APPENDIX B
TOPOGRAPHIC DATA REQUIRED FOR BRIDGE BACKWATER ANALYSIS
2005

1.0 Introduction

This appendix discusses the field data that is required to conduct a bridge backwater analysis. This data is required for bridge replacements, bridge widening, and new bridge crossings. The hydraulics designer should meet onsite with the survey party chief to go over the required cross section locations and other unique data requirements of the site. This will ensure that the survey will be cost effective, gather the necessary data and avoid repeat visits to the site by the surveyors to gather additional data.

2.0 Digital Terrain Model

A method of obtaining hydraulic survey data using cross-sections and profiles is described. An alternative to surveying individual cross-sections is to develop a digital terrain model (DTM) for the project site. The structure survey guidelines in the ODOT Highway Design Manual are typically used for the DTM, and they are supplemented by additional hydraulic survey data as needed. Usually the DTM covers the project vicinity, and profiles and individual cross-sections are used beyond the DTM coverage. Care should be used to assure that the DTM and the remainder of the hydraulic survey are compatible. As an example, both surveys should use the same stream profile stationing and elevation datum.

The DTM should extend far enough upstream and downstream to include the bridge construction, detour structures, access roads, erosion control features, and temporary water management. Other features to be shown on a DTM are property and easement boundaries, trees and large bushes to be preserved, and utilities. Experience shows that a DTM extending from the nearest downstream cross-section through the approach section is usually enough. The nearest downstream section, full valley, and approach sections are all “cut” from the DTM. The water surface profiles and cross-sections beyond the DTM limits are surveyed individually.

The structures and irregular terrain at most water crossings are a challenge to accurately model with a DTM. It is important to construct the DTM based on available survey data and plot the vicinity map, cross-sections cut from the DTM, and the stream profiles. These drawings should be taken to the site and compared to the existing terrain. Often additional data points will be needed at critical locations, and the model will need to be adjusted so it represents actual conditions. These quality control steps should be completed before the model is submitted to the designers.

3.0 Required Field Data

3.1 General

a. Vertical Reference should be identified. All brass disks within project limits should be referenced and identified. Surveys in FEMA floodplains need to tie the reference marks used in the Flood Insurance Study to the project survey. The hydraulics designer can supply the locations and descriptions of the reference marks. The preferred vertical reference hierarchy is:

- known benchmark,
- assumed datum (as shown on plans), or
- other assumed datum.

b. Site Sketch should be prepared. The sketch should include north arrow, stream alignment, highway alignment, cross-section locations, horizontal control and turning angles of cross-sections, hydraulic structure(s), skew angle of each hydraulic structure(s) with respect to flow, buildings, scour holes at existing bridge piers, and other unique features at the site. The sketch should also show right-of-way and easement boundaries, utilities, and trees or bushes to be preserved.

c. Photographs. Each photograph should include a description of the item(s) shown. Record the name and address of the photographer and the date the photos were taken. Take photographs, either film or digital, of:

- Existing structure. This photo should show the waterway opening provided by the structure.
- Overflow structure(s). This photo should show the waterway opening provided by the structure(s).
- Channel upstream and downstream from structure. Take a photo looking upstream and a photo looking downstream while standing on the bridge or roadway.
- Overflow channels upstream and downstream from the overflow structure(s). Take a photo looking upstream and a photo looking downstream while standing on the overflow structure.
- Channel and floodplain upstream and downstream from structure at all cross-sections. Show features needed to estimate roughness, such as channel bottom, sides, vegetation, etc.
- Roadway overflow areas.
- Erosion or scour problem areas.
- Approaches to bridge. Take a photo looking ahead on line and a photo looking back on line from the bridge.
- Locations where floor elevations are obtained.
- Hydraulic controls, such as rock outcrops, rock ledges, weirs, dams, etc. (See chapter text.)

- Developed property in or adjacent to the waterway, such as pump intakes, retaining walls, fences, pedestrian bridges, structures, etc. These photos will record the condition of the facilities before the project is constructed. They may be valuable if there is future litigation.
- Ordinary High Water elevation marks. Usually these elevations are located and staked by the biologist or the hydraulic designer.

d. Describe significant debris accumulation near the bridge or in the channel within project limits.

e. Obtain floor elevations and locations of upstream houses and buildings.

3.2 Bridge/Highway

a. Roadway

- Obtain roadway profile; the profile should reflect the highest part of the roadway and also define the overtopping limits or the limits of the Full Valley Cross-Section (see subsection 3.3).

  At many sites, water will overtop at other places before it overtops the roadway centerline at the bridge. A profile is needed across the apex of the location where the water starts to overflow. An example is a bridge on a roadway with a constant grade. Overtopping occurs adjacent to the upstream face of the bridge, it flows down alongside the road to a nearby bridge several hundred feet away, then it crosses under the road in the nearby stream. A profile would be needed across the high point in the roadside ditch near the upstream face of the bridge where overtopping initially occurs.

b. Existing Bridge

- Obtain a minimum of three (3) deck elevations at locations corresponding with spot elevations on the plans. If no elevations are identified on the plans, obtain gutter elevations on each corner of the structure.
- Obtain top-of-footing and bottom-of-footing elevations if exposed.
- Define limits of existing scour holes with cross sections or sketches.
- Obtain cross-section of downstream and upstream bridge waterway opening. Obtain multiple waterway ground points, including underwater ground points, sufficient to accurately define the channel bottom. The cross-sections should include the bottom-of-beam elevation at each bent. Note that the bottom-of- beam elevation refers to the longitudinal beams and not the cross beams which support the longitudinal beams. The cross-sections should define the location of the abutments and the location and width of any intermediate bents. Also note the shape of the bents.

