7-1-2009

Limnological Assistance for the Lake Mead National Recreation Area in Meeting the Challenge of the Water 2025 Initiative: Annual Report, Period Ending July 1, 2009

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UNLV
UNIVERSITY OF NEVADA LAS VEGAS

ANNUAL REPORT
University of Nevada, Las Vegas
Period Ending July 1, 2009

Cooperative Agreement Number H8R07060001
Task Agreement Number J8R07070010

Limnological Assistance for the Lake Mead National Recreation Area in Meeting the Challenge of the Water 2025 Initiative

Executive Summary

Project 1

- Eighteen advisory team meetings were attended this year; technical input was provided as appropriate; and summaries were prepared and delivered to Kent Turner. The SCOP Selenium Management Plan has been reviewed and a report is in preparation.

Project 2

- A formal report titled, *Surface Water Monitoring for Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area,* was delivered in the second quarter of this year. Subsequently, a poster presentation on this topic was delivered at the Lake Mead Science Symposium and a manuscript has been prepared for submission to the journal, *Lake and Reservoir Management*.

Project 3

- An Interagency Monitoring Action Plan (I-MAP) has been prepared and is near completion. The document has undergone a review and comment period by sub-committees of agency staff formed for this purpose; review comments have been received, which are being incorporated. Six interagency meetings were organized and facilitated.

Project 4

- A poster presentation summarizing the bibliographic database created for this project was presented at the Lake Mead Science Symposium. Data mining for 1980's Lake Mead benthos study has been completed. A draft Access database and associated metadata record was sent to researchers conducting current Benthos studies on Lake Mead for review and input. The field data portion of the database is undergoing quality control for finalization next quarter.

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Project 5

- The Lake Mead Science Symposium was delivered on January 14-15, 2009. The technical committee invited the development of 14 articles based on presentations for submission to *Lake and Reservoir Management* by August 1, 2009. A special issue of this journal will serve as symposium proceedings.

Project 6

- Five Interagency "Water 2025" Team meetings were coordinated for project information sharing and input into the ecological monitoring plan for Lakes Mead and Mohave. An expanded framework for the plan has been prepared, circulated, and is currently under review.

Project Progress

During Quarter 4, UNLV Public Lands Institute (PLI) conducted a task audit for all years of this project. Tasks and progress were summarized within a matrix (Appendix A). This matrix was presented to and discussed informally with Kent Turner (Agreement Technical Representative; ATR) on May 27, 2009. Activity on some tasks has been stalled, as shown, due to unforeseen delays by other participating entities. How to fulfill or modify these tasks will be discussed with Mr. Turner in August 2009.

Project 1 Technical Assistance to LAME with Interagency Monitoring Program

C.2(a) Continue to attend and participate in technical advisory committees related to planning and implementation of monitoring programs on Lakes Mead and Mohave (SCOP, Lake Mead Water Quality Forum, Las Vegas Wash Coordination Committee). Provide a summary of each meeting attended noting important technical issues and challenges.

The meetings listed below were attended during year 2 of this project. Summaries were prepared and delivered to Kent Turner via e-mail by David Wong (UNLV) or Jennell Miller (UNLV) in the case of the Las Vegas Wash Coordination Committee meeting. These summaries may not be posted on the Internet or otherwise distributed electronically because they do not represent formal minutes for these meetings. However, copies are maintained by and available at PLI.

6/10/2008	Las Vegas Watershed Advisory Committee Meeting
6/23/2008	SCOP/Boulder Basin Adaptive Management Meeting WATER QUALITY OBJECTIVES, MODELING and SELENIUM MANAGEMENT
7/22/2008	Las Vegas Wash Coordination Committee
7/28/2008	SCOP/Boulder Basin Adaptive Management Meeting WATER QUALITY OBJECTIVES, MODELING, and SELENIUM MANAGEMENT
8/25/2008	SCOP/Boulder Basin Adaptive Management Meeting WATER QUALITY OBJECTIVES AND MIXING ZONE MONITORING
9/16/2008	Lake Mead Water Quality Forum
9/22/2008	SCOP/Boulder Basin Adaptive Management Meeting

WATER QUALITY OBJECTIVES AND MIXING ZONE MONITORING
(summary to be provided in the upcoming quarter)

9/23/2008 ELCOM/CAEDYM/PLUMES Modeling Workshop

10/27/2008 SCOP/Boulder Basin Adaptive Management Meeting
WATER QUALITY OBJECTIVES and MODELING

11/18-20/2008 Colorado River Basin Science and Resource Management Symposium

Associated professional presentation:

D. Wong and S. Gerstenberger. A Standardized Design for Long-term Quagga Mussel Monitoring in Lake Mead**.** Presented at the Colorado River Basin Science and Resource Management Symposium, Scottsdale, AZ. Symposium organizers have invited Dr. Wong and Shawn Gerstenberger (UNLV, Principal Investigator) to develop this presentation into a manuscript.

12/03/2008 Lake Mead Water Quality Forum

12/09/2008 Las Vegas Watershed Advisory Committee Meeting

02/18/2009 Lake Mead Water Quality Forum

02/23/2009 Boulder Basin Adaptive Management Program

04/27/2009 Boulder Basin Adaptive Management Program

The following Las Vegas Valley Watershed Advisory Committee Meetings were also attended by this group on the dates shown below. But, summaries were not prepared because the Committee began posting official minutes (see URLs below to access the files) on the Las Vegas Wash website.

01/18/2009 http://www.lvwash.org/cfml/calendar/index.cfml/5C627C16-C3DE-24F2-E064F7A4DE71C516.pdf?calendarparam=file&doc_id=5C627C16-C3DE-24F2-E064F7A4DE71C516

02/10/2009 http://www.lvwash.org/cfml/calendar/index.cfml/D7567271-9449-92DE-3FFC1CB0017321F4.pdf?calendarparam=file&doc_id=D7567271-9449-92DE-3FFC1CB0017321F4

The Regional Water Quality Plan presented at the 2/10 meeting is available at: http://www.lvwash.org/cfml/calendar/index.cfml/6750D89A-9B78-1E44-1BA5AF3CE3A317BD.pdf?calendarparam=file&doc_id=6750D89A-9B78-1E44-1BA5AF3CE3A317BD

03/10/2009 http://www.lvwash.org/cfml/calendar/index.cfml/AC3E2F9E-EC59-D570-DE6991D13EAF6B74.pdf?calendarparam=file&doc_id=AC3E2F9E-EC59-D570-DE6991D13EAF6B74

C.2(b) Continue to provide technical input into the development of these monitoring programs. Submit technical reports to LAME staff for review and input prior to submission to committees.

Technical input is on-going through meeting attendance and participation [see C.2(a) above] and as described throughout project 1 activities, below.

C.2(c) Review updated modeling data from ELCOM/CAEDYM/PLUMES. Provide management and monitoring recommendations to NPS in an annual report.

A Boulder Basin Adaptive Management Plan Modeling workshop hosted by the Clean Water Coalition was held on September 23, 2008. Shawn Gerstenberger (Project PI), Craig Palmer (Project PI), and Dr. Wong attended this workshop and provided comments on the ELCOM/CAEDYM/PLUMES modeling data. Dr. Wong provided Mr. Turner with a summary of this workshop on October 13, 2008. Major concerns and questions about "next steps" were expressed at the workshop. UNLV project staff will continue to participate and assist, but their specific role has not yet been defined.

C.2(d) Provide technical assistance in the review of suggested monitoring programs under the SCOP BBAMP, particularly Issues of Concern and Management Indices.

A three-page document describing the issues of concern (IOCs) was prepared by the committee of the SCOP BBAMP program. This document, which will be the basis for the management indices, is under review by Drs. Gerstenberger and Wong. It was decided not to prepare a formal report on this preliminary document because the 2009 meetings would focus on the details of the IOCs, and direct input could be given at these meetings.

At the February 23, 2009 meeting, the 2009 agenda and outlines for the IOCs were discussed. There will be six meetings this year, which will cover the Management Action Plan, IOCs, including their status under baseline conditions, and anticipated changes to the management plan after SCOP completion.

The June 24, 2009 SCOP meeting focused on *Recreation* and *Ecological Health* IOCs. For this meeting, Dr. Miller assisted Mr. Turner in coordinating the content for and designing a PowerPoint presentation outlining Lake Mead NRA monitoring efforts (i.e., visitor survey; aquatic dependent birds; quagga mussel transects and substrate monitoring; and other diving activities) relevant to these two IOCs. This information is also pertinent to Project 6 of this task agreement. The PowerPoint file was delivered to Michael Boyles (Lake Mead NRA) on June 17, 2009.

C.2(e) Participate in the completion and review of the Selenium Management Plan. Provide recommendations.

As mentioned in part C.2 (a), Dr. Wong attended the SCOP Selenium subcommittee meetings held in July and September. On September 22, 2008 a draft report titled "Basis of Plan Report for Selenium Management in Las Vegas Wash" prepared by Brown and Caldwell for the Clean Water Coalition was distributed at the SCOP BBAMP meeting. This document was reviewed by Dr. Wong. Dr. Wong prepared a draft report (available upon request from PLI) of his review comments. Dr. Gerstenberger is currently adding additional information to this report at Mr. Turner's request.

C.2(f) Conduct a review and provide recommendations for the BBAMP Annual Operating Plan

As reported previously, Dr. Gerstenberger has received an abridged version of the BBAMP Annual Operating Plan. He has reviewed this document and provided some informal recommendations on this document. Depending upon the availability of time and resources, he will more detailed review of the full version of the document when he receives it.

C.2(g) Participate in the development of the biannual data and trend review of BBAMP data as required by BBAMP. Provide recommendations.

Depending on the availability of time and resources, Drs. Gerstenberger and Wong will participate as needed/required when data is made available.

Project 2 Science Support for Water 2025 Interagency Monitoring & Research Initiatives

D.2(a) Continue to conduct scientific reviews of data and reports resulting from Water 2025 CI projects as requested by ATR.

As reported previously, under the direction of Dr. Palmer, bacterial microbiologist Vanessa L. Stevens (UNLV) worked with Jessie Rinella (Lake Mead NRA) to review data and reports originating from samples collected by Lake Mead NRA staff and analyzed by the Southern Nevada Water Authority for indicator bacteria in high-use areas. This effort was then turned over to Dr. Patricia Cruz (UNLV). A formal report titled, *Surface Water Monitoring for Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area,* was delivered in the second quarter of this year. Subsequently, a poster presentation on this topic was delivered at the Lake Mead Science Symposium (Project 5 of this task agreement) and an invited manuscript was prepared for submission to the journal, *Lake and Reservoir Management*.

D.2(b) Provide an annual synthesis of the above reviews, addressing technical soundness of the projects, identify management implications, provide recommendations.

See D.2(c) below.

D.2(c) Develop the annual synthesis into an annual summary for SNAP Board. Prepare a presentation and present to SNAP Board.

To date, the annual synthesis has not been completed nor developed into a summary and presentation for the SNAP Board. This will be accomplished following completion of the finalization of the report on bacteria in high-use areas and at the request of the ATR.

Project 3 Technical Assistance related to Quagga Mussel and other nuisance species

We continue to track Project 3's Year 1 activities as they are completed. Also please note that typographic errors are present in the numbering scheme pertaining to this project within the original task agreement. To avoid confusion, we maintain the same coding used within the task agreement and match like activities from both years as you will see below.

E.1(a) and E.2(a)

Provide assistance for the development of a monitoring program to evaluate the emerging ecological effects of the quagga mussel infestation (Year 1). Provide assistance in planning, implementation, data review, and reporting related to the monitoring program evaluating the emerging ecological effects of the quagga mussel infestation (Year 2).

Development of an ecological monitoring program for the effects of quagga mussel infestation is underway. The first step has been to create a standardized monitoring plan for veligers and adults, which is described in subsequent sections. This task will follow after development of the quagga mussel population-monitoring plan described below, which is the foundation for monitoring ecosystem response and trophic level analyses.

