Determining Restoration Potential Using the Stream Functions Pyramid Framework

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Restoration Potential

Restoration potential is defined in *A Function-Based Framework for Stream Assessment and Restoration Projects* as the highest level of restoration that can be achieved based on the health of the contributing catchment, reach-scale constraints, and the results of the reach-scale function-based assessment. Restoration potential is determined by the degree to which physical, chemical and biological processes at both watershed and reach scales are maintained or restored. The “highest level” refers to the five pyramid levels in the Stream Functions Pyramid, and whether or not a project can restore functional capacity within each of the levels to a reference condition. A project with full restoration potential would restore the functional capacity within all five levels (the highest level being biology) back to a reference condition. Partial restoration would improve functions within some but not all levels of the pyramid. For example, partial restoration might mean improving stability and aquatic habitat back to a reference condition by implementing activities that manipulate processes in the Hydrology, Hydraulics, and Geomorphology Functional Categories, but not improving Physicochemical or Biology to a reference condition due to watershed stressors (Beechie et al. 2010; Harman et al., 2012).

<u>Full Restoration Potential</u> – The project reach has the potential to restore functions within all five pyramid levels, including biology, back to a reference condition. Reference condition captures the pristine or culturally unaltered condition (i.e., the condition expected in the absence of anthropogenic influences) to the degree that it can be represented by existing data and best professional judgement (Stoddard et al. 2006). This definition aligns with the reference standards definition in the federal Mitigation Rule, which is defined as the least disturbed aquatic resources in a given class of resource and exhibits the highest levels of functions by that class (Federal Register 73:70 (April 10, 2008) p. 19624) Reference condition and reference standard does not necessarily equate to the best attainable condition that a site can achieve after restoration activities are implemented. Therefore, it is important to understand the difference between reference standard condition and best attainable condition. This is consistent with the ‘full-restoration’ concept identified by Beechie et al. (2010), where actions restore habitat-forming processes and return the site to its natural or reference standard range of conditions and dynamics.

Partial Restoration Potential – The project reach has the potential to restore some functions to conditions better than pre-project or baseline conditions. One or more functional categories may be restored to conditions typical of or approaching reference standard conditions, but some catchment stressors or reach-scale constraints are preventing the site from reaching full potential.

This is the most common restoration-potential level for stream restoration projects. For example, watershed processes and reach-scale constraints influencing a project site are often functioning at a level where some functions/conditions, such as floodplain connectivity, channel stability (dynamic equilibrium) and in-stream habitat can be restored, but watershed and reach-scale processes may be limiting the restoration of physicochemical and/or biological functions to reference standard condition. For partial restoration projects, improvements in all pyramid levels may be observed, but these improvements may not reflect a fully functioning reference condition. This is consistent with the 'partial-restoration' concept identified in Beechie et al. (2010), where actions restore some processes and functions, but do not return the site fully to its natural or reference range of conditions and dynamics.

There are likely situations where even partial restoration is not possible due to the severity of the catchment stressors and project constraints. For example, flow alteration (catchment-scale stressor) may modify the hydrologic and sediment transport processes within a catchment, and these factors may be outside of the control of the practitioner. Land use constraints like sewer lines and roads may artificially constrain the project limits. Some stressors and constraints limit restoration potential to such a degree that the site is not appropriate for restoration activities. If the underlying processes do not have the potential to support at least partial restoration, the site may not be an appropriate site for restoration.

Catchment Assessment and Stressors

Understanding watershed condition is critical to understanding a site's potential for restoration. A catchment-assessment form is used to identify stressors that could limit the restoration potential. This form includes various categories and qualitative ratings that can be used to identify catchment stressors/perturbations that exist outside of the project reach. This assessment is designed to assist the practitioner in understanding whether any anthropogenic stressors may have altered the underlying stream processes, including hydrologic, sediment transport, chemical and biological processes. Oftentimes, the problems that alter these processes and limit restoration potential cannot be changed as part of the reach-scale project; they are beyond the practitioner's control. The catchment-assessment form primarily includes an investigation upstream of the project reach; however, some questions, like impoundment locations, also look downstream. The catchment assessment form is not meant to create an overall score, but rather to aid practitioners in determining how catchment conditions could limit the ability of the project activities in restoring a site to a reference standard condition. The final part of this process is to determine if the restoration activities can overcome any or all of the catchment perturbations. This may require work beyond the project reach as part of a catchment management plan, and would typically be beyond the scope of many stream restoration or mitigation projects.

At the reach scale, practitioners should consider several factors, including the size of the restoration project in relation to the watershed. For small catchments where the length or area of the restoration project is large compared to the total stream length or area of the contributing catchment, reach-scale activities associated with the project may be able to overcome the stressors and perturbations.

Catchment-scale efforts, in combination with a restoration project, may be able to overcome catchment perturbations/stressors. For example, flow alteration may be so severe that dry-up points are occurring within reaches above the project reach, and restoration may not be successful unless the practitioner can restore important aspects of the flow regime. These broader-scale efforts could also include managing sources of sediment imbalances within the contributing watershed, improving stormwater management practices, restoring more natural hydrology, removing connectivity barriers, etc. Evaluating and addressing stressors to underlying hydrologic or sediment transport processes will require additional design and/or modeling analyses that are outside the scope of many stream restoration projects.

