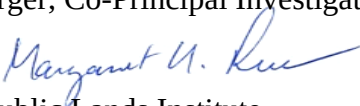




December 2, 2009

TO: Kent Turner, Chief of Resource Management
National Park Service – Government Technical Representative

E-COPY: Dr. Angela Evenden, NPS CESU Research Coordinator
Mr. Bill Black, Interim Acting SNAP Executive Director
Dr. Craig Palmer, Co-Principal Investigator
Dr. Shawn Gerstenberger, Co-Principal Investigator

FROM: Dr. Margaret N. Rees 
Executive Director, Public Lands Institute

RE: Final Project Report
Task Agreement # J8R07070010

Enclosed please find the Final Project Report for the project entitled:

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

The Final Project Report reflects activities and accomplishments that occurred during the 24-month course of the Task Agreement.

A hard copy of Project Compendium will be provided via mail. Copies of the Compendium will also be mailed to Dr. Angela Evenden, NPS CESU Research Coordinator, Mr. Bill Black, Interim Acting SNAP Executive Director, and Dr. Craig Palmer, Co-Principal Investigator, Dr. Shawn Gerstenberger, Co-Principal Investigator, and Ms. Linda Whitson at the Pacific West Regional Office.

If you have any questions after reviewing this report, please do not hesitate to call me at (702) 895-3890.

MNR:wd
Enclosures (1)

Public Lands Institute
Box 452040 • 4505 S. Maryland Parkway
Las Vegas, NV 89154-2040
Main 702-895-4768 • Fax 702-895-5166
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Executive Summary and Concise Statement of Accomplishments

Limnological Assistance for the Lake Mead National Recreation Area in Meeting the Challenge of the Water 2025 Initiative was a Southern Nevada Public Land Management Act (SNPLMA)-funded project. It was implemented by the University of Nevada, Las Vegas (UNLV) Public Lands Institute (PLI) cooperatively with the UNLV Department of Environmental and Occupational Health and the UNLV Harry Reid Center for Environmental Studies on behalf of and in cooperation with the National Park Service, Lake Mead National Recreation Area (Lake Mead NRA). This effort consisted of six projects for which the following results were achieved:

1. Technical Assistance with Interagency Monitoring Programs

- Technical advisory committee meetings of the following groups were attended, participated in, and summarized: Boulder Basin Adaptive Management Plan (BBAMP; various committees, including the ELCOM/CAEDYM Modeling Workshop); Lake Mead Water Quality Forum; Las Vegas Wash Advisory Committee; and Las Vegas Wash Coordination Committee.
- Technical input/assistance was provided through the creation of a draft section of the BBAMP (titled: Item of Concern: Quagga Mussels).
- A thesis (titled: Mercury Concentrations in Muscle Tissue from Sportfish, Lake Mead, Nevada) was completed to address mercury as an emerging contaminant of concern within Lake Mead.
- Participation in the development of a Selenium Management Plan was accomplished through the development of the following reports:
 - A Review of Selenium Fate and Toxicity Relative to the Las Vegas Wash
 - Review and Recommendations on the Las Vegas Wash (LVW) Selenium Management Plan

2. Review and Synthesis of Project Information for Water 2025 Conservation Initiatives

- Data of interest to the NPS were reviewed and synthesized within the following topic areas:
 - Bacteria in High-use Sites
 - Limnology and Water Quality Baseline Data
 - Zooplankton Trend
 - Carp Die-Off
 - Threadfin Shad (Thesis: Trophic Interactions Associated with Introduction of the Invasive Quagga Mussel in Lake Mead, Nevada)
- A review of a modeling report (titled: 2009 ELCOM-CAEDYM Model Whole Lake Addition of Years 2006-2007), prepared for the BBAMP and later expanded to include the whole lake, was conducted with an emphasis on the potential for the model's best use and future enhancement.
- Task-tracking summaries and project overviews were created for Water 2025 Conservation Initiatives being carried out by other NPS partner agencies.

3. Technical Assistance with the Development of Quagga Mussel Monitoring and Research Programs

- The major effort of Project 3 was the creation of a long-term quagga mussel-monitoring plan [titled: Interagency Management Action Plan (I-MAP) for Quagga Mussels]. In addition to providing monitoring goals and methods, this document includes discussions of agency needs and objectives; potential ecological and economic impacts; history and synthesis of findings to date; and quagga mussel life history. An internal core group was coordinated to initiate I-MAP development and provide critical suggestions and review comments on the document. In addition, as part of this effort, a zebra/quagga mussel bibliographic database containing 420 entries was constructed.
- An external group of quagga mussel experts was coordinated to assist in identifying immediate needs related to quagga mussels through a peer review of proposals, and to refine elements within selected projects. Two projects were chosen to be carried out by UNLV: (1) Quagga Mussel Monitoring and (2) Impacts to Fisheries. These projects resulted in the following theses, “Substrate Monitoring, Contaminant Monitoring, and Educational Outreach on Quagga Mussels (*Dreissena bugensis*) in Lake Mead, NV” and “Trophic Interactions Associated with Quagga Mussel in Lake Mead, NV.”
- Nine Interagency Quagga Mussel Meetings were coordinated, facilitated, and summarized; all meeting materials and presentations were archived and provided to meeting participants upon request. The purpose of these meetings was to share information and findings about quagga mussels across multiple agencies. A presentation (titled: Bacteria and Cyanobacteria in Lake Mead: Do Invasive Quagga Mussels Affect Them?) was prepared and delivered to evaluate a potential emerging ecological effect of quagga mussels.
- Four manuscripts resulting from Project 3 have been approved by the Lake Mead Science Symposium (Project 5) technical committee and entered into the *Lake and Reservoir Management* peer-review process.

4. Strategic Data Mining of Historic Data

- A Lake Mead literature and informational material search was conducted and a comprehensive, relational bibliographic and research-activity database for Lake Mead was created.
- Data were mined for a historic Lake Mead Benthos Study (1986-1987). An Access database was developed and data were inserted from the 311 field data sheets and 440 laboratory data sheets available from the original study.
- A UNLV Libraries Special Collection, “Lake Mead National Recreation Area Limnology” was created to ensure permanent placement and access to available research material and reports. The collection was populated with James F. LaBounty’s datasheets provided by the Southern Nevada Water Authority.

5. Coordination of Lake Mead Science Symposium

- The Lake Mead Science Symposium was held January 13-15, 2009 on the campus of UNLV and attended by more than 150 people. It featured a multi-keynote speaker plenary session; a memorial for renowned limnologist James F. LaBounty whose life’s work centered on Lake Mead; six concurrent sessions; a closed session of technical committee chairs, which served as the launch of Project 6 (below); a poster session; exhibitors; and a reception. A printed program was provided detailing all aspects of the symposium; a

website was created and posted at www.lakemeadsymposium.org. Participants' suggestions for a monitoring plan for Lakes Mead and Mohave were captured, reviewed, and archived.

- A special issue of *Lake and Reservoir Management*, for which 14 manuscripts were invited (four from this UNLV project), will serve as the symposium's proceedings; all symposium presentations have been archived.