- Define the skew angle relative to the flow direction of the abutments and intermediate bents.
- Obtain the same data for overflow structures if any exist within the limits of the Full Valley Cross-Section.

3.3 Full Valley Cross-Sections

a. Located on the upstream and downstream side of the structure at the toe-of-slope and/or beyond the abutment wingwalls (if present). The intent is to capture what the natural channel looked like before the bridge and roadway embankments were constructed.

b. Oriented parallel to roadway alignment.

c. Skew angle relative to the flow direction should be the same as the bridge.

d. Obtain multiple channel ground points, including underwater ground points, sufficient to accurately define the channel bottom.

e. Width. The cross-section should extend across the full valley width, which includes the channel and adjacent floodplain.

f. The following guidelines describe the <u>minimum</u> cross-section widths that are usually adequate for the hydraulic analysis; however, there may be exceptions.

- For well-defined floodplain boundaries, obtain floodplain ground points high enough to extend to roadway overtopping elevation.

- For relatively flat and expansive floodplain, survey ten (10) bridge lengths (total maximum width, centered on bridge). If the floodplain is flat or at a constant grade beyond last surveyed point, indicate this on field notes.

3.4 Stream Cross-Sections

a. Width. Refer to subsection 3.3 e.

b. Should be taken perpendicular to the direction of flow. Note that perpendicular to the flow in the floodplain may differ from perpendicular to the flow in the channel in which case the section will have a “dogleg” and the direction of the section in floodplain will be different than in the channel. Left and right for the cross-sections are defined by looking downstream.

c. Should define limits of vegetation types. Note where vegetation changes from grass to brush, etc. This can be identified in the cross-section notes.

d. Should be taken at locations as shown in Figures 1 to 7. Additional downstream sections may be necessary to establish downstream controls that will influence the water surface profile. Highly irregular channels may require additional up and downstream cross sections. The cross-section locations shown in Figures 1 to 7 assume subcritical flow. Additional cross-sections are required upstream for supercritical flow.

3.5 Stream Profile

a. The profile should extend a sufficient distance upstream and downstream from the project site to accurately determine the slope of the channel.

b. Should extend upstream and downstream from the bridge centerline for the distances listed in the Stream Profile Chart (see Section 6.4.4.2). Additional profile length may be needed in some cases to satisfy subsection 3.5 a. Elevations should be located along the channel thalweg (lowest point in channel) and be taken every 50 feet and at significant channel bottom grade breaks. To orient the cross-sections looking downstream, stationing should run from upstream to downstream.

c. Should include stream bottom profile and water surface profile at time of survey.

d. Include past flood profiles if evidence from previous high water is apparent.

e. Include Ordinary High Water elevation marks. Usually these elevations are located and staked by the biologist or the hydraulic designer.

3.6 Miscellaneous Structures

a. Bridges within 500 feet or two bridge lengths (whichever is further) of project. Obtain one full valley section on downstream side of bridge, downstream waterway opening including bottom-of-beam elevation, and roadway profile.

b. Obtain elevations and dimensions of miscellaneous structures such as irrigation dams or weirs within 500 feet or two bridge lengths (whichever is further) of project.

3.7 Local Knowledge of Past Floods

a. Source of historic flood information is from local residents or maintenance personnel. If local knowledge is obtained, give name and phone number of contact, otherwise give name and phone number of people that can be contacted later.

b. Highest water elevation and date of occurrence. If a high-water elevation is available, the exact location and elevation of the high-water mark should be surveyed.

c. Is roadway overtopped? If so, obtain depth of water over road and length of roadway overtopped.

