Zebra Mussel Control at Hydroelectric Generating Stations

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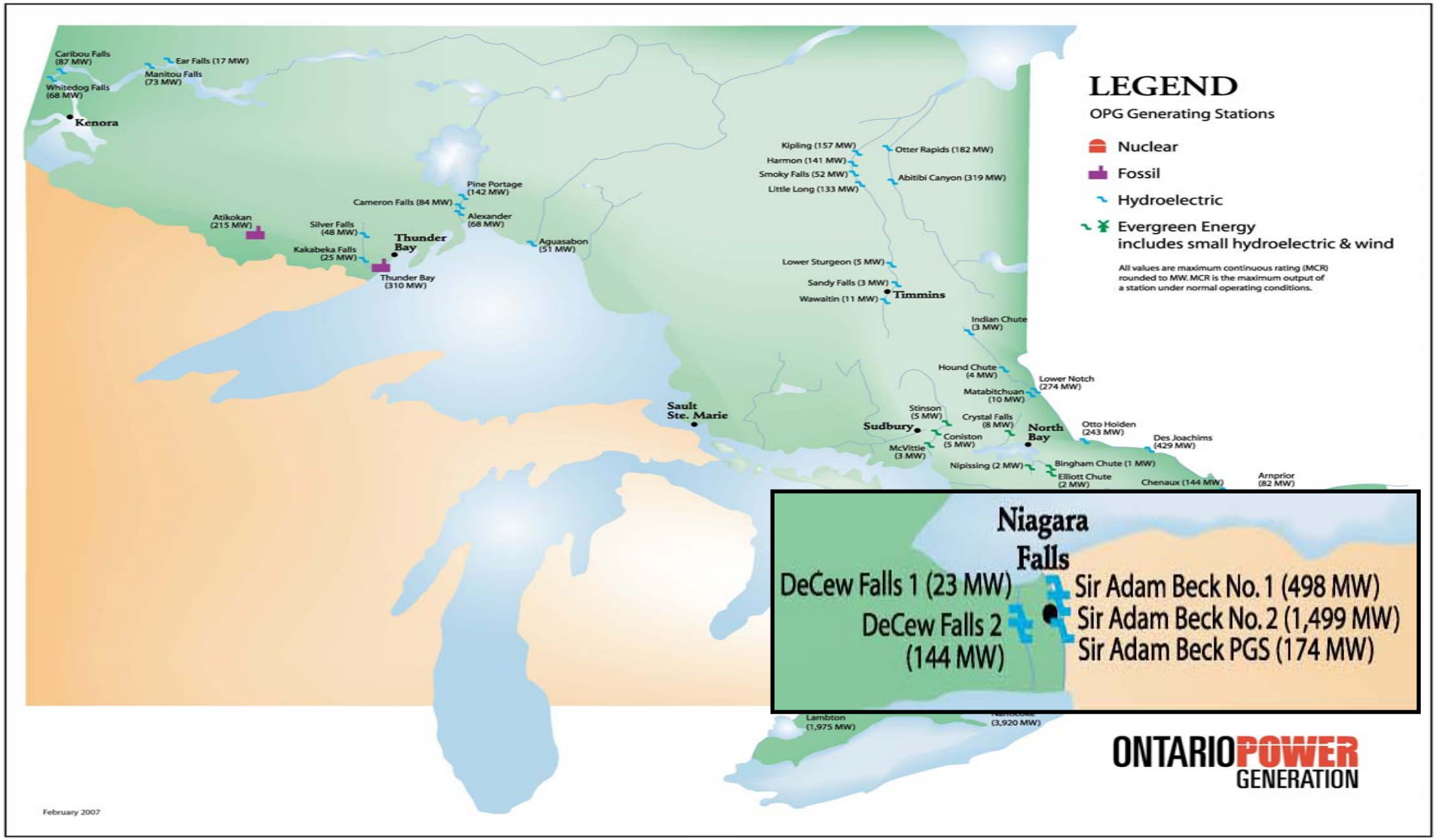
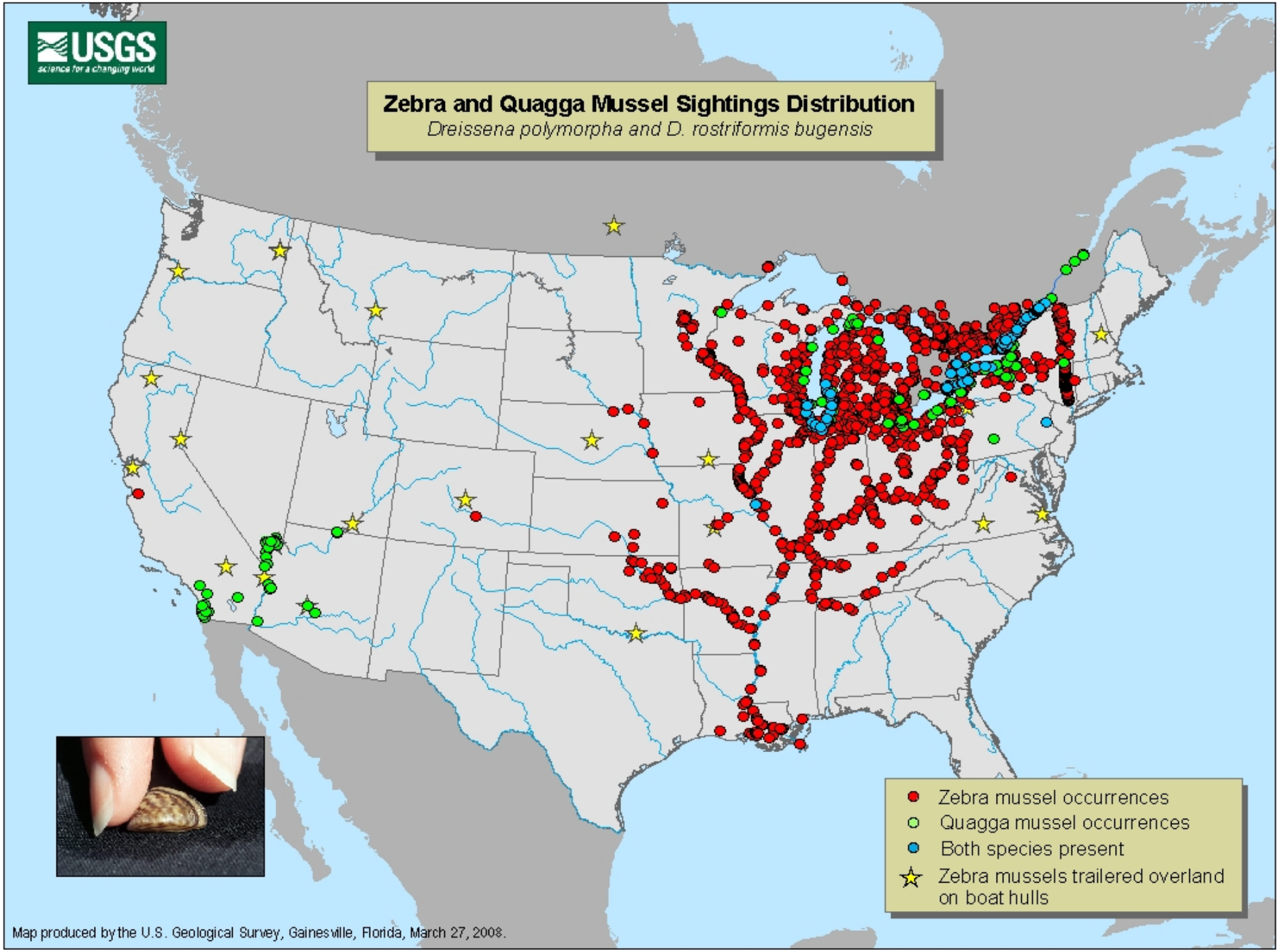
Niagara Plant Group Location and Facilities



