



Contaminants and Remediation Directorate (CARD)

Indian and Northern Affairs Canada (INAC)
5103 48th St, Waldron Building
PO Box 1500, Yellowknife, NT, X1A 2R3

June 11, 2009

**RE: Johnson Point Site Remediation Water Licence # N7L1-1824 - Provision of Information
Required for Licence Amendment**

NWT Water Board

PO Box 1326
Yellowknife, NT
X1A 2N9

Attention: Sarah McKenzie, Regulatory Coordinator

Dear Sarah McKenzie,

As previously discussed, we are respectfully requesting an amendment to our Johnson Point Site Remediation Water Licence #N7L1-1824 to revise the wastewater treatment to include a de-chlorination process for removal of residual chlorine prior to discharge.

During the 2008 field season, analytical results from the treated wastewater have shown an elevated residual chlorine level slightly exceeding the Water Licence discharge criteria. To meet the Water Licence criteria, our Contractor, E. Grubens Transport (EGT), is proposing to add Sodium Thiosulfate to the treated wastewater held in the lined sump at the end of the treatment process. Following the addition of the Sodium Thiosulfate to the sumps, the wastewater will be aerated to facilitate thorough mixing and complete reaction of the residual chlorine with the Sodium Thiosulfate. Samples of the wastewater will then be submitted for analysis and the wastewater will be discharged to land as previously approved once the discharge criteria are achieved. The attached Revised Wastewater Treatment Plan outlines the proposed change in more detail and provides an MSDS for the product along with two references of established procedures for using this chemical for the de-chlorination of wastewater to be released to the environment.

Should you have any questions regarding the Revised Wastewater Treatment Plan, please feel free to contact myself at your earliest convenience in the office at (867)669-2423, on my cell at (867)446-1838 or by email at joel.gowman@inac.gc.ca Alternatively, you can contact Katherine Silcock at (867)669-2461. I trust that this revised plan will meet your requirements.

Sincerely,

Joel Gowman
Project Officer
CARD

Enclosure (1)

cc: Jan Davies, INAC Water Licence Inspector, via email

E. Gruben's Transport Ltd.

Extended Aeration Grey-Water Treatment System

OBJECTIVE:

To treat all grey-water generated from camp operations to meet the following effluent disposal parameters as outlined in the NWT Water Board type "B" water license # N7L1-1824 for Johnson Point Remediation Project.

- Mineral Oil & Grease – Maximum Concentration 5 mg/L and none visible
- Total Suspended Solids – Maximum Concentration 100 mg/L
- Residual Chlorine – Maximum Concentration 0.1 mg/L

CAMP INFORMATION:

- The camp facility will not generate "Black- Water" as the camp has been outfitted with "Patco Waterless Toilets" and all toilet waste will be incinerated.
- The Kitchen plumbing system will have a grease trap clean-out system.
- The camp will use chlorine free, environmentally friendly cleaning products through the duration of the project.
- The on-site camp can accommodate 34 people; average camp occupancy is expected to be 22-26 people. It is expected that 1500 to 2000 liters of grey-water per day will be generated. The camp will be operational for approximately 45 days in the summer of 2008 and approximately 75 days in the summer of 2009.

PROCESS:

Kitchen water will filter through a grease trap to contain the mineral oil and grease. This unit will have a clean-out thus allowing for trapped grease and oil to be cleaned out and incinerated. Water will be transferred out of the camp into an 18,000 liter lined sump. The lined sump will serve as a batch holding and initial settling area for the "Grey-Water". The Grey-water will remain in the 18,000 liter lined sump for up to 48 to 72 hours and then be transferred into an 18,000 liter aeration tank housed inside the treatment plant. The grey-water will be aerated for approximately 24 to 36 hours. After the aeration process the grey-water will be fed continuously into a 4,000 liter final settling tank, through a UV light and into a 42,485 liter lined sump. The system will consist of two 42,485 liter lined sumps, this will allow for alternate sumps to be used while waiting for analytical results of previous batches. EGT will have sufficient liner material on site to construct an additional two 42,485 liter sumps if required. Should the system not meet discharge criteria, the lined sumps can be covered with additional liner material in such a

manner that will manage precipitation for over winter storage and ensure the sumps do not overflow and allow for the inadvertent release of the contained effluent into the environment.

TESTING:

Testing of grey water will be conducted by "Maxxam Analytics Inc" at 9619 42nd Ave. Edmonton Alberta (780-465-1212). Samples will be sent bi-weekly as volumes dictate. Maxxam Analytics will test for total suspended solids, Mineral Oil and Grease and residual chlorine content as per the Water License.

LOCATION OF TREATMENT SYSTEM & SUMPS:

The treatment system and sumps will be located 100 meters to the southeast of the camp location on potential borrow area 8. Grey-water will be transferred with a pump and hoses from the rear of the camp into an 18,000 liter lined sump.

PROPOSED DISCHARGE LOCATION:

EGT proposes to discharge the treated approved for discharge grey-water on the west side of the access road in a location where dumping was permitted on past programs by the water board.

DETAILS of CHEMICAL ADDITIVE (SODIUM THIOSULFATE):

Grey-water samples from the 2008 field season have consistently indicated slightly elevated residual chlorine levels which exceed the discharge criteria of 0.1 mg/L. As chlorine-containing products have been excluded from camp operation, the resulting chlorine levels are likely a result of low-levels of chlorine compounds in the local source water or from cross-contamination during analysis. The low chlorine demand observed in the treated wastewater is a result of the extensive treatment conducted which includes aeration to address organic loading and ultraviolet treatment of microbial components. The proposed additive, Sodium Thiosulfate, is commonly used by pool and aquarium managers to address elevated residual chlorine levels due to its ability to react with the residual chlorine producing non-toxic products and by-products (as indicated in Section 12: Ecological Information of the attached MSDS). While other de-chlorination products such as Sulphur Dioxide are available, Sodium Thiosulfate can be handled and transported with fewer risks while accomplishing the desired result.

The product will be wastewater and aerated in the lined sumps as outlined in the attached diagram. This revised process will facilitate efficient mixing of the chemical product with the wastewater to allow adequate reaction with the residual chlorine. The lengthy period of aeration in the lined sumps, in combination with the discharge of the treated wastewater to land away from fish-bearing waters, will ensure that any additional oxygen demand from the Sodium Thiosulfate does not adversely affect aquatic habitats in the area. Once the sump contents have been thoroughly mixed, the

wastewater will be re-sampled and analyzed to ensure compliance with Water License criteria prior to discharge. Please see the attached MSDS for Sodium Thiosulfate along with the two additional references which provide details on the correct application of this chemical to supplement the information provided above.

DETAILS of SUMP LINER:

The various sumps associated with the grey-water treatment system will be dug out with a dozer and an excavator to a depth of 30 centimeters. The material from the excavated sump will be used to form retaining berms on the outside of the sump to achieve 60 centimeter walls with the intent of having 30 centimeter liquid depth within the sump. The model EGT will be using is Enviro-Liner 4030, details of liner specifications are below as well a drawing of the berm can be seen following the liner description.

Enviro Liner® 4000 series of geomembranes

The Enviro Liner® 4000 series is a specialized polyethylene lining material that combines flexibility, UV stability, and chemical resistance. The Enviro Liner® 4000 series was originally designed as a flexible cap material for landfills. Its good flexibility allows it to accommodate differential settlement in landfill cap applications. This flexibility also allows it to be prefabricated (welded, folded and rolled) so that many jobs can be lined using a one-piece liner.

The Enviro Liner® 4000 series is manufactured by Layfield. Each step in the production of your liner panel, from the geomembrane production, to fabrication into a custom panel, is governed and directed by EPI's quality control system. The resulting process is professionally designed to ensure your geomembrane meets specified properties, and performs to the highest possible standards in the field.

The Enviro Liner® 4000 series is ideally suited to small, exposed ponds, or for liquid or effluent containment. The Enviro Liner® 4000 series is excellent for use in backfilled water ponds, run-off collection ponds, channels, and other water and waste water containment applications. The Enviro Liner® 4000 series is UV stabilized with the addition of carbon black and is suitable for exposed use in a number of applications.

	Enviro Liner® 4000 Minimum Properties			
Style	ASTM	Enviro Liner® 4020	Enviro Liner® 4030	Enviro Liner® 4040
Thickness (Minimum Average)	D5199	20 mil 0.5 mm	30 mil 0.75 mm	40 mil 1.0 mm

Thickness (Lowest Individual)	D5199	-10%	-10%	-10%
Density (Max)	D792	0.939	0.939	0.939
Tensile Strength at Break	D638 Type IV	76 ppi 13.3 N/mm	114 ppi 20.0 N/mm	152 ppi 26.6 N/mm
Elongation	D638	800%	800%	800%
Tear Resistance	D1004	11 lbs 49 N	16 lbs 71 N	22 lbs 98 N
Puncture Resistance	D4833	32 lbs 142 N	48 lbs 213 N	61 lbs 271 N
Carbon Black Content	D1603	2.0-3.0%	2.0-3.0%	2.0-3.0%
Low Temperature Impact Resistance	D746	-69°F -56°C	-69°F -56°C	-69°F -56°C

Enviro Liner® 4000 Minimum Shop Seam Strengths				
Style	ASTM	Enviro Liner® 4020	Enviro Liner® 4030	Enviro Liner® 4040
Heat Bonded Seam Strength	D6392 25.4 mm (1") Strip	35 ppi 6.1 N/mm	48 ppi 8.4 N/mm	68 ppi 11.9 N/mm
Heat Bonded Peel Adhesion Strength	D6392 25.4 mm (1") Strip	FTB 28 ppi 4.9 N/mm	FTB 43 ppi 7.4 N/mm	FTB 58 ppi 10.2 N/mm

Enviro Liner® 4000 Minimum Field Seam Strengths				
Style	ASTM	Enviro Liner® 4020	Enviro Liner® 4030	Enviro Liner® 4040
Heat Bonded Seam Strength	D6392 25.4 mm (1") Strip	28 ppi 4.9 N/mm	43 ppi 7.5 N/mm	58 ppi 10.2 N/mm
Heat Bonded Peel Adhesion Strength	D6392 25.4 mm (1")	FTB 24 ppi 4.2 N/mm	FTB 38 ppi 6.7 N/mm	FTB 51 ppi 8.9 N/mm

Each and every liner panel we produce is a custom panel. The way we set up our shop is unique in that our shop welders produce prefabricated panels to best match your containment area. We size each panel to fit, without waste, in a logical sequence in your containment area. In containments with irregular shapes we size our panels to best accommodate the irregular size.

There are no theoretical limits to the size of the liner panels that we can prefabricate but there are some practical limits, notably panel weight. Panel weight is important because of the limits of handling equipment that will be available in the field. EnviroLiner is normally limited to a maximum panel weight of 2,500 lbs (1,200 kg); however, if a skilled installation crew is available then a panel of up to 4,000 lbs (1,800 kg) is possible.

Panels are accordion folded in one direction and then rolled in the other direction. Unfolding instructions and dimensions are marked on the individual liner panel. Each panel is wrapped in an opaque, weather resistant covering suitable for shipment and storage.

All shop fabricated seams are 100% visually inspected by the welding operator. Every panel is tested for Film Tear Bond and destructively tested in peel and shear. Quality control reports are available with each panel produced.

DETAILS OF UV TREATMENT SYSTEM

The System will incorporate a "Hallett 30" UV Wastewater Treatment System from UV Pure Technologies details of system as follows:

Hallett³⁰

Community & Commercial Ultraviolet Water Purification Systems

Hallett™ UV systems are the world's only NSF/ANSI 55 Class A Certified UV water purification systems with patented Crossfire Technology.™ UV Pure's Hallett™ 30 for community and commercial applications, outperforms conventional systems for disinfection of all pathogens including viruses, bacteria, cryptosporidium, giardia, legionella and E. coli.



CROSSFIRE TECHNOLOGY IS THE MOST EFFECTIVE UV TREATMENT

- NSF/ANSI 55 CLASS A CERTIFIED to 30 US gpm, 113 L/min, 6.7 m³/hr
- Highest UV Dose – proprietary high-output long-life lamps
- UV dose rate at max flow is 40 mJ/cm² at end of lamp life
- Elliptical reflectors target and deactivate pathogens from 360°
- Lamps air-cooled – operate at most effective UV output at all times

CROSSFIRE TECHNOLOGY IS ENGINEERED TO BE RISK FREE AND FAIL-SAFE

- Dual smart UV sensors monitor both UV output and water quality
- Built-in microprocessor monitoring with both visual & audible alarm notification
- Automatic shut-off fail-safe solenoid valve – if the water is running, the water is safe

CROSSFIRE TECHNOLOGY IS SELF-CLEANING

- Automatic mechanical quartz cleaning system – quartz does not foul
- No quartz cleaning or system drainage required, so no risk of quartz breakage
- Water softening is not required, saving money and the environment

CROSSFIRE TECHNOLOGY IS VIRTUALLY MAINTENANCE FREE

- Lamps mounted in air – easy to replace, no system draining required

CROSSFIRE TECHNOLOGY IS SIMPLE TO INSTALL

- Flexible stainless FIP connections for quick and simple installation
- Compact size

Find out everything: www.puresafe.com

Pure, safe water.




Always.

