Hexavalent Chromium Remediation System with Online Chromium Monitoring System Provides Affordable & Reliable Cr(VI) Treatment

aqua metrology systems

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Agenda

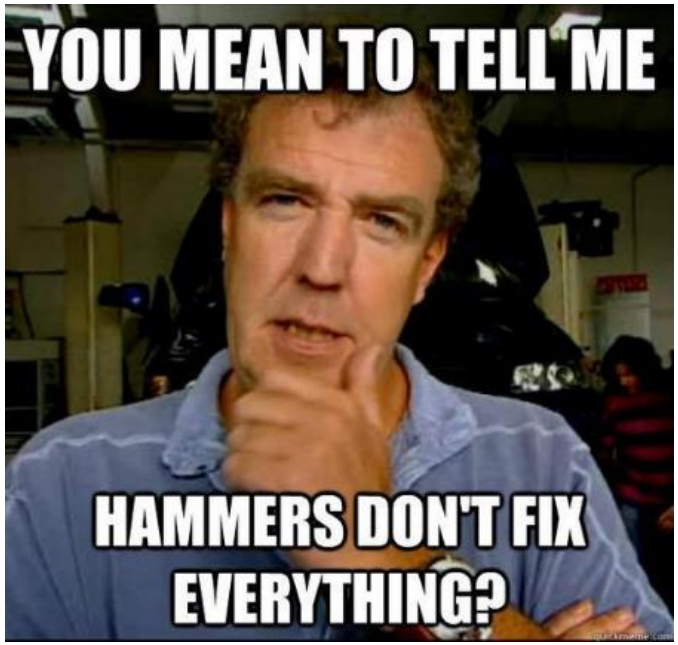
- Introduction to AMS
- The Role of Real-time Monitoring
- The Need for Innovation in Hexavalent Chromium Treatment
- The AMS Intelligent Treatment System for Hexavalent Chromium
- Further Innovation Opportunities
- Q&A

Our History

- Based in Silicon Valley
- Market leaders in intelligent online monitoring of THM, THM Formation Potential and Trace Metals – Arsenic, Chrome, Lead, Copper, Selenium etc.
- 19 year heritage in intelligent online monitoring of contaminants of concern – accurately and reliably with >99% uptime
- 100+ Installations in Americas and Europe
- Municipal clients: Cal American, Suez, SF PUC, City of Phoenix, El Paso, Birmingham, Des Moines, Scottsdale, Gilbert, etc…
- Industrial clients: Batelle, Barrick Gold, Broadcom, Coca Cola, Duke Energy, Samsung, Sandia National Laboratories, Teck

INVENTORS OF THE ON-SITE STANNOUS GENERATOR

Smart Networks –



Getting better performance from the same basic engine.

The Value of High Frequency Real-Time Cr(VI) Data

CHARACTERIZATION	Extensive data stream to enable the design of cost- effective remediation processes
PILOT AND WHAT IF STUDIES	Simulation (“what if ?”) of the impact of multi-parameter operational changes on contaminant levels
TECHNOLOGY VALIDATION	Fast feedback permits rapid assessment and validation of remediation process
PROCESS OPTIMIZATION	Captures changes in contaminant levels to enable timely and cost effective remediation
RISK MANAGEMENT	Captures non-compliance risk to enable timely action before non compliance occurs, ensures regulatory and contract compliance

Voltammetric Analytical Method

Voltammetry, subset of amperometry, measures electric current through an electrode at specific potentials.

