,854147.625,2013611.644,517.086,H2O
1034,854167.052,2013652.803,517.383,H2O
1035,854173.637,2013711.759,512.080,H2O
1036,854200.436,2013769.196,510.189,H2O
1037,854212.550,2013823.456,513.170,H2O
1038,853935.780,2013945.251,519.364,GR DS
1039,853946.288,2013895.830,516.411,GR DS
1040,853950.654,2013848.836,512.490,GR DS
1041,853952.680,2013826.574,510.192,CB DS
1042,853953.098,2013824.092,506.699,TE DS
1043,853953.153,2013823.098,506.563,H2O DS
1044,853953.360,2013821.460,506.564,H2O DS
1045,853953.402,2013820.472,506.672,TE DS
1046,853956.852,2013816.580,509.395,CB DS
1047,853942.704,2013764.101,510.063,GR DS
1049,853933.010,2013723.213,513.257,GR DS
1050,853933.006,2013723.194,513.257,GR DS
1051,853924.756,2013678.363,516.231,GR DS
```

Except for the first two shots or entries, these shots can be in random order and do not need to follow this pattern as long as valid codes are used. A header or a structure ID is needed above the first shot.

N.6 Cross Section Survey

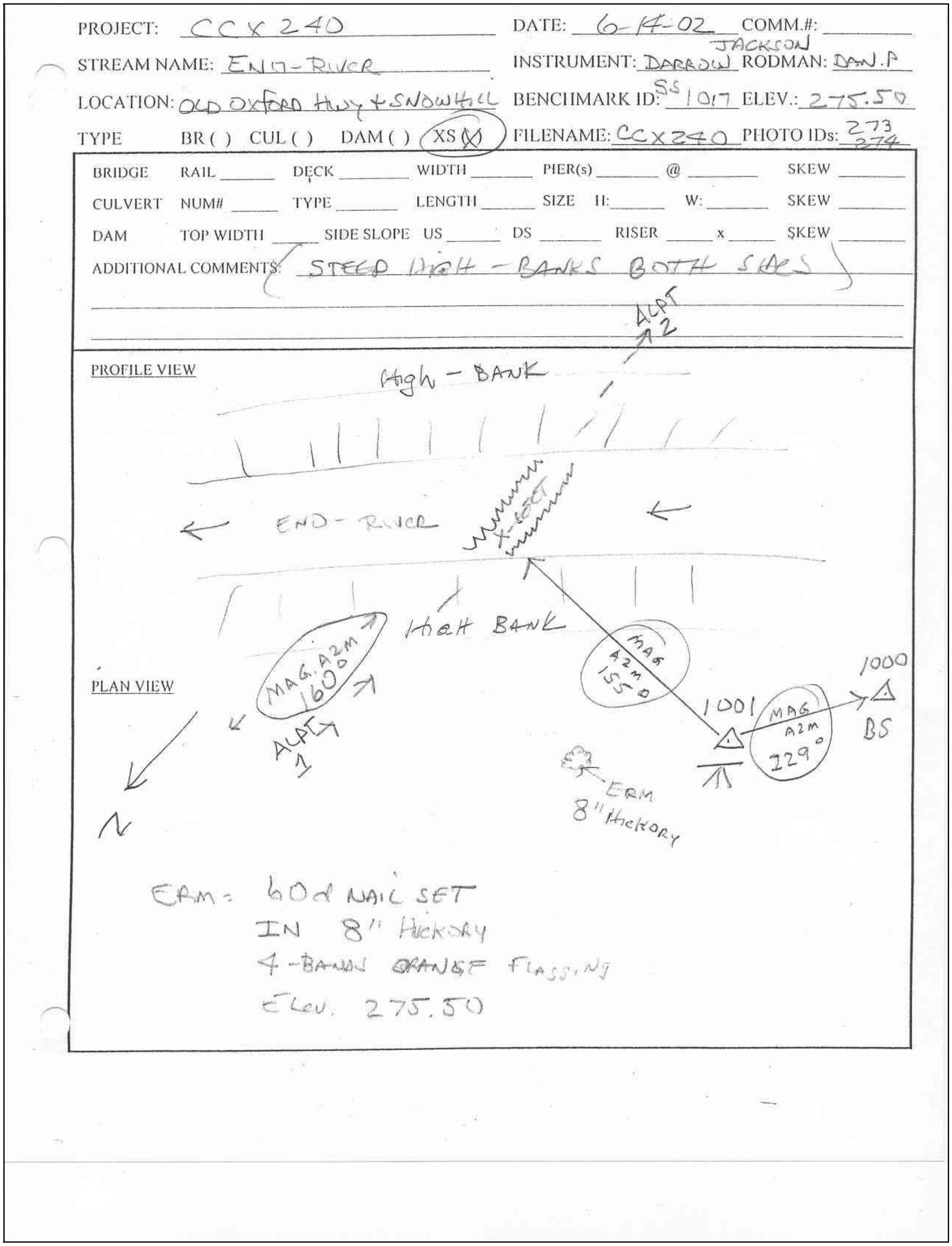
N.6.1 Cross Section Sketch

Each sketch for a cross section shall include the following:

- Project Name - Name of project being studied.
- Stream Name – Name of the studied stream.
- Location – Nearest road intersection.
- Date of survey
- FEMA Contract number
- Filename – Survey filename in the data collector.
- Surveyors – Names of those surveying, listed as last name, comma, first initial.
- ERM ID - Specific location and type of benchmark (i.e. set in a telephone pole (# 43 C 3887) with 2 guy wires and transformer.)
- Elevation – Elevation of the ERM in the correct datum.