ULTRAVIOLET WATER PURIFICATION SYSTEMS



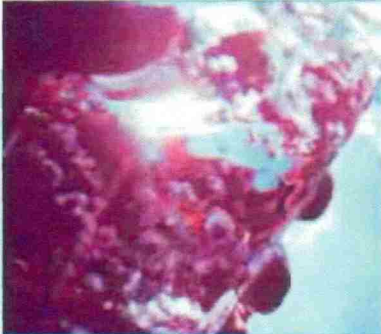
Hallett systems with patented Crossfire Technology provide microbiological purification of drinking water. With a Hallett system properly installed, fail-safe engineering ensures that no potentially dangerous microorganisms can enter a drinking water distribution system. UV Pure recommends the use of other filtration systems to treat chemical and other non-microbiological contaminants. To find out everything visit www.puresafe.com

Hallett™ 30 with Crossfire Technology™ Specifications

Certification	 NSF/ANSI 55 Class A Certified
Flow Capacity	30 US gpm, 113 L/min, 6.7 m³/hr
Multiple System Flow Capacity	Run in parallel - up to 600 US gpm
UV Dose	40 mJ/cm² at end of lamp life
Built-in microprocessor	Dual smart sensors monitor UV output and water quality
Alarms	Visual & audible notification of: 1. System is working & water is safe 2. Lamp output alarm 3) Water quality alarm
Monitoring	Continuous UV transmittance feedback
Solenoid Valve	Auto shut-off fail-safe valve so only safe water can enter your water distribution system
Self-Cleaning	Stainless steel wiper prevents quartz fouling
Maintenance	Automatic alarm reminder - 2 lamps - replacement required every 12 months, a simple 2 minute process
Redundancy	Additional back-up systems can be installed cost effectively
Inlet & Outlet Connections	Flexible FIP Connections - 1" inlet and 1" outlet
Pre-filtration	5 micron sediment filter recommended and/or carbon filter for taste and odour
Maximum Pressure	100 PSI, 690 kPa (tested to 240 PSI)
Pressure Drop	20 PSI @ 22 gpm (138 kPa @ 83L/min)
Voltage	120/220 VAC - 140W
Electronic ballast	Auto power regulated, protected from power fluctuations
Dry Contacts	Available for remote monitoring or auto dialers
Electrical	Entela (UL & CSA equivalent)
Dimensions	32" H x 8" W x 9" D (81cm H x 20 cm W x 23 cm D)
Warranty	3 years on all electrical components, 5 years on housing

Hallett™ System Pre-treatment Conditions

WITH CROSSFIRE TECHNOLOGY™ - NO WATER SOFTENER REQUIRED

	Water Conditions	Effective Treatment Range	
		MIN	MAX
	Hardness	0	50 Grain (855 mg/L)
	Iron	0	3 mg/L (ppm)
	Manganese	0	0.5 mg/L
	% UV Transmittance	75%	100%
	pH	6.00	9.00
	Total Dissolved Solids (TDS)	0	1000 mg/L
	Water Temperature	1° C (34° F)	38° C (100° F)
	Air Temperature	7° C (45° F)	38° C (100° F)
	Turbidity	0 NTU	1 NTU
	Water Pressure	10 PSI (69 kPa)	100 PSI (690 kPa)

Microbiological Drinking Water Purification Scorecard

THE HALLETT™ SYSTEM WITH CROSSFIRE TECHNOLOGY™ SCORES 10/10

	HALLETT SYSTEM	CONVENTIONAL UV	OZONE	REVERSE OSMOSIS	CHLORINATOR	SAND FILTER
Real-time indicator of water quality	✓	-	-	-	-	-
NSF certified	✓	selected units	-	-	-	-
Works in high TDS	✓	-	✓	✓	✓	✓
No softener required	✓	-	✓	✓	✓	✓
Self-cleaning/low maintenance	✓	-	-	-	-	✓
Not hazardous to your health	✓	✓	-	✓	-	✓
Economical	✓	✓	-	-	-	-
Effective removal of all pathogens	✓	✓	-	-	-	-
Fail-safe shut-off	✓	selected units	-	-	-	-
Doesn't put contaminants back in the environment	✓	✓	✓	-	-	-
SCORE	10/10	5/10	3/10	3/10	2/10	4/10



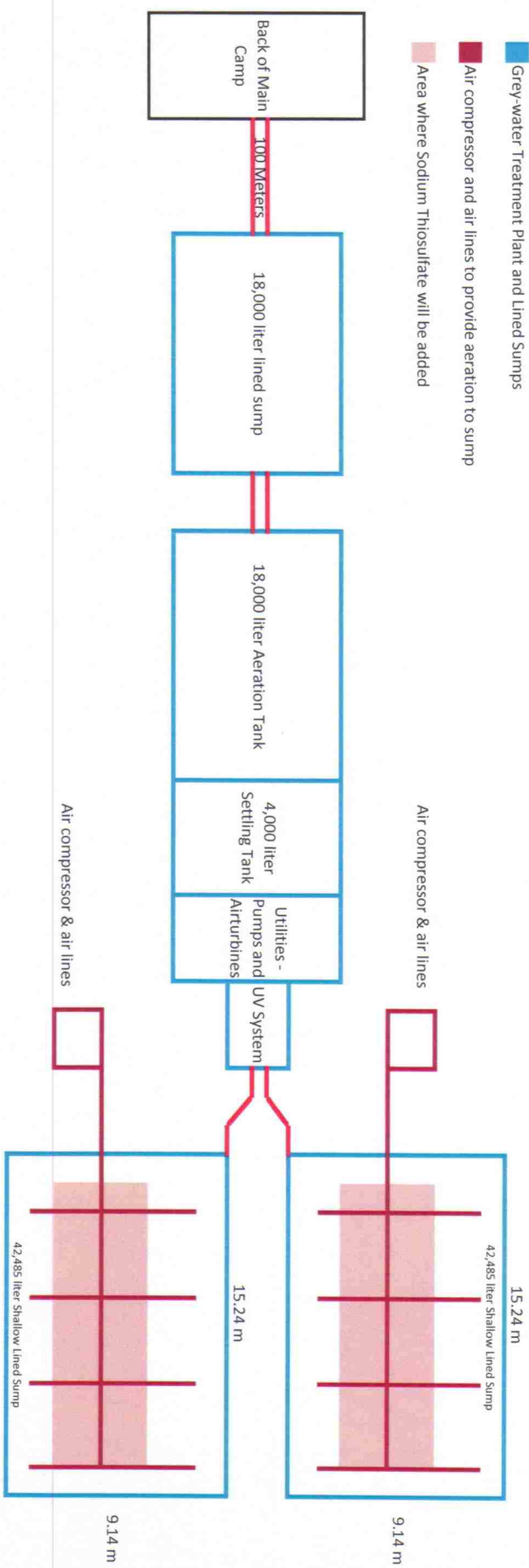
UV PURE TECHNOLOGIES INC.

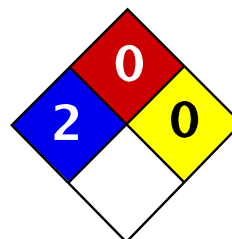
T 416.208.9884 F 1.888.407.9997 F 416.208.5808 E safe@uvpure.com 60 Venture Drive, Unit 19, Toronto, Canada M1B 3S4

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Lined Sumps and Treatment Plant Layout for Grey Water Settling, Treatment and Storage

- Fluid Transfer Lines
- Grey-water Treatment Plant and Lined Sumps
- Air compressor and air lines to provide aeration to sump
- Area where Sodium Thiosulfate will be added





Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet

Sodium thiosulfate pentahydrate MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium thiosulfate pentahydrate

Catalog Codes: SLS2341, SLS2962

CAS#: 10102-17-7

RTECS: WE6660000

TSCA: TSCA 8(b) inventory: No products were found.

CI#: Not available.

Synonym: Ametox, Antichlor; Sodium Hyposulfite, pentahydrate

Chemical Name: Thiosulfuric Acid, disodium salt, pentahydrate

Chemical Formula: Na₂S₂O₃.5H₂O

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium thiosulfate pentahydrate	10102-17-7	100

Toxicological Data on Ingredients: Sodium thiosulfate pentahydrate LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:

Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant).

Potential Chronic Health Effects:

Slightly hazardous in case of skin contact (irritant, sensitizer).

CARCINOGENIC EFFECTS: Not available.

MUTAGENIC EFFECTS: Not available.

TERATOGENIC EFFECTS: Not available.

DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention if irritation occurs.

Skin Contact:

Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:

Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:

Risks of explosion of the product in presence of mechanical impact: Not available.

Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: When heated to decomposition it emits toxic fumes of sulfur oxides, hydrogen sulfide, and sodium oxide

Special Remarks on Explosion Hazards: An explosion may occur if triturated with nitrates, chlorates, or permanganates.

Section 6: Accidental Release Measures

Small Spill:

Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:

Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:

Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Keep away from incompatibles such as oxidizing agents, acids, alkalis.

Storage: Hygroscopic. Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Odorless.

Taste: Saline.

Molecular Weight: 248.19 g/mole

Color: Colorless. White.

pH (1% soln/water): pH of a 5% solution: 6.0-8.4

Boiling Point: >100°C (212°F)

Melting Point: 48°C (118.4°F)

Critical Temperature: Not available.

Specific Gravity: 1.7 - 1.75(Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:

Soluble in cold water, hot water.

Solubility in water:

79 g/100 ml @ 4 deg. C (39 deg. F)

680 g/liter @ 20 deg. C

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, moisture

Incompatibility with various substances: Reactive with oxidizing agents, acids, alkalis.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:

It is a strong reducing and can react with oxidizers.

Reacts with acids to release sulfur dioxide.

Sodium Thiosulfate pentahydrate dissolves in its own water of hydration; it effloresces in warm dry air.

Sodium Thiosulfate pentahydrate loses water at 100 deg. C.

It is incompatible with iodine, acids, lead, mercury, and silver salts (e.g. silver nitrate), halogens.

Hygroscopic; keep container tightly closed. Protect from moisture

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:

LD50: Not available.

LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:

Hazardous in case of ingestion, of inhalation.

Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:

Acute Potential Health Effects:

Skin: It may cause mild skin irritation.

Eyes: Can cause mechanical eye irritation.

Inhalation: May cause upper respiratory tract and mucous membrane irritation.

Ingestion: Sodium Thiosulfate is an agent with a low order of toxicity. Ingestion of large doses may cause gastrointestinal irritation disturbances with nausea, vomiting, abdominal cramping, diarrhea, metabolic acidosis, and hypernatremia. May also affect respiration (cyanosis, respiratory stimulation), cardiovascular (hypotension), behavior (ataxia, convulsions)

Chronic Potential Health Effects:
Skin: Prolonged or repeated skin contact may allergic dermatitis, and irritation.
The toxicological preperities of this substance have not been fully investigated.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:

Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: No products were found.

Other Regulations: Not available.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):

This product is not classified according to the EU regulations.

S24/25- Avoid contact with skin and eyes.

S28- After contact with skin, wash immediately with plenty of water.

S37- Wear suitable gloves.

S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves.

Lab coat.

Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate.

Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/11/2005 12:38 PM

Last Updated: 11/06/2008 12:00 PM

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

Dechlorination Procedure using Sodium Thiosulfate

STEPS

COMMENTS

Scope and Application

This method is based on *Standard Methods 18th Edition*, 1992, Method 4500-Cl. It can be used to remove chlorine from bioassay, algal assay, microbiology and any other aqueous samples that need to be dechlorinated.

Summary of Method

Residual chlorine is measured. Based on the concentration of residual chlorine, the volume of sodium thiosulfate needed to dechlorinate the sample is calculated. The sodium thiosulfate is added to the sample. The residual chlorine is measured in the "dechlorinated" sample. Additional manipulations are performed if the chlorine residual is > 0.1 mg/L.

Materials

1. Thermometer, 0-30 °C range
2. Chlorinated sample
3. Sodium thiosulfate (Na₂S₂O₃·5H₂O), 0.025 N, ACS grade
4. Magnetic stir-bar, 2.5cm
5. Magnetic stirrer
6. Magnetic stir-bar retriever
7. Disposable pipets, 1 mL and 2 mL
8. Hach pocket colorimeter[®] or DR-100 chlorine test kit
9. Erlenmeyer flask, 4 L, one each
10. Graduated cylinder, 2 L, one each
11. Laboratory calculator

Calibrated per SOP TA-06.13 (Certified electronic thermometer can be used)
The total residual chlorine (TRC) of the sample should have already been measured. The sample should have been warmed for the TRC measurement.
This lab uses Fisher brand.

The DR-100 kit is used if the "pocket colorimeter" is out of service.

Documentation and Corrective Action

1. To correct raw data entries, place a single line through the incorrect entry, write the corrected entry near the error and initial the correction.
2. If a problem occurs during sample processing, a nonconformance report (NCR) is submitted describing the problem and the corrective action.
3. Use a black waterproof pen for all logbook and benchsheet entries.
4. Permanent black marker
5. Labeling tape
6. FDEP Laboratory Information Management System (LIMS)
7. *Total Residual Chlorine logbook*

If the correction requires an explanation, write a comment and reference the error.

Use sequential alphabetical annotation to identify errors and corresponding comments (use A for first error and use A for corresponding explanatory comment; use B for second error, etc.). The corrected entry is written as near its appropriate space as possible or else in the comment box on the appropriate bench sheet. An explanation of the error is written, initialed and dated.

See Biology Quality Manual, sec. 13.0

To create NCR, open LIMS and go to **Laboratory/Administrative/Non-Conformance Report**.

For labels

STEPS

8. *Bioassay Benchsheets*

Safety

1. Lab hood or chemical ventilation system
2. Lab coat
3. Latex gloves
4. Safety glasses

Pollution Prevention and Waste Management

Methods

1. Warm the chlorinated sample to 20.0 – 25.0 °C. (If not previously warmed.)
2. Use the Hach chlorine test kit to determine the total residual chlorine in the sample (if not previously done). Record the result on the sample bench sheet (usually the bioassay benchsheet) and also in the *Total Residual Chlorine Logbook*.
3. Use the following formula to determine the amount of sodium thiosulfate to add to the sample. $X = [(A) \times (\text{total volume}) / 886.25]$ where X is the volume (mL) of 0.025N sodium thiosulfate to add to the total volume (mL) of sample to be dechlorinated. A is the TRC (total residual Chlorine) in the sample.
4. Use the graduated cylinder to add the desired volume of sample to the 4-L flask.
5. Put the stir bar in the 4-L flask and place both on the magnetic stirrer
6. Turn the magnetic stirrer on and adjust to medium speed.
7. Use the 2-mL disposable pipet to add the calculated volume of 0.025 N $\text{Na}_2\text{S}_2\text{O}_4$ to the flask. Keep track of the volume added to the flask as the total volume of sodium thiosulfate added to the sample (expressed as mL of sodium thiosulfate per L of sample) will have to be recorded on the *Bioassay Benchsheets*.
8. Use the Hach chlorine test kit to determine the total residual chlorine in the dechlorinated sample. Record the result on the *Bioassay Benchsheets* and in the *Total Residual Chlorine Logbook*.

