

RiverRAT: SCIENCE BASE AND TOOLS FOR ANALYZING STREAM ENGINEERING, MANAGEMENT, AND RESTORATION PROPOSALS

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Abstract

Stream management activities, even well intentioned restoration efforts, have all too often degraded aquatic ecosystems. Site- and reach-scale habitat improvement projects have become the default solution to many habitat deficiencies and constraints, and are often planned and implemented without proper consideration of their landscape context, process drivers, or geomorphic fitness. Failure to recognize these broader scale concerns may lead to poor project selection and increased potential for project failure.

To address these issues, we developed a suite of River Restoration Analysis Tool (*RiverRAT*) resources to guide more efficient, consistent, and comprehensive reviews of stream management and restoration proposals. Resources help determine the depth of review required, assure that a project proposal is complete, and guide reviewers through a thorough and scientifically sound project review. The *RiverRAT Science Document* and its *Appendices* provide a comprehensive synthesis of science behind stream management and restoration project development. Training is ongoing for federal and state regulatory agency staff throughout western states.

The ultimate, long-term goals of RiverRAT include:

- Enabling consistent, comprehensive, transparent, and documented project reviews;
- facilitating improved project planning and design;
- encouraging projects that are attuned to their watershed and geomorphic context; and
- improving the science and technology of stream restoration and management.

The *RiverRAT* tools, the supporting *Science Document*, and the detailed technical appendices, are available to the public at **www.restorationreview.com**.

BACKGROUND AND NEED

Management of stream corridors spans a wide range of intended outcomes, including reconstruction/renovation of structural assets, channel rehabilitation, stabilization of eroding streambanks, management or diversion of in-stream and flood flows, sediment management, river restoration and habitat enhancement to promote a species or biodiversity, or for mitigation. However, streams are complex and dynamic systems, and projects undertaken with the best of intentions may still cause unintended outcomes that could pose unacceptable risks to fisheries or habitat, either directly or by imposing additional constraints on natural processes. While implementation may result in short-term impacts, alteration of fluvial processes may result in longer-term, and thus more adverse, effects.

Guidelines and manuals do currently exist for the development of specific elements of stream management projects; however their focus is typically on the engineering or design aspects without provision for a watershed process or management context. No accepted standard of guidance exists for stream management projects; hence all guidelines are limited in scope with respect to the specific needs of the reviewing regulatory agencies.

NOAA's National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) (Services¹), given Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultation authorities, and review authority under the Fish and Wildlife Coordination Act (FWCA), have a responsibility to evaluate river projects funded, authorized, permitted, conducted, or consulted on in any way by the Federal agencies—in essence, any project in a river environment that may have an impact on protected species or the stream processes, habitat, or ecosystem they depend upon. Other federal and state agencies bear similar responsibilities for evaluating proposed stream projects in a range of specific regulatory contexts. All organizations that fund stream projects have an inherent responsibility to evaluate projects and measure their success relative to stated goals and objectives. Our team has identified a specific need for Services staff to review river management projects in the context of both watershed setting and fluvial geomorphic processes. To this end, we have produced *RiverRAT* (River Restoration and Analysis Tool) and a suite of evaluation tools, supporting science, and training that create a solid scientific foundation for a thorough and comprehensive review of river restoration projects, beginning with problem identification, developing goals and objectives, understanding physical and biological processes in relation to project effects, assessing risks to resources and risks of the project, post-project appraisal, and compliance and effectiveness monitoring.

OVERVIEW OF RiverRAT, APPROACH AND PRODUCTS

Our team produced three products: (1) a widely-vetted and peer-reviewed science document that emphasizes the physical processes related to the formation and maintenance of river system habitats, (2) integrated evaluation tools that provide for a transparent review process, including a

¹ “Services” herein refers primarily to NOAA's National Marine Fisheries Service (NMFS) and USFWS as a primary audience, though not intended to be exclusive of state fish and wildlife agencies. Acknowledging that Services employees are largely trained in biological sciences, these resources emphasize understanding of physical processes that influence stream habitat and that are affected by management actions.

project screening matrix, information checklist, and on-line project analysis tool, and (3) training in the use and application of the science document and tools.

