Precision Among Observers using DEQ's Aquatic Plant Visual Assessment Form in Montana Streams and Rivers

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Executive Summary

Standardized methods for completing visual assessments of stream and river aquatic flora are of great utility to monitoring and assessment programs charged with surveying and monitoring aquatic plant communities, as well as for research on the effects of aquatic system manipulation and management. The Montana Department of Environmental Quality (DEQ) and its predecessor agencies have used standard visual estimation forms to document aquatic plant communities and conditions in streams and rivers for decades. However, prior to the present study, DEQ has not evaluated inter-observer variability of its Aquatic Plant Visual Assessment method. The objectives of this study were to (1) assess the precision of trained observers' evaluations of quantifiable components of DEQ's Aquatic Plant Visual Assessment form, and (2) provide guidance for improvements to the method for future use.

In 2025, DEQ Aquatic Plant Visual Assessment forms were completed on 23 different western Montana rivers and streams having a wide variety of aquatic plant conditions. Site conditions ranged from those dominated by a thin coating of microalgae on the stream bottom, to dominance by filamentous algae or *Didymosphenia glomerata* (Didymo), to those dominated by macrophytes or moss. Waterbodies varied from small streams 1-2 m wide to medium rivers 30 m wide.

All 11 participants received DEQ's one-day training in how to carry out aquatic plant visual assessments in streams/rivers, however participant's experience ranged from beginner (started in 2025) to those with over 25 years of experience. All participants used clear-bottom viewing buckets to perform the visual assessments. Study participants evaluated each stream or rivers' visual assessment quadrilaterals (i.e., defined rectangular areas of stream bottom) independently from other participants working at the site and using separate forms; all work was completed the same day. Each observation quadrilateral was considered an experimental unit for statistical analysis. As such, there were up to 230 different observer-pair combinations for each flora type observed.

The study revealed that, overall, there is high degree of consistency in assessing flora coverage among trained observers. Assessment of flora coverage among observers were strongly or very strongly correlated (Spearman's *rho* 0.71 to 0.95, depending on which flora cover was assessed). Further, the mean absolute difference (MAD) between observers was smaller than the ranges one chooses amongst on the form, except for the microalgae MAD (11.3%) which was slightly wider than one of the categorial choices (the "sparse" category, which has a 10% range).

Observers' years of experience carrying out aquatic visual assessments was not an important factor in reducing variability relative to the most experienced observer (expert) who had >25 years of experience doing this work. There was no correlation between observer's ranked experience (in years, which ranged from 1-25) and their ability to align with the expert's observations.

Based on the study results, a few recommendations were provided that may help improve the method's precision going forward. The study showed that (1) greater care needs to be taken when assessing attached algae thickness, particularly thickness of the algae Didymo; (2) observers' filamentous algae length estimates are particularly variable when the algal filaments are in the 5-15 cm length range, therefore greater care in measuring them is needed in that range; and (3) based on a literature review, it is a good practice for field team members to consult one another and come to consensus when filling out the Aquatic Plant Visual Assessment form.

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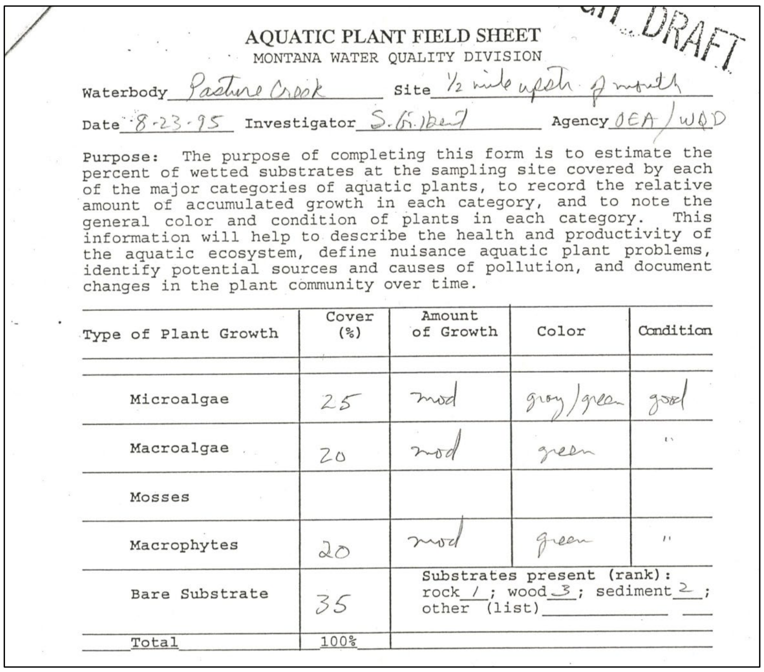
ACRONYMS

