WASHINGTON STATE DEPARTMENT OF ECOLOGY

April 2016

USE DESIGNATIONS FOR EROSION AND SEDIMENT CONTROL

For

Chitosan-Enhanced Sand Filtration using 3% HaloKlear® LiquiFloc™ chitosan acetate solution

Ecology's Decision:

Based on Ecology's review of HaloSoure Inc.'s (HI) application submissions and the findings by the Chemical Technical Review Committee (CTRC), Ecology is hereby issuing the following use designations for the Chitosan Enhanced Sand Filtration (CESF) technology for adequately controlling small particulate turbidity (clays, silt, etc.) in stormwater discharges at construction sites:

1. **General Use Level Designation for the CESF technology with the discharge of chitosan acetate treated water to retention systems capable of infiltrating all storms to the ground with no discharge to surface water. Base the design of the infiltration system on the criteria in Volume V of Ecology's most recent Stormwater Manual for Western Washington. Strictly adhere to the design and operational criteria for the CESF specified in this document. Keep records showing that you achieved total retention on site.**

2. **General Use Level Designation for the CESF technology with a discharge of chitosan acetate treated water from the sand filters to temporary holding ponds or basins then discharged to surface water (batch treatment). The design and operational criteria specified in this document shall be strictly adhered to.**

3. **General Use Level Designation (GULD) for the CESF technology with the chitosan acetate treated discharges conveyed directly or indirectly to surface water (flow-through system).**

Conditions Applicable to CESF under this designation

1. **Formal written approval from Ecology is required for the use of chemical treatment at each site. Operators must obtain written approval from Ecology.**

2. **This use level designation applies only to HaloKlear® LiquiFloc™ (3% chitosan acetate solution).**

3. **The chitosan dose rate for water entering the filters shall not exceed 1 mg/L HaloKlear® LiquiFloc™ (as chitosan by weight). Operators must record all calibration results simultaneously with the flowrates and keep the results on site.**

4. **Operators shall implement source control procedures to the maximum extent feasible to minimize the need for the use of additional chitosan acetate for the pretreatment of stormwater. You may use additional HaloKlear® LiquiFloc™ (amounts greater than 1 mg/L chitosan by weight) to pretreat water that exceeds 600 NTU. Operators may use a portion of the 1 mg/L HaloKlear® LiquiFloc™ to pretreat water less than or equal to 600 NTU. Pretreatment must occur in a tank or basin dedicated to pretreatment. All pretreated water must enter the sand filters. Pretreated water must have no less than 50 NTU and no more than 600 NTU before final dosing. This will help ensure that free chitosan does not enter the CESF system. In addition, 1 mg/L HaloKlear® LiquiFloc™ (chitosan by weight) is sufficient to treat water in this range. Operators must continuously monitor water exiting the pretreatment tanks for turbidity. You shall locate an automatic integrated turbidity sensor on the output from the pretreatment tanks or basins. This sensor will alert the operator when turbidity values fall outside of the 50 to 600 NTU range. If this occurs, operators can reroute the out of spec water to the untreated stormwater pond, shut the system down, or conduct additional residual chitosan tests. One of these actions must occur each time the alarm goes off. Operators must use jar tests to determine proper pretreatment dosing and proper treatment dosing.**

5. **This approval applies to discharges to streams, lakes and marine waterbodies.**

6. **Conduct jar tests at startup to determine the dosage level of chitosan acetate solution. Conduct additional jar tests when influent turbidity changes by 20% or greater. Record jar test results in the daily operating log. If the results of the jar test indicate that you need to adjust the dose, the jar testing results and the indicated dose rate change shall be documented in the daily operating log.**

7. **Operators shall continuously monitor influent and effluent water quality during CESF operation for pH, turbidity, and flow. For batch treatment systems, Operators must monitor pH, turbidity, and flow during discharge from the batch treatment basins or tanks at the outlet of the tank used to store treated water.**

8. **Operators shall continuously meter and record the discharge flowrate. For batch treatment systems, monitor water discharged from the batch treatment basins or tanks for flowrate.**

