# Water Quality Monitoring in the Distribution System

91st Annual

Water & Wastewater Operators School

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# Why Monitor?

- KDHE regulations
- Build a “fingerprint” of the system
- Maintain quality of drinking water
- Determine problems and find solutions quickly
- Ensure water safety for consumers

# Sampling Requirements

- Population based
- Sites are representative of the distribution system
- Sample commercial and residential

Monitoring the distribution system allows us to determine if the finished water meets standard, or has been compromised.

Tests include:
- pH
- Turbidity
- Total Residual Chlorine
- Ammonia
- TOC
- IC Scan
- Metals
- Total Coliform / Ecoli

# Sample Collection

One of the most common causes of error in water quality analysis is improper sampling.

# Accurate Sampling

- Collect samples that accurately represent the water quality.
- Analysis results only show what is present in the sample.
- Useful results come from useful samples.

# Unacceptable Sampling Containers

# Acceptable Sampling Containers

# Sampling Procedure

- Remove aerator if present and are able to do so
- Turn COLD water on full stream
- Allow water to run 3-5 minutes to flush the line
- Open labeled sampling containers carefully so no contamination is introduced
- After specified time, turn flow down and fill labeled sample containers
- Seal containers
- Record time, date and location of sample
- Transport to the lab within a cooler

# Field Testing

- pH
- Turbidity
- Chlorine

# Transportation

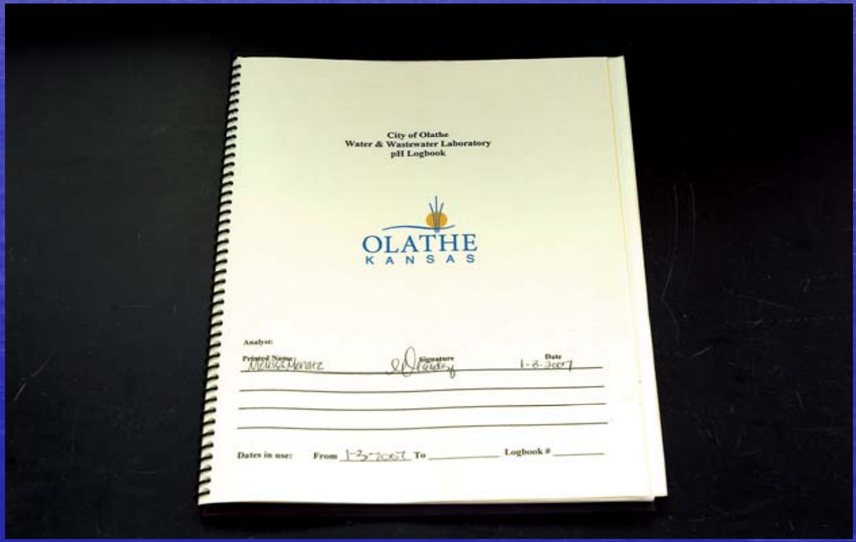

- Samples must be chilled to 4.0°C
- Samples must be transported on ice

# Transport Time

- Samples must be transported within 30 minutes to minimize sample degradation
- Some sample holding times are very short!

# Analysis

- All results are recorded in a bound logbook using black ink
- No results are recorded on scrap paper
- No results are recorded using pencil
- If a mistake is made, draw a single line through and initial



Data generated must be able to be re-created and legally defensible

# What to Look at and Why…

# What is pH

In chemistry, **pH** is a measure of the acidity or basicity of a solution. It approximates but is not equal to **p[H]**, the negative logarithm (base 10) of the molar concentration of dissolved hydronium ions ($H_3O^+$); a low pH indicates a high concentration of hydronium ions, while a high pH indicates a low concentration.

# Why pH?

- Determines efficiency of treatment process
- Indicates changes in water quality
- Part of USEPA Lead and Copper Rule
- Helps determine if water is corrosive (stability)

# What is Turbidity

**Turbidity** is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye. The measurement of turbidity is a key test of water quality.