Phytoplankton are expected to be deleteriously impacted by the quagga mussel invasion. Thus, in Year 2, Quarter 1, Dr. Wong was requested to contact Tom Burke (U.S. Bureau of Reclamation), Alan Sims, (Las Vegas Valley Water District), Jim LaBounty (Southern Nevada Water Authority; SNWA), and Peggy Roefer (SNWA) for information to prepare a white paper on the status of plankton monitoring in relation to quagga mussels, and give a recommendation on using chlorophyll-a as an indicator and the overall adequacy of current phytoplankton monitoring. Recent scholarly publications have focused on this topic but need to be interpreted for management use and reviewed for any gaps in information that might be useful to management.

*E.1(b) **Complete a review of the natural history of quagga mussels (Year 1).***

A draft section titled "Life History of Quagga Mussels" has been completed and presented within the draft document, *Interagency Monitoring Action Plan (I-MAP): Quagga Mussels in Lakes Mead and Mohave* (described below). This information will also become part of the ecological monitoring plan to detect changes resulting from quagga mussels, which is prescribed by E.1(a) and E2(b), above.

*E.1 (e) **Provide assistance in the development of a quagga mussel population monitoring and assessment program (Year 1) and***

*E.2(b) **Provide assistance in planning, implementation, data review, and reporting to the quagga mussel population monitoring and assessment program (Year 2).***

As reported previously, this task has been the major focus of Shawn Gerstenberger (UNLV, Project PI) and David Wong (UNLV) over the course of year 2. Work stemming from an outline prepared by Mr. Turner (ATR) on September 30, 2008 resulted in the development of a 101-page draft document titled, *Interagency Monitoring Action Plan (I-MAP): Quagga Mussels in Lakes Mead and Mohave* (the document's table of contents was submitted as Appendix B of the Year 2, Quarter x report).

Prior to distribution to attendees of the Interagency Quagga Mussel Meetings, which are organized through this project, a draft of the I-MAP was provided to Mr. Turner for comments, and subsequently revised. The concept of the I-MAP was introduced on October 15, 2008 and participants volunteered to meet to discuss the document at a sub-committee meeting formed for this purpose on November 19, 2008. The resulting document introduction was presented at the Interagency Quagga Mussel Meeting in hard copy on December 4, 2008 for discussion. Individuals in attendance were asked to supply Dr. Gerstenberger with the names and contact information of key personnel of agencies with management responsibility on Lakes Mead and Mohave who should contribute to the document.

Unfortunately, no comments were received. Therefore, this quarter, Drs. Gerstenberger and Wong split the document into its major sections: "Life History," "Artificial Substrates," "Veliger Monitoring," and "Adult Monitoring." Specific sections were then e-mailed on February 17, 2009 to individuals who volunteered to serve on sub-groups pertaining to each section. Sub-group membership is listed below. Note that each sub-group includes staff members from agencies with management oversight as shown below. Drs. Wong and Gerstenberger, and Mr. Turner are members of every sub-group and so are not listed below.

Life History

- Wen Baldwin, NPS Lake Mead NRA Volunteer / Lake Mead Boater Owners' Association
- Peggy Roefer, Southern Nevada Water Authority
- Tod Tietjen, Southern Nevada Water Authority

Artificial Substrates

- Wen Baldwin, NPS Lake Mead NRA Volunteer / Lake Mead Boater Owners' Association
- Lynn Orphan, Clean Water Coaltion
- Peggy Roefer, Southern Nevada Water Authority
- Jon Sjöberg, Nevada Department of Wildlife
- Tod Tietjen, Southern Nevada Water Authority

Veliger Monitoring

- Mark Buttner, UNLV Harry Reid Center for Environmental Studies
- Patricia Cruz, UNLV Harry Reid Center for Environmental Studies
- Peggy Roefer, Southern Nevada Water Authority
- Tod Tietjen, Southern Nevada Water Authority

Adult Monitoring

- Gerald Hickman, U.S. Bureau of Reclamation
- Bryan Moore, NPS Lake Mead NRA
- Peggy Roefer, Southern Nevada Water Authority
- Tod Tietjen, Southern Nevada Water Authority
- Leonard Willet, U.S. Bureau of Reclamation

In addition to the above sub-group members, Dr. Marion Wittmann (University of California, Davis – Tahoe Research Center) volunteered to review and provide comments on I-MAP sections pertaining to life history and monitoring.

Comments were due via e-mail to Drs. Wong and Gerstenberger on March 13, 2009. Dr. Wong has addressed and incorporated the comments received for each of the sections to the extent possible. The revised draft I-MAP was distributed at the Interagency Quagga Mussel meeting on May 19, 2009. This distribution generated another series of comments that require Mr. Turner's input as to whether they should be incorporated. The revised Word document was provided to Mr. Turner in June, and Dr. Wong will discuss the comments further with Mr. Turner in August.

The draft document is available upon request from Dr. Gerstenberger. Note that the *Interagency Monitoring Plan (I-MAP)* incorporates the previously reported 50-page document titled *Suggested Standard Methods for Interagency Long-Term Quagga Mussel Monitoring in Lake Mead*.

E.1(f) Prepare a report: Long-term Quagga Mussel monitoring and research needs for Lakes Mead and Mohave (Year 1).

This is a component of *Suggested Standard Methods for Interagency Long-Term Quagga Mussel Monitoring in Lake Mead* discussed in part E.1 (e) and E.2 (b) above.

E.2(d) Prepare a report: Emerging Quagga Mussel Monitoring and Research Needs for Lakes Mead and Mohave not previously identified.

As reported in Year 1, The Agency Core Management Team for Quagga Mussels decided to develop three projects that are to be funded outside of this task agreement. They are (1) quagga mussel monitoring and (2) impacts to fisheries and (3) a benthic survey.

Throughout Year 2, Dr. Wong worked with project primary investigators on their projects, two of which resulted in completed Master of Public Health (MPH) theses, which are listed below. Within these theses include discussions of *Emerging Quagga Mussel Monitoring and Research Needs for Lakes Mead and Mohave.* The benthic survey is conducted outside of this group by researchers at the University of Nevada, Reno.

- Loomis, Eric Michael. "Trophic Interactions Associated with Introduction of the Invasive Quagga Mussel in Lake Mead, Nevada." MPH thesis, University of Nevada, Las Vegas, 2009.

- Mueting, Sara Ann. "Substrate Monitoring, Contaminant Monitoring, and Educational Outreach on Quagga Mussels (*Dreissena bugensis*) in Lake Mead, Nevada." MPH thesis, University of Nevada, Las Vegas, 2009.

Also delivered to Mr. Turner via e-mail on May 11, 2009 was a report titled, "Final Report for the development of a suitable substrate sampling device for monitoring Quagga Mussels (*Dreissena bugensis*) in Lake Mead, Nevada" by Mueting, S., Gerstenberger, S., Wong, D., Urban, Mitch, and Baldwin, W.

E.2(e) Organize and conduct the second annual meeting of the Quagga Mussel science advisory committee. Prepare a report: Recommendations from the committee.

Dr. Gerstenberger continues to assist Mr. Turner in the facilitation of the multi-agency, interdisciplinary meetings listed below. Summaries of these meetings, documented by Dr. Miller, have been e-mailed to meeting participants, supplied at subsequent meetings, and posted to GroveSite. PowerPoint presentations delivered at each of the Interagency Quagga Mussel Meetings have been archived at PLI and provided on CD to meeting participants upon request.

Meetings took place this quarter as follows:

- August 26, 2008 Interagency Quagga Mussel Meeting
- September 24, 2008 Sub-committee meeting for completion of the interagency quagga mussel monitoring plan
- November 17, 2008 Sub-committee meeting for completion of the interagency quagga mussel monitoring plan
- December 04, 2008 Interagency Quagga Mussel Meeting
- February 25, 2009 Interagency Quagga Mussel Meeting

- May 19, 2009 Interagency Quagga Mussel Meeting

Attendees of these meetings have represented the Arizona Game and Fish Department; City of Henderson; City of Havasu City; Clark County Water Reclamation District; Clean Water Coalition; Imperial Irrigation District; Coachella Valley Water District; Lake Las Vegas Resort; Las Vegas Valley Water District; Los Angeles Metropolitan Water District; National Park Service; Nevada Division of Environmental Protection; San Diego County Water Authority; Southern Nevada Water Authority; University of Nevada, Las Vegas; University of Nevada, Reno; US Bureau of Reclamation; U.S. Fish and Wildlife Service; and U.S. Geological Survey.

Other accomplishments related to Project 3

The UNLV project team worked closely with Bryan Moore (NPS, Lake Mead NRA) to create an archive of adult quagga mussels for contaminants analysis; these mussels were collected from approximately 10 locations in Lakes Mead and Mohave by divers at several depths. It is hoped that these data will be used to provide baseline information about contaminants transfer facilitated by quagga mussels through filter feeding.

The following professional presentations co-authored by Drs. Gerstenberger and Wong were presented at the Lake Mead Science Symposium (Project 5 of this task agreement):

- Baldwin, W.; Mueting, S.; Gerstenberger, S; and Wong, D. Growth and Recruitment of Quagga Mussels (*Dreissena bugensis*) in Lake Mead

- Gerstenberger, S.; Turner, K.; and Wong, D. Interagency Response to Quagga Mussel Invasion at Lake Mead: Detection, Prevention, Control, and Monitoring.*

- Loomis, E.; Wong, D.; Gerstenberger, S. Threadfin Shad and Invasive Quagga Mussels in Lake Mead, Nevada.

- Moore, B.; Gerstenberger, S.; and Wong, D. Quagga Mussel Invasion into Lakes Mead and Mohave in 2007: Abundance, Distribution, and Size Frequency

- Mueting, S.; Gerstenberger, S.; Wong, D.; Baldwin, W.; Urban, M. The Development of a Suitable Substrate Sampling Device for Monitoring Quagga Mussels (*Dreissena bugensis*) in Lake Mead, Nevada.

- Wong, D.; Tietjen, T.; Gerstenberger, S.; Mueting, S.; and Loomis, E. Potential Ecological Consequences of Invasion of the Quagga Mussel (Dreissena bugensis Andrusov 1897) into Lake Mead.

*The Lake Mead Science Symposium invited the submission of a manuscript based on this presentation to the journal *Lake and Reservoir Management*.

The following presentation was prepared for the Colorado River Basin Science and Resource Management Symposium (Scottsdale, AZ). During this quarter, authors have developed and submitted a manuscript invited by symposium organizers. The manuscript is currently undergoing revisions.

- D. Wong and S. Gerstenberger. A Standardized Design for Long-term Quagga Mussel Monitoring in Lake Mead**.** Presented at the Colorado River Basin Science and Resource Management Symposium, Scottsdale, AZ.

Project 4 Strategic Data Mining for Lake Mead

We continue to track Project 4's Year 1 activities as they are completed.

F.1 (b) Create Access database with metadata about each of the projects identified in F.1(a) (research topics, study areas, duration of study, parameters, data availability)

Work on the Lake Mead Research database over the course of Years 1 and 2 has been described in previous reports. The database is nearing completion and is scheduled for release at the close of June 2009. Efforts during this quarter consisted of quality assurance (QA) checks for data completeness and accuracy, and fine-tuning of the data processing experience.

F.1(c) Create a prioritized list with the Water 2025 Science Team of significant projects whose data are not available electronically (Year 1).

As previously reported, the project selected for data mining was a Lake Mead benthos study conducted by the University of Nevada, Las Vegas in 1986-1987. Other projects suggested for mining by Mr. Turner include zooplankton studies, phytoplankton studies, and Nevada Department of Wildlife's shad/fish data.

F.1(d) Prepare, quality assure, document and submit to NPS and other information portals electronic data sets for the above top priority projects (Year 1).

The original field and laboratory data sheets were located for the Lake Mead benthos study. An Access database was developed with data-entry forms allowing students to enter information. Over the past year, information from 311 field data sheets and 440 laboratory data sheets has been entered into the database.

F.2(a) Complete data mining projects from the prioritized list. Prepare, quality assure, document and submit to NPS and other information portals electronic data sets for the above top priority projects.

