ORNL/TM-2019/1184

Instruction Manual: River Function Questionnaire

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May 2019

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

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Environmental Science Division

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1. THE RIVER FUNCTION QUESTIONNAIRE

1.1 BACKGROUND

The regulatory process for US hydropower is time- and resource-intensive to all involved. For instance, licensing new facilities or relicensing existing facilities, including pre-negotiation procedures, may take in excess of 15 years. This process typically involves evaluating project effects through a scoping and study implementation process. While some studies are critical to understanding project effects, certain studies may be unnecessary if they do not directly connect with potential project effects.

Part of the attempt of determining environmental issues is defining what constitutes "the environment" effected by hydropower development and operations. In a recent literature review and meta-analysis on global hydropower-environmental studies, Parish et al. (2019) assembled a meta-analysis and database representing the "universe" of potential environmental metrics used to measure the effects of hydropower on river environments (completed Fiscal Year (FY) 2018). Subsequently, Pracheil et al. (in review) categorized these metrics into 51 non-reducible river functions, which represent the dimensions of the hydropower-river environment. These functions provide a template to reduce complexity by organizing environmental effects into a series of indicator groups.

The River Function Questionnaire (Questionnaire) is a series of questions designed to help stakeholders determine the impacts of hydropower on river functions as outlined in Pracheil et al. (in review; Table 2.1) that may need to be understood or addressed through additional field studies or environmental assessments. In order to provide a platform accessible to many users, we developed the questionnaire in Microsoft Excel with convenient macro-enabled interactive features, such as print and navigation buttons. The Questionnaire was developed under the Department of Energy (DOE)-funded Environmental Metrics for Hydropower (EMH) project in FY 2018. The Questionnaire was iteratively reviewed by a 25-member advisory Board comprised of federal and state agencies, environmental non-governmental organizations, utility and developer interests, tribes, and scientists. After each review, the Questionnaire was subsequently updated to incorporate Board member comments.

The Questionnaire was designed with the expectation that individuals familiar with the specific river system and facility, preferably natural resource experts, would complete the questions. Ideally, Questionnaire users should also have some familiarity with major concepts in river ecology (e.g., River Continuum Concept, Vannote et al. 1980; Natural Flow Regime, Poff et al. 1997; Indicators of Hydrologic Alteration, Richter et al. 1996) and the environmental effects of hydropower. Individuals filling out the Questionnaire will likely be environmental consultants as an early-stage assessment, or resource agencies and NGOs familiar with the system or having years of experience working with the system.

1.2 HOW IT WAS DEVELOPED

ORNL assembled an initial compilation of 425 journal articles and reports from previous projects and reviews related to environmental effects of hydropower, including: environmental indicators for hydropower sustainability (Parish et al. 2019), future hydropower planning, siting, and landscape considerations (McManamay et al. 2015b); environmental flows, habitat fragmentation, and geomorphic considerations (McManamay 2014; McManamay et al. 2010, 2012, 2013a, 2015a; 2016a), meta-analyses of hydrologic alterations from dams (Poff and Zimmerman 2010; McManamay et al. 2013b), types of dams and hydropower operations (Poff and Hart 2002; McManamay et al. 2016b), and effects of dams on water quality (Olden et al. 2010). We then selected literature pertaining to each river function individually with the objective of identifying generalized effects of dams on each function and what factors could serve as predictors or indicators of those effects.

Each of the questions are considered "generic" to identify common environmental effects of hydropower and dams on river functions and are accompanied by a scientific reference to scientifically justify inclusion of the question. Questions were determined through scientific literature review and the direction of effect is based on outcomes of consensus among multiple sources (See "Bibliography" in Questionnaire). While it is recognized that dams and specific rivers are complex and inherently context-specific, there is much scientific literature that suggests that some environmental responses are generic to dams, given certain properties of the structure and the river. For example, a diversion-bypass that dewaters a stream is likely to result in riparian encroachment on the stream channel. As another example, a dam that discharges water from the hypolimnion of a thermally stratified reservoir is likely to result in lower temperatures than would normally be expected. In these cases, the phenomena above lead to more evidence for evaluating the “Stream Channel” and “Water Temperature” river functions, respectively.

Each question pertains to at least one river function but may pertain to multiple river functions. On average, there are five questions supporting each river function, but the number of questions per function may range from four to eight. All questions must be answered “yes”, “no”, “uncertain”, or "not applicable". Based on all answers, the total “yes”, “no”, and "uncertain" responses for a given river function are totaled and provided in a final summary table and graphs.

Questions were framed using an eco-evidence approach (Norris et al. 2012) and should be answered using existing information. All questions are structured in such a way that “yes” answers lead towards more evidence for a given river function being potentially impacted by a project or that might require further consideration. Questions answered "uncertain" also provide evidence of river functions where more information or data is needed. The questions (and associated river functions) are also organized by spatial scale (Basin, Project, Reservoir, and Downstream) and according to which types of taxa (e.g., fish, amphibian, bird, etc.) may be relevant. The spatial scale is automatically built into the Questionnaire, but users can specify which taxa are relevant to a given question by answering "yes" under each taxa column. These results are also summarized in the summary table.

An internal database keeps track of all responses, spatial scale relevance, taxa-relevance, and the river functions applicable to all responses. The Questionnaire automatically summarizes the number of questions answered “yes”, “no”, or “uncertain” responses according to river function. These summaries are provided in tabular and graphical form for users to evaluate evidence (from 0 to 1) for any river function.

2. GENERAL GUIDANCE FOR USE

The River Function Questionnaire is one component of the Environmental Decision Support (EDS) Toolkit and was created to help foster dialog among stakeholders and to focus discussions about the study needs of a given hydropower project. However, the Toolkit does not recommend or suggest mitigation actions or study methodology. For example, the Questionnaire may foster discussions regarding what environmental conditions are uncertain or where existing information is available or needed to address a given environmental issue (i.e., river function). The Questionnaire can be used at any stage of the FERC licensing procedure, but its most suitable application was envisioned for early in the regulatory process as project details and potential impacts are starting to be assessed.

Thus, used of the Toolkit may include (but not limited to):

1) hydropower applicants in identifying potential environmental issues within the Pre-Application Document (PAD) or Stage 1 Consultation

2) environmental stakeholders in identifying knowledge gaps and environmental concerns needing to be addressed through studies or mitigation, and/or

3) all stakeholders within scoping phases discussing what environmental issues need to be addressed.

All questions must be answered “yes”, “no”, “uncertain”, or "not applicable". Furthermore, to affirmatively answer a question as “yes” or “no”, some form of existing information must be provided (e.g., data, analysis, picture, literature, website, stream gage reading, etc). Questions were written so that “yes” answers provide more evidence of an affected river function, questions answered "uncertain" also provide an indication of where more information or data is needed. If questions cannot be answered “yes” or “no” confidently and with evidence, questions should be answered as "uncertain" or "not applicable". In some cases, questions may not be relevant to the project such as in cases where a resource does not exist at a facility or when an impact to a river function may be caused by an already existing alteration. For instance, environmental assessments evaluating the addition of hydropower to existing non-powered dams typically only consider the environmental effects of adding electrical generation infrastructure (e.g., turbines, penstocks, powerhouse) and not the pre-existing effects of the dam and reservoir. In these cases, answers to questions targeting dam development, in general, might be answered "not applicable".

Table 2.1. River functions and their descriptions used as indicators of the effects of hydropower on the river environment. From Pracheil et al. (in review).