The goals of this joint project were to enable project reviewers to:

- Understand the connections between physical processes and aquatic habitat.
- Understand the connection between common management actions, effects, and associated risks to protected species and habitat.
- Understand alternatives that can minimize project-related risks to protected species and habitat.
- Provide science and understanding that promote the design of sustainable projects, resilient to physical processes and changing environmental conditions.
- Document and streamline project review, and foster consistency among project reviewers.
- Promote effective post-project appraisals, leading to more effective future river management.

While an emphasis on salmonid recovery and ESA context in the Pacific Northwest and California is inherent in this NMFS-led effort, the resources and tools have broader utility and could easily be adapted to other agencies jurisdictions, other geographic regions, and specific ecological resources.

RiverRAT Science Document

The *RiverRAT Science Document* begins with a description of three new tools for project review: a project screening matrix to help determine the depth of review a project might require, a project information checklist to help assure that a proposal includes everything necessary for review, and web-based River Restoration and Analysis Tool itself. The bulk of the *Science Document* is then devoted to a synthesis of the integrated science of fluvial geomorphology as it relates to river habitat, starting with physical watershed controls, and progressing through stream processes and channel forms, thus providing a thorough scientific foundation for evaluating the potential impacts of stream projects. The document presents a logical process for the development of engineering or management actions in rivers, including those intended to improve habitat, such as restoration and stabilization projects. In addition, it provides tools for the evaluation of project proposals. Together, the document and tools provide a sound foundation in fluvial geomorphology and its relevance to river habitat so that proposed projects may be thoroughly evaluated in a timely manner with respect to their potential risks to species and habitat.

To facilitate deeper review of project design and analyses, the science document also includes:

Appendix 1: investigative analyses that form the basis for evaluating existing and proposed conditions.

Appendix 2: design approaches and the application of design criteria to development of specific design elements as well as for developing specific monitoring metrics.

Appendix 3: additional management alternatives.

Appendix 4: annotated bibliography of stream management and restoration design guidelines.

The *Science Document* highlights common approaches to stream management (including restoration) that may not account for temporal or spatial variability or may actually constrain natural channel processes. Projects proposed as restoration, stabilization, and/or remediation often include project elements that are site-specific (e.g. 10's to 100's of meters in stream length), in large part because many constraints to aquatic species are identified at this scale. Many projects are unsuccessful because they address local-scale symptoms without understanding the wider causes of habitat loss or degradation, which are often reach or watershed scale problems. Site-specific actions, such as meander reconstruction, the addition of weirs, installation of large wood structures, and biotechnical bank stabilization, have become the default solution to many habitat problems and constraints, yet they are often planned and implemented without consideration of physical processes that may influence their outcomes or the potentially negative impacts of some project elements.

Application of traditional engineering design standards, such as 'factors of safety' biased towards structural stability, affords certain benefits in terms of professional accountability and rigorous analysis, but also simultaneously tends to increase risk aversion. The inherent problem with risk aversion in 'stream restoration' schemes is that it commonly leads to over-design, and hence a greater reliance on engineered structures to ensure an acceptable 'factor of safety'. The resulting projects often impose unnecessary and undesirable constraints on natural channel adjustment and evolution - limiting long-term habitat value and potentially inhibiting habitat creation and maintenance.

To address these issues, the science document and tools facilitate identification and evaluation of the constraints, uncertainties, and risks associated with proposed projects. To this end, the document and tools discuss and encourage project development and review to include:

- Understanding how engineering and management actions affect the physical stream processes operating at varying scales (e.g., site, reach, and watershed).
- Accepting that uncertainty is inherent to all engineering and management actions in rivers with respect to predicting project outcomes and potential risks to physical processes and the habitats and species they sustain.
- Promoting solutions to identified problems that address the root causes at appropriate scales, rather than simply treating the symptoms of the problem at the site-scale.
- Acknowledging that human influences are fundamental components of all ecosystems, at all scales.

While an emphasis on salmonid recovery and ESA context in the Pacific Northwest and California is inherent in this NMFS-led effort, the resources and tools have broader utility and could easily be adapted to other agencies jurisdictions, other geographic regions, and specific ecological resources.

