Prepared in cooperation with the Bureau of Reclamation

Glen Canyon Dam Adaptive Management Program Budget and Annual Work Plan—Fiscal Year 2009

Prepared by

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PROJECT TITLE AND ID: A.1. Personnel Costs

General Project Description: This project represents Reclamation staff costs to perform the daily work activities required to operate the Adaptive Management Work Group. The work includes completing assignments resulting from AMWG meetings, consulting with stakeholders on a variety of AMP issues relating to the operation of Glen Canyon Dam (GCD), disseminating pertinent information to the AMWG, preparing and tracking budget expenses, and updating Reclamation's web page.

Project Goals and Objectives: The **primary goal** is to perform all work associated with the AMWG in a timely and efficient manner, while using the funds available as prudently as possible. **Secondary goals** include increasing each stakeholder's awareness of significant budget and legislative issues related to the AMP, improving working relationships with the AMWG members/alternates, finding constructive ways to resolve differences, and addressing individual concerns in an open and accepting forum of discussion.

Expected Results: Personnel costs will not exceed what has been proposed in the budget and Reclamation staff will provide budget information to the AMWG on a regular basis. Completed work products will be of high quality and promptly distributed to AMWG members/alternates and interested parties. Budget reports will be presented in a format conducive to AMWG needs.

Budget: FY 09 = $163,726

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	113,537	116,375	119,866	123,462	
Subtotal	113,537	116,375	119,866	123,462	
DOI Customer Burden (29%)	41,993	43,043	34,762	35,805	
Project Total	155,530	159,418	154,628	159,267	163,726
% Total Outsourced	--	--	--		

PROJECT TITLE AND ID: A.2. AMWG Member Travel Reimbursement

General Project Description: This project covers the costs to reimburse AMWG members or alternates to attend regularly scheduled AMWG meetings.

Project Goals and Objectives: The primary goal for reimbursing travel expenses to AMWG members or alternates is to encourage their attendance at all meetings. Because the meetings are often scheduled in Phoenix, Arizona, many members must incur air or POV travel, and by having Reclamation reimburse those and other related travel costs, e.g., hotel, per diem, rental car, etc., opportunities are increased for more members to participate in a variety of AMWG assignments. Also, because Reclamation can purchase airline tickets at the Federal Government rate, there are additional cost savings to the program.

Expected Results: The Glen Canyon Dam Adaptive Management Program will benefit by having all AMWG members participating in regularly scheduled meetings. As a collective body, they address and resolve concerns associated with the operation of Glen Canyon Dam and make recommendations to the Secretary of the Interior for continued science efforts performed below the GCD.

Budget: FY 09 = $17,150

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	13,000	15,725	16,197	16,651	17,150
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	13,000	15,725	16,197	16,651	17,150
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	13,000	15,725	16,197	16,651	17,150
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: A.3. Reclamation Travel

General Project Description: This project covers travel expenses Reclamation staff incur to attend AMWG and ad hoc group meetings. In order to work on AMWG/ad hoc assignments, the meetings are often held in Phoenix, Arizona. As such, Reclamation staff must make additional trips throughout the year in completion of those assignments.

Project Goals and Objectives: The primary goal is for Reclamation staff to be able to travel to meetings and participate in completing AMWG/TWG assignments. By doing so, the program benefits from greater interaction among its members as well as continued improvement and commitment to operating GCD in the best manner possible and obtaining the results from science work being done in the canyon.

Expected Results: Reclamation staff will be involved with AMWG/TWG members in completing work assignments and resolving issues that affect the AMP. They will develop better working relationships with all involved and work toward consensus on a variety of sensitive issues.

Budget: FY 09 = $14,178

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	15,540	13,000	13,390	13,765	14,178
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	15,540	13,000	13,390	13.765	14,178
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	15,540	13,000	13,390	13,765	14,178
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: A.4. Facilitation Contract

General Project Description: This project represents the work assigned to one individual under contract to the Bureau of Reclamation to facilitate at Adaptive Management Work Group meetings. This person may also assist AMWG ad hoc groups in completing AMWG assignments.

Project Goals and Objectives: The facilitator's primary responsibility is to keep the AMWG meetings organized and help the members reach consensus on important issues. The facilitator creates a setting in which all members and the public are able to express their views.

Results: The facilitator will create an atmosphere in which the members and other participants at AMWG meetings feel comfortable expressing their individual viewpoints. The facilitator will bring the AMWG members to consensus on pertinent issues affecting the GCD AMP.

Budget: FY 09 = $54,530

FUNDING HISTORY					
	2005	2006	2007	2008	2009
USBR Reimbursements	21,000	25,000	25,000	25,700	26,471
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	21,000	25,000	25,000	25,700	26,471
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	21,000	25,000	25,000	25,700	26,471
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: A.5. Public Outreach

General Project Description: This project covers the expenses for Reclamation staff and the Public Outreach Ad Hoc Group (POAHG) to develop materials for the GCDAMP public outreach efforts.

Project Goals and Objectives: Reclamation Public Affairs staff and the POAHG will work jointly in developing materials to inform and educate the public on the goals and administration of the GCDAMP. They will keep other AMP members advised of progress and expenditures.

Expected Results: Products will include fact sheets, website information, tribal outreach materials, video B-roll, special events, conference participation, and other pertinent means of advising the public and program members on the achievements of the GCDAMP. The POAHG will maintain accurate records of payments made against the contracts and will keep Reclamation staff informed of discrepancies or concerns.

Budget: FY 09 = $54,530

(The AMWG approved carryover of $25,000 but not to exceed a total budget of $75,000 each fiscal year.)

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	**0**	**50,000**	**51.500**	**37,662**	
Subtotal	**0**	**50,000**	**51,500**	**37,662**	
DOI Customer Burden (32%)	--	--	--	**15,383**	
Project Total	**0**	**50,000**	**51,500**	**53,045**	**54,530**
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: A.6. Other

General Project Description: This project represents some of the other "miscellaneous" expenses incurred in operation of the AMWG. For example:

- overnight mailings of AMWG meeting packets
- copying of reports
- purchasing meeting materials (cassette tapes, markers, paper, software upgrades for AMP website posting, etc.)
- equipment (audio recording/transcribing machines)

In addition to the above, training courses are often required for staff to keep current on environmental issues, Federal Advisory Committee Act changes, computer technology improvements, etc. Also included in this category are monetary awards given to Reclamation staff who have contributed significantly to the success of the GCDAMP.

Project Goals and Objectives: The primary goal is to limit spending on "other" items as much as possible. By doing so, more money can be applied to science and research.

Expected Results: Other expenses will be kept to a minimum in an effort to reduce the administrative portion of the AMP budget.

Budget: FY 09 = $7,825

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training/Awards	5,000	5,000	5,390	5,597	
Operations/Supplies	2,000	2,175	2,000	2,000	
USBR Salaries	--	--			
Subtotal	7,000	7,175	7,390	7,597	
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	7,000	7,175	7,390	7,597	7,825
% Total Outsourced	--	--	--	--	--

Note: Because many of the AMWG and TWG meetings are held at the Bureau of Indian Affairs Office in downtown Phoenix, Arizona, there is a cost savings of approximately $12,800 for not having to use hotel conference rooms where the room costs range between $600-$800 a day. Also, because BIA has been able to host many of the AMWG and TWG meetings, they provide use of their copiers and other equipment needed for the meetings at a savings of at least $1,000 a year to the program.

PROJECT TITLE AND ID: B.1. Personnel Costs

This project represents Reclamation staff costs to perform the daily work activities required to operate the Technical Work Group, a subgroup of the AMWG. The work includes completing assignments resulting from TWG meetings, consulting with stakeholders on a variety of AMP issues relating to the operation of Glen Canyon Dam, disseminating pertinent information to the TWG, preparing and tracking budget expenses, and updating Reclamation's web page.

Project Goals and Objectives: This project represents Reclamation staff costs to perform the daily work activities required to operate the Technical Work Group. The work includes completing assignments resulting from AMWG or TWG meetings, consulting with stakeholders on a variety of AMP issues relating to the operation of Glen Canyon Dam, disseminating pertinent information to the TWG, preparing and tracking budget expenses, and updating Reclamation's web page.

Expected Results: Personnel costs will not exceed what has been proposed in the budget and Reclamation staff will provide budget information to the TWG on a regular basis. Completed work products will be promptly distributed to TWG members/alternates and interested parties.

Budget: FY 09 = $74,814

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	51,881	53,178	54,773	56,416	
Subtotal	51,881	53,178	54,773	56,416	
DOI Customer Burden (32%)	19,189	19,669	15,884	16,361	
Project Total	71,070	72,847	70,657	72,777	74,814
% Total Outsourced	--	--	--		

PROJECT TITLE AND ID: B.2. TWG Member Travel Reimbursement

General Project Description: This project covers the costs to reimburse TWG members or alternates to attend regularly scheduled TWG meetings.

Project Goals and Objectives: The primary goal for reimbursing travel expenses to TWG members or alternates is to encourage their attendance at all meetings. Because the meetings are often scheduled in Phoenix, Arizona, many members must incur air or personal vehicle travel. By reimbursing those and other related travel costs, e.g., hotel, per diem, rental car, etc., opportunities are increased for more members to participate in a variety of AMWG/TWG assignments.

Expected Results: The Glen Canyon Dam Adaptive Management Program will benefit from having all the TWG members participate in regularly scheduled meetings. As a collective body, they address and resolve concerns associated with the operation of Glen Canyon Dam and make recommendations to the AMWG for continued research in the canyon.

Budget: FY 09 = $23,518

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	15,540	20,836	22,211	22,833	23,518
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	15,540	20,836	22,211	22,833	23,518
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	15,540	20,836	22,211	22,833	23,518
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: B.3. Reclamation Travel

General Project Description: This project covers travel expenses Reclamation staff will incur to prepare and attend TWG meetings as well as ad hoc group meetings which result from AMWG/TWG assignments. In order to work on those assignments, the meetings are often held in Phoenix, Arizona, because it is centrally located to those entities/states represented on the AMWG/TWG. This often requires Reclamation staff to make additional trips throughout the year in completion of AMWG/TWG assignments.

Project Goals and Objectives: The primary goal is for Reclamation staff to be able to travel to meetings and participate in completing AMWG/TWG assignments. By doing so, the program benefits from greater interaction among its members as well as continued improvement and commitment to operating GCD in the best manner possible and for obtaining the necessary results from science work done in the canyon.

Expected Results: Reclamation staff will continue to be involved in meeting with AMWG/TWG members in completing work assignments and resolving issues that affect the operation of GCD. They will develop better working relationships with all involved and work toward consensus on a variety of AMP issues.

Budget: FY 09 = $17,339

FUNDING HISTORY					
	2005	2006	2007	2008	2008
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	15,510	15,898	16,375	16,834	17,339
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	15,510	15,898	16,375	16,834	17,339
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	15,510	15,898	16,375	16,834	17,339
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: B.4. TWG Chair Reimbursement

General Project Description: This project represents the work assigned to one individual under contract to the Bureau of Reclamation to act as chairperson at Technical Work Group meetings. This person may also work on AMWG/TWG ad hoc group assignments.

Project Goals and Objectives: The chairperson's primary responsibility is to conduct regularly scheduled TWG meetings. The chairperson also participates in ad hoc group assignments and works closely with Reclamation and GCMRC in setting meeting agendas. The chairperson follows up on TWG and ad hoc group assignments and ensures that information is shared with the members and alternates in a timely manner.

Expected Results: The chairperson creates an atmosphere in which the members and other participants at TWG meetings feel comfortable expressing their individual viewpoints. The chairperson will bring the TWG members to consensus on sensitive issues with the ultimate goal of making recommendations to AMWG that incorporate the best scientific information available to the GCDAMP. The chairperson will follow up on action items and make assignments as necessary to accomplish TWG objectives.

Budget: FY 09 = $24,179

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	21,630	22,171	22,836	23,474	24,179
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	21,630	22,171	22,836	23,474	24,179
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	21,630	22,171	22,836	23,474	24,179
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: B.5. Other

General Project Description: This project represents some of the other "miscellaneous" expenses incurred in operation of the TWG. For example:

- overnight mailings of TWG meeting packets
- copying of reports
- purchasing meeting materials (cassette tapes, markers, paper, etc.)
- equipment (audio recording/transcribing machines)

Project Goals and Objectives: The primary goal is to limit spending on "other" items as much as possible. By doing so, more money can be spent on science and research.

Expected Results: Other expenses will be kept to a minimum in an effort to keep within the AMP budget.

Budget: FY 09 = $2,236

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	2,000	2,050	2,112	2,171	2,236
USBR Salaries	--	--	--	--	--
Subtotal	2,000	2,050	2,112	2,171	2,236
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	2,000	2,050	2,112	2,171	2,236
% Total Outsourced	--	--	--	--	--

Note: Because many of the AMWG and TWG meetings are held at the Bureau of Indian Affairs Office in downtown Phoenix, Arizona, there is a cost savings of approximately $12,800 for not

having to use hotel conference rooms where the room costs range between $600-$800 a day. Also, because BIA has been able to host many of the AMWG and TWG meetings, they provide use of their copiers and other equipment needed for the meetings at a savings of at least $1,000 a year to the program.

PROJECT TITLE AND ID: C.1. Compliance Documents

General Project Description: This project covers the costs for preparing compliance documents for AMP-proposed actions in order to comply with the Endangered Species Act, National Environmental Policy Act, and National Historic Preservation Act. In FY07much of this funding will be used for compliance documents for the Long-term Experimental Plan. This will include changes in dam releases and non-flow actions perhaps including testing of a temperature control device on Glen Canyon Dam.

Project Goals and Objectives: Reclamation staff will keep informed on changes to the ESA, NEPA, and NHPA and will consult with AMWG stakeholders to ensure appropriate compliance is undertaken for actions taken in support of the GCDAMP.

Expected Results: Reclamation staff will be involved in all compliance issues related to the Glen Canyon Dam Adaptive Management Program. They will utilize travel expenses to meet with the AMP stakeholders to resolve any differences.

Budget: FY 09 = $50,000 (Reduced per Dennis Kubly during BAHG Conference Call on 3/26/08; savings of $229,134 will be applied to Canyon Treatment Plan, Line 31)

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	90,510	
Logistics Field Support	--	--	--	--	
Project Related Travel/Training	--	--	--	--	
Operations/Supplies	--	--	--	--	
USBR Salaries	26,780	22,450	263,622	128,525	
Subtotal	26,780	22,450	263,622	128,525	
DOI Customer Burden (32%)	--	--	--	52,496	
Project Total	26,780	22,450	263,622	271,531	50,000
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: C.2 Administrative Support for NPS Permitting

General Project Description: This project provides funding to support the Grand Canyon National Park permitting of research and monitoring projects conducted under the GCDAMP. Grand Canyon National Park employs a permitting specialist and staff who review all proposals for projects to be completed in the Park under the auspices of the GCDAMP. The program provides these funds to offset the administrative burden of the Park in providing these services.

Project Goals and Objectives: The primary goal is to ensure that projects conducted under the GCDAMP are reviewed and permitted by the National Park Service.

Expected Results: Projects conducted under the GCDAMP will receive permits from the NPS in a timely manner.

Budget: FY 09 = $116,699

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor			--	--	--
Logistics Field Support			--	--	--
Project Related Travel/Training			--	--	--
Operations/Supplies					
USBR Salaries			--	--	--
Subtotal		**100,000**	**110,000**	**113,300**	**116,699**
DOI Customer Burden (32%)			--	--	--
Project Total		**100,000**	**110,000**	**113,300**	**116,699**
% Total Outsourced			--	--	--

PROJECT TITLE AND ID: C.3. Contract Administration

General Project Description: This project covers the expenses for Reclamation staff to prepare and monitor contracts associated with the GCD AMP. Specifically, these contracts are for AMWG Facilitation, TWG Chairperson reimbursement, tribal participation, and Programmatic Agreement work.

Project Goals and Objectives: Reclamation contract specialists will accurately apply funds spent on individual contracts to ensure costs do not exceed contract limits. They will keep other Reclamation staff informed as to those charges so accurate reporting can be made to both AMWG and TWG members.

Expected Results: Contract specialists will ensure that individual contractors are fulfilling the requirements of their contracts. They will maintain accurate records of payments made against the contracts and will keep Reclamation staff informed of discrepancies or concerns. Work will be completed on time and within the limits of the contract.

Budget: FY 09 = $34,320

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	25,750	24,394	32,413	23,703	
Subtotal	25,750	24,394	32,413	23,703	
DOI Customer Burden (32%)	--	--	--	9,682	
Project Total	25,750	24,394	32,413	33,385	34,320
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: C.4. Experimental Carryover Funds

General Project Description: This budget item reserves funds for conducting experiments under the GCDAMP. The estimated need for a large scale (BHBF) experiment based on past experience is approximately $1.5 million. This amount will be reserved over the course of several years so that the effects on annual budget and workplan are minimized.

Project Goals and Objectives: As above.

Expected Results: The funds will be available to conduct a large scale experiment when conditions are appropriate.

Budget: FY 09 = $500,000 (These funds are committed to the FY08 and FY09 HFE evaluation; See GCMRC Line 153; 3/26/08 reduced from $515K to $500K per Dennis Kubly - $15K to go against Canyon Treatment Plan, Line 31.)

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries					
Subtotal					
DOI Customer Burden (32%)					
Project Total		424,675	500,000	500,000	500,000
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: C.5. Integrated Tribal Resources Monitoring

General Project Description: Funding is provided for identification of TCPs and implementation of monitoring protocols developed in the FY07 resources monitoring as agreed to by the Technical Work Group as part of core monitoring development.

Project Goals and Objectives: Primary goal is to evaluate effects of dam operations and other actions under the authority of the Secretary of the Interior on resources of value to Native American tribes.

Expected Results: Annual reports detailing their activities, findings, and monitoring results from implementing protocols as part of core monitoring.

Budget: FY 09 = 140,296

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--			
Subtotal	--	125,000	132,500	136,475	140,296
DOI Customer Burden (32%)	--	--			
Project Total	--	125,000	132,500	136,475	140,296
% Total Outsourced	--		--	--	--

PROJECT TITLE AND ID: D.1. PROGRAMMATIC AGREEMENT: Reclamation Administrative Costs

General Project Description: Reclamation's regional archeologist administers the PA program and tribal contracts. This project funds salary, travel, and indirect costs of program administration. The costs integrate the PA and tribal consultation into the larger AMP.

Project Goals and Objectives:

- Management of five $95K (FY08 appropriated funds) tribal sole source contracts for participation in the AMP. Management of five $28K (FY09 power revenue funds) tribal sole source contracts to implement Native American monitoring protocols.

- Management of the treatment plan contract (first option year) for data recovery of at-risk historic properties.

- Chair one PA meeting and attend TWG and AMWG meetings.

- Oversee completion of the Native American Consultation Plan and the Historic Preservation Plan.

Expected Results: The major product is administration of the Glen and Grand Canyon treatment plans, accountability for the tribal contracts and use of both appropriated dollars and power revenues.

Budget: FY09 = $59,075

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	51,500	54,107	71,892	57,354	59,075
Subtotal	51,500	54,107	71,892	57,354	59,075
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	51,500	54,107	71,892	57,354	59,075
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: D.2 NPS Support for Archeological Treatment Plan

General Project Description: This funding is to provide support for National Park Service involvement in data recovery work at Grand Canyon archaeological sites.

Project Goals and Objectives:

Excavation of five to six historic properties. In exchange for this funding, NPS will make available the professional services of one on-site archaeologist to assist the Reclamation contractor and manage all NAGPRA issues that may arise. NPS will also provide logistical assistance (see project D.4. Glen and Grand Canyon Treatment Plan Implementation).

Budget: FY09 = $70,000

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	--	--	--	--	--
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries			**67,500**	**0**	**70,000**
Subtotal			**67,500**	**0**	**70,000**
DOI Customer Burden (32%)				**0**	**0**
Project Total			**67,500**	**0**	**70,000**
% Total Outsourced	--	--	--	--	--

PROJECT TITLE AND ID: D.3. Glen and Grand Canyon Treatment Plan Implementation

General Project Description: In consultation with Grand Canyon NPS, the Arizona SHPO and the remainder of the PA signatories, Reclamation completed a scope-of-work for the development of a treatment plan for the cultural resources of Grand Canyon. An RFP based on this scope-of-work was issued in FY08 and the contract was awarded to Utah State University and the Zuni Cultural Resource Enterprise. Four sites were targeted for data recovery in FY08 and five to six sites will be excavated in FY09.

Project Goals and Objectives:

- Implementation of a treatment plan MOA through consultation with SHPO, NPS, Tribes and other stake holders.
- Government-to-Government consultation with tribal councils based upon the treatment plan recommendations.
- Field work to be initiated in winter of 2008 and completed in spring and fall of 2009. Five to six sites will be selected for treatment in FY09.
- Collaboration with NPS archaeologists in carrying out field activities (see project D.2 NPS Support for Archeological Treatment Plan).

Expected Results: Prioritization, based on significance, of all affected Glen and Grand Canyon properties and implementation of an MOA for treatment of adverse effects. Detailed and comprehensive reports on consultant activities, results and recommendations.
Evaluation and implementation of mitigative measures or total data recovery, following the Secretary of the Interior Standards and Guidelines for Historic Preservation and guidance of the Advisory Council on Historic Preservation.

Budget: FY09 = $500,000

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	676,340	270,000	145,000	300,000	500,000
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	676,340	270,000	145,000	300,000	500,000
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	676,340	270,000	145,000	300,000	500,000
% Total Outsourced	100%	100%	100%	100%	100%

PROJECT TITLE AND ID: E. TRIBAL CONSULTATION: Sole Source Contracts with Tribes

General Project Description: Government-to-government consultation will be maintained between the five AMP tribes (Hopi Tribe, Hualapai Tribe, Kaibab Paiute tribe, Pueblo of Zuni, Navajo Nation) and five Interior agencies (US Geological Survey, National Park Service, Reclamation, U.S. Fish and Wildlife Service, and Bureau of Indian Affairs) with Reclamation serving as lead agency.

Project Goals and Objectives: The purpose of the continued funding of tribal contracts is to ensure tribal viewpoints are integrated into continuing AMP dialogs, votes, and in the final recommendations made to the Secretary of the Interior.

Expected Results: The most important product is the incorporation of tribal perspectives into the recommendations forwarded to the Secretary. In addition, the tribes prepare annual reports on activities funded under the contracts. Continued funding of government-to-government consultation through the agreements ensures enhanced communication and understanding of the AMP issues and concerns.

Budget: FY09 = $ 475,000 (appropriated funds)

FUNDING HISTORY					
	2005	2006	2007	2008	2009
Outside USBR Science/Labor	477,375	477,375	475,000	475,000	475,000
Logistics Field Support	--	--	--	--	--
Project Related Travel/Training	--	--	--	--	--
Operations/Supplies	--	--	--	--	--
USBR Salaries	--	--	--	--	--
Subtotal	477,375	477,375	475,000	475.000	475,000
DOI Customer Burden (32%)	--	--	--	--	--
Project Total	477,375	477,375	475,000	475,000	475,000
% Total Outsourced	100%	100%	100%	100%	100%

Chapter 2. U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center Annual Budget and Work Plan—Fiscal Year 2009

Introduction

The Glen Canyon Dam Adaptive Management Program (GCDAMP) is a science-based process for continually improving management practices related to the operation of Glen Canyon Dam (GCD) by emphasizing learning through monitoring, research, and experimentation. The U.S. Geological Survey's (USGS) Grand Canyon Monitoring and Research Center (GCMRC) is responsible for the scientific monitoring and research of the GCDAMP. GCMRC staff worked cooperatively with GCDAMP participants to identify the scope, objectives, and budget for the monitoring and research projects for fiscal year 2009 (FY2009) presented in the Grand Canyon Monitoring and Research Center Fiscal Year 2009 Budget and Annual Work Plan (AWP). As was the case in FY2007–08, the AWP for FY2009 is a transitional plan designed to fund the GCDAMP Science Program for 1 year while GCMRC's Strategic Science Plan (SSP) and Monitoring and Research Plan (MRP) are updated to reflect the requirements of the 2008 Environmental Assessment and Biological Opinion on the operation of Glen Canyon Dam. Beginning in FY2010, the expectations are that biennial work plans (BWP) will be developed for elements described in the SSP and MRP.

Purpose

The purpose of the AWP is to describe the core-monitoring, long-term experimental, research and development, and other related activities that will be implemented in FY2009 to address priority goals, questions, and information needs specified by the GCDAMP.

Overview of the GCMRC Strategic Science Plan and Monitoring and Research Plan

The AWP is designed to implement and be consistent with the draft GCMRC SSP and MRP dated May 5, 2006, and June 21, 2006, respectively. The principal elements of the MRP and SSP that that are addressed by the FY2009 AWP include:

Adaptive environmental assessment and management (AEAM) approach—The GCMRC science program will be based on the AEAM approach to natural resources management that was developed by Holling (1978) and Walters (1986) and articulated in the Adaptive Management Program Science Plan (AMPSP).

Collaborative science planning process—The GCMRC will continue to use the established planning process to update science plans and related work plans.

Priority strategic science questions—The GCDAMP priority questions and the associated strategic science questions (SSQs) provide the primary (but not exclusive) basis for designing the science program (appendix A).

Interdisciplinary integrated river science—Increasing emphasis will be provided on employing an interdisciplinary, integrated science approach over the next 5 years. Principal elements of this approach involve

- aligning GCMRC staffing/organization to facilitate integrated, interdisciplinary science;
- enhancing the Grand Canyon Ecosystem Model (GCEM) to identify critical ecosystem interactions and data gaps; and
- initiating an effort to gather and evaluate baseline data and develop modeling capabilities to assist in long term experimental planning, including future high flow experiments, etc.

Bridging science and management—The GCMRC will develop and implement a collaborative plan/assessment among scientists and GCDAMP participants to improve the effectiveness of the GCDAMP and better integrate the use of scientific information into the GCDAMP process.

Overview of Annual Work Plan and Budget

The FY2009 AWP was developed based on guidance provided in the:

- Monitoring and Research Plan (MRP) to Support the Glen Canyon Dam (GCD) Adaptive Management Program (AMP) which was approved by the Adaptive Management Work Group (AMWG) in August 2007,and
- Conservation Measures included in the 2007 and 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinions on the Shortage Criteria EIS and operation of GCD, respectively.

In addition, GCMRC discussed FY2009 budget priorities with the Budget Ad Hoc Work Group, the Technical Work Group (TWG), the Adaptive Management Work Group (AMWG) and the Department of the Interior (DOI) agencies participating in the AMP. Results of those discussions were considered in the development of the FY2009 AWP

The AWP is based on the assumption that the FY2009 hydrograph will consist of Modified Low Fluctuating Flow (MLFF) operations including experimental steady flows in October 2008 and September 2009. An additional 5 days of steady flows at 8,000 cfs will be needed in late May to accommodate the planned remote sensing overflight of the Colorado River. The preliminary budget does not provide for a potential High Flow Experiment (HFE) in FY2009. Currently, a HFE has not been authorized for FY2009 and no funding remains in the Experimental Fund to support a HFE (all the experimental funds are committed to the current test at least through FY2009).

The proposed budget provides for the continued implementation of a number of ongoing projects included in the approved AMP FY2008 Work Plan and Budget. The budget also provides for several new starts or major expansions of existing projects, including:

- Implementation of a Near Shore Ecology Study to evaluate the importance of various near shore habitats to humpback chub (HBC) recovery. This study will also be designed to address the effects of late summer–fall steady flows (as described in the Biological Opinion) on HBC (line 73 and line 148)
- Resumption of nonnative fishes control and associated native fishes monitoring in the confluence of the Little Colorado and Colorado rivers (line 74)
- Expanded efforts to refine and further develop an integrated flow, temperature, and sediment model for the Colorado River ecosystem (CRE) (line 94)
- Implementation of the recommended integrated core sediment monitoring project (combined effort related to several AMP goals, see lines 93, 99, and 115)

- Acquisition, post-processing and analysis of digital aerial imagery of the Colorado River ecosystem (line 115)
- Compilation and analysis of existing recreation safety data (line 104)

To achieve a balanced budget, a number of projects had to be eliminated or scaled back to accommodate the increased funding being requested for the new or expanded projects noted above and for other non-discretionary increases in costs for continuing projects. These adjustments are noted in the attached spreadsheet (see line 179).

Several ongoing projects and new projects that were identified in the MRP to start in FY2008 or 2009 will need to be deferred to accommodate the available funds. These include:

- Evaluation of the relative importance and effects of different flows on the recreation experience (originally scheduled to start in FY2008, but deferred to FY2009)
- 1973 Weeden campsite survey revisited (FY2009)
- Quantify vegetation encroachment on campsites (FY2009)
- Evaluate geomorphic changes to archaeological sites using remotely sensed imagery (FY2009–10)
- Geomorphic model of archaeological site vulnerability (FY2009–10)
- Feasibility study to explore the use of decision support tools to integrate the scientific information into science planning and GCDAMP recommendation processes, including resource tradeoff assessments (FY2008–09)
- Protocol Evaluation Panels (PEPs):
  - Lake Powell
  - Kanab ambersnail
  - Camping beaches

The proposed budget addresses all of the Conservation Measures included in the 2007 and 2008 USFWS Biological Opinions that are within the purview of GCMRC. This was accomplished in part based on additional appropriations that are expected from the Bureau of Reclamation (Reclamation) in the amount of $110K and $485K in FY2008 and FY2009, respectively. In addition, National Park Service (NPS) and Reclamation are expected to provide separate funding for the Conservation Measure to translocate HBC from the Little Colorado River (LCR) to several tributary streams in Grand Canyon including, Havasu Creek, Shinumo Creek, and Bright Angel Creek in FY2008 and FY2009. Since GCMRC will not lead these translocation projects, they are not addressed in the GCMRC preliminary FY2009 budget proposal.

Table 1summarizes core-monitoring, research and development, and experimental activities in the FY2009 annual work plan for the GCMRC. Activities address GCDAMP goals 1–11, including related science questions and information needs. Priority and related SSQs are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A) and the core-monitoring information needs developed by the Science Planning Group (SPG). Three categories of activities are identified:

1. **Core-monitoring activities—**Core monitoring is consistent, long-term repeated measurements using scientifically accepted protocols to measure status and trends of key resources. Core-monitoring activities are those that have been pilot tested for one to several years, undergone a protocols evaluation panel (PEP) evaluation and peer review, and have been formally approved by the GCDAMP for core-monitoring status. In FY2009, the monitoring activities associated with the status of HBC in the LCR and mainstem Colorado River are scheduled for PEP evaluation by the GCMRC and the TWG for core-monitoring status.
2. **Research and development activities—**Activities aimed at (1) addressing specific hypotheses or information needs related to a priority GCDAMP resource(s) and (2) developing/testing new

technologies or monitoring procedures. Examples of research and development activities in the FY2009 work plan include:

- linking whole-system carbon cycling to food webs in the Colorado River—the project that will provide the basis for the food base monitoring program;
- renewed research to advance integrated development of downstream flow, temperature, and suspended-sediment models.

3. Experimental activities—A suite of flow and nonflow treatments and/or management actions designed to improve conditions of target resources (HBC, sediment, etc.) while allowing for an understanding of the relationship between treatments/management actions and the target resources. The only experimental activity planned for FY2009 is the evaluation of 5 years of experimental steady flows from Glen Canyon Dam for September and October beginning 2008. These flows were prescribed through the "Final Environmental Assessment: Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012" dated February 29, 2008, and the "Final Biological Opinion for the Operation of Glen Canyon Dam" dated February 27, 2008. By July 2009, GCMRC intends to: 1) Complete the design and development of a September/October Steady Flow Science Plan for 2009-2012, including recommended flow parameters, 2) work with the AMWG and TWG to establish measures of scientific success as part of the Science Plan, and 3) report to AMWG by June 1 of each year on the projects included in the Science Plan.

Table 1. Summary of core-monitoring, research and development, and experimental activities in the fiscal year 2009 (FY2009) annual work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Several long-term experimental options currently under discussion are not reflected in the table; additional experimental options will be developed upon approval by the U.S. Department of the Interior. Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 in relation to science questions and information needs. Priority and related strategic science questions are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, and SA = GCDAMP Science Advisors summary questions.

GCDAMP goal	*Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)*	*Core-monitoring activities*	*Experimental activities*	*Research and development activities*
1. Food base	AMWG Priority: 1, 3, and 5 *SSQ 1-5. What are the important pathways that link lower trophic levels with fish and how will they link to dam operations?* *SSQ 1-6. Are fish populations, trends, or indicators from fish, such as growth, condition, and body composition, correlated with patterns in invertebrate flux?* *SSQ 5-2. Is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations?*			FY2006–09: Determine carbon budget to understand how energy is exchanged among organisms in the Colorado River; develop monitoring techniques and metrics for key organisms FY2008: Diet, drift, and predation data analysis
2. Humpback chub (HBC) and other native fishes (A.)	AMWG Priority: 1, 3, and 5 *SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?* *SSQ 1-4. Can long-term decreases in abundance of rainbow trout be sustained with a reduced leve of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.* CMIN 2.1.2 Determine and track abundance and distribution of all size classes of HBC in the Little Colorado River (LCR) and the mainstem.	FY2007–09: Monitor status and trends of HBC in LCR and mainstem using existing protocols		FY2006 and ongoing: Stock assessment FY2007–08: Gear efficiency/sampling evaluation FY2007–11: Statistical review of existing HBC monitoring protocols and habitat data FY2007–11: Evaluate protocols for warmwater and coldwater nonnative fish monitoring, removal, and control; effects on native fish

Table 1. Summary of core-monitoring, research and development, and experimental activities in the fiscal year 2009 (FY2009) annual work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Several long-term experimental options currently under discussion are not reflected in the table; additional experimental options will be developed upon approval by the U.S. Department of the Interior. Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 in relation to science questions and information needs. Priority and related strategic science questions are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, and SA = GCDAMP Science Advisors summary questions.—Continued

GCDAMP goal	*Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)*	*Core-monitoring activities*	*Experimental activities*	*Research and development activities*
2. HBC and other native fishes (B.)	AMWG Priority: 1, 3, and 5 *SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?* *SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action?* *SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?* CMIN 2.4.1 Determine and track the abundance and distribution of nonnative predatory fish species in the CRE and their impacts on native fish. RIN 2.4.1: What are the most effective strategies and control methods to limit nonnative 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?	FY2007–09: Continue mainstem monitoring of fish community		FY2007–10: Develop and test nonnative fish management plan FY2007–11: Develop abundance estimation framework that allows scientists to better estimate nonnative fish numbers in mechanical removal reaches FY2007–10: Develop bioenergetic model to predict changes in fish communities in response to environmental changes
2. HBC and other native fishes (C.)	AMWG Priority: 1, 3, and 5 *SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of YoY and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?* *SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?* SA 1. What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?			FY2007–10: Review data and literature on HBC in upper basin to see if HBC habitat can be identified, protected, and recreated below GCD

GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
2. HBC and other native fishes (D.)	AMWG Priority: 1, 3, and 5 *SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?*			FY2007–09: Develop alternative, noninvasive HBC monitoring gear to reduce stress on fish (e.g., DIDSON camera, remote passive integrated transponder (PIT) tag reading, and sonic tags) FY2007–09. Evaluate the effects of trammel net sampling
3. Extirpated species		No projects	FY2007–11: Evaluation and planning of temperature control device	No projects
4. Rainbow trout (RBT)	AMWG Priority: 3 *SSQ 3-6: What Glen Canyon Dam operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability?* CMIN 4.1.2 Determine annual proportional stock density of rainbow trout in the Lees Ferry reach. CMIN 4.1.4 Determine annual standard condition (Kn) and relative weight of rainbow trout in the Lees Ferry reach.	FY2007–11: Monitor status and trends of Lees Ferry RBT population FY2009: Review/evaluate RBT monitoring for core-monitoring status		

GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
6. Springs /riparian	AMWG Priority: 4 *SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?*			FY2009: Terrestrial monitoring FY2009 and ongoing: Terrestrial mapping

Table 1. Summary of core-monitoring, research and development, and experimental activities in the fiscal year 2009 (FY2009) annual work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Several long-term experimental options currently under discussion are not reflected in the table; additional experimental options will be developed upon approval by the U.S. Department of the Interior. Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 in relation to science questions and information needs. Priority and related strategic science questions are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, and SA = GCDAMP Science Advisors summary questions.—Continued

GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
	SSQ 3-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs? CMIN 6.1.1., 6.6.1., 6.2.1., 6.5.1. Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.			FY2007–11: Vegetation synthesis project
7. Quality-of-water	AMWG Priority: 1, 3, and 5 *SSQ 3-5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations?* *SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE)?* *SSQ 5-3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish?* CMIN 7.3.1. What are the status and trends of water quality releases from Glen Canyon Dam?	FY2007–09: Lake Powell monitoring using existing protocols FY2007–11: Downstream integrated quality-of-water (IQW) monitoring (including suspended-sediment flux)		FY2007–11: Advanced development of downstream flow, temperature, and suspended-sediment models
8. Sediment (fine and coarse sediment)	AMWG Priority: 1,2,3, and 4 *SSQ 4-1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with (beach/habitat-building flows (BHBFs), without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?*	FY2007–11: Implementation of recommendations from the final sediment transport modeling review-protocols evaluation panel (SEDS-PEP) (summer 2006) FY2009: Fine sediment "SED TREND" monitoring—detection of trends in lower elevation channel sand deposits through annual reach-scale topographic measurements of sand storage between		FY2007–11: Map change in nearshore habitat resulting from 2004 and 2008 High Flow Experiments; convert existing overflight analog images to digital to facilitate research

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GCDAMP goal	*Priority science questions and information needs (Questions from Strategic Science Plan and Monitoring and Research Plan in italics)*	*Core-monitoring activities*	*Experimental activities*	*Research and development activities*
		suspended-sediment flux monitoring stations. In FY2009, the reach between river mile 0 and 30 will be mapped using multibeam acoustic bathymetry methods for comparison with 2000-01 measurements. FY2009: Coarse sediment—no core-monitoring activities are scheduled at present until the next remote-sensing overflight occurs in FY2009.		
9. Recreation (A)	AMWG Priority: 3 and 4 *SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?* CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.	FY2007–11: Monitor change in sandbar campable area, topography, and volume (see above, project linked to sandbar monitoring)		FY2007–08: Complete campsite inventory and Geographic Information Systems (GIS) atlas FY2007–08: Evaluate use of field data vs. remotely sensed data for campable area monitoring
9. Recreation (B)	AMWG Priority: 3 *SSQ 3-7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE?* *SSQ 3-8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?* *SSQ 3-10. How can safety and navigability be reliably measured relative to flows?*			FY2008: Compile and analyze existing safety data

Table 1. Summary of core-monitoring, research and development, and experimental activities in the fiscal year 2009 (FY2009) annual work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Several long-term experimental options currently under discussion are not reflected in the table; additional experimental options will be developed upon approval by the U.S. Department of the Interior. Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 in relation to science questions and information needs. Priority and related strategic science questions are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, and SA = GCDAMP Science Advisors summary questions.—Continued

	SSQ 3-11. How do varying flows positively or negatively affect visitor safety, health and navigability of the rapids? *SSQ 3-12. How do varying flows positively or negatively affect group encounter rates, campsite competition, and other social parameters that are known to be important variables of visitor experience?*			
10. Hydropower	AMWG Priority: 3 *SSQ 3-3. What are annual hydropower replacement costs of the modified low fluctuating flow (MLFF) since 1996?* *SSQ 3-4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase of experimental design)?* CMIN 10.1.1. Determine and track the marketable capacity and energy produced through dam operations in relation to the various release scenarios (daily fluctuation limit, upramp and downramp limits, maximum flow limit of 25,000 cfs minimum flow limit of 5,000 cfs).	FY2007–11: Monitor power generation and market values under current and future dam operations		
GCDAMP goal	*Priority science questions and information needs (Questions from Strategic Science Plan and Monitoring and Research Plan in italics)*	*Core-monitoring activities*	*Experimental activities*	*Research and development activities*
11. Cultural	AMWG Priority:2, 3, and 4 *SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites in the CRE, and if so, how?* *SSQ 2-4. How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term?* *SSQ 2-7. Are dam-controlled flows affecting TCPs and other tribally-valued resources, and if so, in what respects?* CMIN 11.1.1 Determine the condition and integrity of archaeological sites and TCPs in the CRE through tracking rates of erosion, visitor impacts, and other relevant variables. (SPG revised CMIN) CMIN 11:2.1 Determine the condition of traditionally important resources and locations using tribal perspectives and values. (SPG revised CMIN)			FY2008: Research and development towards core monitoring (development of protocols for archaeological sites and TCPs) FY2008: Implement Technical Work Group (TWG) approved tribal monitoring projects

Table 1. Summary of core-monitoring, research and development, and experimental activities in the fiscal year 2009 (FY2009) annual work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Several long-term experimental options currently under discussion are not reflected in the table; additional experimental options will be developed upon approval by the U.S. Department of the Interior. Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 in relation to science questions and information needs. Priority and related strategic science questions are paraphrased from the Draft GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, and SA = GCDAMP Science Advisors summary questions.—Continued

12. High-quality monitoring, research, and Adaptive Management Program (A.) Data acquisition, storage, and analysis	AMWG Priority: 1,2, 3, 4, and 5	FY2007–11: Remote-sensing activities related to the preparation, acquisition, and storage of 2009 terrestrial resource monitoring data	No projects	FY2007–11: Convert existing analog images (especially overflight imagery) and reports to digital (see also goal 8) FY2007–11: Shoreline habitat and change detection mapping (see goals 2 and 8)

There are a number of projects and activities associated with GCDAMP goal 12—the maintenance of a high-quality monitoring, research, and adaptive management program—presented in this annual work plan. In general, these activities are aimed at effective management and administration of the GCMRC science program, logistical support for field activities, data management and analysis, independent peer review, and developing an action plan to improve the effectiveness of the GCDAMP. These science support activities fall into eight categories:

1. Data acquisition, storage, and analysis (DASA):
    - Conduct next quadrennial aerial overflight to acquire remote-sensing data of the entire CRE in May 2009,
    - Maintain, update, and enhance Oracle database,
    - Convert analogue data (report and imagery) to digital format,
    - Provision of Geographic Information Systems (GIS) support,
    - Support library functions,
    - Begin next phase of protocol to map near-shoreline habitat changes over a 4-year period (2005 versus 2009).
2. Logistical support for field activities/river trips and Survey operations support.
3. Compilation, synopsis, and synthesis of the data and results of the studies carried out in conjunction with the 2000 low steady summer experimental flows.
4. Engaging the services of a senior ecosystem scientist to review, revise where possible and appropriate and improve the Grand Canyon Ecosystem Model (GCEM) as a means of better integrating interdisciplinary science in GCMRC activities and supporting discussions related to long term experimentation.
5. Various services related to administrative support for the GCMRC and it cooperative science programs.
6. Continue support of GCMRC program planning and management.
7. Obtain independent peer review and science advisor support,
    - Review/assess integrated, interdisciplinary science approaches.
8. Obtain Southwest Biological Science Center (SBSC) information technology (IT) support.

