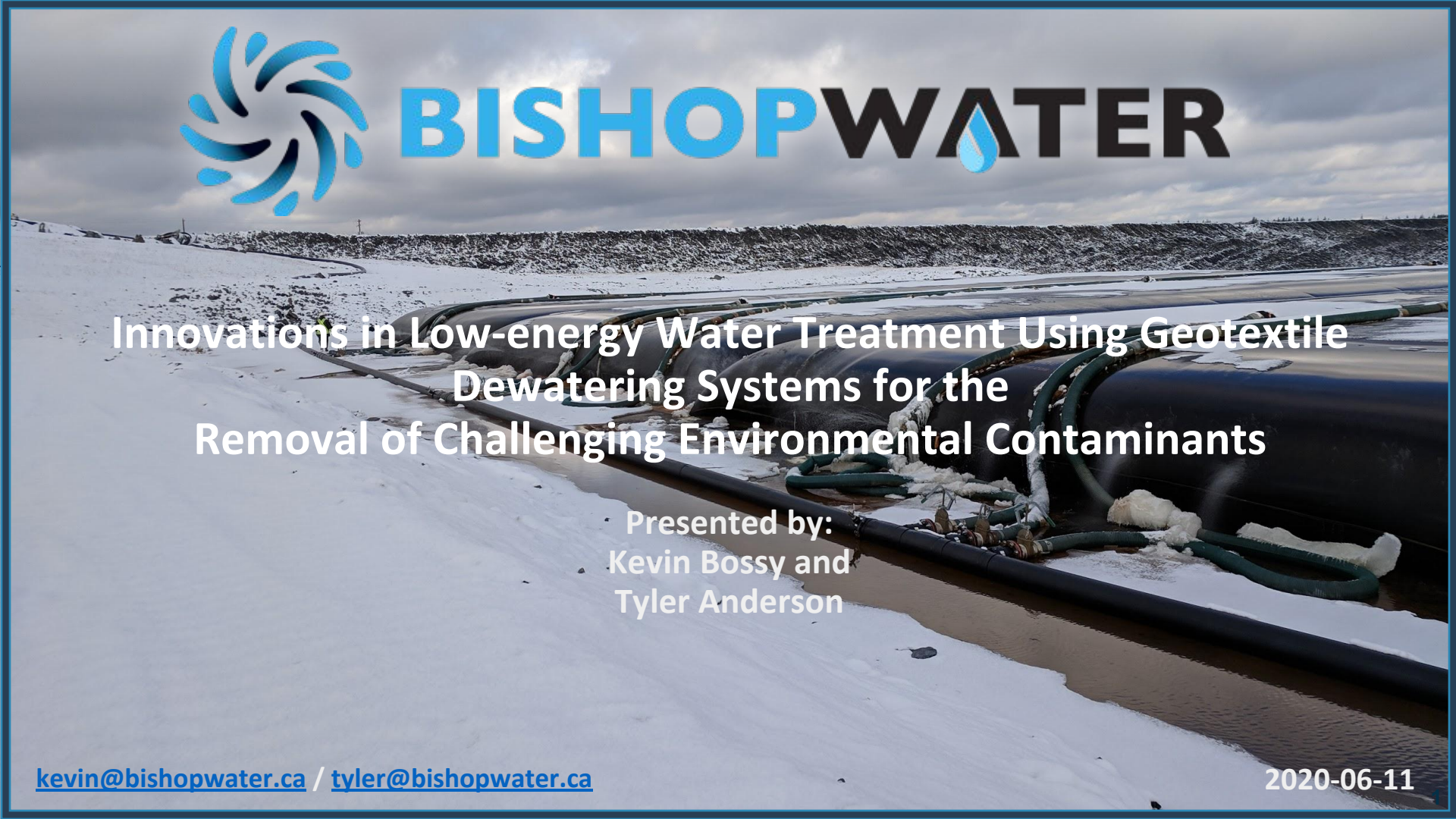

Innovations in Low-energy Water Treatment Using Geotextile Dewatering Systems for the Removal of Challenging Environmental Contaminants

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Bishop Water Technologies: Who we are

- Bishop Water specializes in simple, reliable, low-energy solutions for solids management and reduction of environmental contaminants.
- These solutions are used by municipal, industrial and agricultural clients to affordably solve water and wastewater challenges while protecting the environment.
- Our highly experienced teams provide exemplary service and work collaboratively with partners to continually enhance the performance, value and sustainability of our solutions.
- Over 10 years of growth and success. Our solutions are distributed by partners in Canada, United States, Australia and Latin America.