Tools For Project Review

The *Science Document* provides the scientific basis for the *Project Screening Matrix*, the *Project Information Checklist*, and the *River Restoration Analysis Tool (RiverRAT)*. The *Screening Matrix* is intended to assist reviewers in making an initial analysis of the level of potential impact to resource associated with a proposed project, in order that reviewers may match the depth of review to the level of risk posed by the project should it be permitted; it is also intended to help reviewers decide whether the potential for impact is sufficiently high to merit technical assistance from specialists in associated disciplines. The *Project Information Checklist* is used to determine whether the project proposal contains sufficient information to allow Services' staff to conduct a comprehensive review and highlights any missing information. The checklist reporting function makes clear to project proponents exactly what information will be needed for a review to proceed, so that the information can be provided efficiently, thus speeding up the review process. After receiving all pertinent information, reviewers can use *RiverRAT* to conduct a thorough, comprehensive, transparent, and documented project review.

RiverRAT Project Screening Matrix

Effective and efficient review of stream projects begins with a determination of relative project impact potential. Assuming that project review workloads will always outpace review capacity, it is critical that reviewers allot their limited time to the projects that pose the greatest potential impact to resource. The need for staff to use their time efficiently means that effort cannot be expended over-scrutinizing proposals that pose very little risk of impact. Clearly, a balance must be struck through which the possibility of missing a high impact project is properly set against the need to move proposals through the review system efficiently.

Experienced reviewers are generally able to achieve this balance, and hence allocate the appropriate level of effort to each proposal based on their professional judgment; however, the natural tendency for new reviewers is a precautionary approach, thus leading to long review times. Decision deadlines introduce an additional danger that a high-risk proposal will be overlooked without proper analysis. To help reviewers develop and improve their capability to match the intensity and extent of review to the inherent project risk, a screening tool has been developed (Figure 1). While initially intended for new reviewers, we believe that even experienced reviewers may find it helpful to refer to the screening tool to refine their approach and increase consistency. The screening tool is **not** intended as an alternative to professional judgment. Rather, it is intended as a training aid that can be used in developing and refining that professional judgment, for which there is no viable alternative.

The *RiverRAT Project Screening Matrix* is in the form of a 2-axis matrix in which the X-axis represents Stream Response Potential, and the Y-axis represents Project Impact Potential.