Function Level	Code	River Function Name	River Function Description
Biota and Biodiversity	F1	Abundance, density	Count or other measures of organisms per area
	F51	Algae/ primary productivity (BB)	Algal blooms which lead to oxygen depletion and eutrophication
	F5	Behavior, movement, colonization, extinction	Behavior of organisms in study area, including colonization, movement patterns, distance, duration, timing, frequency and/or extinction.
	F6	Demographics, age, sex, size	Population demographics, including age, sex, and size
	F7	Fitness, survival, growth, condition, reproduction, mortality	Fitness, survival, growth, condition, reproduction, or mortality of organisms
	F8	Functional group, or species or trait composition	Grouping of organisms by functional or trait status, percentage composition

Table 2.1. River functions and their descriptions used as indicators of the effects of hydropower on the river environment. From Pracheil et al. (in review). (continued)

Function Level	Code	River Function Name	River Function Description
	F9	Genetics, mixing, metapopulation	Genetics and population mixing, including metapopulation dynamics
	F10	Habitat, critical habitat, or surrogates of such	Indices of habitat, area, suitability, and so on, for organisms
	F11	Internal composition nutrient abnormalities	Nutritional composition and makeup of organisms, including elemental stoichiometry. Includes levels of internal homeostasis, as well as morphological, genetic, or hormonal abnormalities caused by contaminants
	F2	Life history trait characteristics	Life history trait characteristics and their values, such as duration of spawning, fecundity, reproductive mode (note this category deals only with characteristics themselves and not the composition of the community.)
	F3	Presence, absence, occupancy, or detection	Organism presence/absence in an area (including pseudo-absence), occupancy, and detection probability
	F4	Species diversity	Species richness, diversity, evenness, or indices-of-biotic-integrity metrics used to characterize one or more components of the biotic community
Water Quality	F40	Algae/ primary productivity (WQ)	Algal concentration including measures of primary productivity such as chlorophyll A or cyanotoxin.
	F41	Buffering capacity	Characteristics including pH, alkalinity
	F42	Dissolved gasses	Concentration of non-greenhouse gases in water
	F43	Dissolved oxygen	Dissolved oxygen in water
	F44	Ecosystem function	Ecosystem vital rates and processes, including gross primary productivity, respiration, biochemical oxygen demand
	F45	Gas emissions	Concentration and ebullution of water-origin greenhouse gases
	F46	Key elements	Elements and compounds that are not listed on the EPA Toxic and Priority Pollutants list
	F47	Macromolecular pollutants	Pollutants listed on the EPA Toxic and Priority Pollutants list that are not included in other EMH categories
	F48	Nutrients and organic material (C, N, P)	Dissolved organic carbon and other organic non-pollutants essential to life, including nitrogen, phosphorous, and inorganic carbon.
	F49	Solid transport, turbidity, and conductivity	Descriptions of dissolved and suspended solids in water such as turbidity, suspended or dissolved solids, conductance
	F50	Water temperature	Water temperature
Geomorphology	F15	Catchment and basin attributes	Upland soil characteristics, topography, and landscape erodibility metrics that could influence soil erosion and wasting related and subsequent sedimentation related to hydropower development
	F16	Channel	Channel properties such as bankfull width, wetted width, bankfull discharge, channel slope, braided channel, channelization
	F17	Floodplain valley	Metrics related to channel confinement, entrenchment, migration, etc.

Table 2.1. River functions and their descriptions used as indicators of the effects of hydropower on the river environment. From Pracheil et al. (in review). (continued)

Function Level	Code	River Function Name	River Function Description
	F18	Sediment and substrate	Sediment and substrate properties such as substrate particle size, bedload, sediment entrainment or deposition, bedrock composition
Connectivity and Fragmentation	F12	Basin area	Some aspect of area of river basin
	F13	Dendritic network and riverscape	Fragment length, dendritic connectivity index, barrier index, river distance between dams and projects
	F14	Fish passage	Mitigated fish passage, including presence of upstream or downstream passage or length of bypass
Water Quantity	F24	Basin attributes	Attributes related to factors that influence hydrology (or were used in the context of hydrology), such as climate and precipitation
	F25	Diversion	Quantitative properties of diversions such as volume or discharge of diversion or water for other uses
	F26-F31	Downstream discharge	Downstream discharge magnitude, duration, rate of change, and timing associated with a specific flow condition (Poff et al. 1997).
	F32	Groundwater	Groundwater characteristics
	F33	Reservoir hydrology	Reservoir hydrological characteristics such as residence time, reservoir fluctuation, reservoir surface area, or degree of regulation
	F34-F39	Upstream inflows	Upstream inflow magnitude, duration, rate of change, and timing associated with a specific flow condition (Poff et al. 1997).
Landscape	F19	Area impacted, project area	Project boundary area, area impacted by the project as whole, not related to reservoir inundation or land cover
	F20	Floodplain or riparian vegetation	Properties of floodplain or riparian vegetation such as riparian encroachment or floodplain area
	F21	Land cover class	Type of land cover, changes in land cover
	F22	Protected land	Spatial properties of protected lands including losses or increases
	F23	Reservoir inundation	Reservoir area, upland or floodplain inundation, biomass inundated/lost

3. INSTRUCTIONS FOR USE

3.1.1 Navigating the Questionnaire

The Questionnaire is a Microsoft Excel file that includes 10 spreadsheets. The spreadsheets include macro-enable features, such as navigation buttons and print commands. Below is a list of each spreadsheet and its function.

- **Instructions** – General overview of the questionnaire and a brief version of the details provided in the instructions

- **Questionnaire** – List of structured questions organized into major themes and pull-down lists of alternative responses to each answer and whether the question is relevant to specific taxa

- **Summary** – Table summarizing the responses to questions associated with each of the river functions. This tabular summary includes the responses according to different spatial scales and taxa.

- **Bar Plots –** These three figures summarize the results of the tabular information from the **"Summary"** Spreadsheet

- **Spider Diagram** – this diagram provides a different way to visualize information from the "Summary" spreadsheet. The spider diagram graphically depicts the evidence that a river function is affected by hydropower development or operations. Specifically, the diagram represents the proportion of questions answered "yes" pertaining to each of the river functions.

- **Question_Details**: List of questions and their attributes including references, spatial scale, and other information. These specific attributes include the following:
  - Project type - type of hydropower projects of potential relevance (EHA & NPD - existing hydropower assets and non-powered dams; All - refers to any type of hydropower project)
  - Area - Spatial scale of relevance to a given question
  - Biota - an indication of whether question is directly related to biota ("Y"= Yes, "N"=No).
  - Taxa - an indication of whether answer to the question could be taxa specific
  - KeyQ - an indication of whether the question is a "key" structural question or not (where some answers might depend on others) ("Y"= Yes, "N"=No).
  - Reference - literature reference used to develop the question

- **Bibliography**: Bibliography of all references used to create questions

- **Q_DB**: Database of unique question-river function combinations used to automatically calculate summary tables based on responses in the questionnaire. [Note: Alteration of the database content or structure will influence the summary output and diagrams. Users should not modify unless they have good reason to do so and are familiar with Microsoft Excel Visual Basic programming].

- **List**: Used to create standard values for entry in Questionnaire. [Note: Alteration of the list will influence the questionnaire, summary output, and diagrams. Users should not modify unless they have good reason to do so and are familiar with Microsoft Excel Visual Basic programming].

When you open the Excel file, you will be prompted to enable the macro-enabled features. Click "yes" when prompted whether you want to "update" links to external sources. Navigate to the "Instructions" spreadsheet and review the instructions (Figure 2.1). Get familiar with all spreadsheets mentioned above.

