7032 East Cortez Drive
Scottsdale, AZ 85254
(888) 788-5807
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www.hctllc.com

**Well-Klean® Solutions**
Water Well Rehabilitation / Restoration Program

**WaterSOLV™ Solutions**
Water & Soil
Plant Remediation Program
Hardness, Sodium, Slime

Solutions increasing the use, reuse, effectiveness and quality of water.



Select formulas accredited with;

The California Department of Food and Agriculture

Subject:

Mr. ,

Thank you for the opportunity to be of service for the rehabilitation of the Potable Water Extraction Well.

For the benefit of everyone new to our technology and services, HCT compares the well dynamics to experiences we have had across more than 800 well rehabilitations over the past 5 years, most wells located throughout the western USA, and with best practices accrued from more than 1,000 professional engineers from a variety of practices including chemistry, corrosion, microbiology, geohydrology and the like.

We have found it is imperative that the success of the rehabilitation for the optimum and longest lasting results is realized by everyone being on the same page with respect to processes and procedures, which may include energy products like air bursting, jetting and even the design of brushes and plungers. Following is what the empirical data recommends be done to this well. Following are more details and the degree of cleaning and methodology for your consideration.

HCT operates as a provider of technology, qualifying chemistry and processes. HCT has also comprised and developed the rehabilitation solutions, including qualifying chemistry, along with specific, detailed, required, processes and procedures. Contractors execute the processes and procedures and when subscribed to, HCT maintains an active role in the project to completion.

We appreciate your considerations.

Thank you.

Todd Eden
Founder
(480) 650-6955

Attachment(s);

Exhibit 1 - Registrations from both CDFA and NSF
Exhibit 2 – HCT Products Environmental Statement

# Contents

# ESTIMATION OF PERCEIVED WORST CASE SCENARIO

Data Reviewed

HCT has reviewed the following information in preparation of the rehabilitation of this well.

| | |
|---|---|
| Ground Water Analysis | ☒ |
| Drillers Log | ☐ |
| Completion Report | ☐ |
| Well Schematic | ☒ |
| Recent downhole video | ☒ |
| CITM Scan | ☐ |

The ground water analysis provides crucial data utilizing the Langelier Saturation Index to define whether the water has scale forming or scale dissolving properties. Groundwater parameters of sulfur, sulfate, iron and bacteria will contribute to indication of biological colonization. Combining the well Schematic, including alloys, age of the well, combined with any additional data, provides further insight to the condition of the well and to the culprits that have compromised it conditions (including production, physical and biological conditions). The CITM scan measures casing wall thickness. The historical data how the well has been operated and or cleaned, combined with visually inspecting the well, all comes together in a best practices' algorithm how this cleaning of this well should commence.

Treatment of the well incorporates a variety of modalities including physical and chemical energy as well as soak times, processes, procedures and specific tools.

## Basic Dynamics of the Well

Please refer to the attached: Water Well Criteria Submission

## Industry Statistics

Most wells, from a pool of more than 800 throughout the western United States, become problematic at 12 to 16 years of service. Most wells become problematic from either the precipitation of scale or mostly from biological colonization of aerobic and or anaerobic bacteria, aka iron reducing or sulfate reducing bacteria, respectively. Groundwater quality quantifies the potential where the Langelier Saturation Index will define the degree of water to either precipitate scale or dissolve scale and identify degrees of corrosion. Sulfur and sulfate levels lead to the potential of biological degradation, including corrosion at perforations and seams at levels as aggressive as 4 mils per year on mild steel. Such corrosion in not experience on stainless and PVC and yet much more concerning where steel louvers and wire wrap are in place.

## Casing Integrity

Casing integrity is assessed on the casing alloy, age of the well, type of perforations, water quality, dielectrics of alloys, a CITM scan if deemed needed and the presence of iron and/or sulfur/sulfate, and the number of bacteria in the ground water. Additionally, the presence of hardness in the ground water

with sulfur, supports the formation and growth of sulfate reducing bacteria (SRB) and associated nodules which can be extremely degrading to steel - SRB produce acidic and gaseous waste that reduces C1010 steel alloy at the rate of 4 mils per year, up to ¼ inch each 10 years.

Casing integrity identifies how much physical energy we can use to remove debris without compromising the well casing. Casing integrity is also of concern at the perforations, where bio-matter can attach and degrade the alloy within the perforations and cause filter pack loss, however not in this case being the perforations are stainless steel.

## Water Analysis

Groundwater quality is used to identify the sulfur levels that support sulfate reducing bacteria, and the parameters used to determine the Langelier Saturation Index (LSI) of the water for scale forming or scale dissolving tendencies.

## Prior Cleaning

Prior cleaning information is pertinent to realizing optimum and long-lasting results. Different cleaning techniques can move matter into the filter pack, which in turn can move colony forming bacteria further into the filter pack and more difficult to reach and mitigate without adding additional techniques. It is imperative of this well has been burst or jetted, it be disclosed for consideration in the cleaning recommendations.

## Rehabilitation Interpretations

The data in hand indicates this well is compromised by the colonization of primarily iron reducing bacteria with under deposit corrosion from sulfate reducing bacteria, without being compromised or interlaced with carbonate scale but perhaps by metallic oxides. This is founded on the groundwater quality and by empirical data and experience.

With sulfate levels low, this indicates the deterioration of casing and moreover at perforations, welds and threaded joints by sulfate reducing bacteria should not be significant, nor would there be encrustations or nodules.

The age of the well lends concern over the perforation gaps. A CITM scan can be recommended however the integrity of the louvers would be difficult to interpret with this method. The CITM scan indicates whether the well casing is in good order. This well is almost all perforated casing and not suitable for CITM scale interpretation. The CITM scan does not shed insight to the perforations and gaps thereof where such loss could cause the loss of filter pack. Therein we recommend another video and interpretation after brushing. At the same tip the level of the filter pack should be continually tagged. Preparation for adding filter pack in case of some loss should be considered.

Brushing and plunging techniques are manipulated to the highest efficiency with care taken to not damage the well casing and wire screen, and with regard to the perforations.

