5.0 SURVEYING FOR WATERCOURSE CROSSINGS

Given the technicalities, standards, and guidelines that are required when installing or replacing instream structures, surveying plays a vital role in ensuring that proper designs are developed. This information can be easily translated into building a set of construction plans that detail all of the crucial vertical and horizontal measurements within a watercourse crossing. This will ultimately confirm that the structure is installed as per design. In doing so, all new structures have a good opportunity to last for its intended life, while also providing fish passage.

When conducting a survey, it is essential to gather all the relevant on-site information that may influence the design and construction of the crossing. A design requires a stream and road survey as well as the recording of the applicable watercourse and land features.

5.1 TERMINOLOGY

Benchmark: A surveyor's mark on a construction site that is used as a reference point in measuring elevations. A benchmark is critical whenever elevations are measured to transfer site-specific information to a plan.

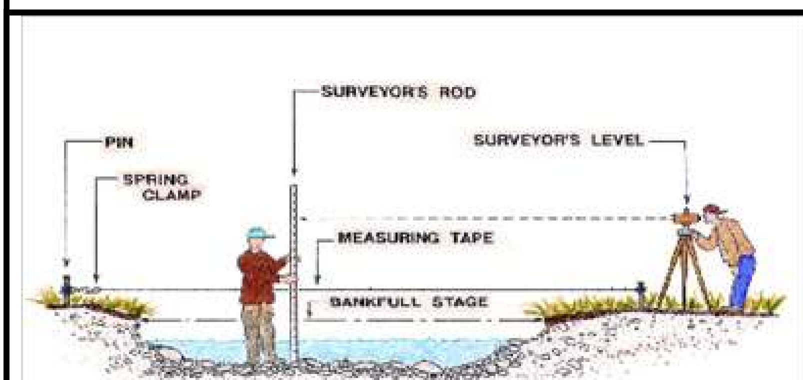
Instrument: A device that is utilized for surveying to collect vertical elevations and horizontal angle information. (Examples include: Total Station, Theodolite, Transit Level, Builders Level, Laser Level, etc.)

Levelling rod: A graduated pole with a movable marker, held upright and used with a surveying instrument to measure differences in elevation.

Elevation: The recorded instrument reading (vertical height) taken in a survey. When using a simple level, this value is equal to the height from the ground to the height of the instrument at any given point within your construction site. When using an instrument that records x,y,z data (i.e. Total Station), elevations can be related to sea level.

Bankfull Width/Stage: The width of the bankfull channel measured at a section perpendicular to the stream flow at bankfull discharge. Typically, the width of the channel where water leaves the channel and enters a flood plain. See Section 1.3.5 *Determining Channel Width* and Figure 5-1.

Figure 5-1 Measuring the cross-section of a channel



Thalweg: The line defining the lowest points along the length of a watercourse; the lowest channel of flow within a watercourse; also known as the current. See Figures 5-2 and 5-3.

Figure 5-2 Common features of a watercourse

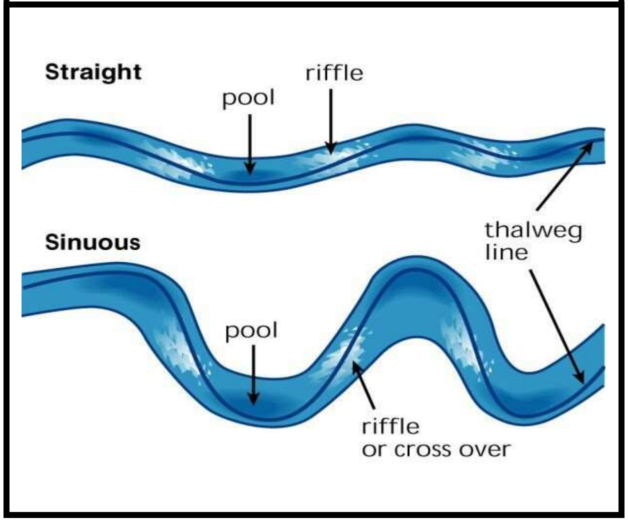
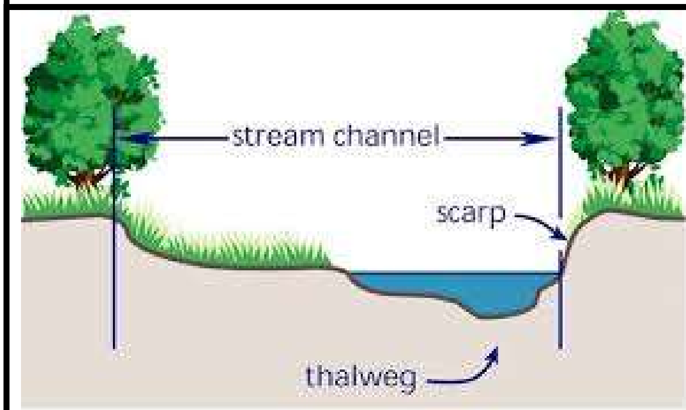