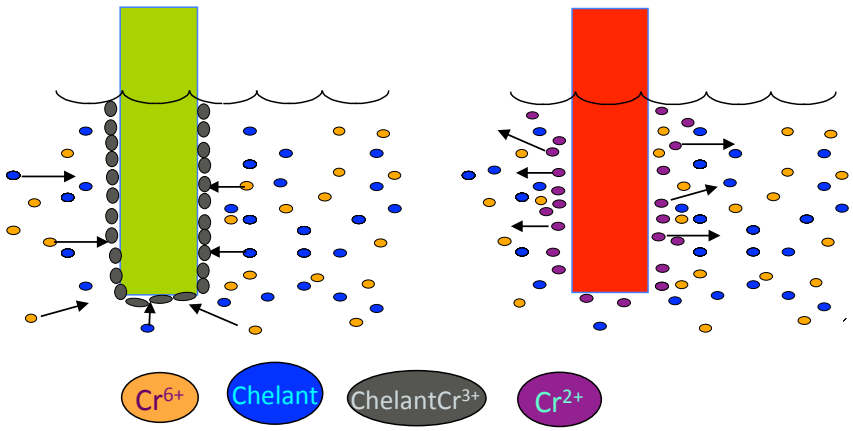
Step 1- Accumulation

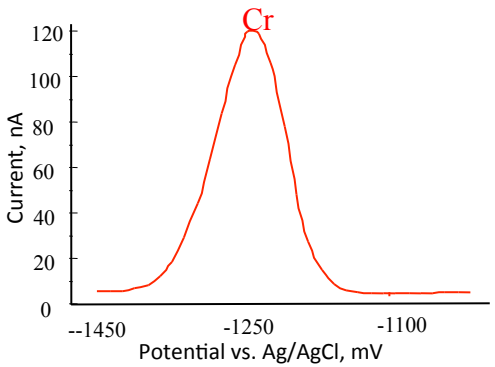
Chel+ Cr^{6+}+ $3e^-$ → $ChCr^{3+}$

Step 2- Stripping

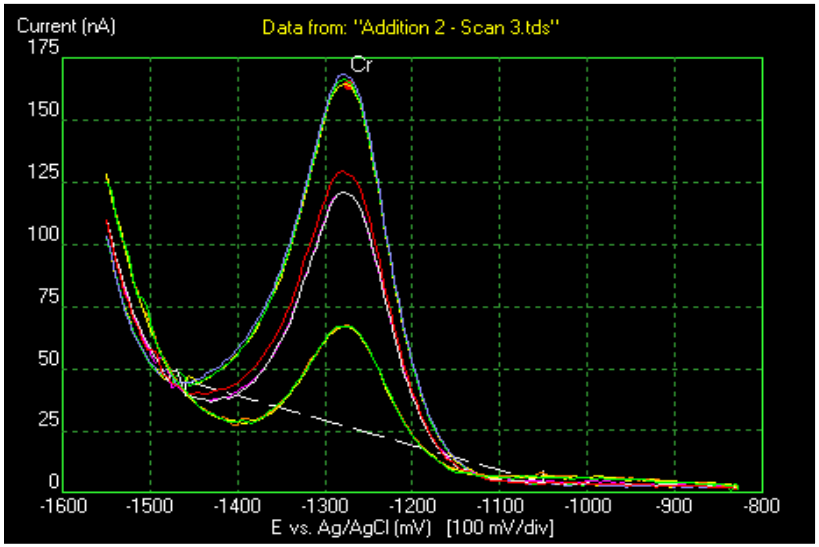
$ChelCr^{3+}$ + e^- → $ChelCr^{2+}$

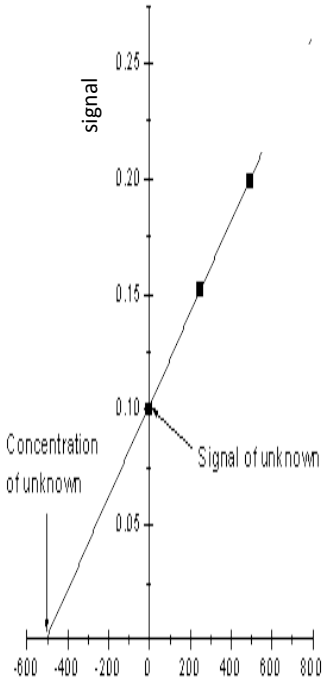
Resulting Signal





# of Standard Addition





- Calibration approach compensates for sample matrix and temperature effects
- Each measurement quality is ensured by calibration curve fit factor
- System maintains calibrated status without any operator interference for virtually unlimited time

Elements Available by ASV and AdASV

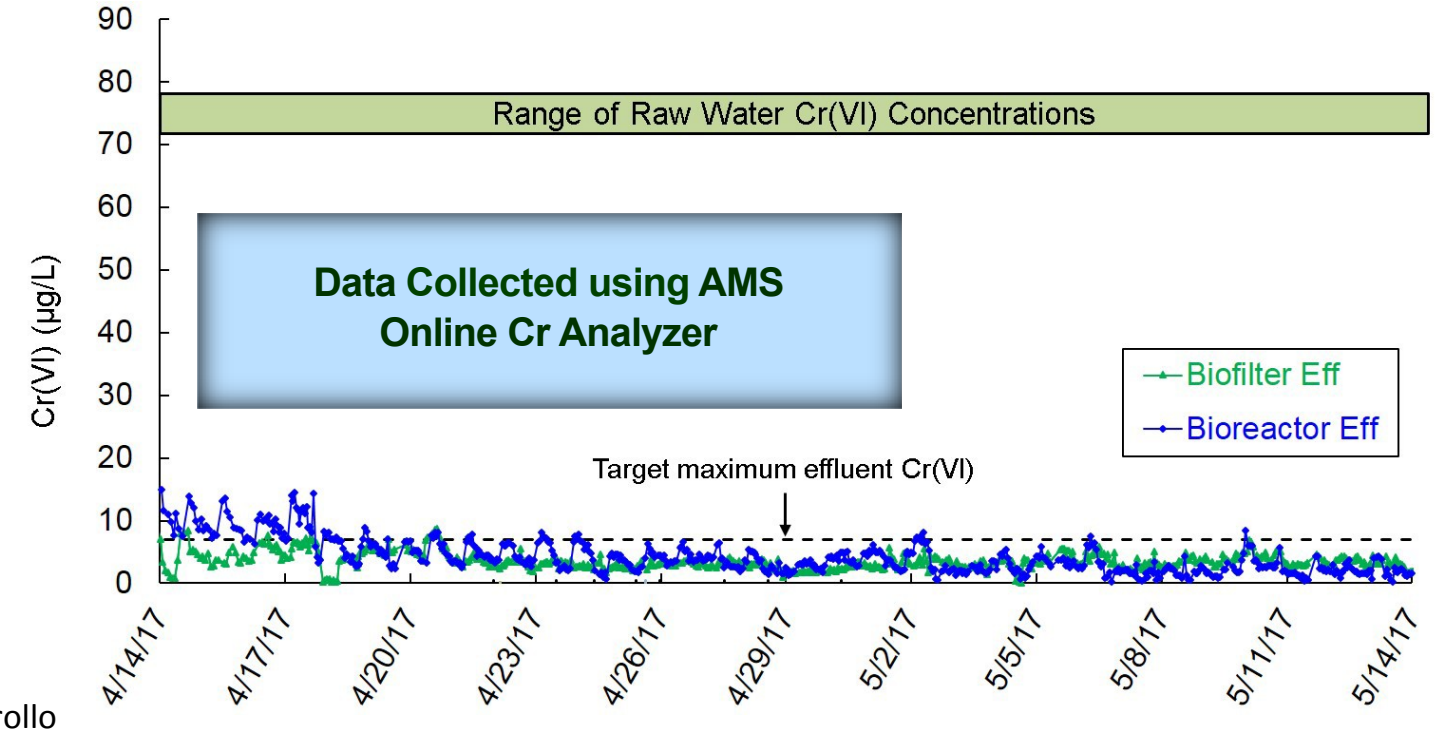
H																He
Li	Be											B	C	N	0	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq		Uuh		Uuo
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Real-Time, High Frequency Intelligent Cr(VI) Monitoring