9. **Monitor the effluent for residual chitosan or aquatic toxicity. If effluent is monitored for aquatic toxicity, you must use the most sensitive test reported in the intended use plan. If you monitor the effluent for residual chitosan, you must collect and analyze a discrete grab sample of homogeneous sand filter discharge within 30 minutes of the onset of operation and 2 hours after startup to confirm a discharge concentration below 0.2 ppm. Repeat the test is whenever there is a change in dosage, or a significant change in influent turbidity or flowrate (20% or greater). For batch treatment systems, only, monitor water discharged from the batch treatment basins or tanks. For batch treatment systems, collect and analyze an additional grab sample of the potential batch treatment discharge for aquatic toxicity or residual chitosan before any discharge from treatment basins or tanks can occur.**

10. **Maintain discharges from the CESF shall be maintained below 0.2 ppm residual chitosan at all times. Monitor discharges for residual chitosan or aquatic toxicity. In the event that the chitosan residual in the discharge is greater than 0.2 ppm, the discharge exhibits aquatic toxicity, or when the CESF system fails to meet discharge quality requirements, include a contingency plan in every SWPPP that immediately corrects the situation. The operation and maintenance manual must include contingency plan measures and must be available on-site.**

11. **An Operating Period Information Form shall be completed for each operating period (system startup, operation, and shutdown). At a minimum, the form shall include the following:**

    - **A record of each recycle event**
    - **A record of each backwash event**
    - **Actions taken when a recycle event occurs**
    - **Actions taken when excessive backwashing is occurring**
    - **A record of pump calibration**
    - **A record of chitosan use for pretreatment**
    - **A record of chitosan dosage immediately prior to filters**
    - **A record of test results for chitosan residual in the effluent**

Weekly, the supervisor shall examine the forms completed the previous week. The supervisor shall sign each daily form indicating that they reviewed it and document actions taken in response to any abnormal conditions observed by the operator.

12. At all construction sites, at the end of the operating period, a delegated responsible person shall record their assessment of the operational efficiency of the CESF process, any upsets, the sand filter discharge chitosan concentrations, and any other relevant observations that relate to CESF proper operation. They must also certify the acceptability of the CESF discharge to surface water.

13. Discharges from the CESF system shall not cause or contribute to receiving water quality violations and shall comply with the discharge requirements of the State of Washington Construction Stormwater General Permit, AKART, and local government requirements for turbidity and other applicable pollutants. Use this designation document as the basis for Stormwater Pollution Prevention Plans (SWPPPs) for all construction projects where chitosan treatment is planned.

14. Discharges from the CESF system under these designations shall achieve performance goals of a maximum instantaneous discharge of 10 NTU turbidity and a discharge pH within a range of 6.5-8.5. These limits reduce interferences associated with the residual chitosan test.

15. The CESF facility contractor shall guarantee that the CESF system, when used as directed, will not produce treated water that exhibits aquatic toxicity caused by chitosan added as a treatment agent.

16. The CESF system shall only be operated by a trained technician certified through an Ecology-approved training program that includes classroom and field instruction. The CESF operator must remain on-site during CESF operation. The technician must have the following minimum training requirements:

Prerequisites:

- **Current certification as a Certified Erosion and Sediment Control Lead (CESCL), through an Ecology-approved CESCL training course.**
- **Fundamental knowledge of, high-pressure sand filter systems.**
- **Fundamental knowledge of water pumping and piping systems.**
- **Fundamental knowledge of stormwater discharge regulations for applicable region/locale.**
- **Fundamental knowledge of stormwater quality testing procedures and methods for parameters applicable to the region/locale.**

Classroom (8 hours)

- **Stormwater regulatory framework and requirements**
- **Stormwater treatment chemistry (chitosan, pH, coagulation, filtration, etc.)**
- **Stormwater treatability (how to do jar testing)**
- **Treatment system components and their operation**
- **Treatment system operation**
- **Troubleshooting**

In the field (32 hours)

