WELL REHABILITATION IN ALASKA'S BUSH COUNTRY: TECHNIQUES TO IMPROVE WELLFIELD PRODUCTIVITY

2019 PNWS-AWWA

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CASE STUDY
KING COVE, ALASKA

01 **Project Background**

02 **Well Problems**

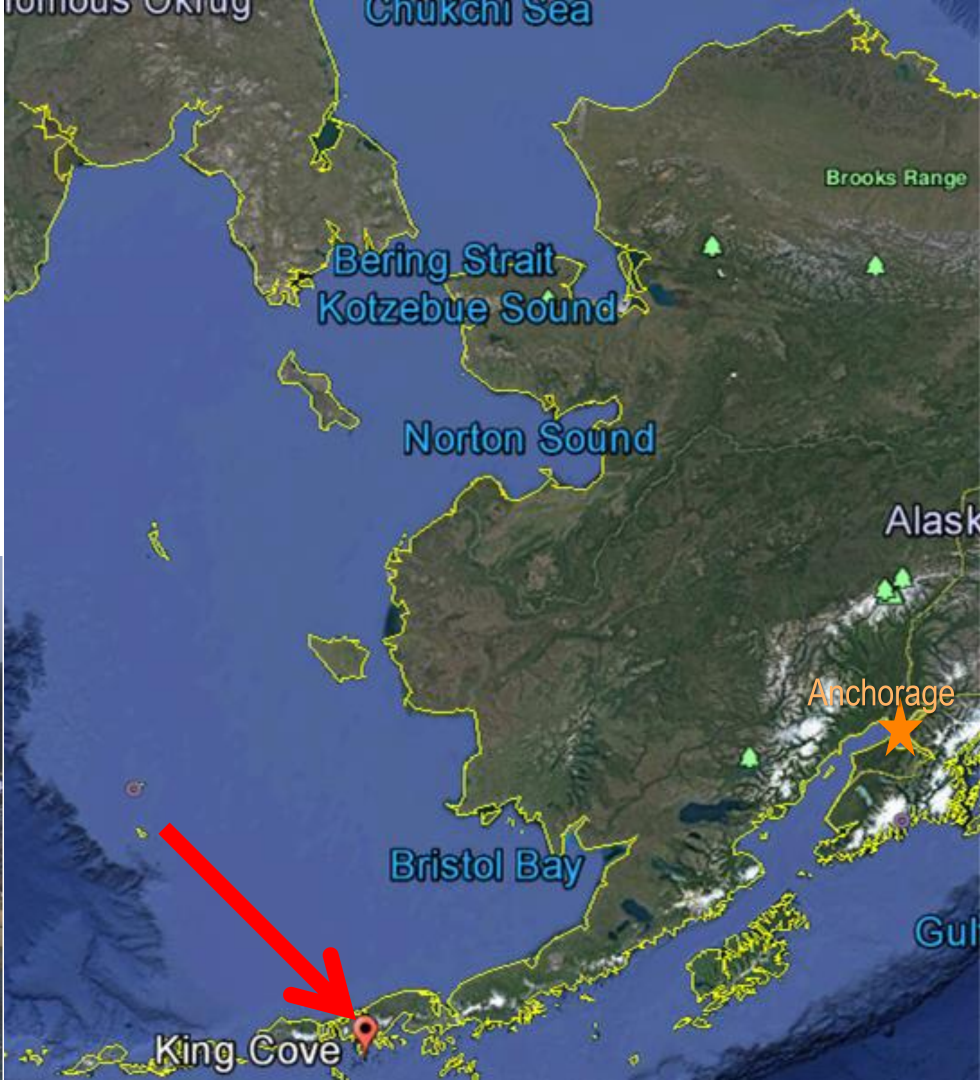
03 **Diagnostic Techniques**

04 **Well Rehabilitation**

05 **Key Points**

PROJECT BACKGROUND

- King Cove, Alaska
- Remote location on Alaska Peninsula



PROJECT MOTIVATION

- 5 well system
- Original production capacity – 1.0 MGD
- Capacity pre-rehabilitation – 0.7 MGD
- Increasing demand

