Memorandum

To: TWG members

CC: TWG Alternates and interested parties

From: Kurt Dongoske, chair

Date: October 8, 2002

Re: TWG meeting, November 7-8, 2002

Our November TWG meeting will be a full one. Perhaps the most important issue on the agenda is complying with the AMWG directive to recommend to them the Information Needs and their sequence order in time for their January meeting.

As a reminder, the following process for putting INs in sequence order was approved by the AMWG at its April 25, 2002 meeting:

A. *The TWG will use a "paired comparisons" exercise to put the Research Information Needs (RINs) and Support Information Needs (SINs) in sequence order. The paired comparisons exercise is one in which the group decides, two at a time, which IN should be addressed before the other. There will be discussion before each decision, so that TWG members can learn from each other about how and why they are making their decisions. The result is a list of RINs and SINs in sequence order.*

   Because there are almost 200 RINs and SINs, the TWG will not have time to put all of them in sequence order during the meeting. They will put only 20 to 30 RINs and SINs in sequence order, based on a sample taken from all goals. After the meeting, TWG members will receive a questionnaire that will aid them in putting the remaining RINs and SINs in sequence order, based on the sequence framework they developed during the meeting. TWG members will assign the remaining INs a numerical score to indicate sequence order, for example, from 1 to 20, with 1 being first in sequence.

B. *The results of the questionnaire will be compiled and the results given back to the TWG. If there are INs addressed in the questionnaire about which the group does not agree, they may continue the paired comparisons exercise to resolve those issues at the next TWG meeting.*

C. *When all the RINs and SINs are in sequence order, the group will review the result for fatal flaws – does the result have any fatal flaws that need to be corrected? These might be violations of legal requirements, putting something early in the sequence that can't be determined until later, etc.*

D. *These results will be sent to the AMWG for approval at its next meeting.*

E. *After the AMWG acts, the GCMRC will use the approved list of RINs and SINs in sequence order to produce its Strategic Plan, which will include the Information Needs that will be addressed during the next 5-year period; and its annual workplan, which will include the Information Needs that will be addressed during the coming year. If, during the process of developing its Strategic Plan or annual workplan GCMRC believes that a lower-ranked IN either needs to be addressed first, or in conjunction with other INs needs to be addressed through a combined RFP, they will bring this recommendation with the accompanying rationale to the TWG for review.*

F. *The GCMRC Strategic Plan and annual workplan will be sent to AMWG for approval, after review by the TWG.*

We are at "C" in the above process description – the fatal flaw analysis and recommendation for approval to the AMWG. In order to be able to accomplish everything we need to do in November, we need to be well prepared for that meeting. This memorandum will give you the information you need to be fully prepared for the November TWG meeting.

1. Complete the sequencing ordering: Eight Information Needs have not yet been sequenced. In addition, there are two EINs that, unlike the others, are not so similar to an RIN that they can be assumed to have been sequenced. Therefore, we will spend some time at the November TWG meeting putting these INs into the sequence order, using the paired comparisons process and the framework (1 through 11) that we have used for all the other sequencing exercises.

   The 10 INs are listed below. **Please review these and be prepared to put them in sequence order at the November meeting.**

   - IN 6.1 Develop GIS coverages of natural communities in the Colorado River ecosystem to use in identification of status and trends.
   - IN 6.2 Develop or adopt an existing ecological community classification system. The system should describe the composition and frequency of vascular plants, vertebrates, arthropods, and mollusks to an appropriate taxonomic level.
   - IN 6.3 How is the abundance of vertebrate consumers affected by seasonal shifts in food base abundance in the Colorado River ecosystem?
   - IN 6.4 How do ecosystem processes shape community dynamics?
   - IN 6.5 How much allochthonous material is exchanged between the terrestrial and aquatic systems?
   - IN 8.1 If sediment cannot be preserved in the system using available management actions, what is the feasibility (including technical, legal, economic, and policy issues) of sediment augmentation as a means of achieving this goal?
   - IN 10.1 Determine and track the impacts to power users from implementation of Record of Decision dam operations and segregate those effects from other causes such as changes in the power market.
   - IN 12.1 Develop information that can be used by the TWG, in collaboration with GCMRC, to establish current and target levels for all resources within the AMP as called for in the AMP strategic plan.
   - EIN 11.3.1 Determine if and how experimental flows and other AMP actions restrict tribal access.
   - EIN 11.3.2 Determine reasonable management actions that should be taken to facilitate tribal access.

2. Recommend the Information Needs to AMWG for approval: The AMWG has directed us to forward to them a recommendation for INs approval for their January meeting. At our last two meetings, we noted some clarifying language and language concerns about some of the INs. For example, we felt that the INs that are in the form of yes/no questions should be revised. Mary Orton took note of your comments and questions for other Information Needs, and of your suggestions for new Information Needs.

GCMRC staff will take those suggestions for changes and new INs, and put them in the form of redline/strikeout for your review. That document will be sent to you as soon as it is completed.

3. Recommend the sequence order of the Information Needs to AMWG for approval: The AMWG has directed us to forward to them a recommendation for sequence order of INs for their January meeting. We need to perform the "fatal flaw analysis," as directed by the AMWG: "When all the RINs and SINs are in sequence order, the group will review the result for fatal flaws – does the result have any fatal flaws that need to be corrected? These might be violations of legal requirements, putting something early in the sequence that can't be determined until later, etc."

   I am sending to you with this memorandum the results of the paired comparisons exercise for the Information Needs we've participated in over the last few months. Note that the first part of the document shows the Information Needs by sequence order (blue), and the second part (green) shows them by goal and then by sequence order.

   I propose that we approve a sequence order, and further:

   a. That we recommend that the sequence ordering be revisited in five years, or less if warranted.
   b. That we recommend that the Budget Ad Hoc Committee use the document to analyze the Center's annual workplan. The Committee will use the sequence ordering to determine whether the workplan addresses the most important and urgent items, taking into account
      - the sequence ordering,
      - the core monitoring program,
      - unforeseen urgent issues that have developed, and
      - other items as appropriate.

   Please review the proposed sequence order of the Information Needs in the attached document, and forward any concerns to Mary Orton (mary@maryorton.com, fax 602.426-9867) by October 23, 2002. By knowing what your concerns are, we will be able to determine if we have set aside enough time for our discussion at that meeting, and to adequately prepare for that discussion.

   Feel free to contact Randy Peterson, Mary Orton, or me if you have any questions about this meeting. Thank you for taking the time to prepare for our November meeting!

Information Needs Sequencing Exercise Results Organized by Sequence Order
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Sequence Order 1
(***2 Information Needs***)

RIN 2.1.2 What are the sources of mortality for humpback chub < 51 mm in rearing habitats in the LCR and mainstem and how are they related to dam operations?

RIN 12.3.3 What are the best scientific methods to determine cause and effect relationships in experiments and other management actions conducted under the GCDAMP?

Sequence Order 1.5
(***1 Information Need***)

RIN 2.1.3 What is the relationship between size of HBC and mortality in the LCR and the mainstem? What are the sources of mortality (i.e., predation, cannibalism, other) in the LCR and the mainstem?

Sequence Order 2
(***13 Information Needs***)

RIN 2.1.4 What habitats enhance recruitment of native fish in the LCR and mainstem? What are the physical and biological characteristics of those habitats?

RIN 2.2.3 What are the measurable criteria that need to be met in order to remove jeopardy for humpback chub in the Colorado River ecosystem?

RIN 2.2.5 What are the appropriate habitat conditions for HBC spawning? Where are these found? Can they be created in the mainstem?