DEQ	Montana Department of Environmental Quality
Didymo	*Didymosphenia geminata*
Lowess	Locally weighted scatterplot smoothing
MAD	Mean absolute difference
SD	Standard deviation (of the mean)

1.0 INTRODUCTION

Visual estimates of aquatic habitat features are used in aquatic ecology because of their minimal equipment requirements, low cost, and ease of collection (Killourhy et al. 2016). Standardized methods are of great utility to monitoring and assessment programs charged with surveying and monitoring aquatic plant communities, as well as for research on the effects of aquatic system manipulation and management (Madsen and Wersal 2018; Suplee et al. 2019). The Montana Department of Environmental Quality (DEQ) and its predecessor agencies have used visual estimate forms to document aquatic flora communities and conditions in streams and rivers for decades (**Figure 1-1**).



DRAFT

AQUATIC PLANT FIELD SHEET
MONTANA WATER QUALITY DIVISION

Waterbody Pasture Creek Site 1/2 mile upstr. of mouth

Date 8-23-95 Investigator S. Gilbert Agency DEA/WQD

Purpose: The purpose of completing this form is to estimate the percent of wetted substrates at the sampling site covered by each of the major categories of aquatic plants, to record the relative amount of accumulated growth in each category, and to note the general color and condition of plants in each category. This information will help to describe the health and productivity of the aquatic ecosystem, define nuisance aquatic plant problems, identify potential sources and causes of pollution, and document changes in the plant community over time.

Type of Plant Growth	Cover (%)	Amount of Growth	Color	Condition
Microalgae	25	mod	gray/green	good
Macroalgae	20	mod	green	"
Mosses				
Macrophytes	20	mod	green	"
Bare Substrate	35	Substrates present (rank): rock 1; wood 3; sediment 2; other (list)		
Total	100%			

Figure 1-1. Example of an Aquatic Plant Visual Assessment Form used by the Water Quality Division in the mid-1990s.

The aquatic plant visual assessment method currently in use by DEQ, along with detailed instructions for completing the form, can be found in Section 7.0 of DEQ (2026). The DEQ (2026) form (see also **Appendix A**, **B**) is a slightly modified version of what was in DEQ's field procedures manual in 2012 (DEQ 2012; **Figure 1-2**).

Madsen and Wersal (2018) describe a variety of visual assessment methods for assessing flora. DEQ's methodology best fits what they call a "quadrat" method, because aquatic flora within the defined area of a quadrilateral (a rectangular area of stream bottom) are identified to type, areal coverage, thickness, and length.

Transect Letter:	F			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
COMMENTS				

Figure 1-2. The Aquatic Plant Visual Assessment Form as of 2012. This form applies to transect F which is the mid-point transect of 11 transects assessed in a fully wadeable stream. The current (2026) version is very similar and is provided in Appendix A, B.

Assessing the accuracy of a stream/river aquatic visual assessment method is difficult because of current-induced movement of aquatic flora and problems with photographing the stream bottom through moving water (Killourhy et al. 2016). Manually harvesting all flora from the stream bottom after completing a visual assessment would address method accuracy but was deemed impracticable for the present study. However, inter-observer variability (precision) can be assessed by evaluating variability among different observers working in the same stream or river quadrilaterals. Killourhy et al. (2016) appear to have carried out the first study in which visual aquatic habitat assessment methods in flowing water were evaluated in terms of consistency among observers. Prior to the present study, DEQ had not evaluated inter-observer variability of its Aquatic Plant Visual Assessment method either. The objectives of the present study were to (1) assess the precision of trained observer's evaluations of components of DEQ's Aquatic Plant Visual Assessment form, and (2) provide guidance for improvements to the method for future use.

1.1 Applicability

The results from this study apply to the version of DEQ's Aquatic Plant Visual Assessment form in DEQ (2024) and DEQ (2026). Earlier but similar versions of the form were in widespread use by DEQ as documented in field procedures manuals of the time (DEQ 2012, 2015), and also in special DEQ studies as early as 2009 (Suplee et al. 2019).

2.0 Methods

Eleven people participated in the inter-observer variability study in the summer and fall of 2025; ten were employees of DEQ and one was affiliated with the University of Montana. All participants received DEQ's basic one-day training in carrying out aquatic plant visual assessments in streams/rivers, however observer experience varied from beginner (first started in 2025) to those having over 25 years of experience carrying out such assessments. All participants used clear-bottom viewing buckets to assist with their visual assessments.

