Field Survey Procedure – Cross Sectional Transect (Channel + Active Bench)

Restoration Monitoring Guidance

31 July 2024

Document details	**A concise overview of a basic cross-sectional transect, including a 1-page field method (Appendix A) and a field data form (Appendix B), for the purpose of monitoring changes in stream geometry and flood-prone width in a reach.**
Document title	Field Survey Procedure – Cross Sectional Transect (Channel + Active Bench)
Document subtitle	Restoration Monitoring Guidance
Date	31 July 2024
Version	0.1
Author	O. Franklin

Document history

Version	Revision	Author	Reviewed by	Date	Comments
Draft	0.1	Oliver Franklin		31 July 2024	
Draft	0.2	Oliver Franklin		13 November 2024	Added floodprone width

Resource Commitments

2 people	Low cost	Little prior experience	Low field time	Low processing time
				

CONTENTS

1. OVERVIEW

Please refer to 'APPENDIX A:
Cross Sectional Transect (Channel + Active Bench) 1-Pager' for a concise step-by-step field method, intended for quick-reference in the field. The main body of this document provides further context and some relevant background.

This protocol collects information regarding the physical dimensions of stream cross-sections. This protocol was developed to estimate reach metrics through multiple randomly chosen transect samples, however it may also be used to estimate mesohabitat metrics through randomly chosen transects through focal habitats (e.g., pools, riffles). Derived metrics include channel dimensions, cross-sectional heterogeneity, indicators of width/depth ratio, entrenchment and floodplain connectivity, and (with inflow discharge) flow turnover rate.

Note that an alternative version of this protocol focuses only on the channel, and can be used if floodplain reconnection or channel incision is not a central aspect of the proposed restoration. For floodplain reconnection projects, it may be of interest to also conduct riparian surveys (the Line Intercept Riparian Survey and/or Canopy Cover protocols can be incorporated at each transect) and hydrometric monitoring to aid interpretation of habitat characteristics and restoration success.

A number of stream cross-section measurement protocols exist, with transects often placed specifically to assess 'typical' sections of a stream, avoiding (e.g.,) impoundments or eroded banks. While this approach may better estimate our expectation of the stream's 'undisturbed' condition, for the purpose of assessing restoration actions (particularly for process-based restoration) it is recommended that transects are randomly assigned along the focal reach, such that they are representative of the true condition. Deviations from the randomly-chosen transect location should only occur in rare cases, such as the transect falling across a culverted portion of the stream, unsafe logjams etc.

The linear measurement approach of this protocol (recording distances from left bankfull) intends to capture more information and reduce the need for field arithmetic, compared with more common methods (recording individual magnitudes for bankfull width, wetted width etc.). In recording distances, both the magnitude and relative locations of features are obtained, which may provide relevant information such as the year-to-year movement of the wetted areas within the bankfull channel.

A summary of the required equipment for cross-sectional transects is provided in Table 1.

Table 1: Equipment Checklist – Cross Sectional Transects

Item	
Field forms (waterproof) / Tablet	☐
Camera	☐
GPS	☐
Flagging tape / pins	☐
Tape measure	☐
Stadia rod	☐
Clinometer	☐

Note: This list includes only equipment necessary for performing the survey and does not include items required for remote work, wildlife safety, or equipment cleaning/decontamination.

2. CROSS SECTIONAL TRANSECT PROCEDURE (CHANNEL + ACTIVE BENCH)

Bankfull width and wetted width data are collected at each transect for the focal channel and are to include any present side channels and in-line ponds. Most other wetted features are measured separately, and are not included in the focal stream's width: Such features are distinct from the scouring flows of the focal channel under bankfull flows, which includes tributaries, spring brooks, sloughs and off-channel features such as oxbows or ponds (i.e., features that do not connect with the focal channel at both upstream and downstream ends).

The location of the transect along the reach is determined by the relevant study design. Transects are established perpendicular to flow in the focal channel. If an island is encountered, continue straight until the side channel, at which point the transect realigns perpendicular to the flow in that channel (Figure 1).

We recommend transects spaced at 2 x bankfull width, or at 15 m intervals if the bankfull width is < 7.5 m. You should walk the reach and take several 'representative' measurements of bankfull to establish the transect spacing.

