

RECLAMATION

Managing Water in the West

Taking No Prisoners Beating Back Invasive Species

**Leonard Willett - Lower Colorado Region
Renata Claudi – RNT Consulting Inc.**



U.S. Department of the Interior
Bureau of Reclamation



Bureau of Reclamation

- Established in 1902, the Bureau of Reclamation constructed dams, powerplants and canals in the 17 western states.
- Reclamation has constructed more than 600 dams and reservoirs including Hoover Dam on the Colorado River and Grand Coulee on the Columbia River.
- Today, Reclamation is the largest wholesaler of water in the country, bringing water to more than 31 million people, and irrigation water for 10 million acres of farmland..
- Reclamation is the second largest producer of hydro power in the United States. 53 power plants annually provide more than 40 billion kilowatt hours, producing enough electricity to serve 3.5 million homes.

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Zebra and Quagga Mussel Sightings Distribution

Dreissena polymorpha and *D. rostriformis bugensis*



- Zebra mussel occurrences
- Quagga mussel occurrences
- Both species occurrences
- Zebra/Quagga mussels eradicated
- Zebra/Quagga mussels failed

First Steps

- **January 2007 adult quagga mussel found in Lake Mead (assumed to be from a mussel infested house boat)**
- **Fall of 2007 – Reclamation's Lower Colorado Dams (LCDO) office completed initial facility reviews with assistance from RNT Consulting Inc.**

Ongoing Activity

- **Installation of bioboxes to monitor fouling**
- **Vulnerability assessments were carried out on all Reclamation facilities**
- **Research activities focused on environmentally friendly controls**

Facility Assessments



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Facility Vulnerability Assessment Template

Invasive Quagga and Zebra Mussels

<http://www.usbr.gov/mussels/>



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May 2009

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Environmental Requirements



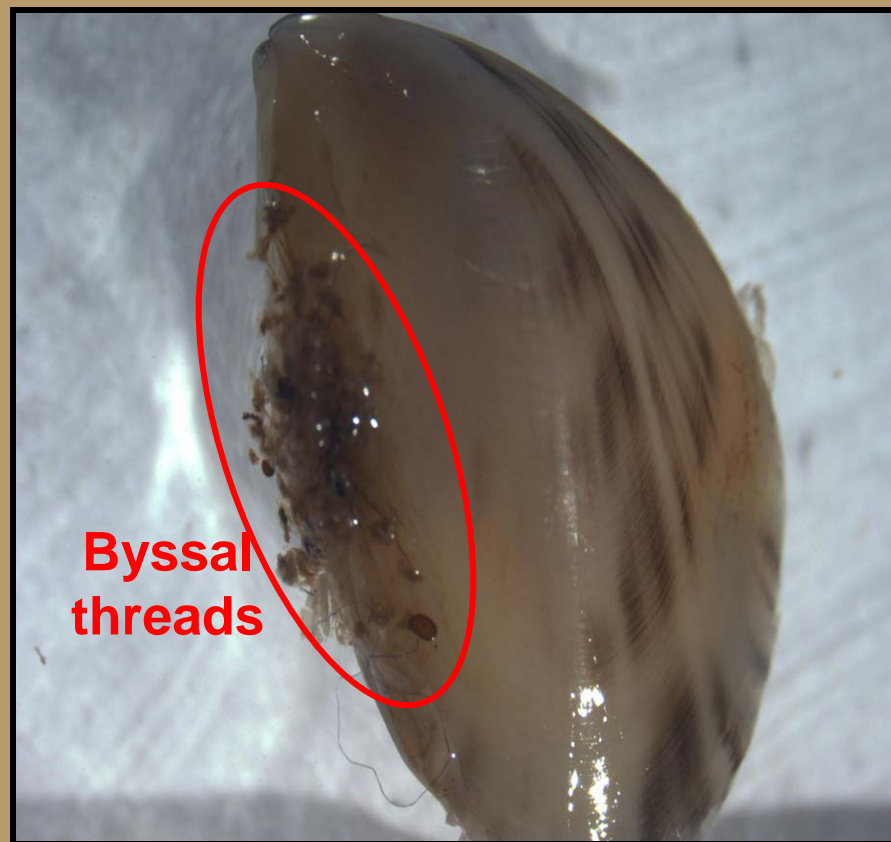
Parameter	Adults do not survive long-term	Uncertainty of veliger survival	Moderate Infestation Level	High Infestation Level
Calcium (mg/L)	<8 to <10	<15	16-24	≥24
Alkalinity (mg CaCO ₃ /L)	< 30	30-55	45-100	>90
Total Hardness (mg CaCO ₃ /L)	<30	30-55	45-100	≥90
pH	<7.0 or >9.5	7.1-7.5 or 9.0-9.5	7.5-8.0 or 8.8-9.0	8.2-8.8
Mean Summer Temperature (°F)	<64	64-68 or >83	68-72 or 77-83	72-75
Dissolved Oxygen mg/L (% saturation)	<3 (25%)	5-7 (25-50%)	7-8 (50-75%)	≥8 (>75%)
Conductivity (μS/cm)	<30	<30-60	60-110	≥100
Salinity (mg/L) (ppt)	>10	8-10 (<0.01)	5-10 (0.005-0.01)	<5 (<0.005)
Secchi depth (m)	<0.1 >8	0.1-0.2 or >2.5	0.2-0.4	0.4-2.5
Chlorophyll a (μ/L)	<2.5 or >25	2.0-2.5 or 20-25	8-20	2.5-8
Total phosphorous (μg/L)	<5 or >50	5-10 or 30-50	15-25	25-35

Example of Systems Evaluated for Vulnerability

Intake Structures	Circulating water systems	Service water systems
Traveling screens	Once through	Pumps
Water towers	Pumps	Piping
Trash racks	Piping	Raw water makeup
Trash bars	Condenser water boxes	Heat exchangers
Forebays	Condenser tubes	Emergency systems
Holding ponds	Fire protection systems	Area coolers