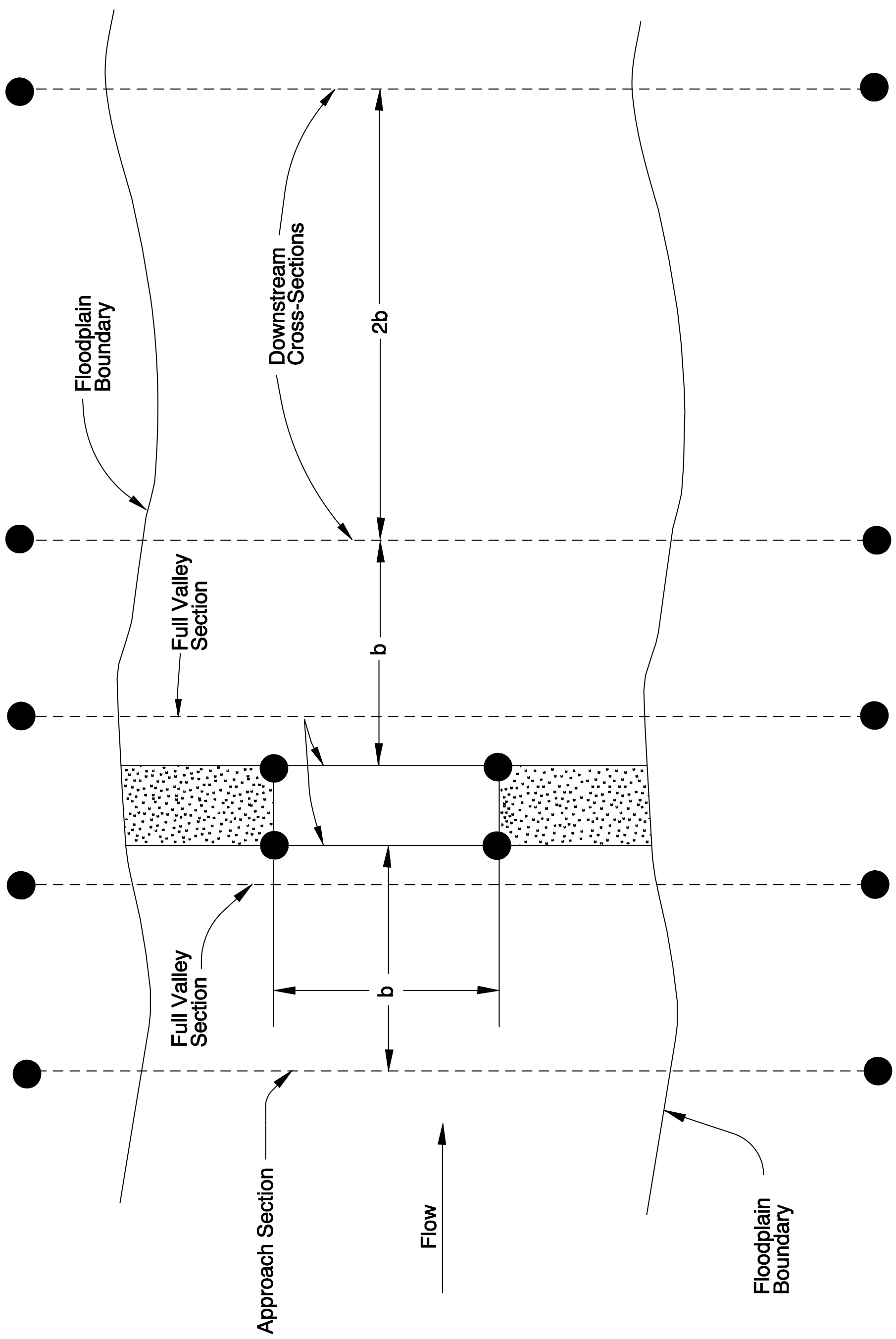
d. Any debris or ice problem?

e. Photos of past floods?

SITUATIONS

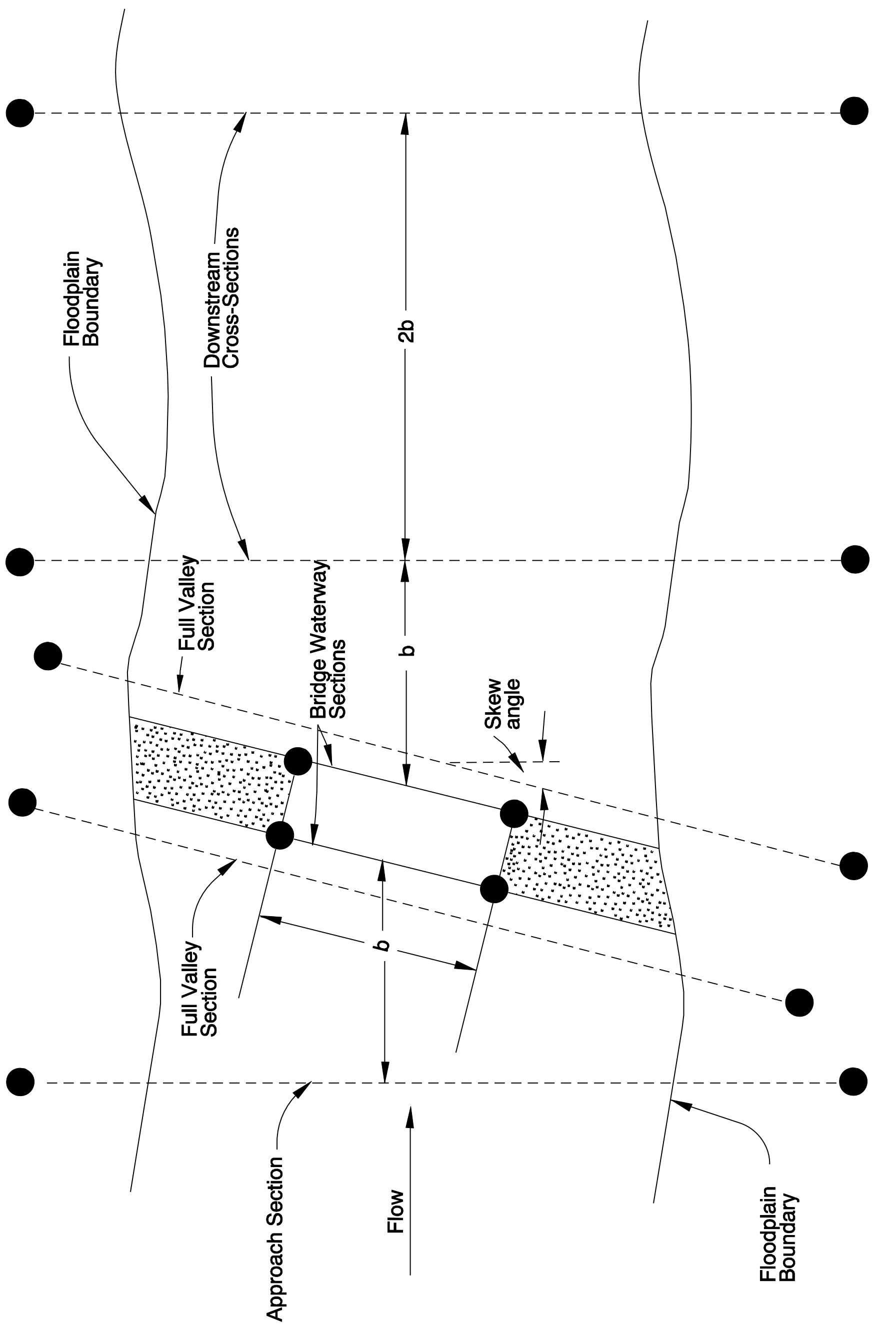
The following figures show typical situations encountered and location of cross-sections needed for the hydraulic analysis:

