WOODARD
&CURRAN

Design Basis Report

Former HoltraChem
Manufacturing Site
Orrington, Maine

Prepared for:
Mallinckrodt US LLC

213894.00

August 19, 2011

woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS

TABLE OF CONTENTS

SECTION PAGE NO.

1. INTRODUCTION 1-1

2. PERMITTING 2-1
    2.1 Discharge Limits 2-1
    2.2 Planned or Potential Modifications to Wastewater Discharge License 2-1

3. FLOWS AND LOADS 3-1
    3.1 Current Flows and Loads 3-1
    3.2 Future Flows and Loads 3-1
        3.2.1 Streams Requiring Silica or Solids Removal 3-2

4. PRE-DESIGN STUDIES 4-1
    4.1 Existing Treatment Plant Review 4-1
        4.1.1 Existing Treatment System Description 4-1
            4.1.1.1 Silica Pretreatment Process 4-1
            4.1.1.2 Primary Treatment 4-1
            4.1.1.3 Secondary Treatment 4-2
            4.1.1.4 MW-601 4-2
        4.1.2 Areas of Potential Improvement for Existing System 4-2
    4.2 Caustic Spill Area Subsurface Investigation 4-3
    4.3 Bench and Pilot Testing of Silica Removal Processes 4-3
    4.4 UF Testing 4-4

5. PROPOSED GWTP DESCRIPTION 5-1
    5.1 Pumping and Equalization 5-1
        5.1.1 SSIT Pumping and Equalization 5-1
        5.1.2 Stormwater Pumping and Equalization 5-1
        5.1.3 Existing 288,000-gallon Storage Tank 5-2
        5.1.4 MW-601 5-2
        5.1.5 Equalization Tanks 5-2
    5.2 Silica and Solids Removal Via CoMag 5-2
    5.3 UF Membrane 5-3
    5.4 GAC and Mersorb Treatment 5-3
    5.5 Effluent Discharge and Monitoring 5-3
    5.6 Chemical Feed Systems 5-3
    5.7 GWTP Building and Utilities 5-4

LIST OF TABLES

TABLE **PAGE NO.**

Table 3-1: Current Average Flows and Loads....3-1
Table 3-2: Future Flows and Loads....3-2

ATTACHMENTS

Attachment A:	Drawings
Attachment B:	Pilot Test Report
Attachment C:	Caustic Spill Memorandum

1. INTRODUCTION

This Design Basis Report (DBR) describes the design basis for a new groundwater treatment plant (GWTP) that will replace the existing groundwater treatment system currently in operation at the former HoltraChem Manufacturing Site (Site) in Orrington, Maine.

The objectives of the design are to provide a new GWTP that will:

- maintain discharge permit compliance;
- consist of simple and reliable processes;
- require minimal operator expertise and input;
- replace the current system with no interruption in service;
- operate in the long-term with minimal component replacement and maintenance; and
- handle increased flows during implementation of the Site remedy.

The GWTP described in this DBR consists of the same unit operations in place in the existing system (i.e., silica removal, solids clarification and filtration, and granular activated carbon (GAC) and Mersorb treatment) with enhancements to address the items in the bulleted list above.

2. PERMITTING

The current GWTP is operated under Waste Discharge License #W001048-5N-C-R dated April 2000. HoltraChem is the current holder of the license and Woodard & Curran is the current operator in responsible charge (ORC). An application for renewal of the license was submitted by CDM to MEDEP on December 8, 2003. Although MEDEP notified CDM on December 23, 2003 that the application had been accepted for processing, MEDEP has not taken final action on the 2003 application and therefore the treatment plant is currently operated under the April 2000 license referenced above.

Since the 2003 application does not reflect current or future conditions, it is assumed for purposes of this DBR, that the current system will continue to operate under the existing 2000 license until the new GWTP design is nearly complete, at which time a new license application will be submitted that will detail the anticipated conditions when the new GWTP is online (planned to occur in mid-2012), the transition from the existing GWTP to the new GWTP, and the conditions under which the GWTP will be planned to operate during the remediation process.

2.1 DISCHARGE LIMITS

The media protection standard (MPS) concentrations for groundwater and on-site surface water discharging to the Penobscot River are 2.0 micrograms per liter (ug/L) and 0.91 ug/L, respectively. The surface water MPS was established based on the freshwater chronic ambient water quality criteria established under 38 M.R.S.A. § 420(1). Per Mallinckrodt's current wastewater license, monthly average and daily maximum mass limits are 0.000456 pounds per day (lbs/day) and 0.001048 lbs/day, respectively. Mercury effluent concentrations currently discharged under the permit are below the MPS for on-site surface water and Maine ambient water quality criteria.

This design assumes that the new permit criteria will be the lesser of the MPS concentrations already identified for the Site (concentrations the current effluent achieves under the existing permit criteria) or the daily or monthly mass limits already in place.

2.2 PLANNED OR POTENTIAL MODIFICATIONS TO WASTEWATER DISCHARGE LICENSE

Planned or potential modifications to the existing wastewater discharge license, all of which are described in the design technical approach, include the following:

- Treatment process description;
- Permanent increase in flow rate once new groundwater extraction wells are installed in the landfill areas;
- Temporary increase in flow rates during remediation (decontamination, excavation water, etc.);
- Relocate Outfall 001 monitoring location to the inside of the new GWTP;
- Future effluent characteristics once new extraction wells/horizontal wells come on line in Landfill No. 3 and Landfill No. 4 areas (e.g., chloropicrin and carbon tetrachloride); and
- Change Outfall 002 to "report only" criteria and also allow Outfall 002 to discharge continuously in the future rather than in discrete batches.

3. FLOWS AND LOADS

3.1 CURRENT FLOWS AND LOADS

The flow into the treatment plant consists of several sources, including: groundwater entering the Southerly Stream Interceptor Trench (SSIT) downgradient of the former caustic spill area; groundwater extracted at well MW-601; stormwater runoff from portions of the manufacturing area; and miscellaneous flows from the existing wastewater treatment system and the laboratory. Estimates of the average flows from the various sources based on flow monitoring conducted over the past several years of operations are provided in Table 3-1. Typical silica, mercury, and pH values are also included for the various sources, based on the past year of monitoring data. Sheet PF-01 (Attachment A) provides a process flow diagram depicting the current and future design flows and loads of silica, mercury, and pH.

Table 3-1: Current Average Flows and Loads

Source	Average Flow (MGY)	Average Flow (gpd)	Average Flow (gpm)	Instantaneous Pumped Flow (gpm)	Silica (mg/L)	Mercury (ug/L)	pH
SSIT	1.4	3,800	2.6	30	40 – 150	0.1 – 3	8.6 – 9.6
Stormwater, Misc.	1.1	3,100	2.2	60	<10	0.2 – 20	6 - 9
MW-601	2.4	6,500	4.5	4.5	<10	50 – 100	6.5 – 7.5
Total	4.9	13,400	9.3				

Notes: MGY = million gallons per year
gpd = gallons per day
gpm = gallons per minute
mg/L = milligrams per liter
ug/L = micrograms per liter

Groundwater collects in the SSIT at a steady rate that appears to vary throughout the year from a low of approximately 1 gpm in the late summer to a high of greater than 3 gpm in the wetter months. The flow is collected in a sump and discharged several times per day at an instantaneous rate of roughly 30 gpm in 400 gallon batches to the existing equalization tanks. Stormwater is collected as necessary from several areas on the Site where stormwater accumulates and is pumped in batches of several hundred to several thousand gallons at a rate of approximately 60 gpm to the existing equalization tanks. Groundwater from MW-601 is pumped at a constant rate of 4.5 gpm continuously using a flow meter and control valve.

3.2 FUTURE FLOWS AND LOADS

As presented in Table 3-2, the design of the new GWTP, in basic terms, will consist of two trains, each designed for a flow of 30 gpm: 1) flows from the SSIT, stormwater, construction dewatering, remediation sidestreams, and miscellaneous flows, all of which may require silica and/or gross solids removal via CoMag and ultrafiltration (UF) prior to GAC and Mersorb treatment; and 2) extracted groundwater from various areas of the Site, all of which is expected to be free of silica and solids, and will require only simple bag filtration prior to GAC and Mersorb treatment. Future flows and loads are shown in Table 3-2 below, and schematically in Sheet PF-01.

Table 3-2: Future Flows and Loads

Source	Current Average Flow (gpd)	Future Design Flow (gpd)[1]	Future Design Flow (gpm)[1]	Future Design Instantaneous Pumped Flow (gpm)[2]	Silica (mg/L)	Mercury (ug/L)	pH
SSIT	3,800	8,000	6	30	30 – 140	0.1 – 2	8.5 – 9.5
Stormwater, Const. Dewatering, Remediation Water, Misc.	3,100	35,000	24	60	<10	0.1 – 40	6 – 9
Total Streams Requiring CoMag and UF	6,900	43,000	30				
Extracted Groundwater from Entire Site	6,500	43,000	30	30	<10	20 – 200	6.5 – 7.5

Notes: 1. The future design flow indicated will be used as the basis for unit process equipment.
2. The instantaneous pumped flow will be used for equalization tank sizing, pump capacity, and pipe sizing.

3.2.1 Streams Requiring Silica or Solids Removal

Flows from the SSIT as well as stormwater and miscellaneous laboratory and process sidestream flows are expected to remain the same in the near future as they are now. The SSIT flows are expected to continue to average 3,800 gpd, however the design provides an allowance of 8,000 gpd to accommodate peak flows in the spring and late fall. Stormwater and miscellaneous flows are expected to average 3,100 gpd, as now; however an additional 30,000 gpd is included in the design to account for construction dewatering and other water streams generated during remediation activities. In the long term, some or all of the stormwater runoff component may be eliminated from the future treatment plant as a result of temporary or permanent closure activities that prevent contact of rainwater with contaminated areas.

Changes to the treatment plant flows are expected once remedial activities are implemented. The primary flow will result from the line of interceptor groundwater extraction wells proposed along the downgradient side of Landfill No. 1 area. These wells will be positioned to intercept the groundwater migrating westerly towards the Penobscot River from beneath the Site. Based on precipitation at the Site, the amount of groundwater flux to the river is estimated to be 20 to 25 gpm, with the highest flows occurring during the spring and late fall, and lower flows during the summer when evapotranspiration is highest, and winter when the ground is frozen, minimizing infiltration.

As the Site remediation evolves, some additional water sources may be directed to the treatment plant. This would include additional wells placed directly beneath the former lagoon at Landfill No. 1 to accelerate the Site's groundwater cleanup. The water that is passing through this area is the same water that would be passing through the barrier wells mentioned earlier. Therefore, these additional wells would not add in any significant way to the amount of water that would be pumped from the ground into the treatment plant.

It is possible that Landfill Nos. 3 and 4 will be underdrained or groundwater will be extracted in an attempt to lower the groundwater table in this area. The amount of flow to the treatment plant due to the groundwater contribution from this ridge would likely be under 5 gpm. This is based on the location of the landfill situated at the crest of a groundwater-divide and the fact that the landfills are underlain by low permeability bedrock. Other flows that may need to be managed within the treatment plant are temporary flows generated from excavation activities on Site during remediation activities. For instance, the excavation of Landfill No. 1 will involve some control of surface runoff that would potentially go to the treatment plant.

Based on historical groundwater data associated with the Site, the groundwater quality from the vicinity of Landfill No. 1 is expected to contain dissolved mercury as well as chloropicrin, similar to that from Well MW-601. The amount of volatile organic compounds (VOCs) present, based on historical data, is expected to be negligible. Other elevated chemical parameters will likely include iron and manganese because of the reduced geochemical environment in the Landfill No. 1 area. The groundwater from the Landfill Nos. 3 and 4 underdrain will contain low concentrations of carbon tetrachloride, but would generally be relatively clean otherwise. Runoff and dewatering flows related to construction and dewatering activities will contain variable levels of mercury and VOCs, and higher levels of total suspended solids (TSS) than are encountered in the current process flows.

4. PRE-DESIGN STUDIES

To maximize the efficiency of the new GWTP, the following pre-design studies were conducted:

- Review of the current treatment system, including interviews and discussions with the treatment plant operators to identify areas of potential improvement or simplification that would provide more robust operations and maintenance or improvements in treatment efficiency.
- Conversations with the Mersorb vendor to determine the optimum operating conditions and appropriate design constraints for effective system operation. For example, preliminary discussions indicated that a neutral pH is as effective as an acid pH when there is limited sulfide in the groundwater. Silicate precipitation may also be most effective at a neutral pH. Therefore, if sulfide treatment remains unnecessary, the additional pH adjustment steps may be eliminated.
- Bench testing of the caustic spill area groundwater for silica precipitation, coagulation, flocculation, and settling using various chemistries and temperatures to optimize the silica removal process.
- Performance of a two-week pilot test using a 10-gpm enclosed, trailer mounted CoMag system.
- Treatment of the CoMag effluent with UF to determine the potential flux rates and filtrate quality to allow the appropriate future sizing of the UF.

4.1 EXISTING TREATMENT PLANT REVIEW

4.1.1 Existing Treatment System Description

4.1.1.1 Silica Pretreatment Process

The SSIT delivers silica impacted groundwater to a collection sump. Submersible pumps and a 3-inch diameter aboveground, heat-traced and insulated pipeline transport this groundwater to three interconnected 20,000-gallon storage tanks (known as the ABC Tanks) that are also heat traced and insulted. These same tanks collect stormwater and miscellaneous flows from the treatment system trench drains (which contain little or no silica). From the ABC Tanks, the groundwater is pumped to the existing treatment building where silica is removed via pH adjustment to 11.5, heated to 140°F via direct steam injection, and 1,500 mg/L of calcium (Ca) added via metering a calcium chloride ($CaCl_2$) brine into the wastewater. This chemical treatment results in the precipitation of calcium silicate. Precipitated solids are removed in an inclined plate settler, recessed plate filter, and 0.5 micron bag filter. Clarified effluent from this silica pretreatment process becomes influent to the primary treatment system.

Dewatered solids from the recessed plate filter press are deposited into a roll-off container for eventual off-site disposal.

4.1.1.2 Primary Treatment

Effluent from the Silica Pretreatment Process is adjusted to a pH of 7.0, filtered through a 0.5 micron backpulse filter, followed by a 0.5 micron nominal bag filter, and a 0.5 micron absolute cartridge filter. Filtrate is sent on to secondary treatment. Backpulse filter backwash is pressed in a recessed plate and frame press. Filter press pressate is returned to the head of the pretreatment system. Filter cake is deposited into a roll-off container for eventual off-site disposal.

4.1.1.3 Secondary Treatment

Effluent from the Primary Treatment process flows through one GAC vessel, followed by four Mersorb vessels, and a final 0.5 micron cartridge filter. The GAC and Mersorb are all pelletized granules comprised principally of activated carbon. The Mersorb granules are impregnated with sulfur, providing more effective mercury removal than conventional activated carbon. VOCs that may be present in the water are adsorbed on both GAC and Mersorb. A final pH adjustment step is conducted to ensure the pH is between the permit limits of 6 and 9, and the final treated effluent is discharged in 9,000 gallon batches through Outfall 002, then flows through the plant process sewer to Outfall 001.

4.1.1.4 MW-601

MW-601 is a 4-inch diameter extraction well. A single 3-inch diameter well pump discharges to a 1-inch diameter, double walled, heat traced and insulted pipeline that transports groundwater from MW-601 to the existing treatment building. The flow from the well is controlled with a flow meter and control valve at a constant rate of 4.5 gpm. This groundwater flows through a 0.5 micron bag filter, one GAC vessel, four Mersorb vessels, and a final 0.5 micron cartridge filter. This treated groundwater is discharged continuously through the plant process sewer to Outfall 001.

4.1.2 Areas of Potential Improvement for Existing System

The unit processes that are in place presently (coagulation and filtration for solids removal, and GAC followed by Mersorb for mercury removal) represent the best available treatment technology for the wastewater and groundwater at the Site. However, based on a review of the existing system and conversations with operations staff, several aspects of the existing treatment plant may potentially be improved to provide more efficient, robust, and/or continuous unattended operation. These items will be addressed in the proposed design to provide a more effective treatment system.

- The building in which the existing treatment system is housed is energy inefficient, resulting in high energy and operations costs.
  - Solution - The proposed design includes a new, energy efficient building to house the new treatment system.
- The majority of the process equipment associated with the existing treatment system is aging and not of a condition or of the proper specification for long term reuse.
  - Solution - The proposed design includes all new process equipment for the new treatment system with the exception of the GAC and Mersorb vessels. While the current size is not optimum for the new groundwater treatment system, the vessels can be moved and utilized without the need to purchase new, more appropriately sized units.
- The flows from the SSIT are comingled with stormwater and miscellaneous flows, so that the silica removal process is applied to all solids laden streams, even those without significant quantities of silica.
  - Solution – The proposed design segregates the SSIT flow from all others, so that this sidestream can be treated separately, allowing more efficient use of chemicals for silica treatment.
- The treatment process steps currently employed to remove silica requires numerous steps, heat, chemicals, pumps, and operator attention, and represents a large percentage of the overall

operations cost. Also, the operation of two different plate and frame presses and the backpulse filter is labor intensive, requiring significant operator attention.

  - Solution – The proposed design includes a state-of-the-art, skid mounted, fully automated CoMag (by Cambridge Water Technologies) process that will operate at ambient temperatures, and along with the UF system discussed below, will take the place of the chemical precipitation, bag filters, cartridge filters, and backpulse filter. A new sludge thickener and plate and frame press, properly sized, instrumented, and controlled, will be provided for final solids dewatering.

- The use of multiple bag filters and cartridge filters is labor intensive and results in potentially unnecessary bag and cartridge disposal costs, and inhibits unattended operations, as filters can quickly foul, limiting forward flow rates.
  - Solution – The proposed design includes a state-of-the-art, skid mounted, fully automated UF system that, in combination with the CoMag process discussed above, will serve the silica removal and filtration functions.
- The existing treatment system employs only minimal automated process control; no Supervisory Control and Data Acquisition (SCADA) system, no remote monitoring, and no alarm dial-out capability.
  - Solution – The proposed design includes a state-of-the-art SCADA system with remote monitoring, data collection, reporting, and alarm dial-out capability.
- The existing effluent monitoring Outfall 001 is remote from the existing treatment building resulting in difficult sample access during the winter months.
  - Solution – The proposed design includes new Outfall 001 and Outfall 002 monitoring locations and equipment; all housed within the new treatment building.

4.2 CAUSTIC SPILL AREA SUBSURFACE INVESTIGATION

As part of the treatment plant design assessment phase, Sevee & Maher Engineers Inc. (SME) evaluated the caustic spill area to define the extent of the former caustic spill or spills in the area and to assess whether it is more cost-effective to remove this source of the underdrain water to the treatment plant vs. continuing to treat this water in the long-term. The investigation included research of historical documents and analytical testing of existing wells, including pH, silica, and mercury, to define the extent of the caustic contamination that contributes silica to the treatment plant. Based on the results of the field investigation, it was determined that the caustic spill area is contained by the existing SSIT; pH values and silica concentrations have steadily declined over the past decade and are continuing to decrease; and the source area cannot be removed cost-effectively, so continued operation of the SSIT is warranted. The SME report is included as Attachment C.