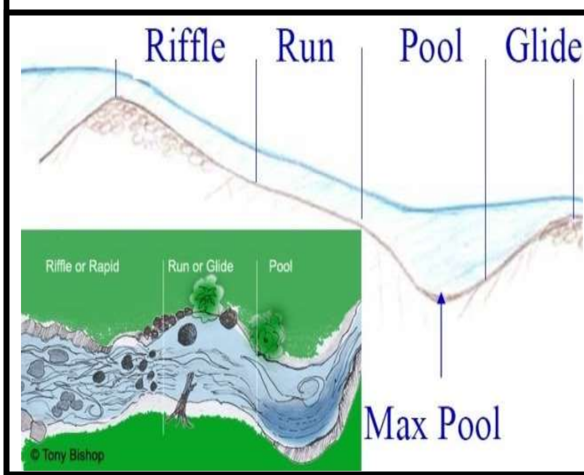
Figure 5-3 Stream channel and thalweg



Riffle: Shallow water extending across the bed of a flowing watercourse with rapid current and with surface flow broken into waves by submerged obstructions such as gravel and cobble. In other words, a small set of rapids or a small dam, which creates the pool. See Figures 5-4 and 5-5.

Figure 5-4 Riffle

Figure 5-5 Riffle



5.2 SURVEYING

Surveying allows for the translation of existing stream and road elevations to a set of construction plans. This information is essential when design decisions are made. It ensures that all elevations captured represent the actual existing state of the stream and road. It is also beneficial when installing and aligning new structures to fit the given site.

Failure to ensure that structures are installed at the correct design elevations can impact the functionality of the structure, including its ability to pass fish.

Figure 5-6 Surveyor's site level

Note: A trained surveyor working on large projects today is equipped with surveying units much more advanced and technical than the site level shown in Figure 5-6. However, the basics of surveying have remained unchanged. The majority of stream surveys related to certification projects are meant to be straight forward, and most of them can be completed using the simplest form of surveying. These methods are very basic and can be learned by anyone that is willing.

5.3 EQUIPMENT

Common equipment used to survey include:

- Transit level, tripod, and leveling rod
- Clipboard, blank paper, and a pencil
- Survey spreadsheet to record data
- Maul and re-bar or nail
- Ribbon and orange spray paint
- Axe or hatchet
- 7.5 metre (25 ft) tape measure
- 100 metre (300 ft) tape measure
- GPS

5.3.1 <u>How to Set Up a Transit Level</u>

1) Secure and anchor the tripod to a stable position and adjust legs to an appropriate height for viewing.
2) Place the level directly on the tripod head and attach it to the base using the thread bolt (hand tighten only).
3) Remove the protective lens covers and place them in the carrying case.

5.3.2 Leveling and Using the Instrument

1) Ensure that the tripod is stable and securely planted to prevent tip-over before starting the instrument levelling process.
2) Ensure that the attachment between the transit level and the tripod is secure.
3) Ensure that the four levelling screws are set to a neutral position to allow fine adjustments in both directions (up and down).
4) Attempt to rough-level the instrument by simply adjusting the legs of the tripod, while watching the levelling bubble. This will make fine adjustments that much easier.
5) Place the levelling screws between your thumb and forefinger; turn two screws at the same time in opposite directions and watch for movement in the levelling bubble. Adjust the instrument 90 degrees, so that it sits over the next two adjustment screws and repeat. Continue this step for all three screws until the bubble is centred.
6) Move the instrument through various stages of the 360° and check if the instrument is level at all points.

If the instrument is not level at all points, the final check must be done again until the bubble is centred at each point. If the bubble does not get centred, there may be damages to the levelling instrument.

5.3.3 How to Read a Transit Level

1) Locate the eyepiece. This component can be adjusted to bring the crosshairs into focus.
2) All instruments are equipped with a focusing knob. Locate and adjust as required.
3) All instruments have a course sight-in located on the top of the instrument. It’s a lot quicker to utilize this tool to locate the levelling rod.
4) Look through the eyepiece and use the horizontal alignment adjustment knob to center the levelling road within the scope.
5) To complete this stage, identify the number from the levelling rod that corresponds with the center horizontal line (crosshair) in the eyepiece.