If the study design involves repeated measures over time, flag each transect with an easily-identifiable marker in a reasonably permanent location, as repeated measures should be conducted at the transects established in the first survey. For all transects, temporarily flag the transect at all banks encountered along the transect (i.e., flag left, right banks, island banks). If collecting riparian data using the line intercept vegetation survey protocol, the same transect can be extended into the riparian area.

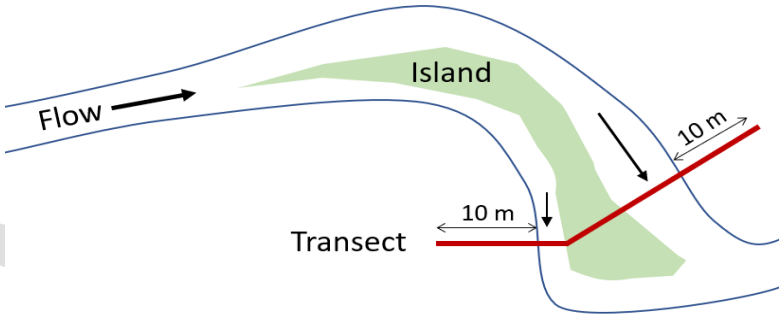

Figure 1 - Example of transect orientation relative to stream flow. Transects are established perpendicular to flow in the focal/main channel, and project across islands. Upon encountering a subordinate channel, the transect is realigned to perpendicular to the flow. In this image, the transect includes both Channel and Riparian areas, combining this protocol with the Line Intercept Riparian Survey.

2.1 Widths

1. Starting on the left bank, identify the bankfull mark at the transect. One person will stay at left bankfull mark with the end of the tape and record distances, a second person will proceed with the tape across the channel perpendicular to thalweg flow.
2. As the second person proceeds across the channel with the tape, they will read out the distance (to nearest 0.01 m) of any transitions into or out of the wetted width (W) and whenever a bankfull mark (BF) is encountered. Person one will record the encounter type (W/BF) and distance measurements.
    a. There may be multiple transitions through the wetted perimeter and bankfull marks (i.e., where multiple channels are separated by bars, islands). Should it not be possible to extend the tape across the full stream from left to right bank (e.g. dense vegetation on islands, deep water), take

interim measures and/or estimate any inaccessible sections to the best of your ability, noting which are estimates.

b. Make a note on the datasheet of wherever the tape was re-zeroed, and measure subsequent locations based on the new zero.

c. Where wetted perimeter is at bankfull mark, record both transitions with the same distance value.

d. Note that the wetted width describes the portion of the channel immersed in water, and does not include off-channel features that are disconnected from the channel, saturated soils etc.

3. Once you have collected all transitions and bankfull mark locations for the focal channel and any side channels along the transect, record the number of islands encountered, and confirm that the sequence is consistent and logical. The sequence starts at left bank bankfull mark (BF) unless the left bank is undercut (record 'UC'; see Special Cases below), and the following are examples of logical and potentially illogical sequences:

   a. Logical: BF 0m, W 0.6m, W 1.4 m, BF 1.7 m, BF 4.2 m, BF 4.9 m. This is a channel with flowing water, a vegetated island, and a dry channel on river right.

   b. Potential error: BF 0m, W 0.6m, BF 1.7 m. This may include an error because it suggests the bankfull on river right is inundated / there is only one wetted perimeter recorded.