Overview of the Presentation

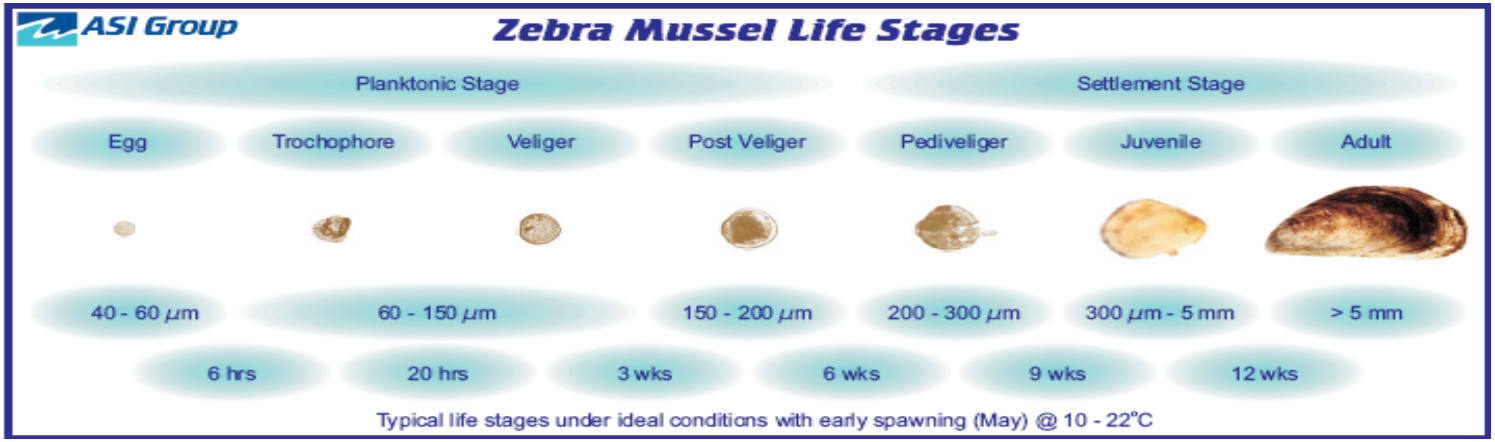
1. Biology of Zebra Mussels
2. What to do before the Zebra Mussels come?
3. What do you do once the Zebra Mussels arrive?
4. Treatment options


USGS
science for a changing world
Zebra and Quagga Mussel Sightings Distribution
Dreissena polymorpha and D. rostriformis bugensis
Zebra mussel occurrences
Quagga mussel occurrences
Both species present
Zebra mussels trailered overland on boat hulls
Map produced by the U.S. Geological Survey, Gainesville, Florida, March 27, 2008.

1.0 Biology of Zebra Mussels

1.1 Requirements and Movement

- pH Level - > 7.2/7.4 <9.3/9.6
- Calcium Level - >15mg/L
- Dissolved Oxygen Level - >2mg/L
- Minimum temp reproduction 12C/54F (Quagga Mussels about 8 C/46 F**)**
- Not able to colonize if the water velocity is greater than **6ft/1.7m/s**
- Can close their shells for extended periods to protect themselves from chemical attack



2.0 What to do before the Zebra Mussels come?

2.1 Monitoring

•Sample headworks using a plankton net & pump to get a count of veligers and their size - advanced warning!

•Use settlement plates in headworks - scrape regularly - analyze in a lab to assess numbers and size distribution

•Establish bioboxes in your plants and monitor attachment rates year round

•A real worst “case scenario” of what is going on inside your plant piping

•How – Install using a slipstream off your service water near generator & transformer cooling

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2.0 What to do before the Zebra Mussels come?

2.2 Risk Assessment & Vulnerable Systems

•Carry out a detailed engineering risk assessment by a team of stakeholders

•Smallest diameter pipes – or other pinch points?

•Check veliger counts and dissolved oxygen levels in firewater piping - should remain below 2 ppm

•Check trash racks, gains and vulnerable piping that has slow or intermittent water movement

•Cooler temps & pressure differentials on strainers

•Is your service water filtered? Secondary risk of clogging from shells coming into your operation