5.3.4 Helpful Hints for Levels

- When the objective lens is not in use, it should be covered with a lens cap to prevent damage to the equipment.
- Detachable sunshades are useful in preventing glare and protecting the objective lens.
- DO NOT lift your level by the telescope; always lift it by the base.
- Ensure to turn both screws at the same time and rate when levelling a transit level.
- Ensure the transit level is level around all 360° of direction; if this is not done, the measurements will be incorrect.
- Ensure the levelling screws are not too tight; overtightened screws will need to be loosened for the most accurate results. Also, if the screws are too tight, they may warp the base plate, causing permanent damage.

- DO NOT look at the sun through the telescope.
- Keep both eyes open when looking through the telescope. This will avoid tiring your eyes and eliminate squinting.
- The jumping of an image is called parallax. With each movement, adjust the focusing knob until the image stops jumping.
- DO NOT touch the tripod once the transit level is mounted. This can cause problems with the measurements as well as the accuracy of the level.

5.3.5 Common Levelling Mistakes

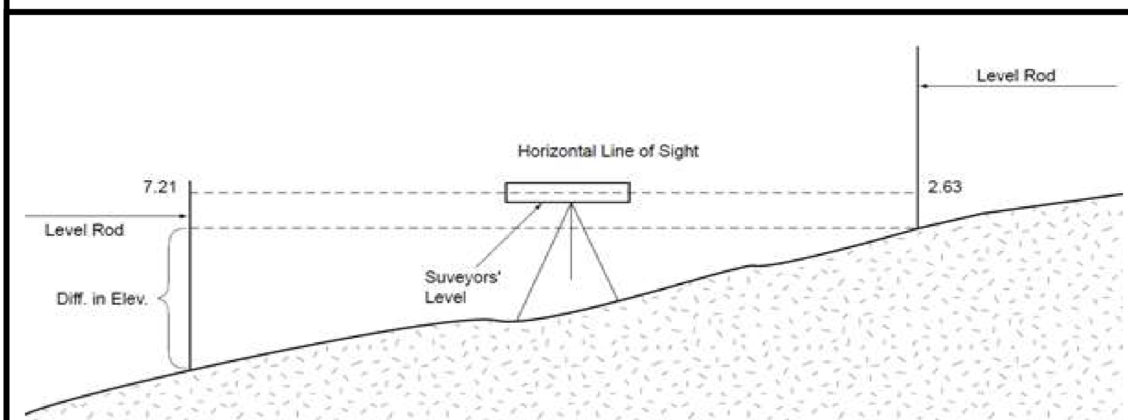
Common mistakes made while levelling are summarized below, along with steps to avoid mistakes.

- Rod section skipped. Fully extend all sections of the rod before starting.
- Rod is not vertical. Stand directly behind the rod. Hold the rod with two hands, lightly grip and balance the rod with both hands.
- Rod held on the wrong point. Communicate clearly to rod person exactly where to place rod.
- Other tips:
  - Try to set up to read at least one-foot above surfaces that are warm to avoid heat waves
  - Set up to keep sights as short as possible
  - Set up to keep backsights and foresights nearly equal in length
  - Use solid benchmarks that can be easily found by others

5.3.6 Calculating Difference of Elevation

To calculate the difference in elevation between two points, a direct reading can be taken on the levelling rod at each point. The difference in elevation is determined by subtracting the lower reading from the higher reading. See Figure 5-7.

Figure 5-7 Calculating differences in elevation



If more than two points are involved, then a levelling procedure is used. The procedure involves starting at the benchmark, establishing the height of the instrument, and then taking rod readings on points where new elevations are to be established. See Section 5.5.2 *Reducing Elevations*.

5.4 SETTING BENCHMARKS

Benchmarks should be set in a stable location that is:

- Far enough from the site, so they are not impacted by construction, but close enough for accessibility. Set two benchmarks in the event one is moved or destroyed.
- Close to a road so that they can be found easily, but not too close that they are impacted by grading and plowing.
- Clearly visible (ribbon or paint), given that vegetation could grow around it in several months, making it very difficult to locate.

There are several options to consider when creating a benchmark. Regardless of which strategy used, the most important rule of thumb to consider is to make sure that its location does not move. You will have to consider the time of year (frost, snow, ice), machinery (*i.e.* graders, plowing), tree mulching, or any other possible activity that could influence the x,y,z coordinate of the site. Benchmarks can be made from a painted mark on ledge rock, a spike or nail in a mature tree, or a cut-off stump. A three-foot spike (cut-off re-bar) driven into the ground (deep enough to prevent frost heaving) also works well.