4.3 BENCH AND PILOT TESTING OF SILICA REMOVAL PROCESSES

Bench and pilot scale tests were conducted to refine the silica removal process. A detailed discussion of the testing is provided in Attachment B. Bench testing was performed on the SSIT groundwater to evaluate silica precipitation, coagulation, flocculation, and settling using various chemistries and temperatures to optimize the chemical dosing and heating scheme. The bench testing results indicated that the adsorption of silica onto precipitated magnesium hydroxide via the addition of magnesium chloride at a pH of 10.5 could provide excellent removal of silica at ambient temperatures. The bench testing also indicated that pH adjustment using sodium aluminate may allow lower doses of magnesium chloride to be used.

Following bench testing, a two-week pilot test was performed using an enclosed, trailer mounted CoMag system. Flows of 10 to 14 gpm were treated with the pilot trailer for approximately 8 hours per day. The pilot test confirmed the results of the bench testing. Effluent turbidities of less than 1 nephelometric turbidity units (NTU) were consistently obtained, and silica concentrations of less than 10 mg/L were obtained using either a combination of 100 mg/L of magnesium and pH adjustment with sodium hydroxide (NaOH), or 50 mg/L of magnesium and pH adjustment with sodium aluminate ($NaAlO_2$). The performance, dosage rates, and chemical costs for the two chemical dosing schemes were nearly identical, so the future design will allow either chemistry to be applied.

4.4 UF TESTING

Ultrafilters are preferred over the existing bag filter and cartridge filter arrangement because they can be operated continuously for weeks or months without cleaning, do not require routine operator intervention for changeouts, and do not generate a solid waste stream (used bags and cartridges). To estimate future UF performance, samples of treated groundwater from the CoMag pilot test were shipped to Dynatec for bench scale UF evaluation. Tests were conducted using a Kynar (polyvinylidene fluoride or PVDF) membrane tube with an 8 millimeter (mm) inside diameter and a nominal 0.03 micron pore size. A feed pressure of 50 psi was utilized. Flux varied from 55 to 150 gallons per square foot per day (gfd). The samples were tested at a temperature of approximately 30°C in the laboratory. To account for full scale treatment temperatures of approximately 10°C, and the corresponding increase in water viscosity at lower temperatures, a flux value of 37 gfd will be used for the design.

Samples of the UF permeate and concentrate were analyzed for calcium, mercury, and silica. As expected, the testing indicated that permeate and concentrate concentrations for these three elements was virtually identical in the concentrate and permeate samples because the CoMag treatment system had already removed nearly all suspended solids, leaving only dissolved elements in solution. UF does not remove dissolved metal ions, only suspended solids. This indicates that fouling of the UF is expected to be minimized, and performance is expected to be consistent over the long term, with the UF acting as a fail-safe for the CoMag treatment system, but not ordinarily experiencing a high solids loading.

5. PROPOSED GWTP DESCRIPTION

The proposed design is shown schematically in Attachment A. The design includes eight primary process areas:

1. Process Area 100 – Pumping and equalization
2. Process Area 200 - Silica and solids removal via CoMag
3. Process Area 300 – UF Membrane
4. Process Area 400 – GAC and Mersorb Treatment
5. Process Area 600 – Effluent discharge and monitoring
6. Process Area 700 – Chemical feed systems
7. Process Area 800 – Utilities
8. Process Area 900 – Solids thickening and dewatering

All of the proposed equipment in the new GWTP is new with the exception of: three of the GAC/Mersorb treatment trains (consisting of one GAC vessel and four Mersorb vessels per train); the single 288,000 gallon storage tank; and the SSIT sump pumps and level controls. The 288,000 gallon tank is included in the design to provide emergency storage capacity in the event of a catastrophic storm event, during an unanticipated maintenance event, and/or potentially during remediation when the highest quantities of construction and decontamination waste water will be generated. The fourth GAC/Mersorb vessel train will be stored for future use or as a spare for in-place equipment. The SSIT sump pump system is in good condition and suitable for reuse.

5.1 PUMPING AND EQUALIZATION

5.1.1 SSIT Pumping and Equalization

The existing SSIT submersible pumps will be operated in a lead/lag/alternating arrangement, using the existing float switches, as they are now. A new flow meter will be installed in the SSIT sump pump house. Data will be integrated into the SCADA system. A remote input/output (I/O) panel with radio communications will be installed to transmit data to the new treatment system SCADA system. The flow from the SSIT will normally be conveyed to a 10,000 gallon dedicated storage tank, or may be diverted to one or both of two new 15,000-gallon influent equalization tanks adjacent to the new treatment building via the existing pipeline extended with new pipe to the new treatment building location.

5.1.2 Stormwater Pumping and Equalization

Woodard & Curran analyzed the stormwater volumes and current management practices at the Site to determine if it may be cost effective to eliminate certain stormwater sources by filling, covering, capping, or regarding portions of the Site to prevent contact of stormwater with contaminated surfaces. The evaluation indicated that it would not be cost effective to perform these activities. Stormwater will continue to be managed in the future as it is now, according to the procedures described in the Draft "Sediment Prevention Plan – Former HoltraChem Manufacturing Facility" prepared by Woodard & Curran in June 2011. Piping and valving will be provided to allow operators to pump stormwater to the new influent equalization tanks, the existing 288,000-gallon storage tank, or to the head end of the treatment system, as conditions warrant.

5.1.3 Existing 288,000-gallon Storage Tank

The design will include two new centrifugal pumps, properly sized, instrumented, and automated to run in a lead-lag arrangement and to alternate. The existing tank will be supplied with a new level instrument to control pump operation and for alarms. A flow meter will be provided. Data will be collected, some displayed locally and the rest integrated into the SCADA system. A remote I/O panel will be installed to transmit data via radio to the new treatment system SCADA system. This flow will be conveyed to the new treatment system in a new, double walled, heat traced and insulated pipeline with leak detection and with piping and valving to allow operators to pump stored water to the new influent equalization tanks or to the head end of the treatment system, as conditions warrant.

5.1.4 MW-601

The design will provide a new pump with VFD and level control in MW-601, so that rather than pumping at a constant rate, the flow will vary to maintain a constant level in the well. Woodard & Curran will relay by radio level and well pump operation data from MW-601 to the new treatment building. The well will be supplied with a new level instrument to control pump operation and for alarms. This flow will be conveyed to the new treatment system in the existing 1-inch diameter pipeline as far as it now runs to the existing treatment building, and extended from there to the new treatment building in a new 3-inch diameter, double walled, heat traced and insulated pipeline with leak detection. This flow will bypass the new CoMag and UF treatment processes and will instead be filtered through a 1 micron bag filter and then treated by GAC and Mersorb.

5.1.5 Equalization Tanks

The design will include two new 15,000-gallon insulated influent equalization tanks adjacent the new treatment building that will receive flow from the silica area, stormwater collection areas, the 288,000-gallon storage tank and/or from building sumps that will collect miscellaneous flow, as conditions dictate and as operators decide. An additional 10,000 gallon storage tank will be provided for SSIT water, providing slightly more than 24 hours storage of maximum anticipated SSIT flows, and slightly less than 24 hours storage for other flows. During average conditions, the equalization tanks will provide roughly three days of storage for SSIT flows, and 10 days of storage for stormwater and miscellaneous flows. These new tanks will be provided in place of the three existing 20,000-gallon equalization tanks (ABC tanks) because the location of the ABC tanks in relation to the proposed GWTP building location results in long piping runs between the GWTP and the ABC tanks, complicating instrumentation, operation, and maintenance activities, and requiring the process feed pumps to be located at the location of ABC tanks remote from the GWTP building.

5.2 SILICA AND SOLIDS REMOVAL VIA COMAG

Duplex centrifugal pumps, properly sized, instrumented, and automated to run in a lead-lag arrangement and to alternate will feed from the equalization tanks either a silica chemical mix tank or a CoMag chemical mix tank, then the CoMag process. The CoMag process will perform pH adjustment, chemical precipitation, and solids removal.

CoMag effluent will be pumped to the UF process. Solids from the CoMag process will be pumped to a sludge holding tank prior to a new, properly sized, instrumented, and controlled recessed plate filter press.

5.3 UF MEMBRANE

Two PVDF tubular membrane skids with a nominal capacity of 15-gpm will be provided. The skids will be automatically controlled and monitored. The flow rate through the skids will vary over time. It may be as high as 50 gpm per skid upon initial startup, and will gradually decline over time. Excess permeate flow beyond what is required for normal processing (typically 30 gpm) will be recirculated. If the flow rate drops below 15 gpm for either skid, a clean-in-place procedure will be conducted using a recirculating caustic or acid solution to dissolve precipitates that have fouled the membrane. The cleaning solutions may have a pH as low as 1.0 or as high as 11.5 without harming the membrane. The spent cleaning solution will be returned to the head of the GWTP for neutralization and solids removal. The same tank that is used for CIP will be used under normal circumstances to store permeate so that if the system is operated in a batch mode (under initial conditions, water will be processed for approximately 30 hours per week at 30 gpm), the UF membrane can be flushed with permeate at the end of the run to remain in a clean condition while off-line and prevent premature fouling.

5.4 GAC AND MERSORB TREATMENT

All of the existing treatment trains, consisting of one GAC vessel and four Mersorb vessels, will be utilized in the new GWTP. One train will be utilized for continuous groundwater treatment, and one train will be utilized for CoMag/UF effluent, with the third train available as a spare for either flow. All three trains will be rated for 30 gpm. The fourth Mersorb train will remain in storage with fresh media. When testing indicates that a GAC or Mersorb vessel has been exhausted, the spent vessel will be swapped with a fresh spare from storage. All vessels will be interconnected with reinforced hose and cam-lock fittings so that vessels may be easily moved, replaced, or rearranged as necessary.

5.5 EFFLUENT DISCHARGE AND MONITORING

The new treatment system will include two new 15,000-gallon insulated effluent storage tanks. At any time, one tank will be filling while the other is being tested or discharging. The two new tanks will be equipped with jet mixer eductor systems, level control and pH control and monitoring features. These tanks will discharge to a short section of pipeline within the GWTP that will serve as Outfall 002. Discharge from these tanks later will merge with extraction well effluent (Outfall 001) also located inside the GWTP. Both outfall locations will be equipped with sample ports for composite sampling equipment, a flow meter, pH control and monitoring, and other permit-required data gathering equipment. Data will be displayed locally as required, and transmitted to the SCADA system for collection, trending, and reporting. Maine Pollutant Discharge Elimination System (MEPDES) Discharge Monitoring Reports (DMRs) will be generated directly from the SCADA system.

5.6 CHEMICAL FEED SYSTEMS

330-gallon permanent totes will be provided for the following chemicals, each tote will be configured to allow a full tote to be set on top of it to allow transfer between the totes by gravity.

- HCl
- $MgCl_2$
- $NaAlO_2$
- $NaOH$

Metering pumps connected to the totes will feed these chemicals to various points in the process as necessary. Dosage will either be flow paced or pH based depending on the application. To the extent possible, the metering pumps will be similar to minimize the number of spare parts and allow fewer shelf spares.

5.7 GWTP BUILDING AND UTILITIES

The design includes a new energy-efficient, insulated building. The proposed building is approximately 65-feet wide by 65-feet long, has an inside eave height of 18 feet and an outside ridge line height of approximately 27 feet. The building contains dedicated space for an office and control room, a locker/restroom, a laboratory, and a mechanical room that will house a boiler, the motor control centers (MCCs), and other building support systems. The boiler will be oil fired and will supply process and building heat. This will replace the existing steam boiler in use now. Because there is no need for steam in the new GWTP, and a much lower heat requirement in general, the existing boiler would be more expensive to operate and maintain, and much larger than necessary for future use. An appropriately sized air compressor will provide clean, dry, oil-free compressed air to the air diaphragm pumps that feed the recessed plate filter press, as well as pneumatic valve actuators.

The preliminarily location for the new GWTP is just to the northeast of the existing Administration Building. This location is close to the current Administration Building where some utilities will be acquired, set back near the edge of potential developable areas, does not contain known impacted subsurface soils, and requires minimal Site preparation. This location is subject to change pending additional on-site investigations.

ATTACHMENT A: DRAWINGS

Under separate cover

ATTACHMENT B: PILOT TEST REPORT

Pilot Test Report

Former HoltraChem
Manufacturing Site
Orrington, Maine

Prepared for:
Mallinckrodt US LLC

213894.00

August 19, 2011

woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS

TABLE OF CONTENTS

SECTION **PAGE NO.**

Executive Summary ES-1

1. PILOT STUDY OVERVIEW 1-1

- 1.1 Objectives 1-1
- 1.2 Existing Treatment Scheme 1-1
- 1.3 Bench Testing of Alternative Treatment Chemistries 1-1

2. HISTORICAL SILICA CONCENTRATIONS AND SILICA REMOVAL OPTIONS 2-1

3. SILICA INTERCEPTOR TRENCH FLOW CHARACTERISTICS 3-1

4. BENCH TEST RESULTS 4-1

5. COMAG TREATMENT SYSTEM OVERVIEW 5-1

6. PILOT TEST RESULTS 6-1

7. FULL SCALE SYSTEM OPERATIONS 7-1

LIST OF TABLES

TABLE **PAGE NO.**

Table 4-1 Summary of Bench Test Results 4-1

Table 6-1 Pilot Test Results Summary 6-2

Table 7-1 Chemical and Sludge Cost Estimation Calculations 7-1

LIST OF FIGURES

FIGURE **PAGE NO.**

Figure 3-1 Rainfall and Silica Trench Interceptor Water Flow Rate Data 3-1

Figure 5-1 Pilot CoMag System Process Flow Diagram 5-1

APPENDICES

Appendix A: Silica vs. pH Graphs
Appendix B: Bench Test Results
Appendix C: Pilot Test results
Appendix D: Chemical Usage And Sludge Generation Cost Estimation Calculations

EXECUTIVE SUMMARY

This report presents a summary of groundwater treatment system investigation and testing activities completed by Woodard & Curran for Mallinckrodt US LLC (Mallinckrodt) at the former HoltraChem Manufacturing site (Site) in Orrington, Maine. These activities were preformed to evaluate more efficient treatment processes for the Site's silica impacted groundwater, stormwater, and miscellaneous waste streams that require silica and/or solids removal prior to mercury removal via adsorption.

The current treatment system collects silica impacted groundwater from the Southerly Stream Interceptor Trench (SSIT), stormwater, and miscellaneous plant wastewater streams in three interconnected equalization tanks (A/B/C Tanks). Silica and solids are removed by batch adjusting the pH to 11.5 using sodium hydroxide (NaOH), heating to 140°F with direct steam injection, and adding 1,500 milligrams per liter (mg/L) of calcium chloride ($CaCl_2$) as calcium (Ca). The batch is than passed through a recessed plate sludge press and 0.5 micrometer (µm) bag filters to remove the precipitated solids and the pH is decreased to 3.5 using hydrochloric acid (HCl). After decreasing the pH the batch goes through a 0.45 µm backpulse filter, and 4 mg/L of ferric chloride ($FeCl_3$) is added. Final filtration is performed through 0.5 µm nominal bag filters, 0.5 µm absolute cartridge filters, and one of three treatment trains consisting of a granular activated carbon (GAC) vessel and four MerSorb vessels in series. Before discharge, the pH of the batch is adjusted within the permit limits of 6 and 9. This batch treatment discharge is denoted as Outfall 002.

Groundwater from extraction well MW-601 is treated at 4.5 gpm continually through a 0.5µm absolute cartridge filter, a GAC vessel, four MerSorb vessels and another 0.5µm absolute cartridge filter before being combining with the batch treatment discharge and flowing via the plant process sewers to a weir structure adjacent to the Southerly Stream. This outfall is denoted as Outfall 001.

Woodard & Curran performed bench testing to determine treatment chemistries that are capable of reducing silica to a manageable level at pH and temperature conditions lower than the current system utilizes. Various tests were preformed using magnesium oxide (MgO), $CaCl_2$, and magnesium chloride ($MgCl_2$) as coagulants at pH values between 7 and 11.5 and temperatures between 20 and 60°C. These bench tests indicated that $MgCl_2$ could be used to remove silica effectively at ambient temperatures at a pH of 10.5 using either NaOH or sodium aluminate as a source of alkalinity.

Pilot scale tests were conducted using $MgCl_2$ as a coagulant in a flow-through CoMag system that treated flows of 10 to 14 gpm, similar to the full-scale 15 gpm flow at the existing treatment plant. The results showed that greater than 90 percent removal of silica is possible with either of two treatment schemes at ambient temperatures:

1. Coagulation with 100 mg/L $MgCl_2$ (as magnesium [Mg]) and pH adjustment to 10.5 with NaOH; or

2. Coagulation with 50 mg/L $MgCl_2$ (as Mg) and pH adjustment to 10.5 with NaOH and sodium aluminate.

The full scale system will allow either treatment scheme to be utilized.

1. PILOT STUDY OVERVIEW

1.1 OBJECTIVES

This report presents a summary of groundwater treatment system investigation and testing activities completed by Woodard & Curran for Mallinckrodt US LLC (Mallinckrodt) at the former HoltraChem Manufacturing site (Site) in Orrington, Maine. These activities were preformed to evaluate more efficient treatment processes for the Site's silica impacted groundwater, stormwater, and miscellaneous waste streams that require silica and/or solids removal prior to mercury removal via adsorption.

1.2 EXISTING TREATMENT SCHEME

The current treatment system collects silica impacted groundwater from the Southerly Stream Interceptor Trench (SSIT), stormwater, and miscellaneous plant wastewater streams in three interconnected equalization tanks (A/B/C Tanks). Silica and solids are removed by batch adjusting the pH to 11.5 using sodium hydroxide (NaOH), heating to 140°F with direct steam injection, and adding 1,500 milligrams per liter (mg/L) of calcium chloride ($CaCl_2$) as calcium (Ca). The batch is than passed through a recessed plate sludge press and 0.5 µm bag filters to remove the precipitated solids and the pH is decreased to 3.5 using hydrochloric acid (HCl). After decreasing the pH the batch goes through a 0.45 µm backpulse filter, and 4 mg/L of ferric chloride ($FeCl_3$) is added. Final filtration is performed through 0.5 µm nominal bag filters, 0.5 µm absolute cartridge filters, and one of three treatment trains consisting of a granular activated carbon (GAC) vessel and four MerSorb vessels in series. Before discharge, the pH of the batch is adjusted to within the permit limits of 6 and 9. This batch treatment discharge is denoted as Outfall 002.

Groundwater from extraction well MW-601 is treated at 4.5 gallons per minute (gpm) continually through a 0.5µm absolute cartridge filter, a GAC vessel, four MerSorb vessels and another 0.5µm absolute cartridge filter before combining with the batch treatment discharge and flowing via the plant process sewers to a weir structure adjacent to the Southerly Stream. This outfall is denoted as Outfall 001.