- **Operating the treatment system**
- **Entering data in the system operations log**
- **Testing turbidity and pH**
- **Optimizing chitosan dose rate**
- **Water quality sampling and testing (turbidity and pH)**
- **Residual Chitosan Test**

17. **The SWPPP is to include a field procedure, accepted by the Department of Ecology, for detecting residual chitosan in stormwater discharges sensitive to 0.2 ppm.**

18. **During the planning of the project, the adverse potential impacts on chitosan efficiency of the use of other erosion and sediment control practices must be evaluated.**

Design Criteria for CESF Systems:

Design systems using the relevant portions of the most current versions of BMP C250 and BMP C251 of the Stormwater Management Manual for Western Washington and the Stormwater Management Manual for Eastern Washington. The most recent versions can be found:
http://www.ecy.wa.gov/programs/wq/stormwater/wwstormwatermanual/final_bmp_c250_12_06.pdf

1. **System design must consider downstream conveyance system integrity.**

2. **The facility shall employ a minimum of three (3) sand filter pods to ensure adequate backwashing capacity. The backwash slurry from the sand filters must be discharged to a holding cell that is separate from the temporary storage cell for the incoming turbid stormwater. he overflow from the backwash slurry detention cell can overflow into the detention basin for the incoming turbid stormwater.**

3. **The operating flow rate shall not exceed 15 GPM per square foot of sand bed filtration area.**

4. **Operators can use only filtration media approved in the Sand Filtration Treatment Facilities section (Volume V, Chapter 8) of the most recent Stormwater Management Manual for Western Washington or Stormwater Management Manual for Eastern Washington in the filter pods. Minimum sand bed depth shall be 18 inches, underlain with a minimum of 6 inches of 1-inch crushed rock.**

5. **The CESF system shall include a flow-regulating valve on the input to and output of the sand filter. These regulating valves will reduce the maximum output of the pump as required and facilitate proper backwash.**

6. **Equip the CESF system treated water output with an automatic integrated turbidity and pH sensor capable of shutting the system down if the output turbidity or pH exceeds preset values. Install an audible alarm and warning light on the treatment system to alert the operator in the event of a system failure.**

7. **Completely enclose the CESF control system (including metering pump, chitosan storage, and instrumentation) in a secure structure with locking door. Store the chitosan liquid concentrate in a non-corrosive storage tank. Provide secondary containment for the Chitosan storage tank, metering pump, and tubing. Provide an anti-siphon valve on the metering pump discharge tubing.**

8. **Perform Chitosan injection with an LMI-brand C77 chemical metering pump, or equivalent. Calibrate the metering pump within 15 minutes of the beginning of each operating period. Recalibrate the metering pump when a significant change occurs in either the flow or influent turbidity.**

Applicant: Dober Chemical Corporation
Tony Weisner
Senior Vice President

Applicant Address: 11230 Katherine's Crossing, Suite 101
Woodridge, IL 60517

Application Documents:

- HaloKlear LiquiFloc Maximum Strength 3% Field Study, November 2007, HaloSource, Inc.
- Chitosan-Enhanced Sand Filtration Using HaloKlear® LiquiFloc™ Maximum Strength 3% Operations and Maintenance Manual, February 2008, HaloSource, Inc.
- HaloKlear® LiquiFloc™ Maximum Strength 3% Solution Intended Use Plan, February 2008, WaterTectonics, Inc
- Amtest Residual Chitosan Test, November 2007, AmTest.
- Toxicity Testing of 3% Liqui-Floc, October, 2007, Nautilus Environmental, LLC.
- Toxicity Testing of 3% Liqui-Floc: Rainbow Trout 96-hr Acute Survival, February 2008, Nautilus Environmental, LLC.

Applicant's Use Level Request:

General use level designation for the operation of flow-through chitosan-enhanced sand filtration (CESF) technology for the reduction of turbidity in construction site stormwater.

Applicant's Performance Claims:

For construction site stormwater runoff with a turbidity of less than 600 NTU (influent), a properly engineered and deployed *Chitosan-Enhanced Sand Filtration System* will remove greater than 95% of the turbidity, producing effluent that will consistently meet the State surface water discharge standards.