Bishop Solids Management Solution:

- A complete, customizable solution for sludge/impacted water conditioning, dewatering and containment.
- Easy to operate and energy efficient. Achieves a high level of dewatering using only Geotube™ filtration, specially selected polymers and gravity.
- Effective for virtually any organic or inorganic slurry material.
- Optimized systems can also remove and retain contaminants such as metals, BOD, TSS, and nutrients such as phosphorus and nitrogen.
- Low lifecycle costs - few components, low energy requirements, automated operation, little operator oversight.

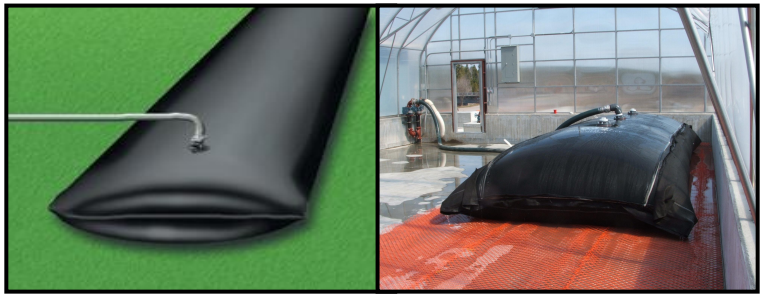
How it works:

1) **Polymer conditioning of waste stream:**

- Occurs in-line as water/slurry is pumped to Geotube.
- Polymer is essential for coagulation of solids, retention of contaminants, acceleration of dewatering, preventing fouling of Geotube™ pores.
- Can be automatically controlled according to flow rate and solids density.

2) **Conditioned material pumped to Geotube unit(s):**

- Single or multiple units can be used depending on sludge volume and desired flow rate.
- Units can be sized to fit available space and storage requirements.



How it works:

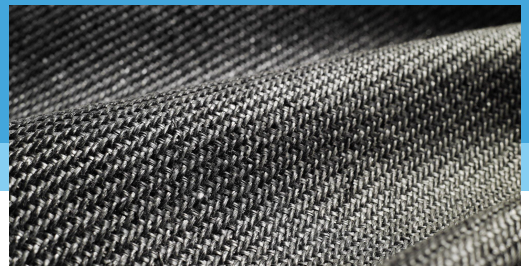
3) Dewatering:

- Clear filtrate is released from the Geotube
- Solids and contaminants are retained
- Process can be repeated until the Geotube container is full
- Filtrate may be suitable for discharge or reuse

4) Consolidation:

- Solids continue dewatering
- Freeze/thaw aids in dewatering
- Increasing options for disposal

Strong and reliable:



High strength fabrics:

- Woven polypropylene with UV protection
- Inert to biological degradation and resistant to naturally encountered chemicals, alkalis and acids

Patented seaming:

- Strong circumferential and linear seams
- Enables Geotube to be pumped higher than others - saving money and increasing efficiency

Bolted-on fill ports:

- 4- or 8-inch fill ports are bolted on, not sewn
- Flanges and gaskets are tightly secured, creating strong connection point

"We selected Geotube containers for our fly-ash dewatering system for their strength and durability."

Mark Elliott
Senior Engineering Technologist
City of London

Metal Leaching/Acid Rock Drainage (ML/ARD):

What is ML/ARD?

ML/ARD occurs when groundwater or surface water passes through a layer of sulfide minerals and becomes acidic forming a low pH sulfuric acid solution. The acidic conditions bring soluble metals from the rock into a solution. The elevated concentrations of metals may subsequently oxidize when coming in contact with air. This acidic water drains from surface stockpiles and underground mines entering into the open environment polluting surface water with ochre, which are red, orange or yellow precipitate sediments *(Tom Stephens, TenCate™ Geosynthetics)*.

Results of ML/ARD→

Metal Leaching/Acid Rock Drainage (ML/ARD): Treatment stages

Stage 1: Equalization Tank
Stage 2: pH adjusted ARD solids precipitate and sink to bottom of clarifier as a sludge
Stage 3: ARD sludge is pumped into polymer conditioning system where polymer is injected and the conditioned slurry is pumped to the Geotube dewatering cell
Stage 4 (optional): As ARD sludge consolidates in Geotube units, stacking Geotubes to create multiple layers occurs to keep the same dewatering cell footprint but allow for more dewatering and consolidation.

Metal Leaching/Acid Rock Drainage (ML/ARD):

Example: Omega Coal Mine Acid Mine Drainage Treatment Plant and Geotube® Dewatering

Operation and Efficiency

- Incoming Flow Rate — 200 gpm (46 m3/hr)
- pH Range — 2.3 to 3.4
- Lime Adjustment pH — 6.0 to 7.5
- Heavy Metals and Sulphate ppm — 1,985
- Allowable Discharge Upper Limit ppm — 3.73
- General Operating Discharge — >1.0
- Since opening in 2016, there have no discharge violations.