1.3 BENCH TESTING OF ALTERNATIVE TREATMENT CHEMISTRIES

Woodard & Curran performed bench testing to determine treatment chemistries that are capable of reducing silica to a manageable level at pH and temperature conditions lower than the current system utilizes. Various tests were preformed using magnesium oxide (MgO), $CaCl_2$, and magnesium chloride ($MgCl_2$) as coagulants at pH values between 7 and 11.5 and temperatures between 20 and 60°C. These bench tests indicated that $MgCl_2$ could be used to remove silica effectively at ambient temperatures at a pH of 10.5 using either sodium hydroxide (NaOH) or sodium aluminate as a source of alkalinity.

2. HISTORICAL SILICA CONCENTRATIONS AND SILICA REMOVAL OPTIONS

The current silica treatment facility was installed in 2001 and was designed to reduce influent silica concentrations of 300-900 parts per million (ppm) down to 50 ppm. The pH values at the time typically varied from 9 to 11. At present, SSIT silica concentrations are approximately 80-150 ppm and are in the range of 30-40 ppm after being blended with stormwater prior to treatment. The theoretical silica solubility is constant at 120 ppm at pH values less than 8, but dramatically increases above pH 8. A graph showing silica solubility versus pH as well as current and historical SSIT pH and silica concentration data is located in Appendix A. Although the influent silica concentration is typically below the theoretical solubility of 120 ppm, plant operating data indicates that filter plugging and fouling typically occurs at silica concentrations above 10 ppm. The current silica removal process typically produces a silica effluent of less than 10 ppm.

Silica is removed in the current treatment process via precipitation as calcium silicate, where 500-1500 ppm of calcium chloride is added to form calcium silicate precipitates which are then dewatered in a filter press. The clarified filtrate is then passed through a 0.5 micron bag filter. The current operation conditions for this process are pH 11.5-12 at 140°F.

An alternative silica removal chemistry is silica removal via adsorption on magnesium hydroxide. In this process, silica adsorbs to magnesium hydroxide particles and is removed with the magnesium hydroxide particles during clarification and filtration. This process can be conducted at ambient temperatures and requires a pH greater than 10.2.

3. SILICA INTERCEPTOR TRENCH FLOW CHARACTERISTICS

The SSIT was constructed in 2000. It is approximately 375 feet long and captures high pH groundwater that contains elevated concentrations of silica. The trench consists of a 3-4 foot thickness of 3/8” peastone on top of bedrock. This high permeability material is surrounded by a nonwoven geotextile and surrounded on all sides by native glacial till to minimize surface water infiltration. Water from the SSIT collects in a sump located adjacent to the trench before it is pumped into the A/B/C Tanks prior to treatment. In addition to the main SSIT, there is a smaller 75’ long trench slightly north of the SSIT near the western end of the SSIT. This smaller trench is identified as the standleg. Water collected in the standleg is pumped into the SSIT sump.

The SSIT flow was estimated by using a HOBO datalogger that recorded every instance that the SSIT sump pumps started or stopped. These intervals, combined with the volume of water between the high and low level set points, allowed the flow from the SSIT to be accurately estimated. Figure 3-1 catalogues the SSIT flow and daily rainfall since the datalogger was installed in mid-May.

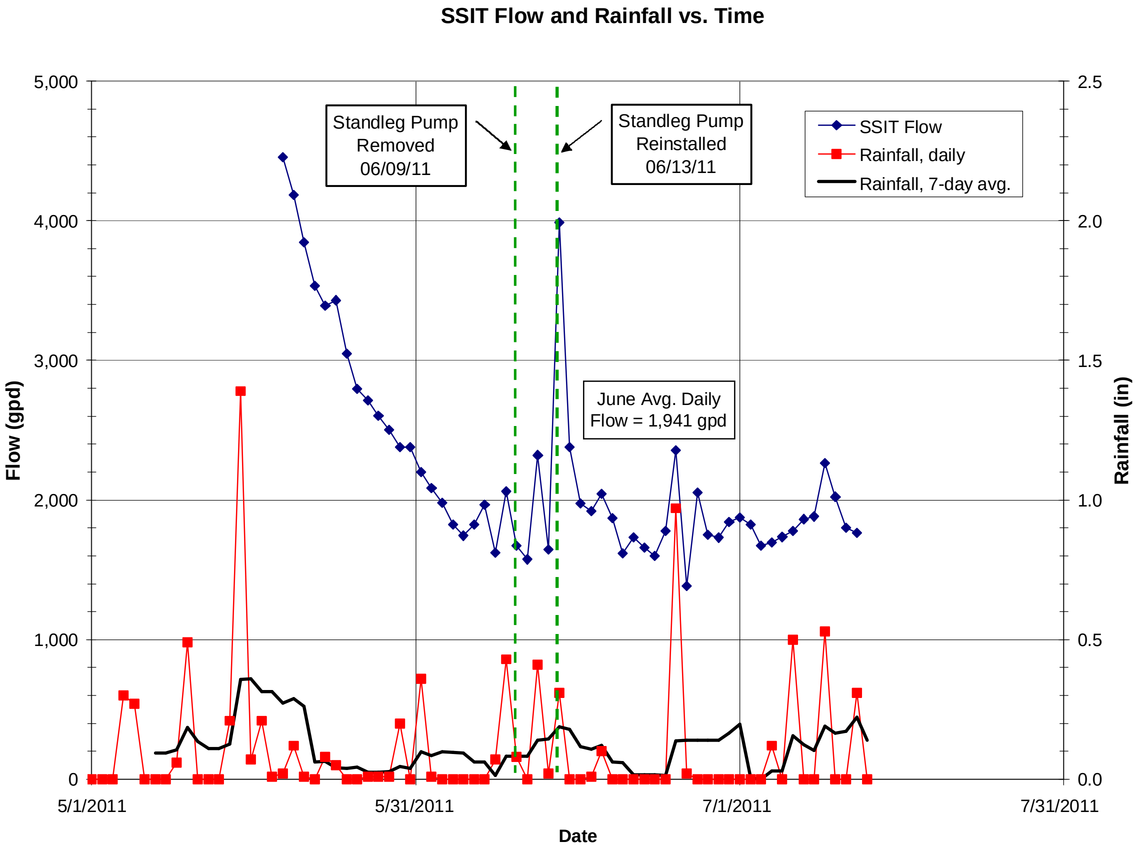


Figure 3-1 Rainfall and Silica Trench Interceptor Water Flow Rate Data

It was once thought that the SSIT flow rate varied drastically with fluctuation in rainfall, but this data shows fluctuations of only a few hundred gallons per day. A large spike in SSIT flow was seen when the standleg pump was reinstalled after being removed and the accumulated water was pumped out from the standleg to the SSIT sump. The datalogger will continue to record the pump activity indefinitely to better profile the SSIT flow characteristics.

4. BENCH TEST RESULTS

Bench tests were performed to determine if an alternative treatment chemistry could reduce silica concentrations to acceptable levels while utilizing fewer chemicals, less heat, or generating less waste than the current treatment process. For these tests, pure SSIT sump water was used, though SSIT groundwater is currently blended with stormwater and miscellaneous plant wastewater prior to treatment in the full-scale system. The battery of tests conducted varied coagulant, coagulant dose, pH, type of acid or base used for adjustment, and temperature. Coagulants trialed were $CaCl_2$, $MgCl_2$, and MgO at concentrations that ranged from 0-1000 ppm. Target test pH was 4.5, 7, 9.5, 10.5 or 11.5 with adjustments made using hydrochloric acid (HCl), Sodium Hydroxide (NaOH), Calcium Hydroxide ($Ca(OH)_2$), or Sodium Aluminate ($NaAlO_2$). Target reaction temperatures tested were 20°C, 40°C, and 60°C.

The tests were conducted by adding the coagulant at the desired dose to two liters of SSIT sample and adjusting the pH to the test target using the selected acid or base and allowing the contents to mix for 45 minutes. Next magnetite was added at a concentration of 5 grams per liter (g/L) and the sample was allowed to mix for 10 minutes. Finally, 20 mg/L of anionic polymer was added, the sample was mixed for 5 minutes, the samples were removed from the mixer, and the sludge was allowed to settle. Temperatures above ambient were achieved by heating the untreated samples in an oven prior to testing. A summarized table of the bench test results is present in Table 4-1 and the entire table is available in Appendix B.

Table 4-1 Summary of Bench Test Results

Sample ID	Coagulant Used	Coagulant Concentration (ppm)	Test pH	Acid/Base Used	Initial Temperature (°C)	Final Total Silica (ppm)	Final Dissolved Silica (ppm)
Baseline	None	-	9.5	-	10	116	117
None-0-20-7-HCl	None	-	6.3	HCl	10	97	92
Ca-800-60-11.5-NaOH	CaCl2	800	11.49	NaOH	58.7	5	4
Mg-500-60-11.5-NaOH	MgCl2	500	11.5	NaOH	58.7	5	5
Ca-400-60-11.5-NaOH	CaCl2	400	11.5	NaOH	58.7	17	16
None-0-60-11.5-NaOH	None	-	11.5	NaOH	58.7	96	60
Ca-800-40-11.5-NaOH	CaCl2	800	11.55	NaOH	37	15	15
Ca-800-20-11.5-NaOH	CaCl2	800	11.47	NaOH	21.4	39	38
Ca-800-60-10.5-NaOH	CaCl2	800	10.79	NaOH	58.7	58	60
Ca-800-60-7-HCl	CaCl2	800	7	HCl	58.7	103	90
None-0-60-11.5-Ca(OH)2	None	-	11.51	Ca(OH)2	63.9	1	1
Ca-800-60-11.5-NaAlO2	CaCl2	800	11.24	NaAlO2	63.9	1	1
Mg-500-20-10.5-NaAlO2	MgCl2	500	10.48	NaAlO2	21.4	<0.9	<0.4
Mg-200-20-10.5-NaAlO2	MgCl2	200	10.48	NaAlO2	21.4	0.9	0.8
Mg-500-40-10.5-NaAlO2	MgCl2	500	10.7	NaAlO2	37	0.7	0.7

Sample ID	Coagulant Used	Coagulant Concentration (ppm)	Test pH	Acid/Base Used	Initial Temperature (°C)	Final Total Silica (ppm)	Final Dissolved Silica (ppm)
Mg-200-40-10.5-NaAlO2	MgCl2	200	10.6	NaAlO2	37	2	2
Mg-200-60-10.5-NaAlO2	MgCl2	200	10.5	NaAlO2	63.9	1	1
MgO-200-20-9.5-None	MgO	200	10.30	-	12	102	103
MgO-500-20-9.5-None	MgO	500	10.45	-	12	89	84
MgO-1000-20-9.5-None	MgO	1000	10.70	-	12	62	59
None-0-20-4.5-HCl	-	-	4.48	HCl	21.4	85	98
Mg-200-20-10.5-NaOH	MgCl2	200	10.47	NaOH	21.4	23	22

The best overall silica removal, across the pH and temperature range, was exhibited by magnesium chloride. This coagulant was able to reduce the silica from 116 ppm to 23 ppm or lower with sodium hydroxide added as a base, and to 2 ppm or lower with sodium aluminate added as a base. The reason for the increased performance seen with sodium aluminate is believed to be due to the presence of aluminum hydroxide floc, which appears to adsorb silica in a similar fashion to the magnesium hydroxide floc generated by the reaction of magnesium chloride at elevated pH. Magnesium chloride was not tested at a pH below 10.5 because magnesium hydroxide floc will not form in sufficient quantities below pH 10.2.

5. COMAG TREATMENT SYSTEM OVERVIEW

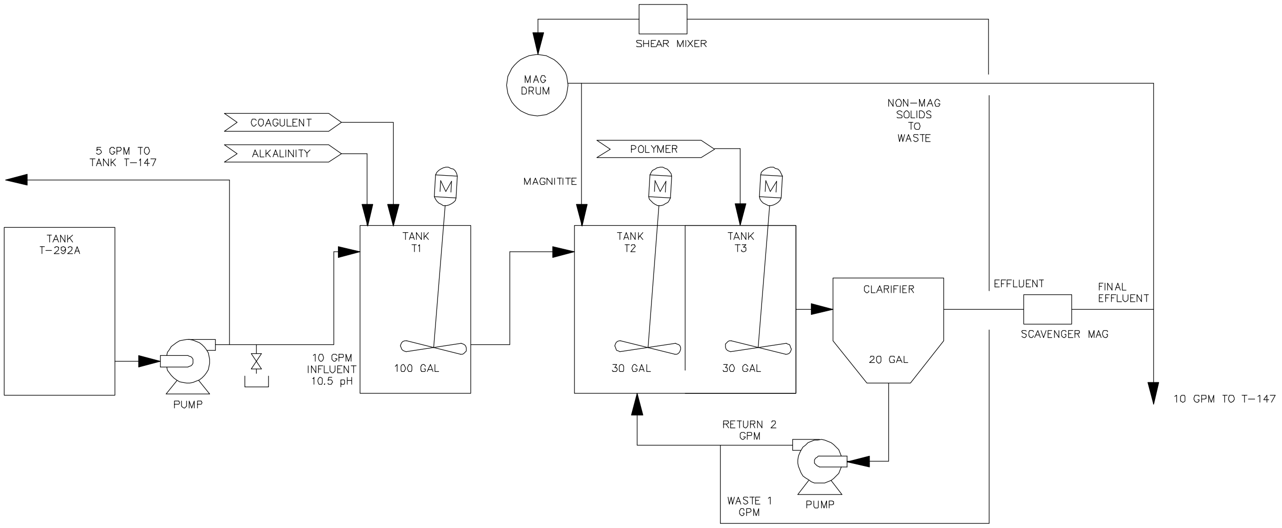
The CoMag process is an enhancement of the conventional flocculation and clarification process. It begins with the flow-paced addition of coagulant to system influent - CoMag operates equally well with all common coagulants and is able to adapt to varying influent conditions. Flocculation and the addition of magnetite occurs in conventional reaction tanks. Magnetite becomes quickly infused into the flocs through simple mixing. Hydraulic retention time (HRT) is short because the CoMag process does not require the development of large flocs typical of conventional flocculation processes. Just prior to clarification, a small dose of polymer is added to enhance the capture rate of fine particles.

The magnetite-laden floc flows to a small clarifier of conventional design (cone bottom or sloped bottom with rake). The high specific gravity of the ballasted floc results in a very rapid and reliable settling rate. About 85 percent of the settled sludge is re-circulated to the reaction tanks where the resulting increase in solids density greatly improves the capture of contaminants and enables the system to withstand high fluctuations in loads and flows as well as reducing the required coagulant concentration.

The remaining 15 percent of the settled sludge flows though a shear mixer which liberates the magnetite from the floc. The resulting two part slurry flows over a magnetic drum that captures approximately 99 percent of the magnetite and recycles it back to the reaction tanks. The remaining slurry flows to the sludge system for further processing and disposal. A process flow diagram for the pilot CoMag system is present in Figure 5-1 below.

Effluent discharged from the CoMag system is capable of attaining turbidity values of less than 1.0 nephelometric turbidity units (NTU). Drinking water turbidity is typically 0.1-0.5 NTU. This degree of effluent clarity minimizes the downstream filter/membrane fouling associated with suspended solids.

Figure 5-1 Pilot CoMag System Process Flow Diagram



6. PILOT TEST RESULTS

Pilot scale treatment tests were conducted over a two week period using a trailer-based CoMag system that was delivered to the Site. This system was fed from tank T-292A where the initial pH adjustment occurs in the current treatment system. The effluent from the trailer was returned to the process at tank 147, prior to the Lamella clarifier. Originally, sludge from the trailer was discharged directly into the sludge settling tank, but the magnesium hydroxide sludge was more difficult to dewater without polymer conditioning than the calcium silicate sludge generated in the current treatment system. This issue was solved by allowing the solids to settle in an unused 350-gallon tank and decant the supernatant into the current process. The solids were then treated at the end of the week with approximately 20 ppm polymer to enhance dewatering and pumped into the sludge settling tank. Dewatering the conditioned sludge was no more difficult than the normal sludge generated by the treatment process.

Magnesium chloride was used as the coagulant for the pilot test based on the results from the bench scale tests. Alkalinity was added using either sodium hydroxide or sodium aluminate. Aries 1668 anionic polymer was used to enhance flocculation. Soda ash was also added to some of the trials to simulate the initial alkalinity and subsequent calcium precipitation that will be seen in the future full scale system when heated calcium silicate precipitation is no longer used. The SSIT sump typically contains two to three times as much silica as calcium. However, during existing treatment operations, recycled side streams from the existing process result in abnormally high influent calcium concentrations. The increase in calcium, coupled with a decrease in silica concentration due to dilution with silica free stormwater results in a calcium concentration in the existing effluent that is two to three times higher than the silica concentration. In the future there will not be any calcium used in the process and the small quantities of calcium that are present are expected to be removed by precipitation with naturally occurring carbonate.

Most trials conducted resulted in a silica removal of 90 percent or greater, and the use of sodium aluminate did appear to aid in silica removal. A summary of the pilot test results can be found in Table 6-1 and the entire data set is present in Appendix C. Effluent silica concentrations of less than 10 mg/L were consistently achieved using a dose of 100 mg/L of $MgCl_2$ and pH adjustment with NaOH, or 50 mg/L and pH adjustment with sodium aluminate. Excellent effluent clarity was achieved at flows up to 14 gallons per minute through the 18-inch diameter CoMag clarifier, corresponding to the maximum clarifier loading rate that is ever allowed in a CoMag system (8 gallons per minute per square foot). The full scale design will be based on a typical design basis of 3-4 gallons per minute per square foot. A clarifier sidewall depth of at least 4 feet is recommended to provide adequate solids storage volume during full-scale operation.