Special Cases

- Although all measurements should be taken along the randomly-selected transect, it is not always possible to identify the bankfull mark along the transect itself (e.g., due to recent erosion). Similarly, bankfull can be distorted around flow-constricting features such as LWD or large boulders, and in meander bends. In these cases, bankfull mark should be established upstream and downstream of the transect location, such that the location of bankfull mark on the transect can be visually estimated with confidence.
- Where **undercut banks** are present, the maximum extent of undercutting should also be recorded as a distance measurement, classified as 'UC'. The left bank bankfull mark should still be at 0.00 m (i.e., the end of the tape), and the 'UC' measurement indicates the extent of undercutting beyond bankfull.
  - Where distance measurements are to the left of left bank (i.e., where undercut banks are present), it is helpful to assign them a negative value.
- Although side-channels are considered part of the focal channel dimensions, a number of other features are considered distinct. These 'excluded features' may be (seasonally or permanently) contiguous with the focal channel (e.g., **tributaries, sloughs**) or may be connected only during less frequent flood events or via hyporheic/groundwater (e.g., **ponds, oxbows**).
  - If the randomly-placed transect is located directly at a confluence, such that it is not possible to measure the width of the focal channel while excluding the 'excluded feature', the transect can be moved immediately upstream. Note that at confluences with side-channels it is not necessary to move the transect, as side-channels are included in the width measurements.
  - Although distinct from the focal channel, dimensional information should also be collected for any contiguous or non-contiguous features that are encountered along the transect or in the adjacent active floodplain.

Any wetted feature encountered within the active floodplain should be recorded, providing the following details:

- A brief description of the feature (e.g., slough, spring brook, oxbow, wetland)
- Whether the feature connects by surface flow to the focal channel (or side channel), and whether this connection is currently wetted and/or flowing;
- If connected to the focal channel, whether it appears accessible to fish (assume flow at bankfull/feature at capacity);
- A visual estimate of the length of the feature (assume flow at bankfull/feature at capacity);
- A visual estimate of the area of the feature (assume flow at bankfull/feature at capacity);
- A visual estimate of the proportion (%) of the area that is currently wetted;
- A depth from bankfull that is considered representative of the feature.

A representative photograph and GPS waypoint should also be taken to mark the location.

2.2 Depths and Heights

At each transect measure the thalweg depth and bankfull height. Depths are measured from the water surface to the streambed, and are recorded as negative values. Heights are recorded up from the thalweg, and are recorded as positive values. In many cases, it is easier to measure from the water surface to the bankfull elevation, and add this to the thalweg depth. The field form includes a column to facilitate this.

2.2.1 Thalweg Depth

Locate the thalweg along the transect. The thalweg is the deepest part of the channel that can be identified as continuously extending from upstream to downstream of the transect.

Measure the thalweg depth, recording 0.00 m if the thalweg is dry or, if wetted, recording water depth as a negative value.

- If the focal channel is a side-channel or the channel is braided or anastomosing, consider the focal channel with the most flow as containing the thalweg at its deepest point.
- If the water is too deep, extend a stadia rod at an angle, recording the depth and angle of the rod using a clinometer.

2.2.2 Bankfull Height

Bankfull height is measured once per transect and, wherever possible, it should be measured on the bank of the channel conveying the most flow (containing the thalweg) and not on an island bank. Where bankfull mark cannot confidently be established at the transect, it can be measured upstream or downstream, but the thalweg depth measurement must also be relocated to a corresponding location.

Measure the bankfull height by:

- For small streams: holding a taut tape between bankfull marks on opposite banks, then measuring the vertical difference between the tape and thalweg bed (or water surface, then added to thalweg depth).
- Where the above method is not feasible: hold a depth/stadia rod horizontally from bankfull mark, or have a colleague hold the tape taut, confirming that the equipment is horizontal using a spirit/bubble

level. Measure the vertical distance between the tape/rod and water surface. If the water surface is not in reach using this method, add intermediate measurements:

- Obtain an elevation difference for a location within reach, then move the tape/rod to the streambed at this new location, confirming that the equipment is again horizontal using a spirit/bubble level.
- Obtain another elevation difference for the next location, and add this elevation to the intermediate measurement(s). Move the tape/rod/ruler to the streambed again and repeat if necessary.
- When using intermediate measurements, avoid measuring elevation gains wherever possible (e.g., measuring atop boulders, islands, raised bars) to minimise error.

- **The bankfull height is the difference between the bankfull mark and the thalweg bed. Add intermediate elevations and/or water depth measurement to record the transect bankfull height.**

2.3 Active Benches & Flood-Prone Area

An active bench is a relatively flat depositional area above the bankfull mark that would be expected to be inundated during flood events. Flood-prone area refers specifically to the extent of active bench that would be inundated by a flood at 2 x bankfull height (Rosgen, 1996).

