



Colorado Department of Transportation Greywater Recycling Pilot Test

CDOT Pilot Test - Water Treatment Background

- 5 Generations of greywater treatment technologies currently utilized at 50 facility locations
- Each generation has built on previous technology
- “Buy-in” from facility personnel to re-use the water has been a challenge due to treatment unit inability to address TDS
- Reduction of TDS is challenging in this setting because water quality is vastly different between facilities, storm events, and seasons
- Traditional TDS treatment technologies are sensitive to variations in water quality and are expensive to maintain and operate

CDOT Pilot Test - Water Treatment Site Specific Challenges

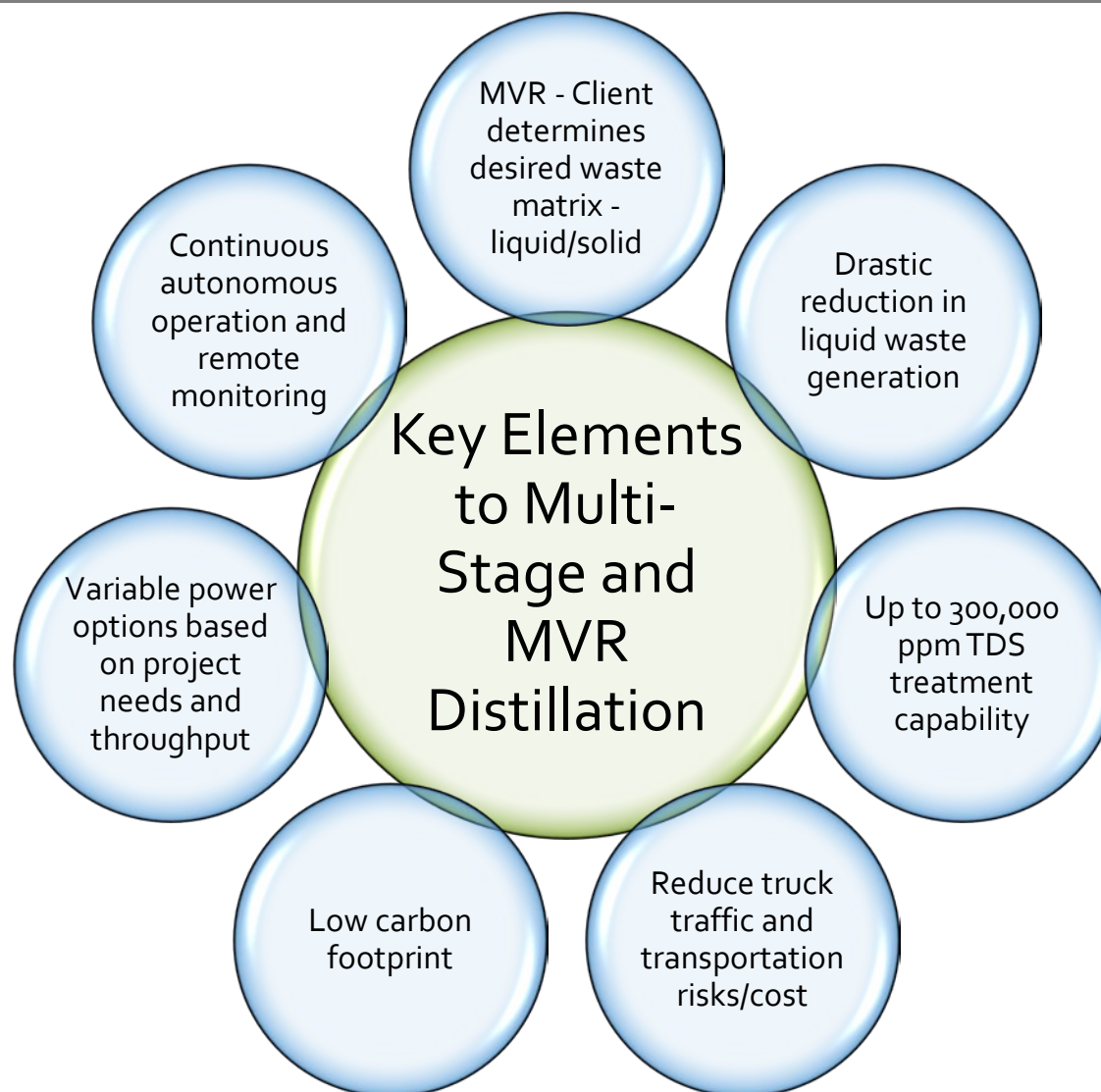
- Facilities with low producing water wells
- Facilities with no viable water source
- Facilities with challenging greywater discharge situations
 - POTW unable to accept industrial waste water
 - POTW connection is not available
 - Facilities faced with trucking wastewater
- Facilities with large number of vehicles and equipment
- Facilities that have large number of plow days generating large volume of ice melt and washwater