- Figure 1: Single Opening Stream Crossing With No Skew
- Figure 2: Single Opening Stream Crossing With Mild Skew
- Figure 3: Single Opening Stream Crossing With Large Skew
- Figure 4: Single Opening Stream Crossing With Skew and Curved Channel Alignment
- Figure 5: Multiple Openings
- Figure 6: Confluence of Two Tributaries
- Figure 7: Dual Bridges



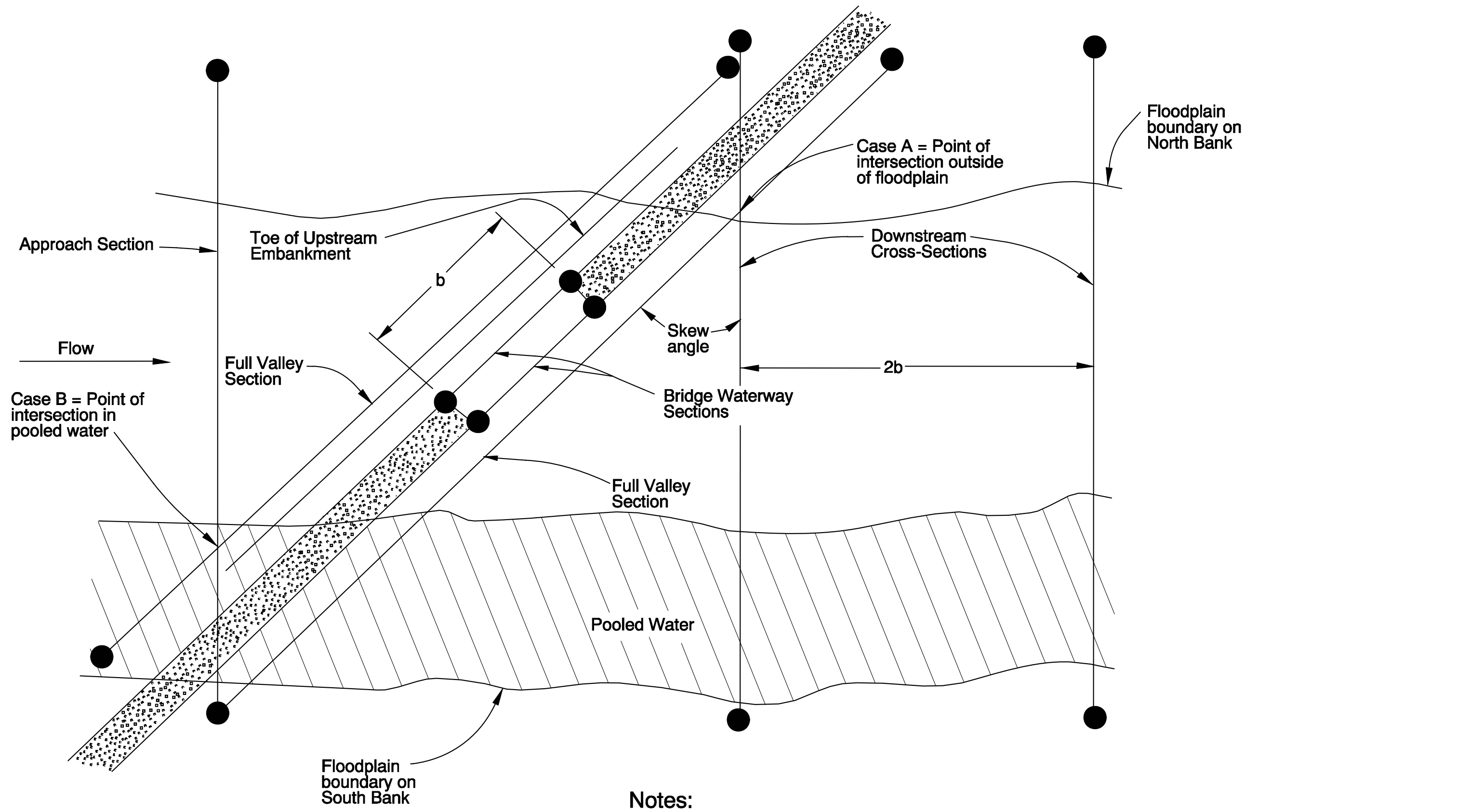
Notes:
1. Ends of all cross-sections are outside of floodplain.
2. Full Valley sections are at toe of embankment slopes.
3. b = Bridge waterway opening width.
4. Distances between sections are measured along channel centerline.