# Why Turbidity?

- High turbidity is health hazard
- Consumers distrust turbid water
- Monitor quality for compliance with drinking water standards
- Turbid samples can be carriers for contaminants or biological species

# What is Chlorine

**Chlorine** (pronounced *KLOR-een*, from the Greek word 'χλωρός' (*khlôros*, meaning 'pale green'), is the chemical element with atomic number 17 and symbol **Cl**. It is a halogen, found in the periodic table in group 17. As the chloride ion, which is part of common salt and other compounds, it is abundant in nature and necessary to most forms of life, including humans. In its elemental form ($Cl_2$ or "dichlorine") under standard conditions, chlorine is a powerful oxidant and is used in bleaching and disinfectants, as well as an essential reagent in the chemical industry. As a common disinfectant, chlorine compounds are used in swimming pools to keep them clean and sanitary

# Why Total Residual Chlorine?

- Ensure continued disinfection of water in the distribution system
- Ensure chlorine doses are not excessive

# What is Ammonia

**Chloramine** (monochloramine) is an inorganic compound with the formula $NH_2Cl$. It is a colourless liquid at room temperature, but it is usually handled as a dilute solution where it is used as a disinfectant. The term chloramine also refers to a family of organic compounds with the formulas $R_2NCl$ and $RNCl_2$ (R is an organic group). Dichloramine, $NHCl_2$, and nitrogen trichloride, $NCl_3$, are also well known.

# Why Ammonia?

- Chloraminate water
- Disinfection parameter

# TOC Analysis

- Determines Total Organic Carbon
- Spikes in results can show if organic material was dumped
- Regulatory compliance for TOC removal

# What is TOC

**Total organic carbon (TOC)** is the amount of carbon bound in an organic compound and is often used as a non-specific indicator of water quality or cleanliness of pharmaceutical manufacturing equipment.

A typical analysis for TOC measures both the total carbon present as well as the so called "inorganic carbon" (IC), the latter representing the content of dissolved carbon dioxide and carbonic acid salts. Subtracting the inorganic carbon from the total carbon yields TOC. Another common variant of TOC analysis involves removing the IC portion first and then measuring the leftover carbon. This method involves purging an acidified sample with carbon-free air or nitrogen prior to measurement, and so is more accurately called non-purgeable organic carbon (NPOC).

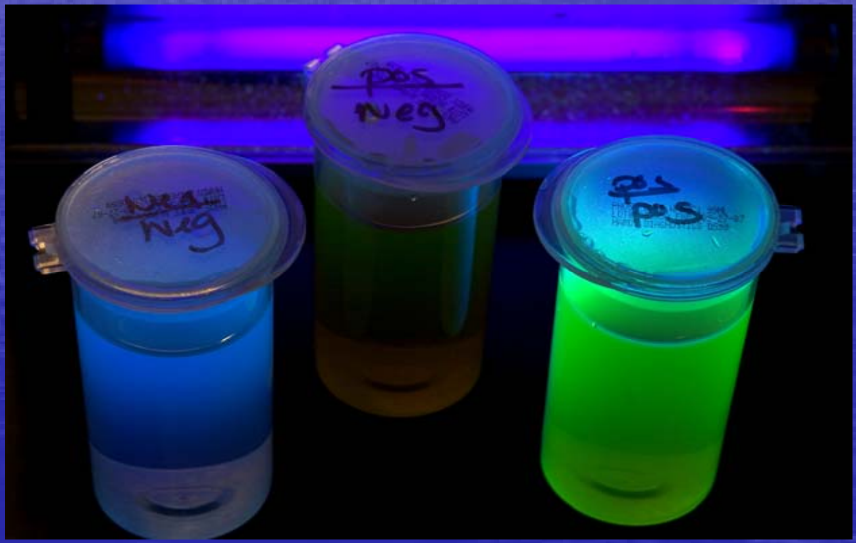
# Ion Chromatography

- Test for Fluoride, Chlorite, Chloride, Nitrite, Nitrate, o-Phosphate, Sulfate
- Monitors fluoride levels within the distribution system
- Determines if nitrification is occurring in the system
- Used as a fingerprint