Prior Cleaning is always a major factor of assessing the well and optimum recovery. If the well has been high pressure jetted or where one directional has been deployed, there is concern over embedded biomatter in the filter pack. Bio-matter form colonies, where colonies of bio-matter within the filter pack can be difficult to reach mechanically and chemically for effective remediation. It appears this well has not been subjected to what we refer to as one directional energy.

# Water Discharge & Runoff, Chemically Treated and Non-treated Water, Biodegradation

The Well-Klean© and WaterSOLV™ Chemistry are founded on environmentally safe chemistry, marketed under varying labels and used for the treatment of water to agriculture, the water that is used to grow vegetables, fruits, nuts and herbs. The active ingredients are the same ingredients we use in out daily lives, and even within our body; hydrochloric acid, glycolic acid, amino acids, glycolates and also peroxide. Oxidized bacteria can be considered organic matter beneficial for most soil conditions, although where iron bacteria are prominent, the presence of red iron oxide can be temporarily unattractive yet extremely valuable to vegetation.

Well-Klean© products are accredited by the National Sanitation Foundation under Standard 60, for the offline use of the cleaning of potable water wells. NSF accreditation is also recognized by ANSI and the Canadian Standards Council. The same products, under alternative tradenames of WaterSOLV™, are accredited by the California Department of Food and Agriculture (CDFA) and as auxiliary soil and plants substance, for the treatment of water to agronomy (vegetation, architectural and food sources).

Registrations from both CDFA and NSF are attached hereto under Exhibit 1, along with HCT's Environmental Statement as Exhibit 2.

Well-Klean© Concentrate and Well-Klean© Pre-blend are degraded by alkali. The degradation products are considered nutritional when diluted in water, and or when neutralized with baking soda (sodium bicarbonate) and diluted with water.

WaterSOLV™ BC is biodegraded by reduction to pure water and dissolved oxygen.

All products disassociate chloride from sodium and calcium, and render sodium inert to vegetation toxicity.

Product Neutralizations:

| | |
|---|---|
| Well-Klean© Pre-blend | 1 lb. of sodium bicarbonate to 1 gl of product. |
| Well-Klean© Concentrate | 100 gl. water to 1 gl. of product. |
| WaterSOLV™ BC | 10 gl. water to 1 gl. product. |

December 27, 2019

HCT
Solutions to Water
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To Whom it may Concern

Subject: HCT Solutions Environmental Products & Overview

HCT is the developer of three proprietary solutions that is impacting the world with respect to the rehabilitation of water wells, as well as treating water that is applied to agronomy including nurseries, turf and agriculture.

Such chemistry is founded on conventional, commodity chemistry, comprised mainly of hydrochloric acid, acetic acid and hydrogen peroxide, all products used in proportion for the treatment of potable drinking water. This is NOT to imply these products may be used as potable water additives and it is explicitly noted they are NOT to be used as direct or indirect potable water additives.

In water well's, HCT's products are certified for "off-line use" for the cleaning, rehabilitation and or restoration of water wells, including potable, ASR and Vadose wells. By certified for use in wells, we are referring to the National Sanitation Foundation, a State Statute in 48 Western US States, and in many other Countries, of NSF Standard 60, where products used in and onto our drinking water systems are subjected to review, approval and an ongoing chain of custody beginning at the raw materials and carried throughout the production facilities to the end use.

Al HCT products prescribed in the use of water well rehabilitation, whether potable or not, are certified within the criteria of NSF Standard 60.

In agronomy, whether nurseries, turf or agriculture, HCT products are registered with the departments of food and agriculture, not as a nutrient, but as an auxiliary soil and plant substance, as defined by the California Department of Food and Agriculture.

| Product | NSF 60 Certification | CDFA Certification | Acidity | PPE as a concentrate |
|---|---|---|---|---|
| Well-Klean© Concentrate | X | | Weak acid | Relatively inert |
| Well-Klean© Pre-blend | X | | Strong acid | Highly acidic |
| WaterSOLV™ BC | X | X | Peroxide | Very Strong Oxidizer |
| WaterSOLV™ Curative | | X | Strong acid | Highly acidic |
| WaterSOLV™ AG | | X | Weak acid | Relatively inert |

NSF adjoining agencies accrediting include Underwriters Laboratories, Standards Council of Canada and American National Standards Institute. All products are organically inhibited to suppress corrosion and prevent the corrosion and oxidation of organic matter.

Disposal criteria will vary between states. The reaction products and biodegradation products of HCT products are typically considered nutrition to vegetation, including the dissolved solids and bio-matter, and when properly diluted and pH adjusted to a pH value greater than 6.0 units. Acid neutralization is recommended by the use of baking soda, sodium bicarbonate. Peroxide neutralization is recommended by dilution with water to less than 3% active peroxide.

Product Functionality

Well-Klean© Concentrate, HCT WaterSOLV™ AG

> Intermediate. Protonates the electron of sodium rending sodium inert, non-toxic to vegetation. Operates as an organic corrosion inhibitor to acids and oxidizers preventing the ionization of elemental metals and

organic matter from strong acids and oxidizers. Catalyzes acids through a wetting and wicking. Increases the solubilization of various bound carbonate salts and metallic oxides I water, the rate of solubilization,

types of scales dissolved and solubility of salts in water. By displacing oxides and carbonates with quazi acetates, most cations become a non-scaling nutrient more desirable and favorable for plant uptake resulting in plant vitality, heat and stress tolerance.

Self-life is indefinite. Thermally stable, non-fuming and technically non-corrosive. Similar to vinegar.

WaterSOLV™ Curative, Well-Klean© Preblend

Readily disassociates bicarbonate, converting carbonate bound cations to quazi acetate nutrition, or in water wells to TDS. Soak time result in the breakdown of metallic oxide deposits. Experienced to suppress the existence of low levels of black matter. Contains sodium protonation chemistry and prevent cations from reabsorbing carbon dioxide and reforming scale.

WaterSOLV™ BC

Utilizes peroxide linear to bacteria to prevent the formation of iron, sulfate and manganese bacteria. Bio-degrades to dissolved oxygen and water promoting an aerobic soil and vegetation profile aiding in plant vitality and plant resistance.