Table 6-1 Pilot Test Results Summary

Date	Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag (PPMV)	Polymer (mg/L)	Alkalinity Source	T1 ph (SU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Silica Removal (%)	Notes (#)
6/7/2011	14:50	10.0	5.0	3.4	50%	34%	100.0	2.5	NaOH	11.8	-	27.2	-	<1	>96%	-
6/8/2011	10:00	10.0	4.5	3.0	45%	30%	225.0	2.2	NaOH	10.6	128.0	28.1	144.0	3.0	89%	-
6/8/2011	12:00	9.6	4.6	1.7	48%	18%	100.0	1.8	NaOH	11.0	168.0	28.1	72.0	2.7	90%	-
6/8/2011	14:45	10.0	5.2	0.5	52%	5%	50	1.2	NaOH	11.6	40.0	39.5	32.0	23.0	42%	1 - feed pumps shut down on high level alarm - no chemicals for 10 min which produced cloudy effluent
6/9/2011	9:00	9.9	-	0.5	-	5%	-	-	NaOH	-	-	46.8	-	22.5	52%	-
6/9/2011	11:30	9.5	4.7	0.5	49%	5%	52.0	1.2	NaOH	11.1	168.0	35.7	104.0	6.1	83%	-
6/9/2011	14:30	9.6	4.6	0.9	48%	9%	52.0	1.2	Aluminate	10.6	104.0	30.3	88.0	2.1	93%	1 - rising sludge blanket at end of run
6/10/2011	11:45	14.0	3.4	1.5	24%	11%	98.5	2.0	NaOH	11.3	239.0	11.5	56.0	3.2	72%	1 - flow very unstable, sludge blanket constantly moving up and down between waste rates and influent rates
6/10/2011	14:30	14.0	3.0	1.4	21%	10%	98.5	2.0	NaOH	10.6	56.0	44.0	40.0	<1	>97%	-
6/20/2011	12:00	13.2	5.3	2.0	40%	15%	46.2	2.0	Aluminate	10.9	112.0	28.5	72.0	2.9	90%	1 - No Shear mixer used, running with spray water. 3 - sludge blanket rising slowly with vfd at 25hz
6/20/2011	14:30	14.0	5.1	1.6	37%	11%	46.0	2.0	Aluminate	11.1	48.0	14.7	32.0	6.2	58%	1 - No Shear mixer used, running with spray water
6/21/2011	11:30	10.0	3.0	0.5	30%	5%	18.8	2.0	Aluminate	11.1	48.0	34.3	32.0	9.2	73%	1 - No Shear mixer used, running with spray water 2 - recycle pipe clogged and clarifier became cloudy, let run for another half an hour to clear clarifier
6/21/2011	14:30	9.7	3.6	0.4	37%	4%	15.9	2.0	Aluminate	10.7	48.0	20.9	32.0	19.1	9%	-
6/22/2011	11:15	10.0	4.9	1.4	49%	14%	51.0	2.0	Aluminate	11.0	104.0	17.5	16.0	13.8	21%	1 - No Shear mixer used, running with spray water
6/22/2011	13:15	10.0	2.3	0.4	23%	4%	21.9	2.0	Aluminate	11.3	72.0	52.4	16.0	23.3	56%	1 - No Shear mixer used, running with spray water
6/22/2011	14:30	10.0	3.0	0.2	30%	2%	10.4	2.0	Aluminate	11.3	64.0	39.8	8.0	29.2	27%	1 - No Shear mixer used, running with spray water 4- soda ash set at approximitly 75ml/min 5- soda ash pumping at a rate of 113ml/min
6/23/2011	1:00	10.0	4.2	1.7	42%	17%	47.0	3.3	Aluminate	11.6	104.0	55.5	16.0	1.5	97%	4- soda ash set at approximitly 75ml/min
6/23/2011	14:30	14.0	3.1	1.3	22%	9%	110.0	2.3	NaOH	11.4	80.0	48.5	16.0	15.4	68%	5- soda ash pumping at a rate of 113ml/min

7. FULL SCALE SYSTEM OPERATIONS

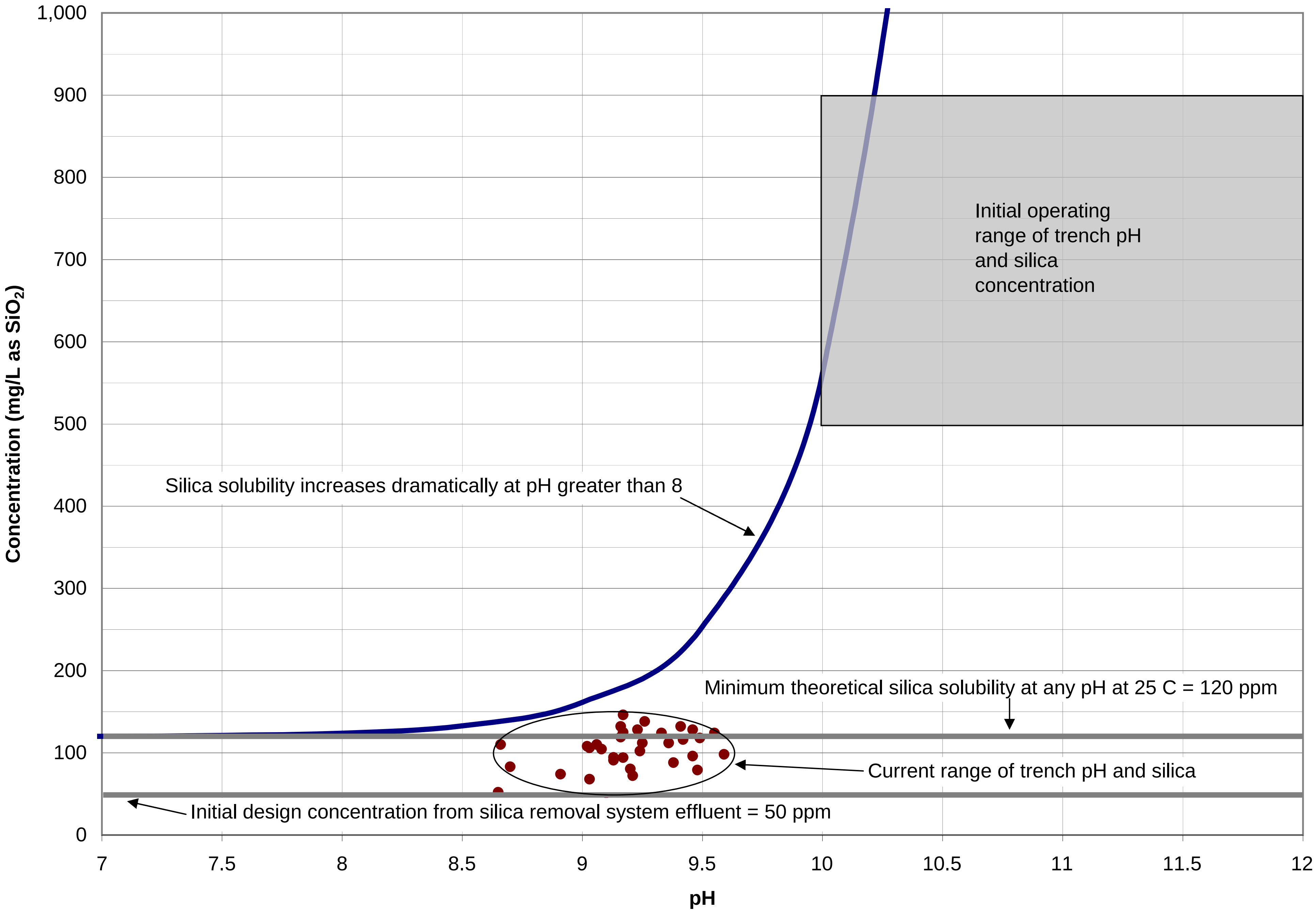
An estimation of the chemical usage and sludge generation costs were preformed for two proposed operation cases. Case 1 utilizes 100 ppm of $MgCl_2$ and NaOH for pH adjustment. Case 2 doses 50 ppm of $MgCl_2$, uses NaOH for the majority of the pH adjustment, and uses $NaAlO_2$ for pH trim. These estimations were based on chemical usage and sludge generation observed in the bench scale and pilot testing activities. For each of these conditions, cost estimation was completed for the typical system flow rate of 6 gpm as well as the maximum expected flow rate of 30 gpm. The estimations are based on 24 hour daily operations, conducted 365 days per year.

Both operations cases produced an annual chemical usage and sludge generation cost of approximately $40,000 per year. Since the estimated costs are so similar, full scale operations trials will be performed to determine the more cost effective case. A summary of the calculated costs are present in Table 7-1 and the complete calculations are present in Appendix D.

Table 7-1 Chemical and Sludge Cost Estimation Calculations

Chemical Usage				
Case 1		Case 2		
Max	Typical	Max	Typical	
11.2	2.2	5.6	1.1	30% MgCl2 as Mg used (gal/day)
0.7	0.1	0.7	0.1	Polymer Used (lb/day)
-	-	12.3	2.5	50% NaOH required (gal/day)
19.7	3.9	9.5	1.9	38% NaAlO2 required (gal/day)
Chemical Cost				
Case 1		Case 2		
Max	Typical	Max	Typical	
$ 14	$ 3	$ 7	$ 1	MgCl2 hexahydrate used ($/day)
$ 3	$ 1	$ 3	$ 1	Polymer Used ($/day)
$ 94	$ 19	$ 60	$ 12	50%NaOH required ($/day)
-	-	$ 66	$ 13	38%NaAlO2 required ($/day)
$ 110	$ 22	$ 136	$ 27	Total Cost ($/day)
Sludge Generation				
Case 1		Case 2		
Max	Typical	Max	Typical	
11,169	2,234	5,178	1,036	Generated Sludge Volume (gal/day)
12.5	2.5	13.7	2.7	Pressed Sludge Volume (cu. ft/day)
Sludge Cost				
Case 1		Case 2		
Max	Typical	Max	Typical	
$ 263	$ 53	$ 288	$ 58	Disposal ($/day)
$ 103	$ 21	$ 113	$ 23	Freight ($/day)
$ 366	$ 73	$ 401	$ 80	Total Cost ($/day)
Total Cost				
Case 1		Case 2		
Max	Typical	Max	Typical	
$ 477	$ 95	$ 537	$ 107	Chemical/Sludge Cost ($/day)
$ 173,936	$ 34,787	$ 195,875	$ 39,175	Chemical/Sludge Cost ($/yr)

APPENDIX A: SILICA VS. pH GRAPHS

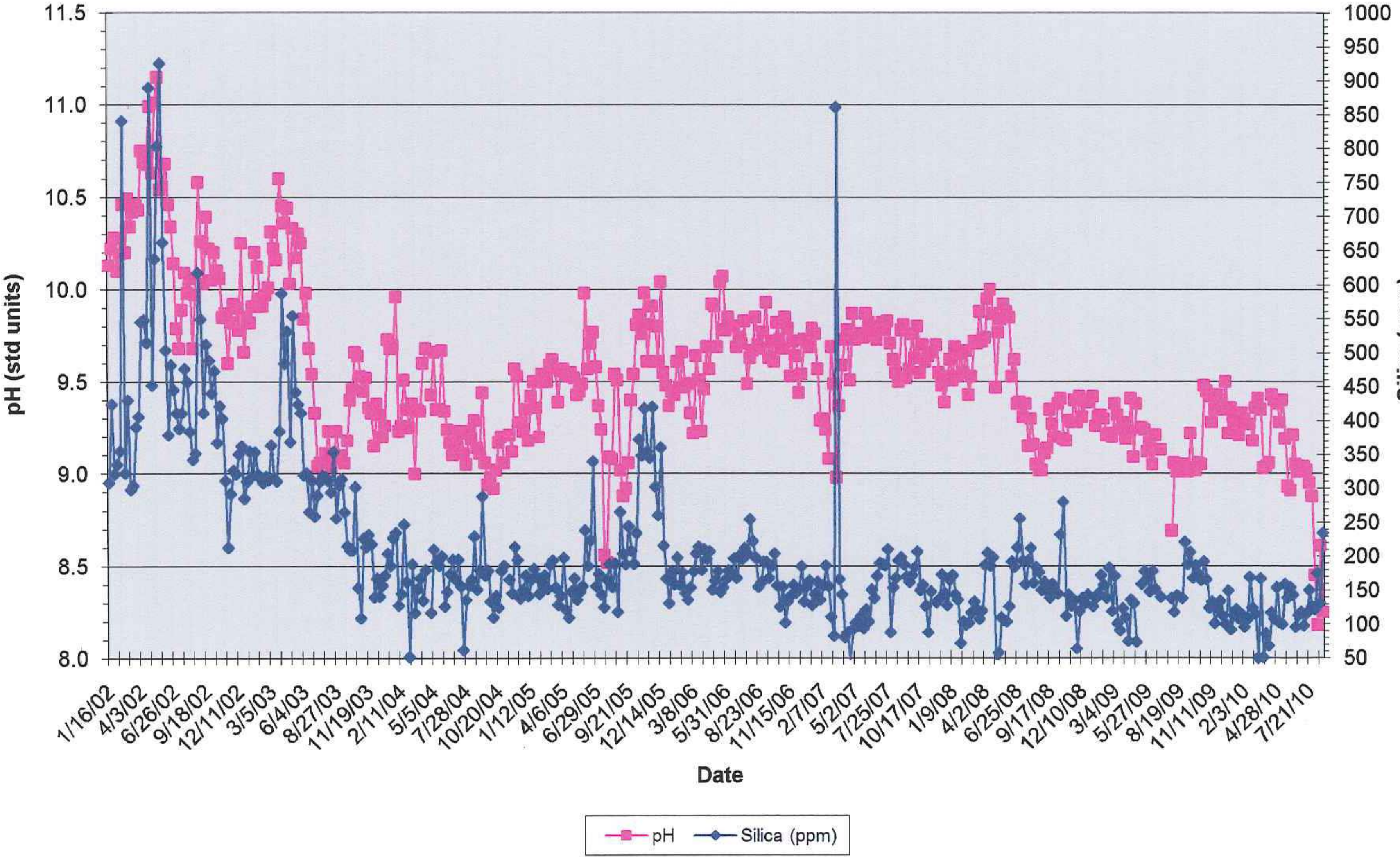


Silica Solubility (SiO_2) vs. pH

HoltraChem Mfg Site
Orrington, ME

CDM

Southerly Stream Groundwater Trends
pH & Silica



APPENDIX B: BENCH TEST RESULTS

Mallinckrodt Bench Test Results Matrix

				Initial				Coagulant Addition						pH Adjustment - mix 45 minutes at 150 rpm					Magnetite (3/4 tsp, 10 minutes at 150 rpm) and					Settled Solution (1 hour settle)							
Test #	Sample ID	Si - Total (ppm)	Si - Dissolved (ppm)	pH	Cond (umho)	Turb (NTU)	Temp (C)	Coagulant type	mL coag added	pH	Cond (umho)	Turb (NTU)	Temp (C)	mL and type acid/base added	pH	Cond (umho)	Turb (NTU)	Temp (C)	Floc solids description	pH	Cond (umho)	Turb (NTU)	Temp (C)	Supernatant description	Sludge desc and volume	pH	Cond (umho)	Turb (NTU)	Temp (C)	Filtration vol (mL), Time (min)	Notes
1	Baseline	116	117	9.5	*1010*	2.66	10																								
2	None-0-20-7-HCl	97	92	9.5	*1010*	2.66	10							6.3 mL 1.0 N	6.3	1.702	4.11	13.8						N/A	N/A	7.30	1.69	2.77	17		
8	Ca-800-60-11.5-NaOH	5	4	9.04	1.745	3.44	58.7	65 mL 10% CaCl2	64.68	7.91	5.25	9.43	53.2	35 mL of 1.0N NaOH	11.49	6.52	551	47.8	Dense, black, small, tight floc; clear supernatant	11.25	6.09	3.2	33.7	Clear	1/2" Sludge layer, dense	11.29	6.14	1.81	36.5		
9	Mg-500-60-11.5-NaOH	5	5	9.04	1.745	3.44	58.7	93 mL 10% MgCl2	93.18	8.56	4.99	4.85	51.1	118 mL of 1.0N NaOH	11.5	7.7	278	44.6	Fluffy, black, loose; clear supernatant, large floc	11.43	6.95	1.17	34.9	Clear	1-1/4" sludge layer, fluffy	11.26	7.32	1.94	37.5		
10	Al-500-60-11.5-NaOH	0	0	0	0	0	60		54.39						11.5																
11	Ca-400-60-11.5-NaOH	17	16	9.04	1.745	3.44	58.7	32 mL 10%	32.34	8.11	3.48	18.9	49	26 mL of 1.0N	11.5	4.6	300	45.6	Tight, dense, gray; clear	11.41	4.23	4.75	34	Clear	3/8" sludge layer,	11.18	4.252	2.87	36.2		
12	None-0-60-11.5-NaOH	96	60	9.04	1.745	3.44	58.7		0.00	0.00	0	0	0	32 mL of 1.0N NaOH	11.5	4.214	56	46.2	Cloudy supernatan, thin sludge layer on bottom	11.5	3.93	60.1	35.9	Cloudy	thin, dense sludge layer	11.14	3.836	35.2	37.9		
13	Ca-800-40-11.5-NaOH	15	15	9.3	1.7	7.16	37	65 mL 10% CaCl2	64.68	8.50	5.28	5.5	34	30 mL of 1N NaOH	11.55	6.1	354	33	Dense, black, small, tight floc; clear supernatant	11.5	5.8	0	29	Clear	1/2" Sludge layer, dense	11.25	5.67	6.27	33.4		
14	Ca-800-20-11.5-NaOH	39	38	9.3	0.917	3.02	21.4	65 mL 10% CaCl2	64.68	8.30	1.71	4.74	20.4	23.5 mL of 1.0 N NaOH	11.47	5.84	299	20.2	Dense, black, small, tight floc; clear supernatant	11.3	5.48	3	20.1	Clear	Thin (1/4") sludge layer	11.22	5.24	3.57	20.6		
15	Ca-800-60-10.5-NaOH	58	60	9.04	1.745	3.44	58.7	65 mL 10% CaCl2	64.68	8.00	5.07	14.7	48.6	18 mL of 1N NaOH	10.79	3.5	230	30.2	Tight, black, large; thin sludge layer on bottom, clear	10.8	4.85	1.96	34.2	Clear	Thin sludge layer	10.45	4.65	2.12	38.7		
16	Ca-800-60-7-HCl	103	90	9.04	1.745	3.44	58.7	65 mL 10% CaCl2	64.68	7.78	5.26	19	53.7	10 mL of 1N HCl	7	5.42	17	47	Very fine, dense, small, black, tight floc, clear supernatant	7.6	4.65	7.19	36.5	Clear	Very thin sludge layer, dense	7.03	5.06	7.53	40.3		
17	None-0-60-11.5-Ca(OH)2	1	1	8.64	1.285	8.7	63.9		0.00	0.00	0	0	0	90 mL of Ca(OH)2	11.51	6.43	>1000	58.2	Fine, dense, small blac floc	11.84	7.43	3.66	38.2	Partly cloudy	1/4" black sludge layer	11.36	7.45	10.3	52.8		
18	Ca-800-60-11.5-NaAlO2	1	1	8.64	1.285	8.7	63.9	65mL 10% CaCl2	64.68	7.47	6.02	14.7	56.3	522	11.24	7.88	>1000	47.1	Medium gray floc, tight, well settled	11.39	7.4	3.12	35.9	Clear	1/4" sludge layer	11.13	7.7	3.14	50		Had to stop adding caustic due to max volume in B-Ker
19	Mg-500-20-10.5-NaAlO2	<0.9	<0.4	9.3	0.917	3.02	21.4	93 mL 10% MgCl2	93.18	8.76	1.8	4.16	21	490 mL of 1N NaAlO2	10.48	5.46	>1000	20.8	Very large gray floc, slow to settle, clear supernatant	10.95	4.994	3.9	20.3	Clear	3-1/4" Sludge layer, fluffy	10.70	5.4	3.12	20.7		
20	Mg-200-20-10.5-NaAlO2	0.9	0.8	9.3	0.917	3.02	21.4	37 mL 10% MgCl2	37.27	9.05	1.36	7.14	21.2	225 mL of 1.0N NaAlO2	10.48	3.663	>1000	20.9	Large gray floc, well settling, clear supernatant	10.65	3.068	5	20.6	Clear	1-7/8" Sludge layer, fluffy	10.47	3.711	3.0	20.3		
21	Mg-500-40-10.5-NaAlO2	0.7	0.7	9.3	1.7	7.16	37	93 mL 10% MgCl2	93.18	8.80	5.22	3.7	0	370 mL of 1N NaAlO3	10.7	5.44	655	32	Large gray floc, well settling, clear supernatant	10.8	5.07	0	29	Clear	1-7/8" Sludge layer, fluffy	10.41	5.35	4.65	35.8		
22	Mg-200-40-10.5-NaAlO2	2	2	9.3	1.7	7.16	37	37 mL 10% MgCl2	37.27	8.90	3.28	3.3	40	200 mL of 1N NaAlO3	10.6	3.8	361	36	Large gray floc, well settling, clear supernatant	10.7	3.7	0	32	Clear	1-1/8" Sludge layer, fluffy	10.45	3.623	1.94	36.2		
23	Mg-200-60-10.5-NaAlO2	1	1	8.64	1.285	8.7	63.9	37 mL 10%	37.27	8.55	3.434	13.6	52.1	420 mL of	10.5	5.53	998	46.5	Small gray floc, well settled	11.08	5.76	3.47	36.3	Clear	1" Sludge layer, fluffy	11.14	5.96	2.2	48.2		
5	MgO-200-20-9.5-None	102	103	9.5	*1.19*	3.67	12	MgO	0.70	10.30	1.692	185												Cloudy	Thin film	10.20	1.72	38	17		
6	MgO-500-20-9.5-None	89	84	9.5	*1.19*	3.67	12	MgO	1.80	10.45	1.762	639												Cloudy	1/4" Sludge layer	10.50	1.8	54.3	16		
7	MgO-1000-20-9.5-None	62	59	9.5	*1.19*	3.67	12	MgO	3.60	10.70	1.806	>1000												Cloudy	3/8" Sludge layer	10.65	1.77	25	17		
3	Fe3O4 DI Blank	0	0	7	*0.002*	0.73	20							None	7.66	0.0067	118	20.9						Clear	1/8" dense, settled	8.90	0.011	15.8	20		
4	Fe3O4 DI Blank	0	0	7	*0.002*	0.73	20							4.5 mL 1.0N	11.52	0.5	105	20						Clear	1/8" dense, settled	11.40	0.44	13.7	20		
0	None-0-20-4.5-HCl	85	98	9.3	0.917	3.02	21.4							14.75 mL 1.0N	4.48	1.902	3.66	18.9						Cloudy	None	7.81	1.823	5.68	20.9		
0	Mg-200-20-10.5-NaOH	23	22	9.3	0.917	3.02	21.4	37 mL 10% MgCl2	37 mL	9.09	3.148	5.44	19	15 mL 1.0N NaOH	10.47	3.313	26.6	19	Small, tight black floc, very well settling	9.91	3.169	2.4	19.8	Clear	1/4" sludge layer, dense	9.77	3.014	2.57	20.1		