Field Forms and Bench Forms within the benthos database are currently undergoing review and editing by Mary Kirby (UNLV-PLI).

Other accomplishments related to Project 4

The following poster presentation co-authored by Mr. Pollard and Ms. Andrew was prepared for the Lake Mead Science Symposium:

- Pollard, J. and Andrew, G. Strategic Data Mining and Database Development for Research Projects at Lake Mead, Nevada-Arizona USA

Harry Reed (UNLV), at the request of Dr. Palmer, has designed a graphical front-end user for the Access database [prescribed by F.1 (b) in year 1]. The Access database with its new front end will be provided to Mr. Turner on CD in the near future.

Data sheets provided by the Southern Nevada Water Authority (three bankers' boxes full), will be placed in the Lake Mead Limnology Special Collection established as a part of this project.

Project 5 Lake Mead Science Symposium

G.2(a) Develop schedule of meeting sessions and speakers. Develop and print conference program and post to Web site.

As reported previously, Dr. Miller in consultation with Mr. Turner created the printed conference program (see Appendix A of the Year 2, Quarter 3 Report) to include a schedule of meeting sessions and speakers, keynote speaker biographies, at-a-glance program tables, presentation abstracts, informational logistics, customized maps, and an author directory. Also included within the program was an *In Memoriam* section highlighting the achievements of Dr. James LaBounty, a renowned limnologist much of whose life's work focused on Lake Mead. Program printing was done by UNLV's Reprographics unit. Review comments were provided by Dr. Palmer and Margaret N. Rees (Project Administrator/UNLV PLI Executive Director). A PDF of the program was posted to the symposium Web site.

G.2(b) Conduct symposium, facilitated by university personnel in collaboration with agency.

Over the course of Years 1 and 2 the Lake Mead Science Symposium was planned and organized. It was delivered successfully at the UNLV Student Union January 13-15, 2009 by university personnel led by Dr. Miller and Rochelle Boyd in consultation with Mr. Turner and Dr. Rees. The symposium included a plenary session with three keynote addresses and four special remarks by water-related agency leadership and six concurrent sessions with 44 talks and 13 posters. Approximately 150 individuals attended. Excellent feedback was received. A detailed report regarding the delivery of the symposium was provided within the Year 2, Quarter 3 report.

G.2(c) Prepare, publish, and distribute symposium proceedings to participants and agency and university libraries.

With the late Dr. Jim LaBounty's assistance, arrangements were made to publish selected papers within a special issue of the journal, *Lake and Reservoir Management*. On Day 3 of the Lake Mead Science Symposium, the technical committee reviewed the entire listing of oral and poster presentations and selected 18 to be developed into manuscripts for potential publication in the special issue. Invitations, invitation tracking, and instructions to authors were coordinated by Dr. Miller. Fourteen author sets accepted the invitation (see listing below, organized by topic area). Dr. Miller has coordinated the effort and is in frequent correspondence with the authors, journal editor Ken Wagner, Chris Holdren (U.S. Bureau of Reclamation), and Todd Tietjen (Southern Nevada Water Authority). Drs. Holdren and Tietjen are Lake Mead Science Symposium technical committee members who have taken the lead in regard to the content of the special issue in consultation with Mr. Turner and Dr. Wagner.

Dr. Miller has provided each technical committee member with copies of the draft manuscripts. Any member who would like to provide helpful comments to the authors has been asked to do so by July 1, 2009. Authors will submit their manuscripts via the online service, "Manuscript Central" by August 1, 2009. The manuscripts will then enter into the journal's review and acceptance process, which includes external peer review.

Aquatic Biota and Fisheries

Kegerries, R.	Lake Mead Razorback Sucker Recruitment: An Informative Anomaly Regarding Continued, Natural, Wild Razorback Sucker Recruitment Despite Non-native Fish Presence
St. Amand, A. et al.	Response of the Algal Community in Boulder Basin, Lake Mead to the Introduction of Quagga Mussels and Reduced Water Levels
Umek, J. et al.	The Contemporary Food Web Structure of Two Bays in Lake Mead

Emerging Issues

Beaver, J. et al.	Characterization of the Phytoplankton Communities in the Basins of Lake Mead -- Do Quagga Mussels Influence Cyanobacteria Biovolume?
Chandra, S. et al.	Lake Mead Zoobenthos: Changes in Composition, Distribution, and Composition over Time with Emphasis on the Ecology of Adult Quagga Mussel
Mueting, S. et al.	The Development of a Suitable Substrate Sampling Device for Monitoring Quagga Mussels (Dreissena bugensis) in Lake Mead, Nevada
Seeb, S. and Choate, D.	The Ecology of Cultural Resources: Issues and Impacts Related to Submerged and Emergent Cultural Resources at Lake Mead National Recreation Area
Wong, D. et al.	Potential Ecological Consequences of Invasion of the Quagga Mussel into Lake Mead → Will become a manuscript about Quagga Mussels in the West

Environmental Contaminants

Kramer, J. et al.	Mercury Concentrations in Muscle Tissue from Sportfish in Lake Mead, Nevada
Trenholm, R. et al.	Occurance of Pharmaceuticals, Personal Care Products, and Potential Endocrine Disrupting Compounds in Lake Mead, NV

Limnology and Water Quality

Cruz, P. et al.	Surface Water Monitoring for Fecal Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area
Ryan, R. and Zhou, X.	TDS and Selenium Projections in the Las Vegas Wash post Implementation of the Systems Conveyance and Operation Program (SCOP)
Tietjen, T.	Long Term Patterns in the Diversity and Composition of Phytoplankton in Las Vegas Bay, Lake Mead

Lake Management

Holdren, C.	Nutrient Budgets for Lake Mead

H.2(a) Assist other committees (SCOP BBAMP, Water 2025, Quagga Mussel) with the development of their monitoring plans.

This activity is ongoing.

H.2(b) Synthesize background information, including information collected from this project (data mining and science symposium.

In Year 1, Dr. Miller analyzed the task agreements for eight interagency "Water 2025" Conservation Initiative-funded projects and created tables summarizing each of the tasks. These tables were provided to Mr. Turner electronically on February 21, 2008.

As part of the Lake Mead Science Symposium, a questionnaire was created to facilitate attendee input and discussion on important issues to be included within the ecological monitoring plan for Lakes Mead and Mohave. Attendee feedback is shown in Appendix B.

This activity is ongoing.

H.2(c) Complete chapters according to schedule.

As reported for Year 2, Quarter 3**,** a schedule for chapter development has not yet been set. During Day 3 of the Lake Mead Science Symposium, the technical committee and Mr. Turner identified major topic areas to be addressed in the Ecological Monitoring Plan for Lakes Mead and Mohave as follows:

- Water Quality and Limnology
- Fish and Aquatic Biota
- Birds
- Abiotic and Biotic Stressors
- Sediment
- Raiparian and Shoreline Resources

Additionally, Mr. Turner established a framework for the monitoring plan, wherein, each topic area will be analyzed and information summarized about the water quality requirements related to fisheries, wildlife, recreation, and community needs. Topic areas will be "stepped down" into suggested monitoring activities needed to meet the related water quality goals. Other components of the framework include an introduction/preamble/broad goals for the monitoring and research plan; plan goals, which are a mutual set of goals of the participating agencies with monitoring responsibility; resource plan and related plan component categories, brief statements of knowledge; relationship to the existing water quality models and regional plans; data management and QA/QC; data analysis and summaries. With Dr. Miller's assistance, the draft framework has been revised and circulated to attendees of the "Water 2025" meetings (see Appendix C). Attendees were asked to provide their comments to Mr. Turner by August, 14, 2009 to be incorporated in time for the next meeting on August 25, 2009. Dr. Palmer prepared a list of components common to monitoring plans of other bodies of water, including the number of plans that featured each component.

Establishing a role for and assignments to UNLV staff to facilitate the development of these chapters, participate in their creation, and setting a schedule for their completion remains to be done.

Other accomplishments related to Project 6

Interagency Water 2025 Meetings
During year 2, Drs. Palmer and Gerstenberger assisted Mr. Turner in the facilitation of the meetings listed below. Documented by Dr. Miller, summaries of these meetings have been e-mailed to Mr. Turner and meeting participants (as previously reported) unless otherwise noted.

09/02/2008 – Interagency "Water 2025" Meeting
10/15/2008 – Interagency "Water 2025" Meeting
12/10/2008 – Interagency "Water 2025" Meeting
02/11/2009 – Interagency "Water 2025" Meeting
06/03/2009 – Interagency "Water 2025" Meeting

Attendees of these multi-agency meetings have represented the Clean Water Coalition; Desert Research Institute, National Park Service; Southern Nevada Water Authority; University of Nevada, Las Vegas; University of Nevada, Reno; US Bureau of Reclamation; U.S. Fish and Wildlife Service; and U.S. Geological Survey.

Lake Mead NRA Website Content
Dr. Miller provided Mr. Turner with draft content for the Lake Mead NRA website, which included general summary information about the lakes and synopses of each of the "Water 2025-funded" projects. Mr. Turner requested that the material be expanded so that separate content is developed about each lake individually and to include additional limnological details.

Submitted by:

[redacted]

Margaret N. Rees, Project Administrator — 7/01/2009 Date

APPENDIX A

Draft Task Audit

TASK AUDIT: Limnological Assistance for the Lake Mead National Recreation Area in Meeting the Challenge of the Water 2025 Initiative

PROJECT 1: Technical Assistance to LAME with Interagency Monitoring Program

Phase I: 6/1/2007 to 5/31/2008

Year	PLI Lead	Deliverable / Activity		Due Date	Details
1	Gerstenberger	**C.1(a)**	Attend and participate in technical advisory committees related to planning and implementation of monitoring programs on Lakes Mead and Mohave (SCOP, Lake Mead Water Quality Forum, Las Vegas Wash Coordination Committee). Provide a summary of each meeting attended noting important technical issues and challenges.	Within 15 days of each meeting	C. Palmer and S. Gerstenberger attended SCOP/BBAMP and other meetings; they did not create summaries.
	Gerstenberger	**C.1(b)**	Provide technical input into the development of these monitoring programs to ensure they are sound and defensible. Submit technical reports to LAME staff for review and input prior to submission to committees.	As created	No technical reports have been prepared.
	Gerstenberger	**C.1(c)**	Provide technical assistance in development of Boulder Basin AMP Management Indices. Work with NPS and BBAMP advisory committee. **Y1 Q2 Report:** S. Gerstenberger received a draft copy of the Boulder Basin Adaptive Management Plan; review was underway. **Y1 Q3 Report:** Substantive work on this task will commence with hiring of the research assistant professor. **Year 1 Annual:** S. Gerstenberger will review the BBAMP Management Indices and recommend additional issues of concern by the end of July 2008.	IOCs and Indices delayed until year 2 by BBAMP Year 1	Where are the additional issues of concern? How can completion of this task be documented?
	Gerstenberger	**C.1(d)**	Review modeling data from ELCOM/CAEDYM/PLUMES. Provide management and monitoring recommendations to NPS. **Year 1 Annual:** No modeling data from ELCOM/CAEDYM/PLUMES has been received to date. D. Wong will review the CWC's modeling report and provide a summary and suggestions for future improvements to the model by the end of July 2008 (contingent upon receipt of the report).	Delayed Year 1	?? No submissions were made thru J. Miller by July 2008. This task continues in Year 2, see task C.2(c).
	Gerstenberger	**C.1(e)**	Provide a review of parameters recommended for measurement of endocrine disruption and emerging contaminants of concern by BBAMP technical and advisory committees. **Year 1 Annual:** Endocrine disruption and emerging contaminants of concern were still in preparation and had not yet been delivered to Kent. S. Gerstenberger attended the endocrine disruption meetings of the SCOP/BBAMP	Delayed Year 1	?? Have the ED/COCs been provided yet? Can they be reviewed?
	Gerstenberger	**C.1(f)**	Conduct a review and provide recommendations for the BBAMP Annual Operating Plan. **Year 1 Annual:** S. Gerstenberger has received an abridged version of the BBAMP Annual Operating Plan. He reviewed the document and provided some informal recommendations. He will provided a more detailed review of the full version when he receives it.	Delayed At the request of ATR	?? Status? Continues in Year 2 C.2(F)
	Gerstenberger	**C.1(g)**	Participate in the development of the Selenium Management Plan. Provide recommendations on plan contents and adequacy. **Year 1 Annual:** S. Gerstenberger attended the Se Management portions of the SCOP/BBAMP in year 1.	Delayed Year 1	?? Status? Continues in Year 2 C.2(E)
	Gerstenberger	**C.1(h)**	Submit annual report summarizing activities, data, and findings from Phase I.	May 31, 2008	Submitted on 6/18/2008

