

# Filter-Clogging Algae Mitigation Evaluation



Prepared for



Prepared by



**CH2MHILL**

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Final Draft Report

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# Executive Summary

This report presents the study undertaken by the City of Bellingham (City) to evaluate alternatives to mitigate the adverse impacts of seasonal algae in Lake Whatcom to the City's Whatcom Falls Water Treatment Plant (WTP). This study was undertaken in the second half of 2011 and completed in early 2012.

## ES.1 Background and Purpose

In late July and August of 2009 the filters at the City's WTP began clogging much earlier in filter runs than typical, requiring more frequent filter backwashing. The result was greatly reduced WTP capacity – to the point the City implemented mandatory water restrictions, for the first time, to reduce customer demand to match the reduced WTP capacity.

Filter clogging was attributed to algae in Lake Whatcom – the City's source water. Although the reasons for the intense algae bloom of the summer of 2009 is the subject of varied speculation, historical and on-going algae monitoring shows that summertime algae blooms in Lake Whatcom have been increasing over the past decade.

In 1998, Lake Whatcom water quality failed to meet the Washington State dissolved oxygen standard and was placed on Washington's list of polluted waters (Section 303d of the Clean Water Act). As a result of the listing, Ecology initiated a Total Maximum Daily Load (TMDL) study to restore lake water quality. The TMDL study showed that human actions were causing increased phosphorous loading and therefore reduced dissolved oxygen. Meeting the TMDL requirements for phosphorous and dissolved oxygen is expected to take many years to complete, and compliance with the TMDL requirements is the cornerstone of the long-term response to improving lake quality.

Despite on-going coordinated efforts, via the Lake Whatcom Management Program, by the City, Whatcom County, and Lake Whatcom Water and Sewer District to reverse this trend, summertime algae blooms are expected to continue increasing in intensity over the near-term future. Recognizing that it is unacceptable to be in a position wherein it risks falling short of meeting summertime customer water demand, the City initiated this study to evaluate alternative solutions and select a path forward for subsequent implementation.

## ES.2 Alternatives Evaluated

The alternatives evaluated for mitigating clogging of the filters at the City's WTP were grouped into three main categories: treatment, intake, and lake management. These alternatives are presented in Table ES-1. In addition to these pro-active alternatives, the "No Action" alternative was included in the Triple Bottom Line Plus evaluation phase as a means of establishing a lowest-cost baseline for comparison.

Each of the treatment alternatives considered for this study are commonly used in the municipal water treatment industry and are commonly-considered alternatives for algae removal. Each would be implemented somewhere at the existing WTP site. They are not, however, equal with respect to removal performance, advantages, disadvantages, and cost.

Three intake alternatives were identified for consideration and evaluation. Each of the intake

**TABLE ES-1**  
Summary of Alternatives Evaluated

Treatment	Intake	Lake Management
Dissolved Air Flotation	Secondary Intake via In-Water Pipeline	Lake Management
Ballasted Sedimentation	Secondary Intake via Over-Land Pipeline	
Plate and Tube Settling	New Dual-Intake System	
Upflow Clarification		
Conventional Sedimentation		
Micro-Screening		
Ozonation		
Additional Filters		

**Notes:**

Other potential solutions were acknowledged and considered but not evaluated in detail because their feasibility was believed to be questionable based on prior experience and/or a lack of prior application or success. These other potential solutions include: hypolimnetic oxygenation, floating shade balls, lake aeration.

alternatives includes withdrawing water from Lake Whatcom at a location different from the existing intake location that has a substantially lower concentration of algae. Each of the intake alternatives includes the capability to withdraw water at more than one depth.

The Lake Management alternative is essentially the Lake Whatcom Management Program. The Lake Whatcom Management Program is the management forum for improving lake quality and via which compliance with the TMDL requirements for dissolved oxygen and phosphorous is being pursued. Lake management will be implemented regardless of the results of this evaluation. Meeting the TMDL requirements is the cornerstone of the long-term strategy to improve water quality, including reducing algae concentrations.