Chemical Technical Review Committee (CTRC) Recommendation:

The CTRC finds sufficient evidence to recommend to Ecology to grant a CULD for flow-through treatment that can remove turbidity from stormwater at construction sites within acceptable limits for chitosan enhanced sand filtration using HaloKlear® LiquiFloc™ 3% chitosan acetate.

Findings of Fact:

1. Performance data is available from two sites in Vancouver, BC. At one site at a dosing rate of about 1.2 mg/L (chitosan acetate by weight), the CESF reduced turbidity by about 80%. At another site dosing at about 26-50 mg/L (chitosan acetate by weight), the CESF reduced turbidity by about 98%. Residual chitosan tests were negative for both sites.

2. Other studies indicate that influent turbidity levels above 600 NTU demonstrate the potential to cause a slow degradation of the turbidity removal performance by the system resulting in eventual system failure. CESF systems shall be limited to influent turbidity levels of 600 NTU or less**.** Turbidity levels above 600 NTU shall be allowed additional settlement time or be pretreated in another manner not covered in this application for conditional use level designation.

3. Water with a pH range outside the CESF treatment window of 6.5 to 8.5 shall be pretreated to achieve this range. This pretreatment process is not covered in this application for conditional use level designation.

4. In the CESF treatment systems that have been constructed and operated to date no aquatic toxicity has been observed in the treated filtrate.

5. Chitosan acetate does exhibit toxicity to rainbow trout and should therefore be used at a maximum dose rate of 1 mg/L as chitosan acetate as a conservative measure to ensure no possibility of toxicity to rainbow trout in receiving water.

6. CEI provided aquatic toxicity data demonstrating that the discharge residual of the chitosan acetate polymer is expected to be within toxicity levels acceptable to Ecology when used as directed.

Description of the Technology:

Chitosan-enhanced sand filtration (CESF) is a stand-alone construction site water treatment technology, which is comprised of four basic components:

- Stormwater transfer pump
- Chitosan addition
- Pressurized multi-pod sand filtration
- Interconnecting treatment system piping

CESF can be used as a flow-through stormwater treatment technology that utilizes chitosan, a natural biopolymer, in conjunction with pressurized sand filtration to remove turbidity (suspended sediment). Each treatment system is designed and installed to be operated on an as need basis, pumping water from a retention basin whenever the water level of the retention basin is high enough to warrant processing. When stormwater is transferred from the retention basin to the sand filtration unit, chitosan is introduced to stormwater to coagulate suspended solids producing larger particles, which are retained within a sand filter. The filtration systems are equipped with automatic backwash systems, which will backwash the collected sediment from the individual filter pods as necessary to maintain the hydraulic capacity of the filtration media. This feature allows the treatment system to operate on a continuous flow-through basis. A link to a diagram of the system is included here:

Recommended Research and Development

Ecology encourages HaloSource, Inc. to pursue continuous improvements to the CESF system. To that end, the following actions are recommended:

- Further field testing is necessary to determine the optimum dose rate for various influent concentrations.

- Further research should be conducted to create a more reliable residual chitosan test. A test that quantifies chitosan concentrations should be developed.

- Determine how different soil types affect chitosan treatment.

- Determine aquatic threshold for marine species.

Contact Information:

Applicant: Tony Weisner, Senior Vice-President
Office: 630-410-7300
Email: tweisner@dobergroup.com