Well	Well 2	Well 6	Well 8	Well 9	Well 16
1996-1999 Pumping Rates (gpm)	100	300	100	100	100
Pumping Rate in June 2017 before Rehabilitation (gpm)	130	30-50	0	NA	10

OPTIONS TO INCREASE SUPPLY

Alternative	Rehabilitation	5 New Wells
Cost	$170,000	$1,800,000
Time Required	5 months	1 - 2 years
Advantages	• Lower cost • Short time frame	• Potentially more production capacity • Potentially better water quality
Disadvantages	• May not fully restore production capacity • Rehabilitation may be needed again in 10 - 20 years • Continue to require water treatment for iron and manganese	• Higher cost

WELL PROBLEMS

Causes of deterioration

- Decline in yield
  - Dewatering
  - Pump wear or impeller detachment
  - Plugging/encrustation
- Failure
  - Corrosion
  - Subsidence/earthquake
  - Improper installation
- Water Quality Decline
  - Biofouling
  - Contamination
  - Corrosion

CORROSION

- Screen slot enlargement
  - Sanding
- Strength reduction
  - Collapse of well screen or casing
- Re-deposition of corrosion products
  - Screen blocking
- Decrease in water quality

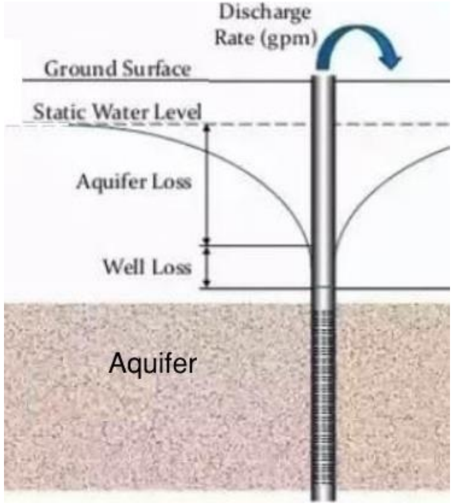
- Depends on:
  - pH
  - Redox conditions
  - Hydrogen sulfide

PLUGGING/ ENCRUSTATION

- Deposition on screen, sand pack, or formation
- Precipitation of minerals: calcium or magnesium carbonates, ferric or magnesium hydroxides, sulfate salts, manganese oxide
- Depends on:
  - Turbulence
  - Oxygen entrainment
  - Microbial oxidation
- Deposition of fines
  - Failure to develop
  - Improper filter pack gradation
  - Improper screen size

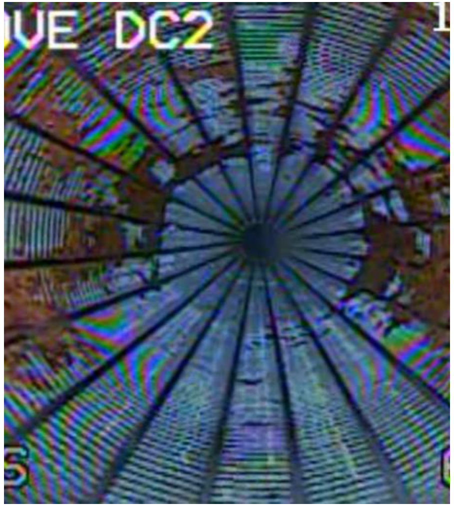
IDENTIFYING THE PROBLEM

Diagnostic Techniques



Pumping Tests – Specific capacity

Visual Inspection – Inspection of column pipe and pumps



Visual Inspection - Video logging

Sample Collection – Mineral scale and water

CAUSES OF WELL YIELD DECLINE

- **VISUAL INSPECTION**: Formation of biological slime and mineral encrustation

- **SCALE MINERAL ANALYSIS**:

Well 9 – deposits of manganese

Wells 2, 6, 8, 16 – deposits of iron, manganese, calcium and decomposed organic matter (biological slime)

- **WATER QUALITY ANALYSIS**:

High Iron: Wells 2, 8, 9, 16

High Manganese: Wells 2 and 9

High Calcium: Wells 2, 6, 9, 16

Parameter	Units	LOQ /CL	Detect. Limit	Drinking Water Std[1]	Delta Creek Wells				
					2	6	8	9	16
					6/14/17	6/14/17	6/13/17	6/13/17	6/13/17
Metals (Dissolved)*									
Calcium	µg/L	500	150	N/A	10800	10100	4370	94700	11400
Iron	µg/L	250	78	300	***582***	U	***386***	***896***	***764***
Manganese	µg/L	1	0.31	50	***60***	14.3	47.6	***913***	24.8

TREATMENT PLAN

- Scale and water quality analysis to determine chemistry
- Amount of chemicals dependent on water volume in well
  - Depth to water
  - Casing diameter
- Field procedure

DavidTHansonAssociates

Field Procedure-Revised

To: HDR, John Koreny	**From:** Dave Hanson	**Date:** July 6 ,2017	**Project:** King Cove AK Wells #8, 9, & 16

Comments: We did an analysis of sludge which determines the likely plugging in the screen is due to Electrolysis as a corrosion byproduct. This plugging requires a Muriatic or hydrochloric acid and Unicid Catalyst combination to dissolve. The calculations recommended are based upon these concentrations. To simplify treatment, I used the dimensions from Well #9. I'm assuming #8 is similar in total depth and static. If you have any questions before/during this treatment, please call. Thank you.

Well #	Well Information Screen or bore hole info	Initial Treatment Product recommended
	8” dia, 85’ total depth - 25’ static = 60’ water column or 156 gal H2O	HCl: 50% of total volume = 80 gal 5% Unicid Catalyst: 0.13 gal/ft x 60’ = 8 gal

Total Chemistry recommended

HCl: 80 gallons

Unicid Catalyst: 8 gallons total for the well. **NOTE: These are recommendations PER WELL.**

Recommended Field Procedure for cleaning the well

Step 1 **Physical Cleaning:** If cleaning the pump, call for recommendations. Pull pump. Wire brush the casing/screen to bottom of well 4-5 times. Use an 8" Steel WireHog Casing Brush to the top of screen. Then use a 6” steel WireHog Casing Brush to the bottom. When done brushing, airlift from the bottom of the well and divert to a tank for disposal if required. NOTE, if using air lifting for development, leave this brush assembly 3’ off the bottom for development (Step 3).

Step 2 **Installing chemistry:** IF < 200’ water: Pour 70 lbs of HCl into the well from surface, followed by 8 gal gal of Catalyst.

Step 3 **Development:** Start development immediately. **BEST OPTION:** Use a surge block but operate in the screen area only. A block speed of 2-3’/second is important to gain velocity through the screen. Start at the bottom of the well screen and work upwards in 3’ or 5’ increments spending 15 minutes per increment. When reach the top of screen, repeat this procedure for 2.5-3 hours. Monitor pH/color with a bailer within the middle portion of the screen. Note: this option may be difficult without a cable tool rig. Use a 6” surge block. Airlift debris when when done. If debris enters into the screen, you can bail to determine if debris or sand/silts. **OPTION:** Air lift the chemistry from the bottom of the well upwards without blowing chemistry out of the well. Use a simple quick release gate valve on the air line to the well. Shut this gate valve, engage the air, and when chemistry reaches 7-10’ from surface, shut the air off from the compressor and open this gate valve releasing pressure from this line. Chemistry will fall for two directional development. Repeat for 3 hours. Monitor chemistry with a ball check bailer from the bottom of the well. See Monitoring. Note, in a 10’ long screen, this type of development has a tendency to allow acidic flow out into the aquifer in areas of an open screen and may not be as effective as the localized development of a surge block.