# ICP

- Scan for metals in the sample
- Determine hardness (Calcium, Magnesium)
- Determine Iron
- Determine Manganese
- Fingerprint of system
- Comply with USEPA Lead and Copper Rule

# Total Coliform

# Why Total Coliform?

- Ensure proper disinfection
- Ensure no biological growth
- Compliance with Total Coliform Rule

# What is Total Coliform

***Coliform is the name of a test adopted in 1914 by the Public Health Service for the Enterobacteriaceae family. It is the commonly-used bacterial indicator of sanitary quality of foods and water. They are defined as rod-shaped Gram-negative non-spore forming organisms. Some enteron forms can ferment lactose with the production of acid and gas when incubated at 35-37°C. Coliforms are abundant in the feces of warm-blooded animals, but can also be found in the aquatic environment, in soil and on vegetation. In most instances, coliforms themselves are the cause of many nosocomial illnesses, they are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Fecal pathogens include bacteria, viruses,or protozoa and many multicellular parasites***

# What is Ecoli

E***scherichia coli*** (commonly abbreviated ***E. coli***; pronounced /□ɛʃɨˈ rɪkiə □koʊlaɪ/, named after Theodor Escherich) is a Gram negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms (endotherms). Most *E. coli* strains are harmless, but some, such as serotype O157:H7, can cause serious food poisoning in humans, and are occasionally responsible for product recalls. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K2, and by preventing the establishment of pathogenic bacteria within the intestine.

*E. coli* are not always confined to the intestine, and their ability to survive for brief periods outside the body makes them an ideal indicator organism to test environmental samples for fecal contamination. The bacteria can also be grown easily and its genetics are comparatively simple and easily manipulated or duplicated through a process of metagenics, making it one of the best-studied prokaryotic model organisms, and an important species in biotechnology and microbiology.

*E. coli* was discovered by German pediatrician and bacteriologist Theodor Escherich in 1885 and is now classified as part of the Enterobacteriaceae family of gamma-proteobacteria

# Total Coliform Results

# Improving Water Quality

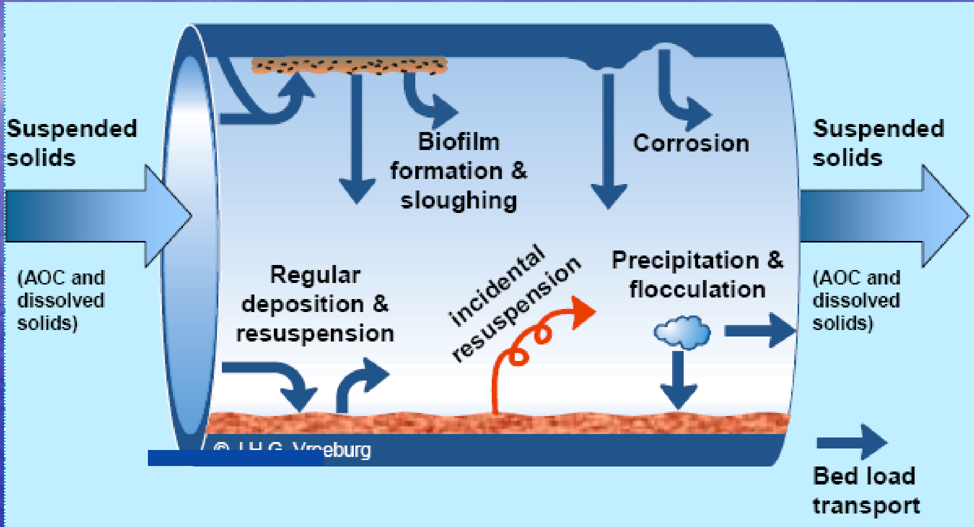
# A Utility Needs a Flushing Program to Improve Water Quality, and Reduce Operating Cost