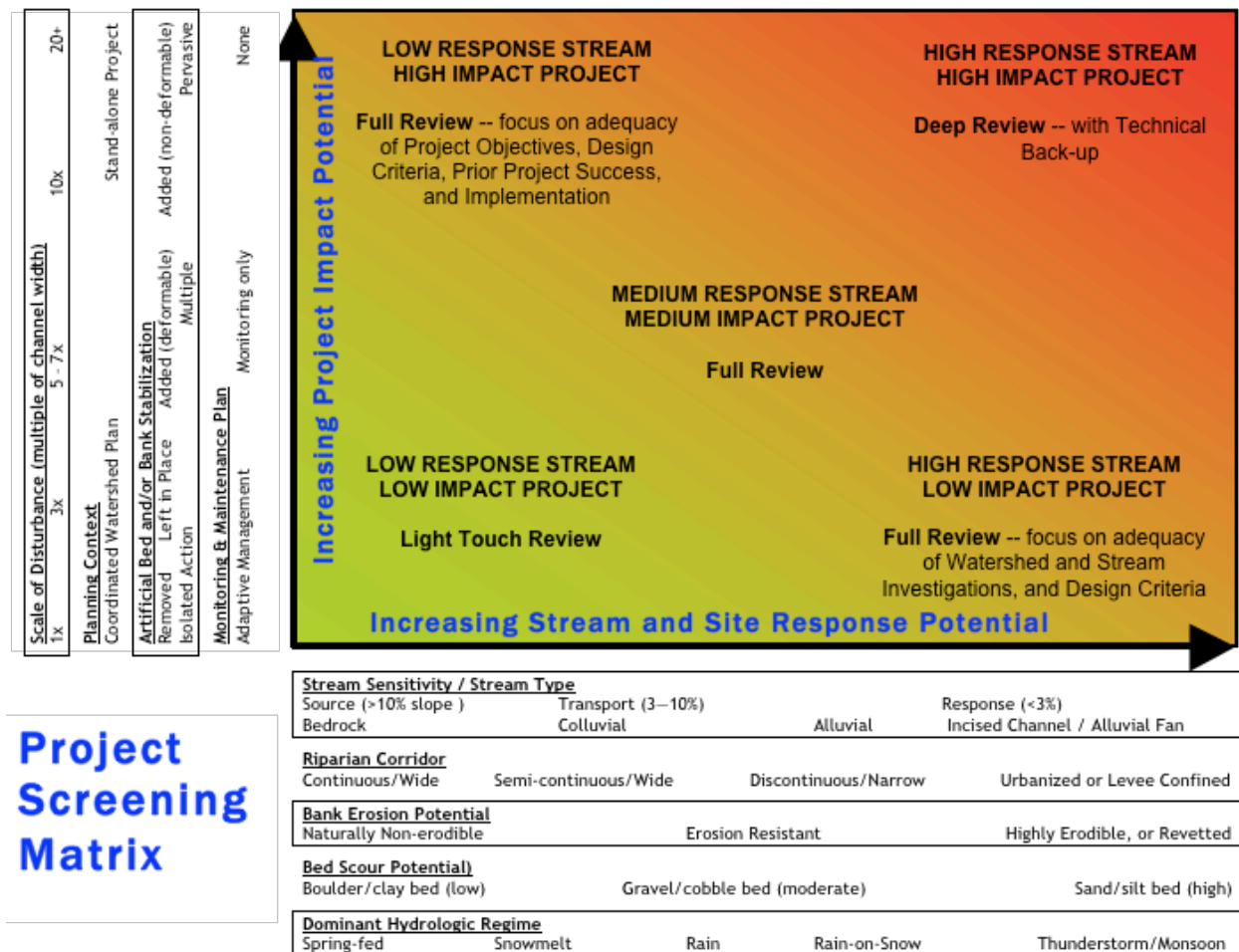


Figure 1. The Project Screening Matrix.

The principle underlying the *Screening Matrix* is that actions and projects should do no lasting harm. Within this principle, reviewers will assess the risk of doing harm to ‘resource’ within the context of the relevant legislation. For example, in the case of NMFS this will usually center on Section 7 of the Endangered Species Act, and so ‘resource’ will refer to one or more listed species and their habitat. However, it should be noted that staff with the US Army Corps of Engineers (USACE), who are also operating under Section 404 of the Clean Water Act, would have an expanded definition of ‘resource’. The ‘resource’ in their case is, primarily, water quality in a ‘Water of the United States’, which is a strictly defined type of water body. USACE staff may also be working under Section 10 of the 1899 Rivers and Harbors Act (as amended), in which case ‘resource’ would be expanded to include navigability.

The *Screening Matrix* as presented here may be adapted for use by different reviewers/agencies and in different contexts according to their needs. However, it is intended primarily for use by staff with NMFS or the USFWS with emphasis on aquatic species and their habitats.

The ***x-axis*** represents the *stream response potential*, or the inherent sensitivity of the stream and its habitat to natural or anthropogenic disturbance. This axis uses stream attributes, such as gradient, bed and bank material, and localized geomorphic context, to assist reviewers in making an initial assessment of the overall risk to resource stemming from the landscape context, natural system resiliency, and imposed human modifications. Some stream types are naturally sensitive to disturbance, while others may have become sensitized due to land use history and past engineering/management in the river network. The inherent sensitivity of a stream to disturbance depends on numerous factors, but we have narrowed these down to the following five:

1. Landscape setting and associated stream type, such as source, transport, and response reaches;
2. The resilience of the stream system to absorb and adjust to changes in flow and sediment, indicated by floodplain extent and condition of the riparian corridor;
3. The ability for the stream to adjust laterally to changes in flow and sediment as determined by the bank characteristics;
4. The ability for the stream to adjust vertically to changes in flow and sediment as determined by the scour potential of the stream bed; and
5. The frequency and degree of hydrologic disturbance associated with typical hydrologic regimes.

The ***y-axis*** represents *project impact potential*, or the potential for impacts to stream resources and processes associated with the proposed action or project type. Some disturbance to the fluvial system is inevitable when performing actions in or near a stream or undertaking a restoration scheme. This axis, therefore, uses indicators of the project scale, context, cumulative impacts, introduced artificial constraints, and the ability to detect impacts to assist reviewers in making an initial risk assessment of the proposed action or project.

There are numerous risks that stem from project implementation and maintenance, which we have narrowed to four overarching factors:

1. The extent of the proposed disturbance;
2. The watershed planning context, including the quality and scope of planning for the action or project and, particularly, whether the catchment context has been properly established;
3. The degree of artificial lateral and vertical constraints and the capability of the stream to accommodate future changes in the flow and sediment regimes;
4. The level of post-project appraisal and adaptive management to address undesirable morphological responses to the action or project that may impact habitat and species.