RIN 2.2.8 What combination of dam release patterns and non-native fish control facilitates successful spawning and recruitment of humpback chub in the Colorado River ecosystem?

RIN 2.2.9 Is humpback chub augmentation a viable and advisable management strategy to establish mainstem spawning aggregations?

RIN 2.3.2 How will warming mainstem temperatures affect the abundance and distribution of parasites/disease?

RIN 2.4.1 What are the most effective strategies and control methods to limit non-native fish predation and competition on native fish?

RIN 2.4.3 To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

RIN 2.6.1 What is a viable population? What is the probability of extinction over what management time period for species of concern? What is the appropriate method to assess viability?

RIN 4.2.6 To what extent are RBT below the Paria River predators of native fish, primarily HBC? At what size do they become predators of native fish, especially HBC, i.e. how do the trophic interactions between RBT and native fish change with size of fish?

RIN 5.2.2 How does the size and quality of the habitat used by Kanab ambersnail change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

RIN 12.9.2 What is the best combination of dam operations and other management actions to achieve the vision, mission, goals, and objectives of the GCDAMP?

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RIN 12.9.3 What are the relationships between dam operations and other management actions in their effects on resources addressed by GCDAMP management objectives?

Sequence Order 2.5
(***7 Information Needs***)

RIN 2.1.1 What is the minimum population size of HBC that should be sustained in the LCR, to ensure a viable spawning population of HBC in the LCR?

RIN 2.2.4 What is the relationship between the "aggregations" in the mainstem and LCR? Are mainstem aggregations "sinks" of the LCR? Are aggregations real or due to sampling bias?

RIN 2.4.2 Determine if suppression of non-native predators and competitors increases native fish populations?

RIN 2.4.6 What are the population dynamics of those non-native fish that are the major predators and competitors of native fish?

RIN 4.2.1 What is the rate of emigration of rainbow trout from the Lees Ferry reach?

RIN 5.1.5 What is the taxonomic identity of the *Oxyloma* snails at Vasey's Paradise? Is a change to the existing taxonomic status warranted?

RIN 5.1.6 Does the Vasey's Paradise taxon occur outside of Vasey's Paradise? [NOTE: Intended to address the issue of whether this is an endemic population or a relict population or part of a metapopulation.]

Sequence Order 3
(***12 Information Needs***)

RIN 1.5.3 How has the value and availability of drift as a food source for Humpback chub changed with the implementation of Record of Decision operations?

RIN 2.2.7 Is implementation and operation of a TCD and/or steady flows a technically feasible, ecologically sustainable, and practical option for establishing mainstem spawning?

RIN 2.2.10 What techniques are available to determine natal stream of native fish in the Colorado River ecosystem?

RIN 2.3.1 How do parasite/disease loads affect population viability?

RIN 2.4.4 What are the target population levels, body size and age structure for non-native fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

RIN 2.4.5 What are the sources (natal stream) of nonnative predators and competitors?

RIN 5.1.9 How can incidental take for Kanab ambersnail at Vasey's Paradise be minimized?

RIN 7.1.3 What are the potential ecological effects of increasing mainstem water temperatures?

RIN 7.4.4 How does flow rate and fluctuation affect habitat availability and utilization by fish and other organisms?

RIN 11.1.3 What are the thresholds triggering management actions?

Note: Information Needs that are **bold** were part of the original framework.

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RIN 12.2.4 What historic data sets currently exist for all resources targeted by management objectives in the GCDAMP?
RIN 12.9.1 What is the impact on downstream resources of short-term increases to maximum flow, daily fluctuations and downramp limits?
Sequence Order 3.5   ***(6 Information Needs)***
RIN 2.2.1 What is a viable population and what is the appropriate method to assess population viability of native fish in the Colorado River ecosystem? What is an acceptable probability of extinction over what management time period for humpback chub throughout the Colorado River ecosystem?
RIN 2.3.3 Does non-native fish control affect disease/parasite loads? [Note: The concept is if there are fewer hosts, there will be a lower incidence of parasites.]
RIN 4.2.7 What dam release patterns most effectively maintain the Lees Ferry RBT trophy fishery while limiting RBT survival below the Paria River?
RIN 11.1.2 What are the historic properties within the area of potential effects?
RIN 12.2.1 What is the most appropriate field sampling method(s) (e.g., sampling size, spatial and temporal distribution, analysis, explicit assumptions, limitations and uncertainties) and statistical analysis to monitor the status and trends of resources targeted by management objectives?
RIN 12.2.6 What are the acceptable detection levels for change in Colorado River ecosystem resources? How should those levels most appropriately be determined and who should make the determinations?
Sequence Order 4   ***(19 Information Needs)***
RIN 1.1 What are the fundamental trophic interactions in the aquatic ecosystem?
RIN 2.2.2 Can a population dynamics model be developed to predict viability of native fish under different flow regimes and environmental conditions?
RIN 2.2.6 What are the criteria for establishment of spawning aggregations (i.e., how does one determine its "established")?
RIN 2.6.4 How are movement patterns for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem affected by age, natal stream and dam operations?
RIN 2.6.5 How is the rate of mortality for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem related to individual body size? What are the sources of mortality for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem?
RIN 4.2.2 What is the most effective method to detect emigration of rainbow trout from the Lees Ferry reach?
RIN 5.1.4 Identify and evaluate alternative Management Actions to ensure viability of Kanab ambersnail at Vasey's Paradise where (1) the population dynamic model predicts loss of population viability, or (2) monitoring discovers substantial habitat or Kanab ambersnail population declines.

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RIN 5.1.8 What are the measurable criteria that need to be met to remove jeopardy for Kanab ambersnail at Vasey's Paradise?
RIN 6.4.1 How has the abundance, composition, and distribution of the sand beach community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 6.5.3 How has the abundance and distribution of non-native species changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 7.1.2 What are the most likely downstream temperature responses to a variety of scenarios involving a TCD on Glen Canyon Dam?
RIN 7.2.3 Which metals should be measured? Where and how often?
RIN 7.4.3 How do changes in flow volume and rate of change affect food base and energy productivity in the Colorado River ecosystem?
RIN 8.5.1 What elements of Record of Decision operations (upramp, downramp, maximum and minimum flow, MLFF, HMF, and BHBF) are most/least critical to conserving new fine-sediment inputs, and stabilizing sediment deposits above the 25,000 cfs stage?
SIN 8.5.3 What is the relationship between turbidity and biological processes?
SIN 8.5.6 What are the grain-size characteristics of sand bars associated with designated riparian vegetation zones?
RIN 11.1.1 What are the sources of impacts to historic properties?
RIN 11.1.3.b How should adverse effects to historic properties be mitigated?
RIN 11.2.3 Determine acceptable methods to preserve or treat traditionally important resources within the Colorado River ecosystem.
Sequence Order 4.5 (***17 Information Needs***)
RIN 2.5.3 What characteristics define suitable habitat for razorback sucker? Does suitable habitat for razorback sucker occur in the Colorado River ecosystem?
RIN 2.6.3 What is the age structure, including relationship between age and size of flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem?
RIN 4.1.3 To what extent is there overlap in the Lees Ferry reach of RBT habitat and native fish habitat?
RIN 4.2.3 How is the rate of emigration of RBT from the Lees Ferry reach to below the Paria River affected by abundance, hydrology, temperature, and other ecosystem processes?
RIN 4.2.5 To what extent is there overlap in the Colorado River ecosystem below the Paria River of RBT habitat and native fish habitat?

