RECLAMATION

Managing Water in the West

Nuisance Aquatic Vegetation Control in Water Delivery Systems: Low-Dose Metered Herbicide Application

Research and Development Office
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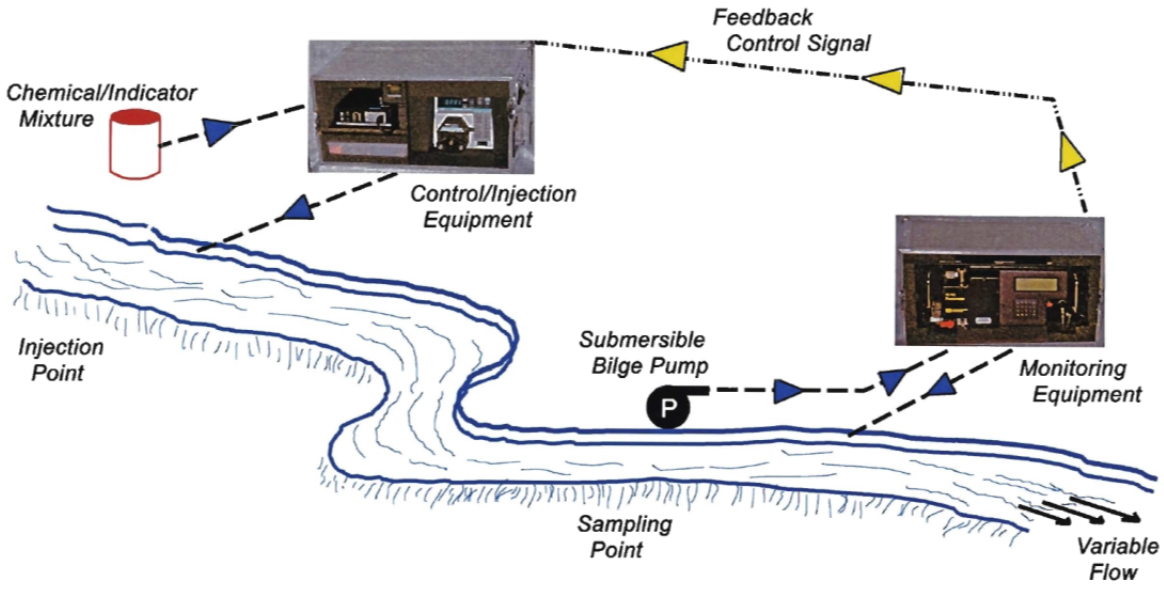

U.S. Department of the Interior
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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Executive Summary

Nuisance aquatic vegetation growth may detrimentally impact water flow and water quality in delivery systems. A traditional method of control is the use of federally-approved herbicides, which are commonly added to the water by slug or surface applications. However, these chemicals may not be as efficacious in flowing water systems due to rapidly diluting concentrations and insufficient exposure time. The problem is further compounded when the flow rate is fluctuating. A prototype automated chemical metering system was developed in 1996 by Reclamation scientists to address these challenges. A U.S. patent was granted in 1999. However, this system has been left in storage in a state of disrepair for nearly 20 years. The Research and Development Office requested an assessment of the current condition of the existing prototype and recommendations for modernizing the system.

Background

In the western United States, Reclamation utilizes an extensive network of reservoirs and delivery canals to carry agricultural, industrial, municipal, and recreational waters. The growth of nuisance aquatic vegetation (NAV) may severely restrict water flow in delivery channels, detrimentally impact fishery and wildlife resources, and reduce water quality. Aquatic vegetation reaches nuisance proportions due to nutrient loading or disturbed habitats such as a reservoir or canal where stable aquatic plant communities are not established. An overabundant of aquatic vegetation may also result from an introduction of exotic species which dominate native plants and grow unchecked.

One aquatic vegetation control technique involves the use of herbicides. Slug or surface application of herbicides is applied to the water. However, this traditional method of application may not be as efficacious in flowing water systems due to rapidly dissipating concentrations and a lack of exposure time. Further complicating matters is the difficulty of continuously applying the correct amount of an herbicide within Environmental Protection Agency (EPA) label use requirements when flow rates are fluctuating.