Metal Leaching/Acid Rock Drainage (ML/ARD):

Metal Leaching/Acid Rock Drainage (ML/ARD):

Combined systems adjusts pH, precipitate metals and capture solids:

Example: *Gold Mine Remediation*

- 202 hectare abandoned site in Eastern Ontario
- Used for approximately 100 years
- Gold mining, arsenic, silver refining and manufacturing of stellate
- Abandoned in 1961, remediation started in the early 1990's
- Due to tailings run off, there was significant contamination of Young's Creek
- Up to 130,000 cubic meters of material contaminated with heavy metals

Combined systems adjusts pH, precipitate metals and capture solids:

Operations:
Bishop Water was able to reach a 97.4% removal of arsenic in treated effluent and a 99.9% removal of TSS.

PARAMETER	UNITS	RAW	FILTRATE	REDUCTION %
		Dec 7, 2011	Dec 7, 2011	
Total Suspended Solids	mg/L	76800	36	99.90%
pH	pH Units	6.99	7.14	-
Aluminum	mg/L	2170	0.43	99.90%
Arsenic	mg/L	235	6.03	97.40%
Cadmium	mg/L	0.95	<0.005	99.50%
Chromium	mg/L	11.3	<0.002	99.90%
Cobalt	mg/L	66.4	0.097	99.80%
Copper	mg/L	128	0.01	99.90%
Lead	mg/L	4.8	<0.02	99.50%
Mercury	mg/L	0.05	<0.00002	99.90%
Molybdenum	mg/L	0.92	<0.01	98.90%
Nickel	mg/L	39.9	0.03	99.90%
Selenium	mg/L	0.4	<0.005	98.70%
Zinc	mg/L	13.2	0.019	99.80%

Permanent treatment/processing facilities:

- Permanent treatment facilities are a viable option for treatment of heavy metals from mining applications as they can operate 24 hours a day, 365 days a year.

Bishop Water has created multiple permanent treatment facilities with many different goals.

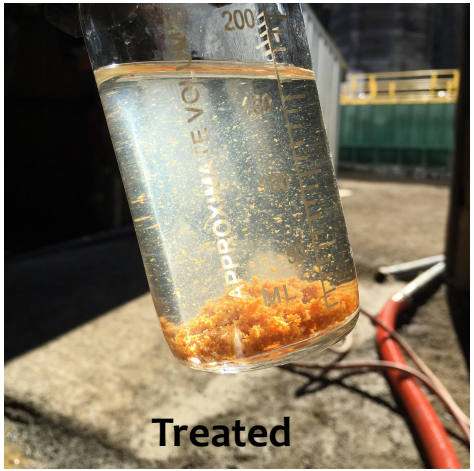
- To treat backwash from gold mine.
- Management of septage and leachate.
- Arsenic sludge management.

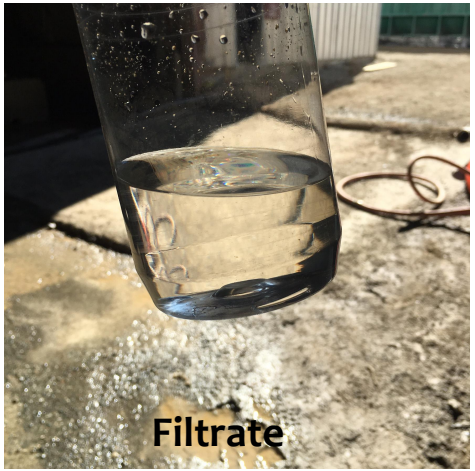
Example 1: Batch treatment of arsenic sludge at gold mine

Challenge: Underground gold mine was undergoing refurbishment of their tailings storage facility and **required a system to manage treated groundwater that had high levels of arsenic.**

Solution:

- Bishop Water treated the backwash sludge from the mix tank in every 12 hours using a VEPAS and an MDS Geotube® system.





Example 2: Dewatering ash slurry from WWTP

Challenge: Avoid expanding ash storage lagoons. Simplify ash handling.

Solution: Bishop Solids Management Solution enabled the plant to decommission storage lagoons and implement a more efficient ash handling process.

Example 3: Dewatering arsenic precipitate at a gold mine

Challenge: As tailings pond filled, a gold mine required simpler, more-cost effective option for sludge management

Solution:

- Bishop Solids Management Solution, which includes Geotube geotextile bags and VEPAS
- Dewaters 2,500,000 m^3 annually over 5 years.
- To maintain the same footprint over 5 years Bishop Water stacked the Geotubes.