6. Development of an Ecological Monitoring Plan for Lakes Mead and Mohave

- A plan (titled: Long-Term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave) was collaboratively designed to provide a framework limited to limnology and water-dependent natural resources to bring together agencies with authorities and interests in Lakes Mead and Mohave within the boundaries of the Lake Mead National Recreation Area. It identifies six fundamental strategic objectives, which can be addressed through six categories of management interest: (1) Water Quality and Limnology; (2) Fish and Aquatic Biota; (3) Stressors; (4) Sediment; (5) Birds; and (6) Riparian Resources. For each category, both monitoring and research questions have been formulated along with the components, drivers, and stressors inherent to each category. Monitoring activities and data interpretation are suggested for each category. Other sections of the document include significance and purpose, coordination, geographic scope, data management and analyses, and relationship to the ELCOM/CAEDYM model.
- Interagency "Water 2025" meetings were coordinated, facilitated, and summarized; 14 meetings were held. Meeting materials were archived and provided to participants upon request.

Background and History

Efforts conducted through this Task Agreement were components of three Southern Nevada Public Lands Management Act (SNPLMA) Conservation Initiative Projects, approved by the Secretary of the Interior. Nominations for these projects were submitted under the title of "Meeting the Challenge of the Water 2025 Initiative" and awarded to the National Park Service (NPS), on behalf of Lake Mead National Recreation Area (Lake Mead NRA), as Phases I, II, and III under SNPLMA Rounds 4, 5, and 6. "Water 2025" was a Department of the Interior initiative designed to help manage scarce water resources in the American West that encouraged the development of partnerships. To meet the challenges of balancing water quality, community needs, and water-based recreation for Lakes Mead and Mohave as envisioned by the 2025 initiative, NPS nominated projects and was awarded SNPLMA Conservation Initiative funding over the three rounds. Lake Mead NRA worked in partnership with the University of Nevada, Las Vegas (UNLV) and multiple other entities (e.g., the U.S. Geological Survey, the U.S. Bureau of Reclamation, the Southern Nevada Water Authority, the U.S. Fish and Wildlife Service, and the Nevada Department of Wildlife) to monitor and conduct research to complete the deliverables of the three Conservation Initiatives.

Through this task agreement, Lake Mead NRA established a cooperative relationship with UNLV to complete the six projects described in subsequent sections of this document. The effort involved interaction with interagency teams on an iterative basis. This work required extensive interagency coordination and cooperative analysis of data. The project included opportunities for and involved graduate student researchers.

Products

Bulleted items, indicated throughout this document with the ► symbol are included in the 3-Year *Limnological Assistance for the Lake Mead National Recreation Area Compendium* binder that accompanies this report.

Principal UNLV Project Participants

Project Administrator	Margaret N. Rees, Ph.D. , Executive Director Public Lands Institute and Vice Provost, UNLV Division of Educational Outreach
Principal Investigator Projects 1-3	Shawn L. Gerstenberger, Ph.D. , Executive Associate Dean/Chair/ Professor, UNLV School of Community Health Sciences/Department of Environmental and Occupational Health
Principal Investigator Projects 2, 4-6	Craig J. Palmer, Ph.D. , Associate Executive Director/Research Professor, UNLV Harry Reid Center for Environmental Studies
Project Manager Lead: Projects 1, 2, and 3	David (Wai Hing) Wong, Ph.D. , Associate Research Professor, UNLV Public Lands Institute and Department of Environmental and Occupational Health
Program Coordinator Lead: Project 5, 6, and Final Report	Jennell M. Miller, Ph.D. , Project Coordinator, UNLV Public Lands Institute
Lead: Project 4	James Pollard , UNLV Harry Reid Center for Environmental Studies
Contributor to Project 1	Thomas C. Piechota, Ph.D. P.E. , Director of Sustainability and Multidisciplinary Research Office of the UNLV Urban Sustainability Initiatives and Associate Professor of Civil and Environmental Engineering
Contributor to Project 2	Patricia Cruz-Perez, Ph.D. , Associate Research Professor, UNLV Harry Reid Center for Environmental Studies
Graduate Students	• Joanna L. Kramer, UNLV Department of Environmental and Occupational Health • Kenneth Lamb, UNLV Department of Civil and Environmental Engineering • Eric M. Loomis, UNLV Department of Environmental and Occupational Health • Sara A. Mueting, UNLV Department of Environmental and Occupational Health

Project 1 Technical Assistance with Interagency Monitoring Programs

At the time of initiation of this task agreement, the developing urbanization of Southern Nevada led to increased concerns regarding potential impacts to the existing high quality water in Lakes Mead and Mohave. A major project was being planned: the Nevada Clean Water Coalition's System Conveyance and Operations Program (SCOP). SCOP would be a means to transport highly treated effluent directly from municipal wastewater treatment facilities to a lake diffuser located deep in the Boulder Basin of Lake Mead, where the effluent would then be adequately diluted. The use of the pipeline was to be triggered by a specific lowered lake level. In anticipation of this pipeline being completed by 2012, the accompanying Environmental Impact Statement (EIS) and Record of Decision prescribed the development of a Boulder Basin Adaptive Management Program (BBAMP) to establish targets and objectives for water quality to ensure that management objectives of maintaining the existing high water quality were met. The BBAMP was cooperatively implemented by the Southern Nevada Water Authority, Clean Water Coalition, U.S. Bureau of Reclamation, and National Park Service, in close association with Nevada Division of Environmental Protection. As of November 2009, construction of SCOP pipeline is on hold and undergoing re-evaluation. New requirements for effluent treatment are under discussion. Whatever direction for effluent treatment is ultimately incorporated, the projects and programs put into place through the BBAMP have provided baseline monitoring data and other products invaluable to the future management of this water body.

The BBAMP established technical committees including baseline monitoring, database management, water-quality modeling, water quality requirements, and downstream water quality issues. It established advisory committees including water-quality protection, decision processes, emerging contaminants of concern, limnology, and fisheries. The BBAMP was to be guided by Items of Concern (IOCs), which are any item with potential to affect water quality in Lake Mead, for example, an index of Secchi depth, total phosphorus, and chlorophyll *a*. The SCOP BBAMP and the U.S. Fish and Wildlife Service Biological Opinion both require the development of a Selenium Management Plan for the Las Vegas Wash and Las Vegas Bay, and a triennial review of monitoring data related to endocrine disrupting compounds and emerging contaminants of concern.

Through Project 1, UNLV provided technical assistance to Lake Mead NRA with interagency monitoring programs including activities conducted under BBAMP SCOP, as described in the following sections.

INTERAGENCY MEETING ATTENDANCE AND PARTICIPATION

The technical advisory committee meetings listed below were attended and participated in during year 2 of this project by David Wong, Ph.D. (UNLV) who also summarized them. Because the summaries do not represent formal minutes for these meetings, which were hosted by entities external to this task agreement, they should not be posted on the Internet or otherwise distributed electronically.