Figure 1: Single Opening Stream Crossing With No Skew



Notes:
1. Ends of all cross-sections are outside of floodplain.
2. Approach and Downstream sections located one bridge waterway opening width upstream and downstream from the structure do not intersect Full Valley sections at points within the floodplain.
3. Full Valley sections are at toes of embankment slopes.
4. b = Bridge waterway opening width.
5. Distances between sections are measured along channel centerline.

Figure 2: Single Opening Stream Crossing with Mild Skew



Notes:
1. Ends of all cross-sections may or may not be outside of floodplain.
2. Approach and Downstream sections located one bridge waterway opening width upstream and downstream from the structure may intersect Full Valley sections at points within the floodplain. If this occurs, Approach and Downstream sections may be moved away from the bridge so they intersect the Full Valley sections at points outside of floodplain. See Case A.
An exception may be made for structures on wide floodplains where water is pooled at the floodplain edges. In these cases, the Approach and Downstream sections may intersect the Full Valley sections at points where the water is pooled. All flow areas within the pool are considered ineffective. See Case B.
3. Full Valley cross-sections are at toes of embankment slopes.
4. b = Bridge waterway opening width.
5. Distances between cross-sections are measured along channel centerline.

Figure 3: Single Opening Stream Crossing With Large Skew

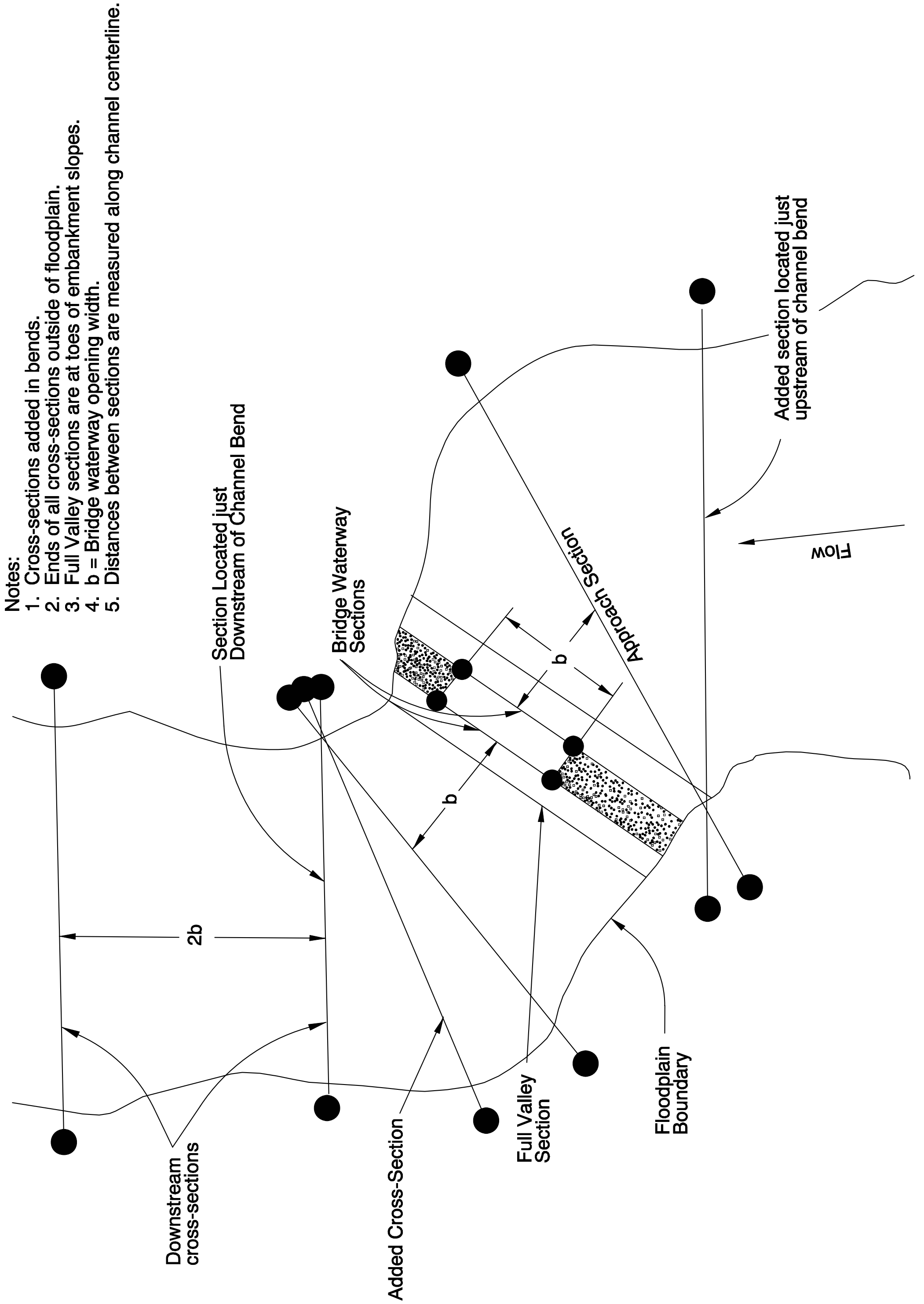
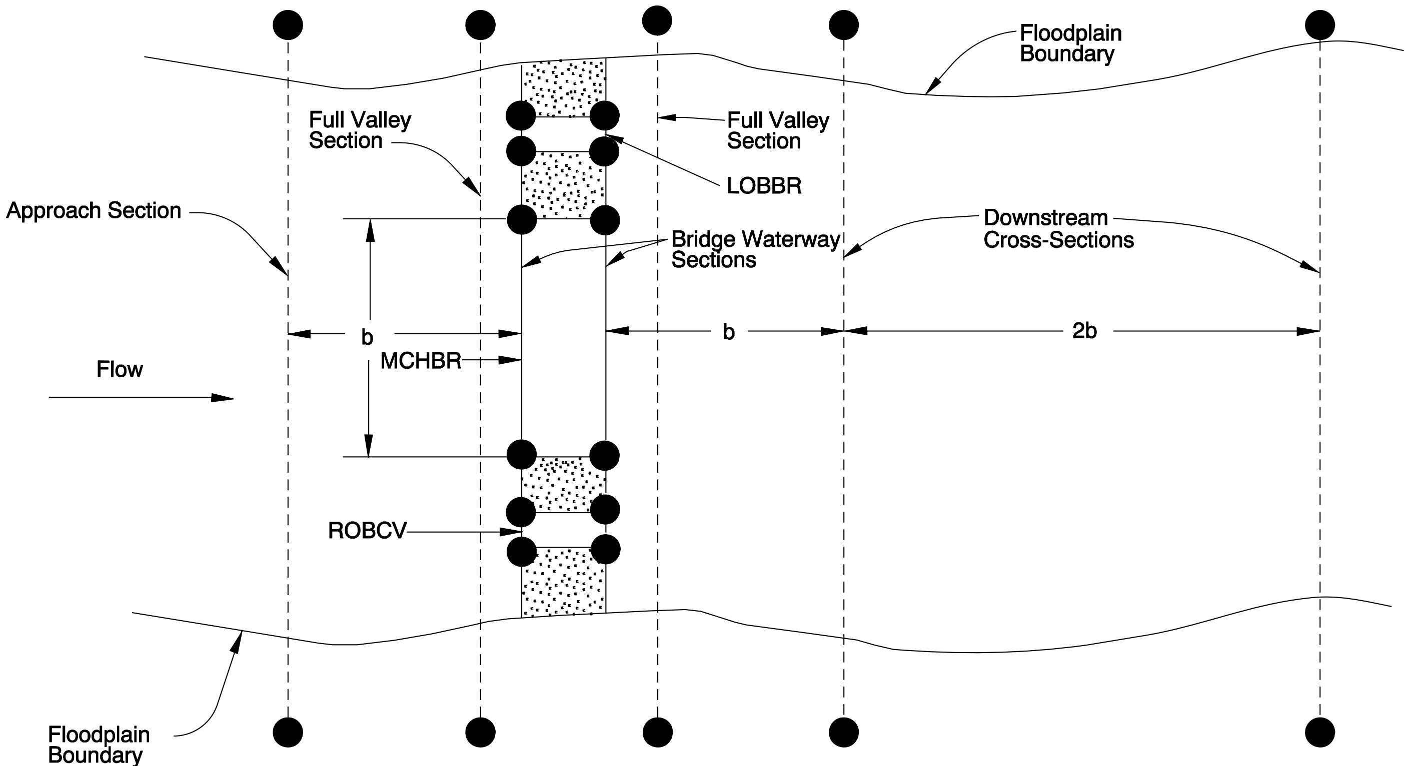