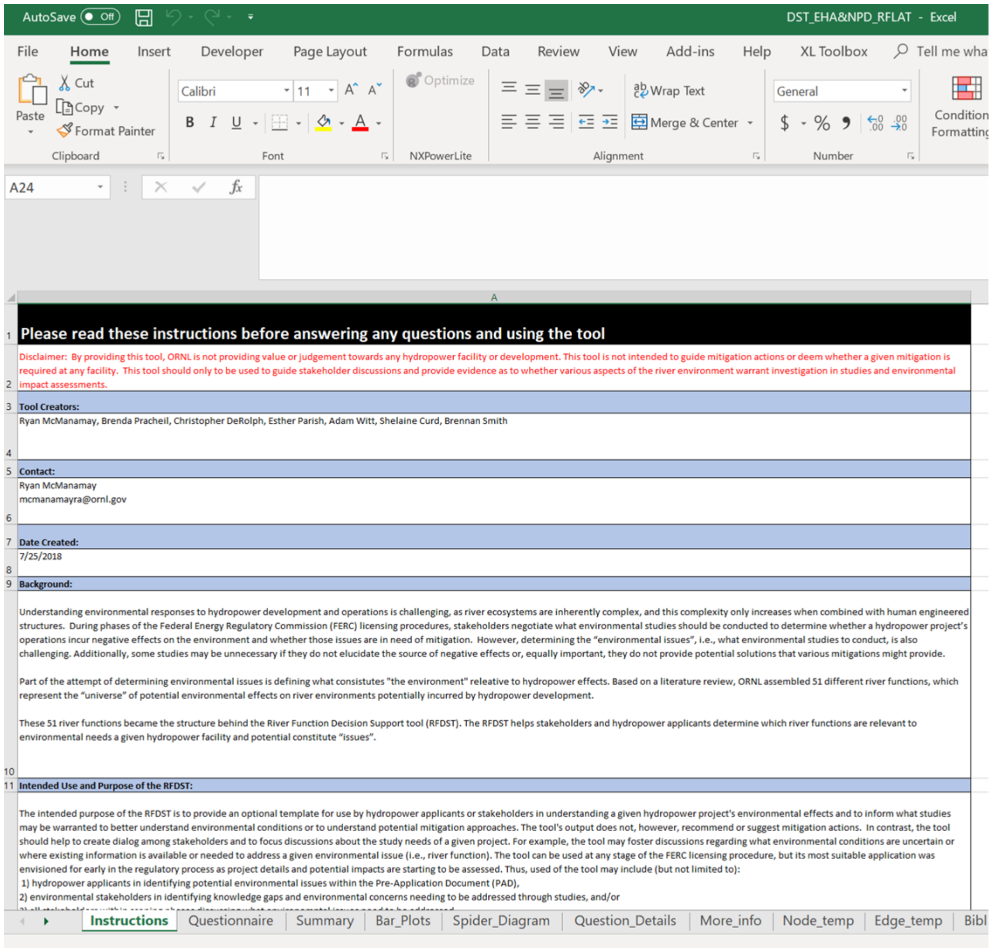


Figure 2.1. Instruction spreadsheet providing an overview of background, purpose, and general insructions for use.

3.1.2 Completing the Questionnaire

- Navigate to the Questionnaire spreadsheet (Figure 2.2). Answer questions using drop-down boxes (first response option highlighted in yellow) – see Figure 2.3.

- If a question is unclear or confusing, use the navigation buttons beside each question (red circle, Figure 3A) to navigate to the "More Info" Spreadsheet (Figure 2.3B). Additional justification is provided for questions prone to interpretation or needing more information. An example is highlighted in yellow (Figure 3B). Navigation buttons are available to allow you to conveniently return back to the same place on the questionnaire (red circle, Figure 2.3B)

- Where relevant, be sure to select whether a question pertains to a specific taxa by selecting "Yes" for each respective column that applies, or "No" if a question does not apply to a given taxa, or if you're uncertain, then select "uncertain" (Figure 2.4).

- Once you have completed all answers to the Questionnaire, you can click on the "Go to Summary" button to navigate to the "Summary" spreadsheet (red circle, Figure 2.5).

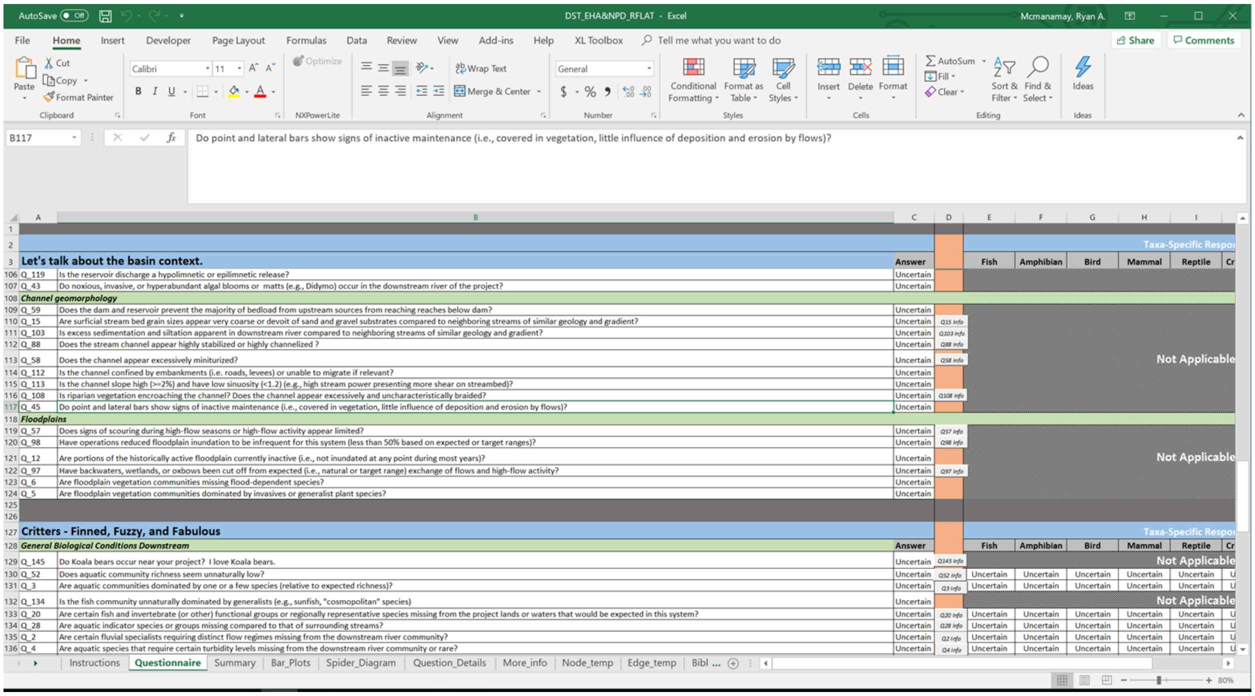


Figure 2.2. Questionnaire spreadsheet.

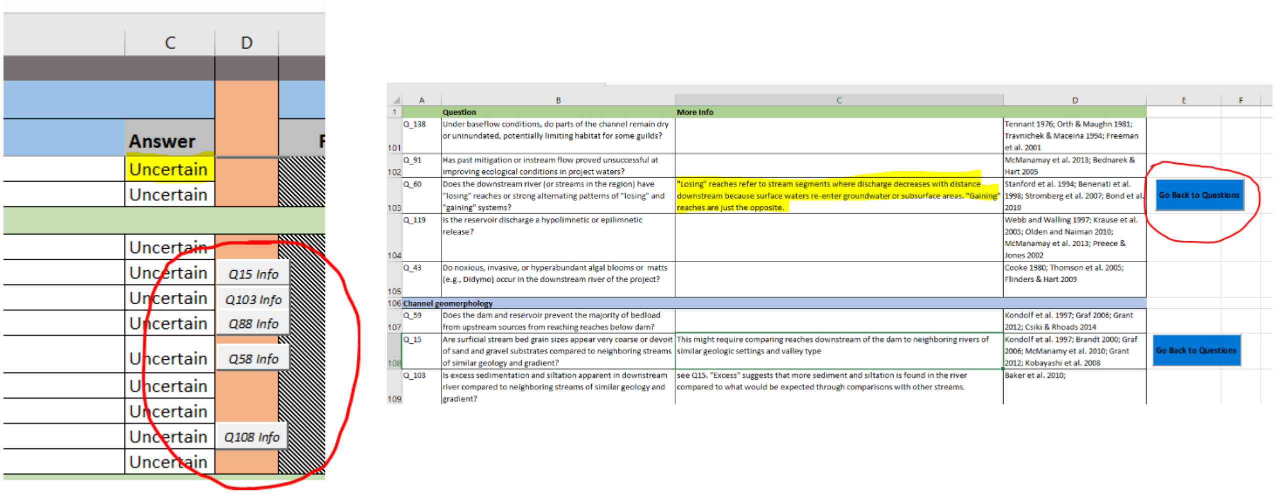


Figure 2.3. (A) Inset displays the response to questions provided by a drop-down list. The response option for the first question is highlighted in yellow. Red circle highlights the navigation buttons to the "More_info" spreadsheet. (B) the "More_info" spreadsheet provides more clarity or explanation behind the questions.