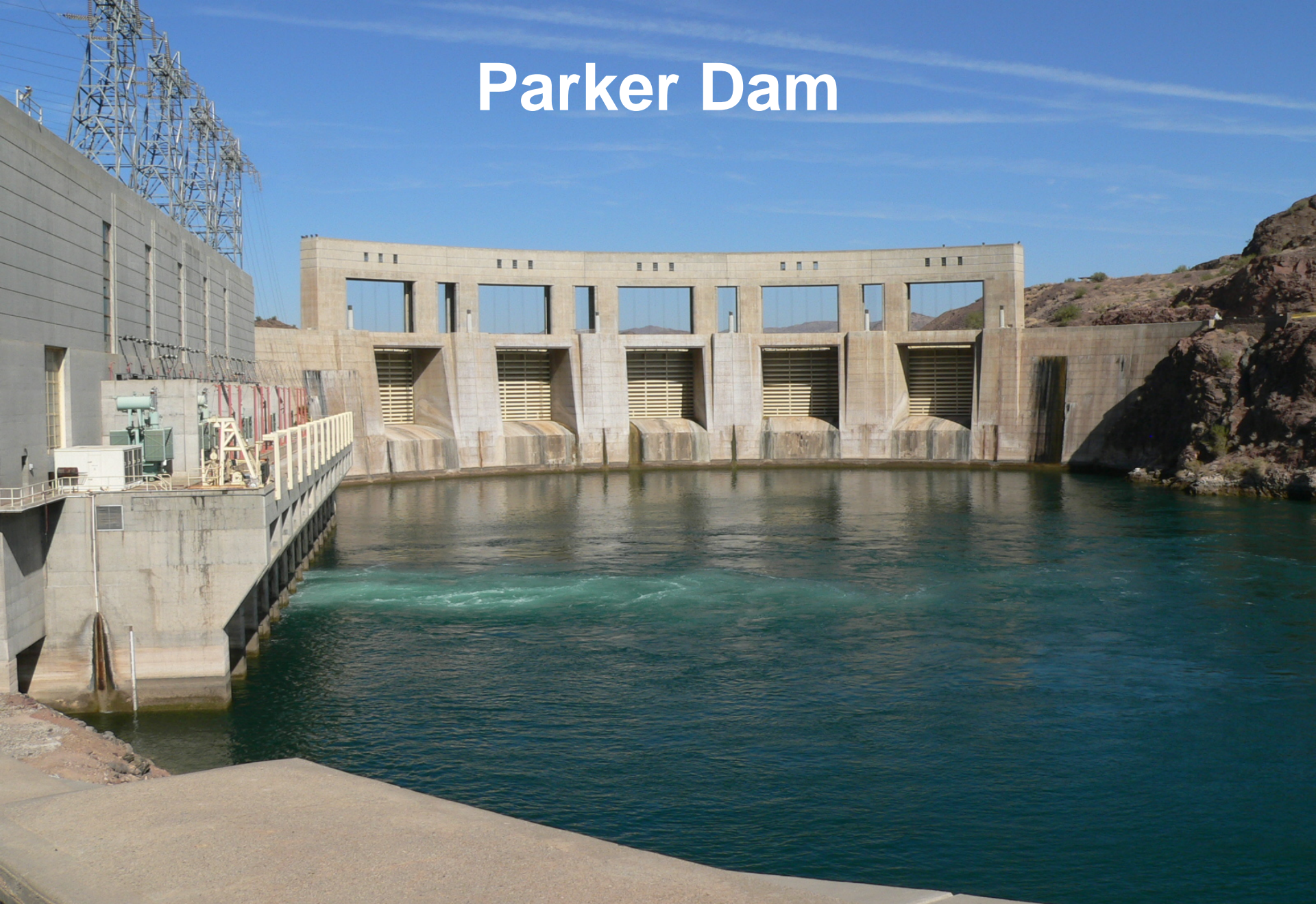
Types of Problems

- **Flow restriction**
 - Roughening (Loss of flow due to increased friction)
 - Blockage
- **Chemical degradation of materials of construction**
- **Biological/Environmental**
 - Food chain
 - Habitat
 - Water quality
 - Water resource industry
 - Accumulations of toxins



Quagga mussel, Lake Havasu – Jan. 2007

Parker Dam



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Sampling Plates at Parker Dam

November 11/07 – 6 Weeks of Settlement



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Trash Rack- Parker Dam - Jan 2013

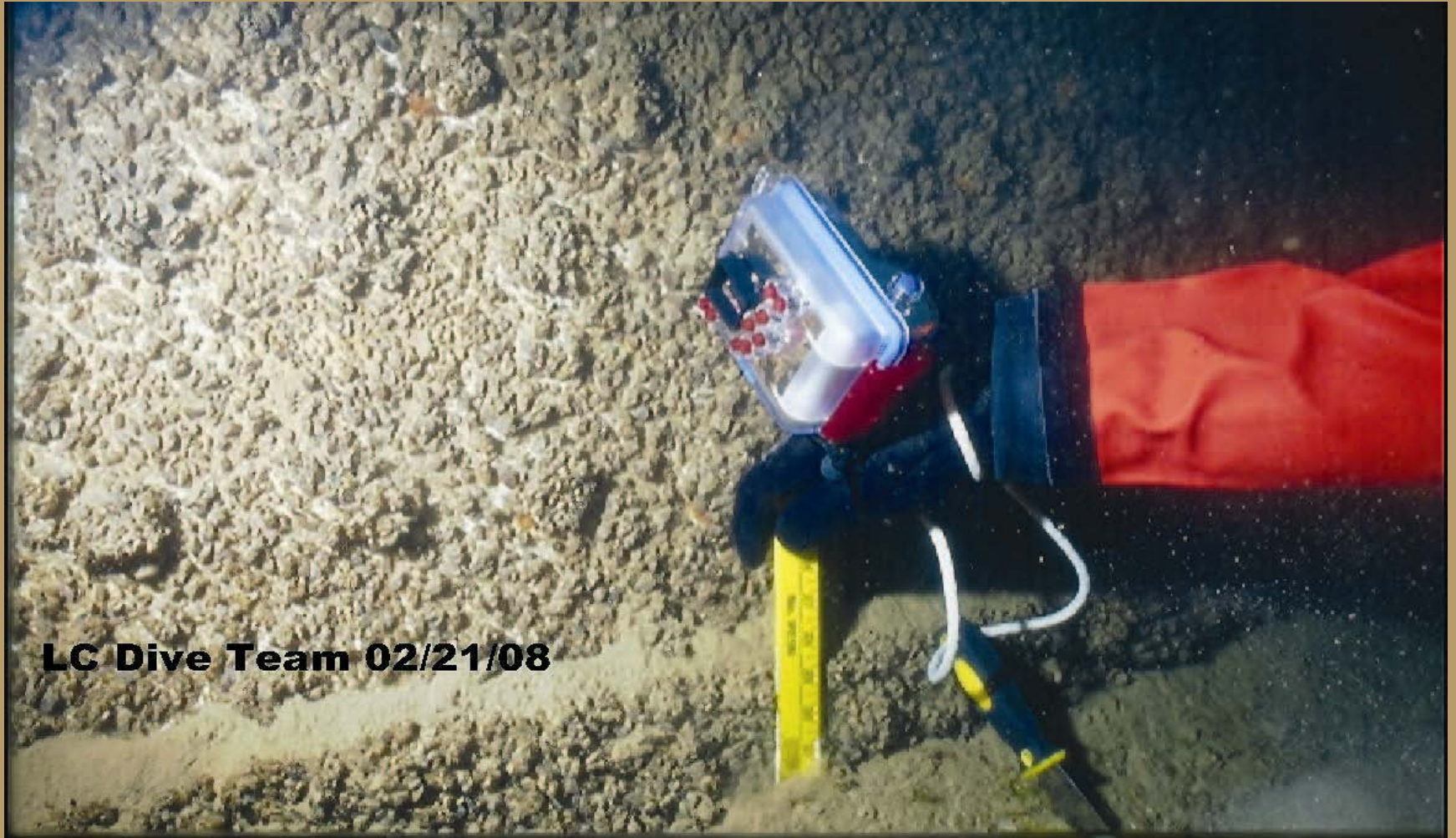


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Domestic Water Intake Parker Dam



Spillway Gates – Parker Dam



LC Dive Team 02/21/08

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Aquatic Weeds – Lake Havasu, AZ

- Evaluate weeds and intake design. Retrofit of trash bar screens with racking systems (Parker Dam)
- Evaluate impacts of mussels on reservoir water quality and environmental impacts.



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Parker Dam Trash Rake – Sept 2013



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Davis Dam



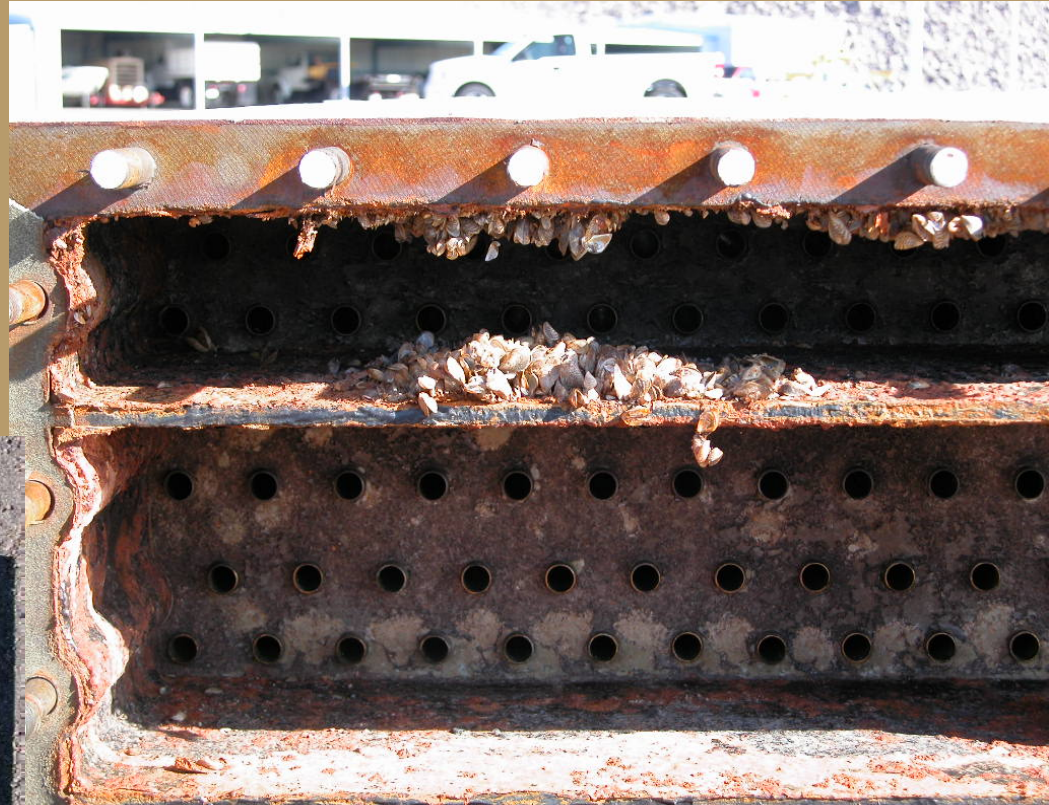
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Davis Dam Fixed Wheel Gate - Oct 07