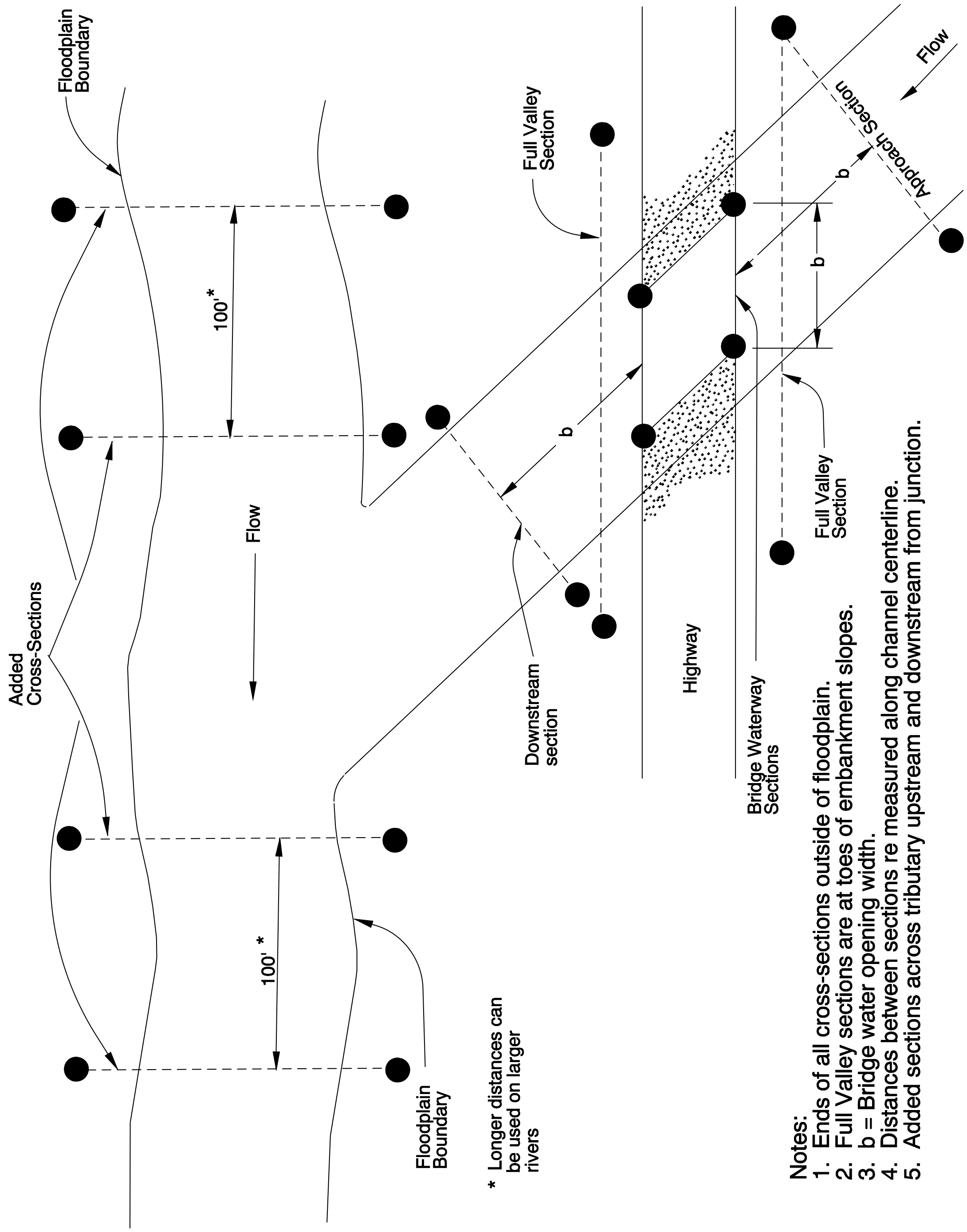
Figure 4 Single Opening Stream Crossing with Skew and Curved Channel Alignment