- Citrus Heights, CA* (w/ Cal-American)
- City of Watsonville, CA (w/ Corona)
- Coachella Valley, CA (w/ Hazen and Sawyer)
- Los Banos, CA
- Moonbeam, CA* (w/ Cal-American)
- US Steel, IN
- Norman City, OK (w/ Carollo)

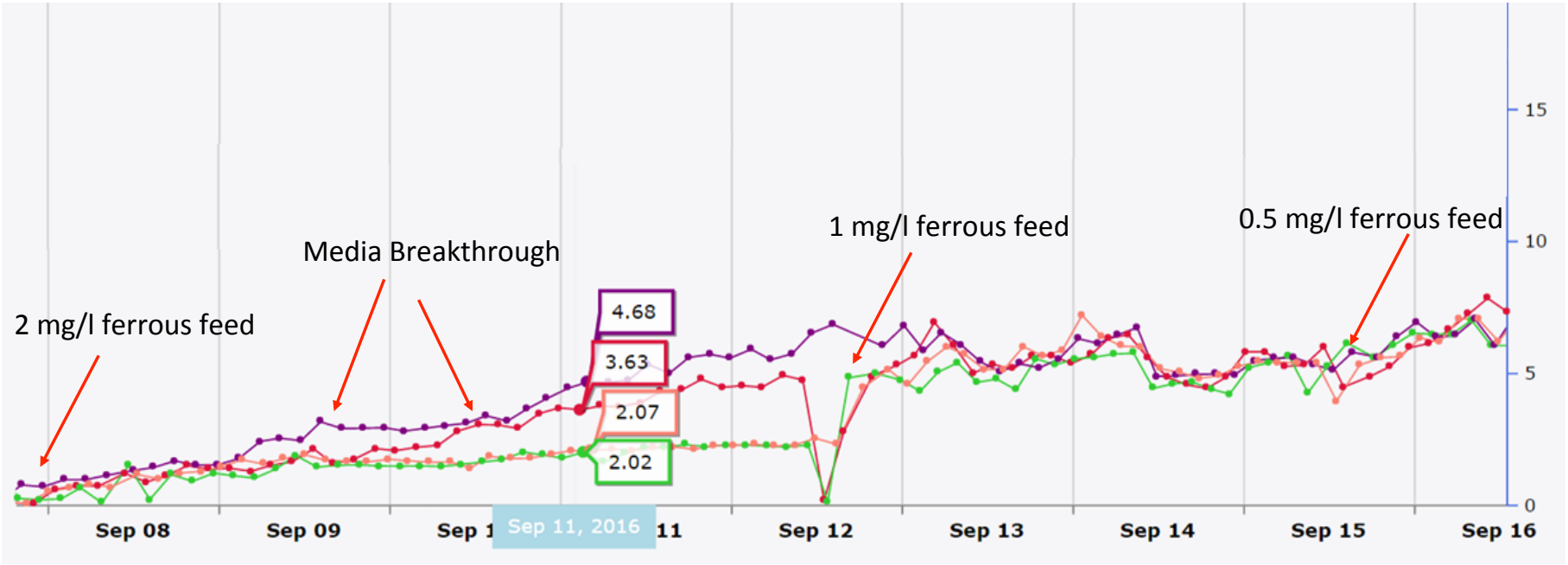
* Long Term Installations

MetalGuard Validation: Carollo (Biotta) Sustained Cr Removal

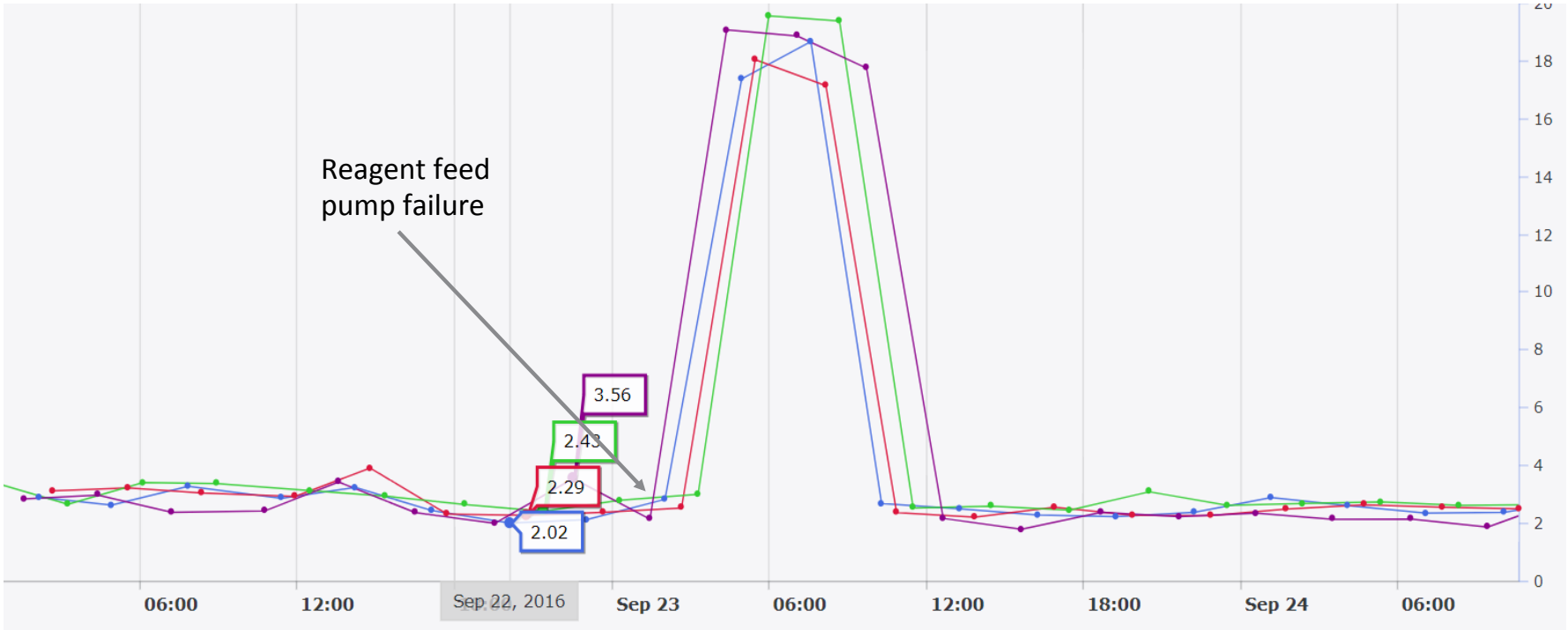


Source: Carollo