- One person stands at left bankfull mark holding one end of a tape measure and with a clinometer held level at an elevation of 1 x bankfull height above the bankfull mark (such that the elevation of the clinometer is 2 x height from the thalweg to bankfull mark).
- A second person holds the other end of the tape and walks perpendicular and away from the channel.
- The person at bankfull mark indicates when the second person stands upon the ground elevation that is level with the flood-prone elevation (2 x bankfull height above the thalweg) as viewed through the clinometer at 0 slope.
- The second person records their distance from bankfull mark. This is the flood-prone width for one bank.
- As the second person returns to the stream, they should note the distance location along the tape of any distinct features or transitions that may be associated with previous flooding (e.g. flood sign) or lower-elevation active benches (e.g., characterised by distinct soils, vegetation)
- Repeat the above steps for the right bank, with person one at the right bankfull mark.

Note that the ground elevation at which flood-prone width is recorded should be an aspect of topography that would be expected to contain flows. Ignore isolated mounds or short berms that floodwater would flow around.

Additional Guidance

- If the flood-prone width is greater than 3 x bankfull width, or if dense vegetation precludes accurate measurement, it may be necessary to estimate the flood-prone width. If this is the case, it must be noted on the field form.
- If the flood-prone elevation is too high for the above method, the person walking the flood-prone width can take the clinometer, looking back frequently and sighting the flood-prone elevation on the stadia rod.

2.4 Slope

Using a clinometer, measure the slope of the water surface between this and the next transect.

- One person remains at the current transect with the clinometer, the second person flags the survey rod at the height of person one's eyes and proceeds to the next transect (2 bankfull widths along the stream)
- With both people stood at the water surface, person one records the slope when the clinometer aligns with the flagging on the survey rod.
- If visibility is limited, take interim measurements at the farthest distances possible and add notes.

APPENDIX A:
CROSS SECTIONAL TRANSECT (CHANNEL + ACTIVE BENCH) 1-PAGER

Spacing for Reach-Scale Study: Reach Transect #1 is one bankfull width upstream of the focal reach's downstream extent. Subsequent Reach Transects are 2 bankfull widths upstream, until a total of 10 Reach Transects. Transect spacing should be 2 x bankfull width or 15 m if bankfull width is <7.5 m.

1. **Widths:** Perpendicular to flow. Include focal and side-channels.
    a. Record *GPS* location, take representative photographs
    b. Flag bankfull mark at: left bank, right bank, and banks of vegetated islands
    c. From left bank, extend a tape across the transect recording the distance (to 0.01 m) along the tape of all transitions across *wetted edge* and *bankfull marks*:
        i. Person 1 secures tape at left bankfull mark and records measurements on field form
        ii. Person 2 reports measurements and whether wetted width (W), bankfull mark (BF) transition, or undercut bank (UC).
        iii. If re-zero required for interim measurements, note on datasheet and measure from new zero location.
        iv. Include undercut banks (coded UC) as horizontal distance from bankfull mark. Include only the distance that extends horizontally beyond bankfull.
    d. Record the number of islands encountered along transect
    e. Record any off-channel features, tributaries, sloughs, etc.
        i. Describe feature type, flow connection, fish accessibility, and visual estimates of length, area, and % wetted. Obtain representative depth (from bankfull) where possible, and take representative photos and GPS location.

2. **Depths and Heights**:
    a. Measure thalweg depth and bankfull height (to 0.01 m)
        i. Record depths as negative values (water surface to streambed)
        ii. Record heights as positive values
        iii. Record dry thalweg as 0.00 m depth
        iv. Only one bankfull height measurement is required per transect
        v. Bankfull height = water depth at thalweg + height from water to bankfull mark

3. Identify **active benches** and **flood-prone width**:
    a. One person holds the end of a measuring tape at left bankfull mark, and uses the clinometer to view, perpendicularly away from the channel, the ground at an elevation that is 1 x bankfull height (established in step 2.a.v.) above the bankfull mark.
    b. A second person walks perpendicularly away from the channel with the other end of the tape, stopping when the person at bankfull mark indicates they have reached the ground elevation sighted through the level clinometer. This distance from bankfull (the flood-prone width) is recorded
    c. The second person returns to the stream, noting the location along the tape of any distinct features or transitions (flood sign, distinct but lower active benches, etc)
    d. Repeat Steps a to c for the right bank, with person one at the right bankfull mark.