Notes:

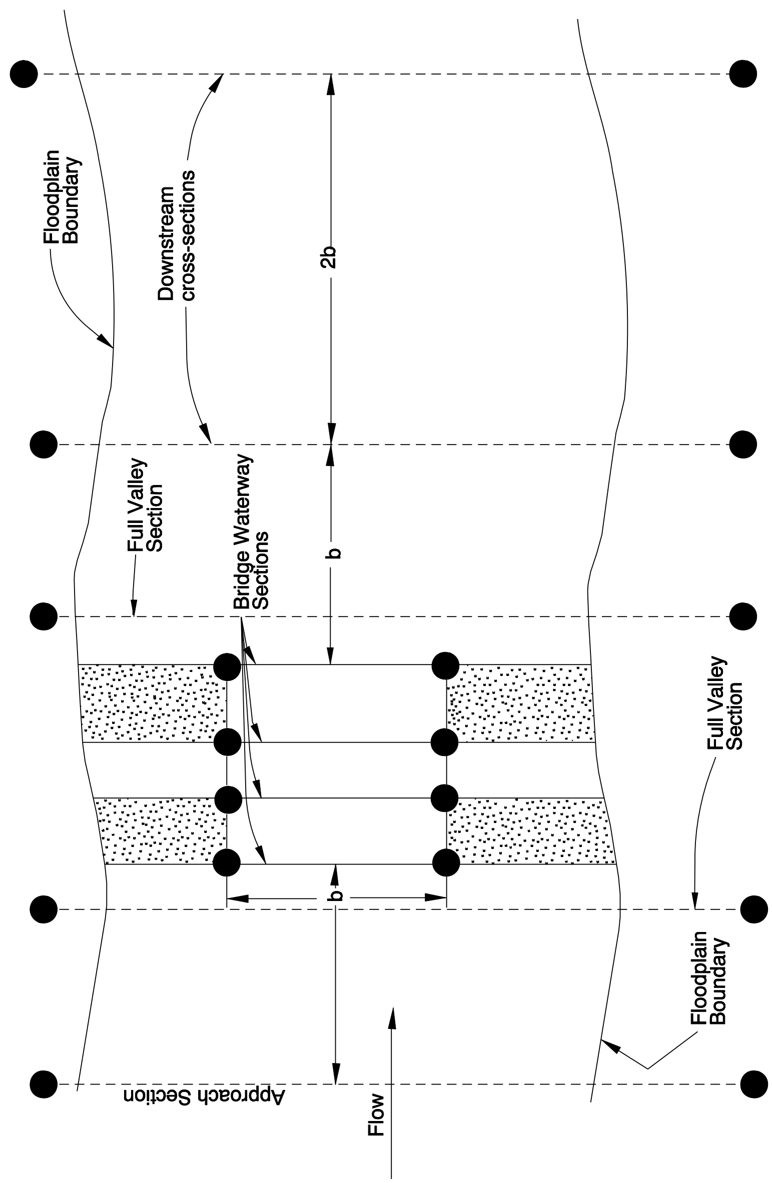
1. MCHBR = Main Channel Bridge
2. LOBBR = Left Overbank Bridge
3. ROBCV = RIght Overbank Culvert
4. Cross-sections of LOBBR and ROBCV are still needed to do analysis if project only includes replacing MCHBR. Sections of all structures are needed regardless of which structure is replaced.
5. Ends of all cross-sections outside of floodplain.
6. Full Valley sections are at toes of embankment slopes.
7. b = Bridge waterway opening width.
8. Distances between sections are measured along channel centerline.
9. Contact hydraulics designer for skewed multiple openings.

Figure 5: Multiple Openings



Notes:
1. Ends of all cross-sections outside of floodplain.
2. Full Valley sections are at toes of embankment slopes.
3. b = Bridge water opening width.
4. Distances between sections re measured along channel centerline.
5. Added sections across tributary upstream and downstream from junction.

