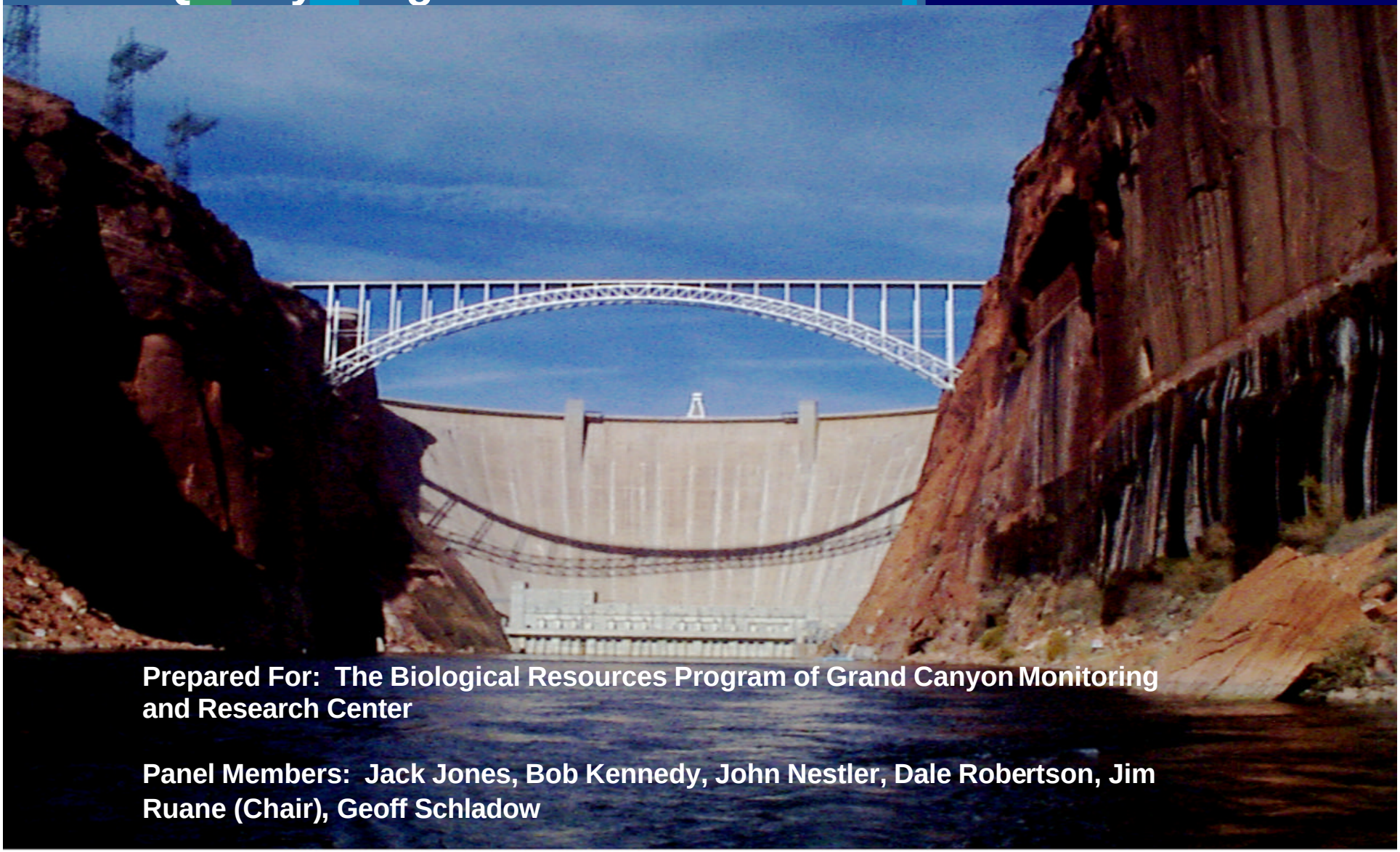
Report of the Protocol Evaluation Panel on the Integrated Water Quality Program



Prepared For: The Biological Resources Program of Grand Canyon Monitoring and Research Center

Panel Members: Jack Jones, Bob Kennedy, John Nestler, Dale Robertson, Jim Ruane (Chair), Geoff Schladow

GCMRC Mission Statement

- **"To provide credible, objective scientific information to the AMP on the effects of operating Glen Canyon Dam on the downstream resources of the Colorado River ecosystem, as well as other information needs specified by the Adaptive Management Work Group, utilizing an ecosystem science approach."**

Key considerations for IWQP under the Record of Decision (ROD)

- "The goal of selecting a preferred alternative was not to maximize benefits for the most resources, but rather to find an alternative dam operating plan that would permit recovery and long-term sustainability of downstream resources while limiting hydropower capability and flexibility only to the extent necessary to achieve recovery and long-term sustainability."

Key considerations for GCMRC under the Record of Decision (ROD)

- "If impacts differing from those described in the final EIS are identified through the AMP, a new ramp rate criterion will be considered (and/or the maximum flow restriction will be reviewed) by the Adaptive Management Working Group (AMWG) and a recommendation for action will be forwarded to the Secretary."