Aquatic Plant Visual Assessment forms (**Appendix A**, **B**) were completed on 23 different western Montana rivers and streams having a wide variety of aquatic plant conditions. Site conditions ranged from those dominated by a thin coating of microalgae on the stream bottom, to dominance by filamentous algae or *Didymosphenia glomerata* (Didymo), to those dominated by macrophytes or moss. Waterbodies varied from small streams 1-2 m wide to medium rivers 30 m wide. Consistent with DEQ's standard operating procedure (DEQ 2026), smaller, fully wadeable streams were evaluated at each of 11 transects by observing flora in the quadrilateral delineated 5 m upstream and 5 m downstream of each transect line, from bank to bank (**Figure 2-1**). In larger streams and medium rivers which were only partially wadeable, quadrilaterals were completed in the safely wadeable parts of three transects as shown in **Figure 2-2** (again, consistent with DEQ 2026). Up to nine quadrilaterals were completed in partially wadeable streams and rivers.

Participants in the study evaluated each stream or river's quadrilaterals independently from the other participants working at the site and using separate forms. All paired observations took place on the same day. Aquatic plant biomass and species composition can vary widely from upstream to downstream and across the channel (Biggs 1996; Gurnell et al. 2006; Wood et al. 2012), and for purposes of this study each quadrilateral was considered an experimental unit. As such, for statistical analyses, all possible observer-pair combinations were compiled for quadrilaterals completed on the 23 rivers and streams, resulting in up to 230 different observer-pair combinations for each flora type. In a few instances, two observers worked together to complete a form; these "duet" forms were retained for analysis and compared against the forms completed by single observers working in the same quadrilaterals[1] (such cases represent 5.6% of the dataset).

[1] To assess the effect duet-completed forms may have had on the results, all observer pairs which included a duet form were removed from the datasets of a subset of flora types. This change had essentially no effect on the results; if anything, removing the observer pairs which included a duet form slightly improved the statistical results. For this reason, the duet observer pairs were retained in the final analyses.

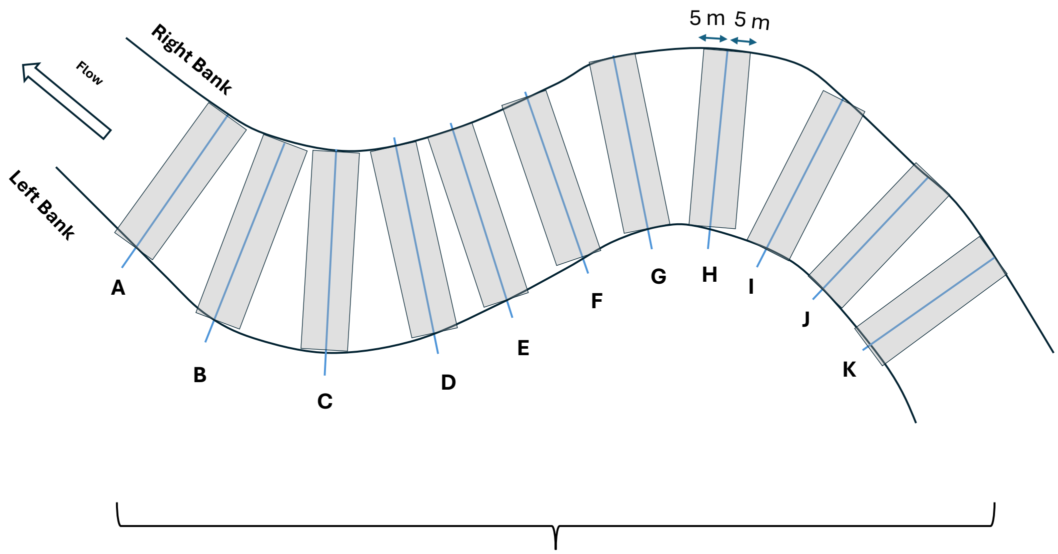


Figure 2-1. Aquatic Plant Visual Assessment in Fully Wadeable Streams. Each observation area (gray quadrilateral around each transect line) was delineated as 5 m upstream, 5 m downstream of the transect, and from wetted streambank edge to wetted streambank edge.