For technical support, contact HCT. We have done lots of tests and have lots of answers. Other applications apply, automotive, car wash, reclaimed water, injection wells, etc.

Todd R. Eden
Principal
(480) 650-6955
teden@hctllc.com

**Sustainable Chemistry Outside the Box of Conventional Wisdom**





## Potential Reactions

The goal of a rehabilitation is the optimum effectiveness and longest lasting results, predictable outcomes and safety. With HCT's program, the most concentrated forms of chemistry and most effective known, are utilized. Such comes with some risk, mainly from the use of hydrogen peroxide, where peroxide can be flammable onto wood and fibers.

Water Eruption - Likewise, peroxide can react with elemental iron within resulting in water being lifted from within the well under force.

Flammability - Additionally, a well head, even though a water well, is subject to be flammable from the release of oxygen and perhaps gaseous fractures.

Sink Holes – There are occasions where wells know to be developing sand could also cause hazardous conditions where he removal of sand by the well has created a potential for the existence of a potential sink hole.

These are all conditions that could exit that are not discernable by further investigation or prediction. All efforts are taken to keep aware of and to mitigate these potential occurrences.

October 21, 2019

To whom it may concern

Subject: Water Well – Rehabilitation
Potential Bioremediation Reactions

Thank you for the opportunity to be of service and for the potential to serve the rehabilitation of Potable Water Extraction Wells.

HCT has been working with water well contractors since 2013 and a multitude of their clients including the military, municipalities, electrical utilities and various well owners.

HCT is 5 years in the trade with over 800 completed well projects located mainly throughout the western USA between northern to southern borders.

The services and products provided by HCT are unique in that the services are provided under the scrutiny of chemistry and science and the products under the regulatory authorities of our drinking water. We are fortunate that we have developed products used in the rehabilitation of water wells that are the same products under different labels that are authorized for treating water used in the agronomy, including the water that is used to grow food. The products noted hereto are described and exhibited in the accompanying "HCT Products Environmental Statement".

HCT diagnoses wells and prescribes up to 5 products and a multitude / variety of processes and procedures for rehabilitating a water well.

1. Well-Klean© Pre-blend: A product containing mainly HCl with Glycolic Acid and other minor additives that converts scale in what is referred to as amino acetates, while deterring corrosion.
2. Well-Klean© Concentrate: A product containing mainly Glycolic Acid and other minor additives that participates in the sequestering water hardness and scale into amino acetates
3. Baking Soda: Sodium Bicarbonate used to neutralize acids and to re-passivate metals of well casing and components – deterring oxidation, rust and biological activity.
4. Chlorine: Disinfection
5. WaterSOLV™ BC: A product containing mainly Hydrogen Peroxide with Glycolic Acid and other minor additives that is very effective at remediating various forms of algae, bacteria and fungi, including mold and yeast, while also deterring corrosion.

The chemistry, processes and procedures hereto are readily found to be state-of-the-art with respect to efficacy – effectivness and durability of results based on current research, standards and empirical evidence.

Rewards of the optimium and most durable resultts also comes with some risk, with regards to chemical reactions within the well, as follows;

> Bioremediation is performed with WaterSOLV™ BC. Based on peroxide, once placing the product downhole, it can react with iorn particulate in the well – similar to dissolving scale in acid. Such a reaction can cause treated water to come of out the top of well. Provisions are taken to minimize the potential reaction but there is no quantative measures than can be taken to forecast or predict the event.

HCT Solutions to Water

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Solutions increasing the use, reuse, effectiveness and quality of water.



Select formulas accredited with;

The California Department of Food and Agriculture

NSF Certified to NSF/ANSI 60

ANSI Accredited Program PRODUCT CERTIFICATION

Standards Council of Canada
Conseil canadien des normes

We can alleviate the WaterSOLV™ BC and eliminate the potential reaction, but the cleanliness of the rehabilitation will be significantly comprimised and the longevity of such a cleaning greatly reduced. Doing this you could also face the potenital of exposing biology that would stop the reactivation of the well unitl resolved, which would lead to the use of the WaterSOLV™ BC to mitigate.

Potential Discharge State – As and Example;

Looking at the prescribed treatments, there is 10,400 gallons of water in the well casing, excluding the filterpack. There is 1.6% active peroxide prescribed to the body of water if considering no dilution from the filterpack. The peroxide is to be tremied at 20 ft. intervals, of which there will be 52 ea. 20 ft. intervals.

This calculates to 307 ppm of product per 20 ft. interval. For each interval tremied (added/treated) the ppm increases another 307 ppm. Household peroxide is 3% active – 30,000 ppm. The total treatment of this well with the peroxide solution will never exceed ½ the strength of household peroxide – and for each tremie it is 1/104$^{th}$ the strength of household peroxide.

Should a reaction occur, referred to as a burp, the biodegradation of the product should have likely already ocurred from the bacteria in the well, leaving the remaining byproducts dissolved oxygen and H2O. Such byproducts, as well as the reacted iron and sulfate reducing bateria, would commonly be beneficial for vegetation.

Should you have additional questions, please give us a call.

Thank you.

Todd Eden
Principal
(480) 650-6955
teden@hctllc.com



# Rehabilitation Approach - Best Practices to be incorporated

1. Frayed wire brush - do not scarify.
    a. Aggressively – 5 minutes per 10 ft segment
2. Remove all debris from the bottom of the well
3. Tremie then plunge Bio-remediation solution
    a. 10 ft. triple V cut plungers
    b. 5 minutes per perforated segment
    c. Soak 36 hours
4. Repeat Steps 3., a, b and c
5. Zonal plunge and lift with water
    a. Maximum 10 ft. tool and suction equivalent to 60 gpm, until water runs clean.
6. Remove debris from the bottom of the well
7. To meet NSF 60 Standards, assure well is flushed with a minimum of 352,000 gallons.
8. Disinfect the well by tremeing water and chlorine.
    a. Disinfect in accordance with AWWA C654-13 or most recent edition. Chlorine used to disinfect the well shall result in a chlorine residual in the well ranging from 50 to 200 mg/L throughout the entire well.

b. The solution shall remain in the well for a minimum of 12 hours.
c. Remove the chlorine solution from the well within 24 hours.