TREATMENT PROCESS

Removal of Pump and Pipe

Brushing

Developed with air + Airlift debris from well

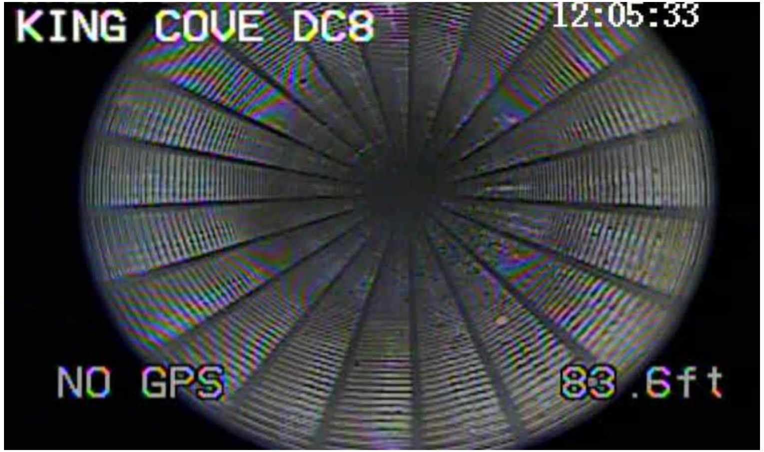
Chemical Treatment

CHEMICAL TREATMENT

- Specified chemicals were applied to the well based on scale analysis
  - Blended treatment – “Unicid”
  - HCl
- Amount of chemicals dependent on water volume in well
- Monitor pH

TREATMENT PROCESS (CONTINUED)

- Clean pump
- Video Inspection
- Reinstallation
- Disinfection



CHECK YOUR WORK – PUMP TESTS

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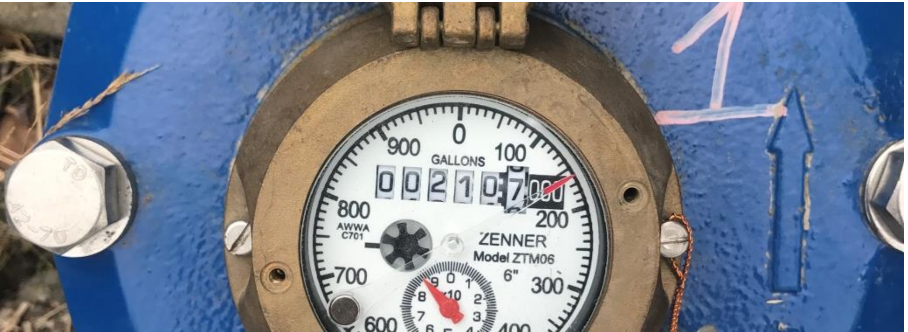
1996-1999 Pumping Rates (gpm)	100	300	100	100	100
Pumping Rate in June 2017 before Rehabilitation (gpm)	130	30-50	0	NA	10
Pump Test Rate (gpm)	109	150	100	180	107
Estimated Future pumping Rate (gpm)	250-320	160	70	180	90

After Rehab



LESSONS LEARNED

- Planning and teamwork are key
- Beware – the bear!

KEY TAKE-AWAYS

- Well rehabilitation is generally cost effective and extends the operating life of a well
- Keep good records
  - Well details (design, completion)
  - Operating history (water levels, discharge rate, efficiency)
  - Maintenance history (pump replacement)
- Appropriate treatment for the well
- Don’t wait too long (extensive and hardened mineralization)

THANK YOU

ACKNOWLEDGEMENTS

- City of King Cove Staff
- Wheaton Water Wells
- David Hanson, David T Hanson Associates

Citations:

Ministry of the Environment. Flowing Artesian Wells. ISBN 978-0-7726-7034-2. http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/flowing_artesian_wells.pdf

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QUESTIONS?