A summary of the anticipated FY2009 funding by funding source is provided in table 2 and figure 1 summarizes GCMRC's FY2009 budget by GCDAMP goal. A breakout of the projects included as part of goal 12 is summarized in figure 2. The budget for each project in the work plan is included in the project descriptions and summarized for the entire budget in the separate budget attachment.

Table 2. Total anticipated funding to support the GCMRC in fiscal year 2009 (FY2009)

FUNDING SOURCES	FISCAL YEAR 2009
Power Revenues Under Cap -- Estimated USGS Portion (1)	$7,876,244
USGS Appropriations -- Assistance with Burden Costs (Cost Share)	$1,000,000
Reclamation Operations and Maintenance (Water Quality Monitoring of Lake Powell and Tailwaters Agreement)	$257,137
Reclamation Funded Near Shore Ecology/Fall Steady Flows - New Initiative	$485,000
TOTAL ESTIMATED AVAILABLE FUNDS FOR FY2009:	**$9,618,381**

Figure 1. Budget comparison of Grand Canyon Monitoring and Research Center fiscal year (FY) 2008 approved budget and FY2009 preliminary budget by Glen Canyon Dam Adaptive Management Program goal.

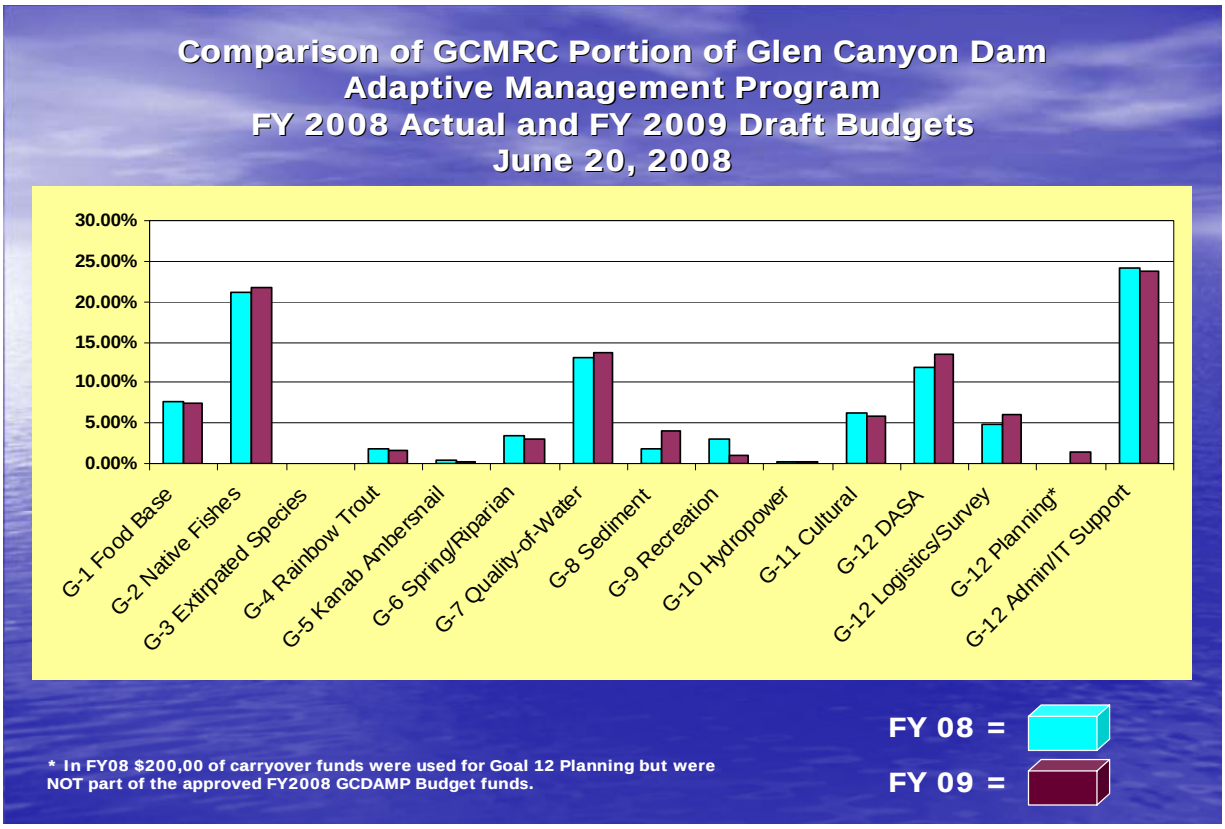
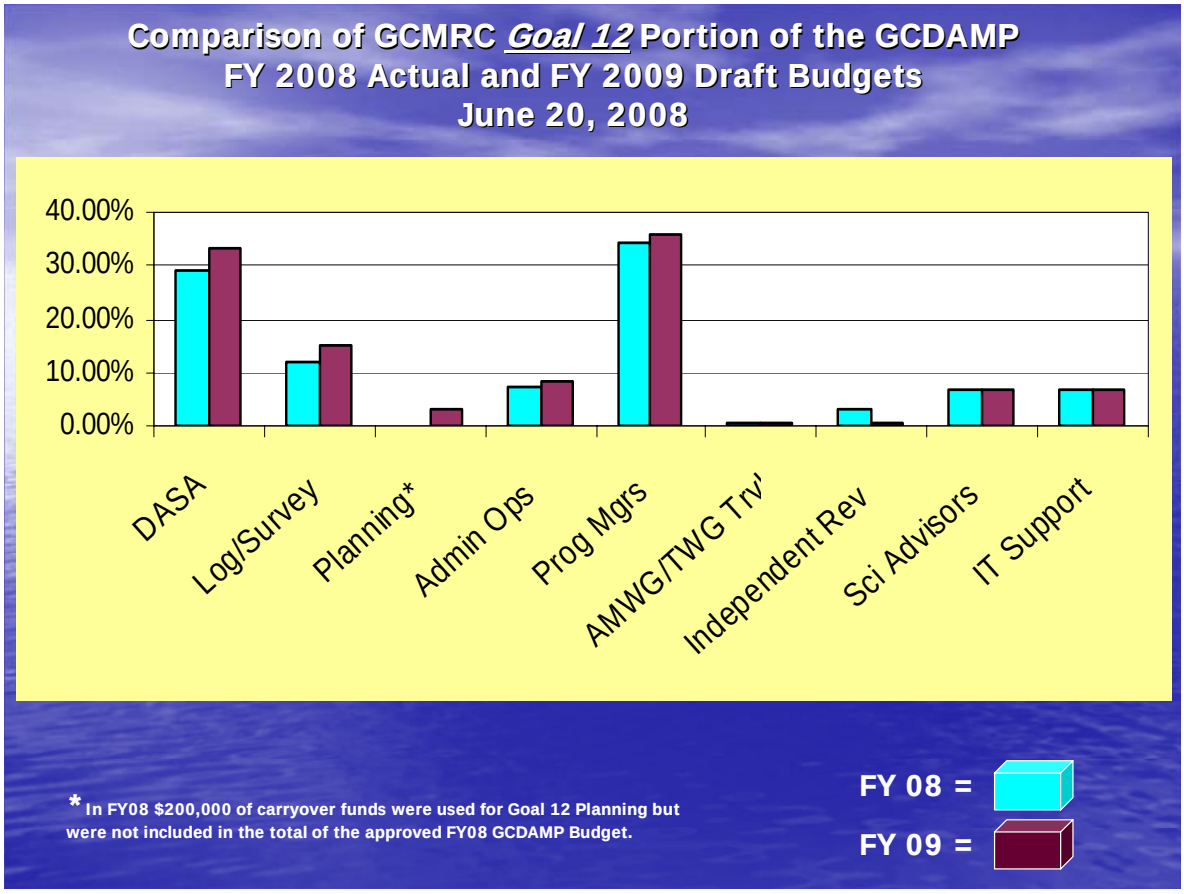


Figure 2. A breakout of the projects included as part of goal 12.



Project Descriptions

Detailed descriptions of each activity included in the AWP are described in the following section. Activities are presented based on the GCDAMP goal they are designed to address. Activities included in the AWP will be carried out in an integrated, interdisciplinary fashion. Integration efforts are described as an element of each description below.

Since its inception, the GCDAMP has attempted to ensure appropriate science program continuity and balance across all goals adopted by the program. The current focus of the GCDAMP is on SSQs associated with high priority AMWG information needs. Other GCDAMP goals will still be pursued, but with less intensity until priority issues of concern are resolved and monies can be reprogrammed or obtained through alternative sources. The AWP, with the exception of GCDAMP goal 3 (restore extirpated species), includes at least one activity to address each GCDAMP goal.

GCDAMP Goal 1: Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.

BIO 1.R1.09: Aquatic Food Base

Start Date

September 2005

End Date

September 2010

Principal Investigator(s)

Robert Hall, Ph.D., Aquatic Biologist, University of Wyoming; Emma Rosi-Marshall, Ph.D., Aquatic Biologist, Loyola University, Chicago; Colden Baxter, Ph.D., Fisheries Biologist, Idaho State University; and Theodore Kennedy, Ph.D., Aquatic Biologist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Systemwide with monthly sampling at accessible sites (Glen Canyon, about river mile (RM) -15–0, and Diamond Creek, about RM 225) and quarterly sampling at less accessible sites (Marble Canyon, about RM 30; below Little Colorado River (LCR) confluence, about RM 61; Randy's Rock, about RM 126; and below Havasu Creek, about RM 163). Three of these sites are known aggregations of humpback chub (HBC).

Project Goals

The overall goal of this project is to determine the role that food is playing in the distribution, condition, and abundance of fishes throughout the entire system. Quantifying the density and production of basal resources (i.e., algae, terrestrial leaf litter, etc.) and invertebrates will determine the amount of energy that is available to support production of fishes. The trophic basis of production calculations, where the types and amounts of different food items eaten by invertebrates and fishes are quantified, will determine the relative contribution of basal resources, invertebrates, and other food items to fish production. The results of this work will establish the degree to which native fishes are limited by food resources, by either low production at the base of the food web or via shunting of energy to nonnative animals such as New Zealand mudsnails or rainbow trout (RBT). This information, in turn, provides guidance to managers considering various management options.

The objectives that are addressed by this project include

- determining the important energy sources and pathways that support fishes, especially native species and trout,

- quantifying the abundance of basal resources using a carbon budget framework to determine potential available energy for higher trophic levels,
- identifying composition and quantity of drifting organic matter and invertebrates,
- incorporating knowledge into bioenergetics model and trophic basis of production calculations, and
- developing core-monitoring strategies for the aquatic food base in the Colorado River from GCD to Diamond Creek.

Need for Project

The aquatic PEP (Anders and others, 2001) and Science Advisor (Palmer, 2004) review of food base monitoring and research both recommended major changes in the GCMRC food base program. Specifically, Anders and others (2001) made the following remarks and recommendations:

> The food base program needs to be critically reviewed because the current level of understanding about the linkages between lower trophic levels and food availability of native fishes are not adequate to interpret food base data in relation to the management goal.
>
> Since there are scientific as well as statistical uncertainties associated with any approach for study[ing] the relation of food base to trends in abundance of fish populations the best approach is likely a fully integrated one, utilizing data on the abundance of prey available to fish in the GCE, the apparent food habits as indicated by stomach content analysis, and indicators from the fish themselves, including isotopes, growth and condition, and body composition.
>
> Because the food habits of specific life stages of most native species are not well known, a broad look at the potentially available food is required for a monitoring program. The best indicator of potential energy available is a measure of production—both primary and secondary—which is a measure of organic matter creation over time (mass/area/time).

These recommendations formed the basis for the food base request for proposals (RFP) released by the GCMRC in May 2005. The research proposal submitted by Dr. Hall and others that was awarded a cooperative agreement by the GCMRC closely followed the recommendations laid out in the PEP and SA reviews and the food base RFP. The GCMRC continues to lead and monitor the project progress.

Strategic Science Questions

Primary SSQs addressed:

> **SSQ 1-5.** What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations?
>
> **SSQ 1-6.** Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (e.g., lipids), correlated with patterns in invertebrate flux?

Information Needs Addressed

> **RIN 1.1.** What are the fundamental trophic interactions in the aquatic ecosystem?
>
> **RIN 1.4**. What is the current carbon budget for the Colorado River ecosystem?

CMIN 1.1.1. Determine and track the composition and biomass of primary producers below Glen Canyon Dam in conjunction with measurements of flow, nutrients, water temperature, and light regime.

CMIN 1.2.1. Determine and track the composition and biomass of benthic invertebrates below Glen Canyon Dam in conjunction with measurements of flow, nutrients, water temperature, and light regime.

General Methods/Tasks

Quantify Basal Resources Using a Carbon Budget Framework (RIN 1.4, CMIN 1.1.1)

Primary production and ecosystem respiration will be quantified using whole-stream metabolism calculations: Use diel changes in dissolved oxygen concentration, a byproduct of algal photosynthesis, to determine rates of algae production for mile-long reaches of the river. Use nighttime sags in dissolved oxygen concentration to determine ecosystem respiration, a measure of basal resource (both leaf litter and algae) consumption. If quantity of carbon consumed during respiration exceeds quantity of carbon produced by algal photosynthesis, this indicates allochthonous inputs may be an important basal resource fueling the aquatic food web. Data collected monthly at Glen Canyon and Diamond Creek and four times per year along the river corridor.

Allochthonous Inputs

Allochthonous inputs originate from riparian vegetation, tributaries, and Lake Powell. Allochthonous inputs from riparian vegetation have been quantified by Ralston and Kennedy (unpub. data). We will use ISCO automated water samplers (only at Paria River and Little Colorado River (LCR)) to collect samples of particulate organic matter during flooding events. We will also sample coarse organic matter on the Paria River during flooding events using large plankton nets. Water samples and plankton nets will be used to quantify the concentration of dissolved nutrients, dissolved organic matter, and plankton coming from Lake Powell. Samples will be collected monthly.

Standing Stocks

The standing stock of algae and organic matter will be quantified using a Hess sampler, a modified suction sampler, or by scraping algae off rocks (method depends on habitat type). These data will provide a measure of basal resource availability within each reach. Collections will occur monthly at Glen Canyon and Diamond Creek and four times per year at downstream locations.

Transported Organic Matter and Invertebrates

The amount of organic matter and invertebrates transported into and out of each reach will determine the extent to which downstream reaches are linked to upstream processes. Depth-integrated water samples will be used to quantify transported organic matter and invertebrates.

Determine Important Trophic Pathways Linking Basal Resources with Fishes (RIN 1.1)

Stable isotope and diet analysis of invertebrates and fish—Collect diet information from gut content studies of invertebrates and fishes. Collect standards of food items (e.g., algae, benthic invertebrates, terrestrial invertebrates) for signatures for use in stable isotope analysis. Samples collected four times per year along the river corridor.

Determine Flux along Trophic Pathways (CMIN 1.2.1)

Invertebrate density, production, and growth measurements—We will sample all benthic habitats (i.e., cobble bars, cliff faces, boulders, talus slopes, sandy bottom, etc.) to quantify density of invertebrates. Habitat-specific density estimates will be made using shoreline and bed-classification data from the Physical Science and Modeling Program. Growth measurements for the most common invertebrates (e.g., New Zealand mudsnails, *Gammarus*, chironomids, simuliids) in controlled chambers. Production of invertebrates will be calculated using density estimates coupled with growth measurements. Invertebrate density will be estimated monthly at Glen Canyon and Diamond Creek and four times per year at downstream locations. Growth measurements will be taken four times per year at Glen Canyon and Diamond Creek.

Fish density and production estimates—Density estimates for small-bodied and juvenile fishes will be determined quarterly using the multi-pass depletion method. Density estimates for larger bodied fishes will be derived using existing fisheries monitoring data. Production estimates will be attempted using existing fisheries data and literature values.

Bioenergetics modeling and trophic basis of production calculations—Invertebrate and fish production data will be coupled with diet information (derived from both gut content and stable isotope analysis) to determine the relative contribution of basal resources to invertebrate and fish production.

Links/Relationships to Other Projects

Physical Sciences

Four of our six study reaches are fine-grained integrated sediment transport (FIST) and integrated water-quality (IWQ) monitoring sites. We will use bathymetry, bed classification, sediment transport, and water quality data to determine how the physical environment affects the standing mass, distribution, and production of basal resources and invertebrates. We will work closely with the Physical Science and Modeling Program, relying on their infrastructure and capabilities, to estimate inputs of organic matter from the Paria River during base flow and flooding events. Finally, the temperature model that is being developed by the Physical Science and Modeling Program will be a valuable tool for estimating systemwide growth rates of algae and invertebrates because temperature is an important determinant of algae and invertebrate growth rates.

Fisheries

Ongoing fisheries monitoring data on the distribution and relative density of common native and nonnative fishes will be used to determine rates of energy flow to fishes in the system. Where possible, we will also rely on existing fisheries monitoring efforts to obtain the fish stomachs and tissue samples required for gut content and stable isotope analysis, respectively.

Terrestrial Resources

Ongoing vegetation mapping efforts will be used to estimate rates of allochthonous inputs to the mainstem Colorado River, a potentially significant basal resource supporting invertebrate and fish growth.

FY2009

In FY2009 we will shift our focus from field data collection to laboratory processing and data analysis and write-up. We will conduct our last Grand Canyon river trip in January 2009 and then our last monthly collections at Diamond Creek and Lees Ferry in March 2009—this will represent 3 years of data collection including a full year after the March 2008 HFE. After March 2009 we will continue making monthly visits to Lees Ferry to recalibrate dissolved oxygen meters used for continuous measurement of algae production and to collect

invertebrate and algae drift samples across a range of discharges (see project Bio 1.R4.09). We will also continue sampling other foodbase components (benthic algae and invertebrate density and biomass, transported organic matter, dissolved nutrients, etc.) at Lees Ferry and Diamond Creek quarterly as these are viewed as potential monitoring protocols. Reducing our field effort is critical as this will free up the time needed to process samples, analyze and write-up the data, and submit a final report summarizing our findings by May 2010.

Products/Reports

Publications

We anticipate at least six publications in peer-reviewed journals will be produced during this project. Tentative subjects for these publications include:

- measuring air-water gas exchange and whole-system metabolism in a large, regulated river (proof-of-concept paper);
- assessing the seasonal and spatial variation in organic matter inputs to the Colorado River, Grand Canyon (synthesis paper of metabolism, allochthonous inputs, lake inputs, tributary inputs, etc.);
- determining spatial variation of secondary production of invertebrates in the Colorado River;
- analyzing the spatial variation in the relative importance of basal resources to invertebrate and fish production in the Colorado River;
- linking whole-river carbon flows with food webs in the Colorado River; and
- determining impacts of New Zealand mudsnails on invertebrate and fish production in the Colorado River.

Reports

- Brief trip reports are completed and submitted to Grand Canyon National Park shortly after each trip to comply with permitting requirements
- Multiple manuscripts using the data from this effort are being prepared for submittal to the peer-reviewed literature
- A final report summarizing major results and recommendations will be submitted by May 2010.

Budget

BIO 1.R1.09	
Aquatic Food Base (FY2007–09)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Anders, P., Bradford, M., Higgins, P., Nislow, K. H., and tate, C., 2001, Final Report of the Aquatic Protocol Evaluation Program Panel; Grand Canyon Monitoring and Research Center

Palmer, M., Baron, J., Dale, V., Gunderson, L., Howard, A., Kitchell, Jl, Robertson, D., Schwartz, D., Watkins, J., and Garrett, D., 2004, A Review of the GCMRC Food Base Science Program by the GCD AMP Science Advisors

BIO 1.R4.09 : Impacts of Various Flow Regimes on the Aquatic Foodbase

Start Date

2008

End Date

2010

Principal Investigator(s)

Theodore Kennedy, Ph.D., Aquatic Biologist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Robert Hall, Ph.D., Aquatic Biologist, University of Wyoming

Geographic Scope

Three sites (Glen Canyon about RM -15–0, Diamond Creek about RM 225, and LCR confluence about RM 61)

Project Goals

The goal of this project is to determine whether dam operations affect rates of primary production or the concentration/loads of drifting algae and invertebrates. This project will be done in close association with research project BIO 1.R1.09, which will quantify, on a monthly basis, the density and production of basal resources (i.e., algae, terrestrial leaf litter, etc.) and invertebrates, and will determine the amount of energy that is available to support production of fishes.

Need for Project

The food base in any aquatic system is an important factor that directly affects fish community dynamics including abundance, reproduction and recruitment, condition, and distribution. Much of the diet of trout and humpback chub consists of food items that have been suspended and are drifting in the water column (Valdez and Ryel, 1995). The drifting food base in the Colorado River ecosystem is generally composed of freely floating aquatic invertebrates and *Cladophora glomerata* (a long, filamentous green algae) that are available to fish for consumption. Primary production at Lees Ferry is dominated by *Cladophora*, which acts as a substrate for various types of epiphytic diatoms which provide a food source for chironomids and simuliids (aquatic insect larvae) and for the shrimp-like amphipod, *Gammarus lacustris* (Pinney, 1991). The nutritional value of *Cladophora* to fish is enhanced by the presence of lipid-rich epiphytic diatoms, and diatoms have been shown to provide an important source of energy for rainbow trout (Leibfried, 1988).

In order to understand the current condition of the aquatic food base, measurements of epiphytic diatoms, aquatic invertebrates, and algal abundance in the Colorado River downstream of Glen Canyon Dam are being conducted as part of BIO 1.R1.09. However, the response of these benthic and drifting resources to various flow management regimes remains uncertain. Thus, this research project will identify the responses of potentially important benthic and drifting food base to various aspects of the proposed flow regime. This adds an important component to the food base research program under BIO 1.R1.09 which may help to identify indirect impacts of flow regimes on humpback chub, rainbow trout, and other fish populations in Grand Canyon.

Strategic Science Questions

Primary SSQ addressed:

SSQ 3-5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations?

Information Needs Addressed

CMIN 1.5.1. Determine and track the composition and biomass of drift in the Colorado River in conjunction with measurements of flow, nutrients, water temperature, and light regime.

General Methods/Tasks

Organic and invertebrate drift concentrations will be measured monthly at Lees Ferry and Diamond Creek and seasonally at the Little Colorado River confluence. Samples will be collected across a range of discharge to determine the effect that dam operations have on drifting food resources. Continuous measurements of whole stream metabolism are being conducted at Lees Ferry to determine the effect that dam operations have on algae production and ecosystem respiration. YSI 6600 sondes are deployed continuously at RM -8 and RM0 and are measuring concentrations of dissolved oxygen, which are used in metabolism calculations. These instruments are re-calibrated once per month concurrent with collection of drift samples.

FY2009

We will continue making monthly measurements of algae and invertebrate drift at Lees Ferry through FY2009. On these monthly trips to Lees Ferry we will also recalibrate the dissolved oxygen sensors used for making continuous measurements of primary production. However, measurements of organic and invertebrate drift at the Little Colorado River confluence will end after the foodbase project's January 2009 river trip as that project will be shifting emphasis from field data collection to laboratory processing (see Project Bio 1.R1.09). In FY2009, measurement of invertebrate and organic drift at Diamond Creek will occur quarterly.

Links/Relationships to Other Projects

Under Research Project BIO 1.R1.09—Aquatic Food Base, four broad tasks are being performed: (1) quantify basal resources using a carbon budget framework, (2) determine important trophic pathways linking basal resources to fish, (3) estimate fish density and production, and (4) model bioenergetics and the trophic basis of production calculations. We will work closely with this project, relying on much of their infrastructure and capabilities, to estimate primary and secondary biomass, productivity, and drift. This project builds upon the aquatic food base program by carrying more intensive observations during various experimental flow regimes with the intent of distinguishing the effects of various flow changes compared to "base" conditions.

Products/Reports

Tentative subjects for publications include (1) the response of primary production and secondary production of invertebrates in the Colorado River to various flow regimes from GCD, and (2) the effect of various flow regimes from GCD on the availability of drifting food base for humpback chub, rainbow trout, and other fish populations.

Reports

A final report summarizing major results and recommendations will be submitted at the close of the project.

Budget

BIO 1.R4.09	
Impacts of Various Flow Regimes on the Aquatic Food Base (FY2008–09)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Leibfried, W. C. 1988. The utilization of Cladophora glomerata and epiphytic diatoms as a food resource by rainbow trout in the Colorado River below Glen Canyon Dam, Arizona. Northern Arizona University, Flagstaff, Ariz.

Pinney, C. A. 1991. The response of Cladophora glomerata and associated epiphytic diatoms to regulated flow, and the diet of Gammarus lacustris, in the tailwaters of Glen Canyon Dam. M.S. Northern Arizona University, Flagstaff, Ariz.

Valdez, R. A., and R. J. Ryel. 1995. Life history and ecology of the humpback chub (Gila cypha) in the Colorado River, Grand Canyon, Arizona. Final Report to Bureau of Reclamation, Contract No.0-CS-40-09110, Salt Lake City, Utah.

GCDAMP 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.

BIO 2.R1.09: Little Colorado River Humpback Chub Monitoring Lower 15 km (HBC Population Estimates)

BIO 2.R2.09: Little Colorado River Humpback Chub Monitoring Lower 1,200 m

BIO 2.R3.09: Humpback Chub Monitoring Above Chute Falls

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

U.S. Fish and Wildlife Service (BIO 2.R1.09 and BIO 2.R3.09) and the Arizona Game and Fish Department (BIO 2.R2.09), with support from the U.S. Geological Survey, Grand Canyon Monitoring and Research Center (M.E. Andersen, L.G. Coggins, Ph.D., staff)

Geographic Scope

Little Colorado River

Project Goals

- Determine the critical physical and biotic factors that may be limiting to, or supportive of, the humpback chub and other native fish populations in Grand Canyon. Seek methods that reduce, eliminate, or control limiting factors.
- Identify habitat characteristics that are most important to all life stages of humpback chub and seek methods that maintain, and possibly replicate, suitable habitats.
- Determine and refine the most appropriate method(s) for estimating the population size of humpback chub and other Grand Canyon fishes, including sampling design, gear selection, and development of remote

monitoring methods. The method(s) developed and selected should be consistent with the second edition of the Colorado River Endangered Fishes Recovery Goals. (The U.S. Fish and Wildlife Service (USFWS) initiated revision of the goals in 2007).

- Improve understanding of dam operations on young-of-year (YoY) and juvenile humpback chub (HBC) survival and habitat use.
- Establish core-monitoring protocols for humpback chub in Grand Canyon.

The overarching goal of this project is to provide an annual assessment of the humpback chub population in the Little Colorado River (LCR). The specific projects that will be conducted in FY2009 are (1) estimating the population size of HBC in the LCR, (2) monitoring HBC above Chute Falls, (3) translocating HBC from near the mouth of the LCR to above Chute Falls, and (4) monitoring HBC in lowest 1,200 meters of the LCR.

Specific objectives of the projects include:

- Obtaining population estimates of HBC ≥150 mm and ≥200 mm in the lower 15 km of the LCR and above Chute Falls;
- Translocating young humpback chub above Chute Falls is to support the areal extension of this population in the LCR;
- Providing other pertinent information related to physical parameters of the LCR (i.e., temperature and turbidity), length frequency data, community composition, sexual condition and characteristics of native fish (gender, ripe, tuberculate, etc.), frequency of external parasites (i.e., primarily Lernaea cyprinacea), and predation; and
- Collecting ancillary data to support the stock assessment models (e.g., mark-recapture tagging data, length frequency data).

Need for Project

A rigorous stock assessment of the endangered HBC is needed to help managers assess action alternatives and the response of this species to experimental and management actions. Because the majority of HBC in Grand Canyon are produced in, and occur near, the LCR (Paukert and others, 2006) the focus on this tributary is warranted. Data collected in the LCR support the annual stock assessment conducted with the Age-Structured Mark-Recapture (ASMR) model (Coggins, 2007). The work described in this project will address these information needs in the LCR. Statistical data analysis, historical reviews, and peer reviews will provide the basis for directing how monitoring of HBC will be conducted in the future. Further review of and recommendations regarding monitoring will be developed at a protocol evaluation panel planned for Grand Canyon fish monitoring in early 2009. This panel activity was planned for March 2008 but was postponed to allow for the high flow experimental release from Glen Canyon Dam in March 2008.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of YoY and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional science question addressed by these projects:

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?

GCDAMP SAs have summarized the SSQs with the following question (the projects outlined here specifically address this question, especially their evaluation of annual spawning success):

SA 1. What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

Primary information needs addressed:

CMIN 2.1.2 Determine and track recruitment (identify life stage), abundance, and distribution of HBC in the LCR.

CMIN 2.1.1. Determine and track year-class strength of HBC between 51-150 mm in the LCR and the main channel.

General Methods/Tasks

Annual Spring (March and April) Humpback Chub Abundance Assessments in the Lower 15 km of the Little Colorado River

In the spring two mark-recapture trips (12-day) are conducted annually in the lower 13.57 river kilometers (rkm) of the LCR to estimate the abundance of HBC (> 150 mm TL). This program has been ongoing since 2000 and annually produces assessments of the abundance of HBC. These efforts rely on multiple event mark-recapture analysis of Passive Integrated Transponder (PIT) tag data to produce abundance estimates using closed population models. Additionally, this sampling effort provides both data for populating the stock assessment model (open population model) as well as measures of relative abundance on the spawning and resident populations of HBC in the LCR below Chute Falls. Unbaited hoop nets (50-60 cm in diameter, 100 cm long, a single 10 cm throat, and covered with 6 mm nylon mesh netting) were the sole fishing gear used in this study. During both monitoring trips, each reach was sampled with 20 nets for the first ~24 h haul, then re-sampled by redeploying nets, often to new locations within the same reach. Evaluation of relative trends of other fishes, especially native bluehead suckers and flannelmouth suckers, is a desirable side benefit of this sampling.

Annual Fall (September and October) Humpback Chub Abundance Assessments in the Lower 15 km of the Little Colorado River

The fall sampling is aimed primarily at providing an estimate of the abundance of subadult fishes rearing in the LCR. These data support the ASMR model to assess HBC population numbers. Two trips into the LCR are conducted to collect the data used to construct these estimates in the fall (September and October). Findings from the fall trip are used as a complimentary comparison to the spring-abundance estimates. Sampling is predominantly conducted using hoop nets evenly distributed throughout the lower 15 km of the LCR. Other types of sampling gear are not used in the LCR because they have been shown to be less efficient at capturing HBC >150 mm total length in the LCR.

Annual Spring Relative Humpback Chub Abundance Assessment in the Lower 1,200 m of the Little Colorado River

This program was established by the Arizona Game and Fish Department (AZGFD) in 1987 and has operated continuously through 2004 with the exception of the years 2000–01 (Ward and Persons, unpub. data). This program annually produces assessments of the relative abundance (i.e., catch per unit effort [CPUE]) of all size classes of humpback chub, flannelmouth suckers, bluehead suckers, speckled dace, and a host of nonnative fishes in the lower 1,200 m of the LCR. Data is collected during a 30–40-day period in spring (April and May) using hoop nets set in standardized locations distributed throughout the reach. In general, this effort represents the longest and most consistent relative abundance dataset available to infer trends for the population of HBC in the LCR. Results provide an independent comparison to the mark-recapture-based assessments. The statistical power of this portion of the monitoring program has not yet been assessed, but statistically significant differences in relative abundance are apparent in current data.

Monitoring and Translocation Above Chute Falls

As part of the monitoring program two separate trips are conducted in the summer above Chute Falls in the LCR to monitor translocated individuals and potential offspring. These trips occur during late May when the LCR discharge is at base flow to provide an annual abundance estimate of HBC within this region. In addition to the annual population estimates, this data can be incorporated into open population models for HBC being developed by the GCMRC. Moreover, because we have and will continue to implant these fish with PIT tags (Biomark, Inc.), it is likely that some individuals will eventually be recaptured in the lower LCR corridor and/or Colorado River, which would increase our knowledge of migration patterns.

During the LCR trip, personnel will reside at the established translocation camp located at 16.2 rkm on Navajo lands. This camp has an established helicopter landing pad and offers high ground protection from most floods. Baited hoop nets (0.5–0.6-m diameter, 1.0-m length, 6-mm mesh, single 10-cm throat) will be set from shorelines to capture and PIT tag humpback chub as part of a mark-recapture program to estimate the abundance of individuals ≥150 mm in the upper 13.6 km of the LCR.

Personnel will be responsible for fishing baited hoop nets in the LCR corridor above Chute Falls (13.6 rkm), which is the upstream extent of the current downstream LCR monitoring. Approximately 50 hoop nets will be fished throughout this upper reach from 13.6 rkm to 18.0 rkm, with the average spacing between nets approximately 100-150 m. Each hoop net will be positioned in favorable habitat suspected of yielding good catches of HBC. Nets will be repositioned as needed. On average, each hoop net will be checked once every 24 hours. Each net will be baited near its cod end by attaching a nylon mesh bag (30 by 30-cm, 6-mm mesh) containing AquaMax™ Grower 600 for Carnivorous Species (Purina Mills Inc., Brentwood, MO). All captured HBC will be examined for colored elastomer tags and PIT tags. Those individuals not previously PIT tagged, but of sufficient size to be tagged without injury, will be held overnight either offshore in an aerated tank or in the LCR in a secured holding pen to allow time for digestion of any consumed bait, whereby they will be tagged and released.

The overall reach will be broken down into two subreaches and each subreach fished for 3 days. The upper reach designation will be from 18.0 to 15.0 rkm (undesignated point below Blue Spring to first travertine dam above Chute Falls). Currently 18 rkm is the highest point in which HBC have been located above Chute Falls. The lower subreach will extend from 15.0 to 13.6 rkm (first dam above Chute Falls to Lower Atomizer Falls where lower LCR monitoring begins). The lower subreach is relatively small because of the time constraints needed to maneuver around major travertine dams so that we can sufficiently sample the myriad of adult HBC habitats (deep pools, large boulders, etc.) existing within this subreach. In addition to fishing baited hoop nets and PIT tagging HBC as detailed above, personnel will be responsible for:

- measuring and recording the fork and total lengths, gender, spawning condition, and sexual characteristics for all captured native fishes (except speckled dace);
- measuring and recording the total length, gender, and spawning condition of all other captured fish;
- recording the stomach contents of all captured large-bodied nonnative fish except common carp;
- recording the location, shoreline habitat, hydraulic unit, and set and pull time, and map locations for each hoop net set; and
- making daily turbidity with the Hach 2100 turbidimeter, water temperature measurements, and CO_2 using titration.

Translocation

The USFWS will lead efforts to once again transfer young HBC from near the Little Colorado River/Colorado River confluence to above Chute Falls. This activity has been reviewed by a genetics expert, resulting in a recommendation to further augment the population based on the successes already observed and the need to maintain the population viability.