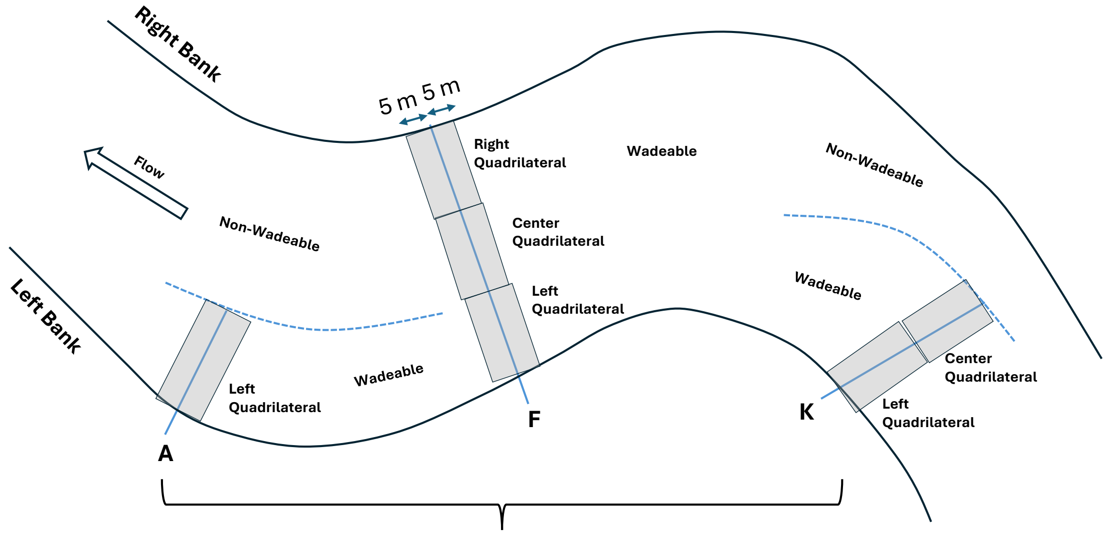


Figure 2-2. Aquatic Plant Visual Assessment in Partially Wadeable Streams and Rivers. In areas which could be safely waded, each observation area (gray quadrilateral) was delineated as 5 m upstream, 5 m downstream of the transect line, and approximately 1/3 of the distance across the channel.

All components of the current Aquatic Plant Visual Assessment form (**Figure 2-3**; **Appendix A**, **B**) that produce a quantifiable result were analyzed. These were (1) the six categories of flora listed under

Transect Letter:	F			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			
COMMENTS				
Macrophytes (dominant, most to least):				

Figure 2-3. The 2026 Aquatic Plant Visual Assessment Form for a Single Quadrilateral. This example applies to transect F of the fully wadeable stream form.

Actual Cover in channel; (2) Microalgae Thickness (mm); (3) Didymo Thickness (mm); and (4) Measured Filamentous Algae Length (cm). Per Suplee et al. (2019), prior to analysis the form's range-based categories were transformed to their midpoints as follows: flora areal cover scores (0%, <10%, 10-40%, 40-75%, and >75%) were converted to the range midpoints (0%, 5%, 25%, 58%, and 88%, respectively); microalgae and Didymo thickness category scores (<0.5 mm, 0.5-3 mm, >3mm) were converted to 0.3 mm, 1.8 mm, and 3 mm, respectively. Measured Filamentous Algae Length values were what each observer directly measured as the average length (cm) of filaments occurring in a quadrilateral, and were therefore used directly as recorded on the form.

Precision of observer estimates were evaluated statistically in Minitab 21 following methods in Killourhy et al. (2016), as follows. For each quadrilateral, observers' midpoints for each flora category (e.g. 5% Microalgae cover Observer 1; 5% Microalgae cover Observer 2) were paired and Spearman's rank correlation (Conover 1999) computed using all available observer pairs for each of the six flora categories. The same was done for Microalgae Thickness, Didymo Thickness, and measured Filamentous Algae Length. By doing so, the similarity (precision) of observers' observations for each flora measurement are being evaluated across a wide spectrum of growth and stream/river conditions. The resulting Spearman's rho ($\boldsymbol{\rho}$) values were compared to conventional categorical descriptions in **Table 2-1** to describe the strength of the correlations (Schober et al. 2018).

Table 2-1. Interpretation of Spearman's *ρ* ranges

Absolute Magnitude of Observed Correlation Coefficient (Spearman's *ρ*)	Interpretation
0.00 to 0.10	Negligible correlation
0.10 to 0.39	Weak correlation
0.40 to 0.69	Moderate correlation
0.70 to 0.89	Strong correlation
0.90 to 1.00	Very strong correlation

Mean absolute difference (MAD; also referred to as mean absolute error) was calculated as:

$$MAD = \frac{\sum | X_i - Y_i |}{n}$$ **Equation 1**

where X_i is the 1st observer of a pair, Y_i is the 2nd observer of a pair, and n is the total number of observer pairs within a flora category. MAD for a group of observer pairs is a descriptive measure of agreement (precision) among observers in the same units as the measurement.