9. Safe Drinking Water Biological Testing
    a. Three bacteriological analysis reports for samples collected on three successive days showing raw well water to be free of coliform organisms
    b. If coliform bacteria are present in the well, disinfect the well again as specified, incorporating plunging during the 12-hour soak period.
10. LAYUP CHEMISTRY WOULD BE REQUIRED IF THE WELL IS TO SIT IDLE LONGER THAN 1 WEEK.
    a. 200 lbs. sodium bicarbonate to 800 gallons of water mixed drained into the well.
11. Disinfect all permanent equipment and material to be installed in the well just prior to its installation. Spray all exposed areas of the items with a solution having a total chlorine concentration of >/= 200 mg/L.
12. Gradually re-develop the well by ramping up to full production.

## Assurances

We do not foresee anything unusual about this well that would hinder it from being restored to optimum productivity, other than the concern of the perforation gaps.

## Chemistry Volumes

| Chemistry Volumes | Product Qty. | Packaging gl/lb | Chemical Unit Volumes |
|---|---|---|---|
| WaterSOLV BC - Peroxide, 53 gl | 2.0 | 53 | 106 |
| Peroxide IBC 90% fill, 248 gl short fill | 4.0 | 248 | 992 |
| Well-Klean ® Concentrate, 5 gl | 4.0 | 5 | 20 |
| Well-Klean ® Concentrate, 55 gl | 2.0 | 55 | 110 |
| Sodium Bicarbonate, 50 lb bag - Neutralizer, Passivation, Layup Solution | 4.0 | 50 | 200 |
| Sodium Hypochlorite 12.5% (If Potable) 5 gl. pail (other) | 2.00 | 5 | 10 |
| Total Product Units | 18.0 | | |
| Water Safety, gl. per person over well | 55 | | |
| Water, Safety, gl., Spill of 100% of product | 10,980 | | |

## Treatment Levels

| Process | Product Name | Application Rate | Product Gallons | % Active at Use Level |
|---|---|---|---|---|
| Bioremediate | WaterSOLV™ BC | 48,000 ppm | 614 | 1.6 |
| | WaterSOLV™ BC | 48,000 ppm | 614 | 1.6 |
| Disinfection | 12.5% Chlorine | 70 ppm | 7.3 | 0.0007 |

# Scope of Work

**Page 1**

City of Santa Fe, NM
Torreon Water Well Rehabilitation
Version 3.1D
October 9, 2019

Contact:

HCT, LLC
T Eden
(480) 650-6955
Teden@hctllc.com

### *Well Data*

| Well Data | |
|---|---|
| Video, Date & No. Vids | 8/13/19 – 1 dropbox |
| Well Completion Report | - |
| Well Schematic | Yes |
| Ground Water Quality | 2018 - non-scaling |
| Sulfate, mg/L | 10 |
| **Well Information** | |
| Age of well (durability) | 22 years |
| Casing alloys | Steel |
| Diameters | 16 inch |
| Perforation Lengths. ft. BGL | 410-610, 620-1210 |
| Perforation types | Louvered |
| SWL, ft. BGL | SWL 196 |
| Aerobic Zones | All |
| Anaerobic Zones | Beneath, all |
| Fill Depth | 1,233 |
| Total Depth | 1,235 (est.) |
| No. 10 ft. intervals | 101.4 |
| Prior Cleaning | None noted |
| Unique Conditions | Age, Louvered, Filter Pack Loss possible |
| CITM Scan | Not viable, all louvered |
| No. 10 ft. Intervals from SWL | 104 |

Continued . . .

## *Preparation*

Contents



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1. Licenses
    a. Contractor must have a current New Mexico Well Drillers Pump Installers license to perform such work. Well Owner shall obtain the necessary approvals and permits from local, state and federal agencies including discharge and disposal of materials from the within the well, if required.

2. Safety
    a. Contractor shall be certified under the HCT Chemical Safety Program.
    b. As part of this process, Contractors must certify that its employees have, or will have, appropriate training on the following subjects:
        i. Basic health and safety issues,
        ii. the Contractor's health and safety programs, and
        iii. the methods and techniques the Contractor will use on the project,
        iv. Procedures for Contractor entrance into and exit from the area of work, and
        v. Informing EPECO about any unique hazards presented by the Contractor's work or found as a result of the Contractor's work.
    c. Provide a health and safety plan for performing the work before starting the disinfection of any Well.
    d. Signage
        i. Site Safety Placards – oxidizer, corrosive
        ii. Well Head Safety Placard – flammable
    e. Potable Water
        i. Sufficient potable water as specified herein in case of accidental loss of 100% of the peroxide
        ii. Personal Safety – 55 gallons per person on the job site, ready to use
    f. Eye Wash and Safety Shower
        i. One per person working over or near the well head or chemistry
        ii. Unobstructed access located within 5 seconds of possible exposure
        iii. Relocate as needed or place additional units where necessary to meet safety criteria established hereto
    g. Personal Protection Equipment (PPE)
        i. Including but not limited to steel toes shoes, long sleeve shirts, hard hat, safety glasses, safety vest, chemical splash face shield, rubber gloves, rubber apron, NIOSH approved ventilator for Organic Vapor/Acid gas (Magenta/Yellow), a self-contained breathing apparatus (SCBA) if fresh air is not continual and assured.
    h. Documentations