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	NDEP Lake Mead Water Quality Forum
9/22/2008	SCOP/Boulder Basin Adaptive Management Meeting WATER QUALITY OBJECTIVES AND MIXING ZONE MONITORING
9/23/2008	ELCOM/CAEDYM/PLUMES Modeling Workshop
10/27/2008	SCOP/Boulder Basin Adaptive Management Meeting WATER QUALITY OBJECTIVES and MODELING
12/03/2008	NDEP Lake Mead Water Quality Forum
12/09/2008	Las Vegas Watershed Advisory Committee Meeting
02/18/2009	NDEP Lake Mead Water Quality Forum
02/23/2009	Boulder Basin Adaptive Management Program
04/27/2009	Boulder Basin Adaptive Management Program
06/24/2009	SCOP/Boulder Basin Adaptive Management Meeting
07/15/2009	NDEP Lake Mead Water Quality Forum Note: D. Wong presented on quagga mussel monitoring at this meeting
08/24/2009	SCOP/Boulder Basin Adaptive Management Meeting
10/14/2009	NDEP Lake Mead Water Quality Forum
10/26/2009	Boulder Basin Adaptive Management Program

- ▶ 19 Meeting Summaries
- ▶ PowerPoint: D. Wong. Interagency Quagga Mussel Monitoring. Presented at the 7/15/2009 NDEP Lake Mead Water Quality Forum, Henderson, NV. (NOTE: For organizational purposes, this presentation is provided under **Project 3 Technical Assistance with the Development of Quagga Mussel Monitoring and Research Programs**)

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

01/18/2009	http://www.lvwash.org/cfml/calendar/index.cfm/5C627C16-C3DE-24F2-E064F7A4DE71C516.pdf?calendarparam=file&doc_id=5C627C16-C3DE-24F2-E064F7A4DE71C516
02/10/2009	http://www.lvwash.org/cfml/calendar/index.cfm/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.cfm/6750D89A-9B78-1E44-1BA5AF3CE3A317BD.pdf?calendarparam=file&doc_id=6750D89A-9B78-1E44-1BA5AF3CE3A317BD
03/10/2009	http://www.lvwash.org/cfml/calendar/index.cfm/AC3E2F9E-EC59-D570-DE6991D13EAF6B74.pdf?calendarparam=file&doc_id=AC3E2F9E-EC59-D570-DE6991D13EAF6B74

TECHNICAL INPUT

Quagga Mussels were not originally identified as a BBAMP IOC. Quagga mussels, however, were found to be relevant to all other IOCs within the BBAMP. Thus, members present at the April 27, 2009 BBAMP meeting agreed that a stand-alone Quagga Mussel IOC was necessary. In response, D. Wong developed a draft of this IOC in the prescribed format for review, comment, and integration into the BBAMP. The document includes listings of specifics, BBAMP goals and objectives addressed, evaluation actions, and suggested management actions.

- Item of Concern: Invasive Quagga Mussels, a draft section of the BBAMP by David Wong

The June 24, 2009 BBAMP SCOP meeting focused on *Recreation* and *Ecological Health* IOCs. For this meeting, Jennell M. Miller, Ph.D. (UNLV) assisted Kent Turner (Agreement Technical Representative; ATR) by working with Michael Boyles (NPS) 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. Contributors to this presentation included Jef Jaeger, Ph.D. (UNLV) and Joe Barnes (UNLV).

- PowerPoint: Turner, K. Lake Mead NRA monitoring efforts relevant to BBAMP IOCs: *Recreation* and *Ecological Health*

CONTAMINANTS

The original task agreement for this project prescribed a review of parameters recommended for measurement of endocrine disruption and emerging contaminants of concern by the BBAMP Technical and Advisory Committees along with an examination of the triennial review of emerging contaminants of concern listed by the BBAMP Technical and Advisory Committees. Due to the complexity of the topic and number of entities involved, the Technical Advisory Committee took longer to prepare and reach agreement on these documents than anticipated; and so they were not provided to the NPS on schedule with this task agreement. Therefore, these lists could not be reviewed. However, a graduate thesis was prepared under the direction of S. Gerstenberger that addressed the issue

of mercury concentration in sport fish, which is pertinent to this task agreement and, for sample collection, relied on interagency relationships with other “Water 2025” group members that were established through this project.

The purpose of the study was to determine the concentrations of mercury present in the most commonly consumed fish (largemouth bass, striped bass, and channel catfish) from four basins within Lake Mead: Boulder Basin, Overton Arm, Virgin Basin, and Gregg Basin.

- ▶ Kramer, Joanna A. “Mercury Concentrations in Muscle Tissue from Sportfish in Lake Mead, Nevada.” MPH thesis, University of Nevada, Las Vegas, 2009.

SELENIUM MANAGEMENT

Selenium is present in soils in Southern Nevada and carried by shallow groundwater into drainage channels flowing into Las Vegas Wash. High concentrations of this mineral pose a risk to the ecosystem by bio-accumulating in wildlife. Selenium management became an aspect of BBAMP development because treated effluent in Las Vegas Wash had diluted selenium from ground water sources, but if effluent was to be diverted via SCOP, reduced flow in the wash would no longer sufficiently dilute selenium. The Technical Advisory Committee for selenium management was tasked with considering various ways to attain 5.0 µg/L standard in the Las Vegas Wash and tributaries. The current U.S. Environmental Protection Agency (USEPA) standards for selenium in freshwater are 5.0 µg/L for continuous or chronic exposure and 20 µg/L for acute exposure (USEPA 1987). To develop a Selenium Management Plan, the Technical Advisory Committee worked with a consultant and used data collected by the Las Vegas Valley Water District’s Las Vegas Wash Team and the Water Quality Forum’s Selenium Sub-committee. UNLV provided technical assistance to the NPS in the development of this plan through the delivery of the following reports:

- ▶ Kramer, J.L., and Gerstenberger, S.L. (2009) A Review of Selenium Fate and Toxicity Relative to the Las Vegas Wash
- ▶ Wong, D. (2009) Review and Recommendations on the Las Vegas Wash (LVW) Selenium Management Plan

Project 2 Review and Synthesis of Project Information for Water 2025 Conservation Initiatives

Funding provided by SNPLMA in Phase I of “Meeting the Challenges of the 2025 Water Management Initiative” provided a more comprehensive monitoring program for the entire Lake Mead area as well as enhanced monitoring for nuisance aquatic species and biotic indicators of environmental health. Phase II added additional biotic components and initiated baseline monitoring lake-wide. Water-quality monitoring was expanded in Phase III to include the upper reaches of Lake Mead and below Hoover Dam on the Colorado River. Nuisance aquatic species monitoring was enhanced along with the development of monitoring programs for shoreline resources such as birds and vegetation.

The goal of Project 2 was to review and synthesize data and information obtained by NPS’s partner agencies for other aspects of the Water 2025 Conservation Initiatives. Topics reviewed and synthesized for Project 2 are described below.

BACTERIA IN HIGH USE SITES

The abundance of recreational activities on Lakes Mead and Mohave can impact the contaminant levels in the water, potentially affecting the health of individuals in contact with the water. The purpose of this study, led by Patricia Cruz, Ph.D. (UNLV) and overseen by Craig J. Palmer, Ph.D. (UNLV) was to examine the distribution and concentration of fecal indicator bacteria during peak months in high-use areas of Lakes Mead and Mohave. Samples were collected by Lake Mead NRA staff between 2003—2008, and they were analyzed by the Southern Nevada Water Authority.

- ▶ Report: Cruz, P., Stevens, V.L., Rinella, J. (2008) Surface Water Monitoring for Indicator Bacteria in High-use Sites of the Lake Mead National Recreation Area.
- ▶ Poster: Cruz, P., Stevens, V.L., Rinella, J. (2009) Surface water monitoring for fecal indicator bacteria in high-use sites of the Lake Mead National Recreation Area. Presented at Lake Mead Science Symposium, Las Vegas, NV.

LIMNOLOGY AND WATER QUALITY BASELINE DATA

Boulder Basin, the basin from which drinking water is drawn, is the most extensively monitored portion of Lake Mead by multiple agencies. D. Wong examined NPS partner-collected limnology and water quality data for Boulder Basin between 2002–2008 and synthesized them within a white paper. Data were those obtained from Monitoring Station CR346.4, the most data-rich station in the basin. Data for the following parameters were synthesized: chlorophyll *a*, phosphorus, total organic carbon, dissolved oxygen, water transparency, total phytoplankton, cyanobacteria, and fecal bacteria.