Aging Pipes

- Biofilm build-up
- Water Corrosivity
- Sediments and deposits

RESULTS

- Increased Pumping costs
- Increased pipe roughness
- Reduction in effective diameter
- Reduction in hydraulic capacity
- Increase in taste and odor problems
- Increased chlorine degradation rate




Particle-related processes in drinking water networks. The incidental resuspension of accumulated particles is the core of the discolouration problem

# Adopting A Proper Flushing Program Will Result in Significant System Improvements and Cost Savings

- Maintains distribution system water quality
  - Restores disinfectant residual
  - Reduces disinfectant demand
  - Reduces bacterial growth
  - Dislodges biofilms
  - Removes sediments and deposits
  - Restores flows and pressures
  - Eliminates taste and odor problems
- Other reasons for Flushing
  - Increases system understanding for staff
  - Identifies missing/broken valves/hydrants
  - Leverages model/GIS investment
  - Corrosion control

# Three Main Flushing Strategies Identified

**Stagnant Area Flushing**

Preventive and short-term measure. Used in areas with longer detention times – dead ends & low demand areas

**Spot Flushing**

Reactive. Used when there are local water quality complaints

**System-wide Flushing**

Preventive and long-term measure. Comprehensive and maintains water quality and useful life of the pipes.

# Unidirectional Flushing is the Most Comprehensive Form of Flushing

**Types of Flushing**

- Conventional Flushing
- Continuous Blow-off
- Unidirectional Flushing - UDF

**For Success flushing velocity must be adequate ! ! ! ! ! !**

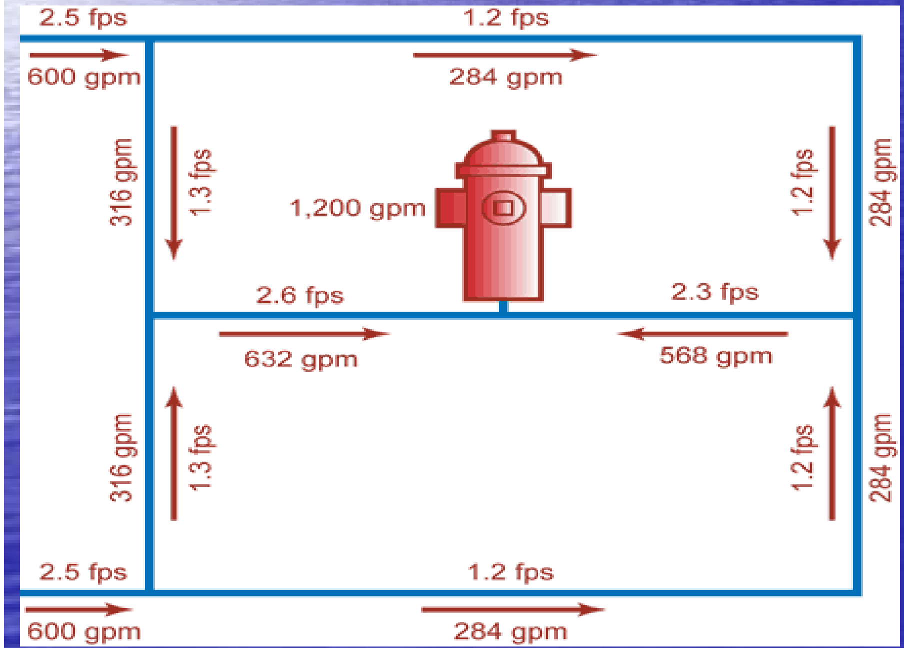
# What is Unidirectional Flushing or UDF?