Notes:

Italics indicate non-specific conductivity (not temperature corrected)
MgCl2 coagulant is Acros Cl2Mg*6H2O
CaCl2 coagulant is Fisher Biotech CaCl2*2H2O

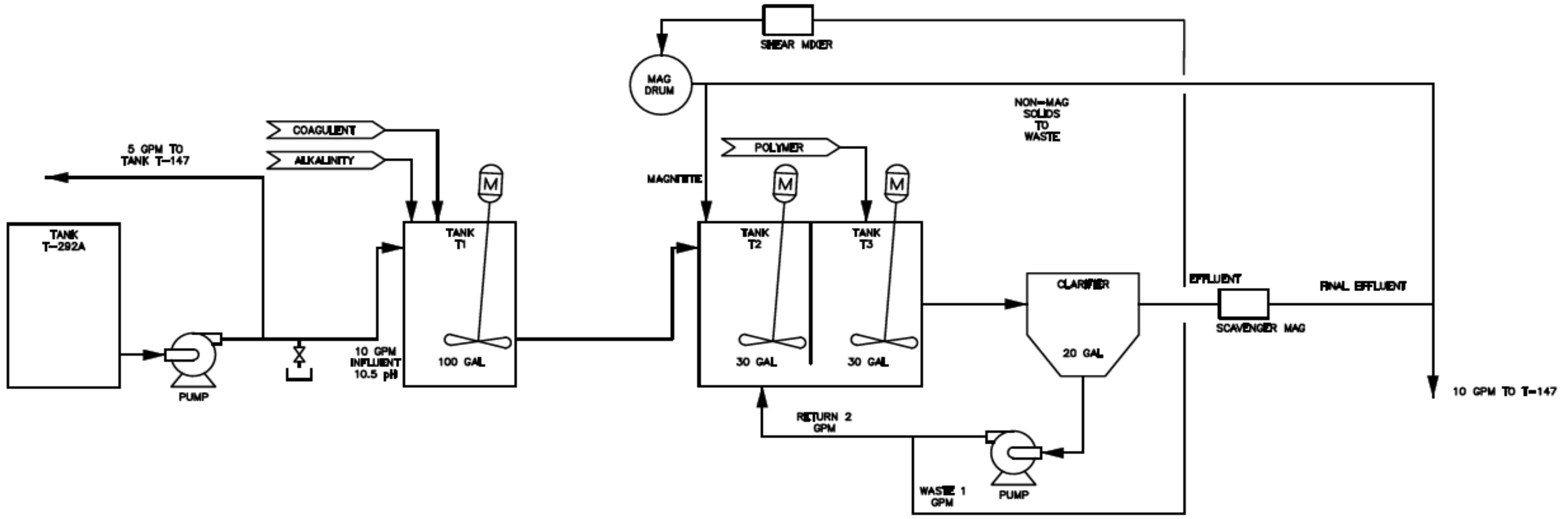
APPENDIX C: PILOT TEST RESULTS

Date: 6/6/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 0.1% (1 mL/liter)
ph Control: NaOH
ph Conc: 25%

Influent from: T-292A
Influent Temp °F:
Operators: Harvey King, Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



							2 sack plus 10.2 gal		35gm in 7gal						Effluent	Efflluent							(from top)			T3	Clarifier	Waste	
Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Clarifier Turb (NTU)	Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	Non-mag TSS (mg/L)	underflow TS (mg/L)	Sludge TS (mg/L)	Notes (#)
13:43	5.5	2.0	1.0	36%	18%	34	300	21?		21%	11.2					0.3													
14:00	6	3.0	2.3	50%	38%	57	300?	21			10.5	11.2																	
15:00	10	3.0	2.5	30%	25%	144	300	57			10.5	11				0.30							15.00	986.00	#DIV/0!	6564.00	16225.00	5592.50	
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
15:00	T1	711.8	662.500	49.3	0.05	986.00		T1			0.0		#DIV/0!
	T3-NM	1002.6	674.400	328.2	0.05	6564.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	29947.4	29298.400	649.0	0.040	16225.00		CU			0.0		#DIV/0!
	WS	29709.8	29486.100	223.7	0.040	5592.50		WS			0.0		#DIV/0!
	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!
	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

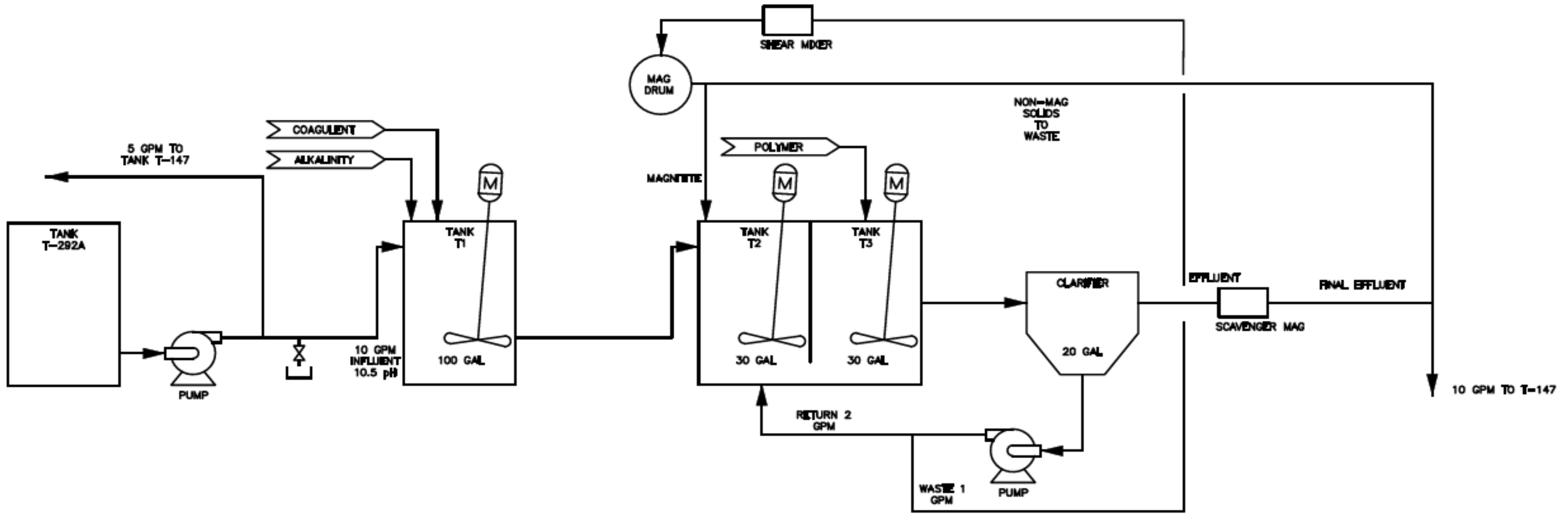
Notes:

Date: 6/7/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 0.1% (1 mL/liter)
ph Control: NaOH
ph Conc: 25% NaOH or 38% aluminate

Influent from: T-292A
Influent Temp °F:
Operators: Harvey King, Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	300ppm 2bags in 10.2 gal			pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Efflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
							Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)																				
9:22	6.0			0.00	0.00	47		75%		45%	10.49	11.410	33.7	122.0		1.6		34.3			<1		27.5	902.00		10520.0	20447.5	5442.5	
11:30	10	3.2	3.9	0.32	0.39	127		75%		45%	10.46	10.910	37.80	119.00	2.39	0.18							28.00		10.00		27245.00	6295.00	
14:50	10	5.0	3.4	0.50	0.34	52	100	71%	2.5		10.23	11.800	81.00	91.50		0.27		27.20			<1		27.50	544.00		11114.00	24820.00	4682.50	
14:20				#DIV/0!	#DIV/0!																<1								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
9:22	T1	696	650.900	45.1	0.05	902.00		T1			0.0		#DIV/0!
	T3-NM	1177.2	651.200	526.0	0.05	10520.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30135.6	29317.700	817.9	0.04	20,447.50		CU			0.0		#DIV/0!
	WS	29559.7	29342.000	217.7	0.04	5,442.50		WS			0.0		#DIV/0!
14:50	T1	694.5	667.300	27.2	0.05	544.00		T1			0.0		#DIV/0!
	T3-NM	1216.9	661.2	555.7	0.05	11114.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	31675.5	30682.7	992.8	0.04	24820.00		CU			0.0		#DIV/0!
	WS	30471.9	30284.6	187.3	0.04	4682.50		WS			0.0		#DIV/0!
11:30	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30620	29530.2	1089.8	0.04	27245.00		CU			0.0		#DIV/0!
	WS	30683	30431.2	251.8	0.04	6295.00		WS			0.0		#DIV/0!

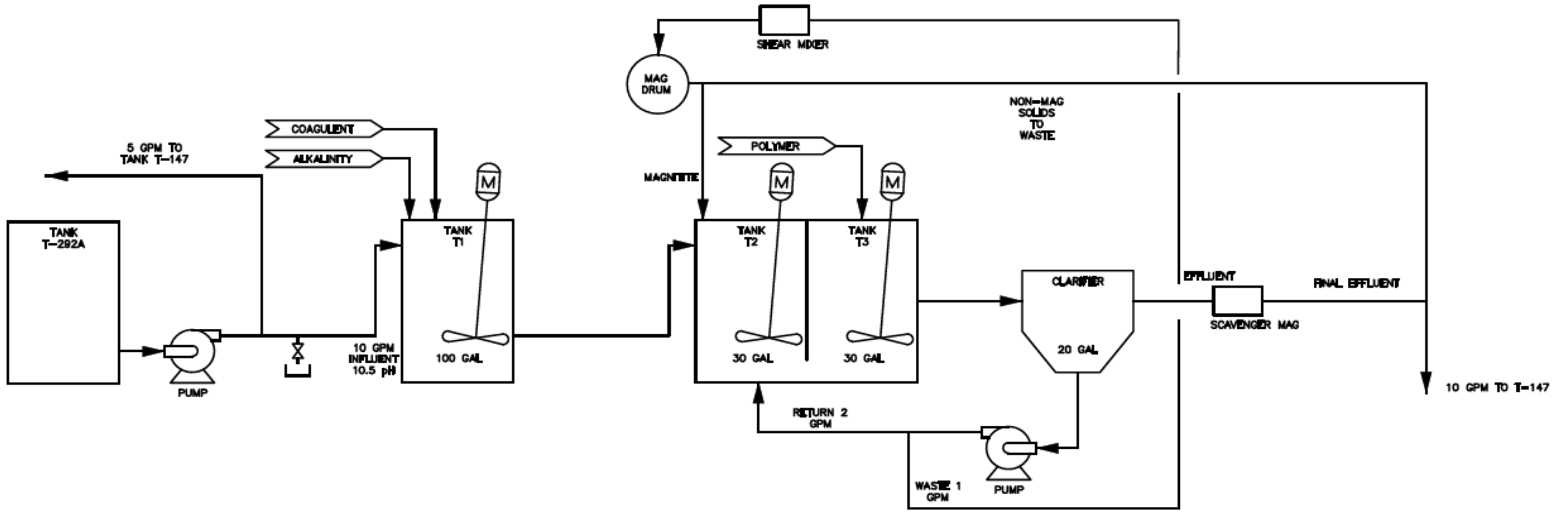
Notes:

Date: 6/8/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 0.1% (1 mL/liter)
ph Control: NaOH
ph Conc: 25% NaOH or 38% aluminate

Influent from: T-292A
Influent Temp °F:
Operators: Harvey King, Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Effllluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	depth from top Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
10:00	10.00	4.5	3.0	45%	30%	108	225	62	2.2	40	11.0	10.60	254.0	263.0		0.6	128.0	28.1		144.0	3.0	18.0	26.0	1014.00	9.1	10534.0	24345.0	7165.0	
12:00	9.60	4.6	1.7	48%	18%	48	100	50	1.8	20	11.0	11.00	227.00	249.00		0.21	168.00	28.10		72.00	2.70	14.90	25.70	866.00		11170.00	31800.00	7887.50	
14:45	10.00	5.2	0.5	52%	5%	25	50	35	1.2	10	11.1	11.60	155.00	156.00		4.50	40.00	39.50		32.00	23.00	9.50	24.00	484.00		8912.00	40110.00	9167.50	1.00
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

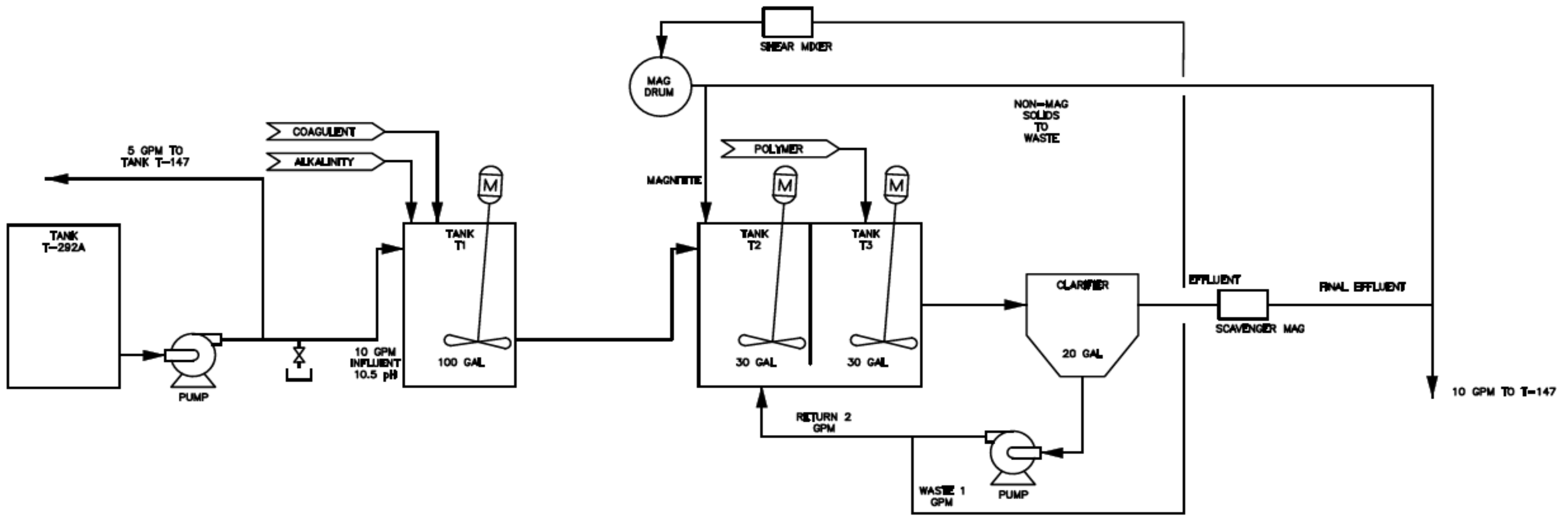
Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
10:10	T1	685.8	635.100	50.7	0.05	1014.00		T1			0.0		#DIV/0!
	T3-NM	1178.4	651.700	526.7	0.05	10534.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	31006.7	30032.900	973.8	0.04	24,345.00		CU			0.0		#DIV/0!
	WS	31583.6	31297.000	286.6	0.04	7,165.00		WS			0.0		#DIV/0!
12:00	T1	703.3	660.000	43.3	0.05	866.00		T1			0.0		#DIV/0!
	T3-NM	1218.5	660	558.5	0.05	11170.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30787.3	29515.3	1272.0	0.04	31800.00		CU			0.0		#DIV/0!
	WS	30081.2	29765.7	315.5	0.04	7887.50		WS			0.0		#DIV/0!
14:30	T1	669.6	645.4	24.2	0.05	484.00		T1			0.0		#DIV/0!
	T3-NM	1090.1	644.5	445.6	0.05	8912.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30975.9	29371.5	1604.4	0.04	40110.00		CU			0.0		#DIV/0!
	WS	27815.4	27448.7	366.7	0.04	9167.50		WS			0.0		#DIV/0!

