Ultrasound

U.S. ARMY CORPS OF ENGINEERS **Building Strong®**

ANS Control: Ultrasound

Targeted Species: Algae are affected by ultrasound. Examples of ANS of Concern – CAWS[1] controlled by this technology may include red macro-algae (*Bangia atropurpurea*), diatoms (*Cyclotella cryptica*, *C. pseudostelligera*, and *Stephanodiscus binderanus*),[2] and grass kelp (*Enteromorpha flexuosa*). See the *Prior Applications* section of this fact sheet for more details.

Selectivity: Sound wave frequencies emitted by the SonicSolutions[3] system and other similar devices are specific for control of algae (Taylor 2011). Selectivity will vary among algal species.

Sound waves are generated by a transducer placed in the water; the transducer is powered by line voltage or solar cells.

Developer/Manufacturer/Researcher: A device specifically developed for algae control is manufactured by SonicSolutions, LLC, West Hatfield, Massachusetts. Ultrasonic irradiation modules used in Lake Senba, Japan (described in the Prior Applications section) were developed by Honda Electronics Company, LTD [3] (Toyahashi, Japan) (Lee et al. 2002). Other manufacturers of similar devices may be available. To date, no commercial ultrasonic device has been developed for control of aquatic vascular plants (Wu & Wu 2007).

Brief Description: Ultrasound is a high frequency sound wave (>20,000 Hz) above the audible frequency range of humans (Wu & Wu 2007; Soar 1985). The device developed by SonicSolutions, LLC, claims to emit sound wave frequencies within a range (proprietary information) that specifically targets nuisance algal species. Complete kill of algal species can take up to 4 to 5 weeks with continuous (24-hour) application. Sound waves are generated by a transducer placed in the water, which floats on the water surface; the transducer is powered by line voltage or solar cells (SonicSolutions, LLC, 2011a).

The effects of ultrasound on plant cells and tissues can be mechanical or thermal in nature (Wu & Wu 2007; Ahn et al. 2003). When plants absorb ultrasonic waves, energy associated with the wave is converted into heat, causing a "thermal" effect. Ultrasound can also cause acoustic cavitation in plant cells. Documented biological effects of sonication on plant cells includes chromosomal anomalies, disruption or collapse of gas vesicles and subsequent loss of buoyancy, damage to or destruction of cellular organelles, cell death, changes in cellular osmotic potential, inhibition of photosynthesis and cell division, destruction of cell membranes, and formation of free radicals (Wu & Wu 2007; Zhang et al. 2006; Hao et al. 2004; Ahn et al. 2003; Lee et al. 2002; Nakano et al. 2001; Soar 1985). These effects have been reported after short exposures to ultrasonic waves, from seconds (Lee et al. 2002) to

[1] For a complete list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.
[2] Cryptic algae (*Cyclotella cryptica*), cylindrical algae (*C. pseudostelligera*), and diatom (*Stephanodiscus binderanus*) are three (3) species of algae that belong to the algal subcategory of diatoms. For the purpose of this fact sheet, they will be referred to collectively as diatoms.
[3] Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.

minutes (Zhang et al. 2006; Hao et al. 2004; Soar 1985). Ahn et al. (2003) reported that algal cell densities and chlorophyll *a* concentrations of *Microcystis aeruginosa* were significantly decreased after 3 days of ultrasonication (20 kHz applied twice daily for 2-minute exposures).

Prior Applications: The use of ultrasound technologies has been evaluated for multiple purposes in many systems and against several species of algae, plants, and bacteria. This technology is best suited for small water bodies, including golf course and ornamental ponds, small lakes and reservoirs, lagoons, and marinas. It also has been used to reduce algal biofilms in some water treatment facilities. The application of ultrasonic irradiation to control cyanobacterial blooms in eutrophic systems (including *M. aeruginosa* and *Spirulina platensis*) has been documented by many researchers (Zhang et al. 2006; Hao et al. 2004; Ahn et al. 2003; Lee et al. 2002; Nakano et al. 2001).

Rockland Country Club (New York) before and after the addition of ultrasound treatment

Laboratory and greenhouse studies by Wu and Wu (2007) demonstrated that ultrasonic waves of 20 kHz, aimed directly at water chestnut (*Trapa natans*) stems and petioles, caused severe damage and plant death. These findings indicate that ultrasound may hold promise as a new control technique for this invasive weed species. The submersed aquatic macrophyte, Eurasian watermilfoil (*Myriophyllum spicatum*), is also susceptible to ultrasound (Soar 1985).

Phull et al. (1997) evaluated the use of ultrasound for wastewater treatment and found that ultrasound, in combination with chlorination, was more effective for reducing bacterial colonies over sonication used alone. Ultrasound also reduced the amount of chlorine required for wastewater disinfection (Phull et al. 1997). Ultrasonic technologies coupled with hydraulic flushing effectively controlled blue-green algae blooms in Lake Senba, Japan (Lee et al. 2002).

General Effectiveness: The manufacturer states that of the five algal species identified as ANS of Concern – CAWS, only diatoms can be controlled with the SonicSolutions ultrasound system. It is unlikely that the filamentous green algae, grass kelp, will be affected by ultrasound due to its plantlike characteristics. It is unknown whether unbranched red macro-algae would be affected by ultrasound; data is currently nonexistent on this species ((D. Taylor, SonicSolutions, LLC, E-mail communication, 2011). The SonicSolutions technology is not effective on vascular aquatic plants (SonicSolutions, LLC, 2011b).

Operating Constraints: Operating constraints identified with use of the SonicSolutions ultrasound system include: the transducer must be positioned in a minimum of 2 feet of water; the placement of transducers is important for maximum effectiveness, as ultrasound waves bounce off hard surroundings such as concrete, rip-rap, large rock islands, sandbars, and weirs, which can degrade signal strength; dense beds of submersed aquatic weeds can reduce signal strength; large and irregularly shaped bodies of water require installation of multiple units; the system is most effective in enclosed bodies of water (e.g., ponds, pools, lagoons, tanks, and small lakes); the system is not effective on vascular aquatic plants or plantlike, macrophytic algae (*Chara* or *Nitella* spp.); and complete kill of algae may take as long as 4 to 5 weeks (SonicSolutions, LLC, 2011b). The use of ultrasound in flowing water systems may not be practical, given the duration of exposure (4 to 5 weeks) required to destroy susceptible algal cells. Massive die-off and/or decay of algae in a short period of time may result in low dissolved oxygen levels in some systems.

According to Wu & Wu (2007), limited research has been conducted to determine the effects of ultrasound frequencies, capable of damaging plant cells (20 kHz was successful for destroying plant cells in these studies), on benthic organisms, fish, or wildlife. These researchers concluded that additional studies should be conducted to investigate the potential impacts of ultrasound on aquatic communities prior to large-scale field application of this technology.

Cost Considerations:

Implementation: Implementation costs would include purchase and placement of units, and costs related to installation of a power source in the area of treatment. Placement requires no equipment and can be accomplished quickly. The number of units required is dependent on the area of water to be treated. Planning and design activities in this phase may include research and development of this Control, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

Operations and Maintenance: In recommended applications, little maintenance is needed. In most applications, the device must be removed from the water for minor cleaning on a monthly basis. Operations would include electricity requirements of approximately 10 watts per hour per unit. Repair and replacement costs would vary, depending on damage from impacts of ice, debris, changing channel depths, and boat traffic. Solar-powered ultrasound units are available, but may have additional maintenance considerations (battery replacement).

Mitigation: Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

Citations:

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