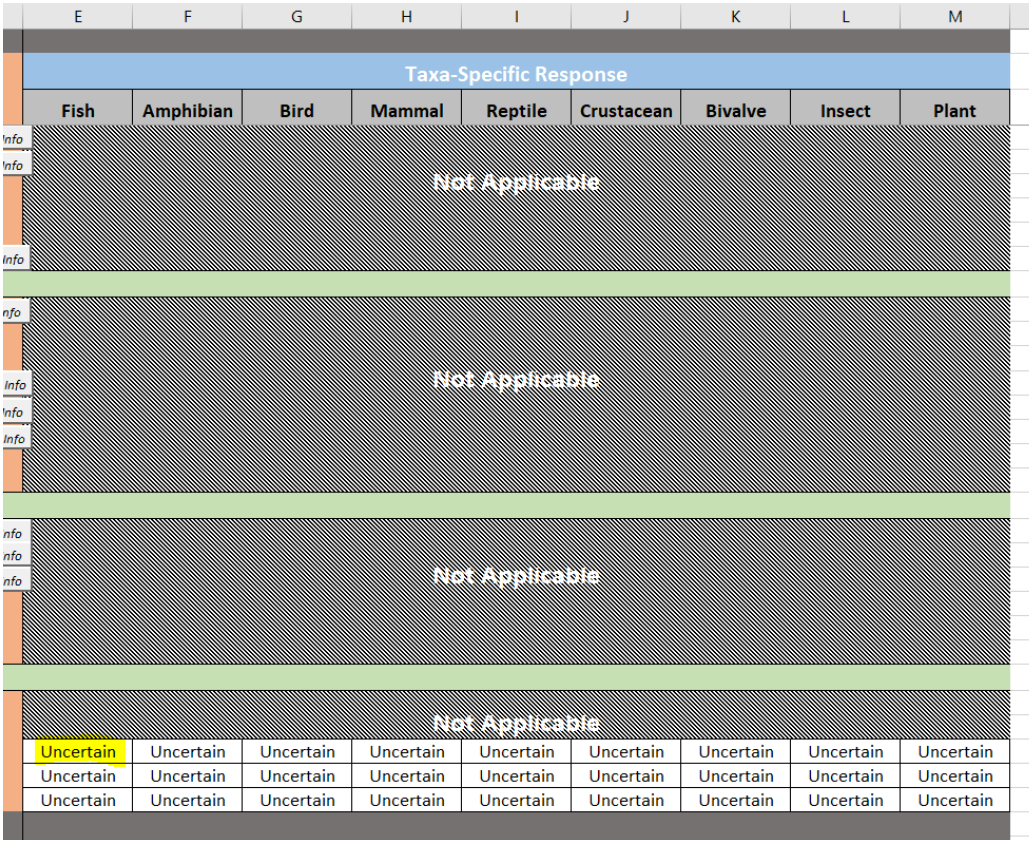


Figure 2.4. Section of questionnaire for determining whether specific taxa (columns) apply to each question. The first response is highlighted in yellow.

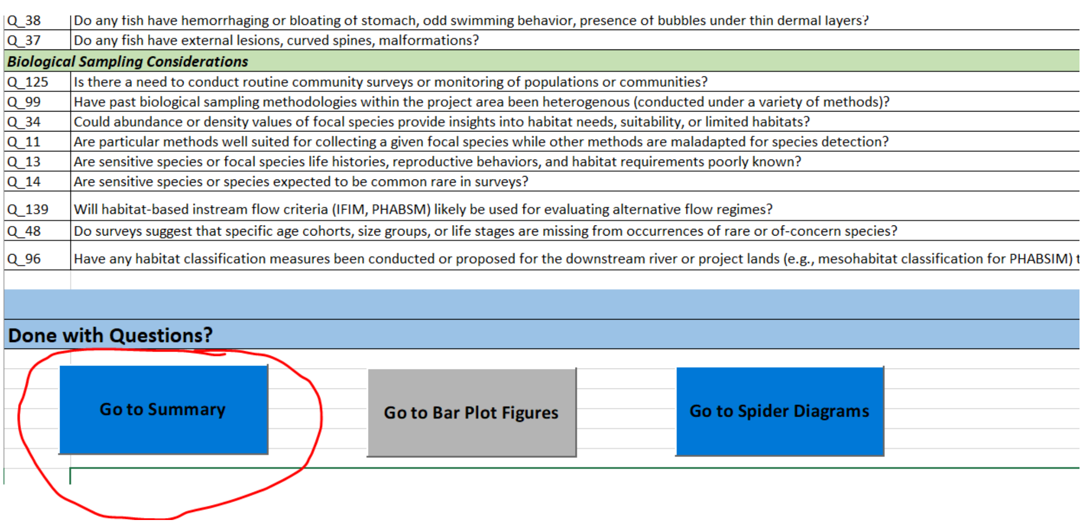


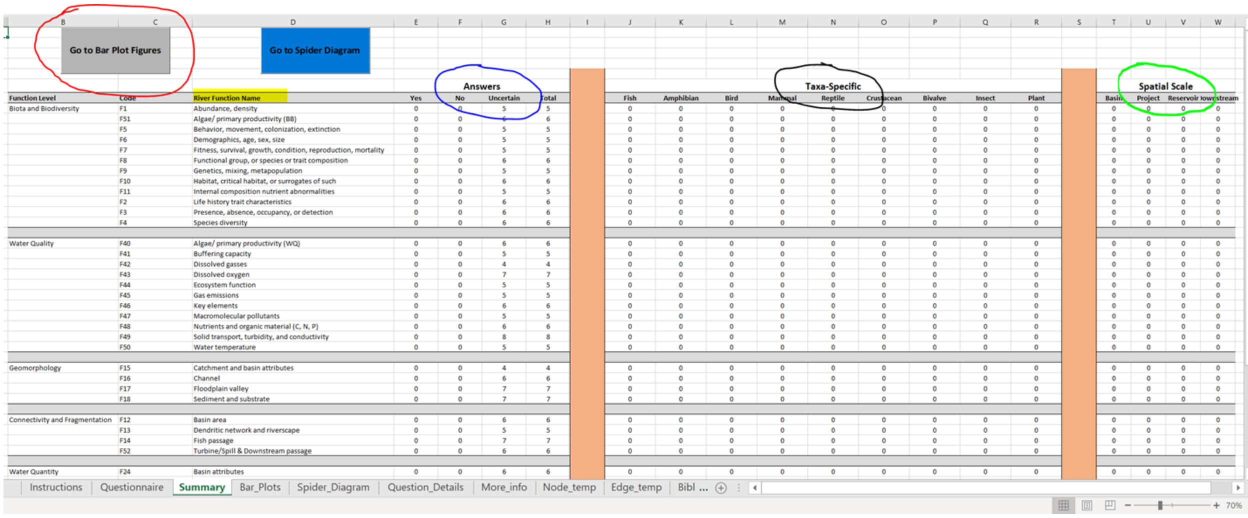
Figure 2.5. At the bottom of the questionnaire, there is a navigation button (red circle) that takes user to the tabular summary.

3.1.3 Interpreting the Questionnaire Output

- The Summary spreadsheet provides a tabular summary of the number of questions answered “yes”, “no”, or “uncertain” (blue circle) related to a given river function (highlighted in yellow, Figure 2.6). Recall that a given question can pertain to more than one river function.

- The number of questions answered “yes” and relevant to specific taxa (black circle) or particular spatial scales (green circle) are also summarized (Figure 2.6).

- Click on the “Go to Bar Plot Figures” (red circle, Figure 2.6) to navigate to that page.



			Answers				Taxa-Specific									Spatial Scale			
Function Level	Code	River Function Name	Yes	No	Uncertain	Total	Fish	Amphibian	Bird	Mammal	Reptile	Crustacean	Bivalve	Insect	Plant	Basin	Project	Reservoir	Downstream
Biota and Biodiversity	F1	Abundance, density	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F51	Algae/ primary productivity (BB)	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F5	Behavior, movement, colonization, extinction	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F6	Demographics, age, sex, size	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F7	Fitness, survival, growth, condition, reproduction, mortality	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F8	Functional group, or species or trait composition	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F9	Genetics, mixing, metapopulation	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F10	Habitat, critical habitat, or surrogates of such	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F11	Internal composition nutrient abnormalities	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F2	Life history trait characteristics	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F3	Presence, absence, occupancy, or detection	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F4	Species diversity	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Quality	F40	Algae/ primary productivity (WQ)	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F41	Buffering capacity	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F42	Dissolved gasses	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	F43	Dissolved oxygen	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	F44	Ecosystem function	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F45	Gas emissions	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F46	Key elements	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F47	Macromolecular pollutants	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F48	Nutrients and organic material (C, N, P)	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F49	Solid transport, turbidity, and conductivity	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0
	F50	Water temperature	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Geomorphology	F15	Catchment and basin attributes	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	F16	Channel	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F17	Floodplain valley	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	F18	Sediment and substrate	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Connectivity and Fragmentation	F12	Basin area	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
	F13	Dendritic network and riverscape	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	F14	Fish passage	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
	F52	Turbine/Spill & Downstream passage	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Quantity	F24	Basin attributes	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 2.6. Summary spreasheet. River functions are listed in rows (up to down), whereas counts of responses are in columns. Total enumeration of “yes”, “no”, and “uncertaint” answers relevant to each river function are provided in the answers section (Blue circle). The total number of questions answered “yes” and applicable to each taxa-type are provided in the middle section (black circle), whereas the number of questions answered “yes” and applicable to specific spatial scales are provided in the far right section (green circle). Navigation buttons to the bar plot figures (red circle) and spider diagram is provided.