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RIN 6.2.1 How has the patch number, patch distribution, composition and area of the NHWZ community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 6.5.1 Are non-native species expanding or contracting at a local scale (patch or reach)?
SIN 7.2.2 Which water quality variables influence food base and fisheries in the Colorado River ecosystem?
SIN 8.5.4 Can turbidity be managed to achieve biological objectives?
RIN 8.6.2 Do ongoing inputs of coarse-sediment from tributaries alter the distribution of main channel habitats needed by benthic organisms within pools, runs and eddies throughout the Colorado River ecosystem?
RIN 11.1.2.a For each tribe and living community, what are the register eligible traditional cultural properties?
RIN 11.2.1 What are traditionally important resources and locations for each tribe and other groups?
RIN 11.2.2 What is the baseline measure for resource integrity?
RIN 12.1.1 What is the necessary quantity and quality of cultural and socioeconomic information for adequate decision-making?
RIN 12.3.1 What are the most effective method(s) to integrate and synthesize resource data to increase our understanding of the past and for ongoing interactions of humans with the Colorado River ecosystem.
RIN 12.4.1 What are the most effective methods to maintain or attain the participation of externally-funded investigators?
RIN 12.5.5 Identify the desired level of information, education, and outreach provided for Glen and Grand Canyon river users and the general public?
Sequence Order 5 (***52 Information Needs***)
RIN 1.2 How is the production, composition, density and biomass of the benthic invertebrate community affected by primary productivity vs. allochthonous inputs?
RIN 1.3 What foodbase criteria do other agencies use to assess aquatic ecosystem health?
RIN 1.1.1 How are the composition and biomass of primary producers between Glen Canyon Dam and the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors.
RIN 1.1.4 What are the habitat characteristics between Glen Canyon Dam and the Paria River that most affect primary productivity? How are these characteristics affected by Glen Canyon Dam operations?
RIN 1.2.1 How are the composition and biomass of benthic invertebrates between Glen Canyon Dam and the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors?

Note: Information Needs that are **bold** were part of the original framework.

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RIN 1.2.2 What is the estimated productivity of benthic invertebrates for the reach between Glen Canyon Dam and the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]
RIN 1.4.1 How are the composition and biomass of benthic invertebrates in the Colorado River ecosystem below the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]
RIN 1.5.2 How do top-down effects (grazing and predation) affect the abundance and composition of drift?
RIN 2.6.6 How does temperature modification in the mainstem affect recruitment and mortality for flannel-mouth sucker, blue-head sucker and speckled dace originating from tributary spawning efforts?
RIN 5.1.2 What parameters have the greatest influence on population viability of Kanab ambersnail at Vasey's Paradise (e.g., parasites, predation, discharges, habitat size, quality, and human use/visitation)?
RIN 5.1.3 Develop a population dynamic model to predict Kanab ambersnail viability under different flows and environmental conditions.
RIN 5.2.1 How does the size, quality, and recovery time of Kanab ambersnail habitat change following natural scours, or other events?
RIN 6.1.1 How has the abundance, composition, distribution, and area of the marsh community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 6.3.2 What management actions have the potential to maintain the OHWZ community at the current stage elevation, or establish the community at a lower stage elevation?
RIN 6.5.2 What management actions have the potential to increase or decrease the distribution and abundance of non-native species?
RIN 6.6.2 Which seeps and springs are culturally important or occupied by rare and endemic species?
RIN 7.1.1 What are the desired ranges of spatial and temporal patterns of water temperatures for the Colorado River ecosystem?
RIN 7.2.1 Which major ions should be measured? Where and how often?
RIN 7.2.2 Which nutrients should be measured? Where and how often?
SIN 7.2.1 Do the hydrodynamics and stratification of Lake Powell influence the food base or fisheries downstream?
RIN 7.3.1 Develop simulation models for Lake Powell and the Colorado River to predict water quality conditions under various operating scenarios, supplant monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.
RIN 7.4.2 What is the desired pattern of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, HMFs, or other flows to meet AMP Goals and Objectives?

Note: Information Needs that are **bold** were part of the original framework.

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RIN 8.1.1 What is the longitudinal variability of fine-sediment inputs, by reach?
RIN 8.1.2 What is the temporal variability of fine-sediment inputs, by reach?
RIN 8.1.3 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]
RIN 8.2.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]
RIN 8.3.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]
RIN 8.4.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]
RIN 8.5.4 What is the significance of aeolian processes in terrestrial sandbar reworking?
RIN 8.5.6 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]
SIN 8.5.2 What is the relationship between the fine-sediment budget and turbidity?
SIN 8.5.5 Can the ongoing fine-sediment supply be managed to achieve sustainable habitats?
RIN 9.3.1 What is the desired target level of camping beaches by reach?
RIN 10.1.2 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of increasing the upramp and downramp limit?
RIN 10.1.3 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of raising the maximum power plant flow limit above 25,000 cfs?
RIN 10.3.1 What are the effects of providing financial exception criteria?
RIN 11.1.1.a What and where are the geomorphic processes that link loss of site integrity with dam operations as opposed to dam existence or natural processes?
RIN 11.1.1.b What are the terrace formation processes and how do dam operations affect current terrace formations processes?
RIN 11.1.1.c Determine if and where dam operations cause accelerated erosion to historic properties?
RIN 11.1.1.d What are the potential threats to historic properties relative to integrity and significance?
RIN 11.1.2.b How do specific sites meet National Register Criteria for Evaluation?
RIN 11.1.2.c Identify AMP activities that affect National Register eligible sites?
RIN 1.1.3.a Determine the necessary information to assess resource integrity.

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Sequence Order September 2002
RIN 11.2.4 If there is resource change, what are the sources?
RIN 12.3.4 How well do research designs and workplans do in incorporating Tribal perspectives and values into the standard western science paradigm? Is it more beneficial to keep the perspective separated?
RIN 12.3.5 How effective is the AMP in addressing the EIS statement "Long-term monitoring and research are … implemented to measure how well the selected alternative meets resource management objectives."?
RIN 12.5.1 What are the most effective means to build AMP public support through effective public outreach?
RIN 12.5.2 What are the most effective means to attain and maintain effective communication and coordination with other resource management programs in the Colorado River basin to ensure consideration of their values and perspectives into the AMP and vice versa?
RIN 12.5.4 What is the most effective way to distribute information to our stakeholders and the public in a secure and accessible fashion?
RIN 12.7.1 Are the current strategies to achieve tribal consultation effective?
RIN 12.7.2 Do these strategies meet legal and AMP protocols?
RIN 12.8.1 Is tribal participation in the AMP research and long-term monitoring programs sufficiently meeting tribal needs and desires?
Sequence Order 5.5 (***15 Information Needs***)
RIN 1.2.4 What are the habitat characteristics between Glen Canyon Dam and the Paria River that most affect benthic invertebrates? How are these characteristics affected by Glen Canyon Dam operations?
RIN 1.3.1 How are the composition and biomass of primary producers in the Colorado River ecosystem below the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors.
RIN 1.4.3 How do top-down effects (grazing and predation) affect the abundance and composition of benthic invertebrates?
RIN 1.5.1 How are the composition and biomass of drift in the Colorado River ecosystem affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors?
RIN 4.2.4 What is the target population size of RBT appropriate for the Lees Ferry reach that limits downstream emigration?
RIN 6.3.1 How has the abundance, composition, and distribution of the OHWZ community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 6.7.5 What is the need, feasibility, and priority of maintaining habitat suitability for southwestern willow flycatcher in the Colorado River ecosystem?
RIN 8.5.2 What is the reach-scale variability of fine-sediment storage throughout the main channel?