Management Plan

Once the initial stock assessment has been completed, USFWS will draft a management plan that will direct any future management action above Chute Falls. This document will evaluate the benefits or disadvantages of additional translocations and, if possible, provide a trigger for when additional movements of fish should be performed.

Quality Control

Quality control relative to data delivery will be assured through the use of standardized data collecting, recording, and electronic entry procedures. These include use of standardized fish handling protocols, field data collection forms, and computerized data entry routines. Additionally, various automated summary reports of submitted data are being developed to aid in identifying errors in electronic versions of submitted data. Copies of original field data sheets are held by the GCMRC library so that future problems encountered with fish databases may be checked against field data sheets. Electronic copies of data are submitted to the GCMRC on a CD/DVD format. Data must meet the GCMRC's data standards.

Analysis of the Little Colorado River Monitoring Program

The value of four LCR sampling occasions, translocating HBC above Chute Falls, monitoring above Chute Falls, and monitoring of the lower 1,200 m of the LCR will be reviewed by the protocol evaluation panel currently planned for March 2009.

Links/Relationships to Other Projects

Improvement of the status of the HBC will be necessary for the species to be considered for down listing or delisting. The GCDAMP can contribute to an improved status for HBC, thereby decreasing the amount of effort required of the GCDAMP stakeholders on behalf of this species. The most recent iteration of the recovery goals for this species (initiated in 2007) required a minimum of 2,100 adults in the Grand Canyon, a steady or increasing trend in the population, and control of environmental threats, among other requirements. One potential element of conservation of HBC in Grand Canyon may be a Glen Canyon Dam flow release regimen that supports this species. These flows can be expected to impact many of the elements of the canyon resources, including sediment, cultural resources, and recreation. Therefore, releases that benefit one resource, HBC in this example, must be consistent with conservation of other resources. Conservation of LCR resources, especially water and protection from catastrophic events, whether accomplished through the GCDAMP process or by other

means, would be important not only to protecting the spawning HBC population in the LCR but also other organisms found there.

Products/Reports

The USFWS will deliver two trip reports annually, including data collected, to the GCMRC. The trip reports will be summarized and analyzed in a final report delivered to the GCMRC in January of the following year. These reports address the lower 15-km monitoring and the monitoring above Chute Falls. The AZGFD will deliver one annual report on the results of their monitoring of the lower 1,200 m to the GCMRC.

Budget

BIO 2.R1.09	
LCR HBC Monitoring Lower 15 km (HBC Population Est; Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R2.09	
LCR HBC Monitoring Lower 1,200 m; Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R3.09	
Humpback Chub Monitoring Above Chute Falls	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

Literature Cited

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Paukert, C.P., Coggins, L.G. Jr., and Flaccus, C.E., 2006, Distribution and movement of humpback chub in the Colorado River, Grand Canyon, Based on recaptures. Transactions of the American Fisheries Society 135:539-544.

BIO 2.R4.09: Monitoring Mainstem Fishes

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

Arizona Game and Fish Department, with support from U.S. Geological Survey, Grand Canyon Monitoring and Research Center (M.E. Andersen, L.G. Coggins, Ph.D., staff)

Geographic Scope

The mainstem Colorado River in Grand Canyon between Lees Ferry and upper Lake Mead

Project Goals

The objectives that are addressed by this project are as follows:

- Determine and refine the most appropriate method(s) for estimating the population size of humpback chub (HBC) and other Grand Canyon fishes, including sampling design, gear selection, and development of remote monitoring methods. The method(s) developed and selected should be consistent with the second edition of the Colorado River Endangered Fishes Recovery Goals. (The US Fish and Wildlife Service initiated review of the goals in 2007).
- Improve understanding of dam operations on young-of-year (YoY) and juvenile humpback chub survival and habitat use.
- Establish core monitoring protocols for humpback chub in Grand Canyon.
- Provide ongoing monitoring of the entire Colorado River fish community in Grand Canyon, including native and nonnative species. These data help support other efforts to characterize and manage the fish community.

The goals of this project are to provide status and trend information on the abundance and recruitment of the fish community in Grand Canyon. It is one of the projects that will be reviewed by the protocol evaluation panel currently scheduled for March 2009.

Need for Project

Native fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam and non-flow actions. To inform these decisions, it is imperative that accurate and timely information on the status of fish populations, particularly the endangered HBC, is available to managers. A suite of adaptive experimental management actions are being contemplated to better understand the mechanisms controlling the population dynamics of native fishes, and to identify policies that are consistent with the attainment of management goals. The assessments generated from this project provide a baseline from which to assess the effects of implemented experimental actions. This information is therefore crucial to (1) inform the program as to attainment of identified goals, (2) provide baseline status and trend information to be used as a backdrop to further understand mechanisms controlling native fish population dynamics, and (3) evaluate the efficacy of particular management policies in attaining program goals. The results of this project are potentially useful in assessing changes to Federal Endangered Species Act listing status of HBC in Grand Canyon.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional SSQs addressed:

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

The Adaptive Management Program Science Advisors have articulated the following summary science questions that are addressed by this project:

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on young of year and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

SA 2. What are the most probably positive and negative impacts of warming the Colorado River on humpback chub adults and juveniles?

Information Needs Addressed

Primary information needs addressed:

CMIN 2.1.2. Determine and track year abundance and distribution of all size classes of humpback chub between in the LCR and the mainstem.

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

General Methods/Tasks

Mainstem fish monitoring, including the monitoring below Diamond Creek, has used boat-operated electrofishing to provide an overall assessment of the status and trends of native and nonnative fishes in the Colorado River between Lees Ferry and Lake Mead. The electrofishing gear is not without its limitations, particularly its lack of effectiveness at sampling deep water habitats. However, it remains the most important tool for providing an overall assessment of the mainstem fish community and its use will be retained in FY2009. Two mainstem electrofishing trips will be conducted in the spring. This timing allows for population approximations and some limited change detection, two important functions of this work. Data from these trips also supports the update of the age-structured mark-recapture (ASMR) model. This monitoring sampling design will be assessed as part of the PEP scheduled for 2009.

Links/Relationships to Other Projects

Understanding the factors influencing the dynamics of the Grand Canyon native fish populations, especially the endangered HBC, is important to evaluating the effects of management and conservation activities, especially Glen Canyon Dam operations. To determine these factors, a combination of large-scale manipulations (e.g., experimental removal of nonnative fish or long-term implementation of contrasting flow regimes) and smaller scale process-oriented research (e.g., assessment of juvenile fish growth rates under various temperature regimes or availability of particular food items) will likely prove most efficient in determining the key mechanisms regulating native fish populations. In each of these endeavors, it is critical that baseline trends in population abundance and recruitment be known. It is only with this knowledge that it is possible to assess population level impacts of large-scale manipulations. Though it is informative to assess the effects of experimental management on processes thought to be important like growth or survival at particular life stages, this is not ultimately sufficient to determine efficacy of particular management actions. Linkages between these processes and ultimate recruitment to populations must be established. Again, these linkages can only be made if baseline trends in population abundance and recruitment are available.

Products/Reports

Annual reports detailing the findings of each of the above activities will be prepared and submitted to the GCMRC for internal and/or external review as center policy dictates. As warranted, project findings will be prepared and submitted for publication in the primary peer-reviewed literature. These data will be utilized in the 2009 PEP.

Budget

BIO 2.R4.09	
Monitoring Mainstem Fishes (includes Diamond Down; Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R5.09: Nonnative Control Planning

BIO 2.R6.09: Nonnative Control Pilot Testing

Start Date

September 2007

End Date

September 2011

Principal Investigator(s)

K.D. Hilwig, Fisheries Biologist; M.E. Andersen, Biology Program Manager; L.G. Coggins, Ph.D. Fisheries Biologist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, in cooperation with the U.S. Fish and Wildlife Service and Arizona Game and Fish Department

Geographic Scope

The Colorado River ecosystem in Grand Canyon Project Goals

These projects seek to address the following goal:

- To elucidate critical physical and biotic factors that may be limiting to, or supportive of, the humpback chub (HBC) and other native fish populations in Grand Canyon and to seek methods that reduce, eliminate, or control limiting factors

The specific goal of the tasks identified in this project description is to evaluate threats to native fishes resulting from nonnative fishes, to develop a plan to control those species that pose the greatest threats to natives, and to test implementation of this plan. This project is expected to be complete in September 2011.

Need for Project

Nonnative fishes are among the greatest threats to native fishes in western North American rivers (Miller, 1961; Minckley and Deacon, 1991). Nonnative fishes may threaten native fishes by direct predation, by competing for available food and other resources, and by habitat modification (Minckley, 1991). Nonnative fishes were introduced into Grand Canyon not later than early in the twentieth century (Woodbury, 1959; Valdez and Ryel, 1995). While native fishes survived these initial introductions at least long enough to be described by early researchers, other system stressors, especially the modification of natural flows as a result of dam installation, appear to have increased the threats to native fishes from nonnative fishes (Minckley, 1991).

The Glen Canyon Dam Adaptive Management Program has recognized nonnative fishes as a threat that needs to be addressed, and proceeded with implementation of a rainbow trout and other nonnative fish control experiment around the Little Colorado River inflow reach from 2002–2006. The work described in this work plan builds on that effort. As the Colorado River mainstem becomes warmer due to climate effects, the potential for an increased threat from warmwater-adapted nonnative fishes increases. There is an immediate need to begin investigating what species pose the greatest threats to natives, how those species might be controlled, and to test control approaches for efficacy.

Strategic Science Questions

Primary SSQs addressed:

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population?

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

The Adaptive Management Program Science Advisors have articulated the following summary science questions that are addressed by this project:

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

SA 2. What are the most probably positive and negative impacts of warming the Colorado River on humpback chub adults and juveniles?

Information Needs Addressed

Primary information needs addressed:

CMIN 2.4.1. Determine and track the abundance and distribution of nonnative predatory fish species in the Colorado River.

RIN 2.4.1. What are the most effective strategies and control methods to limit nonnative 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 2.4.4. What are the target population levels, body size, and age structure for nonnative fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

General Methods/Tasks

A project manager was hired in October 2006 to begin working on this project full time. She is reviewing relevant literature, especially the history of fish introductions in Grand Canyon, life histories, and habitat used by those species, and case histories of nonnative control in other big river systems. Currently, the manager is developing a comprehensive nonnative control plan, due for completion by September 2011, and a short-term response plan due for completion in 2008. The short-term plan emphasizes known methods and known threats. The long-term plan will evaluate known and potential threats, using known and potential gear types, based on empirical evidence and bioenergetic modeling results. The field study planned for 2009 will be directed by the results of the

pilot project scheduled for 2008. Beginning in 2008, a brief annual progress report will be delivered which will include the results of annual control method and gear testing projects. The 2009 project will test the effectiveness catfish capture techniques at capturing and monitoring channel catfish.

Links/Relationships to Other Projects

Understanding the status and trends of the Grand Canyon fish populations, especially the endangered HBC is important to evaluating the effects of management and conservation activities, especially Glen Canyon Dam operations. If HBC populations are stable or increasing, then dam operations are unlikely to be having a negative effect on the population, and may be supporting population stability and growth. If the populations are decreasing, the operations may be having a negative impact and may need to be critically evaluated, along with other physical and biotic factors, especially nonnative fish populations.

One of the management approaches that have been proposed to support HBC and other native fishes in Grand Canyon is the installation of a selective withdrawal structure on the GCD so that water of various temperatures, especially warmer water from the reservoir's epilimnion, may be released. A potential concern with this approach is that warmer mainstem temperatures may also favor warmer water nonnatives, increasing the risk from these species to natives. This project will help address the potential threat from nonnatives and how it may be addressed, thereby helping evaluate the impact of a selective withdrawal structure.

Products/Reports

Brief annual reports will be produced each year of the project. One experimental trip is anticipated each year. Each experimental trip will be preceded by a complete trip plan and followed by a complete trip report. These field studies will supplement literature studies to be incorporated into a comprehensive nonnative control document scheduled for completion in September 2011.

Budget

BIO 2.R5.09	
Nonnative Control Planning (FY2007–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R6.09	
Nonnative Control Pilot Testing (FY2007–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

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Minckley, W.L., 1991, Native fishes of the Grand Canyon, an Opituary?, in Marzolf, G.R. ed., Colorado River ecology and dam management: Washington, D.C., National Academy Press, p. 124-177.

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Valdez, R.A. and Ryel, R.J., 1995, Life history and ecology of the humpback chub (Gila cypha) in the Colorado River, Arizona. Report to Bureau of Reclamation, September 1995.

Woodbury, A. M., 1959, Ecological studies of flora and fauna in Glen Canyon. Report no. 40. Salt Lake City, Utah, University of Utah Press.

BIO 2.R7.09: Stock Assessment of Native Fish in Grand Canyon

Start Date

October 2006

End Date

Ongoing

Principal Investigator(s)

Lewis G. Coggins, Jr. Ph.D., Fisheries Scientist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The Colorado River and Little Colorado River in Grand Canyon

Project Goals

The goal of this project is to determine and refine the most appropriate method(s) for estimating the population size of humpback chub (HBC) and other Grand Canyon fishes, including sampling design, gear selection, and development of remote monitoring methods. The method(s) developed and selected should be consistent with the second edition of the Colorado River Endangered Fishes Recovery Goals. (The USFWS initiated revision of the goals in 2007).

The specific tasks identified in this project description are to annually update and refine stock assessment models for HBC and to attempt to develop stock assessment models for flannelmouth sucker and bluehead sucker.

Need for Project

Native fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam (GCD) and other non-flow actions. To inform these decisions, it is imperative that accurate and timely information on the status of native fish populations, particularly the endangered HBC, be available to managers. An annual update of the HBC population is one of the actions prescribed by the 2008 Biological Opinion regarding operation of GCD.

A suite of adaptive experimental management actions are being contemplated to better understand the mechanisms controlling the population dynamics of native fishes, and to identify policies that are consistent with the attainment of management goals. The assessments generated from this project will be used, in part, to assess the effects of implemented experimental actions. This information is therefore crucial to (1) inform the program as to attainment of identified goals, (2) provide baseline status and trend information to be used as a backdrop to further understand mechanisms controlling native fish population dynamics, and (3) evaluate the efficacy of particular management policies in attaining program goals. Finally, results from this project are potentially useful in assessing changes to Federal Endangered Species Act listing status of native fishes in the Colorado River.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of YoY and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional SSQ addressed:

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

The Adaptive Management Program Science Advisors have articulated the following science question, which is partially addressed by this project:

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

RIN most directly addressed:

RIN 2.2.2. Determine if a population dynamics model can effectively predict response of native fish under different flow regimes and environmental conditions.

The activities in this project will refine and apply modeling to investigation of native and nonnative fish populations, allowing for comparison with various environmental factors, including flow regimes. Other RINs that ask questions about fish responses to environmental conditions that can be partially addressed with accurate modeling of the populations include the following:

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

RIN: 2.2.12. What are the impacts of research activities on mortality, recruitment, and the population size of humpback chub?

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

General Methods/Tasks

To provide HBC status and trend information, the GCMRC mark-recapture database will be annually updated with most recent data collected during routine monitoring efforts. Following this update, the HBC mark-recapture database will be reanalyzed using (where appropriate) both open and closed mark-recapture-based abundance estimators to provide the most current information on HBC status and trend. In particular, we will rely heavily on the age-structured mark-recapture models (ASMR; Coggins and others 2006a and 2006b; Coggins 2007) to determine trends in HBC abundance and recruitment. Ultimately we will consider the performance of a suite of assessment models to infer the current status of the HBC in Grand Canyon. Finally, we will evaluate the applicability of similar techniques as described above to assessing stocks of flannelmouth sucker and bluehead sucker.

Links/Relationships to Other Projects

The status and trend of the Grand Canyon HBC population are two of the key metrics utilized in GCDAMP to evaluate the success of the GCDAMP and actions undertaken under the sponsorship of the GCDAMP. Therefore, consistently updating the HBC population size is an activity related to many of the other GCDAMP work plan elements, especially those that implement experimental actions such as the March 2008 high flow experiment (described completely in a separate science plan) or removal of nonnative fishes. The annual population status information will be important to projects studying biotic and abiotic aspects of the system, including the aquatic food base, riparian vegetation mapping, and near shore ecology projects, because changes in parameters measured by these parallel projects can be compared to the trends of the humpback chub population to search for potentially relevant correlations.

Products/Reports

- Annual assessment results will be presented to the TWG/AMWG as requested via oral reports.
- Biennially, native fish assessments will be compiled in peer-reviewed reports.

Budget

BIO 2.R7.09	
Stock Assessment of Native Fish in Grand Canyon (FY2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Coggins, L.G., Jr., W.E. Pine, III, C.J. Walters, D.R. Van Haverbeke, D. Ward, and H.C. Johnstone. 2006a. Abundance trends and status of the Little Colorado River population of humpback chub. North American Journal of Fisheries Management 26:233-245.

Coggins, L.G., Jr., W.E. Pine, III, C.J. Walters, S.J.D. Martell. 2006b. Age-structured mark-recapture analysis: a virtual-population-analysis-based model for analyzing age-structured capture-recapture data. North American Journal of Fisheries Management 26:201-205.

Coggins, L.G., Jr. 2007. Abundance trends and status of the Little Colorado River population of humpback chub: an update considering 1989-2006 data. U.S. Geological Survey Open-File Report 2007-1402, 53 p. ACCESS: *http://pubs.usgs.gov/of/2007/1402/*

BIO 2.R9.09: Mainstem Fish Survival

Start Date

October 2006

End Date

September 2010

Principal Investigator(s)

L.G. Coggins, Jr. Ph.D., U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center, Flagstaff, Ariz., using data from the Colorado and Little Colorado Rivers in Grand Canyon

Project Goals

The objectives addressed by this project are the following:

- To improve understanding of factors influencing survival of YoY and juvenile native and nonnative fishes
- To identify biotic and abiotic habitat characteristics that are important to juvenile life stages of native fishes, particularly humpback chub, and nonnative fishes

This project was titled Bioenergetic Modeling for FY2007. However, we have retitled this project to more closely describe the purpose, rather than the method, of the project. Although bioenergetic models are one potential tool to evaluate the effect of dam operations, water temperature, and biotic interactions on survival rate of young native fishes, we are also investigating the use of other models to achieve this goal. In FY2009 we intend to expand the scope of this work to support work on the long term nonnative control plan.

Need for Project

Informed predictions of ecosystem responses from well-constructed models to particular biotic and abiotic perturbations are useful for a number of reasons. First, they are useful as a policy screening mechanism to select potential experimental management actions or treatments that have a high probability of achieving desired resource responses, or eliminating from consideration those that have low success probability. Second, they can be used to predict consequences of unintended actions such as introduction of nonnative fishes not presently in the system. Lastly, they can be used to evaluate hypotheses about the relative importance of factors influencing the survival rate of juvenile native fish and the fish community as a whole. We conclude that bioenergetic models as well as other predictive tools will have great utility in investigating and making inferences on the fish populations in Grand Canyon.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and

from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on YOY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

This project is aimed at providing information on the relative magnitude of effects of dam operations, water temperature, and nonnative fish abundance on the survival of juvenile native fish in the mainstem Colorado River.

General Methods/Tasks

We will construct a mechanistic model to describe the abundance of juvenile native fish in the mainstem Colorado River below the confluence of the LCR. We will populate the model with the relative abundance measurements collected during mechanical removal and select monitoring trips during 2003–04. We will attempt to relate apparent survival of these fish to changes in dam operations, water temperature, and nonnative fish abundance. Additionally, we may populate an ecopath model (http://www.ecopath.org/) using data available from previous studies conducted in Grand Canyon as well as the relevant scientific literature to provide auxiliary information on the magnitude of mortality effects from nonnative fishes. Of particular importance will be the diet data collected associated with the mechanical removal project.

Links/Relationships to Other Projects

Adaptive management, as described in the DOI handbook, requires predictive models to evaluate potential management actions or experimental policies relative to resource response and learning. These predictive models can take many forms such as bioenergetic models or more mechanistic observational models. We will attempt to use monitoring data on juvenile native fish near the mouth of the LCR to model survival rate of those fish as a function of dam operations, water temperature, and nonnative fish abundance. Additionally, we will continue to evaluate the utility of a specific kind of bioenergetic model (ecopath) to investigate linkages to all elements of the aquatic ecosystem. These linkages will foster better collaboration between terrestrial, aquatic food base, and fisheries investigations by making these linkages explicit in a common modeling framework. Using the ecosim functionality allows for policy simulations, and, therefore, this model could be very useful used in a planning context at all levels of the biological program to address questions about the aquatic ecosystem. We will integrate these efforts with the development of the long-term nonnative control plan.

Products/Reports

This work will be developed into submittals for the primary peer-reviewed literature. This work will also support the development of the long-term nonnative control plan.

Budget

BIO 2.R9.09	
Mainstem Fish Survival	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R10.09: Backwater Seining

Start Date

September 2001

End Date

Ongoing

Principal Investigator(s)

M.E. Andersen, Biology Program Manager; L.G. Coggins, Ph.D. Fisheries Biologist, K.D. Hilwig, Fisheries Biologist; U.S. Geological Survey, Grand Canyon Monitoring and Research Center, in cooperation with the U.S. Fish and Wildlife Service and Arizona Game and Fish Department

Geographic Scope

The mainstem Colorado River in Grand Canyon between Lees Ferry and upper Lake Mead

Project Goals

The goals that are addressed by this project are:

- Determine and refine the most appropriate method(s) for estimating the population size and size structure of humpback chub (HBC) and other Grand Canyon fishes, including sampling design and gear selection. The method(s) developed and selected should be consistent with the second edition of the Colorado River Endangered Fishes Recovery Goals. (The US Fish and Wildlife Service initiated revision of the recovery goals in 2007).
- Improve understanding of dam operations on young-of-year (YoY) and juvenile humpback chub survival and habitat use.
- Establish core monitoring protocols for YoY humpback chub and other small bodied native and nonnative fishes in Grand Canyon.

The goals of this project are to provide status and trend information on the abundance and recruitment of the fish community in Grand Canyon. This is one of the projects that will be the subject of a protocol evaluation panel (PEP) in FY09.

Need for Project

Native fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam and other non-flow related actions. To inform these decisions, it is imperative that accurate and timely information on the status of fish populations, particularly the endangered HBC are available to managers. A suite of experimental actions are being contemplated to better understand the mechanisms controlling the population dynamics of native fishes, and to identify policies that are consistent with the attainment of management goals. The assessments generated from this project provide a baseline from which to evaluate the effects of implemented experimental actions. This information is therefore crucial to: 1) inform the program as to attainment of identified goals, 2) provide baseline status and trend information to be used as a backdrop to further understand mechanisms controlling native and nonnative fish population dynamics, and 3) evaluate the efficacy of particular management policies in attaining program goals. The results of this project are

potentially useful in assessing changes in YoY HBC and other small bodied native and nonnative fishes in the Colorado River.

Strategic Science Questions

The primary science question addressed by this project is:

> **SSQ 1-1.** To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning, and incubation in the mainstem, survival of YoY and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional science questions addressed by this project are:

> **SSQ 1-4.** Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.
>
> **SSQ 1-7**. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?
>
> **SSQ 1-8.** How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

The Adaptive Management Program Science Advisors have articulated the following summary science questions that are addressed by this project:

> **SA 1.** What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?
>
> **SA 2.** What are the most probably positive and negative impacts of warming the Colorado River on HBC adults and juveniles?

Information Needs Addressed

The primary information needs addressed by this project are:

> **CMIN 2.1.2.** Determine and track year abundance and distribution of all size classes of HBC in the LCR and the mainstem
>
> **CMIN 2.4.1.** Determine and track the abundance and distribution of nonnative predatory fish species in the Colorado River.
>
> **RIN 2.4.2.** Determine if suppression of nonnative predators and competitors increases native fish populations.

The mainstem sampling described in this project description will provide an evaluation of the trend of HBC abundance, especially those less than 150 mm. Seining samples have shown to be of value for assessing distribution and community composition of YoY HBC and other small bodied native and nonnative fish in the

Colorado River and may help address questions regarding success or failure of HBC to recruit in the mainstem under various experimental regimes.

General Methods/Tasks

Backwater seining has provided relative trend information regarding small-bodied native and nonnative fish use of Grand Canyon backwater habitats for the last 6 years. The seining gear is not without its limitations, particularly its focused application to sandy bottom backwaters or beach faces. However, it remains an important tool for providing an assessment of the small bodied fish community in Grand Canyon. One mainstem backwater seining trip will be conducted in the fall of every year the project is conducted. This monitoring sampling design will be assessed as part of the PEP scheduled for 2009.

Links/Relationships to Other Projects

Understanding the factors influencing the dynamics of the Grand Canyon native fish populations, especially the endangered HBC, is important to evaluate the effects of management and conservation activities, especially Glen Canyon Dam operations. It is critical that baseline trends in population abundance and recruitment are known. It is only with this knowledge that it is possible to assess population level impacts of large scale manipulations. Though it is informative to assess the effects of experimental management on processes thought to be important like growth or survival at particular life stages, this is not ultimately sufficient to determine efficacy of particular management actions. Linkages between these processes and ultimate recruitment to populations must be established. Again, these linkages can only be made if baseline trends in population abundance and recruitment are available.

The published assumptions regarding which habitats are optimum and available for different life stages of HBC and other fish need to be tested, but they could serve to direct long-term monitoring, population modeling, and the selection of flow regimens. To the extent possible, the characteristics of habitats that are most important to native fishes (physical, water quality), particularly in the mainstem Colorado River, need to be identified. Habitat characteristics required by YoY and juvenile HBC are most important to identify and protect because of the endangered status of this species. The focus of this project is backwater habitats. GCMRC is currently developing a separate project to use existing and new data to investigate use of other habitats by young HBC and other native and nonnative fishes, especially in the mainstem Colorado River. Backwater seining samples have been collected for the past 6 years and will be valuable information to integrate into the future nearshore habitat project currently under development.

Products/Reports

Annual reports detailing the findings is prepared and submitted to GCMRC for internal and/or external review as center policy dictates. As warranted, project findings are prepared and submitted for publication in the primary peer-reviewed literature. These data will be utilized in the 2009 PEP.

Budget

BIO 2.R10.09	
Backwater Seining (FY2009–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 2.R13.09: Remote PIT Tag Reading

Start Date

October 2006

End Date

September 2010

Principal Investigator(s)

M.E. Andersen, Biology Program Manager; L.G. Coggins, Ph.D. Fisheries Biologist, K.D. Hilwig, Fisheries Biologist; U.S. Geological Survey, Grand Canyon Monitoring and Research Center, in cooperation with the U.S. Fish and Wildlife Service and Arizona Game and Fish Department

Geographic Scope

The mainstem Colorado and Little Colorado Rivers in Grand Canyon

Project Goals

The goals addressed by these projects are the following:

- To determine and refine the most appropriate method(s) for estimating the population size of humpback chub and other Grand Canyon fishes, including sampling design and development of remote monitoring methods. The method(s) developed and selected should be consistent with the second edition of the Colorado River Endangered Fishes Recovery Goals. (The US Fish and Wildlife Service initiated revision of the recovery goals in 2007).
- To determine movement patterns of fishes in Grand Canyon.

The specific goal of the tasks identified in this project description is to provide evaluation of potential monitoring techniques. This project proposes to test monitoring methods that do not require repeated handling of fishes, capture of evasive species, or additional field sampling trips. Remote antennae can read the passive integrated transponder (PIT) tags that pass the station. PIT tags are already implanted in a large fraction of the adult population of humpback chub (HBC) in Grand Canyon.

Need for Project

A limited number of HBC and other native fishes are present in the modern day Colorado River in Grand Canyon. Nonnative fish species are also present, and are important to study because of the known predatory and competitive threats they pose to native fishes. Scientists and managers wish to know how many of these species are present, their spatial and temporal movement patterns, and effectiveness of sampling gears in sampling populations; they also wish to obtain population information in the least intrusive manner(s) possible, especially when sampling the endangered HBC. Remote PIT tag antennae have been shown in other habitats to be very effective at continuous monitoring (Connolly and others, 2008), alleviating the need for additional field sampling trips and multiple fish handling events.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

Information Needs Addressed

CMIN 2.1.2. Determine and track year abundance and distribution of all size classes of HBC between in the LCR and the mainstem.

CMIN 2.1.1. Determine and track year-class strength of HBC between 51-150 mm in the LCR and the main channel.

RIN 2.2.2. Determine if a population dynamics model can effectively predict response of native fish under different flow regimes and environmental conditions.

General Methods/Tasks

Experimentation with the use of remote antennae to read PIT tags will be conducted by personnel from GCMRC, AZGFD, and the USGS Columbia River Research Lab. Initial efforts will focus on capturing native and nonnative fish that will be implanted with PIT tags and released to see if the equipment is effective in detecting tags. The study area will focus, at least initially, on the Little Colorado River because of the smaller width of this river and because HBC spawn in and are concentrated there.

Links/Relationships to Other Projects

Just which mainstem habitats are most important for native fishes is still a matter of debate among scientists and managers who study the Colorado River in Grand Canyon. The river is deep, wide, and swift in Grand Canyon, making fish sampling challenging. Remote-sensing techniques may provide increased documentation of tributary and even habitat use. This will be especially useful if it turns out that fishes spend a measurable proportion of their time in habitats not susceptible to traditional gear types, such as nets and electroshocking. With increasing knowledge and quantification of fish habitat preferences, scientists and managers can make increasingly specific recommendations for dam releases that favor creation and maintenance of specific riverine habitat types.

Products/Reports

Annual reports, including results and recommendations, will be provided on the use of remote-sensing techniques by September 30th of each year. These reports will be used to evaluate whether additional studies are warranted or whether one or more techniques should be abandoned

Budget

BIO 2.R13.09	
Remote PIT Tag Reading (FY2007–09)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Connolly, P.J., Jezorek, I.G., Martens, K.D., and Prentice, E.F., 2008, Measuring the performance of two stationary interrogation systems for detecting downstream and upstream movement of PIT-tagged salmonids: North American Journal of Fisheries Management 28: 402-417.

BIO 2.R15.09: Near Shore Ecology / Fall Steady Flows

Start Date

October 2008

End Date

September 2012

Principal Investigator(s)

M.E. Andersen, L.G. Coggins, Ph.D., M.D. Yard, Ph.D, and staff, U.S. Geological Survey, Grand Canyon Monitoring and Research Center in cooperation with External Cooperator(s) identified through open competition in 2008

Geographic Scope

The mainstem and tributaries of Colorado River in Grand Canyon located between Lees Ferry and upper Lake Mead.

Project Goals

The primary goal of the near shoreline fish ecology study is to relate river flow variables and ecological attributes of near shore habitats to better understand the relative importance of the biotic and abiotic attributes of these habitats to juvenile (less than 200mm total length) native and nonnative fishes.

The objectives that are addressed by this project are as follows:

- Develop sampling approaches and analytical methods to use for determining abundance, density, or occurrence of native and nonnative fishes among different near shoreline habitat types.
- Assess past and current data and integrate data across multiple sources and disciplines to determine small-bodied and juvenile fish near shoreline habitat selection at local, geomorphic, and landscape scales.
- Evaluate past habitat classification schemes and associated data collection efforts. This effort should include both habitat information associated with the fisheries database and the DASA GIS habitat classification methods.
- Develop methods to use for measuring and estimating small-bodied and juvenile fish vital rates (growth and survival) among different near shoreline habitat types and during steady versus fluctuating flow operations.
- Determine the key factors (abiotic and biotic) influencing near shoreline habitat selection among small-bodied and juvenile fish.
- Determine the effect(s) fluctuating and steady flow releases have on near shoreline habitat selection, movement, growth, and survival of native and nonnative fishes.

The goal of this project is to provide information for developing future models having the capabilities to predict small-bodied and juvenile fish composition, distribution, and abundance in relationship to changes in management actions (e.g., flows, temperatures, and nonnative fish interactions) and near shoreline habitat availability.

Need for Project

The long-term goal of the near shoreline fish ecology study is to relate flow operations to ecological attributes of near shoreline habitats and to determine the relative importance of such habitats to important life stages of native and nonnative fishes (US DOI 2008a, and 2008b). This science program is intended to identify juvenile native fish habitat requirements, and how habitat selection, preference, and availability affect native fish vital rates such as growth and survival. Findings from this solicitation are intended to provide information on native fish habitat requirements and guide future Glen Canyon Dam Adaptive Management Program recommendations for the Department of the Interior to consider as management or experimental actions.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

SSQ 3-2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

SSQ 5-4. What is the relative importance of increased water temperature, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish?

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

Information Needs Addressed

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?

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 2.4.3 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 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 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 12.9.1 What is the impact on downstream resources of short-term increases to maximum flow, daily fluctuations, and downramp limits?

RIN 2.6.6 How is the rate of mortality for flannelmouth sucker, bluehead sucker, and speckled dace in the Colorado River ecosystem related to individual body size? What are the sources of mortality for flannelmouth sucker, bluehead sucker, and speckled dace in the Colorado River ecosystem?

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?

RIN 8.5.4 What is the role of turbidity and how can it be managed to achieve biological objectives?

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?

EIN 2.1.1 How does the abundance and distribution of all size classes of HBC in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.1.2 How does the year class strength of HBC (51 – 150 mm) in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.4.1 How does the abundance and distribution of nonnative predatory fish species and their impacts on native fish species in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.6.1 How does the abundance, distribution, recruitment and mortality of flannelmouth sucker, bluehead sucker and speckled dace populations in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

General Methods/Tasks

This Near Shoreline Fish Ecology study (external cooperator(s) to be determined in 2008) is to incorporate findings from ongoing studies, and to develop new studies, examining the effects of the March 2008 high flow experiment on near shore habitats and address the effects of MLFF, including September – October steady flows, on juvenile HBC and other native fishes. The external cooperator(s) for this new science program have not been determined to date; therefore, we are unable to specify the exact methods that are to be used in accomplishing the research tasks. GCMRC identified in the solicitation some of the knowledge gaps and structure needed to accomplish the scope of work. Rather than imposing constraints on methods and approaches, GCMRC has encouraged prospective cooperators to use novel sampling methodologies and modeling frameworks that may not have been used in this system previously. The technical and contracting elements to identify and secure the external cooperator were initiated in 2008 and the cooperator should be identified before the beginning of FY2009.

Links/Relationships to Other Projects

Prior integration among the GCMRC Physical and Biological programs has resulted in only limited understanding of how dam operations and management actions affect the Colorado River ecosystem and ecological factors that regulate distribution and abundance of native and nonnative fishes. Obviously, there is a need to integrate this research effort with current monitoring and research activities being conducted in the CRE. The cooperator(s) is expected to develop a research plan that conceptually identifies how they will attempt to integrate their studies across multiple sources and disciplines. This project will be carefully reviewed by the GCMRC Senior Ecologist to identify structural and functional linkages that will be integrated with other independent research projects (biological and physical).

Products/Reports

Annual progress reports on the status of the project will be delivered to the GCMRC. A draft final report is to be submitted 3 months prior to the end of the Cooperative Agreement period and a final report by termination of the Cooperative Agreement. Also, the final report will contain executive summary suitable for dissemination to management entities. Data resulting from this project is to be compatible with existing data and/or data collected under other projects, as appropriate. Databases are to be in appropriate format and electronically accessible. The lead project researchers will make 2-3 presentations as requested by the GCDAMP, for the purpose of disseminating information to stakeholders and other members of the public. A copy of all data and publications are to be shared by the GCMRC and funded research cooperator(s).

Budget

BIO 2.R15.09	
Near Shore Ecology / Fall Steady Flows	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

Reference

U.S. Department of the Interior. 2008a. Final Biological Opinion for the Operation of Glen Canyon Dam., U.S. Fish and Wildlife Service, AESO/SE 22410-1993-F-167R1, 88 p. ACCESS: http://www.usbr.gov/uc/envdocs/bo/FinalGCDBO2-26-08.pdf

U.S. Department of the Interior. 2008b. Final Environmental Assessment Experimental Releases from Glen Canyon Dam., Arizona, 2008 through 2012. . Bureau of Reclamation, Upper Colorado Region, 60p. ACCESS: http://www.usbr.gov/uc/envdocs/bo/FinalGCDBO2-26-08.pdf

1

BIO 2 R16.09: Mainstem Coldwater Fish Control

Start Date

May 2009

End Date

September 2012

Principal Investigator(s)

M.E. Andersen, L.G. Coggins, Jr. Ph.D., U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The mainstem Colorado River in the reach of the confluence with the Little Colorado River

Project Goals

The goals of this project are:

- Calculate the abundance of rainbow trout (RBT) in the confluence reach of the Colorado River.
- Reduce the abundance of RBT in the confluence reach.

Need for Project

Rainbow trout (RBT) have been implicated as a threat to native fishes in habitats where RBT have been introduced, including the confluence of the Colorado River with the Little Colorado River in Grand Canyon. The mechanisms of the threat are thought to be both predation and competition. These assumptions have been supported by the findings of Coggins (2008) and Yard and others (*in Prep.*). This threat to native fishes, especially humpback chub (HBC) has lead the U.S. Fish and Wildlife Service to define control of the RBT as a conservation measure in their 2008 Biological Opinion regarding operation of Glen Canyon Dam (US DOI 2008). Ongoing control of the confluence RBT population, as well as other nonnative fishes, was also a recommendation of the 2007 Scientific Work Shop held in Flagstaff, Ariz. (GCMRC, 2008). Current anecdotal information from agency personnel monitoring fish in the confluence reach suggests that the RBT population may be rebounding from the 2003−06 removal effort. This new project seeks to address the need to document the status and trend of the confluence RBT population, to reduce the threats to HBC and other native fishes, and to implement a conservation measure from the 2008 Biological Opinion.

Strategic Science Questions

Primary SSQs addressed:

SSQ 1-2. Does a decrease in the abundance of rainbow trout (RBT) and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population?

SSQ 1-4. Can long-term decreases in abundance of RBT in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

Information Needs Addressed

Primary RINs addressed:

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

General Methods/Tasks

This project will launch a single, annual trip to enumerate and control RBT in the confluence reach. This will be accomplished with four passes of the reach (approx. RM 56-70) utilizing nighttime boat-mounted electrofishing. All RBT and other nonnative fish species will be removed and humanely euthanized. Initial conversations with the Hualapai tribe suggest that they would be willing to receive the remains for use as fertilizer. This approach will allow for an estimation of the RBT population in this reach of the Colorado River. The anticipated timing of this project is during May.

Because the removal work is conducted after dark, this trip will also allow for deployment of hoop nets along shorelines of the study reach to monitor small bodied fishes. Previous experience with this method suggests that such deployments will capture young HBC, and so will contribute additional data to help monitor and assess this species in conjunction with the primary effort of enumeration and removal of RBT.

A public outreach program to describe this project to interested members of the public will be initiated through the GCDAMP Public Outreach Ad-Hoc Group.