An analysis was also carried out to see how MAD varied between the most experienced practitioner ("expert") and other participants working in the same quadrilaterals. Observers who assessed the same sites as the expert were ranked numerically based on their years of experience, and all six flora cover (%) categories were compiled into a single dataset for Spearman's Rank correlation between the MAD of expert-observer pairs and their corresponding observer ranks. Presumably, if years of experience was important, there should be a reasonable correlation between MAD values and numeric rank, with those having the most experience having the lowest MAD values relative to the expert, and the opposite for those with the least experience.

Lastly, observer pair averages (i.e., the average of observer 1 and observer 2 at a quadrilateral) were plotted (on X) against the standard deviation (on Y) of the same pair for each flora cover category. This analysis would reveal if the variability in observer's observations changed in accordance with the level of plant growth observed; presumably there would be less variation among observers at the end points (very low and very high coverage), and more variation within the mid-range options.

3.0 RESULTS

Across all 23 streams and rivers in the study, the visually assessed quadrilaterals provided a large range of flora types and levels of stream bottom cover. Filamentous algae, Didymo, macrophytes, and moss were all recorded (by one or more observers) across the maximum range possible on the form (0% to 88% cover), while microalgae was observed from 5% to 88% cover and *Chara* from 0% to 58% cover. There were strong or very strong correlations among observers' assessments for all six flora cover categories (**Table 3-1**). Correlation among observers was strongest for *Chara* and macrophyte cover (Spearman's ***ρ*** = 0.95, very strong), while filamentous algae cover had the lowest correlation (0.71; strong).

Mean absolute difference among observers for flora cover ranged from 0.4% to 11.3% (**Table 3-1**). Therefore, the average % difference among observers is narrower than the ranges observers choose amongst on the form (**Appendix A, B**), except for microalgae cover where the Sparse cover choice (>0% to <10%, i.e. a 10% range; **Figure 2-3**) is a bit narrower than the microalgae observer MAD of 11.3%.

There were fewer observations of microalgae and Didymo thickness, and filamentous algae length, because these measurements were only made when those types of flora were present. The weakest correlation among observers were estimates of Didymo thickness (Spearman's ***ρ*** 0.18), indicating poor agreement among observers in their estimates of the thickness of the mats. Microalgae thickness showed a moderate correlation strength among observers (Spearman's ***ρ*** 0.61). Observer's MAD for microalgae and Didymo were narrower than the ranges observers can choose amongst on the form. Average filamentous algae length was strongly correlated among observers (Spearman's ***ρ*** 0.80) and, on average, observers estimated filament lengths within 2.2 cm of one another.

Table 3-1. Spearman's Rank Correlation Results for Flora Cover, Thickness, and Length Categories. Mean Absolute Difference (MAD) among observers is provided for each flora evaluation category.

Flora Category Assessed	Number of paired observations	Spearman's *ρ**	Interpretation of Spearman's *ρ*	MAD
Microalgae cover	230	0.73	Strong correlation	11.3%
Filamentous algae cover	229	0.71	Strong correlation	7.1%
Didymo cover	230	0.90	Very strong correlation	5.8%
Chara cover	230	0.95	Very strong correlation	0.4%
Macrophyte cover	230	0.95	Very strong correlation	2.9%
Moss cover	230	0.86	Strong correlation	4.4%
Microalgae thickness	224	0.61	Moderate correlation	0.24 mm
Didymo thickness	120	0.18	Weak correlation	0.26 mm
Filamentous algae length	202	0.80	Strong correlation	2.2 cm

*All correlations are significant ($p \leq 0.05$).

Figure 3-1 is a scatterplot of observer pair measurements of filamentous algae length (n = 201 pairs). This was the only case where the observation was a continuous variable (all others in the study were categorical) because observers recorded their direct measurements of average filament length on the form. The relationship is significant and strong ($p < 0.001$, ***ρ*** = 0.8).