- GPS location – can use hand held
- North Arrow
- Direction of stream flow
- Photo IDs and Location – location and direction of where the photograph was taken. Place the circled photograph number where the picture was taken and an arrow in the direction the photograph was taken.

Each sketch shall include both planimetric and profile view. The profile view should be oriented looking downstream. The planimetric view shall show where the cross section was surveyed. The sketches shall show the geometry of the cross section, ERM location, etc. A typical sketch is shown.

Figure 35. Example of Cross Section Sketch



PROJECT: CCX 240 DATE: 6-14-02 COMM.#:

STREAM NAME: ENO-RIVER INSTRUMENT: DARROW RODMAN: JACKSON DAN.P

LOCATION: OLD OXFORD HWY + SNOWHILL BENCHMARK ID: SS 1017 ELEV.: 275.50

TYPE BR ( ) CUL ( ) DAM ( ) XS (X) FILENAME: CCX240 PHOTO IDs: 273 274

BRIDGE RAIL DECK WIDTH PIER(s) @ SKEW

CULVERT NUM# TYPE LENGTH SIZE H: W: SKEW

DAM TOP WIDTH SIDE SLOPE US DS RISER x SKEW

ADDITIONAL COMMENTS: STEEP HIGH - BANKS BOTH SIDES

PROFILE VIEW

PLAN VIEW

N.6.2 Cross Section Survey Text File

The text file must begin with two shots or entries that provide the program with a useful description of the cross section. The first shot number one provides the type of survey and the abbreviated structure name. For example, **XS CCX1** identifies the structure as cross section (**XS**) with the benchmark identification of **CCX1**. The second shot provides the name of the nearest road, property owner, or any location descriptor.

N.6.3 Cross Section Photographs

A minimum of two digital photographs will be submitted for each cross section. The required aspects or view of the photographs include:

- XS_1_USC. Standing at the cross section, looking upstream at the channel.
- XS_1_DSC. Standing at the cross section, looking downstream at the channel.

Figure 36. Examples of Cross Section Photographs

N.6.4 Cross Section Survey

Each Mapping Partner will determine the location of the cross section. Refer to Appendix A of the *Guidelines and Specifications for Flood Hazard Mapping Partners* for methods to determine location.

The survey may be done in state plane, depending on the project specifications. Alignment points (ALPTs) are required.

The survey is similar to a cross section of an upstream face of a structure, but the survey will only extend approximately 50 feet past the channel banks. The survey of a cross section should always be oriented so that looking downstream, the survey stations would increase from left to right (Northing) and increase from downstream to upstream (Easting).

N.6.4.1 Ground Sections

The cross section shall represent the natural ground. The ground section should represent where the water would go once the water goes outside the channel.

The stream channel is defined as the water being contained in the channel at normal levels. The survey codes for the stream channel are **CB** (channel bank), **TE** (top and edge), and **H2O** (water). All cross sections must have two **CB**s, two **TE**s, and adequate number of **H2O** shots. Channel bank (**CB**) is defined as the top of the stream channel. Top and edge (**TE**) of water is defined as the top of the water in the streambed and where the water meets the land or the side of the channel. Water (**H2O**) is defined as the shots in the water of the streambed. Water shots define the bottom of the channel.

The number of water shots taken depends on the size of the channel. Water shots should be taken where there is a break in elevation in the channel. If the water is not clear, then probe the water to find any change in depth. There should be a minimum of three **H2O** shots. Two of those shots are at the bottom of the slope of the creek bed. If there is only one **H2O** shot in the middle of the creek, the representation of the channel would look like a “V”. More **H2O** shots will be needed based on the size of the channel.

[April 2004]

Table 4. Survey Codes for a Cross Section

Valid Codes	Example	Notes for use
HEADER		
XS BM	XS CCX1	Shot 1 only. Cross Section with Benchmark
Road Name	New road off Stowe Road	Shot 2 only.
FIELD SHOTS (Cross Section)		
ERM	ERM CCX1	Elevation reference mark
GR	GR	Ground Field Data
TE	TE	Edge H2O
H2O	H2O	Underwater Field Data Shot
CB	CB	Channelbank
OPEN	OPEN	Open Area Field Shot
BRUSH	BRUSH	High Brush Field Shot
WOOD	WOOD	Wooded Canopy Field Shot
ALPT	ALPT1, ALPT2	Alignment points (left, right)

Figure 37. Sample Survey Text File for a Cross Section

```
CCX_WA233
1,763755.1600,2057543.8200,289.95,XS CCX_WA233
2,763755.1600,2057185.2000,290.53,CCX_WA233.
3,763755.7242,2057202.7587,288.99,ALPT1
3,763755.7242,2057202.7587,288.99,GR
4,763755.9892,2057176.0401,290.56,GR
5,763757.0299,2057170.3985,288.69,GR
6,763757.1382,2057166.8245,285.40,GR
7,763759.5638,2057159.2319,284.14,CB
8,763759.0692,2057151.3914,281.47,GR
9,763759.1727,2057145.0171,277.39,TE
10,763759.3727,2057142.5860,274.83,H2O
11,763759.5044,2057129.5670,274.30,H2O
12,763759.7048,2057114.9193,276.17,H2O
13,763759.0849,2057112.1385,277.53,TE
14,763757.2932,2057105.4344,281.61,GR
15,763757.1510,2057097.7461,284.52,CB
16,763757.4565,2057083.2396,284.56,GR
17,763756.8081,2057075.8987,287.16,GR
18,763755.1600,2057061.3327,281.91,GR
18,763755.1600,2057061.3327,281.91,ALPT2
```

Except for the first two shots or entries, these shots can be in random order and do not need to follow this pattern. A header or a structure ID is needed above the first shot.