- Once on the Bar_Plot spreadsheet (Figure 2.7), you will see three bar plots, two of which have summary pie charts underneath. You will notice that there are navigation buttons provided but also an ability to print the bar charts to .pdf files to save the output.

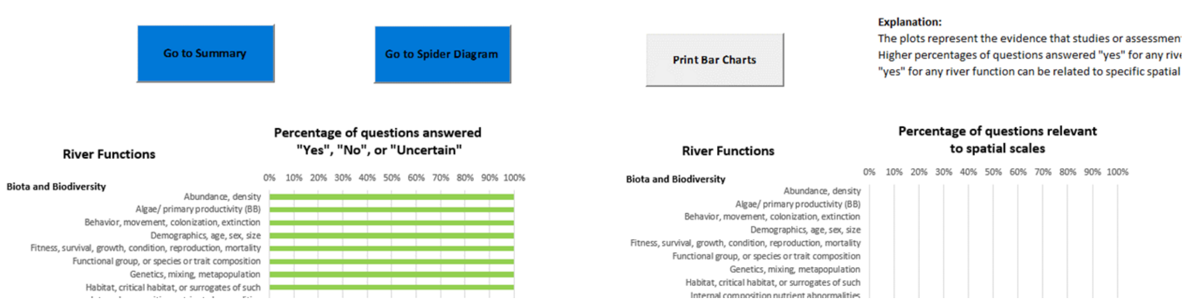


Figure 2.7. Top of Bar_plot spreadsheet with navigation buttons and first two bar plots.

- The bar plot on the far left represents the percentage of “yes”, “no”, and “uncertain” questions for a given river function (Figures 2.7-8). In short, they summarize the evidence that studies or assessments of specific environmental issues (i.e. river functions) may be warranted based on percentage of “yes” responses and issues that may be uncertain. River functions are listed vertically and represent different facets of the environment (Figure 2.8).

- Higher percentages of questions answered "yes" for any river function indicates more evidence that a river function is affected by development or operations at the facility. This may suggest that studies or assessments for that river function may be needed.

- Additionally, the percentage of questions answered "yes" for any river function can be related to specific spatial scales (Figure 2.9) or specific taxa that are most relevant in order to study or assess that function (Figure 2.10). This provides users with an indication of what spatial scales are most applicable to studies and the taxonomic groups that may require the most attention.

- Find the navigation buttons at the top of the bar_plot spreadsheet and click on “Go to Spider Diagram” (Figure 2.7)

- The Spider diagram (Figure 2.11) relies on the same information presented in Figure 2.8 but displays it differently. The spider diagram represents evidence of which river functions may be affected by development or operations at the facility (Figure 2.11). Specifically, the proportion of questions answered "yes" for each river function provide an indication that the project has or will effect specific environmental factors. For instance, if River Function F1 - Abundance/density has a value of 0.75, then this indicates that 75% of questions related to abundance and density were answered "yes". This suggests that studies monitoring abundance may be needed. Refer to the "relevant taxa" in the "Bar Plot Figures" to determine which taxa may need to be monitored.

- The Spider_Diagram spreadsheet provides navigational buttons and print commands (Figure 2.12). Users can print either the spider diagram or the river function summary table.

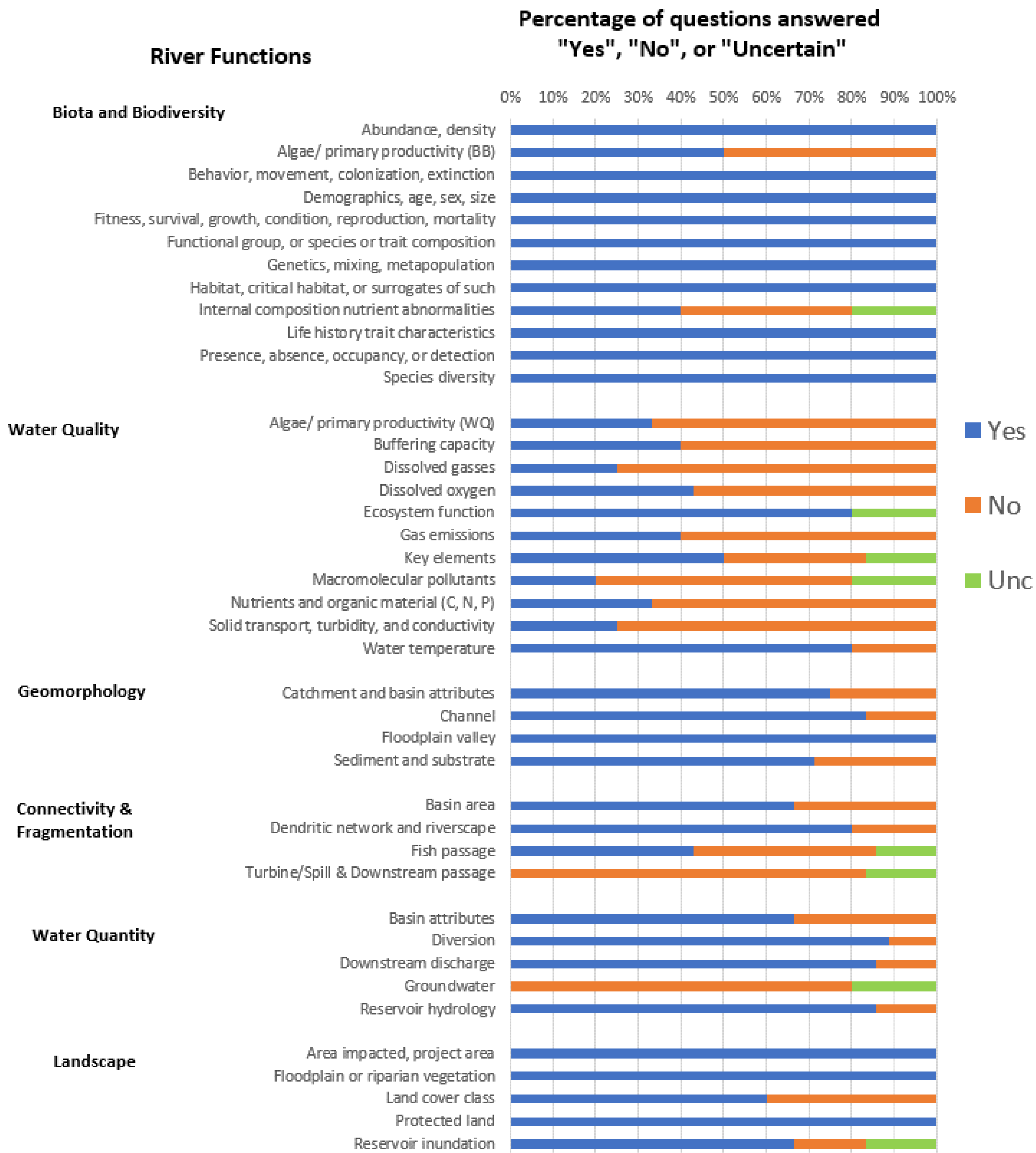


Figure 2.8. Bar plot depicting the percentage of "yes", "no", and "uncertain" responses relevant to each of the river functions. The example provided represents responses to the questionnaire with respect to Smoky Mountain Hydropower Project in North Carolina and Tennesee.