- ▶ White paper: Wong, D., (2009) Limnology and Water Quality Baseline Data of Boulder Basin, Lake Mead from 2002 to 2008.

ZOOPLANKTON TREND

The U.S. Bureau of Reclamation (USBR) Technical Service Center (TSC) conducted a long-term zooplankton-monitoring program for Lake Mead with 32 monitoring stations located in Boulder Basin, Virgin Basin, and Gregg Basin. D. Wong examined the USBR-collected zooplankton data and synthesized them within a white paper. Trends for cladocerans, copepods, rotifers, and planktonic quagga mussel veligers are reported.

- ▶ White paper: Wong, D., Trend of Zooplankton and Quagga Mussel Veligers in Lake Mead from 2002 to 2008.

CARP DIE OFF

On May 19, 2009, Lake Mead NRA received reports that noticeable numbers of dead carp were present in and around Katherine Landing, Cottonwood Cove, and other areas of Lake Mohave over the few days immediately prior. Nevada Division of Wildlife and Arizona Game and Fish Department also observed a carp die-off in Lake Mohave. D. Wong prepared a whitepaper in which he documented the observations surrounding the die off; described

symptoms and cause of the disease; synthesized temperature data, a key factor leading to a koi herpes virus (KHV) outbreak, which was the cause of the die off; and discussed implications for management.

- White paper: Wong, D. (2009) Carp Die-Off at Lake Mohave in Late Spring 2009.

THREADFIN SHAD TRENDS

Introduced threadfin shad (found throughout the Colorado River System by 1956) are a key element to the food web in Lake Mead's Boulder Basin, constituting a primary food source for game fish such as largemouth and striped bass. Eric M. Loomis (UNLV), under the direction of Shawn L. Gerstenberger, Ph.D. (UNLV) conducted thesis research examining historic trends in lower trophic interactions among threadfin shad and zooplankton pre and post quagga mussel invasion. This effort was awarded funding through a separate task agreement, but also relied on this project for completion. This effort is discussed further under Project 3. The portion of this work relevant to this project is the trend analysis using 19 years of annual larval threadfin shad trawl data, collected by the Nevada Department of Wildlife (see Chapter 4 of the thesis).

- 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, Chapter 2: Review of Related Literature, Subsection – Threadfin Shad, pp. 17-19. (NOTE: For organizational purposes, this thesis is provided under **Project 3 Technical Assistance with the Development of Quagga Mussel Monitoring and Research Programs**, where it is also discussed in relation to that project).
- Abstract and PowerPoint: Loomis, E., Wong, D., and Gerstenberger, S. Threadfin Shad and Invasive Quagga Mussels in Lake Mead, NV. (NOTE: For organizational purposes, this presentation is provided under **Project 3 Technical Assistance with the Development of Quagga Mussel Monitoring and Research Programs**, where it is also discussed in relation to that project).

ELCOM-CAEDYM MODEL

ELCOM-CAEDYM couples the three-dimensional hydrodynamics Estuary and Lake Computer Model (ELCOM) with the Computational Aquatic Ecosystem Dynamics Model (CAEDYM). This combined model system allows for investigations into the spatial and temporal relationships between physical, biological, and chemical variables in water bodies, over single events or seasonal to annual timescales. The ELCOM/CAEDYM models were first developed at the Centre for Water Research (CWR) at the University of Western Australia.

Development of an ELCOM/CAEDYM model was a specified component of the BBAMP. Flow Science Inc. (Santa Fe, NM) was contracted to develop a three-dimensional ELCOM/CAEDYM model for Boulder Basin. Initially, the model was intended to be used (1) for routine prediction of reservoir water quality and optimizing the operation of the SCOP system in order to meet the water quality goals in Boulder Basin and (2) to help define a management action plan if an IOC was identified. The NPS and the Southern Nevada Water Authority recognized the value in extending the model beyond the Boulder Basin to include the entire lake. SNPLMA Water 2025 Conservation Initiative funding supported expansion of the model to a "Whole Lake Model," comprising the entire Lake Mead, from Hoover Dam to the mouths of the Muddy, Virgin, and Colorado Rivers. The model was calibrated for years 2000–2007. The following parameters are included in the model: temperature, conductivity, perchlorate, bromide, chlorophyll *a*, total phosphorus (various species), nitrate, ammonium, total organic carbon, pH, and dissolved oxygen.

The 379-page Flow Science, Inc. report (titled: Whole Lake Mead ELCOM-CAEDYM Model Addition of Years 2006 and 2007) and accompanying animations became available in late October 2009. Doctoral student Kenneth Lamb (UNLV College of Engineering) reviewed the report under the direction of Thomas Piechota, Ph.D. (UNLV), a professor with interdisciplinary hydrology/hydroclimatology and water resources planning expertise. Mr. Lamb was asked to provide: (1) an overview of his impressions of the model; (2) a recommended list including brief descriptions of best future applications using the existing ELCOM-CAEDYM model as an analytical and predictive tool in support of lake management decision making; and (3) technical comments and suggestions related to how the model could be improved upon (i.e., what additions should the NPS and its partners consider to enhance the model in the future) and rationale and justification for each.

- ▶ Lamb, K. and Piechota, T.C. (2009) Memorandum: Review of Whole Lake Mead ELCOM-CAEDYM Model Addition of Years 2006 and 2007 by Flow Science, Inc. [Confidential Review: Please do not post to the Internet]

Project 3 Technical Assistance with the Development of Quagga Mussel Monitoring and Research Programs

In early January 2007, invasive quagga mussels (*Dreissena bugensis*) were found in Lake Mead. Subsequent investigations identified populations in Lake Mohave as well. In the Great Lakes Region, quagga mussels have caused millions of dollars of damage to water system infrastructure and to boats, and have affected native ecosystems and sport fisheries. Following discovery of this species in Lake Mead, a Lake Mead Quagga Mussel Core Team was established by the NPS. Lake Mead NRA then launched an initial management response (K. Turner, Sandee Dingman, and Josh Hoines; NPS) and led a three-month effort to identify ways to manage the invasion for Lakes Mead and Mohave, and the Lower Colorado River.

Through Project 3 of this task agreement, UNLV provided technical assistance to the core team with the establishment of a monitoring program to establish a baseline and evaluate ecological effects. Additional support was provided through a review of the literature regarding the natural history of quagga mussels, the development of a population-monitoring program, and the identification of long-term monitoring and research needs. The original task agreement called for the coordination of an annual science advisory team. However, an ad hoc interagency group formed, which began meeting quarterly following a meeting of external quagga mussel experts. Over the course of the initial response effort, interagency quagga mussel meetings were identified as a valuable activity. These meetings were formalized as part of this project, and grew to include a membership of approximately 120 participants representing approximately 25 agencies and organizations interested in learning about and sharing information and findings about quagga mussels in the West.

The goal of Project 3 was to provide technical assistance in the development of quagga mussel monitoring and research programs, which involved extensive coordination with a variety of agencies. Specific efforts included the development of a bibliographic database, development of an interagency quagga mussel plan, hosting interagency quagga mussel meetings, evaluating substrates for quagga mussel colonization, evaluating impacts on threadfin shad, and evaluating emerging effects.

BIBLIOGRAPHIC DATABASE

Under the direction of S. Gerstenberger, graduate student Sara Muetting (UNLV) conducted a quagga mussel and zebra mussel literature search. She has cited and organized within an Excel spreadsheet 420 references among 11 categories: Abiotic Interactions, Biotic Interactions, Contaminants, Control, Endocrine, Genetics, History, Monitoring, Mussels in Diet, Water Quality, and Other. A paper copy of this report was provided at the 10/11/2007 Interagency Quagga Mussel Meeting and the electronic file was delivered to K. Turner. The quagga/zebra mussel bibliography has also been published to the 100th Meridian web site (www.100thmeridian.org/biblio.asp) including links, as available, to the journals in which each citation was published.