N.7 Overview and Problem Surveys

N.7.1 Overview Survey

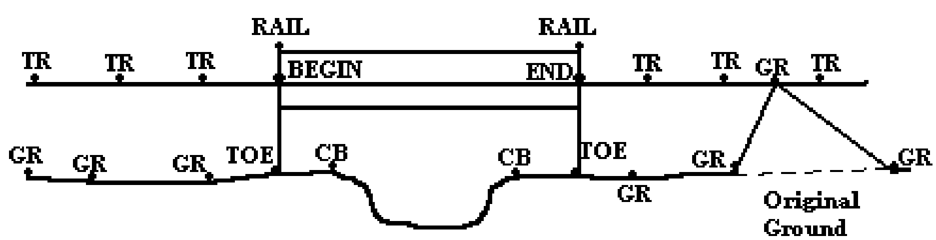
For an overview survey, survey two cross sections, the geometry of the top of road (**TR**) and the upstream ground section (**GR**) with the streambed between channel banks as well as the structure shots. Shots can be in any order. The survey should run along the line of the backsight or the alignment points (**ALPT**).

The ground section will be taken at the bottom of the fill of the structure.

The survey file will allow for the creation of three data sections: top of road section, field (ground) section, and structure data block. **Only** the **TR**s, **BEGIN**, **END**, and **RAIL** shots will be part of the top of road data. **Only** the **GR**s, **CB**s, **TE**s, and **H2O**s will be part of the ground section. The **TOE**s, **P**iers, culvert inverts, and downstream inverts are part of the structure data block.

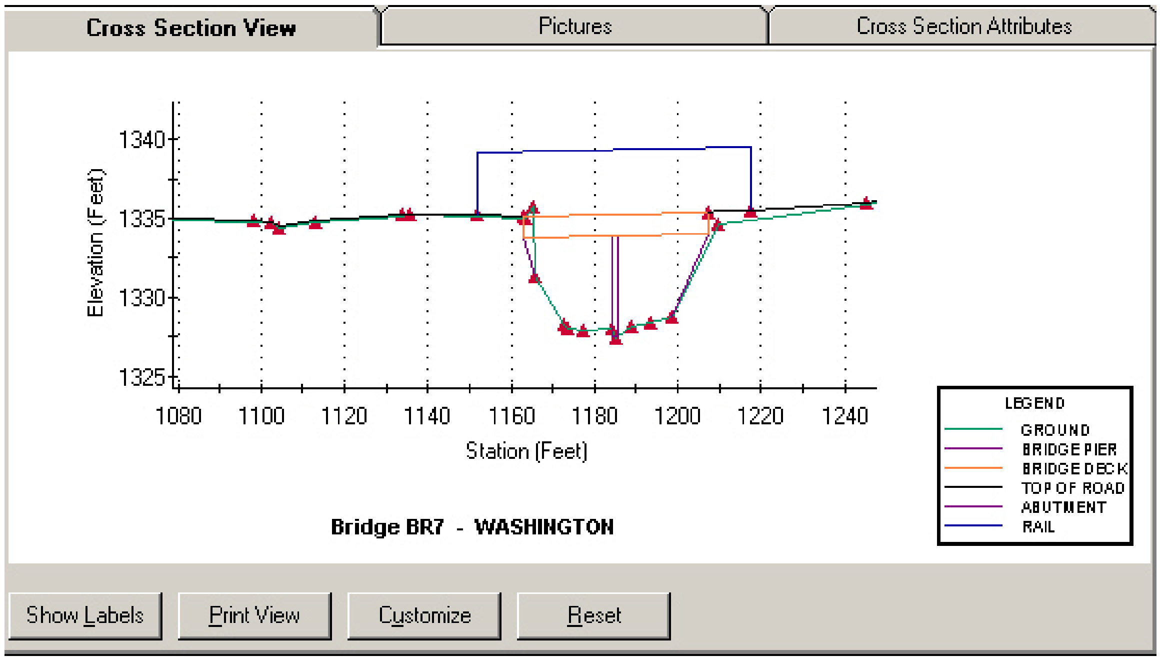
Other codes such as **ERM** (benchmark), **ALPT**s, and GPS shots are needed for the survey. Do not take a **GR** shot on top of the road. Below is an example of a top of road shot being coded as a **GR**, which results in an incorrect ground section.

Figure 38. Example of Top of Road Shot Coded Incorrectly as GR



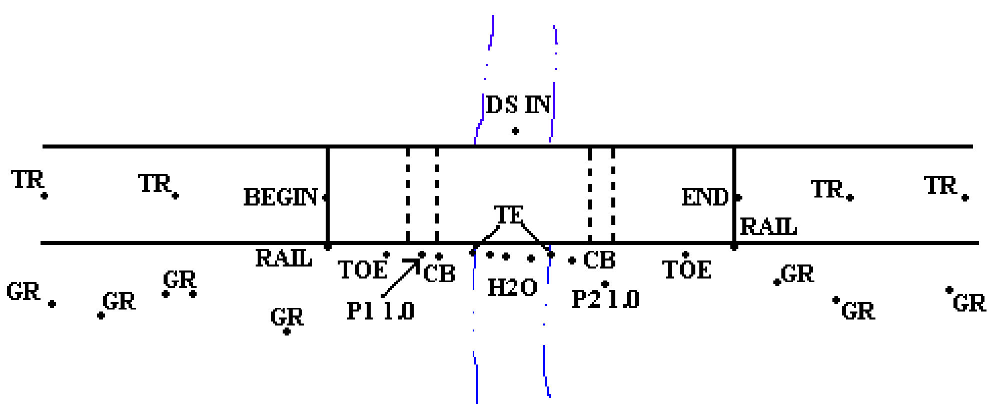
The survey should be looked at in a profile view rather than a planimetric view. Below is an example of a profile view imported into WISE. The green line represents a ground shot (**GR**) surveyed in the field. The top line represents the top of road. The rail is represented by the code RAIL and will be added to the top of the road elevation where the rail shot was taken. The area in the middle of this view is the trapezoidal opening of the structure. This represents what the creek will pass through. The gray represents the fill or the blockage. The vertical lines are the piers and the red dots are the channelbanks. WISE will connect these dots creating a profile view of that ground cross-section as well as the top of road (**TR**) section.