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i. Safety Data Sheets



ii. Multilingual Safety Field Guide

i. Daily Log
   i. Daily Safety Qualifications, Sign-in, Check-list, activity to Scope of Work

j. Product Storage
   i. Keep Well-Klean© Pre-blend and WaterSOLV™ BC separated
      1. Assure accidental loss drains safely
      2. Assure in case of spillage, Well-Klean© Pre-blend and WaterSOLV™ BC do not mix
   ii. Always store products in upright position, sealed and adequately vented
   iii. Secondary containment is recommended

k. Adequate ventilation is MANDATORY at all times

3. Equipment/Tools

Contractor shall provide the following equipment;

a. Brushes
   i. Polypropylene (not nylon) or frayed wire as specified, fixed in place, the same diameter of the inner diameter of the casing, constructed of a spiral configuration similar to a drill bit, wherein a 10-ft. stroke shall result in the brush covering 720 degrees of brushing.
      1. Specified Brush Casing ☐ Polypropylene ☒Frayed wire - light
      2. Specified Brush Perforations ☐ Polypropylene ☒Frayed wire - light
      3. Specified Maximum Brush length may be; ☐10 ☒ 20 ☐ 30 ft. length

b. Double Dual Plunge Discs
   i. Constructed of heavy rubber, ½ inch thick, the same inner diameter of the casing, fixed in place.
      1. Each disc shall be slotted ☐ ¼ inch in width - ☒ V's 1 ½ inches, ☐ 4 - ☒ 8 - ☐ 16 slots, placed evenly across the diameter of the disc.
      2. Each disc shall be slotted a minimum of 30% deep.
      3. The metal plates supporting the disc shall be 70% the diameter of the rubber.
      4. One 10 ft. tool with two discs, top and bottom

c. Tremie
   i. 100 gl. or more container, where the appropriate amount of chemicals will be placed and gravity feed into the treatment zones.
      1. Chemicals shall not be pushed out of the targeted zone with water.
      2. WaterSOLV BC may be diluted 3-fold with water above ground, then placed into the treatment zone.

CAUTION – IF THERE MAY BE ELEMENTAL IRON IN THE BOTTOM OF THE WELL, OR ELEMENTAL METALS INCOMPATIBLE WITH PEROXIDE, THE MATTER AT THE BOTTOM OF THE WELL SHALL BE THOUOUGHLY REMOVED PRIOR TO TREMING.

Many common materials of construction such as iron, steel, copper, brass, nickel and chromium are not suitable for handling solutions of hydrogen peroxide, and recommended materials must be used. See Table 1 for incompatible materials.

ii. Tremie pipe shall be PVC, stainless, clean iron piping or Viton hose.
iii. All fittings, connection and equipment shall be suitable for use with 34% hydrogen peroxide.
iv. Operator(s) may tremie up to a maximum of 20 ft. at one time.
v. A check valve or ball valve must be placed on the tremie line to prevent back pressure and back pressure from entering the treatment solution containers.
    1. The check-valve must be acid and peroxide compatible – Check Compatibility **Table 1.**
    2. A ball valve should be used to divert tremie pressure back into the top of the well casing. Such ball valve shall be acid and peroxide proof. Check Compatibility **Table 1.**

d. Zonal Pump and Lift Tool
    i. The tool shall be constructed of the double dual plunging discs as specified above.
    ii. During the zonal pump and lift process, the distance between the inner most plunging discs shall be no more than ☐5 ft. ☒10 ft. ☐20 ft. when plunging and 10 ft. when plunging and lifting – 5 ft. preferred depending on pumping rate.
    iii. The end cap shall be closed when Pre-cleaning, Remediating and Descaling and open 1 inch during the Passivation, Neutralization.
    iv. The pump shall lift the water from the annulus, into the tool, above ground, into a settling tank.
    v. Water shall be pumped onto the top of one end of the settling tank. The other end of the settling tank can be plumbed back into the well.
        1. For injection wells, the discharge shall be sent to a frack tank and no water from the pumping shall be paced back in to the well.
    vi. Piping to the settling tank should be equipped with a valve for taking water samples.
    vii. If the water exiting the tank is murky with visible debris, a secondary settling tank shall be setup.

e. Samples and Bottles
    i. 400 ml, clear wide mouth containers (Barrel Accessories - Sun West Container Co.- www.sunwestcontainer.com - BOT 7262P Bottle - BOT 6962 Cap - $0.67 each, 12 per box).

f. Chemical Container Hoist
    i. Shall be OSHA Approved

g. Cleanup
    i. When Well-Klean© Pre-blend is used, all tools and equipment shall be hydro blasted with sodium bicarbonate and water to rinse equipment of sodium and chlorides which can lead to various forms of corrosion, including surface pitting and crevice corrosion (as in threaded couplers).

1. Blend ratio of sodium bicarbonate to water is 1 lb. to gallon.
    a. Such material is beneficial to agriculture and horticulture.

**Scope of Work**
**Page 5**

h. Downhole Videos
    i. The video should have a descend rate of about 30 ft. per minute. It should stop and take a side view of any anomaly; such anomaly should have a still image of 5 seconds. Each casing joint should be videoed 360 degrees over 5 to 10 seconds depending on the severity of any anomalies. The fill should be tapped with the camera to demonstrate the density of the fill. The video should continue throughout the camera extraction.
i. Lifting Debris from the bottom – Fill
    i. Whenever lifting debris from the bottom, a representative sample should be grabbed, labeled and retained for inspection. Include at which process the sample was taken.

4. Supplemental Energy Products
    a. None

***Processes and Procedures***

Contents

1. Brush
2. Bail
3. Bio-remediation I
4. Bio-remediation II
5. Plunge & Lift
6. Disinfect

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1. Initial Cleaning
    a. Brush the casing with the specified brush to physically remove as much material as possible.
    b. After brushing, remove matter from the bottom of the well with a bailer.

2. Bio-remediation I
    a. Tremie into place 614 gallons of WaterSOLV™ BC - consisting of 53 gallons WaterSOLV BC, 2 totes of hydrogen peroxide with 30 gallons each of Well-Klean© Concentrate (**NOT Well-Klean© Pre-blend**)
        i. Per 10 ft. Blank Interval – 4.8 gallons
        ii. Per 10 ft. Perforated Interval - 6.3 gallons
    b. Triple Disc Plunge each interval 5 minutes
    c. Allow to soak minimum to 36 hours

3. Bio-remediation II – Repeat Step 2.

4. Plunge & Lift
    a. Subjectivity: Zonal plunging and lifting is subjective to varying zone conditions where some zones may be clear in seconds, and other zones may not clear for hours and even days. Focus on

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zones that do not clear can be due to fishers of colonies of bacteria of both aerobic iron and anaerobic sulfate, within the filter pack and strata. The overall amount of time could be defined where the time saved in areas that cleared could be allocated to go back to the areas that did not clear. The removal of the matter is essential as colonies of bacteria reproduce exponentially. Therefore, the more that is removed the more effective the cleaning and likely the longevity.



i. Log zones for time and clarity
ii. Starting at the top - zonal plunge as specified.
iii. Complete process by removing debris from the bottom of the well.