A prototype automated chemical metering system was developed by Reclamation scientists to address these challenges. The system works by using a non-toxic fluorescent dye as a measurable *in-situ* surrogate for the treatment chemical to be applied to a fluctuating water flow system. Since it is not possible to obtain a real-time concentration measurement of the treatment chemical itself, a known quantity of the fluorescent dye is premixed with a known quantity of the treatment chemical. The automated chemical metering system controls the concentration of the treatment chemical by measuring and controlling the concentration of the fluorescent dye in the flowing stream, regardless of the characteristics of the flowing stream or the ability to detect and quantify the treatment chemical itself. A U.S. patent for the automated chemical metering system was granted in 1999. The Research and Development Office (R&D) has since been seeking partner companies to expand the prototype for a wide range of applications and commercialize the system.

Proposal Development

A 2014 R&D scoping project assembled a team of resource specialists and managers to identify comprehensive control solutions for NAV in water delivery systems. A need was identified to find a more efficient and effective control of NAV by optimizing the schedule and prescriptions for various treatments. This later became a 3-year R&D conducting research project tracking and mapping NAV growth in water delivery systems, with the goal that field information collected may help schedule treatment for optimal time and location. This project is still on-going.

One of the recommendations made was to explore the possibility of refurbishing and modernizing the existing prototype automated chemical metering system for demonstration purposes in stakeholder irrigation districts. This system has been left in storage in a state of disrepair for nearly 20 years and was no longer operable. R&D requested an assessment of the

current condition of the existing prototype and recommendations for modernizing the system. These are the goals of this scoping project.

Previous Work

The prototype automated chemical metering system was originally developed by Reclamation in 1996 as an environmentally safe method to control the concentration of herbicides used for weed/algae control in canals and rivers with fluctuating flow rates. Using traditional application methods, herbicides may be applied outside of the EPA label use requirements. An overdose of the herbicide during decreasing flow rates would lead to increased concerns over toxicity to fish and wildlife. Conversely, underdose of the herbicide during increasing flow rates may reduce its efficacy in controlling NAV. The metering system allows the application of an herbicide at a lower constant dose for the purpose of maintaining unrestricted flows.

In the prototype, a prescribed mixture of fluorescent dye and treatment chemical was metered into the flowing water using a digital metering pump. The concentration of the fluorescent dye in the flowing water was measured approximately 100 feet downstream using a fluorometer. The measured value was converted to a voltage signal and sent to a controller via a feedback wire loop that changed the speed of the metering pump. Changes in the speed of the metering in a direct response to changes in the water flow rate maintained a target constant concentration of the dye in the flowing water. This in turn maintained a constant target concentration of the treatment chemical which was premixed in a known ratio with the fluorescent dye. The response time of the system was reported to be typically less than 2 minutes, so the system was able to compensate quickly for large changes in the flow rate. The automated chemical metering system was designed to be portable and can be operated at remote locations using conventional A.C. power, batteries, or solar panels. The original schematic of the prototype is shown on the cover of this report.

The prototype system was successfully demonstrated with different herbicides in several irrigation districts for aquatic weed and algae control. Manpower requirements were significantly reduced compared to conventional management approaches, maintenance or calibration were not required during the studies, and concentration and exposure time studies with several classes of treatment herbicides can be performed to determine the minimum rates and exposures necessary for control of a given nuisance species. The system may also be used for the application of other treatment chemicals in fluctuating water flow systems, such as molluscicides in the control of zebra and quagga mussels in canals and pipes, antibiotics in the management of aquaculture diseases (e.g., fish hatcheries), or precipitating agents in the reduction of toxic metals in drainages.

Recommendations

The automated chemical metering system was first developed 20 years ago and still exists as a prototype today. Technologies have changed or become more readily available. The needs and requirements for NAV controls have evolved. New herbicides or formulations have become available. EPA label use requirements and concerns over the toxicity of herbicides in the

environment are driving a need to utilize a low-dose metering technology such as the prototype patented by Reclamation.