COMMENTS

See <http://depnet/burlabs/safety.htm> (Intranet)

Proper laboratory protection is required when working with chemicals and unprocessed samples.

Vinyl gloves can be substituted for individuals allergic to latex.

See <http://depnet/burlabs/safety.htm> (Intranet)

The total residual chlorine and the temperature of the sample should have already been determined. If necessary perform Steps 1 and 2, else go to Step 3. Measure temperature per SOP TA-06.05. The sample is warmed by placing the sample container into a basin of warm water.

Measure total residual chlorine per SOP TA-06.22. (SOP for the Hach Pocket Colorimeter.)

$$X = [(A) \times (\text{total volume}) / 886.25]$$

X = mL of 0.025N sodium thiosulfate to add to sample

A = TRC of sample in mg/L

Total volume = volume of sample to be dechlorinated in milliliters

An example: TRC = 0.5 mg/L, 2500 ml of sample to be dechlorinated would require 1.4 mL of 0.025N sodium thiosulfate. This is 0.56 mL per L of sample.

Set the speed fast enough to the stir the sample without aerating it.

To determine the mL of sodium thiosulfate per liter of sample, divide the total mL of sodium thiosulfate by the volume (in liters) of sample.

TA-09.18-1.9

STEPS

9. If the TRC of the dechlorinated sample is less than 0.1 mg/L (ideally <0.03 mg/L) the sample is ready to be used (go to Step 10). If the TRC is > 0.1 mg/L check the original calculation and then (if calculation is correct) repeat Step 3, Step 7 and Step 8. DO NOT ADD more than three times the original calculated volume (if correct) of sodium thiosulfate to the sample.
10. Record the total volume (expressed as mL/L) of sodium thiosulfate used to dechlorinate the sample on the bench sheet. Record the final TRC of the dechlorinated sample on the *Bioassay Benchsheets*.
11. Place the used pipet in the disposable glass container. Place dirty glassware on the "to be washed" cart.

Appendix of Changes

12/21/07 Added *Scope and Application; Summary of Method and Appendix of Changes*. Moved reference from title to *Scope and Application*.

COMMENTS

The necessity of adding more than the original calculated volume of sodium thiosulfate to the sample is usually the result of interfering substances in the sample.

FINAL REPORT
Chlorine Monitoring and Dechlorination Techniques Handbook

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November, 1997

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INTRODUCTION

This handbook is published in combination with a series of Guidelines, which provide management measures for releases of chlorinated municipal water. Guidelines are available for the following categories of water use:

- Agricultural Water Use
- Construction Water Use
- Domestic Water Use
- Municipal Water Use
- Industrial/Commercial Water Use

Based on public input, in June, 1994, the GVRD Board selected the use of chlorine solution for secondary disinfection of drinking water. Ozone cannot be used because it breaks down too quickly. The public said they preferred the use of chlorine over chloramine because it presents a lower risk to the environment - even though chlorine will cost more and may add a chlorine taste and odour to the water.

In choosing chlorine over chloramine, the GVRD has already provided its water users with a first step in mitigating the impacts of potable water discharges by selecting a secondary disinfectant with a lower potential impact.

1.1 Background

Chlorine is a strong oxidizing agent and is the oldest method of continuous disinfection for public water supplies in North America. In the GVRD, chlorine is used as the primary disinfectant for water supplied to the 18 member municipalities.

Chlorine, being a very reactive element, will oxidize organic and inorganic matter present in the water supply and in the pipe distribution systems. The chlorine will, therefore, decrease in concentration with distance from the source to the point where the chlorine level can become ineffective as a disinfectant. Bacteria growth will occur in distribution systems when very low levels of chlorine are encountered. Bacterial growth is particularly evident at the extremities of the pipe distribution systems in the greater Vancouver region. Source control of bacteria regrowth can be augmented by the use of Best Management Practices such as flushing/pigging the distribution mains on a routine basis.

In order to address the problem of bacteria growth, the GVRD plans to boost chlorine levels in the municipal water distribution system using a series of secondary disinfection stations. These stations will be located throughout the greater Vancouver region.

Since the municipal water system is used for more than supplying water for human consumption, for instance cooling water, the potential exists for this water to be discharged directly to the environment. If chlorinated water reaches an aquatic system, it has the potential to kill fish and other aquatic organisms because of the chlorine concentration. One mode of action is likely through damaging the gills, thus preventing the fish from breathing.

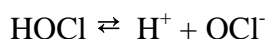
Therefore, in many instances, it will be necessary to dechlorinate the water in order to make it safe for discharge to the environment. This handbook provides guidance and recommended dechlorination techniques as well as methods for monitoring chlorine levels in municipal water.

1.2 Chemical Reactions

Chlorine gas hydrolyzes in water almost completely to form hypochlorous acid, under the following reaction:



The hydrogen ions released in the reaction cause a reduction in pH. The pH is important in determining to what extent the hypochlorous acid (HOCl) can dissociate to produce hypochlorite (OCl⁻) ions:



The hypochlorous acid form of chlorine is the prime disinfecting agent. The term “free available chlorine” or “free chlorine” refers to both the HOCl and OCl⁻ portions present in the water. The ratio between HOCl and OCl⁻ is primarily a function of pH. For example, 96 percent of the free available chlorine is present as HOCl at pH 6, 75 percent at pH 7 and only 3 percent at pH 9.

If chlorine is added to water which contains ammonia, the ammonia will combine with the chlorine to form chloramines. The portion of chlorine that is present as chloramines as well as chlorine combined with other specific nitrogenous compounds¹ is referred to as “combined available chlorine”. “Total residual chlorine” (or “residual chlorine” as used in this handbook) is the sum of the “free available chlorine” plus the “combined available chlorine”. This includes all the forms of chlorine which are able to act as an oxidant and are hazardous to aquatic life.

¹ for example, N-chloramides

Generally, only “free residual chlorine” should be present in a municipal water supply, while both “free residual chlorine” and “total residual chlorine” can be present in a receiving environment. Both these forms of chlorine will need to be measured in the field.

1.3 Dechlorinating Agents

To neutralize an oxidant, such as hypochlorous acid, a neutralizing or dechlorinating chemical can be used. Four types of dechlorinating agents have been used:

- sulfur dioxide (SO_2)
- sodium bisulfite (NaHSO_3)
- sodium sulfite (Na_2SO_3)
- sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$)

Sulfur dioxide is a gas, and as such is not routinely used, or recommended because of its hazardous nature, for field dechlorination purposes. Sodium bisulfite, sodium sulfite, and sodium thiosulfate have been used in field application and are typically purchased in powdered or solid forms. Sodium sulfite is available in “pucks” which are typically 140 gram solid puck shaped pieces.

Sodium thiosulfate is the most frequently used dechlorinating agent in the greater Vancouver region. This is due to the fact that sodium sulfite can cause an oxygen depleting environment. The toxic threshold of sodium sulfite as listed in the MSDS (Material Safety Data Sheet) is 2,600 mg/L as opposed to 24,000 mg/L for sodium thiosulphate. Sodium thiosulphate is available in both anhydrous ($\text{Na}_2\text{S}_2\text{O}_3$) and pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) forms. The difference between the two forms is that anhydrous sodium thiosulphate will dissolve much slower, and last a longer time when added to water, such as a creek. On the other hand, the pentahydrate form is already hydrated, and therefore will dissolve much faster than the anhydrous form. It is cheaper to use the less soluble anhydrous form.

It takes about 1.5 parts of sodium thiosulfate pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) to neutralize 1 part of chlorine residual. For example, if the residual chlorine in tap water was measured at 1 mg/L, it would take 1.5 lbs of sodium thiosulfate pentahydrate to dechlorinate 100,000 Imp. gallons (455,000 L). A more detailed explanation of how to prepare a neutralizing compound is shown in Section 3.2.6.

1.4 Other Considerations

Oxygen Depletion

Dechlorinating agents containing sulphite, such as sodium sulfite and sodium bisulfite, exert an oxygen demand on the water it is being applied to. If excess chemical is used and it enters

a creek or lake, an environmental impact can result because of a reduction in the oxygen content of the water. Care must be taken to ensure that oxygen levels are not significantly altered with the addition of such chemicals. The best way to ensure that oxygen is not depleted is to use sodium thiosulphate as the dechlorinating agent rather than sodium sulphite or sodium bisulfite.

pH Levels

Although not specifically related to dechlorination it should be noted that chlorine solutions (eg. sodium hypochlorite) used to super chlorinate water mains have a very high pH level to ensure that chlorine gas does not form in the solution. Adding sodium hypochlorite to water having a low buffering capacity, such as is the case with the GVRD water supply, could cause elevated pH levels. In addition to dechlorinating this disinfection water prior to discharge, the pH level should be determined prior to discharge of this water and, if necessary, measures taken to adjust the pH to appropriate levels. The optimum pH range is 6.5 to 9.0 as per the *BC Environment Approved and Working Water Quality Criteria* (1996). If the pH requires adjusting, it can be adjusted using a tank of carbon dioxide bubbled into the water to reduce a high (basic) pH or by adding sodium bicarbonate to a low (acidic) pH.

1.5 When to Dechlorinate

In order to assess whether dechlorination is necessary during or after a water release, the following conditions should be considered:

- (1) the volume of chlorinated water being discharged;
- (2) the concentration of total residual chlorine in the water;
- (3) the proximity of the point of discharge to a natural aquatic system; and
- (4) the volume or flow of the receiving environment available to dilute the release.

For instance, using a garden hose to wash down a truck would not generate sufficient water to warrant dechlorination. However, creeks should be protected from detergent or silt releases. Similarly, if there are no natural aquatic systems within several kilometres of the point of discharge, and the volume of water released is low, then the need for dechlorination techniques would be diminished. In other cases, though, dechlorination would be mandatory. For example, flushing an 8" water main can generate 780 gallons of water per minute and higher. This flow exceeds the flow of many small creeks and could cause significant impact if water is discharged directly to a creek without removal of chlorine residuals.

Dechlorination is required when the combination of the volume of municipal water being released, the concentration of total residual chlorine, and the proximity of the site to a natural aquatic system indicates a potential risk to the environment. The type of water releases that

require dechlorination can be found in the Guidelines for mitigating the releases of municipal water from specific types of activities. If there is any doubt as to the need to dechlorinate it would be more prudent to dechlorinate.

If there is any question about the potential to impact the environment, the chlorine levels should be monitored at the point of discharge, and in the receiving environment.

CHLORINE MONITORING

2.1 Background

Monitoring for “free residual chlorine” and “total residual chlorine” (ie. free available plus combined available chlorine) is a requirement during most dechlorination efforts. The concentration of residual chlorine in the discharge water will determine if dechlorination techniques are required, and the dosing rate of the dechlorinating agent. The following sections outline the procedures for monitoring the residual chlorine levels in municipal water.

2.2 Chemical Analysis

Chlorine concentrations can be measured either in the field using simple field kits or in the laboratory using more sophisticated procedures and equipment. Most field kits work from a similar principal where a chemical (ie. an indicator) is added to a water sample and the colour of the solution is compared to a set of coloured standards. The colours in the standards have been calibrated in a laboratory to match set concentrations of chlorine. For instance, if a water sample is placed in a glass vial containing an indicator, and the solution turns dark red, this indicates a higher concentration than if the solution turns faint pink.

The limitation to field kits is their detection limits. The detection limit is typically 0.1 ppm, which is well above environmentally safe levels. The free chlorine concentrations which have killed fish vary from 0.03 mg/L to 0.05 mg/L depending on exposure time and fish species. However, even though it cannot be quantified, these kits can identify trace concentrations of chlorine if a faint colour is present. Dechlorination should be undertaken with any sign of colour. Laboratory methods, on the other hand, have lower detection limits, but are generally not applicable because the chlorine dissipates more quickly and will be lost during transport (unless it's in the combined chlorine form).

Examples of the types of field kits available and laboratory procedures are given in the following sections. The field kits can be purchased from local scientific equipment suppliers. The suppliers will provide current pricing and availability of product. The larger suppliers have websites on the Internet where information on the field kits can be obtained (see Appendix A for names, addresses, and website addresses).

2.2.1 Orthotolidine Indicator

One sampling kit uses a liquid “indicator” called orthotolidine. The kit includes sampling vials of preset volumes. The sampler places the water to be tested into the sampling vial and

then pipettes the indicator into the vial. Usually a set number of “drops” of the indicator are required. The water in the vial will turn colour following addition of the indicator. By comparing the colour of the water in the vial to that on a sheet of paper supplied with the kit, or to a colour disk, the concentration of chlorine is measured. The colours correspond to concentrations of chlorine in parts per million (ppm or mg/L).

This type of kit usually detects 0.1 to 1.0 ppm chlorine with an accuracy of 0.1 ppm. Cost² of the kit is around \$130 but varies between suppliers. This kit has not been used recently by the GVWD staff because of the concern with the chemicals used in the kit. This method is not recommended since it gives poor accuracy and precision and a high overall error in comparison with the other chlorine method³.

2.2.2 DPD Indicator

One kit uses N,N-Diethyl-p-Phenylenediamine (DPD) as the indicator solution. This method determines chlorine content according to the N,N-Diethyl-p-Phenylenediamine (DPD) method 409F described in the 17th edition of *Standard Methods for Examination of Water and Wastewater*.