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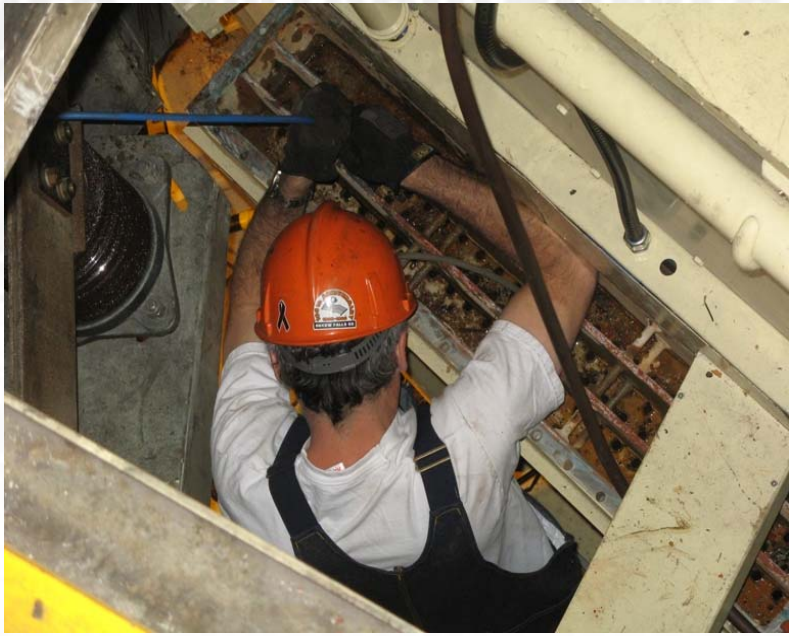
3.0 What to do After Zebra Mussels arrive?

3.1 Short Term

•Based on monitoring, carry out non-permitted treatments: closed loop heat treatment, mechanical removals, oxygen deprivation in problem/risk areas



•Continue to better understand vulnerabilities as well as what longer term treatment options will work best for you

•What kind of treatment strategy is suited to your operation – preventative or reactive

•Initiate lower cost changes to reduce risk

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3.0 What to do After Zebra Mussels arrive?

3.2 Mid Term - Turnkey Treatments?

•Consider for sodium hypochlorite and other capital intensive treatments.

•Reduces short term expenses and provides a semi-rapid response solution

•Helps you understand how a full scale treatment will work and the extent of infestation in your system

•We have experience with one company that can do turnkey treatments using portable tanks, pumps, analyzers, hoses and trained staff. They can also de-chlorinate prior to discharge if necessary

•Permitting can be negotiated on your behalf

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3.0 What to do After Zebra Mussels arrive?

3.3 Long Term

•Develop business cases and outage plans and get them approved for selected treatment options

•Try treatment on small facility first to "work out the bugs" - then apply your experience to other sites

•Get permits as soon as you can

•Review and negotiate conditions of permit(s) carefully, and make sure it is workable and achievable in your situation – focus on flexibility

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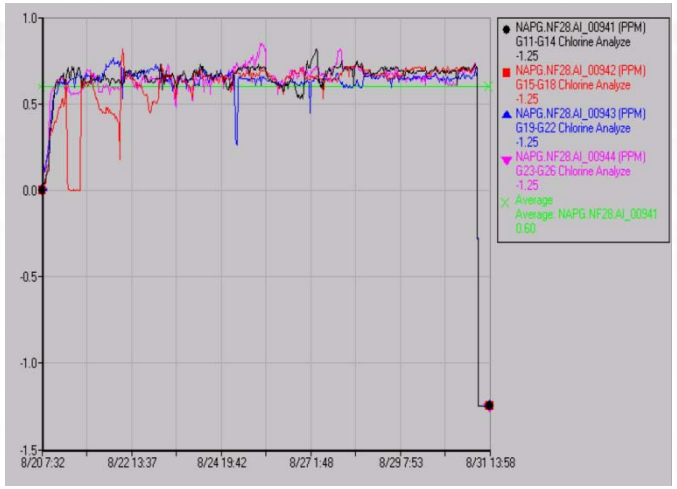
4.0 Treatment Options

4.1 Overall Design Philosophy

•Important to use the KISS principle in your design – better to keep it simple……

•What treatment approach suits your facility? Can you continue what your are doing now, or should you change

- o Proactive – Continuous or Semi Continuous
- o Reactive - Periodic



•Work with someone that has experience with zebra mussel treatment so that you end up with the right type of treatment

4.0 Treatment Options

4.2 Hot Water Treatments

- 32° C for 48 hours (90° F)
- 40° C for 1 hour (104° F)

• **Pros:**

• Effective to kill zebra mussels in a few hours

• No permitting likely required unless discharges to environment exceed 10 degrees Celsius over ambient