Note: Information Needs that are **bold** were part of the original framework.

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RIN 8.5.5 What are the historic and ongoing longitudinal trends of fine-sediment storage, above 25,000 cfs?
SIN 8.5.7 What are the limiting factors that regulate substrate availability and its distribution?
RIN 9.4.1 Identify the elements of wilderness experience specific to the Colorado River ecosystem.
RIN 10.1.4 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of lowering the minimum flow limit below 5,000 cfs?
RIN 11.1.2.d Identify NPS permitted activities that affect National Register eligible sites.
RIN 11.1.5 What are appropriate strategies to preserve resource integrity?
RIN 12.2.8 Determine accurate, reliable, and standardized methods for measuring erosion at historic sites.
Sequence Order 6 (***15 Information Needs***)
RIN 1.1.3 How do top-down effects (grazing and predation) on primary producers affect food base productivity?
RIN 1.2.3 How do top-down effects (grazing and predation) affect the abundance and composition of benthic invertebrates?
RIN 1.3.3 Do top-down effects (grazing and predation) on primary producers affect food base productivity?
RIN 1.3.4 What are the habitat characteristics in the Colorado River ecosystem below the Paria River that most affect primary productivity? How are these characteristics affected by Glen Canyon Dam operations?
RIN 1.4.4 What are the habitat characteristics in the Colorado River ecosystem below the Paria River that most affect benthic invertebrates? How are these characteristics affected by Glen Canyon Dam operations?
RIN 2.2.11 What are the impacts of current recreational activities on mortality, recruitment and the population size of humpback chub?
RIN 2.6.2 What are the physical and biological characteristics of habitats that enhance recruitment of flannel-mouth sucker, blue-head sucker and speckled dace populations in the Colorado River ecosystem?
SIN 7.3.1 Measure appropriate water quality parameters to determine the influence of these parameters on biological resources in the Colorado River ecosystem.
SIN 8.5.8 What is the total area of different aquatic habitat types (cobble, gravel, sand, talus, etc,) in the Colorado River ecosystem?
SIN 8.5.9 Are sandbar textures related to cultural site stability, if so, then how?
RIN 10.1.1 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of increasing the daily fluctuation limit?
RIN 10.4.1 What are the effects on the Colorado River ecosystem and marketable power and energy of increasing Automatic Generation Control at Glen Canyon Dam?

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RIN 12.2.3 What digital, or other, technologies exist and should be used to record field observations and spatially reference these data to facilitate their integration into GCMRC databases and use by PI's and stakeholders?

RIN 12.3.2 What are the differences between western science and tribal processes for design of studies and for gathering, analyzing, and interpreting data used in the adaptive management program?

RIN 12.5.3 To what extent does the public understand and support the GCDAMP?

Sequence Order 6.5
(***6 Information Needs***)

RIN 1.4 What is the current carbon budget for the Colorado River ecosystem?

RIN 5.1.1 What constitutes population viability for Kanab ambersnail at Vasey's Paradise?

RIN 5.2.3 Can remote sensing technologies be used to less intrusively and more cost effectively characterize and monitor Kanab ambersnail habitat at Vasey's Paradise (vegetation type and distribution)?

RIN 7.2.4 What are the water-borne pathogens that are a threat to human health? How should they be monitored? Where and how often?

RIN 8.6.1 Do ongoing inputs of coarse-sediment from tributaries influence storage of fine sediment within pools, runs and eddies throughout the Colorado River ecosystem?

RIN 12.2.2 What remote sensing technologies are available to less intrusively and more cost effectively monitor, characterize and map: (a) the aquatic food base, (b) fish, (c) fish habitat features, (d) Kanab ambersnail habitat, (e) water quality parameters, (f) bathymetry and associated substrates and (g) cultural sites?

Sequence Order 7
(***4 Information Needs***)

RIN 6.5.4 How can remote sensing assist in the development of a map of non-native species distributions in the Colorado River ecosystem including characterization of the types of habitat that supports non-native species?

RIN 9.5.1 What effects do administrative trips, including research and monitoring activities have on recreational users?

RIN 12.2.5 What remote sensing data are available or can be obtained that will support the production of a system-wide resource map?

RIN 12.2.7 Can habitat designation using a GIS application be utilized as an effective method to adjust site-specific population estimates (e.g., mark-recapture or depletion methods) to system-wide extrapolations by using catch-per-unit-effort values that are scaled relative to the proportion of different habitat types available in Glen Canyon?

Sequence Order 7.5
(***2 Information Needs***)

RIN 7.3.1.a Determine the status and trends of chemical and biological components of water quality in Lake Powell as a function of regional hydrologic conditions and their relation to downstream releases.

SIN 8.5.10 Are sandbar textures related to recreational site stability, if so, then how?

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results
Organized by Sequence Order
September 2002

Sequence Order 8
(***6 Information Needs***)

RIN 1.3.2 What is the estimated primary productivity in the Colorado River ecosystem below the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]

RIN 1.4.2 What is the estimated productivity of benthic invertebrates in the Colorado River ecosystem below the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]

RIN 2.5.4 What is the feasibility and advisability of augmenting razorback sucker in the Colorado River ecosystem to attain a viable population including technical/legal/policy constraints?

RIN 6.7.1 What is the function of the Colorado River ecosystem as a migratory corridor for southwestern willow flycatcher?

RIN 6.7.2 What is the foodbase that supports southwestern willow flycatcher and other terrestrial vertebrates?

RIN 6.7.3 What constitutes suitable southwestern willow flycatcher habitat?

Sequence Order 8.5
(***1 Information Need***)

RIN 6.6.3 How has the composition, abundance and distribution of seep and spring communities changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?

Sequence Order 9
(***9 Information Needs***)

RIN 1.1.2 What is the estimated productivity for the reach between Glen Canyon Dam and the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]

RIN 2.5.5 What are the genetic and ecological criteria for reintroducing razorback sucker into the Colorado River ecosystem?

RIN 4.1.2 What is the minimum quantity and quality of spawning substrate necessary for maintaining a wild reproducing rainbow trout population in the Lees Ferry reach?

RIN 5.1.7 What is the historic range of Oxyloma haydeni? Can this range be determined from subfossil or fossil evidence? [NOTE: This is intended to determine if this is a relict species and the initial work would be done at Vasey's Paradise, South Canyon and other probable sites within the Colorado River ecosystem.]

RIN 6.6.1 How is seep and spring habitat affected by variation in dam operations, variation in seep or spring flow, and variation in water quality? How do flow rates and water quality parameters at seeps and springs compare with historic measurements?

RIN 6.6.4 What is the distribution, patch size, total area, and composition of seep and spring communities and the flow rate and water quality of all seeps and springs within the Colorado River ecosystem?