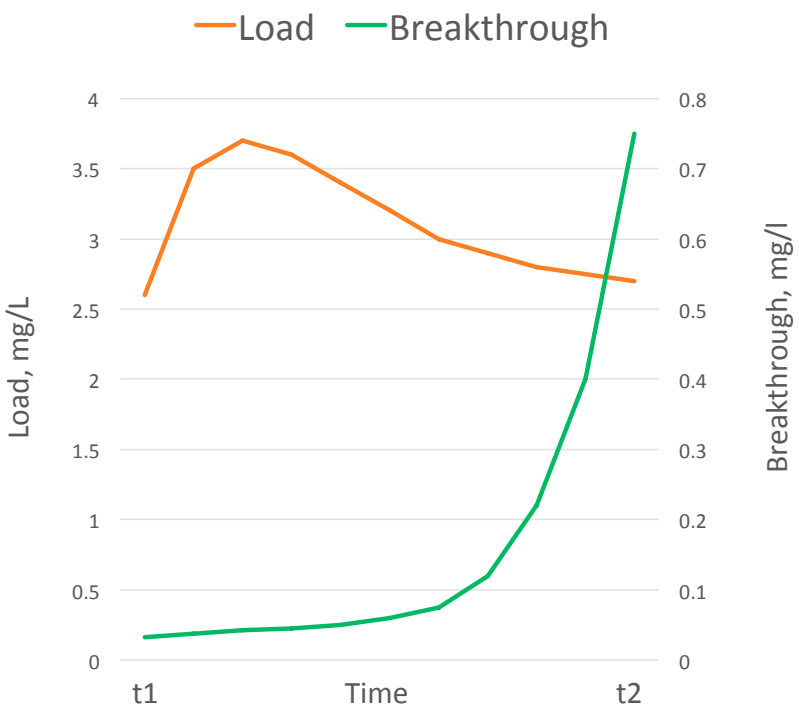
MetalGuard Validation of Pilot Plant: Cr (VI) Treatment



MetalGuard Risk Management: Cr(VI) Treatment



MetalGuard Assessing Ion Exchange Capacity and Cost Performance



IX capacity Q_{act} > L!!!

Ionic load (L) entering IX system during time period t_2 - t_1:

$$L = 1/t2 - t1 \int t1 \uparrow t2 \blacksquare C(t) \int t1 \uparrow t2 \blacksquare F(t)$$