4. **Slope:** Using a clinometer, measure the slope of the water surface between this and the next transect.

APPENDIX B:
CROSS SECTIONAL TRANSECT (CHANNEL + ACTIVE BENCH) FIELD FORM

Cross Sectional Transect

Study Reference	Stream Name	Date
	Direction of survey: Travelling upstream / downstream	Staff

		multiple rows per Transect		One row per transect				Optional: Active Benches		
Transect	GPS Waypoint (1 per transect)	Location Code (BF/W/UC)	Distance from Left BF /m (2dp)	Slope to next Transect / %	Thalweg Depth / m (2dp)	Bankfull above water surface / m (2dp)	Bankfull Height (from Thalweg) / m (2dp)	Flood-prone width LB / m (2dp) From L bankfull	Flood-prone width RB / m (2dp) From R bankfull	Notes

General Notes

Location codes: BF = bankfull, W = wetted edge, UC = undercut (beyond bankfull only)

If visibility between transects is limited, record interim slope measurements and add note

APPENDIX C: KEY TERMINOLOGY

Active Floodplain / Active Bench

Adjacent to the streambank, the active floodplain is a relatively flat depositional area which often features distinct vegetation communities (typically with a relative abundance of hydrophytic obligate to facultative vegetation), rafted debris, and/or recent alluvium. It is an area that we expect to be inundated by the 1 in 5 year return period flow. The active floodplain may be a section of a broader floodplain that includes areas historically but not presently subject to inundation.

Bankfull

Bankfull is often defined as the water level (stage) of the watercourse at which any further rise would cause the watercourse to flow over the banks and onto the floodplain. Bankfull reflects flows that are 'channel-forming' in alluvial streams. However, in many impacted watersheds or following larger flood events, streams may exhibit incision, channelisation, or atypically eroded banks. So in many restoration reaches, the bankfull mark (boundary) is below the elevation of the floodplain. Bankfull mark can be recognised by a transition in soil/substrate and rooted vegetation, whereby the regular action of flows in ordinary years distinguishes the areas below the bankfull mark from those above.

Bankfull height (also referred to as bankfull depth) indicates the difference in elevation from the bankfull mark to the thalweg at that particular cross-section.

Bankfull width indicates the horizontal distance, measured perpendicular to the stream flow, between bankfull mark on the left bank and bankfull mark on the right bank, including only those sections of the stream that are beneath the elevation of the bankfull stage (i.e., would be underwater at bankfull flows). As such, bars are included in the bankfull width, but the widths of vegetated islands are not.

Flood Sign

Flood sign is anything that provides evidence of flood flows above bankfull elevation, typically including rafted debris, scour, or recent fluvial deposits (loose sands, gravel), which may be on the ground or suspended on vegetation.

Focal Channel

The stream channel that typically conveys most flow and contains the thalweg, which may or may not be the stream's main channel, depending on the focus of the project. For example, if side-channels are being specifically evaluated, the focal channel would be the side-channel that conveys most flow and contains the deepest longitudinal profile of that network of side-channels.

Islands

Islands are above the elevation of bankfull stage and as such are distinct from bars and the streambed in their vegetation and soil/substrate composition. Islands can typically be recognised by being vegetated by multi-year non-hydrophytic growth.

Side-Channel

A channel that conveys flows and is connected to the focal/main channel seasonally or year-round at both the upstream and downstream ends. Note that this is distinct from sloughs, spring brooks / groundwater channels that are only connected at one end to the focal/main channel.

Thalweg

The longitudinal path of a stream that connects the deepest part of the channel, typically conveying the most flow. In a cross section, the difference in elevation between the thalweg and the bankfull mark defines the bankfull depth. Note that, in some cases the focal channel may not contain the stream's actual thalweg (e.g., for studies specifically focused on side-channels), however we still consider the focal side-channels deepest longitudinal path as its thalweg.