- Excel spreadsheet: Bibliographic Citations of Quagga Mussel and Zebra Mussel Literature.

INTERAGENCY MANAGEMENT ACTION PLAN (I-MAP) FOR QUAGGA MUSSELS

A core interagency group composed of Tom Burke (U.S. Bureau of Reclamation; USBR) G. Chris Holdren, Ph.D. (USBR), James F. LaBounty, Ph.D. (Southern Nevada Water Authority; SNWA), Tod Tietjen, Ph.D. (SNWA), and K. Turner (NPS) recognized the need for the development of a monitoring plan for quagga mussels. Through this task agreement, the concept evolved into the Interagency Management Action Plan (I-MAP) for Quagga Mussels, authored by D. Wong and S. Gerstenberger. The I-MAP is a standardized, long-term, cost-effective, and consistent monitoring plan for quagga mussels in Lake Mead. Its purpose is to inform various agencies of the needs and objectives outlined in it, and to gain efficiencies from shared operations and information. The plan attempts to build upon current monitoring activities and capabilities, identifies the next steps that can occur within existing capabilities, and, finally, outlines gaps and areas of future need. The I-MAP required extensive coordination and discussion with staff from the agencies with management responsibility for Lake Mead that will be implementing the directives of the plan: NPS, Nevada Department of Wildlife, Southern Nevada Water Authority, USBR, U.S. Fish and Wildlife Service, and U.S. Geological Survey.

The I-MAP contains four major sections: “Life History,” “Artificial Substrates,” “Veliger Monitoring,” and “Adult Monitoring.” The opportunity to review each section was provided 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. D. Wong, S. Gerstenberger, and K. Turner are members of every sub-group and so are not listed below.

Life History	Wen Baldwin, NPS Lake Mead NRA Volunteer/Lake Mead Boat Owners’ Assoc. Peggy Roefer, Southern Nevada Water Authority Tod Tietjen, Southern Nevada Water Authority
Artificial Substrates	Wen Baldwin, NPS Lake Mead NRA Volunteer/Lake Mead Boat Owners’ Assoc. Lynn Orphan, Clean Water Coalition 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, Marion Wittmann, Ph.D. (University of California, Davis – Tahoe Research Center) also reviewed and provided comments on I-MAP sections pertaining to life history and monitoring. Through this process, the I-MAP was extensively reviewed. At the August 20, 2009 Interagency Quagga Mussel Meeting, participants approved the I-MAP for implementation. The I-MAP, however, is a living document, and as such, is expected to change over time as the need to do so arises.

- ▶ Wong, D. and Gerstenberger, S.L. (2009) Interagency Management Action Plan (I-MAP) for Quagga Mussels.

The presentations below were delivered to detail the I-MAP and the interagency effort.

- ▶ Abstract and PowerPoint: Wong, D. and Gerstenberger, S.L. (2008) 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.
- ▶ Abstract and PowerPoint: Gerstenberger, S.L., Turner, K., and Wong, D. (2009) Interagency Response to Quagga Mussel Invasion at Lake Mead: Detection, Prevention, Control and Monitoring. Presented at the Lake Mead Science Symposium, Las Vegas, NV.
- ▶ PowerPoint: D. Wong. (2009) Interagency Quagga Mussel Monitoring. Presented at the NDEP Lake Mead Water Quality Forum, Henderson, NV.

INTERAGENCY QUAGGA MUSSEL MEETINGS

Through these meetings, the I-MAP [see **INTERAGENCY MANAGEMENT ACTION PLAN (I-MAP) FOR QUAGGA MUSSELS**] was launched, discussed, and approved to contain the integrated needs, objectives, requirements, and protocols of the different agencies represented in the monitoring of quagga mussel juveniles and adults. The Interagency Quagga Mussel meetings also became an important forum for participants to provide to a larger audience, individual updates on quagga mussel findings and effort status across the southwest region. Meetings were facilitated by S. Gerstenberger and documented by J. Miller. Mailings and maintenance of a participant e-mail list housed at UNLV are conducted by J. Miller. Meeting materials, including summaries and participant PowerPoint presentations, were archived and distributed upon request.

Meeting Dates:

08/02/2007	<u>Highlights:</u> This was the first formal all-agency “Interagency Quagga Mussel Meeting.” It established the format for the subsequent meetings. Presentations were provided by NPS, Nevada Department of Wildlife, U.S. Bureau of Reclamation, City of Henderson, Southern Nevada Water Authority, Lake Las Vegas, Arizona Game and Fish Department, U.S. Geological Survey, 100th Meridian Initiative, Metropolitan Water District of Southern California, U.S. Fish and Wildlife Service, California, UNLV, Coachella Valley Water District, and Imperial Irrigation District. An in-depth general discussion with a question and answer session was held, followed by a needs discussion. The literature search to be carried out by S. Mueting was introduced and participants were invited to submit protocols for quagga mussel monitoring, so that a standardized protocol could be developed.
10/11/2007	<u>Major topics:</u> Agency presentations; update on quagga mussel bibliography by S. Mueting; identification of short-term, gap-filling monitoring projects (request for proposals); discussion of standardization of quagga mussel monitoring protocols; and announcement of the “save the date” for the Lake Mead Science Symposium.
01/17/2008	<u>Major topics:</u> Agency presentations; special presentation on changes to the Lake Huron food web; discussion of prioritized needs list; results of proposal reviews (projects identified were quagga mussel monitoring, including artificial substrate preference analysis, and impacts to fisheries); scoping session for an ecological/limnological monitoring plan for Lakes Mead and Mohave; special presentation on past benthic studies at Lake Mead NRA; and announcement of additional details for the Lake Mead Science Symposium.
08/26/2008	<u>Major topics:</u> Agency presentations; updates on artificial substrate preference study (S. Mueting) and shad project (E. Loomis); presentation of the first draft of the quagga mussel monitoring plan (which would become the I-MAP), identification of a group of volunteers from the agencies represented in the plan to serve as a sub-committee, and invitation to participate in its review; update on the benthic monitoring study recommended by this group and underway by S. Chandra at the University of Nevada, Reno; USBR briefing on quagga mussels; and announcement of additional details for the Lake Mead Science Symposium.
12/04/2008	<u>Major topics:</u> Agency presentations; updates on artificial substrate preference study (S. Mueting) and shad project (E. Loomis); I-MAP update and distribution of its first section; and announcement of additional details for the Lake Mead Science Symposium.
02/25/2009	<u>Major topics:</u> Agency presentations; updates on artificial substrate preference study (S. Mueting) and shad project (E. Loomis); I-MAP update, announcement

that the I-MAP was subdivided into its major sections and distributed to volunteers for review, and request for review comments; and follow up on the Lake Mead Science Symposium.

- 05/19/2009 Major topics: Agency presentations; updates on artificial substrate preference study (S. Mueeting) and shad project (E. Loomis); I-MAP update / discussion of how it had been pared down to align with more modest funding levels; and discussion of a funding opportunity for high-priority quagga mussel research projects (immediate needs).
- 08/20/2009 Major topics: Agency presentations; approval to implement the I-MAP (as a living document that is subject to change); discussion of predatory fish studies; and priorities for proposed quagga mussel monitoring and research projects.

- Meeting summaries and associated materials for the Interagency Quagga Mussel Meetings listed above.