Phase II: 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Details
2	Gerstenberger (Wong)	**C.2(a)**	Continue to attend and participate in technical advisory committees related to planning and implementation of monitoring programs on Lakes Mead and Mohave (SCOP, Lake Mead Water Quality Forum, Las Vegas Wash Coordination Committee). Provide a summary of each meeting attended noting important technical issues and challenges. LMWQF = Lake Mead Water Quality Forum LVWAC = Las Vegas Watershed Advisory Committee SCOP/BBAMP = Systems Conveyance and Operations Program Boulder Basin Adaptive Management Plan LVWCC = Las Vegas Wash Coordination Committee	Within 15 days of each meeting	**The following meetings were attended with summaries provided:** 06/10/08 – LVWAC 06/23/08 – SCOP/BBAMP 07/22/08 – LVWCC 07/28/08 – SCOP/BBAMP 08/25/08 – SCOP/BBAMP 09/16/08 – LMWQF 09/22/08 – SCOP/BBAMP 09/23/08 – ELCOM/CADYM 10/27/08 – SCOP/BBAMP 11/18/08 – CO River Basin Science and Resource Mgmt Symposium 12/03/08 – LMWQF 12/09/08 – LVWAC 02/18/09 – LMWQF 02/23/09 – SCOP/BBAMP
	Gerstenberger	**C.2(b)**	Continue to provide technical input into the development of these monitoring programs. Submit technical reports to LAME staff for review and input prior to submission to committees. To date, verbal technical input has been ongoing though attendance at and participation at the meetings listed above. Contaminants thesis (Kramer) – completed May, 2009.	Determined by ATR	

	Gerstenberger (Wong)	**C.2(c)**	Review updated modeling data from ELCOM/CAEDYM/PLUMES. Provide management and monitoring recommendations to NPS in an annual report. **E-mail communication from D. Wong to J. Miller:** On 9/23/09, CWC asked Flow Science to hold a workshop on the two models: ELCOM/CAEDYM. Kent Turner, Craig Palmer, and David Wong attended this workshop. Basically, the model can predict most of the parameters in Lake Mead. However, there are some questions that these two models cannot give an accurate answer. For example, CAEDYM significantly underestimates the degree of the microalgal bloom (green algae; *Pyramichlamys dissecta*) in 2001. This model always shows that there is a 2nd peak of chlorophyll a in each fall. Actually this peak doesn't exist in many of the recorded years (LaBounty & Burns 2005). Therefore, the efforts on model calibration need to be continued.	Year 2	Information to the left needs to be enhanced and documented in report form.
	Gerstenberger (Wong)	**C.2(d)**	Provide technical assistance in the review of suggested monitoring programs under the SCOP BBAMP, particularly Issues of Concern and Management Indices. **From memo by D. Wong:** On 02/23/09 at the Water Quality Objectives portion of the SCOP/BBAMP meeting, an outline of the Items of Concern was provided. There will be six more meetings this year to discuss the IOCs and their associated management indices.	Year 2	
	Gerstenberger	**C.2(e)**	Participate in the completion and review of the Selenium Management Plan. Provide recommendations. **Y2 Q1 Report:** Brown and Caldwell prepared, "Basis of Plan Report for Selenium Management in Las Vegas Wash." This document is currently under review by D. Wong.	Year 2	Will be completed in 2009
	Gerstenberger	**C.2(f)**	Conduct a review and provide recommendations for the BBAMP Annual Operating Plan **Y2 Q1 Report:** S. Gerstenberger has not received a full version of the BBAMP Annual Operating Plan. He has provided informal recommendations to ATR on the abridged version he received.	At the request of ATR	?? Status? Was the full operating plan ever received?
	Gerstenberger (Wong)	**C.2(g)**	Participate in the development of the biannual data and trend review of BBAMP data as required by BBAMP. Provide recommendations. **Y2 Q1 Report:** To date, data have not been available for review. S. Gerstenberger and D. Wong will participate as needed/required when data is made available.	At the request of ATR	To be discussed with ATR
	Gerstenberger	**C.2(h)**	Submit annual report summarizing activities, data, and findings from Phase II.	May 31, 2009	To be delivered this year.

Phase III: 6/1/2009 to 11/30/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
3	Gerstenberger	**C.3(a)**	Continue to attend and participate in technical advisory committees related to planning and implementation of monitoring programs on Lakes Mead and Mohave (SCOP, Lake Mead Water Quality Forum, Las Vegas Wash Coordination Committee). Continue to provide technical input into the development of these monitoring programs. Submit technical reports to LAME staff for review and input prior to submission to committees.	Year 3	
	Gerstenberger	**C.3(b)**	Conduct a review of the BBAMP Annual Operating Plan and provide recommendations.	Determined by ATR	
	Gerstenberger	**C.3(c)**	Participate in the triennial review of Emerging Contaminants of Concern data required by the USFWS Biological Opinion for the SCOP project.	Determined by ATR	
	Gerstenberger	**C.3(d)**	Submit to LAME and CESU a final close-out report, incorporating NPS review comments.	November 30, 2009	

PROJECT 2: Science Support for Water 2025 Interagency Monitoring and Research Initiatives

Phase I – 6/1/2007 to 5/31/2008

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
1	Gerstenberger Palmer	**D.1(a)**	Conduct scientific reviews of data and reports resulting from Water 2025 CI projects as requested by ATR, including: — Data collection/baselines — Development and implementation of ELCOM/CAEDYM/PLUMES model — Assessments of shoreline health — Shoreline resources (rare plants, birds, cultural resources) — Blue-green algae — **Bacteria in high-use areas** — Other nuisance species — Habitat enhancements for fisheries **Year 1 Annual:** V. Stevens worked with J. Rinella to review data and reports and prepare a summary related to bacteria in high use areas. The resulting summary was not submitted to the ATR but was turned over to P. Cruz.	Determined by ATR	COMPLETED for one project in Year 2. See D.2 (a)
	Gerstenberger	**D.1(b)**	Provide an annual synthesis of the above reviews, addressing	May 31, 2008	COMPLETED for one

	Palmer		technical soundness of the projects, identify management implications, provide recommendations.		project in Year 2. See D.2 (b)
	Gerstenberger Palmer	**D.1(c)**	Develop the annual synthesis into an annual summary for SNAP Board. Prepare a presentation and present to SNAP Board.	Determined by ATR	Fall 2009

Phase II – 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
2	Gerstenberger Palmer	**D.2(a)**	Continue to conduct scientific reviews of data and reports resulting from Water 2025 CI projects as requested by ATR. "Surface Water Monitoring for Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area" by P. Cruz et al. was submitted on 12/24/2009 as an appendix to the **Y2 Q3 Report**.	Determined by ATR	COMPLETE for one project Bacteria in High-Use Areas
	Gerstenberger Palmer	**D.2(b)**	Provide an annual synthesis of the above reviews, addressing technical soundness of the projects, identify management implications, provide recommendations. "Surface Water Monitoring for Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area" by P. Cruz et al. was submitted on 12/24/2009 as an appendix to the **Y2 Q3 Report**. In addition, a journal article is being prepared for submission.	May 31, 2009	COMPLETE for one project Bacteria in High-Use Areas
	Gerstenberger Palmer	**D.2(c)**	Develop the annual synthesis into an annual summary for SNAP Board. Prepare a presentation and present to SNAP Board.	Determined by ATR	Not yet requested

Phase III (6/1/2009 to 11/30/2009)

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
3	Gerstenberger	**D.2(a)**	Complete scientific reviews of data and reports resulting from Water 2025 CI projects as requested by ATR.	Determined by ATR	
	Gerstenberger	**D.2(b)**	Submit to LAME and CESU a final close-out report, incorporating NPS review comments.	May 31, 2009	
	Gerstenberger	**D.2(c)**	Develop the close-out report into a product for the SNAP Board. Prepare a presentation and present to SNAP Board.	Determined by ATR	

PROJECT 3: Technical Assistance related to Quagga Mussel & other nuisance aquatic species

Phase I – 6/1/2007 to 5/31/2008)

Year	PLI Lead	Deliverable / Activity		Due Date	Details
1	Gerstenberger	**E.1(a)**	Provide assistance for the development of a monitoring program to evaluate the emerging ecological effects of the Quagga Mussel infestation. **Y1 Q2 Report – Year 1 Annual:** S. Mueting prepared and distributed to the Interagency Quagga Mussel group an Excel spreadsheet organizing approximately 420 quagga mussel and zebra mussel references among 11 categories. This was delivered to Kent on 10/11/07 and also published on the 100th Meridian Web site. **Year 1 Annual:** As part of the Interagency Quagga Mussel Meetings [see E.1(g)], standardizing sampling protocols, substrate monitoring, and veliger/adult monitoring were regularly discussed, and several small research studies were launched to answer questions that arose. **This task will become D. Wong's responsibility in Year 2**	Year 1	COMPLETED
	Gerstenberger (Wong)	**E.1(b)**	Complete a review of the natural history of Quagga Mussels. **Y1 Q2 Report:** S. Mueting prepared and distributed to the Interagency Quagga Mussel group an Excel spreadsheet organizing approximately 42 quagga mussel and zebra mussel references among 11 categories. **This task will become D. Wong's responsibility in Year 2 (note that the original TA did not plan for this task to extend beyond year 1)** **Year 2** **Y2 Q2 Report:** A draft section titled "Life History of Quagga Mussels" has been completed and presented withi the draft "Suggested Standard Methods for Interagency Long-Term Quagga Mussel Monitoring in Lake Mead." **Y2 Q3 Report:** The "Life History of Quagga Mussels" (and the suggested Standard Methods) were incorporated into a document titled "Interagency Monitoring Action Plan (I-MAP): Quagga Mussels in Lakes Mead and Mohave. **Note from J. Miller:** A sub-group has been formed to review/edit this section of the I-MAP. Comments were due on 03/13/09, at which time D. Wong would address and incorporate the comments into the document.	Delayed Year 1	In Preparation: Delayed to Year's 2 and 3. Year 2 activities for this task are also listed at the left because there is no code for this task in Year 2 of the Task Agreement.
	Gerstenberger	**E.1(e)**	Provide assistance in the development of a Quagga Mussel population monitoring and assessment program.	Year 1	COMPLETED