**UDF - the sequential closing of system valves and opening of hydrants to obtain adequate pipe velocities to flush debris, dirty/discolored water from the system**

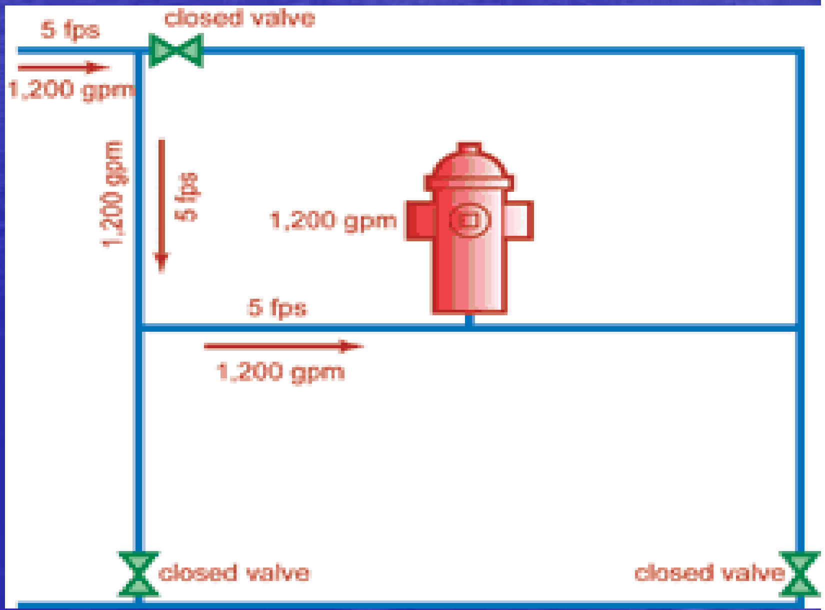
# UDF Uses up to 40% Less Water than conventional Flushing, and Allows for a Better Response to Localized Water Quality Complaints

- Water from all directions
- Low flow velocities
- Less scouring
- Don't control flushing directions

- Water channeled
- Higher flow velocities
- More scouring and better cleaning
- Systematic valve operation




Conventional Flushing




Unidirectional Flushing

# UDF Results Summary

| Sequence | Color (mg/L Pt-Co) | | Iron (ug/L) | | Turbidity (NTU) | | Reduction (%) |
|---|---|---|---|---|---|---|---|
| | Before | After | Before | After | Before | After | |
| 4 | 304 | 62 | 6241 | 1892 | 19.40 | 4.97 | 74.4 |
| 7 | 180 | 26 | 1926 | 296 | 14.80 | 5.16 | 65.1 |
| 9 | 75 | 13 | 1053 | 124 | 14.60 | 2.68 | 81.6 |
| 11 | 179 | 9 | 4120 | 94 | 36.00 | 1.03 | 97.1 |
| 12 | 213 | 10 | 3790 | 73 | 39.60 | 0.57 | 98.6 |
| 14 | 276 | 10 | 8649 | 124 | 56.60 | 0.49 | 99.1 |
| 18 | 172 | 21 | 4744 | 331 | 42.30 | 4.25 | 90.0 |

# Water Quality Sampling

- Each hydrant was sampled at the start and finish of each flushing sequence
- The City's Laboratory performed all the water quality analysis