SUBSTRATE MONITORING

Early in the invasion, participants in the Interagency Quagga Mussel Meetings and external quagga mussel experts agreed that it would be important to determine which types of substrates quagga mussels would preferentially colonize in Lake Mead. An understanding of preference could aid in management decisions related to material choice for public infrastructure and in the protection of property and sensitive environmental areas. To address this need, a master's thesis project was conducted by S. Mueeting under the direction of S. Gerstenberger. Six substrates were studied: Acrylonitrile Butadiene Styrene (ABS) plastic, High Density Polyethylene (HDPE) plastic, Concrete Underlayment Board (CUB), aluminum, stainless steel, and fiberglass at multiple depths. In addition to substrate monitoring, S. Mueeting's project also examined contaminants in quagga mussels and included an educational outreach study. This thesis project was additionally supplemented with separate SNPLMA Water 2025 Conservation Initiative Funds awarded to S. Gerstenberger.

- Mueeting, 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.
- Abstract and PowerPoint: Mueeting S., Gerstenberger, S., Wong, D., Baldwin, W., and Urban, M. (2009) The Development of a Suitable Substrate Sampling Device for Monitoring Quagga Mussels (*Dreissena bugensis*) in Lake Mead, Nevada. Presented at the Lake Mead Science Symposium, Las Vegas, NV.

THREADFIN SHAD

As with **Substrate Monitoring** (see above), understanding the potential impact of quagga mussels on threadfin shad was of grave concern because the Lake Mead sport fishery depends in large part on threadfin shad production. Threadfin shad are the primary forage fish of largemouth and striped bass, and other species. Under the direction of S. Gerstenberger, E. Loomis studied the trophic interactions between threadfin shad and zooplankton that could be altered by quagga mussels to determine whether a shift occurred in food preference for this species following the quagga mussel invasion.

- ▶ 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, Chapter 2: Review of Related Literature, Subsection – Threadfin Shad, pp. 17-19. (NOTE: For organizational purposes, this thesis is provided under this project, however, components of this research were previously discussed within Project 2).
- ▶ Abstract and PowerPoint: Loomis, E., Wong, D., and Gerstenberger, S. Threadfin Shad and Invasive Quagga Mussels in Lake Mead, NV. (NOTE: For organizational purposes, this presentation is provided under this project, however, components of this research were previously discussed within Project 2).

EMERGING EFFECTS OF QUAGGA MUSSELS

Fecal coliform bacteria are listed in U.S. EPA’s Drinking Water Contaminant List and cyanobacteria are listed in the Contaminant Candidate List. The quick spread of quagga mussels (*Dreissena bugensis*) in Lake Mead, Nevada-Arizona may have the potential to increase the concentrations of bacteria and/or cyanobacteria in the water column. D. Wong, S. Gerstenberger, and C. Palmer worked with members of the Environmental Division of the City of Las Vegas and the Southern Nevada Water Authority to compare total fecal coliform bacteria and *E. coli* abundances at different depths of the open water of Boulder Basin of Lake Mead, before (2003-2006) and after (2007-2008) the quagga mussel invasion.

- ▶ Abstract and PowerPoint: Wong, D. Gerstenberger, S.L., Schiefer, S., Palmer, C., Roefer, P., and Tietjen, T. (2009) Bacteria and Cyanobacteria in Lake Mead: Do Invasive Quagga Mussels Affect Them? Presented at the Nevada Public Health Association Conference, Reno, NV.

Project 4 Strategic Data Mining of Historic Data

A strategic data-mining project was funded in the Phase III Water 2025 Conservation Initiative to compile information on previous water quality studies from Lake Mead that are not currently accessible and to make them available to the current team of interagency limnologists. Topics of particular interest included water quality, limnology, emerging contaminants, fisheries and aquatic biota, and riparian/shoreline resources, especially from the upper reaches of the lake including the Overton Arm.

The overall goals of Project: (1) identify research and monitoring projects on Lake Mead that have been conducted in the past; (2) prioritize those projects whose data are of particular interest to the Water 2025 scientist team, yet not readily available; and (3) make these data readily available by converting them into an electronic format, assuring quality of these data, preparing metadata regarding these data sets, and then posting them to agency and interagency information systems.

BIBLIOGRAPHIC DATABASE

Gretchen Andrew (UNLV), under the direction of James Pollard (UNLV) and C. Palmer, conducted a comprehensive literature search to discover research projects focused on Lake Mead, particularly those focused on the topics of water quality, limnology, contaminants, fisheries, aquatic biota, and riparian/shoreline resources. The search for legacy research literature was focused on Lake Mead and began with a comprehensive investigation of the

University Libraries resources, including books, periodicals, electronic databases, government information, special collections, microforms, and borrowed materials from other libraries. In addition to the University Libraries, the Internet was queried for Lake Mead subject matter, and individuals and agencies known to be involved in Lake Mead data collection and research were contacted. Initially, approximately 1700 articles were identified for inclusion into the database. A screening and prioritization process was implemented to focus the included articles to historic water quality, benthos, fisheries, contaminants, sediments, and plankton. At present, approximately 700 bibliographical records are stored in the database representing journal articles, agency reports, theses and dissertations, maps, photographic collections, data sets, audio and visual recordings, bulletins, correspondence and memorandums, remote imagery, and other format types.

A relational database was created using Microsoft Access to serve as a repository for descriptive data for Lake Mead research projects. Data was structured to allow multi-field searches for project results with sub-headings such as research topics, research locations, parameters measured, and date or duration of research.

- ▶ Access File: Lake Mead Literature and Research Projects Database and associated user guide
- ▶ Poster: Pollard, J. and Andrew, G. (2009) Strategic Data Mining and Database Development for Research Projects at Lake Mead, Nevada-Arizona USA. Presented at the Lake Mead Science Symposium, Las Vegas, NV.

HISTORIC DATA MINING

Through Interagency “Water 2025” meetings and the Lake Mead Science Symposium, it was determined that, in light of the quagga mussel invasion, the most immediately significant gap in Lake Mead data lay in the area of the benthic community composition. Studies conducted in the Great Lakes region following mussel invasion revealed changes in the benthic community structure. Due to environmental differences between Southern Nevada and the Great Lakes region, it was unknown how the Lake Mead benthos would be affected. Fortunately, a dataset existed from studies conducted at UNLV in the 1980s that could potentially serve as a baseline. Data were mined from “Lake Mead Benthos Study (1986-1987).” An Access database was developed and data were inserted from the 311 field data sheets and 440 laboratory data sheets available.

- ▶ Lake Mead NRA Benthic Database

UNLV LIBRARIES SPECIAL COLLECTION

A UNLV Libraries Special Collection: **Lake Mead National Recreation Area Limnology** was established on October 20, 2008 to ensure permanent placement and access to available research material and reports. As part of this project, the collection was populated with James F. LaBounty’s datasheets provided by the Southern Nevada Water Authority.

- ▶ Letter announcing the Lake Mead Special Collection from Patricia Ianuzzi, Ph.D., Dean of University Libraries to William K. Dickinson, Superintendent, NPS Lake Mead NRA

Project 5 Coordination of the Lake Mead Science Symposium

Numerous monitoring and research efforts were conducted, are ongoing, or are in the planning stages for Lake Mead and Lake Mohave. Lake Mead NRA recognized the value in bringing together the individuals participating in this work as an approach to help determine the overall ecological health of the lakes, identify emerging concerns challenging this health, and uncover gaps in understanding. To this end, the Lake Mead Science Symposium was designed as a state-of-the-science symposium.