5. Video Inspection of the well is recommended.

6. Disinfection
    a. Prepare above ground a solution of 7.3 gallons of chlorine and 6,385 to 12,770 gallons of water.
    b. Tremie into place and lightly swab throughout the well casing and screens.
        i. Based on 12,770 gallons of water
            1. Per 10 ft. casing interval – 100 gallons
            2. Per 10 ft. Perforated casing – 130 gallons
    c. Allow to soak a minimum of 12 hours, no more than 24 hours.
    d. Evacuate the solution from the well within 12 hours of addition to the well, after 12 hours minimum exposure.

7. Flush
    a. To NSF Standard 60 Standards, flush the well a minimum of 352,452 gallons.

8. Pass safe drinking water standards prior to use for human consumption. See Rehabilitation Approach, Item 8.

9. Layup Procedures
    a. If this well remains offline for an extended period of greater than 7 days, the well casing should be flooded with soda water to deter biological growth.
    b. For every 10 gallons of water, add ¼ lb. of sodium bicarbonate.

## Table 1 – Peroxide Materials Compatibility

| Suitable Materials | Not Compatible Materials |
|---|---|
| Aluminum; 5254, 1060, B356<br>Stainless Steel; 316, 304L<br>Plastics: HDPE, PTFE, PVC*<br>Gaskets; Viton, Teflon, PP363 Vinyl, Garlock, Gylon<br><br>* *Short term contact only* | Carbon Steel<br>Brass<br>Bronze<br>Lead<br>Copper Chromium<br>Mag Alloys<br>Nickel<br>Monel<br>Lubricating Oil<br>Pipe Dope<br>Graphite<br>Fiberglass<br>Nylon<br>Epoxies |

## Container Volumes, gallons per inch

| | | | |
|---|---|---|---|
| 55 gl drum | upright | 1.6 | gallons per inch |
| | sideways | 23.25 | gallons per inch |
| 275 gl IBC | | 6.1 | gallons per inch |
| 330 gl IBC | | 7.5 | gallons per inch |

Under 50 gl, reduces to 7 gallons per inch

## Water Volume in Piping per ft.

| Pipe Volume Guide | | | | | |
|---|---|---|---|---|---|
| 3 to 8 in. | | 9 to 17 in. | | 18 to 32 in. | |
| Diameter of Casing (inches) | Gallons per foot of Depth | Diameter of Casing (inches) | Gallons per foot of Depth | Diameter of Casing (inches) | Gallons per foot of Depth |
| 3.0 | 0.37 | 9.0 | 3.31 | 18.0 | 13.22 |
| 3.5 | 0.50 | 10.0 | 4.08 | 19.0 | 14.73 |
| 4.0 | 0.65 | 11.0 | 4.94 | 20.0 | 16.32 |
| 4.5 | 0.83 | 12.0 | 5.88 | 22.0 | 19.75 |
| 5.0 | 1.02 | 13.0 | 6.90 | 24.0 | 23.50 |
| 5.5 | 1.23 | 14.0 | 8.00 | 26.0 | 27.58 |
| 6.0 | 1.47 | 15.0 | 9.18 | 28.0 | 31.99 |
| 7.0 | 2.00 | 16.0 | 10.00 | 30.0 | 36.72 |
| 8.0 | 2.61 | 17.0 | 11.79 | 32.0 | 41.78 |



## Required Attachments

1. Best Practices
2. Well-Klean© Solutions Safety Test

# Biocides for Industrial Use

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

**ANS Controls:** See Table 1 of this fact sheet for a list of biocides.

**Targeted Species:** Biocides may control many types of species. See Table 2 of this fact sheet for the types of Organisms of Concern – CAWS that may be controlled by biocides.[1]

**Selectivity:** Biocides are non-selective. See Table 2 for more details.

**Developer/ Manufacturer/ Researcher:** There are many manufactures of biocides.


**Biocides are chemicals designed to kill all sizes and life stages of organisms, especially microorganisms.**

**Pesticide Registration/Application:** Pesticides, including biocides, must be applied in accordance with the full product label as registered by the U.S. Environmental Protection Agency (USEPA). Users must read and follow the pesticide product label prior to each application. The registration status, trade name, and availability of pesticides are subject to change. The listing of a pesticide in this fact sheet or Appendix B does not represent an endorsement by the U.S. Army Corps of Engineers or the USEPA regarding its use for a particular purpose.

**Brief Description:** Biocides are chemicals designed to kill all sizes and life stages of organisms, especially microorganisms, and the effectiveness of biocides varies with the concentration of a biocide and duration of the exposure. Species that are exposed to sub-lethal concentrations, or for too short of time, may be injured but may survive.

Biocides are used for drinking water treatment, wastewater treatment, ship ballast water treatment, disinfectants and as antifouling agents that prevent mollusks from accumulating in industrial pipes. Biocides are produced in liquid and powder forms, in ready-to-use formulations or as concentrates, and are applied using a variety of techniques. Table 1 provides a list of biocides that have been evaluated to potentially control or inactivate ANS in ballast water. Though examined for use in ballast water treatment, these biocides may be effective at controlling select Organisms of Concern – CAWS[2] (Bowman et al. 1998, Chattopadhyay et al. 2004, TenEyek 2009). See Table 2 and the *General Effectiveness* and *Operating Constraints* sections of this fact sheet for more information on biocide effectiveness.

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[1] For a list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.

[2] Algaecides, herbicides, molluscicides and piscicides are also considered biocides. They are each covered in more detail in separate fact sheets (titled "Algaecides," "Aquatic Herbicides," "Molluscicides," and "Piscicides").