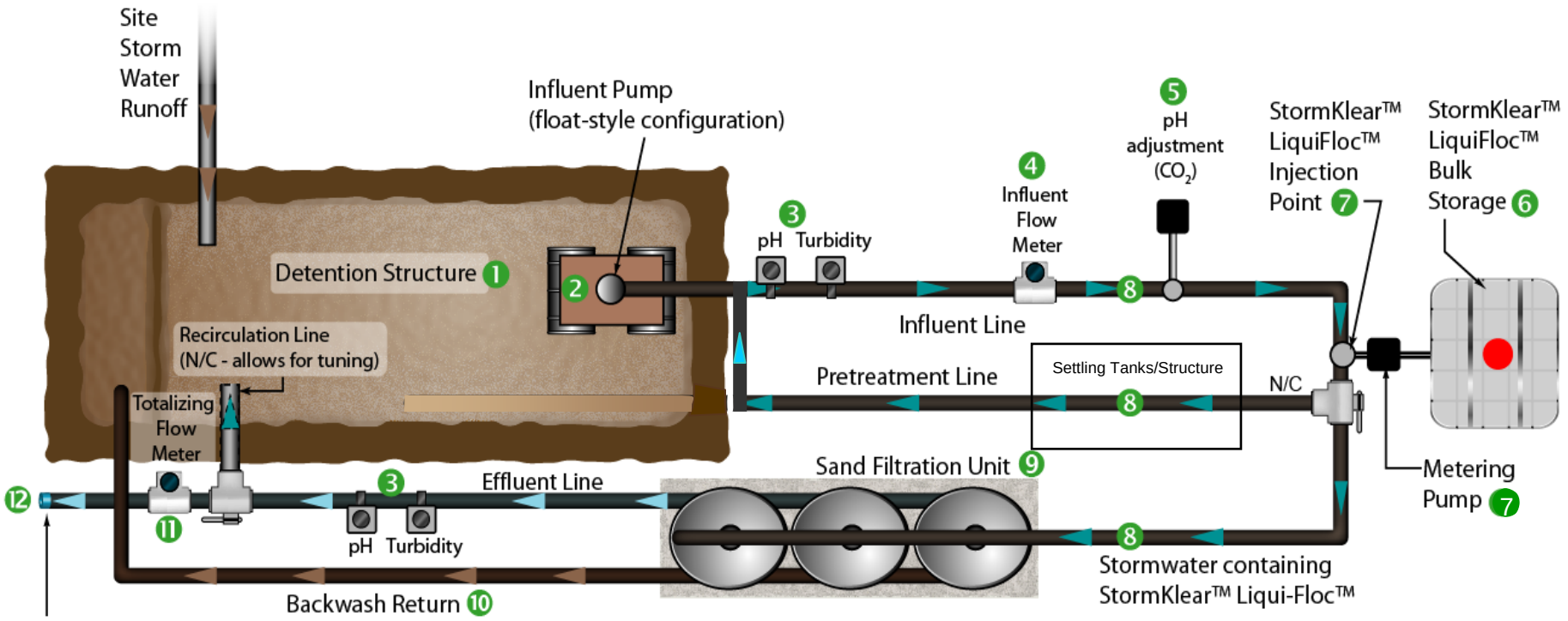
Applicant Website: www.dobergroup.com

Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Date	Revision
April 2008	Initial GULD Determination
August 2010	Revised Expiration, QAPP, and TER dates
March 2015	Revised Contact Information and Expiration, QAPP, and TER dates
December 2015	Revised StormKlear to HaloKlear and changed to GULD for water conveyed directly to surface waters
April 2016	Revised contact information following sale of business by HaloKlear

Schematic Diagram of CESF System



Clarified effluent to outfall (<10 NTU; pH 6.5-8.5)

Note: Pretreatment line shown is conceptual, additional equipment/piping may be required.
If pretreatment dosing is used, water quality after settling will be read at the influent pH and turbidity location.

Rev2.1

Approval of the *HaloKlear® LiquiFloc™ Maximum Strength 3%* Chitosan-enhanced Sand Filtration System Intended Use Plan
DECEMBER 14, 2015

HaloSource, Inc. submitted an Intended Use Plan dated November 9, 2007 (revised February 26, 2008) to describe how a chitosan-enhanced sand filtration (CESF) system using HaloKlear® LiquiFloc™ containing 3% chitosan acetate will be operated to keep the chitosan concentration below its toxic threshold to key species. Stormwater is dosed at a concentration below the toxic threshold. Only turbid stormwater will be dosed and, if properly dosed, chitosan acetate will bind to suspended solids which will then be caught in the sand filter. There is little potential for a discharge of chitosan acetate from a properly operated CESF system.