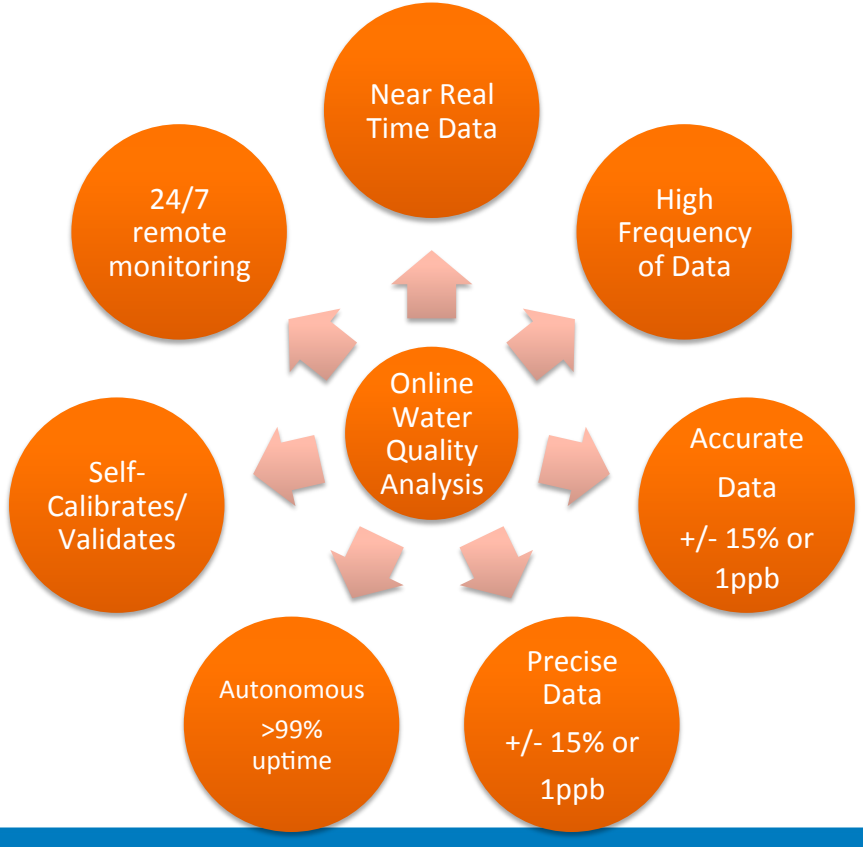
IX system mass balance:

$Q_{act} = Q_{th} - (L - BT)$

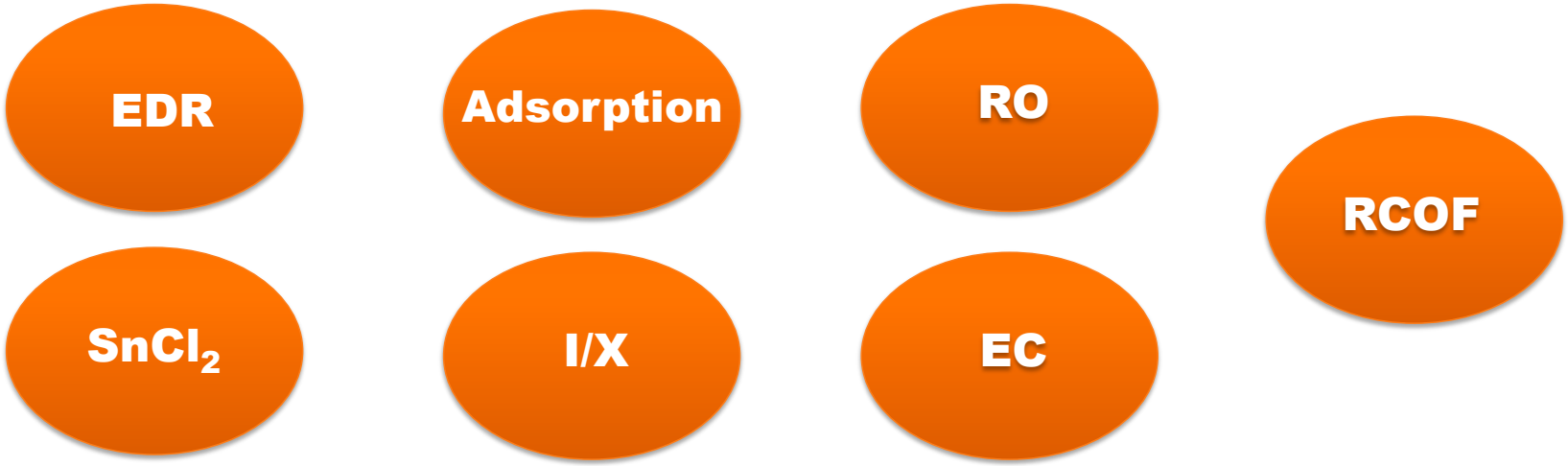
IX system efficiency:

$E = Q_{act}/Q_{th}$ x100%

MetalGuard Cr(VI) Analyzer Performance Characteristics



Cr(VI) Treatment Options



These technologies generate unique waste products with various handling and disposal challenges. Limitations and costs associated with waste disposal influence the selection of Cr(VI) treatment technology.

Why is Innovation Essential to Address Cr(VI) Contamination?

300+

CA water systems with Cr(VI) levels above 10 ppb

10ppb

Standard would affect economic feasibility, especially for SWSs

$3-7/1000gal

Cost of traditional Cr(VI) removal, depending on system design and waste disposal

Innovation can reduce the costs of Cr(VI) remediation …

Cost of Cr(VI) Removal Based on Los Banos (CA) Water Characteristics

SafeGuard H2O treatment system, without filtration, ranges between $0.7-1.4/1,000 gal treated. Includes 3 monitors.

This cost is dependent on monitoring implemented, both influent Cr(VI) levels and targeted effluent level (MCL).