Additional issues confronting GCMRC

A TCD is being considered for the hydropower releases from GCD.

Cost impact of 2000 steady flow operations was $25 million (this figure was questioned by Barry Gold) in just one year.

- The water and energy situation in the West is likely to alter the current water use regime for Lake Powell and result in revised operations of GCD.

Current IWQP

- Addressing Information Needs established by the TWG
- Reservoir:
- Tailwater:
- Downstream:
- Results: reports, graphical analyses

This Panel was tasked to review and assess current and future plans and protocols for water quality studies designed to address the INs developed by the TWG.

The Panel also was provided the opportunity to comment on the appropriateness of the specific objectives in the context of the overall program.

The Panel was asked to address a series of questions that were put forth by the GCMRC. This report addresses the following main issues: technical, programmatic, and institutional.

MAJOR FINDINGS AND RECOMMENDATIONS regarding plans for IWQP

- Shift emphasis from Lake Powell to downstream

- Employ water quality-ecosystem models in Lake Powell and the Colorado River to link GCD operations and physical/chemical/ecosystem responses in a timely manner using the best information available.

MAJOR FINDINGS AND RECOMMENDATIONS regarding plans for IWQP, cont.

- Work with other programs in the GCMRC Biological Resources Program in the integration of results to allow decision-making by the TWG and AMWG by linking operations of GCD and various ecosystem responses (RBT, ESA, etc.)
- Develop “proactive” long-range water quality monitoring strategy to prepare for a wide range of possible management actions

MAJOR FINDINGS AND RECOMMENDATIONS regarding plans for IWQP, cont.

- GCMRC should work with TWG to improve MO/IN process
- Lake Powell forebay station should be changed to the White Category
- It is imperative that the GCMRC provide critical information in a timely manner to allow cost-effective and environmentally-effective decisions for the AMP.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

1. **Inflows:**

- Colorado River near Cisco, Utah; Green River at Green River, Utah; and San Juan River near Bluff, Utah
- IWQP reactivate the water-quality sampling of these three tributaries near where they are gaged for flow

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

In Lake:

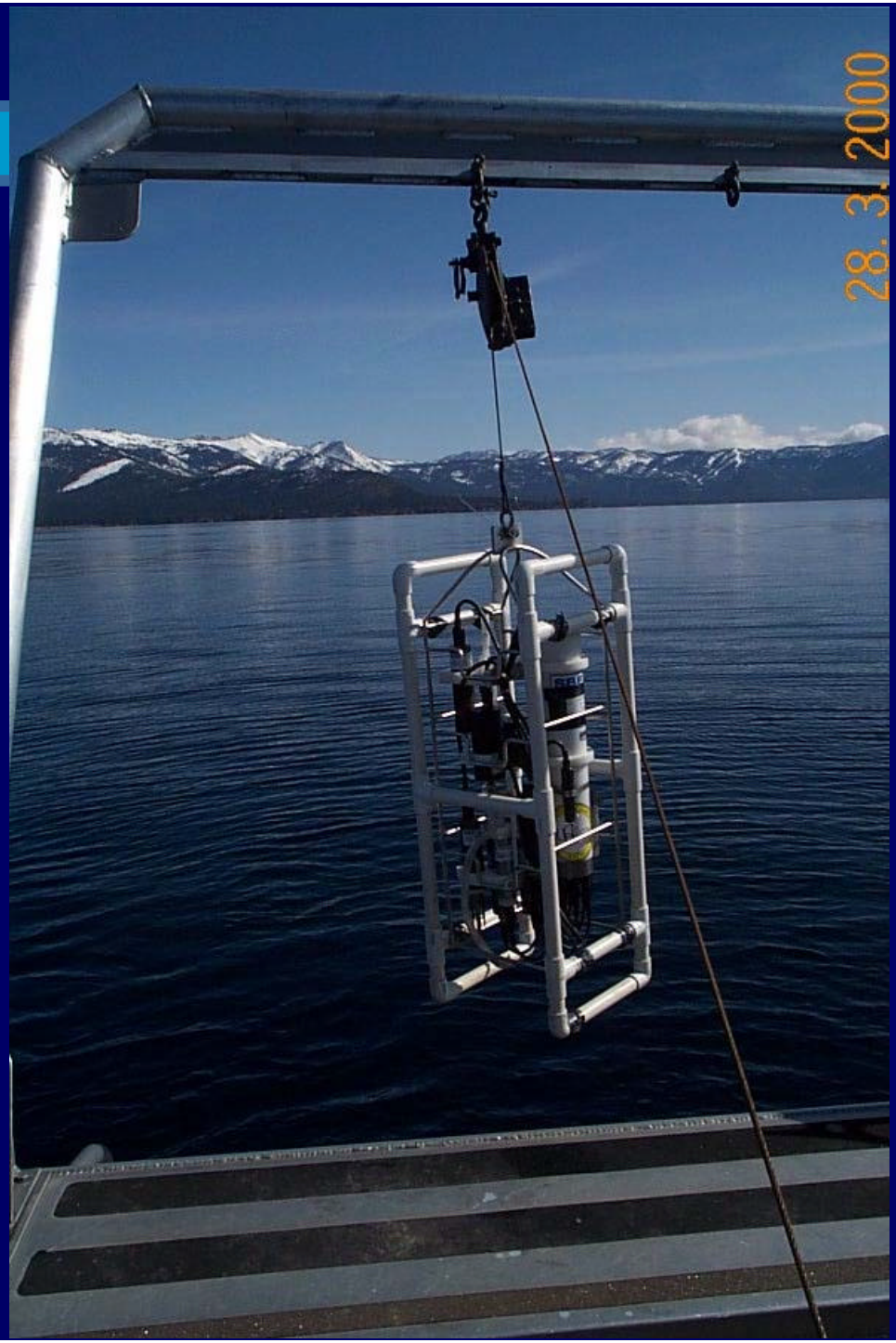
- The existing program has produced a sound basis upon which a general understanding of the lake dynamics has been established.
- Current CE-QUAL-W2 modeling results by the BOR and additional sensitivity analyses should be used to determine additional primary data needs as soon as possible.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- The absence of complete chlorophyll profiles and TOC measurements is a shortcoming of the present sampling program.
- IWQP should review the adequacy of the number of samples that are currently collected at the Wahweap station to ensure they are sufficient.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- The USGS Seabird SBE-19 profiler should be considered. Also, consideration should be given to purchasing a Seabird SBE-25.
- Phytoplankton and zooplankton sampling could be cut to quarterly collections at the Wahweap site, a mid-lake site in the main channel, and at an up-lake site until it is determined if this information is needed for modeling efforts.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SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- The absence of meteorological data at several locations on the lake could be a major shortcoming of the existing data set.
- The Panel believes that a timescale of one to two years will be required to collect sufficient inflow, meteorological, chlorophyll, and organic data to produce the desired data set for model calibration and application.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- The forebay profile represents the best approximation of lab parameters for the river model. This profile also allows forecasting potential water quality problems for the downstream. Water quality in the forebay varies in response to hydrology and GCD operations.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- A multi-parameter profiling station should be considered for the forebay. These data, together with data from the tailrace, would be telemetered to GCMRC and GCD in real time. These data will define the linkage between the lake and the river as well as provide the basis upon which a TCD is operated. An “intelligent model” could be developed that would define tailwater water quality based on the water quality profile in the lake and operating conditions at GCD. The panel recommends that the inclusion of such a station be considered as part of the TCD project.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