			Y1 Q1 Report: S. Gerstenberger requested electronic copies of the monitoring protocols used by all agencies participating in the Interagency Quagga Mussel Meeting. (These were compared and a map showing a compilation of monitoring areas by agency was presented at an Interagency Quagga Mussel Meeting.) **Y1 Q2 Report:** S. Mueting prepared and distributed to the Interagency Quagga Mussel group an Excel spreadsheet organizing approximately 42 quagga mussel and zebra mussel references among 11 categories. **Year 1 Annual:** UNLV conducted a call for proposals and subsequent peer review for projects addressing immediate monitoring needs that Lake Mead NRA could fund. Three projects were selected: (1) Quagga Mussel Monitoring; (2) Impacts to Fisheries; and (3) Benthic Survey. Sub-committees were formed related to these projects. During Years 2 and 3, D. Wong will work with the sub-committees to develop a formal quagga mussel population monitoring and assessment program.		
	Gerstenberger (Wong)	**E.1(f)**	Prepare a report: Long-term Quagga Mussel monitoring and research needs for Lakes Mead and Mohave. **Y2 Q2 Report:** This task is a component of "Suggested Standard Methods for Interagency Long-Term Quagga Mussel Monitoring in Lake Mead," which, in turn, became part of the I-MAP.	Year 1	Delayed to Years 2 and 3. Year 2 activities for this task are also listed at the left because there is no code for this task in Year 2 of the Task Agreement. It doesn't make sense to prepare a separate report as this is part of the I-MAP.
	Gerstenberger	**E.1(g)**	Organize a Quagga Mussel science advisory committee. Conduct an annual meeting. Prepare a report: Recommendations from the committee In November 2007, J. Miller organized an external peer review by Quagga Mussel Experts for advice on immediate funding needs. Six Interagency Quagga Mussel Meetings were held. The open meetings were documented as summaries, which were distributed to participants for review and finalization. PowerPoint Presentations are also retained and distributed upon request. The formal documents resulting from the meetings (such as the I-MAP) are reviewed by and incorporate the needs and suggestions of the participating agencies (thus no separate recommendation report has been prepared).	Year 1	Interagency Quagga Mussel Meetings were held on the following dates and documented: • 08/02/07 • 10/11/07 • 12/17/07 (core) • 01/17/08 • 03/14/08 (core) • 05/08/08 A separate recommendations report has not been prepared.
	Gerstenberger	**E.1(h)**	Submit annual report summarizing activities, data, and findings from Phase I.	At the request of ATR	Submitted on 6/18/2008

Phase II – 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
2	Gerstenberger (Wong)	**E.2(a)**	Provide assistance in planning, implementation, data review, and reporting related to the monitoring program evaluating the emerging ecological effects of the Quagga Mussel infestation. **Y2 Q2 Report:** This task will follow after development of the quagga mussel population monitoring plan.	Year 2	Continuing from Year 1. Is there any other documentation of activities done in fulfillment of this task?
	Gerstenberger (Wong)	**E.2(b)**	Provide assistance in planning, implementation, data review, and reporting to the Quagga Mussel population monitoring and assessment program. [this is a continuation of E.1 (e)] **Y2 Q2 Report:** Draft I-MAP was prepared (101 pages); provided to Interagency Quagga Mussel Group for review. **Y2 Q3 Report:** Draft I-MAP was split up into major sections and distributed to sub-groups; comments were due on 03/13/09 **Note:** The actual population monitoring is one of the separate projects funded following the call for proposals in Year 1.	Year 2	On-going in year 2
	Gerstenberger (Wong)	**E.2(d)**	Prepare a report: Emerging Quagga Mussel monitoring and research needs for Lakes Mead and Mohave not previously identified. **Y2 Q2 Report:** In Year 1, the Agency Core Management Team for Quagga Mussels decided to develop three projects to be funded outside of this task agreement related to emerging needs related to Quagga Mussels. The three projects are: (1) Quagga Mussel Monitoring; (2) Impacts to Fisheries; and (3) a Benthic Survey.	Year 2	A separate report that the TA prescribes has not been written, but two of which will result in theses (May 2009).
	Gerstenberger (Wong)	**E.2(e)**	Organize and conduct the second annual meeting of the Quagga Mussel science advisory committee. Prepare a report: Recommendations from the committee. **Note from J. Miller:** Regular Interagency Quagga Mussel Meetings were documented as summaries, which were distributed to participants for review and finalization. PowerPoint Presentations are also retained and distributed upon request. The formal documents resulting from the meetings (such as the I-MAP) are reviewed by and incorporate the needs and suggestions of the participating agencies (thus no separate recommendation report has been prepared).	Year 2	Interagency Quagga Mussel Meetings were held on the following dates and documented: • 08/26/08 • 09/24/08 (monitoring plan sub-committee) • 11/17/08 (monitoring plan sub-committee) • 12/04/08 • 02/25/09 A separate recommendations report has not been prepared.

	Gerstenberger	**E.2(f)** Submit annual report summarizing activities, data, and findings from Phase II.	May 31, 2009	

Phase III – 6/1/2009 to 11/31/2009

Year	PLI Lead	Deliverable / Activity	Due Date	Delivered
3	Gerstenberger	**E.3(a)** Continue to provide assistance in planning, implementation, data review, and reporting related to the monitoring program evaluating the emerging ecological effects of the Quagga Mussel infestation.	Year 3	
	Gerstenberger	**E.3(b)** Continue to provide assistance in planning, implementation, data review, and reporting to the Quagga Mussel population monitoring and assessment program.	Year 3	
	Gerstenberger	**E.3(d)** Submit to LAME and CESU a final close-out report, incorporating NPS review comments.	November 30, 2009	

PROJECT 4: Strategic Data Mining for Lake Mead

Phase I – 6/1/2007 to 5/31/2008

Year	PLI Lead	Deliverable / Activity	Due Date	Delivered
1	Pollard	**F.1(a)** Conduct a comprehensive literature search to identify research projects on Lake Mead, including water quality, limnology, contaminants, fisheries and aquatic biota, and riparian/shoreline resources. **Y1 Q1 Report:** J. Pollard previously completed a similar literature search in 2000 for the USGS. The USGS Report was provided to Mr. Turner. G. Andrew will acquire recent reports and other documents not part of the USGS Report. **Y1 Q2 Report:** G. Andrew is conducting the literature search. As of 12/17/07, 1,645 citations had been found.	July 31, 2007	Complete
	Pollard	**F.1(b)** Create Access Database with metadata about each of the above projects (research topics, study areas, duration of study, parameters, data availability). **Y1 Q2 Report:** G. Andrew created a draft Access database and provided it on CD to Kent on 12/06/07. In this database the citations above have been organized into 27 topic areas. This database was to be reviewed by NPS Staff and comments given to G. Andrew. NPS Staff Mark Sappington (12/07/2007) and Michael Boyles (12/31/2007) sent review comments via e-mail. **Y1 Q3 Report**: G. Andrew is continuing to add to and organize the database. M. Stalling was brought in to improve the database and its usability. The list of 27 topic areas has been expanded to 73 "subjects." During the upcoming quarter NPS staff will be invited to review. **Y1 Annual Report:** Lake Mead NRA staff will be invited to review in upcoming quarter.	December 31, 2007	Will be complete in 2009
	Pollard	**F.1(c)** Create a prioritized list with the Water 2025 Science Team of significant projects whose data are not available electronically. Team did not create a prioritized list, but chose a benthic study as the one project to mine.	January 31, 2008	Will be complete in 2009
	Pollard	**F.1(d)** Prepare, quality assure, document and submit to NPS and other information portals electronic data sets for the above top priority projects.	On-going	Will be complete in 2009
	Pollard	**F.1(e)** Submit annual report summarizing activities, data, and findings from Phase I.	May 31, 2008	

Phase II – 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity	Due Date	Delivered
2	Pollard	**F.2(a)** Complete data mining projects from the prioritized list. Prepare, quality assure, document and submit to NPS and other information portals electronic data sets for the above top priority projects. **Y2 Q1:** Data mining project chosen was a Benthos Study conducted between 1986-1987. An Access database and a metadata record has been created. It has all been sent to S. Chandra.	At the request of ATR	One project has been done: benthos / currently undergoing QA
	Pollard	**F.2(b)** Submit to LAME and CESU a final close-out report, incorporating NPS review comments.	May 31, 2009	

PROJECT 5: Lake Mead Science Symposium

Phase I – 6/1/2007 to 11/30/2007

Year	PLI Lead	Deliverable / Activity	Due Date	Delivered

1	Lauckner	**G.1(a)**	Form a technical committee to develop goals and objectives for the symposium. Develop a meeting outline including sessions on water quality, limnology, emerging contaminants, fisheries, aquatic biota, riparian/shoreline resources, etc.	September 30, 2007	COMPLETE
	Lauckner	**G.1(b)**	Form a program committee to select a venue for the meeting, arrange for Web site and online registration, prepare conference printed materials, and handle on-site registration.	Year 1	COMPLETE
	~~Lauckner~~ (Miller)	**G.1(c)**	Invite agencies, universities, and other interested parties conducting research on Lake Mead to present findings.	November 30, 2007	COMPLETE
	~~Lauckner~~ (Miller)	**G.1(d)**	Select and invite keynote speakers.	January 30, 2008	COMPLETE
	~~Lauckner~~ (Miller)	**G.1(e)**	Make and finalize logistical arrangements: advertising, registration, room reservations, A/V support, and food and beverage service. Provide monthly progress reports on all aspects of symposium planning.	May 31, 2008	COMPLETE

Phase II – 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
2	~~Lauckner~~ (Miller)	G.2(a)	Develop schedule of meeting sessions and speakers. Develop and print conference program and post to Web site.	Year 2	COMPLETE See Report: Y2 Q3
	~~Lauckner~~ (Miller)	G.2(b)	Conduct symposium, facilitated by university personnel in collaboration with agency.	December 2008	COMPLETE See Report: Y2 Q3
	~~Lauckner~~ (Miller/ Chris Holdren)	G.2(c)	Prepare, publish, and distribute symposium proceedings to participants and agency and university libraries.	April 2009	Coordinating the development of a special issue of Lake and Reservoir Management
	~~Lauckner~~ (???)	G.2(d)	Submit to LAME and CESU a final close-out report, with key findings of symposium and implications to the development of the long-term monitoring plan, incorporating NPS review comments.	May 31, 2009	Feedback from symposium attendees was received and documented

PROJECT 6: Ecological Monitoring Plan for Lakes Mead and Mohave

Phase I (6/1/2007 to 5/31/2008)

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
1	Palmer	H.1(a)	Prepare framework of interagency goals for Lakes Mead and Mohave. Note from J. Miller: This has been started by Kent and the Symposium Technical Chairs. Kent has created the topics outline for review by the Water 2025 Group (January-March 2009).	July 31, 2007	Will be completed in 2009
	Palmer	H.1(b)	Identify the elements (format?) of existing monitoring programs on Lakes Mead and Mohave.	December 31, 2007	Completed
	Palmer	H.1(c)	Develop the detailed outline of the monitoring plan, which will be reviewed by the Water 2025 Team. Revise accordingly. Include completion schedule for each chapter of the plan.	March 31, 2008	Will be completed in 2009
	Palmer	H.1(d)	Complete chapters according to schedule.	According to schedule above	Will be completed in 2009
	Palmer	H.1(e)	Submit annual report summarizing activities, data, and findings from Phase I.	May 31, 2008	

Phase II – 6/1/2008 to 5/31/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
2	Palmer	H.2(a)	Assist other committees (SCOP BBAMP, Water 2025, Quagga Mussel) with the development of their monitoring plans.	Year 2	To be discussed with ATR
	Palmer	H.2(b)	Synthesize background information, including information collected from this project (data mining and science symposium)	November 30, 2008	To be discussed with ATR
	Palmer	H.2(c)	Complete chapters according to schedule.	According to schedule, year 1	??
	Palmer	H.2(d)	Submit annual report summarizing activities, data, and findings from Phase II.	May 31, 2009	

Phase III – 6/1/2009 to 11/30/2009

Year	PLI Lead	Deliverable / Activity		Due Date	Delivered
3	Palmer	H.3(a)	Complete remaining chapters.	According to schedule (year 1)	
	Palmer	H.3(b)	Submit draft monitoring plan to Water 2025 Team for review.	August 31, 2009	
	Palmer	H.3(c)	Send revised monitoring plan out for peer review. Create reconciliation memorandum.		
	Palmer	H.3(d)	Submit final monitoring plan, including incorporated review comments.	November 30, 2009	

APPENDIX B

Feedback on
Developing an Ecological Monitoring Plan
For Lakes Mead and Mohave

My responses within this questionnaire refer to the following topic area (please select one):

■ Aquatic Biota and Fisheries	□ Lake Management	□ Other
□ Contaminants	□ Limnology and Water Quality	
□ Emerging Issues	□ Riparian and Shoreline Resources	

1. **What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?**

- Making mistakes that fisheries are changing due to emerging issues (contaminants, mussels, lake level) when there is poor data on fisheries catch $ the general ecological interactions (food be energetic, etc) in each basin. Quagga mussel & other invasives (*Bythotrephes*) coming down the pipeline.
- Quagga
- The lack of turbidity in Mohave which could reduce the razorback sucker population
- In the short term I would say the drought conditions. But, in the long term Quagga Mussels will be the big problem. They just seem unstoppable.
- Non native species which cause limited recruitment in native fish. Also the Quagga Mussel and the impact it has on the food web.
- Quagga, gizzard shad, water elevation & use.
- Exotic species interactions.
- Management of threatened & endangered species (fish) is a critical concern.
- Alteration of phyto & zooplankton corrosives, issues with pipes & fish.
- Decline of endangered species and inability to get survival and recruitment of stocked fish.
- Potential food web changes fr. QM, NZMS, gizzard shad and other invasives sp. establishment.
- Quagga mussels/lake level
- Quagga
- Quagga Mussels
- Contaminants, primarily of Las Vegas Wash – pharmaceuticals, emerging contaminants, endocrine disrupting compounds.
- Poor water quality and non native threats to ecosystems, this includes non native predation of razorback Quagga threats to food web, contaminant threats to water quality.
- Since the Quagga are already in Lake Mead, I believe that now the most serious threat is the further spread of New Zealand mud snails in the lake and the spread to other lakes. They are very small and can be easily spread by waders, swimmers children with beach toys, dogs or any other items that have touched the lake bottom where the snails are found.