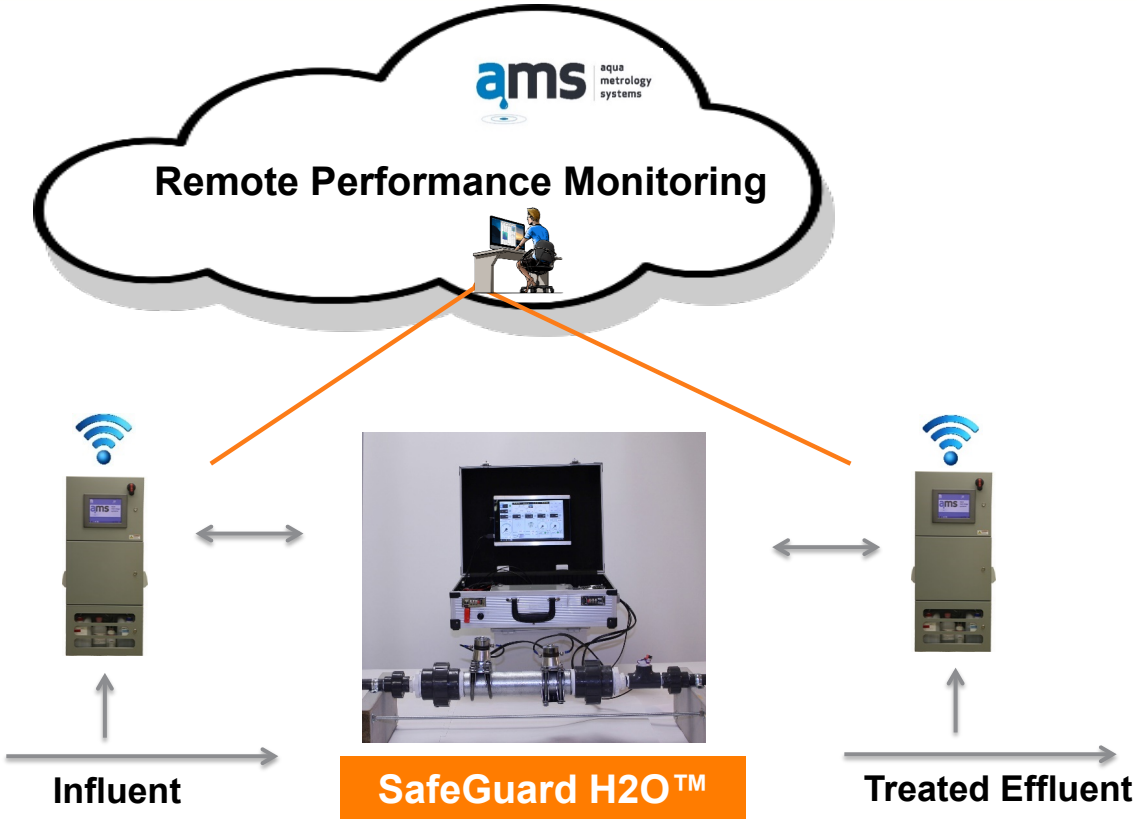
(Based on WQTS Model)

Capital Cost ($M)	Lower End	Upper End
SBA Treatment	$2.1	$4.5
WBA Treatment	$2.7	$5.9
RCF Treatment	$2.5	$5.3
SafeGuard H2O Treatment	<$1	
Annual O&M Cost ($/yr.)	**Lower End**	**Upper End**
SBA Treatment	$260,000	$558,000
WBA Treatment	$259,000	$555,000
RCF Treatment	$166,000	$356,000
SafeGuard H2O Treatment	$96,000	$165,000
Annualized Cost ($/yr.)	**Lower End**	**Upper End**
SBA Treatment	$429,000	$920,000
WBA Treatment	$478,000	$1,025,000
RCF Treatment	$363,000	$779,000
SafeGuard H2O Treatment	$240,000	$480,000