It will be necessary to invest in the upgrade and modernization of the automated chemical metering system before it can be used again for field demonstrations and for garnering interests from stakeholders and private companies. Testing of the system in the field using new herbicides under certain current field conditions would be advantageous in updating the capability of this technology. A R&D conducting research proposal by Reclamation scientists in partnership with irrigation districts and commercial aquatic product manufacturers would be a logical next step in advancing this technology. The proposal should consider the following recommendations:

1. Refurbish prototype automated chemical metering system. The existing prototype has been in storage for nearly 20 years and is no longer operable. However, parts and supplies are still available to restore the instrument to operating condition. This should be one of the first priorities.

2. Herbicide concentration exposure time studies. Numerous laboratory studies have shown that many herbicides may be used in a low-dose regime with good to excellent efficacy by applying the herbicide at lower concentrations during longer exposure periods of time. In some cases, dosage rates of some herbicides approached the acceptable residue level in drinking water which decreased toxicity to nontarget organisms in the environment and opened the possibility of reduced restrictions on water use. Field studies should consider extrapolations of the laboratory studies to evaluate the efficacy of metering low concentrations to control NAV in flowing waters.

3. Metering system programming. Herbicide use patterns have evolved since the development of the low-dose metering prototype. Some herbicides are now used under "Factor" recommendations. As an example, a "Factor 24" application may refer to the application of an herbicide at 4 parts per million (ppm) for 6 hours or 2 ppm for 12 hours and so on. In some cases, a very low dose over extended periods of time proved to provide greater control of NAV. This should work well with the automated chemical metering system. For example, a 0.4 ppm/84 hours concentration exposure time (CET) using endothall was found to be more effective in controlling sago pondweed (*Potamogeton pectinuatus* syn. *Stuckenia pectinata*) than the regular program of +4 ppm/8 hours CET. In addition, work has been done examining synergistic responses using combinations of herbicides, such as chelated coppers and a reduced rate of the dipotassium endothall salt. Currently, the prototype automated chemical metering system is set up to maintain a single constant concentration of herbicide. The herbicide is premixed with the fluorescent dye and the ratio remains fixed for the duration of the metering application. This may be adequate for most applications, but it may be more desirable for the system to have the capability and flexibility of programming the dosages of multiple herbicides over the duration of the treatment.

4. Telemetry. The existing prototype used a hard wire over a short distance on land as the feedback loop for controlling the injection rate of the herbicide. The surrogate dye was monitored 100 feet downstream of the metering pump. The prototype also required a person

standing next to the instrument to monitor the performance of the system while it is operating. In most irrigation districts, there may be a need to monitor the dye and the application of herbicides over much greater distances. It would also be desirable to minimize manpower requirements by implementing communication technologies that would allow for remote performance monitoring of the chemical metering with a cellular device or a desktop application. Reclamation has pursued and taught for many years automated canal operations that has enhanced system performance and make more efficient use of district staff and resources. NAV control via automated chemical metering should be incorporated in the wider effort of canal operation automation.

5. Replacement *in-situ* surrogates. Like herbicides, dyes are also becoming increasingly scrutinized when applied to waters of the United States. There are concerns over the injection of a strongly fluorescent dye into waters that are used for agriculture or recreation. Although water tracer dyes have been used for many years, certain locations are now requiring the filing of a National Pollutant Discharge Elimination System (NPDES) permit. Therefore, it may be desirable to substitute tracer fluorescent dyes with naturally-occurring surrogates that can be detected and measured by the automated chemical metering system using a different *in-situ* detector. A naturally-occurring signature may also double as a direct indicator of the amount of NAV present in the water and provides for a mean to determine the metering rate of an herbicide. Such a direct indicator would not need to be premixed with an herbicide as it is now with the existing prototype. For example, photosynthetic pigments such as carotenoids and chlorophylls may be useful replacement surrogates.

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