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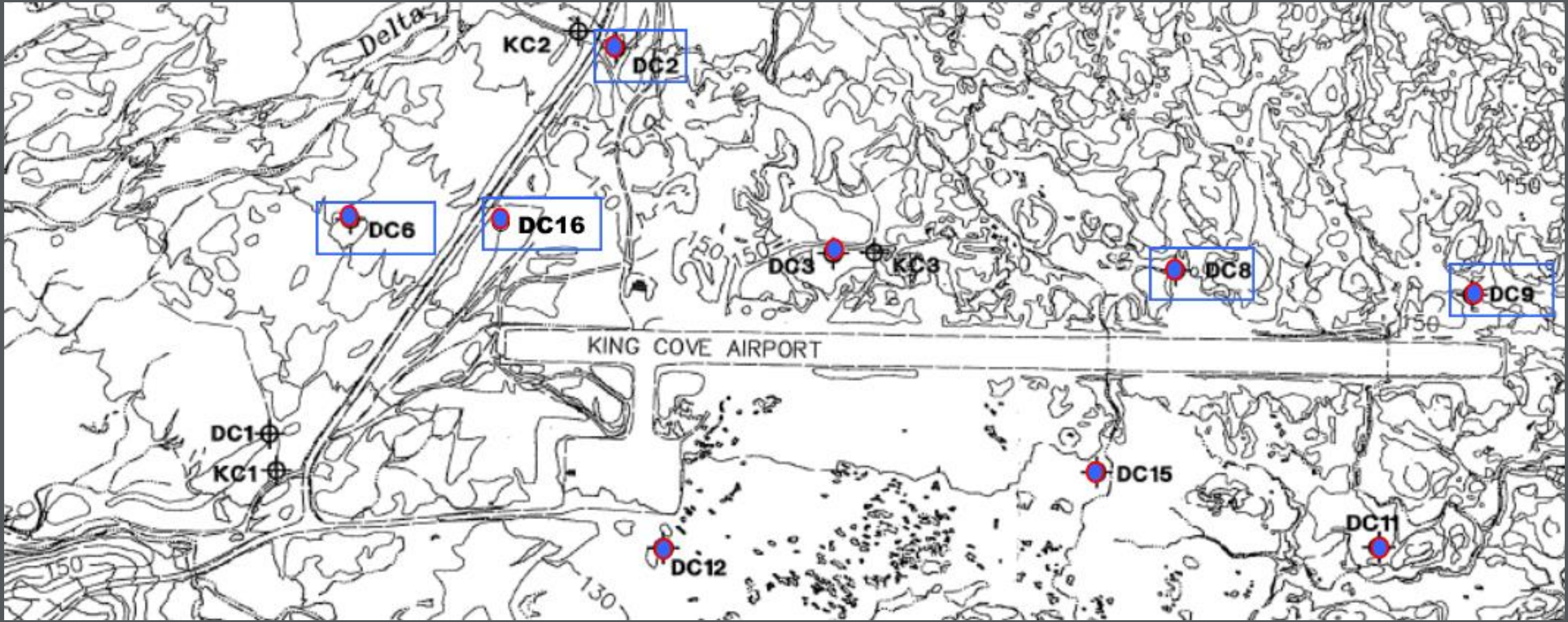
SUPPORTING SLIDES



AREA TOPOGRAPHY MAP

ESTIMATING PUMPING RATE

Well	Well 2	Well 6	Well 8	Well 9	Well 16
Groundwater Levels and Pumping Rates During Pump Tests					
Static Depth to Groundwater, October 2017 (feet)	36.06	15.04	48.42	42.13	20.72
Pumping Test Flow Rate (gpm)	109	150	100	180	107
Duration of Pumping Test (hrs:min)	23:31	24:32	57:53	23:09	24:18
Maximum Depth to Groundwater During Pumping (feet)	40.85	30.35	64.58	59.13	45.97
Maximum Groundwater Drawdown During Pumping (feet)	4.79	15.31	16.16	17.00	25.25
Time to Achieve Maximum Drawdown (hrs:min)	23:31	23:42	57:53	23:09	23:27
Depth to Top of Well Screen (feet btoc)	64	47	71	76	65
Available Drawdown (feet) = 0.5 * (Depth to Top of Screen-Static Groundwater Depth)	14.0	16.0	11.2	16.9	22.1
Specific Capacity (gpm/foot drawdown)	22.76	9.80	6.19	10.59	4.24
Future Estimated Well Pumping Rates					
Estimated Max. Long-Term Pumping Rate (gpm) = Specific Capacity x Available Drawdown[1]	250 to 320[2]	160	70	180	90