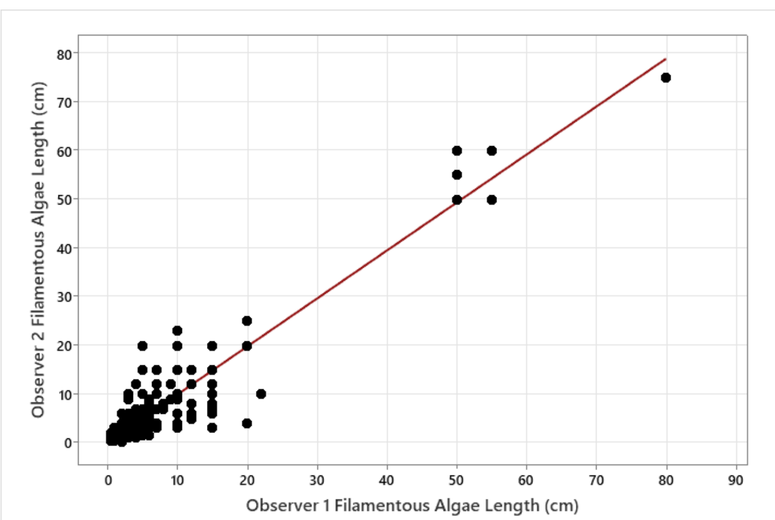


Figure 3-1. Scatterplot between First Observer's and Second Observer's Measurements of Filamentous Algae Length (cm).

Table 3-2 shows the MAD between the most experienced participant in the study ("expert") and other observers who carried out assessments in the same quadrilaterals. The tabular results suggest that, across all flora cover/thickness/length categories, there was little pattern between years of experience and MAD (i.e., more years of experience did not reduce an observer's MAD relative to the expert). Supporting this, Spearman's rank correlation between observer experience rank and MAD (based on the pooled flora cover categories) was not significant ($p = 0.3$, $\rho = 0.049$).

Table 3-2. Mean Absolute Difference (MAD) between the most Experienced Individual ("Expert") and other Observers. Following the expert, observers are arranged in order sequentially from most (#2) to least (#7) experienced.

Observer and Rank*	Microalgae cover (%)	Filamentous algae cover (%)	Didymo cover (%)	Chara cover (%)	Macrophyte cover (%)	Moss cover (%)	Microalgae thickness (mm)	Didymo thickness (mm)	Filamentous algae length (cm)
1 (Expert)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	0.0%	4.7%	11.4%	0.0%	4.3%	4.7%	0.21	0.00	4.4
3	11.0%	6.7%	11.0%	0.0%	0.0%	15.2%	0.25	0.80	0.8
4	0.0%	0.0%	0.0%	0.0%	6.7%	0.0%	0.00	n/a	n/a
5	9.8%	7.2%	4.8%	1.9%	4.1%	1.0%	0.20	0.11	2.4
6	11.5%	6.4%	7.5%	0.1%	4.1%	4.4%	0.45	0.57	1.5
7	14.3%	8.0%	0.3%	0.3%	3.5%	15.0%	0.00	n/a	2.4
n	89	88	89	89	89	89	87	39	79
Average †:	**10.3%**	**6.5%**	**5.9%**	**0.6%**	**3.8%**	**6.0%**	**0.27 mm**	**0.40 mm**	**2.2 cm**

* No observer pairs involving a duet were included in this analysis.

† Computed as the average of all MAD values for expert-observer pairs in the dataset.

Figure 3-2 shows the quadratic regression between observer pair means and their corresponding standard deviations (SD). The regression is significant ($p < 0.001$) with a weak R^2 of 0.27. Both the parametric (quadratic) line and the nonparametric Lowess (locally weighted scatterplot smoothing) line show that variability in paired observations is highest among the midrange flora coverage levels and lowest at the low and high flora coverage levels.