CDOT Pilot Test - Water Treatment and Re-Use Goals

- Identify a robust cost efficient technology capable of removing dissolved solids from greywater so that treated water is purified and can be re-used for power spraying vehicles/equipment.
- Determine if the salt/heavy brine produced from water treatment can be collected and reused in de-icing operations.
- Determine if excess treated water is clean enough to be misted or surface discharged.
- Determine if the treatment technology can be implemented program wide

CDOT Pilot Test Summary

- Conducted a 30-day pilot test to demonstrate the use of thermal distillation to treat waters generated from vehicle/equipment cleaning and ice melt from plow trucks.
- Pilot utilized the Epiphany E5H hybrid distillation system with MVR technology.
- 1-2 operators on-site each day collecting samples and monitoring system operation.
- Test consisted of 2 stages –Routine Operation and Simulated Operation



CDOT Pilot Test Results

Runtime, Volume, and Flowrate		
Total Pilot Test Hours		269.5 hrs.
Total Gallons Treated		11,430.0 gal.
Average Throughput Flow Rate		42.4 gph.
Average Throughput Flow Rate		1,017.9 gpd.

Consumable Energy Use and Cost			
	Consumables	Total Cost for Pilot Test	Cost Per Treated Gallon
Electrical Power Use	4,142.83 kWh	\$497.14	\$0.04
Total Propane Used	400.47 gal.	\$840.59	\$0.07
Est. Total Natural Gas Used	38,245.16 ft ³	\$307.49	\$0.03
Combined Operating Cost w/ Propane		\$1,337.73	\$0.12
Combined Operating Cost w/ Natural Gas		\$804.63	\$0.07

CDOT Pilot Test Results

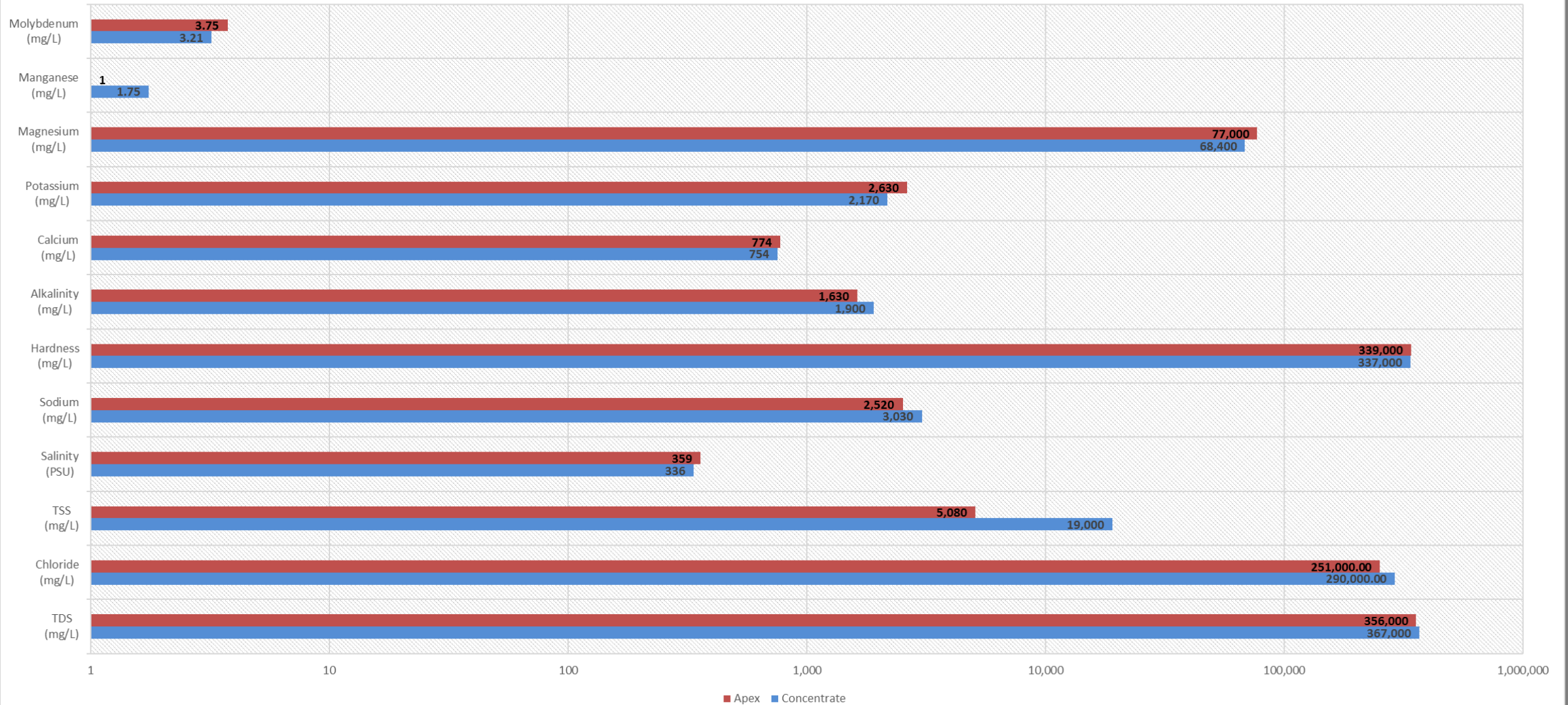
Pilot Step	Routine		
Constituent	Influent	Effluent	% Reduction
TDS	5,050	16	99.68%
Chloride	2,700	2.72	99.90%
TSS	272	ND	100.00%
Salinity	5.27	0.372	92.94%
Sodium	1,030	ND	100.00%
Hardness	1,750	ND	100.00%
Alkalinity	495	458	7.47%
Calcium	83.8	ND	100.00%
Oil and Grease	310	ND	100.00%
pH	8.3	8.3	
Potassium	54.8	ND	100.00%
Phosphorus Total	0.947	0.166	82.47%
Iron	3.16	ND	100.00%
Magnesium	478	ND	100.00%
Molybdenum	0.0223	ND	100.00%
Zinc	0.116	ND	100.00%