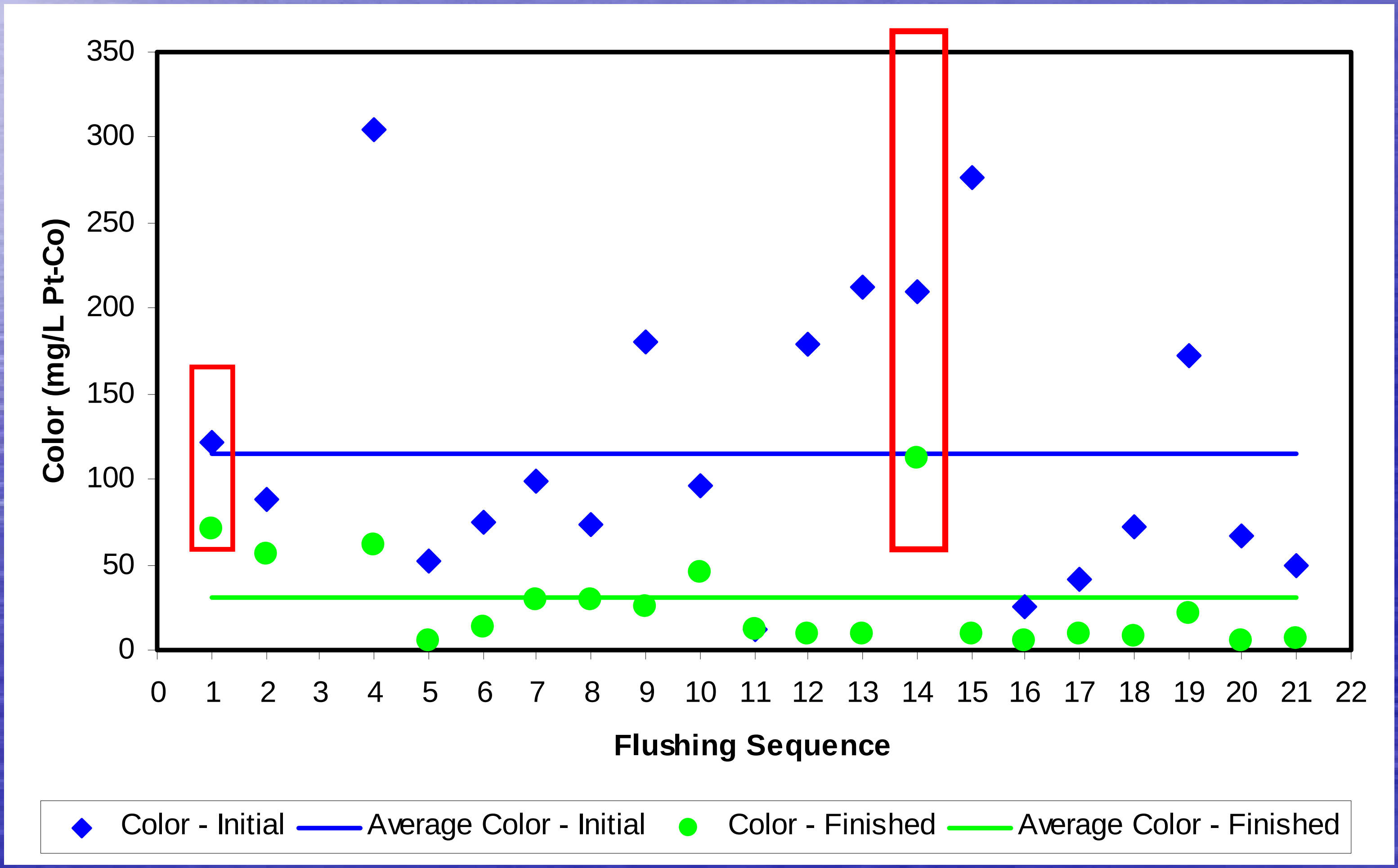
| |
|---|
| Color |
| Iron |
| pH |
| Total Chlorine |
| Turbidity |
| Magnesium |
| Calcium |