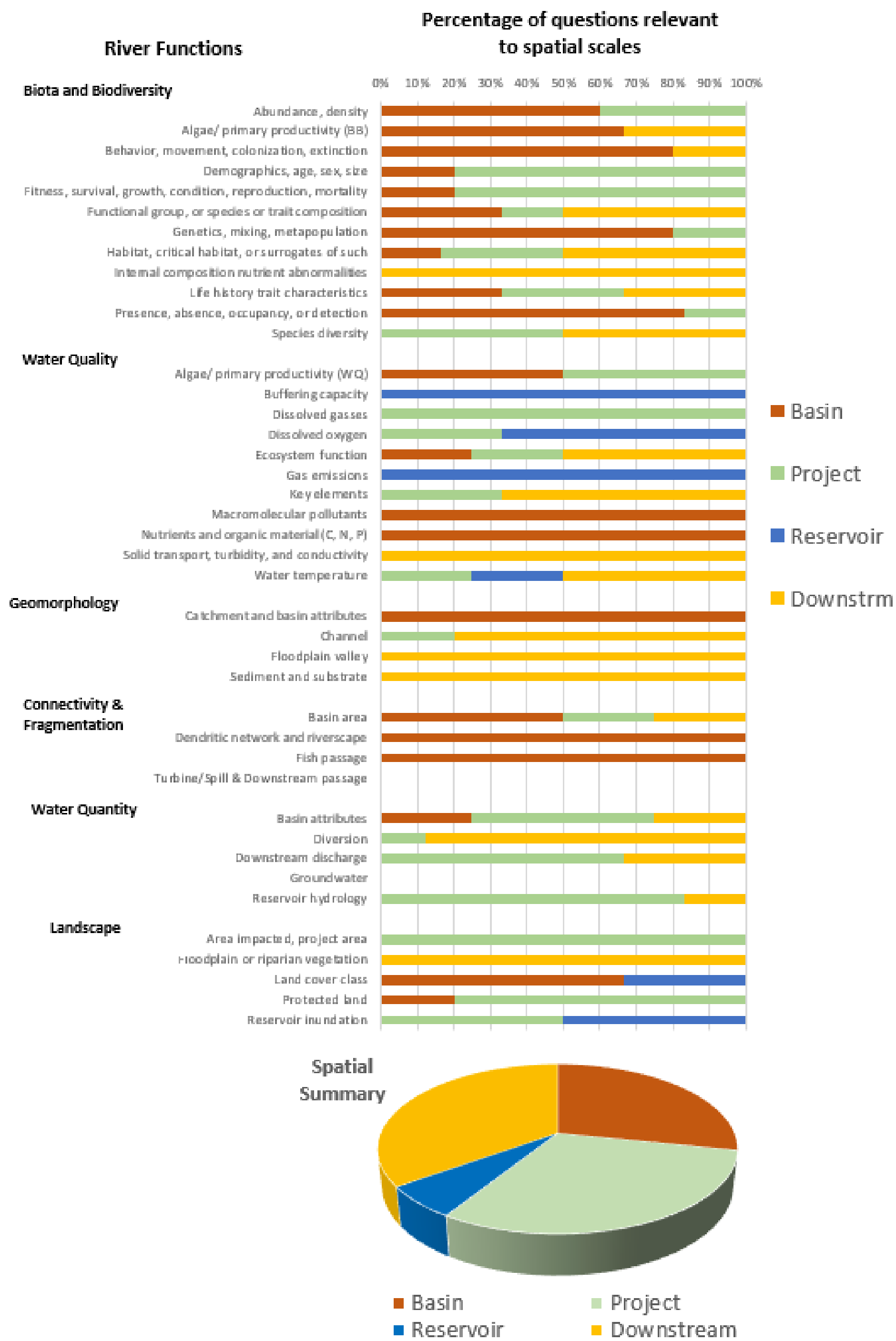


Figure 2.9. Bar plot depicting the percentage of "yes" responses that were relevant to specific spatial scales and a given river function. The pie chart provides a summary of all questions answered "yes" and relevant to a given spatial scales. The example provided represents responses to the questionnaire with respect to Smoky Mountain Hydropower Project in North Carolina and Tennesee. In this case, most "yes" responses were relevant to the entire project or basin or environments downstream. Fewer responses were relevant to the reservoirs associated with the project.

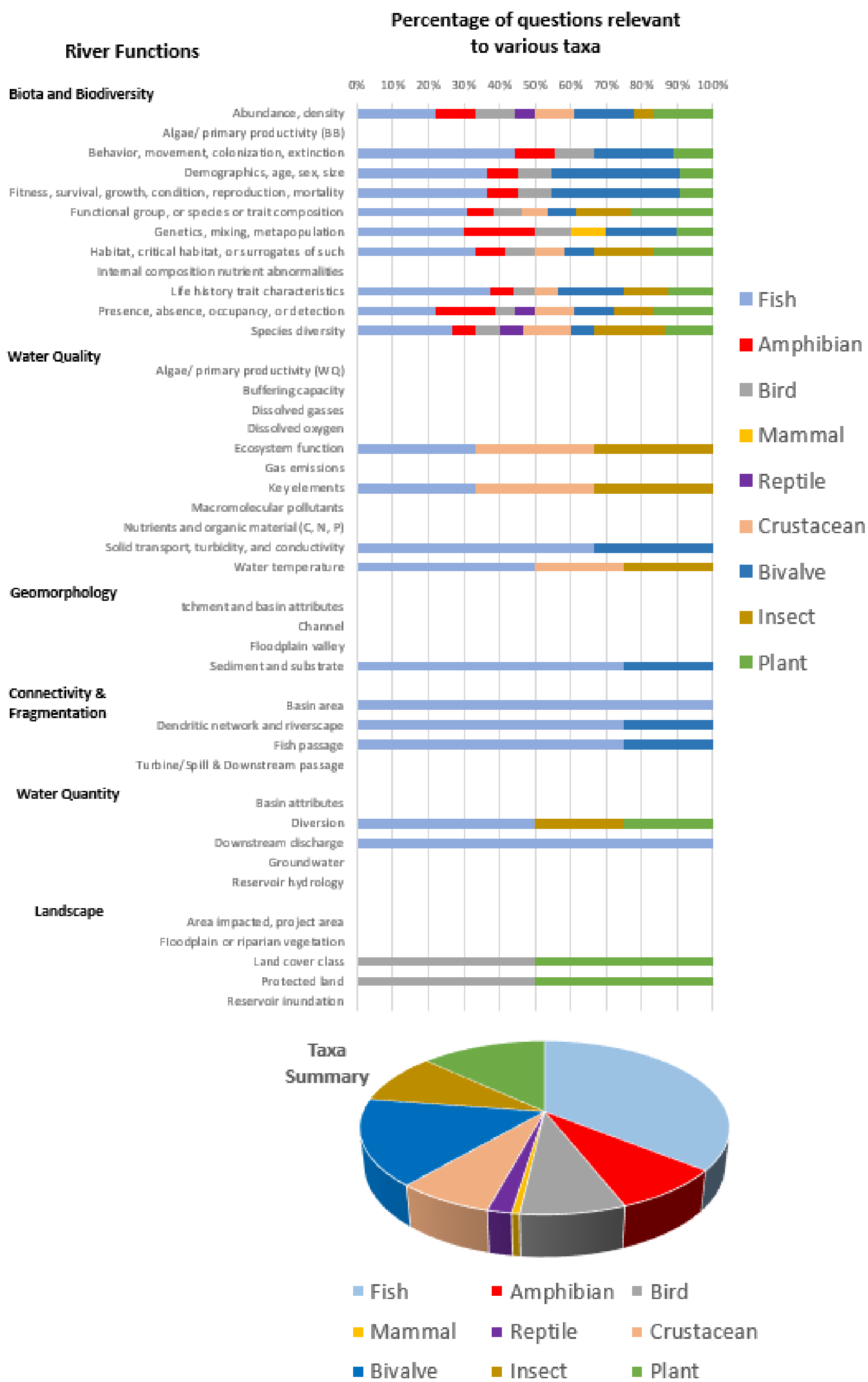


Figure 2.10. Bar plot depicting the percentage of "yes" responses that were relevant to specific taxa and a given river function. The pie chart provides a summary of all questions answered "yes" and relevant to a given taxonomic group. The example provided represents responses to the questionnaire with respect to Smoky Mountain Hydropower Project in North Carolina and Tennesee. In this case, most "yes" responses were relevant to fish and mussels; however, many taxa were relevant to the Smoky Mountain project as there are multiple developments and significant land assets.