Tailwater:

- The current location of the tailrace Hydrolab does not provide representative data. More representative locations are needed.
- This reach of river is very important for supplying organic matter and a food base for the Colorado River down to Lake Mead. Productivity in this reach needs to be monitored using Howard Odum's "upstream-downstream approach."

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Collection

- 1. **Downstream:**
- • The temperature data collected by continuous monitors at selected locations in the downstream reach are invaluable data for calibrating a water quality model.
- • Additional sampling should be linked to the needs of the water quality-ecosystem model and miscellaneous biological assessments.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Sample Preservation And Analytical Procedures

- Chemical Parameters
- Preservation Techniques
- Sample Analysis QA/QC
- Phosphorus Analyses

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Data Management

- Use USGS WRD data management systems

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- • A cursory review of the INs that have a ranking of medium or high priority indicates that all of them can best be addressed using reservoir and river models.
- · Future management decisions will need to be made in the context of a very different set of operating conditions than what has prevailed in the past. Different lake levels, the possible use of a TCD, different flow regimes, different power demands may all make the value of past correlations questionable.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- The Panel is concerned that there is insufficient linkage between the physical processes that are initiated at the dam and the present modeling of ecosystem effects downstream.
- Emphasis should be placed on applying the model to assist scientists and engineers in GCMRC, TWG, and AMWG in sufficiently making decisions, not on developing a model that represents all aspects of the real system.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- It is strongly recommended that a model be developed for those variables that are readily predictable using current, deterministic engineering models (the time varying values of flow, stage, temperature). This model would then provide a vehicle upon which to attach a light model, a water quality model, an ecological model, etc. The present “conceptual model” could well provide many of these latter components.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- GCMRC should consider convening another panel to assist them in determining the best modeling approach for the river. Ideally, however, an experienced person responsible for the reservoir model might be suitably qualified to take the lead role in directing the river modeling activities.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

