WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

WELCOME

2017 Safe Drinking Water Program Workshop

Better Water, Better Wells

WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

2017 Safe Drinking Water Program Workshop

Better Water, Better Wells

Charlene King, Program Manager

November 7, 2017

Program

9:20 – 10:00

WRD Safe Drinking Water Program & WRD DAC Pilot Program

Charlene King, WRD, Maria Kennedy, Kennedy Communications, Steven Rojo, GM Maywood Mutual #2

10:00 – 10:30

Salinas Valley Distributed Water Treatment Project

Yoram Cohen, Ph.D. – UCLA Distinguished Professor

10:30 – 11:00

California Drinking Water Program Updates

Sutida Bergquist, State Water Resources Control Board, Division of Drinking Water

11:00 – 12:00

Nitrate Biological Treatment

Catherine Swanson & Kelsey Hakes, Evoqua Water Technologies LLC

12:45 – 2:45

Well & Pump Rehabs, BACT and Other Common Well Issues

Michael Bodart, General Pump Company

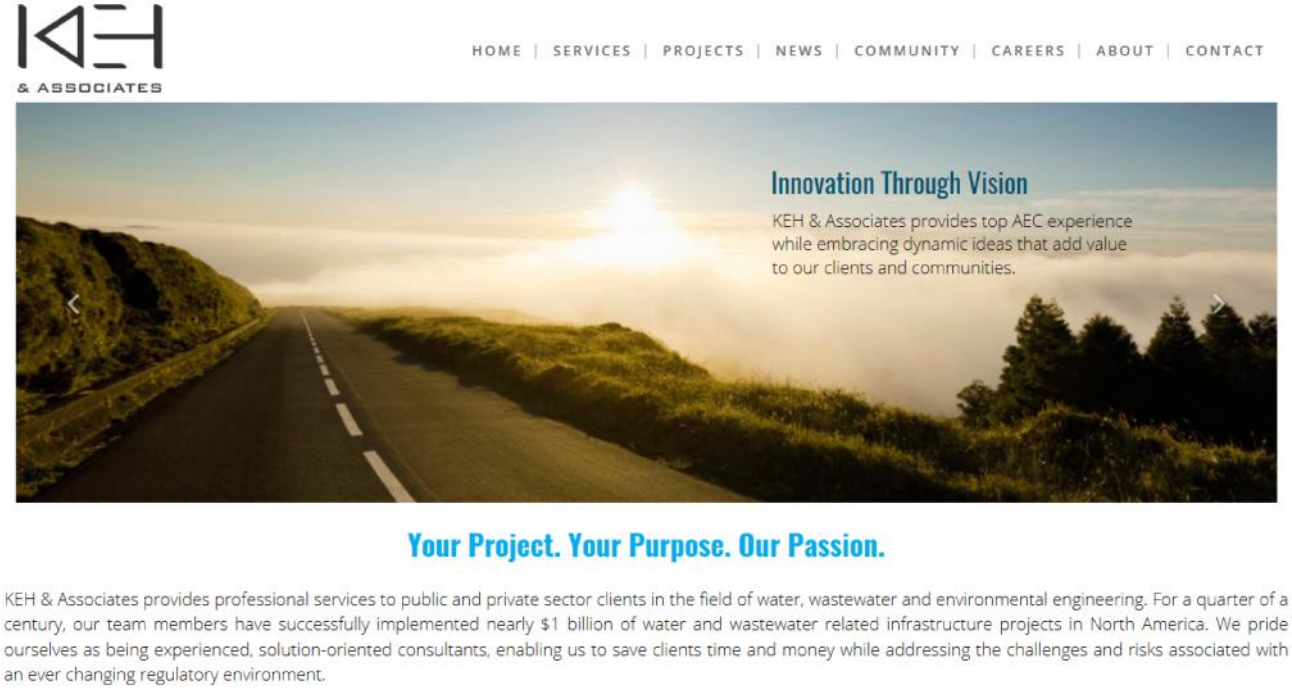
WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

The presentations will be emailed to the participants and/or uploaded to http://www.wrd.org

Program

12:00 – 12:45

Lunch provided by KEH & Associates



WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

WRD Safe Drinking Water Program

Program History

The WRD Safe Drinking Water Program (formerly the WRD Wellhead Treatment Program) was implemented in 1991 to promote groundwater cleanup by extracting and treating contamination at specific well locations.

The program provides grant or loan assistance for wellhead treatment at groundwater wells impacted by man-made or natural sources.

WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

WRD Safe Drinking Water Program

Success of the WRD Safe Drinking Water Program

Since the creation of the program, the District has funded:

- Twelve (12) grant projects to remove Volatile Organic Compounds (VOCs),
- Four (4) loan projects to remove Secondary Constituents and
- One (1) demonstration project researching various media for Arsenic removal.

The WRD Safe Drinking Water Program has restored the use of 17 production well facilities (approximately 38,000 acre-feet per year).

WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

DAC Outreach Assistance Pilot Program

The Safe Drinking Water Program's Disadvantage Communities (DAC) Outreach Pilot Program was developed to assist small water systems in applying for State funding to help fill the gaps where resources may be needed.

The District will provide assistance with the funding application submittals including engineering resources for the technical analysis. WRD will also assist with the construction of the project for continued technical support.

WRD Safe Drinking Water & DAC Outreach Assistance Program

The District is currently working with three (3) water systems for through the Safe Drinking Water Program.

The District is currently working with seven (7) water systems with applying for State funding.

Safe Drinking Water DAC Pilot Program

WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

Program Guidelines

Type of Assistance	Contamination	Assistance Policy
GRANT	Volatile Organic Compounds (VOCs) Primary constituents of man-made origin exceeding the Maximum Contaminant Level (MCL).	WRD will design and construct the treatment system at any drinking water well with a consistent trend of VOC contamination.
LOAN *Through* *Revolving Fund*	Secondary or naturally occurring primary constituents exceeding the MCL. (Non-VOCs)	WRD will provide to the owner interest-free financing to design & construct treatment equipment for Non-VOC removal.
DAC OUTREACH ASSISTANCE	VOCs and Non-VOCs	WRD will provide State funding application assistance for water systems in disadvantaged communities (DACs).

WATER REPLENISHMENT DISTRICT
OF SOUTHERN CALIFORNIA

Thank You!

Charlene King
cking@wrd.org
562.275.4252

Safe Drinking Water for Disadvantaged Communities: Maywood Mutual Water Company No. 2 Case Study

Maria Elena Kennedy

Kennedy Communications

Maywood Mutual Water Company No. 2

- Maywood has faced many water quality challenges over the years.
- AB 240 (Rendon) provided $1M in funding to improve the water quality in the Maywood area.
- This funding was not enough to solve the problem
- WRD created the Safe Drinking Water for DACs pilot program in 2014 to help small systems access funding from the state to help improve water quality and water supply though local sources which are less costly
- After a very detailed analysis of the three water systems, Maywood Mutual Water Company No. 2 was selected to receive the $1M.
- WRD then applied for $224,000 in planning funding to start the preliminary design for the treatment system
- WRD is now negotiating a final agreement with the state for $1M in addition to the AB240 funding and the planning funding

Safe Drinking Water for DACs Pilot program

- WRD is committed to helping the retailers in the service area
- The Safe Drinking Water for DACs is a program by which WRD provides the technical assistance to help the retailers access funding through the State Water Resources Control Board
- WRD provides the grant writers and engineering services necessary for a successful application
- We are ready to help you with your challenges!

Questions?

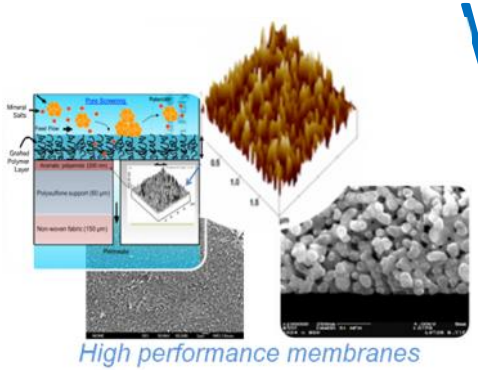
MAYWOOD MUTUAL WATER COMPANY NO. 2

STEVEN ROJO, GENERAL MANAGER

MAYWOOD AVENUE WELL

- WRD HAS BEEN A GREAT PARTNER IN HELPING MAYWOOD MUTUAL WATER COMPANY NO. 2 ACCESS THE FUNDING WE NEED TO ENSURE OUR RESIDENTS HAVE WATER THAT IS CLEAN, SAFE AND RELIABLE.
- WRD HAS PROVIDED US WITH GRANT WRITERS AND ENGINEERS WHO HAVE WORKED WITH US EVERY STEP OF THE WAY. WE ARE TRULY GRATEFUL.

Salinas Valley Distributed Water Treatment Project



UCLA WATER TECHNOLOGY RESEARCH CENTER

Yoram Cohen, Anditya Rahardianto, Madelyn Glickfeld and Maria Kennedy

UCLA Department of Chemical and Biomolecular Engineering
& UCLA Institute of the Environment and Sustainability

For More Information regarding this presentation, Contact Dr. Yoram Cohen, (310) 825-8766 Email: yoram@ucla.edu

California Drinking Water Program Regulatory Update

Safe Drinking Water Workshop

November 7, 2017

Sutida Bergquist, P.E., District Engineer

Central District, Southern California Coast Section

SWRCB – Division of Drinking Water

California's Division of Drinking Water

- **Northern California Field Operations Branch**
- **Southern California Field Operations Branch**
- **Program Management Branch**
  - Technical Operations Section
  - Environmental Laboratory Accreditation Program (ELAP)
  - Quality Assurance Section - **NEW**

District Offices and LPAs:

- 7500+ Water Systems
- 5 Regions
- 24 State District Offices
- 30 County Local Primacy Agencies

Priority Regulations - Drinking Water

1. 1,2,3-TCP MCL
2. Revised Total Coliform Rule
3. Lead and Copper Rule Revisions
4. Annual MCL Review – Perchlorate
5. Cross-Connection Control

1,2,3-TCP Maximum Contaminant Level
(1,2,3-Trichloropropane)

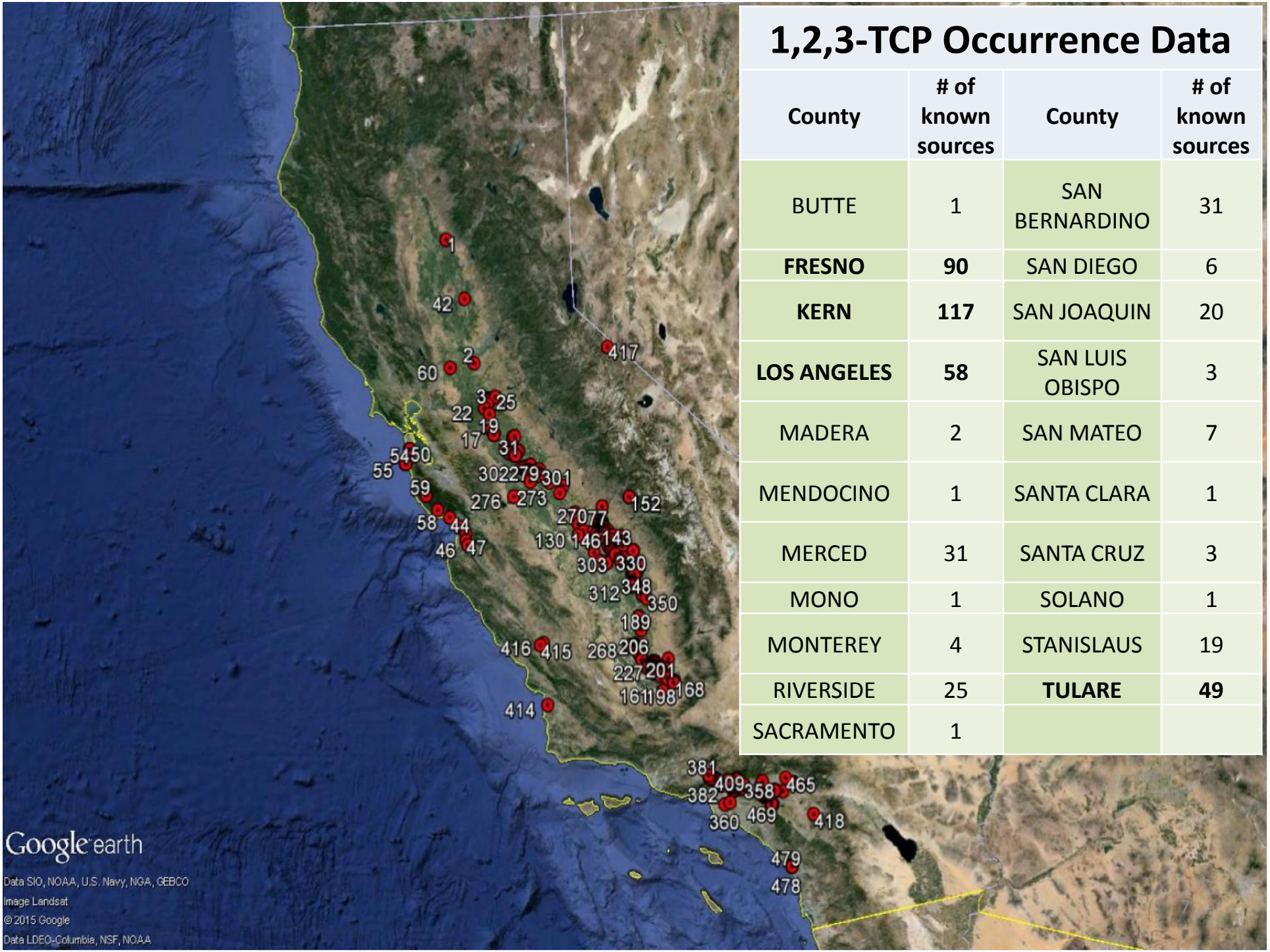
- Synthetic organic chemical (SOC)
  - Industrial solvent, degreaser
  - Ingredient in soil fumigants widely used for many decades
- Public Health Goal (PHG) established 2009
  - 0.7 ppt (parts per trillion)
  - Possible carcinogen
- **MCL adopted by Board on July 18, 2017**
  - **5 ppt (DLR also 5 ppt)**
- GAC is a best available technology

1,2,3-TCP Maximum Contaminant Level

- Effective October 2, 2017
- Initial monitoring period begins January 1, 2018
  - 4 quarterly samples
- Compliance determination
  - For PWS serving >3,300 population, compliance based on initial, confirmation sample(s), and 6 monthly samples
  - For PWS serving <3,300 population, compliance based annual average of initial, confirmation sample(s), and quarterly samples
- Grandfathering of previous monitoring
  - Results collected within two calendar years of effective date
  - Substituted for same quarter of initial period
    - 2nd quarter 2016 for 2nd quarter 2018
  - Only substitute 3 of 4 required initial samples
  - Request must be in writing to DDW

1,2,3-TCP Maximum Contaminant Level

- 2001-2015 Occurrence Data:
  - **471 wells with confirmed detections above 5 parts per trillion (ppt)**
  - Range of Detections: **5 ppt to >10,000 ppt**
- Vast majority of detections in groundwater
  - Most in Central Valley (Kern, Fresno, Tulare counties)
  - Riverside – 25 sources
  - San Bernardino - 31 sources
  - Los Angeles – 58 sources



1,2,3-TCP Occurrence Data

County	# of known sources	County	# of known sources
BUTTE	1	SAN BERNARDINO	31
FRESNO	**90**	SAN DIEGO	6
KERN	**117**	SAN JOAQUIN	20
LOS ANGELES	**58**	SAN LUIS OBISPO	3
MADERA	2	SAN MATEO	7
MENDOCINO	1	SANTA CLARA	1
MERCED	31	SANTA CRUZ	3
MONO	1	SOLANO	1
MONTEREY	4	STANISLAUS	19
RIVERSIDE	25	**TULARE**	**49**
SACRAMENTO	1		

Hexavalent Chromium (Cr 6)

- July 1, 2014, CA adopted a state MCL of 10 ug/L for Cr6
- May 31, 2017, the Superior Court of Sacramento County invalidated the Cr 6 MCL stating the regulator did not adequately document the economic feasibility of complying with the MCL
- August 1, 2017 the State Board adopted a resolution to remove the current Cr 6 MCL
- Staff will begin the process of having the regulatory text deleted, which should take effect in late September 2017, and develop a new standard as soon as possible

Lead and Copper Rule – DDW Recommendations

- March 7, 2016, DDW issued a letter to all community and nontransient noncommunity water systems
- Recommendations on improving public access to Lead and Copper Rule (LCR) information
- Reminder to provide sample results to those participating in LCR tap sampling:
  - w/in 30 days of receiving the results from lab, and;
  - w/in 1-2 working days if lead and/or copper levels over the respective action levels are found

http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/leadandcopperrule.shtml

Lead in Drinking Water

- U.S. EPA is working to issue a **Revised Federal Lead & Copper Rule**
- EPA Resources on its Web Site
  - Basic Information about Lead in Drinking Water
  - Lead and Copper Rule Revision White Paper October, 2016
  - Lead in Drinking Water at Schools and Child Care Facilities
  - 3Ts for Reducing Lead in Drinking Water in Schools
- State Board priority regulation
- **NEW** Electronic submittal of lead and copper tap sample results using Lab to State Portal
  - Training for laboratories provided on June 20, 2017, check with your certified lab
  - August 23, 2017 webinar for water systems

Lead Sampling in Schools

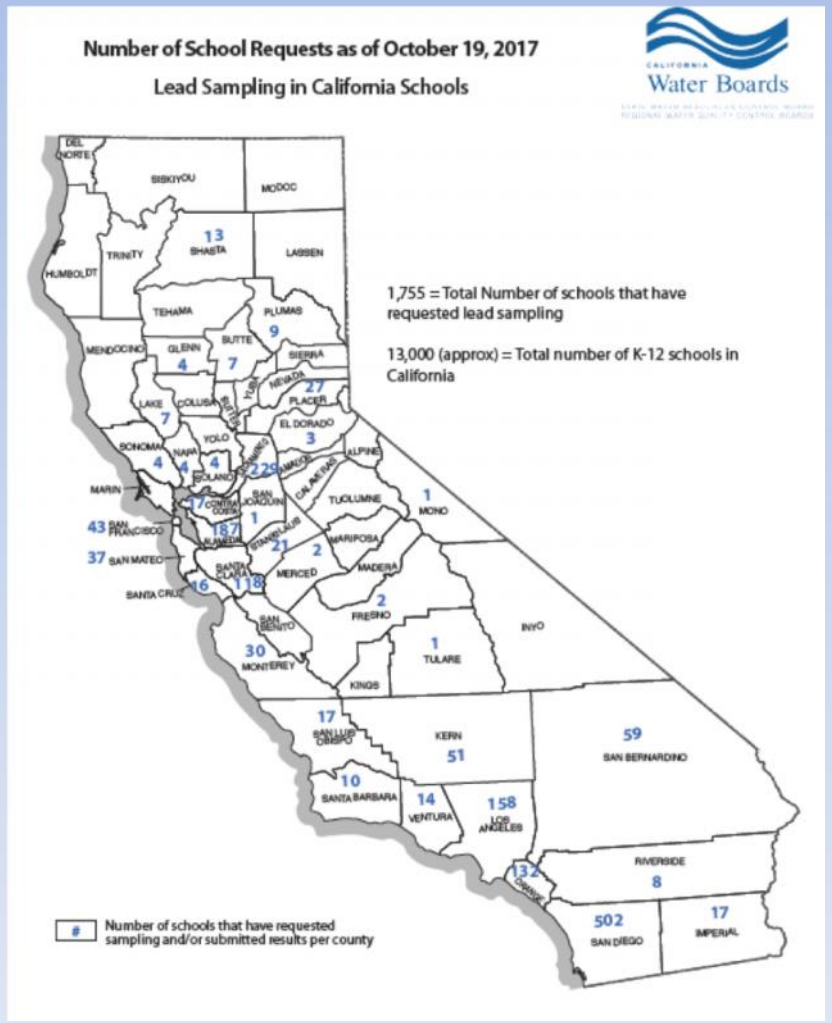
- Meetings with the Governors office and Department of Education throughout 2016 resulted in the decision for DDW to issue an amended permit to all community water systems who serve a K-12 school
- Permit requires water systems to sample at school (5 sample sites) when a school official makes a request in writing to the water system for sampling assistance
- Permits issued January 17, 2017 along with a media release and resources on the DDW website (FAQs, details of sampling procedures, lab data submittals)

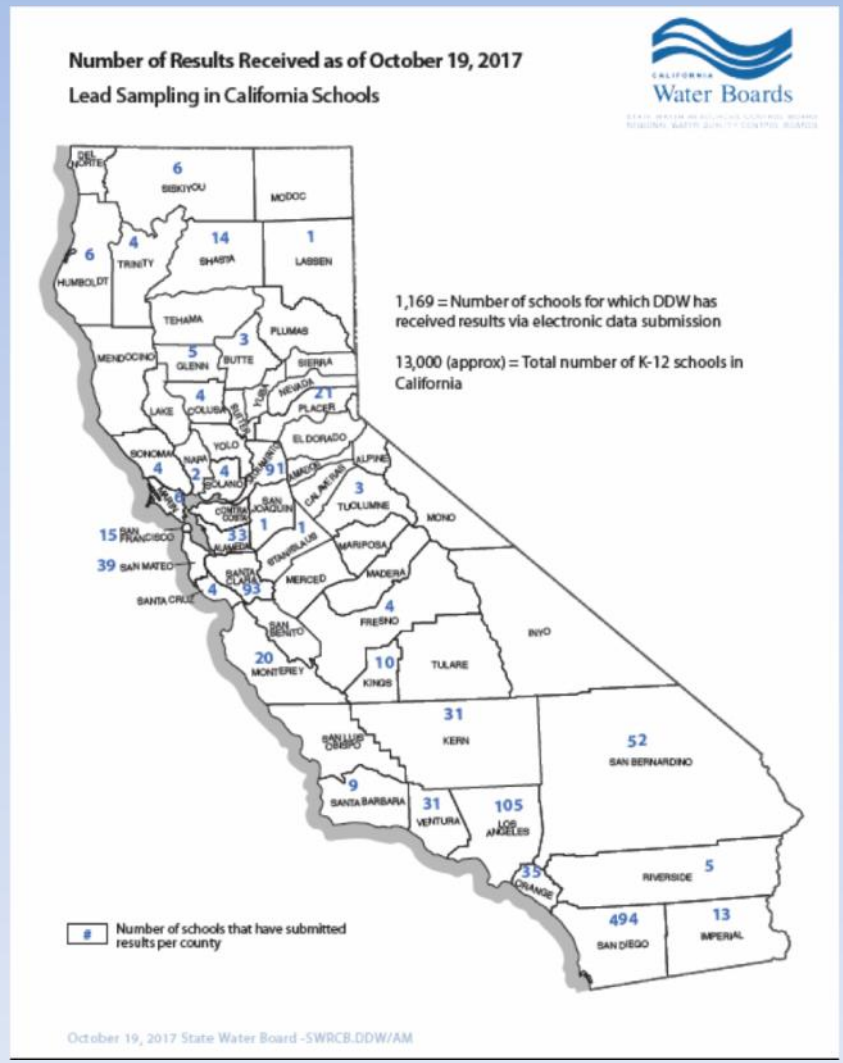
http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/leadsamplinginschools.shtml

Lead Sampling in Schools

- Schools can request sampling assistance anytime prior to November 1, 2019.
- As of October 19, 2017, a total of 1,755 schools have provided a copy of their request letter to the Division, and 1,169 schools have submitted results
- Schools will be responsible for corrective actions (removing/replacing drinking fountains, POU devices, etc.)
- Drinking Water for Schools Grant Program
  - $9.5 M available, serving small DACs

School Requests and Results Received





Lead Sampling of DW in CA Schools
AB 746

- AB 746 was signed on October 13, 2017
- Added Section 116277 to H&S Code (1/1/2018)
- Similar requirements to DDW permit
- Requires CWS to sample all "Local Educational Agencies" defined as school district, county office of education or charter school located in a public facility
- FAQ being written and added to current webpage along with updated documents

Lead Sampling of DW in CA Schools AB 746

- Sampling Guidance from DDW will be the same as DDW permit
- Section (e)(4) – allows schools that have been previously sampled by DDW permit to count toward this requirement
- Section (e)(3) – Allows schools previously sampled prior to 1/1/2009 which post their results to count toward this requirement

Lead Service Lines: Requirements of SB 1398 and SB 427

- All ~~public~~ community water systems must compile an inventory of known lead service lines by July 1, 2018
- PWS must also identify areas that may have lead service lines and identify any areas where the PWS cannot identify the service line material
- By July 1, 2020, PWS will be required to propose a schedule to replace all the known lead service and service lines constructed of unknown material
- SB-427 has been signed - the requirement only applies to community water systems
- DDW will have a web portal available in 2018 to begin receiving documents for the water system's inventory.
- FAQs, guidance and updates available on DDW website

http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/lead_service_line_inventory_pws.shtml

Revised Total Coliform Rule

- Federal RTCR effective April 1, 2016
- Interim Period before state adoption
  - All PWS must comply with existing CA rule and Federal RTCR
- CA regulation in development and anticipated in 2018
  - Draft regulation available on DDW website

Revised Total Coliform Rule

- Overall approach is to “Find and Fix” problems
- Minor changes to routine and repeat sampling
  - No changes to # of samples per week or month
  - 3 repeat samples for each TC+ routine
    - Existing location, U/S and D/S within 5 service conn.
    - PWS collecting 1 routine/month, 4 repeats still needed
- Established E.coli MCL
  - EC+ Routine, TC+ Repeat
  - TC+ Routine, EC+ Repeat
  - EC+ Routine, no repeats collected
  - TC+ Routine, TC+ Repeat, fail to analyze repeat for E.coli
- Established Coliform Treatment Technique

Revised Total Coliform Rule

Level 1 Coliform Treatment Technique

- Triggers when:
  - > 5% of samples TC+, if collecting 40 or more samples/month
  - 2 or more samples TC+, if collecting fewer than 40 samples/month
  - Failure to collect all repeats following TC+ routine
- Water system must complete Level 1 assessment and make corrective actions within 30 days
- Issue Tier 2 public notice within 30 days
  - INTERIM PERIOD ONLY

Revised Total Coliform Rule

Level 2 Coliform Treatment Technique

- Triggers when:
  - E. Coli MCL violation
  - Second Level 1 trigger within a 12-month period
- Issue Tier 1 Public Notice by end of day
- Contact DDW (or LPA) by end of day
- DDW (or LPA) staff will conduct Level 2 assessment and water system must complete and make corrective actions within 30 days

Revised Total Coliform Rule

- Failure to conduct the Level 1 or Level 2 assessments within 30 days or failure to complete corrective actions is a violation requiring a Tier 2 Public Notice
- New requirements for seasonal water systems to follow approved start-up protocol including sampling before serving water to the public

http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/rtcr.shtml

Perchlorate MCL Revision

- Current MCL 6 ug/L is greater than revised Public Health Goal of 1 ug/L (2015).
- Current Detection Level for Reporting (DLR) is 4 ug/L.
- July 5 Board meeting decision to initiate two-step process for revising perchlorate MCL
  1. Amend Title 22 regulations to lower DLR
  2. Gather occurrence data below 4 ug/L for use in considering a revised perchlorate MCL

Cross-Connection Control Regulations

- Work on updating these regulations, which are currently in CCR Title 17, is anticipated to begin soon

Resources

- **Website:**

  http://www.swrcb.ca.gov/drinking_water/programs/index.shtml

- **Subscribe to Email List:**

  - Go to **http://www.waterboards.ca.gov/resources/email_subscriptions/**
  - Select "State Water Resources Control Board"
  - Fill in contact information with your email address and full name
  - Select category “Drinking Water” and then select the first box "Drinking Water Program Announcements"
  - You may select other categories as well
  - Click "subscribe“

- **Drinking Water Watch:**

  https://sdwis.waterboards.ca.gov/PDWW/

Questions?