2. **What are the major expected consequences of this threat/stressor?**

- Variable & less predictable growth for game fish (striped bass, trout, largemouth bass)

- Change in food web structure, particularly as related to the relative contribution of benthic and pelagic resources in the system
- Decline in immature fish (RASU) Razorback suckers
- Lower lake levels would increase conductivity/salinity. This could be harmful for the base of the food web. The Quagga Mussels are out of control and a definite threat to the food web.
- To outcompete natives for food & non native eating natives before they have a chance to reproduce. The Quagga Mussel will cause water clarity which in turn will negatively affect reproduction.
- Poor angling
- Alteration of food web/ecosystem.
- Lots of money and effort to avoid extinction. Extinction (if things go badly). Continued strife & conflict between T&E species.
- Decrease in sport fisheries/complications in docks and pipes.
- Possible extinction, lawsuits from environmental groups, difficulties getting water supplies because of ESA and decline of endangered species (ie Delta smelt issues in CA)
- Effects of available food resources for pelagic sport fish sp. and native fish (e.g. razorback). Affects to littoral dependent fisheries (e.g. LMB, sunfish) are less clear & unknown. Potential charge/decline on avail. resources for multiple parts of aquatic biota (maybe)
- Reduced benthic diversity – potential fishery crash coupled with less available littoral habitat as the lake falls (steeper slope as the basin recedes into the river channel).
- Changing "mid" of the ecology
- Diminished nutrient availability through stress on the food web – which could result in a crash of the sport fishery.
- Bioaccumulation, endocrine disruption, impacts on fisheries including endangered razorback sucker, birds/eggs.
- Potential harm to multiple uses of Lake Mead including drinking water wildlife habitat wastewater assimilation recreation and others – all these uses rely on and benefit from high quality water. Monitoring and protecting water quality is paramount.
- Although they are very small, New Zealand mud snails are extremely prolific and are known to blanket lake and stream bottoms to the point of suffocating out all native growth.

3. What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?

- Two of the bays are clearly driven from benthic resources. We need to establish a strong, quantitative benthic ecology (invertebrates, algae) monitoring program as well as a fish monitoring (game & non game fish) sampling program per basin. For assistance & help on developing a comprehensive program see those established at Pyramid Lake, Tahoe, or Crater Lake (by park staff).
- Monitoring of benthic/pelagic organisms (e.g. invertebrates) is important to understanding the effects of the quagga mussel on bemthic/pelagic resources by comparing quagga-impacted assemblages to historically-documented assemblages.

- Turbidity areas and habitat/spawning sites & lack of turbidity. Is there a correlation?
- Conductivity measurements are needed along with algal ID's and enumeration to correspond with the conductivity. And continued Quagga monitoring is needed to find ways to control them.
- More research needs to be done on Quagga Mussels to determine their effects on the water clarity & their place & effect on the food web. Continue to look at gape size of large stripe bass & determine a minimum size razorback suckers should be stocked at so their chance of being eaten will be reduced and they might have a chance to reproduce.
- Effects of Quagga onYOY fish.
- Measurements of aquatic biota (distribution, relative densities)
- Monitoring of T&E species. Monitoring of exotic species, including lg. predators.
- Document the increase in populations and movement of populations downstream.
- What species of aquatic biota are utilizing Quagga as a food resource and at which life stage are they utilizing them?
- Need comprehensive monitoring in Lake Mead to determine why there is recruitment and emulate those factors in Lake Mead, also need to do more work on bonytail – Are they recruiting naturally at all anywhere?
- Maintain intensive zoo/phytoplankton and veliger monitoring in Boulder Basin and expand intensive effort to other lake basins. Continue consistent and comparable annual/seasonal monitoring and DB for threadfin shad (immature/production), sportfish and razorback lakewide.
- Benthos/fisheries
- How will nitrates & copper & zinc change
- Continued water quality sampling counting organisms which represent the food web profile.
- LVW & Bay water quality monitoring, carp tissue samplings bird egg sampling, razorback sucker population.
- Continue funding to support research to better understand biological significance of contaminants emerging and conventional Quagga wastewater discharges etc.
- Be aware of areas that are inhabited by the mussels and make sure those using the NZMS inhabited areas are advised how to prevent their spread

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Prioritize by establishing sites related to other Limnological stations currently funded (BOR, USGS, SNWA) balanced with those cations from previous studies so historical information can be utilized.
- A clearer understanding in Lake Mead is needed! (e.g. age at 1st reproduction, number of reproductive events per year).
- Position passive scanners (plate) if allowable in turbid areas
- Survival of razorback sucker. Effects of Quagga Mussels.
- Radio or transgender tagging of T&E species. Radio or transgender tagging of lg. predatory species.

- Quaggas are abundant here. We should look at how we can use them for some sort of beneficial use now that we are dealing with them anyway. Possibly biological filtration or biomass for some use.
- Correlate spawning of razorbacks with water quality, etc. start with factors such as WQ where data exists and start new data collection efforts as questions.
- Need to develop methods/protocols for differencing between early life stages gizzard & threadfin sword.
- Need data for beasts & fisheries in Lake Mojave.
- Mass biota for all metal contaminants what comes is core & long to the lake what goes out at boulder dam
- An interagency cooperative management team should be assembled representing the Colorado River Basin.
- Continue focus on cooperative, collaborative public – private partnerships.
- Continued funding for Biowest studies on razorback suckers is essential.
- Make sure that all employees of all agencies that do any work in or around the lakes are taught to identify the New Zealand snail and how to prevent their spread. They should also be made knowledgeable enough about the NZMS and how to prevent their spread so that they can inform others including the public, how to prevent the spread.

My responses within this questionnaire refer to the following topic area (please select one):

☐ Aquatic Biota and Fisheries	☐ Lake Management	☐ Other
■ Contaminants	☐ Limnology and Water Quality	
☐ Emerging Issues	☐ Riparian and Shoreline Resources	

1. **What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?**

- Decrease in recreational usability and drinkability of the resource.
- Wastewater & where it is placed in lake
- Wastewater and run off inputs
- The loss of water volume in lake Mead and the associated change in contaminant levels
- Carry over into human population of possible endocrinological consequences
- Increasing wastewater efficient discharge could be the most serious stressor to Lake Mead and Mohave
- Emerging contaminants/pharmaceuticals
- Endocrine disrupting chemicals from hormones to WWTP officials contaminating other endocrine disruptors
- The increased volumes of wastewater which is released into the Lakes with a focus on the water soluble chemicals which may biologically active but do not bioaccumulate
- Discharges associated with the SCOP project
- Waste discharge from Las Vegas – Both from MTP and urban runoff
- Increase discharge of unregulated chemical contaminants impacting/stressing native aquatic life.

2. **What are the major expected consequences of this threat/stressor?**

- Inability to properly filter lake water for consumption. Inability to healthfully withstand prolonged contact with water during recreational activities. Shifts in wildlife populations due to water quality changes.
- Collapse of fish populations
- Reduced reproductive fitness in wildlife and humans.
- More adverse effects on wildlife – e.g. feminization of fish
- Endocrinological/biomarker responses efficiently reproductive capability of animals/humans
- Variety of contaminants could result in various consequences in the biota of the Lakes and humans due to the complex functions that the Lakes provide major concerns health of fish and the ecosystem.
- Emerging contaminants pose serious health risks for the many water users on Lake Mead, especially within our drinking water.
- To effect reproduction of fish in the lake, especially endangered species and is razorback sucker
- Most of these chemicals have been studied with regards to their biological effects. As more of those are found to be endocrine disruptors, monitoring effects need to be done to look for the pressure and distribution of these chemicals.
- Uncertain impacts on Boulder Basin.
- Continued and possibly increased input of emerging contaminants.
- Toss of natives/disruption of mature systems

3. **What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?**

- Identify sources of contamination as early as possible. Identify effects of even low levels of contaminants ecologically.
- Bioindicators & passive sampling/yeast estrogen screens
- Monitor carp and largemouth at wash, bay & Overton and points in Mohave as needed. Fund seasonal fathead studies with efficient exposure (see poster). If piping waste to clean site, monitor there. Work with wastewater plants in waste reductions.
- Continue to monitor contaminant levels in water samples & passive samplers.
- Well defined site definitions. There will be shifting contamination evaluation overtime with more urbanization upstream so need to modify reference site definitions
- Fish health in organism and population levels.
- Increased contaminant analysis pre/post waste treatment and after final drinking water treatments.
- To evaluate exposure to fish from water by testing water directly or with passive samples to mimic organism upstream or food chain/web transfer of these contaminants.
- Much is known about the transport/distribution/fate of hydrophritoc organism chemicals. Expand research and monitoring of the hydrophilic (water soluble) needs to be performed.
- EDCs, nutrient & pathogens

- Understand through waste stream monitoring (Las Vegas, Wash) what is going in the Lake. Understand the long term consequences of the new discharge point.
- Monitoring an expanded range of chemicals contaminants, focus on high probability inflow areas – LV Wash, SCOP releases, Virgin River, Muddy River, etc.