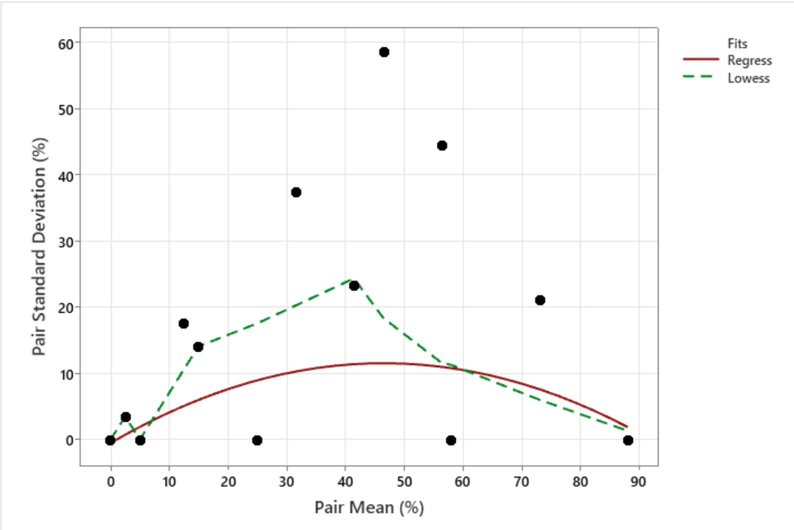


Figure 3-2. Pair Mean vs. Pair Standard Deviation for Observer Pairs for All Six Flora Cover Categories Combined (n = 1,386). The fitted regression line (red) is a quadratic and the Lowess smoother line (green) was set at 0.3.

Figure 3-3 shows the quadratic regression between observer pair means and their corresponding SDs. The regression is significant ($p < 0.001$) with a weak R^2 of 0.26. Unlike the quadratic regression line, the Lowess line does not show a reduction in pair SD at high filament length measurements. The plot suggests that observers had the most variability in measuring filament lengths when the filaments are in approximately the 5 to 15 cm length range.

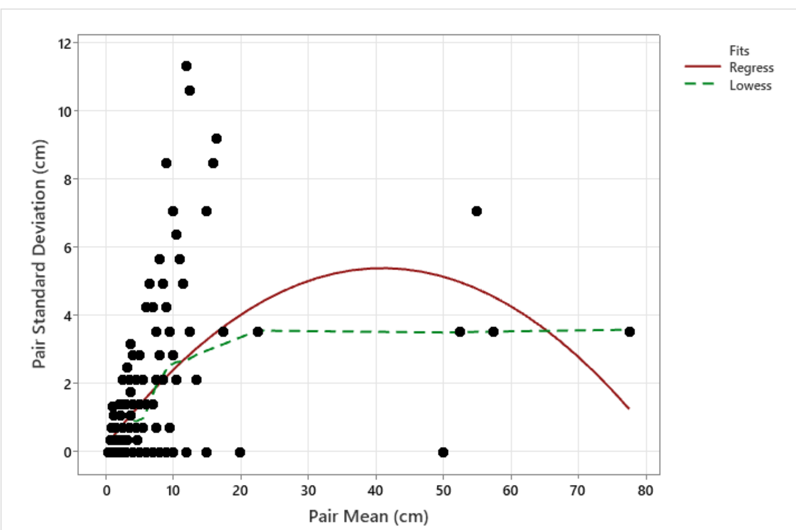


Figure 3-3. Pair Mean vs. Pair Standard Deviation for Observer Pairs for Measured Filamentous Algae Length (n = 201). The fitted regression line (red) is a quadratic and the Lowess smoother line (green) was set at 0.3.

4.0 Discussion, Conclusions, Recommendations

This evaluation of DEQ's Aquatic Plant Visual Assessment method (DEQ 2026) indicates, overall, that there is high degree of consistency among evaluations carried out by trained observers, with a few notable exceptions. Assessments of flora coverage among observers were strongly or very strongly correlated (**Table 3-1**). Further, the MAD between observers was smaller than the ranges one chooses amongst on the form, except for microalgae MAD (11.3%) which was a bit wider than one of the categorial choices (Sparse, which has a 10% range). Similarly, Killourhy et al. (2016) find that the precision of trained observers evaluating stream bottom cover by macrophytes and algae were all strong (0.84 to 0.87 Pearson correlation coefficient, which is a parametric coefficient analogous to Spearman's $\boldsymbol{\rho}$). The present study shows that there is much room for improvement in observers' evaluations of Didymo thickness, and to a lesser degree in observers' estimates of microalgae thickness. It is also evident that observers should be particularly careful when measuring average filamentous algae length when the filaments are in the 5 to 15 cm range, as this was the range where observer estimates varied the most (**Figure 3-3**).

Observers' years of experience carrying out aquatic visual assessments was not an important factor in reducing variability relative to the most experienced observer, as there was no correlation between observer's experience (ranked) and their ability to align with the expert's observations (see also, **Table 3-2**). This is further supported by the fact that the average MAD of expert-observer pairs (last row of **Table 3-2**) were very similar to the average MAD of *all* observer pairs (**Table 3-1**, right column). If years of experience were important, there should have been less average variation between expert-observer pairs compared to all-observer pairs, which is not the case. Killourhy et al. (2016) also found that MAD between all observer pairs was basically the same as the MAD between inexperienced observer estimates of % areal cover and the expert observer's estimates.