Figure 39. WISE Profile View of Overview Survey



Below is a planimetric view of a bridge structure. This shows that all shots do not have to be directly on a base line. The TRs are in the center of the road due to the crown being higher than the edge of pavement. If the top of road is higher on the downstream side, then survey the TRs along that baseline. Trees, branches, telephone poles, and road signs can get in the way of the survey which cause the ground shots to not be in a straight line. The example below shows that a GR shot can be moved horizontally to allow for an easier shot as long as the shot doesn't change vertically. Also, all the CBs, TEs, H2Os, DS IN, TOEs, and pier shots were taken from the top of the bridge.

Figure 40. Adjusting Problem Bridge Shots



N.7.2 Channel Shots

There should be a minimum of three H2O shots. Always, two of these shots are at the bottom of the slope of the creek bed. If there is only one H2O shot in the middle of the creek, the representation of the channel would look like a "V". To the left is an example of one H2O. More H2O shots will be needed based on the size of the channel. H2O shots should be taken at the upstream face of a structure.

Below are two types of channels. The drawing to the left has two CBs, two TEs, and three H2Os. Notice two of the H2O shots are at the edge of the channel bottom. The drawing above only has one and shows a poor representation of the channel. The TEs determine the stream centerline. It is critical for those shots be taken at the inside edge of the channel. The drawing on the right has a dry channel. Two TEs are required in a survey to determine the centerline and shape of the channel. The shot in the middle of the channel is a GR since there is no water. Water shots (H2O) are not always needed. There will be times when there could be a GR between a CB and a TE.

Figure 41. Types of Channel Shots

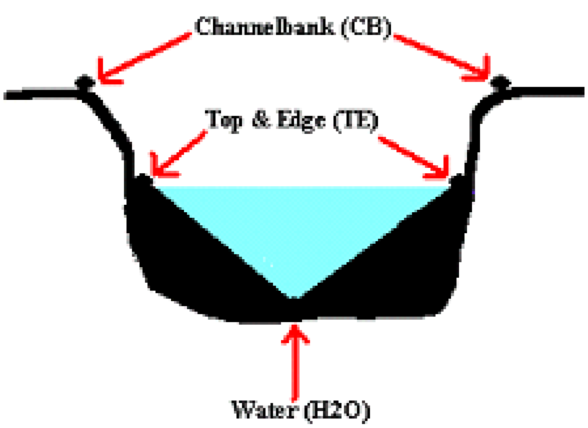
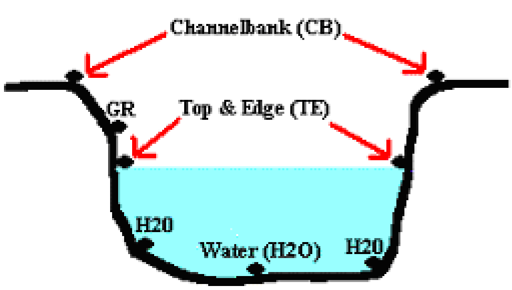
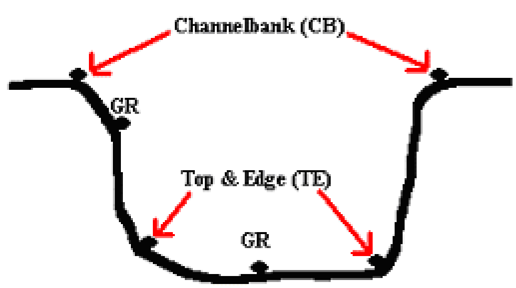


Figure 42. Two Types of Channels





N.7.3 Skewed Streams

Skewed streams are not perpendicular to the structure. All skewed streams are unique. For a culvert, all the **TE**'s, **CB**'s, and **H2O**'s will be taken near the opening of the structure. When surveying a skewed stream for a bridge, survey the ground and channel section in line with the bottom of fill. The channel section will not be lined up with the channel at the structure. Remember, the back sight should remain parallel with the road while trying to keep ground and channel section in line with the structure.