The water is collected in a sample tube and the indicator is added to this tube. It uses tablets or powder to dye water samples to a degree proportional to the chlorine content in the sample. When the water in the tube changes colour, the colour is compared to 9 or 10 colours present in similar smaller tubes located on a colour disk. The colour disk is rotated until the colour closely matches that inside the test tube. The disk colour relates to a concentration. The method can differentiate between “combined chlorine” and “free available” forms by using different types of indicator. Fresh indicator should always be used as old DPD can give false readings.

This type of kit detects from 0.1 to 5.0 ppm chlorine. Cost of the tablets is around \$10 for a package of ten tablets. Vials are around \$20 each. Colour disks cost in the range of \$50 to \$250, depending on the supplier and the sophistication of the colour disk.

The GVWD⁴ staff use the HACH Colour Comparator model CN-D70, which uses the DPD indicator, for chlorine monitoring. This kit is reliable at low chlorine levels.

² Costs are estimated based on 1996 dollars. Contact suppliers directly for more accurate costs.

³ Harp, Daniel L. “Current Technology of Chlorine Analysis for Water and Wastewater”, Technical Information Series - Booklet No. 17, Hack Technical Center for Applied Analytical Chemistry.

⁴ Greater Vancouver Water District

Be sure that the reagent expiry date is clearly marked and that staff check the expiry date before using each reagent pouch.

2.2.3 Spectrophotometers

There are a number of field spectrophotometers that can be used for measurement of residual chlorine levels. One model is a pocket-sized instrument that tests for free and total residual chlorine over the operating range of 0 to 3.9 ppm. The meter reads in 0.01 ppm increments with an accuracy of ± 0.05 ppm. The meter itself has dimensions of 4.5 x 12 x 8.9 cm. The reagent used in these types of instruments is typically DPD, as described above.

The cost of the pocket device is approximately \$300. The GVWD staff have had some difficulties with using this equipment in the field due to weather conditions and prefer the colour comparator kit which can be kept in the service truck.

2.2.4 Laboratory Analysis

Laboratory analysis for total residual chlorine in water is not recommended due to the very short storage time that a sample can remain stable, and the relatively long turnaround time for results. Chlorine dissipates from a water sample very quickly as a result of exposure to light, increased temperature, and agitation. According to the US EPA standard laboratory techniques for residual chlorine analysis Method 4500-Cl, samples to be analysed for residual chlorine should not be stored at all, but analysed immediately.

The US EPA Standard Method 4500-Cl outlines different methods to detect residual chlorine, including:

- the Iodometric Method;
- the Amperometric Titration Method;
- the Low-Level Amperometric Titration Method
- the DPD Colorimetric Method;
- the Syringaldazine (FACTS) Method; and
- the Iodometric Electrode Technique.

The advantage of these methods is that the detection limits are as low as 0.010 mg/L (ppm or 10 $\mu\text{g/L}$ (ppb), depending on the sophistication of the equipment.

It is recommended that sampling for total residual chlorine be completed in the field using a field testing kit to obtain the best results. In special cases, lower detection limit methods could be used by setting titration equipment in the field.

2.3 Interferences

The field methods used to measure total residual chlorine can give false readings in some circumstances. For example, the DPD indicator method is subject to interference by oxidized forms of manganese. The test may indicate chlorine is present when it is the interfering compound reacting with the indicator to give a false reading. High sample colour and turbidity may also cause interference and give inaccurate readings.

When an interference is suspected, chlorine free samples should be measured to establish background readings. This can be done by taking a water sample and agitating the water for a few minutes to decrease chlorine levels in the sample, and then taking a chlorine reading on that sample. If the reading does not decrease repeat the agitation procedure a few more times. If a positive result is still obtained, it is likely that an interference is present, which must be taken into account during the monitoring program. For example, in the case of the pocket photometer the background reading can be subtracted from the reading obtained with the true sample for low turbidity samples, but not for samples that have a false positive interference. If there is any doubt in the readings, continue to dechlorinate as a precautionary measure.

Another interference may occur when the chlorine residual is a high enough concentration that the reagent (DPD) will bleach out and no colour will develop. This will result in a false negative reading.

2.4 Training

It is necessary to undergo training in procedures for chlorine monitoring as well as general dechlorination methods prior the use of these methods in the field. Explanation of the potential problems that can arise by someone knowledgeable in these procedures will reduce the potential for errors and frustrations associated with new procedures. The GVRD, for example, has developed a training program for staff that will be involved in dechlorination procedures.

APPROACH TO DECHLORINATION

3.1 Types of Responses

The methods and equipment used to dechlorinate a water release will be dependent on the type of water release encountered. For ease of discussion, three types of water releases have been defined, as follows:

- Emergency
- Planned Short-term
- Permanent

During an emergency water release, such as a water main break, the location and volume of the water release are not known prior to its occurrence. Therefore, equipment, chemicals and supplies needed for dechlorination must be assembled prior to the event, and they must be ready to deploy in a very short time. Furthermore, as the conditions of the event are generally not known until a crew arrives at the site, the dechlorination method used must be relatively easy and quick to deploy in a variety of situations.

As an example, the GVWD has emergency dechlorination kits ready to deploy at all times and are kept in their vehicles. Their response to an emergency water release is to place fibre mesh bags containing granular sodium thiosulphate in the flow path of the released water (the bags allow water to easily contact the chemical). These bags and ancillary equipment needed to deploy the bags are made up in advance and are immediately available for a response.

Where the location and volume of water to be released are known and can be controlled, this is referred to as a planned release. Planned releases include events such as water main flushing or concrete curing at a construction site. It should be noted that water originating from a concrete curing operation likely has a high (basic) pH which can also be lethal to fish.

For a planned release, time is not as critical as an emergency event. Time is available for preparation at the site. In these situations, the GVWD typically uses a solution of sodium thiosulphate for dechlorination instead of the solid form. This solution is metered into the flow of the released water. Using a solution of sodium thiosulphate is much more cost effective than using bags of solid sodium thiosulphate as much less dechlorinating agent is used in the dechlorination process.

Where chlorinated water will be released on a long term or permanent basis, such as in cooling water systems, a more permanent approach to dechlorination is required. In these

circumstances, a more engineered approach is used, which is discussed in more detail in Section 5.0.

Figure 3-1 outlines a decision flow chart for dechlorination of municipal water releases.

3.2 General Steps

This section discusses the steps for emergency and planned response to a chlorinated water release, where *Section 5.0* focuses on the dechlorination approaches for permanent water releases.

A checklist of nine general steps has been prepared for dechlorination methods:

- Step 1 - Preparation
- Step 2 - Notify Authorities and Record Activities
- Step 3 - Measure the Total Residual Chlorine (TRC)
- Step 4 - Prepare Stock Solution (Planned Response Only)
- Step 5 - Determine Flow Rates
- Step 6 - Determine Dosing Rate (Planned Response Only)
- Step 7 - Add Dechlorinating Agent
- Step 8 - Provide Flow Control Measures
- Step 9 - Monitor TRC after Treatment

Details of each of these steps are provided in the following sections.

3.2.1 Step 1 - Preparation

The first step in any response to a water release is to be prepared. Both supplies and equipment must be prepared in advance, must be readily available, and appropriate staff training is required.

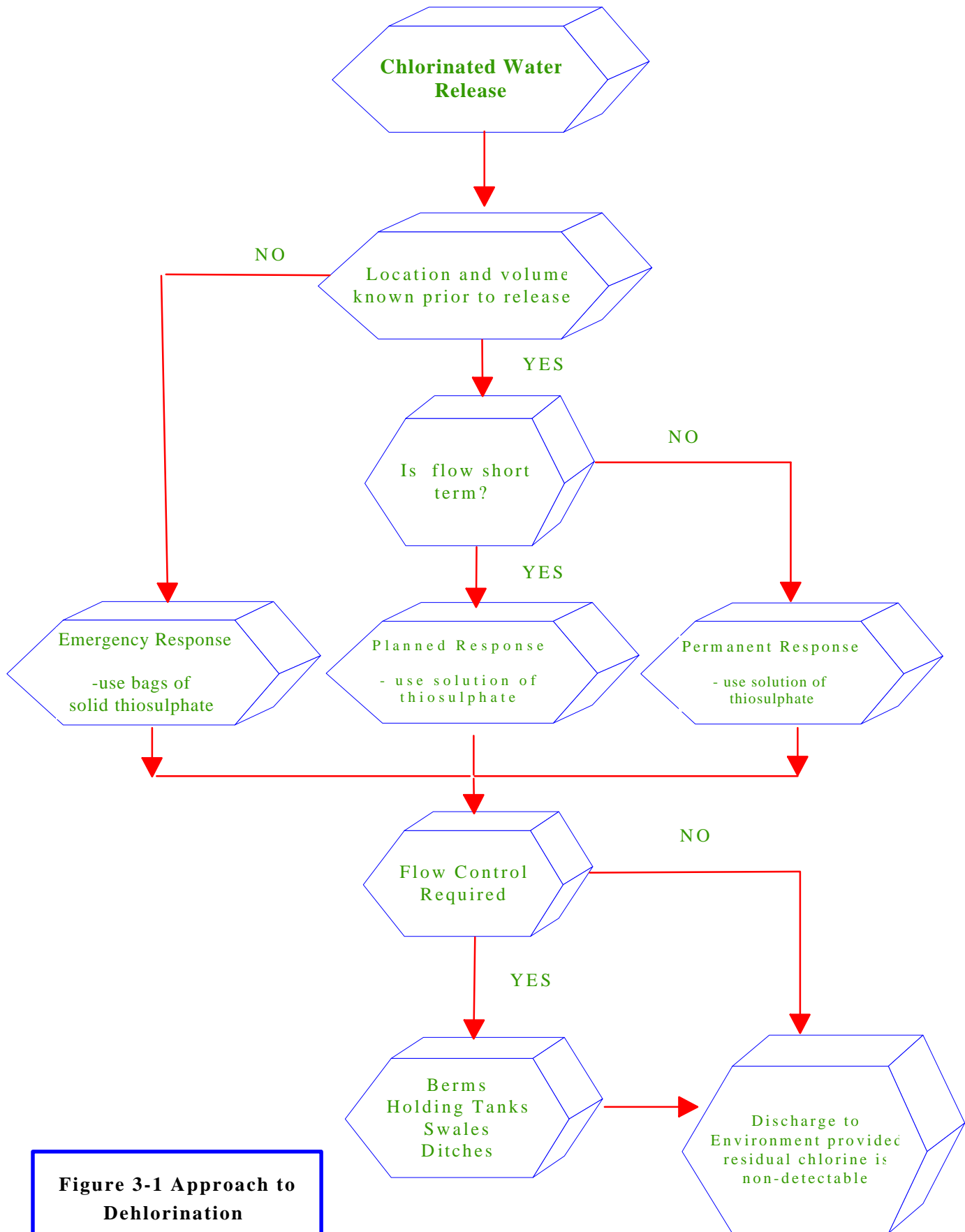


Figure 3-1 Approach to Dechlorination

Emergency Response

An emergency response kit should be prepared prior to it being needed. A list of equipment and supplies used by the GVWD for emergency response is shown in Table 3-1. This kit is always available to the response crew. Photos 1 and 2 display a typical emergency kit.

**Table 3-1
Emergency Response Kit Supplies**

	Items
<i>Chemical Supplies</i>	<ul style="list-style-type: none"> - two 20 lb. bags of technical grade anhydrous sodium thiosulphate - three or four pre-filled mesh bags filled with technical grade anhydrous sodium thiosulphate - 6 spare empty bags
<i>General Equipment</i>	<ul style="list-style-type: none"> - ropes (at least two, 10 m long each) - record book - camera, film and batteries - joint sleeves and fabricated fittings to adapt to fire hydrants and other facilities
<i>Testing Equipment</i>	<ul style="list-style-type: none"> - field chlorine testing kit (eg: HACH kit) - Record of Activities Sheet (RAS)/record book - portable pH meter
<i>Personal Safety Equipment</i>	<ul style="list-style-type: none"> - clear plastic goggles (the kind that suction around your eyes) - rubber gloves - particle mask - MSDS for sodium thiosulphate and for the chlorine testing reagent
<i>Telephone Numbers</i>	<ul style="list-style-type: none"> - a list of municipal, district and environmental agency emergency telephone numbers

The approach used by GVWD staff for dechlorination in an emergency situation is to use the solid form of anhydrous sodium thiosulphate. This agent is put into fibre mesh bags, which are then placed in the flow path of the released water. Therefore, a number of bags should be readily available. Rope is included in the equipment list as often the bags need to be tied in place. Personal safety equipment is also required.

It is important to have Material Safety Data Sheets (MSDS) on the site for both the dechlorinating agent and for the chlorine testing kit. If there is contact with either of these agents, the MSDS provides information pertaining to treatment, if required. The MSDS will also indicate the exact personal protection equipment (PPE) that should be worn by workers who are in contact with the chemicals.

Planned Situation

In a planned release, the equipment and supplies will be different from an emergency response as the liquid form of the dechlorinating agent can be used.

Sufficient dechlorinating agent should be delivered to the site prior to the beginning of any planned operation. Excess dechlorinating agent should be available at all times. Since it may not be available from the suppliers on short notice.

Table 3-2 indicates typical supplies that should be kept on site for a planned response.

3.2.2 Step 2 - Notify Authorities and Record Activities

In an emergency situation, it is important to notify the correct authorities immediately upon learning of an unplanned release of chlorinated water. Notify the authorities with jurisdiction in the vicinity of the release. For instance, if a City of Vancouver water main broke in Vancouver, the City would have jurisdiction and has a designated reporting number for water main breaks. Alternatively, if a water main operated by the GVWD broke, the GVWD should be contacted. Exact procedures for contacting authorities should be pre-planned by all municipalities, and the GVWD. An *Emergency Call Report Form*, as outlined in the *Generic Environmental Emergency Response Plan for Chlorinated Water* (GVRD 1997), should be filled out to record all persons and agencies notified.

In the event of a large spill, the Provincial Emergency Program (PEP) should be contacted. Although, they will likely refer the call to the Department of Fisheries and Oceans, this agency should also be contacted directly.

