Field Survey Procedure - Pebble Count (Targeted Mesohabitats)

Restoration Monitoring Guidance

7 April 2025

Document details	**A concise overview of pebble counts, including a 1-page field method (Appendix A) and a field data form (Appendix B), for the purpose of monitoring restoration project success through examination of changes in sediment size distributions.**
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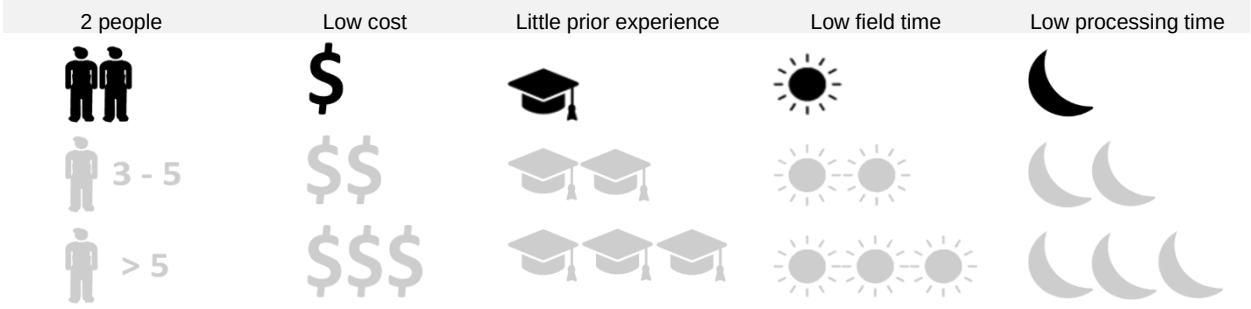
Resource Commitments



CONTENTS

1. OVERVIEW

Please refer to 'APPENDIX A: Pebble Count 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 method collects surface substrate data using pebble counts (Wolman 1954) within targeted mesohabitats. Targeted mesohabitats are chosen for their value for your focal species and/or their expected sensitivity to detect changes caused by your project. Data collected using this method will generate sediment size distributions, and these size distributions can be compared among reference or control sites, or against known benchmarks (e.g., suitable gravel size for spawning for your focal population).

The data processing files (.html and .rmd) associated with this document will generate sediment size distributions, produce figures and tables, and run inferential tests to detect changes among years of data.

This method is primarily intended for use in riffles, to explore spawning suitability or changes in substrate size distribution (e.g., coarsening) over time. However, the protocol can be applied to other mesohabitats, providing that the area sampled can be considered a single patch (facies) characterised by a recognisably distinct substrate composition. This approach cannot be used to average across multiple distinct substrate patches (e.g., cannot include a well-sorted gravel patch with a gravelly sand bar, nor include a pool with a riffle, a bank with a bed, etc.).

Sediment size distribution can be used to assess actions that intend to restore desirable sediment sizes to particular mesohabitats, e.g., riffles suitable for spawning. However, this protocol does not assess the sizes of those mesohabitats. We recommend pairing this protocol with our Longitudinal Profile protocol, which classifies mesohabitats and provides information on mesohabitat lengths within the reach. Together, riffle sediment size distribution and estimates of riffle area within the reach can provide a more complete picture of how your project has altered surface substrates within the reach

This protocol is intended for use during low-flows and in wadeable streams. Mesohabitat identification and collection of sediments from the streambed may be biased and considerably more difficult outside of this time.

Note that this protocol does not provide direct information regarding incubation or emergence suitability of substrates. Alternative protocols that involve bulk sampling of subsurface sediment before or after spawning are more appropriate. Similarly, this protocol has limited utility for areas dominated by fine sediment. Should excess fines be a particular concern, protocols such as V* (Hilton and Lisle 1993), which measure sediment accumulated in pools, may be appropriate. See Kondolf et al (2003) for a detailed summary of substrate measurement approaches.

A summary of the required equipment for pebble counts is provided in Table 1.

Table 1: Equipment Checklist – Pebble Counts

Item	
Field forms (waterproof) / Tablet	☐
Camera	☐
GPS	☐
Ruler with mm gradations; *or* gravelometer (sheet metal sieve)*	☐

**This protocol assumes the use of a ruler. Whichever approach is used must remain consistent among sites and throughout repeat visits. Our data analysis guidance includes inferential tests that require individual pebble measurements and we do not (yet) have an equivalent test for binned data (i.e. from gravelometer/sieve data).*

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. PEBBLE COUNT PROCEDURE

Please refer to 'APPENDIX A: Pebble Count 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.

2.1 Mesohabitat Identification

This protocol is implemented at targeted mesohabitats (e.g. riffles) which have already been identified. To make reach-scale inferences of a particular mesohabitat, three distinct mesohabitats of the same type should be randomly chosen for pebble counts.