The goal of Project 5 was to plan, organize, execute, and document a state-of-the-science symposium for Lake Mead.

PLANNING

J. Miller, in consultation with K. Turner and the technical committee established for the symposium, led planning and delivery of the symposium. Assistance from Rochelle Boyd (UNLV PLI) and input from S. Gerstenberger, C. Palmer, M. Rees, and other PLI staff refined plans and helped execute the event. C. Palmer and J. Miller provided regular planning updates at the Interagency “Water 2025” Meetings. During these meetings, input from those in attendance was welcomed. The open symposium sessions took place January 13-14, 2009 and a closed meeting of the technical committee occurred on January 15, 2009. Planning details have been compiled in a report that includes such topics as: Budget, Registration, Venue, Food and Beverage, Flow, Communications, Services, Exhibitors, Media, and Assessment.

- Report: Lake Mead Science Symposium Planning Information

CONFERENCE PROGRAM

The symposium agenda and event timing was created in consultation with K. Turner and the technical committee. Described within the printed program is the final configuration of opening and special remarks, keynote addresses, 44 presentations within six concurrent sessions (Aquatic Biota and Fisheries, Emerging Issues, Environmental Contaminants, Lake Management, Limnology and Water Quality, and Riparian and Shoreline Resources) 13 poster presentations, breakfasts, breaks, lunches, and an evening reception. J. Miller served as the liaison between the technical committee and all presenters for invitations, confirmations, and other communications, and designed the printed program. Information about the symposium venue, programmatic components, and the ability to register were made available at www.lakemeadsymposium.org, a website managed and maintained over the course of this project by PLI.

- Conference Program: Lake Mead Science Symposium (January 13 and 15, 2009; Las Vegas, NV). Public Lands Institute, University of Nevada, Las Vegas.
- Website: www.lakemeadsymposium.org

ATTENDANCE

Approximately 150 individuals attended the symposium, and the following organizations were represented:

Federal	National Park Service U.S. Bureau of Reclamation U.S. Coast Guard Auxiliary U.S. Environmental Protection Agency U.S. Fish and Wildlife Service U.S. Geological Survey The Office of U.S. Senator Harry Reid (D-NV) The Office of U.S. Senator John Ensign (R-NV)
State	Arizona Game and Fish Department Nevada Department of Wildlife Nevada Division of Environmental Protection
Regional	Colorado River Commission of Nevada Imperial Irrigation District Metropolitan Water District of Southern California Southern Nevada Water Authority
City	City of Glendale City of Lake Havasu City City of Las Vegas Los Angeles Department of Water and Power
University	Louisiana State University New Mexico State University University at Buffalo University of Arizona University of California, Davis University of Colorado University of Nevada, Las Vegas University of Nevada, Reno University of New Mexico
Consulting Firms	BIO-WEST, Inc. BSA Environmental Services, Inc. EarthSoft FlowScience, Inc. MWH Global PhycoTech, Inc. Precision Measurement Engineering SWCA Environmental Consultants Zeus Environmental, LLC
Non-Profit	Outside Las Vegas Foundation

TECHNICAL COMMITTEE

A technical committee was convened for the Lake Mead Science Symposium and coordinated by J. Miller. Members volunteered or were invited by K. Turner to include:

Scott Abella, Ph.D., University of Nevada, Las Vegas
Shawn Gerstenberger, Ph.D., University of Nevada, Las Vegas
Steven L. Goodbred, Ph.D., U.S. Geological Survey
G. Chris Holdren, Ph.D., U.S. Bureau of Reclamation
Jef Jaeger, Ph.D., University of Nevada, Las Vegas
Michael S. Lico, U.S. Geological Survey
Erik Orsak, U.S. Fish and Wildlife Service
Peggy Roefer, Southern Nevada Water Authority
Michael R. Rosen, Ph.D., U.S. Geological Survey
Jon Sjöberg, Nevada Department of Wildlife
Todd Tietjen, Ph.D., Southern Nevada Water Authority
Cris Tomlinson, Nevada Department of Wildlife
Kent Turner, National Park Service

On Day 3 of the symposium, technical committee members launched development of the monitoring plan (see Project 6, below).

PROCEEDINGS

Arrangements were made to publish selected papers within a special issue of *Lake and Reservoir Management (LRM)*. LRM functions as a record of advances in lake management and as a resource for lake managers, researchers, and policy makers. All papers must demonstrate relevance to lake management, integrate findings with current knowledge, apply sound study design and data analysis, and convey an important message clearly and concisely. With this understanding of the expectations of LRM, symposium technical committee members felt that a special issue of this journal would be of greater value than a proceedings volume of any other type. James F. LaBounty, the journal's Editor in Chief at the time this decision was reached, initiated the process. Following J. LaBounty's passing, Ken Wagner, Ph.D. became the Editor in Chief, and all aspects of the special issue were subsequently coordinated with him.

During the closed session (Day 3) of the Lake Mead Science Symposium, the technical committee carefully discussed and selected symposium presentations for potential development into manuscripts (see Report: Lake Mead Science Symposium Invited Manuscripts). J. Miller provided coordination between authors and the technical committee beginning the first week in February 2009. Following committee review and approval, the manuscripts were electronically submitted to K. Wagner by authors to be entered into the journal's formal peer review process. Over the course of this task agreement, G. Chris Holdren, Ph.D. (U.S. Bureau of Reclamation) and Tod Tietjen, Ph.D., both of whom are members of the technical committee, became associate editors of the journal, and as such, have also assisted greatly with this process, primarily through formal review of manuscripts. Note that all manuscripts must undergo the journal's standard selection and peer-review process before publication. At the time of this reporting, the journal's peer-review process is still underway.

- Report: Lake Mead Science Symposium Invited Manuscripts

FINDINGS

All PowerPoint presentations delivered during the symposium were archived to represent the key findings presented. As they are the property of the presenting agency, presentations should not be further distributed or cited without the authors' permission.

- PowerPoint Presentations from the Lake Mead Science Symposium

J. Miller, K. Turner, and the technical committee also developed a questionnaire for the Lake Mead Science Symposium to extract from attendees, major topics to be included within an ecological monitoring plan for Lakes Mead and Mohave. Results were compiled within a report.

- Report: Questionnaire Results: Monitoring Plan for Lakes Mead and Mohave

Project 6 Development of an Ecological Monitoring Plan for Lakes Mead and Mohave

As described for Project 5 (above) numerous monitoring and research efforts were conducted, are ongoing, or are in the planning stages for Lake Mead and Lake Mohave. Lake Mead NRA recognized the value in working in partnership as an approach to help determine the overall ecological health of the lakes, identify emerging concerns challenging this health, uncover gaps in understanding, and to share resources. To this end, "Long-Term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave" was designed jointly with other agencies that have management responsibility for Lakes Mead and Mohave to provide a framework -- limited to limnology and water-dependent natural resources -- to bring together agencies with authorities and interests in Lakes Mead and Mohave within the boundaries of the recreation area. The plan is a living document that is expected to change over time.

With assistance provided by UNLV through this agreement, Lake Mead NRA led an effort to obtain significant input from its partners with management responsibility for the lakes in developing the plan. Documentation, general content development, technical editing, and coordination of content was provided by J. Miller. Development of this plan proceeded from the Lake Mead Science Symposium (Project 5) and required coordination of input from members of the symposium's technical committee (multi-agency representation) and other assigned staff as acknowledged within the plan. The following individuals lent their expertise to the document within the topic areas listed below, which correspond to subject areas of the Lake Mead Science Symposium.