The *Screening Matrix* transitions from green in the lower left corner, indicating that a “light touch” project review may be sufficient, to red in the upper right corner indicating that a deep review of the project may be justified or necessary. The matrix indicates an appropriate level of design and review as a function of potential risk to natural resources - it does not mean that a project is either good or bad for habitat. For example, many restoration projects that provide great benefit to habitat and species may also plot in the red zone, due to the level of disturbance necessary to restore or connect valuable habitat.

The axes of the screening matrix presented here purposefully have no scales; similarly, no examples are given of projects that might typify a particular level of impact potential or streams that possess representative levels of response potential. The lack of quantification and examples does not reflect a lack of knowledge or understanding of potential project impact and stream response. Rather, the matrix has not been quantified or populated because there is no cookbook way to assess the risks associated with a proposed action or project *a priori*. Our purpose here is not to tell end-users the answers to difficult questions, but to help them to understand risks and pose the right questions in the first place.

In screening out low risk projects on low risk streams and using the time saved to allow deeper scrutiny of higher risk projects and more sensitive streams, responsibility for balancing expediency against thoroughness rests with the individual making the decisions on a daily basis. In this spirit, the *Screening Matrix* is offered as a training aid with which Services staff who are new to reviewing proposals can quickly and effectively develop and refine their decision making skills. By populating the *Screening Matrix* with their own examples, new reviewers will learn both from more senior colleagues and through their own experience how to recognize project types that pose greater risk to resource, and which streams in their geographical area are more sensitive to disturbance.

Table 1. Selection of treatment based on project impact potential and stream response potential.

Impact & Response Potential	Level of Review	Indicated Treatment
Low Response Stream Low Impact Project	Light	<ul style="list-style-type: none"> • Only light review needed • Light touch okay for RiverRAT evaluation
Low Response Stream High Impact Project	Full	<ul style="list-style-type: none"> • Full review needed • Particular attention paid to adequacy of: <ul style="list-style-type: none"> • Project objectives; • Project elements that pose greatest threats; • Design criteria; • Evidence of prior success with similar projects • Implementation plan • Since stream risk is low, responses to action may be limited to project and adjacent reaches • Lighter touch okay for evaluating wider watershed and stream channel contexts and implications of proposed work
Medium Response Stream Medium Impact Project	Full	<ul style="list-style-type: none"> • Full review needed • Careful application of RiverRAT recommended
High Response Stream Low Impact Project	Full	<ul style="list-style-type: none"> • Full review needed • Particular attention paid to adequacy of: <ul style="list-style-type: none"> • Watershed and stream investigations; • Design criteria related to preventing project impacts on greater fluvial system; • Plans for post-project monitoring and adaptive management to limit unforeseen impacts within project reach
High Response Stream High Impact Project	Deep	<ul style="list-style-type: none"> • Full extensive review needed • Proposals may be complicated or groundbreaking, requiring backup from subject specialists to deal with challenging technical aspects • Reviewers should not hesitate to seek assistance where necessary

RiverRAT Project Information Checklist

The *RiverRAT Project Information Checklist* (Figure 2) queries the user regarding information sufficiency and applicability. The user is encouraged to enter comments and print the results, which can be filed for documentation of the review, or shared with a project applicant if appropriate.

	A	B	C	D	E	H
1	Item #	Yes - Sufficient	No - Insufficient	NA - Not Applicable	CHECKLIST CONTENT - HEADINGS	Comments
2						
3					PROJECT SPONSOR AND TEAM	
9					ESA SECTION 7 AND CONSULTATION HISTORY	
13					EXISTING CONDITIONS AND CONTEXT	
33					DESCRIPTION OF PROPOSED ACTION	
72					DESIGN DOCUMENTATION	
93					MONITORING AND MANAGEMENT PLAN	
97					EFFECTS ANALYSIS - WHAT IS AT RISK?	
112						
113						
114						
115						
116						
117						
118						
119						

Figure 2. The major information categories in the *Project Information Checklist*.

The *Project Information Checklist* is a comprehensive list of all information that a project proposal could contain for a thorough review by Services' staff and has been developed for use as a template for a Biological Assessment (BA), thus providing a consistent model for the organization and content of a complete BA. The primary purpose of the *Checklist* is to determine if there is sufficient information provided to facilitate the use of *RiverRAT*. However, it may also be used to determine if there is sufficient information to conduct a pre-consultation or pre-application review, or it may be employed during or after evaluation to ensure that the review process has been properly completed.