REHABILITATION VS. REPLACEMENT

Alternative Name	Option 1 Rehabilitation of Wells 2, 6, 8, 9 and 16	Option 2b 5 New Wells
Description	Mechanical and chemical treatment to remove encrusted minerals from well screens and improve production	Construction of five new wells, 2,500 feet of conveyance pipeline.
Potential Supply (gpm)	Up to 600 gpm assuming full rehabilitation, not including well 9 (poor water quality)	1,000 gpm (assuming 200 gpm per well)
Cost	$42,000 for Phase I Up to $121,000 for Phase II (City can self perform some work if desired) $163,000 total.	$1,800,000
Time Required	2-4 months	1-2 years
Probability of Success	Medium to High	Medium to High
Reliability of Supply	Medium to High (rehabilitation likely required again in 10 to 20 years)	High (assumes better water quality)
Advantages	• Lower cost compared to other options. • Short-time frame, easy to implement for summer 2017.	• Same as Option 2a, but more supply capacity.
Disadvantages	• There is a risk rehabilitation may not fully restore production capacity. • Rehabilitation may be needed again in 10 to 20 years if wells encrust again. • Water treatment will continue to be required for high iron and manganese concentrations in these wells.	• Higher cost.

REPLACEMENT COST BREAKDOWN

Item	Unit	Unit Cost	5 Well Option 5 Wells @ 200 gpm each = 1,000 gpm Quantity	Total
Mob/demob drill rig	LS	$76,000	1	$76,000
Access road, rough[1]	LF	$20	2500	$50,000
10" x 120' steel cased well, surface seal, 20' ss screen	EA	$45,000	5	$225,000
Permanent sub pump 200 gpm	EA	$5,700	5	$28,500
Pitless adaptor	EA	$2,500	5	$12,500
Drop pipe and wire, 100' per well	FT	$65	500	$32,500
Conveyance pipe (HDPE)	LF	$30	2500	$75,000
Control wiring	LF	$20	2500	$50,000
New Booster Pump	EA	$75,000	1	$75,000
Booster Pump Control Integration	LS	$50,000	1	$50,000
Controls/Electrical Shed at Well	EA	$5,000	5	$25,000
Well Pump Controls at WTP	LS	$30,000	1	$30,000
Modifications at WTP[2]	LS	unknown	0	unknown
Subtotal Well Drilling				$301,000
Well Drilling Contingency @ 15%				$45,150
Total Well Drilling				$346,150
Subtotal Construction				$428,500
Construction Contingency @ 25%				$107,125
Total Construction				$1,227,925
Professional Engineering Services				
Wells				$150,000
Engineering Design				$75,000
Project Grand Total				**$1,799,075**
Project Grand Total (Rounded)				**$1,800,000**

SUMMARY OF PROBLEMS AND CAUSES

- Pumping water level decline – reduced hydrodynamic efficiency in well, or regional water level declines or well interference
- Lower specific capacity – drop in puping water level (increased drawdown) or pumping yield reduction
- Lower or insufficient yield – dewatering, caving in of major fracture or water bearing zone, insufficient development, pump wear, perforation of column pipe, or increased total dynamic head in delivery system
- Lower efficiency – usually a pump problem (wear, corrosion, inadequate power supply)
- Complete loss of production – dewatering, plugging, subsidence, collapse, pump failure
- Sand or silt pumping – open borehole, leakage in casing, problems with filter pack, enlarged screen openings
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