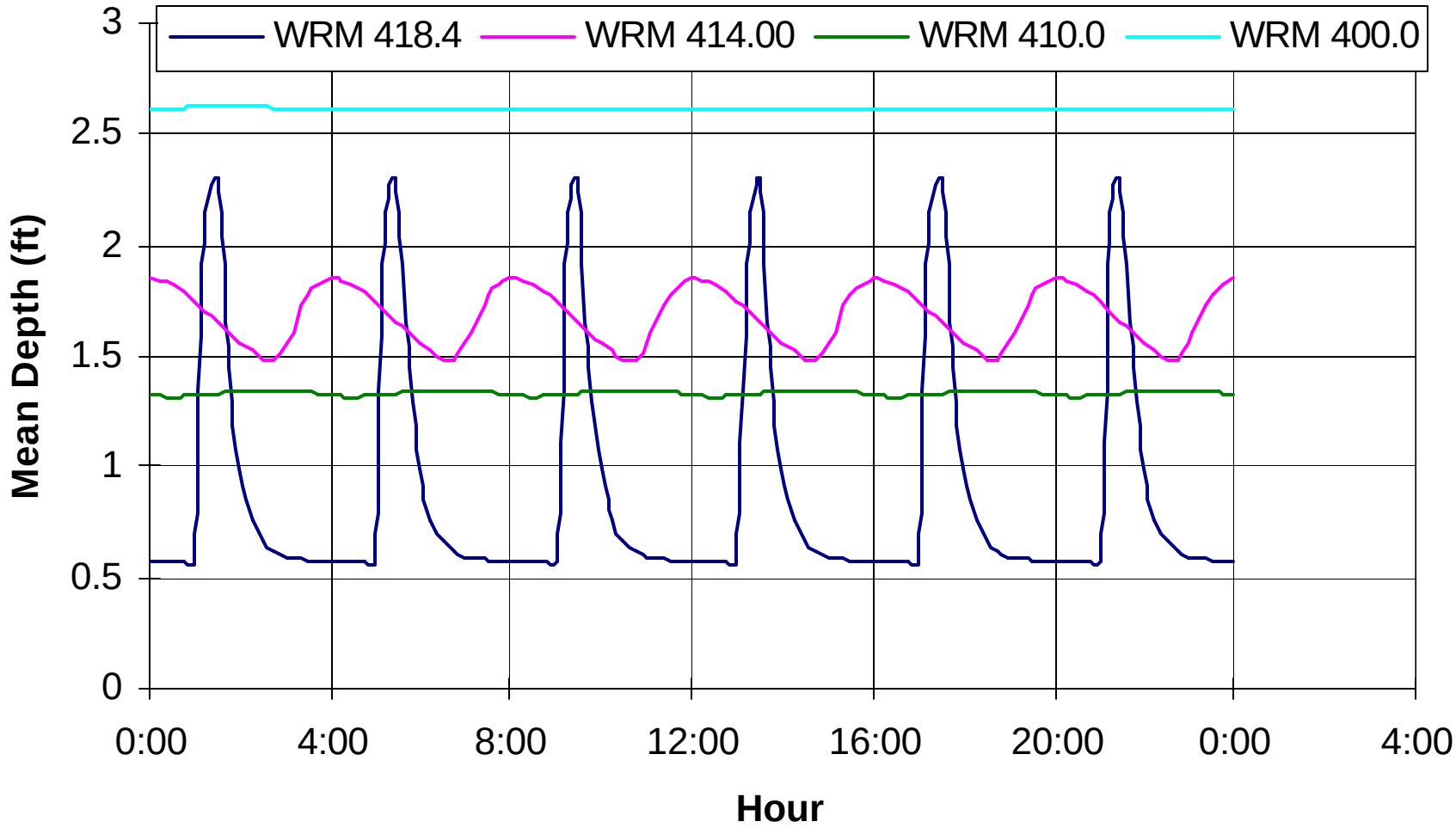
- The order of accuracy for river water quality models is as follows:
- 1. 1-D flow regime (flow and stage),
- 2. temperature,
- 3. other water quality parameters (e.g., DO, turbidity and light, carbon, phosphorus, nitrogen, photosynthesis),
- 4. biological effects of water quality,
- 5. biological effects of habitat, and
- 6. biological effects of competitive fish species