Links/Relationships to Other Projects

The evaluation of the RBT population in the confluence reach is anticipated to support growth and survival of HBC in this reach, especially the younger age classes of HBC. The large-scale RBT removal project of 2003−2006 occurred at the same time as the Grand Canyon HBC population was increasing from a historically low level, though warmer water temperatures that occurred concurrently prevent an absolute cause/effect relationship determination. It is reasonable to conclude that the reduction of a predator and competitor such as RBT in the confluence reach, known to support the majority of the Grand Canyon HBC population (Paukert and others, 2006) will have benefits for HBC, one of the goals of the GCDAMP. Because cooler water temperatures are currently being released from GCD, implementation of this project allows for comparison of the effects on HBC from RBT removal when mainstem water temperatures are cold, in contrast to the 2003−2006 removal effort.

The GCMRC, with GCDAMP and Bureau of Reclamation support, is initiating a project to study the ecology of HBC in mainstem, nearshore habitats. The work conducted by the enumeration and removal project will give the selected cooperator additional information about the RBT and other nonnatives in the confluence reach. The reduction of this predator/competitor is likely to allow greater survivorship of young HBC in this reach, thereby increasing the likelihood that the cooperator will find HBC in multiple habitats to study.

Products/Reports

This project will be summarized in an annual report.

Budget

BIO 2.R16.09	
Mainstem Coldwater Fish Control	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Coggins, L.G., Jr. 2008. Active adaptive management for native fish conservation in the Grand Canyon: Implementation and evaluation. Doctoral Dissertation. University of Florida, Gainesville, FL.

GCMRC (Grand Canyon Monitoring and Research Center), 2008, USGS workshop on scientific aspects of a long-term experimental plan for Glen Canyon Dam, April 10-11, 2007, Flagstaff, Arizona: U.S. Geological Survey Open File Report 2008-1153, 79 p.

Paukert, C.P., L.G. Coggins, Jr., and C.E. Flaccus. 2006. Distribution and movement of humpback chub in the Colorado River, Grand Canyon, based on recaptures. Transactions of the American Fisheries Society 135:539-544.

U.S. Department of the Interior. 2008. Final Biological Opinion for the Operation of Glen Canyon Dam., U.S. Fish and Wildlife Service, AESO/SE 22410-1993-F-167R1, 88 p. ACCESS: *http://www.usbr.gov/uc/envdocs/bo/FinalGCDBO2-26-08.pdf*

Yard, M.D., L.G. Coggins Jr., and C.V. Baxter. (In preparation) Foraging ecology of nonnative trout in the Colorado River, Grand Canyon: predation on native fishes and the effects of turbidity.

GCDAMP 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.

BIO.4.M1.09: Monitoring Lees Ferry Trout

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

Arizona Game and Fish Department and Grand Canyon Monitoring and Research Center

Geographic Scope

Colorado River from Glen Canyon Dam to Lees Ferry

Project Goals

Operation of the Glen Canyon Dam (GCD) affects the ecology of nonnative rainbow trout (RBT) and the aquatic food base in the Lees Ferry reach (McKinney and others, 1999, 2001). The Lees Ferry fishery was recognized as a resource of concern in the Operation of Glen Canyon Dam Final Environmental Impact Statement (US DOI 1995): "NPS, AZGFD, Hualapai, and Navajo objectives for the trout fishery are to provide a recreational resource while maintaining and recovering native fish in Grand Canyon." The management goal of stakeholders is to maintain a blue-ribbon trout fishery that will produce a healthy self-sustaining population of at least 100,000 Age II+ rainbow trout that achieve 18 inches in length by Age III with a mean annual relative weight (Wr) of at least 0.90.

The objective addressed by this project is the following:

- Monitor the status and trends of the rainbow trout population in response to management actions.

This fishery project is designed to monitor the status of this trout fishery and to determine how abundance, reproduction, survival, and growth are influenced by modified low fluctuating flows (MLFF). Trend analysis using indices of abundance can be used to compare operational changes at GCD to determine if these changes are

having population-level effects on this fishery. The sampling protocols used for this fishery project will potentially be modified considering recommendations from 2009 Protocol Evaluation Panel.

Need for Project

The downstream fish community is an assemblage of native and nonnative fish that occur in the CRE. The status and trends of the fishery are regulated by biotic and abiotic mechanisms that may in turn be affected by the operations of GCD. Monitoring basic fish population measures including abundance and distribution of native and nonnative fishes provide information necessary to assess the status of these resources and inform the Adaptive Management Program.

The AZGFD has worked with other fishery cooperators including the GCMRC, USFWS, and SWCA Environmental Consultants over the past 5 years to develop consistent, repeatable sampling methods for fishes in both the mainstem Colorado River and LCR. The overall objective of this proposal is to continue standardized sampling and continue to work to develop a long-term monitoring program for all fish populations. The AZGFD will also assist with other special projects and research needs as appropriate.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 3-6.** What GCD operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability?

Information Needs Addressed

Monitoring plans have been designed to address specified Stakeholder Information Needs (SIN). Information needs are the basis for developing and implementing the long-term strategic and annual monitoring and research programs. Identified below are the current information needs pertinent to the monitoring plan for the Lees Ferry Glen Canyon trout fishery.

Primary information needs addressed:

> **CMIN 4.1.2.** Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.

> **CMIN 4.1.4.** Determine annual standard condition (Kn) and relative weight of rainbow trout in the Lees Ferry reach.

There are a number of RINs that are partially addressed by this project, or which depend, in part, on the results of this project. The primary RIN addressed is the following:

> **RIN 4.1.1.** What is the target proportional stock density (i.e., tradeoff between numbers and size) for rainbow trout in the Lees Ferry reach?

Data collected from this monitoring project provide the basis which managers make decisions.

General Methods/Tasks

Rainbow trout are sampled using electrofishing to estimate biological parameters to assess the status and trends of the fishery. The sampling design, methods, and analyses (e.g., mixed model approach) provide sufficient information on the occurrence, relative abundance and distribution of fish species comprising the fish community in Glen Canyon/Lees Ferry. The purpose of this sampling design is to have a monitoring tool with the temporal "power" to detect population trends without biases in site selection, as well as, a means to precisely estimate

status (Urquhart et al., 1998). Electrofishing provides information on size composition, relative abundance (catch per minute as an index of population size), condition (length-weight relationships), and disease. Samples are collected for whirling disease examination. Electrofishing occurs three times per year with sampling effort stratified over 27 random and 9 fixed sites. Present sampling design can detect a 6–10-percent linear change in abundance over a 5-year period. Work is currently underway to assess the statistical power of intra- and inter-annual comparisons.

Present methods for assessing abundance using catch rate indices may or may not be adequate for addressing management objectives and targets. If managers require an "n" (number of fish), further work needs to be done to find the most cost-effective way to generate reliable population estimates. For this reason, we are evaluating other methods to estimate abundance, including snorkel surveys (Korman and others, 2006), mark-recapture population estimates similar to those done in 1991 and 1998, and depletion sampling to convert CPUE estimates to population estimates. Additionally, we are evaluating different abundance estimators and discussing management targets with managers (AZGFD) and anglers. We will likely suggest some alternative methods to assess the abundance objective rather than "annual population estimates" as stated in CMIN 4.1, or attempt to clarify the CMIN.

Links/Relationships to Other Projects

Understanding the status of the Lees Ferry RBT population is critical to estimate the risk that this species may pose to native fishes in the Lees Ferry reach and further downstream in the Colorado River ecosystem. Following implementation of a 4-year project to remove RBT from the LCR reach of the Colorado River, it will be critical to understand the status and trends of Lees Ferry RBT to help evaluate the movement and repopulation RBT that may occur in downstream reaches.

Products/Reports

Separate reports will be provided for the mainstem sampling on or before January 1 of the year following the sampling for internal and external review. The revised final deliverable will be submitted on or before March 31 of the year following the sampling.

Budget

BIO 4.M1.09	
Monitoring Lees Ferry Trout (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

Reference

Korman, J., Yard, M., and Speas, D., 2006, An evaluation of the utility of snorkel surveys for estimating population size and tracking trends in relative abundance of rainbow trout in the Lee's Ferry reach of the Colorado River. Final report prepared for the Arizona Game and Fish Department, 43 p.

McKinney, T., D.W. Speas, R.S. Rogers, and W.R. Persons, 1999, Rainbow trout in the Lees Ferry recreational fishery below Glen Canyon Dam, Arizona, following establishment of minimum flow requirements, Final Report, US Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona.

McKinney, T., D.W. Speas, R.S., Rogers, and W.R. Persons, 2001, Rainbow trout in a regulated river below Glen Canyon Dam, Arizona, following increased minimum flows and reduced discharge variability, North American Journal of Fisheries Management 21:216-222.

Urquart, N.S., Paulsen, S.G., and Larsen, D.P., 1998, Monitoring for policy-relevant regional trends over time. Ecological Applications, 8(2) 246-257.

U.S. Department of the Interior, 1995, Operation of Glen Canyon Dam Final Environmental Impact Statement: Bureau of Reclamation, Upper Colorado Region, 337 p. plus appendices, Salt Lake City, Utah.

GCDAMP Goal 5: Maintain or attain viable populations of Kanab ambersnail.

BIO 5.R1.09: Monitor Kanab ambersnail (concurrent with monitoring backwater habitats)

Start Date

April, 2007

End Date

September 2010

Principal Investigator(s)

Arizona Game and Fish Department (in cooperation with U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Barbara E. Ralston, Keith Kohl)

Geographic Scope

Vaseys Paradise, located 31.5 RM downstream of Lees Ferry; surveys encompass the springs around the pour-off at Vaseys Paradise. The monitoring of Kanab ambersnail (KAS) is conducted in conjunction with monitoring of backwater habitats for small-bodied fishes.

Project Goals

The goals of this project are to determine the extent and kind of vegetation that exists as habitat for the KAS and to track the abundance and distribution of KAS at Vaseys Paradise.

Need for Project

Knowing the extent of habitat is needed in the event of a high flow to support development of a biological opinion and to help determine snail densities. Changes in snail numbers can be associated with changes in vegetation. By monitoring the vegetation at Vaseys Paradise, the snails are indirectly monitored, based on the assumption that if the preferred habitat is present then snails will also be present. Total habitat can be measured using remote methods, but the composition of the habitat may still require on-the-ground sampling. Sampling at Vaseys Paradise can also provide data for GCDAMP goal 6, which refers to the protection and improvement of riparian and spring communities.

Strategic Science Questions

There are no SSQs that are directly related to the goal of maintaining or attaining viable KAS populations. The specific information needs addressed by the project are indicated below.

Information Needs Addressed

Primary information needs addressed:

CMIN 5.1.1. Determine the abundance and distribution of Kanab ambersnails at Vaseys Paradise in the lower (below 100,000 cfs) and upper zone (above 100,000 cfs).

CMIN 5.2.1. Determine and track the size and composition of habitat used by Kanab ambersnail at Vaseys Paradise.

General Methods/Tasks

Habitat Sampling

Determine percent cover, diversity, and distribution of vegetation that constitutes KAS habitat. Random samples in the habitat record percent cover, plant height of dominant plants, and soil moisture. Survey total habitat and plots using conventional survey methods. Habitat area is calculated by the GCMRC survey department. Data are analyzed using univariate and multivariate approaches.

- Monitor relocated vegetation associated with high flow experimental conservation measures.
- Sample vegetation plots at Vaseys Paradise to determine patch composition and areal extent (fall of each year). Sample for the presence of snails in plots.
- Enter data and conduct quality control on data entry. Provide data to the GCMRC for vegetation analysis.
- Compare previous vegetation composition to previous vegetation/habitat surveys to assess habitat. Provide abundance estimates of snails. Report writing by the GCMRC (winter of each year).

Links/Relationships to Other Projects

Riparian vegetation, including vegetation at springs, is a critical interface between aquatic and terrestrial environments around the world. There are multiple components that riparian and spring communities either contribute to or influence (e.g., food base, available habitat). In the CRE, the spring vegetation itself serves as a host for invertebrates, like KAS, provides breeding and foraging habitat for small mammals and birds, provides cover in the heat of the day, and the spring water may be used for ceremonial purposes. Changes in the composition or structure of riparian spring communities like expansion of an exotic species may alter these interactions. Riparian and spring vegetation regulates nutrient exchange between the land and water, and leaf litter is a terrestrial carbon source that may influence in-stream invertebrate production. The relative importance of terrestrial carbon in the aquatic food web is, in part, being addressed through the food base initiative. The linkage could be further defined through studies that focused on terrestrial productivity and processes. Again, changes in abundance or kind of riparian carbon sources may influence aquatic and terrestrial productivity processes.

Products/Reports

- An annual report for KAS habitat and density estimates is produced by Arizona Game and Fish Department.

Budget

BIO 5.R1.09	
Monitor Kanab Ambersnail (FY1995–FY2010)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

GCDAMP Goal 6: Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

BIO 6.R1.09: Vegetation Mapping

BIO 6.R2.09: Vegetation Transects

Start Date

October 2006

End Date

September 2010

Principal Investigator(s)

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and other cooperators (e.g., U.S. Geological Survey, Northern Arizona University) to be determined

Geographic Scope

The riparian zone, including the old high-water zone (OHWZ; >97,000 cfs), in the Colorado River corridor from Glen Canyon Dam to Lake Mead

Project Goals

The goals of these projects are to determine the areal extent of vegetation classes among the major habitat zones in the CRE (e.g., new high-water zone (NHWZ), sand beach community, old high-water zone) and how GCD operations affect vegetation cover, richness, diversity, and wetland indicator value by surface elevation measured at a meaningful time interval, as per the protocol evaluation panel (PEP) recommendations (Cooper and others, 2008).

Need for Project

Riparian vegetation expansion, since operations at GCD began in 1963, has had a pivotal role in the ecology of the postdam river corridor. The reduction in annual flood volumes has allowed vegetation to expand and more permanently occupy land previously subjected to scouring in most years. The expansion has included marsh habitat occurring throughout the CRE, whereas previously, these habitats were restricted to Glen Canyon and the western Grand Canyon (Clover and Jotter, 1944; Turner and Karpiscak, 1980). The plants associated with the expansion include alien species like salt cedar (*Tamarix ramossisma*), camel thorn (*Alhagi maurorum*), and peppergrass (*Lepidium latifolium*), but also native species, arrowweed (*Pluchea sericea*), seepwillow (*Baccharis emoryi*), and coyote willow (*Salix exigua*). The variable operations over the years have resulted in an ebb and flow of vegetation expansion with vegetated area generally increasing over time (Turner and Karpiscak, 1980; Waring 1995; Ralston and others, 2008). The increase in terrestrial vegetation contributes to aboveground

primary productivity, arthropod densities, and associated food resources for terrestrial and aquatic vertebrates; is a source of culturally important plant species; and also can cause conflicts with recreational activities like available camping area. Because riparian vegetation is linked to multiple resources, knowing how vegetation is changing via monitoring (e.g., which species are expanding or declining and where) is an important source of data when evaluating dam operations.

To address the AMWG needs associated with riparian vegetation requires systemwide assessment of vegetation change at the broad scale (new high-water zone) as well as at the local scale (plot data). While knowing how much vegetation in the river corridor exists is useful, it is equally useful to know how the species that make up the vegetation may be changing. Riparian systems are highly susceptible to exotic species introductions (Nilsson and Jansson, 1995). Because riparian vegetation contributes to aquatic productivity (Naiman and others, 2005) and serves as a host to terrestrial invertebrates and higher order vertebrates (e.g., lizards, birds), assessing the quality of these plants can help explain changes observed in higher order vertebrate abundances, including fish species (Nakano and Murakami, 2001). Changes in riparian vegetation are associated with dam operations (Stevens and others, 1995; Kearsley, 2006) and can affect the propagation of exotic species like tamarisk (Porter, 2002). Monitoring transects at a biologically meaningful frequency to detect changes among herbaceous species, including invasives, can assess how operations inhibit or encourage invasive species colonization and expansion that cannot be determined through remote sensing techniques (the scale is too small for image resolution). Remotely sensed data can assess changes in overstory wood species that change more slowly.

These two field-based projects complement each other. Vegetation dynamics is a monitoring effort of sufficient frequency (e.g., annual, biennial, see Cooper and others, 2008) that records species diversity, richness, and cover at specific stage elevations. The changes in vegetation parameters that this monitoring detects are relevant to perennial and annual herbaceous species like bunch grasses, marsh species and invasive species that can change at higher frequencies than woody vegetation. Vegetation mapping utilizes the digital overflight imagery (product of the DASA Program) to quantify larger scale area changes (e.g., expansion of arrowweed patches, or extent and type of vegetated shoreline). Imagery is from 2005 overflight and compared with the 2002 imagery for the purposes of change detection. Analysis of change detection in the vegetation mapping project incorporates the annual transect survey results to help explain patterns of change that may occur over a 5-year timeframe. The two projects complement each other because they provide information about changes in riparian habitat at different ecological scales which may affect other riparian community constituents like invertebrate biomass and riparian bird abundances.

Strategic Science Questions

Primary SSQs addressed:

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possible mortality of young humpback chub) associated with high flows?

SSQ 5-7. How do warmer releases affect viability and productivity of native/nonnative vegetation? GCDAMP goal 6 is directed at the protection or improvement of riparian and spring communities. This goal is based on the recognition that the riparian and spring environments are hosts for some endangered species like the southwestern willow flycatcher (Empidonax traillii extimus). The protection of these species' critical habitats is part of this goal. Riparian plant communities can be viewed at either a single resource level without ecosystem linkages, or at an integrative level where riparian vegetation is linked to aquatic and terrestrial ecosystem processes (e.g., contributes to secondary production, cover), interacts with cultural

resources associated with recreation (e.g., camping sites) and traditional cultural properties (TCPs), or affects aeolian sand transport and possibly archaeological site erosion rates. Understanding how riparian vegetation responds to flows and affects other resources of concern forms a basis for managing critical resources like native fish, archaeological properties, and recreational components

Information Needs Addressed

Determine and track the status and trends of the identified riparian communities (e.g., marsh community, sand beach, nonnative invasive species, etc.) at the appropriate timescale (CMIN 6.1.1, 6.2.1, 6.5.1. 6.6.1). This need will be addressed through the following:

- Semidecadal color infrared (CIR) digital imagery mapping that quantifies (1) area change of dominant overstory species, (2) community composition and possibly changes in understory community composition through groundtruthing associated with mapping, and (3) coarse primary productivity estimates for riparian vegetation.

- Vegetation transects/grid surveys conducted at an appropriate frequency that correlate with river stage elevations of 15,000 cfs; 25,000 cfs; 35,000 cfs; 45,000 cfs; and 60,000 cfs. Quantifies cover, richness, and diversity, and wetland species scores at each stage elevation. This work is most informative for herbaceous annuals and perennials, including invasive species. This component may incorporate marsh-monitoring needs of tribes.

General Methods/Tasks

Vegetation Mapping

Community identification will be done using 100 m² plots in the field where the presence and cover of species is recorded. Cover scales use a Daubenmire scale. Data are recorded as categorical data, but plant height of the dominant species is also recorded. Number of samples for each community class is dependent on the abundance of the vegetation type. A minimum of 10 samples will be taken for each community (6 community types identified in 2002, Ralston and others, 2008). These data are analyzed using non-metric multidimensional scaling (Minchin, 1987; McCune and Grace, 2002) as per the PEP recommendations (Cooper and others, 2008) to identify the dominant communities along the river corridor.

Vegetation classification will use supervised classification routines that are available in an image-processing software package ENVI (ITT, 2005). Training areas will be selected from previous groundtruthed areas. Classes that will likely be used for this effort include tamarisk, *Baccharis/Salix*, marsh/wetlands, mesquite/acacia, arrowweed and bare ground (Ralston and others, 2008). User and producer accuracies will be determined and class aggregation may be required to meet national vegetation mapping standards. The scheduled 2009 overflight will be compared with 2005 and 2002 imagery for vegetation area change detection purposes in subsequent years.

Quantification of changes in riparian communities will be done using a Geographic Information Systems (GIS) platform (ArcMap, ESRI, Inc. 2002).

The following tasks based on FY2008 progress are designed to reach the goal for vegetation mapping:

1. Develop draft report of community change based on October 2007 field data (February 2008).
2. Use results of accuracy assessment of vegetation classification (September/October 2008) to develop report on 2005 vegetation map (Spring/Summer 2009).
3. Compare revised vegetation map to 2002 vegetation map (Ralston and others, 2008) to determine area change for vegetation classes. Draft report writing (Summer 2009).

4. Prepare request for proposals (RFP) as per PEP recommendations for plot monitoring using vegetation transects perpendicular to the river at specific stage elevations (15,000 cfs; 25,000 cfs; 35,000 cfs; 45,000 cfs; and 60,000 cfs) (fall 2009), as per PEP recommendations (Cooper and others, 2008). Anticipate number of samples per site to expand as per PEP recommendations. Field collection to occur in September 2009.

Vegetation Transects

More detailed methods will be developed following the PEP recommendation and incorporated into an RFP for release in fall 2008. In general, data collection involves recording vegetation cover of species within multiple 1-m² plots at each elevation (note: the number of plots per site to be determined as per PEP recommendations [Cooper and others, 2008]). Transects are located throughout the river corridor and sampled in a rotated panel design so that some plots are sampled every year (n = 20) and 40 other plots are rotated each year. A total of 60 sites are sampled each year and after 3 years, 140 sites are sampled. The frequency of plot monitoring will also be evaluated prior to release of RFP (i.e., biennial sampling frequency may be sufficient with more samples sites visited per year). Vegetation sampling of each transect corresponds to five stage elevations (15,000 cfs; 25,000 cfs; 35,000 cfs; 45,000 cfs; and 60,000 cfs).

Sample locations are determined by using the sediment transport and river simulation (STARS) model of Randle and Pemberton (1987), which predicts elevation rise based on river stage in combination with the Colorado River flow, and sediment storage/graphic user interface (CRFSSGUI) model (Ecometric, Inc.), which uses STARS model data and information on channel gradient, width, and roughness to predict the timing and height of the hydrograph at any point along the river.

At each elevation point, a 1-by-1-m sighting frame (per Floyd and Anderson, 1982) with 100 crosshair intersections is placed and leveled with one side along the transect and the riverward corner of the transect side directly over the pin flag. Once a frame is surveyed, the frame is moved upstream or downstream at the same level so that multiple 1-by-1-m areas are sampled along the elevation point.

Vegetation data include a list of all species present in the 1-by-1-m areas are recorded. These data are included in the univariate measures (cover, richness, diversity) but are excluded from the multivariate analyses. Percent vegetative cover is recorded by counting the number of sighting points that intercept each species within the frame. If multiple species were present under a single sighting point, all are recorded once so that the total cover of all species can collectively sum to more than 100 percent. Species which are encountered in at least one of the frames, but which are not seen beneath any of the 400 sighting points, are assigned an arbitrary “trace” cover value of 0.001 percent.

The following tasks based on FY2008 progress are designed to reach the goal for vegetation transects:

- Prepare RFP as per PEP recommendations (Cooper and others, 2008) for plot monitoring using vegetation transects perpendicular to the river at specific stage elevations (15,000 cfs; 25,000 cfs; 35,000 cfs; 45,000 cfs; and 60,000 cfs) (fall 2009).
- Anticipate number of samples per site to expand as per PEP recommendations.
- Field collection to occur in September 2009.

Links/Relationships to Other Projects

Riparian vegetation is a critical interface between aquatic and terrestrial environments around the world. In the CRE, the vegetation itself serves as a host for invertebrates, provides breeding and foraging habitat for birds,

provides cover in the heat of the day, and may be harvested for cultural utility. Changes in the composition or structure of riparian vegetation like expansion of an exotic species may alter these interactions. Riparian vegetation regulates nutrient exchange between the land and water, and leaf litter is a terrestrial carbon source that may influence in-stream invertebrate production. The relative importance of terrestrial carbon in the aquatic food web is, in part, being addressed through the food base initiative. The linkage could be further defined through studies that focus on terrestrial productivity and processes. Again, changes in abundance or kind of riparian carbon sources may influence aquatic productivity processes. The 2005 Knowledge Assessment Workshop (KAW) revealed that there was some certainty about the relationship of marsh community development and flows for the CRE, but that this certainty decreased as one progresses upslope (Melis and others, 2006). The outcome of the KAW and the science questions for riparian habitats indicate that, besides knowing the influence of flow on composition and extent of riparian vegetation, an understanding of the integrated role of riparian vegetation with other resources is needed (e.g., aquatic or cultural resources). This understanding would come from a combination of monitoring, synthesis, and field research.

Products/Reports

USGS draft report on vegetation change 2002–2005.

Updated vegetation base layer for GIS.

Budget

BIO 6.R1.09	
Vegetation Mapping (FY2007–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

BIO 6.R2.09	
Vegetation Transects (FY2007–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	

GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

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BIO 6.R3.09: Vegetation Synthesis

Start Date

October 2006

End Date

September 2010

Principal Investigator(s)

Barbara E. Ralston, Ph.D., U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and other cooperators to be determined

Geographic Scope

The riparian zone, including the old high-water zone (>97,000 cfs), in the Colorado River corridor from Glen Canyon Dam to Lake Mead.

Project Goals

The goal of this project is to utilize existing data from previous investigations associated with the riparian zone to characterize temporal and spatial responses of riparian vegetation to Glen Canyon Dam operations. Characterization can include species compositional changes over time and the effects of spatial scale on data interpretation. Results of both aspects have implications for long-term monitoring approaches for riparian vegetation in terms of frequency and sampling location aspects.

Need for Project

A large amount of information exists in the gray literature associated with riparian vegetation for the Colorado River. Several studies were specific research projects associated with the EIS for Glen Canyon Dam (Waring and Stevens, 1986; Anderson and Ruffner, 1987; Stevens and Ayers, 1993; Kearsley and Ayers, 1996) or associated with experimental flows from 1996 or 2000 (Kearsley and Ayers, 1999; Stevens and others, 2001; Porter 2002). The project is intended to utilize data and results of these studies to construct a more cohesive view of riparian vegetation changes within the Colorado River ecosystem (CRE). A multi-temporal and spatial scale approach can possibly better characterize vegetation dynamics and vegetation change along the river corridor. By establishing a basic depiction of riparian vegetation constituents and identifying variables that affect riparian vegetation dynamics along the CRE, more integrative analyses and hypothesis testing involving aquatic and terrestrial resources are likely.

Strategic Science Questions

Primary SSQs addressed:

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possible mortality of young humpback chub) associated with high flows?

SSQ 5-7. How do warmer releases affect viability and productivity of native/nonnative vegetation?

Information Needs Addressed

The primary information needs addressed by these projects are CMINs 6.1.1., 6.2.1, 6.5.1, and 6.6.1, which are summarized as the following:

- Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.
- Determine parameters and metrics to be measured, and the information needs that address each element.
- Determine how the abundance, composition, and distribution of the OHWZ, NHWZ, and sand beach community have changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of ROD operations (RIN 6.2.1, 6.3.1, 6.4.1, 6.5.1, 6.5.2, 6.5.3).

General Methods/Tasks

Transect data (2001-2005 (Kearsley, 2006) will be reanalyzed to consider tributary effects on richness and diversity and to evaluate scale effects on interpretation of change. Discharge frequency and magnitude from GCD and the tributaries (the Paria and Little Colorado Rivers) will be used in the analysis to determine how frequency of disturbance affects richness and diversity downstream.

Large scale area change detection will use GIS analysis tools (ArcMap, ESRI, Inc. 2002) to identify area change for vegetation classes or zones of interest between years. Identification of tamarisk in black and white imagery will be conducted using 2002 and 2005 imagery and comparing imagery characteristics of the vegetation. The scanning project in DASA intended to orthorectify historic imagery that would permit retrospective analysis of vegetation change has been delayed, due to funding limitations. As a consequence, smaller areas already orthorectified will be compared to determine the feasibility of retrospective analysis.

Tasks

Compare vegetation patches from the 2002 vegetation base map (Ralston and others, in press) with previous vegetation maps (Waring, 1995) that were completed for sections of the river for years 1965, 1973, 1984, 1990, and 1991 to determine distribution and abundance information at a gross scale (e.g., NHW, OHW, sand beach, marsh). Area coverage will be provided for different zones.

Perform change detection between years to identify change in area and distributional changes for woody exotics (e.g., tamarisk).

Quantification of allochthonous inputs will use a combination of field and mapping data to estimate annual inputs.

Links/Relationships to Other Projects

The expansion of vegetation along the river corridor affects multiples resources. The increased shoreline vegetation contributes to aquatic drift and may serve as supplemental source of carbon for aquatic food webs in addition to in-stream production. The ecology of human behaviors along the river corridor is affected by riparian vegetation. Exotic species that spread by tributary introductions (e.g., camel thorn) impact campable area by making some beaches unusable. Available campsite area is dependent on amount of open sand, availability of trees and shrubs for shade and wind breaks, and accessibility to the river (i.e., steepness of bank) among other variables (Kearsley and others, 1994; Kaplinski and others, 2005). In a similar vein, culturally important plants and locations have been monitored under the auspices of the adaptive management program since the 1990s (Phillips and Jackson, 1996; Austin and others, 1997; Lomaomvaya and others, 2001). How these data have changed over time also needs to be incorporated into a synthesis to provide a holistic view of the riparian community.

Products/Reports

Individual reports anticipated to be submitted for publication.

- Marsh and riparian species richness and diversity patterns with the Colorado River Corridor (Ralston, in prep)
- Vegetated area changes and rates of change within the Colorado River Corridor since 1965. (Product uses 2002 and 2005 vegetation map information (Pr 6.2) as well as legacy data to document vegetated area change and rates of change among vegetation classes)
- Quantification of annual allochthonous of marsh and riparian vegetation to the aquatic system in the Colorado River ecosystem (Kennedy and Ralston, unpub data)

Budget

BIO 6.R3.09	
Vegetation Synthesis (FY2007–10)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

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GCDAMP Goal 7: Establish water temperature, quality, and flow dynamics to achieve the Adaptive Management Program ecosystem goals.

BIO 7.R1.09: Water Quality Monitoring of Lake Powell and the Glen Canyon Dam Tailwater

Start Date

Ongoing

End Date

Ongoing (current Interagency Agreement with US Bureau of Reclamation in place through September 30, 2009)

Principal Investigator(s)

William S. Vernieu, Hydrologist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Lake Powell and its major tributary arms, inflow tributaries entering Lake Powell, and the tailwater from Glen Canyon Dam to Lees Ferry

Project Goals

The objectives addressed by this project are the following:

- To maintain water-quality monitoring program for Lake Powell to predict and track processes in the reservoir that may influence Glen Canyon Dam (GCD) release water quality
- To maintain water-quality monitoring in GCD tailwater to directly evaluate the quality of GCD releases, the effects of GCD operations, and suitability for downstream aquatic resources
- To contribute to ongoing modeling efforts by US Bureau of Reclamation, currently the CE-QUAL-W2 model, to predict future changes to the water quality of Lake Powell and GCD releases; simulate the effects of various proposed and hypothetical climate, experimental, and operational scenarios; and guide future monitoring program revisions
- To complete comprehensive database of water-quality information from the 43-year monitoring program and publish results as USGS Data Report for further interpretation, synthesis, and analysis
- To revise monitoring program, as needed, in conjunction with development of CE-QUAL-W2 model and historical data analysis, to ensure most efficient means of maintaining cost-effective and reliable monitoring program

Need for Project

Processes within Lake Powell, climate changes in the upper Colorado River Basin, the structure of GCD, and various aspects of dam operations affect the quality of water released from GCD to the Colorado River in Grand Canyon. Temperature, dissolved oxygen concentrations, nutrient concentrations, biological composition, and other characteristics of GCD releases can have a profound effect on the aquatic ecosystem below the dam.

The 5-year period of below-normal inflows in the upper Colorado River Basin from 2000 to 2004 resulted in a drawdown of Lake Powell of over 140 ft to 3,555 ft, representing 38 percent of total capacity, in 2005. Increasing influence of Lake Powell surface layers on GCD releases can be expected to cause warmer release temperatures, decreased release nutrient concentrations, and increased export of aquatic biota from Lake Powell. The lowering of warm surface layers in relation to the penstock withdrawal elevation resulted in above-normal late-summer release temperatures from 2003 to 2007. Release temperatures of 16 °C were recorded in October 2005, representing the warmest releases since 1971. Resuspension of exposed deltaic sediments from reservoir drawdown by 2005 inflow currents resulted in a plume of hypoxic water that appeared at GCD and began to be incorporated in GCD releases in July 2005. This resulted in dam releases containing the lowest concentrations of dissolved oxygen on record, reaching 3.3 mg/L in October 2005. Changes to individual turbine operations at GCD in September and October 2005 were shown to have a significant effect on the reaeration of hypoxic releases.

Differential routing of winter inflow currents can cause longer-term changes to the water quality of Lake Powell and eventual dam releases. For the past 7 years, with the exception of 2006, winter underflow density currents moved along the bottom of the reservoir and refreshed oxygen concentrations in the deepest layers of Lake Powell, displacing older hypolimnetic water upward to be entrained in penstock releases. In contrast, from 1994 to 1999 and during other periods in Lake Powell's history, winter density currents moved through the reservoir in intermediate layers as an interflow, which caused stagnation and a reduction of dissolved oxygen concentrations in the deepest hypolimnetic water of the reservoir. This interflow pattern again appeared in 2006. Exceptionally cold winter inflows caused an underflow in January 2007, increasing hypolimnetic density and increasing the likelihood of future interflow conditions, which may cause reductions in hypolimnetic dissolved oxygen in future years. A weak underflow current was observed in early 2008.

The GCMRC works in cooperation with Reclamation on development of the CE-QUAL-W2 model by providing monitoring data that is used for model calibration and verification. This monitoring data consists of information describing the quality of water in GCD releases, Lake Powell, and tributary inflows into Lake Powell. In addition, the GCMRC provides comments on the direction of model development so that a product can be developed that meets the needs of both the Reclamation and the Glen Canyon Dam Adaptive Management Program. It is anticipated that once a functional model is in place, the different entities involved will have different questions to be addressed by the model.

As model development progresses, many components of the water-quality monitoring program and Lake Powell data synthesis can be facilitated with results from the model, such as identifying parameters for which the model is more or less sensitive and restructuring monitoring efforts appropriately. This process can be used to identify the need for more detailed inflow water-quality monitoring, establish and maintain of additional meteorological stations at the reservoir, and modify sampling methods and frequency for biological parameters such as chlorophyll and plankton, in order to refine the model's ability to simulate productivity processes in the reservoir.

Strategic Science Questions

While the 2005 KAW specified many science questions addressing the effects of water quality on various resources (sediment, food base, fisheries, recreation), no SSQs were proposed directly dealing with tracking and predicting changes in water quality in Lake Powell or GCD releases. The following questions are the SSQs most closely related to the effects of water quality on key resources:

AMWG Priority 3: What is the best flow regime?

SSQ 3-5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations?

AMWG Priority 5: What will happen when we test or implement the Temperature Control Device (TCD)? How should it be operated? Are safeguards needed for management?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

SSQ 5-3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish?

Information Needs Addressed

The following information needs (including supporting information needs [SINs]) (as updated June 23, 2003) relate directly to water-quality monitoring in Lake Powell and the GCD tailwater.

CMIN 7.1.1. Determine the water temperature dynamics in the main channel, tributaries (as appropriate), backwaters, and nearshore areas throughout the Colorado River ecosystem.

CMIN 7.2.1. Determine the seasonal and yearly trends in turbidity, water temperature, conductivity, DO, and pH changes in the main channel throughout the Colorado River ecosystem.

CMIN 7.3.1. What are the status and trends of water quality released from GCD?

SIN 7.2.1. How do the hydrodynamics and stratification of Lake Powell influence the food base or fisheries downstream?

SIN 7.2.2. Which water-quality variables influence food base and fisheries in the Colorado River ecosystem?

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.

7.3.1.a. Determine 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.

7.3.1.b. Determine stratification, convective mixing patterns, and behavior of advective currents in Lake Powell and their relation to GCD operations to predict seasonal patterns and trends in downstream releases.

RIN 7.3.3. How do dam operations affect reservoir limnology?

SIN 7.3.1. Measure appropriate water-quality parameters to determine the influence of these parameters on biological resources in the Colorado River ecosystem.

EIN 7.3.1. How does the water quality of releases from GCD change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Other information needs (as updated June 23, 2003) require supporting information from water-quality monitoring in Lake Powell and the GCD tailwater:

RIN 7.1.1. What are the desired ranges of spatial and temporal patterns of water temperatures for the CRE?

RIN 7.1.2. What are the most likely downstream temperature responses to a variety of scenarios involving a TCD on GCD?

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

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?

RIN 7.2.3. Which metals should be measured? Where and how often?

General Methods/Tasks

Lake Powell monitoring is conducted monthly in the GCD forebay and quarterly at 25 to 30 sites throughout the reservoir. Profiles of physical parameters (temperature, specific conductance, pH, dissolved oxygen, turbidity, redox potential) are collected through the water column at each site in the reservoir. Chemical (major ions and nutrients) and biological samples (chlorophyll and plankton) are collected at selected sites to characterize major strata and advective currents in the reservoir.

GCD tailwater monitoring consists of continuous monitoring (temperature, specific conductance, pH, dissolved oxygen, turbidity) with monthly chemical and biological sample collection. Grand Canyon monitoring consists primarily of collection of temperature and conductance at various locations.

Lake Powell monitoring parameters include temperature, conductance, pH, dissolved oxygen, redox potential, and turbidity. Chemical analyses include determination of major ionic constituents and nutrient compounds of phosphorus and nitrogen. Plankton analyses include enumeration and identification of species, biomass estimates, and relative abundance calculations. All measurements and laboratory analyses are performed in accordance with standard approved methods.

Reservoir modeling is performed cooperatively between Reclamation and the GCMRC to achieve predictive capabilities and guide, redirect, or supplant some aspects of monitoring. Current model development has progressed to include calibrations for dissolved oxygen concentration, algal components, and oxygen demand from deltaic resuspension.

Links/Relationships to Other Projects

The quality of dam releases and subsequent in-stream changes can have a profound effect on various aspects of the aquatic ecosystem in Grand Canyon. Temperature affects metabolic rates of various organisms, including bacteria, plants, invertebrates, and vertebrates. It also affects reproductive processes, larval development, and behavior of native and nonnative fishes. Nutrient concentrations in dam releases can influence primary productivity processes in the clear water Lees Ferry reach. Dissolved oxygen is essential to maintaining healthy fish and invertebrate populations throughout Grand Canyon. Temperature and dissolved oxygen have the most direct effect on native and nonnative fish populations. Suspended sediment concentrations limit the light available for primary productivity and affect the behavior of various fishes. Tracking status and trends of these water-quality parameters forms a direct link to various food base and fishery studies currently underway in Grand Canyon.