- Unless other predetermined size criteria are established, randomly select three mesohabitats which feature a length of 60% or more of bankfull width. If using our Longitudinal Profile protocol, this corresponds to selecting habitats that span three or more standard intervals.
    - If this criteria is adjusted based on the stream attributes, ensure the criteria are consistently applied among before/after and control/impact reaches.
- The mesohabitats should all be in the focal channel, to avoid variation expected among side-channels.
- A total number of 108 particles must be sampled. If less than three of the focal mesohabitat exist within the focal reach, conduct more transects within the available mesohabitats.
- Where monitoring over time, mesohabitat locations may shift. Although GPS locations of sample locations should be recorded, samples in subsequent years must be obtained from recently classified target mesohabitats (i.e., not simply repeated at the same coordinates). Representative photographs and details of the classification process should be recorded to inform mesohabitat classification for subsequent sampling visits.
- It is not valid to combine particles from different 'populations' of sediment (facies). If sediment size distribution of an entire reach is of interest, not less than 100 particles must be sampled in each facies type and the area occupied by each facies must be measured to properly 'weight' the sediment size distribution. If this level of effort is not feasible, ensure that your interpretation and communication of changes in sediment size distribution relate specifically to the given mesohabitat within that reach (e.g., the observed change in *riffle* median pebble size, rather than in *reach* median pebble size).

2.2 Patch Identification

At each randomly-selected mesohabitat it is necessary to identify patches that consist of recognisably distinct substrate composition.

Patches represent distinct local depositional and erosional environments. The patch may be well-sorted (e.g., all gravels of similar size) or well mixed (e.g., contains a mixture of sand and gravel, with the size composition and proportions appearing relatively consistent throughout the patch).

The full bed of a geomorphic feature - such as a riffle, pool, glide, or run - may largely correspond to a distinct substrate patch. However, it is also possible for a certain geomorphic feature / mesohabitat to contain multiple patches of distinct substrate composition, such as a pool containing discrete sand deposits and a discrete gravel bed.

Visually identify distinct patches within the focal mesohabitat that represent the targeted salmon habitat function (typically spawning gravels). If there are no sufficiently large patches, sample from several smaller patches that display consistent substrate compositions.

2.3 Pebble Count

The pebble count involves picking individual particles from transects within the patch and measuring the b-axis of each particle. The b-axis is perpendicular to the longest axis of the pebble (see Figure 1). A total of 108 particles must be measured to characterise a mesohabitat.

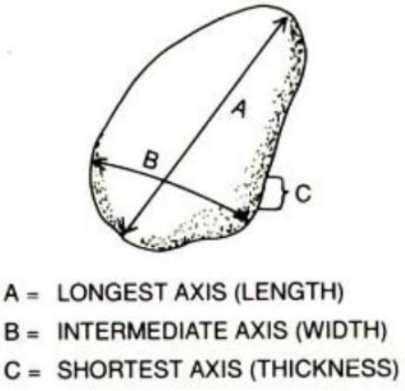


Figure 1: Pebble axes. Measure the b-axis, which is the largest measurement that is perpendicular to the pebble's longest axis. Image from Harrelson (1994)

Assuming three mesohabitats of the same type will be sampled, at each mesohabitat:

- Visually estimate locations of three equally spaced transects to be sampled along the length of the identified patch.
    - If the mesohabitat is a riffle, ensure one of the transects is at the riffle crest, and record 'RC' for that transect on the datasheet.
    - Ensure that the transects do not intersect, such that the same particle cannot be measured twice.
- At each transect 12 particles must be measured. Select particles from the bed only (not the banks), and equally space the particle selection locations across the width of the patch.
- Standing along the transect and not looking at the substrate, vertically descend your finger (or toe/staff) until touching the substrate. Using a predetermined 'pinpoint' location, such as the right side

of the tip of your fingernail, or a particular corner of a staff, select only the particle that comes into contact with this pinpoint.

- Be careful not to introduce bias by looking at the substrate or automatically selecting the larger particle if you happen to touch two or more.
- If you touch sediments too small to individually pick up, pinch to collect a sample and record the diameter of a typical piece if greater than 1mm b-axis. If typical particles are <1mm classify it as either sand (if gritty between fingers) or fines.
- If there are fine sediments or sand atop larger substrates, but not enough fine sediment or sand to pinch, measure the larger substrate particle below.
- If individual particles cannot be picked up to measure due to their size or concretion, make an assumption of the particle's b-axis and measure to the best of your ability. Note on the datasheet an 'E' for particles that are concreted into the bed and cannot be dislodged.
- If bedrock or obstacles are encountered (LWD, or errant boulders that are not considered part of the patch substrate framework), record their presence. Note that they do not count toward the 12 particles that must be sampled in each transect.