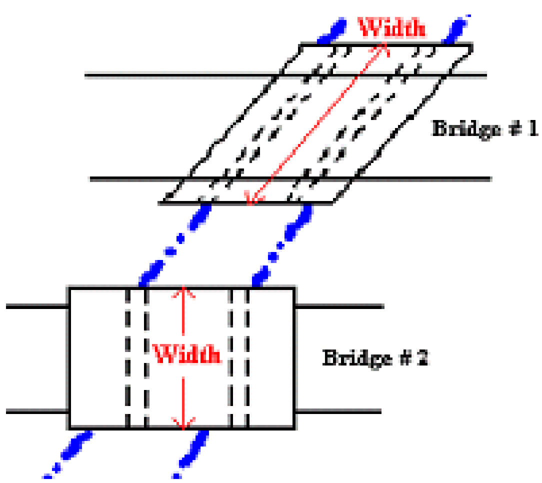
There will be special situations that the survey needs to be translated to align the top of road with the GR section in the office. The adjustment needs to be made to the top of road section. Bring the survey data into Autocad or Microstation and translate the **TR** section to line up with the **GR** section. The channel section of the ground section should align with the opening of the structure. Another way of adjusting the survey is to move the culvert boxes over to fit inside the channel, which can only be done in WISE.

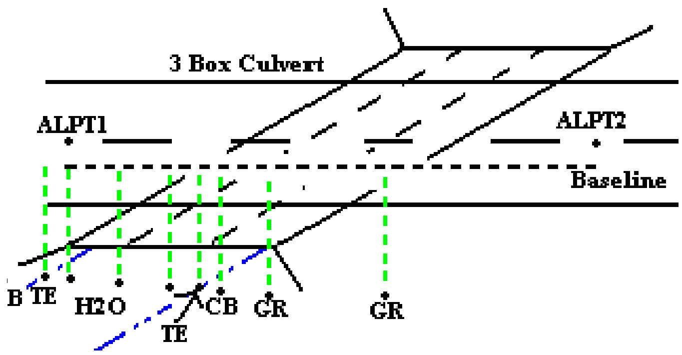
Figure 51 shows two examples of skewed bridges. Bridge # 1 is skewed but the angle of the water entering the bridge is 90 degrees. The stream flows through the piers. Bridge # 2 is also skewed but the angle of the water entering the bridge is at ~ 55 degrees. This angle must be written on the survey drawing template. This means the piers are acting wider than their actual size. The actual pier width should be recorded.

Figure 52 is a diagram of a skewed culvert. The baseline is created by the alignment points (**ALPT**). All the **TR**s will be part of the top of road baseline and all the **GR**s, **TE**s, **CB**s, and **H2O**s will be part of the ground section baseline. The diagram explains what happens to the survey points. Notice the left TE (top and edge of water) is not inside the culvert and the right CB (Channelbank) is in between Box 2 and 3. This will enclose box three with sediment and give a false survey. Culverts do not require a skew angle.

Figure 44. Skewed Culvert

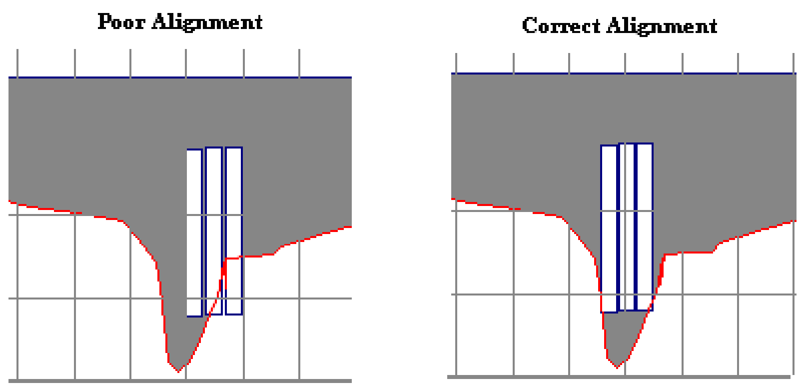
Figure 43. Skewed Bridges





Below are two HEC-RAS examples of a poor alignment and the correct alignment. WISE can correct a poor alignment by changing the culvert stations. This moves the culvert boxes over to fit inside the channel.

Figure 45. Poor and Correct Alignment of Skewed Culvert

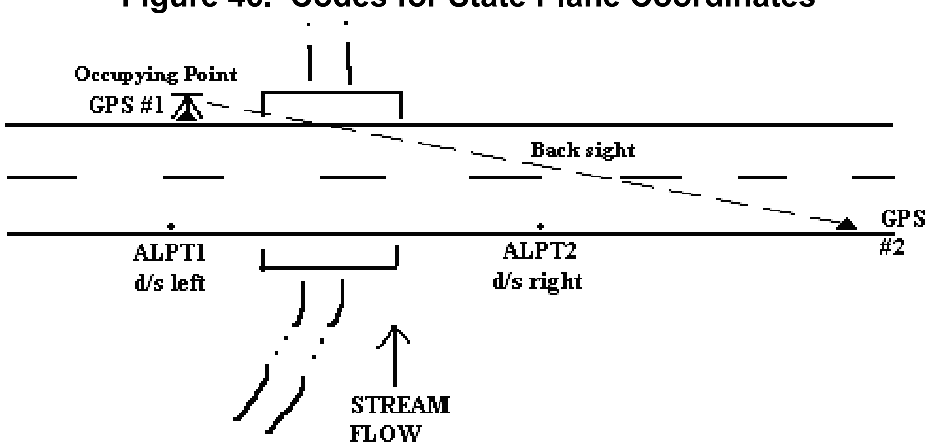


N.7.4 State Plane Coordinates

State plane coordinates must be used rather than assumed coordinates. Two extra codes need to be taken to allow the alignment of the survey to be perpendicular to the stream. The codes are ALPT1 (station alignment point 1) and ALPT2 (station alignment point 2). When both ALPT1 and ALPT2 are present, they define a stationing baseline for all the shots. ALPT1's station will be 1000 by default. ALPT1 should be left of ALPT2 looking downstream.