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(818) 551-2048

BIOLOGICAL REMEDIATION OF NITRATE FOR DRINKING WATER

Cathy Swanson
Kelsey Hakes

November 7, 2017

Nitrate Reduction System

- **Why consider Biological Treatment?**
- **Overview of Biological Treatment**
- **Hall Reactor Overview**
- **Typical Data**

Relative cost of each treatment to purveyors

Treatment	Cost
RO	$2000/AF
IX – onsite regen with waste haul off	$1500/AF
IX – onsite regen with access to brine line	$400/AF
IX – offsite regen	$1500 – $2000/AF
Biological treatment for treated water	$500 - $750/AF

Nitrate Reduction System

- **Why consider Biological Treatment?**
- **Overview of Biological Treatment**
- **Hall Reactor Overview**
- **Typical Data**

Biological Remediation

- **The basic principle of nitrate and perchlorate removal by biology:**
  - **Remove the oxygen**
  - **Add nutrients (hydrogen donor)**
  - **Let nature reduce the nitrate to nitrogen gas and water, and perchlorate to chlorides and oxygen**

$$NO_3^- + H^+ \rightarrow N_2 + H_2O$$

$$ClO_4^- + H^+ \rightarrow Cl^- + O_2 + H_2O$$

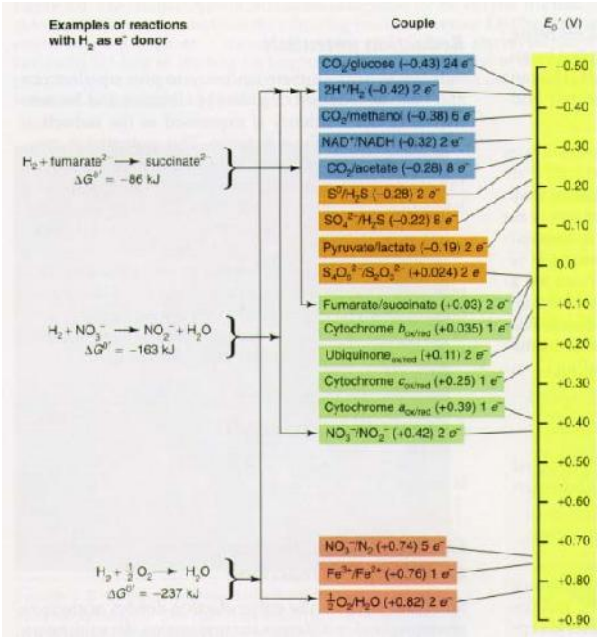
- **After biological treatment, the water must go through post filtration and disinfection – like surface water**
- **The water is also re-oxygenated with an aerator.**
- **This is the way nature has cleaned the earth for millennia**
- **Biological Reduction can also be used for chrome VI, selenium and other metals.**

Why do bacteria degrade anions? → Energy

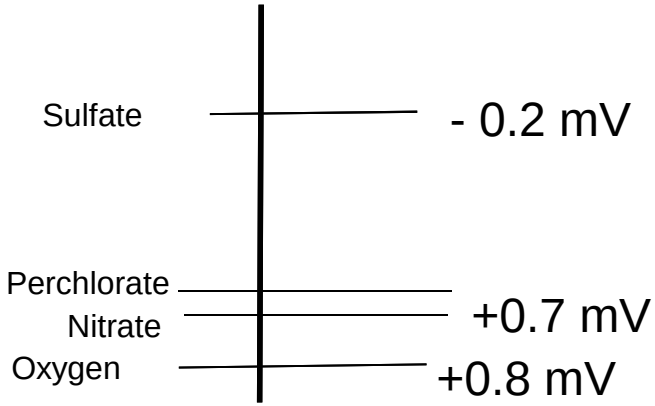
- **Redox Potential (E_h)**
- **Redox potential is the tendency for a reaction, specifically the movement and transfer of electrons, to occur spontaneously and is reported as E_h in mV.**
- **Reactions with a higher redox potential yield more net energy for the organism performing them, and this results in higher growth rates (in terms of population).**

Electron Tower

- **Microbes will successively use the highest energy yielding electron acceptors available in the order indicated on the electron tower, which is a ranking of common redox reactions by the amount of energy that can be obtained from them.**
- **O_2, the lowest oxidizing agent on the tower, yields the most energy when reduced in a redox reaction with a specific electron donor and will be the first electron acceptor depleted when commonly available.**
- **When oxygen in the system is unavailable, it will begin using other available electron acceptors which provide the next highest amount of energy. Overall, this process of succession will continue as each electron acceptor supply is used.**



Energy E_h



Succession of Electron Acceptors

The main succession of electron acceptor :

- Aerobic respiration: ½ O_2 + $2e^-$ + $2H^+$ -> H_2O
- Denitrification: $2NO_3^-$ + 12 H^+ +$10e^-$ -> N_2+ $6H_2O$
- Perchlorate reduction: ClO_4^- + $8H^+$ + $8e^-$ -> O_2 + Cl^- + 4 H_2O
- Sulfate reduction: SO_4^{2-} + $10H^+$ +$8e^-$ -> H_2S + $4H_2O$

Major Types of Biological Treatment

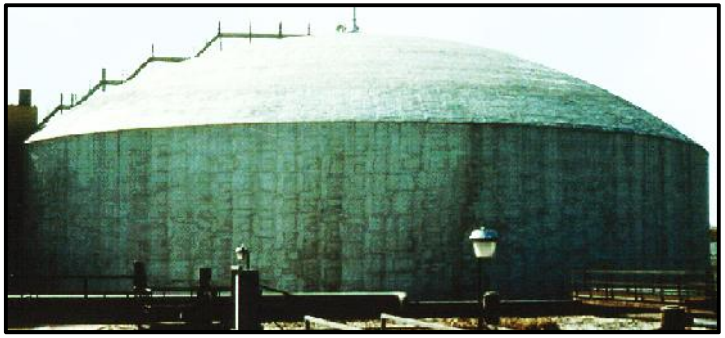
- **Aerobic:**
  - **Process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth. CO2 is an off gas of this type of treatment.**
- **Anaerobic:**
  - **Here, the bacteria species do not require free oxygen. They convert the organics to methane gas (main carbon conversion), CO2 gas, N2 gas, and some trace others like Sulfur.**
- **Anoxic:**
  - **Denitrification is the removal of nitrogen, in the form of nitrates, by its conversion to nitrogen gas. In a situation lacking oxygen, bacteria will shift to using nitrogenous compounds as an oxygen source. It occurs where oxygen, a more energetically favorable electron acceptor, is depleted, and bacteria respire nitrate as a substitute terminal electron acceptor. small amounts of methanol, acetate, glycerin, or proprietary products are added to the wastewater to provide a carbon source for the denitrification bacteria.**

Aerobic Types of Technologies

- **Activated Sludge:**
  - **Complete Mixed**
  - **Plug Flow**
  - **Sequencing Batch Reactor (SBR)**
  - **Rotating Biological Clarifier (RBC)**
  - **Moving Bed Biological Reactor (MBBR)**
  - **Membrane Bioreactor (MBR)**

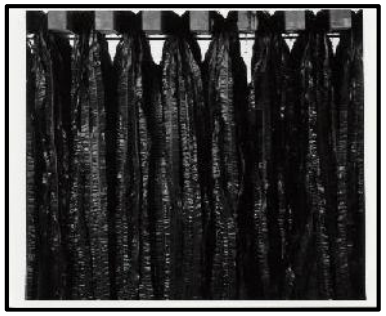
Anaerobic Types of Technologies

- **Upflow Anaerobic Sludge Blanket (UASB)**
- **Anaerobic Contact Process (AnCP)**
- **Continuously Stirred Tank Reactor (CSTR)**
- **Lagoon**



Fixed Film Biological Systems

- **Use a porous medium which provides a bed to support the biomass film that digests the waste material in the wastewater.**
- **The media can be:**
  - **Structured Plastic**
  - **Carbon**
  - **Sand**
  - **Stationary Webs**
  - **Rotating Discs**



Why Fixed Film?

- **Fixed Films Bioreactor Provides:**
  - **More robust process**
  - **Recovery from upsets more quickly**
  - **More flexible in operation**
  - **Lower formation extracellular polymeric substances (EPS) than floc forming bacteria**
  - **Higher active fraction of biomass resulting in a smaller footprint**
  - **Simpler system**

Fixed Film Energy Needs and Operational Interests

- **Different growth substrates →**
  - **Different energy requirements**
  - **Mixing requirements**
  - **Heavy dense dispersed medias require significantly more energy than lighter weight materials.**

Electron Donor

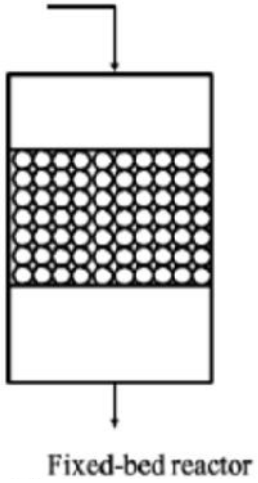
- **C / N ratio: For 100 mg/L NO_3, 1 – 4 mg/L carbon**
- **Very low carbon requirements yields low sludge production.**
- **When forced low concentrations of carbon are used, the generation of very little excess biomass is seen. However, you must observe the nitrite levels. This is one method of carbon addition optimization.**
- **Electron donor usage makes up about 50% of the operating costs. Important to optimize**

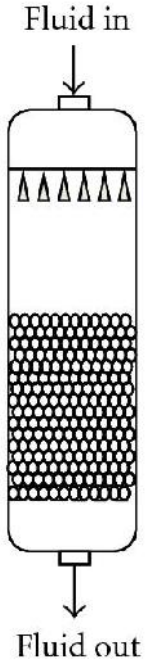
Carbon Sources

- **Carbon Sources:**
  - **Acetic Acid**
  - **Glycerin**
  - **Glucose**
  - **Molasses**
  - **Acetate**
  - **Methanol**
  - **Ethanol**

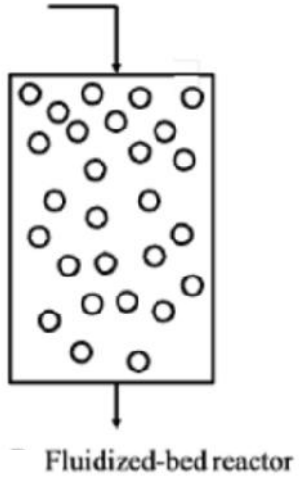
- **Alcohols of Methanol and Ethanol provide the best "bang for the buck" as the bacterial utilization is far more complete and efficient when compared to the other carbon sources.**

Biological Reactor Technologies – Fixed Bed

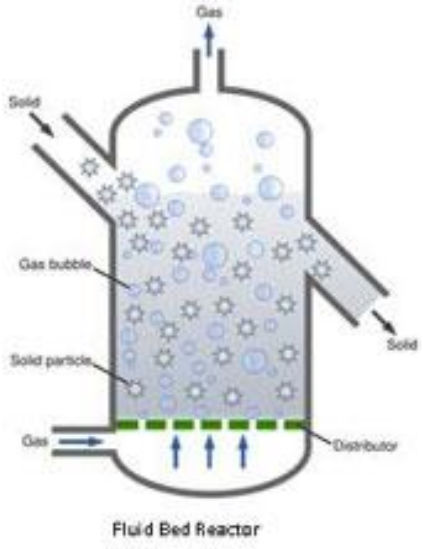




Biological Reactor Technologies – Fluidized Bed

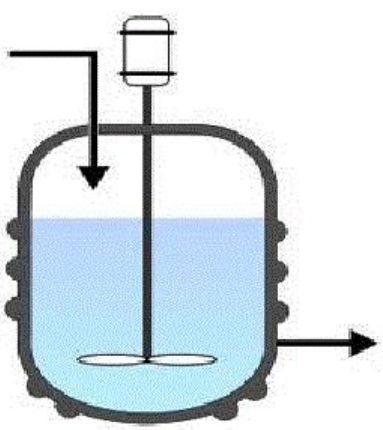


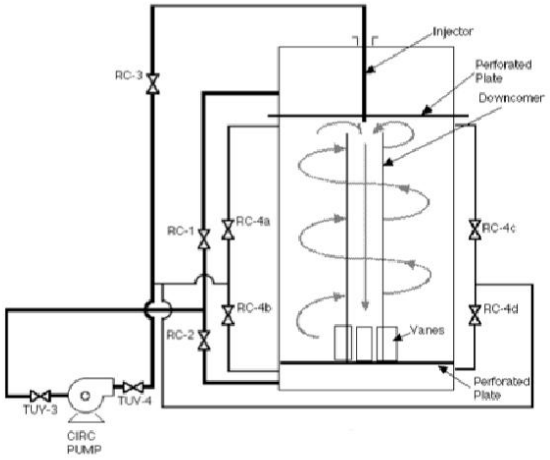
Fluidized-bed reactor



Fluid Bed Reactor

Biological Reactor Technologies – Continuously Stirred Tank Reactor





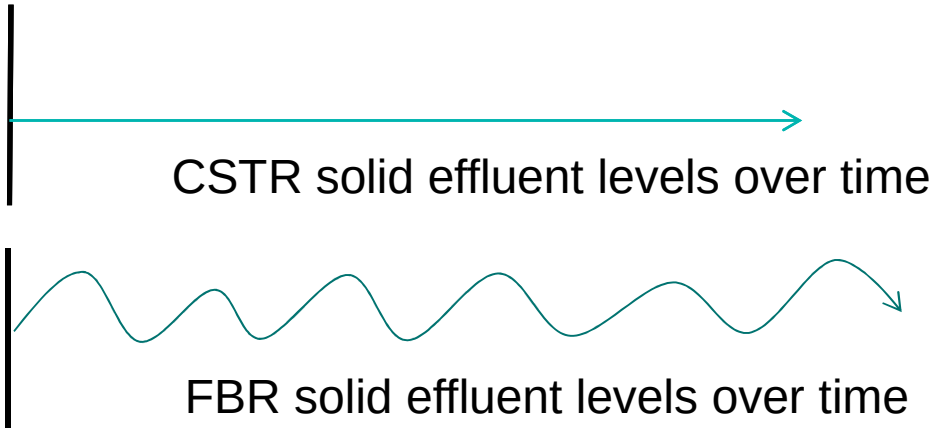
Comparison of Biological Technologies

Parameter	Fixed Bed	Fluidized Bed (FBR)	CSTR
Odor	Yes	Yes	No
Liquid Waste	10%	10%	<1%
E- Donor	2-3 x stoichiometric ratio	2-3 x stoichiometric ratio	1.1 x stoichiometric ratio
Reactor max flow	300 gpm for 10 ft diameter tank	1000 gpm for 18' diameter tank	1500 gpm for 12 ft diameter tank
Solid Waste	High	High	Very low
Toxic bacteria	Present	Present	Absent
Minimum perchlorate achievable	ND	1 ppb	ND
Continuous cleaning	No	Yes	Yes
Waste Stream from biological reactor	Yes	No	No
Flexibility of operation	Response can be delayed, slugs of material with no warning, stagnant and still during downtime so startup can be slow	Similar to CSTR, but slugs of solids are still an issue, especially with changes in flow rate, need to startup very slowly after downtime. Enough energy to fluidize bed, but not displace or slough bacteria	Very flexible, quick startup after shutdown for both short and long term because of recycle abilities.

Comparison of Biological Technologies

Parameter	Fixed Bed	Fluidized Bed (FBR)	CSTR
Odor	Yes	Yes	No
Liquid Waste	10%	10%	<1%
E- Donor	2-3 x stoichiometric ratio	2-3 x stoichiometric ratio	1.1 x stoichiometric ratio
Reactor max flow	300 gpm for 10 ft diameter tank	1000 gpm for 18' diameter tank	1500 gpm for 12 ft diameter tank
Solid Waste	High	High	Very low
Toxic bacteria	Present	Present	Absent
Minimum perchlorate achievable	ND	1 ppb	ND
Continuous cleaning	No	Yes	Yes
Waste Stream from biological reactor	Yes	No	No
Flexibility of operation	Response can be delayed, slugs of material with no warning, stagnant and still during downtime so startup can be slow	Similar to CSTR, but slugs of solids are still an issue, especially with changes in flow rate, need to startup very slowly after downtime. Enough energy to fluidize bed, but not displace or slough bacteria	Very flexible, quick startup after shutdown for both short and long term because of recycle abilities.

Solids from effluent of bioreactor



- **Get bigger slugs with hydraulic changes**
- **Solid loading has an effect on the disinfection system at the end of the system**

Solids handling for High Solids Systems – Additional Capital

- **Sometimes Dissolved Air Floatation Required (DAF)**

- **Sometimes Filter Press Required**

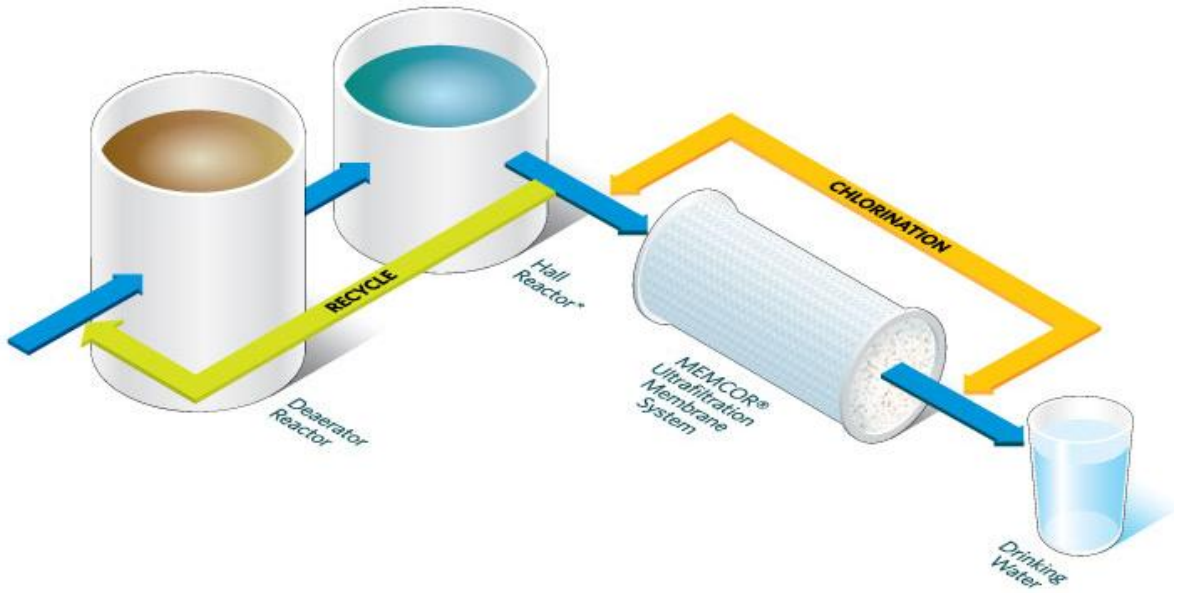
Solids off the bioreactor on Continuously Stirred System

Sample pulled off the bioreactor before filtration

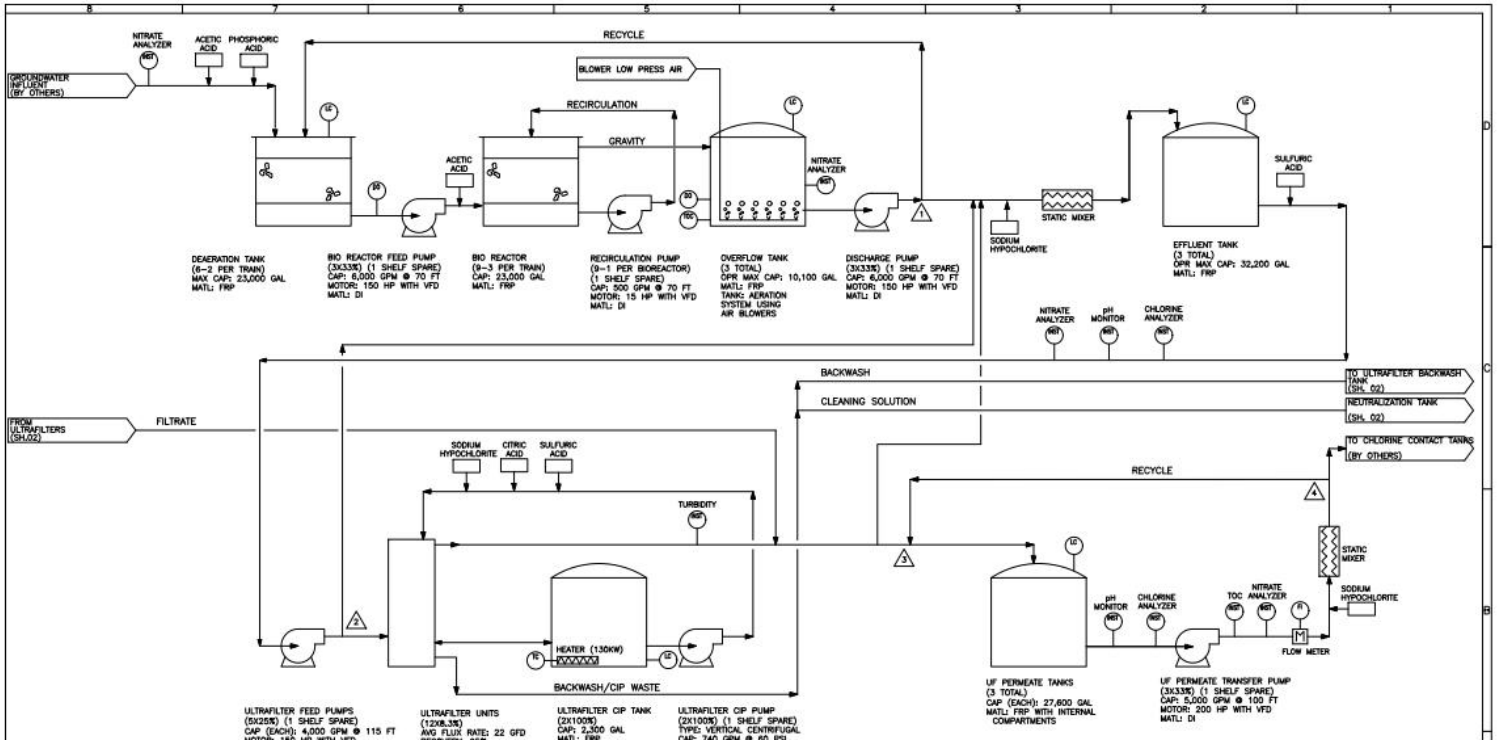
Nitrate Reduction System

- **Why consider Biological Treatment?**
- **Overview of Biological Treatment**
- **Hall Reactor Overview**
- **Typical Data**

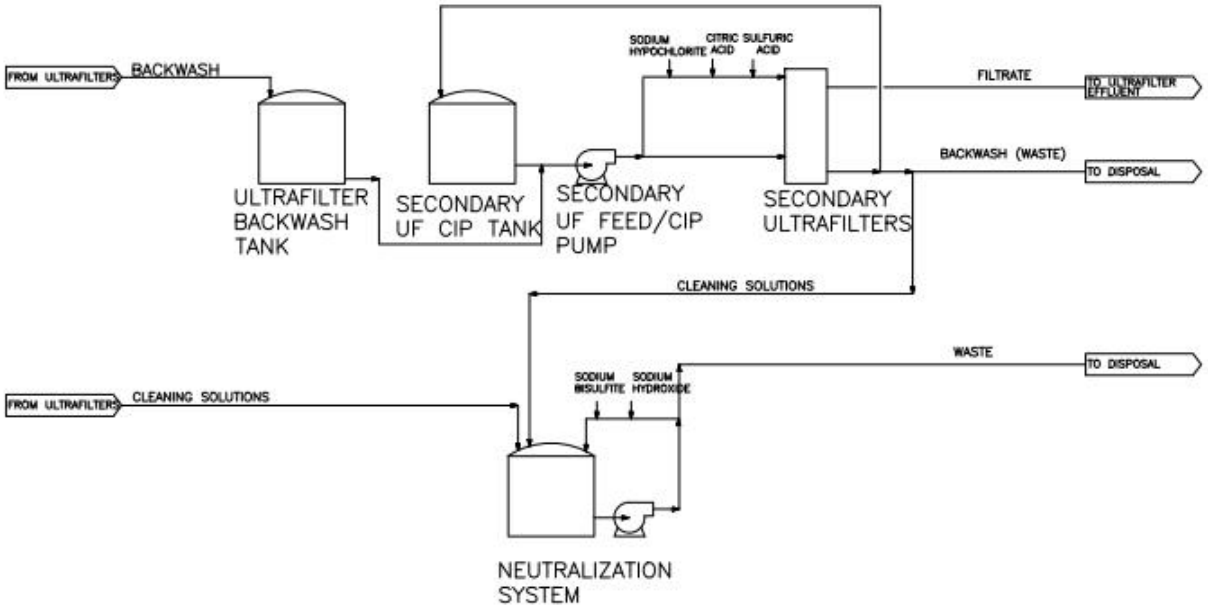
Evoqua Nitrate System Overview



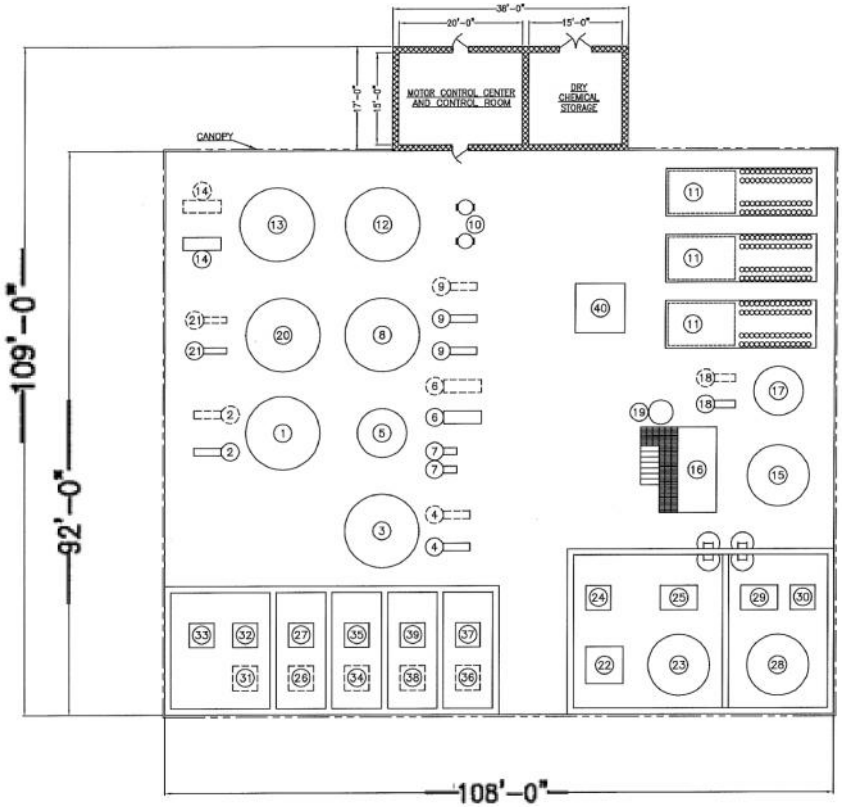
Process Flow Diagram for One Train – page 1



Process Flow Diagram for One Train – page 2



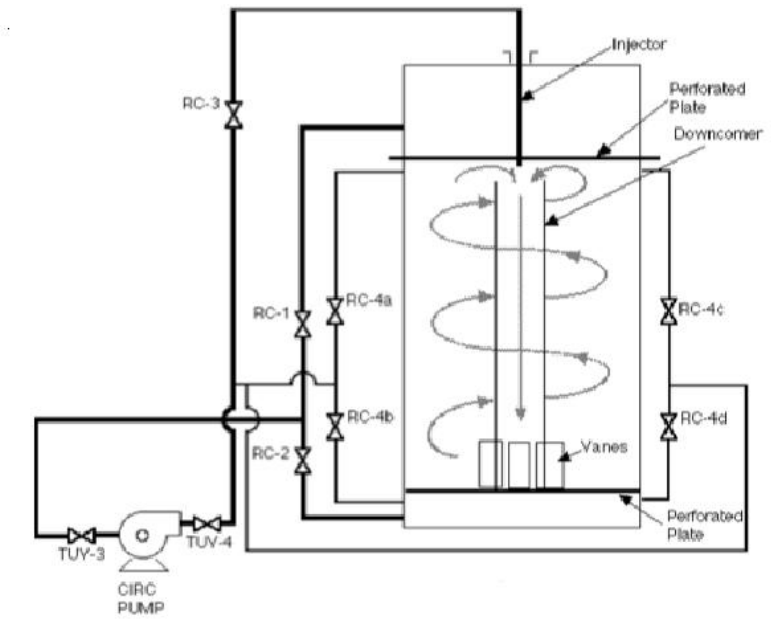
Hall Reactor Layout – 1000 gpm system



~ 13,000 sq ft

Hall Reactor Diagram

- **Circulation driven by a pump and injection**
- **Note circulation pattern**
- **Carrier in circulation**
- **Bacteria in and on carrier**
- **Continuous cleaning of carrier**
- **CSTR prevents rapid changes in reactor conditions**
- **Maximum concentration of active bacteria in reactor**



Carrier

- **Carrier is a polyurethane material that becomes the foundation for the bacteria to grow on**
- **The crouton like material circulates in the Hall Reactor and is unique to the system**
- **The combination of high concentration of bacteria in a CSTR is the key to system efficiency**

Hall Reactor: Continuously Stirred Tank Reactor (CSTR)

What is a CSTR?

- No gradient in concentration, uniform concentration
- Ratio of flow to volume greater than 15
- No rapid change in concentration in system

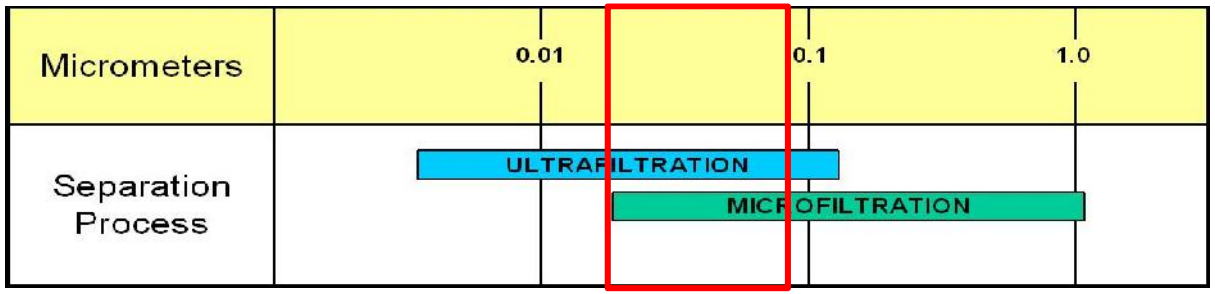
Effects of a CSTR

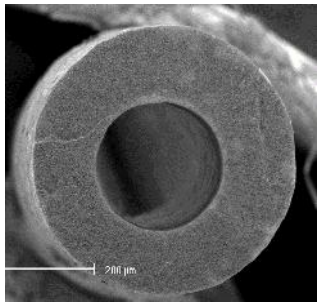
- Continuous flow of bio-solids out of system
- No bio-solids upsets downstream
- Less upsets for bacteria
- More active bacteria
- Efficient use of electron donor
- No sulfide reduction with positive ORP
- No sulfide production under upset conditions

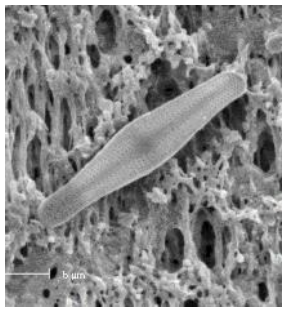
Result – Most Efficient Bio System Available

Post Filtration: Memcor® Ultrafiltration – provides >4 log physical barrier for removal of bacteria

Most PVDF membranes bridge the “Ultrafiltration” and “Microfiltration” categories with pore size ~0.04 micron

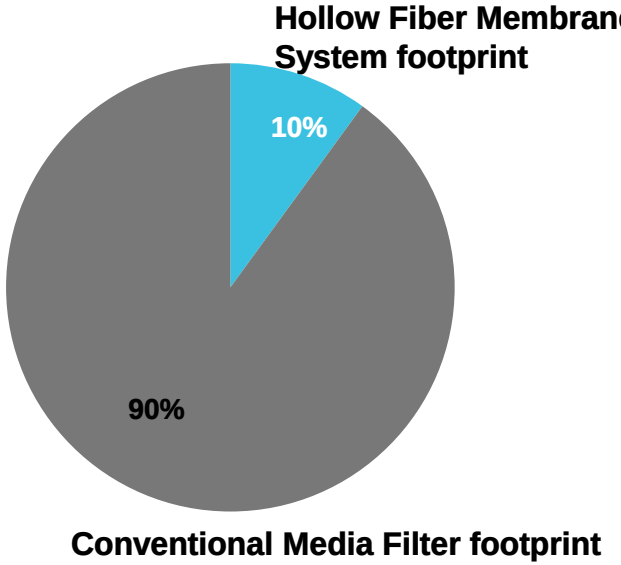




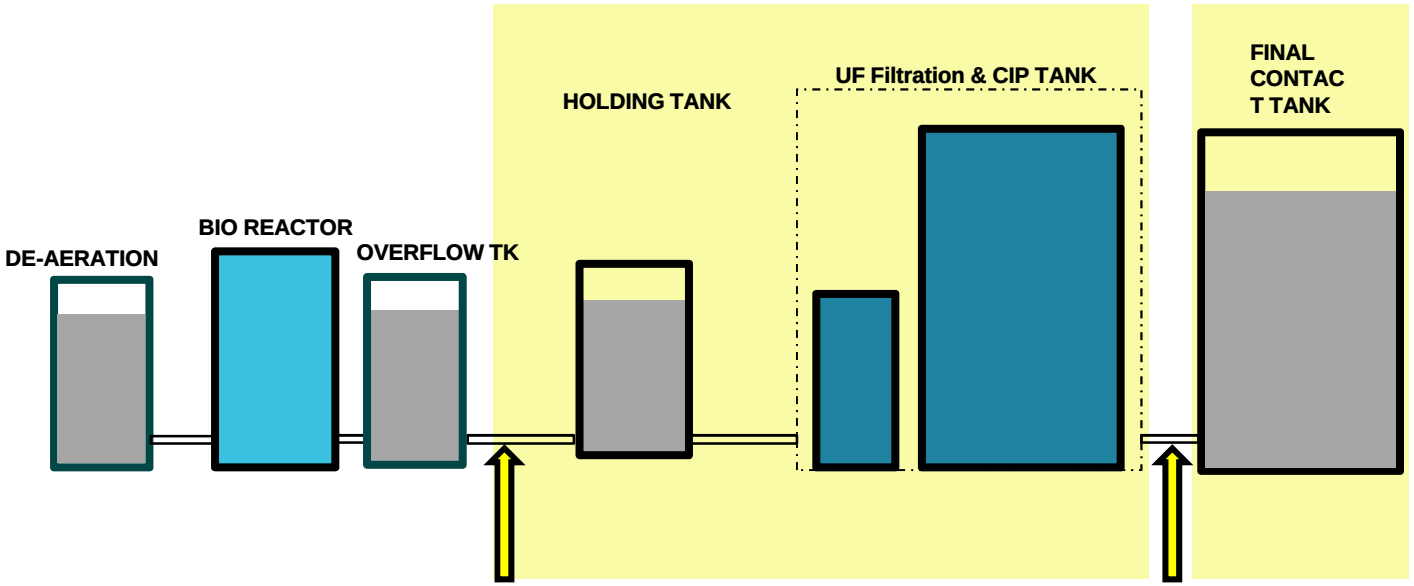


Influenza Virus
0.1 microns

Membrane Systems enables overall plant system footprint savings when compared to media filters