Pilot Step	Simulated		
Constituent	Influent	Effluent	% Reduction
TDS	126,000	48	99.96%
Chloride	61,800	4.58	99.99%
TSS	306	ND	100.00%
Salinity	82.1	0.198	99.76%
Sodium	1,200	ND	100.00%
Hardness	91,800	ND	100.00%
Alkalinity	813	235	71.09%
Calcium	253	ND	100.00%
pH	8.3	7.1	
Potassium	758	ND	100.00%
Phosphorus Total	0.388	ND	100.00%
Iron	ND	ND	
Magnesium	22,300	1.55	99.99%
Molybdenum	1.1	ND	100.00%
Zinc	ND	ND	

Results in mg/L

CDOT Pilot Test Results

Concentrate Vs. APEX



CDOT Pilot Test Results

- The unit was robust and dependable for the duration of the test – handled variations in O&G, TSS, and TDS with no operational issues.
- Greywater was successfully treated and was suitable for washbay operations.
- The treated water met regulatory standards for surface discharge
- The concentrate brine closely matches the characteristics of APEX suggesting it is suitable for re-use in de-icing operations.
- APEX cannot be concentrated to a solid – remains in a liquid form.
- The unit operates very efficiently costing \$0.12 per gallon using propane dropping to \$0.07 per gallon using natural gas.
- E5H treatment unit is turn-key – suitable for program wide implementation

Working with CDOT to achieve the following:

- Evaluating each facility to determine how to best approach site specific greywater management, reuse, and/or disposal
- Integrate TDS removal technology to efficiently address greywater treatment – location specific treatment, centralized facility treatment, and mobile treatment options.
- Developing a waste water management strategy
- Presenting the findings to the five CDOT management regions to inform managers of our proposed program wide greywater treatment logic and co-develop overall implementation framework