An excerpt of the detailed questions is provided in Figure 3. By providing all information suggested in the checklist, a project team can avoid delays during the review process, and a reviewer can be reasonably assured that a project team has put in the effort required to develop a well-thought-out project that encompasses appropriate spatial and temporal scales, landscape

context, risk, design approach, and adaptive management. Ideally, use of the checklist by both project developers and reviewers will promote time and resource efficiency and will make the review and consultation process more transparent to both parties.

DESIGN DOCUMENTATION

	Y	N	NA	
				Design team
57	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Name and titles of firms and individuals responsible for design.
58	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	List of project elements that have been designed by a licensed Professional Engineer.
				Hydrologic analysis
59	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Description of historic, ongoing, or anticipated impacts to basin hydrologic regime.
60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Summary of hydrologic analyses conducted, including data sources and period of record.
61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	List design discharge (Q) and return interval (RI) for each design element.
				Sediment transport and dynamics analysis
62	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Description of previous or anticipated impacts to basin or reach sediment supply.
63	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Summary of sediment supply and transport analyses conducted, including data sources.
64	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Describe sediment size gradation used in streambed design.
				Hydraulic analysis
65	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Summary of hydraulic modeling or analyses conducted and data source.
66	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Inundation map for design and flood flows before and after implementation.
				Vegetation design
67	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Species list, materials sources, and plant form.
68	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Planting plan map (distribution and density by species) and irrigation plan.
				Soils and geotechnical analysis
69	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Summary of geotechnical analyses including stratigraphy and grain size of materials.
70	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Groundwater elevation, flow direction and seasonality within floodplain and banks.

Figure 3. An example of details in the *Checklist*, under the design documentation section.

The Project Analysis Tool – *RiverRAT*

RiverRAT is an on-line framework for project evaluation that guides reviewers through a thorough review of a project proposal (Figure 4). The entire project development process is addressed, beginning with problem identification in the planning stages, progressing through the design phase, and culminating with project monitoring. While *RiverRAT* is geared toward answering the question of “what are the potential impacts and risks to resource”, it also enables a review of project and design integrity with respect to species or ecosystem recovery. In an ESA context, *RiverRAT* can be used during pre-consultation, in preparation of a Biological Assessment, or in effects analysis for a Biological Opinion. In a FWCA context, *RiverRAT* can also be used for pre-application discussions or evaluation of potential project impacts to the Services trust resources. Access to *RiverRAT* by project sponsors, stakeholders, and specialists will give them insight regarding the review process and will guide them to developing project

proposal documents that are both more informative and better tuned to the needs of the Services' staff who must review the proposal.