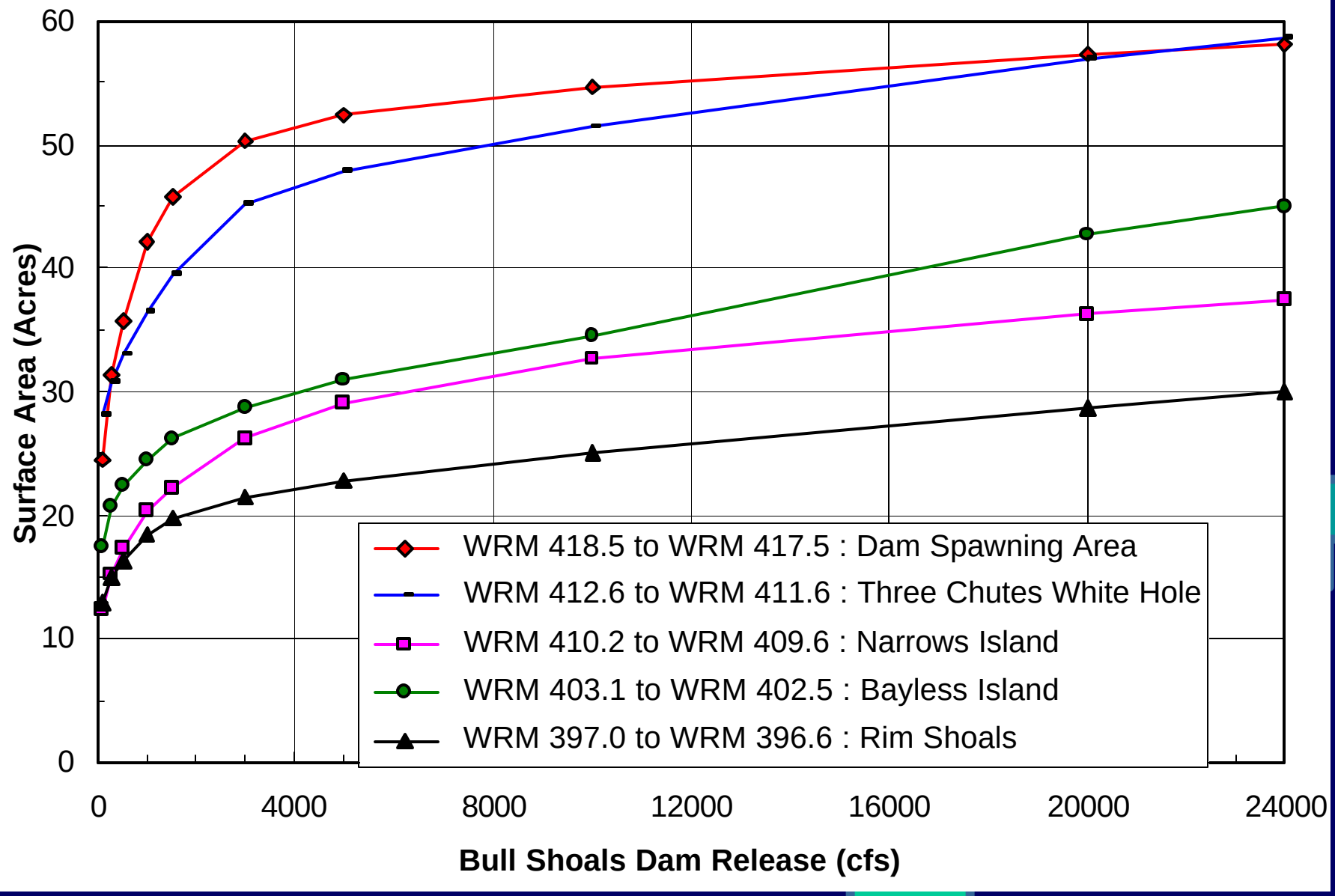
SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- Many decisions on water resources management in the United States have been based on models that only include the first two or three types of models, with biological considerations being addressed either externally to the model or through water quality and ecological models that are attached to the physical model.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Water Quality-Ecosystem Modeling

- Based on a cursory review of “steady flow” decision for operating Glen Canyon Dam in the year 2000, an unsteady state model of flow and temperature for the Colorado River between Glen Canyon Dam and Lake Mead would have proven extremely useful and may have resulted in a more cost-effective decision for operations at Glen Canyon Dam without jeopardizing the biological objectives.


WRM 418.4
WRM 414.00
WRM 410.0
WRM 400.0
Mean Depth (ft)
3
2.5
2
1.5
1
0.5
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
4:00
Hour


Surface Area (Acres)
60
50
40
30
20
10
0
0
4000
8000
12000
16000
20000
24000
Bull Shoals Dam Release (cfs)
WRM 418.5 to WRM 417.5 : Dam Spawning Area
WRM 412.6 to WRM 411.6 : Three Chutes White Hole
WRM 410.2 to WRM 409.6 : Narrows Island
WRM 403.1 to WRM 402.5 : Bayless Island
WRM 397.0 to WRM 396.6 : Rim Shoals