Aquatic Biota and Fisheries

Erik Orsak, U.S. Fish and Wildlife Service
Jon Sjöberg, Nevada Department of Wildlife

Riparian and Shoreline Resources

Scott Abella, Ph.D., University of Nevada, Las Vegas (Riparian Resources)
Jef Jaeger, Ph.D., University of Nevada, Las Vegas (Birds)
Cris Tomlinson, Nevada Department of Wildlife

Emerging Issues

Shawn L. Gerstenberger, Ph.D., University of Nevada, Las Vegas

Peggy Roefer, Southern Nevada Water Authority

Environmental Contaminants

Michael R. Rosen, Ph.D., U.S. Geological Survey

Steven L. Goodbred, Ph.D., U.S. Geological Survey

Lake Management

G. Chris Holdren, Ph.D., U.S. Bureau of Reclamation

Kent Turner, National Park Service

Limnology and Water Quality

Michael S. Lico, U.S. Geological Survey

Todd Tietjen, Ph.D., Southern Nevada Water Authority

The living plan identifies six fundamental strategic objectives addressed through six categories of management interest: (1) Water Quality and Limnology, (2) Fish and Aquatic Biota, (3) Stressors, (4) Sediment, (5) Birds, and (6) Riparian Resources. These categories were identified on Day 3 of the Lake Mead Science Symposium and later refined and agreed upon at Interagency “Water 2025” Meetings (see below). For each category, both monitoring and research questions were formulated along with the components, drivers, and stressors inherent to each category. Additional content for each of these subheadings was obtained through work-group sessions that took place during Interagency “Water 2025” meetings (see below). Sections were also distributed to participating individuals via e-mail for additional feedback. Background information and a listing of existing monitoring programs are provided for each category. At the heart of the plan are the monitoring and research questions, tied to meeting the objectives that were formulated for each category. Category context is provided by descriptions of the components, drivers, and stressors inherent to each category. Suggested monitoring activities and data-interpretation recommendations are included for each category. Within the plan, data management mechanisms, synthesis reporting, and relationship to the ELCOM/CAEDYM model are discussed.

- ▶ Turner, K. and Palmer, C. (2009) Long-term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave.

INTERAGENCY “WATER 2025” MEETINGS

To facilitate Projects 5 and 6 of this agreement, eight Interagency “Water 2025” meetings were coordinated, conducted, and summarized; meeting presentations were archived and provided to meeting participants upon request. Attendees of this multi-agency meeting have represented the Clean Water Coalition; National Park Service; Southern Nevada Water Authority; Nevada Department of Wildlife; University of Nevada, Las Vegas; University of Nevada, Reno; U.S. Bureau of Reclamation; U.S. Fish and Wildlife Service; and US Geological Survey. The Interagency “Water 2025” meetings were also an opportunity for participants to provide updates about their specific task / interagency agreements and were used as planning meetings for the Lake Mead Science Symposium. C. Palmer assisted K. Turner in facilitating the meetings list below over the course of this task agreement. J. Miller prepared all meeting materials and documented the meetings. Meetings wherein materials focusing on the joint

development or review of materials for the Lake Mead Science Symposium or the monitoring and research plan involved direct work on documents projected onto to a screen rather than recording discussion summaries.

Meeting Dates:

09/07/2007	<u>Major topics:</u> Summary of the purpose of “Water 2025” meetings; information gathering for the Lake Mead Science Symposium; and overview of agreements and projects underway.
10/09/2007	<u>Major topics:</u> Lake Mead Science Symposium planning update; baseline monitoring project update; and relevant SNPLMA projects and funding.
11/26/2007	<u>Major topics:</u> Member updates; quagga mussel project updates; Lake Mead Science Symposium planning update; data-mining efforts; and review of lake monitoring objectives from other lakes.
01/08/2008	<u>Major topics:</u> Member updates; FlowScience, Inc. meeting update; quagga mussel project proposal review; Lake Mead Science Symposium planning update; discussion on possible charter documentation for this group; and review of “Water 2025” deliverables.
03/21/2008	<u>Major topics:</u> Member updates; three special presentations on endocrine disrupting compounds in Lake Mead (G. Linder, USGS / R. Patino, USGS / S. Blunt and D. Moser, Desert Research Institute; special presentation on the ecological characterization of two bays in Lake Mead (S. Chandra, University of Nevada, Reno); Lake Mead Science Symposium planning update; and quagga mussel project update.
05/23/2008	<u>Major topics:</u> Agency updates; overview of discussion with fisheries team regarding quagga mussel research initiatives; future NPS web site related to SNPLMA-funded Lake Mead projects; overview of other water-related meetings; discussion of a potential memorandum of understanding (MOU) for this group similar to the Lake Mead Water Quality Forum MOA; and Lake Mead Science Symposium planning update.
09/02/2008	<u>Major topics:</u> Agency updates; benthic and shad study (related to quagga mussels) updates; special presentation on lacustrine sediments to reconstruct contaminant histories (M. Rosen, USGS); quagga mussel project update; water-related meeting identification and possible consolidation; and presentation of a draft MOU for this group with request for comments.
10/15/2008	<u>Major topics:</u> Agency updates; quagga mussel monitoring update; Lake Mead Science Symposium planning update; and MOU discussion seeking support of participating agencies in signing.

12/10/2008	This meeting served as an information session for the Technical Committee of the Lake Mead Science Symposium – an overview of the event was provided with a question and answer discussion to prepare the committee for hosting their sessions.
02/11/2009	<u>Major topics:</u> Agency updates; special issue of Lake and Reservoir Management as proceedings for the Lake Mead Science Symposium; and MOU status.
04/13/2009	<u>Major topics:</u> Agency updates; quagga mussel monitoring update; Lake Mead Science Symposium follow up; MOU status; and remaining SNPLMA funding and potential uses.
06/03/2009	<u>Major topics:</u> Agency updates; special issue of Lake and Reservoir Management as proceedings for the Lake Mead Science Symposium; draft framework for the ecological monitoring plan for Lakes Mead and Mohave; and possible proposal topics for future funding.
08/25/2009	This meeting served as a workgroup for category sections of the ecological monitoring plan. Individuals volunteered to adopt specific sections of the plan and send review comments to or meet with J. Miller and K. Turner as noted below. Category Section: Water Quality and Limnology — Todd Tietjen Category Section: Fish and Aquatic Biota — Erik Orsak Category Section: Stressors — Michael Rosen, Shawn Gerstenberger, and Erik Orsak Category Section: Sediment — Michael Rosen Category Section: Birds — Erik Orsak Category Section: Riparian — Kent to discuss with NPS staff (and others) Document Section III A. and B. — Peggy Roefer
10/28/2009	<u>Major topics:</u> Agency updates; special presentation on the surficial geology of the floor of Lake Mead derived from geophysical mapping (D. Twichell and V. Cross; U.S. Geological Survey); and workgroup for category sections of the ecological monitoring plan.

- Summaries and associated materials from the above listed meetings.

PARTNER PROJECT OVERVIEWS

J. Miller reviewed and summarized tasks prescribed within eight interagency agreements between Lake Mead NRA and other project partners for SNPLMA-funded projects; these summaries were used in discussions with partner agencies by K. Turner in identifying key items to include within the “Long-Term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave.” They were also used as the basis for synopses created to potentially be included in a Lake Mead NRA web page dedicated to the Limnology of Lakes Mead and Mohave.

- ▶ Report: Task Tracking Summaries
- ▶ Report: Draft Lake Mead NRA Limnology Web Content