Depending on the type of biocide, ship ballast water treated with biocides must be detoxified using methods that avoid discharging unwanted concentrations of residual biocide and toxic byproducts into the environment (Chattopadhyay et al. 2004). Many biocide applications for ballast water treatment require chemical neutralization prior to discharge. Most ships neutralize treated ballast water before discharge, but some rely on minimum hold times to provide an opportunity for sufficient degradation of residuals (Lloyd's Register 2010). Water temperature and salinity affect the rate at which chemical biocides function and break down (Albert et. al. 2010).

**Prior Applications:** Biocides are widely used in the health, food, and water treatment industries. Biocides have been studied as a means to prevent ANS introductions in ballast water via international shipping (Chattopadhyay et al. 2004).

**General Effectiveness:** Biocides used in industry can be effective at controlling ANS when used properly. Factors that influence the efficacy of biocides on microorganisms and other aquatic species include the biocide's chemical properties, the size and characteristics of the organism, biocide concentration, treatment/application process, contact time, and water quality (e.g., salinity, pH, temperature, oxygen content) (Chattopadhyay et al. 2004).

The U.S. Coast Guard (USGS) Research and Development Center conducted a qualitative assessment of potential ballast water biocides and their effect on different organisms (Table 2). For this qualitative assessment, this evaluation of biocide effectiveness does not consider conditions under which the biocide was tested; rather the evaluation considers only whether the outcome of the study resulted in the desired effect. Except for otherwise noted, the information on biocide effectiveness referenced in this fact sheet was obtained from literature search conducted to complete USGS's assessment and was not the result of scientific research targeted specifically for ballast water treatment or use in an open flowing system, and must be used cautiously (Chattopadhyay et al. 2004).

**Operating Constraints:** Biocides have specific use restrictions and requirements, which are found on the product label. The following are only a few of the numerous operating constraints that would require consideration. To be effective, target concentrations and specific contact times must be obtained throughout the water column. Additionally, depending on the selected biocide, it may be necessary to deactivate or neutralize the biocide to avoid killing non-target organisms upon release of treated water, or downstream of a treatment area. Certain biocides may create toxic by-products, persist in the environment and accumulate in sediment, making sediment reuse or disposal problematic.

A compilation of the physiochemical properties, treatment efficacy against target organisms, environmental acceptability, and other vendor information for many biocides can be found in Chattopadhyay et al. (2004).

**Table 1. Biocides Considered for Potential Treatment of Ballast Water**
(adapted from Table 3-1 and Table 3-3, Chattopadhyay 2004[3] unless otherwise noted in footnote)

| Biocide | Common Application | General Characteristics |
|---|---|---|
| **Metal** | | |
| Silver (ionic or salts) | Disinfection of industrial water systems | • Limited applications of metal ions or salts<br>• Not generally used due to human side effect risk |
| **Oxidizing – *Halogen containing compounds*** | | |
| Bromine | Disinfection of drinking water, cooling systems, and surfaces | • Corrosive<br>• Presence of organic matter limits the effectiveness and may require higher dosage<br>• Residuals remain in water after treatment<br>• Possibly create harmful byproducts<br>• Requires frequent applications<br>• Presence of organic matter limits the effectiveness and may require higher dosage |
| Chlorine (free chlorine, hypochlorous acid, hypochlorite salts) | | |
| Chlorine dioxide | | |
| Iodine | | |
| Sodium chlorite | | |
| **Oxidizing – *Non-halogen containing compounds*** | | |
| Hydrogen peroxide | Disinfection of drinking water, cooling systems, and surfaces | • Presence of organic matter limits the effectiveness and may require higher dosage<br>• Moderately corrosive<br>• Some residuals remain in water after treatment |
| Potassium permanganate | | |
| **Oxidizing – *Acids*** | | |
| Peracetic acid (Peraclean®) | Wastewater treatment | • Effective disinfectant with no known toxic residual<br>• More potent than hydrogen peroxide<br>• Rapidly active at low concentrations against a wide range of microorganisms<br>• Corrosive<br>• Highly efficient in presence of organic matter |
| **Non-oxidizing Biocides – *Aldehydes*** | | |
| Glutaraldehyde | Disinfectant in hospitals, laboratories, and biological fixatives | • Slight to moderate efficiency in presence of organic matter<br>• Some residuals remain in water after treatment |

[3] Of the biocides that are identified in the *Chattopadhyay, 2004* paper, only ones that are not identified in a different fact sheet or that have been found to be effective on the ANS of Concern – CAWS are included. Biocides identified in *Chattopadhyay, 2004* but are found in other fact sheets are copper compounds found in the "Algaecides" and "Molluscicides" fact sheets, and ozone found in the "Alteration of Water Quality" fact sheets. Biocides listed in the *Chattopadhyay, 2004* report that were not included because they were not effective on the ANS of Concern – CAWS are the following: cationic surfactants, Grotan, and zinc pyrithione. Formaldehyde was not included as it was classified as a carcinogen in the 2011 National Toxicology Program in it Twelfth Report on Carcinogens.

**Table 1 (cont.). Biocides Considered for Potential Treatment of Ballast Water**
(adapted from Table 3-1 and Table 3-3, Chattopadhyay 2004[4] unless otherwise noted by footnote)