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Generator Cooling Water Heat Exchanger Davis Dam - Dec 2009



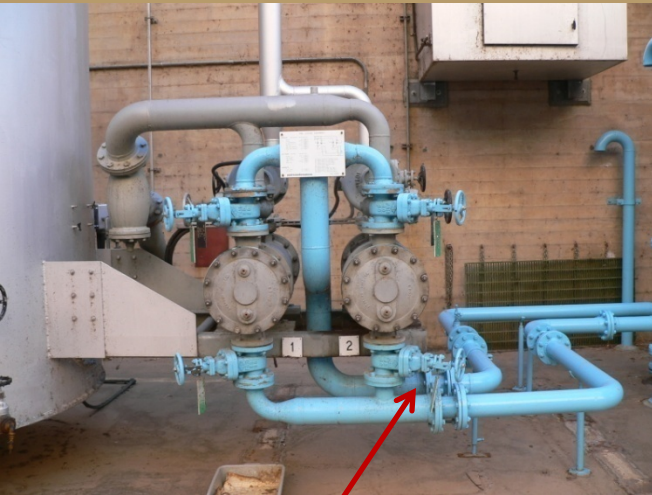
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Hoover Dam



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Fire protection and other cooling water systems need protection



**Transformer
cooling water**

Fire nozzles



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Intake Towers - April 2009



**Trash Racks
6/2009**

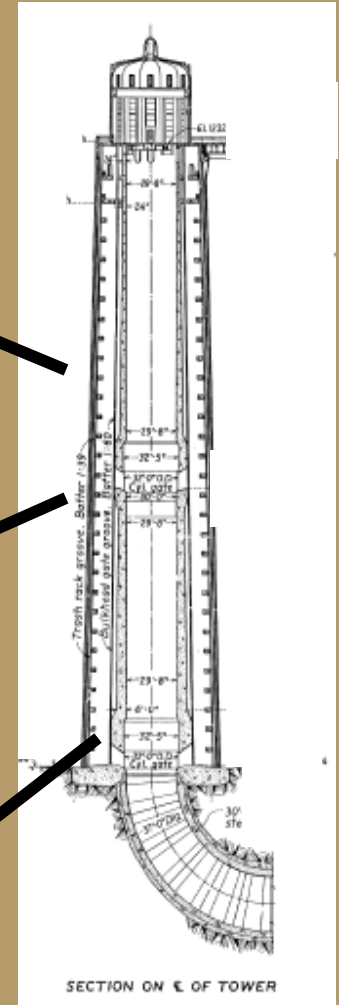
**Upper
Cylinder Gate
11/2007**



**Fore bay
1094 ft**

**Intake -
1045 ft**

**Intake -
895 ft**



Penstock Interior Surfaces Inspection

Mussel Shell Debris in Penstock serving Multiple Laterals



Penstock Drain – Heavy Settling



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Penstock belly drain – Oct 2010



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Clogged generator air cooler connection



Shell Debris - Oil and Bearing Coolers

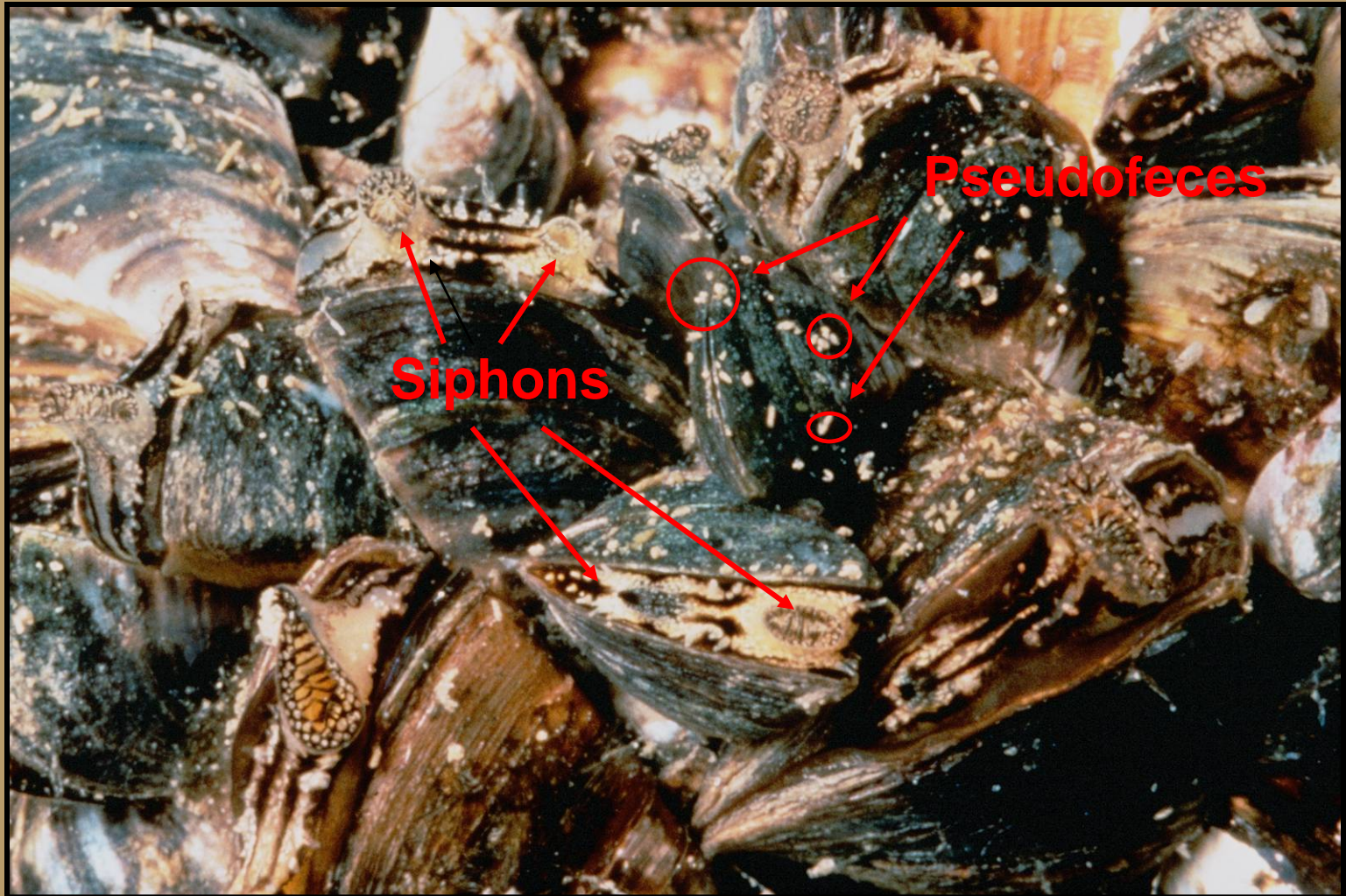


Shell debris from thrust bearing cooler piping



Clogged thrust bearing cooler

Chemical Degradation - Corrosion



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Hoover Dam Pressure Relief Valve Shaft Corrosion – April 2013