Example 4: Process waste from an oil refinery

Challenge:

- Dredge and dewater sediment from stormwater pond
- Annual cleanout of sludge from storage tanks that hold process waste

Solution:

- Bishop Solids Management Solution permanently installed to collect and dewater process sludge
- Solids are first mixed to homogenize solution prior to polymer conditioning and dewatering in Geotube containers

Bench testing: Experience has shown that several considerations are critical to ensure a successful project implementation and long term operation. This includes;

1. Collection of a “representative sample” to perform treatability tests.

2. Determination of project objectives and realistic expectations for each specific application.

Bench testing: Experience has shown that several considerations are critical to insure a successful project implementation and long term operation. This includes;

3. Background information collection and documentation

4. Proper Chemical Conditioning

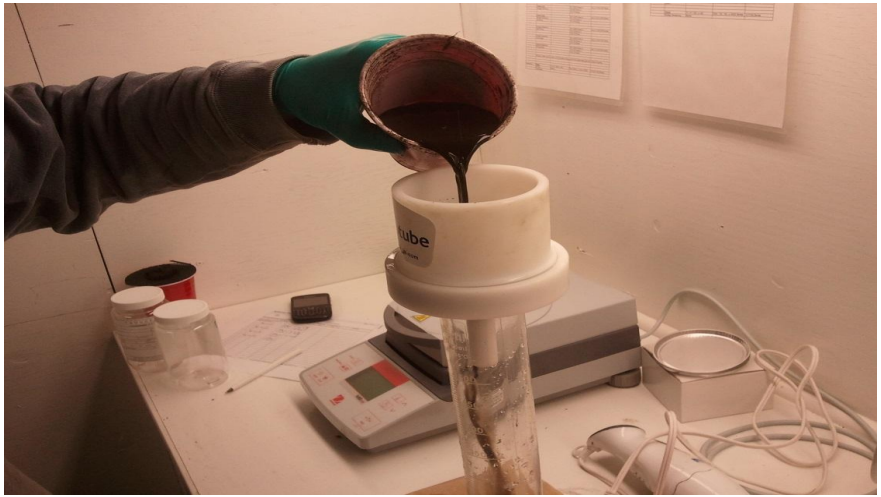
Project Example: Gold Mine Bench Testing and Trial Dewatering

Several polymer products were “made-down” to 0.5% solution and tested with the waste streams to determine the best product for optimum flocculation.

Raw Sample

Treated Sample

Project Example: Bench Testing and Trial Dewatering



Once the ideal polymer for the project was selected the material was run through a *Rapid Dewatering Test* to determine the effectiveness of the technology at dewatering the material.

Project Example: Bench Testing and Trial Dewatering

Percent Solids of the dewatered material were analyzed after 1, 4 and 24 hours of dewatering time

Waste Stream 1

1 Hour: 20.4%

4 Hours: 21.92%

24 Hours: 24.35%

Waste Stream 2

1 Hour: 20.0%

4 Hours: 21.68%

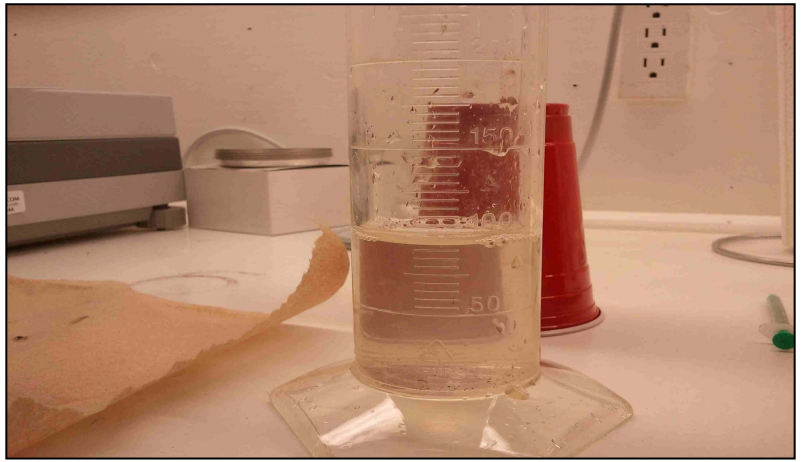
24 Hours: 24.35%

Waste Stream 1

Waste Stream 2

Example: Deloro Bench Testing and Trial Dewatering

Waste Stream 1



Waste Stream 1

Captured filtrate was analyzed to determine the reduction in heavy metals, specifically arsenic.

Why choose the Bishop Solids Management Solution?

- Simple, low-energy solution
- Proven to provide reliable and cost effective containment and dewatering of process solids
- Robust process works effectively in challenging Canadian climate
- Capable of meet regulatory requirements for effluent discharge
- Effectively replaces clarifiers while providing storage for dewatered solids

BISHOPWATER

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