Smart Monitoring

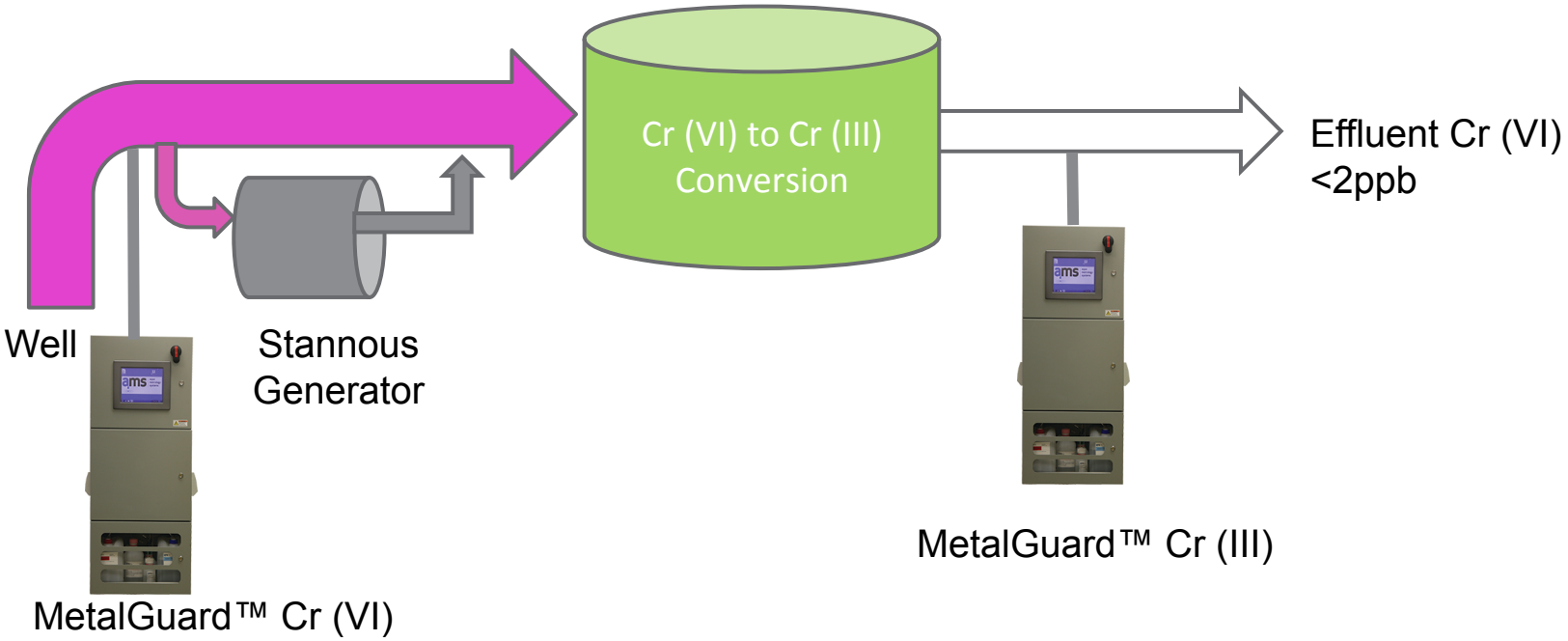
Lab → Network

Characteristics of an Intelligent Water Treatment System

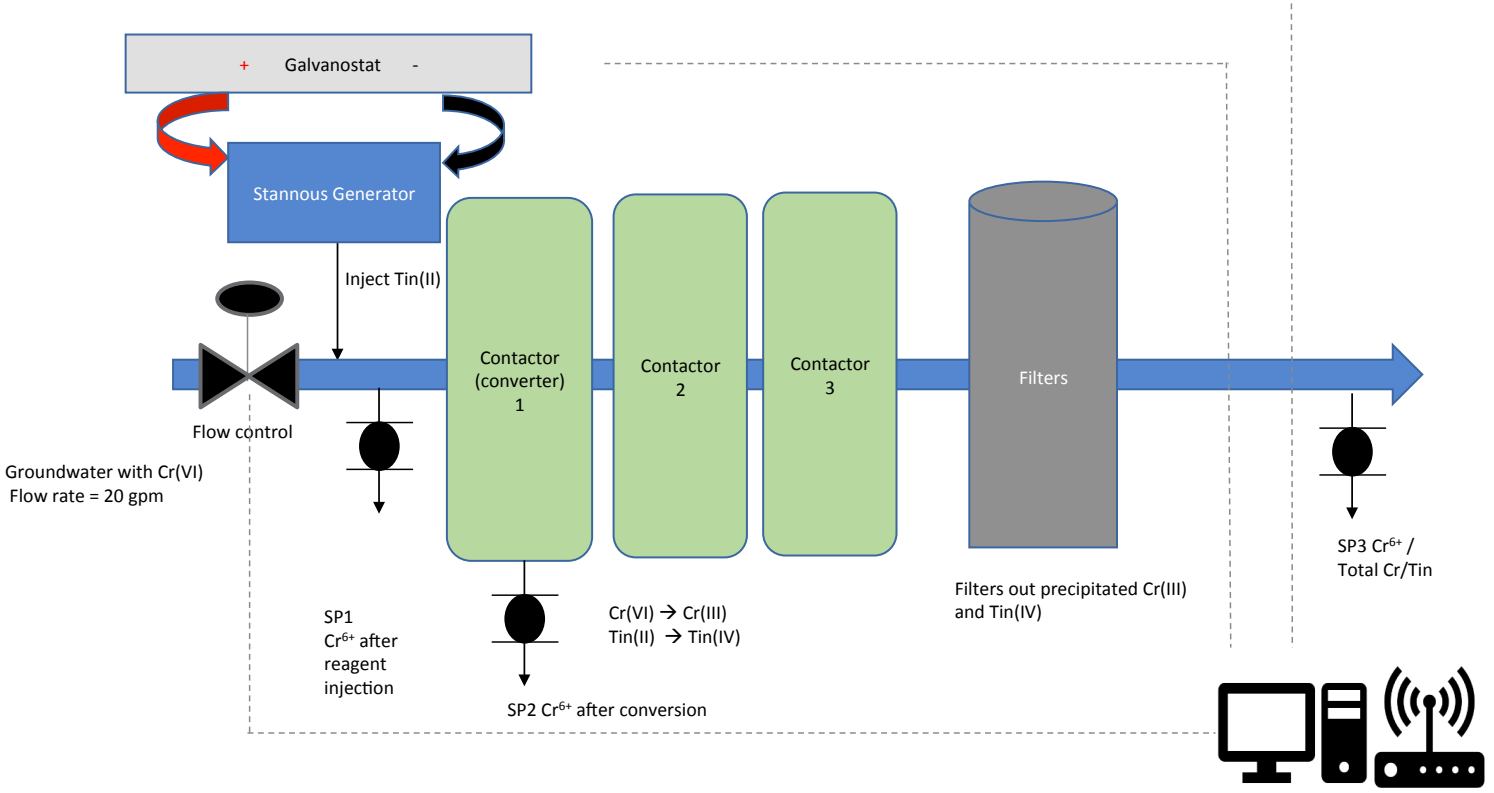


SafeGuard H2O™ Standard Process Diagram

$$2CrO_4^{2-} + 3HSnO_2^{-} + 5H_2O = 2CrO_3^{3-} + 3Sn(OH)_6^{2-}$$



SafeGuard H2O™ & Microsand Filtration Process Diagram



Total Cr and Total Tin Filtration Performance (Pilot Scale Testing)

Raw water and treatment parameters

- Oklahoma and California drinking waters: Cr(VI) levels ranging from 19-92 ppb;
- Stannous dose: 0.2-1.5 ppm
- Contact time: less than 5 min
- Typical water sand filter operated under optimized conditions (depth filtration)

Results and conclusions

- Conventional sand depth filtration removed Cr(T) under 10 ppb;
- Total Tin was removed by sand filtration down to under 15 ppb

*A. M. Kennedy et al. 2018. April 2018, 110:4. Journal AWWA

Common Misconceptions

- Not Stannous Chloride! NO
- Reconversion of Trivalent Chrome to Hexavalent Chrome within 2 days! NO
- Tin will plate distribution and service lines and cause them to clog! NO

Innovative Intelligent Cr(VI) Removal System- SafeGuard H2O™

- Proven to remove Cr(VI) to less than 2ppb.
- An order of magnitude cheaper than conventional Cr (VI) capture methods. How?
  - Very low capital costs
  - Easy and fast to install
  - Low engineering and design costs
  - Low operating costs
    - Operates un-attended (ideal for remote wells or small systems)
    - No toxic reagent handling and storage costs
    - No toxic waste disposal costs

SafeGuard H2O™: Innovative Pricing Model

For funding constrained cities AMS will offer the SafeGuard H2O on the basis of a long-term toll contract (cents/gallon treated) with volume and water quality guarantees.

Innovations

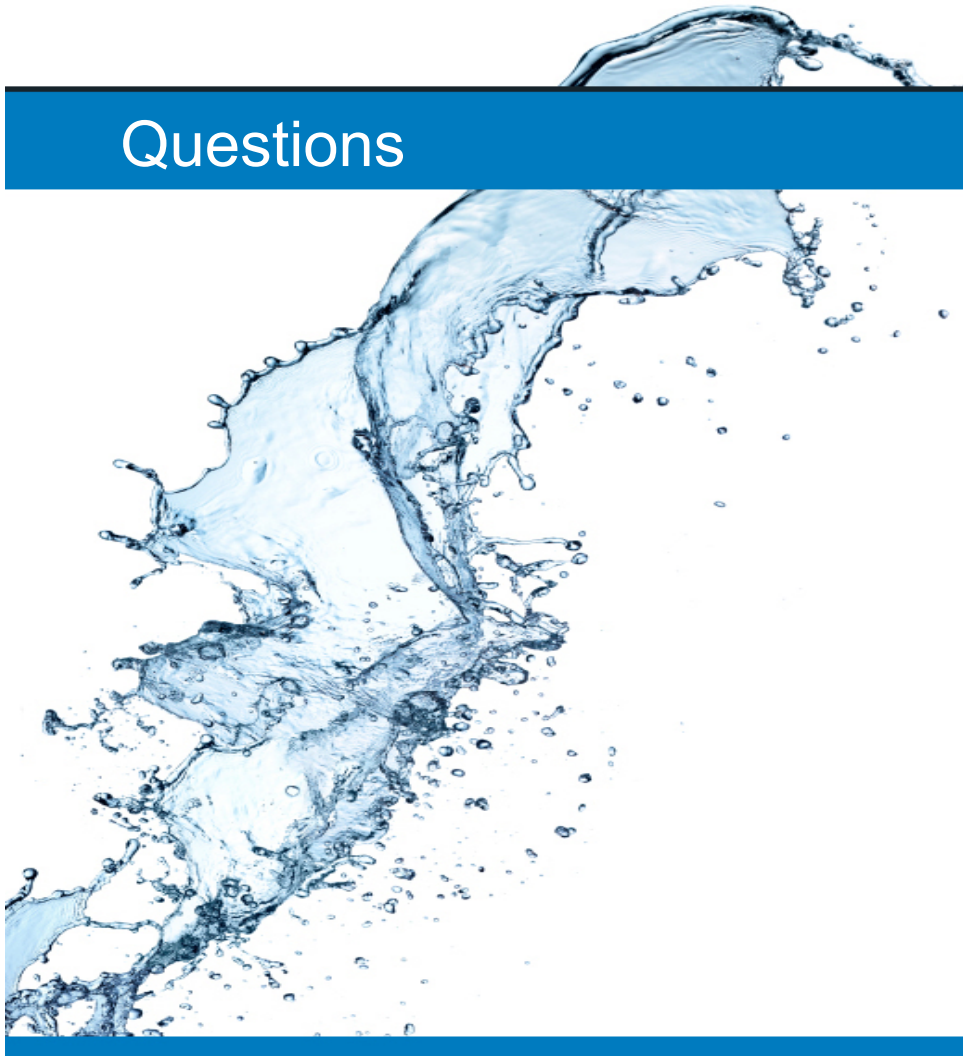
SafeGuard H20

- Mercury/Selenite removal (FGD waste treatment)
- Lead/Copper abatement in drinking water service lines

Monitoring

- Real-time THM Formation Potential (Treated Water)
- Real-time THM Formation Potential (Raw Water)

Questions



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