Table 3-2
Planned Response Kit

	Items
<i>Chemical Supplies</i>	- excess dechlorinating agent to prepare the stock solution of liquid dechlorinating agent
<i>General Equipment</i>	<ul style="list-style-type: none"> - 1 record book - barrels or holding tank(s) for dechlorinating solution - electric generator and mixer - joint sleeves and fabricated fittings to use with tanks and mixer - balance to measure mass of dechlorinating agent that will be required to mix the stock solution - chemical metering pump with a quick-fix-it kit containing spare parts in the event that the pump becomes disabled - source of water to mix the stock solution - flow meter
<i>Testing Equipment</i>	<ul style="list-style-type: none"> - field chlorine testing kit (eg: HACH kit) - flow meter, if required for permanent situation
<i>Personal Safety Equipment</i>	<ul style="list-style-type: none"> - clear plastic goggles (the kind that suction around your eyes) - rubber gloves - particle mask - MSDS for sodium thiosulphate and for the chlorine testing reagent
<i>Telephone Numbers</i>	- a list of municipal, district and environmental agency emergency telephone numbers

It is recommended that a Record of Activities sheet (RAS) be completed for each dechlorination event, whether it be an emergency response or a planned situation. The sheet records such information as the date, the staff involved, the residual chlorine levels, and dechlorination techniques. A sample of RAS for both emergency and planned situations is provided in Appendix B.

The RAS will become invaluable both as historical information, and as a record of due diligence. It may also provide important insight into refining different dechlorination techniques.

3.2.3 Step 3 - Measure the Total Residual Chlorine (TRC)

For either an emergency or a planned event, the total residual chlorine (TRC) concentration should be measured in the water that is being released or planned to be released. A field testing kit, as discussed in *Section 2.0*, should be used for this purpose. A number of samples should be taken to ensure reliability of the numbers.

3.2.4 Step 4 - Prepare Stock Solution (for Planned Response)

The liquid form of sodium thiosulphate is recommended for use in planned events. In this case, it is more cost effective to prepare your own stock solution of sodium thiosulphate than purchasing it. A solution of dechlorinating agent can easily be prepared on-site. Stock solutions are made up by mixing the solid form (usually crystals) of dechlorinating agent, such as sodium thiosulphate pentahydrate, with water. Two forms of sodium thiosulphate can be purchased: sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) in the anhydrous form and sodium thiosulphate pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$). As the pentahydrate form is the easiest to dissolve and is typically used, this form is used in all of the calculations for this manual.

The strength of a stock solution is measured as a percentage by weight. For instance, a 10% stock solution of sodium thiosulphate pentahydrate would contain 10% by weight of sodium thiosulphate pentahydrate and 90% by weight of water.

Table 3-3 outlines the mass of sodium thiosulphate pentahydrate required per unit volume of water to prepare different strengths of stock solution. A list of chemical suppliers is provided in Appendix C.

Table 3-3
Stock Solution Preparation
Required Mass of Sodium Thiosulphate Pentahydrate
per Unit Volume of Water

Strength of Solution (% by weight as grams of solute/100 g water)	Mass (g) of Sodium Thiosulphate Pentahydrate needed to be added per Litre of water (g/L)	Mass (g) of Sodium Thiosulphate Pentahydrate per Gallon of water (g/imp. gallon)
1%	10.1	46.0
2%	20.3	92.4
5%	52.0	236.6
10%	108.3	492.8

Preparation of a 45 gallon drum of 2% sodium thiosulphate pentahydrate would be as follows:



- 1) Using the table above, 0.0924 kg or 92.4 g of sodium thiosulphate pentahydrate must be added to each gallon of water.
- 2) For 45 gallons, it would take (92.4 g) x (45 gallons) = 4,158 grams or about 4.2 kg.

3.2.5 Step 5 - Calculate Flow (Q) of Discharge Water

Flow rates are required in order to calculate the corresponding dosing rate of dechlorinating solution required to neutralize the discharge water. Two ways to determine the flow rate (Q) of discharge water are by calculations or by measurement. A third way would be to estimate flow by experience, however, this is obviously not as accurate.

Calculating Flow Rates

It is possible to calculate the flow rate (Q) of water by knowing the velocity of water being discharged, and the cross-sectional area of the source of discharge, eg., a pipe. The following steps outline how to calculate the flow rate knowing the velocity of water exiting the pipe:

- i) Cross Sectional Area of Pipe (CA) = $1/4 \pi d^2$; where $\pi = 3.14...$ and d = diameter in metres
- ii) Calculate flow in cubic metres/second (m^3/s) = (CA) x (Velocity of water in m/s)
- iii) Calculate the flow in L/min (Q) = (m^3/s) x 1000 L/ m^3 x 60 s/min

The value for Q will be in L/min (litres per minute).

Flow Meter

The flow rate at the discharge from the pipe can be measured using a flow or current meter. Flow meters can be purchased from local suppliers. The concept involves placing a probe or stick with a bucket wheel on the end into the flow of water. Water velocity is determined by counting the number of revolutions of the bucket wheel over time. The operator can manually convert the number of revolutions and compare them to a rating chart.

3.2.6 Step 6 - Determine the Dechlorinating Solution Dosing Rate (for Planned Response)

In this section, two approaches are given related to the way the dechlorinating agent is added to the released water. In the first approach, the **volume** of the stock solution needed to dechlorinate a specific flow rate and chlorine concentration is used. In the second approach, the **weight** of the dechlorinating agent needed to dechlorinate a specific flow rate and chlorine concentration is used.

Basis of Calculations

For all calculations, the dechlorinating rates given in the *AWWA Standard for Disinfecting Water Mains (1986)* was used as follows:

Table 3-4. Pounds of Chemicals Required to Neutralize Various Residual Chlorine Concentrations in 100 000 U.S. gallons (378,500 L) of water.

Residual Chlorine Conc. (mg/L)	Sodium Thiosulfate Pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)
0.3	0.4 (0.16) ¹
0.6	0.7 (0.33)
0.9	1.1(0.49)
1	1.2 (0.544)
1.3	1.6(0.71)

¹() denotes kg

Volumes of Stock Solutions needed for Dechlorination

Tables 3-5 and 3-6 provides the volumes of stock solutions of dechlorinating agent (in mL) required to dechlorinate 10,000 litres and 10,000 Imp. gallons of chlorinated water, respectively, using a solution of sodium thiosulphate pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$).

Simple ratios can be used to calculate the required volume of stock solution for values of TRC which are not indicated in the Tables.

Table 3-5
Volume (in mL) of Sodium Thiosulphate Pentahydrate Solution
Required to Neutralize 10,000 Litres of Chlorinated Water

	Stock Solution of Sodium Thiosulphate Pentahydrate			
	1%	2%	5%	10%
<i>Trace Residual Chlorine (TRC) as mg/L present in the water to be neutralized</i>				
0.1	142	71	28	13
0.3	427	212	83	40
0.5	711	354	138	66
0.7	996	496	193	93
0.9	1281	637	221	119
1	1423	708	276	133
2	2846	1416	553	265

NB: Stock solution can be prepared by using sodium thiosulphate pentahydrate. Refer to Table 3-3 for requirements to make up the solutions.

Table 3-6
Volume (in mL) of Sodium Thiosulphate Pentahydrate Solution
Required to Neutralize 10,000 Gallons of Chlorinated Water

	Stock Solution of Sodium Thiosulphate Pentahydrate			
	1%	2%	5%	10%
<i>Trace Residual Chlorine (TRC) as mg/L present in the water to be neutralized</i>				
0.1	647	322	126	60
0.3	1,942	966	377	95
0.5	3,237	1,610	629	302
0.7	4,531	2,255	880	423
0.9	5,826	2,899	1,132	543
1	6,473	3,221	1,257	604
2	12,947	6,441	2,516	1,207

NB: Stock solution can be prepared by using sodium thiosulphate pentahydrate. Refer to Table 3-3 for requirements to make up the solutions.

This information can be used to calculate the volume of dechlorinating agent needed for different flow rates. For example, if one had a flow rate of 250 gallons per minute (GPM), this would mean a volume of 15,000 gallons per hour would need to be dechlorinated. If the TRC in the water was 1 mg/L and a 2% stock solution of sodium thiosulphate pentahydrate was prepared, this would mean that 4,832 mL (Table 3.6*1.5 to convert to 15,000 gallons) or about 4.8 L would have to be metered into the flow over a one hour period or a stock solution flow rate of 80.5 mL per minute. Figure 3-2 illustrates an example of a dechlorination system.

Weight of Sodium Thiosulphate for Different Flow Rates and Chlorine Concentrations

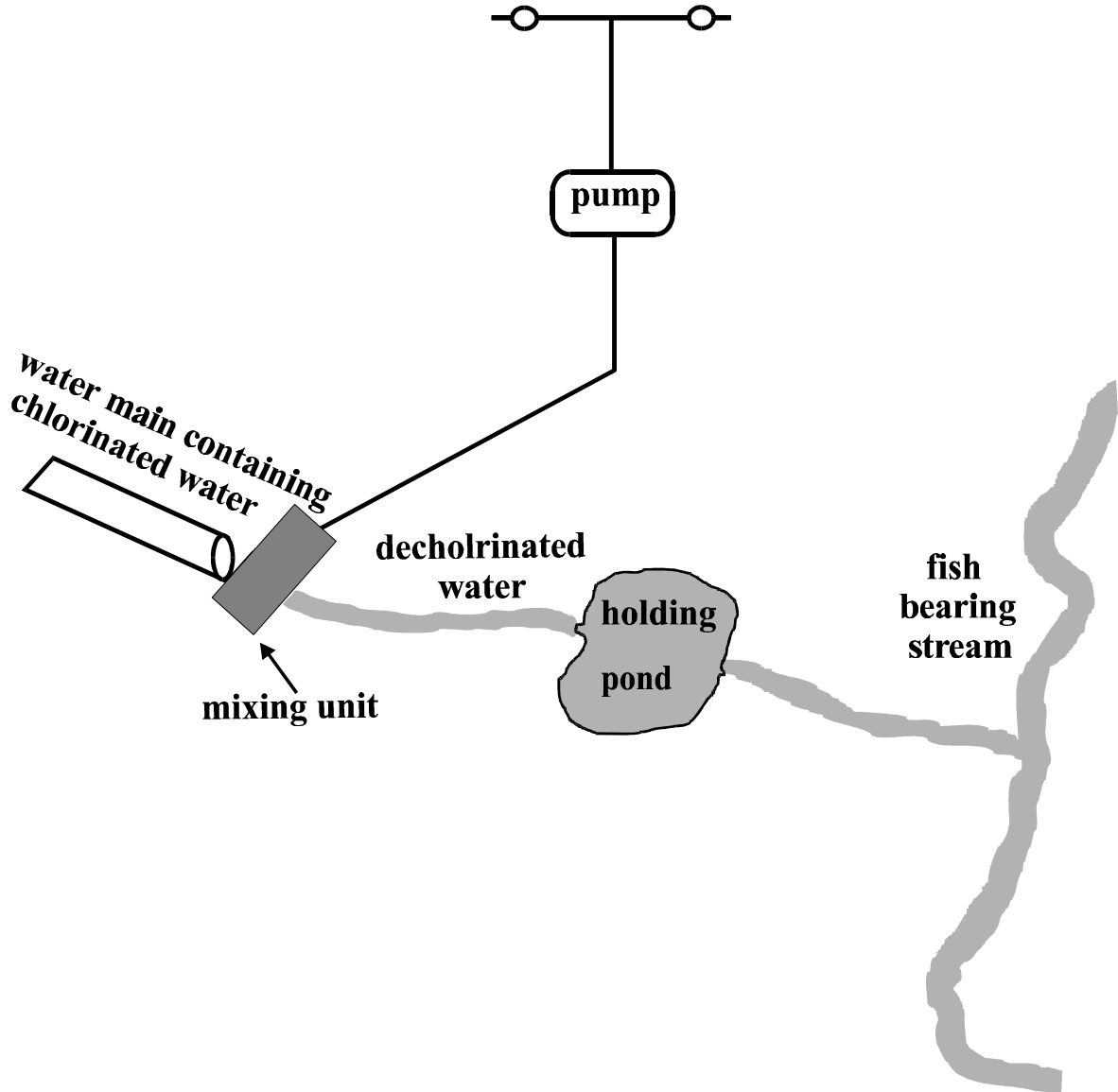
Table 3-7 provides the weight of sodium thiosulphate pentahydrate needed to neutralize various concentrations of chlorine at different flow rates. These values have been taken directly from the *BCWWA School Committee 1994 UBC Operations Workshop*⁵ report using the 1.6 multiplier for conversion of anhydrous form to the pentahydrate form.

Table 3-7 Weight of Sodium Thiosulphate Pentahydrate Needed to Neutralize Various Concentrations of Chlorine at Different Flow Rates. Units are pounds of sodium thiosulphate pentahydrate per hour.

Chlorine Concentration in mg/L			
	0.5	1	2.5
Flow (GPM)			
100	0.048	0.096	0.24
250	0.095	0.19	0.48
500	0.19	0.38	0.96
1000	0.38	0.77	1.92
2000	0.77	1.54	3.84

5 BCWWA School Committee 1994 UBC Operations Workshop. Disinfection of Water Systems and Dechlorination of Discharges to the Environment. Monday, May 16, 1994.

solution of sodium thiosulphate



Example of
De-Chlorinating Set-up

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Figure 3-2

An example is used to illustrate the use of this table. Assume that there is release of 500 GPM of chlorinated water with a residual chlorine concentration of 2.5 mg/L. Using Table 3.7, a flow rate with this chlorine concentration could be neutralized by adding 0.96 pounds of sodium thiosulphate pentahydrate over each one-hour period. As it is much easier to add this agent as a solution, 0.96 pounds of sodium thiosulphate pentahydrate is added to 45 gallons of water. The 45 gallons of solution is then metered into the flow over that one hour period. Alternatively, 1.92 pounds of agent could be added to 45 gallons of water and used over a two hour period.