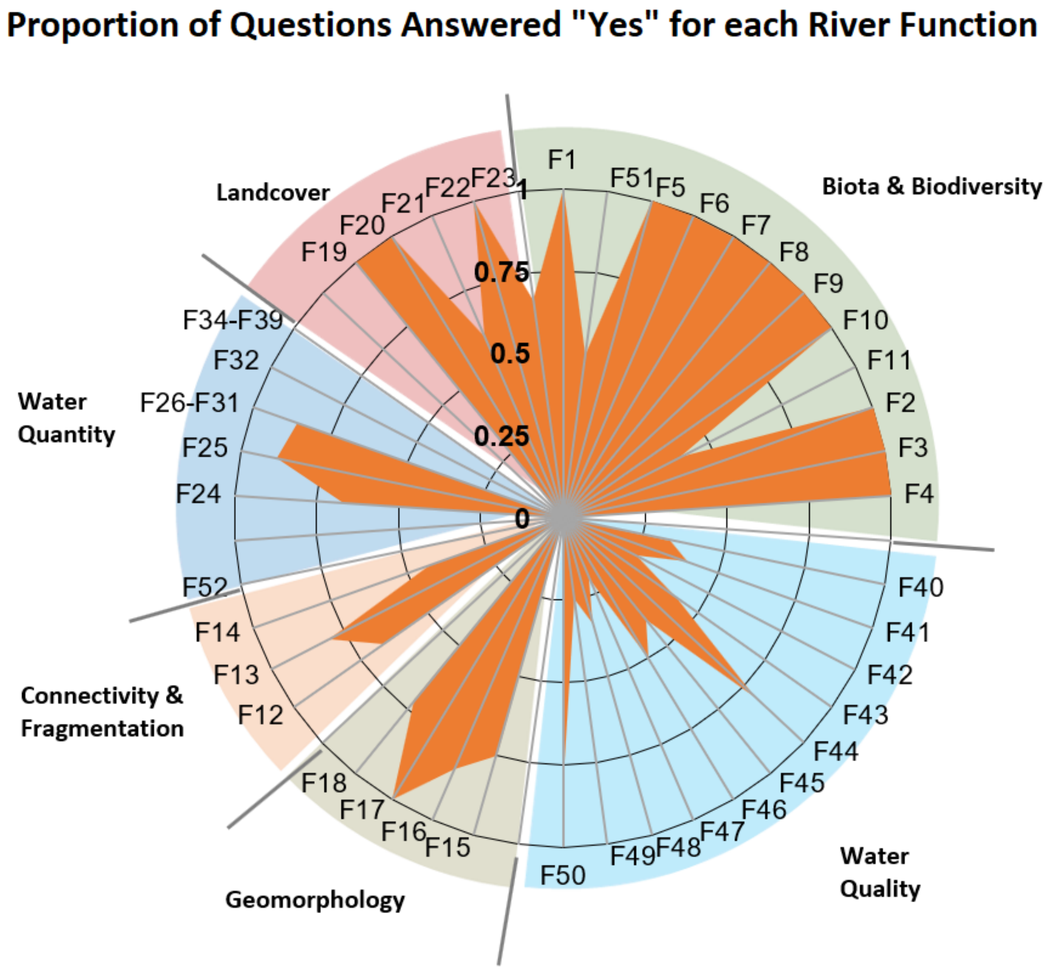
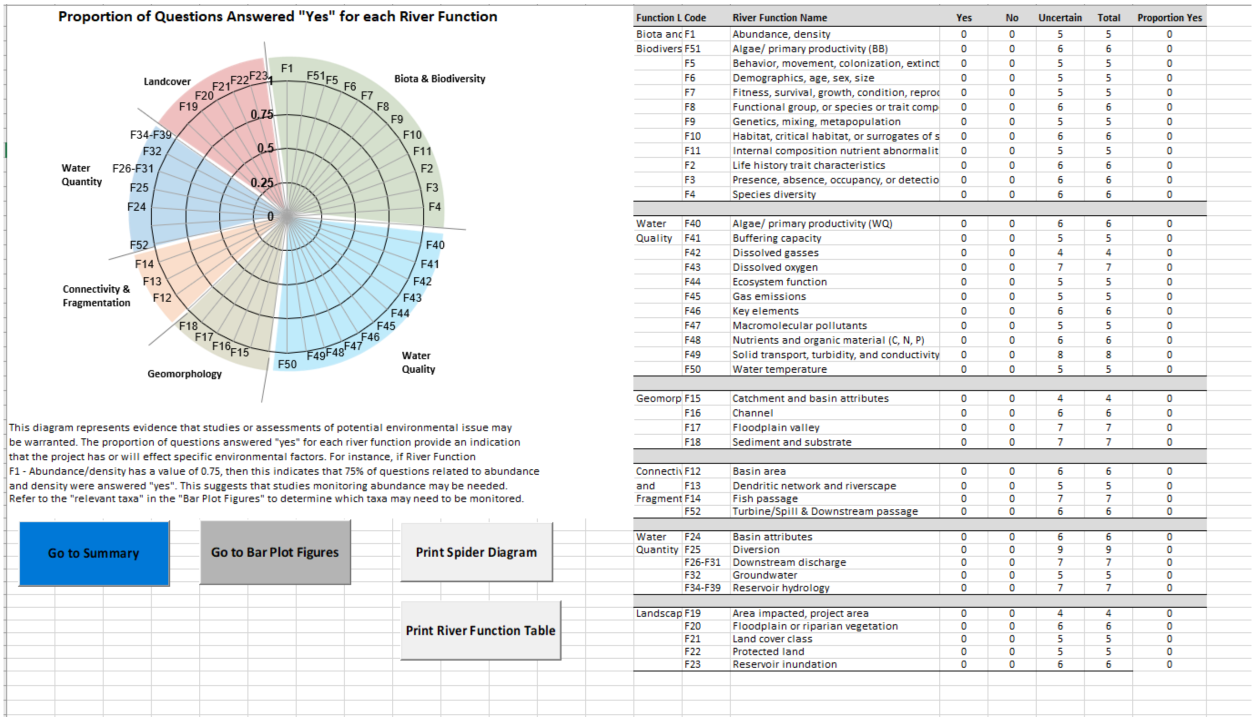


Figure 2.11. Spider diagram depicting the proportion of questions answered "Yes" for each river function. The diagram provides the same information captured in Figure 2.8. These proportions represent the likelihood that a river function is affected by the hydropower facility and ranges from 0 to 1. This example is provided for Smoky Mountain Hydropower Project in North Carolina and Tennessee. The diagram suggests that certain river functions in all six categories are affected by operations, with many of the biota and biodiversity functions having a high likelihood of being affected.