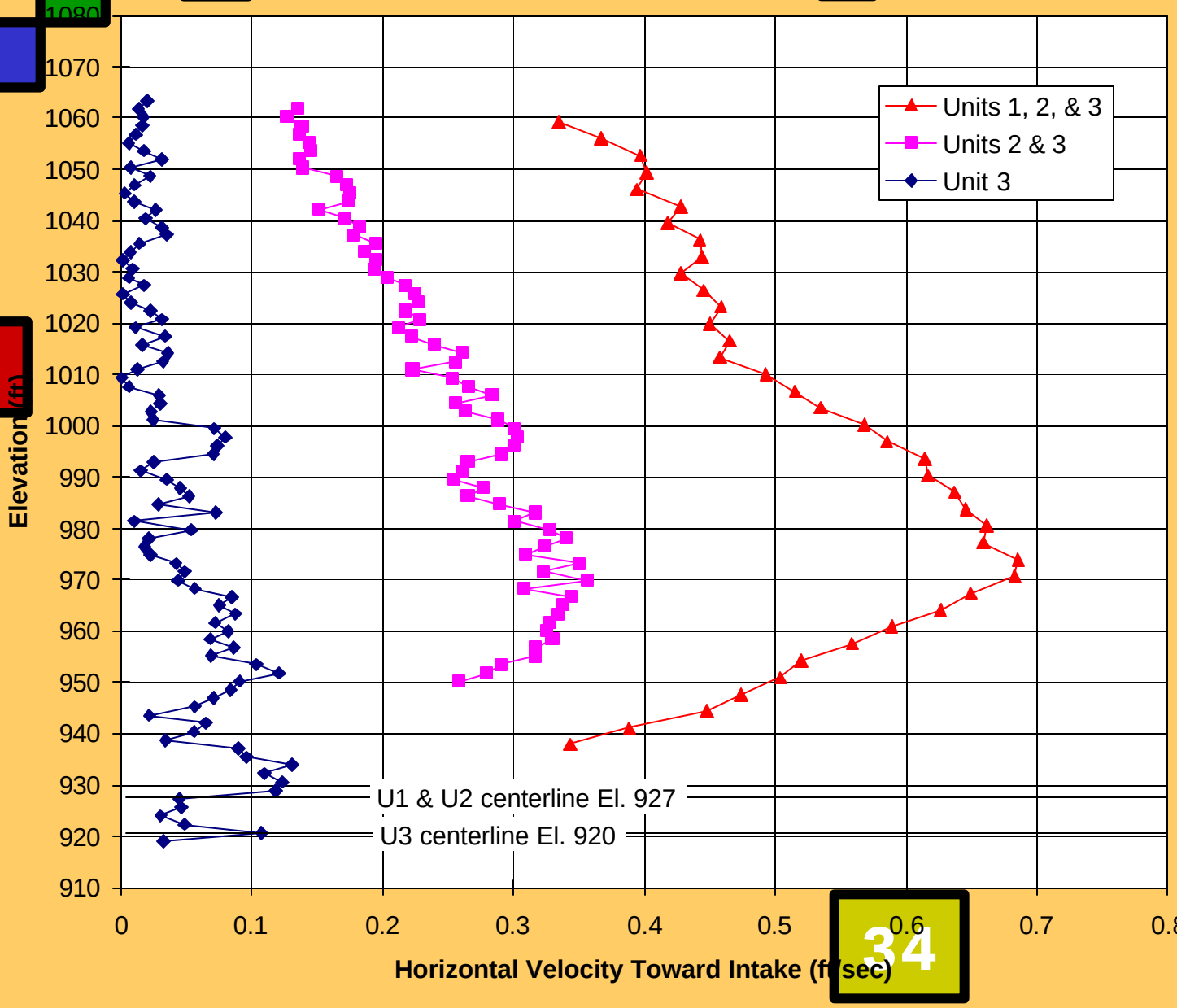
SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Priorities For Sampling

- Long-term monitoring is a major need due to the decadal nature of the hydrologic cycle for this system in addition to considering that this is a managed system that is still undergoing engineering and operational modifications.
- The Panel recommends that IWQP develop a long-term monitoring plan that can be maintained annually for about 20 years.

SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Additional Findings And Recommendations

- **TCD Withdrawal Zone Considerations--** Withdrawal zones for hydropower intakes often are higher in the water column than might be assumed and result in the discharge from the project being warmer than might otherwise be expected. The Panel recommends that the GCMRC inquire about the considerations that the BOR has given to the withdrawal zone for the TCD designs being considered.

Buford Dam Intake Velocity Profiles
Between Units 1 & 2, 50' Upstream of Intake



SPECIFIC TECHNICAL FINDINGS AND RECOMMENDATIONS—Additional Findings And Recommendations

- The Panel recommends that GCMRC consider using an ADCP to measure the withdrawal zone for the current intakes for
- • several representative operating conditions,
- • several representative turbine units,
- • the most important period of the year with respect to thermal stratification, and
- • appropriate timing for the desired temperature increases for the downstream fisheries.