3.2.7 Step 7 - Add the Dechlorinating Agent

Emergency Response

For an emergency response, mesh bags containing the solid form of anhydrous sodium thiosulphate should be placed directly into the flow path of the released water. If chlorinated water has already entered a stream or water body then a bag of dechlorinating agent should also be placed directly into the water body. These bags may need to be secured by rope to maintain their position. Although this approach uses excess dechlorinating agent it is the quickest and easiest method to employ. In some cases, it may also be necessary to hand broadcast dechlorinating agent into the water, if bags cannot be used effectively.

During emergency response it may be necessary to divert, or temporarily store the water in order to provide more control for dechlorination. Details of flow control methods are provided in *Section 4.0*.

Planned Response

For a planned response, it is more cost effective to use a solution of sodium thiosulphate. Where and how the dechlorinating agent is added will be critical factors in successfully neutralizing chlorine residuals. The single most important factor is to allow the dechlorinating agent to thoroughly mix with the water.

The point of chemical addition should be chosen based on mixing capability. A chemical metering pump provides the best way to both control the injection rate of dechlorinating agent, and ensure that sufficient dechlorinating agent is applied to the discharge water. Some specifications for chemical metering pumps are provided in Appendix E.

Figure 3-2 illustrates an example of a dechlorination plan that has been used by the GVWD staff. In this case, a chemical metering pump is attached to piping, which originates at two storage drums. The pipe is directed toward a mixing unit. An example of a mixing unit is an energy dissipater, normally used when flushing water mains. It is a rectangular metal box

approximately 1 m long and 30 cm wide. Water from the water main and the dechlorinating solution are both directed into the mixing unit. From the mixing unit, the flow travels to a flow control area, such as the pond shown in the Figure 3.2. The pond is used as extra insurance to ensure sufficient mixing of the dechlorinating agent with the chlorinated water prior to discharging the treated water to a natural water course. A flow meter is used to estimate flow.

If a metering pump is not used, it may be possible to set up a gravity flow system, although this would be less accurate.

3.2.8 Step 8 - Flow Control Measures

In some cases, it may be necessary to employ flow control measures. Flow control measures serve two purposes, they prevent or delay water from reaching a receiving environment, and, thus, provide more time for mixing of the chlorinated water with the dechlorinating solution.

If it is determined that more time for mixing is required, or that diversions are necessary for the protection of aquatic life, flow control measures should be employed. Section 4.0 provides detailed descriptions of flow control measures that can be used on-site.

3.2.9 Step 9 - Monitor the Total Residual Chlorine Concentration after Treatment

Monitor the discharge water for total residual chlorine (TRC) prior to it reaching the receiving environment throughout the dechlorination process. Non-detectable readings should be obtained at all times. Use one of the monitoring procedures outlined in *Section 2.0*.

If detectable concentrations of chlorine are found in the discharge water, the flow of water should be stopped or redirected to an area to allow additional dechlorination.

3.2.10 Summary of Dechlorination Steps

Table 3-8 provides a summary of the steps needed for dechlorination.

Table 3-8
Summary of Dechlorinating Steps

<i>Steps</i>	<i>Emergency Response</i>	<i>Planned Response</i>
Step 1 - Preparation	<ul style="list-style-type: none"> - prepare emergency response kit in advance 	<ul style="list-style-type: none"> - have excess dechlorinating agent on-site - have tools and equipment ready, including spare parts
Step 2 - Notify Authorities and Record Activities	<ul style="list-style-type: none"> - notify the authorities having jurisdiction in the area of the release of chlorinated water - record all activities in the field for future reference and as part of the due diligence process 	<ul style="list-style-type: none"> - record all activities in the field for future reference and as part of the due diligence process
Step 3 - Measure the TRC	<ul style="list-style-type: none"> - assume chlorine is present 	<ul style="list-style-type: none"> - measure using field monitoring kit
Step 4 - Prepare Stock Solution	not applicable	<ul style="list-style-type: none"> - prepare the solution in advance using information provided in tables
Step 5 - Determine Flow Rates	<ul style="list-style-type: none"> - estimate flow as best as possible 	<ul style="list-style-type: none"> - determine flow rate by calculating, measuring or estimating - can also determine total volume over a set time period using the flow rate
Step 6 - Determine Dosing Rate	<ul style="list-style-type: none"> - overdosing is best approach 	<ul style="list-style-type: none"> - determine dosing rate of dechlorinating solution
Step 7 - Add Dechlorinating Agent	<ul style="list-style-type: none"> - add solid dechlorinating agent in pre-filled fibre mesh bags 	<ul style="list-style-type: none"> - add dechlorinating agent solution by using chemical metering pump

Table 3-8
Summary of Dechlorinating Steps

<i>Steps</i>	<i>Emergency Response</i>	<i>Planned Response</i>
Step 8 – Provide Flow Control Measures	<ul style="list-style-type: none">- as required to protect aquatic life- as required to provide for more mixing	<ul style="list-style-type: none">- as required to protect aquatic life- as required to provide for more mixing
Step 9 - Monitor TRC after Treatment	<ul style="list-style-type: none">- monitor for TRC using field measuring device in release water and receiving environment	<ul style="list-style-type: none">- monitor for TRC using field monitoring device in released water and in receiving environment

FLOW CONTROL MEASURES

During both emergency and planned responses, it may be necessary to construct temporary or permanent flow control measures. Flow control measures involve construction of physical structures to provide both the opportunity for better mixing of the dechlorinating agent than would have been otherwise obtained without these structures, and to prevent discharge water from entering directly into a water body, without treatment.

A number of relatively simple measures can be taken to provide flow control. These measures may be used separately or, in some cases, a combination of measures may be appropriate, as follows:

- berms
- swales
- ditches
- holding tanks
- redirection pipes
- ponds

It should be noted that high water flows also cause bank erosion and scouring in creeks. For more guidance on this aspect, refer to the *Land Development Guidelines* (DFO and Ministry of Environment, Lands and Parks, 1992).

4.1 Berms

Berms can be constructed to control flows or direct water towards ponds or away from a receiving water body to allow easier addition of the dechlorinating agent and appropriate mixing. There are a number of simple materials that could be used to construct a berm including:

- sand bags
- hay bales
- gravel with a filter fabric core
- plywood

Sand bags are a good way to construct a temporary berm. Sand bags placed in a semicircle can be used to enclose the area of discharge. If the sand bags are used in combination with a depression in the ground, a pond may be formed allowing residence time of the water in the depression prior to discharge. These bags could be prepared at the site if the appropriate materials are present, or brought to the site. Hay bales may be used in a similar manner.

In some cases, it may be necessary to make an earth berm or small depression, for example, using a backhoe. This could easily be done at construction sites. An earth berm can use material present on-site.

Figure 4-1 illustrates a typical berm structure.

4.2 Swale

Using a swale or other natural depression could provide an area for the necessary mixing and residence time. If the natural setting is such that a low lying field or swale is present near the site, the discharge water can be redirected into the swale. Constructing a berm at one end of the swale could increase the holding capacity significantly. Addition of the dechlorinating agent into the swale will provide good mixing prior to reaching the receiving environment.

A combination of berms and/or piping may be required to ensure that the discharge water travels into the swale first prior to reaching the receiving environment.

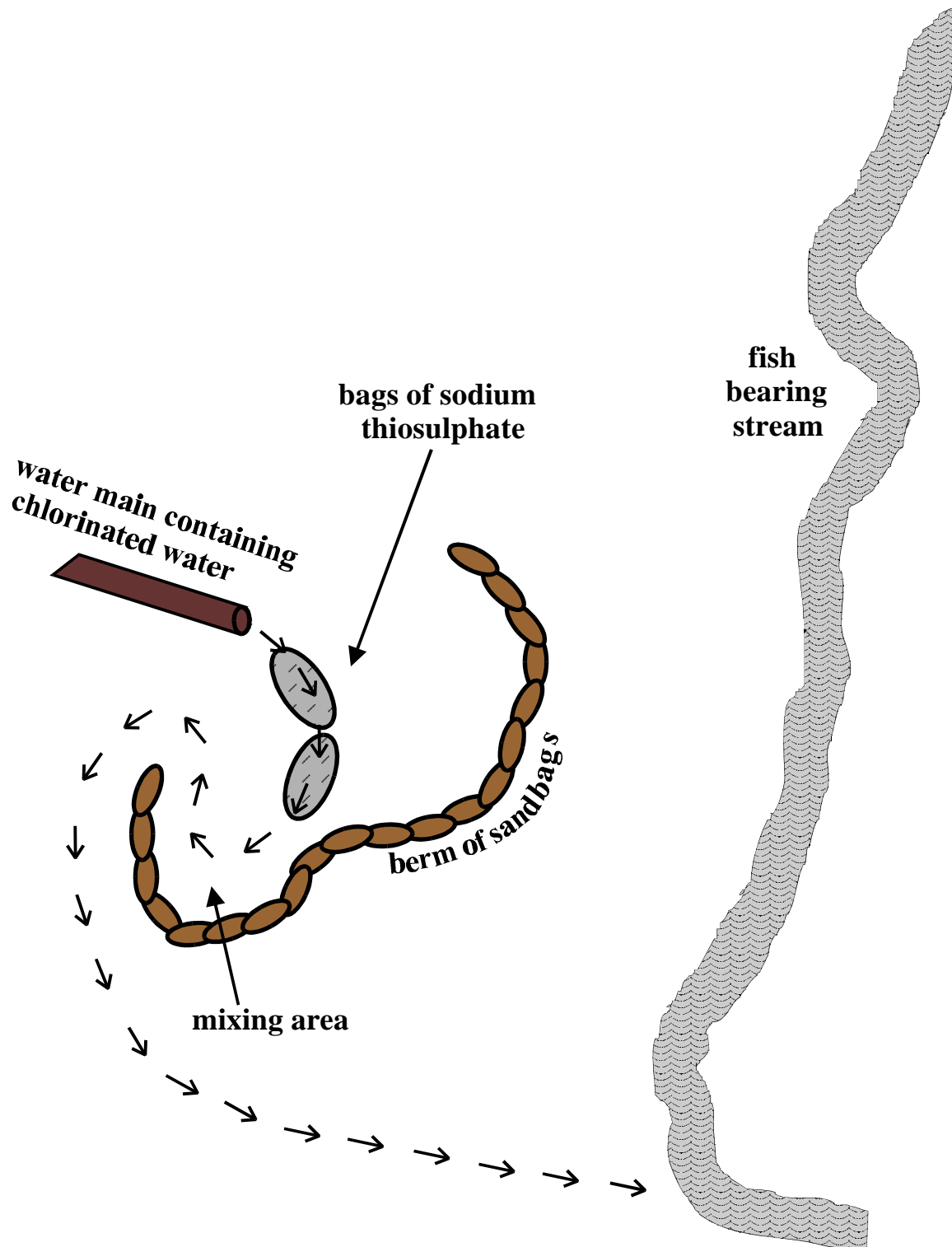
4.3 Ditches

A ditch can provide a mixing zone and the residence time needed to apply the dechlorinating agent. Check dams could also be used in the ditch to retain and pond the water to improve mixing. Sand bags and hay bales can be used as check dams, or used to direct the discharge water into the ditch if it is not already moving in that direction. The ditch used should, however, have no environmental significance in terms of aquatic habitat. If there is any doubt as to the significance of the ditch, the DFO should be contacted.

Add the dechlorinating agent solution at the point where the water enters the ditch. This will allow the dechlorinating agent to mix with the water in the ditch.

4.4 Holding Tanks

In some cases, space may be at a minimum and ditches or swales may not be available. In these situations, holding tanks provide a controlled structure for mixing of the dechlorinating agent.



Typical Berm Structure

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Figure 4-1

The size of the holding tank should be such that water entering the holding tank has a residence time of at least a few minutes. For instance, if the structure discharging water is flowing at a rate of 50 gallons per minute, the holding tank should be capable of holding at least 150 gallons or 3 minutes of flow. In the case of larger volumes tanker trucks, which hold greater than 3,000 gallons, could be used. In these case the truck has its own pumps that would likely handle the flows. In very low flows, a 45 gallon drum may be sufficient.

The water will likely need to be redirected into the holding tank. A redirection pipe can be used to accomplish this. For instance, on an 8" water main, use 8" diameter PVC pipe connected to the discharge end of the water main. Elbows, connectors and adaptors can be used to manipulate the pipe route. Direct the pipe to the bottom half of one end of the holding tank.

Once the pipe is directing water into the holding tank, the liquid dechlorinating agent can be added into the holding tank by tapping into the tank.

Water can be emptied out of the tank by constructing a tap on the opposite end of the tank. The tap will allow for controlled discharge from the tank. The tap should be placed in the op quarter of the tank. This will allow the water to enter at the bottom, mix with the rechlorinating agent and rise to the top where it empties out, thus providing for optimum mixing.

4.5 Redirection Pipe

A redirection pipe can be used to redirect the flow of water to a specific area or into a holding tank. It could also be used as a treatment option if an in-line injection system is used to inject the dechlorinating agent into the pipe.

The best material for constructing a redirection pipe is PVC (polyvinylchloride) since it resists corrosion and is lightweight for easy manoeuvrability. PVC pipe is reasonably priced, readily available, and can be obtained in various pipe sizes with appropriate adaptors for odd-sized pipe from most hardware stores.

Construct the redirection pipe such that it is connected to the discharge point and extends to the area that will be used for adding the dechlorinating agent. Alternatively, if the dechlorinating agent is to be added into the redirection pipe itself, there should be an injection point at the end closest to the source of the chlorinated water. This permits the dechlorinating agent to mix within the redirection pipe prior to entering the environment.

The injection point can be a vertical pipe which intercepts the discharge pipe. The injection point can be constructed by putting a "T-joint" into the pipe. The vertical pipe should not be

higher than 1 m so that the dechlorinating agent does not have to be lifted by the operator during the process. A chemical metering pump can be fitted to the top of the injection point to allow the operator to control the flow rate of dechlorinating chemicals into the injection point.