Function L	Code	River Function Name	Yes	No	Uncertain	Total	Proportion Yes
Biota anc	F1	Abundance, density	0	0	5	5	0
Biodivers	F51	Algae/ primary productivity (BB)	0	0	6	6	0
	F5	Behavior, movement, colonization, extinct	0	0	5	5	0
	F6	Demographics, age, sex, size	0	0	5	5	0
	F7	Fitness, survival, growth, condition, reproc	0	0	5	5	0
	F8	Functional group, or species or trait comp	0	0	6	6	0
	F9	Genetics, mixing, metapopulation	0	0	5	5	0
	F10	Habitat, critical habitat, or surrogates of s	0	0	6	6	0
	F11	Internal composition nutrient abnormalit	0	0	5	5	0
	F2	Life history trait characteristics	0	0	6	6	0
	F3	Presence, absence, occupancy, or detectio	0	0	6	6	0
	F4	Species diversity	0	0	6	6	0
Water	F40	Algae/ primary productivity (WQ)	0	0	6	6	0
Quality	F41	Buffering capacity	0	0	5	5	0
	F42	Dissolved gasses	0	0	4	4	0
	F43	Dissolved oxygen	0	0	7	7	0
	F44	Ecosystem function	0	0	5	5	0
	F45	Gas emissions	0	0	5	5	0
	F46	Key elements	0	0	6	6	0
	F47	Macromolecular pollutants	0	0	5	5	0
	F48	Nutrients and organic material (C, N, P)	0	0	6	6	0
	F49	Solid transport, turbidity, and conductivity	0	0	8	8	0
	F50	Water temperature	0	0	5	5	0
Geomorp	F15	Catchment and basin attributes	0	0	4	4	0
	F16	Channel	0	0	6	6	0
	F17	Floodplain valley	0	0	7	7	0
	F18	Sediment and substrate	0	0	7	7	0
Connectiv	F12	Basin area	0	0	6	6	0
and	F13	Dendritic network and riverscape	0	0	5	5	0
Fragment	F14	Fish passage	0	0	7	7	0
	F52	Turbine/Spill & Downstream passage	0	0	6	6	0
Water	F24	Basin attributes	0	0	6	6	0
Quantity	F25	Diversion	0	0	9	9	0
	F26-F31	Downstream discharge	0	0	7	7	0
	F32	Groundwater	0	0	5	5	0
	F34-F39	Reservoir hydrology	0	0	7	7	0
Landscap	F19	Area impacted, project area	0	0	4	4	0
	F20	Floodplain or riparian vegetation	0	0	6	6	0
	F21	Land cover class	0	0	5	5	0
	F22	Protected land	0	0	5	5	0
	F23	Reservoir inundation	0	0	6	6	0

Figure 2.12. Spider diagram spreadsheet provides navigational buttons (to navigate to other sheets) and provides convenient print buttons to print the diagram or the river function summary table to .pdf.

4. QUESTIONNAIRE CROSS-CUT WITH REGULATORY CRITERIA

4.1 BACKGROUND

The Questionnaire is a scientific tool based on scientific principles. It is flexible in that it can easily be applied to many different regulatory procedures, including FERC licensing. The Code of Federal Regulations (CFR) Title 18-Conservation of Power and Water Resources Chapter 1 outlines the role and conduct of FERC and the standards and procedures of the federal hydropower licensing process. Subchapter 5 (CFR 18, § 5) outlines the Integrated Licensing Process, which includes criteria for stakeholders making study requests (CFR 18, § 5.9) and criteria for the applicant in developing a study plan (CFR 18, § 5.11) (see FERC 2005). Appropriate use of the Questionnaire, and the results obtained from its use, can generally be helpful in addressing the following sections of § 5.9 (b) for study request criteria, which are equally analogous to sections of § 5.11 (d):

- § 5.9 (b.1). Describe the goals and objectives of each study proposal and the information to be obtained

- § 5.9 (b.4). Describe the existing information concerning the subject of the study proposal, and the need for additional information

- § 5.9 (b.5). Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how they study results would inform the development of license requirements.

4.1.1 § 5.9 (b.1) and § 5.11 (d.1)

In making a study request or in developing a study plan, stakeholders and applicants, must establish the goals and objectives of a given study and what information is required to meet those objectives. The Questionnaire assists all parties in establishing and understanding the rationale and justification behind why some aspects of the river environment (i.e., functions) are likely to have been affected by operations, and why others have not been. It also requires all parties to critically assess environmental conditions, compile and analyze existing information on environmental conditions and effects, and gain consensus over facts and data, in hopes of identifying natural resource issues that are well-justified by scientific information. Alternatively, the Questionnaire also highlights areas that are highly uncertain and may require additional information to fully understand. Finally, the nature of questions in the Questionnaire helps develop the scope and understand the role of specific studies in identifying causal relationships between operations and environmental conditions. In this way, the Questionnaire identifies the most relevant spatial scales and taxa for study or mitigation design.

The Questionnaire is a tool that supports, but does not replace, complex negotiation dialogue and procedures. In most relicensings, there is a multitude of study requests that could be used to address the natural resource issues identified. The Questionnaire provides all parties with a transparent evaluation of the environmental conditions present at the facility that have the highest likelihood of being impacted by construction or operation activities at a variety of temporal and spatial scales based on existing information. While the Questionnaire tallies the types of responses for questions about each function, it does not set thresholds for the number of “yes” responses indicate a river function should or should not be studied. Similarly, the questionnaire does not how or whether impacts to a river function could be mitigated.

4.1.2 § 5.9 (b.4) and § 5.11 (d.3)

Studies are typically used to fill information gaps, i.e. gaps in knowledge about project operation effects on environmental resources and potential outcomes of alternative mitigation strategies. Obviously, justifying any study or planning for a study requires parties to be cognizant of existing information, from the Pre-Application Document (PAD) or other sources. This prevents studies from being redundant with past efforts (e.g. previous relicensing) or, in the least, helps ensure studies are appropriately focused on filling information gaps. The use of the Questionnaire facilitates the process of identifying existing information. The instructions of the Questionnaire explicitly stipulate that to answer any question "yes" or "no" requires that a user must provide some existing information (e.g., past study, data, picture, stream gage reading, etc.) to qualify the response. The Questionnaire indirectly benefits the study request and study plan process through assisting in the development of the PAD. If an applicant uses the Questionnaire to develop the PAD, the early process of gathering and documenting sources of information could provide more efficient communication among parties and result in time savings in sequent licensing steps.

The negotiation process must determine whether the existing information is sufficient to understand project effects on the environment or whether more information is needed. The Questionnaire helps to identify environmental resources whose condition is highly uncertain and requires gathering of more information or the justification for a study request. The Questionnaire also helps identify the type and spatiotemporal scales of data required to understand environmental conditions.

4.1.3 § 5.9 (b.5) and § 5.11 (d.4)

The Questionnaire can assist parties determine what effected resources can be mitigated through understanding causal linkages between the project and resources, including the role of diffuse stressors at larger spatial- and temporal-scales. Clear connections between the project operations and the effects on environmental resources must be established. The Questionnaire helps all parties draw lines of inference between project operations and direct or indirect effects on river functions. Questions were developed from a review of scientific literature and focus on well-established and common relationships between hydropower and river environments. The Questionnaire also poses questions that require users to critically evaluate whether environmental conditions are related to project operations or an artifact of human activities upstream or in adjacent basins outside the applicant's control or outside the purview of the project. For instance, several questions ask whether hydrology or water quality conditions at the project are influenced from upstream sources. In these cases, the role of project operations on the current environmental conditions must be isolated from other anthropogenic stressors. Related to this, questions require critically analyzing conditions and causal factors, some of which cannot be mitigated with a cost-effective solution.

The Questionnaire provides an objective basis from which study request and plans can be made. A highly controversial aspect of understanding project nexus with environmental resources is that of delineating the baseline condition – i.e. the reference or standard from which one measures the current state of resources. The identification of the quantity and identity of resources are affected by project operations is contingent on baseline delineation. FERC's policy defines baseline conditions as the environmental condition at the time of licensing, specifically stipulating that applicants are generally not required to re-create pre-project conditions (i.e., historical conditions) (FERC 2012). However, in order to evaluate the effects of project operations and alternatives, FERC requires that continuing effects on resources be assessed (presumably including those established since the time of development), as long as the purpose of the information is to evaluate appropriate mitigation under continued project operation (FERC 2012). The Questionnaire provides a transparent evaluation of environmental conditions and a tally of which aspects of the river environment have been affected by project operations. Some of the questions do require users to identify a baseline to make comparisons and understand environmental effects appropriately. These comparisons may include evaluating conditions at neighboring regulated or non-regulated river systems to objectively establish causal relationships between project operations and resources, but also understand what factors can be reasonably mitigated. The Questionnaire is flexible in that questions can be answered differently depending on how the baseline condition is defined. Given that the questionnaire is grounded in scientific literature that predominately measures resource effects through comparisons of pre- and post- development and regulated and non-regulated systems, one suggestion is that the Questionnaire be used to develop a holistic understanding of the current state of the river ecosystem (and associated terrestrial ecosystems) relative to stated resource goals using river functions as indicators. Establishing this understanding does not suggest that mitigation is warranted or even achievable under continued project operations. However, a comprehensive understanding of the ecosystem characteristics inclusive of present and historical stressors can be useful in isolating the most meaningful causal factors between project operations and environmental conditions including which factors can be mitigated to improve conditions.

5. ACKNOWLEDGEMENTS

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