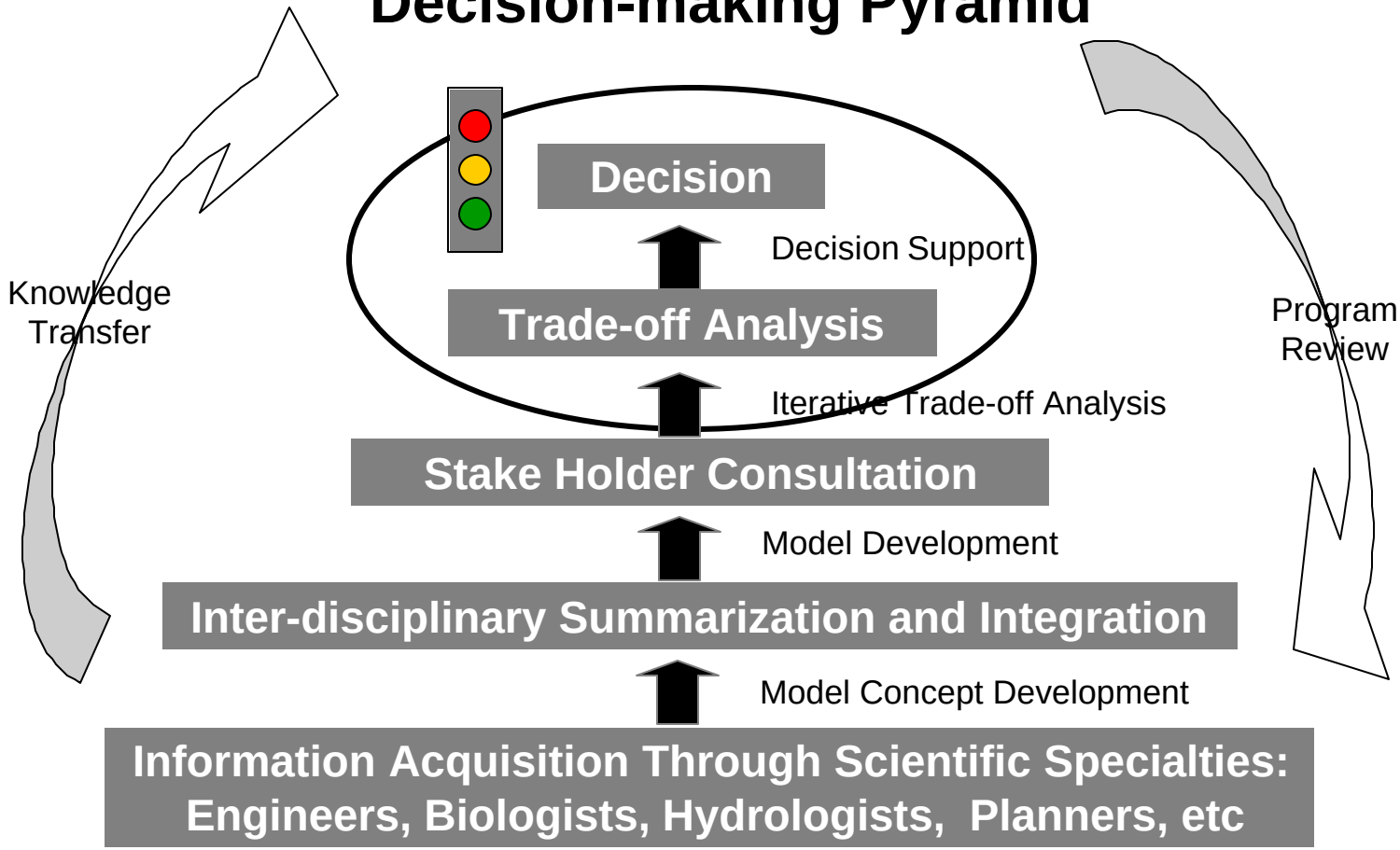
SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS-- Adequacy of IWQP for MOs and INs

- IWQP appeared to be collecting data in response to the INs
- However, it is unclear how findings from individual studies will be integrated either within the subject program or how information will be integrated between the subject program and other programs within the larger GCMRC.

SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS-- Adequacy of IWQP for MOs and INs

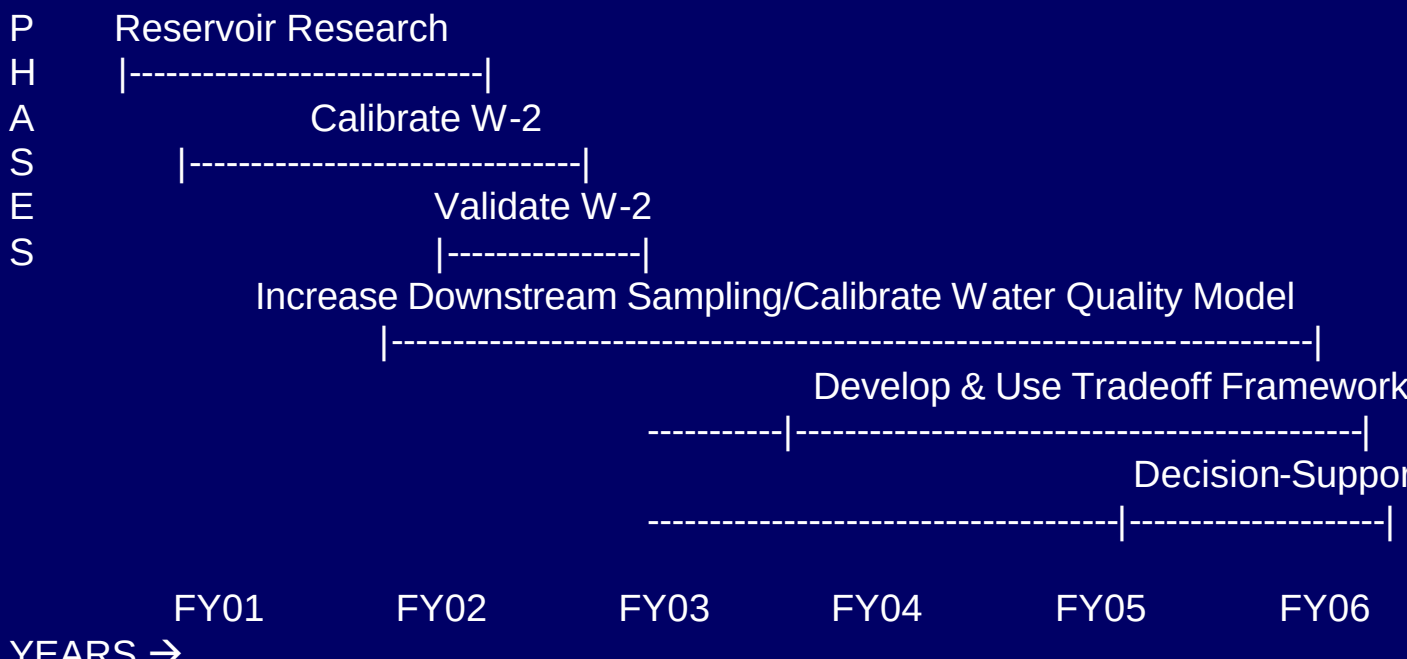
- Science-based water resources decision-making can be envisioned as an information pyramid
- GCMRC program management should consider discussions with the TWG and AMWG to obtain feedback and guidance on how modeling and other integration approaches could best be structured to address their INs.