# On the Average UDF Reduced Color by 73 Percent

Min Reduction = 36.4%

Average Reduction = 73.2%

Maximum Reduction = 96.4%

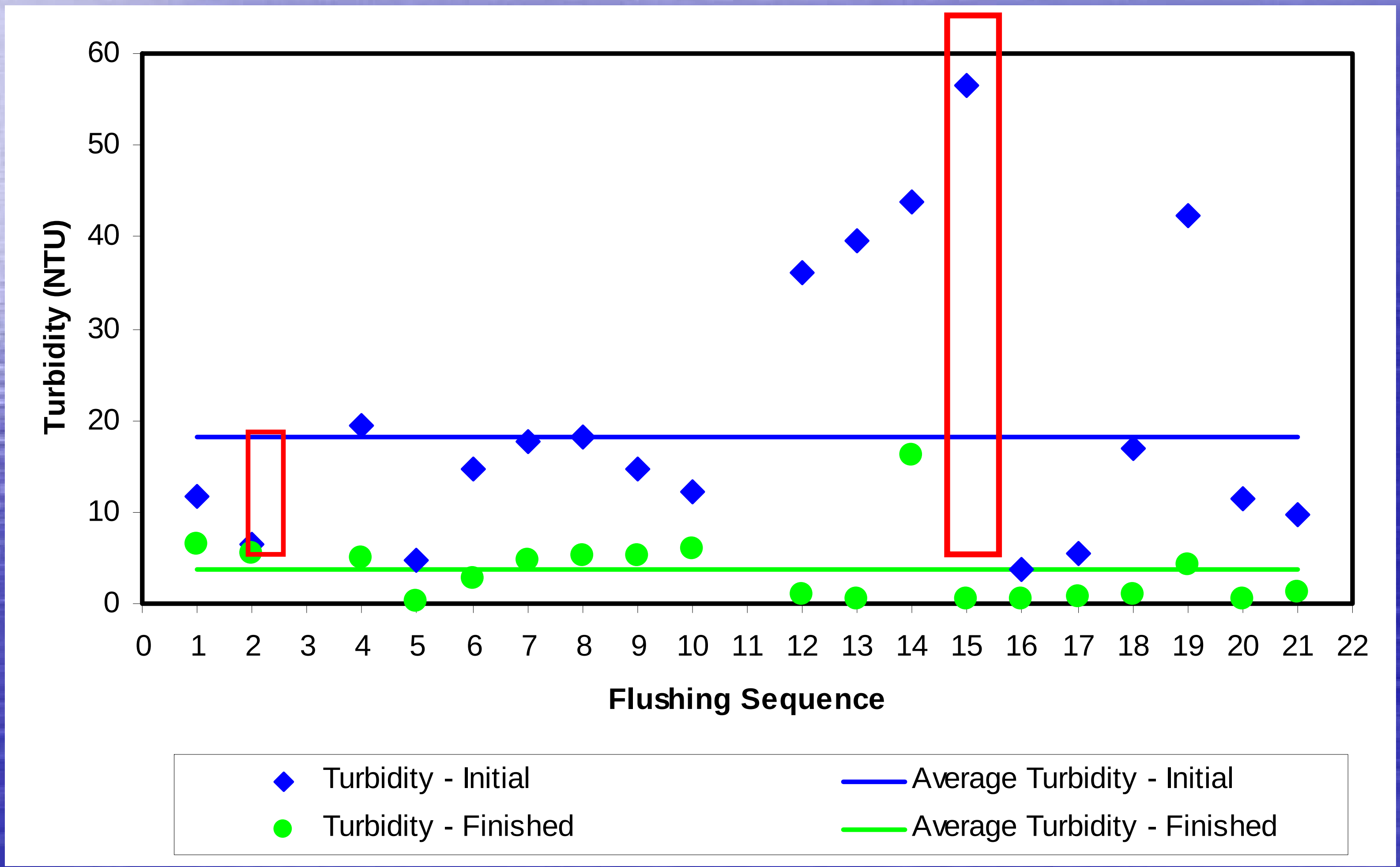


# On the Average UDF Reduced Turbidity by 79 Percent

Min Reduction = 15.5%

Average Reduction = 79.1%