•**Cons:**

• Problem is that it can result in a very large flush of shells – larger than your plant can handle

•Difficult to get high temperature in water consistently throughout the plant

•Requires an outage

•Treatment done in isolated sections

•May also require flushing of shells with high pressure water afterwards

4.0 Treatment Options

4.3 Potash Treatments

- Potash is injected as a liquid at 100 ppm concentration and allowed to flow into the system till it reaches the other end of the target piping– static or semi static
- Can cause a complete kill of zebra mussels in about 48 hrs
- Normally has been used in fire water systems and irrigation systems but is something to consider for service water treatment during outages

Pros:

- Much less toxic than sodium hypochlorite and relatively quick
- Might be done without a permit depending on your local laws

Cons:

- Requires an outage
- May need to flush out shells afterwards to prevent small openings from being plugged

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4.0 Treatment Options

4.4 Sodium Hypochlorite

- Proven technology
- Kills all sizes of zebra mussels

Pros:

- @ 0.6 ppm in warm 20C + water for about 10 days can achieve a 100 % kill rate
- Very effective and relatively quick
- Proven application with drinking water and sewage
- Can be done with portable equipment
- Turnkey treatments can be cost effective
- No outage required

Cons:

- Sodium hypochlorite requires specialized handling
- Health, Safety and Environment impacts
- Normally requires permitting
- Expensive to install a permanent system

4.0 Treatment Options

4.5 Ozone Treatment – Newer Technology

• Ozone generator creates ozone gas that is released at an injection point into service water system

•> 98 % in settlement of veligers in piping at 50-80 ppb

Pros:

- Ozone breaks down into harmless natural products in the environment
- Treatment is very effective

Cons:

- Ozone is a toxic gas to humans & heavier than air
- Typically requires permitting
- May have to seal areas to prevent off-gassing
- Expensive compared to sodium hypochlorite

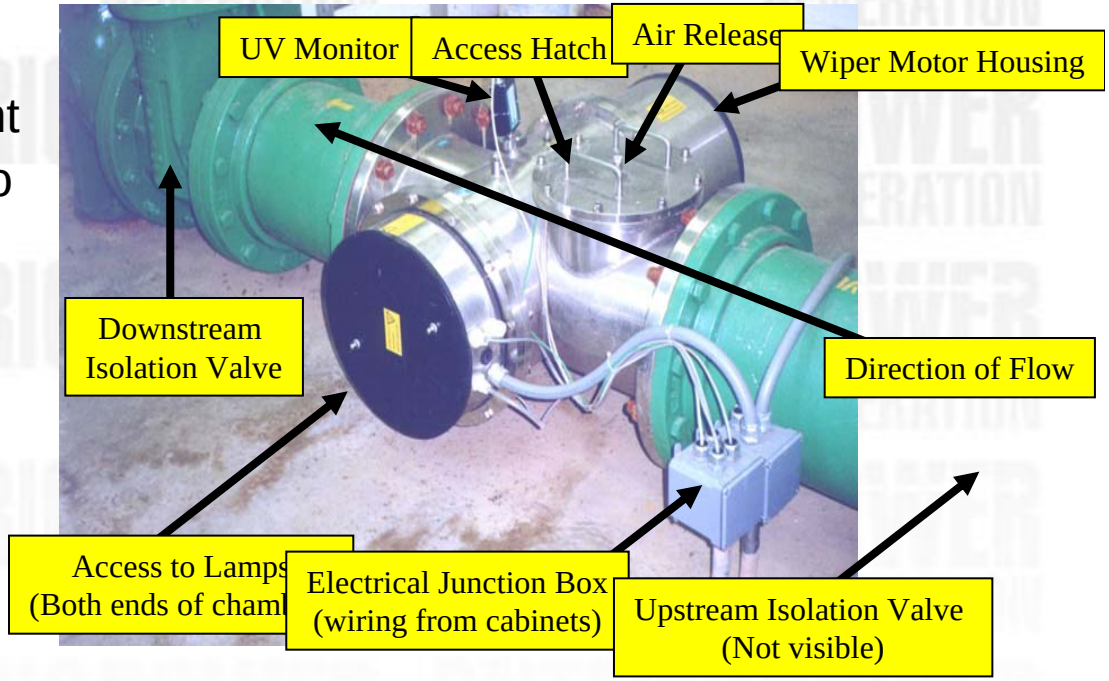
4.0 Treatment Options

4.6 UV Treatment – New Technology

- Trial testing at the Bruce GS achieved 85% reduction in downstream settlement
- Prevents settlement of veligers – due to "sunburn" – flow through plant