The purpose of these codes is to eliminate the need to align the total station parallel to the structure or cross section to capture the station in the northing coordinate. The ALPT codes establish a stationing axis that can be used to calculate station for all other shots.

Figure 46. Codes for State Plane Coordinates



N.7.5 Super-Elevated Curves

Super-Elevated Curves refer to bridges or culverts on these sections of road. The top of road section will be taken at the highest elevated side of the road. The deck thickness is measured as the distance between the BEGIN (at highest elevated road) and the deck at the lowest side of the bridge. For example, if the highest elevated road (upstream) is at an elevation of 100 feet and the lowest elevated road (downstream) is at 97 feet with a measured deck of 4 feet. To find the correct deck thickness, calculate the difference between the two road elevations (3 feet) and adding the deck (4 feet), which makes the deck 7 feet. This means that when the high water reaches the bottom of the deck, the water will need to go 7 feet until it goes over the road. This is to determine two things: how high does the water have to get to go over the road and how low is the actual deck (top of the trapezoid). Shooting the low chord (LC) is another way to determine the deck thickness.

N.7.6 Relief Structures

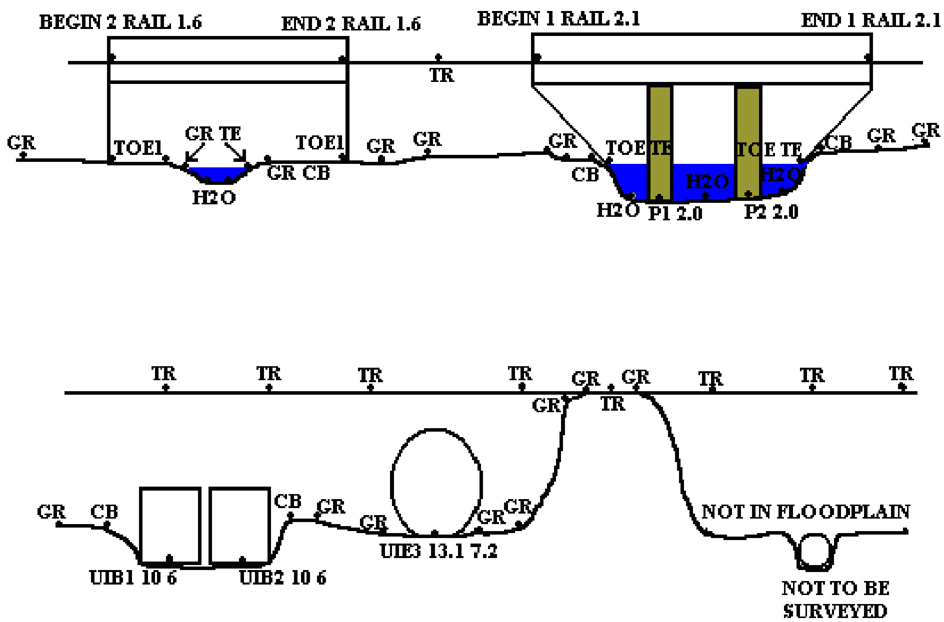
A Relief structure is defined as a structure that will give relief to the main channel, still allowing floodwater to pass under the road. The relief structure will allow any water to pass through the structure before it will reach the top of road. A relief structure can be another stream that may merge with the studied creek downstream, or a bridge or culvert. The relief structure must also be part of the stream's flood plain.

If it appears that the floodwaters will overtop the road before they pass through the relief structure, the relief structure is not be surveyed. For example, if the water is rising to flood levels, will that relief structure be used before the water floods over the road?

A relief culvert must be 3 feet in diameter or greater. Relief culverts will be numbered from left to right. The channel codes for the relief structure will require a **GR** in front of them (**GR CB**, **GR TE**). The survey can only have two channel banks and two top and edges. This allows the shots to be coded within the ground section. Two side-by-side bridges will require two **BEGIN**s, **END**s, and **TOE**s. Those bridge shots will need either a 1 or 2 after those shots (**BEGIN 1**, **BEGIN 2**, etc). The relief channel code shots will need the **GR** in front of the codes similar to the culvert. Since there will be two or three structures surveyed, there will be two or three downstream inverts (**DS IN**). Place a 2 or 3 after each **DS IN** but do not place a 1 after the main structure. Keep the shots for each structure together in the survey.

See the following examples of relief structures.

Figure 47. Relief Structures



N.7.6.1 Upstream and Downstream Face of Structure

The USSTRUCT / DSSTRUCT codes are required as they measure the hydraulic width of the structure. The shots are to be taken on top of the bridge at the upstream (USSTRUCT) and downstream (DSSTRUCT) face of the structure over the stream. Using these codes will over-write the existing hydraulic width value found in the first shot. For a Culvert, these shots will be taken at the middle culvert.

[April 2004]

Table 5. Optional Survey Codes for Structures and Cross Sections

Valid Codes	**Example**	**Note**
DSSTRUCT (structures only)	DSSTRUCT	Downstream face at C/L of stream
USSTRUCT (structures only)	USSTRUCT	Upstream face at C/L of stream
ALPT1	ALPT1	Station Alignment Pt. 1 (left d/s)
ALPT2	ALPT2	Station Alignment Pt. 2 (right d/s)
BM BMid	BM GPS051	Horizontal and vertical control pt.

Notes about Optional Survey Codes
When both ALPT1 and ALPT2 are present, they define a stationing baseline for all the shots. ALPT1's station will be 1000 by default. ALPT1 should be left of ALPT2 looking downstream. The purpose of these codes is to eliminate the need to align the total station parallel to the structure or cross section alignment in order to capture the station in the northing coordinate. Using these points requires processing by the Watershed Information SystEm (WISE) program or manual reduction to get the station of the shots. If the user anticipates having to adjust the stations of some of the points (typical for a skewed structure), then this option is not recommended.