Notes: 1 - feed pumps shut down on high level alarm - no chemicals for 10 min which produced cloudy effluent

Date: 6/9/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 0.1% (1 mL/liter)
ph Control: NaOH or sodium aluminate
ph Conc: 25% NaOH or 38% aluminate

Influent from: T-292A
Influent Temp °F:
Operators: Harvey King, Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT
EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Efflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	measured from top Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
9:00	9.90		0.5	0%	5%											0.6		46.8			22.5								
11:30	9.50	4.7	0.5	49%	5%	25	52	35	1.2	"6% NaOH	10.6	11.1	271.00	248.00		0.54	168.00	35.70		104.00	6.10		18.00	814.00		13084.00	42610.00	13310.00	
14:30	9.60	4.6	0.9	48%	9%	25	52	35	1.2	odium Alum	10.3	10.6	15.30	145.00		0.72	104.00	30.30		88.00	2.10		13.00	350.00		10270.00	29062.50	6237.50	1.00
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
11:30	T1	709	668.300	40.7	0.05	814.00		T1			0.0		#DIV/0!
	T3-NM	1337.8	683.600	654.2	0.05	13084.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	31201.4	29497.000	1704.4	0.04	42,610.00		CU			0.0		#DIV/0!
	WS	30276.8	29744.400	532.4	0.04	13,310.00		WS			0.0		#DIV/0!
14:30	T1	669.6	652.100	17.5	0.05	350.00		T1			0.0		#DIV/0!
	T3-NM	1164.4	650.9	513.5	0.05	10270.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30518.9	29356.4	1162.5	0.04	29062.50		CU			0.0		#DIV/0!
	WS	27675	27425.5	249.5	0.04	6237.50		WS			0.0		#DIV/0!
	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

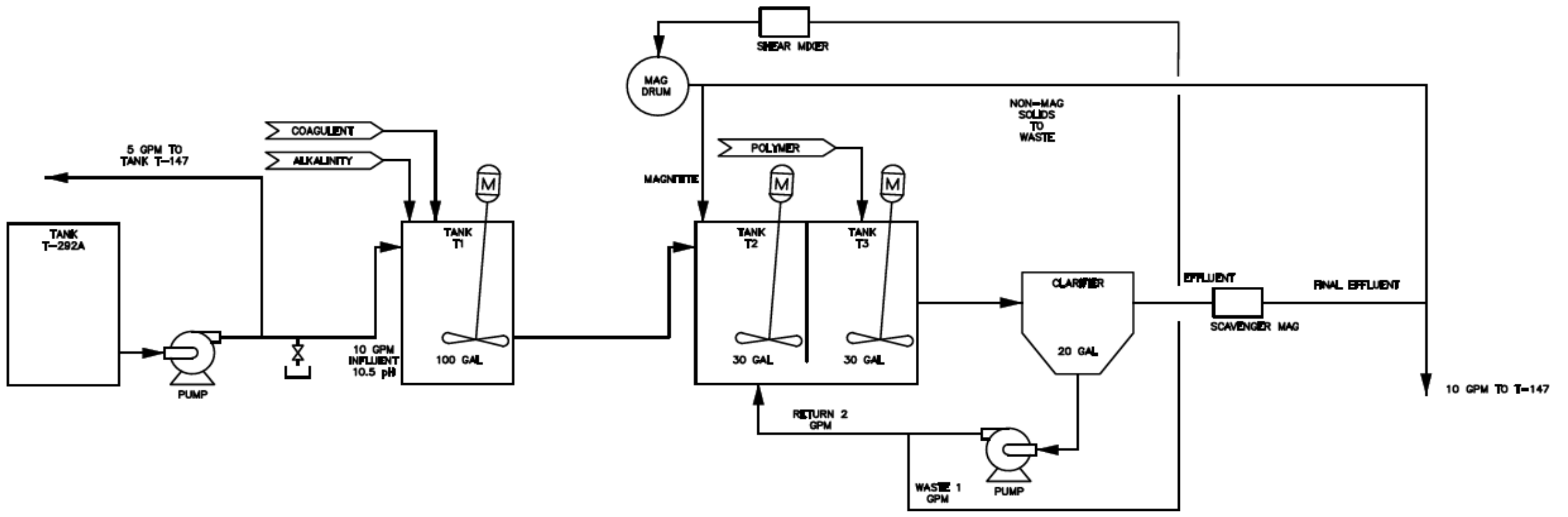
Notes: 1 - rising sludge blanket at end of run

Date: 6/10/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 0.1% (1 mL/liter)
ph Control: NaOH
ph Conc: 25% NaOH or 38% aluminate

Influent from: T-292A
Influent Temp °F: 19.5
Operators: Harvey King, Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Efflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	measured from top Effluent SDI	Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
8:01	14.00	5.1	2.5	36%	18%	66	99	57	1.4	36		10.6													12.3				
11:45	14.00	3.4	1.5	24%	11%	66	99	79	2.0	36	11.5	11.3	113.00	184.00		0.46	239.00	11.50	NA	56.00	3.20	15.00	-		9.70				1.00
14:30	14.00	3.0	1.4	21%	10%	66	99	79	2.0	45	10.6	10.6	157.00	155.00		0.18	56.00	44.00	NA	40.00	<1	18.00	-						
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
9:22	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!
14:50	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!
11:30	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

Notes:

1 - flow very unstable, sludge blanket constantly moving up and down between waste rates and influent rates

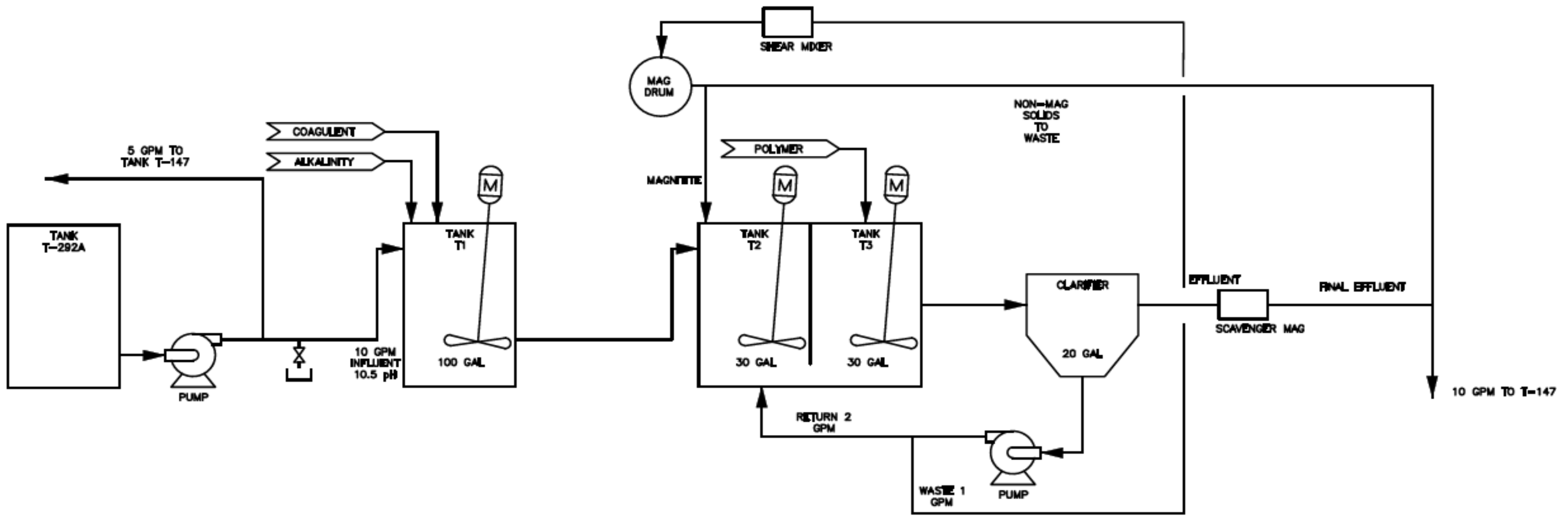
waste sludge sample from yesterday settled to 525mL from 1000mL

Date: 6/20/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 5dry grams per gallon
ph Control: Aluminate
ph Conc: 38% aluminate cut in half with h20

Influent from: T-292A
Influent Temp °F: 19.1
Operators: Greg Worster
Today's purpose:

19.0

Sample ID:Location-DD-TTTT
EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



																						measured from top							
Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Efflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
11:00	13.50	6.3	2.5	46%	19%	30	45	79	2.0	23	11.1	11.0	5.8										24.5						1, 2
12:00	13.20	5.3	2.0	40%	15%	31	46	79	2.0	23	11.0	10.9	4.87	106	1.3	0.27	112.00	28.50	17.00	72.00	2.90	17.00	20.50	410.00	10,075.00	7975.00	19417.50	3287.50	1, 3
14:30	14.00	5.1	1.6	37%	11%	31	46	79	2.0	23	11.3	11.1	63.60	169.00	0.48	0.29	48.00	14.70	17.96	32.00	6.20	18.40	27.00	742.00	10,029.00	9392.00	6710.00	34997.50	1
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
12:00	T1	641.9	600.900	41.0	0.10	410.00		T1			0.0		#DIV/0!
	T3-NM	1398.5	601.000	797.5	0.10	7975.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	30076.5	29299.800	776.7	0.04	19,417.50		CU			0.0		#DIV/0!
	WS	29618.5	29487.000	131.5	0.04	3,287.50		WS			0.0		#DIV/0!
14:30	T1	676.3	602.100	74.2	0.10	742.00		T1			0.0		#DIV/0!
	T3-NM	1538.3	599.1	939.2	0.1	9392.00		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU	29587.3	29318.9	268.4	0.04	6710.00		CU			0.0		#DIV/0!
	WS	30743.2	29343.3	1399.9	0.04	34997.50		WS			0.0		#DIV/0!
	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

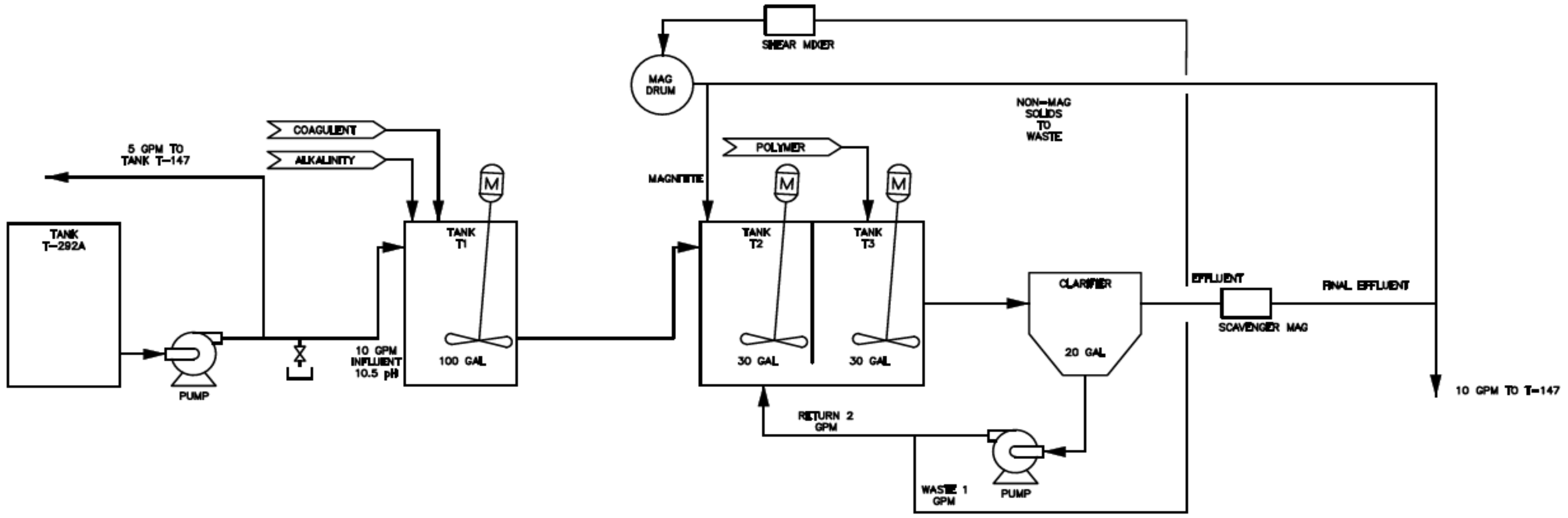
Notes:
1 - No Shear mixer used, running with spray water
2- Pin flock floating in clarifier, seems to be captured by scav mag - pin flock cleared and I realized that mgcl2 had been shut off.
3 - sludge blanket rising slowly with vfd at 25hz

Date: 6/21/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 25% solution
Polymer Type: Aries 1668
Polymer Conc: 5dry grams per gallon
ph Control: Aluminate
ph Conc: 38% aluminate cut in half with h20

Influent from: T-292A
Influent Temp °F: 18.8
Operators: Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Effllent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	measured from top Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
8:30	10.00	5.3	0.5	53%	5%	9	19	58	2.0	20	11.29	11.08																	1
11:30	10.00	3.0	0.5	30%	5%	9	19	58	2.0	18	11.2	11.1	71.10	149	0.9	0.49	48.00	34.30	16.10	32.00	9.20	13.90	27.00	487.00	8,050.00	8,028.00	29,327.50	9,932.50	1, 2
13:15	10.10	1.5	0.4	15%	4%	11	11.5	58	2.0	15		10.9																	4
14:30	9.7	3.6	0.4	37%	4%	15	16	58	2.0	21	9.9	10.7	27.60	123.00	41.0	32.50	48.00	20.90	NA	32.00	19.10	NA	clarifier to tu	507.00	15,020.00	6,476.00	19,912.50	8,157.50	
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
11:30	T1	648.1	599.400	48.7	0.10	487.00		T1			0.0		#DIV/0!
	T3-NM	1403.8	601.000	802.8	0.10	8028.00		T3-NM			0.0		#DIV/0!
	T3-Mag	30467	29662.000	805.0	0.10	8050.00		T3-Mag			0.0		#DIV/0!
	CU	30666.5	29493.400	1173.1	0.04	29,327.50		CU			0.0		#DIV/0!
	WS	30137.8	29740.500	397.3	0.04	9,932.50		WS			0.0		#DIV/0!
14:30	T1	652.9	602.200	50.7	0.10	507.00		T1			0.0		#DIV/0!
	T3-NM	1250.8	603.2	647.6	0.1	6476.00		T3-NM			0.0		#DIV/0!
	T3-Mag	27252	25750	1502.0	0.1	15020.00		T3-Mag			0.0		#DIV/0!
	CU	30155	29358.5	796.5	0.04	19912.50		CU			0.0		#DIV/0!
	WS	27752	27425.7	326.3	0.04	8157.50		WS			0.0		#DIV/0!
	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

Notes:

1 - No Shear mixer used, running with spray water
2 - recycle pipe clogged and clarifier became cloudy, let run for another half an hour to clear clarifier

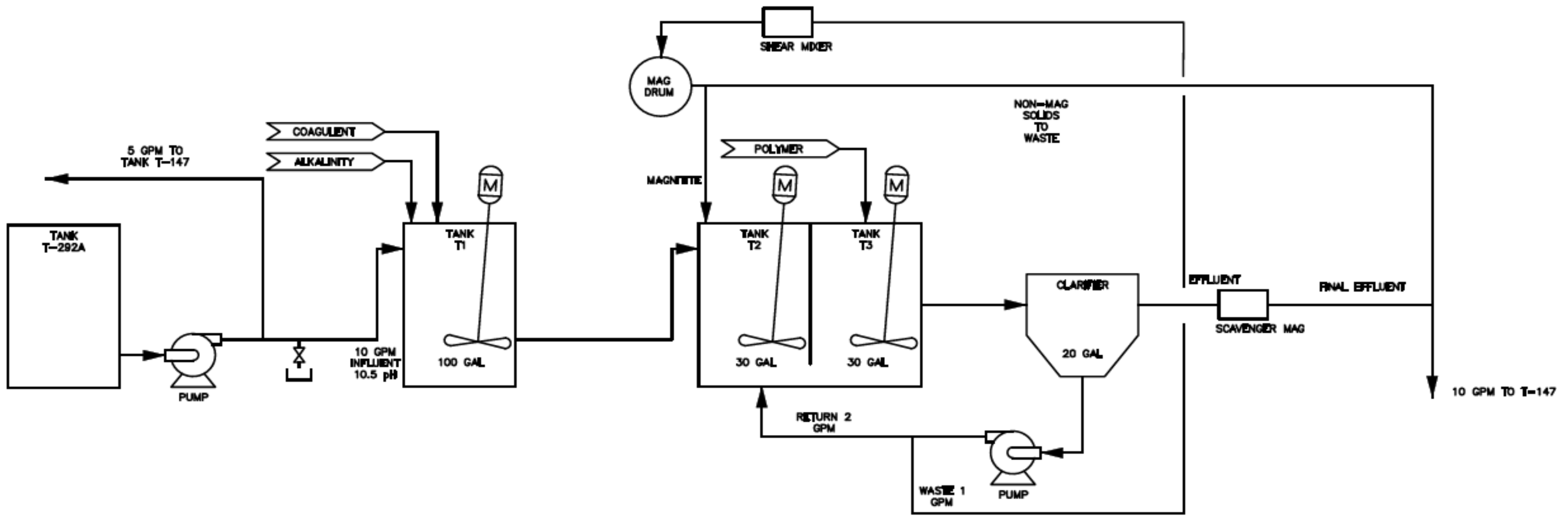
3- when attempting to dose 10ppm of Mg the pump syphoned back into the tank the floc to decrease in size and the clarifier to become very terbid (26.7 ntu) - increased the Mg back to 20ppm

4 - diluted mgcl2 solution in half, sludge built up in corners of clarifier decreasing volume of tapered tank. Flock very small
5 - at 14:00 the mgl2 dose was 8.7ppm, increased pump speed to 15.9mg/L

Date:	6/22/2011	**Influent from:**	T-292A
Facility:	Mallinckrodt US LLC	**Influent Temp °F:**	19.4
Location:	Orrington, ME	**Operators:**	Greg Worster
Coagulant:	Magnesium chloride	**Today's purpose:**	
Coag Conc:	12.5% solution		
Polymer Type:	Aries 1668		
Polymer Conc:	5dry grams per gallon		
ph Control:	Aluminate		
ph Conc:	38% aluminate cut in half with h20		

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Efflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	measured from top Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
9:30	9.80			0%	0%	49	51	57	2.0	16	11.80	12.00																	1 ,2, 3
11:15	10.00	4.9	1.4	49%	14%	49	51	57	2.0	16	11.47	11.0	869.00	253	0.5	0.37	104.00	17.50	NA	16.00	13.80	NA	26.25	792.00	15,090.00	10,424.00	25,030.00	#VALUE!	1
13:15	10.00	2.3	0.4	23%	4%	21	21.9	57	2.0	16	11.3	11.3	91.70	196.00	0.44	0.39	72.00	52.40	17.90	16.00	23.30	14.60	23.50	659.00	7,740.00	10,117.00	33,080.00	3,570.00	1
14:30	10.0	3.0	0.24	30%	2.4%	10	10.4	57	2.0	16	11.2	11.3	70.60	181.00	0.7	0.37	64.00	39.80	14.70	8.00	29.20	11.00	26.00	596.00	16,260.00	19,371.00	76,042.50	9,332.50	1, 4, 5
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
11:15	T1	680.3	601.100	79.2	0.10	792.00		T1			0.0		#DIV/0!
	T3-NM	1646.2	603.800	1042.4	0.10	10424.00		T3-NM			0.0		#DIV/0!
	T3-Mag	7242	5733.000	1509.0	0.10	15090.00		T3-Mag			0.0		#DIV/0!
	CU	31032.3	30031.100	1001.2	0.04	25,030.00		CU			0.0		#DIV/0!
	WS	Dropped Sample		#VALUE!		#VALUE!		WS			0.0		#DIV/0!
13:15	T1	663.6	597.700	65.9	0.10	659.00		T1			0.0		#DIV/0!
	T3-NM	1611.2	599.5	1011.7	0.1	10117.00		T3-NM			0.0		#DIV/0!
	T3-Mag	6338	5564	774.0	0.1	7740.00		T3-Mag			0.0		#DIV/0!
	CU	30901.1	29577.9	1323.2	0.04	33080.00		CU			0.0		#DIV/0!
	WS	31439.9	31297.1	142.8	0.04	3570.00		WS			0.0		#DIV/0!
14:30	T1	662.5	602.9	59.6	0.1	596.00		T1			0.0		#DIV/0!
	T3-NM	2536.4	599.3	1937.1	0.1	19371.00		T3-NM			0.0		#DIV/0!
	T3-Mag	7305	5679	1626.0	0.1	16260.00		T3-Mag			0.0		#DIV/0!
	CU	33026.8	29985.1	3041.7	0.04	76042.50		CU			0.0		#DIV/0!
	WS	27107.7	26734.4	373.3	0.04	9332.50		WS			0.0		#DIV/0!