Pros:

- Well suited for smaller systems
- No permitting typically required
- Minimum effort to install
- Proven application with drinking water, sewage and ballast water



Cons:

- Lamp cost can be high
- Requires clear water
- Does not deal with translocators
- Still under some development - availability

4.0 Treatment Options

4.7 Environmentally Friendly Microbial Pesticide – New Technology

- High kill rate (70-98%) achieved in small scale power plant trials
- Uses a natural strain of soil bacteria *Pseudomonas fluorescens* lethal to zebra mussels

Pros:

- Treatment in 6-12 hrs – no outages
- Can be injected using injection pump
- Not harmful to fish and other biota
- Developer/researcher is looking for additional trial locations
- High mortality in cold water

Cons:

- Just coming to market – availability
- A pesticide – permitting unknown?

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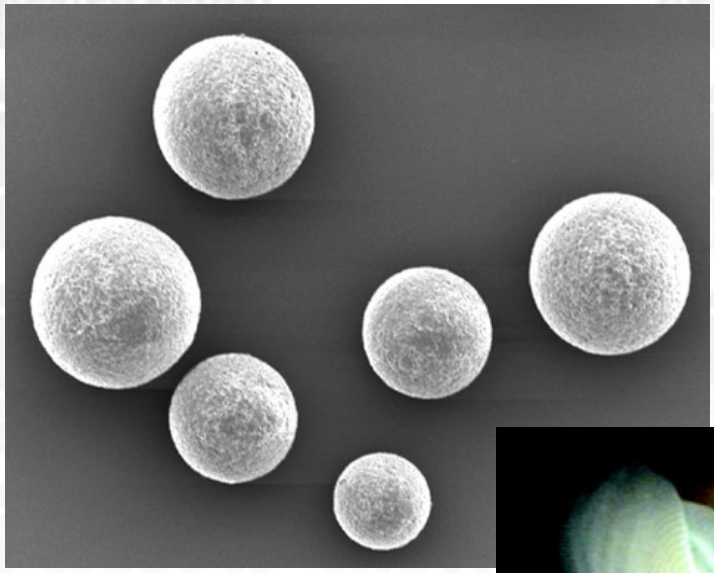
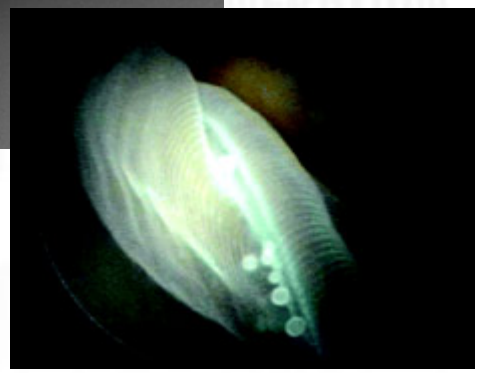
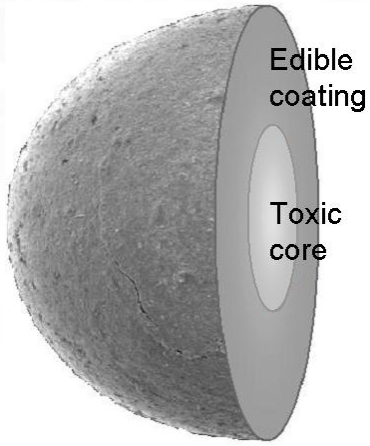
4.0 Treatment Options

4.8 Biobullets – New Technology

- Small salt particles “coated” with a protein that zebra mussels will feed on
- "biobullets" slowly release small amounts of potassium chloride - poisonous to zebra mussels







Pros:

- Treatment in 12-24 hrs – no outages
- 60-80 % kill rate
- Can be injected using injection pump
- Little or no harm to fish and other biota

Cons:

- Just coming to market – availability?
- A pesticide – permitting unknown?

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5.0 Roundtable Discussion and Questions

Thank you for your participation

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