Disinfection



1) **Chlorination to prevent fouling**

2) **Chlorination for inactivation credits**

Pilot Unit on WVWD Well 39

- **Mobile unit able to treat up to 10 gpm**
- **Flexible in power needs from 3 phase 480v to single phase 220v**
- **System as viewed used to obtain DDW Conditional Approval**

Inside Pilot Unit

- **Circulation in the reactor**
- **Controls on desktop**
- **No odor in small space**
- **Room for field testing equipment**

Inside Trailer

- **Deaeration tank**
- **Reactor**
- **Overflow tank**
- **Metering pumps**

Full Scale Remediation System

- **Full scale reactors (8 ft. Diameter) treating nitrate, perchlorate, hex chrome and selenium**
- **Two Hall Reactors shown**
- **Over 2 years of operation**
- **Hollister, CA**

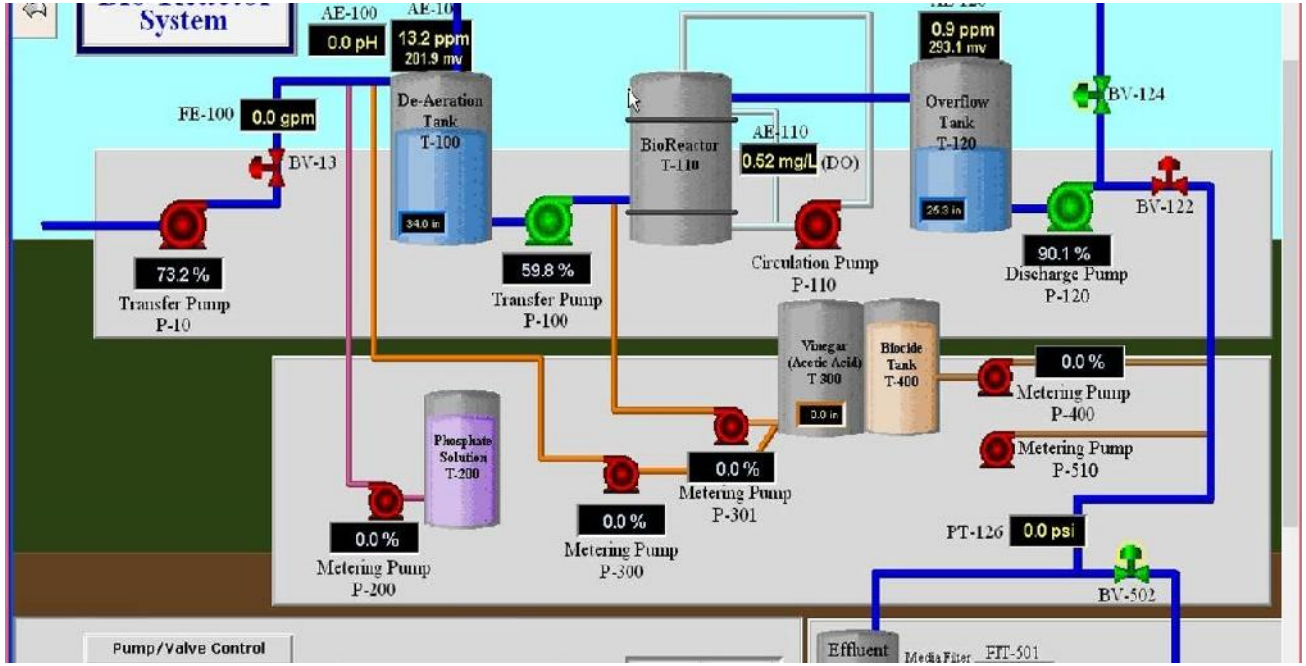
Contaminant	Influent	Effluent
Nitrate (ppm as nitrogen)	20	<1
Hex chrome (ppb)	25	<1
Perchlorate (ppb)	1000	<1
Selenium (ppb)	25	<4

Other Sites with Perchlorate and Nitrate Treatment

- **Full scale system at Edwards Air Force Base**
- **Pilot at City of Industry, CA**
- **Pilot in Henderson, NV**
- **Pilot at Well 22, West Valley Water District, Rialto, CA**
- **Able to treat perchlorate from ppm levels to non-detect**
- **Pilot at San Antonio Water Company Well 31, Upland, CA**
- **Pilot in Sacramento, CA non-potable**

Typical Alarms on System

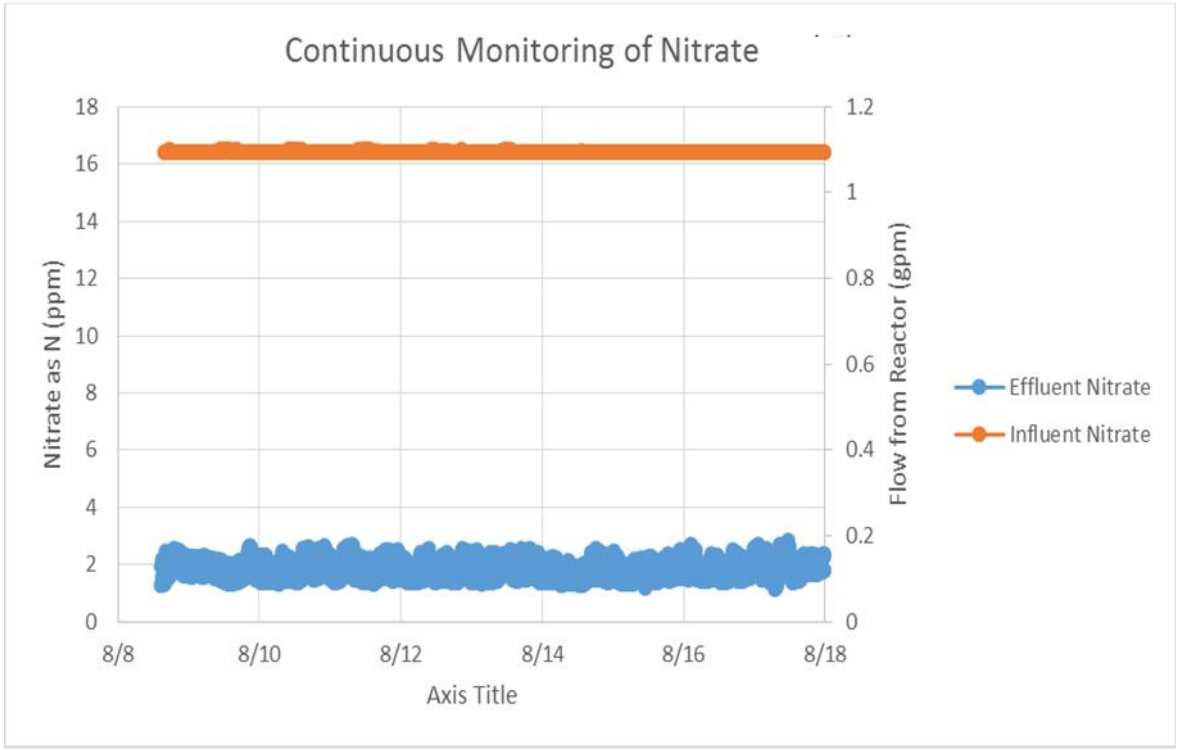
- **Nitrate**
- **Turbidity**
- **DO**
- **pH**
- **Flow**
- **Metering Pumps**
- **Spill**



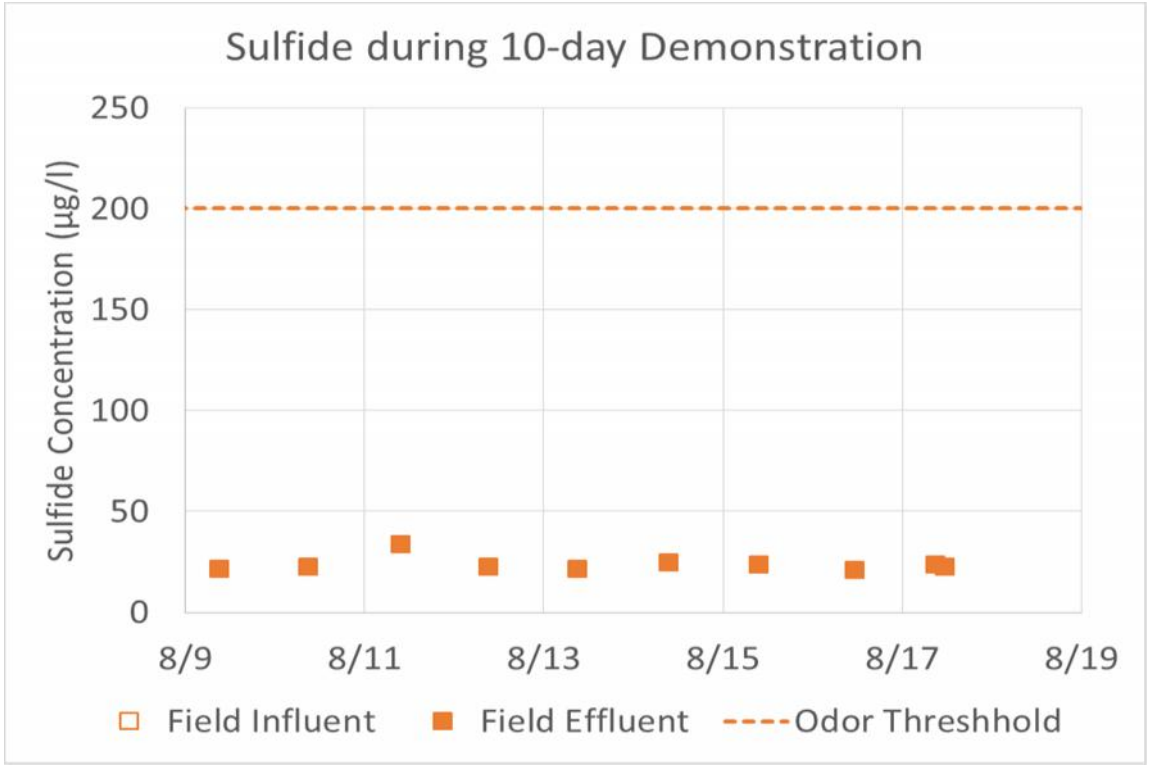
Nitrate Reduction System

- **Why consider Biological Treatment?**
- **Overview of Biological Treatment**
- **Hall Reactor Overview**
- **Typical Data**

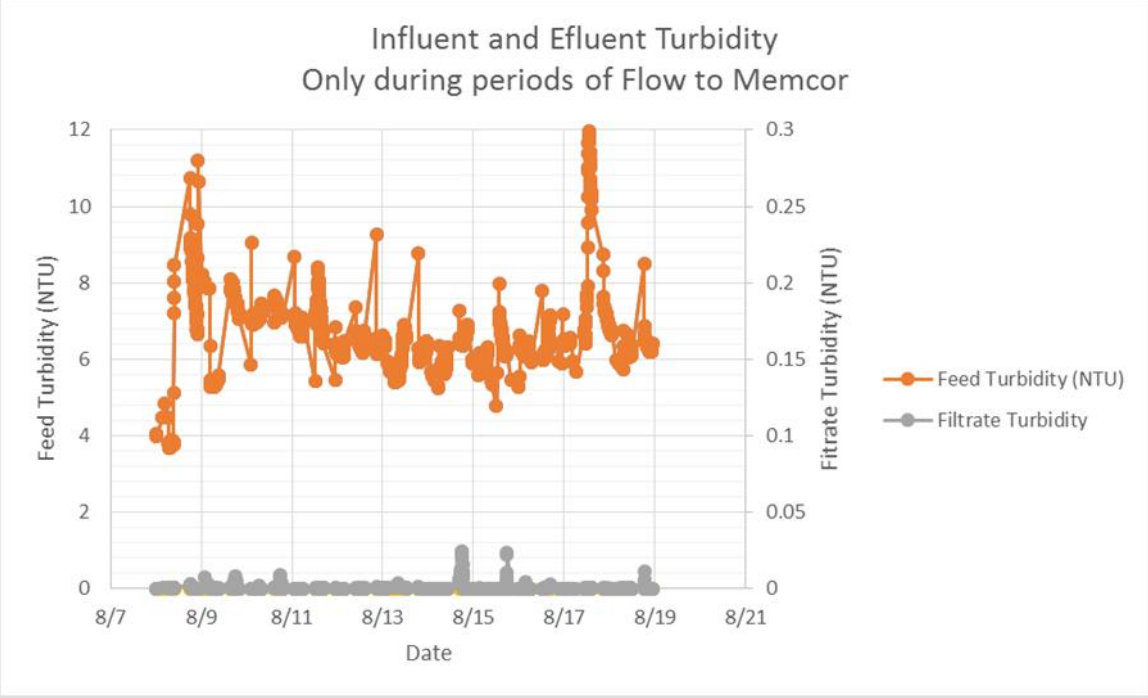
Typical Operating Data



Typical Operating Data

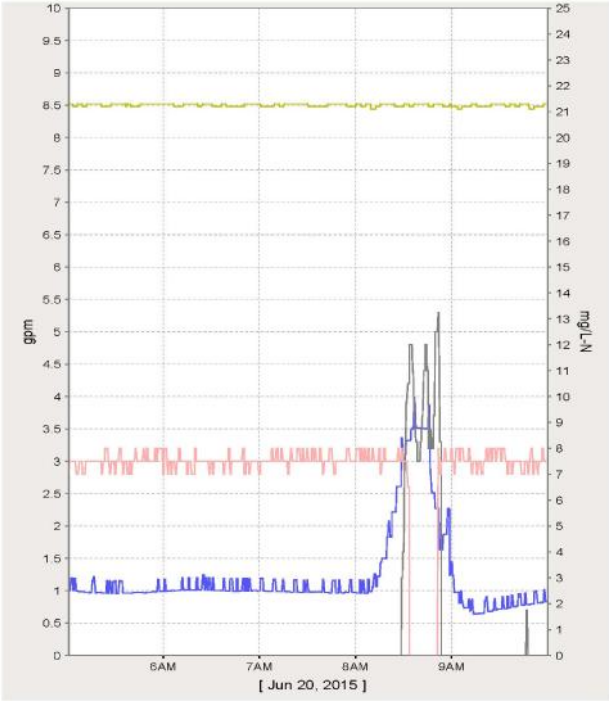


Typical Operating Data



Typical Operating Data

Electron Donor Shut off and Re-Start



Blue – Effluent Nitrate (mg/l-N)
Red – System Flow (gpm)
Yellow – Influent Nitrate (mg/l-N)

Typical Operating Data

Date Sampled	Sample Position	TOC (ppm)	Test Source
06/10/15	Post Overflow Tank (post Bioreactor w Air)	3.5 (avg)	Online TOC
06/11/15	Post Overflow Tank (post Bioreactor w Air)	3.2 (avg)	Online TOC
06/12/15	Post Overflow Tank (post Bioreactor w Air)	5.1 (avg)	Online TOC
06/16/15	Post Overflow Tank (post Bioreactor w Air)	6.0 (avg)	Online TOC
06/17/15	Post Overflow Tank (post Bioreactor w Air)	6.1	Online TOC
06/18/15	Post Overflow Tank (post Bioreactor w Air)	11.6	Online TOC
06/20/15	Influent (well)	ND	Outside Lab
06/20/15	Post Overflow Tank (post Bioreactor w Air)	3.6	Outside Lab

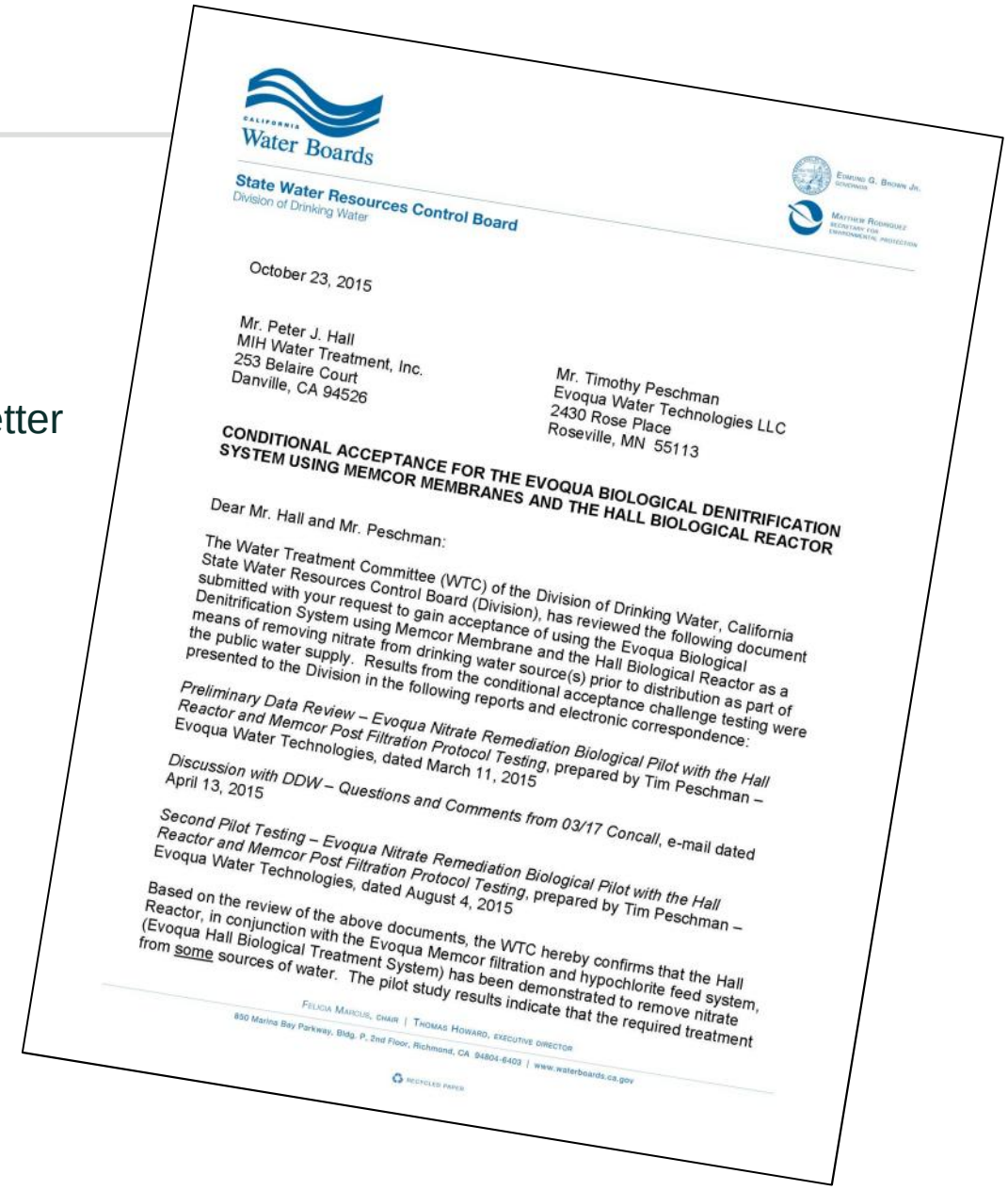
Table 4 – TOC Continuous and Third Party Testing

Disinfection By-Product Analysis in Piloting

Analyte	Post Chlorine Retention Tank
Total Trihalomethanes (ug/l)	17
Bromodichloromethane (ug/l)	4.1
Bromoform (ug/l)	3.4
Chloroform (ug/l)	4.7
Dibromochloromethane (ug/l)	5.1
Haloacetics (HAA5) (ug/l)	8.5
Monochloracetic Acid (ug/l)	ND
Dichloroacetic Acid (ug/l)	3
Trichloroacetic Acid (ug/l)	2.6
Monobromoacetic Acid (ug/l)	ND
Dibromoacetic Acid (ug/l)	2.7

Discussion of Disinfection By-Products (DBPs) During System Piloting - Total trihalomethanes (TTHMs) and haloacetic acids (HAA5) were analyzed by Babcock Labs during the piloting operation.

Conditional Approval Letter



California Water Boards

State Water Resources Control Board
Division of Drinking Water

October 23, 2015

Mr. Peter J. Hall
MIH Water Treatment, Inc.
253 Belaire Court
Danville, CA 94526

Mr. Timothy Peschman
Evoqua Water Technologies LLC
2430 Rose Place
Roseville, MN 55113

CONDITIONAL ACCEPTANCE FOR THE EVOQUA BIOLOGICAL DENITRIFICATION SYSTEM USING MEMCOR MEMBRANES AND THE HALL BIOLOGICAL REACTOR

Dear Mr. Hall and Mr. Peschman:

The Water Treatment Committee (WTC) of the Division of Drinking Water, California State Water Resources Control Board (Division), has reviewed the following document submitted with your request to gain acceptance of using the Evoqua Biological Denitrification System using Memcor Membrane and the Hall Biological Reactor as a means of removing nitrate from drinking water source(s) prior to distribution as part of the public water supply. Results from the conditional acceptance challenge testing were presented to the Division in the following reports and electronic correspondence:

Preliminary Data Review – Evoqua Nitrate Remediation Biological Pilot with the Hall Reactor and Memcor Post Filtration Protocol Testing, prepared by Tim Peschman – Evoqua Water Technologies, dated March 11, 2015

Discussion with DDW – Questions and Comments from 03/17 Concall, e-mail dated April 13, 2015

Second Pilot Testing – Evoqua Nitrate Remediation Biological Pilot with the Hall Reactor and Memcor Post Filtration Protocol Testing, prepared by Tim Peschman – Evoqua Water Technologies, dated August 4, 2015

Based on the review of the above documents, the WTC hereby confirms that the Hall Reactor, in conjunction with the Evoqua Memcor filtration and hypochlorite feed system, (Evoqua Hall Biological Treatment System) has been demonstrated to remove nitrate from some sources of water. The pilot study results indicate that the required treatment

Felicia Marcus, Chair | Thomas Howard, Executive Director

850 Marina Bay Parkway, Bldg. P, 2nd Floor, Richmond, CA 94804-6403 | www.waterboards.ca.gov

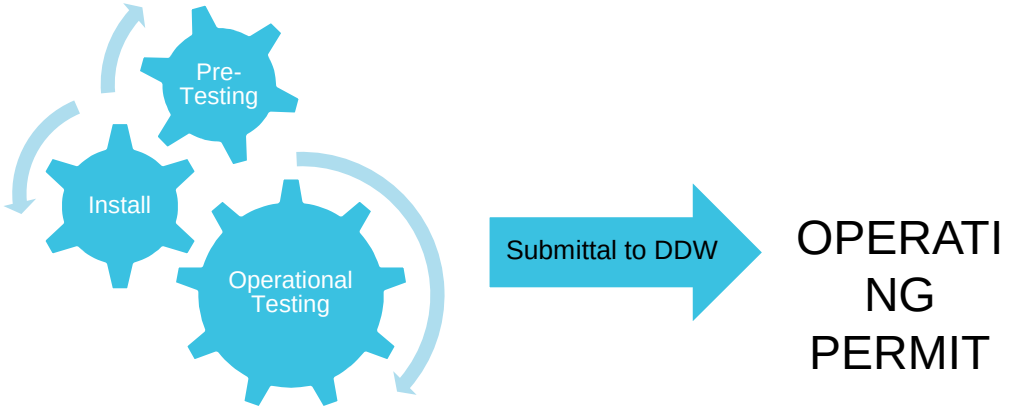
Recycled Paper

Onsite Piloting for O&M Development

- **Prior to sale of equipment, DDW requires piloting on the water to be treated for nitrates to show the following:**
  - **Continuous operation (10 days) showing effluent nitrate compliance**
  - **Development of O&M costs for full scale system operation**
  - **Determination if any other changes/additions to system need to be made to maintain compliance – electron donor changes, instrumentation, etc.**
  - **Write-up/summary of piloting for submittal to client and DDW**

Post Installation – Operation Performance Evaluation

- **Equipment has been purchased and installed**
- **System has gone through a "shake down" and is ready for a test operation**
  - **DDW requires 14 day continuous operation of system with analytical collection and conformance to "Critical Outcomes"**
  - **Complete report of operational data collection, observations, and request for Operating Permit to put unit into service**



THANK YOU FOR
YOUR ATTENTION

Cathy Swanson (562) 217-0419
Catherine.e.swanson@Evoqua.com

Kelsey Hakes (562) 209-2169
kelsey.hakes@evoqua.com

www.Evoqua.com

WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

2017 Safe Drinking Water Workshop

November 7, 2017 – 9:00 a.m. to 3:00 p.m.

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If you make a decision without evaluating **all of the data** first, you might look like Steve Martin in the movie “Jerk”, which can be **very dangerous**

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Well and Pump Rehabs, BACT and Other Common Well Issues

- **Why does chlorine rarely solve your bacteria issues with wells?**
- **Learn how to effectively clean your well.**
- **Water flush turbine pumps are your best choice for water well pumps.**
- **Water Flush vs. Water Lube – Learn about why water flush pumps are the better option when you are replacing an oil lube pump.**

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NSF ???

“Raw water is natural water found in the environment, such as rain water, groundwater, and water from bodies like lakes and rivers.”

Wikipedia

“Raw water becomes drinking water when it meets drinking water standards.”

“Groundwater is tested and treated as needed before it is approved to become drinking water.”

“At this point, NSF rules apply”

Michael Bodart

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measurements of the groundwater level during peak rainfall periods; extraction wells shall not be used to influence the highest anticipated groundwater level;

(E) Provided with a minimum of two groundwater level monitoring wells drilled to a depth at least 20 feet below the reservoir bottom and sited within 100 feet and on opposite sides (upgradient and downgradient) of the reservoir; and

(F) If the roof is to be buried and have a function (e.g., recreation, landscape, parking) in addition to covering the reservoir:

1. Designed and constructed pursuant to AWWA D110-04 (Wire- Strand-Wound, Circular, Prestressed Concrete Water Tanks), which is hereby incorporated by reference;

2. Equipped with an impervious connection, such as a pvc waterstop, between the wall and buried roof; and

3. Watertight, sloped for drainage and coated with a damp proofing material.

Article 7. Additives

§64590. Direct Additives.

No chemical or product shall be added to drinking water by a water supplier unless the chemical or product is certified as meeting the specifications of NSF International/American National Standard Institute (NSF/ANSI) 60-2005 (Drinking Water Treatment Chemicals—Health Effects), which is hereby incorporated by reference. Certification shall be from an ANSI accredited product certification organization whose certification system includes, as a minimum, the following criteria for ensuring the chemical or product meets NSF/ANSI Standard 60.

(a) Annual product testing,

(b) Annual facility inspections,

(c) Annual quality assurance and quality control review,

(d) Annual manufacturing practice reviews, and

(e) Annual chemical stock inspections.

§64591. Indirect Additives.

(a) Except as provided in Section 64593 or where a more stringent statutory requirement exists, after March 9, 2008, a water system shall not use any chemical, material, lubricant, or product in the production, treatment or distribution of drinking water that will result in its contact with the drinking water including process media (carbon, sand), protective materials (coatings, linings, liners), joining and sealing materials (solvent cements, welding materials, gaskets, lubricating oils), pipes and related products (pipes, tanks, fittings), and mechanical devices used in treatment/transmission/distribution systems (valves, chlorinators, separation membranes)

NOTE: This publication is meant to be an aid to the staff of the State Board's Division of Drinking Water and cannot be relied upon by the regulated community as the State of California's representation of the law. The published codes are the only official representation of the law. Refer to the published codes—in this case, 17 CCR and 22 CCR—whenever specific citations are required. Statutes related to the State Board's drinking water-related activities are in the Health & Safety Code, the Water Code, and other codes.

Article3. Water Sources

§64560. New Well Siting, Construction, and Permit Application.

(a) To receive a new or amended domestic water supply permit for a proposed well, the water system shall provide the following information to the State Board in the technical report as part of its permit application:

(1) A source water assessment as defined in Section 63000.84 for the proposed site;

(2) Documentation demonstrating that a well site control zone with a 50-foot radius around the site can be established for protecting the source from vandalism, tampering, or other threats at the site by water system ownership, easement, zoning, lease, or an alternative approach approved by the State Board based on its potential effectiveness in providing protection of the source from contamination;

(3) Design plans and specifications for the well; and

(4) Documentation required for compliance with the California Environmental Quality Act (CEQA).

(b) After the State Board has provided written or oral approval of the initial permit amendment application and the water system has constructed the well, the water system shall submit the following additional materials for its permit application:

(1) A copy of the well construction permit if required by the county or local agency;

(2) Department of Water Resources well completion report;

(3) A copy of any pump tests required by the State Board;

(4) Results of all required water quality analyses; and

(5) As-built plans.

(c) Each new public water supply well shall:

(1) As a minimum, be constructed in accordance with the community water system well requirements in California Department of Water Resources Bulletins 74-81 and 74-90, which are hereby incorporated by reference;

(2) Be constructed in accordance with American Water Works Association (AWWA) Standard A100-06 (Water Wells), which is hereby incorporated by reference;

(3) Be installed such that:

(A) All equipment is accessible for operation, maintenance, and removal;

(B) Protection is provided against flooding;

(C) The wellhead terminates a minimum of 18 inches above the finished grade;

(D) Wellhead and electrical controls are not installed in vaults;

(E) The well is equipped with:

1. Fittings and electrical connections to enable chlorination facilities to be readily installed;

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2. A non-threaded down-turned sampling tap located on the discharge line between the wellhead and the check valve. Sampling taps used for obtaining samples for bacteriological analysis shall not have a screen, aerator, or other such appurtenance;

(F) Provisions are made to allow the well to be pumped to waste with a waste discharge line that is protected against backflow.

§64560.5. Well Destruction.
Destruction of a public drinking water supply well shall be in accordance with the California Department of Water Resources Bulletins 74-81 and 74-90.

§64561. Source Flow Meters.
Each water system shall:

(a) Except for inactive sources, install a flow meter at a location between each water source and the entry point to the distribution system;

(b) Meter the quantity of water flow from each source, and record the total monthly production each month.

Article 4. Materials and Installation of Water Mains and Appurtenances

§64570. Materials and Installation.

(a) All newly installed water mains shall comply with the materials and installation standards of the American Water Works Association pursuant to tables 64570-A and 64570-B. The standards are hereby incorporated by reference.

Table 64570-A
Materials Standards for Water Mains

Type of Material	*Diameter of Main*	*Applicable Standard*
PVC	4 in. through 12 in.	C900-97
PVC	14 in. through 48 in.	C905-97
Polyethylene (HDPE)	4 in. through 63 in.	C906-99
Fiberglass	All sizes	C950-01
Ductile Iron	All sizes	C150/A21.50-02
Ductile Iron, Centrifugally cast	All sizes	C151/A21.51-02
Steel	6 inches and larger	C200-97
Copper	All sizes	C800-05
Concrete		
Reinforced steel-cylinder	All sizes	C300-04
Prestressed steel-cylinder	All sizes	C301-99, C304-99
Reinforced noncylinder	All sizes	C302-04
Bar wrapped/steel cylinder	All sizes	C303-02
PVC, Molecularly oriented polyvinyl chloride	All sizes	C909-02

California-Nevada Section, AWWA and the Water Well Technology Committee
Present

Water Well Testing and Operations Workshop

Lakewood, California ■ July 30, 1997

AGENDA

Time	Topic	Speaker
7:30-8:30	Registration	
8:30-8:40	Opening Remarks	
8:40-10:00	Aquifer Testing:Step Drawdown and Constant Rate Tests, Test Specifications	Kevin McGillicuddy, Roscoe Moss
10:00-10:15	Break	
10-15-11:00	Selecting the Proper Pump	David Hines, Layne-Christensen
11:00-11:45	O & M Strategy and Procedures for Wells and Pumps	Brain Ragland, Long Beach Water Department
11:45-12:00	Questions and Answers	
12:00-1:00	Lunch	
1:00-1:45	Water Quality Standards-Testing Municipal Wells	Toby Roy, DOHS
1:45-2:30	Determining Pump and Well Efficiency	Tom Olson, Layne-Christensen
2:30-2:45	Break	
2:45-3:45	Utilizing Records for Efficient Pump Operation and Prescribing Rehabilitation - What is Needed for an Evaluation, Case Study	Mike Bodart, General Pump
3:45-4:00	Questions and Answers, Closing Remarks	

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Well Disinfection and Monitoring Policy

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Raw Water Monitoring

Raw well water samples should be considered "other" samples not routine distribution samples.

Initial Sampling: Monthly monitoring of the raw water.

After six months of negative results, the Department may reduce the monitoring to one sample per quarter.

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Any groundwater source which produces coliform bacteria shall be immediately removed from service.

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AWWA Standard C64-87
Disinfection of Wells

- Add chlorine to disinfect to 50 ppm.
- Surge the well three (3) times.
- Allow to rest in casing for 12-24 hours.
- Circulate water and pump to waste.
- After there is not residual, collect coliform samples.

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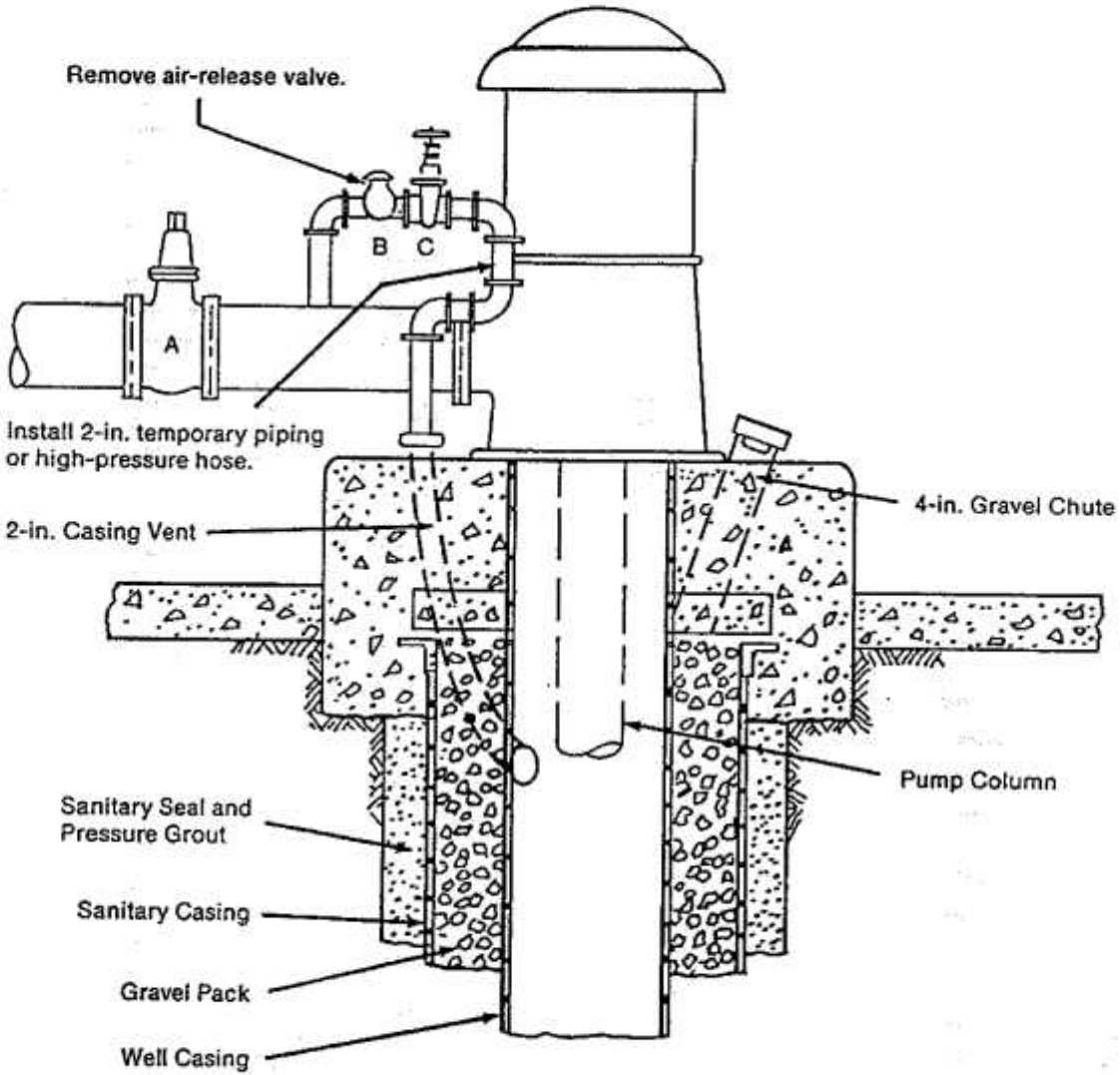
Circulating Chlorinated Water Inside Well Casing (AWWA: C654-87, Figure A.2)



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How to Resolve Coliform Issues in Water Wells

(Nuisance) Coliform Bacteria

Coliform could be the most frustrating and challenging issue that you might face with operating your well.

Coliform naturally live in the subsurface environment and can multiply quickly

When we pour our chlorine into the sounding tube and surge the pump per AWWA recommendations, the chlorine will magically seek out and find each of the bacteria throughout the well screens.

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“ We have had no bacteria issues with our well for over 10 years. After cleaning the well, our plate count went sky high and we got positive coliform samples.”

The Contractor must not have followed AWWA recommendations for well and pump disinfection.

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You could have gotten better results for under $5,000 and you spent $50,000.

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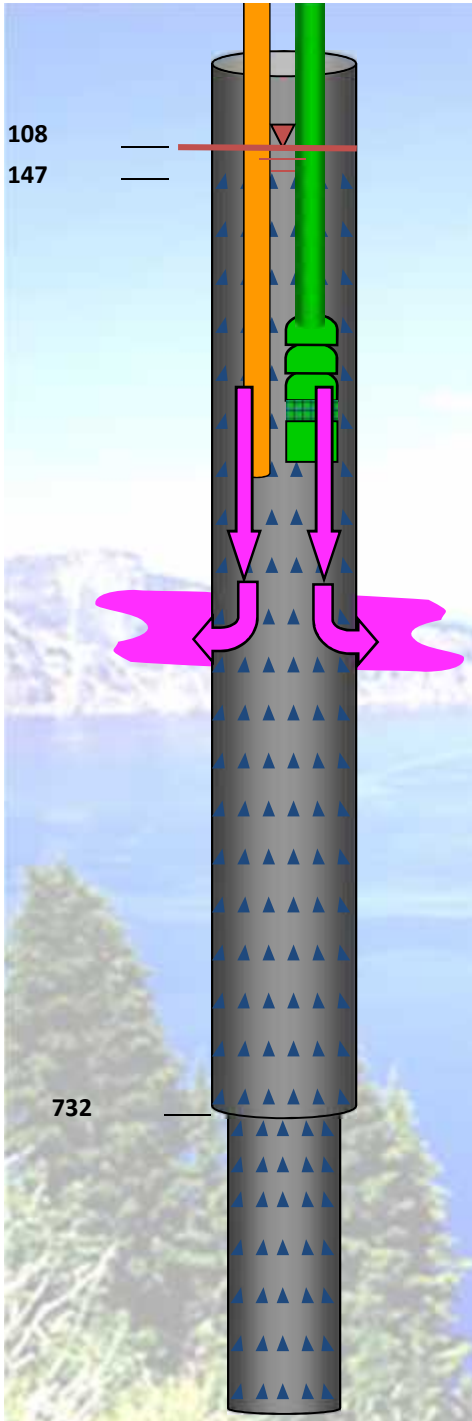

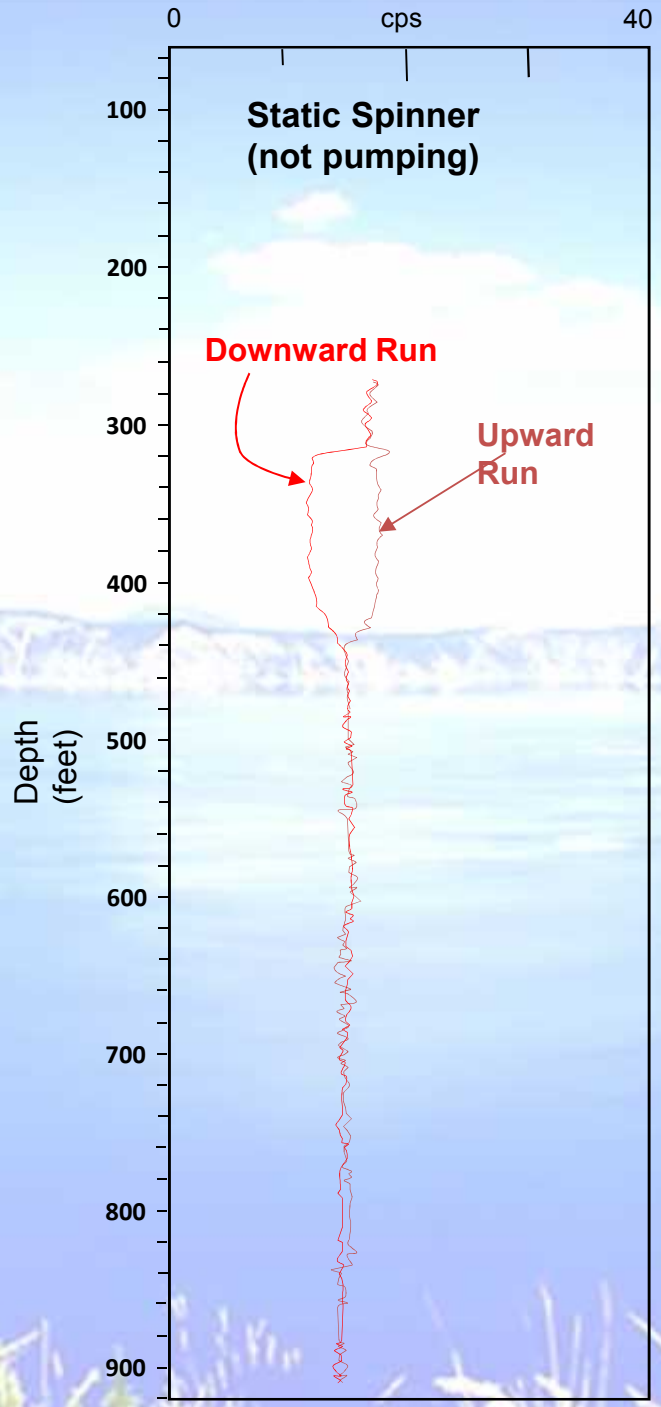

You chlorinated 40’ of your 750’ of perforated casing.

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1. Sandy material.

$K = 50$ ft/day

$dh/dl = 1$ ft/1000 ft

$n_e = 0.22$

$$v = \frac{K}{n_e} \times \frac{dh}{dl}$$

$$v = \frac{50 \text{ft}}{\text{day}} \times \frac{1}{0.22} \times \frac{1 \text{ ft}}{1000 \text{ ft}}$$

$v = 0.227$ ft/day

2. Clayey material.

$K = 0.00001$ ft/day

$dh/dl = 1$ ft/100 ft

$n_e = 0.02$

$$v = \frac{K}{n_e} \times \frac{dh}{dl}$$

$$v = \frac{0.00001 \text{ft}}{\text{day}} \times \frac{1}{0.02} \times \frac{1 \text{ ft}}{100 \text{ ft}}$$

$v = 0.000005$ ft/day

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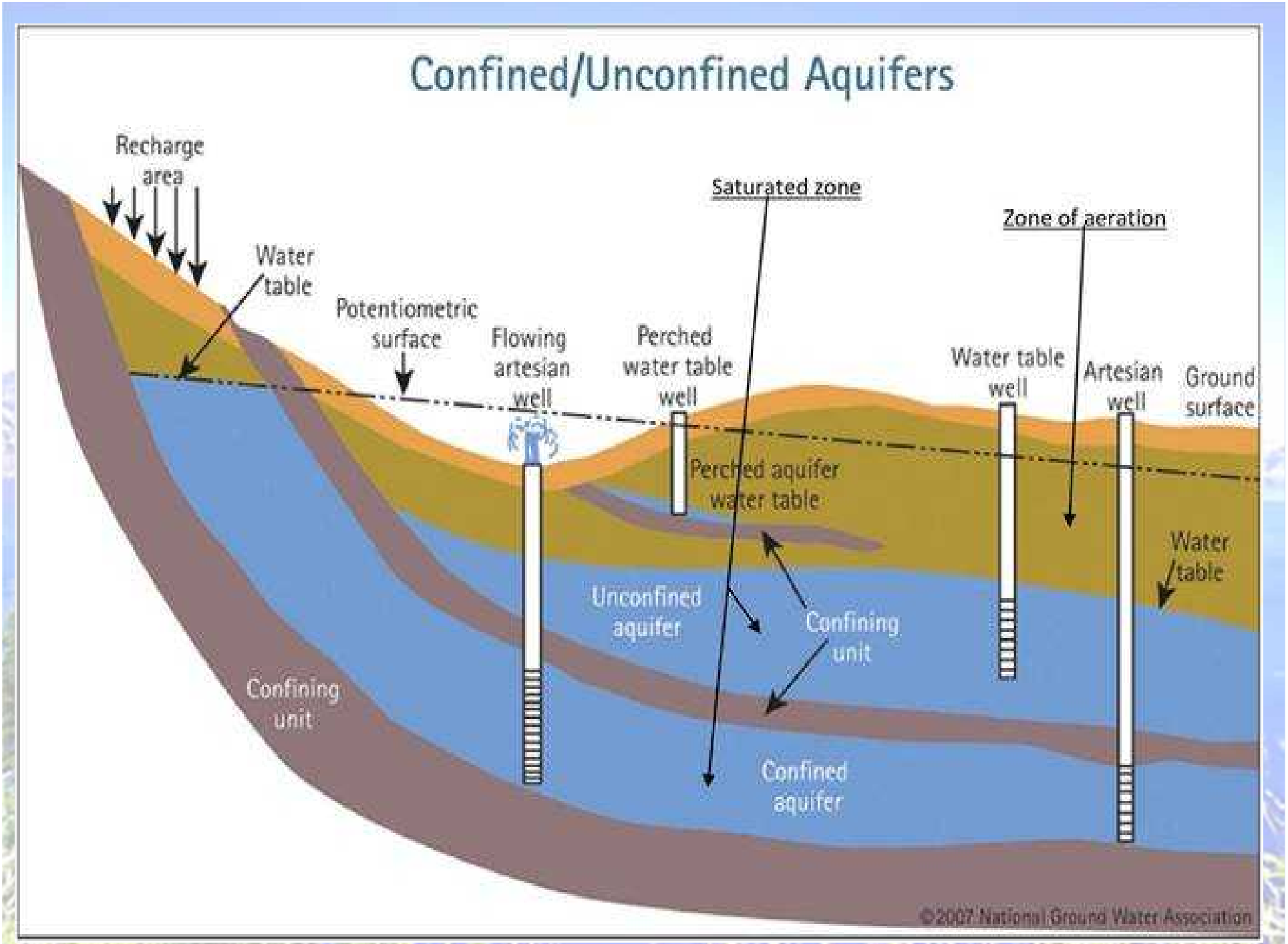
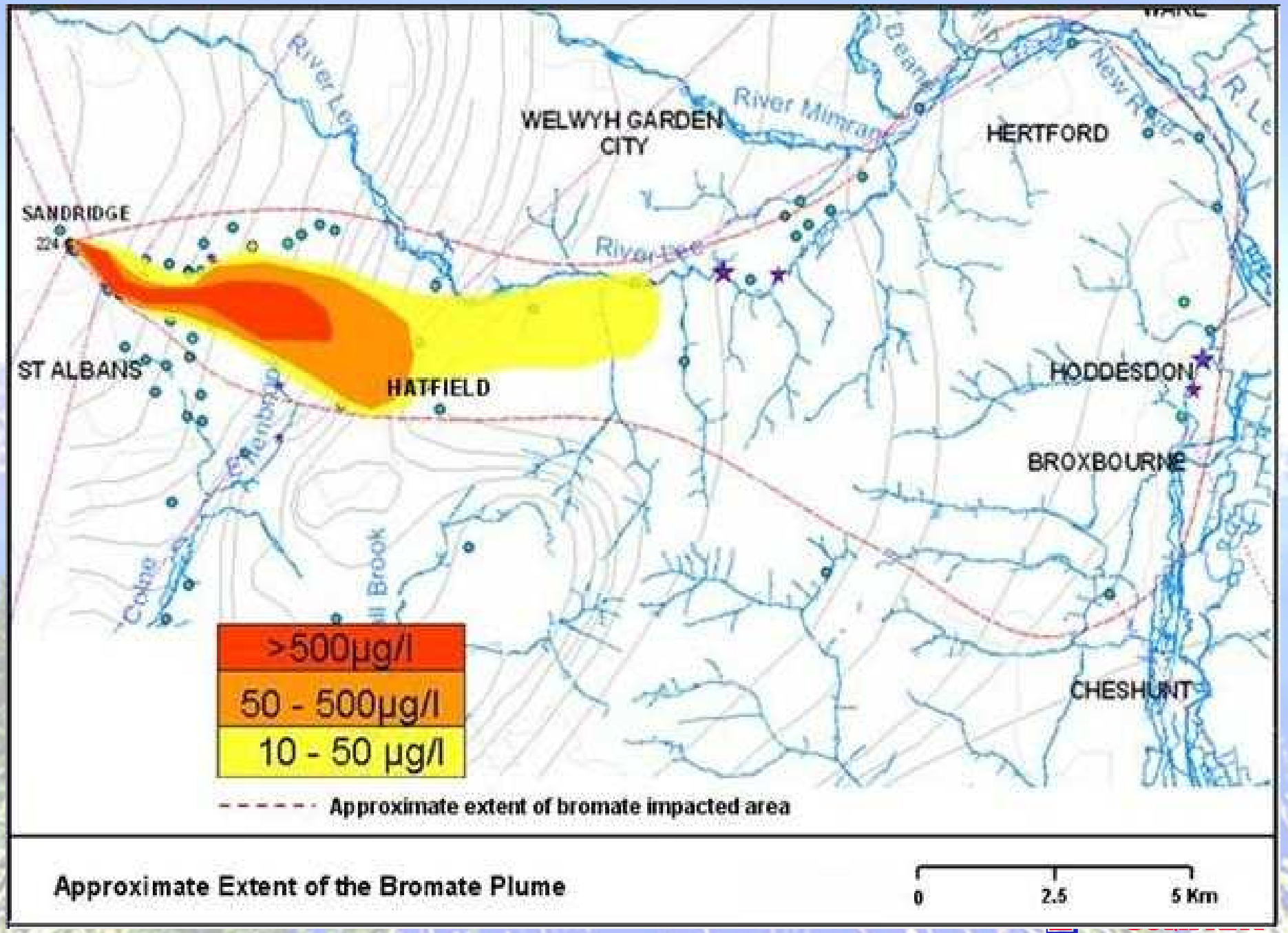
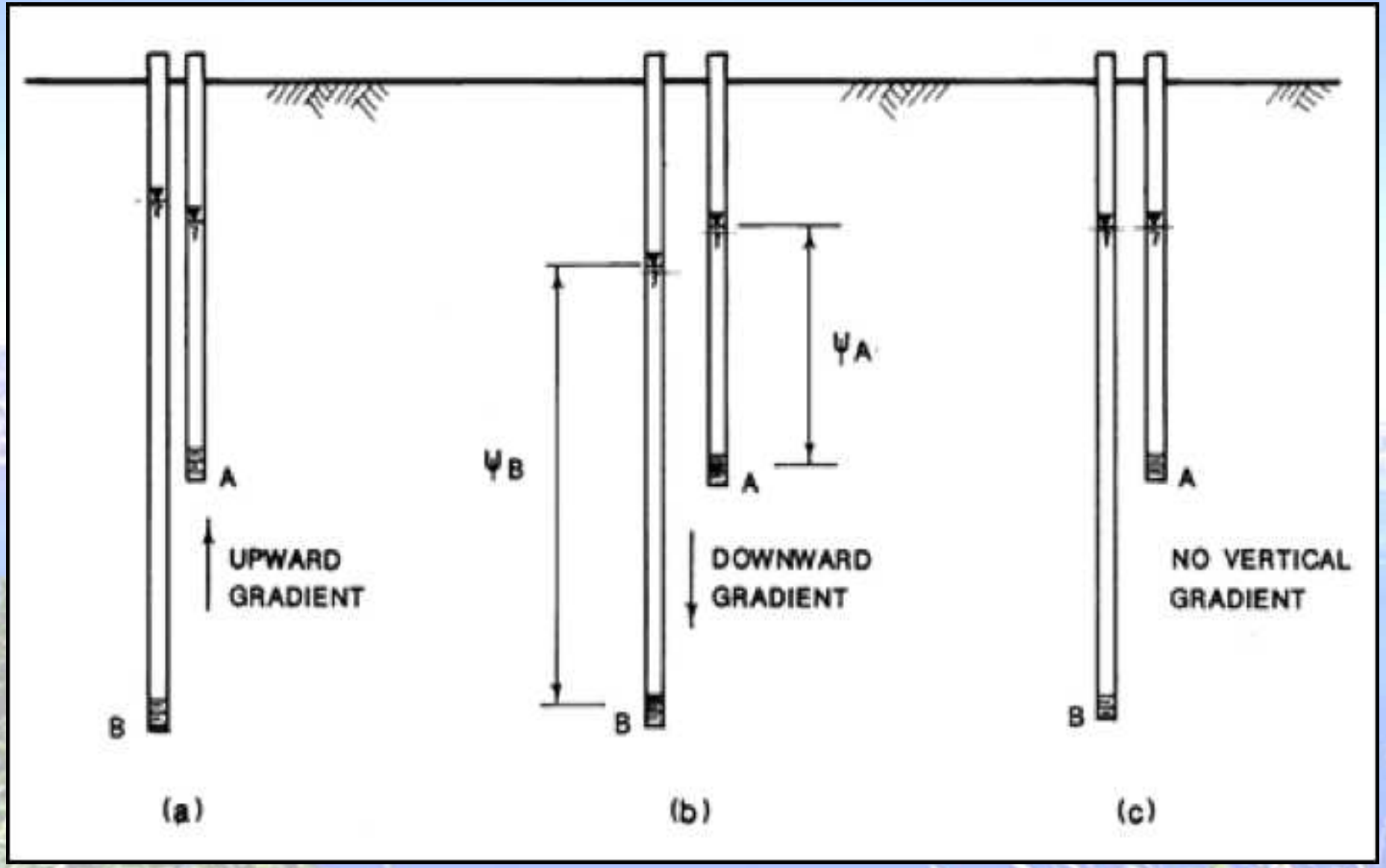

Confined/Unconfined Aquifers
Recharge area
Water table
Potentiometric surface
Flowing artesian well
Perched water table well
Saturated zone
Zone of aeration
Water table well
Artesian well
Ground surface
Perched aquifer water table
Water table
Unconfined aquifer
Confining unit
Confining unit
Confined aquifer
©2007 National Ground Water Association


WELWYH GARDEN CITY
HERTFORD
SANDRIDGE
ST ALBANS
HATFIELD
HODDESDON
BROXBOURNE
CHESHUNT
River Lee
River Mimram
New River
>500µg/l
50 - 500µg/l
10 - 50 µg/l
Approximate extent of bromate impacted area
Approximate Extent of the Bromate Plume
0
2.5
5 Km



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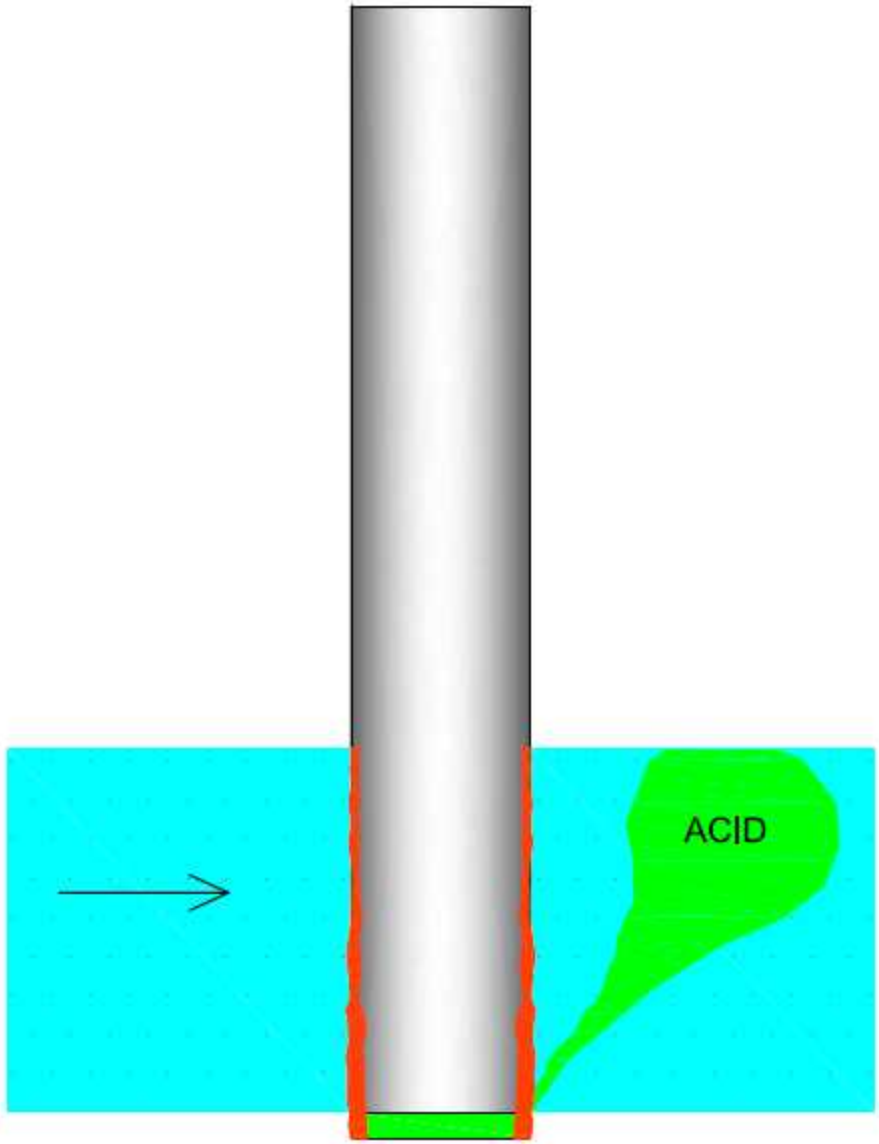
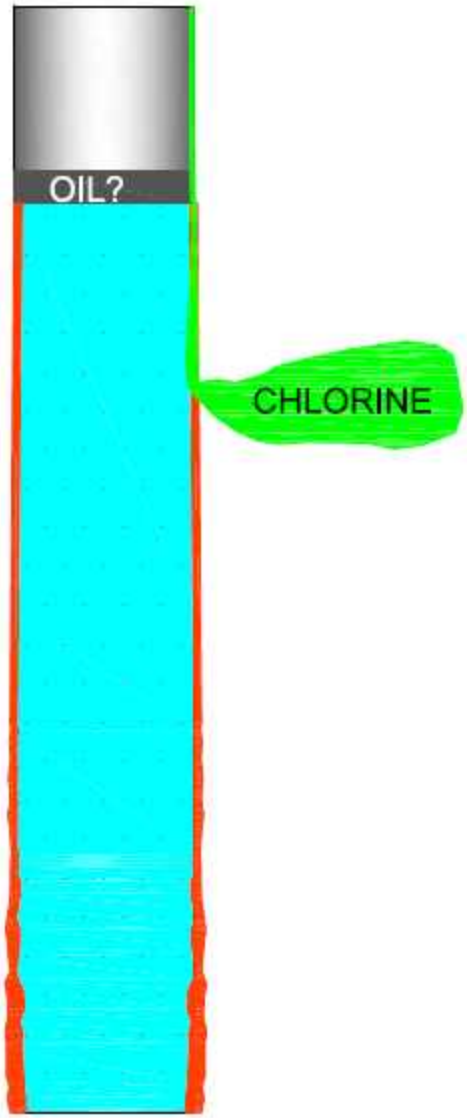
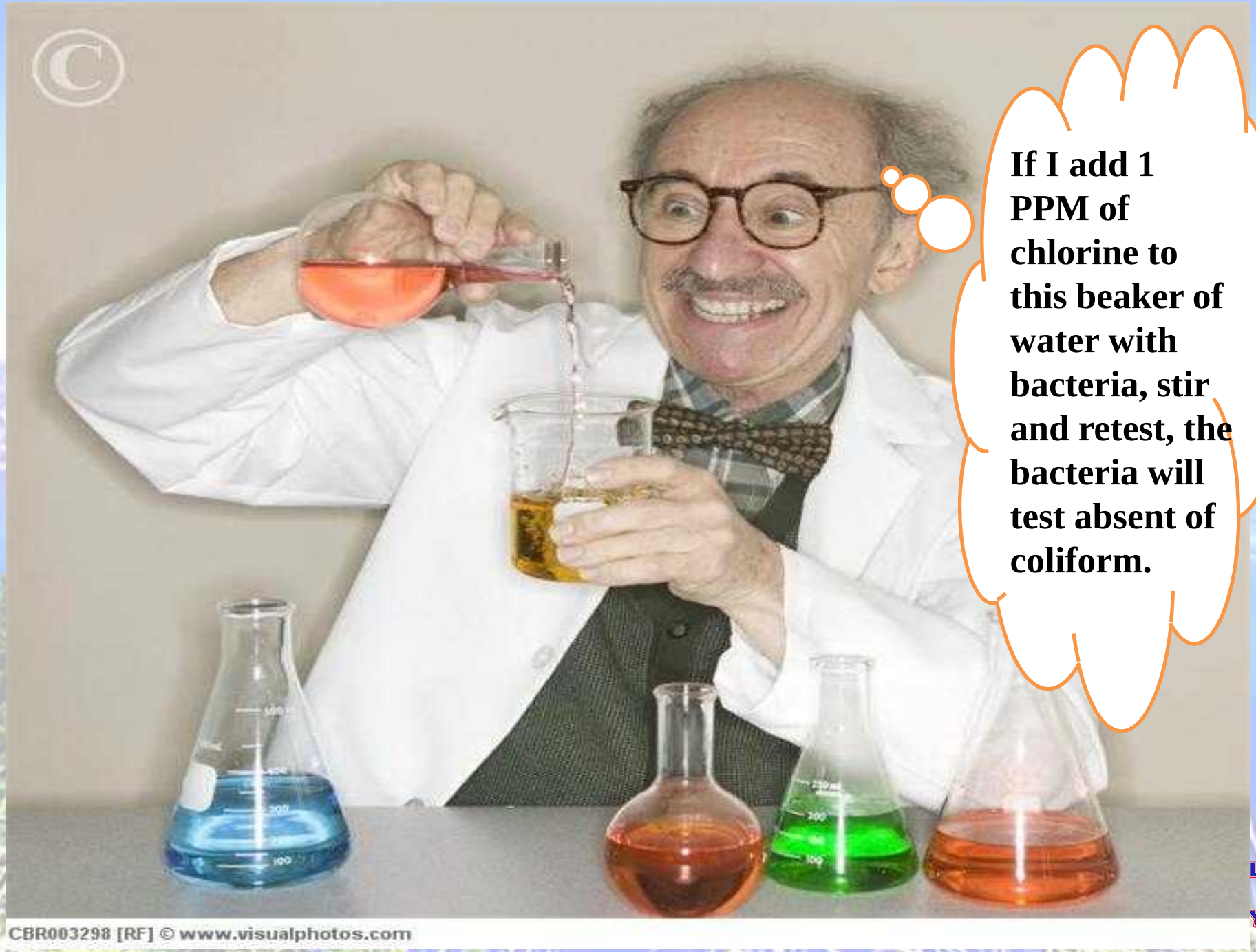
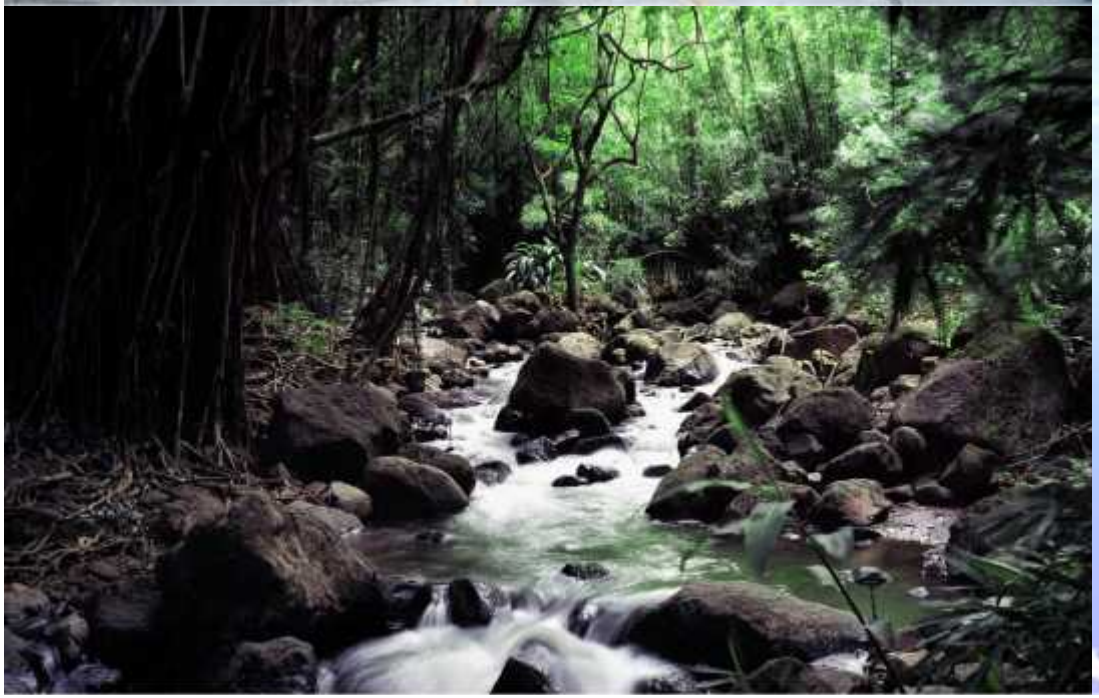





If I add 1 PPM of chlorine to this beaker of water with bacteria, stir and retest, the bacteria will test absent of coliform.
CBR003298 [RF] © www.visualphotos.com



Rate of Reaction is critical

Many treatments assume you have stagnant water similar to a swimming pool, but in reality water is moving underground like a slow moving stream (measured as feet per day)

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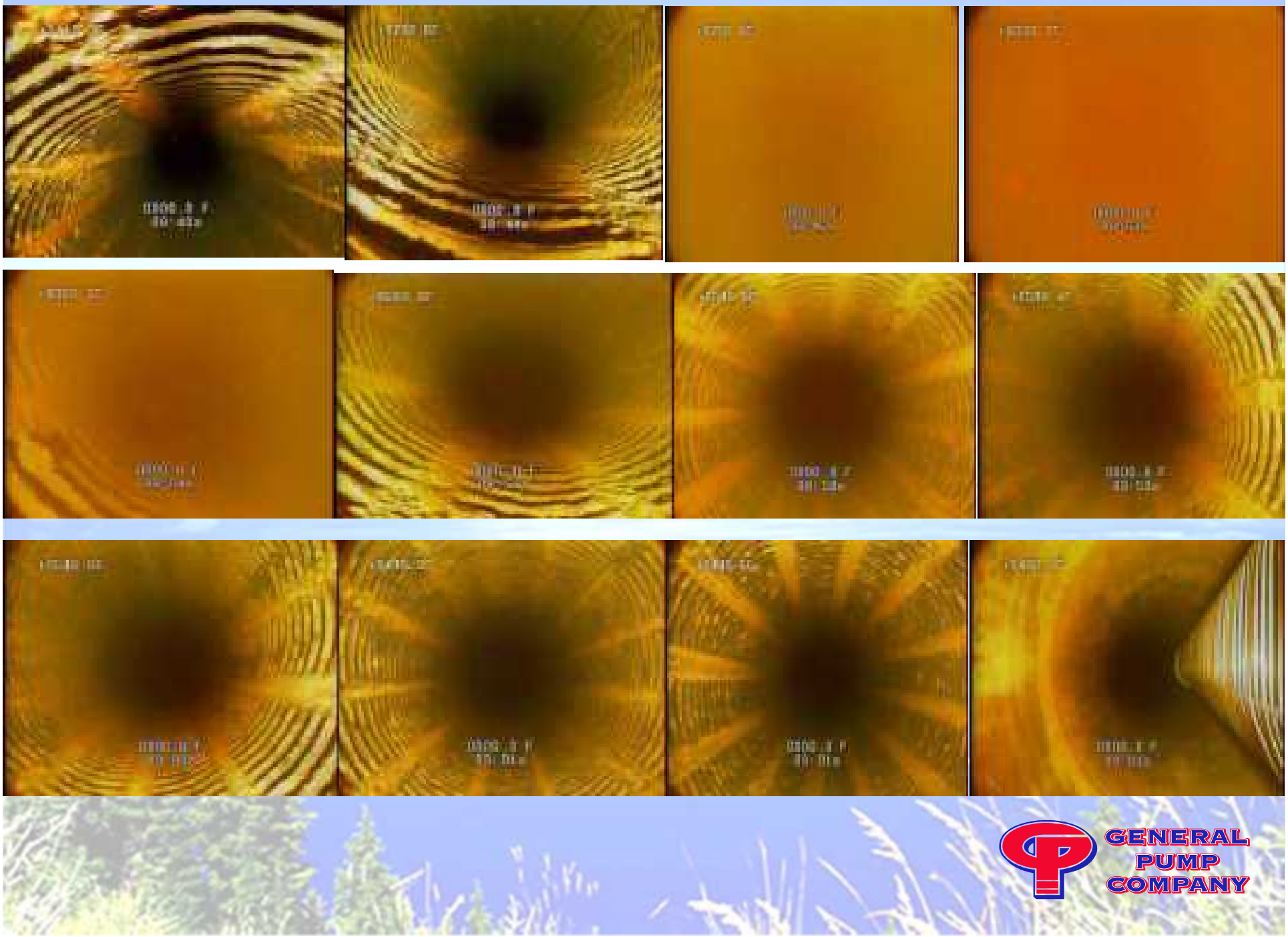
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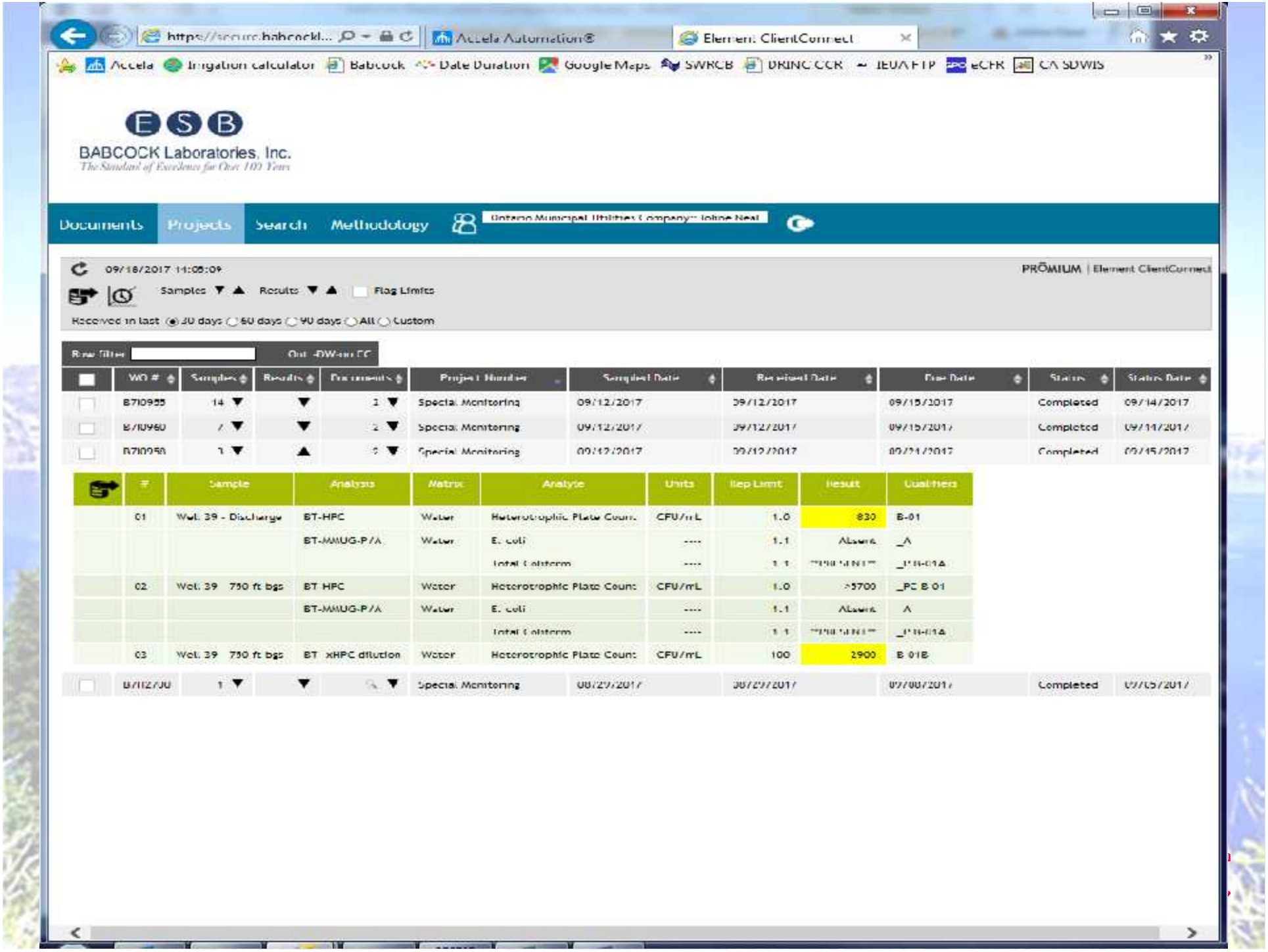

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Documents | Projects | Search | Methodology | Ontario Municipal Utilities Company:: Johne Neal

09/18/2017 14:05:09 PREMIUM | Element ClientConnect

Samples ▼ ▲ Results ▼ ▲ Flag Limits

Received in last (•) 30 days ( ) 60 days ( ) 90 days ( ) All ( ) Custom

Row filter: Out -DW-on CC

	WO #	Samples	Results	Documents	Project Number	Sampled Date	Received Date	Due Date	Status	Status Date
☐	B710955	14 ▼	▼	1 ▼	Special Monitoring	09/12/2017	09/12/2017	09/15/2017	Completed	09/14/2017
☐	B710960	7 ▼	▼	2 ▼	Special Monitoring	09/12/2017	09/12/2017	09/15/2017	Completed	09/14/2017
☐	B710956	1 ▼	▲	2 ▼	Special Monitoring	09/12/2017	09/12/2017	09/21/2017	Completed	09/15/2017

#	Sample	Analysis	Matrix	Analyte	Units	Rep Limit	Result	Qualifiers
01	Well 39 - Discharge	BT-HPC	Water	Heterotrophic Plate Count	CFU/mL	1.0	830	B-01
		BT-MMUG-P/A	Water	E. coli	----	1.1	Absent	_A
				Total Coliform	----	1.1	[illegible]	_[illegible]
02	Well 39 750 ft bgs	BT HPC	Water	Heterotrophic Plate Count	CFU/mL	1.0	>5700	_PC B 01
		BT-MMUG-P/A	Water	E. coli	----	1.1	Absent	A
				Total Coliform	----	1.1	[illegible]	_[illegible]
03	Well 39 750 ft bgs	BT xHPC dilution	Water	Heterotrophic Plate Count	CFU/mL	100	2900	B 01B

☐	B712700	1 ▼	▼	1 ▼	Special Monitoring	08/27/2017	08/27/2017	09/08/2017	Completed	09/15/2017

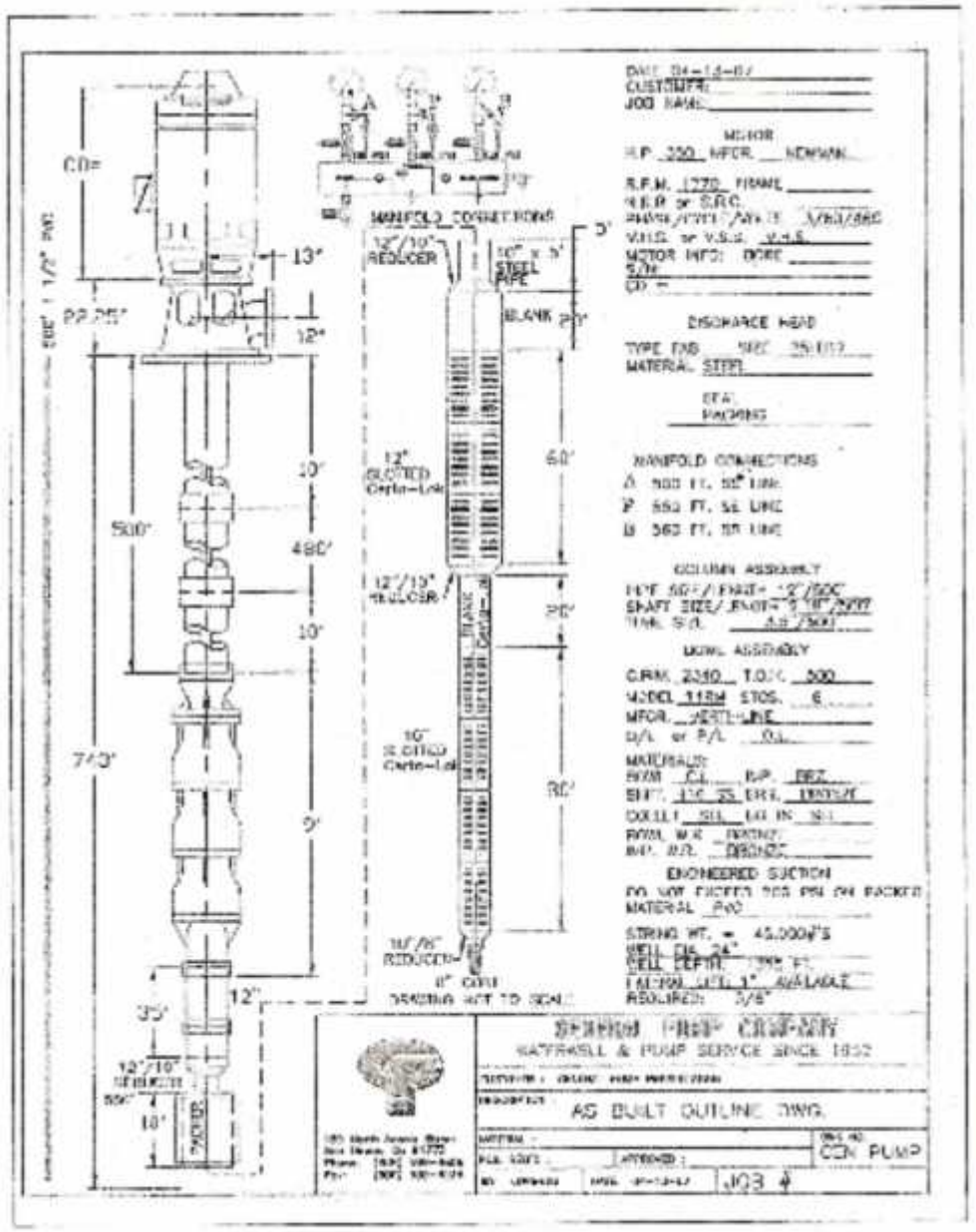

Figure 12.19. Engineered suction and pressurized packer assembly (General Pump Company of Los Angeles).

Startup & Testing

Startup of a pump with an inflatable packer requires a very strategic approach in order to avoid a catastrophic failure.

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Chlorine

Chlorine is available for use as a disinfectant, both as the hypochlorite ion and as hypochlorous acid. The hypochlorous acid form is a minimum of 100 times more effective as a disinfectant, particularly against free-swimming planktonic bacteria. The pH of the cleaning solution determines the availability of the two forms.

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The Wrong Way to Chlorinate Your Well to Solve a Coliform Problem

- Chlorinate through a sounding tube when you have an oil lube pump.
- Pour concentrated bleach (sodium hypochorite) into the well and surge the pump.
  - Do you have a high water level?
  - Does the pump have a check valve?
- Not purge your well prior to chlorination.
- Over chlorinate – If 200 ppm did not work, try 2000 ppm or higher.
- Add an acid to the chlorine prior to injection.

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The Wrong Way to Chlorinate Your Well to Solve a Coliform Problem

- Don’t evaluate your well prior to treating it.
  - Does your well have an upward or downward gradient?
  - Does your well water move a few feet per day?
  - Do you have a chlorine injection tube?
  - Is your pump suction near the bottom of the well?
  - Can you inject chemicals into the pump?
  - Do you have a water supply on site?

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The Wrong Way to Chlorinate Your Well to Solve a Coliform Problem

- Is your crew trained in using the chemicals and have the proper safety gear?
- Do you have the ability to pump continuously to waste?
- Do you have a plan to neutralize the chemicals?
- Do you have two (2) Labs for testing?
- Do you test for HPC (heterotrophic plate count)? ***Note:*** A high HPC count indicates ideal conditions for bacteria re-growth.
- Do you use the membrane filter (MF) technique or multiple tube fermentation or P-A Coli ant.

What do you do to prevent another bad test????

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If you believe that the Well & Pump Service Company adds no value to the success of the project, award the job to the

Cheapest
Unqualified
Unsafe
No Expertise
No Engineering
No Machine Shop
No Warranty
Contractor with a C57 License
NO WAIT! You Asked For References

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Water Flush Pumps – the Fastest Growing New Pump Design in Southern California

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AZ Water Association

Professionals Dedicated To Arizona's Water

Out with the Oil, in with the New… Water-Flush Line-Shaft Turbine Pumps and Their Applications

Nathan Nutter, P.E.

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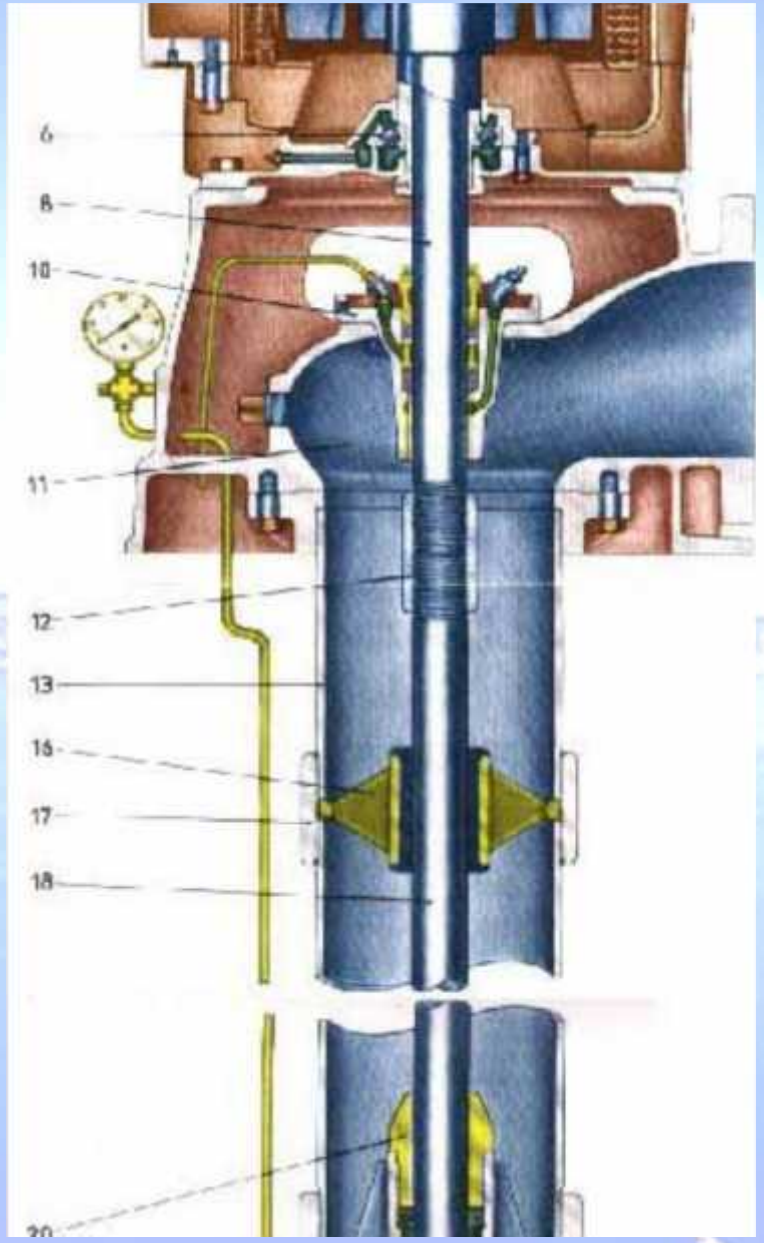

Water Lubricated

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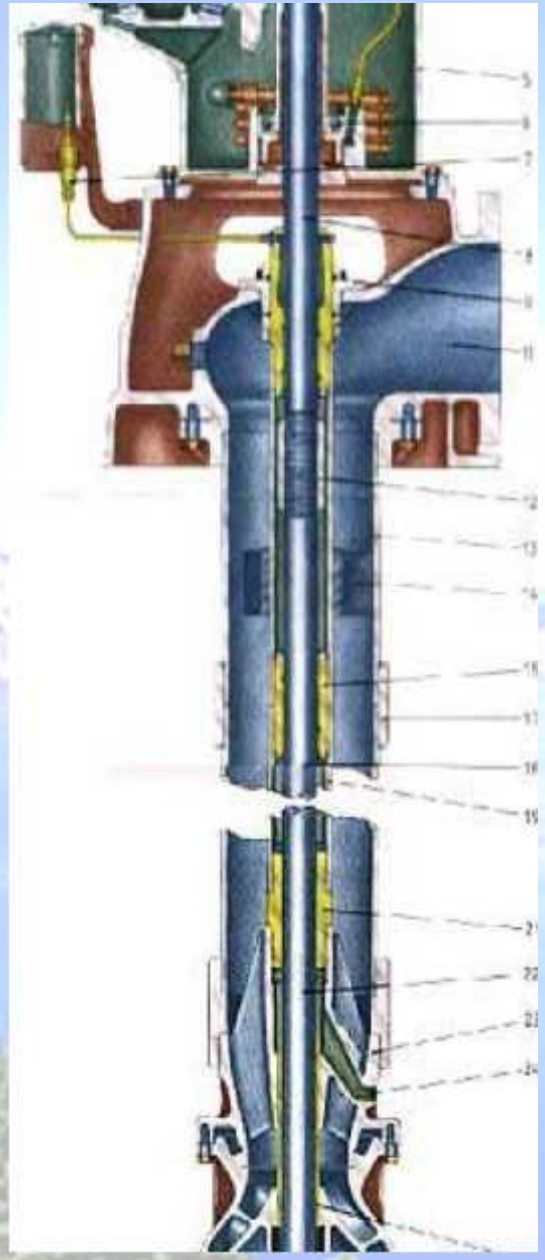
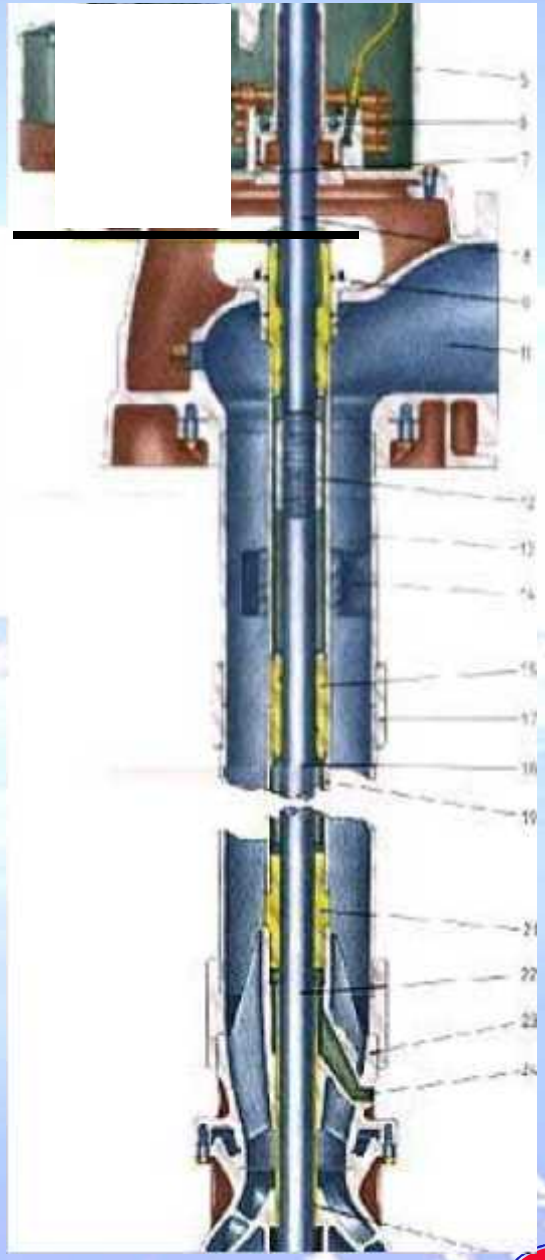


Oil Lubricated



Water Flush

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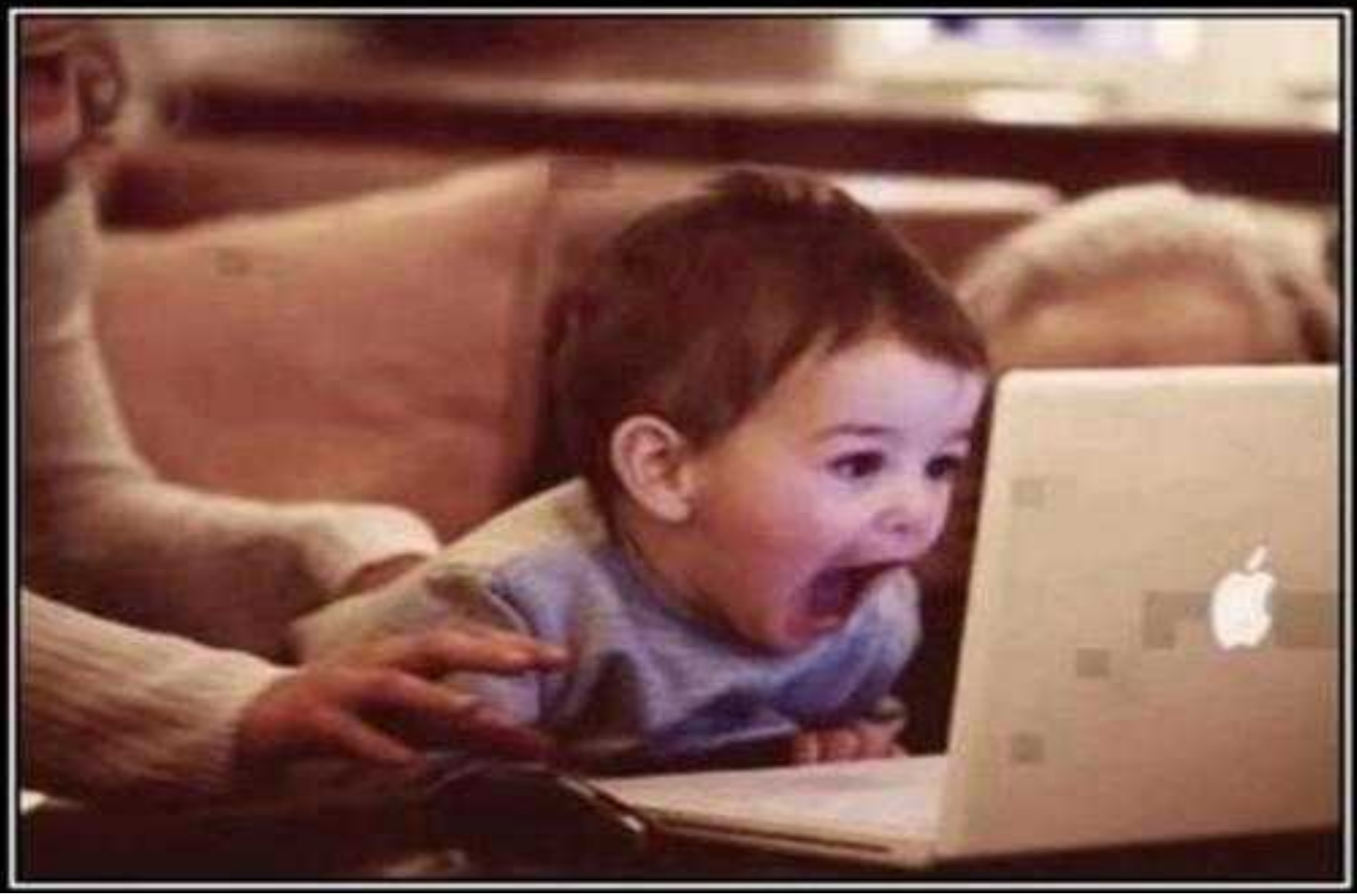
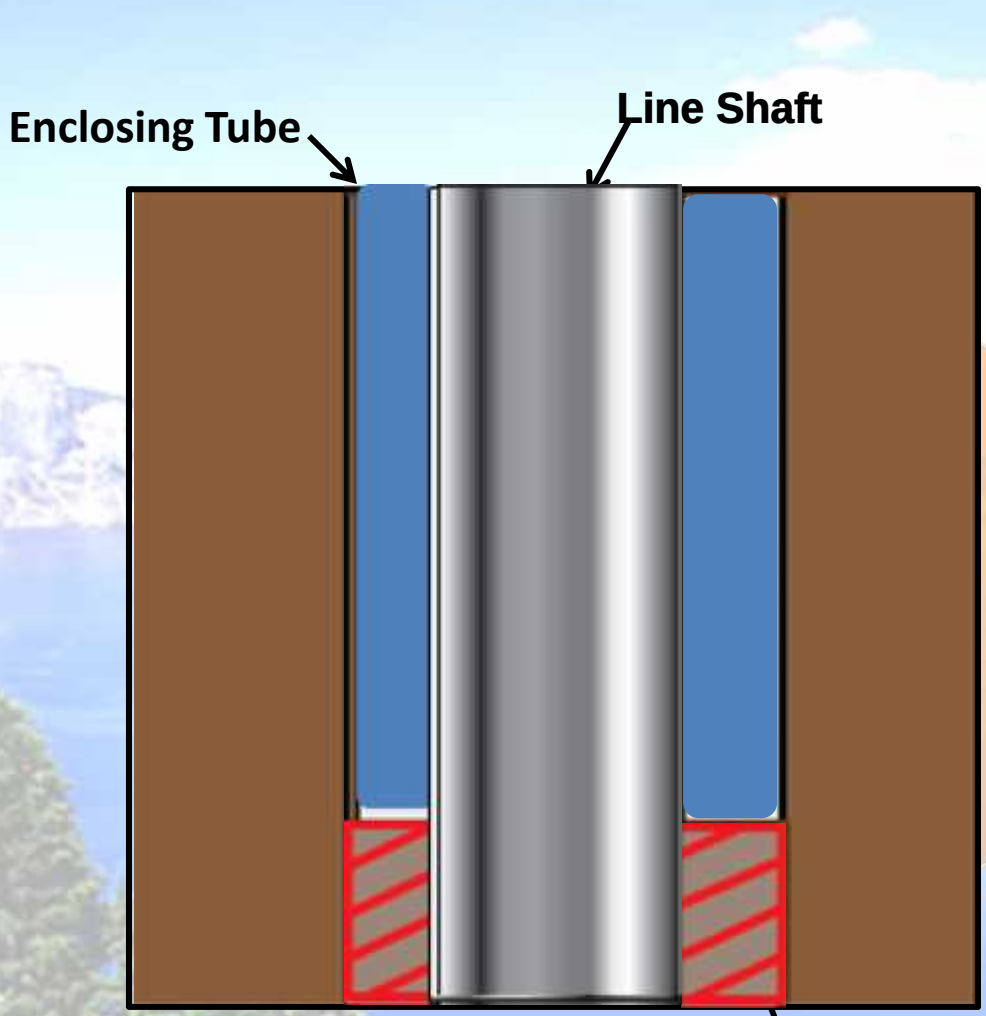
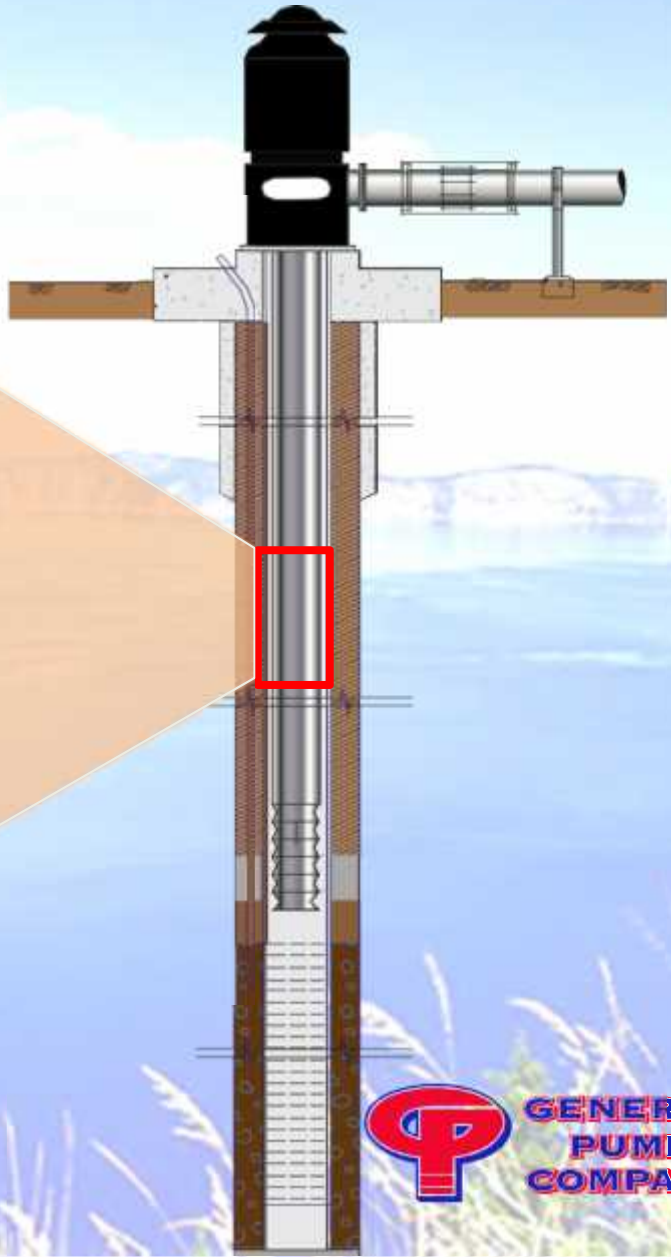


That moment when you realize that you pumped 200 gallons of used oil into your system.

Deep Well Turbine Pumps Require Bearing Lubrication





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The Methods of Lubrication are:

1. Oil Lubricated (Conventional)
2. Water / Product Lubricated (No Pre-Lube)
3. Water / Product Lubricated (Pre-Lube)
4. Water Flush

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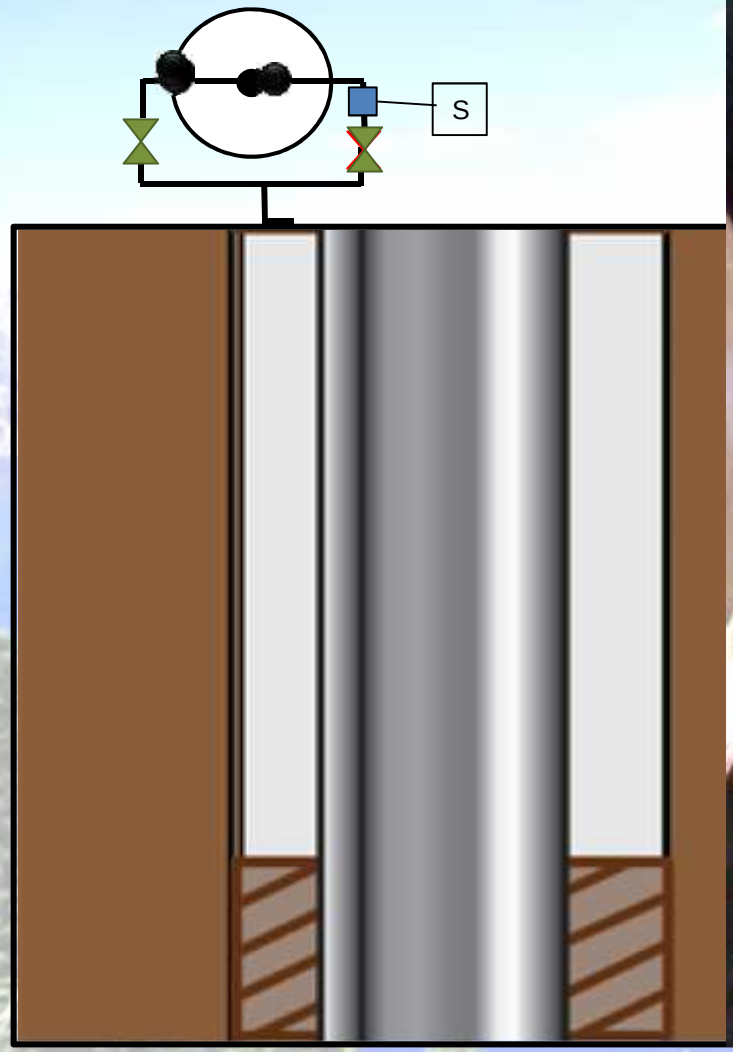
Oil Lubricated



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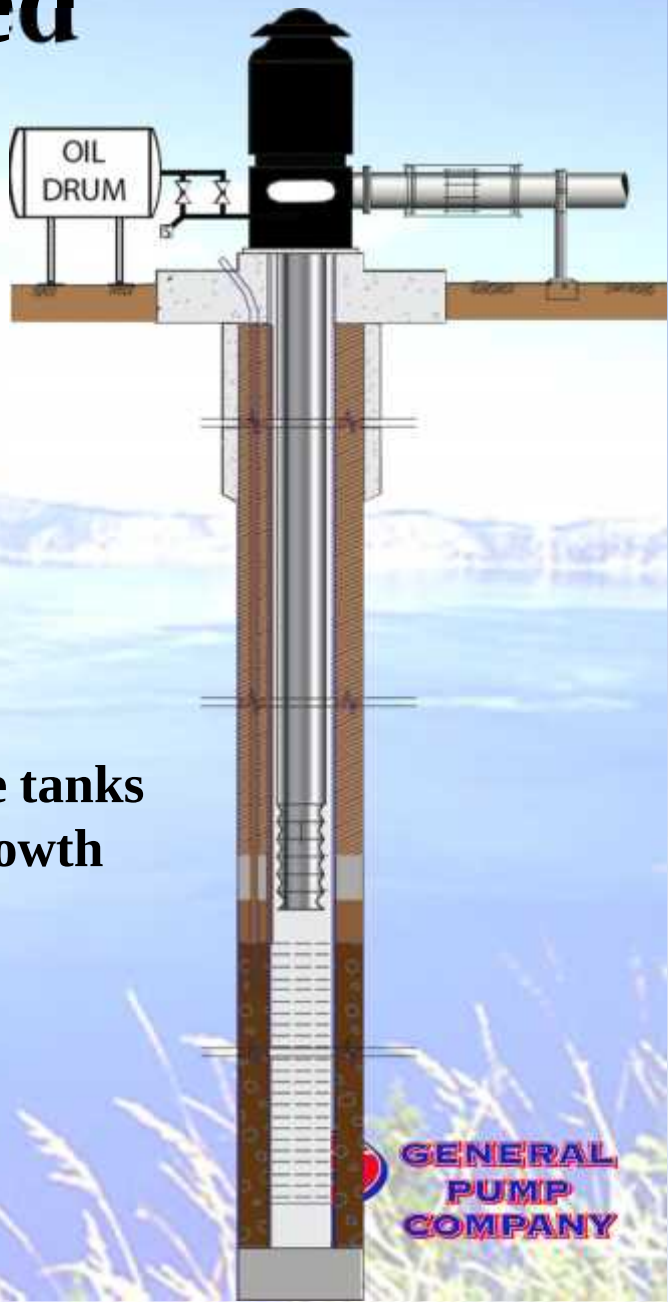
Oil Lubricated

PROS

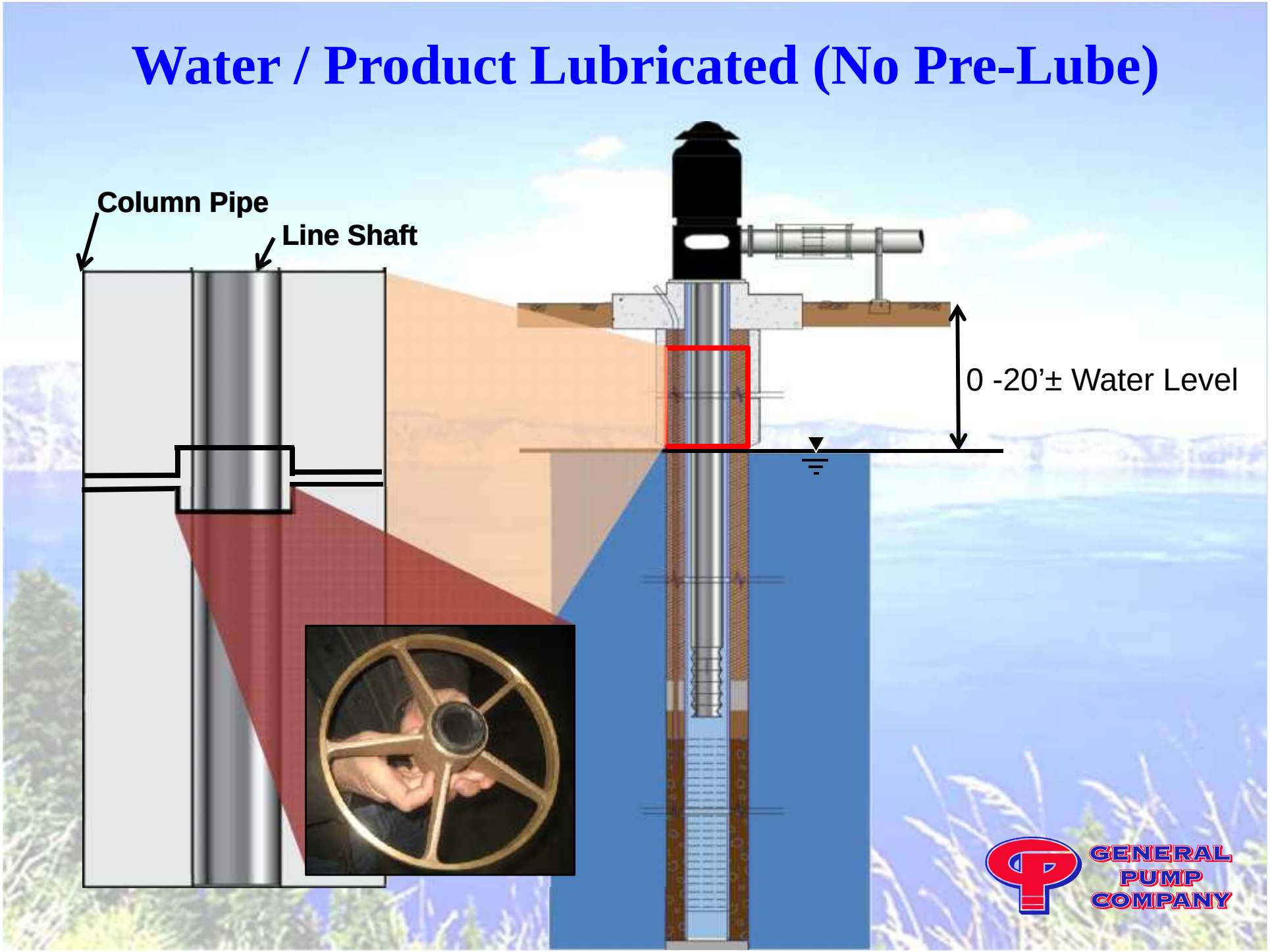
- **Better lubricant than water**
- **Less wear on components**
- **Sand does not go up tube**
- **More bearing support**
- **No critical speed issues**

CONS

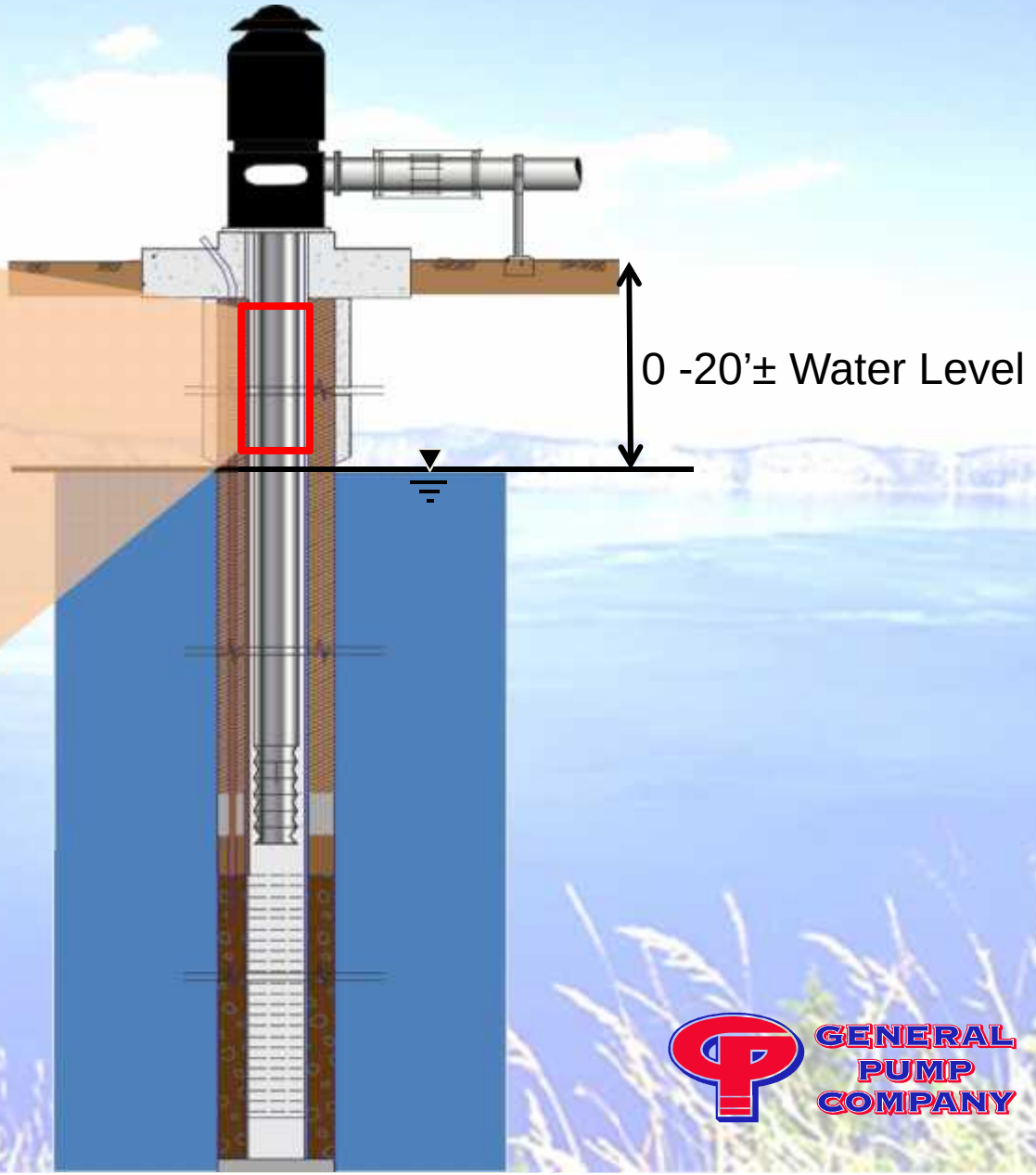
- **Oil can get in well bore**
- **Oil can get into distribution system or in storage tanks**
- **Oil in filter pack or formation may cause bio-growth and fouling**
- **Daily monitoring of oil feed system**



Water / Product Lubricated (No Pre-Lube)



Water / Product Lubricated (No Pre-Lube)



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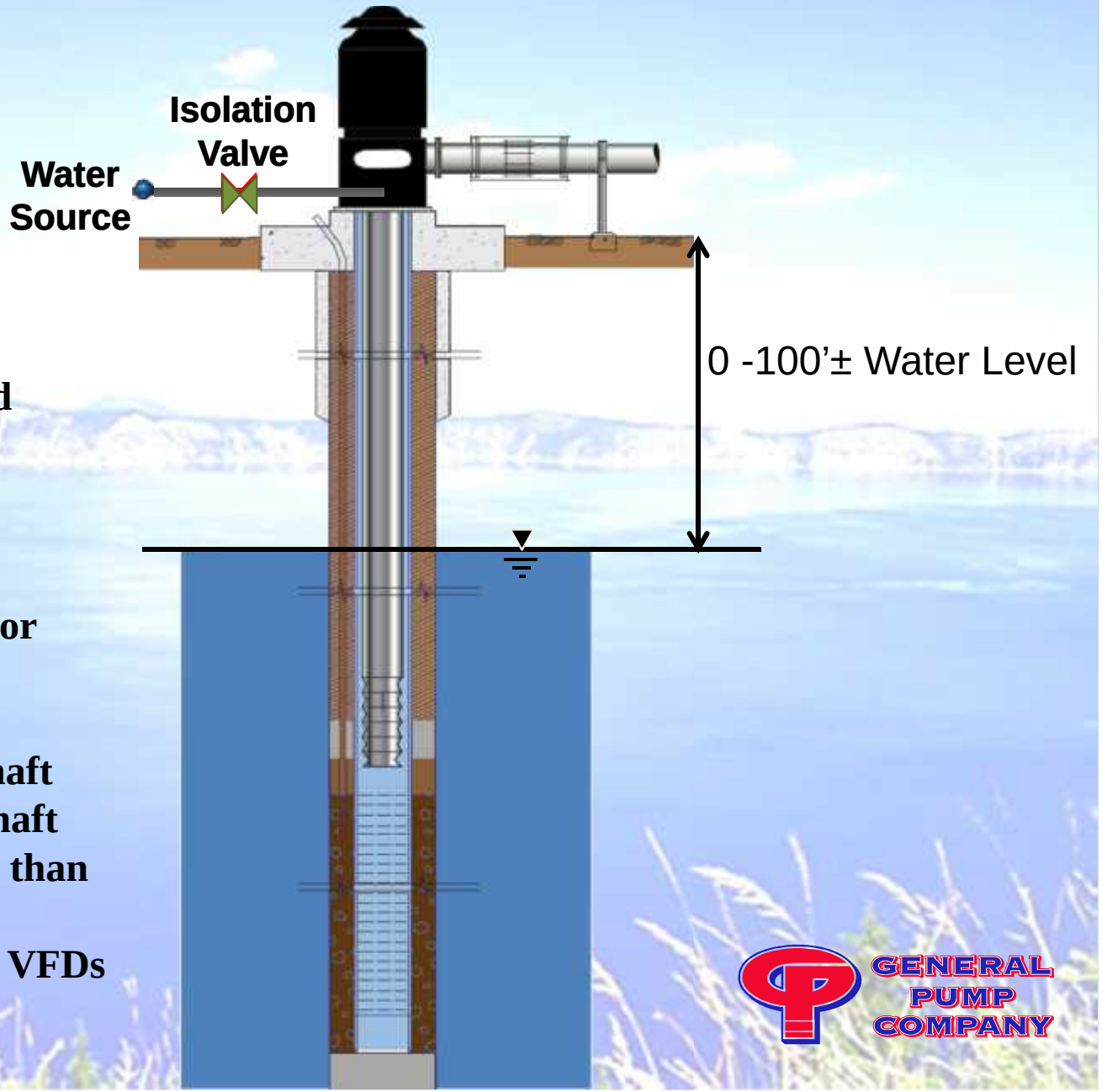
Water Lubricated (Pre-Lube)

PROS

- No enclosing tube
- No oil in well bore or distribution system
- Low daily maintenance costs
- Don't lose water because weeping ports are plugged
- Less friction loss / more energy efficient

CONS

- Possible bearing seizure for deeper water tables
- Not good with sand
- Requires stainless steel shaft sleeves or stainless steel shaft deep set pumps cost more than oil lube
- Critical speed issues with VFDs



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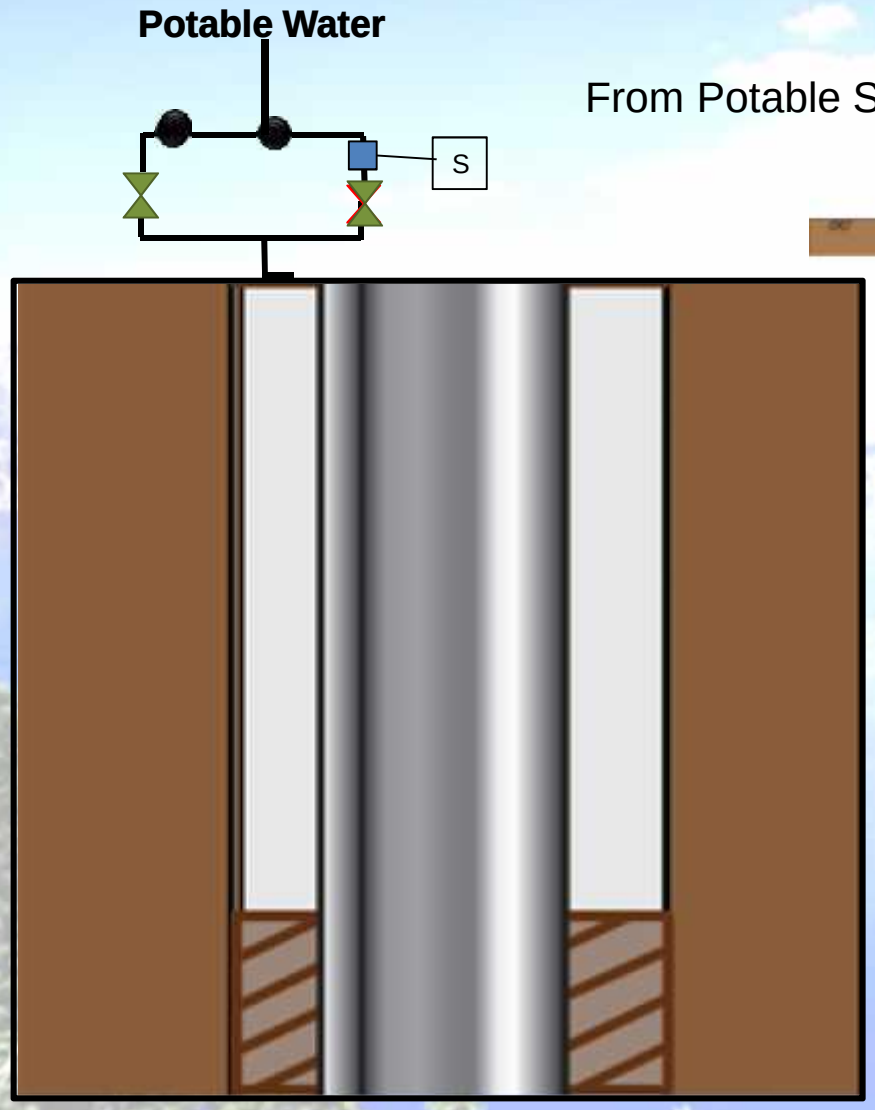
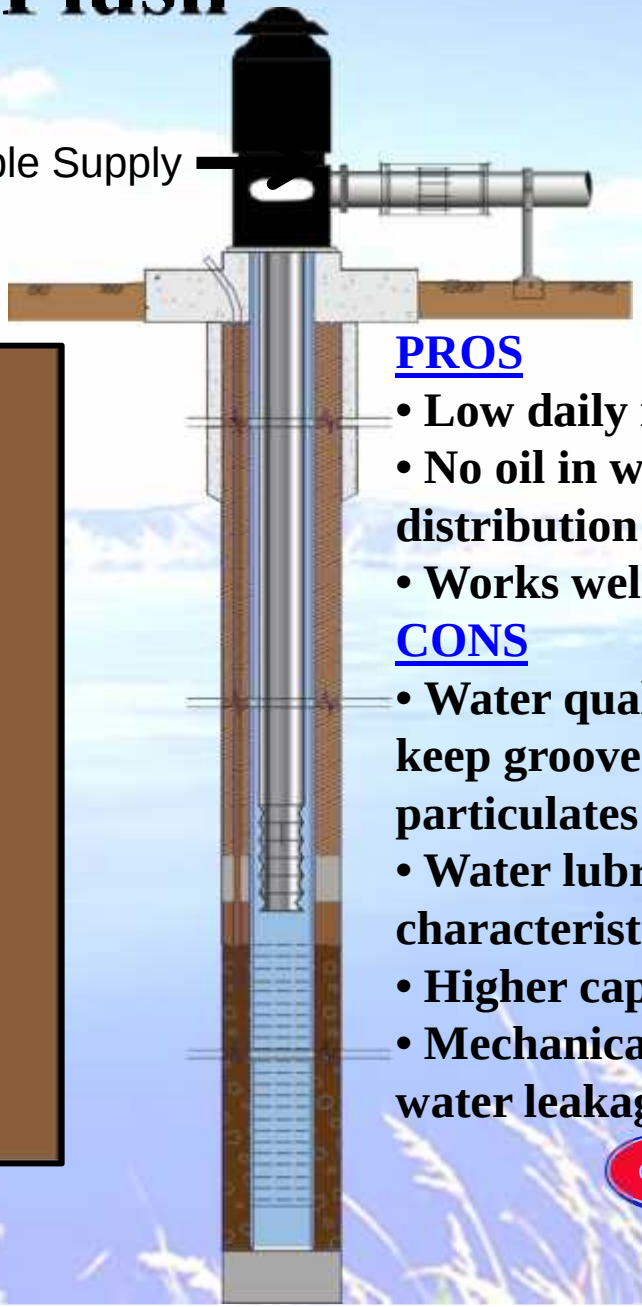
Water Flush





PROS

- **Low daily maintenance costs**
- **No oil in well bore or distribution system**
- **Works well with VFDs**

CONS

- **Water quality important to keep grooves clear from particulates or fouling**
- **Water lubrication characteristics inferior to oil**
- **Higher capital costs**
- **Mechanical seal or packing water leakage**

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Considerations for Water-Flush Applications

- ASR wells
- Aboveground infrastructure - Reduces impacts to:
  - Arsenic Media
  - Granular Activated Carbon (GAC)
  - Reverse Osmosis (RO)
- Decreased potential for disinfection byproducts from oil-chlorine contact
- Water level decline in aquifer
- Recharge credits for ASR wells

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Converting from Oil Lubricated to Water Flush

- Pull pump
- Modify inner column:
  - Shaft: 1045 to stainless steel
  - Bearings: Cut extra grooves for flushing
  - Bearing Type: Bronze,
- Change packing box setup
- Modify tube adapter bearing
- Connect water flush piping
- Open valve!

Standard Water Flush System

TRIM BALANCING VERTICAL PUMPS

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Motors and Pumps Are Individually SHOP-BALANCED

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When we install the motor and pump together onsite, the residual unbalance in both rotor components combines, resulting in excessive unbalance vibration.

TRIM BALANCING

- **Trim balancing a vertical pump is a procedure performed after installation.**
- **Vertical, hollow shaft motors are usually designed for easy trim-balance correction on the ratchet assembly atop the motor (under the top cone).**

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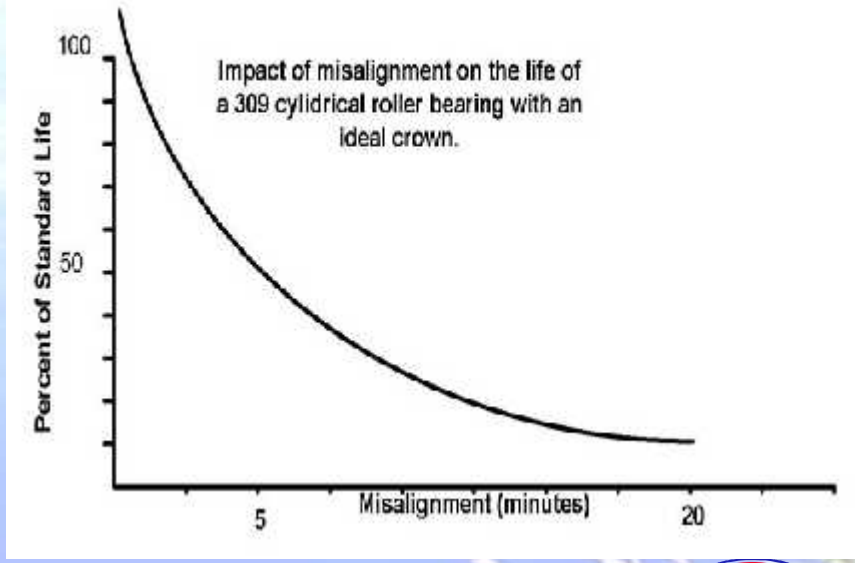
Benefits of precision alignment and trim balancing

Impact of Vibration Reduction on Bearing Life

(Assuming Dynamic Load is the Major Force Component)

% Reduction in Vibration	% Increase in Bearing Life	
	Ball Bearings	Other Rolling Element Bearings
5	17	19
10	37	42
15	63	72
20	95	110
25	137	161
30	192	228
40	363	449
50	700	908

Source: L. Douglas Berry, Vibration Versus Bearing Life, Reliability, Vol. 2, Issue 4, November 1995



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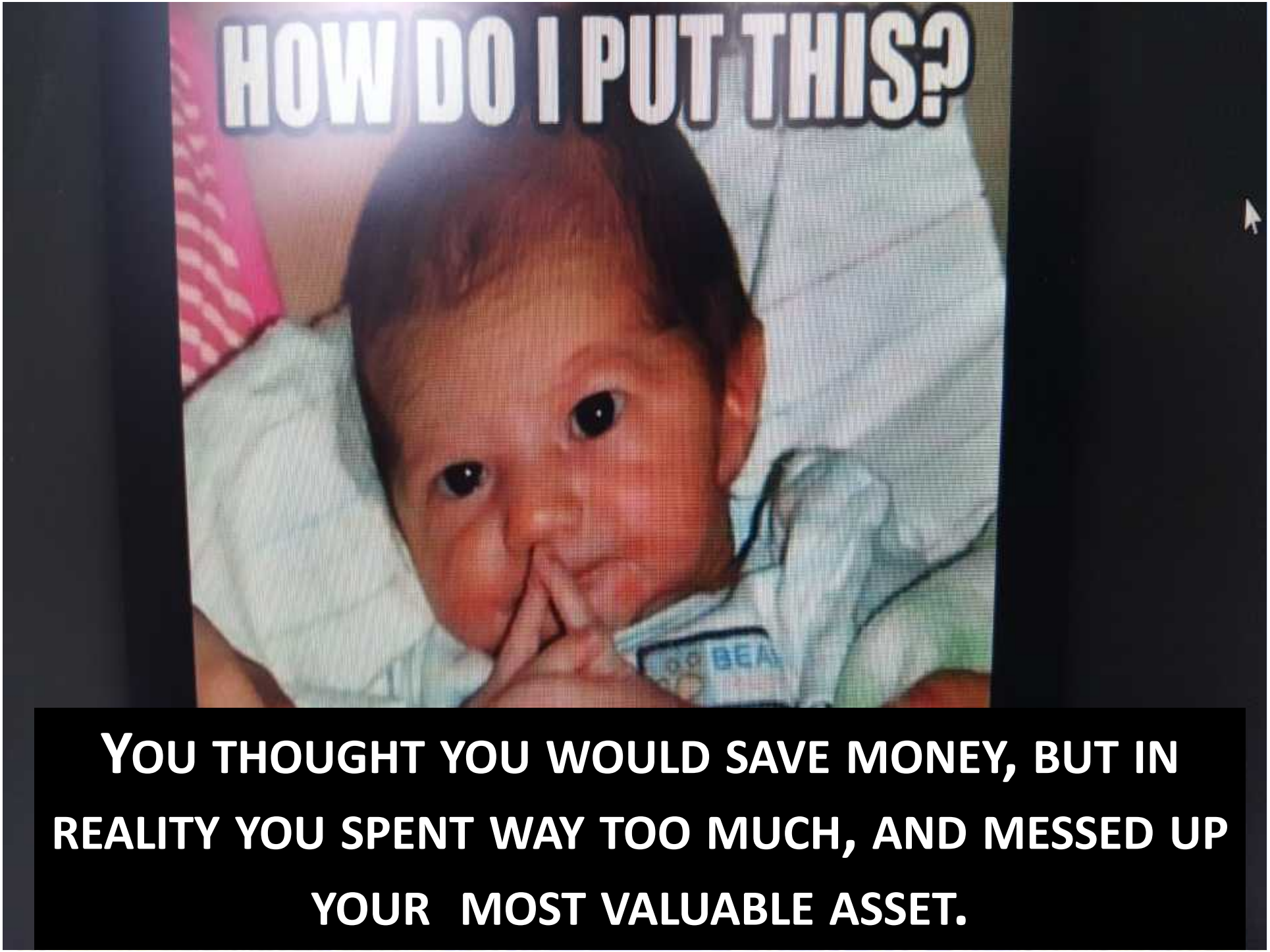
How to Perform a Cost-Effective Well Redevelopment


HOW DO I PUT THIS?
YOU THOUGHT YOU WOULD SAVE MONEY, BUT IN REALITY YOU SPENT WAY TOO MUCH, AND MESSED UP YOUR MOST VALUABLE ASSET.

“All Redevelopment Tools and Processes” are a waste of Public Funds and are extremely dangerous to your most valued assets.

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Unless ……..

You follow the Step-By-Step Process.

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Step I

- **Build your team of experts!**
- **Determine the issues that exist.**

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Build Your Team of Experts

(Not this team of experts…..)

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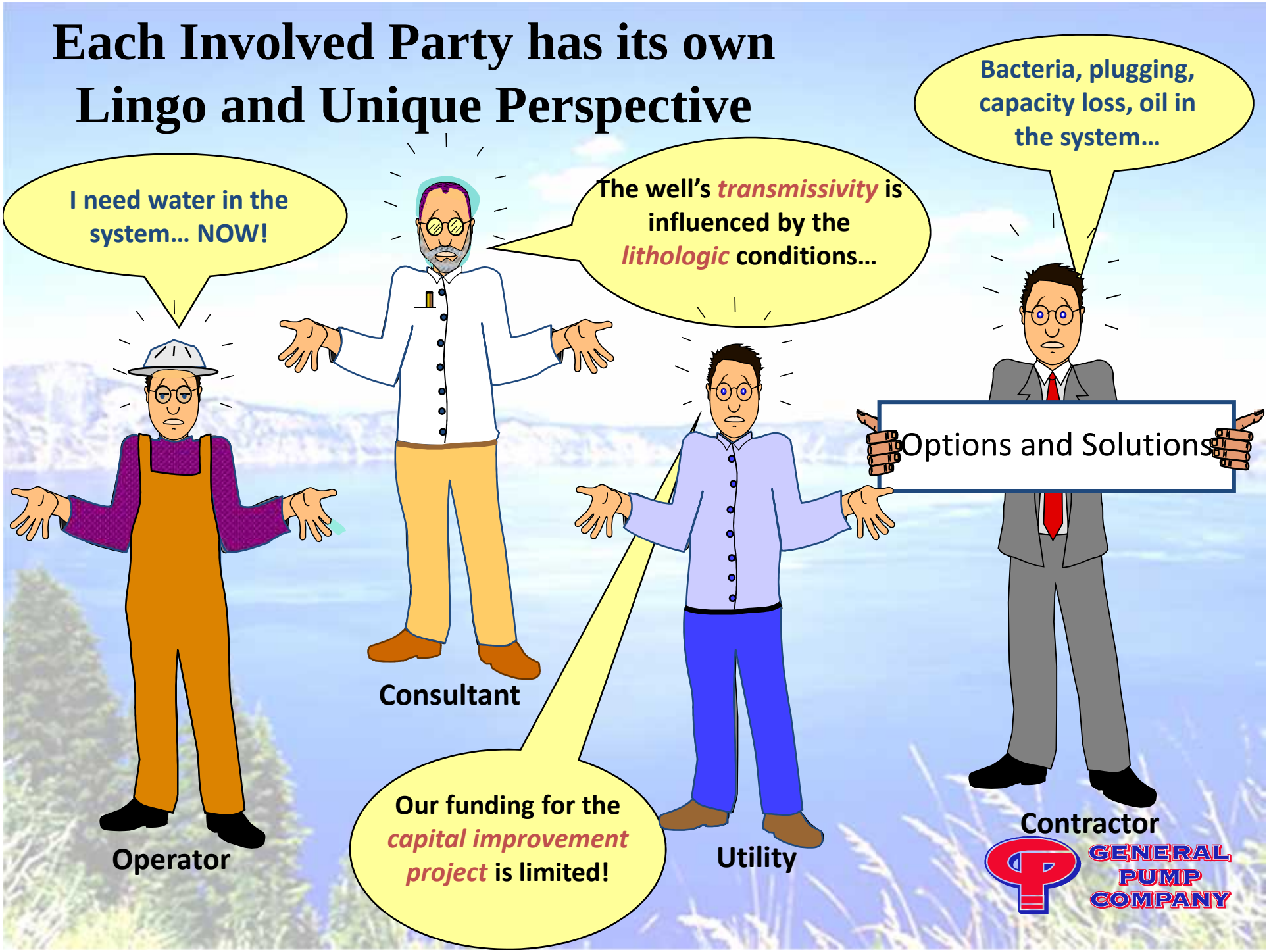
Each Involved Party has its own Lingo and Unique Perspective
I need water in the system… NOW!
The well's transmissivity is influenced by the lithologic conditions…
Bacteria, plugging, capacity loss, oil in the system…
Options and Solutions
Consultant
Operator
Our funding for the capital improvement project is limited!
Utility
Contractor
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What issues do you have?

Nitrates? TCE? Arsenic? Colored Water?
Sanding? Air? Perchlorates? Iron? Manganese?
Bacteria? Low Specific Capacity? Loss Capacity?
Gravel Pumping? Oil in Water?

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If you're not careful, you will hire the "Step Brothers" to work on your $2,000,000 water well.

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Interview / Visit / Question

- Interview P.M., Production, Application Engineer, Foreman
- Knowledge – Local & Specific to Current and Future Projects
- Visit Shop, Capabilities, Experience
- Review Equipment / Capabilities
- Review Rehabilitation Processes
- Safety, Practices and Procedures

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Your Consultant and Contractor Should Not Compete

Everyone Loses!

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Example: **Customer has lost capacity in their well and they <u>think</u> it is due to well plugging.**

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Step II

- **Review all of the historical records.**

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Deteriorating Well Performance

Well performance deteriorates through a combination of factors

Mineral Encrustation

- Iron, manganese and calcium
- pH > 7.5
- Physical plugging
- Silts, clay and fine sands (velocity)

Biological Fouling

- Iron related bacteria (IRB)*
- Sulfate reducing bacteria (SRB)
- Slime forming bacteria

Corrosion

- pH < 7.5, DO > 2 ppm
- H_2S >1 ppm, TDS > 1000 ppm
- CO2 > 50 ppm , Chloride > 300 ppm

Structural Change

- Weak or failed casing
- Age of structure
- Aggressive or encrusting waters
- Sand production
- Change in operation, over pumping
- Well liner – wrong design for application

Maintenance

- Years between redevelopment
- Aggressive mechanical and/or chemical
- Coliform bacterial – excessive chlorine
- Run to fail

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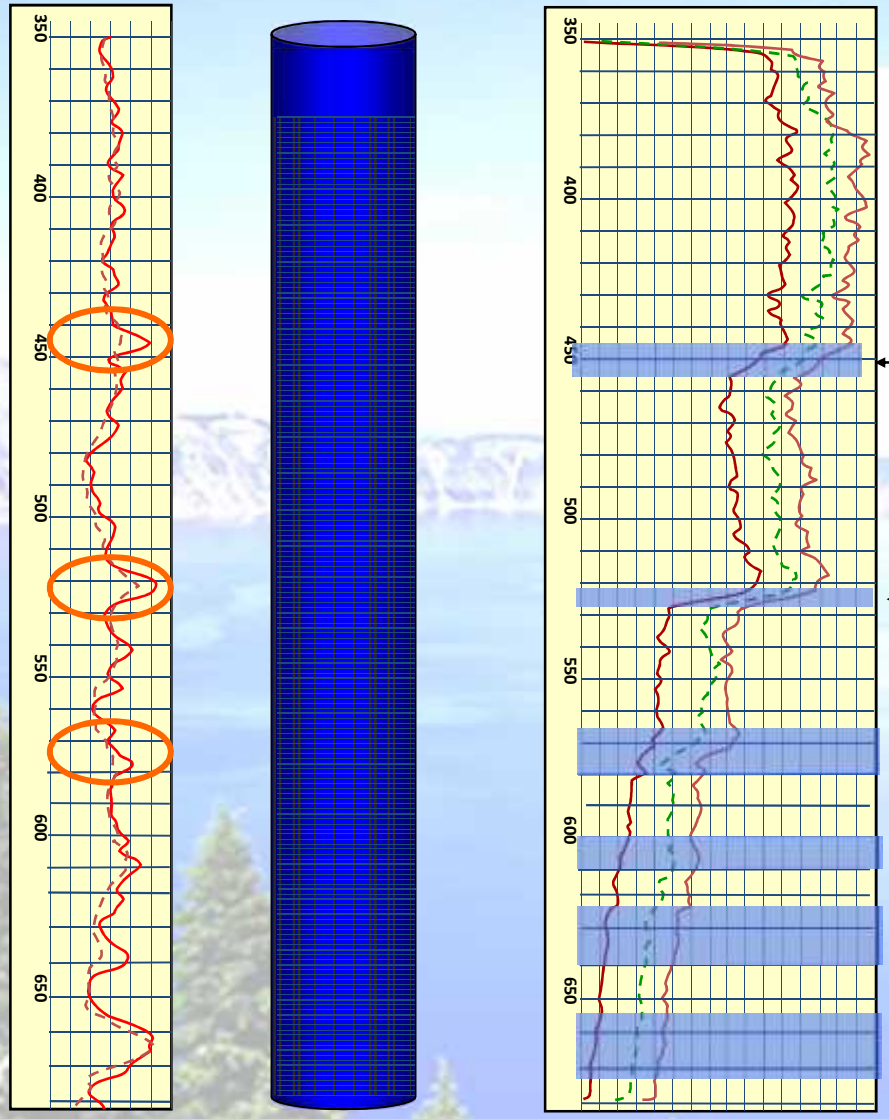
Geophysical Logs and Spinner Logs Provide Different Information



Well pumped at 1,700 gpm during spinner logging of a 300-foot screen interval

26% of flow from a 10-foot sand

35% of flow from a 5-foot sand

19% of flow from a 15-foot sand

7% of flow from a 10-foot sand

6% of flow from a 20-foot sand

7% of flow from a 20-foot sand

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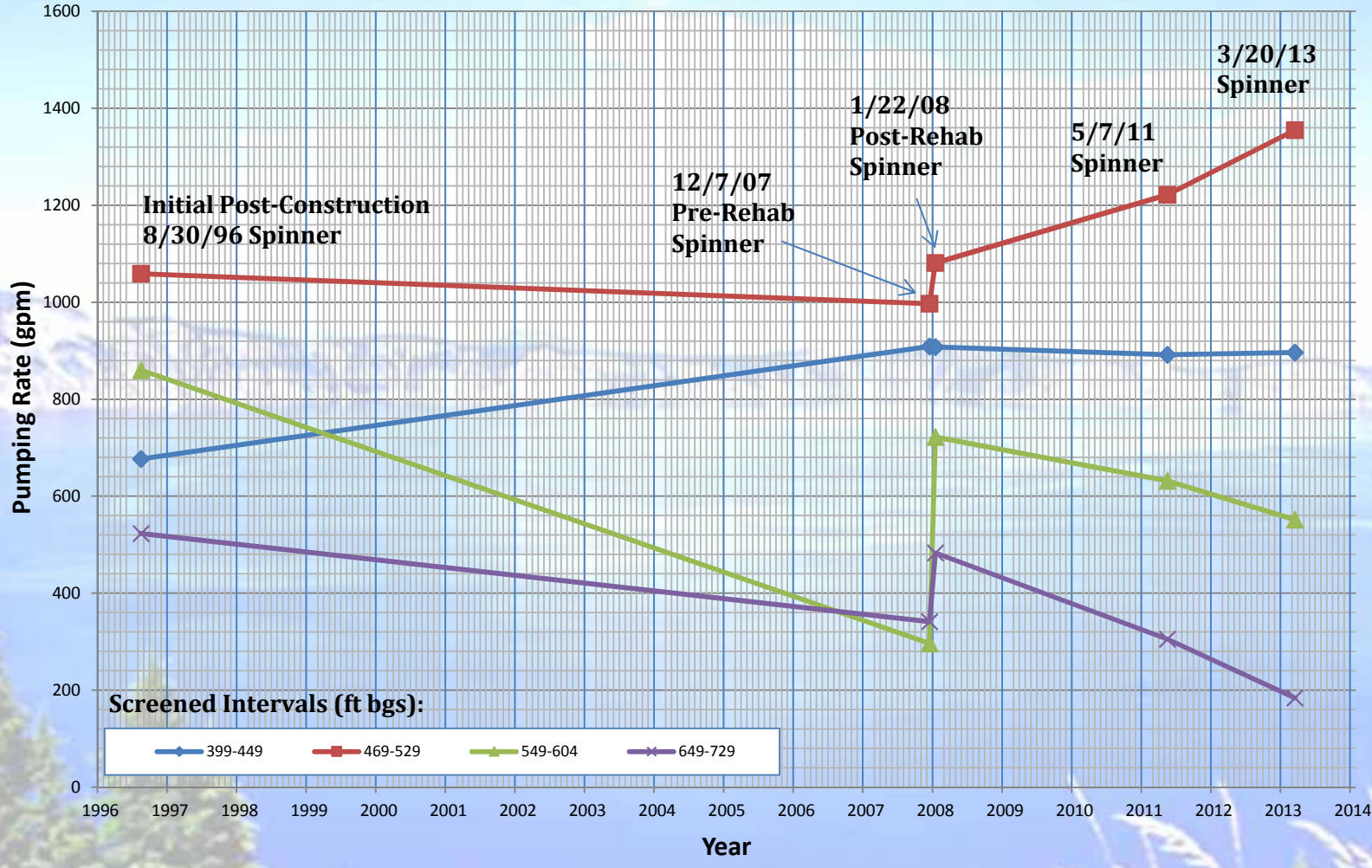
80% of the water production is from only 30 feet (10%) of the screen

Graph of Results (GPM)



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Well issues typically develop over months or years. If you are monitoring your Well, you will see the issues developing.

Don't be like this operator!

"The Well was operating perfectly for years, then yesterday we pumped a sh!# load of sand into the system."

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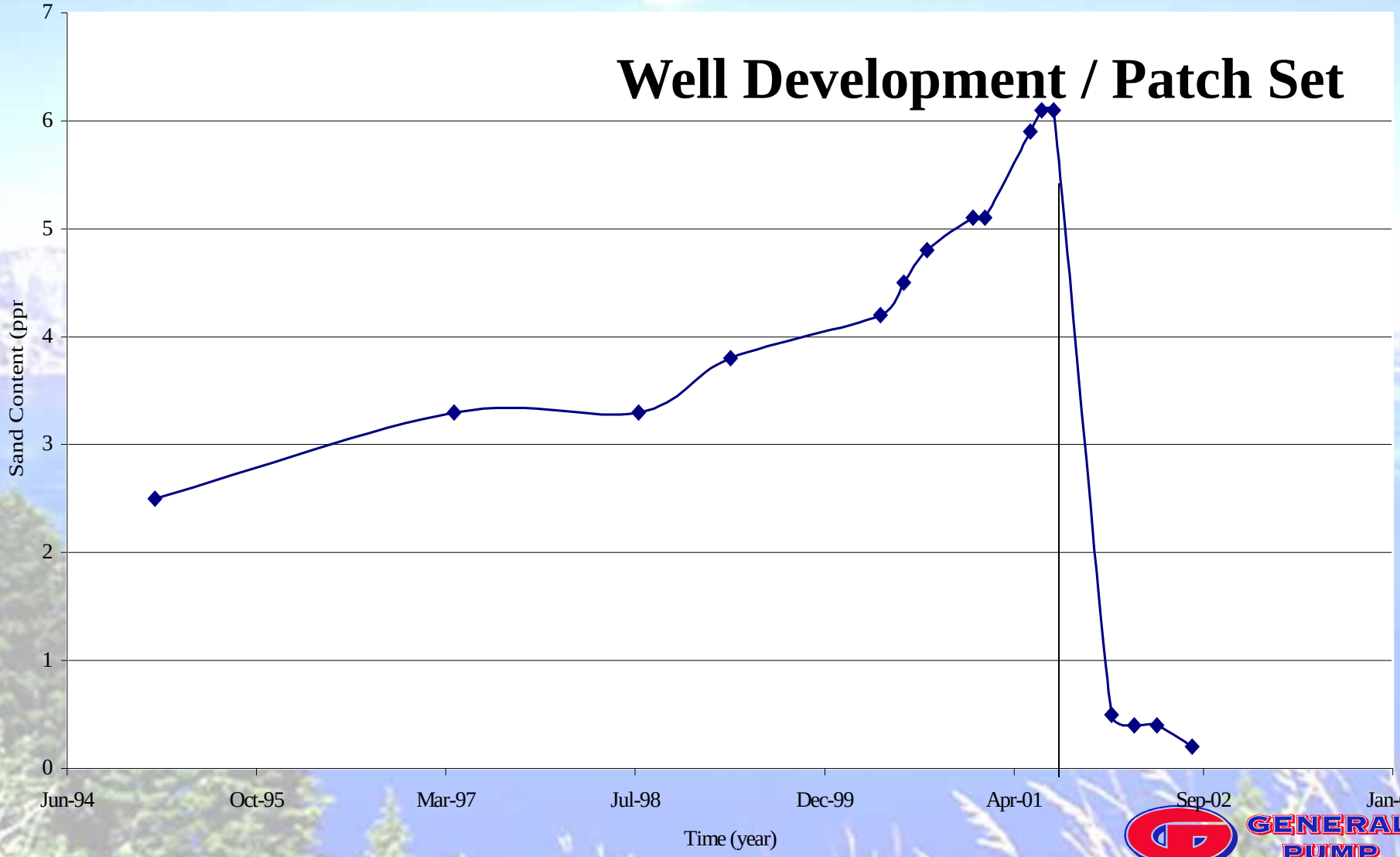
Sand Test Over Time



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Step III

- **Perform additional testing before you pull the pump.**
- **Change flow and/or conditions and monitor changes.**
- **Dynamic video logging**
- **Dynamic spinner logging**
- **Dye testing “Besst”**
- **Dynamic zone sampling.**

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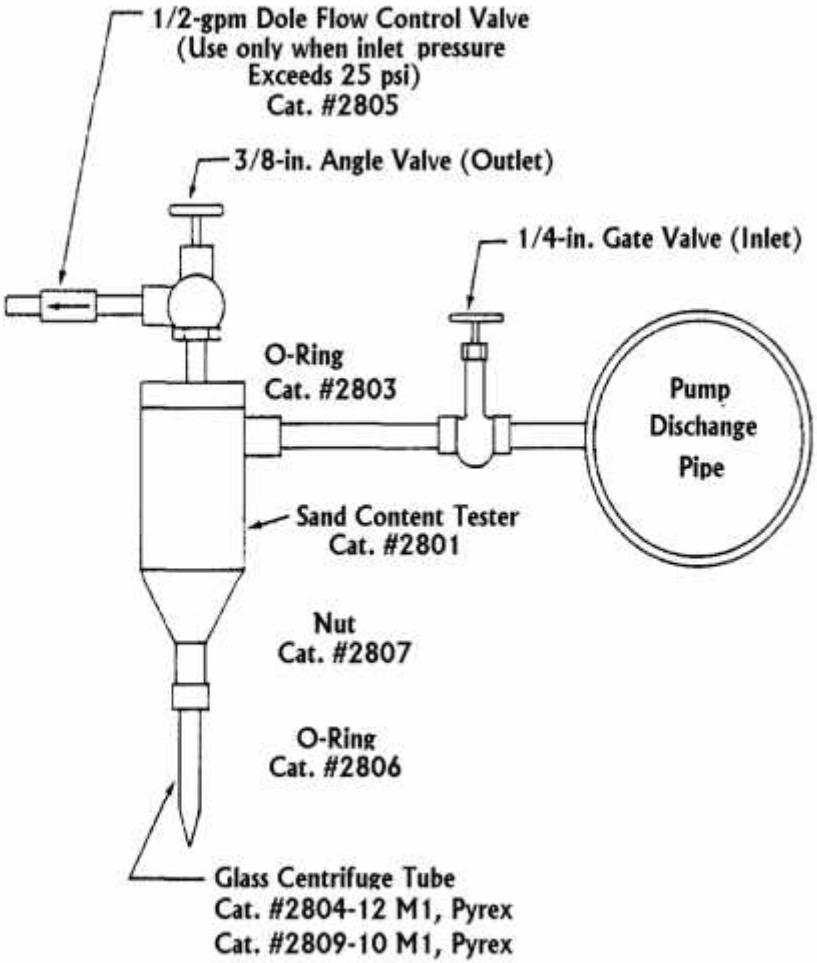
Sand Content Measurement



The sample line shall be tapped as close to the pump head as possible to ensure that turbulence is high enough to keep the sand uniformly distributed in the water stream

Rossum Centrifugal Sand Tester

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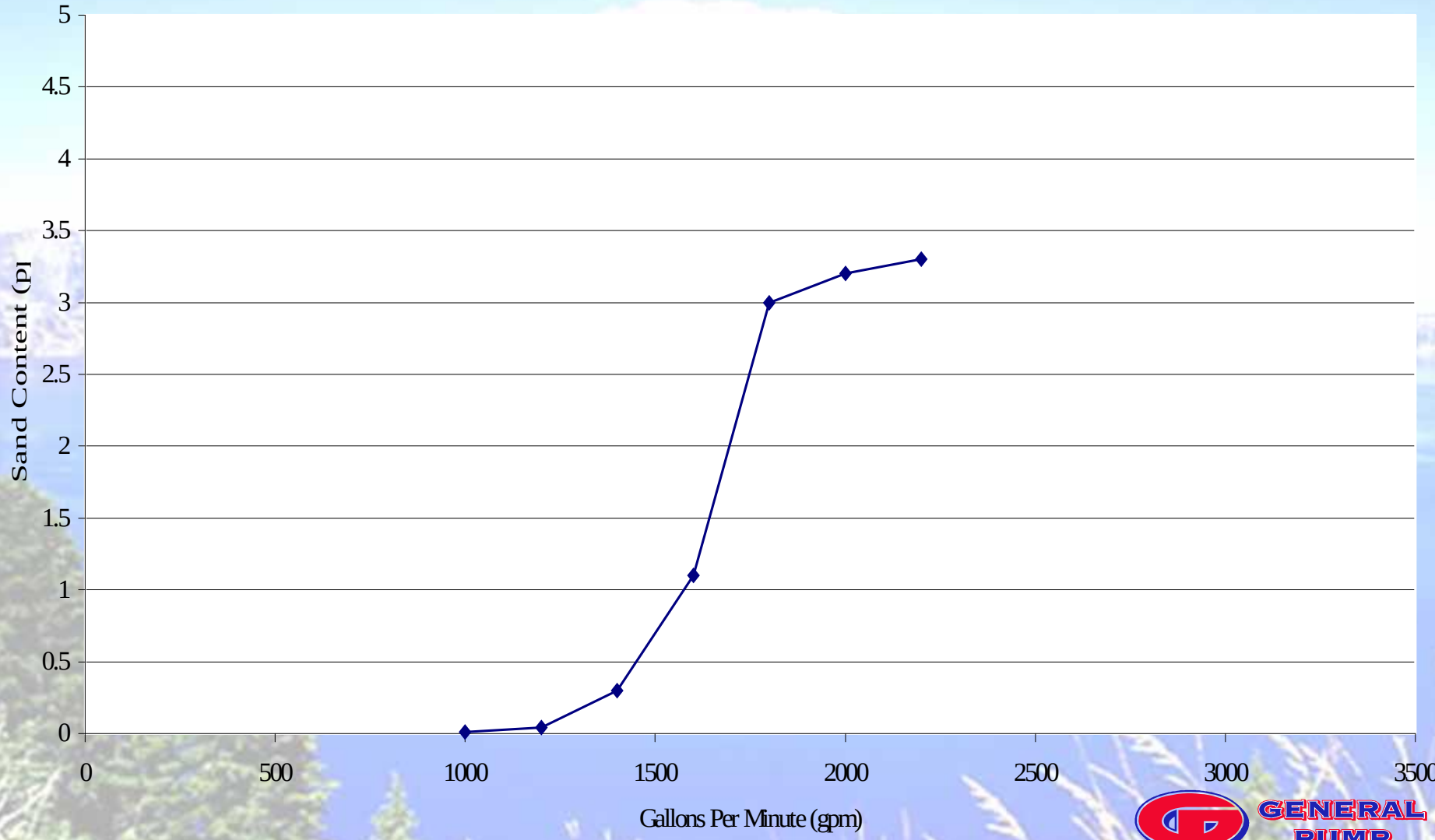
Sand Test at Various Flow Rates



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0548.2
0426.2
0903.7

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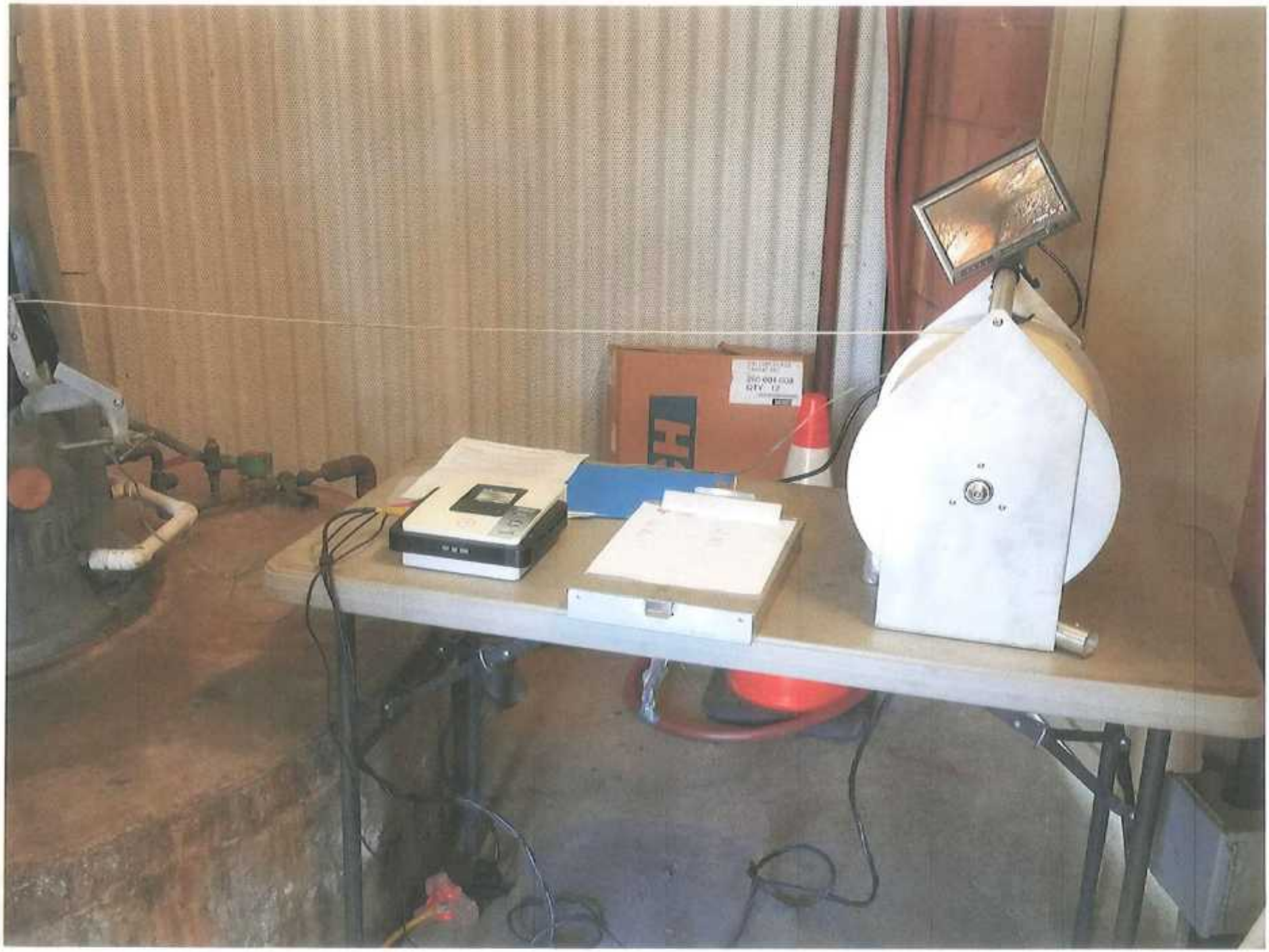

Step IV

- **Evaluate the new data along with the historical records to determine the next step.**

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Step V

- **Pull the pump.**
- **Video log.**
- **Static spinner?**
- **Zone sample?**

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Step VI

- **Determine the first process.**

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Sit down with Contractor's *experienced* engineer or geologist, the customer's staff and discuss the *options*.

The rehabilitation you choose needs to be based on your complete understanding of risk, benefits, and cost. It's our job to make sure we give you the information and a clear understanding of risk, benefits and cost.

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How much extra is it going to cost for all of this evaluation? IT'S INCLUDED!

Why would you invest so much money to hire the most talented personnel and not charge for it?

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- **Maintenance Agreements**
- **Partnership with Consultants and Water Purveyors.**
- **Best safety record in the industry.**
- **Protect our reputation in the biggest market (Southern California) in the US**
- **Being #1 in this market requires a constant investment in talent and equipment.**

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Step VII

- Team of experts meets again.
- Evaluate results.
- Continue with the step-by-step process to completion.

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"The nicest thing about not planning is that failure comes as a complete surprise, rather than being preceded by a period of worry and depression."

Sir John Harvey-Jones

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"It's not the plan that is important, it's the planning. "

Graeme Edwards

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Mechanical Cleaning Methods

- Nylon brush
- Wire brush
- Bail
- Swab, Line
- Dual Air Swab
- Airlift
- Rawhide – engine
- Development - motor

- Bore Blast
- Dry Ice
- Water Jet
- AirBurst
- Sonar Jet
- Primer Cord
- Aqua Freed

Weak

Very Aggressive

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My chemical treatment did not improve my well. Must be the chemical's fault. Do you sell a chemical that will magically seek the 10% of my blocked zones that is causing my well to not perform???

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We have a cleaning process that works for all wells, and by the way …..

We Can Fly!!!

Well Cleaning Chemicals

Acids

- Hydrochloric
- Sulfamic
- Phosphoric
- Hydroxyacetic
- Carbonic
- Citric

Additives

- Well Klean
- Nu-Well 220
- Nu-Well 310
- QC-21
- Nu-Well 410
- LaCo 60

Chlorination

- Sodium Hypochlorite
- Calcium Hypochlorite
- Chlorine Dioxide

Polymers

SeaQuest Amber Quest
SAPP (Sodium Acid Phosphate)

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Chemical Work Questions

- **What data would you like to review before prescribing your chemical *Options*?**
- **Do I need chemicals to clean my well?**
- **What chemicals would you recommend?**
- **Why did you choose that acid?**
- **How did you calculate the treatment volume?**
- **What percentage did you use and why? What additives would be beneficial and why? How did you calculate the amount? Are they NSF?**
- **Why did you not choose sulfuric, glycolic? Hydrochloric? Citric, Phosphoric?**
- **What applications warrant each of those chemicals and why?**
- **Place into the well and chase with water?**
- **Inject through a double swab (5', 10', 20')?**
- **Inject through tremie? A single swab or tight single line swab to agitate?**
- **How long do we leave the chemical in the hole without any agitation?**
- **Chemically treated water removal; what are my options?**

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Not all 80-year old wells are in great shape, so you may want to rethink your approach.

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Develop my chemical treatment based on a water sample

I sent to the lab

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When you evaluate your rehabilitation options, remember there is risk of doing nothing

1. **Corrode your casing and screen**
2. **Well collapse**
3. **Sanding**
4. **Jetting**
5. **Higher pump cost**
6. **Lower yield**

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How do you write the perfect specification for a well and pump rehabilitation?

The #1 redevelop process that needs to be used for all well redevelopments.

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Sorry, no Magic Pill !!

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Well Development.

What some sales people don't want you to know.

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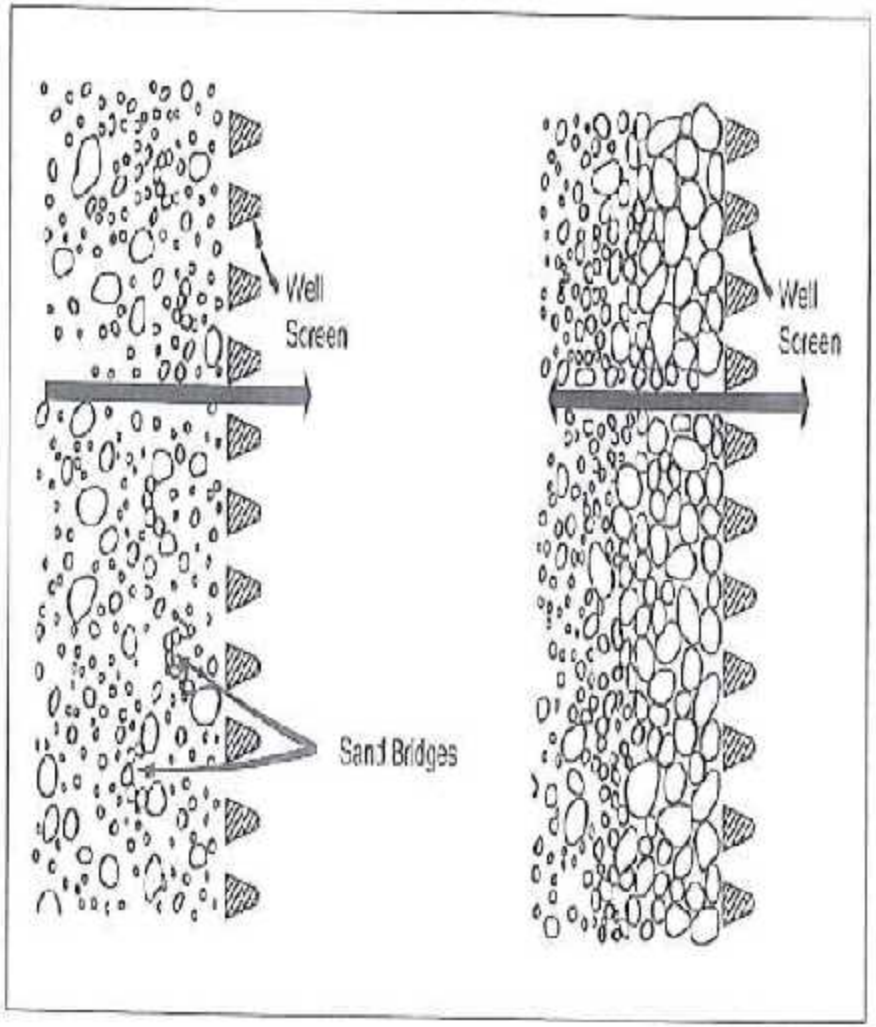

Figure 11.6. Effective development requires movement of fluid in both directions through screen openings (see right side of figure). Movement in only one direction (see left side of figure) does not produce the proper development effect.

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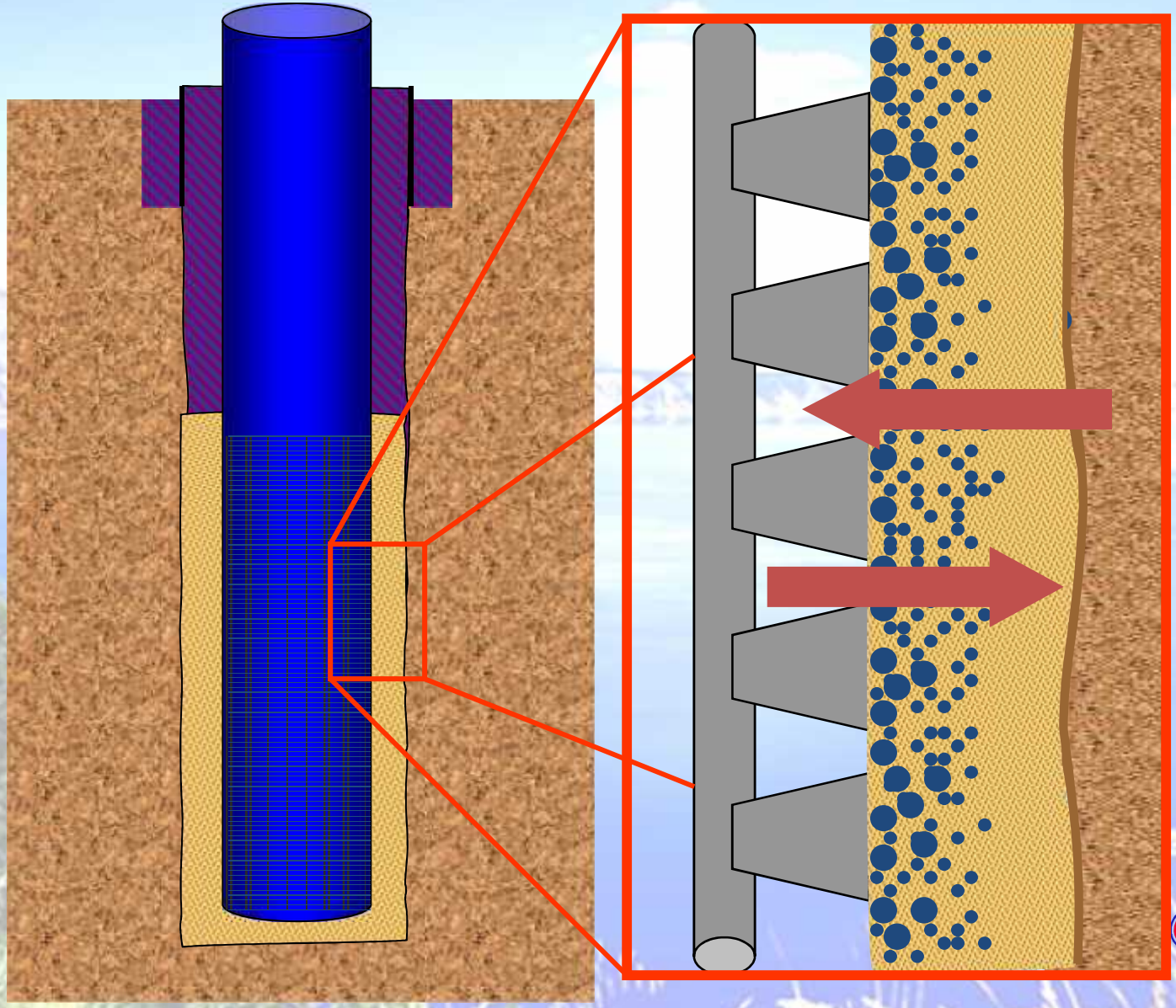
How a Well Works



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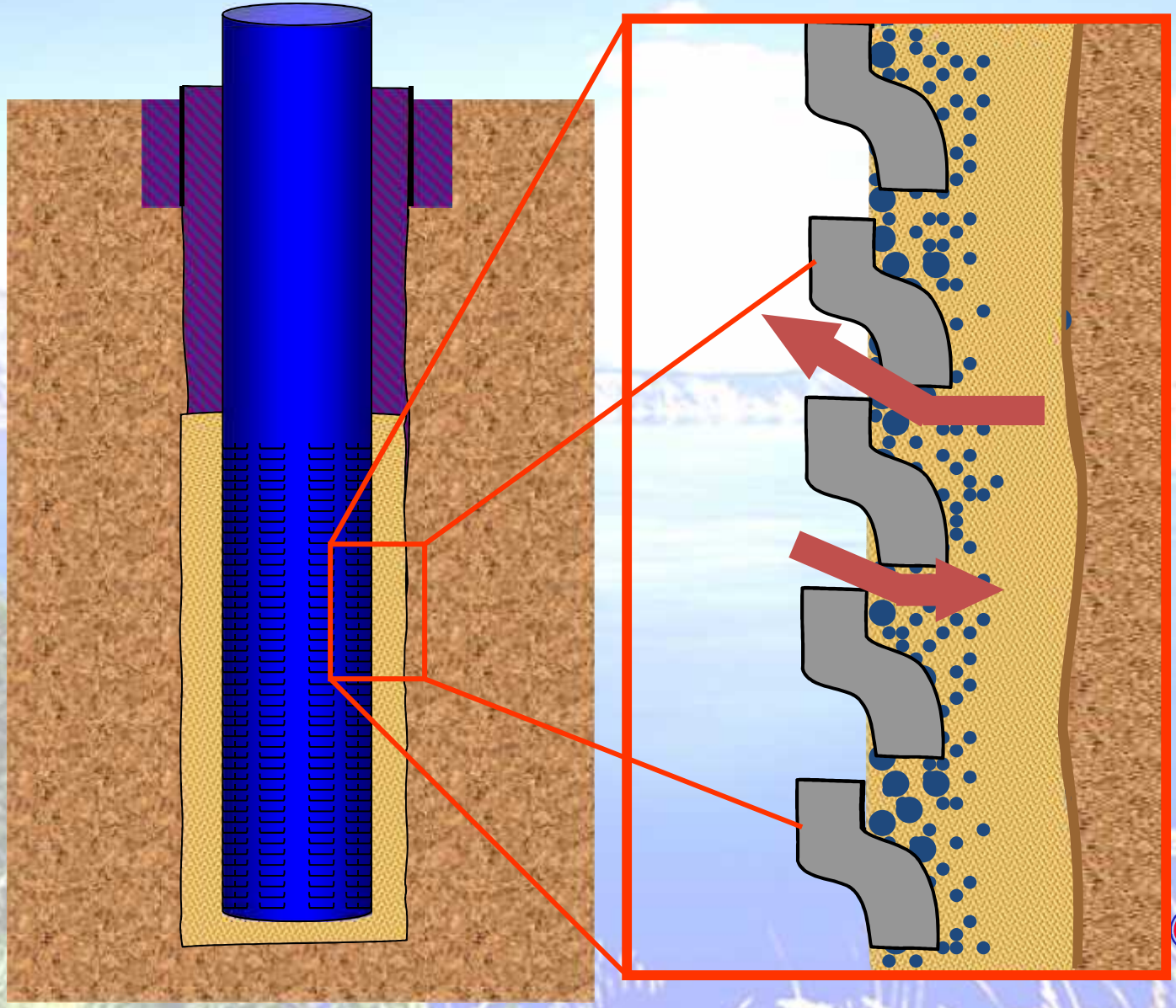
How a Well Works



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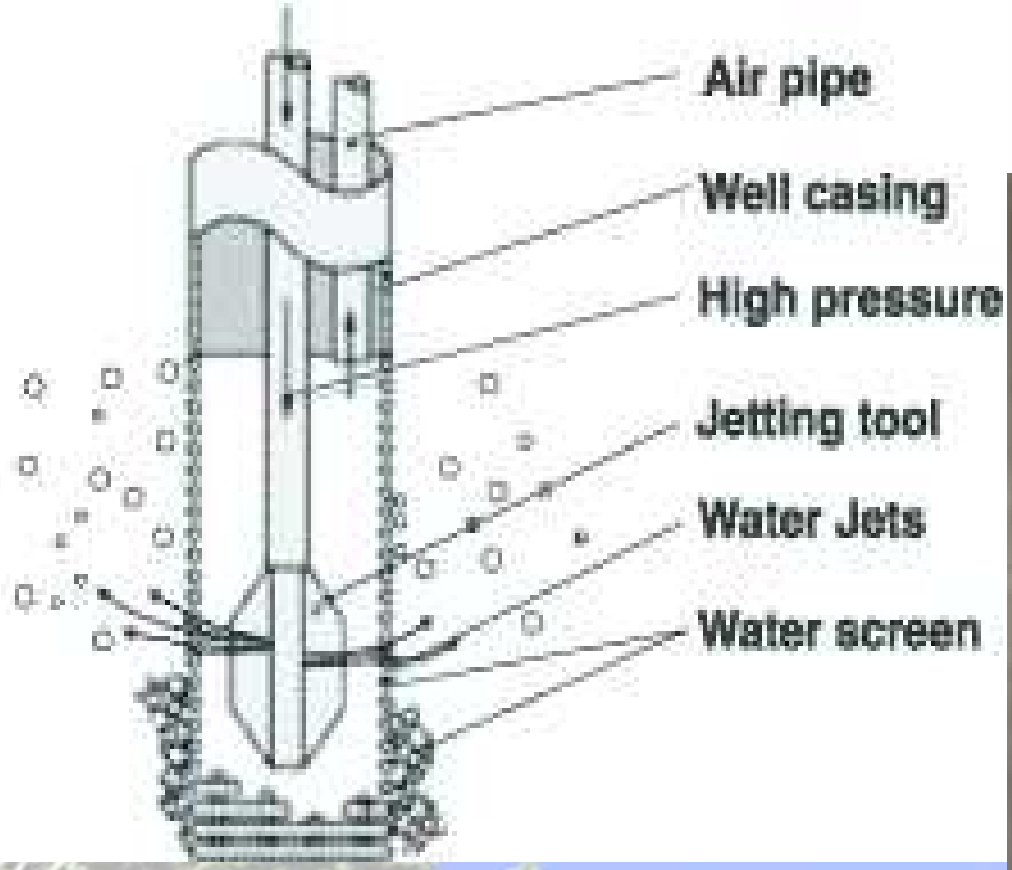
Jetting Tool



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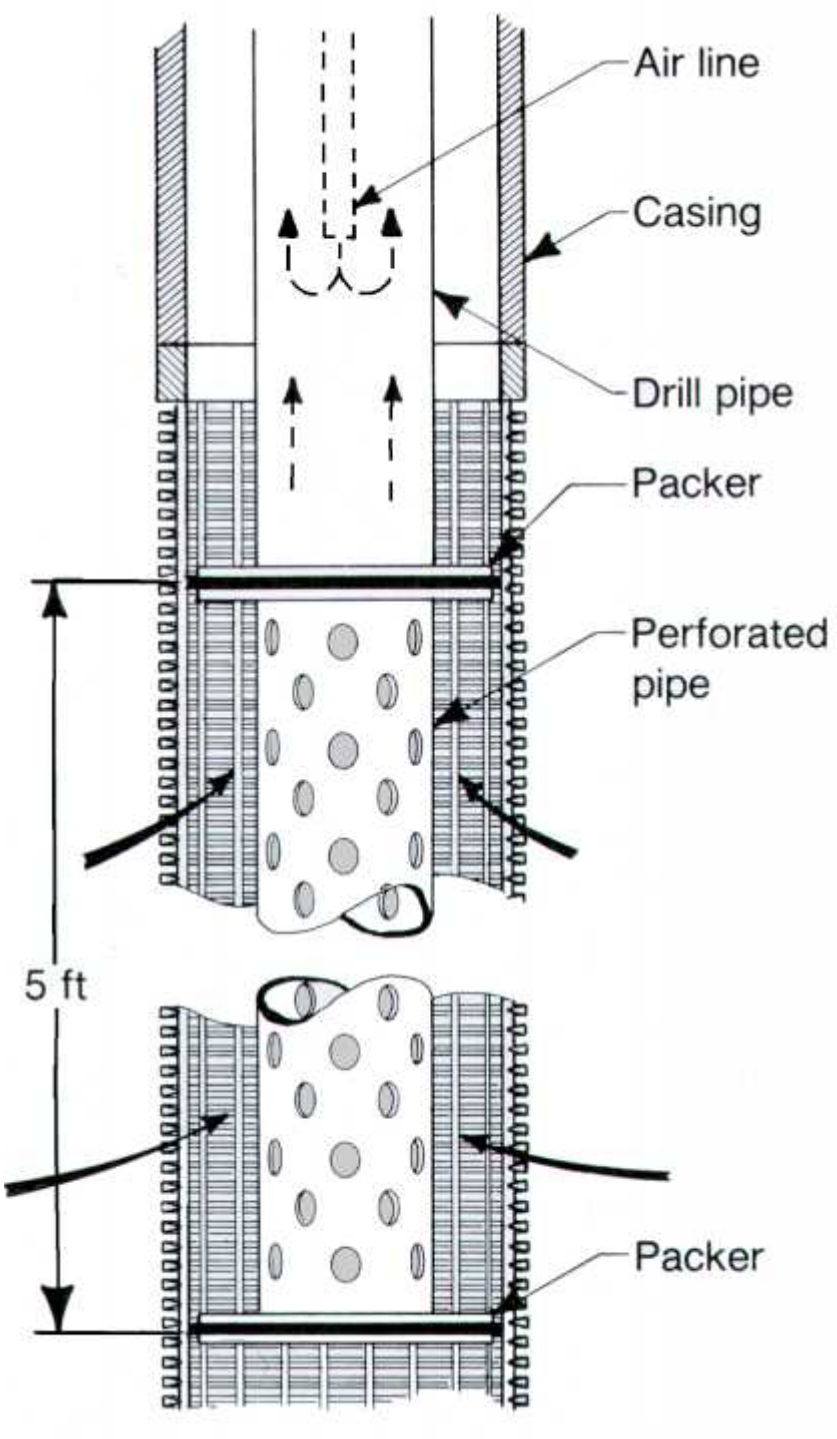

Isolation tools (i.e., dual swabs) are used to apply energy to a specific part of the aquifer and to remove sediments and materials from those areas.

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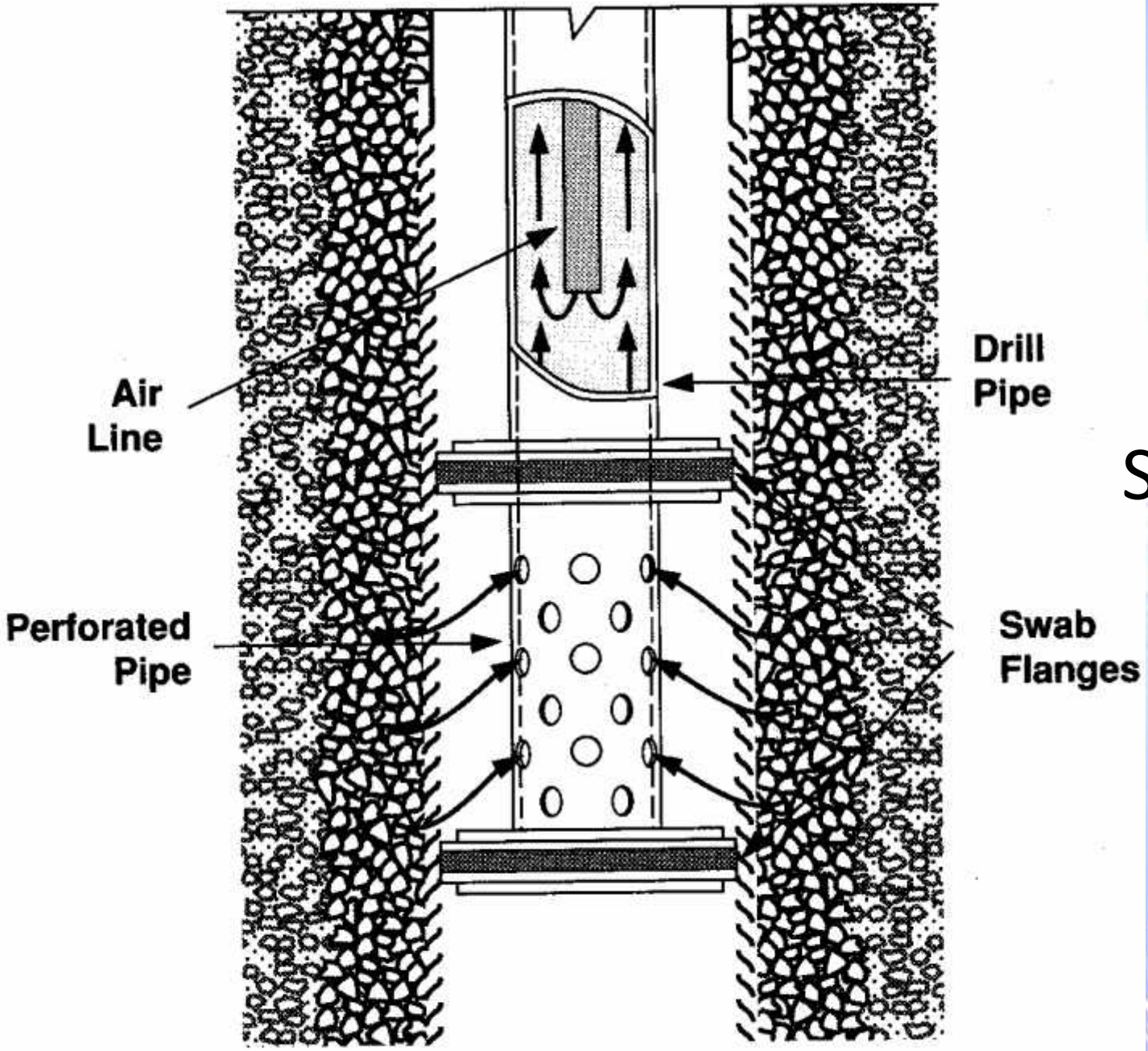

Airlift swabbing tool.

Airlift Swabbing Tool

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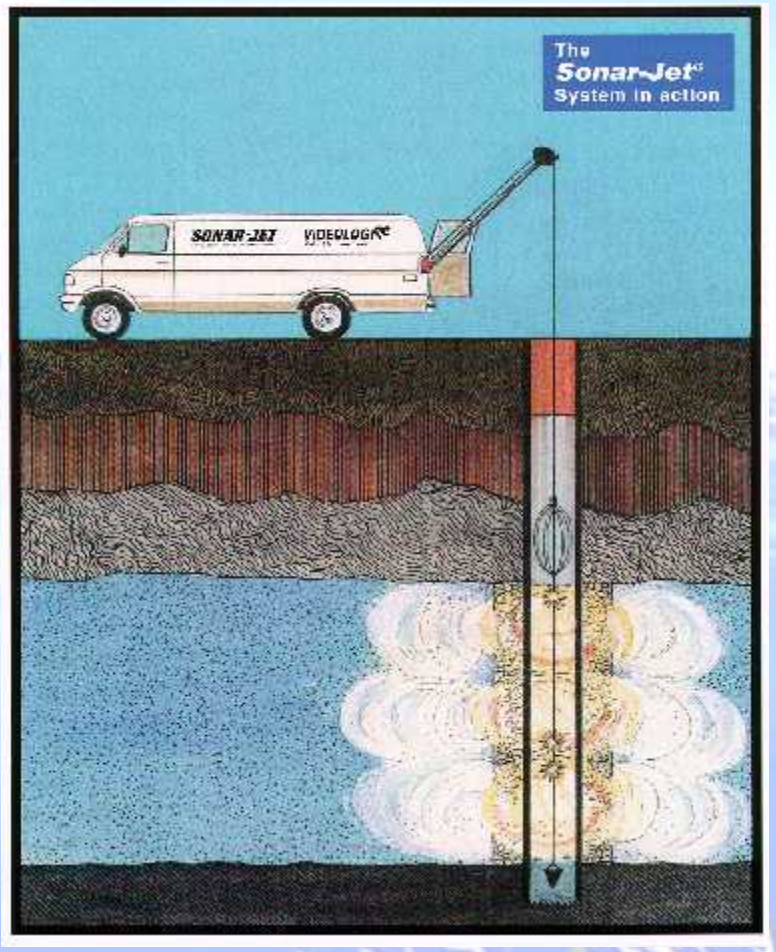
Sonar-Jet / Primer Cord

- How do they work?
- Do Sonar-Jet and Primer Cord work in the same way?
- What risks am I taking?
- How do I reduce risk without losing effectiveness?
- What well designs work best for this process?



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AirBurst® or Approved Equal

- **Air Jetting Tool**
- **AirBurst® or Water Jet**
- **AirBurst® or Boreblast®**
- **AirBurst® or Sonar-Jet®**

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Impulse Generator

The generator fires automatically once every 2-3 seconds and each burst lasts just several dozens of milliseconds.

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SECTION 11 – AIRBURST WELL DEVELOPMENT (BID ITEM NO. 5)

Scope

This work task shall consist of hydraulically stimulating with an air jet method the well screen interval to loosen the encrustation and biomass that has developed in the well screen, gravel pack, and aquifer materials in the production zone. This task will also serve to agitate and mix the chlorine disinfectant out into the surrounding area around the well screen and expose bacteria to the chemical solution.

AirBurst Materials and Method

Contractor shall clean the well using the AirBurst method (patented process no. 5,579,845). AirBurst stimulation shall be conducted utilizing progressively increasing pressures to clean and agitate (disperse) the chlorine mixture into the well screen and the surrounding gravel pack materials. AirBurst stimulation shall be conducted from the bottom of the well (approximately 1,100 feet) up to approximately 870 feet. The 230- foot screen interval shall be stimulated at one (1) shot per foot at each pressure setting. The AirBurst procedure shall consist of five consecutive passes which shall be conducted at 800 psi, 1,000 psi, 1,200 psi, 1,400 psi, and 1,600 psi. The process shall be conducted using high pressure air compressor with the minimum ratings of 3,000 psi and 15 cfm. The air gun shall have a chamber size of 40 cubic inches. It is anticipated that each pass will require approximately 1 hour to complete.

The entire process shall be conducted by a Contractor licensed in the State of California to perform this process. Contractor shall provide proof, with its bid, how it intends to perform the AirBurst portion of the work and a list of technical support equipment and personnel. Personnel involved in the AirBurst cleaning shall demonstrate proper knowledge of the work required, shall have been certified in the equipment utilized, shall have successfully treated at least 40 wells in Southern California with the AirBurst process. ***Contractor shall provide proof, with bid, verifying compliance with the training and experience requirements of this specification.***

Question: What IS AirBurst Technology?

Answer: Water Well REHABILITATION and DEVELOPMENT Process.

- Uses a small volume of compressed gas (air) that is explosively released from an airgun, which generates high intensity pressure pulses
- Pulses create high frequency vibrations
- Creates intense surging action

AIRBURST® Technology, LLC

QUESTION: HOW does AirBurst work?

Answer:

Airgun is fired.

- **Intense Vibration Is Created**

- Breaks up mineral cementation on the screen/well wall and in water bearing formation

- **Explosive Pressure Wave**

- Instantaneously created by rapidly expanding air bubble
- Air displaces water around the airgun
- Surges water against/through the screen and into the filter gravel and/or surrounding geological formation

- **Negative Pressure**

- Created when the air bubble collapses
- Draws dislodged material into the well bore for evacuation

- **Recompression**

- Occurs as the initial bubble reforms into a smaller bubble
- Causes secondary less intense pressure wave

Air is the energy source, NOT the contacting force

AIRBURST Technology, LLC

Question: What SPECIFICALLY will AirBurst do?

Answer:

- **CLEAN screen and well bore**
- **REDEVELOP gravel filter**
- **ELIMINATE sand production**
- **REMOVE neat cement**

Cleaned Well Screen and Gravel

AIRBURST Technology, LLC

Question: What else will the Process do?

Answer:

- **BREAK UP mineral cementation of gravel pack and formation**
- **REMOVE silt and fine sand from gravel pack and formation**
- **SCOUR bio-slime from screen, gravel pack and formation**
- **REMOVE sand and silt from fractures in rock wells**
- **ENLARGE & EXTEND fractures in rock wells**

AIRBURST® Technology, LLC

AirBurst Also Aids in Drilling Mud Removal

Drilling mud and iron from a 20 year old well

AIRBURST® Technology, LLC

…Experience Real Time Results

- **Pump or airlift between AirBurst cycles**
- **Airlift during AirBursting to remove huge amounts of solids**
- **Monitor pumping rate and water levels minute by minute, adjust procedures**
- **Televise well to see cleaning effect**

AIRBURST® Technology, LLC

Before AirBurst–200 GPM

Limestone Well – Wildwood, Florida

(Engineers at Test Well 75 Feet Away in Background)

AIRBURST® Technology, LLC

After AirBurst–2500 GPM

Limestone Well
Wildwood, Florida

AIRBURST® Technology, LLC

Rate Your Evaluation

- Video log inspection 5%
- Water analysis 5%
- Historical construction/redevelopment records. 10%
- Monthly pump test 20%
- Dynamic evaluation (new vs. current) 25%
- Meet with Contractor, Consultant, and Owner to discuss options 35%

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Grade Your Evaluation

0-20%	Hope you're lucky!! Suggest you fill the well with concrete and drill a new one.
20%-40%	Your odds are getting better, but you are still guessing which is dangerous!
40%-60%	Nice try! Tell your boss that the benefits outweigh the risk and update your resume to be safe.

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Grade Your Evaluation

60%-80% Now we are talking evaluation! Most quality evaluations fall in this range.

80%-100% No one will second guess your decision. You have done your homework. Your risk is as low as it can be and then you will be cost-effective.

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Questions and Comments

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Serving the Water Industry for Over 60 Years

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934 Verdulera Street
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