Figure 6: Confluence of Two Tributaries



Notes:
1. Cross sections needed of both bridges, regardless of structure replaced.
2. Ends of all cross-sections outside of floodplain.
3. Full Valley sections are at toes of embankment slopes.
4. b = Bridge waterway opening width.
5. Distances between sections are measured along channel centerline.

Figure 7: Dual Bridges

HYDRAULIC SURVEY CHECK LIST

Bridge No.:		Checked By:		Date:	

GENERAL DATA

- ☐ **Vertical Reference Used**
  - ☐ **Known Benchmark**
  - **or**
  - ☐ **Assumed Datum (as shown on plans)**
  - **or**
  - ☐ **Assumed Datum**
- ☐ **Brass Disks**
- ☐ **FEMA Reference Marks**
- ☐ **Site Sketch**
  - ☐ North Arrow
  - ☐ Hydraulic Structures
  - ☐ Buildings
  - ☐ Scour Holes
  - ☐ Utilities
  - ☐ Stream Alignment
  - ☐ Cross-Section Locations
  - ☐ Horizontal and Vertical Controls
  - ☐ Turning Angles Between Cross-sections
  - ☐ Highway Alignment
  - ☐ Skew Angle (bridge deck to flow)
  - ☐ Right-of-Way and Easements
  - ☐ Trees and Bushes to be Preserved
- ☐ **Site Photos** ☐ **Name and Address of Photographer**
  - ☐ Existing Structure Waterway Opening
  - ☐ Upstream Channel (from bridge)
  - ☐ Downstream Channel (from bridge)
  - ☐ Upstream Floodplain (from bridge)
  - ☐ Downstream Floodplain (from bridge)
  - ☐ Approach to Bridge (ahead on line)
  - ☐ Approach to Bridge (back on line)
  - ☐ Overflow Structure(s) Waterway Opening
  - ☐ Overflow Upstream Channel (from structure)
  - ☐ Overflow Downstream Channel (from structure)
  - ☐ Overflow Upstream Floodplain (from structure)
  - ☐ Overflow Downstream Floodplain (from structure)
  - ☐ Roadway Overflow Areas
  - ☐ Erosion or Scour Problem Areas
  - ☐ Ordinary High Water marks (usually marks are staked)
- ☐ **Debris** accumulation near bridge or in channel within project limits
- ☐ **Floor Elevations**

BRIDGE/HIGHWAY DATA

- ☐ **Roadway Profile**
- ☐ **Bridge Waterway**
  - ☐ **Downstream Face** ☐ **Upstream Face**
- ☐ **Bottom-of-Beam** elevation at each bent.
- ☐ **Cross Section Scour Holes**
- ☐ **Bent Information**
  - ☐ Location ☐ Shape ☐ Width ☐ Skew Angle (relative to flow)
- ☐ **Deck Elevations** (3 min.)
- ☐ **Top-of-Footing Elevations**

FULL VALLEY CROSS-SECTION

- ☐ **Downstream Side** at toe-of-slope and/or beyond wingwalls
- ☐ **Parallel to Roadway Alignment**
- ☐ **Skew Angle** (relative to flow; should be same skew as Bridge)
- ☐ **Waterway Ground Points** sufficient to accurately define the channel bottom, including underwater ground points
- ☐ **Width**
  - ☐ Obtain Floodplain Ground Points high enough to extend to roadway overtopping elevation

    or
  - ☐ Ten (10) bridge lengths (total maximum width, centered on bridge)

STREAM CROSS-SECTIONS

- ☐ **Location**
  - ☐ APPR: One bridge length upstream of upstream face of bridge
  - ☐ EXIT: One bridge length downstream of the downstream face of the bridge
  - ☐ DOWN: Three bridge lengths downstream of the downstream face of the bridge
  - ☐ OTHER: Constrictions, controls, added upstream sections if supercritical flow
- ☐ **Width**
  - ☐ Obtain Floodplain Ground Points high enough to extend to roadway overtopping elevation

    or
  - ☐ Ten (10) bridge lengths (total maximum width, centered on bridge)
- ☐ **Perpendicular to Flow** ☐ **Oriented Facing Downstream**
- ☐ **Waterway Ground Points** (including underwater ground points)
- ☐ **Define Vegetation Limits**

STREAM PROFILE

- ☐ **Stationing Beginning Upstream** and increasing downstream
- ☐ **Thalweg Profile** (i.e., low point in channel)
- ☐ **Water Surface Profile**
- ☐ Extend **profile to distances as per Subsection 6.4.4.2**
- ☐ Elevations **every 50 feet** and at significant channel bottom grade breaks
- ☐ Elevations of **Ordinary High Water** marks

MISCELLANEOUS STRUCTURES

Obtain information as described in *Bridge/Highway Data and Full Valley Cross-Section for:*

- ☐ **Control/Irrigation/Weir Structures** within 500 feet or 2 Bridge Lengths (whichever is greater)
- ☐ **Overflow Structures** within limits of Full Valley cross-section

LOCAL KNOWLEDGE

- ☐ **Source**
  - ☐ Name ☐ Date ☐ Telephone
- ☐ **High Water**
  - ☐ Date ☐ Elevation/Location ☐ Historical Photos
- ☐ **Roadway Overtopping**
  - ☐ Date ☐ Depth ☐ Length
- ☐ **Debris or Ice Problems**