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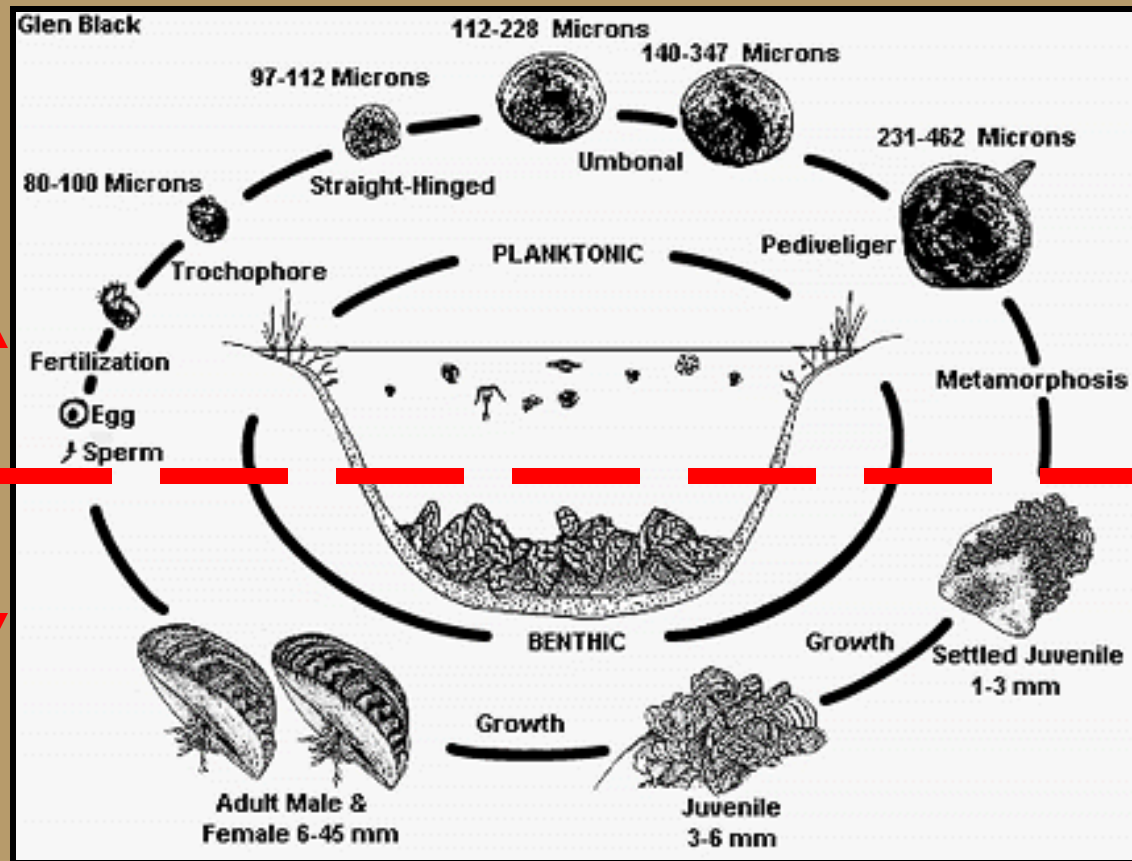
Minimizing Impact

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Control Strategies

- Proactive:
 - Preventive

- Reactive
 - “Clean” after establishing
 - Can be labor intensive
- Redesign/Retrofit



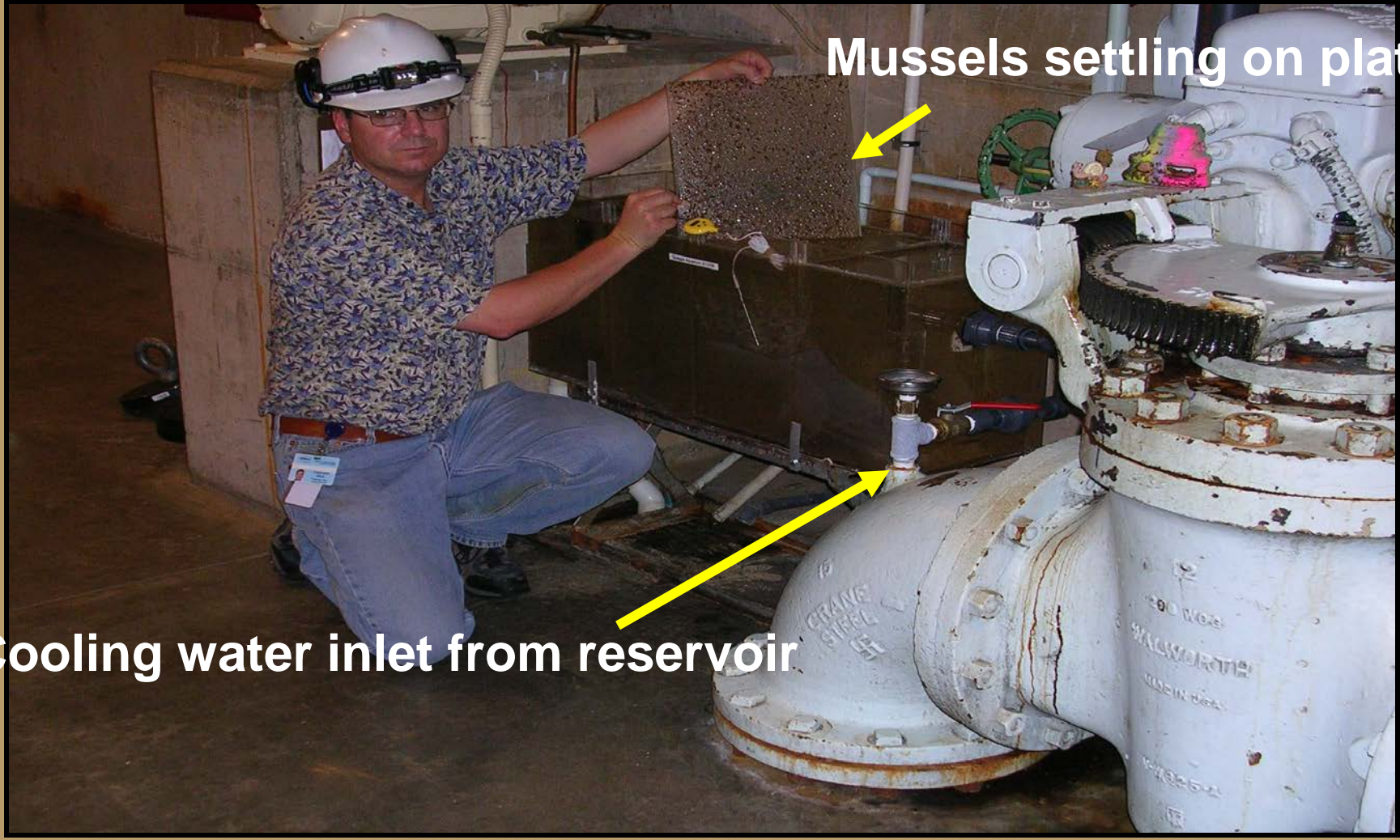
Reclamation Lower Colorado Region Research Activities

- **Installed bio-boxes**
- **Evaluating ultra-violet light treatment (on-going)**
- **Tested micro-filtration systems
(40-80 micron) (completed)**
- **Evaluating water jetting system for exterior cleaning**

Reclamation Lower Colorado Region Research Activities

- **Evaluating anti-foul coatings and materials to resist mussels (Dr. Allen Skaja, TSC Denver)**
- **Evaluation of Zequanox treatment (completed)**
- **Copper Ion Generator (completed)**
- **pH down or up evaluation (completed)**
- **Turbulence study on cooling water (completed)**
- **Pulse Treatment – Laser (Future)**

Installed Bio-Box Sampler for Monitoring

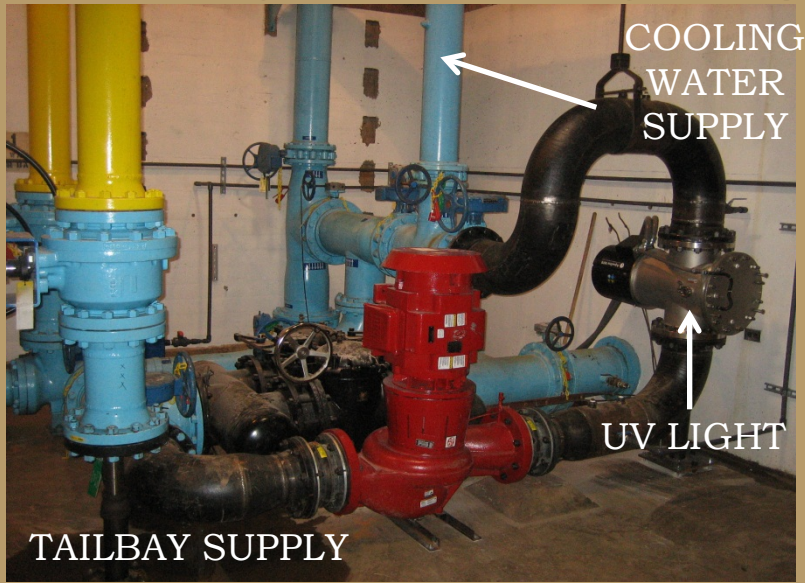


Mussels settling on plates

Cooling water inlet from reservoir

Evaluation Of Medium Pressure UV System at Hoover Dam

Hoover Dam Cooling Water Mussel Control UV System (research)



Started August 2010
2 lamps

Renata Claudi (RNT Consulting)
starting 4 lamp evaluation



Upgrade to 4 lamps to increase
dosage April 2011

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No mussel settlement downstream of UV Lights at Dose of approx. 130 mj/cm²

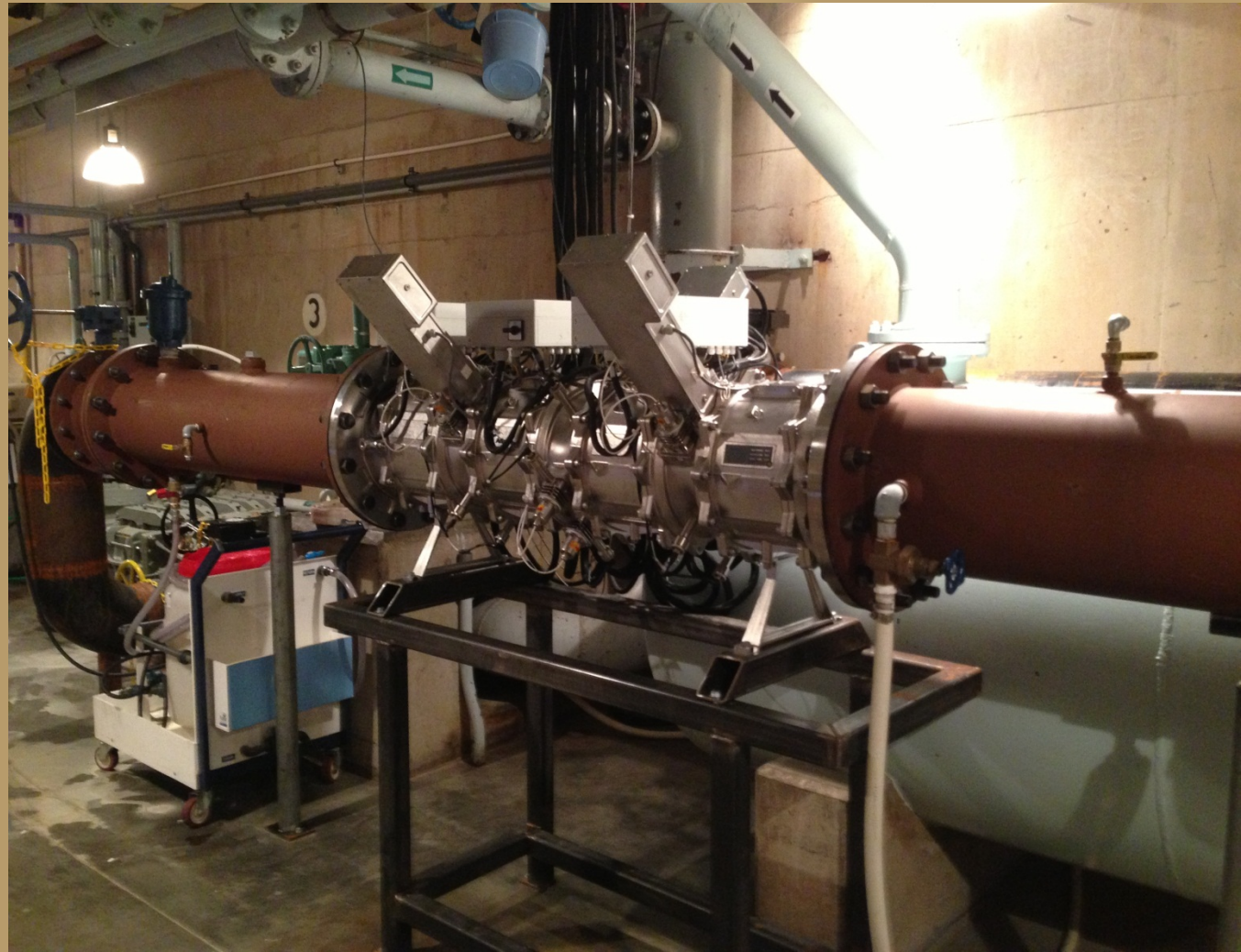
- The UV system set to accommodate maximum flow rate and minimum UVT of water
- Dose had to be kept at a maximum to guarantee success

Evaluation Of Medium Pressure UV System at Davis Dam

- System adjust to actual flow based on data from flowmeter to maintain selected dose
- System adjust to UVT to maintain actual dose
- System adjust to declining lamp life to maintain actual dose
- Dose to be tested selected from the control panel with software, no hardware changes required

Power Plant Mussel Control System Atlantium (HOD) UV Light System

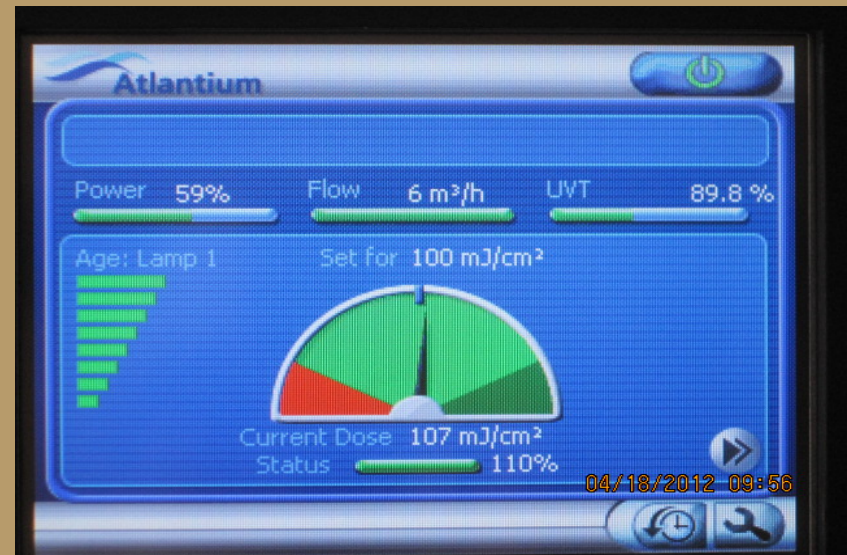
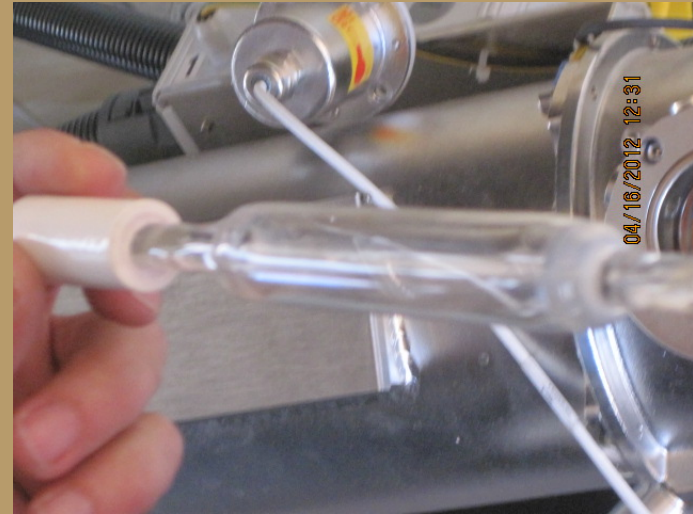
UV Cooling Water System
installed July 2013 on a
4000 GPM system



UV dosage response evaluation for settlement prevention of mussels

UV equipment cost \$100 – 150K
1250 gpm with UVT of 85
dosage of 100 mJ/cm²
Power operational cost \$2500/yr
\$0.035/kwh

UV equipment cost \$225 – 375K
4000 gpm with UVT of 85
dosage of 100 mJ/cm²



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Total settlement of mussels per sq/ft, including percent reductions

Experiment	Dose (mJ/cm ²)	Control (Box 1)	UV (Box 2)	Box 1 to 2
1	50	160	8	95%
2	40	386	8	98%
3	20	223	26	88%
4	40	1445	18	99%
5	40	810	76	91%
6	100	1314	10	99%

Evaluation Of Medium Pressure UV System at Parker Dam

Power Plant Parker Dam Mussel Control System Atlantium (HOD) UV Light System

UV Cooling Water System installed Nov. 2015 on cooling water of each of The four units (1600 GPM) As well as the domestic water supply line

Self Cleaning Strainer →



Wipers and Lamps

Evaluation Of Self Cleaning Filters at Parker Dam and Hoover Dam

Cooling Water Filter Options

40 & 80 micron filter
cartridge inside of all
housing

Parker Dam
Research Filter
2008 - \$100K



Hoover's SCADA Filters
\$200K - 2010

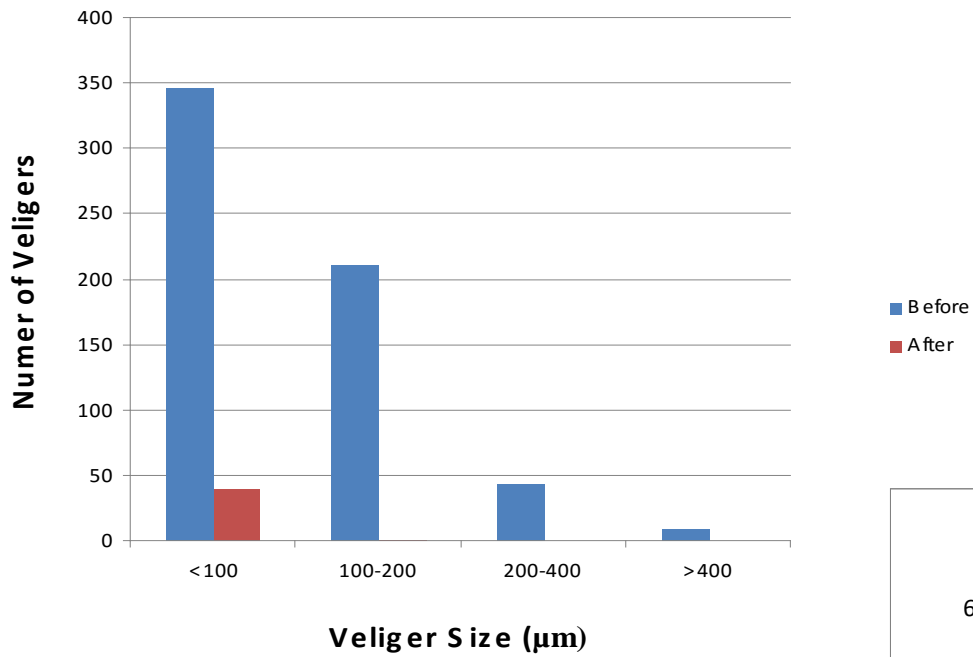


Hoover's cooling
water
\$333K - 2010
(4 filters purchased for
A2, N2, N1, & N8)

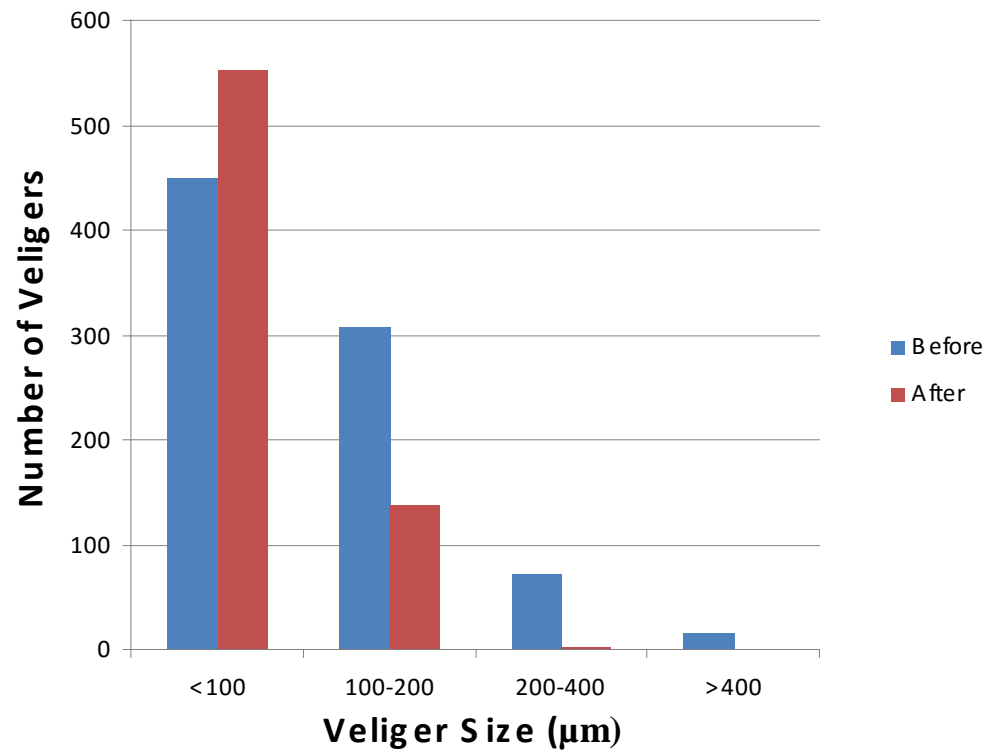


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40 Micron Filter Tests



80 Micron Filter Tests



Mesh Requirements

Square Weave Mesh is Essential

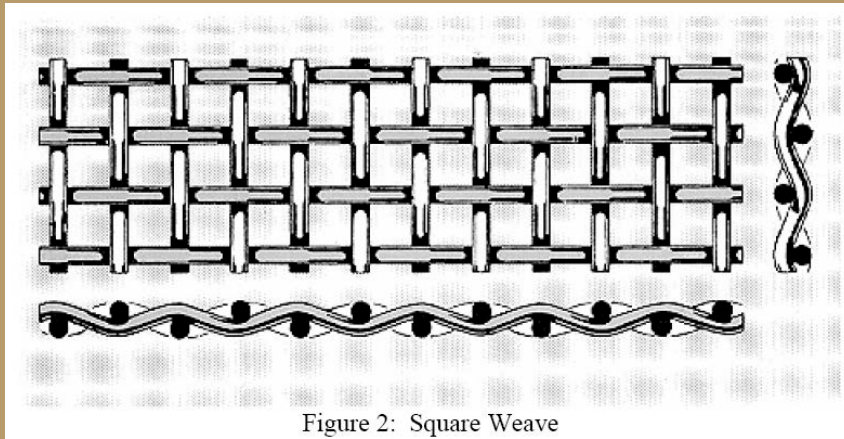


Figure 2: Square Weave

Robust Support of the Mesh is Critical

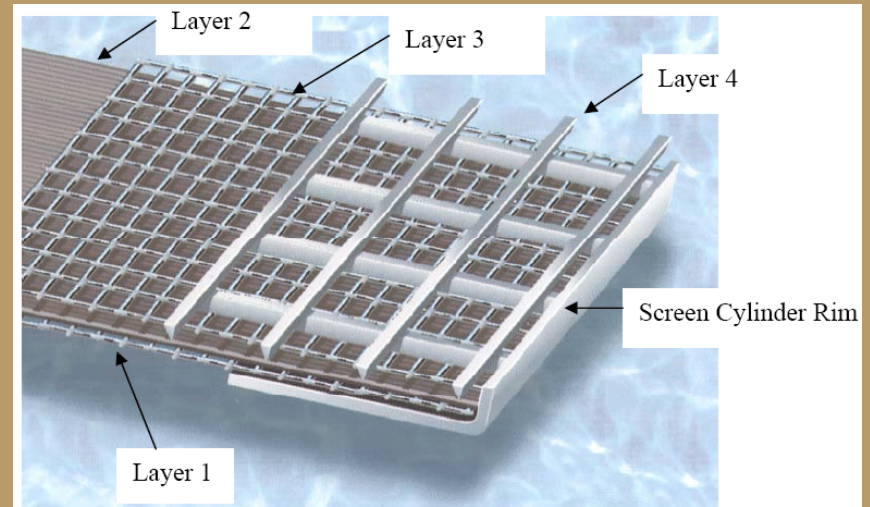
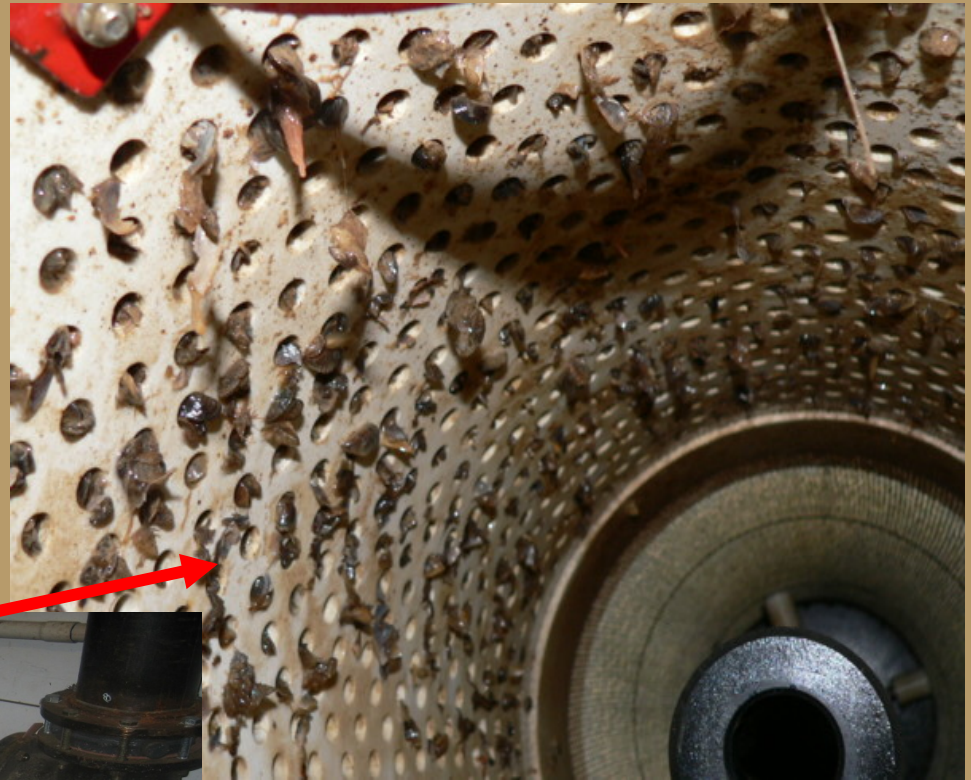


Figure 4: Patented Four-layer Screen

Self Cleaning Ballast Safe Filter



Pre-strainer (filter)



Filter Cartridge – 40 micron

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Mechanical Cleaning

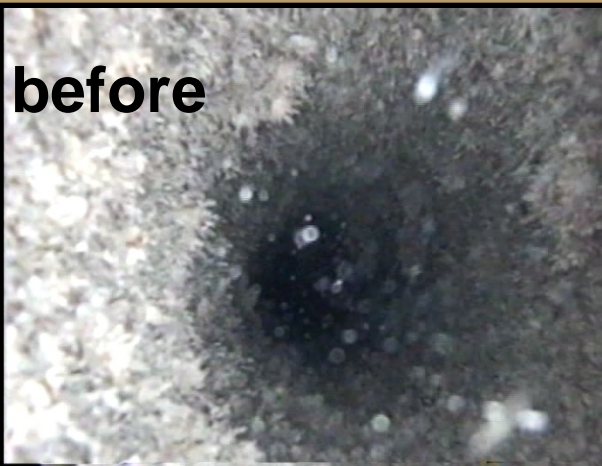
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Water Jetting Equipment



Video

- pre inspection
- water jetting
- post inspection



before



after

Coatings

Coatings Panels Locations – Parker Dam



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Coatings Panels



**3-month
fouling
rate**



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International



**Amercoat
Sigmaglide**



Silicone – 6 months



Silicone – 18 mo.



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Zequanox-Biopesticide

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Zequanox Regulatory Status

North America

- Bacterial product (Developed at NY State Museum and commercially developed by Marrone Organic Innovations for quagga & zebra mussels)
- How does it work? The bacteria produce natural compounds that kill the mussels when they use it as food source. It destroys the mussels' digestive system.



Healthy gut



Treated gut

Zequanox Trials Davis Dam – Mar 2009



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Zequanox Treatment Programs

- Product applied with standard equipment
- Treatments can be completed within hours
 - ~2-6 hrs depending on program
- Mortality occurs over time, reducing damage to equipment from shell debris
- Safe for employees in the surrounding area
- Mortality typically monitored via biobox systems

Annual

Designed for facilities with tolerance for moderate to large shell sizes (larger than 4 mm in size)

Treatments occur annually; typically end of season

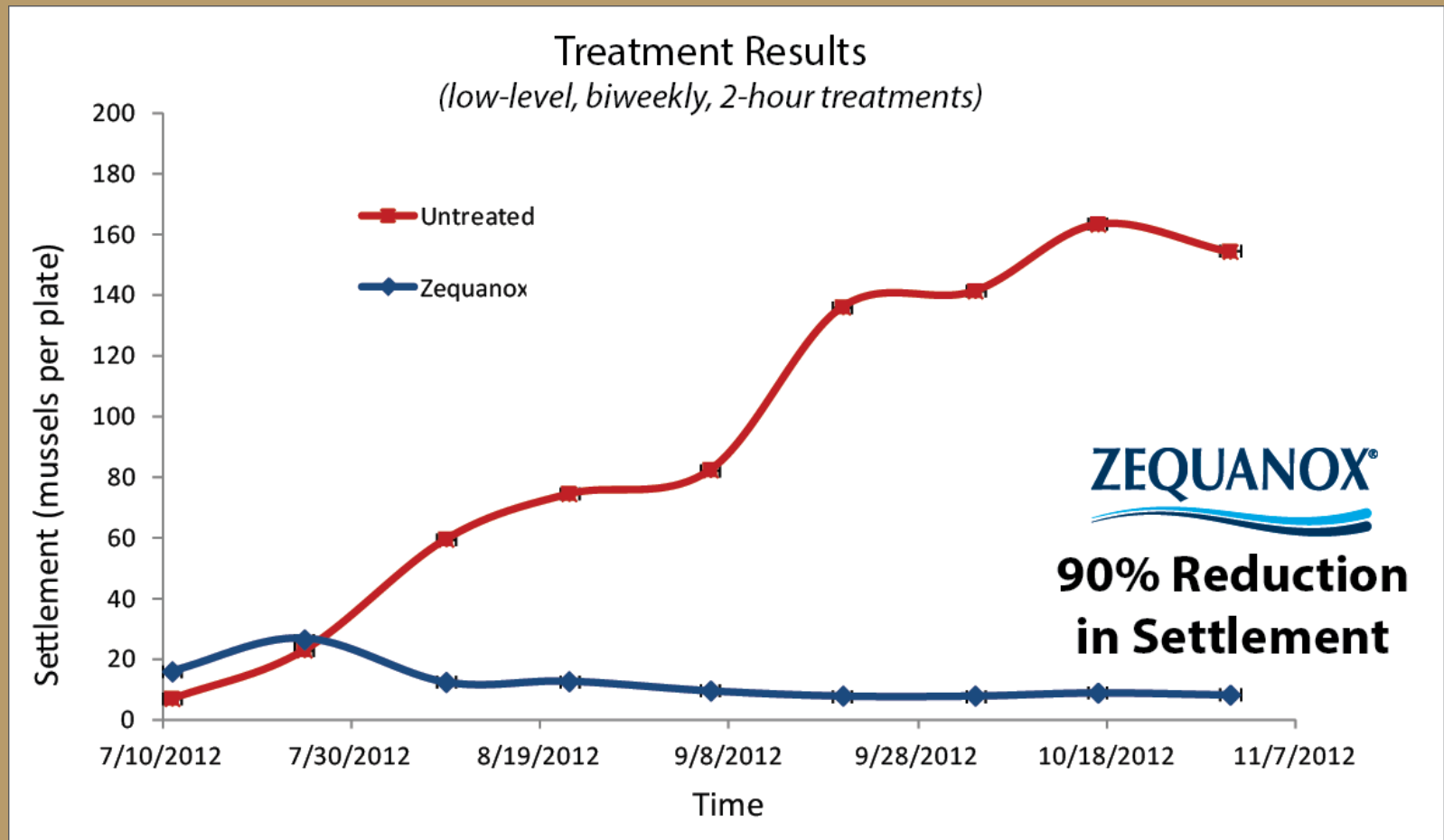
Bi-Weekly

Goal is to limit the number of mussels that exceed 4 mm in size (adult sized)

Ideal for sensitive systems and equipment

Treatments are performed every other week throughout the settlement season

Bi-Weekly Regimen Reduces Settlement by 90%



Copper Ion

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Copper Ion Generator Unit

Anodes and Cathodes are installed in cells (fresh water units). A side-stream of water is passed thru the unit and a copper-rich concentrate is formed. The concentrated solution is then distributed to one or more intakes to treat desired water streams.



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Copper is very effective at the ppb level in killing adult mussels and preventing infestation from developing

Significant operational problems with the hardware tested

Copper Ion Generator Unit

Copper Based Molluscicide Approved for open waters



Molluscicide Applications

- Anecdotal Reports of Quagga and Zebra Mussel Kill When EarthTec Was Used for Algae and Organic Pretreatment
- Funded Successful Academic Research at UNLV
- EPA Label Approved for EarthTec QZ Formulation as Molluscicide (August, 2013)

 **EARTHTEC**

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Mortality of zebra mussels exposed to EarthTec QZ in flowing water.