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Sequence Order September 2002
RIN 6.7.4 How has the abundance, distribution and reproductive success of southwestern willow flycatcher changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?
RIN 7.3.3 How do dam operations affect reservoir limnology?
SIN 8.5.1 Do sandbar textures influence biological processes, if so, then how?
Sequence Order 9.5 (***2 Information Needs***)
RIN 3.1.1 What information (including technical, legal, economic, and policy issues) should be considered in determining the feasibility and advisability of restoring pikeminnow, bonytail, roundtail chub, river otter, or other extirpated species?
RIN 8.5.3 What is the pre- and post-dam range of grain-size in fine-sediment deposits, by reach?
Sequence Order 10 (***2 Information Needs***)
RIN 4.1.1 What is the target proportional stock density (i.e., trade-off between numbers and size) for rainbow trout in the Lees Ferry reach?
RIN 4.1.4 Has there been a change in the genetics or "strain" of rainbow trout in the Lees Ferry reach that might account for the decrease in average size of fish creeled by anglers?
Sequence Order 10.5 (***0 Information Needs***)
Sequence Order 11 (***9 Information Needs***)
RIN 2.5.1 Would the introduction of razorback suckers into the Colorado River ecosystem compromise the genetic integrity of flannelmouth suckers due to hybridization?
RIN 2.5.2 Is the existing hybridization between razorback sucker and flannelmouth sucker a source of concern for the genetic integrity of either species? What are the factors contributing to this ongoing hybridization?
RIN 2.5.6 What are the measurable criteria that would need to be met to remove jeopardy for razorback sucker in the Colorado River ecosystem?
RIN 7.3.2 How accurately can modeling predict reservoir dynamics and operational scenarios?
RIN 9.1.1 What are the attributes of a quality river experience? (How do you define a quality river experience?)
RIN 9.1.2 Are the visitor capacities for recreational activities consistent with NPS management plans? Are NPS management plans consistent with Colorado River ecosystem capacities to absorb visitor impacts?
RIN 9.1.3 Do ongoing inputs of coarse-sediment from tributaries diminish or enhance navigability of rapids throughout the Colorado River ecosystem?
RIN 12.1.3 What are the use (e.g., hydropower, trout fishing, rafting) and non-use (e.g., option, vicarious, quasi-option, bequest and existence) values of the Colorado River ecosystem

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Sequence Order September 2002
RIN 12.1.4 How does use (e.g., hydropower, trout fishing, rafting) and non-use (e.g., option, vicarious, quasi-option, bequest and existence) values change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?
Sequence Order 11.5 (4 Information Needs)
RIN 7.3.1.b Determine stratification, convective mixing patterns, and behavior of advective currents in Lake Powell and their relation to Glen Canyon Dam operations to predict seasonal patterns and trends in downstream releases.
RIN 7.4.1 What is the desired range of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, and habitat maintenance flows, or other flows that meet AMP goals and objectives?
RIN 10.1.5 How do power-marketing contract provisions affect Glen Canyon Dam releases?
RIN 12.1.2 What is the economic value of the recreational use of the Colorado River ecosystem downstream from Glen Canyon Dam?

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
Goal 1 Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.	***Sequence Order***
RIN 1.5.3 How has the value and availability of drift as a food source for Humpback chub changed with the implementation of Record of Decision operations?	**3**
RIN 1.1 What are the fundamental trophic interactions in the aquatic ecosystem?	4
RIN 1.2 How is the production, composition, density and biomass of the benthic invertebrate community affected by primary productivity vs. allochthonous inputs?	5
RIN 1.3 What foodbase criteria do other agencies use to assess aquatic ecosystem health?	5
RIN 1.1.1 How are the composition and biomass of primary producers between Glen Canyon Dam and the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors.	5
RIN 1.1.4 What are the habitat characteristics between Glen Canyon Dam and the Paria River that most affect primary productivity? How are these characteristics affected by Glen Canyon Dam operations?	5
RIN 1.2.1 How are the composition and biomass of benthic invertebrates between Glen Canyon Dam and the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors?	5
RIN 1.2.2 What is the estimated productivity of benthic invertebrates for the reach between Glen Canyon Dam and the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]	5
RIN 1.4.1 How are the composition and biomass of benthic invertebrates in the Colorado River ecosystem below the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]	5
RIN 1.5.2 How do top-down effects (grazing and predation) affect the abundance and composition of drift?	**5**
RIN 1.2.4 What are the habitat characteristics between Glen Canyon Dam and the Paria River that most affect benthic invertebrates? How are these characteristics affected by Glen Canyon Dam operations?	5.5
RIN 1.3.1 How are the composition and biomass of primary producers in the Colorado River ecosystem below the Paria River affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors.	5.5

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 1.4.3 How do top-down effects (grazing and predation) affect the abundance and composition of benthic invertebrates?	5.5
RIN 1.5.1 How are the composition and biomass of drift in the Colorado River ecosystem affected by flow and water quality (including nutrients, temperature, light regime, toxins, dissolved oxygen), and water borne diseases, or other factors?	5.5
RIN 1.1.3 How do top-down effects (grazing and predation) on primary producers affect food base productivity?	6
RIN 1.2.3 How do top-down effects (grazing and predation) affect the abundance and composition of benthic invertebrates?	6
RIN 1.3.3 Do top-down effects (grazing and predation) on primary producers affect food base productivity?	6
RIN 1.3.4 What are the habitat characteristics in the Colorado River ecosystem below the Paria River that most affect primary productivity? How are these characteristics affected by Glen Canyon Dam operations?	6
RIN 1.4.4 What are the habitat characteristics in the Colorado River ecosystem below the Paria River that most affect benthic invertebrates? How are these characteristics affected by Glen Canyon Dam operations?	6
RIN 1.4 What is the current carbon budget for the Colorado River ecosystem?	6.5
RIN 1.3.2 What is the estimated primary productivity in the Colorado River ecosystem below the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]	8
RIN 1.4.2 What is the estimated productivity of benthic invertebrates in the Colorado River ecosystem below the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]	8
RIN 1.1.2 What is the estimated productivity for the reach between Glen Canyon Dam and the Paria River? [Note: If the cost of obtaining this data, relative to the benefit of the information suggests the information is not worth the expense, this RIN will not be pursued.]	9
Goal 2 Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.	***Sequence Order***
RIN 2.1.2 What are the sources of mortality for humpback chub < 51 mm in rearing habitats in the LCR and mainstem and how are they related to dam operations?	**1**

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 2.1.3 What is the relationship between size of HBC and mortality in the LCR and the mainstem? What are the sources of mortality (i.e., predation, cannibalism, other) in the LCR and the mainstem?	1.5
RIN 2.1.4 What habitats enhance recruitment of native fish in the LCR and mainstem? What are the physical and biological characteristics of those habitats?	2
RIN 2.2.3 What are the measurable criteria that need to be met in order to remove jeopardy for humpback chub in the Colorado River ecosystem?	2
RIN 2.2.5 What are the appropriate habitat conditions for HBC spawning? Where are these found? Can they be created in the mainstem?	2
RIN 2.2.8 What combination of dam release patterns and non-native fish control facilitates successful spawning and recruitment of humpback chub in the Colorado River ecosystem?	2
RIN 2.2.9 Is humpback chub augmentation a viable and advisable management strategy to establish mainstem spawning aggregations?	2
RIN 2.3.2 How will warming mainstem temperatures affect the abundance and distribution of parasites/disease?	2
RIN 2.4.1 What are the most effective strategies and control methods to limit non-native fish predation and competition on native fish?	2
RIN 2.4.3 To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?	2
RIN 2.6.1 What is a viable population? What is the probability of extinction over what management time period for species of concern? What is the appropriate method to assess viability?	2
RIN 2.1.1 What is the minimum population size of HBC that should be sustained in the LCR, to ensure a viable spawning population of HBC in the LCR?	2.5
RIN 2.2.4 What is the relationship between the “aggregations” in the mainstem and LCR? Are mainstem aggregations “sinks” of the LCR? Are aggregations real or due to sampling bias?	2.5
RIN 2.4.2 Determine if suppression of non-native predators and competitors increases native fish populations?	2.5
RIN 2.4.6 What are the population dynamics of those non-native fish that are the major predators and competitors of native fish?	2.5
RIN 2.2.7 Is implementation and operation of a TCD and/or steady flows a technically feasible, ecologically sustainable, and practical option for establishing mainstem spawning?	3
RIN 2.2.10 What techniques are available to determine natal stream of native fish in the Colorado River ecosystem?	**3**