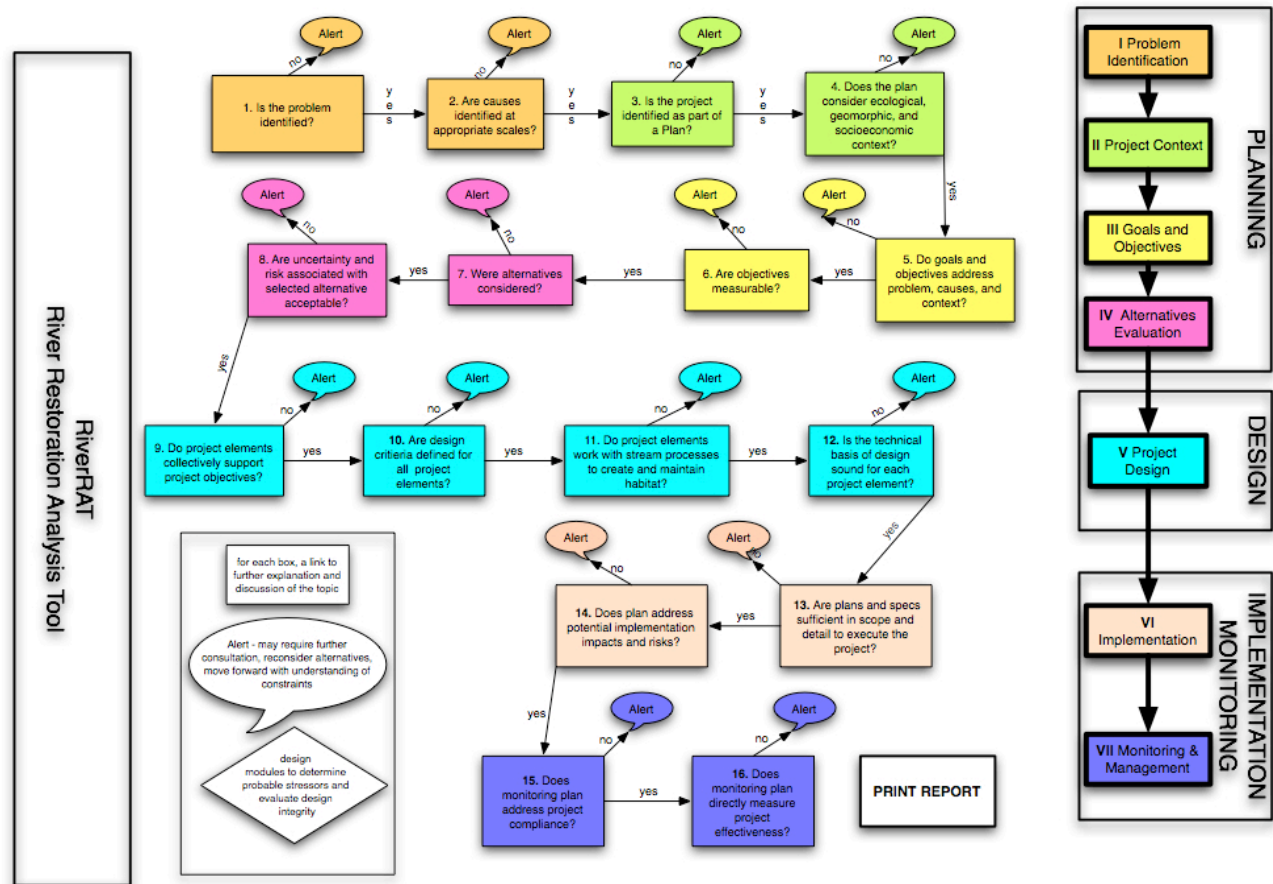


Figure 4. The *RiverRAT* framework.

RiverRAT provides a framework and links to additional technical resources and assistance that may be needed to support in-depth and detailed scientifically based and objective treatment that is justified for projects that carry a high risk to resource. The *RiverRAT* homepage (Figure 5) also provides access to the *Science Document*, its supporting *Appendices*, the *Screening Matrix*, and the *Project Information Checklist*, all anonymously. To gain access to *RiverRAT* through the webpage requires a login with a username and password that are obtained by request via email.

Project

Welcome to River Restoration Analysis Tool, or RiverRAT. River RAT is a river project development and evaluation tool. It was developed to facilitate consistent and thorough evaluation of the potential impacts of proposed projects on river habitat. The tool is supported by a source document that provides a comprehensive synthesis of the watershed and river sciences relevant to restoration planning and design, a project risk evaluation matrix, and a separate comprehensive checklist of information necessary to review project proposals.

The RiverRAT tool will walk you through a series of 16 questions that parallel the phases of restoration project development. Each question is designed to help you evaluate whether a project has addressed fundamental considerations at each step of the project development process. You will be able to record your responses and thoughts for each question, and print a final report to document your review.

If you would like to explore River RAT click [here](#).

If the tool suits your needs, [request your own username and password by contacting us here](#).

[Download the Science Base for Evaluating Stream Project Proposals - \(PDF 7MB\)](#)

[Download the Science Base Appendices - \(PDF 2MB\)](#)

[Download the Risk Matrix](#)

[Download the Project Information Checklist](#)

[Download the RiverRAT Overview](#)

[RiverRAT Development Team and Information](#)

Log In

Account:

Password:

Your Name:

Log Me In! ➡

Figure 5. The *RiverRAT* homepage at restorationreview.com.

Once logged in, a user must enter a project name, which can be unique or shared with other users in collaboration. The review tool then steps the user through a series of questions in *yes/no* format. *RiverRAT* is multi-layered in its supporting information to help the user thoroughly evaluate each question in the proper context. Clicking '*need more information*' provides excerpts from the *Science Document* that support the need for the information as well as a reference to the actual supporting document where the topic is thoroughly discussed (Figure 6).