Consistent with Killourhy et al. (2016), there was higher variability in flora area cover estimates at the intermediate category ranges as opposed to the extremes (**Figure 3-2**). This finding was not unexpected as it is fairly easy for all observers to select the same category when coverage by a flora is 0% or approaching 100%, whereas the intermediate cover ranges can be challenging to select amongst.

4.1 Recommendations

Per findings in this study, it is recommended that DEQ institute some additional best practices to provide for more consistent measurements of Didymo thickness. This is a challenging flora type because (1) it can build up thickness on a rock as well as grow longitudinally away from the rock, (2) thickness can be variable and patchy, and (3) removing rocks from the stream bottom for measurement out of the water can result in slumped mats which may underestimate measurements. For periphyton (including Didymo), DEQ measures mat thickness by placing a mm-scale ruler into the mat as outlined in Stevenson and Bahls (1999); this is consistent with methods described in Zamorano et al. (2019). Recommended refinements are that more time be spent estimating what appears to be the average thickness of the Didymo patches in a quadrilateral. Then, if measuring the Didymo thickness *in situ* is problematic due to depth/velocity/etc., the observer should remove a rock with average-thickness Didymo on it and place it in a Tupperware container with water covering the mat. The mat thickness can then be easily measured with the ruler. These steps should reduce inter-observer variability.

It would also be advisable for DEQ to emphasize during annual training that estimating average filamentous algae lengths is particularly difficult when they are in the 5-15 cm length range. In such circumstances, observers should take extra time and care when recording the average length they are observing.

There could be some improvement in the determination of microalgae cover, which is something that can be addressed during annual training. Closely-attached microalgae can intermix with very short filamentous algae and Didymo, and additional time should be spent in training to show observers how to distinguish the differences.

Under normal circumstances (i.e., not during this study), and as a general practice, DEQ field teams carrying out visual assessments on a stream or river will discuss their observations and try to come to a consensus as to which categorical level to select on the form. This is a good best practice as demonstrated by others (Kodani et al. 2024) and should be continued to the degree practicable going forward.

5.0 ACKNOWLEDGEMENTS

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APPENDIX A. THE AQUATIC PLANT VISUAL ASSESSMENT FORM FOR FULLY WADEABLE STREAMS AND RIVERS

Waterbody: ____________________ Site Visit Code: ____________________

Date: ______________ Reach: 11-transect layout

Visit No.: ________

Transect Letter:	A			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter:	B			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter:	C			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Site Visit Code: ____________________

Date: ________________

Transect Letter:	D			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter:	E			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter:	F			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Site Visit Code: ____________________

Date: ________________

Transect Letter: G

AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter: H

AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter: I

AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Site Visit Code: ____________________

Date: ______________

Transect Letter:	J			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Transect Letter:	K			
AQUATIC PLANT VISUAL ASSESSMENT FORM	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W**=White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes (list below)	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS

Macrophytes (dominant, most to least):

Appendix B. The Aquatic Plant Visual Assessment Form for Partially Wadeable Medium Rivers

Waterbody: ______________________________ Site Visit Code: ______________________

Date: ______________ Visit No.:______ Site/Reach: ______________________/______

Transect Locale: Right

AQUATIC PLANT VISUAL ASSESSMENT FORM Medium or Large River	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W** = White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick =** > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS:

Macrophytes (dominant, most to least):

Transect Locale: Center

AQUATIC PLANT VISUAL ASSESSMENT FORM Medium or Large River	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W** = White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick =** > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS:

Macrophytes (dominant, most to least):

Transect Locale: Left

AQUATIC PLANT VISUAL ASSESSMENT FORM Medium or Large River	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **W** = White **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick =** > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS:

Macrophytes (dominant, most to least):

Waterbody: ____________________________ Site Visit Code: ______________________

Date: _______________ Visit No.: _____ Site/Reach: __________________/__________

Transect Locale: Entire	Only use this form if the entire transect can be clearly viewed and assessed			
AQUATIC PLANT VISUAL ASSESSMENT FORM Medium or Large River	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin =** < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick =** > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**Microalgae/*Didymo*:** Thickness (Thin, Medium, Thick) and/or Measured Thickness (mm). **Filamentous Algae:** Length (Short or Long) and/or Measured Length (cm).
Microalgae	0 1 2 3 4			mm:
Filamentous Algae	0 1 2 3 4			cm:
Didymosphenia	0 1 2 3 4			mm:
Chara	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			

COMMENTS:

Macrophytes (dominant, most to least):