4.6 Constructed Ponds

Large constructed ponds are not likely to be used for short term or emergency response situations. However, they may be appropriate for long term or permanent discharges. Details of holding ponds are provided in *Section 5.0*.

PERMANENT SYSTEMS

Permanent systems would apply to water releases such as cooling water distribution systems, agricultural sites with process or irrigation water, and in line syphon systems used to dewater manholes. A long term solution is needed for dechlorination in these cases and the system should allow mechanical dosing as it would not be practical to have the process completed manually.

5.1 Ponds

One approach is to discharge the chlorinated water into a pond prior to its release. Two methods could be used.

- storing the water in a holding pond and recirculating it for re-use on-site, with no discharge (no dechlorination needed); or
- injecting a liquid dechlorinating agent, allowing the water to mix in the pond, and discharging the water to the environment following thorough mixing.

Pond Size

The size of the holding pond will depend on the flow rate and required residence time as well as the end use of the water in the pond. The general configuration should be rectangular with the inlet and outlet pipes located at opposite ends of the rectangle. This allows a longer time for mixing of the water. Baffles may also be needed to prevent short circuiting of the water flow. The pond will need to be sufficient in size to take into account the potential uses.

Pond Dimensions

A pond excavated to a depth not exceeding one metre, and measuring 3 m wide by 6 m long will hold 18,000 L (4,000 gallons) of water. This should be sufficient to handle the volume of water from a typical 4" water main given a flow rate of 250 to 300 gallons per minute. The pond will be filled every 12 to 15 minutes.

As the diameter of the pipe gets larger, and the flow rates increase, it will take less time to fill the same size pond. For instance, an 8" pipe can have a flow rate of 780 gallons/minute, depending on the pressure in the line. In this case, it would take approximately 3 minutes to fill the same size pond. This means, that the pond size should be increased to maximize the water retention time, and therefore the mixing time in the pond. The longer the water is retained in the pond, the better it will be mixed with the dechlorinating agent. Table 5-1

provides a guide to increasing the size of the holding pond with the size of the pipe or flow rate.

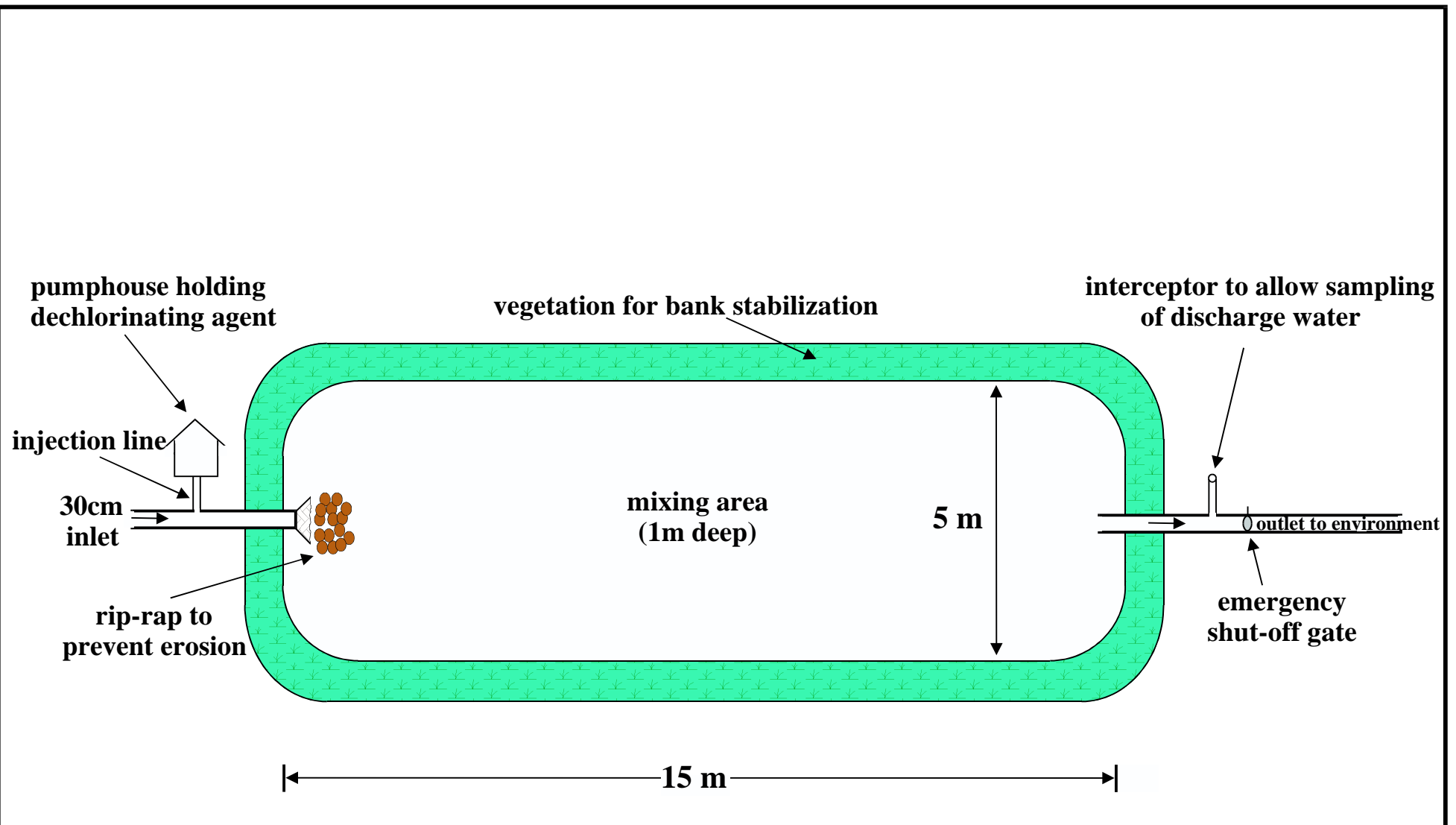
The banks of the pond should be vegetated or armoured with rip rap in order to prevent bank erosion over time. In addition, there should be a 0.5 m high freeboard around the entire pond.

Figure 5-1 illustrates a plan view of a holding pond.

**Table 5-1
Examples of Pond Dimensions**

Pipe Diameter (inches)	Flow rate (gallons per minute or GPM and litres per second or LPS)	Volume¹ produced after 10 minutes (gallons/litres)	Minimum required pond dimensions (Depth x width x length in feet and metres)
4"	200 GPM 15 LPS	2,000 gal. 9,100 L	3 x 10 x 10 feet 1 x 3 x 3 metres
6"	450 GPM 34 LPS	4,500 gal. 20,475 L	1 x 3 x 7
8"	780 GPM 59 LPS	7,800 gal. 35,490 L	1 x 4 x 9
10"	1200 GPM 91 LPS	12,000 gal. 54,600 L	1 x 5 x 11
12"	1750 GPM 133 LPS	17,500 gal. 79,625 L	1 x 5 x 15
14"	2400 GPM 182 LPS	24,000 gal. 109,200 L	1.5 x 5 x 14
16"	3150 GPM 239 LPS	31,500 gal. 143,325 L	1.5 x 5 x 20
18"	3975 GPM 301 LPS	39,750 gal. 180,863 L	2 x 5 x 18
21"	5400 GPM 410 LPS	54,000 gal. 245,700 L	2 x 5 x 24

¹ These volumes have been calculated using a velocity of 1.8 m/s. Velocity will vary with pressure.



Designed for 30cm (12") diameter pipe flowing at 8000 L/min (1750 gpm)

Example of Holding Pond	
GVRD	
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Construct the injection point

The injection point should be constructed to intercept the inlet pipe to the pond. This allows mixing prior to the water entering the pond.

A chemical metering pump⁶ can be fitted to the top of the injection point to allow the operator to control the flow rate of dechlorinating chemicals into the injection point. Some specifications for pumps are attached in Appendix C. To calculate the dosing rate of dechlorinating agent in solution, refer to *Section 3.0*. Routine monitoring of the water for chlorine residuals should occur to ensure proper dechlorination.

In the case of a pond, the structure is likely to be permanent. In this case it is recommended that a shed be constructed to house the dechlorinating chemicals, and the chemical metering pump. Power would need to be provided to the site. The shed should be kept locked to prevent tampering. The shed will also ensure that the chemical metering pump is protected from the elements.

It is also recommended that some rip-rap be placed at the base of where the inlet pipe will discharge water into the pond. This will prevent erosion of sediments on the base of the pond and discourage sediments from being churned up by the energy of the incoming water.

5.2 In-line Injection

The in-line injection method involves mechanically injecting dechlorinating agent into some type of piping system. As the type of systems that may require this approach varies greatly, only general concepts can be provided in this handbook.

Injection Point

The injection point should be constructed to intercept the existing piping a minimum of 10 m from the point of discharge to a receiving water body. The system must ensure sufficient mixing of the chlorinated water with the dechlorinating agent while the water is still inside the pipe. The method of injection should also ensure throughout mixing of the water with the dechlorinating agent.

Flow Measurement

In a pipe with relatively constant flow, a metering system can be set at one specific addition rate. No monitoring of the flow in the pipe would be required. However, if large variations

⁶ Chemical metering pumps are available from local suppliers.

in water flow will be encountered a system will need to be put into place to adjust the injection rate of the dechlorinating agent accordingly. The system will need to measure the flow rate in the pipe and feed this information back to a control unit that would adjust the metering rate. See Appendix C for some details.

Injection Rate Calculations

As in the pond structure, the injection rate of dechlorinating solution can be calculated as outlined in *Section 3.0*.

Permanent Structure

In the case of a permanent structure, such as for a cooling water system, the injection point can be structurally modified to suit the existing pipeline.

The orientation of the injection point should be such that the dechlorinating chemical enters the pipeline with no back pressure. A vertical injection point is suggested (ie. above the water level in the pipe).

A chemical metering pump is the best device for injection of the dechlorinating chemical into the pipeline. A chemical metering pump allows continual injection at a predetermined rate and ensures that the dechlorinating chemicals enter the system as required. The automatic pump also requires the least amount of operator attention.

5.3 Automated Dosing System

Automated dosing systems can be purchased from a number of companies. Photos 7 and 8 illustrates an example of the D-CHLOR® System made by Eltech International Corporation. The two main components of the system are the flow-through feeder and the D-CHLOR tablets (sodium sulphite). These units can be sized for a variety of flows.

The sodium sulphite tablets are placed in the feed tubes of the flow-through feeder. As water passes through the feeder, slots in the feed tubes allow contact of the tablets with the water. The tablets have been specially formulated by a proprietary process so that they dissolve at a controlled rate. Thus, a controlled amount of sulfite is added to the water as it flows through the feeder.

The feeder readily adapts to changes in flow rate. As the flow rate increases, a weir located at the outlet of the feeder causes the water level in the feeder to rise. This causes more tablets to be in contact with the water, thus increasing the amount of sulfite being dissolved. The result is a constant sulfite concentration in the treated water in spite of fluctuations in the flow rate. The sulfite concentration is set by choosing the proper number of tubes to be filled

with tablets and the size of the outlet weir. All of this is accomplished without the use of complicated instruments, controls, or even electrical power.

The tablet feeders made by EIC can handle up to 50,000 gallons per day (GPD). Larger capacities up to 500,000 GPD can be treated by using a by-pass arrangement. Smaller capacities can be handled with smaller feeders.

Installation is by gravity feed. The inlet of the D-CHLOR Tablet Feeder is piped directly to the chlorinated water outlet, or installed anywhere along the final discharge line. The outlet of the D-CHLOR Tablet Feeder can free-fall into a ditch, trench, or a drop box connected to a discharge pipe.

It is possible that overdosing of sulfite can cause an oxygen deficient environment in the aquatic system. The extent to which this could occur will depend on the concentration of sulfite that is dosed to the environment. Dissolved oxygen measurements should be taken if sodium sulfite tablets are used.

CASE SCENARIOS

This section provides two examples of chlorinated water releases and the steps taken to dechlorinate the water. The first example gives a scenario for planned, intermittent flow while the second example describes a permanent system.

6.1 Scenario 1 - Planned, Intermittent Flow Situation

The first example involves flushing a water main to remove accumulated solids. The following conditions apply:

- Diameter of pipe = 20 cm or 0.20 m (8")
- Velocity of flushing water = 1.8 m/s
- Duration of flushing activity: 30 minutes
- a 2% stock solution of sodium thiosulphate pentahydrate will be used to dechlorinate
- Discharge of the water will be to the street and to a stormwater drain

To dechlorinate this water released the following steps are required:

- Prepare the stock solution
- Determine the total residual chlorine (TRC) present in discharge water in mg/L (ppm);
- Determine the Flow rate (Q) of water leaving the pipe in litres per minute;
- Determine the total volume of water leaving the pipe over the 30 minute time period;
- Determine the dosing rate of dechlorinating solution; and
- Determine the best manner to apply the dechlorinating solution.