Maximum Reduction = 99.1%

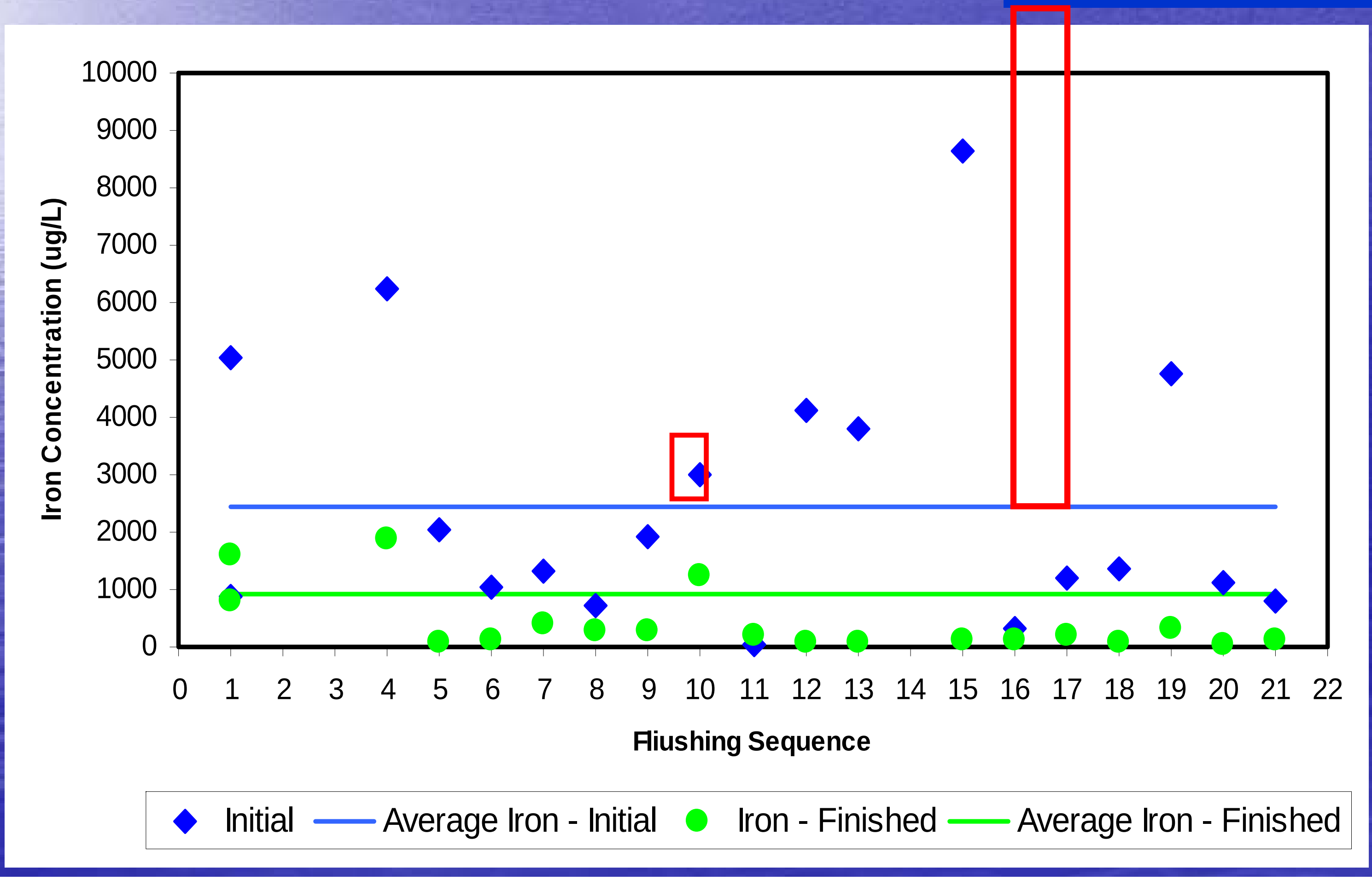


# On the Average UDF Reduced Iron Concentration by 70 Percent

Min Reduction = 60%

Average Reduction = 70%

Maximum Reduction = 98.5%



# QUESTIONS?

# Contact Information

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