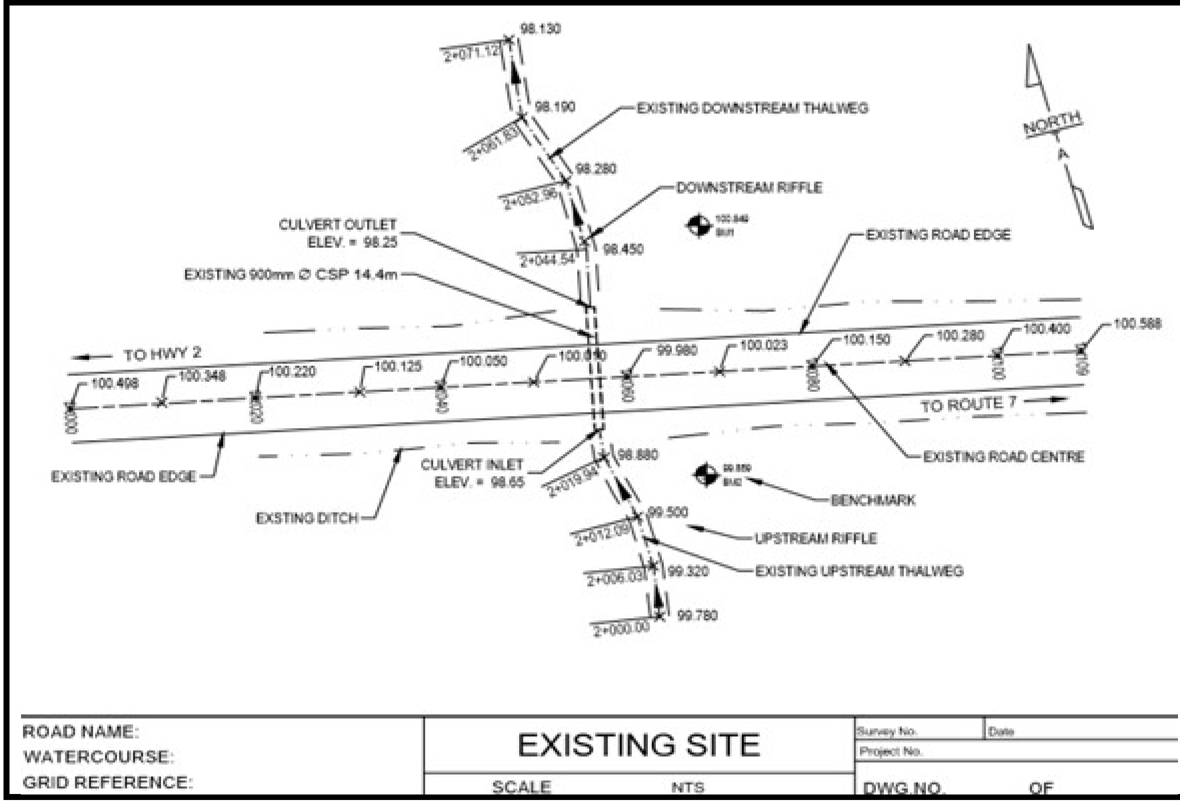
Once a benchmark is set, all elevations are now referenced from this point.

5.5 SITE SURVEY

5.5.1 Begin Survey

- Draw a site sketch. Try to capture all relevant information (*e.g.* road and direction, stream, riffles, pools, power lines, wetland, flood plain, benchmarks, culvert). See Figure 5-8.

Figure 5-8 Site sketch



- Record benchmark elevations. Take a grid and label elevation on drawing.
- Record road survey elevations; 10 metre intervals work well. The goal is to capture enough elevations in both directions so that you know where to tie in if your proposed site requires a road lift. When the proposed design is complete, the transition from the existing road through your new site should almost be unnoticeable when driving. Start at Road/Culvert center and proceed in each direction with your shots.
- Record instream elevations, but make sure first to run a tape to measure your distance. Five metre intervals will suffice along with important stream characteristics, such as an existing culvert inlet/outlet, riffles, meanders, and pools. You can record this on a generic spreadsheet as you will find that your drawing will get too cluttered. See Table 5-1.
- By capturing the existing elevations of both the stream and road (when replacing a culvert) through a survey, while also collecting all relevant details and expressing them on a plan view, a final 'Existing' drawing can be made. Capturing and drawing the existing conditions in a plan view is a crucial step to transitioning into the design phase.