The presence of two BM codes allows for complete translation and rotation of the shots into the state plane coordinate system provided the benchmarks' XYZ locations are available. A difference in the change in elevation between the survey shots and the true BM elevations of 0.1' will be flagged by the WISE program.

For example, a survey has BM GPS051 survey = 100.0 and BM GPS053 survey = 105.5, GPS051(NAVD88 elev) = 571.1 and GPS053(NAVD88 elev) = 577.0. The Survey Diff. = 5.5', but NAVD88 Diff. = 5.9'. Since 5.9 – 5.5 > 0.1 a warning would be raised in the WISE program.

The first benchmark encountered in the file is assumed to contain the most accurate horizontal and vertical positioning. The second BM is only used for rotation and for checking the real world coordinates. A difference greater than 1.0 feet in the horizontal distance between the BM shots and the true state plane coordinate distance will be flagged as a problem. If only one BM code is provided, the survey will be translated, but not rotated.

N.8 Approximate Survey

The survey measurements for approximate structures shall be taken on the upstream side of the structure. The hydraulic opening shall be measured using a level rod, survey wheel, wooden foldout ruler, and a hand level. Elevation will be referenced to the highest point on the road at the structure. The vertical datum for all hydraulic structures will be interpolated from the digital elevation model.

Channel inverts, channel bank elevations, and deck measurements will be referenced to the top of crown. The channel measurements shall be taken at the upstream face of the structure. Channel top width, channel bottom width, channel bank elevation, and the invert are the four measurements that are needed for the channel.

All measurements are to be rounded to the nearest foot except channel height, deck thickness, and culvert dimensions. Data will be entered into a GIS point coverage (using either WISE or ArcView) showing the location and the attributes for structures surveyed for approximate or limited detailed studies.

N.8.1 Digital Photographs

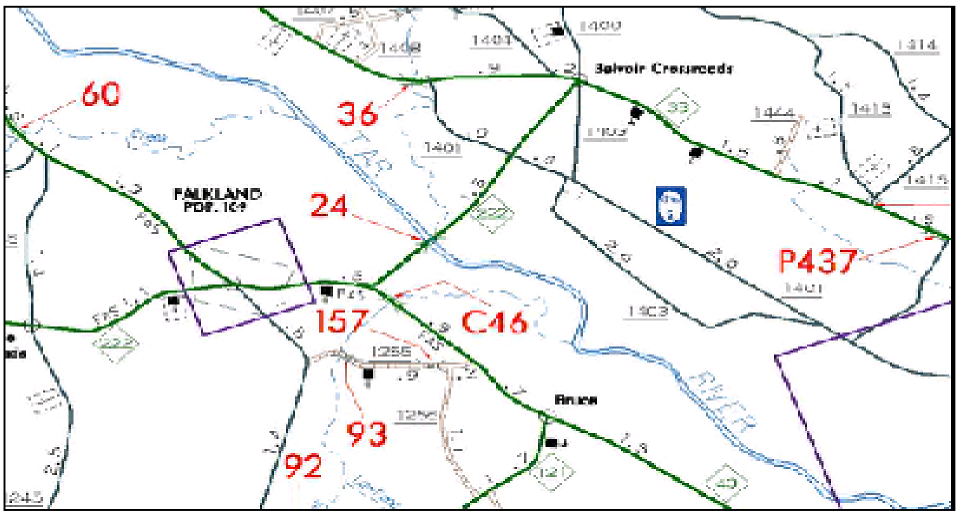
One photograph will be taken at looking at the upstream face of each structure. The photograph shall represent the channel, top of road, and the structure. If the upstream face is unattainable, the photograph can be taken at the downstream face and with a note in the comments field.

Figure 48. Example of Approximate Survey Photograph

N.8.2 DOT Bridge Survey Reports Recon

DOT Bridge Survey Reports (BSR) and Culvert Survey Reports (CSR) may be used to gather survey data for the approximate structures. The BSRs and CSRs could be filed with the Bridge Maintenance Unit or the Hydrology Department. County maps with the BSR and CSR numbers can be found digitally at the DOT website or order them with the Bridge Maintenance Unit. The DOT county structure number shall be part of the GIS point coverage.

Figure 49. DOT Bridge Survey Report



N.8.3 Approximate Bridge Survey

A trapezoidal opening with the low cord, number of bents and widths, and hydraulic width of bridge will represent the bridge.

The channel measurements shall be taken at the face of the bridge.