## ES.3 Evaluation of Alternatives

Evaluation of the alternatives to mitigate the adverse impacts of filter-clogging algae at the City's water treatment WTP was implemented in three distinct phases. These three phases include:

- **Screening of Alternatives:** This first phase, "screening of alternatives," was implemented to eliminate from further consideration and evaluation alternatives that were deemed "not selectable" based on one or more screening criteria. This approach enabled more subsequent focus and effort in developing and evaluating those alternatives that were deemed to have greater promise for selection and implementation. Three treatment alternatives, one intake alternative, and the lake management alternative were eliminated from further consideration during screening because they did not meet all of the screening criteria.
- **Evaluation of Alternatives:** This second phase of the evaluation process reflects a more-detailed evaluation of the remaining alternatives. This evaluation phase resulted in identification of the best alternative within categories as well as a best overall alternative based primarily on technical criteria. During this evaluation phase Dissolved Air Flotation (DAF) was determined to be the best treatment alternative and "Secondary Intake via In-Water Pipeline" (Intake Alternative 1) was determined to be the best intake alternative. DAF was determined to be the best overall alternative based on technical performance criteria.

- Triple Bottom Line Plus Evaluation:** This third phase of the evaluation process reflects evaluation based on a “Triple Bottom Line Plus” (TBL+) approach for the best alternatives per category (as determined in the second phase of evaluation). Additionally, the “No Action” alternative was evaluated as a baseline comparison. This approach enabled scrutiny with respect to financial, social, environmental, and technical objectives. The alternatives evaluated using the TBL+ approach included: DAF, Intake Alternative 1, Additional Filters, and No Action.

The results of the TBL+ evaluation are presented in Figure ES-1 at the end of the Executive Summary. The evaluation criteria are presented in Section 7 of the main body of the report. The TBL+ evaluation results, as well as the results of the more-technically-based second phase of the evaluation process, showed DAF to be the superior alternative for mitigating the filter-clogging algae condition at the City’s WTP.

In recognition of the fact that DAF technology is ideally suited to address the filter-clogging algae issue at the Lake Whatcom Water Treatment Plant, DAF was pilot testing during the summer of 2011 to confirm its performance. The pilot testing showed that DAF was very effective at removing algae from the Lake Whatcom supply. Not only was it effective at removing algae, but it was also shown to be effective at removing total organic carbon (TOC), reducing (by up to 25 percent) the formation potential for total trihalomethanes (TTHMs) – a key disinfection byproduct, and most-importantly it was shown to greatly extend filter runs. Extended filter runs results in increased total filter production during algae bloom conditions, which was the primary limitation during the 2009 Lake Whatcom algae bloom.

## ES.4 DAF Implementation

In recognition of DAF’s ranking as the best alternative for filter-clogging algae mitigation at the City’s WTP, a discussion of DAF implementation was developed. Key elements of the implementation discussion relate to project schedule and options for reducing initial capital cost – should the City decide to pursue implementation of a DAF system. An example project schedule that reflects compliance with key Washington State Department of Health requirements and milestones is presented in Figure ES-2 at the end of this Executive Summary. The example schedule conveys the overall timeframe for DAF implementation.

A summary of the initial capital cost (construction and non-construction) for three DAF facility capacities, ranging from 30 mgd to 16 mgd is presented in Table ES-2. A three-train DAF system offers maximum redundancy and capacity to meet significant growth in long-term future customer water demand. The 2-train DAF options are geared toward matching initial capacity with recent trends in peak customer water demand and minimizing initial capital cost. Regardless of the initial capacity and the number of parallel treatment trains, a new DAF facility would be designed to be easily expanded if customer water demand changes.