Notes:

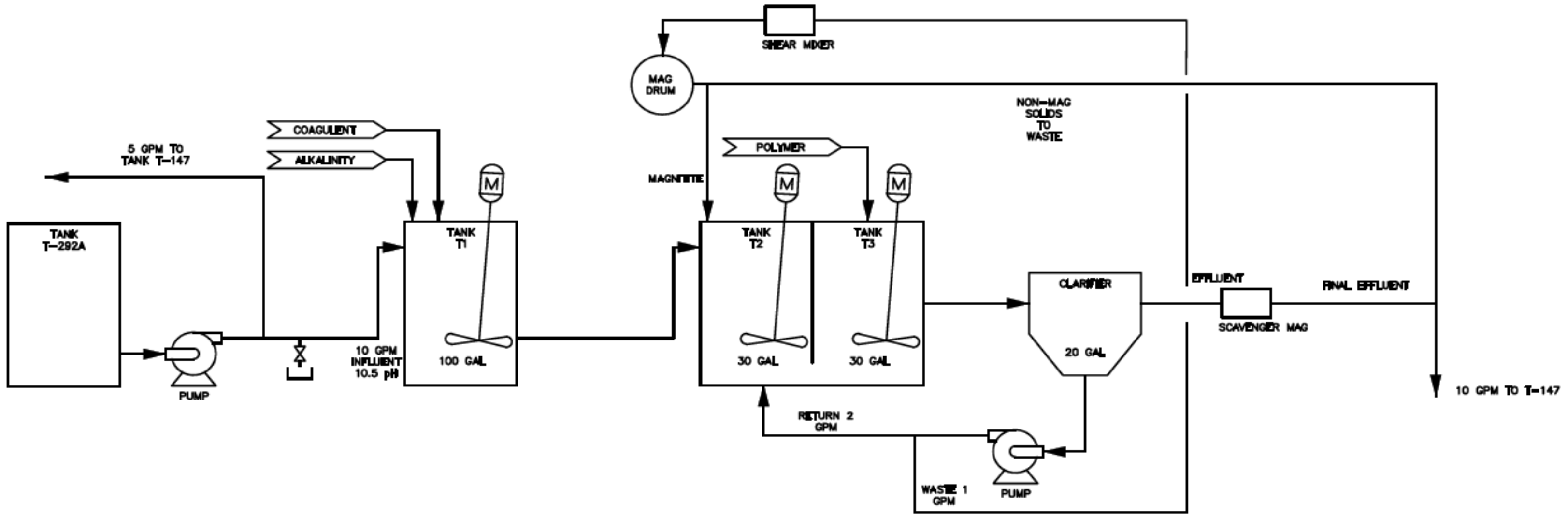
1 - No Shear mixer used, running with spray water
2 - influent pH 11.8, asked to turn down to 11
3- soda ash prepped at 2268gm in 6 gal of water. Feeding at a rate of 73ml/min
4- rat holing seen in the bottom of clarifier, cleared it out after 20ppm trial but quickly reappeard
5- rat hole built up and shot sludge up like volcano, increased recycle seemed to reduce rat hole

Date: 6/23/2011
Facility: Mallinckrodt US LLC
Location: Orrington, ME
Coagulant: Magnesium chloride
Coag Conc: 12.5% solution
Polymer Type: Aries 1668
Polymer Conc: 5dry grams per gallon
ph Control: Aluminate AM, NaOH pm
ph Conc: 38% aluminate cut in half with h20

Influent from: T-292A
Influent Temp °F: 20.6
Operators: Greg Worster
Today's purpose:

Sample ID:Location-DD-TTTT

EX: T3NM-06-1350 for June 6 at 1:50 pm fir Tank 3 non-magnitite solids



																						measured from top							
Time (24 hr)	Influent (GPM)	Recycle (GPM)	Waste (GPM)	Recycle (%)	Waste (%)	Coag. (ml/min)	Coag (PPMV)	Polymer (ml/min)	Polymer (mg/L)	pH feed (ml/min)	Influent ph (SU)	T1 ph (SU)	Influent Turbidity (NTU)	T1 Turbidity (NTU)	Effluent Clarifier Turb (NTU)	Effflluent Scav Mag Turb (NTU)	Influent Ca (mg/L)	Influent SiO2 (mg/L)	Influent SDI	Effluent Ca (mg/L)	Effluent SiO2 (mg/L)	Effluent SDI	Blanket Depth (in)	T1 TSS (mg/L)	T3 Magnetite (mg/L)	T3 Non-mag TSS (mg/L)	Clarifier underflow TS (mg/L)	Waste Sludge TS (mg/L)	Notes (#)
8:30	13.80			0%	0%	64.8	48.3	81	2.0	34									-			-			9.3				1, 2
1:00	10.00	4.2	1.7	42%	17%	45	47	93	3.3	55	11.64	11.6	59.70	237	1.1	0.52	104.00	55.50	-	16.00	1.50	-	26.00		28.15				4
14:30	14.00	3.1	1.3	22%	9%	148	110.0	93	2.3	54	11.6	11.4	78.30	208.00	1.12	0.30	80.00	48.50	-	16.00	15.40	17.10	22.00		21.98				5
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								
				#DIV/0!	#DIV/0!																								

Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)	Time (24 hr)	Sample Type	Tin Tare (mg)	Tin Gross (mg)	Net Wt (mg)	Volume (L)	Conc. (mg/L)
11:15	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!
13:15	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!
14:30	T1			0.0		#DIV/0!		T1			0.0		#DIV/0!
	T3-NM			0.0		#DIV/0!		T3-NM			0.0		#DIV/0!
	T3-Mag			0.0		#DIV/0!		T3-Mag			0.0		#DIV/0!
	CU			0.0		#DIV/0!		CU			0.0		#DIV/0!
	WS			0.0		#DIV/0!		WS			0.0		#DIV/0!

Notes:
1 - No Shear mixer used, running with spray water
2- soda ash prepped at 2268gm in 6 gal of water. Feeding at a rate of 108ml/min
3- T1 whiter than during other trials
4- soda ash set at approximitly 75ml/min
5- soda ash pumping at a rate of 113ml/min

APPENDIX D: CHEMICAL USAGE AND SLUDGE GENERATION COST ESTIMATION CALCULATIONS

Mallinckrodt Full Scale Chemical and Sludge Cost Estimation

System Parameters

30	Max System Flow (gpm)
6	Typical System Flow (gpm)
10.7	30% $MgCl_2$ Soln (lb/gal)

Chemical Costs

Cost ($/lb)	Chemical	Quantity
$ 0.38	$MgCl_2$ Hexahydrate	Pallet
$ 4.15	Aries 1668 Polymer	Partial Bag
$ 0.39	50% NaOH	700lb drum
$ 0.56	38% Sodium Aluminate	680lb drum

Sludge Costs

Cost ($/lb)	Service	Note
$ 0.23	Disposal	$450/ton
$ 0.09	Freight	$2600/15 ton load

Case 1	Case 2		Notes
100	50	$MgCl_2$ as Mg Concentration (ppm)	based on flow rate
2	2	Polymer Concentration (ppm)	based on flow rate
0.0056	0.0036	50% NaOH usage rate (lb/gal treated)	based on usage from bench test, adjust to pH 10.5
-	0.0027	38% $NaAlO_2$ usage rate (lb/gal treated)	based on pilot test, used as pH trim
26%	12%	Average waste rate during pilot trials	
6.28	14.84	Average Sludge Solids (g/L)	Assume pressed to 50% solids with 1.5SG

Chemical Usage

Case 1		Case 2		
Max	Typical	Max	Typical	
35.97	7.19	17.98	3.60	$MgCl_2$ as Mg used (lb/day)
76.53	15.31	38.26	7.65	$MgCl_2$ hexahydrate used (lb/day)
0.72	0.14	0.72	0.14	Polymer Used (lb/day)
-	-	156.54	31.31	50%NaOH required (lb/day)
242.86	48.57	116.98	23.40	38% $NaAlO_2$ required (lb/day)

Chemical Usage

Case 1		Case 2		
Max	Typical	Max	Typical	
11.21	2.24	5.60	1.12	30% $MgCl_2$ as Mg used (gal/day)
0.72	0.14	0.72	0.14	Polymer Used (lb/day)
-	-	12.33	2.47	50% NaOH required (gal/day)
19.74	3.95	9.51	1.90	38% $NaAlO_2$ required (gal/day)

Chemical Cost

Case 1		Case 2		
Max	Typical	Max	Typical	
$ 13.74	$ 2.75	$ 6.87	$ 1.37	$MgCl_2$ hexahydrate used ($/day)
$ 2.99	$ 0.60	$ 2.99	$ 0.60	Polymer Used ($/day)
$ 93.50	$ 18.70	$ 60.27	$ 12.05	50%NaOH required ($/day)
-	-	$ 65.51	$ 13.10	38%$NaAlO_2$ required ($/day)
$ 110.23	$ 22.05	$ 135.63	$ 27.13	Total Cost ($/day)

Sludge Generation

Case 1		Case 2		
Max	Typical	Max	Typical	
11,169.00	2,233.80	5,177.53	1,035.51	Generated Sludge Volume (gal/day)
584.41	116.88	639.78	127.96	Sludge Solids Generated (lb/day)
93.43	18.69	102.28	20.46	Pressed Sludge Volume (gal/day)
0.46	0.09	0.51	0.10	Pressed Sludge Volume (cu yards/day)
1,168.83	233.77	1,279.56	255.91	Pressed Sludge Weight (lb/day)

Sludge Cost

Case 1		Case 2		
Max	Typical	Max	Typical	
$ 262.99	$ 52.60	$ 287.90	$ 57.58	Disposal ($/day)
$ 103.32	$ 20.66	$ 113.11	$ 22.62	Freight ($/day)
$ 366.31	$ 73.26	$ 401.02	$ 80.20	Total Cost ($/day)

Total Cost

Case 1		Case 2		
Max	Typical	Max	Typical	
$ 476.54	$ 95.31	$ 536.64	$ 107.33	Chemical/Sludge Cost ($/day)
$173,936.15	$ 34,787.23	$ 195,875.34	$ 39,175.07	Chemical/Sludge Cost ($/yr)

pH Usage Estimation

Aluminate Trim

at 50ppm MgCl2 based on pilot tests

Density 12.3 lb/gal

Influent Flow (gpm)	pH Trim Flow (mL/min)			
13.5	23	1.70		
13.2	23	1.74		
14	23	1.64		
9.8	16	1.63		
10	16	1.60		
	Average	1.66	mL/gal	The dose requirement of 38% Sodium Aluminate diluted 1:1 with water
		0.83	mL/gal	The dose requirement of 38% sodium aluminate
		0.0027	lb/gal treated	The 38% sodium aluminate requirement

NaOH usage

at 200ppm MgCl2 based on bench tests

Density 12.7 lb/gal

Volume (L)	1.0N NaOH added (mL)		mL
2	15	1.2	50% Equivalent (mL)
		0.0006	Dose of 50%NaOH (gal/gal)
		0.00762	The 50%NaOH requirement (lb/gal treated)
		0.003996476	The 50%NaOH requirement for 200ppm Mg (lb/gal treated)
		0.003623524	The 50%NaOH requirement due to buffering (lb/gal treated)

Sludge Generation Estimation

Case 1

100ppm Mg with NaOH

Inf Flow (gpm)	Waste Flow (gpm)	Waste Solids (g/L)	Waste %
10	3.4	4.682	34.0%
9.6	1.7	7.887	17.7%
Average	2.55	6.2845	26%

Case 2

50pp Mg with NaOH and Aluminate

Inf Flow (gpm)	Waste Flo	Waste Solids (g/L)	Waste %
9.6	0.9	6.237	9.4%
13.2	2	3.287	15.2%
14	1.6	35	11.4%
Average	1.5	14.8	12%

ATTACHMENT C: CAUSTIC SPILL MEMORANDUM

SME
Sevee & Maher Engineers, Inc.

ENVIRONMENTAL • CIVIL • GEOTECHNICAL • WATER • COMPLIANCE

June 7, 2011

10166
20110603tp.docx

Ms. Tracy Planinsek
Sr. Project Mgr.
Woodard & Curran Inc.
41 Hutchins Dr.
Portland, ME 04102

Subject: Caustic Spill Investigation

Dear Tracy:

Over the past month or so, Sevee & Maher Engineers, Inc. (SME) has made several trips to the Holtrachem site to inspect the Southerly Stream Interceptor System (as referred to in the MEDEP Order) and to evaluate available records on the systems' design. We discovered there are two interceptor trenches: (1) an older trench with no identifiable design records that is reportedly about 70 feet long, according to our discussions with on-site personnel that have worked at the Holtrachem facility for over a decade (see attached Figure 1), and, (2) a newer trench. The newer trench was designed by Acheron Engineering Services, Inc. in 1999, and approved by MEDEP in response to the Administrative Consent Agreement and Enforcement Order dated December 17, 1997. The newer trench is on the south side of the older trench. The newer trench is approximately 300 feet long. It was designed to "extend approximately 50 feet on either side of the area where caustic was observed" and to vertically extend to the top of bedrock. Both trenches lie parallel to, and on the north edge of, the Southern Drainage Ditch (see Figure 1). A geoprobe investigation was conducted by Acheron prior to design of this newer trench. The geoprobe investigation was used to determine the lateral extent of caustic in overburden groundwater. Both trenches discharge into a common wetwell which is then pumped back to the treatment plant. pH measurements of water in the new and old trenches, made by SME on May 6, 2011, confirm the presence of elevated pH ranging from to approximately 9.2 to 10.3.

We also were successful in finding a topographic map from 1966 when the plant was first developed. This map shows the original topography in the vicinity of the trenches as well as the railroad loading shed. It shows that there is currently up to about 25 feet of fill beneath the railroad shed. According to site personnel that we spoke with, this fill contains permeable sands and gravel. These same personnel indicate that excavations in the area of the former caustic tanks, as well as for the trenches, show up to about ten feet of permeable sandy soils over a dense impervious glacial till. The glacial till is difficult to dig according to these individuals and does not transmit much water. The overlying sands on the other hand are capable of transmitting a significant amount of water. Thus, the former employees were able to confirm the geologic conditions that we developed during the hearings that show a layer of permeable soils (i.e., outwash sands and fills) overlying a shallow glacial till. The 1966 topographic map shows that the caustic tanks and the railroad shed are located on the south side of a natural topographic divide between the interceptor trenches and the main plant area and Landfill Area 1. Site filling and leveling has covered this natural ridge or divide. Groundwater flow directions would be largely controlled by the configuration of the glacial till surface, which likely mimics the original topography. This would suggest that groundwater is generally migrating toward the Southern Drainage Ditch from the caustic tank and railroad shed, which is supported by the Acheron Geoprobe investigation.

These same site employees indicated that caustic spills occurred at the railroad loading shed during filling of the rail cars. The spillage would either percolate into the ground or flow overland toward the Southern Drainage Ditch. A containment basin was built at some point south of the railroad loading shed, which was piped to a sump west of the shed for collection. A containment dike was also built at some point across the Southern Drainage Ditch in an attempt to contain overland spills and prevent them from directly entering the river. The employees we spoke to also indicated that the former caustic tanks leaked based on observation of liquid levels in these tanks over time. Again, these tanks also are positioned on the south side of the natural topographic divide that directs groundwater towards the Southern Drainage Ditch.

Another relevant finding relates to subsurface drain pipes in the main plant area and in particular the former main plant drain pipe, in use prior to the treatment plant construction. A portion of the former plant drain runs north-south just west of the railroad loading shed and, according to facility plans from 1967, turns westerly near the interceptor trenches and discharged by gravity to the Southern Drainage Ditch (see Figure 1). The plant drain pipe manholes are now plugged with concrete so water cannot move through them, but, the pipe bedding reportedly consists of permeable sand/gravel which transmits water by gravity towards the Southern Drainage Ditch. There are also shallow perforated pipes in the main plant area that drain into the plant drain pipe and, according to plant personnel, the permeable plant drain pipe bedding is continuous with these pipes. The perforated pipes were installed to control the groundwater table in heavy traffic areas. When it rains or there is snow melt, it infiltrates into the permeable plant drain pipe bedding and underdrains, where it then flows towards the Southern Drainage Ditch. A cross-section or profile of the former plant drain pipe shows it to apparently pass through or next to one or both of the interceptor trenches. Thus, stormwater infiltration entering the permeable drain pipe backfill would be directed towards the interceptor trench(es) backfill. The Acheron Geoprobe investigation also identified a "steep" groundwater gradient in the vicinity of the former plant drain pipe, further supporting the interpretation that the drain pipe backfill acts as a local collector for groundwater. This stormwater infiltration therefore adds to the groundwater flows historically recorded as coming from the trenches. Use of water level transducers by SME confirmed a nearly immediate increased flow in the older trench during two stormwater events.