Products/Reports

- A comprehensive report describing the 43-year history of Lake Powell water-quality monitoring is in progress and will be completed in FY2008.
- An interpretive data synthesis report will be developed in FY2009 to build upon the monitoring data and provide insights in how climatological, meteorological, hydrodynamic processes and the operation of Glen Canyon Dam affect inflow routing and stratification in the reservoir, and the quality of releases from Glen Canyon Dam
- Periodic reports of water-quality conditions will be posted via Internet.
- Updates on water-quality conditions will be provided to AMWG, TWG, and other interested parties through written reports or oral presentations periodically.

Budget

Bio 7.R1.09	
Water-Quality Monitoring Lake—Powell & Tailwaters (FY2007–09)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

PHY 7.M1.09: Core Monitoring of Downstream Integrated Quality of Water (below Glen Canyon Dam)

Start Date

October 2006

End Date

Ongoing (FY2009 will be the third year of a project that was initiated to provide core-monitoring information to meet the information needs related GCDAMP goals 7 and 8. This monitoring project follows a 6-year research and development phase conducted during FY 2001 to FY2006).

Principal Investigator

David Topping, Ph.D., U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The downstream Integrated Quality of Water (IQW) project is primarily focused on the main channel of the Colorado River from just below GCD (RM -15) downstream to the upper end of Lake Mead (as measured at the gaging station above Diamond Creek at RM 226). In addition, an important component of the project is a combination of monitoring and modeling of tributary sediment inputs such that sediment and flow monitoring activities are also carried out in various tributary watersheds, such as the Paria River at Lees Ferry, the LCR near Cameron, Arizona, another site above the confluence with the mainstem Colorado River, and various lesser tributaries in Glen, Marble, and Grand Canyons.

Project Goals

The downstream IQW project focuses on monitoring and supports implementation of flow research related to stable flow testing, evaluation of alternative fluctuating flows, tests of beach/habitat-building flows (BHBF) and ongoing development and evaluation of numerical modeling. In some instances, it is difficult to separate these elements from experimental elements because they support each other. For example, monitoring the suspended-sediment budget may be considered core monitoring, but it is also required to assess a trigger for a BHBF such that it could be considered experimental research support. In the section on project tasks, the individual project elements are described.

The downstream IQW monitoring project is focused primarily on measurements of surface flow throughout the river ecosystem, as well as quality-of-water parameters such as temperature, specific conductivity, dissolved oxygen, and suspended-sediment transport. The monitoring project directly supports achievement of the following GCDAMP goals:

Goal 7: Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.

Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Because this monitoring project addresses the physical framework of the ecosystem, which underlies many biological, cultural, and recreational resource objectives, it indirectly supports achievement of almost all other GCDAMP goals, as described below:

Goal 1: Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.

The downstream IQW monitoring project supports this goal by providing information on flows, water temperature, and turbidity that aids in food base studies, such as the assessment of primary productivity and allochthonous inputs.

Goal 2: Maintain or attain a viable population of existing native fish, remove jeopardy for HBC and razorback sucker, and prevent adverse modification to their critical habitats.

The downstream IQW monitoring project also supports the native fish program by providing nearshore water temperature data for the assessment of growth rates, sediment concentration data that is used to adjust for catch efficiency in population models, flow and stage data that is important to understanding the effects of nearshore habitat disruption caused by fluctuating flows, and information on sandbars which create backwater habitats that are thought to be important for native fish.

Goal 4: Maintain a wild reproducing population of RBT above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.

The downstream IQW monitoring project also monitors dam release and Glen Canyon quality of water, which proved critically important in fall 2004 when dissolved oxygen levels were low, requiring modifications to release patterns in order to raise oxygen levels.

Goal 6: Protect or improve the biotic riparian and spring communities within the CRE, including threatened and endangered species and their critical habitat.

The downstream IQW monitoring project also tracks the transport and fate of fine sediment, which provides the substrate for riparian vegetation and marsh communities.

Goal 9: Maintain or improve the quality of recreational experiences for users of the CRE within the framework of GCDAMP ecosystem goals.

The downstream IQW monitoring project also produces monitoring data and supports experimental and modeling research to understand flow dynamics and the size and abundance of sandbars, which are resources that affect the recreational experiences of Colorado River users such as rafters and fishermen.

Goal 11: Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.

The downstream IQW monitoring project also provides monitoring data related to riverine sandbars that provide a source of sediment, through aeolian transport, to high-elevation sand deposits that contain archaeological resources. In addition, the downstream IQW monitoring project has also developed stage modeling capabilities that allow for the assessment of the flow level that inundates a given cultural site.

In August 2004, the AMWG reviewed these goals and identified priority questions. The top five priority questions are as follows:

Priority 1: Why are HBC not thriving, and what can we do about it? How many HBC are there and how are they doing?

Priority 2: Which cultural resources, including TCPs, are within the Area of Potential Effect (APE), which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?

Priority 3: What is the best flow regime?

Priority 4: What is the impact of sediment loss and what should we do about it?

Priority 5: What will happen when a TCD is tested or implemented? How should it be operated? Are safeguards needed for management?

As with the GCDAMP goals, the downstream IQW monitoring project directly supports some priorities while indirectly supporting others. For example, monitoring and research on flows, sediment transport, and water temperature clearly support priorities 3, 4, and 5 directly, while also indirectly supporting priorities 1 and 2 by providing information on the general physical framework of the riverine environment.

Need for the Project

Information on flow, water quality, and suspended-sediment transport is critical to understanding the physical environment upon which biological and sociocultural resources depend (see details in Section 1 of this project description). In order to understand responses of these resources to dam operations, we must first understand the effects of dam operations on the physical environment. The goal of the downstream IQW project is to provide this information and link dam operations to changes in the physical environment.

Strategic Science Questions

The downstream IQW monitoring project is designed with the goal of providing data that supports answering the two primary physical resources questions identified during the KAW conducted in the summer of 2005, as follows:

SSQ 4-1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

Also, as detailed throughout this project description, the downstream IQW monitoring project provides information on the physical environment that is critical to other resource areas and will thus contribute indirectly to answering a variety of other science questions related to other resources.

Information Needs Addressed

The downstream IQW monitoring project directly addresses several of the CMINs and RINs related to GCDAMP goals 7 and 8. A selection of the information needs that are addressed by downstream IQW monitoring project are listed below. The downstream IQW monitoring project addresses many more CMINs, but the ones listed below are considered most relevant to answering the science questions outlined above.

CMIN 7.4.2. Determine and track flow releases from Glen Canyon Dam, under all operating conditions, particularly related to flow duration, upramp, and downramp conditions.

CMIN 7.1.2. Determine and track LCR discharge and temperature near the mouth (below springs).

CMIN 7.1.1. Determine the water temperature dynamics in the mainstem, tributaries, backwaters, and nearshore areas throughout the CRE.

CMIN 8.1.3. Track, as appropriate, the monthly sand and silt/clay volumes and grain-size characteristics, by reach, as measured or estimated at the Paria and LCR [near Cameron, Ariz., and above the confluence] stations, other major tributaries like Kanab and Havasu Creeks, and "lesser" tributaries?

CMIN 8.1.2. What are the monthly sand and silt/clay export volumes and grain-size characteristics, by reach, as measured or estimated at Lees Ferry, Lower Marble Canyon, Grand Canyon, and Diamond Creek Stations?

The monitoring data from the downstream IQW monitoring project not only fulfill the CMINs listed above, but are also intended to feed new information directly into modeling efforts (see PHY 07.R2.09) that will allow sediment-transport modelers the opportunity to address RINs related to GCDAMP goals 7 and 8.

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 GCDAMP goals and objectives?

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 8.5.1. What elements of ROD operations (upramp, downramp, maximum and minimum flow, MLFF, high modified flow (HMF), and BHBF) are most/least critical to conserving new fine sediment inputs, and stabilizing sediment deposits above the 25,000 cfs stage?

General Methods/Tasks

Streamflow, stage, water temperature, conductivity, turbidity, and suspended-sediment data are collected using standard USGS protocols with Quality Assurance/Quality Control (QA/QC) (Rantz and others, 1982a). Suspended-sediment sampling is supplemented through the use of emerging technologies, including acoustics and laser-diffraction (Melis and others, 2003; Topping and others, 2004, 2006, 2007). Stage, water temperature (Voichick and Wright, 2007), conductivity (Voichick, in press), turbidity, and suspended-sediment surrogates (i.e., acoustics and laser-diffraction) are monitored with in situ instrumentation recording at 15-min intervals. River flow is measured episodically and used to develop a stage-discharge rating curve, providing 15-min flow records (Rantz and others, 1982b). Similarly, suspended-sediment concentration is measured episodically using standard USGS protocols (Edwards and Glysson, 1999) and used to calibrate acoustic and laser diffraction instrumentation, providing 15-min records of concentration (sand and silt/clay), and sand grain size.

FY 2009 Tasks:

Flow and Stage Monitoring

Continued monitoring of flow and stage at established mainstem locations and major tributaries (RM -15, RM 0, RM 30, RM 61, RM 87, RM 166, RM 226, Paria River at the HWY 89 bridge and near Lees Ferry, and two sites on the LCR). Category(s): Core Monitoring. Schedule: Ongoing. Official surface water records are collected at Paria River at the HWY 89 bridge and published by the USGS Utah Water Science Center. Official surface water records are collected and published by the USGS Arizona Water Science Center at the following tributary gage sites: Paria River near Lees Ferry, Ariz.; LCR near Cameron, Ariz.; LCR above the mouth near Desert View, Ariz.; Kanab Creek near Kanab, Utah; Havasu Creek above the mouth near Supai, Ariz.; and at the mainstem gages at RM 0, RM 8, and RM 226, Ariz. The RM -15 flow measurements are reported by Reclamation.

Quality-of-Water Monitoring

Continued monitoring of water temperature at established mainstem locations and major tributaries (RM -15, RM 0, RM 30, RM 61, RM 87, RM 166, RM 226, RM 246, Paria River at Lees Ferry, two sites on the LCR, and Kanab and Havasu Creeks). Continuation of a new nearshore/backwater temperature monitoring program. Continued monitoring of conductivity at established stations (RM -15, RM 0, RM 30, RM 61, RM 87, and RM 226). Continued monitoring of turbidity at established stations (RM 30, RM 61, and RM 226). Category(s): Core Monitoring. Schedule: Ongoing for mainstem temperature, conductivity, and turbidity monitoring; continuation of nearshore/backwater monitoring program in FY 2008, then ongoing; monitoring data supports completion of downstream thermal model development during FY 2008, applications ongoing.

Suspended-Sediment Flux Monitoring

Continued monitoring of suspended-sediment flux at established mainstem locations and major tributaries (RM 30, RM 61, RM 87, RM 166, RM 226, Paria River at Lees Ferry, and one site along the LCR [near Cameron, Ariz.]). Because BHBF triggers are based on sediment retention within the mainstem, it is insufficient to monitor tributary inputs only. Category(s): Core Monitoring. Schedule: ongoing.

Collaboration with and Support of Aquatic Food Base Program

Integrated research studies with the aquatic food base program, including submerged aquatic vegetation and bed texture classification with acoustics, monitoring algal drift with acoustics, and quantification of tributary inputs of organic material. Category(s): Support for Research and Development. Schedule: ongoing.

Coordination with Other Resource Areas

Regular meetings and interaction with other resource area personnel, particularly at the program manager level, in order to facilitate an ecosystem approach to our scientific studies and ensure that the downstream IQW monitoring project is providing useful information regarding the physical environment to the other resource areas. Category(s): Program Management. Schedule: ongoing.

Links/Relationships to Other Projects

Aquatic Food Web Research

The downstream IQW monitoring project supports new research focused on the food web of the river ecosystem by providing continuous data on surface flow in the main channel and major tributaries, as well as related quality-of-water data, such as water temperature, specific conductivity, dissolved oxygen and suspended-sediment concentrations and grain size for suspended particles in transport.

Fisheries Monitoring and Research

The downstream IQW monitoring project also supports science activities in the fisheries program by providing flow and quality-of-water data that may be used by fisheries biologists in evaluating their fish catch data, as well as growth, movement, and habitat use information.

Products/Reports

- Streamflow, stage, and tributary sediment data will be published annually in Arizona and Utah Water Resources Data reports (surface water and sediment records published by the USGS Utah and Arizona Water Science Centers) and served through the GCMRC Web page (http://www.gcmrc.gov/products/) (data delivered on or before February 28, 2010).
- Mainstem sediment transport and water-quality data will be summarized in a biennial data report; data will also be served through the GCMRC Web page (The GCMRC leads in preparing these reports.).

- Conference abstracts and proceedings articles (2–4), journal articles (1–3), and frequent presentations at stakeholder meetings will result from this project.

Budget

PHY 7.M1.09	
Integrated Quality-of-Water Monitoring (Downstream of GCD; FY 2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (21% burden)	
GCMRC project-related travel/training (21% burden)	
GCMRC operations/supplies (21% burden)	
GCMRC equipment purchase/replacement (21% burden)	
AMP logistical support (21% burden)	
Outside GCMRC and contract science labor (21% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

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PHY 7.R2.09: Integrated Flow, Temperature, and Sediment Modeling

Start Date

October 2008

End Date

September 2009. This project parallels the downstream IQW monitoring project, and it is expected that support for model development and improvements will continue in parallel to the monitoring program. The scope of work for FY2009 is expanded, using FY2008 carry-over funds. As new data are collected, existing models can be continuously tested, improved, and applied.

Principal Investigator(s)

Scott A. Wright, U.S. Geological Survey, California Water Science Center; Mark Schmeeckle, Arizona State University; David J. Topping, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Peter R. Wilcock, Johns Hopkins University; Paul E. Grams, U.S. Geological Survey, Grand Canyon Monitoring and Research Center.

Geographic Scope

The one-dimensional flow, temperature, and sediment transport modeling activities are linked to the IQW project in a spatially parallel way and are, therefore, also focused on the main channel of the CRE, between GCD (RM -15) to Diamond Creek (RM 226). Multi-dimensional modeling efforts will be focused on specific locations where appropriate topographic, bathymetric, and other calibration data have been collected. In FY2009 multi-dimensional modeling will be developed and calibrated for the reach near RM 45.

Project Goals

The FY2009 modeling initiative described below is designed to advance predictive modeling capabilities needed to predict the fate of flow releases from GCD and associated water-quality constituents such as temperature and suspended sediment. Work to be conducted under this project in FY2009 will include the development of new multi-dimensional modeling capabilities, furthering the advancement of existing one-dimensional modeling capabilities, and completing work on sand bar stability modeling. Achieving progress in each of these areas represents a substantial expansion over modeling efforts of FY 2008, which included some initial work on multi-dimensional modeling and limited work on one-dimensional modeling. Advancements in both detailed multi-dimensional models, which can only be applied to a few specific locations, and general one-dimensional models, which can be applied to the entire CRE, is required to improve the ability to predict downstream thermal regimes and the fate of fine sediment inputs that enter the ecosystem from sources such as the Paria and Little Colorado Rivers.

Ongoing development of models to simulate flow, sediment transport, and downstream water temperature are intended to be closely interfaced with ongoing monitoring activities throughout the science program. As stated in the previous section, the downstream IQW monitoring project (Project PHY 07.M1.09) is focused primarily on measurements of surface flow throughout the river ecosystem as well as quality-of-water parameters such as temperature, specific conductivity, dissolved oxygen, and suspended-sediment transport. As described in the section on Project PHY 07.M1.09, the monitoring project directly supports achievement of the following GCDAMP goals and specific modeling tasks:

Goal 7: Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.

Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Need for Project

Information on flow, water quality, and suspended-sediment transport is critical to understanding the physical environment upon which biological and sociocultural resources depend, as described in detail for project PHY 07.M1.09. In order to understand responses of these resources to dam operations, we must first understand the effects of dam operations on the physical environment. The goal of the modeling support activities linked to the downstream IQW monitoring project is to provide increased predictive capabilities (simulations) that can be used as planning tools for linking dam operations to changes in the physical environment, as well as exploring interdisciplinary relationships with biological, cultural, economic, and recreational elements of GCDAMP.

Strategic Science Questions

The downstream IQW modeling activities are designed with the objective of providing predictive capability that supports answering the two primary physical resource questions identified during the KAW conducted in the summer of 2005:

SSQ 4-1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

The above questions are only partially addressed through collection of monitoring data. Likewise, both questions are related to issues that can be at least partially resolved through focused experimental research in combination with ongoing modeling research activities. Following collection of monitoring data in Project PHY 07.M1.09, development and refinement of the models for simulating flow, suspended-sediment transport, and downstream temperature evolution is the next step toward resolving these critical questions in the next phase of monitoring and research.

Information Needs Addressed

The modeling support subelement of the downstream IQW directly addresses several of the RINs related to GCDAMP goals 7 and 8:

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 GCDAMP goals and objectives?

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 8.5.1. What elements of ROD 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?

General Methods/Tasks

The method used for verification of the existing flow, sediment, and thermal models will vary from one model to another, depending upon how managers and scientists propose to use the models to support planning activities. Generally, historical monitoring data will be used in combination with real or projected boundary conditions for the ecosystem (on a reach-scale basis) to determine how accurately models can recreate conditions measured around specific flow periods or events, such as the fate of Paria River sand inputs, BHBF releases, etc. For downstream temperature simulations, model behavior will be evaluated and compared to measured responses for purposes of testing and calibrating the temperature model. Additional meteorological data (if available) may also be added to the model to further evaluate performance with respect to historical patterns. Projected release patterns for flow and temperature (from the Lake Powell model) shall also be used to evaluate future conditions of downstream temperature in the main channel and along nearshore habitats.

Multi-dimensional modeling of flow, temperature, and sediment transport

Multi-dimensional models allow for the simulation of detailed flow and transport processes in short reaches over short time scales, and can be used to parameterize complicated processes for use in simplified models applicable to broader scales, such as the "shifting rating curve" model described below. Multi-dimensional models can be used to evaluate, e.g., sandbar responses to high-flow events and backwater warming during steady flows.

We are applying the Delft-3D modeling suite to simulate hydrodynamics, sediment transport, and water temperature in short reaches where detailed datasets are available. Delft-3D is a proprietary, general use package that has been applied extensively throughout the world. While there are other multi-dimensional packages available that could be used, Delft-3D has been chosen because it has all of the desired capabilities and the USGS Coastal and Marine Geology Team in Santa Cruz has an existing cooperative agreement with Delft that provides access to the package. The desired capabilities include: 3D hydrodynamics with depth-averaging options; multiple grain size transport with bed sorting and subsurface layering; water temperature capabilities; conservative tracer capabilities; user-interface. Work in FY2009 will focus on 1) hydrodynamics calibration (e.g. grid parameters 2D vs 3D, roughness coefficients, eddy viscosity coefficients) using detailed data collected in middle Marble Canyon during the March 2008 high-flow releases; 2) water temperature calibration, focused primarily on backwater environments, at locations where ongoing temperature monitoring is occurring (and with available bathymetry); and 3) sediment transport and sandbar morphology calibration at the same sites used for hydrodynamics calibration (dependent on time and funds available upon completion of tasks 1 and 2).

Sandbar stability experiments and modeling

A model for sand bar beach failure under elevated pore water pressures during rising and falling river stages has largely been developed by research scientists at Arizona State University (ASU). Currently the model uses the method of slices to determine the factor of safety for failure. The model exhaustively checks each possible slip surface. The model also includes preservation of failed material at the base of the beach face and unsaturated flow. With the proposed funding the model would be used to test the stability of several different beach faces under differing dam operation scenarios. The computer model will be validated by doing test runs in ASU's full-scale (8 ft high, 26 ft long, and 2 ft wide) beach stability slot, which is capable of matching the hydrologic conditions due to rising and falling river stage in Grand Canyon beaches imposed by varying dam operations. This apparatus has already been built, but funding is needed for tensiometers and linear position sensors. Student support is necessary to complete model development and run the validation experiments. The product of this proposed funding will be an experimentally validated model that managers can use to evaluate the mass failure potential of sand bar beaches under differing dam operation scenarios.

Development of one-dimensional modeling tools

A "shifting rating curve" model has been developed that takes a simplified approach in order to estimate the overall sand budget over long time scales. Detailed description of the model is available in draft journal article form that is currently in USGS peer-review (planned submittal to the Journal of Hydraulic Engineering). Because of the empirical nature of the model, it is desirable to include recent sand transport data (e.g. Oct 2006 – Mar 2008) in the model calibration and validation; this is the primary task for FY2009. Also, as new data become available in future years through the sand transport monitoring program, updates to the model may be warranted. This model will be useful for evaluating various dam operational scenarios with respect to the long-term (i.e. annual to decadal scale) sand budget over relatively long reaches (~ 30 miles).

Connecting local changes in sand storage to dam operations requires an ability to forecast the interaction between water and sand supply throughout the CRE. Previous modeling efforts in the CRE resulted in the development of a one-dimensional unsteady flow and sediment routing model that was tested against monitoring data collected during the 2004 BHBF (Wiele and Griffin, 1998; Wiele and others, 2007). Results from this effort demonstrated that the abstracted reach-average approach has potential for evaluating the effects of different dam operation scenarios on sediment transport and storage, and that additional testing and calibration of the model is warranted. Tasks for FY2009 will include (1) model documentation to facilitate use of the model by a larger group of scientists, (2) sensitivity analysis, (3) additional calibration, and (4) developing a basis for incorporating full channel mapping and unsteady sediment rating curves in a system-scale forecast.

Links/Relationship to Other Projects

Because ongoing modeling efforts are linked to the downstream IQW monitoring project, it is also intended to address and support elements of the physical framework of the ecosystem, which underlies many biological, cultural, and recreational resource objectives. As a result, the modeling efforts indirectly support achievement of almost all other GCDAMP goals, as described in the previous section on Project PHY 07.M1.09. The ongoing activities associated with development of simulation capabilities and verification of existing models already in existence can effectively benefit from the collection of monitoring data from the downstream IQW project. These simulation models include flow routing, suspended-sediment transport, sandbar evolution, and downstream thermal simulations throughout the main channel. Improved predictive capabilities for physical resources related to dam operations will be of great value as a support tool in planning future experimental treatments, as well as evaluating proposed management actions in the river ecosystem that generally relate to GCDAMP goal 1, goal 2, goal 4, goal 6, goal 9, and goal 11. In addition, goal 12 is also supported by efforts to advance modeling activities for the ecosystem.

Aquatic Food Web Research

Both the downstream IQW monitoring project and its modeling support link to thermal and suspended-sediment transport can help to support new research focused on the food web of the river ecosystem by providing continuous data on surface flow in the main channel and major tributaries, as well as related quality-of-water data, such as water temperature, specific conductivity, dissolved oxygen, and suspended-sediment concentrations and grain size for suspended particles in transport, but also by providing simulations for predicting downstream boundary conditions that limit in-stream productivity.

Fisheries Monitoring and Research

The downstream IQW modeling activities provide support beyond IQW data by making simulations for physical habitat changes, such as backwaters, available to fishery scientists before future BHBF tests. Such information can assist scientists in planning better integrated studies.

Products/Reports

- Testing and refinement of nearshore water temperature modeling capabilities, including simplified "pond" backwater models and detailed multidimensional models of areas with available bathymetry. This work is in progress in FY2008 and will be continued, resulting in peer-reviewed publications and model delivery in FY2009.
- Testing and refinement of multidimensional models of eddy-sandbar environments. Work in progress during FY2008 includes evaluation and summary of available datasets for sediment transport and morphology of eddy-sandbar environments and collection of additional calibration data during the 2008 high flow experiment. Work to be conducted in FY2009 will result in a report to be completed by the end of calendar year 2009 describing the development, calibration, and performance of a multi-dimensional eddy-sandbar model for the RM 45 reach.
- Experimentally validated bar face stability model that managers can use to evaluate the mass failure potential of sand bar beaches under differing dam operation scenarios.
- Documentation and calibration information for existing one-dimensional sand routing model.
- Preparation of conference abstracts and proceedings articles (1+ per year), journal articles (1+ per year), and presentations at GCDAMP meetings (as necessary).

Budget

PHY 7.R2.09	
Modeling Support Linked with Integrated Quality-of-Water Monitoring (FY 2009)	
	Fiscal year 2009
GCMRC personnel costs (21% burden)	
GCMRC project-related travel/training (21% burden)	
GCMRC operations/supplies (21% burden)	
GCMRC equipment purchase/replacement (21% burden)	
AMP logistical support (21% burden)	
Outside GCMRC and contract science labor (21% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 21% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics) NOTE: $125,663 of the gross funding is included in the FY09 budget. The remaining $173,260 comes from FY07 and FY08 carry-over funds.	

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Wiele, S.M., and Griffin, E.R., 1998, Modifications to a one-dimensional model of unsteady flow in the Colorado River through the Grand Canyon, Arizona, US Geological Survey Water-Resources Investigation Report 97-4046, 17 p.

GCDAMP Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the Adaptive Management Program ecosystem goals.

PHY 8.M1.09: Core Monitoring for the Sediment Budget and Sandbar Status throughout the CRE Utilizing Direct Topographic/Bathymetric Measurements and Remote Sensing

Start Date

October 2008

End Date

Ongoing

Principal Investigator(s)

Roderic Parnell, Matt Kaplinski, and Joseph E. Hazel, Jr., Northern Arizona University, Department of Geology; David J. Topping, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; David M. Rubin, U.S. Geological Survey, Coastal and Marine Team; Paul E. Grams, U.S. Geological Survey, Grand Canyon Monitoring and Research Center.

Geographic Scope

Core monitoring for the sediment budget and sandbar status throughout the CRE utilizing direct topographic/bathymetric measurements and remote sensing is focused on detecting long-term (i.e., 4-year to multidecadal) trends in the CRE sediment budget for both fine (sand and finer material) and coarse sediment. In addition, this project utilizes a combination of direct topographic measurement and remote sensing to monitor the status of high-elevation (> the stage associated with a discharge of 8,000 cfs) sandbars on an annual to 4-year basis. The total geographic extent of this monitoring is from GCD to the upper end of Lake Mead (near Separation Canyon). The remote-sensing component is scheduled for spring 2009 and will cover the entire geographic extent, as described in section DASA 12.D1.09 of this work plan. During FY2009, channel mapping will occur from RM 0 (Lees Ferry) to RM 30, referred to herein as upper Marble Canyon. Sandbar status will be monitored at selected study sites between GCD and RM 225 (Diamond Creek). Collectively, these three components comprise the SED TREND monitoring program.

Project Goals

The primary objective of Goal 8 SED TREND monitoring is to determine magnitudes and trends in fine sediment storage throughout the CRE in the main channel and eddies at all elevations, specifically broken down into three

bins: (1) below the stage associated with a discharge of 8,000 cfs (where over 90 percent of the fine sediment in the CRE is typically stored), (2) between the stages associated with discharges of 8,000 and 25,000 cfs, and (3) above the stage associated with a discharge of 25,000 cfs.

The secondary goals of this project are to determine magnitudes and trends in campsite area and distribution (in support of Goal 9), backwater geometry and distribution (in support of Goal 2), and the availability of open dry sand on sandbars that can be transported by the wind upslope into archeological sites thereby helping preserve these resources (in support of Goal 11).

The SED TREND monitoring program directly supports achievement of the following GCDAMP goals:

> **Goal 8**: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve AMP ecosystem goals.
>
> **Goal 9:** Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem within the framework of AMP ecosystem goals. The monitoring provides information on the size and abundance of sandbars, which are resources that affect the recreational experiences of Colorado River users.
>
> **Goal 11:** Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations. The SED TREND program includes monitoring sandbars that provide a source of sediment, through aeolian transport, to high-elevation sand deposits that contain archaeological resources.

Because SED TREND monitoring addresses the physical framework of the ecosystem, which underlies many biological resource objectives, it also indirectly supports achievement of the following AMP goals:

> **Goal 1:** Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels. The SED TREND monitoring supports this goal by providing information on coarse sediment inputs which provide the substrate for parts of the aquatic food base.
>
> **Goal 2:** Maintain or attain a viable population of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitats. The SED TREND monitoring supports this goal by providing information on sandbars which create backwater habitats that are thought to be important for native fish.
>
> **Goal 6:** Protect or improve the biotic riparian and spring communities within the Colorado River ecosystem, including threatened and endangered species and their critical habitat. The SED TREND monitoring monitors the status of the fine sediment deposits which provides the substrate for riparian vegetation and marsh communities.

Need for Project

Sediment forms the physical template for the CRE downstream from GCD (U.S. Department of the Interior, 1995; National Research Council, 1996). The endangered and threatened native fishes evolved in a highly turbid river (Gloss and Coggins, 2005), with turbidity predominantly due to suspended silt and clay and, to a lesser degree, suspended sand. Before the closure of GCD, 60 percent of upstream sediment supply from the Colorado River in Glen Canyon was silt and clay (Topping and others, 2000). Closure of GCD reduced the supply of silt and clay by about 96 percent at the upstream boundary of Grand Canyon National Park, with the Paria River now the major supplier of silt and clay at this location (Topping and others, 2000). The postdam Colorado River in Marble and Grand Canyons is much less turbid (with clearer water conditions than ever occurred naturally) and, because the in-channel storage of sand, silt, and clay in the postdam Colorado River is greatly reduced from

predam conditions, the Colorado River in the CRE is now turbid only during periods of tributary activity downstream from the dam.

Sandbars and other sandy deposits in and along the Colorado River in Grand Canyon National Park were an integral part of the natural riverscape, and are important for riparian habitat, native fish habitat, protection of archeological sites, and recreation (Rubin and others, 2002; Wright and others, 2005). Recent work has shown that the low-elevation parts of these sandbars (< the stage associated with a discharge of 8,000 cfs) in lateral recirculation eddies contain the bulk of the sand, silt, and clay in storage (Hazel and others, 2006), and the surface grain size of these sandbars is the dominant regulator of sand transport over multiyear timescales (Topping and others, 2008). Thus, the low-elevation parts of sandbars and the channel (as will be shown below) comprise the long-term bank account or reserve for sediment in the CRE. Following closure of Glen Canyon Dam in 1963, the supply of sand at the upstream boundary of Grand Canyon National Park was reduced by about 94 percent (Topping and others, 2000). In response to this reduction in sand supply and the alteration of the natural hydrograph by dam operations (Topping and others, 2003), sandbars in Marble Canyon and the upstream part of Grand Canyon have substantially decreased in size since closure of the dam (Schmidt and Graf, 1990; Schmidt and others, 2004) and are still in decline under normal powerplant operations at the dam (Wright and others, 2005).

A major outstanding question is whether repeated BHBFs conducted under sediment-enriched conditions (such as those that existed during the 2004 and 2008 BHBF tests) can result in the rebuilding and maintenance of sandbars throughout the CRE. Scour of the low-elevation eddy and channel pool environments during sand-depleted BHBF tests, such as the 1996 Controlled Flood, is not subsequently offset by deposition of new sand under normal powerplant releases (Schmidt and others, 2004; Topping and others, 2006). Analysis of surveys conducted one to four times per year during the 1990s indicates that sandbars in Marble Canyon and the upstream part of Grand Canyon contained about 25 percent less sand at lower elevations in 2000 than in 1991, and that the lower elevation parts of these sandbars and the adjacent channel bed never fully recovered in sand volume after scouring during the 1996 flood. We also know that there has been progressive and continued scour of the bed in the CRE between GCD and Lees Ferry (Grams and others, 2006). This net decrease in low-elevation fine sediment volume occurred despite the fact that tributary inputs of sand during this period were well above average. Thus, controlled floods conducted under sediment-depleted conditions, such as those that existed in 1996, cannot be used to sustain sandbar area and volume. In addition, the dominant response (downstream from the upstream half of Marble Canyon) during the 2004 BHBF test was that eddies lost sand. If BHBFs are to be a sustainable tool for rebuilding and maintaining sandbars in the CRE, then the volume of fine sediment stored at lower elevations (i.e., in the long-term fine sediment reserve) must not decrease over decadal timescales as a result of the occurrence of repeated BHBFs.

Computing fine sediment budgets for various reaches in the CRE over decadal or longer timescales is required for evaluating the effects of dam operations, including BHBFs. Over timescales of one to several years, this is accomplished by the "mass balance" program described under goal 7. However, because of the increasing uncertainties over time associated with the mass balance approach, another approach is needed to track the fine sediment budget for the CRE over longer timescales. This complementary sediment monitoring is required to evaluate whether future dam releases (including BHBFs) continue to mine the sediment reserve or whether the reserve (stored largely at elevations less than the stage associated with a discharge of 8,000 cfs) remains stable or increases under future dam releases. If the amount of sediment in the reserve continues to decrease, then operations will ultimately not be able to sustain the fine sediment resources at higher elevations.

At the 2004 AMWG priority-setting workshop, questions relating specifically to sediment (and tracked by the herein described SED TREND monitoring) were identified under three of the top five priorities of the AMP. These priorities were, in decreasing order of relevance to sediment:

GCDAMP Priority 4: What is the impact of sediment loss and what should we do about it?

GCDAMP Priority 3: What is the best flow regime?

GCDAMP Priority 2: Which cultural resources, including traditional cultural properties, are within the Area of Potential Effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?

Strategic Science Questions

Several SSQs were identified by scientists and managers during the knowledge assessment workshop conducted in the summer of 2005 (Melis and others, 2006). The SED TREND monitoring project provides valuable information to help answer several of the questions related to sediment conservation, and in particular the primary sediment question:

SSQ 4-1. Is there a "Flow Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will rebuild and maintain sandbar habitats over decadal timescales?

Information Needs Addressed

The 2003 AMP Strategic Plan identified Core Monitoring Information Needs (CMINs) related to sediment storage (goal 8). The CMINS that are addressed by the SED TREND monitoring are listed below. For each, the prioritization ranking applied by the AMP SPG in 2006 is also included. The SED TREND monitoring during FY 2009 will directly address the third of the top five goal 8 CMIN priorities; the first two of these five are addressed by the mass balance project described under goal 7.

CMIN 8.1.1. Determine and track the biennial sand bar area and fine-sediment volume and grain-size changes within eddies below 5,000 cfs stage, by reach. (fourth-ranked goal 8 CMIN).

CMIN 8.2.1. Track, as appropriate, the biennial or annual sandbar area, volume and grain-size changes within and outside of eddies between 5,000 and 25,000 cfs stage, by reach. (second-ranked goal 8 CMIN).

CMIN 8.5.1. Track, as appropriate, the biennial sandbar area, volume, and grain-size changes above 25,000 cfs stage, by reach (fifth-ranked goal 8 CMIN).

During FY2009, the SED TREND monitoring also addresses these unranked goal 8 CMINs:

CMIN 8.6.1. Track, as appropriate, changes in coarse sediment (> 2 mm) abundance and distribution.

The SED TREND monitoring also directly addresses this top-ranked goal 9 CMIN priority (jointly with REC 9.R1.09: Sandbar and Campable Area Monitoring**)**:

CMIN 9.3.1. Determine and track the size frequency, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons (top-ranked goal 9 CMIN).

Developing and testing monitoring protocols for these CMINs was the primary focus of research and development conducted during FY1998–FY 2006, and was reviewed during the physical sciences Protocols Evaluation Program, SEDS-PEP III (Wohl and others, 2006).

General Methods/Tasks

During FY2009, SED TREND monitoring will include work on all three tasks described below. Task 3 is conducted using standard ground-based surveying protocols and multibeam-sonar bathymetric surveying protocols (including error analyses) described in Kaplinski and others (2000, 2007). The grain-size data collected under task 3 (recommended by the final PEP, Wohl and others, 2006) are collected and processed using protocols described in Rubin and others (2006, in press) and Rubin (2004). The task 1 sandbar monitoring will be completed using protocols described by Hazel and others (1999, 2000) and the task 2 remote sensing is described in section DASA 12.D1.09 of this work plan.

Task 1. Annual Effectiveness Monitoring for Higher Elevation Sand Deposits (subsample of sandbars with emphasis on campsite areas)

Task 1 includes monitoring the area and volume of fine sediment above the stage associated with 8,000 cfs for subsets of sandbars and campsites throughout the CRE using conventional ground-based surveying methods. This dataset is commonly referred to as the "NAU sandbar time series" and is the longest running dataset on the state of sandbars currently available (initiated in 1990). This task is conducted in coordination with goal 9 core monitoring and will take place in the fall of each year. The campsite monitoring component of Task 1 is covered under project REC 9.R1.09: Sandbar and Campable Area Monitoring.

Task 2: Repeat Systemwide Inventory of Higher Elevation Sand Deposits

Approximately every 4 years (but only in years without BHBFs, see "Schedule by task" section below for details), monitoring of systemwide area and volume of fine sediment (especially open sand) above the stage associated with a discharge of 8,000 cfs (i.e., approximately 10 percent of the fine sediment in the CRE) based on aerial overflight data (light detection and ranging [LIDAR] and orthrectified hyperspectral aerial photography). These remote-sensing data are also used to help monitor the magnitude and trends in campsite area, backwater area and distribution, the availability of open dry sand on sandbars, as well as for other resource areas such as riparian vegetation monitoring. These data will also be used to help quantify the inputs of gravel from tributaries. These gravel inputs provide important substrate for the aquatic food web. Task 2 is scheduled to occur in spring 2009 as part of DASA 12.D1.09.

Task 3. Annual Repeat Mapping of Lower Elevation Channel Sand Deposits

Annually (but only in years without BHBFs, see "Schedule by task" section for details), monitoring the area and volume of fine sediment at all elevations over long reaches using multibeam bathymetric surveys, ground-based topographic surveys, underwater video transects, and limited underwater microscope data collection for bed grain size. This task is planned to be performed on a systemwide basis every 5–10 years in order to estimate fine sediment budgets over timescales for which the goal 7 mass balance sediment budgets likely become inconclusive due to accumulating measurement errors. In addition to providing this key sediment budget information (i.e., the status of the fine sediment "bank account"), these data will provide information on the location and geometries of backwaters thought to be important habitat for native fish. Currently, it is logistically impossible to survey the bathymetry of the entire river in any given year. Therefore, a different reach of the river will be surveyed each year on a rotating basis. The reaches will correspond to the segments outlined in the goal 7 mass balance core-monitoring project, such that upon completion of a repeat survey for a given reach all components of the sediment budget for that reach will have been measured directly. The reaches are as follows: Reach 1: RM 0 to RM 30 (upper Marble Canyon); Reach 2: RM 30 to RM 61 (lower Marble Canyon); Reach 3: RM 61 to RM 87 (eastern Grand Canyon); Reach 4: RM 87 to RM 166 (central Grand Canyon); Reach 5: RM 166 to RM 226 (western Grand Canyon).

These surveys will occur in the late spring and will only be completed in years without BHBFs (see "Schedule by task" section for details); thus, in the absence of BHBFs, each reach would be surveyed every 5 years, or, if BHBFs occurred on average every other year, then each reach would be surveyed on average every 10 years. The 5–10 year interval is considered by sediment scientists to be sufficient to detect long-term trends in the fine sediment budget based on changes in topography and bathymetry. Because reaches 4 and 5 are much longer than reaches 1-3, it is possible that portions of these reaches will not be surveyed, using existing side-scan sonar data to identify the portions of these reaches that are most likely to store fine sediment. It is also possible that continued technological advancements and improvements in methods will allow for complete surveys of these reaches in the future.

The schedule for SED TREND monitoring under goal 8 is complicated by the potential for BHBFs, except for task 1 sandbar and campsite surveys which will occur annually in the fall whether or not a BHBF is scheduled. For task 2, remote-sensing missions and task 3 reach surveys, it is advantageous to have these occur in years without BHBFs so that the monitoring data are not dominated by the effects of a single BHBF (BHBF monitoring is described under a separate science plan developed by the GCMRC in 2007). Rather, remote-sensing and reach survey monitoring should represent the integral response of the system to several years of dam operations and tributary inputs. Further, logistical constraints would make it difficult to conduct the remote-sensing and reach survey core monitoring in addition to the BHBF monitoring. Thus, without knowing the exact frequency of BHBFs, it is impossible to outline the exact schedule for the channel mapping component of SED TREND monitoring.

Table 3 presents two possible 10-year schedules based on different assumptions regarding BHBF frequency for illustrative purposes. The first is the schedule in the absence of BHBFs where the exact schedule can be delineated. The second schedule assumes that BHBFs occur every other year, which would be the approximate frequency under previous triggers based on tributary sediment supply. In reality, even if the frequency were every other year on average, there would likely be periods with successive years of BHBFs and successive years without BHBFs such that the core-monitoring schedule for remote-sensing and reach surveys must be flexible.

Table 3. Two possible schedules for the completion of the tasks outlined under project PHY 8.M1.09.

Year	Schedule without BHBFs			With BHBFs every other year		
	Task 1: subsample campsites/ sandbars	Task 2: 4-year over flights	Task 3: channel mapping	Task 1: subsample campsites/ sandbars	Task 2: 4-year over flights	Task 3: channel mapping
2009	X	X	Reach 1	X		Reach 1
2010 (BHBF)	X		Reach 2	X		
2011	X		Reach 3	X	X	Reach 2
2012 (BHBF)	X		Reach 4	X		
2013	X	X	Reach 5	X		Reach 3
2014 (BHBF)	X		Reach 1	X		
2015	X		Reach 2	X	X	Reach 4
2016 (BHBF)	X		Reach 3	X		
2017	X	X	Reach 4	X		Reach 5
2018 (BHBF)	X		Reach 5	X		

Links/Relationships to Other Projects

The SED TREND monitoring provides data (i.e, the maps showing the topography and distribution of sediment types over about 30-mile reaches of the river) that are essential to the development and testing of numerical predictive models of discharge, stage, sediment transport, and sandbar morphology. These predictive models can be used to evaluate a wide range of resource responses, such as the fate of sandbar habitats, to various dam release scenarios, such as controlled floods, steady flows, fluctuating flows, etc.

The SED TREND monitoring provides the data used to evaluate the effectiveness of dam operations (including BHBFs) on rebuilding and maintaining sandbars in the CRE. Additionally, the SED TREND monitoring will provide the data showing whether dam operations continue to mine the long-term fine sediment reserve stored at elevations below the stage associated with a discharge of 8,000 cfs (over 90 percent of the fine sediment in the system is currently stored below this elevation). If the amount of sediment in this "bank account" continues to decrease, then operations will ultimately not be able to sustain the fine sediment resources at higher elevations.

The SED TREND monitoring supports the campsite inventories conducted under goal 9 by characterizing the status and trends of the sandbars used as campsites (covered under project REC 9.R1.09: Sandbar and Campable Area Monitoring under goal 9).

The SED TREND monitoring supports goal 11 by characterizing the status of fine sediment at higher elevations in and around cultural sites, and by characterizing the amount of open dry sand available to be transported by the wind into these cultural sites (thereby helping preserve these sites).

The SED TREND monitoring also supports new research focused on the food web of the river ecosystem by providing data on the input of gravel used as a substrate by the aquatic food web.

The SED TREND monitoring also provides information on the distribution of the fine sediment deposits that form the substrate for the riparian ecology.

Finally, the SED TREND monitoring supports science activities in the fisheries program by providing the data (as part of the long about 30-mile data collection effort described under task 3) to characterize the locations and geometries of backwaters thought to be important habitat for native fish.

Products/Reports

Annual updates of the NAU sandbar time series published as USGS Data Series reports showing trends in the area and volume of the high-elevation parts of sandbars, in addition to providing annual data showing the effectiveness of dam operations on rebuilding and maintaining sandbars. .

Topographic maps of the CRE in the first of five long reaches: upper Marble Canyon, lower Marble Canyon, eastern Grand Canyon, central Grand Canyon, and western Grand Canyon. During FY2009, monitoring will focus on upper Marble Canyon. These maps will be produced one to two times per decade for each reach on average. These maps will characterize the geometries of the backwaters (thought to be important habitat for native fish) in each about 30-mile reach (by the end of calendar year 2010). These maps will be made available through the USGS-GCMRC Internet Map Server.

Mapping conducted during FY2009 will ultimately result in decadal timescale sediment budgets for these five reaches of the CRE. These data will provide managers information on the long-term status of the fine sediment reserve. These sediment budgets will be compared to the sediment budgets computed for these reaches under the complementary mass balance project described under goal 7. This comparison will help evaluate the uncertainties associated with the SED TREND monitoring and mass balance approaches (by the end of calendar year 2010).

Where possible, data collected in Upper Marble Canyon in FY 2009 will be compared with earlier multi-beam-sonar data collected in 2000, 2001, and as part of the 2002–04 FIST project to evaluate volume changes in the fine sediment reserve (2000 vs. 2009) (by the end of calendar year 2010).

Annual peer-reviewed USGS data reports documenting results of the monitoring project. Contribution to other research-related peer-reviewed publications (such as models). Biannual presentations at GCDAMP meetings and GCMRC science symposiums. (By the end of calendar year 2010).

Budget

PHY 8.M1.09	
Long-Term Monitoring of Changes in Sediment Storage (FY 2008–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (21% burden)	
GCMRC project-related travel/training (21% burden)	
GCMRC operations/supplies (21% burden)	
GCMRC equipment purchase/replacement (21% burden)	
AMP logistical support (21% burden)	
Outside GCMRC and contract science labor (21% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 21% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

NOTE: Approximately $95,000 of this funding was included in Goal 9 in FY08 and is now included in Goal 8.

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GCDAMP Goal 9: Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

REC 9.R1.09: Campsite Area Monitoring

Start Date

October 2008 (This monitoring project is a continuation of monitoring efforts that have been occurring annually since 1998.)

End Date

Ongoing

Principal Investigator(s)

R. Parnell, M. Kaplinski, and J. Hazel, Northern Arizona University, Geology Department; in cooperation with U.S. Geological Survey, Grand Canyon Monitoring and Research Center staff scientists

Geographic Scope

Campable area monitoring has historically focused on 45 sandbars along the main channel of the Colorado River between GCD (RM -15) and Diamond Creek (RM 226). The reach below Diamond Creek has been of increasing interest to NPS and tribal managers due to the persistent sandbars that are now exposed along a flowing river reach as a result of the recent years of lower reservoir elevations and storage in Lake Mead, and the fact that this westernmost reach of the study area is frequently used for recreational camping and boating. Therefore about five additional sites are being proposed for inclusion in this monitoring project below RM 225, downstream to the western boundary of the geographical scope of the GCDAMP program (approximately RM 278).

Project Goals

The goal of this project is to track change in campable area using established monitoring protocols (repeat total station surveys) while alternative monitoring approaches using remotely sensed data are being explored and tested.

The specific objectives of this study include the following:

- Measuring campsite area at a series of long-term monitoring sandbar sites annually
- Evaluating changes in campsite area in relation to bar volume and topography
- Evaluating changes in campsite area in relation to past monitoring results at different flow stages

Need for Project

Public concern with the ongoing loss of sandbar "beaches" and recreational capacity in the Colorado River corridor was a key factor leading to the development of the 1995 Glen Canyon Dam Final Environmental Impact Statement and passage of the Grand Canyon Protection Act (GCPA) in 1992. Given that the supply of new sand below the dam is estimated to be about 6 percent of the predam supply in Marble Canyon and about 16 percent of the predam supply below the confluence with the LCR (RM 61–278), there is still uncertainty about the future fate of sandbar campsites below GCD under proposed operational strategies intended to promote sand conservation of tributary inputs. The protection of visitor use values is specifically identified as a goal of GCPA. This project directly addresses one part of the top-priority core-monitoring information need (change in campsite size) for goal 9 of the GCDAMP Strategic Plan. This project will provide data to managers about the status and trend of campsites throughout the CRE below GCD that have been monitored annually since 1998.

Strategic Science Questions

In terms of questions that are specific to the AMP goals for recreation, this project directly addresses the following SSQ:

> **SSQ 3-9.** How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Because campsite size, distribution, and physical attributes are known to affect visitor experience, this project also indirectly addresses two other important science questions related to recreation in the CRE:

> **SSQ 3-7.** How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE?

> **SSQ 3-8.** What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Indirectly, this project is also relevant to resolving the primary strategic science question for sediment, in that it provides another measurement of sand bar habitats (in this case, human habitat):

> **SSQ 4-1.** Is there a "Flow Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

Information Needs Addressed

This project directly addresses one part of the top-priority CMIN for goal 9 (campsite size):

> **CMIN 9.3.1.** Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons. (This project specifically addresses the part of the CMIN concerned with campsite size.)

This project partially addresses a second campsite CMIN (9.3.2) that is very closely related to the top-priority CMIN for camping beaches (Note: The Science Planning Group of the TWG recommended that CMINs 9.3.1 and 9.3.2 be combined as one):

> **CMIN 9.3.2.** Determine and track the effects of ROD operations on the size, quality, and distribution of camping beaches in the CRE.

This monitoring project will also contribute to tracking the long term effects of the 2008 experimental flow on camping beaches (campable area), as defined by EIN 9.3.1:

> **EIN 9.3.1.** How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the ROD, unanticipated event, or other management action?

General Methods/Tasks

Repeat surveys of long-term sandbar monitoring sites have been conducted since 1990 using trained field personnel under the joint direction of the GCMRC's survey department staff and scientists from the NAU Department of Geology. Campable area survey protocols have been established and applied consistently by the same team of scientists since the late 1990s (Kaplinski and others, 2005). As described in the State of the Colorado River Ecosystem in Grand Canyon report (Kaplinski and others, 2005, p. 196), campable area surveys are conducted annually in the fall, at the conclusion of the prime river recreation season. Survey crews from Northern Arizona University (NAU) Department of Geology survey the study sites using standard total station survey techniques (U.S. Army Corps of Engineers, 1994). Topographic data are collected and referenced to Ariz. State-Plane Coordinates generated through the GCMRC's survey control network throughout the CRE. Data are reduced and analyzed by the NAU team in cooperation with GCMRC partners and presented in a variety of formats, but most typically are reported as cumulative area totals. The campable areas are also assessed relative to flow and stage elevations linked to dam operations. These data will be integrated with and analyzed in relation to sandbar measurement data (area and volume relative to stage elevations) that are being collected as a component of the core monitoring program for sediment (see project PHY 8.M1.09).

Surveyors follow the criteria of Kearsley (1995) and Kearsley and Quartaroli (1997) to identify campable area. Campable area is defined as "a smooth substrate (preferably sand) with no more than eight degrees of slope with little or no vegetation" (Kaplinski and others, 2005, p.196). Although the goal is to capture the total campable area at each site, camping areas located at considerable distance (>100 m) from the main mooring/cooking areas are generally not included in the totals. In the future, these protocols may be adjusted to measure all campable area with variable slope criteria within the National Park Service (NPS)-defined campsite boundaries using remotely sensed data (see research project description 9.R2.08 in the FY2008 work plan); however, until new protocols are tested and refined, the existing monitoring program will continue.

Links/Relationships to Other Projects

Sand Bar Monitoring

This monitoring project will occur in conjunction with and will be analyzed it relation to the data collected from NAU's long term sandbar monitoring sites, a project that has been underway since the early 1990s. The associated campable area surveys that this project is focused on have occurred annually at a subset of these sandbars since 1998. Both the NAU sandbar survey and campable area monitoring projects are concerned with monitoring sandbar sediment, albeit in different respects. The NAU sandbar survey tracks changes in total area and volume of the sandbars above the 5,000 cfs level, while the campable area monitoring project specifically evaluates changes in campable area at a subset of these sandbar sites. In combination, these two projects provide a holistic assessment of how flows are affecting the sandbar habitats used by recreational boaters for camping.

Campsite Inventory and GIS Atlas

The assessments of campable area throughout the river ecosystem will be evaluated as a subset of sites included in the campsite inventory. Data resulting from this monitoring project will be incorporated into the GIS campsite atlas that is under development in FY2007–08 (REC 9.R3.08).

Changes in High Elevation Sand Availability

In addition to recreation resources, sandbars are closely linked with other resources of GCDAMP concern, such as terrestrial and aquatic habitats related to native fish rearing areas (backwaters) and cultural site preservation. Campable area monitoring provides information on changes in area of open sand above the active fluctuating-flow operating zone (above 25,000 cfs stage) and indirectly provides information about whether sand storage in those areas is stable, increasing or decreasing through time in response to normal operations or experimental high flows intended to promote conservation of new sand supplies. The abundance of open sand areas along shorelines also provides another indirect measurement of the potentially available sand for transport by wind to higher elevations where archaeological preservation sites are located. In the future, additional process studies at such cultural sites may be tied more directly to sandbar monitoring at existing camping sites, as well as by adding additional monitoring sites over time that are proximal to cultural research sites.

Products/Reports

Annual report documenting the change in campable area will be prepared that summarizse the annual findings. The data gathered as a result of the project will also be served through the GCMRC Web page and Campsite GIS Atlas. Project findings will also be presented at the biennial GCMRC science symposium.

Budget

REC 9.R1.9	
Campsite Area Monitoring (FY2007–11)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Kaplinski, M., Behan, J., Hazel, J.E., Jr., Parnell, R.A., and Fairley, H.C., 2005, Recreational values and campsites in the Colorado River ecosystem, in Gloss, S.P., Lovich, J.E., and Melis, T.S., eds., The state of the Colorado River ecosystem in Grand Canyon: U.S. Geological Survey Circular 1282, p. 193–205.

Kearsley, L.H., 1995, Monitoring the effects of Glen Canyon Dam interim flows on campsite size along the Colorado River in Grand Canyon National Park (final report): National Park Service, Division of Resources Management, Grand Canyon National Park.

Kearsley, L.H., and Quartaroli, R., 1997, Effects of a sand bar/habitat building flow on campsites in Grand Canyon: Final report of Applied Technology Associates for the Glen Canyon Environmental Studies, 18 p.

U.S. Army Corps of Engineers, 1994, Engineering and design-topographic accuracy standards: EM1110-1-1005, p. 2–1 to 2–12.

REC 9.R4.09: Compile and Analyze Recreational Safety Data

Start Date

October 2008

End Date

December 2010

Principal Investigator(s)

Helen Fairley, Sociocultural Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, in coordination with a cooperator (TBD) and staff at Grand Canyon National Park.

Geographic Scope

Entire Colorado River ecosystem, from base of Glen Canyon Dam to Lake Mead (RM 277)

Project Goals

The goal of this project is to compile all existing safety-related data (accidents, injuries, and major on-river incidents) related to recreational rafting and angling on the Colorado River and to analyze these data in relation to historical flows and other river conditions tied to dam operations.

Need for Project

Concerns over recreational rafter and angler safety was one of the top issues identified by the American public when Reclamation proposed modifying dam operations in the late 1980s to improve power generation capacity (Lloyd Greiner, personal comm.. 2005; DOI 1995). This issue continued to be a concern throughout the 1990s, as the EIS was being completed and new regulations over dam operations were being imposed. The issue continues to be a priority concern of the public and federal managers whenever changes in dam operations are proposed, particularly in relation to proposed experimental releases. Despite public interest and concern for safety, a comprehensive independent assessment of how dam operations and varying flows affect rafter and angler safety has not be compiled for the Glen Canyon Dam Adaptive Management Program to inform future decisions about dam operations. This project will fill a crucial information gap needed to by the GCDAMP to make informed recommendations concerning future dam operations.

Strategic Science Questions

The primary SSQ directly addressed by this project is:

> **SSQ 3-10.** How can safety and navigability be reliably measured relative to flows?

Because safety is an important attribute influencing visitor experience, this project will also provide information relevant for addressing a second SSQ about the effects of flows on the quality of recreational experience in the CRE:

> **SSQ 3-8.** What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Information Needs Addressed

This project will lay the foundation for future research and monitoring efforts that are designed to address management objectives 9.1 and 9.2. CMIN 9.1.1, as modified and ranked by the AMP Science Planning Group in 2005, is a high priority core monitoring information need for goal 9:

> **CMIN 9.1.1.** Determine and track the changes attributable to dam operations in recreational quality, opportunities and use, impacts, serious incidents, and perceptions of users, including the level of satisfaction in the Colorado River Ecosystem.

Another CMIN that this project will directly address is CMIN 9.2.2.

> **CMIN 9.2.2.** Determine and track accident rates for visitors participating in river-related activities including causes and location (i.e. on-river or off-river), equipment type, operator experience, and other factors of these accidents in the Colorado River Ecosystem.

This project will also have utility for addressing a broad information need concerning effects of experimental flows on visitor experience, as defined by EIN 9.1.1.

> **EIN 9.1.1.** How do recreational use trends, impacts, and perceptions change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

General Methods/Tasks

Using graduate student labor, all existing safety data from published and unpublished reports and maintained in various NPS and USGS databases will be compiled into a single data base, evaluated for quality assurance purposes (accuracy and reliability), and analyzed in relation to the most current available historical flow data. The results of this work will be compiled into a comprehensive report. This database and report will provide historical baseline information for conducting future safety studies, including monitoring safety and navigability attributes under experimental flows.

Links/Relationships to Other Projects

A number of studies have been conducted in the past to look at the issue of recreation safety in relation to flows. One study was conducted by the National Park Service in the mid eighties, in which boater accidents and injuries were analyzed in relation to low, medium and high volume flows (Brown and Hahn-O'Neill, 1988). Other past efforts have involved short term unpublished studies tied to specific flow events (e.g., Jalbert, 1997.) In at least one case (the LSSF experiment of 2000), safety data were collected for a study but never fully analyzed or reported (Jalbert, personal comm. 2003). In addition, in the late 1990s, an independent study was conducted to compile data about injuries and deaths on Colorado River trips and analyze the factors contributing to these events (Myers and others, 1999). In the latter study, flows were one of several variables considered in the analysis. Over the years, NPS has collected considerable data tied to search and research incidents in the river corridor that have not been compiled or analyzed. While all of these previous studies and data sets are relevant to the present study, none of the past studies have evaluated safety issues broadly in relation to the full spectrum of recreational activities on the Colorado River and specifically analyzed the effects of ROD flows and proposed experimental flows on safety, nor is there any study in which all the available recreation incident data were compiled systematically in a single comprehensive independently peer-reviewed report.

In the future, GCMRC plans to conduct a study to evaluate how changes in flows through Glen Canyon Dam affect varying aspects of the visitor experience; this future study will also analyze the tradeoffs to recreational experience quality that result from implementing various flow regimes. The quality of visitors' recreation experience is known to be determined by multiple interacting physical, biological, and social factors, many of

which are affected by flows. One attribute of importance to the quality of visitor experience is safety — the likelihood of being involved in an accident or sustaining an injury while navigating the river and rapids in Grand Canyon — under varying flow conditions. The FY2009 safety study will provide a comprehensive up-to-date data set and evaluation to help inform this future study.

This project will be undertaken with the cooperation of staff from Grand Canyon National Park. In addition to meeting GCDAMP needs, data from this project will be useful to the NPS as they develop plans and resource monitoring projects tied to the Colorado River Management Plan.

Products/Reports

This study may serve as the basis for a master's thesis in outdoor recreation. Whether or not a master's thesis is produced with these data, a comprehensive database and final, independently peer reviewed report will be created as a result of this study.

Budget

REC 9.R4.09	
Compile and Analyze Safety Data on Recreational Rafting and Flows	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

Brown, C.A. and Hahn-O'Neill, M.G., 1987, Effect of flows in the Colorado River on reported and observed boating accidents in Grand Canyon, Glen Canyon Environmental Studies Technical Report, National Technical Information Service PB88-183553. Washington DC.

Jalbert, L., 1997, The effects of the 1996 Beach/Habitat Building Flows on Observed and Reported Boating Accidents on the Colorado River in Grand Canyon National Park. Un published report on file, Grand Canyon Monitoring and Research Center Library, Flagstaff.

Jalbert, L., 2003, The effects of the low summer steady flows on whitewater boating safety in Grand Canyon National Park, Oral presentation at the Colorado River Ecosystem Science Symposium, November 2003. Tucson, Arizona.

Myers, T. M., Becker, C.C., and Stevens, L. E., 1999, Fateful Journey: Injury and Death on Colorado River Trips in Grand Canyon: Red Lake Books, Flagstaff.

GCDAMP Goal 10: Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of the Adaptive Management ecosystem goals.

HYD 10.M1.09: Monitor Power Generation and Market Values under Current and Future Dam Operations

Start Date

October 2006

End Date

Ongoing

Principal Investigator(s)

Data will be provided by Western Area Power Administration and distributed via the Grand Canyon Monitoring and Research Center Web site

Geographic Scope

Hydropower generation data and market values for the energy generated by Glen Canyon Dam

Project Goals

The goal of this core-monitoring project is to monitor and document hourly hydropower generation and potential opportunity (replacement) costs under current and future flow regimes.

Need for Project

Power generated at GCD is marketed mostly in six western states by the Department of Energy's Western Area Power Administration (WAPA). WAPA's primary mission is to sell power from Federal water project powerplants under statutory criteria in the Reclamation Project Act of 1939, the Flood Control Act of 1944, and the Colorado River Storage Project (CRSP) Act of 1956. These criteria include the following:

- Preference in the sale of power must go to municipalities, public corporations, cooperatives, and other nonprofit organizations.
- Power must be marketed at the lowest possible rates consistent with sound business practices.
- Revenues generated from power sales must pay for power generation and all allocated investment costs under the original CRSP Act.

- Projects should generate the greatest amount of power and energy that can be sold at firm power and energy rates, consistent with other project purposes.

Tracking generation (as impacted by operations for other project purposes), power market rates, necessary power purchases, and Basin Fund cash flow provides the means to assess the impact of changes in GCD operations in relation to the four statutory criteria.

Currently, there are no ongoing core-monitoring activities related to goal 10. Although data on GCD hydropower generation and opportunity costs under MLFF operations are currently being gathered by Reclamation and WAPA as routine agency functions, these data are not readily accessible to the GCDAMP. The need for this information in a readily accessible format has been identified as a program need, and this project will help to fill this critical information gap.

Strategic Science Questions

Primary SSQs addressed:

SSQ 3-3. What are the hydropower replacement costs of the modified low fluctuating flow (MLFF) annually since 1996?

SSQ 3-4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase experimental design)?

Information Needs Addressed

This project responds to the core-monitoring information need for goal 10, as originally articulated in the 2003 version of the GCDAMP Strategic Plan, and redefined by the SPG:

IN 10.1. Determine and track the impacts to power users from implementation of ROD dam operations and segregate those effects from other causes such as changes in the power market.

CMIN 10.1.1 (as redefined by SPG). Determine and track the marketable capacity and energy produced through dam operations in relation to the various release scenarios (daily fluctuation limit, upramp and downramp limits, etc.).

General Methods/Tasks

WAPA and Reclamation continuously schedule and monitor power generation to meet anticipated and real-time power demand. This information is available on an hourly time step reported daily, weekly, and monthly from System Control and Data Acquisition (SCADA) data. WAPA and its customers track power source, availability, and market changes on an hourly basis in assessing the need, cost, and accessibility for additional power resources to meet contractual obligations or unanticipated demand. Market pricing, resulting cost of purchases, and the impact on Basin Fund cash flow are recorded in the WAPA Energy Tracking Database (ISA). This information is reported monthly and annually and is available through WAPA-CRSP, but not publicly published. Table 4 summarizes the metrics and frequency of data collection for power costs.

Table 4. Metrics and frequency of data collection for power costs.

Objective	Parameters	Methods	Location(s)	Frequency	Accuracy & Precision
Monitor monthly energy generation	MW	SCADA	SCADA Phoenix – Dumped Energy Management System (ISA)	Hourly	N/A
Monitor hourly power market price	$/MWH	WAPA Energy Tracking Database (ISA)	WAPA – Montrose	Hourly	N/A
Monitor monthly firming power purchases	$ and MW purchased	WAPA Energy Tracking Database (ISA)	WAPA-Montrose	Monthly	N/A
Monitor monthly Basin Fund Balance	$	WAPA Energy Tracking Database (ISA)	WAPA-CRSP	Monthly	N/A

Data Sources

Energy generated: The SCADA system that measures generation at GCD is reported to a database that is accessible by the WAPA Phoenix office. Currently, those data are dumped into the CRSP-Montrose office ISA, and from ISA monthly generation is calculated by summing all the hourly values. Hourly generation totals are not currently reported but can be accessed by WAPA-CRSP or WAPA-Montrose. For the purposes of this project, hourly data will be reported.

Hourly market prices: Market prices vary at different purchase points throughout the system. The price that WAPA-Montrose pays for power is pertinent to WAPA and its customers. This value is available only for the hours in which WAPA buys or sells power; therefore, the dataset is incomplete. If complete data is needed by WAPA-Montrose, they may look at the Dow Jones for a representative point of sale and record that data price. These data can be accessed via the Web and reported to an Excel spreadsheet if access is requested and granted by WAPA-Montrose.

Basin fund balance: The financial manager for the CRSP office completes an end-of-month cash balance and Basin Fund balance report found on WAPA's Web site. The reports are usually completed by the 15th of the month. These data will be for the previous month's billing on the 2 months previous services.

Monthly firming purchases: These data are found in the WAPA-Montrose TDB database. Purchases made by WAPA for customers are reported by the 10th of the following month, broken out by customer (purchased from). This report is sent to WAPA and can be made available.

Links/Relationships to Other Projects

This project is specifically related to the current overall long-term planning needs of the GCDAMP.

Products/Reports

Hourly data will be collected by WAPA and delivered to the GCMRC on a daily basis. These data will be served through the GCMRC Web site. Monthly data will be delivered to the GCMRC at the conclusion of each month.

Budget

HYD 10.M1.09	
Monitor Power Generation and Market Values under Current and Future Dam Operations (FY2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

* GCMRC salaries are for setting up Web site and connections to receive and deliver the data.

GCDAMP Goal 11: Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.

CUL 11.R1.09: Research and Development towards Core Monitoring, Phase II

Start Date

October 2005

End Date

September 2011

Principal Investigator(s)

Individual tasks are being accomplished using a combination of Grand Canyon Monitoring and Research Center personnel, National Park Service staff, and various outside cooperators. It is anticipated that the National Park Service will assist with collecting the field data in FY2009.

Geographic Scope

Colorado River ecosystem as defined in the Glen Canyon Dam Adaptive Management Program Strategic Plan

Project Goals

The goal of this project is to develop an interrelated suite of objective, quantitative monitoring protocols suitable for the logistically challenging field setting of Grand Canyon National Park to be applied in a routine, systematic manner in order to determine effects of Glen Canyon Dam operations on historic properties and other cultural resources valued by the American people. The monitoring program is also being designed to (1) generate data useful for studying effects of experimental flow and non-flow actions on cultural resources in the CRE; (2) provide data suitable for informing and/or building future geomorphic models, and (3) provide data useful for determining future treatment needs at archaeological sites and choosing the most effective treatment methods, regardless of the ultimate cause of the deterioration.

Need for Project

The FY2000 cultural PEP recommended redesigning the 1999–2000 programmatic agreement monitoring program to focus more specifically on tracking effects of dam operations and evaluating the efficacy of erosion control efforts (Doelle, 2000). Subsequently, the Science Planning Group (SPG) and Cultural Resources Ad Hoc Group (CRAHG) redefined the primary core-monitoring need for historic properties to track status and trends of site condition and integrity through monitoring rates of erosion, visitor impacts, and other variables or processes known to affect archaeological site condition. This project is exploring and testing various options for measuring

change and achieving these defined monitoring objectives, before they are implemented as part of a long-term core-monitoring program.

Given that Grand Canyon is one of the classic erosional landscapes of the world, and geomorphic data as well as empirical observations show it continuing to evolve, some degree erosion of unconsolidated deposits in the Colorado River corridor and the cultural resources they contain is inevitable. Nonetheless, many cultural resources are being damaged by rapid gully erosion, and recent studies have shown that erosion of the sediment that forms the context of cultural sites has increased in the past few decades (Hereford and others, 1993). Several hypotheses have been proposed to explain this purported increase in erosion, including removal of sediment and lack of replenishment due to dam operations, secondary effects from visitation, and climatic factors. Regardless of what ultimately causes change in resource condition, the AMP is charged with tracking the status and trends of resources in the CRE, evaluating effects of dam operations, and preserving National Park resources, therefore, development of an accurate, reliable, and objective monitoring program to track the amount and rate of change occurring at cultural sites in the CRE is a key need of this program.

Strategic Science Questions

This research and development project, and the future cultural monitoring program, is designed to addresses two primary SSQs:

> **SSQ 2-1.** Do dam-controlled flows affect (increase or decrease) rates of erosion, and vegetation growth, at archaeological sites and TCP sites in the CRE, and if so, how?
>
> **SSQ 2-4.** How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term?

Information Needs Addressed

This project is a research and development effort aimed at addressing the highest priority CMIN for historic properties (as revised by the CRAHG and SPG in fall 2005), specifically, the properties known as archaeological sites:

> **CMIN 11.1.1 (**SPG revised**).** Determine the condition and integrity of prehistoric and historic sites in the CRE through tracking rates of erosion, visitor impacts, and other relevant variables. Determine the condition and integrity of TCPs in the CRE.

This project also directly addresses EIN 11.1 (formerly CMIN 11.1.2 of the GCDAMP Strategic Plan renumbered by CRAHG/SPG as EIN 11.1):

> **EIN 11.1.** Determine the efficacy of treatments for mitigation of adverse effects to historic properties.

This project also addresses an AMP research IN (no number) (formerly identified as CMIN 11.1.4 in the GCDAMP Strategic Plan):

> How effective is monitoring, what are the appropriate strategies to capture change at an archaeological site—qualitative, quantitative?

General Methods/Tasks

This cultural monitoring project is part of a phased program of research and development towards implementation of a long-term core-monitoring program. The first phase of this project (Phase I) began in the spring of 2006 and focused on completing a comprehensive assessment of the geomorphic and archaeological attributes of sites to

aid in the development of the long-term monitoring approach. It also involved testing a variety of survey techniques for objectively measuring change in resource condition.

When the project was initially conceived, Phase I was intended to continue for 2 years (FY2006–2007), and FY2008 was intended to be the first year of a 3-year monitoring cycle employing the refined protocols developed during the preceding phase. However, a later than anticipated start in 2006, coupled with the High Flow Experiment in 2008, delayed the project schedule by approximately 8 months. Therefore, 2008 became a transitional year in which we continued to build on several research and development activities initiated in FY2006, including (1) continuing to gather data on several short-term, small-scale studies to evaluate the effectiveness, efficiency, and accuracy of various field measurement techniques before implementing them as part of a long-term monitoring program (including weather monitoring, LiDAR mapping, and thalweg survey measurements at a subset of sites); (2) compiling, analyzing, and preparing reports on all the data collected during the previous 2 years of field work; and (3) compiling and evaluating legacy data needed for assessing geomorphic characteristics related to site stability and preparing the foundation for the future monitoring program.

In FY2009, we will begin to implement the pilot monitoring program. The scope of this project encompasses the full range of archaeological resources in the Colorado River corridor during the time of human occupation. The actual number of archaeological sites that will be included in the pilot monitoring program will be determined upon completion of the data analysis phase of this project (currently underway). The ultimate outcome of this research and development effort will be a final report with specific monitoring protocol recommendations. The program will ultimately be subject to a final review by a PEP in FY2011, with additional refinement of protocols (if necessary) before being implemented as the long-term program.

Specific tasks that will be undertaken in FY2009 as part of Phase II include the following:

Continue to Monitor Topographic Change and Establish New Baseline Topographic Records

In FY2009, we will continue to develop baseline data needed for tracking topographic change at archaeological sites using a combination of conventional total station mapping (or RTK GPS) for gully surveys and ground-based high-density LiDAR data for site surfaces at a sample of study sites. Total station ground surveys will be directed by either GCMRC personnel or cooperating scientists following methods employed by previous GCMRC researchers for capturing topographic changes using high-density data collection methods (e.g., Yeatts, 1996; Hazel and others, 2000; Pederson and others, 2003). LiDAR data will be manually edited and filtered to produce a “bare-earth” terrain model without reflections from vegetation canopy.

Weather Monitoring

In FY2007, 10 weather stations were established at 8 study sites in the CRE. The study sites include the same ones where gully measurements and LiDAR surveys are occurring, plus two additional sites. In FY2008, three additional stations, plus additional sand traps were installed to capture additional data related to the 2008 HFE. In FY2009, these stations will continue to collect data on precipitation amount and intensity, wind direction and velocity, temperature, humidity, barometric pressure, and sediment transport rates. Because of the spatially isolated nature of monsoon thunderstorms and the significant role that precipitation and wind play in downcutting and backfilling gullies, weather stations and sand traps have been distributed throughout the length of the river corridor, in proximity to several sites that will continue to be monitored periodically in future years, so that changes detected from repeat topographic mapping can potentially be related to timing and duration of local or regional weather events. Equipment maintenance, data collection, and sediment sample processing tasks are being managed internally by the GCMRC; data processing and analysis will be handled through an internal USGS sub-allocation to USGS Western Coastal Geology and Marine Division.

Supplementary Site Condition Evaluations

Concurrent with the topographic monitoring work, data will be collected on surface indicators of condition using a standardized recording format. These data will document a combination of indicators that reflect both geomorphic and human agents of change affecting site condition in the CRE. The specific recording formats will vary, depending on the type of site being monitored.

Geomorphic Data Compilation and Workshop

In FY2008, as part of the legacy data analysis component of this project, GCMRC initiated an extensive review and re-assessment of all existing geomorphic data related to the Holocene deposits in the CRE in anticipation of bringing these legacy data together in a single GIS layer. Previously, in September 2007, an independent panel of scientists had strongly recommended that any future monitoring program should be structured in relation to a model that has the capability to predict site vulnerability to future deterioration. Other independent scientific panels had made similar recommendations in the past, either by recommending development of quantitative geomorphic models (geomorphology symposium panel, 2005) or maps of the Holocene deposits (cultural PEP panel, 2000) to help inform the future cultural resources monitoring program. GCMRC staff concluded that a comprehensive assessment of existing geomorphic data was the first step needed, and this exercise is currently (FY2008) underway. While still in progress, it is clear from the analysis conducted to date that additional work is needed in FY2009 to bring existing legacy together in a format that will be useful for developing the long term monitoring plan. Therefore, in FY2009 we are directing a small portion of the cultural monitoring research and development budget towards continuing this legacy data compilation, part of which will be used to host a small workshop to resolve issues related to the interpretation and integration of the various geomorphic data sets collected from the CRE over the past 30 years.

Links/Relationships to Other Projects

This project builds upon several past research efforts, including the previous work of Draut and Rubin (2005, 2006), Pederson and others (2003), and Damp and others (2007.) Specifically, it builds upon the work of Draut and Rubin (2005, 2006) by extending the weather monitoring record and measurements of Aeolian sand transport at selected locations in the CRE. It also expands information on gully erosion rates initiated by Utah State University (USU) in FY 2001–2002 and continued in 2006–2007, and it expands on the geomorphic baseline dataset collected for the 151site treatment plan (Damp and others, 2007). This study is also closely linked to the NPS Colorado River Management Plan (CRMP) implementation effort, in that monitoring protocols for assessing impacts of human visitation at archaeological sites are being developed cooperatively with NPS to serve the monitoring needs of both GCDAMP and the CRMP.

Other ongoing projects that have benefited or are likely to benefit from the work being undertaken for the cultural monitoring research and development effort include (1) the integrated flow, temperature and sediment modeling project (currently uses temperature data from the weather stations); (2) the vegetation monitoring program (will use the full suite of weather data for interpreting observed changes in vegetation); (3) the conceptual modeling project (will incorporate data on terrestrial/geomorphic processes); and (4) the geomorphic model project proposed for FY2010–11 (will require specific data on geomorphic processes and rates of change to populate the model.)

Opportunities for integrating the results of this research and development effort with those of the tribal monitoring projects will be explored after completing the initial research and development phase of this project. This delay in integration is necessary in order for the needs and approaches of the tribal monitoring programs and the Federal agencies to be articulated and the appropriate protocols identified. Integration of monitoring efforts, as appropriate, will occur during implementation of the pilot monitoring phase (FY2009−11).

Products/Reports

Annual reports will be prepared by cooperators during Phase II of the pilot monitoring program. In addition, a synthetic peer-reviewed report summarizing the entire project will be prepared at the conclusion of this study.

Budget

CUL 11.R1.09	
Research & Development toward Core Monitoring (FY2007)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

References

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GCDAMP Goal 12: Maintain a high-quality monitoring, research, and adaptive management program

DASA 12.D1.09: Preparation for Monitoring Data Acquisition (remote sensing)

Start Date

October 2007

End Date

Ongoing to support quadrennial, systemwide overflights

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Thomas Gushue, GIS Coordinator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and Michael Breedlove, Ph.D., Geographer, Utah State University

Geographic Scope

Entire Colorado River ecosystem corridor from forebay of Glen Canyon Dam to upper Lake Mead

Project Goals

Conduct aerial overflight to acquire digital imagery of the CRE: mission planning, contract solicitation, mission execution, and support.

Need for Project

This year will see a quadrennial overflight. The airborne data to be collected are multispectral orthorectified images of the CRE. Area and volumetric analysis of these datasets are used to identify and classify elements of interest. Comparison of datasets acquired over time allow for change detection as long as the data continue to be collected. Airborne data is the basis for many of the science questions and research activities conducted in the Grand Canyon. Sandbar habitat change including vegetation encroachment, shoreline location and character at different flow regimes and the distance to cultural sites, backwater existence and changes, and maps used for positioning GCMRC monitoring areas are a few of the applications of airborne data.

A primary fiscal objective is to reserve sufficient funding to cover mission costs during implementation. No salaries are funded for this project; work performed will be addressed by GIS personnel funded by the GIS General Support Project (DASA 12.D5.09). Due to the dependent nature of remote-sensing and GIS technologies, products described in this project will result from a combination of efforts across multiple DASA projects.

Strategic Science Questions

Some of the resource areas and science questions identified during the 2005 Knowledge Assessment and found within the GCMRC's Strategic Science Plan and Monitoring and Research Plan (see appendix A) that can be addressed with airborne image data include those listed below.

Additional SSQs addressed:

SSQ 4-1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 2-2. How do flows impact old high-water zone terraces in the CRE (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits?

SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Information Needs Addressed

Numerous GCDAMP goals and resource area programs that are concerned with remote-sensing analysis are the chief beneficiaries.

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

CMIN 4.1.6. Determine quantity and quality of spawning habitat for RBT in the Lees Ferry reach as measured at 5-year intervals.

CMIN 6.1.1. Determine and track the abundance, composition, distribution, and area of the marsh community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

CMIN 6.4.1. Determine and track composition, abundance, and distribution of the sand beach community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.

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 ROD operations (1996)?

RIN 8.6.1. How do ongoing inputs of coarse-sediment from tributaries influence storage of fine sediment within pools, runs and eddies throughout the CRE?

EIN 4.1.1. How does RBT abundance, proportional stock density, length at age, condition, spawning habitat, natural recruitment, whirling disease and other parasitic infections change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 6.1.1. How do marsh community abundance, composition, distribution, and area change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 6.4.1. How do the abundance, composition, and distribution of the sand beach community change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 9.3.1. How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

In total, approximately one-third of the GCDAMP information needs may be directly or indirectly addressed through analysis and use of the systemwide digital imagery.

General Methods/Tasks

- Efforts will be focused on obtaining a contractor that can provide greatest accuracy, greatest number of spectral bands, and a variety of onboard imaging instruments. Delivery of orthorectified images is expected early in FY2010.
- A data collection permit must be reviewed and updated through Grand Canyon National Park to reflect the types of remote-sensing technologies that will be required to help fulfill the core-monitoring and experimental research needs for all GCMRC programs.
- DASA and Survey support will include deploying Rim GPS Reference points during overflight.

Links/Relationships to Other Projects

Acquisition of systemwide digital images in this project supports addressing numerous resource questions within other programs, such as abundance and systemwide distribution of both aquatic and terrestrial habitats related to fish, vegetation, and availability and status of campsites along the CRE. The digital products procured by the DASA directly support a varied array of projects within GCDAMP goals 1–11, such as detecting shoreline habitat and changes tied to dam operations and high-flow tests. Additionally, these data are used in terrestrial vegetation and sandbar mapping projects for determining surface texture and land cover classifications within designated study reaches, as well as canyonwide over subsequent years following the overflights (trend analysis).

Products/Reports

Datasets are expected in early FY2010

Budget

DASA 12.D1.09	
Preparation for Monitoring Data Acquisition (Remote Sensing; FY2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	—

DASA 12.D2.09: Grand Canyon Integrated Oracle Database Management System

Start Date

October 2007

End Date

Ongoing

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and Paul Alley, Database Administrator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead

Project Goals

The goal of the database management system at the GCMRC is to provide an organized, secure, and readily available electronic repository for all scientific data collected in the ongoing research and monitoring activities of the center. The Relational Database Management System (RDBMS) also serves as the electronic storage foundation of GCMRC's GIS, providing the repository for all aerial photography, survey control, and geographic layers. The program is therefore a vital component of the decision support process and for the adaptive management of the GCD.

Need for Project

This project establishes the electronic repository and tools necessary to analyze and interpret scientific data collected by the center, thereby providing a fundamental support service to GCMRC scientific investigations and decision support processes.

Strategic Science Questions

This project provides the foundation for all projects concerned with scientific data analysis.

Information Needs Addressed

Provides access for analysis for all GCMRC datasets

RIN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

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?

General Methods/Tasks

Working with data stewards from each scientific program at the GCMRC, the integrated database design will be extended in modular fashion to accommodate both newly collected data, such as with aquatic food base monitoring, and legacy data that have yet to be imported into the RDBMS. This process involves extensive review of existing datasets as well as current data collection protocols, and the information needs of each discipline. As these information needs are fully understood by programming staff, applications will be written that enable users to extract related datasets from the RDBMS and perform appropriate analyses. Generally these applications are written with a Web or Windows Application interface.

The following are core tasks that will continue during FY2009:

- Electronically archive all incoming datasets in their original form.
- Error check and import newly collected datasets to the centralized RDBMS.
- Administer database, including backup, recovery, and security.
- Continue to consolidate and import legacy data to the system.
- Continue to support data acquisition, import, and analyses by disciplines such as fish and water sampling in the Colorado River, and survey control.
- Extend database structure to incorporate newly acquired datasets, such as aquatic food base and daily downstream water quality.
- Extend routines to automate the process of error checking and importing datasets.
- Extend Web application architecture to distribute newly collected datasets.
- Provide data analysis support for scientific monitoring and research analyses.
- Integrate tabular and spatial datasets in conjunction with DASA GIS staff

Links/Relationships to Other Projects

Most programs generate datasets that will be archived, served, and analyzed using DASA database services. The best example of the power and utility of the Oracle database is its ability to handle terabytes of data generated in multiple years, such as those data that are associated with system wide airborne digital imagery.

Products/Reports

Database modules and web applications:

- Terrestrial biology
- Kanab ambersnail
- Stanton repeat photography

Applications and Software:

- DASA Data-Sync application with duplicate record checking / prevention
- Mark – Recapture specimen tag synchronization

If above products completed ahead of schedule, the following products will be produced as time permits:

Database modules and web applications:

- Survey control points
- Integrated tabular/GIS data query tools

Applications and Software:

- Field-based electronic data collection system(s) for Near Shore Ecology
- Supplement DASA Data-Sync application with additional validation and error checking; web delivery of downloadable Metadata
- Develop software for documenting and archiving incoming datasets/reports

Budget

DASA 12.D2.09	
Grand Canyon Integrated Oracle Database Management System (FY2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	—

DASA 12.D3.09: Library Operations

Start Date

October 2007

End Date

Ongoing

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Esther Hamilton, Computer Assistant, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Lindsay Marr, Library Specialist, Northern Arizona University

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area—forebay of Glen Canyon Dam and upper Lake Mead

Project Goals

Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos.

Need for Project

The GCMRC library acts as the physical repository for reports and data generated by GCMRC scientists as well as materials related to the Colorado River, Grand Canyon and Adaptive Management.

Strategic Science Questions

This project provides a research resource to aid in answering science questions.

General Methods/Tasks

The library catalogs all new materials that come from staff scientists, contractors, and cooperators as well as items related to Grand Canyon, the Colorado River, and Adaptive Management. Library staff provides support to cooperators, contractors, and staff scientists by researching and obtaining current and legacy articles and reports related to science projects.

Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos.

Information Needs Addressed

The library provides access to current and historical scientific findings of the GCDAMP.

> **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?

Links/Relationships to Other Projects

This project supports all other projects.

Products/Reports

- Online library catalog which provides access to more than 8,000 publications continually updated
- Catalog records of all materials—continually updated
- Monthly update of new reports received in the library
- Assistance to cooperators, stakeholders, media contacts, and the public by providing access to reports, aerial photos, maps, slides, and photos in hard-copy and digital form
- Research in locating contemporary and legacy materials
- A research facility for researchers, GCMRC employees, cooperators, and the public

Budget

DASA 12.D3.09	
Library Operations (FY2007–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	0%

DASA 12.D4.09: Legacy Analog Data Conversion (Analog to Digital—Reports and Imagery)

Start Date

October 2007

End Date

Ongoing

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and Esther Hamilton, Computer Assistant, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area—forebay of Glen Canyon Dam and upper Lake Mead

Project Goals

The library has undertaken a project to convert all materials in the library to digital format and make them accessible and searchable on the GCMRC Web site. Having materials available through the Web site will allow multiple users to access data concurrently from remote locations as well as protect unique items from damage or loss. Overflight imagery digitally available for spatial analysis will extend the historical spatial record allowing change detection throughout the CRE.

Need for Project

The conversion project will allow for greater access to and protection of legacy and current materials.

Strategic Science Questions

This project provides a research resource for answering spatially defined science questions and extending the period of record of digitally available overflight imagery.

Information Needs Addressed

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

CMIN 6.1.1. Determine and track the abundance, composition, distribution, and area of the marsh community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

RIN 6.1.1. How have 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 6.4.1. How have 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)?

EIN 6.1.1. How do marsh community abundance, composition, distribution, and area change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

General Methods/Tasks

- Scanning and converting paper reports into digital PDF files, making the documents searchable by using optical character recognition software (depending on quality of hardcopy and as time allows), and then posting the files in the library database on the GCMRC Web site
- Scanning all analog aerial film and photos using the Vexcel Ultrascan 5000, allowing the digital results to be used for 2-D and 3-D change detection
- Digitizing flight line maps to provide a searchable mechanism to locate individual scanned aerial photos
- Converting VHS tapes to DVDs
- Scanning legacy slides to create digital images using the Nikon SuperCoolScan scanner

Links/Relationships to Other Projects

This project supports projects concerned with spatial change over time.

Products/Reports

- Access to 17,652 aerial photographs, 9,000 digital aerial images, 8,000 hard-copy reports, 8,000 photos and slides, and 700 videos in broadcast and VHS format. In addition, once the library scanning project is complete, this information will be available in digital format from the library via digital media such as DVD and online via the Web.
- As these conversion products are produced, they are cataloged and made available: see DASA 12.D3.09: Library Operations.

Budget

DASA 12.D4.09	
Legacy Analog Data Conversion (Analog to Digital—Reports & Imagery; FY2007–11)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	—

DASA 12.D5.09: GIS General Support for Integrated Analyses and Projects, GIS Lead

Start Date

FY2007

End Date

Ongoing

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and Thomas Gushue, GIS Coordinator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin

Project Goals

Create specialized maps, advanced spatial analysis, and intuitive data retrieval; and to provide classification, inventory, and change detection of geomorphic, biological, and cultural areas and volumes.

Need for Project

The traditional role of the GIS program is inherently service oriented, providing spatial database development and programming and analysis support to the science programs and their cooperators on both a planned and an as-needed basis. To continue functioning in this capacity it is imperative to factor in designated blocks of time to maintain and in some cases improve the level of GIS support. GIS general support benefits core monitoring, experimental programs, and research and development projects alike in the form of GIS and remote-sensing software installation, maintenance and support, creation and maintenance of spatial databases used by science projects, and the development of mapping and analysis tools for use by GCMRC staff and cooperators across all resource programs. There is also a need for a higher level of support for more specific GIS application development and analysis of available spatial data. This higher level of support is often achieved through automation of data processing and manipulation procedures to standardize and streamline repetitive tasks as well as provide a basis for standard operating procedures. DASA projects: DASA 12.D1.09: Preparation for Monitoring Data Acquisition (remote sensing), and DASA 12.D7.09: Integrated Analysis and Modeling are dependent on efforts from those funded through this project.

Strategic Science Questions

The spatial aspects of Grand Canyon investigations are addressed in this project.

Information Needs Addressed

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

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?

General Methods/Tasks

The collection of spatial data is achieved through a variety of methods that include, but are not limited to, remote-sensing data collection missions, traditional survey and global positioning system (GPS) operations, field mapping using hard-copy map or pen tablet computers, onscreen digitizing using previously collected remote-sensing data as source information, and through other standard data entry methods. Spatial data are generally stored in one of the standard ESRI file types (shape file, coverage, geodatabase) as well as in ASCII format. Methods used for spatial data processing and analysis will vary depending on the questions that need to be answered.

Links/Relationships to Other Projects

Most GCMRC projects have a spatial component tied to the data being collected in support of the science questions developed for each project. The GIS provides a stable platform upon which all data collected along the CRE are catalogued within a consistent spatial reference system. At the most basic level, this allows for the overlaying and querying of datasets collected from any and all projects within the GCMRC.

Products/Reports

As a result of GIS support, a wide range of products will be produced:

- Maps for publications; generation and printing of maps and graphics for posters
- Creation of improved base maps for Lake Powell and Grand Canyon
- Instructional sessions for staff, cooperators, and contractors on GIS layer development, integration and analysis
- Advanced spatial analysis for monitoring projects

Budget

DASA 12.D5.09	
Geographic Information Systems (GIS) Support for Integrated Analyses and Projects, GIS Lead (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	—

DASA 12.D7.09: Integrated Analysis and Modeling (FY2009–10)

Start Date

October 2009

End Date

Ongoing through FY2011

Principal Investigator(s)

Glenn Bennett, Data Acquisition, Storage, and Analysis Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Thomas Gushue, GIS Coordinator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Timothy Andrews, Geographic Information Systems Engineer, Utah State University; and Michael Breedlove, Ph.D., Geographer, Utah State University

Geographic Scope

Entire Colorado River ecosystem corridor between forebay of Glen Canyon Dam and upper Lake Mead

Project Goals

Develop a Near Shore Ecology pilot site selection criteria, rule based Shoreline Habitat Units, and derived statistics. Create an updated baseline bathymetric surface for upper Marble Canyon. This is a new project that builds on a previous project: DASA 12.D6.08 Integrated Analysis and Modeling—Mapping Shoreline Habitat Changes (FY2007–08) where advanced methods and techniques were developed in a research mode to support evaluation of the November 2004 High Flow Experiment at Glen Canyon Dam. This new project shall apply those mapping and change-detection methods and the lessons learned in the prior research and development phase toward collaboration with the Near Shore Ecology studies and toward the long-term sediment monitoring protocols described under Goal 8.

Need for Project

Remote-sensing data are snapshots in time. These data can be analyzed to provide a basis for interpretive studies on change detection. The current focus is to collaborate with two other major biological and physical studies with an array of remote sensing analysis techniques.

Strategic Science Questions

Primary SSQs addressed:

> **SSQ 1-4.** Is there a "Flow-Only" (nonsediment augmentation) operation that will restore and maintain sandbar habitats over decadal timescales?
>
> **SSQ 4-2.** How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

Other science questions:

- What is the rate of change in eddy storage (erosion) during time intervals between BHBFs?
- What are the most appropriate methods for detecting change in shoreline habitat along the entire CRE given the available datasets collected using different technologies (scanned analog vs. digital), different platforms (Leica ADS-40/ISTAR vs. DMC/3001, Inc.), and different image resolutions (30 cm, 22 cm, or 18 cm)? What is the most appropriate scale/minimum mapping unit to map the shoreline habitat for all years in order to support related science questions?
- What level of change can be detected in shoreline habitat using remotely sensed data collected in the past 5 years? What changes have occurred to the shoreline habitat across the CRE in the past 5 years?
- Where have the most significant changes taken place in shoreline habitat along the CRE in the past 5 years, and within which shoreline habitat classes are the most noticeable changes? How does the shoreline habitat relate to backwater environments/habitats? What have been the changes in backwater abundance/size/shape over the past 5 years?
- As historical analog overflights become available in digital format, can the timeline be extended back to previous years?

A time-series comparison of shoreline characteristics may prove quite useful for the following SSQ:

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

Information Needs Addressed

Primary information needs addressed:

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

CMIN 2.1.2 Determine and track recruitment (identify life stage), abundance and distribution of HBC in the mainstem.

CMIN 2.6.1 Determine and track the abundance and distribution of flannelmouth sucker, bluehead sucker, and speckled dace populations in the Colorado River ecosystem.

CMIN 8.2.1. Track, as appropriate, the biennial sandbar area, volume, and grain-size changes outside of eddies between 5,000 and 25,000 cfs stage, by reach.

CMIN 8.4.1. Track, as appropriate, the biennial or annual sandbar area, volume, and grain-size changes within eddies between 5,000 and 25,000 cfs stage, by reach.

EIN 6.4.1. How does the abundance, composition, and distribution of the sand beach community change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

General Methods/Tasks

Advanced remote sensing and GIS techniques will be applied to several datasets. Interaction with GCMRC researchers will guide final products in terms of "cutoff" points for certain physical interpretations.

Task 1: Develop Near Shore Ecology pilot site selection criteria based on Shoreline Habitat.

Task 2: Develop Shoreline Habitat statistics applicable to Near Shore Ecology study.

Task 3: Create updated baseline bathymetric surface for upper Marble Canyon from legacy data to allow for volumetric comparisons in FY10 with channel mapping data collected by PHY 8.M1.09.

Links/Relationships to Other Projects

A number of projects in the past few years have used the shoreline habitat data developed from the March 2000 imagery dataset. Shoreline habitat type has been used in conjunction with native and nonnative downstream fish sampling in the mainstem of the Colorado River, and it has also been used as a guide to delineate sampling sites of redds in Glen and Marble Canyons. Similarly, this data is currently being incorporated into the new aquatic food base initiative at the GCMRC. This layer has also been applied to studies of the terrestrial environment including the vegetation mapping project and initial campsite monitoring efforts conducted over the past 2 years. It is expected that new, more recent classifications will be used in similar fashion for future analysis. With newer tools, it may be possible to more closely relate availability with Catch rates. In the Sediment realm, reworking previously collected multi-beam data to align with the current GCMRC Control Network will allow for change detection in upper Marble Canyon in FY10.

Products/Reports

Spatial databases, spatial analysis results, and associated metadata:

- Surface Habitat classification layers for entire river corridor based on criteria derived from collaborative efforts with the Near Shore Ecology study.
- Surface Habitat classification statistics for entire river corridor based on criteria derived from collaborative efforts with the Near Shore Ecology study.
- Upper Marble Canyon Bathymetric surface edited and aligned with current GCMRC control network.

If above products are completed ahead of schedule, the following products will be produced as time permits:

- Update and extend USU backwater time series through year 2005. GIS polygon layer will represent inventory for interpretable backwater areas from 2002, 2004 and 2005 imagery datasets.
- Nearshore habitat classifications and statistical summaries for selected flow regimes in the CRE between Lees Ferry and Diamond Creek. In order to do canyonwide flow regimes, more stage discharge elevation data are needed for Glen Canyon and western Grand Canyon below Diamond Creek. Currently, Hydrologic Engineering Center River Analysis System (HEC-RAS) cross sections developed by Chris Magirl do not exist for these reaches. Future analysis of flow regimes will be dependent upon need for reprocessing of virtual shorelines for use in statistical summaries of nearshore habitat classifications.

Budget

DASA 12.D7.09	
Integrated Analysis and Modeling—Mapping Shoreline Habitat Changes (FY2009)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	—
DOI customer burden (combined 6.09%, 19% and/or other rates)	—
Project Total (Gross)	—
Percent outsourced (outside of GCMRC; includes 50% of logistics)	—

Logistics, Support, and Control

SUP 12.S1.09: Logistics Base Costs

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

Carol Fritzinger, Logistics and Survey Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin

Project Goals

Provide cost effective, efficient, and complete logistical support for all GCMRC funded projects

Need for Project

The GCMRC will provide complete logistical support for 25 to 40 research, monitoring, and administrative river trips through the Grand Canyon annually. These trips range in length from 7 to 21 days and from 4 to 36 people in size. Trips will utilize a variety of motor- and oar-powered boats operated by contracted boat operators. Projects operating in the Glen Canyon reach of the Colorado River (GCD to Lees Ferry) will be supported by a variety of motor-powered boats operated by GCMRC researchers and contracted boat operators. Additionally, research activities on the LCR and at other locations outside of the Grand Canyon National Park boundaries are supported by helicopter services contracted with Reclamation. Ground-based support for other research activities outside of the river corridor is also coordinated with GCMRC for use of leased vehicles.

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

The GCMRC will use Government-owned boats and river logistical equipment in conjunction with a contracted vendor who supplies technical and logistical boat operators. Put-in and takeout transportation is provided with the use of General Service Administration (GSA) leased vehicles and contracted shuttle drivers.
Effective communication with principal investigators and sensitivity to and awareness of the challenges they face in implementing their studies enable the GCMRC to offer more customized (and therefore more cost-effective

and productive) logistical support than other support strategies utilized previously. Retaining control over the process of supporting trips also facilitates compliance with NPS regulations and allows greater control over issues sensitive to the general public and the "recreational river community."

Links/Relationships to Other Projects

All GCMRC projects which have field data collection components are supported by the GCMRC logistics program.

Products/Reports

Research projects supported by the GCMRC will obtain necessary permits from Federal, State, Tribal, or local agencies in compliance with requirements of the location in which project activities are conducted. Research activities conducted within Grand Canyon National Park and Glen Canyon National Recreation Area require NPS Research and Collecting Permits and Access Permits for all river launches, back country use, overflights, and media (filming) production. All NPS permits acquired for GCMRC supported projects are processed and submitted by the GCMRC Logistics Coordinator to the NPS Science Center Research Permitting Coordinator.

Budget

SUP 12.S1.09	
Logistics Base Costs (Other costs dispersed throughout projects; Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

SUP 12.S2.08: Survey Operations

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

Keith Kohl, Grand Canyon Monitoring and Research Center, U.S. Geological Survey

Geographic Scope

Survey operations occur throughout the CRE in support of scientific activities.

Project Goals

We must supply GCMRC principal investigators with all necessary information, equipment, and survey knowledge to address their scientific needs. In some cases, that means performing all collection, processing and documentation of all spatial data required by their research. The principal investigators and researchers must be educated regarding the limits of various mapping techniques. Datasets used for change detection analysis must be conscientiously evaluated for accuracy and blunders so as not to skew scientific analysis and resulting decision making.

Need for Project

Spatial measurements are required for any long-term monitoring program. The measurements are made using a variety of survey methods and stored in a variety of formats. All measurements reference a position of greater confidence whether the measurement is made using the Global Positioning System (GPS), Light Detection and Ranging (LIDAR), digital or analog imagery, conventional survey angles and distances to reflective prisms, or sub aqueous bathymetry. With consistent reference, and explicit protocols, the survey operations program ensures the integrity of spatial data sets, which increases confidence in scientific analysis.

Strategic Science Questions

Many strategic science questions require stage discharge relationships to determine inundation extents under various flows. These relationships must be collected in the field using consistent survey methods and be referenced to validated control. Answers to questions relating to habitat (e.g. sand bar, sand terraces, old and new high water zones, reach morphology, etc) will all require survey measurements. All SSQ's addressed in projects supported by Survey Operations are applicable.

Information Needs Addressed

Accurate and consistent spatial positioning of scientific data is necessary for facilitating change detection. Change detection methods are applied to spatial data collected within the cultural, biological, and physical programs to determine impacts on habitat, validate models, and determine fine and course sediment storage. Survey protocols

also provide spatial data as the foundation of the GIS database. All information needs addressed in projects supported by Survey Operations are applicable.

General Methods/Tasks

Survey marks are typically stable positions (referred to as survey marks, survey monuments, control points, stations, etc) on bedrock or large boulders with positions preserved by chiseling or scribing marks, or by physical attachment of foreign substances (nails, caps, screws, bolts, rebar, etc.). These stations were placed in a manner that allows for tripods and conventional or GPS survey equipment to set up over the control point. The points that are occupied regularly are located above the stage reached by the flow of 30,000 cubic feet per second (ft3/s) and have fair but diminishing line of sight due to expanding vegetation. Some stations may be lower in elevation and are occasionally inundated by water during normal dam operations. The survey marks are reference for measurements of:

- sandbar sites located throughout the CRE- many of which have a spatial dataset of topographic and bathymetric data collected at least once per year since 1990
- long term monitoring reaches where topography, bathymetry, lidar, digital imagery were collected between 2000 and 2008
- line-of-site stations between Glen Canyon Dam and Bright Angel Creek, plus 15 miles of traverse points from Blue Springs to the LCR/ CR confluence. The traverses used acceptable distances for conventional optical equipment (typically 600 meters and consistently less than 1000 meters)
- photo-identifiable fixed points
- cultural sites including locations of features, artifacts, erosion controls
- USGS stage gages 09380000 :"Colorado River at Lee's Ferry" and 09402500 "Colorado River near Grand Canyon"
- instrumentation sites (weather, LISST, Acoustic Doppler, water quality, pump samplers)

Links/Relationships to Other Projects

Any and all spatial data collection required by GCDAMG is supported through this program.

Products/Reports

Control monuments are established at consistent intervals throughout the CRE and at locations required for accurate positions and elevations of past, current, and future datasets. Stable control monuments and accurate coordinates should be completed prior to spatial data acquisition to reduce post processing efforts, conserving considerable manpower. Documentation of station information, coordinate history and network accuracy are provided. Current and historical datasets are accurately prepared for integration into the GIS database.

Budget

SUP 12.S2.09	
Survey Operations (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

SUP 12.S3.08: Control Network (Ongoing)

Start Date

Ongoing

End Date

Ongoing

Principal Investigator(s)

Keith Kohl, U.S. Geological Survey, Grand Canyon Monitoring and Research Center,

Geographic Scope

Geodetic control now encompasses the entire Colorado River ecosystem corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin.

Project Goals

The objective of this effort is to 1) document methods and results of the geodetic control network developed within Grand Canyon's Colorado River ecosystem (CRE), 2) maintain the integrity of the network and all future spatial data referenced to the network by proposing data collection, processing, adjustment and documentation standards, 3) provide reference and methods for consistent and accurate error determination for several spatial data measurement types, and 4) provide valid reference for emphasis on spatial data collection and evaluation of remote sensing surveying techniques for river monitoring.

Need for Project

According to Executive Order 12906 (OMB< 2002), federal agencies must: 1) prepare, maintain, publish, and implement a strategy for advancing geographic information and related spatial data activities appropriate to their mission, 2) allocate agency resources to fulfill the responsibilities of effective spatial data collection, production, and stewardship, and 3) coordinate and work in partnership with federal, state, tribal and local government agencies, academia and the private sector to efficiently and cost-effectively collect, integrate, maintain, disseminate, and preserve spatial data, building upon local data wherever possible, 4) use Federal Geographic Data Committee (FGDC) data standards, such as the Geospatial Positioning Accuracy Standards and the Content Standard for Digital Geospatial Metadata, and other appropriate standards to ensure all relevant data and metadata are appropriately documented before finally making the metadata available to the public online. These standards include publications on reporting methodology, standards for geodetic networks, and the National Standard for Spatial Data Accuracy (NSSDA). It is the purpose of this effort to document adherence to these standards and add recommendations that will ensure policy decisions based on long term monitoring data and analysis are based on accurate and quality assured datasets.

Strategic Science Questions

Many strategic science questions require stage discharge relationships to determine inundation extents under various flows. These relationships must be collected in the field using consistent survey methods and be referenced to validated control. Answers to questions relating to habitat (e.g. sand bar, sand terraces, old and new high water zones, reach morphology, etc) will all require survey measurements. All SSQ's addressed in projects supported by Control Network Operations are applicable.

Information Needs Addressed

Accurate and consistent spatial positioning of scientific data is necessary for facilitating change detection. Change detection methods are applied to spatial data collected within the cultural, biological, and physical programs to determine impacts on habitat, validate models, and determine fine and course sediment storage. Survey protocols also provide spatial data as the foundation of the GIS database. All information needs addressed in projects supported by Control Network Operations are applicable.

General Methods/Tasks

The geodetic control network establishes the foundation for all spatial measurements within the CRE. The survey stations are all referenced to the most accurate and up-to-date coordinates available; designated as NSRS2007. This is the most recent realization of the North American Datum of 1983 as determined in a multi-year nationwide readjustment performed by the National Geodetic Survey (NGS) and completed in 2007. These stations provide the primary reference for both kinematic GPS positioning of aircraft during remote sensing flights, and static GPS surveys to hundreds of monuments along the river corridor. This consistent framework allows for accurate and reliable accuracy assessment of all spatial data collected within the CRE, and assures the integrity of spatial analysis and resulting management decisions.

Links/Relationships to Other Projects

Any and all spatial data collection required by GCDAMG is supported through this program.

Products/Reports

We will work with GCMRC staff to identify realistic and achievable accuracies using existing technologies and theory. This will also include meeting with GCMRC scientists to establish accuracy requirements that are appropriate for supporting CRE scientific investigations.

We will generate a comprehensive report on the survey control network. The report will include collection and processing methodologies, analysis and discussion of results, accuracy validation per FGDC requirements, and recommendations for ensuring the network meets the positioning needs of GCMRC for current and future scientific endeavors.

Budget

SUP 12.S3.09	
Control Network (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

Reference

Office of Management and Budget Circular A-16 (2002) National Spatial Data Infrastructure [available online at *http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html*

PLAN 12.P1.09: Enhancing the Grand Canyon Ecosystem Model (GCEM) to Identify Critical Ecosystem Interactions and Data Gaps

Start Date

October 2007

End Date

December 2009

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead (emphasis in 2008-09 will be on review and revision of submodels dealing with aquatic ecosystem interactions, with next phase to emphasize landscape evolution pertaining to interactions with the terrestrial ecosystem environment)

Principal Investigator(s)

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Dr. Carl Walters, University of British Columbia

Project Goals

In FY2007–09, the GCMRC will continue to work with the SAs to identify and incorporate more robust integrated ecosystem science approaches into its overall program effort. The first step will be to evaluate redesign and expansion of the ecological model originally developed for the Colorado River ecosystem in the late 1990s – Grand Canyon Ecosystem Model (GCEM) (Walters and others, 2000). The 2008 effort was temporarily delayed owing to implementation of the 2008 High Flow Experiment, but efforts were resumed in summer and fall 2008. A list of priority topics associated with advancing the GCEM model include:

- Review of potential for expanding the fishery elements to address coldwater and warmwater fish predation on HBC, YoY, HBC habitat use, etc., through use of EcoPath/EcoSim methods,
- Review and explore advanced modeling approaches pertaining to nonflow management activities (i.e., operation of a temperature control device, mechanical removal of nonnatives, translocation efforts for HBC, tributary sediment triggers for high flow experiments),
- Explore strategies for more effectively linking Lake Powell water quality monitoring and modeling with downstream temperature simulations, as well as relationships to fine sediment, food web, and fisheries submodels; including discussions to support the use of climate change input data that might drive advanced ecosystem simulations,
- Financial impact simulations coupled to the flow/dam operations submodels,
- Scoping of possibilities and needs associated with expanding the GCEM to provide a broader landscape perspective by incorporating Lake Powell, the Lower Colorado River, and Paria River, and addressing relationships to terrestrial habitats in the CRE,
    - Recreational use and campsite size/abundance/distribution,
    - Cultural site change and protection strategies (archaeological sites, TCPs).

The GCMRC has worked with the Science Advisors to explore options for enlisting the involvement of a senior ecosystem scientist. During summer 2008, GCMRC took the first steps toward recruiting a part-time ecologist to work with GCMRC staff and cooperators to develop and implement an integrated, interdisciplinary ecosystem science program. The initial efforts of the senior ecologist in 2008−09 will be to: 1) actively participate in synthesis efforts related to the 2000 Low Summer Steady Flow experiment (LSSF), 2) assist GCMRC with integrating SA recommendations into the new research initiative on Near Shoreline Ecology Studies, and 3) to lead the GCEM review process with GCMRC staff and key cooperators. This three-fold strategy for enlisting a senior ecologist will initially focus on the aquatic ecosystem and will embrace the SA's proposal to promote any opportunities for incorporating an ecosystem science approach into the current science program. In 2009−10, additional efforts will be planned for expanding the previous GCEM efforts into more of a landscape-scale ecological modeling approach – specifically with a focus on cultural and recreational uses and terrestrial and aquatic interactions.

Need for Project

Developing ecological submodels provides a forum for scientists and resource managers to summarize our current understanding of ecosystem or community function, or species life history, clarify likely responses to management actions and pressures (i.e., stressors, causes of change, Atkinson and others, 2004). In 1998, Walters and others (2000) conducted Adaptive Environmental Assessment and Management Workshops to assist Grand Canyon scientists and managers in development of a conceptual model of the CRE affected by dam operations. The GCEM proved to be useful at helping to reveal the complex relationships among various ecosystem components, identify knowledge gaps and monitoring needs, and demonstrate the difficulty in predicting some ecosystem responses to certain flow policies (thermal modification through implementation of multi-level intake structures at the dam to promote warmer releases) or other influences, such as introduction of exotic species. The inability of GCEM to predict key policy outcomes on several key areas such as long-term sediment storage, fisheries response to habitat restoration, and socioeconomic effects, was important as a means of informing resource managers about which longer-term field experiments were priorities. Following a decade of expanded monitoring and field experimentation, a detailed review of the original GCEM (data and methods formerly used in its development) is needed to advance the GCMRC's ecosystem science planning processes. The review is also intended to familiarize the current stakeholder group with how GCEM was developed and how it might continue to be improved and used by scientists and managers to address strategies for achieving high-priority GCDAMP goals and answering strategic science questions.

Strategic Science Questions

The ecological modeling efforts will be directed at addressing priority AMWG questions and information needs and related SSQs in an integrated modeling effort.

Information Needs Addressed

N/A

Link/Relationship to Other Projects

One of the primary purposes of the GCEM is to identify the linkages and relationships between various ecosystem components. As in the earlier phase (1998−2001), information derived from the modeling review and revision discussions will assist GCMRC in identifying data gaps and critical dependencies between/among science projects and allow for the effective design of an integrated, interdisciplinary science program. Future needs for long and short-term experimental studies, such as those tied to stable flows and high flow tests, will be emphasized; particularly where knowledge assessment indicates that direction of resource response cannot be predicted through simulations for higher trophic level intereactions. The Near Shoreline Ecology studies will be

of particular interest relative to stable flow testing and climate changes that might lead to increased river warming.

General Methods/Tasks

- The GCMRC will work with the SA and TWG to review the current GCEM and identify needed updates and revision (FY2009).
- Modeling meetings will be held to revise/update the various GCEM submodels (using EcoSim/EcoPath and other approaches) to address GCDAMP information needs and to identify data gaps and experiments or research and development projects to fill critical data gaps (FY2009).
- The modeling will be planned and conducted by GCMRC throughout FY2009.
- A part-time ecologist will work with GCMRC staff and selected cooperators to develop and implement an integrated, interdisciplinary ecosystem science program (FY2008–09).

Products/Reports

- Updates and reports to workgroups related to Science Advisors' recommendations and input from senior ecologist for enhancing the GCEM and improving integrated ecosystem science in the GCDAMP.
- A revised and fully documented GCEM (with metadata).
- Report of modeling activities, results, and recommendations related to various submodel revisions. Sediment, temperature and flow will be the initial submodel reviewed with revision set for FY08 and 09.

Budget

This budget includes $50,000 for ongoing part-time support for senior aquatic ecologist.

Plan 12.P1.09	
Review and Enhancement the Grand Canyon Ecosystem Model (GCEM) to Identify Critical Ecosystem Interactions, Identification of Critical Data Gaps and Inform Experimental Design Discussions	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	—
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

Reference

Atkinson, A.J., Trenham, P.C., Fisher, R.N., Hathaway, S.A., Johnson, B.S., Torres, S.G., and Moore, Y.C., 2004, Designing monitoring programs in an adaptive management context for regional multiple speciesconservation plans: U.S. Geological Survey Technical Report, 69 p.

Walters, C., Korman, J., Stevens, L.E., and Gold, B., 2000, Ecosystem modeling for evaluation of adaptive management policies in the Grand Canyon: Journal of Conservation Ecology, v. 4, no.2,http://www.consecol.org/vol4/iss2/art1, accessed May 19, 2008.

PLAN 12.P3.09 Maintain a high-quality monitoring, research, and adaptive management program

AMWG Requested Project—low steady summer flows—data and research compilation, synopsis, and synthesis

Start Date

August 2007

End Date

July 2010 (conducted in phases with specific end dates)

Principal Investigator(s)

Barbara Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, will coordinate the effort with cooperators involved in low steady summer flows data collection, Grand Canyon Monitoring and Research Center Data Acquisition Storage and Analysis Group (DASA)

Geographic Scope

Entire Colorado River ecosystem corridor from forebay of Glen Canyon Dam to upper Lake Mead.

Project Goals

The overall goal of this project is to develop a synthesis of the effects of the 2000 low steady summer flows (LSSF) experiment on the Colorado River ecosystem (CRE) in Grand Canyon. The four phases we will employ to achieve the goal are:

- Phase I. Status of reports/data and synopsis. Identify data and products associated with the 2000 LSSF experiment; synopsize the results of the individual projects (FY2008, draft OFR June 2008, final OFR August/September 2008).
- Phase II. Data evaluation and identification of secondary analyses. Evaluate individual datasets and provide recommendations for further analysis and/or integration of resource responses to operations (FY2008, workshop August 2008).
- Phase III. Synthesis. Use integrated analysis results to develop a synthesis of the effects of the 2000 LSSF Experiment on the CRE (pending recommendations of Phase II workshop).
- Phase IV. Publication. Publication of secondary analysis in a special volume of a journal or USGS circular or other publishing source.

The project outcome is intended to provide managers, and others interested in resource management, with information about how multiple resources respond to a series of flows that varied in duration from several days to several months and in magnitude from 8,000 cubic feet per second (cfs) to 31,000 cfs.

Need for Project

In August 2007 the Glen Canyon Dam Adaptive Management Program Adaptive Management Work Group (AMWG) identified the need to produce a summary document of the effects of the LSSF experiment

(implemented in spring and summer 2000) on resources. The managers requested this summary project so that the results could be used by managers as they implement long-term experiments associated with the Adaptive Management Program for Glen Canyon Dam.

The data collected in association with the 2000 experiment were in the areas of sediment transport and storage, mainstem and shoreline water temperature, small-bodied fish sampling, long-term monitoring methods development for mainstem fishes, vegetation change, and recreational aspects of the varied flows. To date several of the data collection efforts have resulted in data reports or journal publications, while other projects remain incomplete, lacking a final report. A unifying document regarding the flow experiment has been lacking to date due to other funding and administrative priorities (e.g., fish removal experiments, long-term planning documents). The lack of such a document may be perceived as an impediment to learning and applying this knowledge in an adaptive management setting. It is for this reason that a summary document is being proposed that synopsizes individual resource response and considers collective resource responses within an ecosystem framework to create a subsequent synthesis.

Strategic Science Questions

The LSSF experiment was expected to affect and possibly show benefit to multiple resources in the CRE. Similarly, there are multiple SSQs, developed as guidance for GCMRC after the LSSF, that pertain to the flow experiment. The summary project will investigate whether, and to what degree, these SSQs were addressed by the 2000 LSSF experiment. Those SSQs most pertinent to the LSSF experiment are listed below.