The following list includes the toxicity tests performed. Results from chronic toxicity testing in April 2015 using topsmelt and a mysid have been added. This approval covers discharges to streams, lakes, and marine waters. *Ceriodaphnia* 7-day survival and reproduction testing was not included because the treatment chemical appeared to react with daphnid food and interfered with the reproduction endpoint.

Toxicity Tests and Results

Liqui-Floc 3% (as mg/L chitosan acetate) Toxicity Test Results

Test	Endpoint	EC_{50} (mg/L)	EC_{25} (mg/L)
daphnid 48-hr acute	survival	38.3	NC
rainbow trout 96-hr acute	survival	2.1	1.7
rainbow trout 7-day survival & growth	survival	4.3	3.4
	weight	> 3.75	> 3.75
fathead minnow 7-day survival & growth	survival	9.2	7.8
	weight	> 7.5	> 7.5
rainbow trout embryo viability	viability	21.4	17.2
fathead minnow embryo-larval survival & teratogenicity	survival	19.0	15.6
	development	19.2	15.8
topsmelt 7-day survival & growth	survival	> 3.75	> 3.75
	weight	> 3.75	> 3.75
mysid 7-day survival & growth	survival	> 3.75	3.75
	weight	> 3.75	3.26

Safety Margin for the Most Sensitive Response (rainbow trout 96-hour survival)

Rainbow Trout Survival Safety Margin in Clear Water

turbidity (NTU)	toxic threshold (EC_{25})	discharge concentration	safety margin
0	1.7 mg/L	0.2 mg/L	1.15 mg/L

The intended discharge concentration is estimated to be a maximum of 0.2 mg/L (chitosan acetate by weight). The toxic threshold from the most sensitive test was over eight times higher than the intended discharge concentration. The maximum dose of chitosan proposed in the intended use plan was 1.05 mg/L which is already below the toxic threshold in clean water. Testing in clean water adds an additional safety factor because chitosan will be removed during treatment by binding to solids which are caught in the sand filter. If properly dosed, nearly all chitosan will be removed by the treatment.

The toxic thresholds are all greater than three times the intended discharge concentrations. Therefore, the safety margins are not considered to be narrow and no flow-through or *in-situ* toxicity testing is needed.

Maintenance of Safety Margin

Chitosan acetate can effectively treat stormwater turbidity up to 600 NTU without using a concentration above 1.05 mg/L. 1.05 mg/L chitosan acetate is below the toxic threshold of 1.7 mg/L in clear water. In addition, chitosan will be removed from solution by binding to solids which will be held in the sand filter. The safety margin will be maintained if the treatment concentration is kept to 1.05 mg/L or below. An anti-siphon valve will prevent HaloKlear® LiquiFloc™ from being siphoned into the system in the event of metering pump failure.

Safety Margin Checklist.

Operational Safety Measures

- This approval applies to discharges to streams, lakes, and marine waters.
- All stormwater treated with HaloKlear® LiquiFloc™ Maximum Strength 3% will be passed through the sand filters, no bypass is allowed.
- The Residual Chitosan Field Screening Test will be performed as specified by Washington State Department of Ecology's Use Level Designation. A positive residual chitosan test greater than 0.2 mg/L will initiate immediate response, all discharge will stop and the system will be thoroughly examined for malfunctions.

Physical Safety Measures

- Secondary containment for the HaloKlear® LiquiFloc™ Maximum Strength 3% tote and metering pump will be sized to contain at minimum the volume of the tote.
- HaloKlear® LiquiFloc™ Maximum Strength 3% will be stored at least 50 feet away from all natural drainages, conveyances and stormdrain inlets or a one foot high earthen berm will be constructed and maintained down-gradient as additional spill control.
- Spill adsorbent materials will be available and put to immediate use to mitigate any spills of HaloKlear® LiquiFloc™ Maximum Strength 3% during transport or tote refill.
- The HaloKlear® LiquiFloc™ Maximum Strength 3% metering pump shall be positive displacement and come equipped with an anti-siphon valve, which shall be inspected and documented at the beginning of each shift.