| Biocide | Common Application | General Characteristics |
|---|---|---|
| **Non-oxidizing Biocides** - *Amines and halogenated amides* | | |
| Dibromonitrilopropionamide (DBNPA) | Pulp and paper water treatment systems; disinfection of industrial water systems | |
| Fatty amines (Mexel® 432) | Corrosion inhibitor; scale dispersant | • Rapid degradation in the environment |
| **Non-oxidizing Biocides** - *Heterocyclic ketones* | | |
| Polyhexamethylene biguanide (PHMB) | Disinfection of industrial water systems | |
| Isothiazolone (Sea-Nine®) | Antifouling agent | • Proposed as alternative to organotin compounds (chemical compounds that contain at least one bond between tin and carbon) |
| **Other Biocides** | | |
| 2-Thiocyanomethylthio benzothiazole (TCMTB) | Disinfection of industrial water systems; antifouling agent | • Proposed as alternative to organotin compounds (chemical compounds that contain at least one bond between tin and carbon) |
| Benzalkonium chloride | Disinfection of industrial water systems | • Corrosive |
| Chlorothalonil | Fungicide | • Proposed as alternative to organotin compounds (chemical compounds that contain at least one bond between tin and carbon) |
| Dichlofluanid | Antifouling agent | • Proposed as alternative to organotin compounds (chemical compounds that contain at least one bond between tin and carbon) |
| 1-(3-Chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride | Metalworking fluids, preservative for paints | • Not persistent and degrades rapidly under acidic conditions |
| 2-Methylthio-4-tertbutylamino-6-cyclo-propylamino-striazine (Irgarol® 1051) | Antifouling agent | • Proposed as alternative to organotin compounds (chemical compounds that contain at least one bond between tin and carbon) |
| Phenol | Disinfectant | • Low corrosivity<br>• Little or no residuals remain in water after treatment |
| Vitamin K (SeaKleen®) | Ballast water treatment | • Toxic to a broad spectrum of marine and freshwater organisms (fish larvae and eggs, planktonic crustaceans, bivalve larvae, *Vibrio* bacteria, and dinoflagellates) |
| Sodium hydroxide [5] | Saponification; food preparation, cleaning agent, industrial drilling, paper making | • Also known as lye, caustic soda, and sodium hydrate<br>• Caustic washing |
| Triclosan | Wastewater treatment | • Stable and incompatible with strong oxidizing agents |
| Zineb (thiocarbamate) | Disinfection of industrial water systems; antifouling agent | |

[4] Of the biocides that are identified in the *Chattopadhyay, 2004* paper, only ones that are not identified in a different fact sheet or that have been found to be effective on the ANS of Concern – CAWS are included. Biocides identified in *Chattopadhyay, 2004* but are found in other fact sheets are copper compounds found in the "Algaecides" and "Molluscicides" fact sheets, and ozone found in the "Alteration of Water Quality" fact sheets. Biocides listed in the *Chattopadhyay, 2004* report that were not included because they were not effective on the ANS of Concern – CAWS are the following: cationic surfactants, Grotan, and zinc pyrithione.

[5] (Bowman et. al. 1998), (TenEyek 2009)

**Table 2. Summary of Biocides Considered for Ballast Water Treatment Adapted From Chattopadhyay 2004[6] Unless Otherwise Noted by Footnote**

| | May Be Effective on ANS of Concern – CAWS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Biocide** | **Algae** | **Annelid** | **Bryozoan** | **Crustacean** | **Fish** | **Mollusk** | **Plant** | **Protozoan** |
| **Metal** | | | | | | | | |
| *Silver* | x | | | | | | | |
| **Oxidizing** | | | | | | | | |
| *Halogen containing compounds* | | | | | | | | |
| Bromine | | x | | x | x | x | | |
| Chlorine (free chlorine, hypochlorous acid, hypochlorite salts) | x | x | | x | x | x | | |
| Chlorine Dioxide | | x | | | x | x | | |
| Iodine | | | | x | | x | | |
| Sodium Chlorite | x | x | | x | x | x | | |
| *Non-halogen containing compounds* | | | | | | | | |
| Hydrogen Peroxide | x | x | | x | | x | | |
| Potassium Permanganate | x | x | | x | | x | | |
| **Non-oxidizing** | | | | | | | | |
| *Acids* | | | | | | | | |
| Peraclean (peracetic acid) | | | | | x | | | |
| *Aldehydes* | | | | | | | | |
| Formaldehyde | x | x | | x | x | x | | |
| Glutaraldehyde | x | x | | | | x | | |
| *Amines and halogenated amides* | | | | | | | | |
| Dibromonitrilopropionamide (DBNPA) | x | | | x | | | | |
| Mexel® 432 (fatty amines) | | x | | | | x | | |
| *Heterocyclic ketones* | | | | | | | | |
| Polyhexamethylene biguanide (PHMB) | | x | | | | x | | |
| Sea-Nine (isothiazolone) | x | x | | x | | x | | |
| *Others* | | | | | | | | |
| 2-thiocyanomethylthio benzothiazole (TCMTB) | | x | | x | x | x | | |
| Benalkonium chloride | | x | | x | x | x | | |
| Chlorothalonil | | | | x | | | | |
| Diclofluanid | | x | | | x | x | | |
| Dowicil® 75 (N-(3-chloroallyl)hexaminium chloride) | | | | x | | | | |
| Irgarol® 1051 (2-methylthio-4-tert-butylamino-6-cyclo-propylamino-s-triazine) | | | | | x | | | |
| Phenol | | x | | | | | | |
| SeaKleen® (Vitamin K) | x | x | | x | x | x | | |
| Sodium Hydroxide[7] | x | x | | x | x | x | | |
| Triclosan | | | | | x | | | |
| Zineb (thiocarbamate) | | | | | x | | | |

[6] Except for sodium hydroxide, a biocide was considered effective and designated with a "X" if the LC50 (i.e., the biocide concentration that is lethal to 50 percent of the tested organisms) was determined to be 1,000 micrograms per liter (µg/L) or less, if the EC50 (i.e., the effective biocide concentration at which 50% of the tested organisms are impacted) included mortality of the organism as an impact, or if the reviewed literature designated the biocide as "effective." "May Be Effective on ANS of Concern – CAWS" was designated with an "X" in this Table and Appendix A if the above criteria were met.

[7] (Bowman 1998), (TenEyek 2009)

**Cost Considerations:**

*Implementation:* Implementation costs of biocide applications would include the cost of the biocide, the detoxicant (if required to neutralize the biocide), and the application method. Planning and design activities in this phase may include research and development of this Control, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

*Operations and Maintenance:* Operations and maintenance costs would include application of the biocide and detoxicant, and effectiveness and water quality monitoring programs.

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

**Citations:**

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Greenman, D., K. Mullen, & S. Parmar. 1997. Ballast water treatment systems: a feasibility study. United States Coast Guard Office of Response, Worcester Polytechnic Institute

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