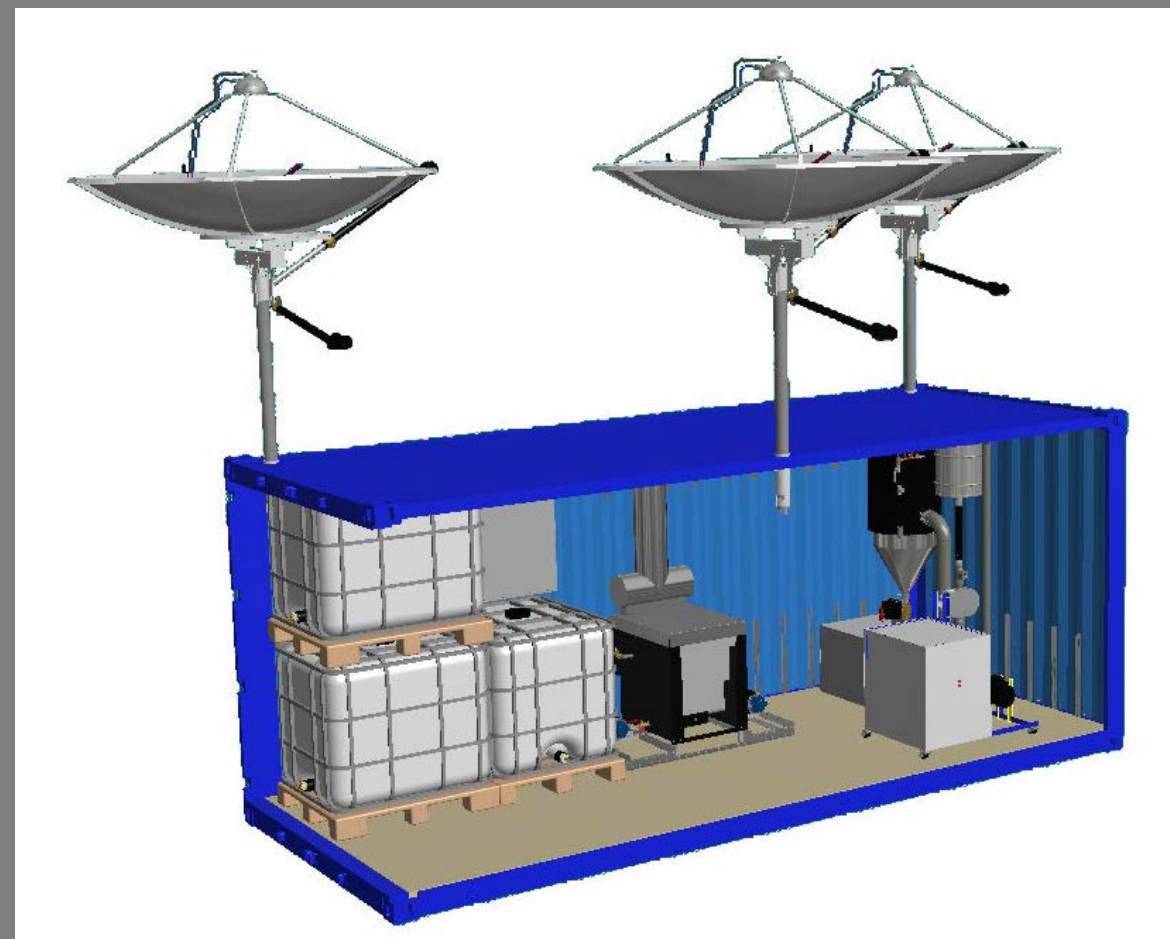
Treatment Units– Low Volume E₃S – Multi-stage Flash Distillation

- **Proprietary/Patented process**
 - Multi-stage flash distillation - 500 gpd treatment rate
 - 100% Solar using Concentrated Solar Power (CSP) heat energy and Photovoltaics
 - Influent water up to 40,000 ppm TDS (ocean water)
 - Effluent streams
 - Less than 500 ppm TDS drinking water quality
 - 70,000 ppm TDS waste water stream
- **Low capital investment**
 - Common off the shelf components
 - Modular and scalable - 20 foot shipping containers
- **Low operating costs**
 - Fully autonomous operation
 - Full remote monitoring and control capabilities
 - 100% solar powered



Treatment Units - E5H - Low Volume MVR Multi-purpose Distillation Solution

- **Proprietary/Patented process**
 - MVR Crystallizer – 1000 gpd treatment rate
 - Optional Concentrated Solar Power (CSP) heat energy
 - Influent up to 300,000 ppm TDS water
 - Effluent Streams
 - Less than 500 ppm TDS water
 - Solids with 25% moisture content
- **Low capital investment**
 - Mass production approach allows unprecedented economies of scale
 - Small 20 foot containers allow system to be optimized for each installation site
- **Low operating costs**
 - Fully autonomous operation
 - Highly efficient process requires minimal energy consumption



Scalable Water Treatment Technology

- **Medium Volume Water Treatment Technology**
 - Mechanical Vapor Recompression Distillation
 - 250 barrel per day capacity (10,500 gallons) per unit
 - Can scale to 2000+ barrels per day
 - Modules can be linked together to create optimized solution
 - Skid mounted – Quick setup
- **“Best Available Technology” with low capital cost**
 - Standardized construction allows for low capital costs
 - Lowest per-barrel processing costs in the O&G industry
- **Pretreatment – metal separation**
 - Pretreatment to drop out heavy metals
 - Creates three byproducts: distilled water, clean salt, heavy metal cake
 - Clean salt can be sold as road salt under co-product determination guidelines



Low to High Volume ERM3000 - Evaporation Unit



- 126 GPH per unit
- 98.7% evaporation rate, no puddling
- Compliments E5H or E10X for evaporation of distilled water
- Wide temperature and humidity operating range
- Modular and scalable for high water volumes
- Low power requirements
- Autonomous operation available

Basic Information Needed for Costing

- Location/Access
- Electric and gas availability
- Water quality data
- Desired throughput
- Treatment objectives - concentrate and distillate quality
- Run time - continuous / intermittent
- Treatment project duration
- Site specific constraints/considerations



Open Q & A

Thank you!



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