We have found from experience that users gain the most from this evaluation tool by using its reporting capability, which is accomplished by entering comprehensive notes to support answers to the questions. The review session may be saved and accessed later, while the notes are date stamped and user identified. A coordinated review can also be shared with collaborators for a panel of reviews. If used collaboratively, the notes of each user are identified so that each user can view their collaborators responses. Reporting the review and comments is in standard text format for use in any word processor.

Back to My Projects
Project Title: Boulder Creek

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

#1: Is the problem identified?

More Information ⓘ

Yes
No
Next Question »

You answered **No** to this question. Please see more information about this issue by clicking [here](#). ⓘ

Your Notes: Question 1

Click here to add a note

If you do not save your note before moving on to the next question, you will lose all unsaved changes.
Save This Note

On 07/22/2009 Brian Cluer wrote:

Yes but not as clearly stated as needed.

Edit This Note
Delete This Note

I Problem Identification

1. **Is the problem identified?**
2. Are causes identified at appropriate scales?

II Project Context

3. Is the project identified as part of a plan?
4. Does the plan consider ecological, geomorphic, and socioeconomic context?

III Goals & Objectives

5. Do goals and objectives address problem, causes, and context?
6. Are objectives measurable?

IV Alternatives Evaluation

7. Were alternatives considered?
8. Are uncertainty and risk associated with selected alternative acceptable?
9. Do project elements collectively support project objectives?
10. Are design criteria defined for all project elements?

V Project Design

11. Do project elements work with stream processes to create and maintain habitat?
12. Is the technical basis of design sound for each project element?

VI Implementation

13. Are plans and specs sufficient in scope and detail to execute the project?
14. Does plan address potential implementation impacts and risks?

VII Monitoring & Management

15. Does monitoring plan address project compliance?
16. Does monitoring plan directly measure project effectiveness?

Figure 6. Example of *RiverRAT* structure and function. Each button links to additional information such as what supports a yes or no response, and more information to educate the user in the importance of the question being asked.

SUMMARY

Our Team produced a suite of tools, supported by scientific synthesis, for analyzing river management projects and proposals, including restoration works; collectively called *RiverRAT*. The River Restoration Analysis Tool—and suite of supporting tools and documents enable project reviewers to understand: (1) the connections between physical processes and aquatic habitat, (2) the connection between common management actions, effects, and associated risks to protected species and habitat, and (3) alternatives that can minimize project-related risks to protected species and habitat. Our aim was to provide science and understanding that promote the design of sustainable river management projects, resilient to physical processes and changing environmental conditions. Utilizing the products can aid documentation and streamline project review, foster consistency among project reviewers, and promote effective post-project appraisals, leading to more effective future river management.

RiverRAT and its supporting tools, the *Screening Matrix* and the *Project Information Checklist*, have a common set of information needs and are coordinated so that information is considered in the same sequence; the sequence proceeds in a logical order in which information is considered in general project development. The three tools help determine the depth of review required, assure that a project proposal is complete, and guide reviewers through a thorough and scientifically sound project review. The tools are coordinated with the *RiverRAT Science Document* — the scientific underpinning of the tools — which includes a synthesis of fluvial geomorphology from physical watershed controls to stream processes and channel forms, as well as a synthesis of the project design process from problem identification through project design and post-project appraisal. Utilizing these tools can improve review consistency and transparency, and we believe that there can be a feedback with project development to improve project designs, and most importantly, place problems and solutions in context with physical process drivers and geomorphic controls on aquatic habitat creation and maintenance.

ACKNOWLEDGMENTS

A team of NMFS and USFWS staff, together with their contractors, developed the products described in this paper. In addition to the principal author team, a panel of experts was convened in December of 2007 for brainstorming the project and giving guidance; and who later reviewed drafts of the document. The expert review panel included William Dietrich, University of California Berkeley, Peter Downs, Stillwater Sciences, Matt Kondolf, University of California Berkeley, Greg Koonce, InterFluve, Inc., and Douglas Shields, USDA-ARS National Sedimentation Laboratory. Additionally, interviews with Services managers, and workshops with over 50 potential end users from a wide range state and federal resource agencies were conducted to solicit input, guidance, and feedback on draft products.

For more information and access to the *RiverRAT Science Document*, *Appendices*, and the associated *tools* discussed in this paper, please refer to **www.restorationreview.com**.