SSQ 4-1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Information Needs Addressed

Information needs that pertain to work done during the LSSF are focused on experimental information needs for each resource. Specific information needs that focus on adaptive management and that are pertinent to the proposed project are the following:

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

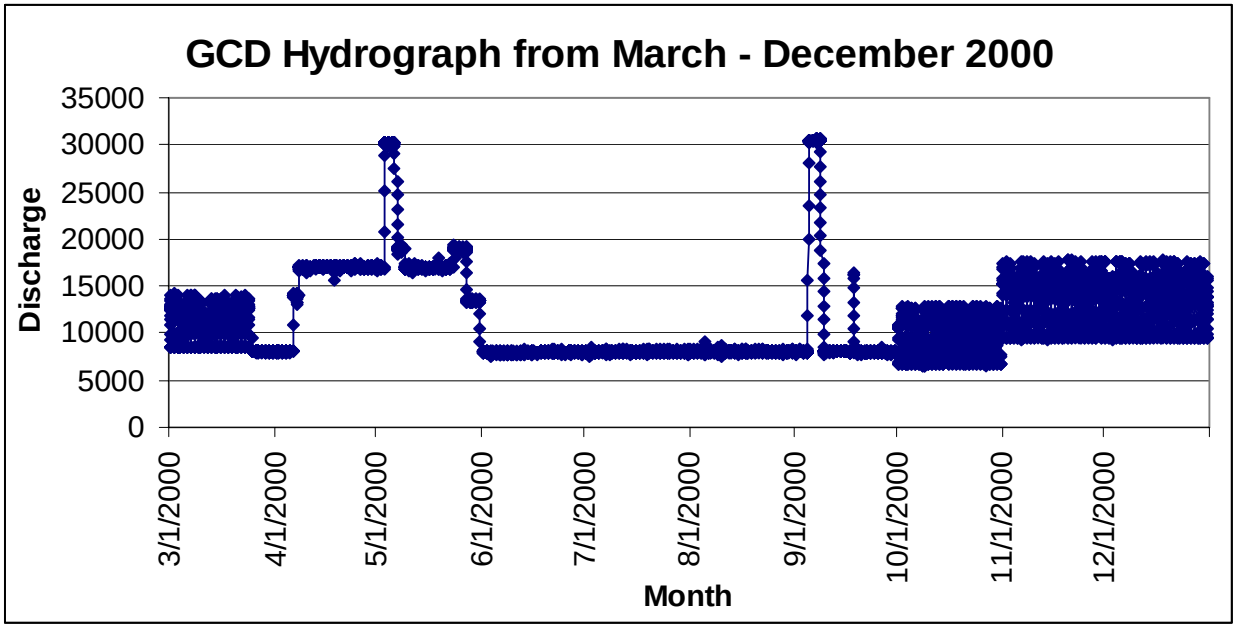
RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

General Methods/Tasks

As a part of the 1995 biological opinion (US FWS, 1995) on the operations of the Glen Canyon Dam, the USFWS provided reasonable and prudent alternatives (RPAs). One element of the RPAs directed Reclamation to initiate a program of experimental dam releases consisting of high steady spring flows and LSSFs. The intention of these experimental releases was to move toward the removal of the jeopardy opinion for humpback chub in the CRE.

A plan of flows was developed by SWCA Environmental Consultants, Inc. (SWCA, 2000). The plan divides the flows into three time periods: March–May (high flows of 21,000 cfs with a 31,000-cfs spike), June–September (steady flows of 8,000 cfs, ending with a 31,000-cfs spike), and October–February (8,000-cfs flows). The flows that were implemented in spring 2000 were slightly different in that the high flows in the spring were a slightly lower discharge of 17,500 cfs rather than 21,000 cfs, and the duration of the flows was shorter by approximately a month in the beginning and by 5 months in the end, ending in September rather than February (figure 3).

Figure 3. Hydrograph from March–December 2000 including discharge pattern associated with the LSSF experiment.



Data collected around these flows focused on physical resources (sediment, water temperature), biological resources (aquatic productivity, fisheries, vegetation), and cultural resources (recreation, economics). SWCA (2000) provided some hypotheses regarding the benefits and risks to abiotic and biotic resources relative to each flow period (table 5). It is proposed that these hypotheses form the basis for data consolidation, synopsis, secondary analysis, and subsequent synthesis.

Table 5. Hypothesized effects of flows on physical and biological resources.

Benefits/risks to resources	*Period I: March–May*	*Period II: June–September*	*Period III: October–February*
Benefit to	–Scouring backwaters	–Storing of sand and	

physical resources/ habitat	–May spike flow to mobilize and store sands and sediment	sediment in river channel –Expansion of campable beach area –September spike flow –Resuspension, storing of sand from summer tributary inputs	
Risks to physical resources/ habitat	–Export of sediment, reduction of campsite areas	–September spike flow, export of sand and sediment instead of storing it	**–No significant risks**
Benefits to biotic resources	–Ponded tributary inflows as thermal refuges for drifting larvae and young fish –Ponded tributary inflows ease access for spawning native fishes –Destabilizing of habitats to disadvantage nonnatives –Redistribution of nutrients –Resetting of community production –Spike flows to flush nonnative fish from nearshore habitats	–Increased growth and survival of young native fishes –Increased autotrophic algal and macroinvertebrate production –Possible mainstem hatching success –Spike flows to flush nonnatives fish from nearshore habitats	**–Increased survival of young native fishes** **–Maintenance of stable winter conditions to minimize energy expenditure** **–Maintenance of overwinter autotrophic production in mainstem, shorelines, backwaters**
Risk to biotic resources	**–Attraction of nonnative fish predators/competitors to ponded tributaries**	**–Mainstem reproduction by nonnative fishes** **–Increased growth and survival of nonnative fishes** **–Increased infestation of parasites and diseases** **–Decreased drift of food for fish** **–Minimized thermal plume at 30-mile may reduce survival of young HBC** **–Increased water clarity leading to increased predation of native fish by sight predators**	**–Possible overwinter survival and expansion of nonnative fishes** **–Possible greater spawning success of downstream populations of trout** **–Increased predation by sight feeders** **–Decreased drift of food for fish**

Status of Project

Phase I. Status of reports/data and synopsis (FY2008)

- Identification of studies in LSSF plan—Completed studies and metadata regarding overflights conducted throughout the period of March through September provided in a summary document. The document, intended as a USGS Open File Report, describes the scope of each completed study and provides recommendations for subsequent analysis. Draft provided in June 2008, finalized in August/September 2008.

- Determination of location of data and other deliverables—call PIs to determine status of project, location of data, and identification of any work that was not done and/or cannot be done and consolidating data. Done in conjunction with summary document.

Phase II. Data evaluation and identification of secondary analyses (FY2008)

- Convene workshop (FY2008, August 2008) to evaluate possibility of subsequent analysis among studies. Workshop composed of LSSF principal investigators (PIs), GCMRC staff, Ecosystem Scientist, Science Advisors and other meta-analysis experts.
- Identification of potential secondary analyses of data including incorporating more recent monitoring and research data to provide longer term analyses of effects.
- Identification of principle investigators available for secondary analysis and collaboration, determination of funding needs and timelines (FY2008, Determined during August workshop).
- Present findings/recommendations to AMWG in September 2008 for FY2009 work plan.
- Pending AMWG recommendations, development of statements of work for subsequent secondary analyses and obligate funds (FY09).

Phase III. Secondary analysis and synthesis (FY2009–10, 15 months)

Recommendations from the workshop may include recommendations for additional analysis associated with some resources (e.g., shoreline infrared overflight data and fish habitat; modeling productivity under steady flow scenarios), and/or finalization of some projects. Collectively the finalized projects and those studies identified for additional analysis could comprise a single peer-review volume similar to that produced for the 1996 Beach Habitat/Building Flow (Webb and others, 1999). At this time, timing of budget development and workshop recommendations precludes providing specific costs, associated with both finalizing reports and potential additional analysis. Current budget estimates are for finalizing reports and publishing in a single document. Outcomes of the workshop may include recommendations for further analysis that will require additional funds. The outcome of the workshop will be presented to the AMWG in September 2008 for the AMWG's consideration of additional funding.

- Present findings/recommendations from August 2008 workshop to AMWG in September 2008 for FY2009 work plan
- Pending AMWG recommendations, development of statements of work for subsequent secondary analysis or project finalization and obligate funds (FY2009)
- Execution of secondary analyses incorporating more recent monitoring data and identification of publishing venue for research (e.g., special issue in Ecological Applications, American Geophysical Union). Collaborators identified in Phase II
- Writing of results and discussion of secondary analyses and conceptual modeling effort to create synthesis document

Phase IV. Publication (FY2010, 3 months)

In coordination with editing staff at the GCMRC/SBSC, complete publication of manuscripts in target journal or circular.

Links/Relationships to Other Projects

Because much of the biological data collected in 2000, in association with the LSSF, represent a single growing season or single cohort, data from subsequent years could be used to understand the effects of conditions in a

single year on recruitment signals or species compositions in subsequent surveys. These LSSF data would be linked to monitoring data from fisheries and vegetation collected since 2000, including using retrospective analysis of imagery to assess change through time.

The sediment response throughout the duration of the project can be incorporated into the current shoreline study project to understand the relationship of reworking eddy sand supply and available shoreline habitats through remote-sensing analysis. In the same vein, water temperature data collected in 2000 is applicable to current water temperature modeling efforts for shoreline habitats. Lastly, recreational aspects associated with downstream travel and visitation could be interpreted under the current Colorado River Management Plan to determine how similar flows, if they occur in the future, might affect recreational experiences.

Products/Reports

- Phase I. USGS open file report providing background information about LSSF, synopses of individual project, metadata, background information about LSSF. Draft submitted by June 2008; Finalized by August 2008
- Phase II. Evaluation of data, identification of potential secondary analysis through workshop bringing together LSSF PIs, SAs and others familiar with meta-analysis. Workshop anticipated in August 2008 to be led by ecosystem scientist. Work plans for secondary analysis. Statements of work established for secondary analysis. Draft report submitted by November 2008; Finalized by December 2008
- Phase III. Initiation of secondary analysis and synthesis (FY 09). Collation of finalized manuscripts reviewed and ready for submission to target journal or circular for publication. Submitted by March 2010 (FY 2010)
- Phase IV. Completed publication of manuscripts. Completed by July 2010

Budget

Plan 12.P3.09	
Lees Ferry Trout Study FY2008: Low Steady Summer Flows—Data and Research Compilation, Synopsis and Synthesis	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden; Workshop Related)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

NOTE: $100,000 of this funding is from fiscal year 2007 carry forward recommended by the AMWG August 30, 2007, Motion 5.

Budget Detail for Phase III

Costs associated with phase III are estimated simply on the cost to identify peer-reviewers, pay principle investigators to revise reports and respond to peer review comments and to publish reports in USGS series publication. Potential additional analysis, pending workshop results and AMWG recommendations, will require additional funds or identified funds can be used for analysis (though total costs for this is still unknown). Finalization of reports would be delayed to FY 2010 when all analysis may be completed.

References

SWCA, Inc. 2000. A program of experimental flow for endangered and native fishes of the Colorado River in Grand Canyon. Final report to Grand Canyon Monitoring and Research Center, USGS., Flagstaff, Ariz. 57 p.

U.S. Fish and Wildlife Service. 1995. Final Biological Opinion on the Operation of Glen Canyon Dam (2-21-93-F-167). U.S. Fish and Wildlife Service, Albuquerque, New Mexico, January 7, 1995.

Webb, R.H, Schmidt, J.C., Marzolf, G.R., and Valez, R.A., eds,1999, The Controlled Flood in Grand Canyon. Geophysical Monograph 110. American Geophysical Union, Washington, D.C. 367 p.

ADM 12.A1.09: Administrative Operations

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The goals of the project are to provide budgetary oversight and support to the Chief, program managers, and all employees of the GCMRC so that they may conduct their responsibilities in the most efficient, ethical, and professional manner possible; to enable the employees to be unburdened, to the largest extent possible, by mundane administrative matters; and to support the USGS and GCMRC missions of conducting scientific research in support of the GCDAMP.

Need for Project

It is necessary to have smooth running, transparent administrative operations that ensure that the GCMRC scientists can focus on their research rather than on the administrative details involved with the payment of rent and utilities, timekeeping concerns, filing, and various other administrative topics. Administrative operations activities provide the oversight and management of facilities, burden, and overhead; personnel issues; expenditure tracking; processing and financial management of cooperative and interagency agreements; processing of contracts; timekeeping; bank card tracking and reconciliation; travel plans and voucher processing; and liaison activities between the USGS administrative groups (Flagstaff Science Center Administration, Western Region Budget and Fiscal Services and Contracting Offices, Headquarters in Reston, and the Biological Headquarters). In addition, this project is innately involved with the USGS nationwide budget tracking and reporting system known as BASIS+, which is used by the USGS Headquarters and Regional offices to make their annual reports to Congress, as well as to respond to Congressional inquiries with turnaround times. (As part of the Glen Canyon Dam Adaptive Management Program, GCMRC administrators have been called upon to provide information of this type from the system on many occasions.)

Many standard overhead charges including facilities, space, general office supplies, costs for the USGS local network, Flagstaff Science Center support, and USGS regional services including contracting and personnel, as well as the salaries and general travel for the GCMRC secretary and budget analyst, are paid for out of SBSC's overhead account. Only charges directly tied and traceable to the GCMRC continue to be directly charged to the Administrative Operations account. These charges include GSA vehicle lease and maintenance; DOI vehicle gas, maintenance, and replacement costs; safety and/or other non-project-specific mandated training; GCMRC non-project-specific personnel support; telecommunications and shipping charges; and others.

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

General methods will include standard accounting procedures and regulatory and legal standards as required by the USGS and other Federal agencies with legal oversight. Monthly updates to program managers will be provided as well as budgetary and other information provided upon request. The GCMRC will follow USGS guidelines as assigned for personnel, travel, and other processes. Administrative personnel will focus on how to accomplish requests most efficiently within Federal laws and regulations. The Administrative Officer for SBSC and the Budget Analyst for the GCMRC will report biannually to the AMWG/TWG on mid-year and year-end projections and on the actual expenditures for the previous fiscal year.

Links/Relationships to Other Projects

This project is innately linked to all other projects. All project budgets are impacted by burden charges that are tracked and managed through Administrative Operations, all employees are required to track their time through a USGS personnel system, and many program managers use cooperative or interagency agreements that are processed and tracked financially via Administrative Operations. Every project is given an account number and must be entered into and tracked, via its budget and its narrative, through the BASIS+ system. Administrative Operations activities are tied to each project at the project's earliest development.

Products/Reports

The Administrative Officer for SBSC and the Budget Analyst for the GCMRC will produce a projection report (usually at the August AMWG meeting) for year end. In addition, they will present a report in actual expenditures for the previous fiscal year that will normally be presented at the March AMWG meeting.

Budget

ADM 12.A1.09	
Administrative Operations (1996 - Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

ADM 12.A2.09: Program Planning and Management

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The GCMRC's goal is to deliver a comprehensive ecosystem science program over the next 5 years that is effective in responding to management needs articulated through the GCDAMP and by DOI. Productive, well-qualified personnel are critical to achieving this goal.

Need for Project

Successful scientific research and reporting can be enhanced by strong and effective leadership that provides close working relationships between managers and employees and between GCMRC and the GCDAMP stakeholders. Good managers can apply knowledge as management actions that can enhance scientific research and imagination. In addition to their program management responsibilities, the GCMRC program managers are also subject area experts in their respective fields. It is important that GCMRC program managers and scientific staff maintain this expertise so they can provide high-quality technical assistance in the form of expert analysis, opinion, and advice to the Chief, TWG, and AMWG, as requested. The Socio-cultural Program Manager also functions as the Native American Coordinator. The program managers supervise additional technical and support staff, and act as project leads with their cooperators.

Beginning in FY2006, in an effort to simplify distribution of program planning and management salaries and travel, the Program Manager salaries were assigned to this category exclusively. Salaries and travel costs, separate from TWG and AMWG meeting travel for the Chief, Deputy Chief and five program managers are included in program planning and management budget. See below for descriptions of each position

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

In order to provide strong leadership of a quality science program that is responsive to the needs of the GCDAMP, the GCMRC will be administered by a core program management staff that includes the following key positions:

Center Chief

Establishes Center science policies and strategic direction and provides accountability for the GCMRC budget. Interfaces with USGS management, Secretary's GCDAMP Designee, and GCDAMP managers to ensure that quality science is provided in a timely manner on priority issues identified by the GCDAMP leadership.

Deputy Chief

The Deputy Chief shall be responsible for oversight of the Physical Science & Modeling and Data Acquisition, Storage and Analysis (DASA) programs and shall ensure that integrated ecosystem science methods and procedures are utilized in science design and analysis.

Program Managers

Responsible for the timely execution of the science program within their program area; interaction with other program areas to ensure integrated ecosystem approaches, quality control of products and contractors/ cooperators; contract/agreement management; management of budget within their program area, and providing reports to GCDAMP work groups as needed. The GCMRC activities now encompass five major program areas:

1. The Physical Science and Modeling Program conducts research and monitoring activities on physical elements of the CRE including studies of sediment storage and transport in the regulated river, and integrated downstream water-quality monitoring and research. The program has been responsible for conducting several experimental high-flow releases from GCD to conserve sediment resources for building beaches and improving habitat for native aquatic species in the Colorado River. More recent tasks have included development of a downstream temperature model for the ecosystem.
2. The Data Acquisition, Storage, and Analysis (DASA) Program provides GIS, data quality control, data management, and library services support to all program areas. In addition, DASA also participates in collaborative science analyses with GCMRC program staff and cooperators to help achieve better integrated science outcomes. The DASA program manager also oversees the GCMRC peer-review process under guidelines of the USGS Fundamental Science Practice protocols.
3. The Biological Program provides scientific information that supports the conservation of native species in the Grand Canyon and the Lees Ferry trout fishery. Elements of the program include assessing the effects of GCD on fishery resources; characterizing the aquatic food base; evaluating terrestrial contributions to the aquatic food base; improving fish community monitoring, developing, and testing of techniques to control nonnative fishes; evaluating terrestrial vegetation changes as a result of dam operations; and water-quality monitoring and modeling in Lake Powell and the Colorado River below GCD.
4. The Cultural and Socioeconomic Program develops research and monitoring projects to access the affects of Glen Canyon Dam on culturally significant sites and recreation activities. The current focus is on development of comprehensive monitoring programs to assess the condition of the culturally significant sites and recreation campsites affected by the operation of GCD.
5. The Logistics and Survey Support Program supports up to 40 river trips per year and coordinates research permit management for the Grand Canyon Monitoring and Research Center. The Logistics Program also provides survey support to various program and activities.

Links/Relationships to Other Projects

This project is linked by nature to all other projects, since each project must be managed by a program manager or the Chief.

Products/Reports

All products and reports produced by the GCMRC are a result of this project.

Budget

ADM 12.A2.09	
Program Planning & Management (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

ADM 12.A3.09: AMWG/TWG Meeting Travel Funds

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

To provide travel funds for employees who participate in AMWG and TWG meetings.

Need for Project

This project is an account to hold funds for travel expenses for GCMRC employees who participate in AMWG and TWG meetings. Project-related travel expenses are accounted for by projects, and administrative travel (e.g., general safety and security training) is planned under the Administrative Operations budget.

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

Methods used are standard USGS travel authorizations and vouchers.

Links/Relationships to Other Projects

N/A

Products/Reports

N/A

Budget

ADM 12.A3.09	
AMWG/TWG Meeting Travel Funds (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	—
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

ADM 12.A4.09: Independent Reviews

AND

ADM 12.A6.09: Biennial Science Symposium

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

To increase the efficiency and quality of the science being developed by the GCMRC and used by the AMWG and the Secretary of the Interior, the GCMRC will establish a peer-review process to ensure that all unsolicited, solicited, or in-house proposals and all draft reports received by the GCMRC undergo independent, external peer review.

Need for Project

Independent external review is at the heart of the GCMRC's approach to program management and implementation. Together with the competitive process, independent external peer review ensures the quality and objectivity of the GCMRC's programs. Independent review panels are used to evaluate the GCMRC's plans and activities. All proposals, reports, programs, etc., are subject to independent peer review according to the GCMRC's peer-review protocols. GCMRC's peer-review process is managed by SBSC secretary under the supervision of the SBSC Deputy Center Director.

To ensure program integrity, a group of Science Advisors (SA) provides independent scientific oversight and technical advice to ensure that all GCMRC science plans and programs are efficient, unbiased, objective, and scientifically sound. The SAs are expected upon request to review and comment on the following:

- Results of ongoing and completed monitoring and research program activities, as well as any synthesis and assessment activities initiated by the GCMRC
- The appropriateness of the GCMRC's RFPs, especially their responsiveness to management objectives
- Protocols used in GCMRC-sponsored scientific activities, including a 5-year review of GCMRC monitoring and research protocols
- GCMRC's long-term monitoring plan
- GCMRC's annual monitoring and research plans

- GCMRC's annual budget proposals, to ensure that the science program is efficiently and effectively responding to AMWG goals (i.e., management objectives)

The SAs and Executive Director also provide other program specific scientific and technical advice it is asked to address by the AMWG, the GCMRC, or the Secretary of the Interior.

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

Peer Review

All of GCMRC's scientific activities undergo an independent, external peer review including all unsolicited, solicited, or in-house proposals. Similarly, all draft reports received by the GCMRC undergo independent, external peer review. The peer-review protocols developed by the GCMRC meet or exceed the standards articulated by the Secretary of the Interior for DOI.

Peer review for proposals received by the GCMRC in response to an RFP is conducted through a panel process, while peer reviews for unsolicited and in-house proposals, as well as project reports, are conducted through correspondence. In all cases, the reviewers are offered anonymity, and the individual and panel reviews, where applicable, are provided to the PIs along with comments from the GCMRC. In addition, the GCMRC conducts PEPs to review and assess GCMRC's projects and methodologies. To date, PEPs have been held for remote-sensing, physical, survey control, terrestrial and aquatic, cultural resource, and the water-quality program.

The GCMRC review process is handled by a SBSC Review Coordinator to ensure that the peer-review process is not under the immediate supervision of individual GCMRC program managers to guard against any conflicts of interest—real or perceived. Strict conflict-of-interest guidelines are adhered to. GCMRC annually recruits new peer reviewers and maintains a database of almost 500 potential reviewers, organized by area of expertise. GCMRC peer reviewers come from academia; Federal, State, and tribal governmental and nongovernmental organizations; and the private sector. Reviewers are selected on the basis of their record of scientific accomplishment and expertise.

Links/Relationships to Other Projects

N/A

Products/Reports

N/A

Budget

ADM 12.A4.09	
Independent Reviews (Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

Science Advisors

The GCMRC works with the Science Advisors (SAs) as one of its independent review panels. The SAs are an advisory group and not a Board or a decision-making body. It is an interdisciplinary group composed of scientists who are qualified on the basis of their record of publication in the peer-reviewed literature, or other demonstrable scientific achievements. An Executive Secretary leads the SAs and serves as the liaison officer to the AMWG and TWG the GCMRC. A primary function of the Executive Director on advisory service and reviews is to draft all individual SA review comments into final reports to GCMRC and AMWG.

Table 6 provides an overview summary of the primary review and advisory service activities planned and budgeted in FY 2009. In FY 08, a new 5-year contract for the Executive Director of the SA will be advertised; the new contract will be executed beginning October 1, 2008.

Table 6. Summary of Science Advisors activities for fiscal year (FY) 2009.

Requesting group	Type of activity	Service request	Completion date and months required
GCMRC	Advisory service	Assist GCMRC in designing and implementing ecosystem science approaches in research and monitoring programs, experimental options, modeling, sampling designs, etc.	ongoing; 24
GCMRC	Review	Assessment of general Core monitoring proposal, i.e. proposed resource and time commitments, general approaches.	11/08; 1
GCMRC	Review	Review of efficiency and effectiveness of new proposed science programs and activities, and their integration into the existingSSP/MRP. Review of effectiveness of proposed budget.	11/08; 1

GCMRC	Advisory Service	Working with GCMRC Chief, Leadership Team, and system ecologist, access opportunities for greater integration and improved overall system assessments of major biological programs, i.e. LSSF, NSE, Food base, Lees Ferry trout etc.	06/09; 9
GCMRC	Review	Review of draft Fall Steady Flow Science Plan	6/09; 1
GCMRC	Review	Review of draft 2000 LSSF proposed synthesis procedure	1/09; 1
TWG	Review	Reviews of HBCCP; Desired Future Condition document	11/08; 1
AMWG TWG	Advisory Service	Input to AMWG workshop(s) on Desired Future Condition; AMP effectiveness, management actions	9/09; 1
GCMRC	Advisory Service	Presentation and discussions at GCMRC 2008 symposium	11/08; 1

Budget

ADM 12.A4.09	
Executive Director of Science Advisors Review and Coordination; includes Science Advisors' Expenses (Independent Reviews; ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	—
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

Biennial Science Symposium

On November 18-20, 2008, the GCMRC will coordinate a Colorado River Basin Science and Resource Management Symposium in Scottsdale, Ariz, to promote the exchange of information on research and management activities related to the restoration/conservation of the Colorado River in the United States. Other sponsors of the conference beside the GCDAMP include USGS, Reclamation, NPS, USFWS, and State fish and wildlife agencies. Funding for this activity was provided for in the FY2008 budget.

Budget

ADM 12.A6.09	
2008 Science Symposium (Ongoing, every other year)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	—
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	—
AMP logistical support (19% burden)	—
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	—
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	%

Products/Reports

- Final products will include final work plans that have undergone peer review (comments maintained on file at GCMRC) and peer-review comments on draft final reports produced related to projects included in the work plan (comments maintained on file at GCMRC).
- The Proceedings of the Colorado River Basin Science and Resource Management Symposium will be published by the GCMRC pursuant to USGS Fundamental Science Practices by June 2009.

ADM 12.A5.09: GCMRC Component of SBSC Computer Systems Support

Start Date

FY2005

End Date

Ongoing

Principal Investigator(s)

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

It is the Information Technology (IT) Department's goal to ensure that GCMRC and all stations within SBSC are able to conduct scientific and administrative functions smoothly and with the least amount of disruption in service as possible. It is the IT Department's task to make IT functions as transparent as possible, to ensure each program has adequate current and future storage, and to provide excellent customer service at all times. IT maintains the security of GCMRC and SBSC networks up to current Federal standards and ensures that all those who access the systems meet Federal security standards in order to protect personal information and scientific research that has not yet been released to the public. At the same time, the IT Department ensures that the public has full and easy access to publicly released data via GCMRC Web sites and works closely with the DASA program to make this possible.

Need for Project

The IT Department of the SBSC supports a variety of technology needs of the GCMRC's various program areas: computer security, systems administration and procurement of new servers and computers, as well as Web site development and Web page maintenance. These support, development, and maintenance services are cost shared between the GCMRC, the SBSC, and the IT Department, and coordinated by the Center's Deputy Director so as to meet the IT needs of all four research stations.

Strategic Science Questions

N/A

Information Needs Addressed

N/A

General Methods/Tasks

The IT Department follows all Federal, DOI, and USGS regulations regarding purchase of, access to, distribution and release of electronic information. Methods also include the following:

- Network environment—Computer interconnectivity is provided using transmission control protocol/internet protocol (TCP/IP) network communication protocol running on a 1000baseT and 100baseT network media. Network traffic is arbitrated by 6 3COM switches and hubs operating at 1 Gbps.
- Internet connectivity—The GCMRC computer network is linked to the Internet through the Flagstaff Science Center GEOnet-3 router that provides a DS-3 (45 Mbps) virtual circuit to Menlo Park, where it joins the USGS GEOnet network. Also located in Menlo Park is a network portal to the Internet operated by the USGS and NASA through a peering partnership. GEOnet provides a secure Survey-wide networking environment that interconnects headquarter region, district, and field offices located throughout the United States.
- Intranet Web site—GCMRC's intranet offers a secure centralized medium for information exchange among GCMRC employees. Among things to be internally shared via the intranet are standard operating procedures, personnel availability and contact info, vehicle and equipment checkout, and an IT support system. The GCMRC intranet is served from a Windows 2003 Server utilizing Active Server Pages (ASP).
- GCMRC.GOV----GCMRC Web site will be redesigned in FY2009–10 to improve functionality and provide direct user/stakeholder access to all GCMRC products.
- Computer security—Network security is provided by firewalls, routers, a patch management server, a systems management server (SMS), and antivirus software. Firewalls and routers are configured and maintained to restrict outside access to authorized systems. Operating systems are updated monthly to minimize vulnerabilities using SUS that automates a central delivery system for patch management. Antivirus updates are downloaded from the Web as released and pushed to all systems the same night.
- Desktop and servers—GCMRC's computing environment is based upon the PC platform, Microsoft Windows operating system, and Microsoft Office automation software. Systems maintenance is performed using a combination of warranty service, service contracts, and in-house service as needed to facilitate quick turnaround, minimize downtime, and reduce costs.
- System backup and disaster recovery—System backup and disaster recovery is accomplished using dual linear tape open (LTO) tape drives in a 30-slot carriage with a capacity of 12 Tbytes native up to 24 Tbytes compressed before swapping tapes. Tapes are stored locally in a fire vault and archival tapes are stored off-site. Server disks are configured to run either a raid-5 array or mirrored for redundancy.
- Troubleshooting and maintenance—Helpdesk support is provided as requested/required. Requests are received via the Web, e-mail, and telephone.
- Assistance with GCMRC's data storage—Over 30 Tbytes of online disk storage is provided by multiple servers with small computer system interface (SCSI) disk arrays. Server disk arrays are hot swappable to minimize downtime. GCMRC also utilizes networked attached storage (NAS) devices. Integrated Drive Electronics (IDE) and Serial Advanced Technology Attachment (STA) drives connected to a SCSI backplane. NAS units are used to provide bulk storage capacity at less expense. Servers are connected via a Fiber 1Gbps backbone to multiple NAS units.

Links/Relationships to Other Projects

All projects are integrated with IT support. Refer to the DASA section for more information on integration with these projects.

Products/Reports

The primary products and services of the SBSC Information Technology Department with respect to ongoing support of the GCMRC's needs are as follows:

- Comprehensive and fully functional Web site development and maintenance, with access to all non-sensitive digital data and information relating to the effects of dam operations on the CRE

- Coordination with GCMRC's DASA to ensure and support a comprehensive and fully functional library containing all hard copy and digital media containing data and information relating to the effects of dam operations on the CRE are cataloged and accessible. Sensitive and non-releasable data and information will be archived and secured separately from releasable data and information
- Fully functional and integrated computing environment
- Web Services—The GCMRC Web site serves to make the mission and findings of GCMRC accessible to the public. The sites offer our updated work plan, descriptions of our program areas, and various interactive stores of data including an Internet Map Server and an online library

Budget

ADM 12.A5.09	
GCMRC Component of SBSC Systems Admin Support (FY2005–Ongoing)	
	Fiscal year 2009
GCMRC personnel costs (19% burden)	
GCMRC project-related travel/training (19% burden)	
GCMRC operations/supplies (19% burden)	
GCMRC equipment purchase/replacement (19% burden)	
AMP logistical support (19% burden)	
Outside GCMRC and contract science labor (19% and/or other burden rate)	
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	
Project Subtotal	
DOI customer burden (combined 6.09%, 19% and/or other rates)	
Project Total (Gross)	
Percent outsourced (outside of GCMRC; includes 50% of logistics)	

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APPENDIX A. Key Science Questions Addressed in the FY2007–11 Science Program

AMWG Priority 1: Why are the humpback chub not thriving, and what can we do about it? How many humpback chub are there and how are they doing? (GCDAMP goal 2)

Key Strategic Science Questions

1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions? [FY2006–11]

2. Does a decrease in the abundance of rainbow trout (RBT) and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population? [FY2006–11]

3. Do RBT immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyons? [FY2007–11]

4. Can long-term decreases in abundance of RBT in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species. [FY2007–11]

5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations? [FY2006–09]

6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (e.g., lipids), correlated with patterns in invertebrate flux? [FY2006–09].

7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained? [FY2008–09].

8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling? [FY2007–11].

AMWG Priority 2: Which cultural resources, including traditional cultural properties, are within the Area of Potential Effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration? (GCDAMP goal 11).

Key Strategic Science Questions

1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and traditional cultural properties (TCP) sites, and if so, how? [FY2007–11]

2. How do flows impact old high-water zone terraces in the Colorado River ecosystem (CRE) (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits? [FY2004–11]

3. If dam-controlled flows are contributing to (influencing rates of) archaeological site/TCP erosion, what are the optimal flows for minimizing future impacts to historic properties? [FY2009–11]

4. How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term? [FY2006–11]

5. What are the TCPs in the CRE, and where are they located? [FY2006–11]

6. How can tribal values/data/analyses be appropriately incorporated into a science-driven adaptive management process in order to evaluate the effects of flow operations and management actions on TCPs? [FY2006–08]

7. Are dam-controlled flows affecting TCPs and other tribally valued resources in the CRE, and, if so, in what respects are they being affected, and are those effects considered positive or negative by the tribes who value these resources? [FY2006–11]

AMWG Priority 3: What is the best flow regime? (GCDAMP goals 1–11)

Key Strategic Science Questions

1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? [FY2008–11]

2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases? [FY2007–08]

3. What are the hydropower replacements costs of the modified low fluctuating flow (MLFF) (annually, since 1996)? [FY2007–08]

4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase experimental design)? [FY2006–07]

5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–08]

6. What Glen Canyon Dam operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability? [FY2007–08]

7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE? [FY2007–08]

8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes? [FY2007–09]

9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience? [FY2009–11]

10. How can safety and navigability be reliably measured relative to flows? [FY2007–08]

11. How do varying flows positively or negatively affect visitor safety, health, and navigability of the rapids? [FY2007–09]

12. How do varying flows regimes positively or negatively affect group encounter rates, campsite competition, and other social parameters that are known to be important variables of visitor experience? [FY2007–09]

AMWG Priority 4: What is the impact of sediment loss and what should we do about it? (GCDAMP goal 8)

Key Strategic Science Questions

1. Is there a "Flow-Only" operation (i.e., a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? (FY2008–11)

2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows? [FY2007–11]

AMWG Priority 5: What will happen when we test or implement the Temperature Control Device (TCD)? How should it be operated? Are safeguards needed for management? (GCDAMP goals 1–4 and 7–10)

Strategic Science Questions

1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE? [FY2006–08]

2. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–08]

3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish? [FY2003–08]

4. What is the relative importance of increased water temperature, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish? [FY2003–08]

5. Will increased water temperatures increase the incidence of Asian tapeworm in humpback chub or the magnitude of infestation, and if so, what is the impact on survival and growth rates? [FY2003–08]

6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance? [FY2007–11]

7. How do warmer releases affect viability and productivity of native/nonnative vegetation? [FY2007–11]

APPENDIX B. GCDAMP Fiscal Year 2009 Budget Explanatory Material

The draft FY2009 GCDAMP budget, which includes budgets for GCDAMP activities preformed by Reclamation and the U.S. Geological Survey (USGS) Grand Canyon Monitoring and Research Center, is attached separately. Table B.1 explains the information found in various columns of the budget document. Following the table is an explanation of USGS policy on cost-recovery accounting and cost share.

Table B.1. Explanation of information found in columns of draft fiscal year 2009 (FY2009) Glen Canyon Dam Adaptive Management Program (GCDAMP) budget.

Column	Title	Key
A	GCMRC Project ID	Column 1–3 Program Area BIO: Biology PHY: Physical Science REC: Recreation HYD: Hydropower CUL: Cultural DASA: Data Acquisition, Storage and Analysis SUP: Support (Logistics and Survey) ADM: Administration and Management PLA: Planning Column 4–5 GCDAMP goal number Column 6–7 GCMRC project number Column 8–9 fiscal year
B	Status	O: Ongoing N: New C: Complete D: Deferred NA: Not applicable
C	Funding emphasis	APM: Administrative program management. Activities/projects that are administrative in nature or are conducted in support of the overall GCMRC science program, including base funding for program managers, logistics staff and permanent DASA staff. COR: Core-monitoring project. Monitoring projects that have been piloted, subjected to initial and secondary protocols evaluation panel (PEP) reviews, documented through a core-monitoring report and formally adopted as a core-monitoring project by the TWG. CRD: Core-monitoring research and development project. Monitoring projects that are currently undergoing research and development, including projects that have been piloted and peer reviewed but which have not yet been formally documented with a core-monitoring report or formally adopted as a core-monitoring project by the TWG. LTE: Long-term experiment. Projects specifically undertaken as part of or in direct support of the Long-Term Experimental Plan. ORD: Other research and development projects. Other research projects or research and development work that is NOT directly tied to the development of core-monitoring projects.

D	Project description	Project title (start date–end date)
E	**Actual FY2008 budget**	Actual GCDAMP budget figures as of this revision date.
F	Estimated FY2009 budget	Estimated FY2008 gross cost of project as of this revision date.

Explanation of USGS Policy on Cost Share

In FY2003, the U.S. Geological Survey (USGS) began full-cost recovery accounting and instituted a Department of the Interior (DOI) customer rate of 15 percent against all DOI agency reimbursable funding. In FY2009, the customer rate is estimated at the 15-percent DOI customer rate with an additional 6 percent added to achieve the required additional facilities costs. The DOI customer rate was established by the USGS Bureau Headquarters and determined to be significantly lower than the "full" burden rate that varies annually and includes facilities and the Cost Center and the Bureau-level burdens. In addition to the above rates, a special "pass through" rate of 6 percent was also instated. As a transitional aid to GCMRC, which had received under a previous administration the guarantee that USGS would not charge the power revenue funds any burden, the Bureau allowed the entire GCMRC power revenue budget to be charged only the 6-percent special rate (3 percent was retained by the Cost Center and 3 percent by Headquarters) for FY2003 only.

Beginning in FY2004, USGS Headquarters approved the special rate of 6 percent for a portion of GCMRC's power revenue funding. This rate is applied to approximately $2 million of funding that is directly "passed through" to GCMRC cooperators. The balance of power revenue funds are charged the full DOI customer rate of 15 percent plus facilities. As a part of the full-cost recovery policy, the USGS established a process referred to as cost share as a means of handling a limited electronic financial system.

Cost share is the funding that "covers" the balance of the full burden rate minus the DOI customer rate. In most cases, reimbursable funding from non-DOI agencies is charged the full burden rate. In FY2008, the full burden rate for GCMRC was approximately 57 percent (including facilities). The difference between the full rate of 57 percent and the DOI customer rate of 19 percent (which includes approximately 4 percent for facilities), equals ~~15~~ 38 percent (all percentages are approximate). In FY2008 the cost share funding requirement for all DOI agency reimbursable dollars received by GCMRC equaled almost $1 million. USGS policy requires that cost share funding be from appropriated dollars only, and those funds are also charged the Cost Center burden rate. In essence, the $1million appropriation provided by USGS to GCMRC in FY2008 had the effect of not adding funding, but merely filling the holes created by the cost share policy.

In previous fiscal years, the USGS appropriation requested for GCMRC (approximately $1 million each fiscal year) has been used for cost share funding. Per the full-cost accounting policy and the requirement that cost share dollars be appropriated dollars only, the effect of these appropriations is entirely transparent and does not add funding to the GCDAMP. The issue relating to how these cost share funds are derived in the future has and continues to be a major area of concern for the GCMRC science program.

APPENDIX C. GCDAMP Fiscal Year 2009 Budget

The oversized budget sheets are provided as a separate document.