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 2.3.1 How do parasite/disease loads affect population viability?	3
RIN 2.4.4 What are the target population levels, body size and age structure for non-native fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?	3
RIN 2.4.5 What are the sources (natal stream) of nonnative predators and competitors?	3
RIN 2.2.1 What is a viable population and what is the appropriate method to assess population viability of native fish in the Colorado River ecosystem? What is an acceptable probability of extinction over what management time period for humpback chub throughout the Colorado River ecosystem?	3.5
RIN 2.3.3 Does non-native fish control affect disease/parasite loads? [Note: The concept is if there are fewer hosts, there will be a lower incidence of parasites.]	3.5
RIN 2.2.2 Can a population dynamics model be developed to predict viability of native fish under different flow regimes and environmental conditions?	4
RIN 2.2.6 What are the criteria for establishment of spawning aggregations (i.e., how does one determine its "established")?	4
RIN 2.6.4 How are movement patterns for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem affected by age, natal stream and dam operations?	4
RIN 2.6.5 How is the rate of mortality for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem related to individual body size? What are the sources of mortality for flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem?	4
RIN 2.5.3 What characteristics define suitable habitat for razorback sucker? Does suitable habitat for razorback sucker occur in the Colorado River ecosystem?	4.5
RIN 2.6.3 What is the age structure, including relationship between age and size of flannel-mouth sucker, blue-head sucker and speckled dace in the Colorado River ecosystem?	4.5
RIN 2.6.6 How does temperature modification in the mainstem affect recruitment and mortality for flannel-mouth sucker, blue-head sucker and speckled dace originating from tributary spawning efforts?	5
RIN 2.2.11 What are the impacts of current recreational activities on mortality, recruitment and the population size of humpback chub?	6
RIN 2.6.2 What are the physical and biological characteristics of habitats that enhance recruitment of flannel-mouth sucker, blue-head sucker and speckled dace populations in the Colorado River ecosystem?	6
RIN 2.5.4 What is the feasibility and advisability of augmenting razorback sucker in the Colorado River ecosystem to attain a viable population including technical/legal/policy constraints?	8

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 2.5.5 What are the genetic and ecological criteria for reintroducing razorback sucker into the Colorado River ecosystem?	9
RIN 2.5.1 Would the introduction of razorback suckers into the Colorado River ecosystem compromise the genetic integrity of flannelmouth suckers due to hybridization?	**11**
RIN 2.5.2 Is the existing hybridization between razorback sucker and flannelmouth sucker a source of concern for the genetic integrity of either species? What are the factors contributing to this ongoing hybridization?	11
RIN 2.5.6 What are the measurable criteria that would need to be met to remove jeopardy for razorback sucker in the Colorado River ecosystem?	11
Goal 3 Restore populations of extirpated species, as feasible and advisable.	***Sequence Order***
RIN 3.1.1 What information (including technical, legal, economic, and policy issues) should be considered in determining the feasibility and advisability of restoring pikeminnow, bonytail, roundtail chub, river otter, or other extirpated species?	9.5
Goal 4 Maintain a naturally reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.	***Sequence Order***
RIN 4.2.6 To what extent are RBT below the Paria River predators of native fish, primarily HBC? At what size do they become predators of native fish, especially HBC, i.e. how do the trophic interactions between RBT and native fish change with size of fish?	**2**
RIN 4.2.1 What is the rate of emigration of rainbow trout from the Lees Ferry reach?	2.5
RIN 4.2.7 What dam release patterns most effectively maintain the LEES Ferry RBT trophy fishery wile limiting RBT survival below the Paria River?	3.5
RIN 4.2.2 What is the most effective method to detect emigration of rainbow trout from the Lees Ferry reach?	4
RIN 4.1.3 To what extent is there overlap in the Lees Ferry reach of RBT habitat and native fish habitat?	4.5
RIN 4.2.3 How is the rate of emigration of RBT from the Lees Ferry reach to below the Paria River affected by abundance, hydrology, temperature, and other ecosystem processes?	4.5
RIN 4.2.5 To what extent is there overlap in the Colorado River ecosystem below the Paria River of RBT habitat and native fish habitat?	4.5

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
RIN 4.2.4 What is the target population size of RBT appropriate for the Lees Ferry reach that limits downstream emigration?	5.5
RIN 4.1.2 What is the minimum quantity and quality of spawning substrate necessary for maintaining a wild reproducing rainbow trout population in the Lees Ferry reach?	9
RIN 4.1.1 What is the target proportional stock density (i.e., trade-off between numbers and size) for rainbow trout in the Lees Ferry reach?	10
RIN 4.1.4 Has there been a change in the genetics or "strain" of rainbow trout in the Lees Ferry reach that might account for the decrease in average size of fish creeled by anglers?	**10**
Goal 5 Maintain or attain viable populations of Kanab ambersnail.	***Sequence Order***
RIN 5.2.2 How does the size and quality of the habitat used by Kanab ambersnail change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?	2
RIN 5.1.5 What is the taxonomic identity of the *Oxyloma* snails at Vasey's Paradise? Is a change to the existing taxonomic status warranted?	2.5
RIN 5.1.6 Does the Vasey's Paradise taxon occur outside of Vasey's Paradise? [NOTE: Intended to address the issue of whether this is an endemic population or a relict population or part of a metapopulation.]	2.5
RIN 5.1.9 How can incidental take for Kanab ambersnail at Vasey's Paradise be minimized?	3
RIN 5.1.4 Identify and evaluate alternative Management Actions to ensure viability of Kanab ambersnail at Vasey's Paradise where (1) the population dynamic model predicts loss of population viability, or (2) monitoring discovers substantial habitat or Kanab ambersnail population declines.	4
RIN 5.1.8 What are the measurable criteria that need to be met to remove jeopardy for Kanab ambersnail at Vasey's Paradise?	4
RIN 5.1.2 What parameters have the greatest influence on population viability of Kanab ambersnail at Vasey's Paradise (e.g., parasites, predation, discharges, habitat size, quality, and human use/visitation)?	5
RIN 5.1.3 Develop a population dynamic model to predict Kanab ambersnail viability under different flows and environmental conditions.	5
RIN 5.2.1 How does the size, quality, and recovery time of Kanab ambersnail habitat change following natural scours, or other events?	5
RIN 5.1.1 What constitutes population viability for Kanab ambersnail at Vasey's Paradise?	6.5

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 5.2.3 Can remote sensing technologies be used to less intrusively and more cost effectively characterize and monitor Kanab ambersnail habitat at Vasey's Paradise (vegetation type and distribution)?	6.5
RIN 5.1.7 What is the historic range of Oxyloma haydeni? Can this range be determined from subfossil or fossil evidence? [NOTE: This is intended to determine if this is a relict species and the initial work would be done at Vasey's Paradise, South Canyon and other probable sites within the Colorado River ecosystem.]	**9**
Goal 6 Protect or improve the biotic riparian and spring communities including threatened and endangered species and their critical habitat.	***Sequence Order***
RIN 6.4.1 How has the abundance, composition, and distribution of the sand beach community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	4
RIN 6.5.3 How has the abundance and distribution of non-native species changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	4
RIN 6.2.1 How has the patch number, patch distribution, composition and area of the NHWZ community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	4.5
RIN 6.5.1 Are non-native species expanding or contracting at a local scale (patch or reach)?	4.5
RIN 6.1.1 How has the abundance, composition, distribution, and area of the marsh community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	5
RIN 6.3.2 What management actions have the potential to maintain the OHWZ community at the current stage elevation, or establish the community at a lower stage elevation?	5
RIN 6.5.2 What management actions have the potential to increase or decrease the distribution and abundance of non-native species?	5
RIN 6.6.2 Which seeps and springs are culturally important or occupied by rare and endemic species?	5
RIN 6.3.1 How has the abundance, composition, and distribution of the OHWZ community changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	5.5
RIN 6.7.5 What is the need, feasibility, and priority of maintaining habitat suitability for southwestern willow flycatcher in the Colorado River ecosystem?	5.5