6.1.1 Steps

- Step 1 -* Prepare for the situation. Ensure there is excess dechlorinating agent on-site.
- Step 2 -* Measure the TRC. Use a field testing kit to do so. In this case, we will assume that the field testing kit indicated a TRC of 0.5 mg/L.
- Step 3 -* Record all of the activities during this situation. Use the record of activities sheet attached, or keep a record book.
- Step 4 -* Prepare the stock solution. Refer to Table 3-3. To prepare a 2% stock solution of sodium thiosulphate pentahydrate, one will need 20.3 grams of dechlorinating agent per litre of water or 92.4 grams per gallon of water, therefore to calculate how much would be needed to make a 45 gallon drum:
- $92.4 \text{ grams/gallon} \times 45 \text{ gallons} = 4,158 \text{ grams or } 4.2 \text{ kg,}$
- where there are 1,000 grams in a kilogram.
- Step 5 -* Determine the flow rate of water. Using Table 3-4 and assuming a flow velocity of 1.8 m/s, one notes that an 8" or 20 cm pipe has a typical flow rate of 59 LPS (litres per second). To determine the volume of water that would be discharged after 30 minutes, apply the following:
- $59 \text{ L/s} \times 60 \text{ s/minute} \times 30 \text{ minutes total} = 106,200 \text{ L or } 23,340 \text{ gallons}^7$
- Step 6 -* Determine the dosing rate. Using Table 3-5 for a 2% solution of sodium thiosulphate pentahydrate, and cross-referencing the TRC at 0.5 mg/L, one would need 354 mL of stock solution for every 10,000 litres of discharge water. Since the water is flowing at a rate of 59 LPS, the dosing rate would be:
- $(354 \text{ mL}/10,000 \text{ L}) \times 59 \text{ L/s} = 2.09 \text{ mL of dechlorinating agent per second or,}$
- $2.09 \text{ mL/second} \times 60 \text{ seconds/minute} = 125.3 \text{ mL/minute}$
- Step 7 -* Add the dechlorinating agent by using a chemical metering pump. The chemical metering pump can be attached to a 45 gallon/204 litre drum. An example of this set-up is shown in Figure 4-1. As in Figure 4-1, the

⁷ Remember that 1 litre = 4.55 gallons.

dechlorinating solution is directed into the flow of discharge water by having additional piping leading from the drum to the chemical metering pump, and from there into the discharge flow of water.

Step 8 - Check the TRC at least every 5 minutes throughout the operation to ensure that the dosing rate is sufficient to neutralize the chlorine in the water.

6.2 Scenario 2 - Permanent System

An industrial facility uses chlorinated municipal water as cooling water to circulate throughout the plant and discharges it to a river. Residual chlorine is present in the discharge water. The company decides to construct a holding pond to allow dechlorination prior to discharging the water to the environment.

The following conditions apply:

- Flow rate (Q) of water leaving the plant site = 5,000 m³/day
- Residual chlorine (TRC) measured in outfall = 1.0 mg/L
- 2% stock solution of sodium thiosulphate pentahydrate will be used as the dechlorinating agent

The following information needs to be determined:

- Flow rate in terms of litres per minute
- Dimensions of the pond
- Dechlorinating solution dosing rate

6.2.1 Steps

Step 1 - Preparation. Make sure that equipment and supplies have been assembled in order to ensure the best and most efficient construction of the holding pond.

Step 2 - The TRC is known to be 1.0 mg/L

Step 3 - Because this is a permanent operation, it is better to have a record book, rather than several sheets on-site.

Step 4 - Prepare stock solution. Since this will be an ongoing operation, it would be beneficial to prepare the stock solution in a large tank, such as a 3,000 gallon holding tank. With reference to Table 3-3, a 2% stock solution requires

20.3 g of sodium thiosulphate pentahydrate per litre of water. A 3,000 gallon tank holds 13,650 litres of water. Therefore, one would need:

$20.3\text{g/L} * 13,650\text{ L} = 277,095\text{ grams}$ or 277.1 kg^8 of sodium thiosulphate pentahydrate to make up one tank of solution.

Step 5 - The flow rate was given as $5,000\text{ m}^3/\text{day}$. It would be easier to know the flow rate in litres per day. In order to convert, use the following:

Since $1\text{ m}^3 = 1,000\text{ L}$, the flow rate of water leaving the site is:

$1000 * 5,000 = 5,000,000\text{ L/day}$.

There are 1,440 minutes in one day. Therefore the flow rate of water in litres per minute would be: $5,000,000\text{ L/day}$ divided by $1,440\text{ minutes/day} = 3,472\text{ L/minute}$.

Step 6 - Determine the dosing rate. Using Table 3-5, cross-reference a 2% stock solution with a TRC of 1 mg/L. The quantity of sodium thiosulphate pentahydrate 2% stock solution is 708 mL for every 10,000 litres of water discharged.

Since the flow rate is known, the dosing rate of dechlorinating solution can be determined as follows:

It will take:

$3,472\text{ L/minute} * 708\text{ mL}/10,000\text{ L} = 245.8\text{ mL of solution/minute}$ to dechlorinate the discharge water.

If the 13,650 L tank of dechlorinating solution is used, it will last for:

$13,650\text{ L} * (1000\text{ mL/L})^9$ divided by $245.8\text{ mL/minute} = 55,533\text{ minutes}$ or 925 hours, or approximately 1 month, assuming that the plant is in operation 24-hours a day.

⁸ Remember that there are 1,000 grams in a kilogram.

⁹ There are 1,000 mL in 1 Litre.

Step 7 - Add the dechlorinating agent. The dechlorinating agent should be added prior to the water entering the holding pond. To determine how large to construct the pond, refer back to *Section 4.0*.

With reference to the Table 4-1, a pond measuring 1 m deep by 4 m wide by 9 m long could provide a sufficient volume for mixing water flowing at a rate of 3,472 L/minute or 763 gallons/minute. A 0.5 m freeboard¹⁰ should also be used.

The injection rate of dechlorinating agent will be controlled by a chemical metering pump. The chemical metering pump should be housed in a shed and attached to the injection pipe leading to the holding pond. If flow rates are going to vary during different plant operations, a flow meter, and control panel connected to the chemical metering pump will be required to ensure that the dosing rate adjusts to the flow in the pipeline.

¹⁰ The freeboard is the area which extends above the high water mark of the pond.

PHOTOS



PHOTO 1:
Emergency Response Kit Safety Equipment

PHOTO 2:
Emergency Response Kit Chemical supplies





PHOTO 3:

Technician mixing a batch of sodium thiosulphate solution.

PHOTO 4:

Pumping sodium thiosulphate into a contact chamber.

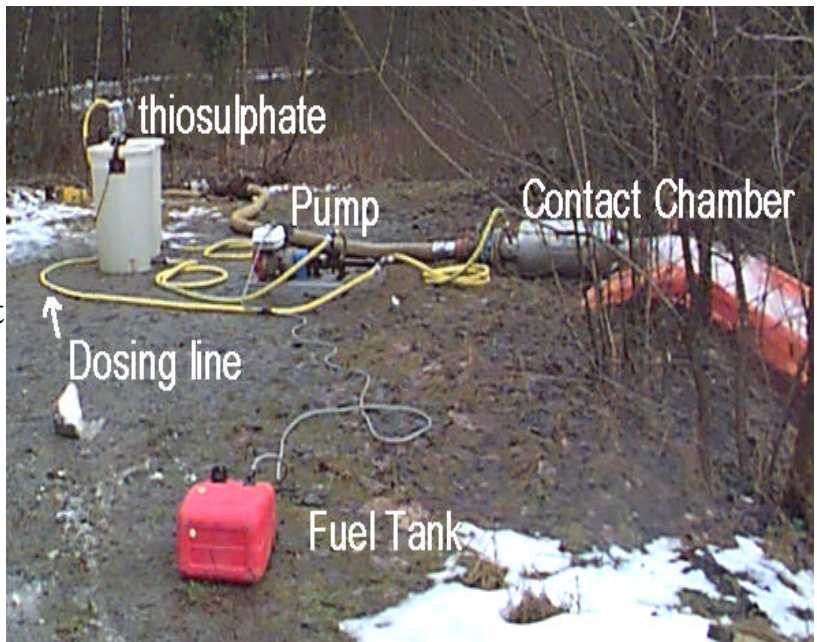




PHOTO 5:

Technician adding sodium thiosulphate to a creek.

PHOTO 6:

Measuring chlorine residuals



Photo 7 - Photograph of D-CHLOR[®] Unit
Front View



Photo 8 - Top view



**APPENDIX A
CHLORINE MONITORING KIT SUPPLIERS
AND
KIT SPECIFICATIONS**

A-1 - Chlorine Monitoring Kit Suppliers

Examples of some suppliers in the Lower Mainland where chlorine monitoring kits can be obtained:

Company	Phone	Web Page Address
Fisher Scientific	(604)872-7641 (Vancouver)	http://www.fisher1.com
Northwest Scientific Supply	(604)946-3837 (Ladner)	e-mail: nwscience@pinc.com
Anachemia Science	(604)270-2252 (Richmond)	n/a
Prairiechem	(604)941-3857	n/a
Van Waters & Rogers Ltd.	(604)273-1441	n/a

A-2 - Chlorine Monitoring Kit Specifications

A good chlorine monitoring kit should be capable of detecting within 0.01 mg/L increments such as that found in a pocket colorimeter. A colour wheel is preferred for ease of reference and to more accurately determine the residual chlorine measurement.

Reagents should be up-to-date, with the kit checked regularly to ensure that there are no expired reagents in the package.

APPENDIX B
RECORD OF ACTIVITIES SHEET

EMERGENCY RESPONSE RECORD

Equipment: Emergency Equipment and Supplies Kit (see attached)

Steps To Take:

1) *Keep Records of:*

Time of Break: _____(a.m./p.m.)

Personnel on Site/agencies/companies: _____

Who has been contacted: _____

PEP Yes () No ()

Department of Fisheries and Oceans Yes () No ()

Environment Canada Yes () No ()

Others: _____

Chlorine residual test results: use the attached table.

(be sure and state the units of measurement, time of measurement)

Type of dechlorinating agent used (e.g.: bags of sodium thiosulphate):

Steps taken to minimize effect of break (any berming, stop flow etc.):

2) *Is there any immediate danger to fish bearing streams? (Assume there is unless you are certain that this is not the case).*

Location of nearest outfall (stream name/water body etc):

RECORD OF DECHLORINATION ACTIVITIES

Date (m/d/y)	Location (Address)	Estimated Flow Rate of Water (include units, eg: gallons/minute)	Total Residual Chlorine (TRC) Measured in Water (mg/L)	Amount of Dechlorinating Agent Added (# of Bags or other)	pH Measured in Discharge Water	TRC Measured in Receiving Stream (note if it is upstream or downstream)	TRC Measured in Discharge Water After Dechlorinating Agent Added

Signature: _____

Print Name: _____

Date: _____

Telephone Number (Supervisor's Daytime #): _____

LONG TERM/CONTINUOUS FLOW CONTROL

Equipment: Emergency Equipment and Supplies Kit (see attached)
General Equipment on-site for long term use

Steps To Take:

1) *Keep Records on attached record sheet.*

2) *Record any significant changes in residual chlorine levels for both water on-site and effluent water.*

3) *Record any alterations to the flow rate and/or equipment already on-site.*

4) *Record any recent detectable residual chlorine levels. Were any regulatory agencies notified? (ie: fisheries, GVRD etc.). Was any emergency response required?*

APPENDIX C
Dechlorinating Agents

Dechlorinating Agent Suppliers
Table C1
Examples of Suppliers of Dechlorinating Agents

Source	Location	Phone #
Anachemia Science	Richmond	270-2252
Advance Chemicals Ltd. ¹¹	Langley	533-3901
VWR Scientific	Vancouver	873-5121
MacDonald & Wilson Ltd.	Surrey	888-7381
Prairiechem	Richmond	272-4000
Van Waters and Rogers Ltd	Richmond	273-1441

This is not an exhaustive list of local suppliers, however it indicates a sampling of suppliers in various geographic locations within the Lower Mainland.

¹¹ Pucks measuring approximately 7.5 cm in diameter and 140 g are available for sodium sulphite, but not for sodium thiosulphate. The pucks come in 45 lb/22.7 kg pails at a price of \$218.

APPENDIX D
Suggested Chemical Metering Pump Specifications

Chemical Metering Pump Specifications

The following outlines the suggested specifications for chemical metering pumps to be installed during dechlorination procedures¹².

General Requirements

The most suitable type of pump will be a diaphragm type pump with positive displacement. It should be mechanically activated complete with a pump, base and motor. If the pump requires transferring from site to site, it should be kept in a protective case to prevent damage during transport. Typical weights of portable pumps are 35 to 40 lbs.

Any parts that come into contact with the dechlorinating solution should be PVC or other corrosion resistant materials. Hoses are recommended to be nalgene, not the normal garden type hose as this is susceptible to deterioration.

It is recommended that the metered liquid enter the metering head at the bottom and exit at the top through gravity seating double (or spring-loaded single) ball check valves. The liquid head connectors should screw on. This eliminates clamps and metal parts that would otherwise be subject to corrosion. Alternatively, use stainless steel crimped bands which are attached by machine. The crimped bands do not allow tampering.

The diaphragm should be supported by a back-up plate. Unsupported flat diaphragms, diaphragms subject to severe stretching, and pistons unprotected or in contact with the feed solution are not acceptable. Pumps should have an isolation chamber to protect the pump body in case the diaphragm leaks. The chamber should have a drainage port that may be directed back to the solution tank. Alternatively, the chamber should be fitted with a leak probe with a contact that can turn the pump off or initiate an alarm. If the pump is a portable one used on-site for temporary purposes, the operator should monitor the pump to ensure that there are no leaks.

The pump should be capable of a manual stroke length adjustment in the range of 0 to 100% of the stroke capability. The stroke length adjustment should have a locking mechanism.

The pump should be checked regularly to ensure that no lubricating oil is leaking into the distribution lines.

¹² Pump specifications have been provided with the guidance of Hayward Gordon Pacific - Process Pumps and Mixers, North Vancouver, BC and Julie LaBonte & David Quinones of the San Francisco Water Quality Branch.

Chemical Metering Pump Specifications

Accessories

It is recommended that a spare parts kit be kept on-site. The kit should contain at a minimum, a spare diaphragm, a set of ball checks and seats, and all appropriate gaskets and o-rings for normal maintenance. Calibration columns are also recommended to test the feed rate of the meter prior to using the actual solution.

If the flow rate within a system will vary in time, a flow meter and associated sensor (4 to 20 milliamp signal) are recommended. The sensor would detect changes in the flow rate, send a signal to a control panel, which in turn would either automatically adjust the chemical injection rate, or inform the operator to adjust it manually.

Try to find a supplier who will demonstrate the product, and provide services as required.