Table 5-1 Record of elevations and field notes

Watercourse Survey Information

Stream Name:				Road Name:			
GPS Location:				Unique ID:			
Dist .(m) Riffle/Pool	Left Bank	Thalweg	Right Bank	Dist .(m) Riffle/Pool	Left Bank	Thalweg	Right Bank
US				Culvert Outlet			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
US				DS			
Culvert Inlet				DS			

BM#1 Description		**Roadway Elevations**	
		Road Name above site (orientation) =	
			Elevation (m)
		30m EL =	
BM#1 EL= GPS=		20m EL =	
		10m EL =	
BM#2 Description		Center Line EL =	
		10m EL =	
		20m EL =	
		30m EL =	
BM#2 EL= GPS=		Road Name below site (orientation) =	
		Flow Direction =	
Bank Full Width =	**Stream Channel Depth=**		
		Road Width =	
Plunge Pool		**Culvert Length =**	
Length=	**Width= Depth=**	**Culvert Diameter =**	
Surveyed By:		**Distance - Road Center to Culvert Inlet =**	
Pictures and Site Sketch Required			
Spoil Site (GPS)-		**Dirty Water Discharge (GPS)-**	
Legend:	* PB (Pool Bottom), * UR (Unstable Riffle), * ST (Stable Riffle), * US (Upstream), * DS (Downstream)		

5.5.2 Reducing Elevations

This refers to equating elevations of survey points with reference to a common assumed datum.

If you do not take this step, rough data shots taken from a site level can be misleading or confusing. For example, as you move downslope with a levelling rod taking elevations, your recorded numbers get higher in value. In contrast, this is also the case for when you move upslope, your recorded numbers get smaller. Reducing elevations simplifies all of your data set so that higher elevations have a higher value, and lower elevations have lower values. It’s much easier to read a plan this way.

For example, it is very common for the main benchmark used on site to be set arbitrarily at 100.00. All elevations will now be above or below this benchmark, as indicated on the site.

For example, the rough elevation of the benchmark is 1.50 metre (reading on the rod).

To reduce all further elevations and to set this benchmark as our reference point; Add 1.50 metre (height of instrument) to 100.00 = 101.50.

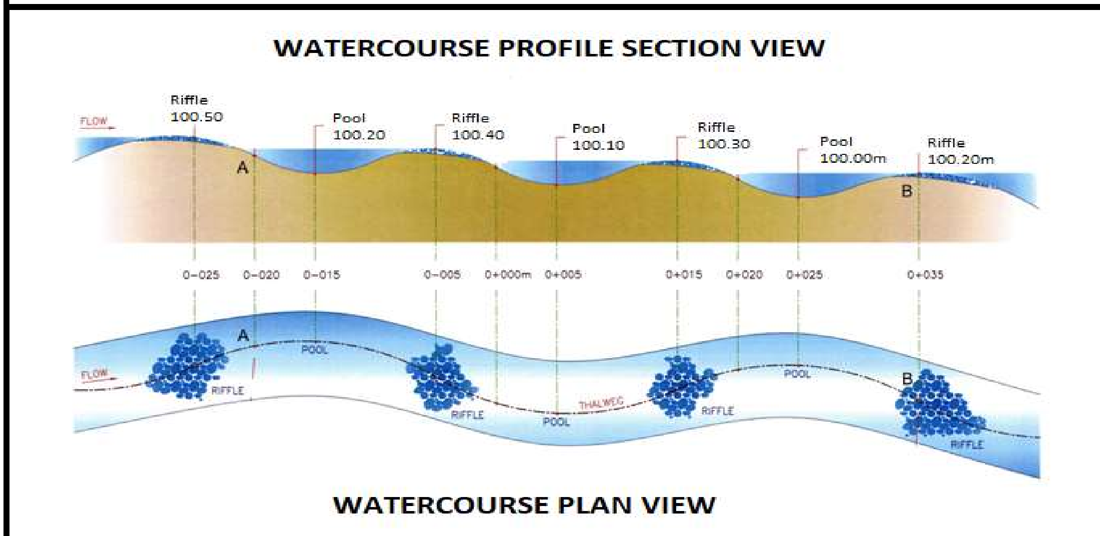
Subtract all rough field elevations from 101.50.

In doing so, we have subtracted the height of the instrument and set this benchmark to 100.00.

5.6 CREATE A WATERCOURSE PROFILE DIAGRAM

Using the survey data, create a watercourse profile diagram. See Figure 5-9 for an example of a watercourse profile diagram created with field-collected data.

Figure 5-9 Watercourse profile view and watercourse plan view



All of the collected field data can now be used to create a plan for the installation of the watercourse crossing.