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Need seasonal and long-term data from many sites
- Choose the most prolific & deleterious of the emerging contaminants (ie birth control) but also get preliminary concentrations for dozens of pharmaceuticals.
- None
- See above

My responses within this questionnaire refer to the following topic area (please select one):

☐ Aquatic Biota and Fisheries	☐ Lake Management	☐ Other
☐ Contaminants	☐ Limnology and Water Quality	
■ Emerging Issues	☐ Riparian and Shoreline Resources	

1. What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?

- New Zealand Mad Snail
- Quagga Mussels effect on the water quality
- Increasing abundance of microcystis
- Invasive species, both already present and those that are only threats at this time
- Quagga Mussels
- The invasion of Quagga Mussels into Lake Mead and other lakes in the Southwest
- Low lake level on Lake Mead
- I'm going to say Quagga mussels
- Quagga mussels
- Quagga mussels acting as a sink for nutrients/food in the Lakes
- Quagga mussels and its impact
- Moving the waste effluent diffusers out to the oligotrophic waters of Boulder Basin, bypassing the productive marshes of the wash
- Invasion of the Quagga mussel
- The Quagga mussel on cultural resources
- Urban encroachment from the LV metro area and threat of fragmentation of contiguous wildlands from AZ development
- The potential for introduction and establishment of additional aquatic invasive species plants vertebrates and invertebrates
- Quagga mussels
- Lack of standardized TIE/Forensic approaches to determine what chemicals are responsible for endocrine effects
- Invasive species such as Quagga Mussel
- Global climate change

- Continued expansion of Quagga Mussel population
- Quagga Mussel invasion
- I can't decide between drought lowering water levels or Quaggas
- The drought & Quagga Mussels lower lake levels
- Quaggas
- Quagga Mussels affecting lower trophic structure
- The next invasive species e.g. New Zealand Mudsnail or Hydrilla
- Current drought conditions and future climate change

2. What are the major expected consequences of this threat/stressor?
- Don't know. That's why I came to the LM Sci. Symposium
- Poor water quality for human consumption & food web of the lake ecosystem
- Food chain disruption. Toxicity (potential) to humans. Development of floating scum (mats)
- Detrimental impact to native and sport species, as well as to water quality and resource use
- Water quality and the whole ecosystem of Lake Mead will be impacted.
- The major consequences of the threat are still yet to be determined. It appears however that the consequences are far reaching from recreation, natural recourses, infrastructure right on down to our drinking water supply and the cost involved in monitoring it.
- Changes in habitat and bird locations. Changes in forging behavior.
- Unknown effects to ecosystems
- Potential increase in taste and odor causing cyanobacteria…decrease in other phytoplankton… disruption of fisheries potential increase in oxygen demand in hypolimnion
- Decline in fish populations due to destruction of food web. Drastic changes in water quality
- Affects of water resources ecology and damages to crucial infrastructure & equipment.
- Waste nutrients & residual contaminants won't be broken down by organisms & uptaken by vegetation before the eater makes its way into the heart of Boulder Basin
- Take over the parks archeological sites and disrupt the Lake Mead food chain and possible infestation of other lakes in the southwest including Lake Tahoe.
- Loss or distraction of cultural resources
- Increased runoff from urbanized footprint/shorter lag time for runoff onto stream erosion…Introduction of non native desert plants from transition to xerographic landscaping…Loss of riparian/water sources on AZ boarder w/LAME
- A perdition of ecological processes maybe biodiversity maybe recreational impacts maybe economic impacts
- Water intakes could be infested w/ Quagga mussels and slow or stop the flow of water
- Can't decide what to do about it
- Probably continued increase in numbers but unknown consequences
- Increased evaporation decreased inflows overallocation of river
- A crash of the food web carving significant impacts to fisheries and recreation

- Changes in ecosystem damages to industry/water supply toxic bacterial blooms
- Drought increased demand for less water ecological & major solid implications Quaggas ecosystem impact millions in damage to infrastructure irreparable damage to cultural resources
- Decreased in species diversity on both plants and animals exotics invasion moving in at faster rates then natives able to reestablish
- Less algae. Less zooplankton. Less fish
- Redirection of food web resources from pelagic to benthic. Size selectivity of mussels might alter lower trophic structure
- Mudsnails will impact the ecology of the lake, specifically detritus forage source for fisheries. Hydrilla once established will not be eradicated and will require continuous control measures to keep marinas clean for boat passage and also fishing impacts
- Lowered water availability. Degraded water quality. Impacted aquatic ecosystems. Impacted supply for human consumption.

3. What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?

- Impacts to planktonic community within each ecosystem
- Phytoplankton monitoring must screen for microcystis (do it with & net sample)
- Monitoring/sampling that is comprehensive, and dissemination of information to educational sources
- Interagency Quagga Mussel monitoring the infestation status of Quagga Mussels and the ecological consequences of Quagga Mussels in Lake Mead
- The monitoring needs within this area should focus on understanding the life cycle and basic biology of Quaggas in the southwest. Understanding this will help recreation managers and water managers as a whole
- Keeping track of the different routes used as water levels change
- Faster, more sensitive and inexpensive methods for Quagga detection and enumeration, such as PCR
- Phytoplankton & zooplankton monitoring / mussel control efforts monitoring / mussel population monitoring / water quality PO profiles / fish populations
- How can we limit their spread how can we suppress growth & proliferation without damaging the existing fish & aquatic biota populations
- Quagga maybe look into photoperiod in conjunction with temp that may be determining breading cycle
- Continued research data collection and problem solving to combat the Quagga mussel impacts
- Baseline monitoring of proposed diffuses sites & proposed drinking water intake. Study what temperature the plume will ride in the stratified water column relative to the intake along with the monitoring of the Beach
- I think right now we need to have a word hand one prevention of Quagga Mussels getting out and into other lakes
- Keep track of build up & destruction the Mussels
- GIS of emerging development hot spots and if the will impact nat./aquatic resources

- System wide early detection protocol especially targeting primary points of invasion eg Las Vegas Wash confluence of Virgin/Muddy/Colorado Rivers marinas & boat launch locations
- TIE/Forensic
- The inclusion development and validation of enhanced molecular methods such as quantitative polymerase chain reaction QPCR
- Evaporation rates water level
- Growth rates reproductive capacity control techniques
- Monitor population size filtration clearance rates materials mussels grow on don't grow on effects to fisheries impacts to water changes in ph conductivity chlorophyll a zoo & phytoplankton turbidity
- Monitoring & managing the impacts of lowering water levels protecting resources empowered by this natural & unnatural try to research eradication of Quaggas
- Continued counts & removal a more vigorous re-veg of native plants once exotics have been removed.
- Quaggas. SCOP project discharge at depth during stratification. Nutrients available Nov-April in photic zone
- Bacterial abundance including cyanobacteria and microbial community structure of water & sediment heterotrophy autotrophy how does the base of the Lake food web work?
- More boat monitoring for these species
- Continuous water quality Continuous flow markers Continuous algal/biotic monitoring

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Quagga Mussels may be less of an ecological threat than New Zealand mud snail.
- Incorporate net samples since microcystis is hard to collect & analyze from water samples only
- Long-term climate monitoring by multiple agencies
- Continue to work with agencies and entities outside of Lakes Mead and Mohave. Only by sharing knowledge can we hopefully fill in the gaps!
- Perform some surveys by aircraft
- Because Cyanobacteria levels seem to be affected by quaggas, methods for monitoring cyanobacteria to the species level and also cyanotoxins should be monitored
- See above plus more organized data collection & methods. Currently, it seems like a shot gun approach w/ many monitoring efforts supported on short term
- ECC's maybe sample wash water after expected high use/high partying periods to determine if plumes of high contaminates concentrations are moving down stream
- The potential impact of moving our waste water effluent closer to our drinking water intake needs serious consideration especially in relation to current velocity & directional data
- Increase partnership w/ conservation organizations increase enforcement of buffer areas
- Need to sort out timing & Forensic issues as well as the so what of nest

- Monitor cyanobacteria and fecal indicator bacteria using enhanced molecular methods important due to effect the these may have on Quagga Mussels populations
- Is there any effort to monitor mussels on Mohave?
- w/ respect to cultural resources as they come out of the water they need to be interpreted to the public there is increased interest & the park needs to respond to the interest
- Is there any desire to diminish the look of the bathtub ring around the lakes?
- To protect drinking water to protect endangered species future urban area runoff so Utah
- Cell counts from multiple locations over time e.g. flow cytometric counts DNA based community assessments who is there? How does the change as invasion progresses?

My responses within this questionnaire refer to the following topic area (please select one):

☐ Aquatic Biota and Fisheries	■ Lake Management	☐ Other
☐ Contaminants	☐ Limnology and Water Quality	
☐ Emerging Issues	☐ Riparian and Shoreline Resources	

1. **What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?**

- Ironically I feel/think Lake Mead is the greatest threat to the Mojave Desert & Colorado River Region. Lake Mead enables Las Vegas, which introduces containments, pollutants, entrenchment, invasives, etc.
- Decline in lake level/elevation
- Excessive human population in the region
- Lack of good biological data
- Reduced water to reservoirs
- Water demands from Las Vegas, Henderson, Clark County, etc.

2. **What are the major expected consequences of this threat/stressor?**

- Loss of native species due to changes in habitat, decreased biodiversity, increased "invasives" species that are capable of living in the Lake environment. Decrease in Lake levels due to a combination of prolonged drought & over population, as well as drastic changes in the Colorado's hydro logic cycles.
- Expected consequences include: change in lake ecology, possible dry up of the lake, impact on submerged cultural resources, impact to visitors, cost to maintain launch ramps, effects to wildlife, etc.
- Excess water demand, waste/chemical loads, invasive species.
- Not able to know good baseline conditions.
- Potential for "trickle-down" effect to all biota on one level or another – possibly into unknown territories!
- Increased drawdown of lake levels. Increased pollutant input into the lake.

3. **What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?**

- I think it's very important to monitor species of both plants & animals that have been displaced to the construction of the Hover Dam/Lake Mead, as well as monitoring recent invasives to see if there is a correlation, are the invasives filling the niche that native displaced species used to fill?
- Water allocation, water conservation, impact to water quality
- Total lead & per capita load of all inorganic and many organic constituents.
- Know better about evasive species threats that are most likely for Lake Mead, then monitor & prevent.
- Work w/ reporters (L. Powell, etc.) on H_2O quality to best of ability. Continue monitoring, esp. invasives – to best of & ability.
- Water usage with population growth

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Very impressed w/ the work of our colleagues.
- The public needs to be aware of the seriousness of this threat. In creased education may help in large scale conservation.
- Per capita values could support public outreach to encourage, then applaud, reductions in these rates.

My responses within this questionnaire refer to the following topic area (please select one):

☐ Aquatic Biota and Fisheries	☐ Lake Management	☐ Other
☐ Contaminants	■ Limnology and Water Quality	
☐ Emerging Issues	☐ Riparian and Shoreline Resources	

1. What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?

- Increased urbanization especially along I-15 corridor through AZ, UT to the North – Mesquite/Overton waste water, as well as Las Vegas Valley SCOP project.
- Urbanization, water shortage, drought, and water quality
- Quagga is a no-brainer, but SCOP concerns me most. What will be the effect of eliminating almost 10 miles of UV radiation & aeration that presently act on discharged effluent?
- Pollution from SCOP project, unknown response after completion of submerged point source pollution
- Limited or decreasing inflow/runoff, lower lake levels
- Algal blooms/nutrient inputs to Lake via LV Wash and new SCOP project. What will the effect be putting efficient deep in sometimes Low DO water?

2. What are the major expected consequences of this threat/stressor?

- Increased phosphorus loading resulting from reduced wetland remediation of phosphorus (LV Wash) as majority of efficient flow is shifted to SCOP diffuser.
- Water shortage. Water quality and economic development.
- Maybe serious impacts to water contact recreation in Boulder Basin. Public perception is that green water is "dirty", which is presently pretty confined to Las Vegas Bay. Will this deep release of high-nutrient, high temperature, high-bacteria water create unsightly, smelly, undesirable conditions? Aeration & UV treatment by nature should not be underestimated. I shudder to think of the unforeseen impacts of this decision that has been forced on us all.

- Unknown, degraded water quality or improved water Q? Reduction in Las Vegas Wash volume & thus potential impacts to riparian & aquatic biology, and possible a more stable system throughout the LV Wash.
- Declining water quality, more extremes
- Unknown – potential for zero DO and associated changes in ecosystem – potential mobilization of reduced elements – sent downstream to other uses

3. What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?

- Improved phosphorus sampling/analysis for low level to high level concentrations. Understand relationship with total-P, ortho-P, dissolved organic-P, etc. driving algal growth.
- Hydrologic water quality and ecosystems.
- Aeration probably allows some toxic substances (metals, etc) to oxidize into less toxic forms. Monitoring of these things will be central & essential long-term for both Lakes Mead & Mohave.
- Water Q, benthic & invertebrate biological monitoring from various areas from this discharge point
- More timely water quality data
- General QW monitoring – profiles and continuous data at existing and maybe expand number of stations

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Continue long-term water quality monitoring for Lake-wide model validation/calibration.
- A comprehensive and integrated monitoring and management plan (Hydrologic water quality and biological studies) is needed.
- Figure out how to spread the responsibility & costs across all the local agencies. It shouldn't fall to one & oversight & some renumbering is needed.
- Physical & biological water quality parameters
- Additional monitoring stations with real-time data.
- Measurement should be as present. T, DO, PH, Turb, Chlor-A.