Reach-Scale Constraints

Constraints are human-caused conditions, structures and land uses that inhibit restoration activities at the reach scale. A constraint is different than a stressor. Constraints occur at the project-reach scale and prevent the practitioner from implementing the ideal design approach. A stressor, as described in the previous section, occurs at the catchment-scale, outside of the project reach, and negatively affects processes need to support full restoration potential (and in extreme cases even partial restoration). Stressors and constraints are beyond the control of the practitioner. Common constraints include land uses within the floodplain or valley bottom that minimize stream-corridor width (e.g., roads, easement widths, levees/berms, etc.), diversion structures that affect the natural timing, magnitude, duration, frequency or rate of change of flows; and existing dams or culverts that function as migration barriers for fish and prevent streambed elevation changes during design.

Natural conditions are not constraints. For example, hillslopes also minimize the lateral extent of meandering; however, they are not a constraint. Hillslopes are a natural condition of the catchment. The presence of bedrock can limit changes to bed elevation and even prevent some aquatic species from migrating upstream. However, these are natural conditions that create heterogeneity of habitats and therefore aquatic life. They are not considered constraints in this methodology and would therefore not limit the restoration potential.

Function-Based Assessment of the Project Reach

The last part of determining restoration potential is the reach-scale function-based assessment. The Stream Quantification Tool (SQT) or other assessment method can be used for this task. The primary purpose is to determine the baseline condition of the reach. For example, is it actually impaired and in need of restoration? And, what is the stage of channel evolution, is the system trending towards higher-level functions or towards a more impaired condition? Based on this trend, can the ecosystem recover from simple management changes, e.g. removing cattle from the stream, or is heavy equipment helpful for moving the system to a higher functional stage in a shorter timeframe.

Channel evolution may be determined two ways. First, the Stream Evolution Model (SEM) presented by Cluer and Thorne (2013) may be used to determine the past, present, and future SEM stage along with a description of the functional impairments. This tool is helpful for projects located in wide alluvial valleys with low sediment supply where the original stream corridor was a stream/wetland complex. Second, the Rosgen Channel Succession Scenario may be selected (Rosgen, 2006). The future SEM and Rosgen Stream Type are determined using the results of the function-based assessment, the constraints, and results from the catchment assessment. Both approaches are provided because the SEM provides more detail for systems that started as stream/wetland complexes (anastomosed) than the Rosgen method, and provides functional descriptions for each stage. The Rosgen approach is provided because it includes channel evolution changes in a wider range of valley types than the SEM, e.g., a single-thread mountain stream. It also includes responses to a wider range of disturbances.

With the above information as a guide, the following is a step-wise approach to determining restoration potential using the Stream Functions Pyramid Framework.

Step-Wise Approach to Determining Restoration Potential

Step 1 Determine the project reach limits and delineate the catchment area to the downstream end of the reach.

Step 2 Complete the catchment assessment form and provide an overall rating of Good, Fair, or Poor. Review the scores for each category as well to determine if the stressor can be overcome or if it will prevent the project reach from obtaining even partial restoration. A stressor that prevents partial restoration may be considered a “deal breaker” that leads to a decision that the project should not be pursued until catchment-scale stressors can be improved.

Step 3 Compare the reach size (length and/or area) to the catchment size. Can the size and type of restoration overcome the catchment stressors and perturbations?

Refer back to the individual category ratings in Step 2. Can the fair or poor ratings for each individual category be overcome by the size of the project or by doing additional work in the catchment? If many of the ratings can change from fair or poor to good, then full restoration may be possible. If not, then partial restoration is more likely. If stressors and perturbations are severe, perhaps the reach is not a good candidate for restoration.

Step 4 Identify reach-scale human-caused constraints. Explain how they could limit restoration potential.

Step 5 Perform a function-based assessment of the project using the SQT or other assessment method.

Step 6 Determine the baseline condition of the reach. If using the SQT, the tool will illustrate functional capacity by parameter and functional category.

Step 7 Using information from above, determine the Stream Evolution Model and/or Rosgen Channel Succession Stages. Is the stream moving towards greater or lesser functionality? What is the realistic final Stage or Stream Type of evolution as compared to the previously undisturbed Stage or Stream Type? Note, in the SQT, this information is used to determine the Proposed or Reference Stream Type.

Step 8 Based on results from the above steps, describe the restoration potential as Full or Partial. Explain the reasons for your selection. Identify which parameters/functions could be restored to a functioning condition following the project (i.e. reference standard condition) and which may not.

Restoration Potential Applications

The determination of restoration potential can be used for a variety of applications. A few are listed below; however, users are encouraged to also find new applications.

1. Clear Communication of Project Expectations – This can simply be the narrative prepared in Step 8 above, perhaps with the supporting information from the catchment assessment, constraints analysis, and reach-scale assessment. The text can be included in a restoration/mitigation plan to clearly communicate project expectations. This will assist future readers and potentially researchers who want to evaluate the project's success in restoring stream functions.
2. Development of Function-Based Goals – Restoration potential can be used to develop realistic project goals. Project goals should be realistic and justified by catchment-scale

stressors and reach-scale conditions/constraints. The goals should not exceed the restoration potential. In other words, goals should not state that native fish communities will be "restored" if the restoration potential is Partial. Fish habitat may be restored and the fish community may be "improved", however, they will not return to a reference condition under a Partial Restoration Potential scenario.

3. Assisting with Alternatives Analysis – The evaluation of restoration potential can help develop design alternatives by raising questions about the size and scope of the project, as well as the removal of constraints, and even catchment stressors. For example, if the project size is increased and constraints are eliminated, the restoration potential may increase.
4. Assisting with Final Site Selection – Determining restoration potential is not the same thing as making a site-selection decision. Stream restoration project sites are selected for a wide variety of reasons, primarily depending on the funding or program driver. However, knowing the restoration potential and comparing it to project goals (including the funding goals) can help make a site-selection decision.

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