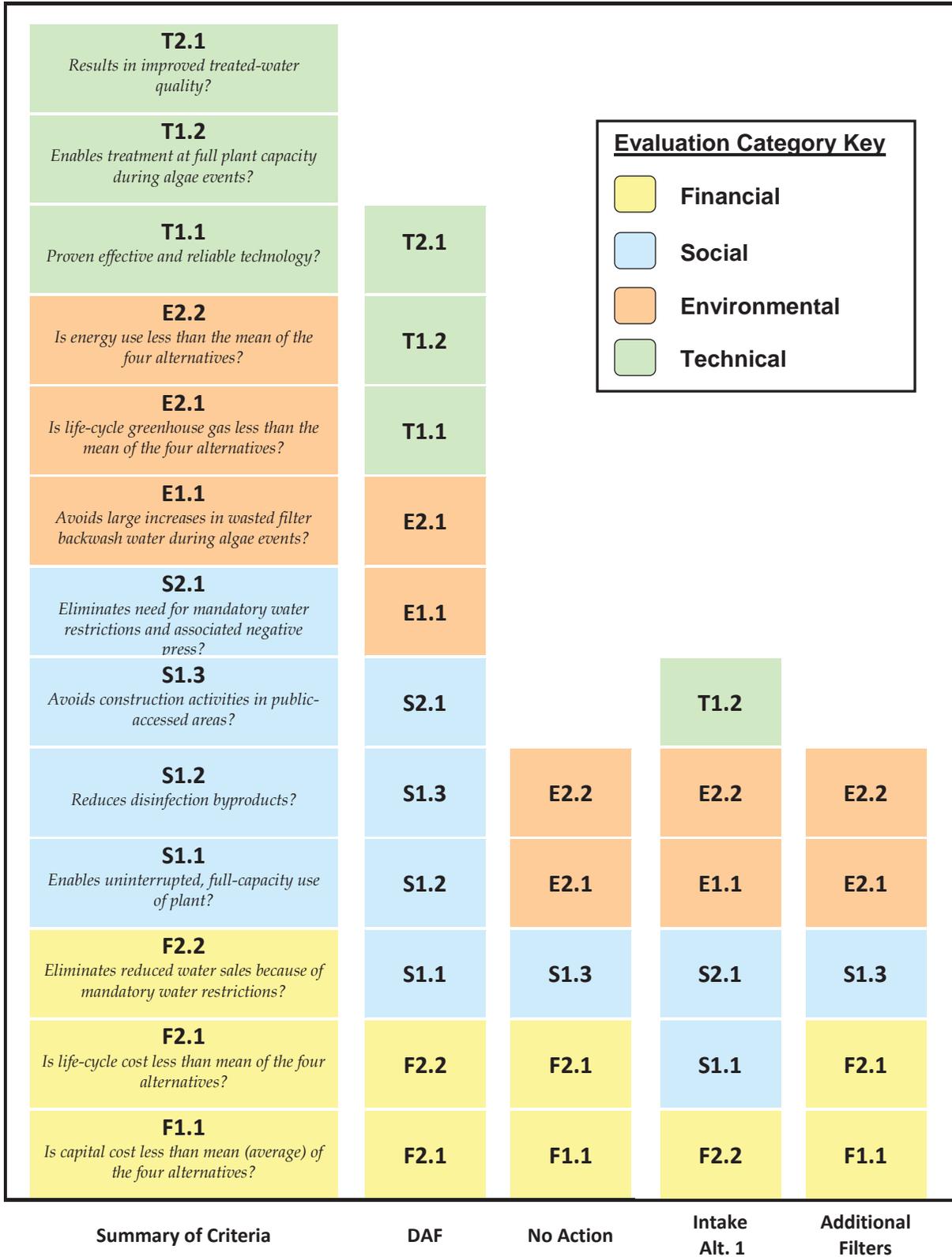
**TABLE ES-2**  
Summary of Initial Capital Cost for DAF Implementation Options

<b>3-Train 30-mgd system</b>	<b>2-Train 20-mgd system</b>	<b>2-Train 16-mgd system</b>
\$ 14,500,000	\$ 11,000,000	\$ 10,400,000

## ES.5 Recommendation

Annual seasonal Lake Whatcom algae blooms present an on-going seasonal risk to the City with respect to meeting the supply needs of its customers. As a result, the City should pursue the design and construction of a new DAF facility in a phased approach based on an initial two-train DAF facility with easy expansion for a potential future third train. The overall timeframe for this first phase of implementation, as well as key milestones, would be similar to that presented in Figure ES-2. A key ancillary benefit of DAF implementation based on the pilot testing completed in the late summer of 2011 is that DAF can be expected to lead to a reduction of the City's TTHMs by 25 percent.

The phased approach will eliminate the potential for constructing more DAF capacity than is necessary to ensure a continuous, reliable, high-quality drinking water supply – even during intense algae blooms in Lake Whatcom. The phased DAF-implementation approach complements the City's on-going commitment to lake management, water quality improvement, and TMDL compliance via the Lake Whatcom Management Program. Over the long-term future, as phosphorous-reducing lake management measures demonstrate success at improving water quality and reducing algae blooms, the need for further expansion of the initial phase of DAF implementation could potentially be avoided entirely.



**FIGURE ES-1**  
TBL+ Evaluation Results