Decision-making Pyramid



SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS-- Five-Year Plan

- The Panel recommends that program management consider a five-year program time frame formally starting in 2002 (the interval between program reviews), but actually getting underway during 2001. The primary goals would be the collection of a full model data set, the calibration of a reservoir model, and the transition to a mode of operation in which model results can supplant much of the present upstream data collection.


PHASES
Reservoir Research
Calibrate W-2
Validate W-2
Increase Downstream Sampling/Calibrate Water Quality Model
Develop & Use Tradeoff Framework
Decision-Support
FY01
FY02
FY03
FY04
FY05
FY06
YEARS →

SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS—Additional Findings And Recommendations

- The IWQP personnel are technically capable, conscientious, energetic, experienced, as well as professionally and personally interested in the Glen Canyon/Grand Canyon system
- The IWQP has produced good products on the results of their monitoring and analyses. Their reports are professionally prepared using state-of-the-art data analyses.

SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS—Additional Findings And Recommendations

- The staff desires to develop and/or apply tools (e.g., models) and collect data needed to assist AMP in making management decisions
- The staff desires to determine linkage between Lake Powell inflows and effects on water quality in the forebay and downstream from Glen Canyon Dam

SPECIFIC PROGRAMMATIC FINDINGS AND RECOMMENDATIONS—Additional Findings And Recommendations

- Hire A Modeler And Consider Convening A PEP To Assist The IWQP In Developing Management Principles For Modeling
- This individual should be capable of providing direction on model selection criteria and approaches as well as providing a foundation of operating principles and philosophies

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—GCMRC should propose restructured INs

- There is no indication that the cost, feasibility, cost-effectiveness, level of significance in decision-making, “critical path” considerations, and potential for success were taken into account in developing the individual INs.
- The Panel believes the GCMRC should consider these factors in developing plans for addressing the MOs and the INs and provide feedback to the TWG and AMWG.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—GCMRC should propose restructured INs

- *The GCMRC's position within the AMP calls for it to play a servant-leader role:* the GCMRC plays the main role as the service provider for the AMP; they also are the organization with the most resources, most information on linkages between Glen Canyon Dam operations and environmental effects, and highest stake. Hence, they need to play a major leadership role within the AMP.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—GCMRC should propose restructured INs

- The Panel recommends that the GCMRC promote the concept of “cost of science” to the TWG. It is more defensible to understand water quality and ecosystem processes to the level that they can be simulated using models. It is less defensible to have a surface understanding of these processes and then use “operational experiments” to select optimum dam operations.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—Forebay Monitoring Proposed For The White Category

- The forebay (Wahweap) station needs to be considered differently than other lake stations. The forebay profile represents in many ways the upper boundary condition of the downstream river (from both data collection and modeling perspectives.)
- Another main reason is that potential water quality problems for the downstream can be forecasted and therefore possibly avoided using data only from the forebay.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—Forebay Monitoring Proposed For The White Category

- • Additionally, IN 5.4 is in the “white category” and calls for a wide range of information on the lake that can only be addressed if data are collected on the lake.
- • Finally, the Panel agrees with the NRC “Downstream” report that rigid definitions of geographic scope will hinder the accomplishment of AMP objectives.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—Modeling Approach With BOR

- The GCMRC needs a model for Lake Powell, and it is only prudent that they use the model that the BOR is applying to Lake Powell. The Panel recommends that the two organizations use the CE-QUAL-W2 model, but that each organization apply the model based on their respective organizational objectives.

SPECIFIC INSTITUTIONAL FINDINGS AND RECOMMENDATIONS—Modeling Approach With BOR

- The following is a list of reasons the GCMRC needs to use the model:
- To develop and evaluate monitoring plans,
- To establish and test hypotheses,
- To develop cause/effect linkages between operations of GCD and environmental effects in Lake Powell,
- To provide information that the AMWG and TWG needs for making decisions about operations and design considerations for Glen Canyon Dam.