My responses within this questionnaire refer to the following topic area (please select one):

☐ Aquatic Biota and Fisheries	☐ Lake Management	☐ Other
☐ Contaminants	☐ Limnology and Water Quality	
☐ Emerging Issues	■ Riparian and Shoreline Resources	

1. What, in your opinion, is the most serious threat/stressor facing Lakes Mead and Mohave for this topic area?

- Noxious Aquatic Plant Invasion
- I feel like loss of habitat with declining lake levels
- Non-native, invasive aquatic plant species and low water affecting bird population
- In non-invasive species, in native trees & larger shrubs & human waste/litter (mainly human impact)

2. What are the major expected consequences of this threat/stressor?

- Decrease in recreation values

- Draw down in water threaten shoreline habitat for riparian bird species, as well as shorebirds and aquatic birds not to mention continuing concentrating contaminants.
- Crowding out native plants/reduced natural native habitat as low water affect habitat
- In water quality (i.e. Nelson comes along Lake Mohave with human waste or Cottonwood comes with litter/human waste), in native species (because of illegal cutting/burning/ in non-natives) would change habitat for wildlife use & species diversity.

3. What are the most important monitoring needs for Lakes Mead and Mohave within this topic area?

- Routine monitoring program is needed to provide a baseline as well as an early warning
- Potentially additional surveys of shoreline species to determine the effects of water faux draw down
- Water quality at high-use comes, cutting &/or burning of native species along shoreline, % of non-native species along shoreline, wildlife use monitoring at high-use comes

4. Additional input (e.g., recommended measurements, how monitoring needs should be prioritized, etc):

- Should compare (develop a risk analysis) species to indentify the most likely to have established in Lake Mead or Lake Mojave.
- Species richness & density

APPENDIX C

Draft Expanded Framework for An Ecological Monitoring Plan for Lakes Mead and Mohave

Long Term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave

A. Introduction/Preamble Broad Goals for the Monitoring and Research Plan

The purpose of this effort is to bring together agencies with authorities and interests in Lakes Mead and Mohave within the boundaries of the Lake Mead National Recreation Area to:

- document mutual limnological and water dependent natural resource goals;
- document and coordinate existing monitoring programs and how they relate to the mutual goals;
- document additional research and monitoring that would assist in achieving the mutual goals;
- coordinate the sharing of resources for efficiencies within existing monitoring and research programs;
- provide a forum for sharing and documenting information for agency managers and the public;
- and seek opportunities for additional funding support for high priority monitoring and research not currently underway.

1) Holistic Understanding for Change Detection – Not Just Chase the Stressor of the Week
2) List of participating agencies
3) Overview of existing/regulatory required monitoring programs
4) Scope – The plan geographically covers the surface waters within Lake Mead NRA. The plan covers the basic limnological and water quality elements that relate to fulfilling the plan mutual goals, as well as water dependent natural resources such as fisheries, aquatic biota, and waterbirds.
5) Coordination – There are a number of existing monitoring programs within the geographic bounds of the plan that relate either to regulatory requirements, such as the program for drinking water source monitoring by SNWA and for NPDES discharge permits by the sanitation districts, and the Boulder Basin Adaptive Management Program by Clean Water Coalition. There are also regional conservation programs that monitoring within this area, such as monitoring related to the Lower Colorado River Multi Species Conservation Program and the Virgin River Habitat Conservation Program. Numerous agencies have statutory authorities and responsibilities for elements within this plan. This plan is not intended to usurp any other authorities, or cause redundancies in monitoring. It is intended to provide coordination for monitoring that meets our mutual goals, identify gaps in existing monitoring, and seek efficiencies in providing monitoring and research that meets the documented gaps.

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B. Plan Strategic Fundamental Objectives

The participating agencies have agreed to the following initial set of goals to be supported by a documented comprehensive monitoring and research needs assessment. These goals are adopted as the strategic fundamental objectives of this plan.

- Lakes Mead and Mohave maintain water quality that supports a healthy sportsfishery
- Lakes Mead and Mohave maintain water quality that supports healthy populations of native fish
- Lakes Mead and Mohave maintain water quality that support healthy populations of aquatic dependent wildlife
- Lakes Mead and Mohave maintain water quality that support healthy populations of riparian, aquatic, and shoreline dependent native vegetation
- Lakes Mead and Mohave maintain water quality in support of existing high quality setting for water based recreation
- Lakes Mead and Mohave maintain water quality that supports regional and community needs for municipal and industrial uses, including domestic water supply and Colorado River System return flow credits.

C. Resource and Related Plan Component Categories

The plan is organized around six categories that summarize all ecosystem and limnological components of resource management interest. A section devoted to each category contains a brief summary of existing programs currently being monitored, a brief summary of general extent of the current knowledge or status related to the category, a listing of research and monitoring questions related to the category, and a break-out "step down" chart listing of suggested monitoring and research elements. The listing of suggested elements will be distinguished by font/color or similar indicator to show which are currently being covered by existing programs and which are not being covered.

Monitoring Plan Category	**Objective 1** Sportfishery	**Objective 2** Native Fish	**Objective 3** Aquatic Dependent Wildlife	**Objective 4** Native Vegetation	**Objective 5** Recreation	**Objective 6** Community Needs
Water quality and limnology	●	●	●	●	●	●
Fish and Aquatic Biota	●	●				
Birds			●	●		
Abiotic and biotic stressors	●	●	●	●	●	●
Sediment	●	●	●		●	●
Riparian			●	●		

Activities within each category will apply to strategic fundamental objectives as indicated by the black dots. This chart can be expanded to include priority questions, etc.

1. Water Quality and Limnology

Insert Introduction to the category here.

Strategic Objective(s):

To support

- a healthy sportsfishery
- healthy populations of native fish
- healthy populations of aquatic dependent wildlife
- healthy shoreline dependent native vegetation
- existing high quality setting for water-based recreation
- regional and community needs for municipal and industrial uses, including domestic water supply and Colorado River System return flow credits

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What are the status and trends of basic water quality parameters (e.g., conductivity, dissolved oxygen, temperature, turbidity, and pH)
- What are the status and trends of nutrients?
- What are the status and trends of plankton?
- What are the status and trends of algal blooms?
- What are the status and trends of chlorophyll *a*?
- What are the status and trends of drinking water precursors and VOCs?
- What are the status and trends of contaminants in water column and fish and wildlife tissues?
- Question related to aesthetics – clarity, odors

Management questions best answered by research:

- What are the relationships between any changes in the water quality parameters and impacts to fish, aquatic dependent wildlife, and recreation?
- Question related to hydrology and transport
- Question related to turnover
- Question related to retention times
- Question related to tributary inputs
- How well has management provided for environmental qualities and values associated with these aquatic ecosystems?

Suggested Step Down/Monitoring Elements: Nutrients, Drinking Water Pre-Cursors, Plankton, DO, Conductivity, Temperature, Hydrology and Transport, Turnover, Retention Times, Tributary Inputs (Floods also); re-suspension of nutrients from sediments, sediments as nutrient sinks; Aesthetics – clarity and odors, algae blooms

Stressor listing specific to this category:

- Floods
- Quagga mussels

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

2. Fish and Aquatic Biota

Insert category introduction.

Strategic Objective(s):

To support

- a healthy sportsfishery
- healthy populations of native fish

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What are the status and trends of sport fish?
- What are the distributions, reproduction, and recruitment native fish?
- What is the biological condition, chemical water quality condition, and physical condition of razorback sucker spawning and rearing habitat?
- What is the status and trend of the forage base/plankton?
- What contaminants are found in fish tissue?

Management questions best answered by research:

- What factors (biotic and abiotic) influence native fish distribution and abundance?
- What factors (biotic and abiotic) influence non-native fish distribution and abundance?
- What food-web dynamics are in place in Lakes Mead and Mohave?
- What are the native and sport fish population dynamics?
- What is the ecosystem status; is the natural range and frequency of aquatic habitat conditions maintained?

Suggested Step Down/Monitoring Elements: Native and Sport Fish Population Dynamics, Reproduction and Recruitment, Contaminants, Plankton, Forage Base and Food-Web Dynamics

Stressor listing specific to this category:

- Contaminants
- Viruses and bacteria
- Quagga mussels

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

3. Birds

Insert introduction to the category.

Strategic Objective(s):

To support

- Healthy populations of aquatic dependent wildlife

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What are the distribution and population dynamics of shorebirds, eagles, peregrine falcons?
- What contaminants are present in shorebirds?
- Xxx
- Xxx
- Xxx

Management questions best answered by research:

- What is the relationship between waterbird to food base and contaminants?
- Xxx
- Xxx
- Xxx
- Xxx

Suggested Step Down/Monitoring Elements: Waterbird population dynamics; water bird relationships to food base and contaminants

Stressor listing specific to this category:

- Contaminants

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

4. Abiotic and Biotic Stressors

Insert introduction to the category.

Strategic Objective(s):

To support

- a healthy sportsfishery
- healthy populations of native fish
- healthy populations of aquatic dependent wildlife
- healthy shoreline dependent native vegetation
- existing high quality setting for water-based recreation
- regional and community needs for municipal and industrial uses, including domestic water supply and Colorado River System return flow credits

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What are the trends in quagga mussel distribution and populations?
- xxx
- xxx
- xxx
- xxx

Management questions best answered by research:

- xxx
- xxx
- xxx
- xxx
- xxx

Suggested Step Down/Monitoring Elements: Selenium, Metals, EDCs, ECCs, Pathogens, all in water column and tissues; QM population dynamics and demographics, QM impacts to nutrient cycling and DO, QM impacts to Boulder Basin and drinking water and SCOP mixing zone, QM impacts to basic limnology and plankton/forage base/food web dynamics, QM impacts to recreation – mats of shells and algae; early detection mechanisms for other non-natives including non-native aquatic plants

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

5. Sediment

Insert introduction to the category.

Strategic Objective(s):

To support

- a healthy sportsfishery
- healthy populations of native fish
- healthy populations of aquatic dependent wildlife
- healthy shoreline dependent native vegetation
- existing high quality setting for water-based recreation
- regional and community needs for municipal and industrial uses, including domestic water supply and Colorado River System return flow credits

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What is the status and trend of re-suspension and transport of contaminants and nutrients from sediments?
- What is the status and trend of contaminants in sediments?
- xxx
- xxx

Management questions best answered by research:

- How do sediments serve as nutrient and contaminant traps or sinks?
- xxx
- xxx
- xxx
- xxx

Suggested Step Down/Monitoring Elements: Selenium, Metals, EDCs, Pathogens, in sediments

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

6. Riparian Resources

Insert introduction to the category.

Strategic Objective(s):

To support

- healthy populations of aquatic dependent wildlife
- healthy shoreline dependent native vegetation

Priority Questions [ONLY SAMPLES AT THIS POINT]:

Management questions best answered by monitoring:

- What are the distribution, connectivity, and area of riparian vegetation (native and non-native)?
- xxx
- xxx
- xxx
- xxx

Management questions best answered by research:

- Is riparian vegetation maintained or restored to a condition that supports key riparian functions?
- xxx
- xxx
- xxx
- xxx

Suggested Step Down/Monitoring Elements: Stepdown Monitoring: riparian birds, riparian vegetation, contaminants in bird tissue and eggs

Stressors:

- Invasive plant species

To be inserted here: an overview or listing of existing monitoring programs in this category and a brief summary of general extent of the current knowledge or status related to the category. Additional materials/info may be placed in an appendix, which is referred to here.

D. locations of protocols (after each category, id what protocols exist and where they can be found)

E. Brief statements of State of Knowledge by categories and simple (one page charts, etc.) conceptual models

F. Relationship to ELCOM/CAEDYM Model and Regional Planning

- Potential Maintenance of Model and use of model to guide monitoring and model to assist in planning and education
- Elements needed to maintain or improve model

G. Data Management/Archival – Use of Existing Mechanisms – QA/QC

H. Data Analysis and Summaries

I. Synthesis Reporting of Ecosystem Dynamics and Conditions