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
RIN 6.5.4 How can remote sensing assist in the development of a map of non-native species distributions in the Colorado River ecosystem including characterization of the types of habitat that supports non-native species?	7
RIN 6.7.1 What is the function of the Colorado River ecosystem as a migratory corridor for southwestern willow flycatcher?	8
RIN 6.7.2 What is the foodbase that supports southwestern willow flycatcher and other terrestrial vertebrates?	8
RIN 6.7.3 What constitutes suitable southwestern willow flycatcher habitat?	**8**
RIN 6.6.3 How has the composition, abundance and distribution of seep and spring communities changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	8.5
RIN 6.6.1 How is seep and spring habitat affected by variation in dam operations, variation in seep or spring flow, and variation in water quality? How do flow rates and water quality parameters at seeps and springs compare with historic measurements?	9
RIN 6.6.4 What is the distribution, patch size, total area, and composition of seep and spring communities and the flow rate and water quality of all seeps and springs within the Colorado River ecosystem?	9
RIN 6.7.4 How has the abundance, distribution and reproductive success of southwestern willow flycatcher changed since dam closure (1963), high flows (1984), interim flows (1991) and the implementation of Record of Decision operations (1996)?	9
Goal 7 Establish water temperature, quality, and flow dynamics to achieve the Adaptive Management Program ecosystem goals.	***Sequence Order***
RIN 7.1.3 What are the potential ecological effects of increasing mainstem water temperatures?	3
RIN 7.4.4 How does flow rate and fluctuation affect habitat availability and utilization by fish and other organisms?	3
RIN 7.1.2 What are the most likely downstream temperature responses to a variety of scenarios involving a TCD on Glen Canyon Dam?	4
RIN 7.2.3 Which metals should be measured? Where and how often?	4
RIN 7.4.3 How do changes in flow volume and rate of change affect food base and energy productivity in the Colorado River ecosystem?	**4**
SIN 7.2.2 Which water quality variables influence food base and fisheries in the Colorado River ecosystem?	4.5

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 7.1.1 What are the desired ranges of spatial and temporal patterns of water temperatures for the Colorado River ecosystem?	5
RIN 7.2.1 Which major ions should be measured? Where and how often?	5
RIN 7.2.2 Which nutrients should be measured? Where and how often?	5
SIN 7.2.1 Do the hydrodynamics and stratification of Lake Powell influence the food base or fisheries downstream?	5
RIN 7.3.1 Develop simulation models for Lake Powell and the Colorado River to predict water quality conditions under various operating scenarios, supplant monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.	5
RIN 7.4.2 What is the desired pattern of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, HMFs, or other flows to meet AMP Goals and Objectives?	5
SIN 7.3.1 Measure appropriate water quality parameters to determine the influence of these parameters on biological resources in the Colorado River ecosystem.	6
RIN 7.2.4 What are the water-borne pathogens that are a threat to human health? How should they be monitored? Where and how often?	6.5
RIN 7.3.1.a Determine the status and trends of chemical and biological components of water quality in Lake Powell as a function of regional hydrologic conditions and their relation to downstream releases.	7.5
RIN 7.3.3 How do dam operations affect reservoir limnology?	9
RIN 7.3.2 How accurately can modeling predict reservoir dynamics and operational scenarios?	11
RIN 7.3.1.b Determine stratification, convective mixing patterns, and behavior of advective currents in Lake Powell and their relation to Glen Canyon Dam operations to predict seasonal patterns and trends in downstream releases.	11.5
RIN 7.4.1 What is the desired range of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, and habitat maintenance flows, or other flows that meet AMP goals and objectives?	11.5
Goal 8 Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the Adaptive Management Program ecosystem goals.	***Sequence Order***
RIN 8.5.1 What elements of Record of Decision operations (upramp, downramp, maximum and minimum flow, MLFF, HMF, and BHBF) are most/least critical to conserving new fine-sediment inputs, and stabilizing sediment deposits above the 25,000 cfs stage?	**4**
SIN 8.5.3 What is the relationship between turbidity and biological processes?	4

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
SIN 8.5.6 What are the grain-size characteristics of sand bars associated with designated riparian vegetation zones?	4
SIN 8.5.4 Can turbidity be managed to achieve biological objectives?	4.5
RIN 8.6.2 Do ongoing inputs of coarse-sediment from tributaries alter the distribution of main channel habitats needed by benthic organisms within pools, runs and eddies throughout the Colorado River ecosystem?	4.5
RIN 8.1.1 What is the longitudinal variability of fine-sediment inputs, by reach?	5
RIN 8.1.2 What is the temporal variability of fine-sediment inputs, by reach?	5
RIN 8.1.3 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]	5
RIN 8.2.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]	5
RIN 8.3.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]	5
RIN 8.4.1 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]	5
RIN 8.5.4 What is the significance of aeolian processes in terrestrial sandbar reworking?	5
RIN 8.5.6 What fine sediment abundance and distribution, by reach, is desirable to support GCDAMP ecosystem goals? [Note: Definition of "desirable" will be derived from targets for other resources and managers goals.]	5
SIN 8.5.2 What is the relationship between the fine-sediment budget and turbidity?	5
SIN 8.5.5 Can the ongoing fine-sediment supply be managed to achieve sustainable habitats?	5
RIN 8.5.2 What is the reach-scale variability of fine-sediment storage throughout the main channel?	5.5
RIN 8.5.5 What are the historic and ongoing longitudinal trends of fine-sediment storage, above 25,000 cfs?	5.5
SIN 8.5.7 What are the limiting factors that regulate substrate availability and its distribution?	5.5
SIN 8.5.8 What is the total area of different aquatic habitat types (cobble, gravel, sand, talus, etc,) in the Colorado River ecosystem?	6

Note: Information Needs that are **bold** were part of the original framework.

Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
SIN 8.5.9 Are sandbar textures related to cultural site stability, if so, then how?	6
RIN 8.6.1 Do ongoing inputs of coarse-sediment from tributaries influence storage of fine sediment within pools, runs and eddies throughout the Colorado River ecosystem?	6.5
SIN 8.5.10 Are sandbar textures related to recreational site stability, if so, then how?	7.5
SIN 8.5.1 Do sandbar textures influence biological processes, if so, then how?	9
RIN 8.5.3 What is the pre- and post-dam range of grain-size in fine-sediment deposits, by reach?	9.5
Goal 9 Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of the Adaptive Management Program ecosystem goals.	***Sequence Order***
RIN 9.3.1 What is the desired target level of camping beaches by reach?	5
RIN 9.4.1 Identify the elements of wilderness experience specific to the Colorado River ecosystem.	5.5
RIN 9.5.1 What effects do administrative trips, including research and monitoring activities have on recreational users?	**7**
RIN 9.1.1 What are the attributes of a quality river experience? (How do you define a quality river experience?)	11
RIN 9.1.2 Are the visitor capacities for recreational activities consistent with NPS management plans? Are NPS management plans consistent with Colorado River ecosystem capacities to absorb visitor impacts?	11
RIN 9.1.3 Do ongoing inputs of coarse-sediment from tributaries diminish or enhance navigability of rapids throughout the Colorado River ecosystem?	11
Goal 10 Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of the Adaptive Management ecosystem goals.	***Sequence Order***
RIN 10.1.2 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of increasing the upramp and downramp limit?	5
RIN 10.1.3 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of raising the maximum power plant flow limit above 25,000 cfs?	5
RIN 10.3.1 What are the effects of providing financial exception criteria?	**5**
RIN 10.1.4 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of lowering the minimum flow limit below 5,000 cfs?	5.5

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Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
RIN 10.1.1 What would be the effects on the Colorado River ecosystem and marketable capacity and energy of increasing the daily fluctuation limit?	6
RIN 10.4.1 What are the effects on the Colorado River ecosystem and marketable power and energy of increasing Automatic Generation Control at Glen Canyon Dam?	6
RIN 10.1.5 How do power-marketing contract provisions affect Glen Canyon Dam releases?	11.5
Goal 11 Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.	***Sequence Order***
RIN 11.1.3 What are the thresholds triggering management actions?	3
RIN 11.1.2 What are the historic properties within the area of potential effects?	3.5
RIN 11.1.1 What are the sources of impacts to historic properties?	**4**
RIN 11.1.3.b How should adverse effects to historic properties be mitigated?	4
RIN 11.2.3 Determine acceptable methods to preserve or treat traditionally important resources within the Colorado River ecosystem.	4
RIN 11.1.2.a For each tribe and living community, what are the register eligible traditional cultural properties?	4.5
RIN 11.2.1 What are traditionally important resources and locations for each tribe and other groups?	4.5
RIN 11.2.2 What is the baseline measure for resource integrity?	4.5
RIN 11.1.1.a What and where are the geomorphic processes that link loss of site integrity with dam operations as opposed to dam existence or natural processes?	5
RIN 11.1.1.b What are the terrace formation processes and how do dam operations affect current terrace formations processes?	5
RIN 11.1.1.c Determine if and where dam operations cause accelerated erosion to historic properties?	5
RIN 11.1.1.d What are the potential threats to historic properties relative to integrity and significance?	5
RIN 11.1.2.b How do specific sites meet National Register Criteria for Evaluation?	5
RIN 11.1.2.c Identify AMP activities that affect National Register eligible sites?	5
RIN 11.1.3.a Determine the necessary information to assess resource integrity.	5

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Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
RIN 11.2.4 If there is resource change, what are the sources?	5
RIN 11.1.2.d Identify NPS permitted activities that affect National Register eligible sites.	5.5
RIN 11.1.5 What are appropriate strategies to preserve resource integrity?	5.5
Goal 12 Maintain a high quality monitoring, research, and adaptive management program.	***Sequence Order***
RIN 12.3.3 What are the best scientific methods to determine cause and effect relationships in experiments and other management actions conducted under the GCDAMP?	1
RIN 12.9.2 What is the best combination of dam operations and other management actions to achieve the vision, mission, goals, and objectives of the GCDAMP?	2
RIN 12.9.3 What are the relationships between dam operations and other management actions in their effects on resources addressed by GCDAMP management objectives?	2
RIN 12.2.4 What historic data sets currently exist for all resources targeted by management objectives in the GCDAMP?	**3**
RIN 12.9.1 What is the impact on downstream resources of short-term increases to maximum flow, daily fluctuations and downramp limits?	3
RIN 12.2.1 What is the most appropriate field sampling method(s) (e.g., sampling size, spatial and temporal distribution, analysis, explicit assumptions, limitations and uncertainties) and statistical analysis to monitor the status and trends of resources targeted by management objectives?	3.5
RIN 12.2.6 What are the acceptable detection levels for change in Colorado River ecosystem resources? How should those levels most appropriately be determined and who should make the determinations?	3.5
RIN 12.1.1 What is the necessary quantity and quality of cultural and socioeconomic information for adequate decision-making?	4.5
RIN 12.3.1 What are the most effective method(s) to integrate and synthesize resource data to increase our understanding of the past and for ongoing interactions of humans with the Colorado River ecosystem.	4.5
RIN 12.4.1 What are the most effective methods to maintain or attain the participation of externally-funded investigators?	4.5
RIN 12.5.5 Identify the desired level of information, education, and outreach provided for Glen and Grand Canyon river users and the general public?	4.5

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Information Needs Sequencing Exercise Results Organized by Goal September 2002	
RIN 12.3.4 How well do research designs and workplans do in incorporating Tribal perspectives and values into the standard western science paradigm? Is it more beneficial to keep the perspective separated?	5
RIN 12.3.5 How effective is the AMP in addressing the EIS statement "Long-term monitoring and research are … implemented to measure how well the selected alternative meets resource management objectives."?	5
RIN 12.5.1 What are the most effective means to build AMP public support through effective public outreach?	5
RIN 12.5.2 What are the most effective means to attain and maintain effective communication and coordination with other resource management programs in the Colorado River basin to ensure consideration of their values and perspectives into the AMP and vice versa?	5
RIN 12.5.4 What is the most effective way to distribute information to our stakeholders and the public in a secure and accessible fashion?	5
RIN 12.7.1 Are the current strategies to achieve tribal consultation effective?	5
RIN 12.7.2 Do these strategies meet legal and AMP protocols?	5
RIN 12.8.1 Is tribal participation in the AMP research and long-term monitoring programs sufficiently meeting tribal needs and desires?	5
RIN 12.2.8 Determine accurate, reliable, and standardized methods for measuring erosion at historic sites.	5.5
RIN 12.2.3 What digital, or other, technologies exist and should be used to record field observations and spatially reference these data to facilitate their integration into GCMRC databases and use by PI's and stakeholders?	**6**
RIN 12.3.2 What are the differences between western science and tribal processes for design of studies and for gathering, analyzing, and interpreting data used in the adaptive management program?	6
RIN 12.5.3 To what extent does the public understand and support the GCDAMP?	6
RIN 12.2.2 What remote sensing technologies are available to less intrusively and more cost effectively monitor, characterize and map: (a) the aquatic food base, (b) fish, (c) fish habitat features, (d) Kanab ambersnail habitat, (e) water quality parameters, (f) bathymetry and associated substrates and (g) cultural sites?	6.5
RIN 12.2.5 What remote sensing data are available or can be obtained that will support the production of a system-wide resource map?	7

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Information Needs Sequencing Exercise Results Organized by Goal ***September 2002***	
RIN 12.2.7 Can habitat designation using a GIS application be utilized as an effective method to adjust site-specific population estimates (e.g., mark-recapture or depletion methods) to system-wide extrapolations by using catch-per-unit-effort values that are scaled relative to the proportion of different habitat types available in Glen Canyon?	7
RIN 12.1.3 What are the use (e.g., hydropower, trout fishing, rafting) and non-use (e.g., option, vicarious, quasi-option, bequest and existence) values of the Colorado River ecosystem	11
RIN 12.1.4 How does use (e.g., hydropower, trout fishing, rafting) and non-use (e.g., option, vicarious, quasi-option, bequest and existence) values change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?	11
RIN 12.1.2 What is the economic value of the recreational use of the Colorado River ecosystem downstream from Glen Canyon Dam?	11.5

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