If there are only two focal mesohabitats in the reach, the above should be modified to sample six transects at each mesohabitat, and if only one mesohabitat is available, sample nine transects. A total of 108 different individual particles must be sampled regardless of the number of mesohabitats.

3. REFERENCES

Harrelson, C.C., 1994. Stream channel reference sites: an illustrated guide to field technique (Vol. 245). US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Kondolf, G.M., Lisle, T.E. and Wolman, G.M., 2003. Bed sediment measurement. Tools in fluvial geomorphology, 347, p.395.

Lisle, T.E. and Hilton, S., 1999. Fine bed material in pools of natural gravel bed channels. Water Resources Research, 35(4), pp.1291-1304.

Wolman, M.G., 1954. A method of sampling coarse river-bed material. EOS, Transactions American Geophysical Union, 35(6), pp.951-956.

APPENDIX A: PEBBLE COUNT 1-PAGER

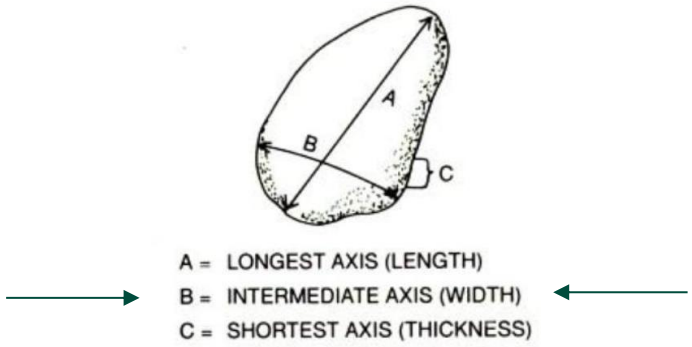
Targeted Mesohabitat: Pebble counts are only valid within a facies (population of sediment), which often corresponds to the bed of a particular habitat unit such as a riffle. It is therefore a prerequisite that habitat units are identified.

To make inferences regarding the sediment population of your targeted mesohabitat, you can either:

- Include *all* focal mesohabitat units (useful for assessing a small number of known mesohabitat units, e.g., median pebble size at specific spawning riffles), or
- *Randomly* select a subset of the focal mesohabitat units (useful for inferences of mesohabitat characteristics across the reach, e.g. median pebble size at riffles across the reach).

This protocol assumes the latter, sampling three random mesohabitats to make reach-scale inferences.

1. **Determine Sample Mesohabitats:**
    a. Define inclusion criteria (e.g., riffle length > 60% bankfull width).
    b. Use a random number generator to select three of the previously-classified focal mesohabitats.
2. **Establish Transects within Focal Mesohabitat Unit**
    a. Do not sample from the banks or cross into areas with distinctly different sediment compositions (e.g., avoid discrete sand deposits located within a riffle)
    b. Visually estimate locations for three transects that do not intersect each other
        i. For riffles, one of the transects should be at the riffle crest
3. **Measure 12 particles at each of the three transects**, equally spaced across the bed width.
    a. Standing along the transect and not looking at the substrate, vertically descend your finger (or toe/staff) until touching the substrate. Use a predetermined ‘pinpoint’ location (e.g., right tip of fingernail) to select only the individual particle that it contacts.
    b. For sediments too small to individually pick up, pinch to collect a sample and:
        i. Record the diameter of a typical piece if greater than 1mm b-axis.
        ii. If typical particles are <1mm classify it as either sand (gritty) or fines
        iii. If fine sediments or sand are too shallow to pinch, measure the larger substrate particle below.
    c. If individual particles cannot be lifted due to size or concretion, make an assumption of the particle’s b-axis and measure to the best of your ability. Note on the datasheet ‘E’ where particles are concreted
    d. If bedrock or obstacles are encountered record their presence. They do not count toward the 12 particles that must be sampled in each transect
4. Repeat Steps 2 and 3 until **a total of 108 particles** have been measured. If there are less than three focal mesohabitats in the reach, increase the number of transects within the available mesohabitats, and do not sample from a different type of mesohabitat.



APPENDIX B: PEBBLE COUNT FIELD FORM

Pebble Count at Mesohabitat Units

Study Ref	Stream Name	Date
Start Waypoint Name/GPS		Observer:
End Waypoint Name/GPS		Focal Habitat Type:

Habitat ID #	GPS Waypoint	Pebble Number	B Axis (mm)			Notes
			Transect 1	Transect 2	Transect 3	
		1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
		11				
		12				
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		1				
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		note				

At riffles, include transect at riffle crest ('RC' in notes)
Include 'E' in notes for embedded/concreted particles

If b-axis <1mm classify as sand (gritty) or fines (smooth)
Do not cross facies (patches of consistent substrate 'populations')