The bridge will be surveyed by measuring the following:

- Deck thickness – distance from top of crown of road to low cord (bottom of bridge at opening)
- Top width – Distance between the top abutments (BEGIN and END)
- Toe width – Bottom of Abutments - Distance between the bottom abutments (TOES)
- Hydraulic width – Distance between US face and DS face of bridge (Outside to Outside)
- Number of piers
- Pier width
- Invert – Distance between the US bottom of channel and the crown of road

- Channel top width – Top width of channel from channel bank to channel bank at structure
- Channel bottom width – Bottom width of channel at the structure
- Channel bank elevation – distance from top of crown of road to the channel bank

Figure 50. Approximate Bridge Survey

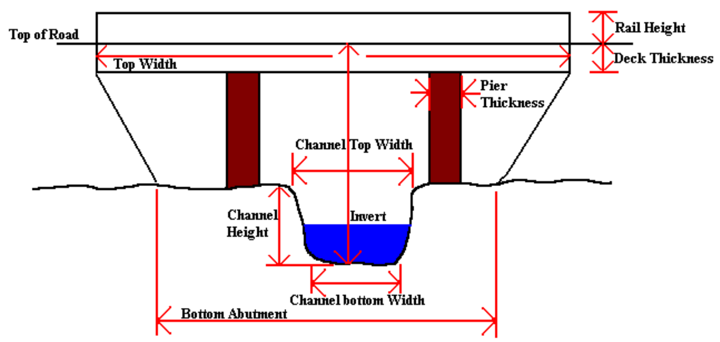
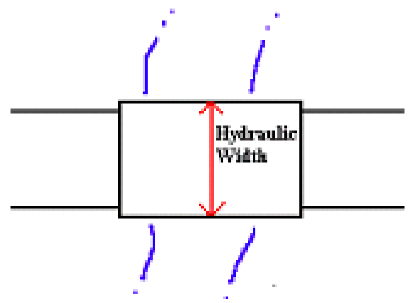


Figure 51. Hydraulic Width of Bridge



N.8.4 Approximate Culvert Survey

Culverts will be represented by the actual barrel dimension obtained from the survey. The four types of culverts are Arch, Box, Circular, and Elliptical. The rise (height) and Span (width) will be measured at all culverts with the exception of circular culverts, which only need the rise. The channel measurements shall be taken at the face of the bridge. A hand level is suggested on determining the channel invert.

These fields will be part of the approximate culvert survey:

- Number of Barrels – Number of Boxes, Circular pipes, or Elliptical pipes
- Shape or Culvert type – Box, Circular, or Elliptical
- Rise – Height of Culvert or Diameter for a circular culvert
- Span – Width of Culvert
- Hydraulic width – Distance between US face and DS face of culvert
- Upstream Invert – Distance between the US bottom of channel and the crown of road

Figure 52. Approximate Culvert Survey

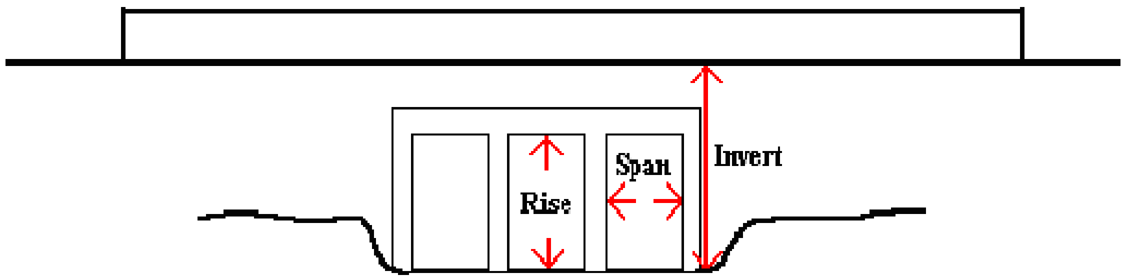
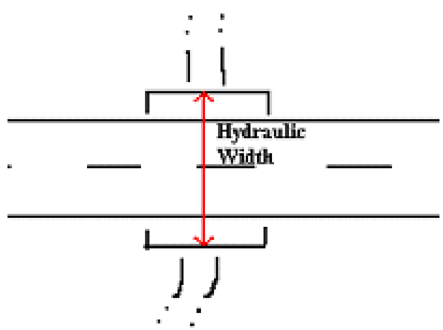


Figure 53. Hydraulic Width of Culvert



N.9 Historical High Water Marks

All streams must have at least two high water marks from different storms. To get this information, ask neighboring landowners if they have witnessed a major storm or hurricane. The surveyor may need to research to help the residents remember what years each hurricane came through the area.

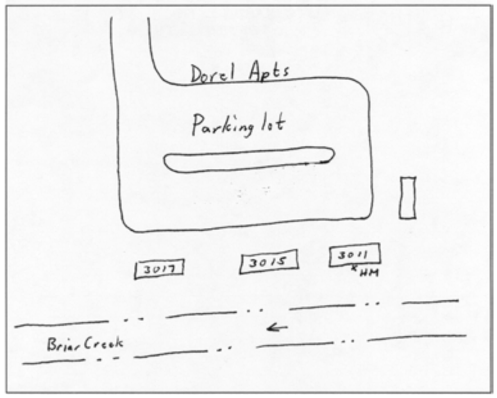
The witness shall determine the precise location of the historical high water mark as well as the date and/or year. If the witness can recall more than one storm, survey each location and use the code (**HIS**) with the year or storm after the code

Each set of notes for a historical shall include a historical title page. The historical title page shall include the following:

- Stream name
- The name of the interviewer
- The name of the witness
- The witness's address
- How long the witness has lived there
- Date of interview
- What type of high water events occurred? Ex. Heavy rain, Hurricane
- How often
- Location of high water mark. Be very descriptive and use distances from landmarks. Ex. oak tree, fence, house, and stream)
- Any other types of comments

After the interview, be sure to ask the owner for permission to survey on the land. Survey to find the elevation of the high water mark.

Figure 54. Sample Sketch for Historical Flooding Survey



N.10 Importing Survey Results into WISE

Since the survey results are stored as an ASCII text file in standard WISE format, the results can be imported directly to the WISE program without resorting to manual entry.

Importing takes place as an integral part of drawing each structure in the plan view. For the complete procedure to create a WISE project file and import the text file, refer to the online Help, or the Open System Inventory tutorial for WISE available from http://www.watershedconcepts.com