Dose as EarthTec	Dose as element	Mortality after:			
		6 days	11 days	13 days	19 days
Control	0 ppb	<5%	<5%	<5%	<5%
3 ppm	171 ppb	100%			
2 ppm	114 ppb	100%			
1 ppm	57 ppb	50%	100%		
0.6 ppm	30 ppb	15%	55%	70%	80%

Notes: Tests conducted in July and August, 2014.

**Temperature range 20-22°C (68-72°F),
alkalinity about 130 mg/L**

pH adjustment

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pH up and pH down evaluation

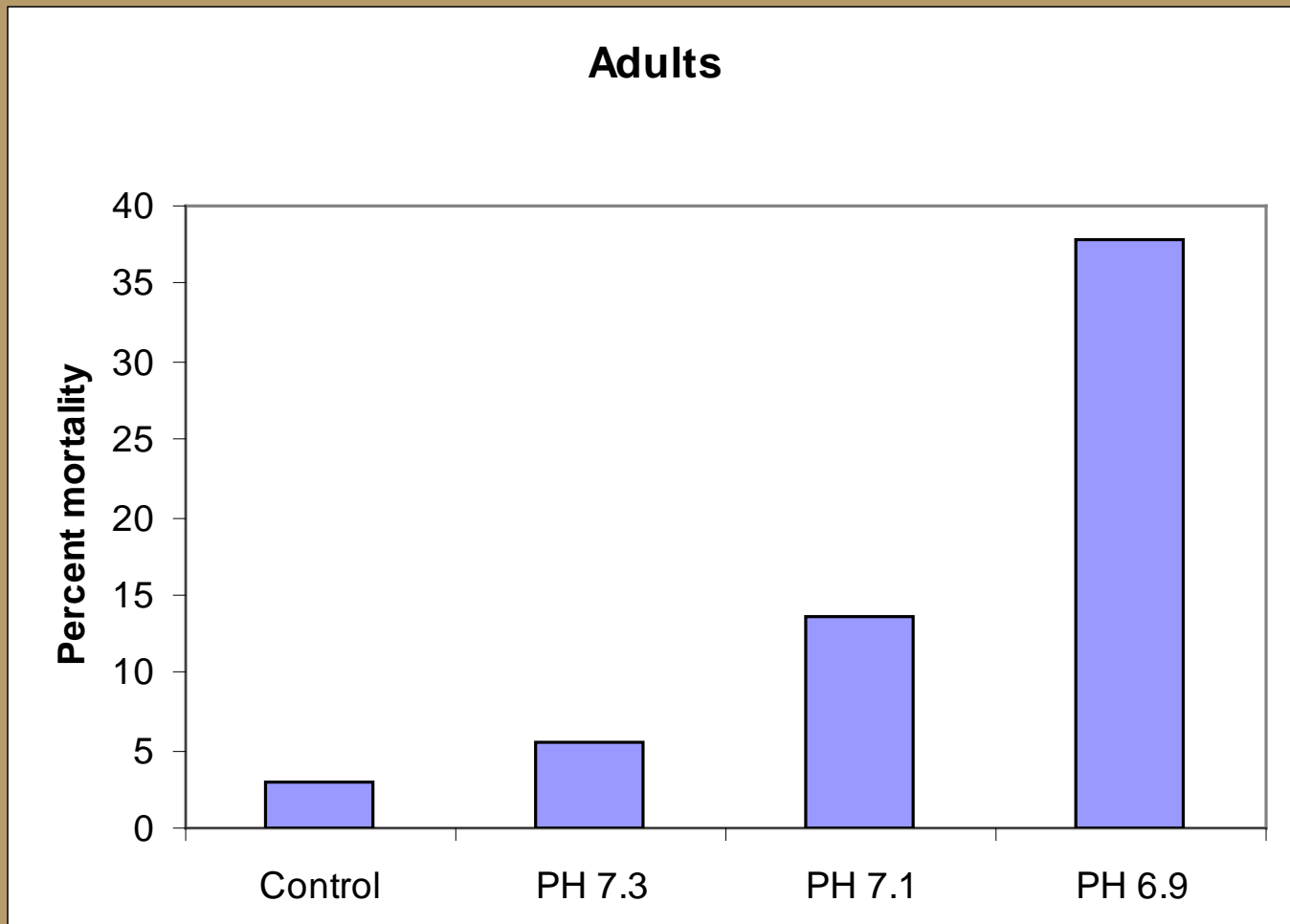


RNT Consulting Inc. Mobile Lab

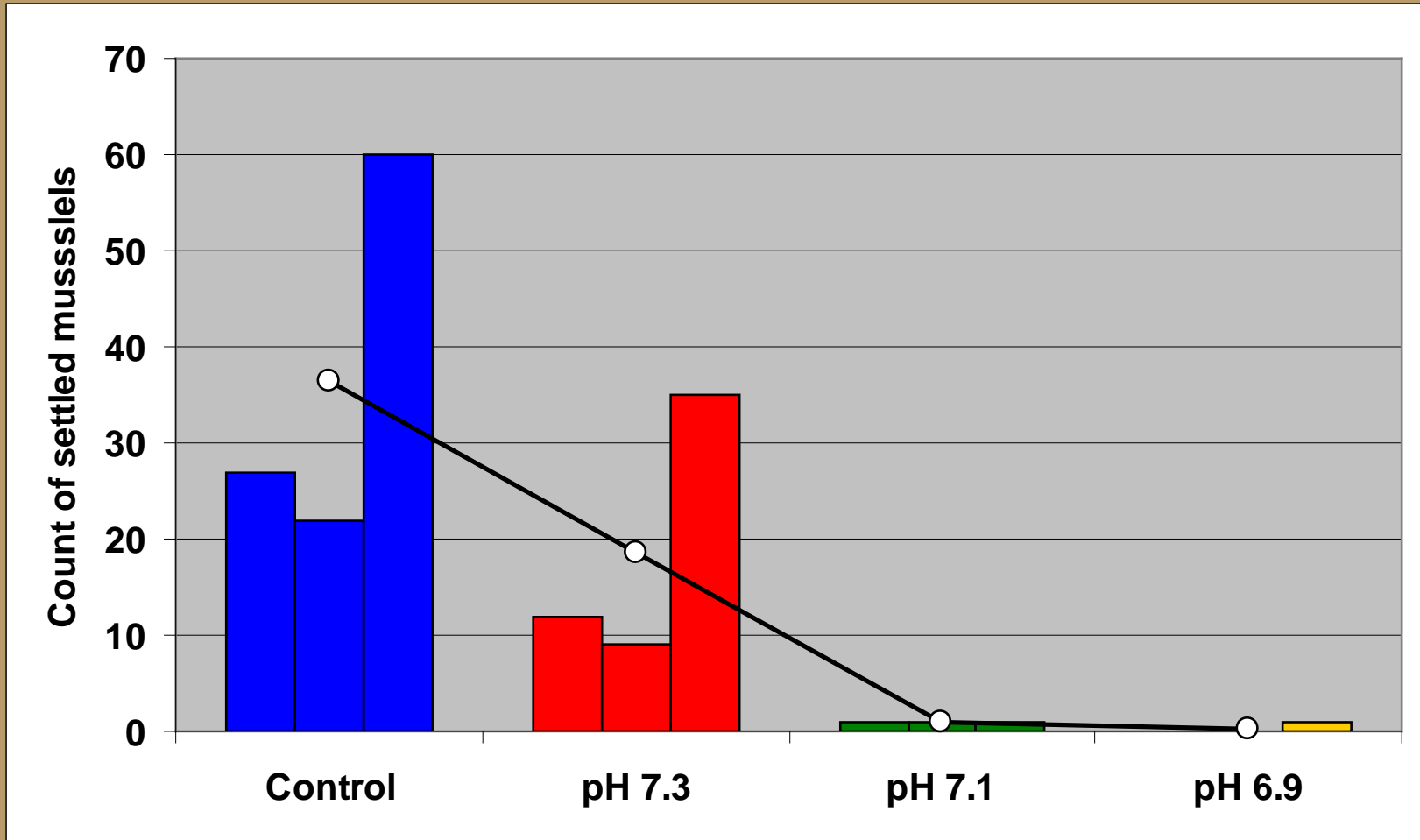


Precipitate observed after 24 hours at pH 9.3

Adult dreissenid mortality in mesh bags after 12 week exposure



Evaluation of new settlement from August 15th to November 15/09



QUESTIONS??

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