On May 6, 2011, during a non-storm period, we sampled the waters within the two interceptor trenches; the two manholes of a 36-inch diameter pipe that diverts the Southern Drainage Ditch below ground in the vicinity of the caustic spill; and a manhole that accesses an auxiliary surface water drain pipe. The attached Figure 1 shows the location of these four subsurface pipes, which are oriented east-west. The auxiliary solid-walled drain pipe starts as an 18-inch diameter pipe at the easterly-most manhole where it is capped, goes through a manhole and continues as a 12-inch diameter pipe that transitions to a 4-inch diameter PVC pipe and ends south of the Southern Drainage Ditch discharge weir. This auxiliary pipe is identified in the 1999 Acheron construction documents as being installed for "future use as a stormwater conveyance pipe." The results of our sampling are summarized in Table 1.

The older trench sump was tested and showed the presence of total mercury at 0.86 mg/L, as well as silica (SiO_2) in the order of 25 mg/L (see Table 1), and a pH of approximately 9.3. The adjacent new trench was tested at the two westerly cleanouts and from the sump at the discharge end of the trench. The cleanout pipe at the upstream end (i.e., easterly end) of this new trench was dry. The sampling of the new trench showed mercury concentrations of less than 0.25 µg/L, silica levels up to approximately 500 mg/L and pH values that ranged from about 9 to 10. For comparison purposes, the bedrock well (MW-509-B1) and the overburden well (MW-327-O1) were sampled (see Figure 1). These show pH values of 11.9 and 11.6, respectively, and silica values in the same order as that of the trenches. The total mercury concentrations in the bedrock groundwater were on the order of 0.6 µg/L and the overburden well had a groundwater total mercury concentration of 30.8 µg/L.

TABLE 1

Sample Location	Total Mercury (µg/L)	Silica SiO_2 (mg/L)	pH (S.U.)	Specific Conductance (µmhos/cm)	Turbidity (NTU)
Old Interceptor Trench Sump	0.86	24.6	9.3	5,800	4
Upstream Cleanout of New Interceptor Trench	DRY	DRY	DRY	DRY	DRY
Center Cleanout of New Interceptor Trench	0.24	455	10.3	485	4.9
Downstream Cleanout of New Interceptor Trench	0.24	108	9.6	1,000	2.3
Sump for Interceptor Trenches	0.15J	74.4	9.2	6,000	1.2

Sample Location	Total Mercury (µg/L)	Silica SiO_2 (mg/L)	pH (S.U.)	Specific Conductance (µmhos/cm)	Turbidity (NTU)
Auxiliary Pipe Manhole	0.16J	49.2	8.1	1,400	7.1
Upstream Manhole of 36" dia. Southern Stream	0.25	4.88	7.7	680	2.7
Manhole for 36" diameter Southerly Stream	0.24	5.28	7.7	784	0.5
36" dia. Pipe Outfall	0.23	5.64	8.4	846	2.9

We also sampled the manholes along the 36-inch diameter pipe which reroutes the Southern Drainage Ditch. The results are shown in Table 1. The interesting aspects of this data are that there are detectable, trace concentrations of mercury, but the concentrations are approximately constant starting from the upstream end of the pipe to its' outfall. This suggests that the mercury is entering the pipe upstream of the uppermost manhole tested. Silica values were in the range of less than 10 mg/L and are not inconsistent with natural surface waters, but did increase from upstream to downstream. pH ranged from 7.7 to 8.4, and also increased from upstream to downstream. Specific conductance also increased from upstream to downstream. The adjacent auxiliary pipe showed similar concentrations of mercury and pH to that in the 36-inch diameter pipe manholes, but showed higher conductivity and silica levels. It is curious that even though the auxiliary pipe appears to be capped at its inlet end, there is water in the pipe. These stormwater pipes lie topographically above the new interceptor trench grades (see attached Figure 1). The amount of leakage into or out of these pipes is unknown, but is likely small due to the pipes' age. We were able to uncover what appeared to be the discharge end of the auxiliary pipe in the northern bank of the Southern Drainage Ditch, just west of the discharge weir.

The 1999 Acheron geoprobe investigation report was helpful in showing that the caustic groundwater plume from the historic spills emanates from both the railroad loading shed as well as from the former caustic tanks. A high-pH plume from the caustic tanks appears to migrate both east and south, ending at the former Southern Drainage Ditch. The high-pH plume from the railroad loading shed appears to extend south to southwest toward the Southern Drainage Ditch. The greater topographic elevations, and geology, south of the Southern Drainage Ditch, prevent the shallow groundwater containing the silica and high-pH, from migrating south beyond the Southerly Stream. Based on available information it is clear how the extent of the new trench was established to intercept the southerly moving high-pH plume before it entered the Southern Drainage Ditch. Rerouting the stream through the solid-walled pipes isolates the stream from the caustic plume. On-site personnel indicated that if the interceptor trenches are not continuously operating then seepage breakouts have occurred on the lower flank of the slope below the railroad loading shed. This seepage reportedly had a "milky white" appearance which is, in all likelihood, dissolved silica. The current efficiency of the underdrain trenches are not known, although they appear to prevent seepage breakouts. According to on-site personnel, the trench has historically been cleaned annually in November; however, this has reportedly not been in a few years.

Based on the investigations SME has completed, we have concluded that the watershed area that drains toward the interceptor trenches includes the railroad loading shed and the former caustic tanks. Based on the interpreted areal extent of this watershed and an average annual precipitation recharge to the groundwater table in the order of 6 to 12 inches, it is estimated that average annual groundwater flows to the trenches should not be much greater than 0.5 to 1 gpm. This assumes limited recharge to the till and bedrock.

From the available information, it appears that the subsurface investigation that was originally proposed to Covidien is unwarranted and would replicate information already available. The highest groundwater pH appears to have dropped in the order of about 1 pH unit over the last decade since the Acheron investigation was conducted. However, it appears that this issue will continue into the future as the infiltration flushes the caustic out of the soil and groundwater system. It appears that the new interceptor trench operation should continue, but that the groundwater flows to this trench are more likely in the order of 0.5 to 1 gpm on an average annual basis, as opposed to the current short-term reported rates of up to 10 gpm or more, based on flow records from the interceptor trench sump. This available flow data which shows flows varying over an order-of-magnitude, is inconsistent with the normal groundwater behavior; groundwater generally doesn't range over an order-of-magnitude or more on a system that has reached approximate steady-state. We believe the higher flows are related to infiltrating stormwater from the backfill around the former plant drain pipe that is apparently intercepted by the interceptor trench(es). The same flow data indicate that our estimated 0.5 to 1 gpm natural groundwater contribution is consistent with dry, low-flow periods when groundwater is the only contributor, trench flows approach approximately 1 to 2 gpm on an average daily basis. This behavior is also supported by our discussions with site employees.

Using the information collected by Acheron in 1999, as well as the site topography, we estimate that approximately 15,000 to 20,000 cubic yards of soil have been impacted by caustic. During Acheron's testing, some of the groundwater was greater than pH 12.5. A pH of greater than 12.5 indicates that the soils would likely need to be handled as a hazardous waste. If these pHs persist today then excavation and disposal would be extremely costly. The cost would be high, however, even if the soils can be hauled to a lined landfill that's licensed to accept non-hazardous soil with high pH. Excavation of the caustic, subsurface source, therefore, does not appear to be a reasonable option for eliminating the caustic seepage issue. Shutting down both trenches would likely lead to seepage breakouts of the silica in the Southern Drainage Ditch, potentially leading to a similar situation as observed years ago. Furthermore, the new trench was installed as part of an MEDEP administrative consent agreement and its removal would need to address that agreement. It appears that the most reasonable approach for the caustic issue (and the resulting need for treatment of silica) is to continue operating the new interceptor trench, but eliminate stormwater flows entering the trenches to the extent feasible. Seepage from the former plant drain pipe backfill or even leakage from the two subsurface rerouting pipes should be investigated and eliminated to the extent practicable. It may also be appropriate to grout the former storm drain pipe bedding or removed the pipe and bedding to eliminate our inferred hydraulic connection between the former stormwater pipe bedding and the interceptor trenches. Ideally, only the groundwater flows to the new trench with high silica and pH should be collected by the trench(es). It is likely that elimination of stormwater infiltration flows will result in a trench flow on the order of 1 gpm or less on an average annual basis. During storm and snow melt periods, these flows may go up to several gallons per minute for periods of time. This groundwater flow would be collected by the trench(s) and sent to the on-site treatment plant.

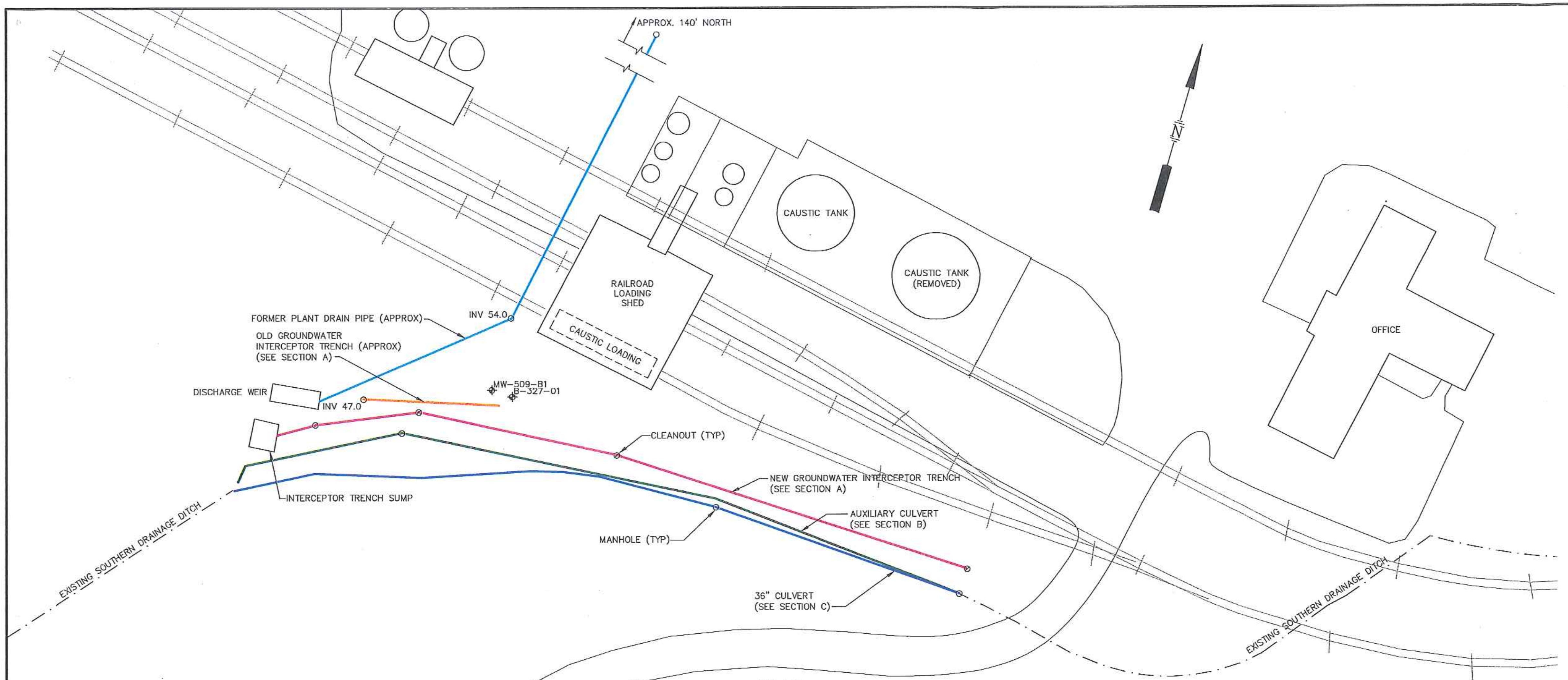
It appears that the older interceptor trench is performing the same task as the new interceptor trench. It is powered by an electrical connection that can be shut off. We would recommend sometime over this summer that the former trench be shutdown to see what the effects are on the overall system. It would be important to monitor daily for any seepage breakouts of the high-pH and silica-laden groundwater that has been reported before. If breakouts occur, the system should be re-energized. However, if no breakouts occur, it may be appropriate that this older trench can be decommissioned at some point in the future. Any seepage breakouts are likely to be associated with precipitation events.

Very truly yours,

SEVEE & MAHER ENGINEERS, INC.

JOHN E. SEVEE NO. 4160

John E. Sevee, P.E., C.G.
President



PLAN

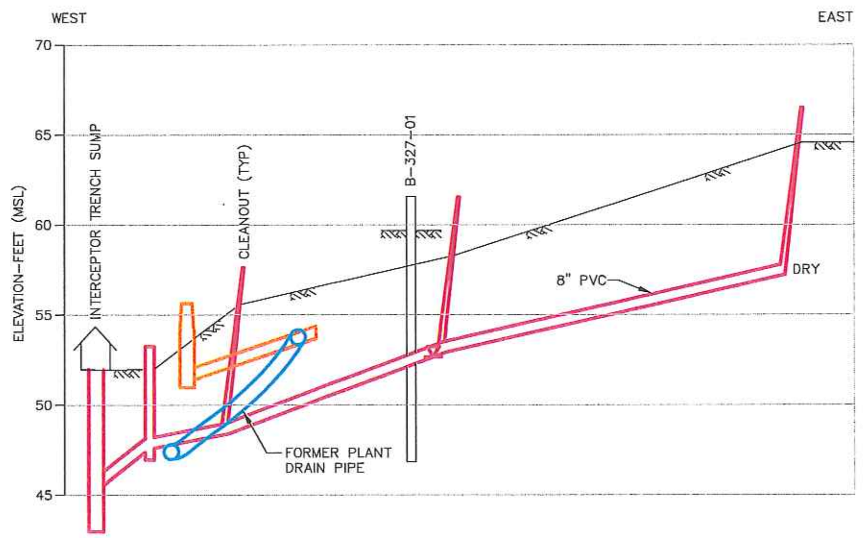
N.T.S.

NOTES

1. BASE MAP IS FROM PLAN BY CDM DATED 2009. ACTUAL SITE CONDITIONS MAY VARY FROM THOSE SHOWN DUE TO ONGOING REMEDIATION ACTIVITIES.
2. STRUCTURES SHOWN FOR ORIENTATION PURPOSES ONLY, NOT SURVEYED. SOME STRUCTURES ARE DEMOLISHED.
3. THIS FIGURE SHOULD NOT BE USED FOR ENGINEERING DESIGN, QUANTITY TAKE-OFFS, GRADES, ETC.

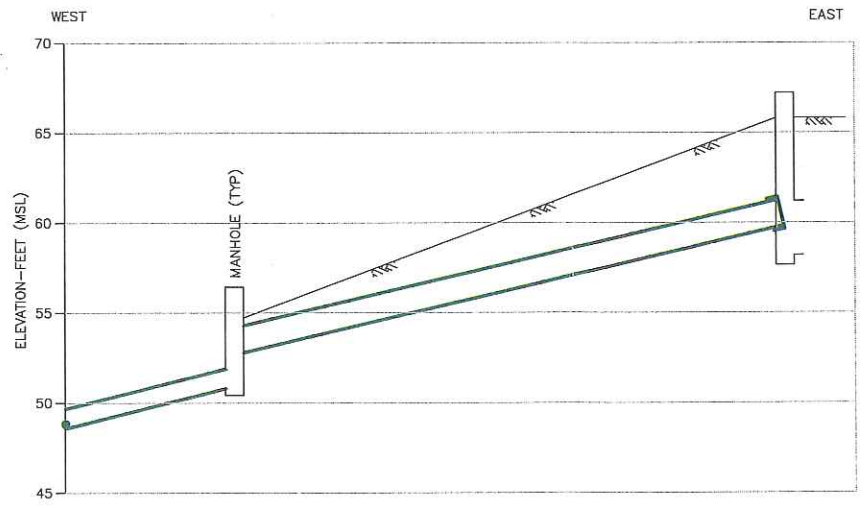
LEGEND

- NEW GROUNDWATER INTERCEPTOR TRENCH
- AUXILIARY CULVERT
- 36" CULVERT
- OLD GROUNDWATER INTERCEPTOR TRENCH (APPROX)
- FORMER PLANT DRAIN PIPE



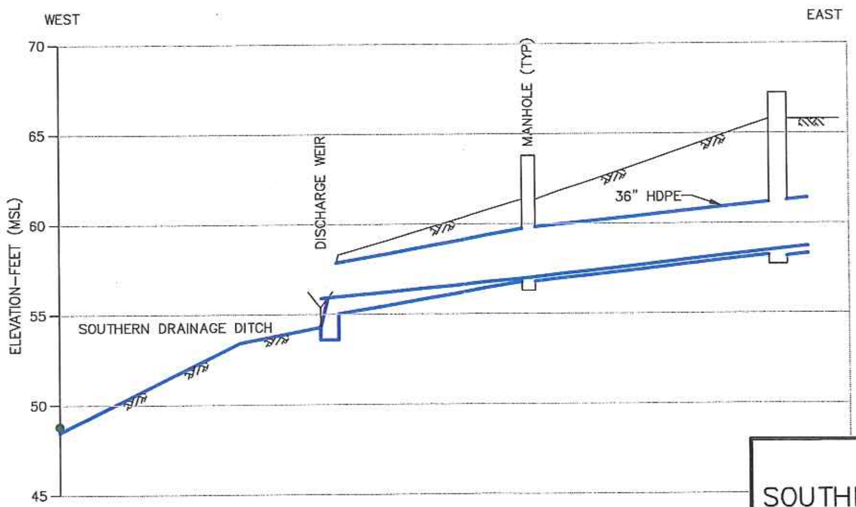
SECTION A
NEW GROUNDWATER INTERCEPTOR TRENCH
OLD GROUNDWATER INTERCEPTOR TRENCH

N.T.S.



SECTION B
AUXILIARY CULVERT

N.T.S.



SECTION C
SOUTHERN DRAINAGE DITCH
(PARTIALLY CULVERTED)

N.T.S.

FIGURE 1
SOUTHERN DRAINAGE DITCH
INTERCEPTOR SYSTEM
HOLTRACHEM FACILITY
ORRINGTON, MAINE

SME
Sevee & Maher Engineers, Inc.
ENVIRONMENTAL · CIVIL · GEOTECHNICAL · WATER · COMPLIANCE
4 Blanchard Road, PO Box 85A, Cumberland Center, Maine 04021
Phone 207.829.5016 · Fax 207.829.5692 · www.smemaine.com

DWG: SITEPLAN LMN: CAUSTIC AREA CTB: CAUSTIC AREA REV: 6/8/2011

\\Nserver\cfs\Covidien\Holtra Chem\Acad\Figures\Siteplan.dwg, 6/8/2011 2:41:36 PM, paf

WOODARD
&CURRAN

woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS