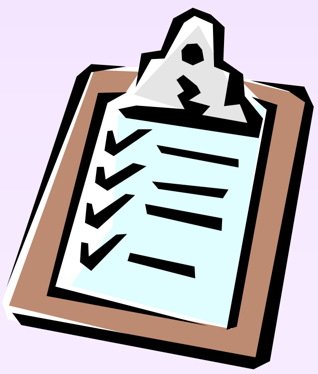
Complying with the Stage 1and 2 DBPR

Anchorage, Alaska

October/November 2006

Outline

- Applicability
- Decision Tree Options
  - MCLs
  - MRDLs
  - Treatment Technique

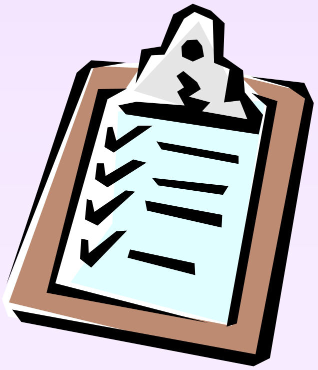


Outline (cont)

- Case Studies
  - Surface water, conventional plant, 50 MGD, TOC = 3.8 mg/L
  - Groundwater, disinfection only, 5 MGD, TOC = 8 mg/L
  - Surface water, softening plant, 50 MGD, TOC = 4.5 mg/L

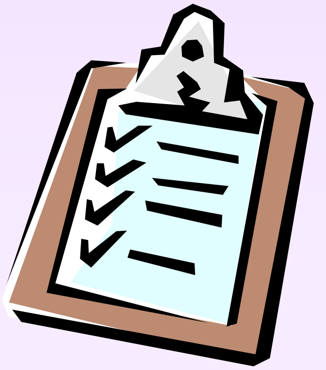
Outline (cont.)

- Case Studies - Workshop
  - Groundwater, iron removal, 10 MGD, TOC = 2 mg/L
  - Surface water, direct filtration plant, 50 MGD TOC = 2.1 mg/L
  - Surface water, conventional treatment plant, 50 MGD, TOC = 10 mg/L
- Summary

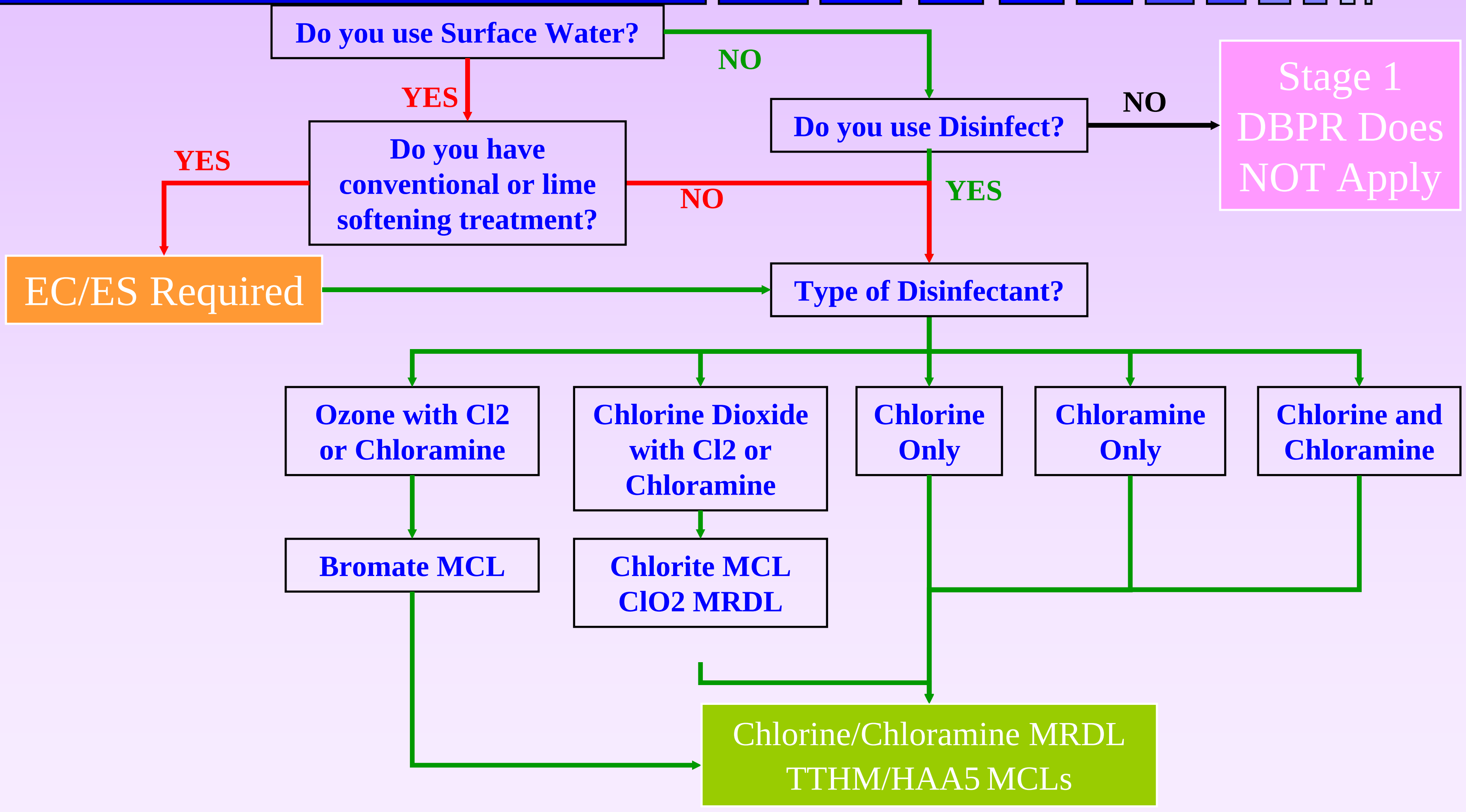


Outline

- Applicability
- Decision Tree Options
- Major Elements/Strategies
  - MCLs
  - MRDLs
  - Treatment Technique



Stage 1 DBPR Applicability Chart



Outline

- Applicability
- Decision Tree Options
  - MCLs
  - MRDLs
  - Treatment Technique

Decision Tree Options: Three Major Elements of Stage 1 DBPR

Maximum Contaminant Levels

Treatment Technique

Maximum Residual Disinfectant Levels

Decision Tree Options: MCLs

Maximum Contaminant Levels Exceeded

Source	Treatment	Distribution
1) Change source/blend 2) Precursor management 3) Modify Chlorination 4) Seasonal Strategies	1) Optimize Coagulation 2) Change Point of Disinfectant Use 3) Change Disinfectant 4) Install Precursor Removal Technology 5) Seasonal strategies	1) Adjust residency time 2) Modify disinfection practice 3) Seasonal strategies

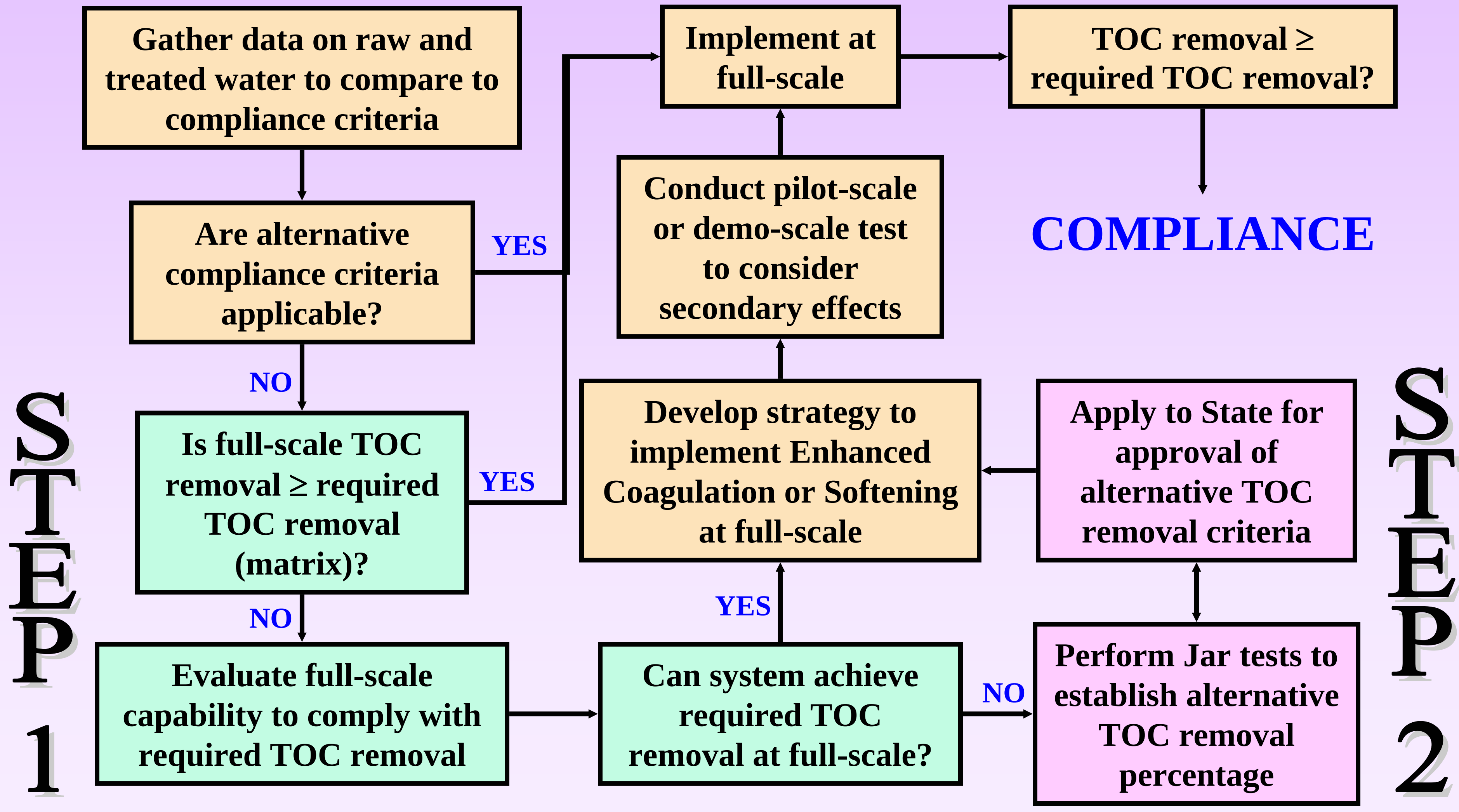
Decision Tree Options: MRDLs

Maximum Residual Disinfectant Levels Exceeded

↓

1) Reduce dosage
2) Change disinfectant
3) Manage distribution system
4) Manage disinfectant demand

Decision Tree Options: Enhanced Coagulation/Softening Triggered



Alternative Compliance Criteria

- (1) Source water TOC < 2.0 mg/L (annual average) OR
- (2) Treated water TOC < 2.0 mg/L (annual average) OR
- (3) Source water TOC < 4.0 mg/L, alkalinity > 60 mg/L (annual average) and
  - annual average TTHM ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L;

Alternative Compliance (

SMALL SYSTEMS CAN INCREASE SAMPLE NUMBERS. THAT IS, 3 AT ART IN ADDITION TO 1 AT MRT.

OR, TRY AND REDUCE DIST. RESIDENCE TIME.

- (4) TTHM ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L (annual averages) and system uses only chlorine for primary and residual disinfection OR
- (5) Source water SUVA ≤ 2.0 L/mg-m (annual average) OR
- (6) Treated water SUVA ≤ 2.0 L/mg-m (annual average)

THE BEST SOLUTION IS TO MODIFY TREATMENT TO MEET REMOVAL REQUIREMENTS (OR 2 MG/L).

Additional Alternative Compliance Criteria for Softening Systems

- (1) Softening that results in lowering treated water alkalinity to <60 mg/L
- (2) Softening that results in removing at least 10 mg/L (as $CaCO_3$) of magnesium hardness
- Meeting any Alternative Compliance Criteria Results in a Performance Ratio of 1.0 for that Month

Enhanced Coagulation/Softening Requirements (cont.)

3x3 Matrix of Required TOC Removal

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L)		
	0-60	> 60-120	>120**
> 2.0 to 4.0	35%	25%	15%
> 4.0 to 8.0	45%	35%	25%
> 8.0	50%	40%	30%

** Softening Plants must meet the TOC reduction in far right column

Decision Tree Options:
DBPR Tool Kit

Source Water → ***Treatment Plant*** → ***Distribution System***

Source Water Change or Management
- Use Alternate Source
- Manage Source Precursors
- Blend Sources

Precursor Removal
- Enhance Coagulation or Softening
- Membranes
- Granular Activated Carbon
- Ozone with BAF

Change Disinfectant or Application Point
- Chlorine Only
- Chlorine Dioxide With Cl2 or Chloramine
- Cl2 & Chloramine
- Ozone w/ Cl2 or Chloramine
- UV w/ Cl2 or Chloramine
- Chloramine Only

Distribution System Modifications
- Decrease Detention Time
- Modify System Disinfectant Application

Precursor Treatment - Enhanced Coagulation

- Do You Have a "Conventional" Plant?
  - Optimize Coagulant Dose
  - Coagulant Selection
  - Optimize pH

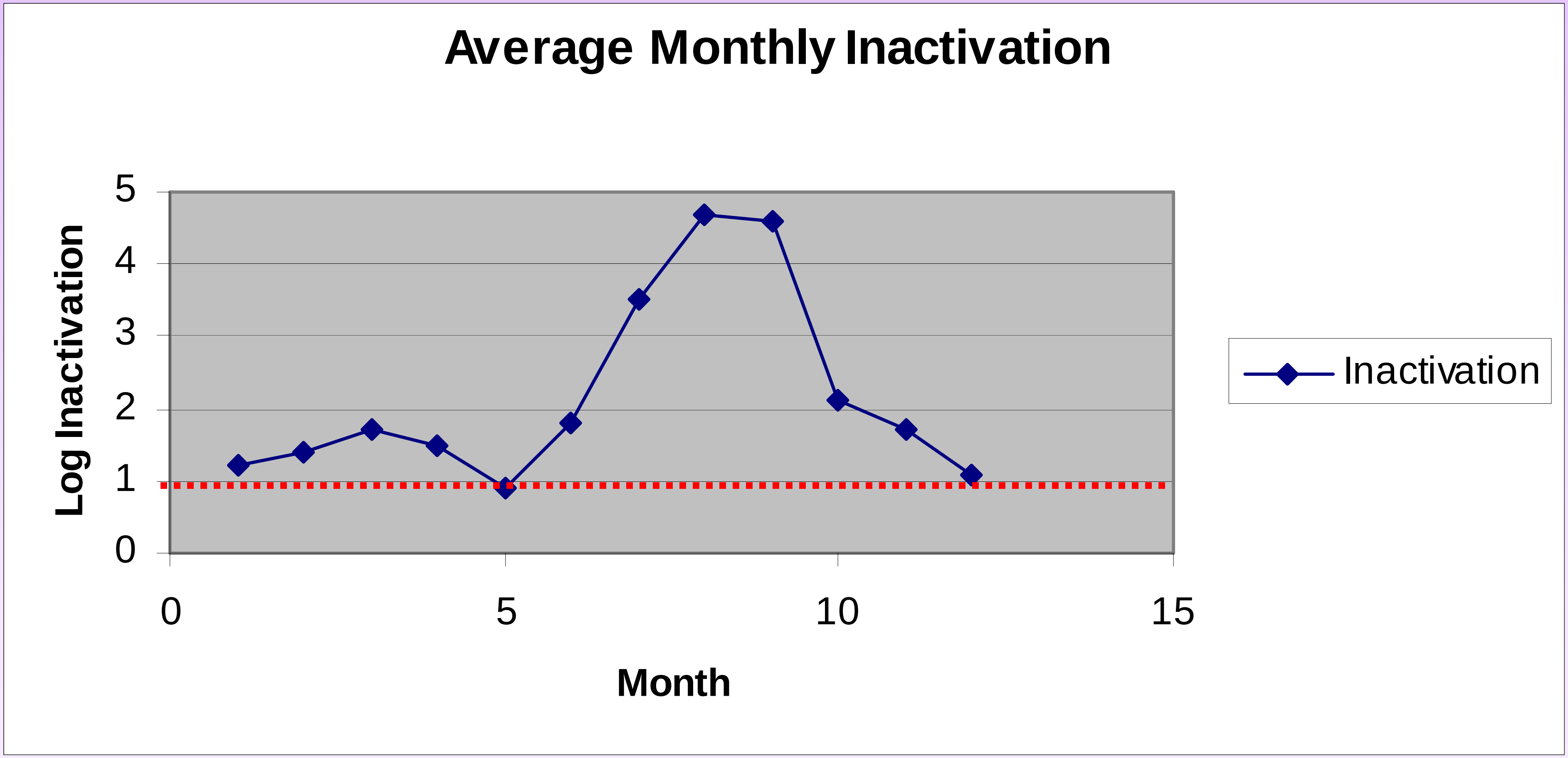
Precursor Treatment Downsides

- Enhanced Coagulation
  - Corrosion
  - Sludge Production
  - Turbidity
- Enhanced Softening
  - Reduced Alkalinity/Corrosion
  - Sludge

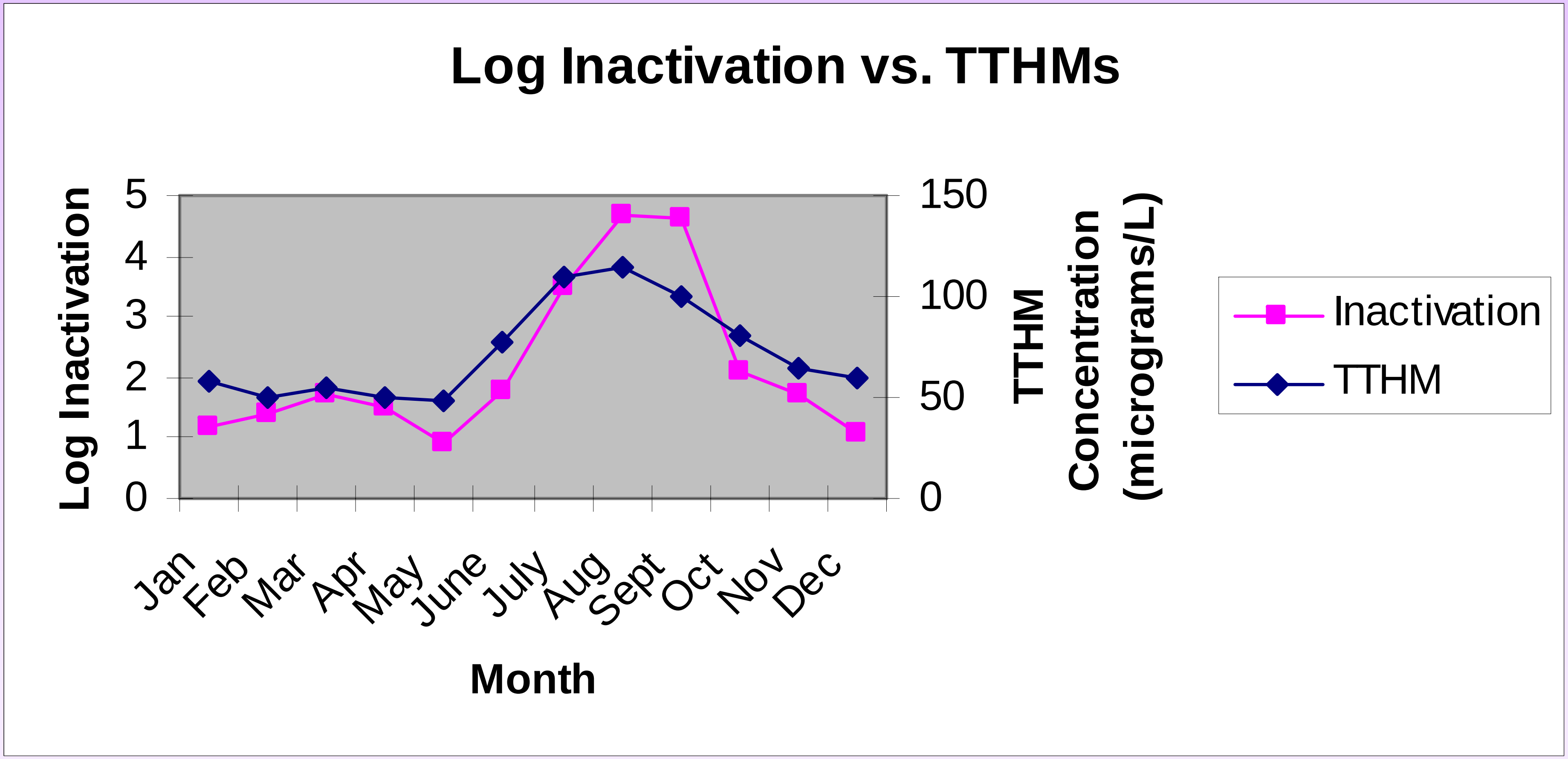
Precursor Treatment Downsides

- Membranes
  - Cost
- Granular Activated Carbon
  - Cost
    - Initial
    - Replacement
- Ozone With Biologically Active Filters
  - Regrowth in Distribution System

Reduced Residual and/or Change in Disinfection Application Point



Look at Seasonal Conditions



Treatment Downsides

- Disinfectant Application Point
  - Benchmark
- Chlorine and Chloramine
  - Nitrification
  - Nitrosodimethylamine (NDMA)
  - Lead/Copper Rule
- UV With Chlorine and/or Chloramines
- Chlorine Dioxide With Chlorine and/or Chloramine
  - Chlorite & Chlorate
- Ozone With Chlorine and/or Chloramine
  - With Biologically Active Filters (BAF)
    - Bromate
    - AOC and Regrowth/Biofilms
- Chloramine Only

Distribution System

- Decrease Detention Time
- Modify Disinfection Practices
- Seasonal Strategies

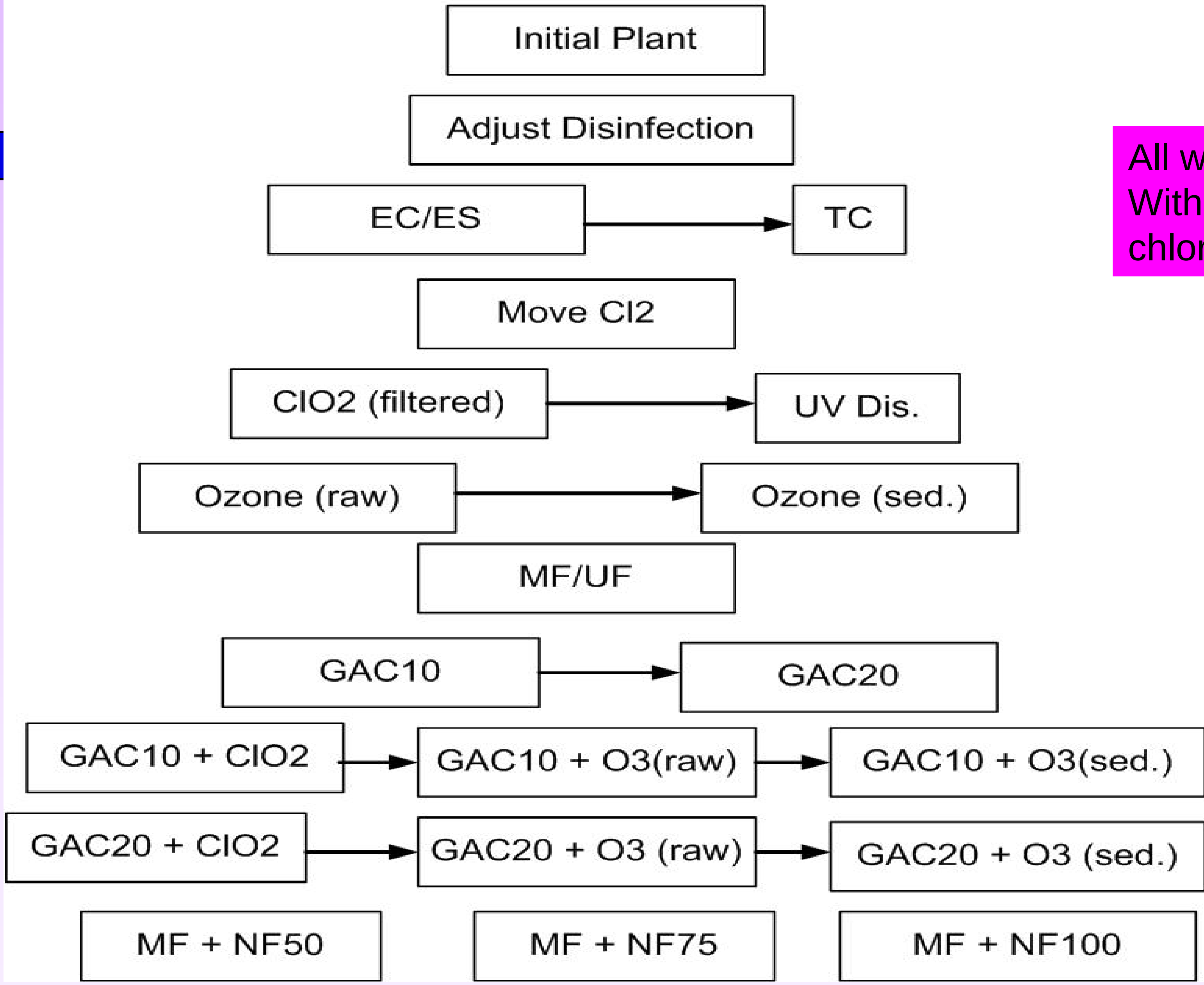
A Few New Slides

Least-cost sorting routine for technology selection for large surface-water systems that filter: Used for Stage 1 Rule development

Treatment Technology

Cl2/conventional
Cl2/NH2Cl
Enhanced Coagulation
Enhanced coagulation + Cl2/NH2Cl
O3/NH2Cl
Enhanced coagulation + O3/NH2Cl
GAC10
Enhanced coagulation + GAC10
Enhanced coagulation + GAC10 + Cl2/NH2Cl
GAC10 + O3/NH2Cl
Enhanced coagulation + GAC10 + O3/NH2Cl
GAC20
Enhanced coagulation + GAC20
GAC20 + O3/NH2Cl
Enhanced coagulation + GAC20 + O3/NH2Cl
Enhanced coagulaton + membranes

Large-system decision tree for Stage 2 and LT2 used in RIA



All with or Without chloramines

Case Studies of Modified Treatment Practices for Disinfection Byproduct Control, AWWARF, 2003

"The decision-making process will actually address multiple water quality objectives as well as operational, engineering, and financial issues."

Multiple Water Quality Objectives

- Color
- Taste and Odor
- Arsenic
- VOCs and/or SOCs
- TDS
- Iron/Manganese

Operational and engineering constraints/issues

- Retrofit issues
- Plant hydraulics
- Plant layout
- Space availability
- Electrical requirements
- Infrastructure replacement
- Capacity of facility
- Compatible with rest of treatment process
- Compatible with other plants in system

Financial constraints/issues

- Access to capital
- Impact on rates
- Staged implementation
- Uncertainty of future regulations

Comparison of different technologies for the control of multiple water-quality objectives*

Issue	EC	ES	NH_2Cl	ClO_2	O_3	UV	GAC	NF/RO
Regulatory use								
Control THM/HAA formation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Remove/inactivate *Giardia*	Yes	---	---†	Yes	Yes	Yes	---	Yes
Remove/inactivate viruses	Yes	---	---†	Yes	Yes	Yes	---	Yes
Remove/inactivate *Cryptosporidium*	Yes	---	No	Yes	Yes	Yes	---	Yes
Remove/oxidize SOCs	No	No	No	---	Yes	No	Yes	Yes
Remove/biodegrade AOC	Yes	---	No	No	No	No	Yes	---
Biodegrade HAAs	No	No	No	No	No	No	Yes	No
Other water-quality objectives								
Remove/oxidize tastes and odors	No	No	No	Yes	Yes	No	Yes	Yes
Remove/oxidize color	Yes	---	No	---	Yes	No	Yes	Yes
Remove hardness	No	Yes	No	No	No	No	No	Yes
Possible tradeoffs								
Form other regulated DBPs	No	No	No	Yes	Yes	No	No	No
Form other DBPs (non-regulated)	No	No	Yes	Yes	Yes	No	No	No
Form AOC	No	No	No	No	Yes	No	No	No
Kidney dialysis issues	No	No	Yes	Yes	No	No	No	No
Nitrification issues	No	No	Yes	No	No	No	No	No
Residuals issues	Yes	Yes	No	No	No	No	---‡	Yes
Corrosion issues	Yes	Yes	Yes	No	No	No	No	Yes

*This is a general, overall comparison. For specific contaminants, each technology has a different level of efficacy.

†Chloramines are not a strong disinfectant for the inactivation of *Giardia* or viruses.

‡Depending on the GAC usage, there is the need for periodic replacement or reactivation of the GAC.

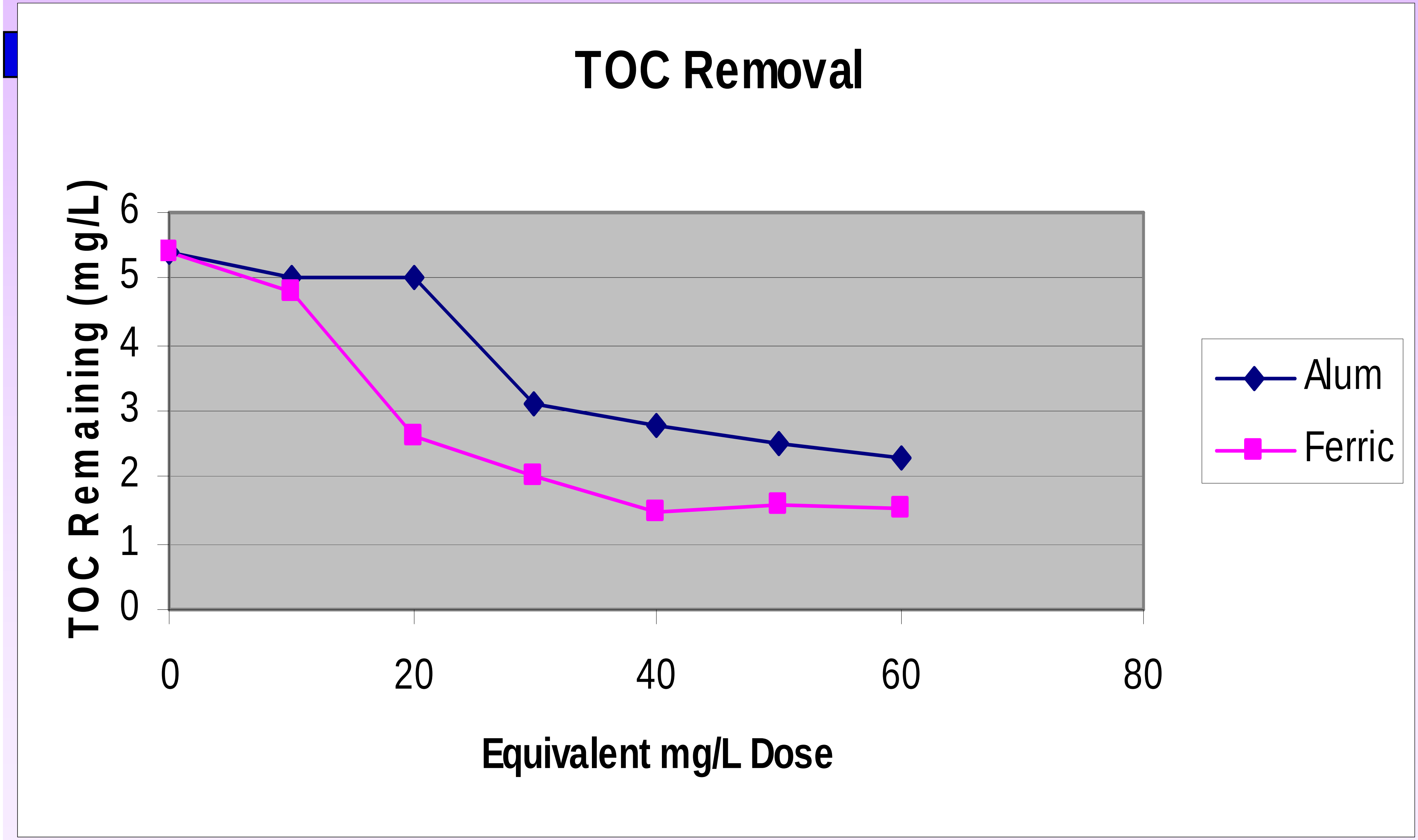
Case 1: Ann Arbor

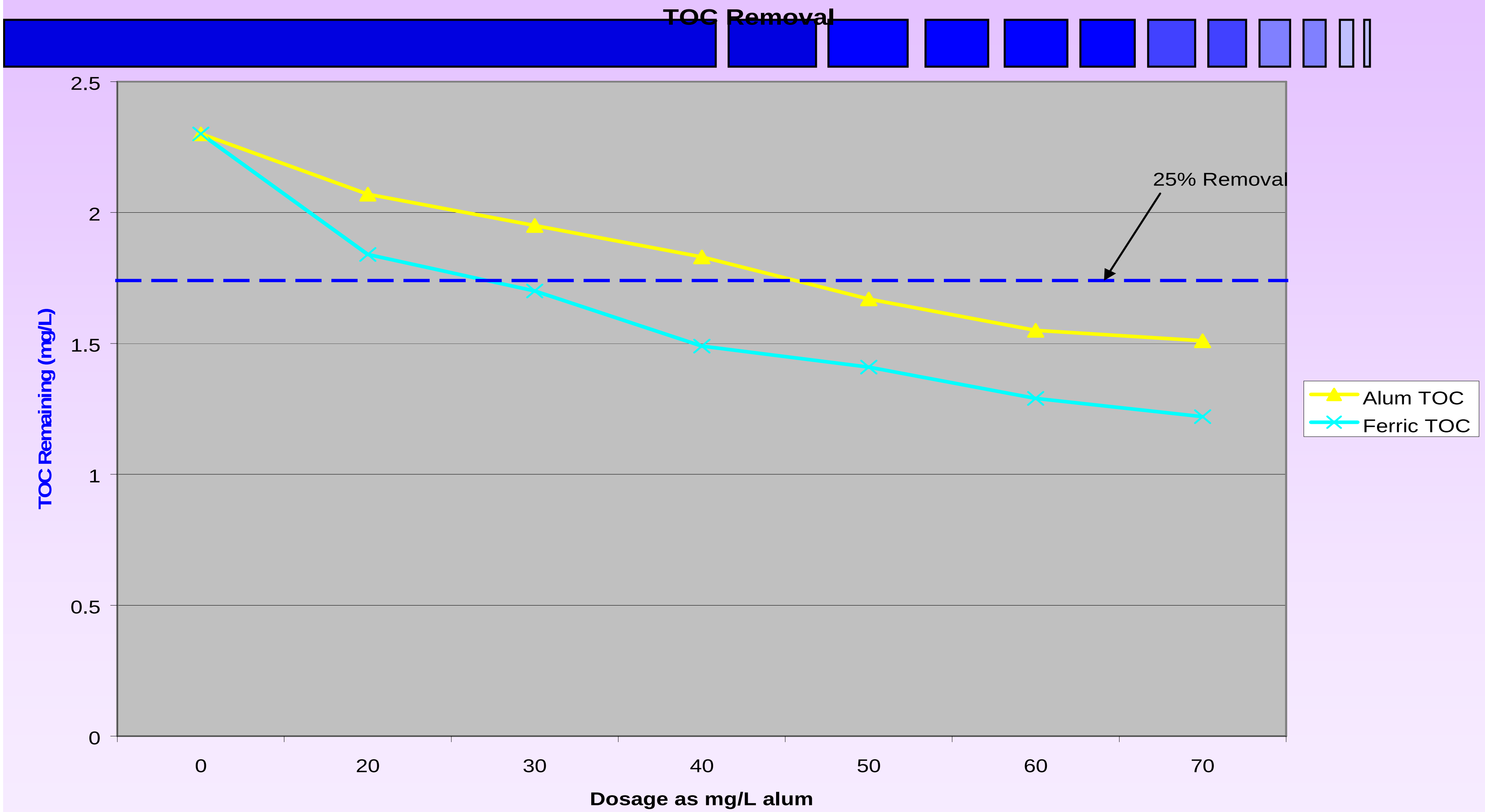
- THMs ok but sometimes out of compliance with SWTR
  - Need to improve disinfection without impacting DBPs
    - Ozone introduced bromate as an issue
      - If bromide was too high, they would have had to pursue another option (or make adjustments to the processes)

Case 2: Tampa

- Optimization of existing processes
  - Optimized coagulation process to get better TOC removal
    - Had the side benefit of removing more color

Jar Testing to Compare Coagulants



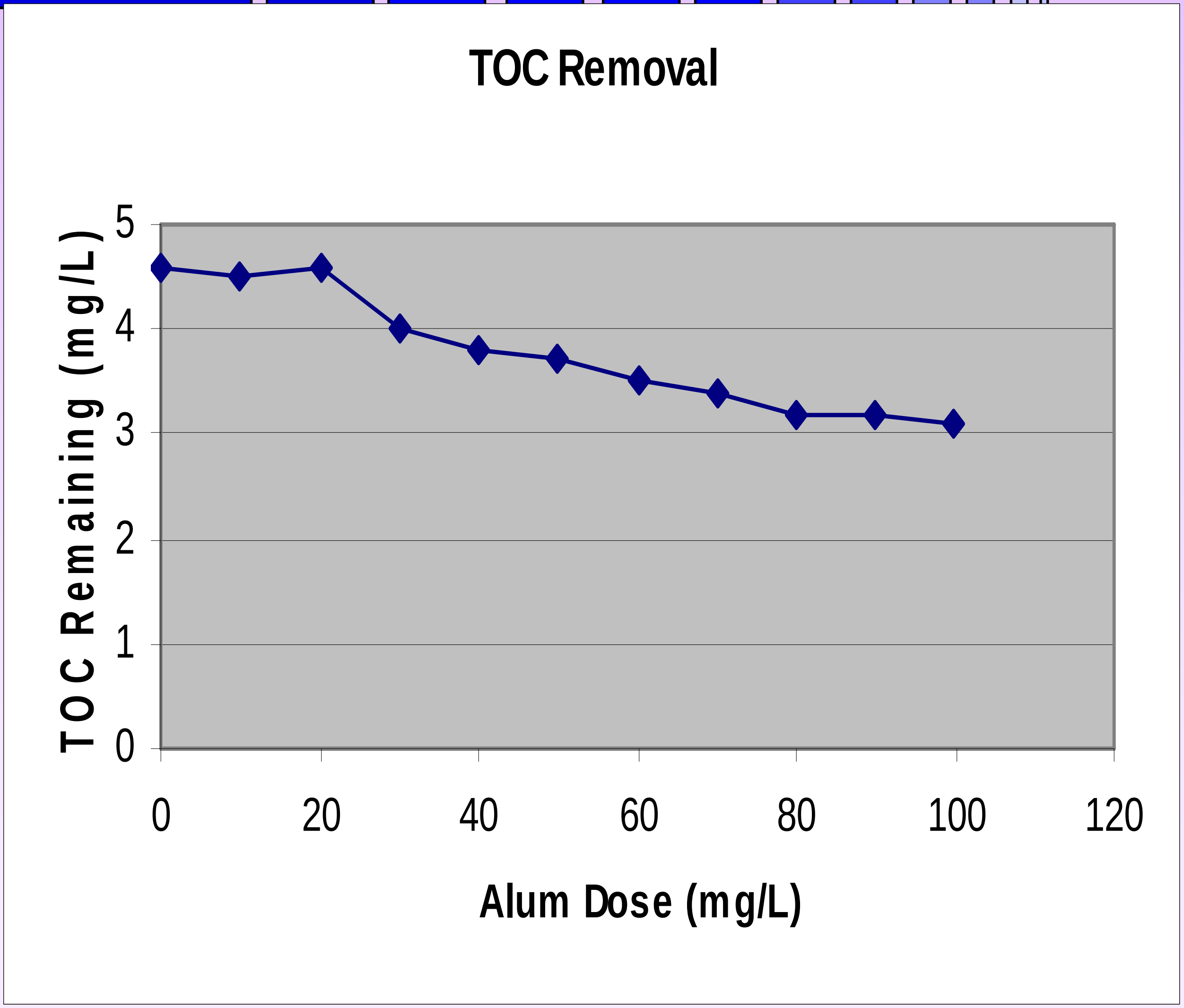

TOC Removal
2.5
2
1.5
1
0.5
0
TOC Remaining (mg/L)
25% Removal
0
20
30
40
50
60
70
Dosage as mg/L alum
Alum TOC
Ferric TOC

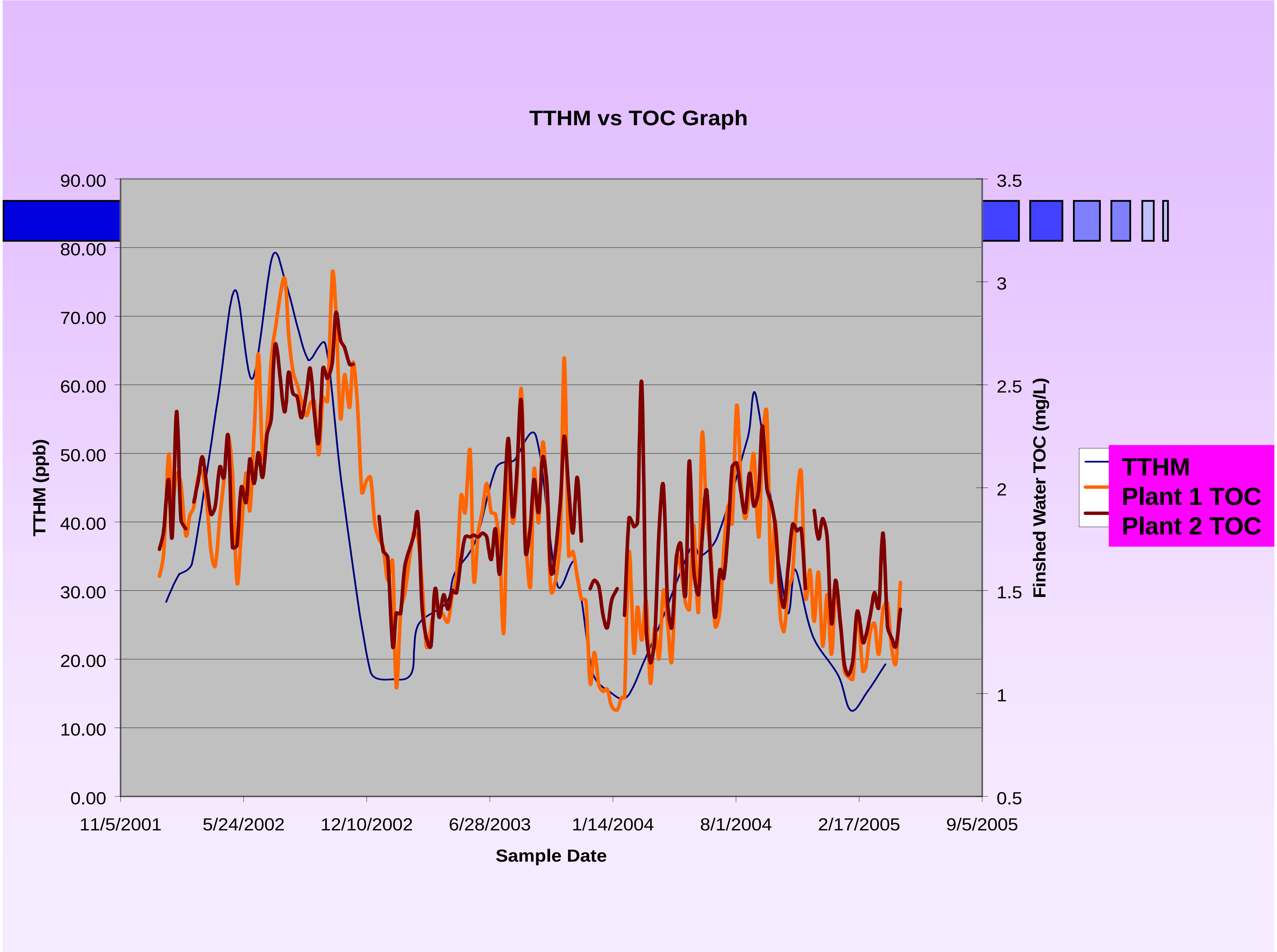
Other Jar Tests

- Optimum Coagulant Dose
- Optimum pH
- Impact of Pre-oxidants
  - $KMnO_4$

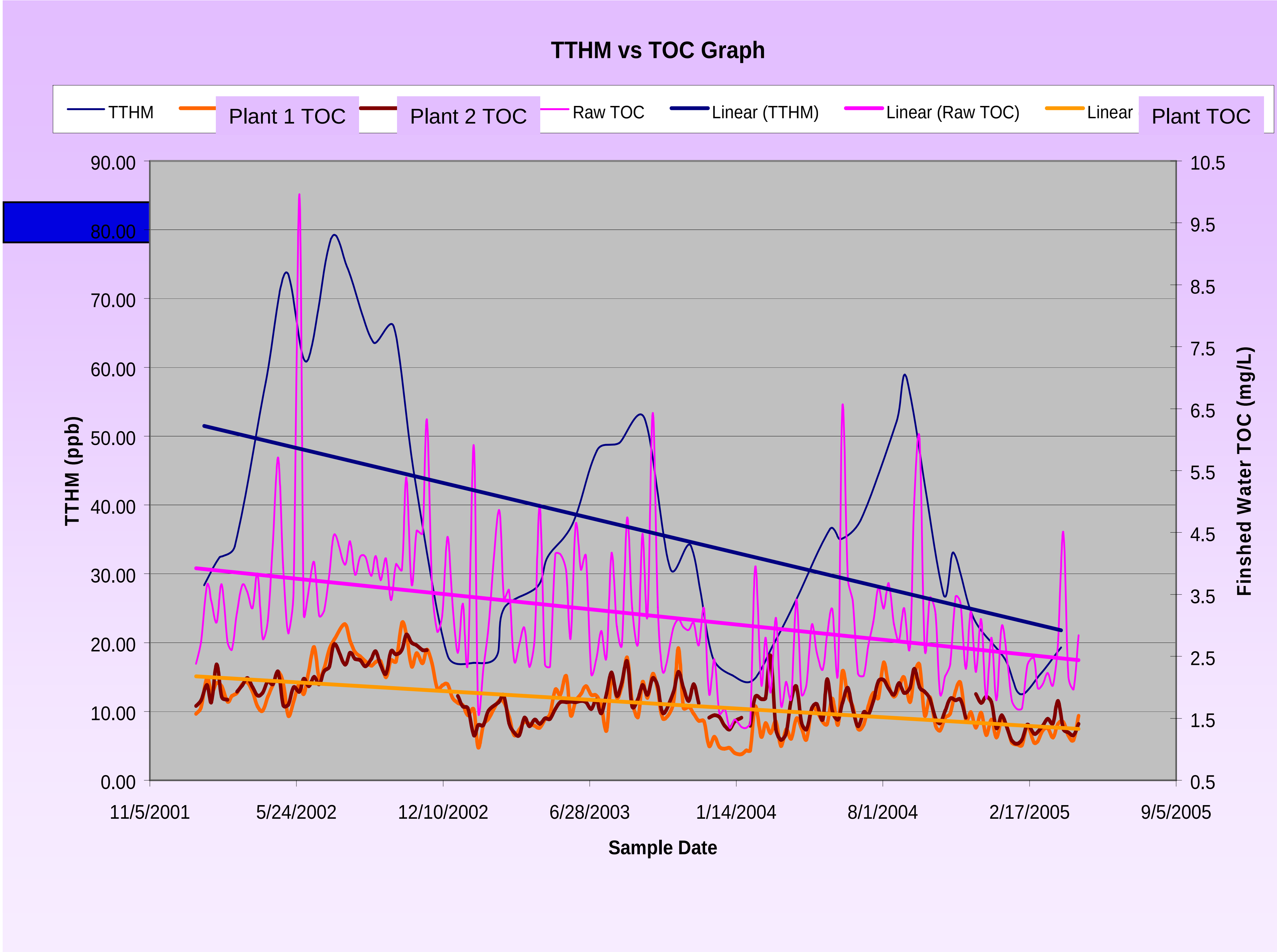
Jar Testing to Determine Removal Potential

Alum Dose	TOC	Removed
0	4.6	
10	4.5	0.1
20	4.6	0
30	4	0.6
40	3.8	0.2
50	3.7	0.1
60	3.5	0.2
70	3.4	0.2
80	3.2	0.2
90	3.2	0
100	3.1	0.1



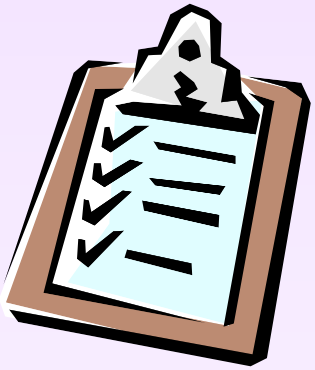

TTHM vs TOC Graph
TTHM (ppb)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Finshed Water TOC (mg/L)
3.5
3
2.5
2
1.5
1
0.5
11/5/2001
5/24/2002
12/10/2002
6/28/2003
1/14/2004
8/1/2004
2/17/2005
9/5/2005
Sample Date
TTHM
Plant 1 TOC
Plant 2 TOC


Maximum Quarterly TTHM LRAA
TTHM LRAA (ppb)
80
70
60
50
40
30
20
Site 1
Site 2
Site 3
Q1 2001
Q2 2001
Q3 2001
Q4 2001
Q1 2002
Q2 2002
Q3 2002
Q4 2002
Q1 2003
Q2 2003
Q3 2003
Q4 2003
Q1 2004
Q2 2004
Q3 2004
Q4 2004
Q1 2005
Q2 2005
Quarter


TTHM vs TOC Graph
TTHM
Plant 1 TOC
Plant 2 TOC
Raw TOC
Linear (TTHM)
Linear (Raw TOC)
Linear
Plant TOC
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TTHM (ppb)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
Finshed Water TOC (mg/L)
11/5/2001
5/24/2002
12/10/2002
6/28/2003
1/14/2004
8/1/2004
2/17/2005
9/5/2005
Sample Date

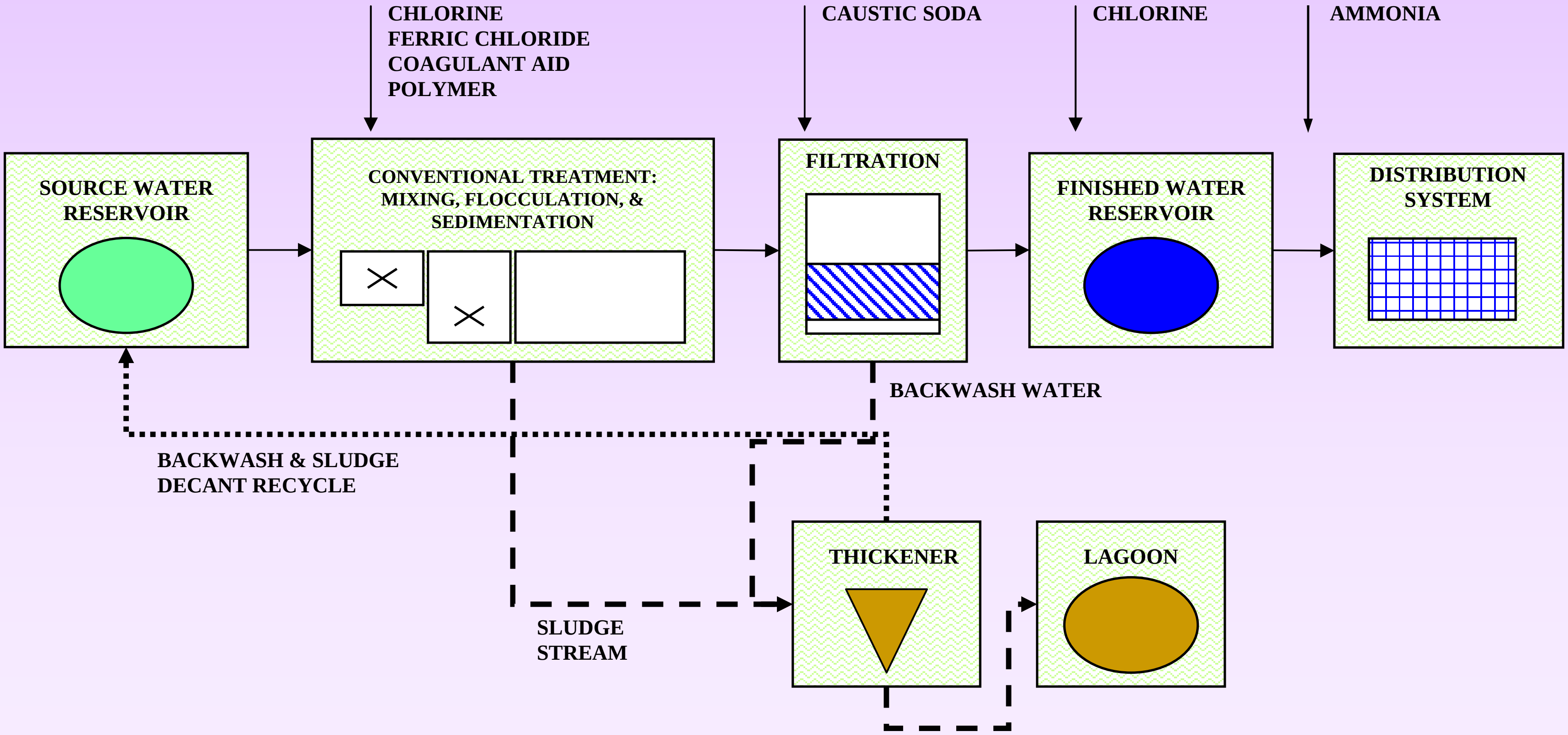
Outline (cont)

- Case Studies - Ensemble
  - Surface water, conventional plant, 50 MGD,
    TOC = 3.8 mg/L
  - Groundwater, disinfection only, 5 MGD,
    TOC = 8 mg/L
  - Surface water, softening plant, 50 MGD,
    TOC = 4.5 mg/L



Stage 1 DBPR Case Study #1

Surface Water Conventional Treatment: 50 MGD



Stage 1 DBPR Case Study #1

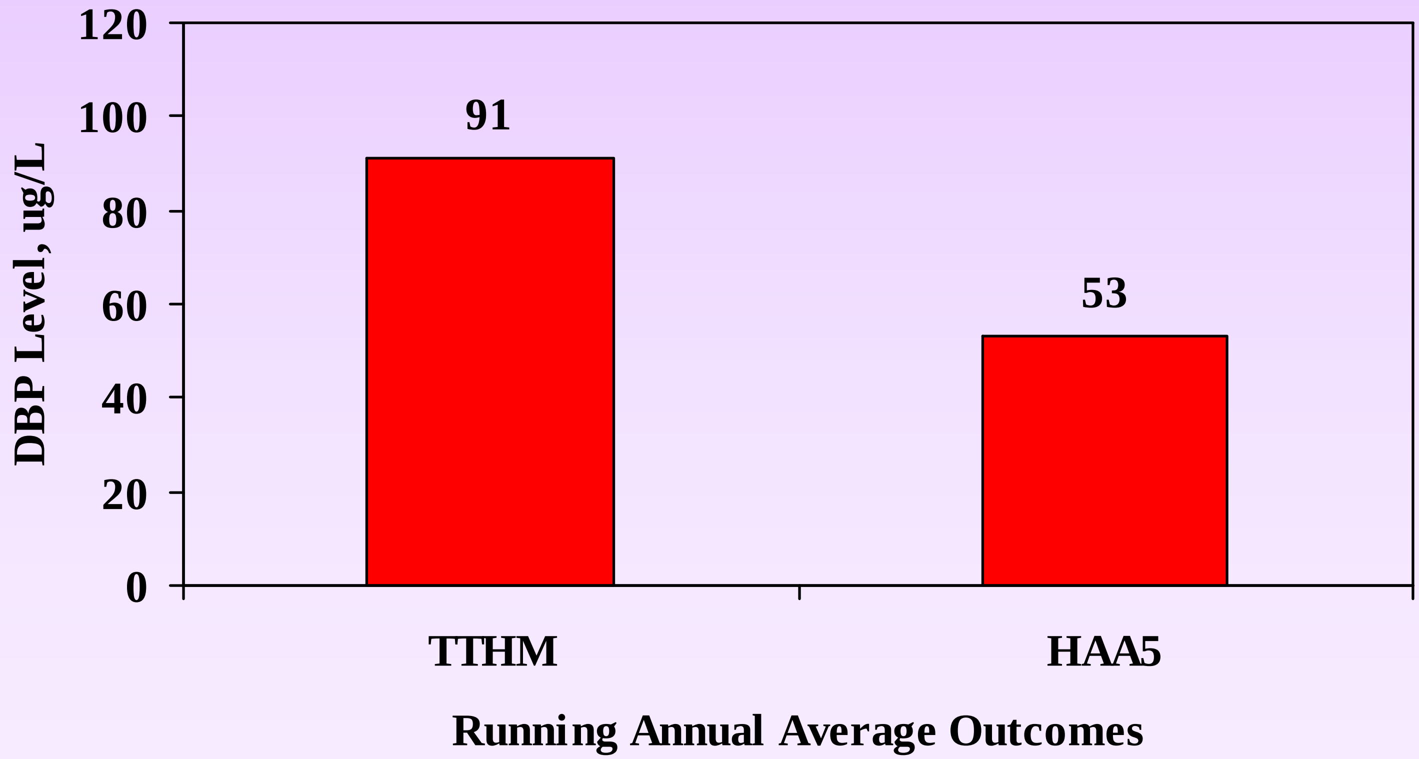
Surface Water Conventional Treatment: 50 MGD

Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L)	3.8	2.2	6.1
Bromide (μg/L)	0.1	0.05	0.25
pH	7.6	6.9	8.4
Turbidity (NTU)	22	9	145
Temperature (^{o}C)	13	4.1	26
Alkalinity (mg/L)	65	42	88
UV-254 (/cm)	0.095	0.032	0.256
SUVA (L/mg-m)	3.6	1.8	6.0
Total Coliform (colonies/100mL)	340	110	980

Stage 1 DBPR Case Study #1

Surface Water Conventional Treatment: 50 MGD



Case Study #1: Observations

Surface Water Conventional Treatment: 50 MGD

- TOC Level Triggers Enhanced Coagulation (EC)
- TTHM MCL is Exceeded and HAA5 MCL is Close Even with Chloramines
- 20% Reduction of TTHMs Needed to Achieve Compliance
- Prechlorination Practiced

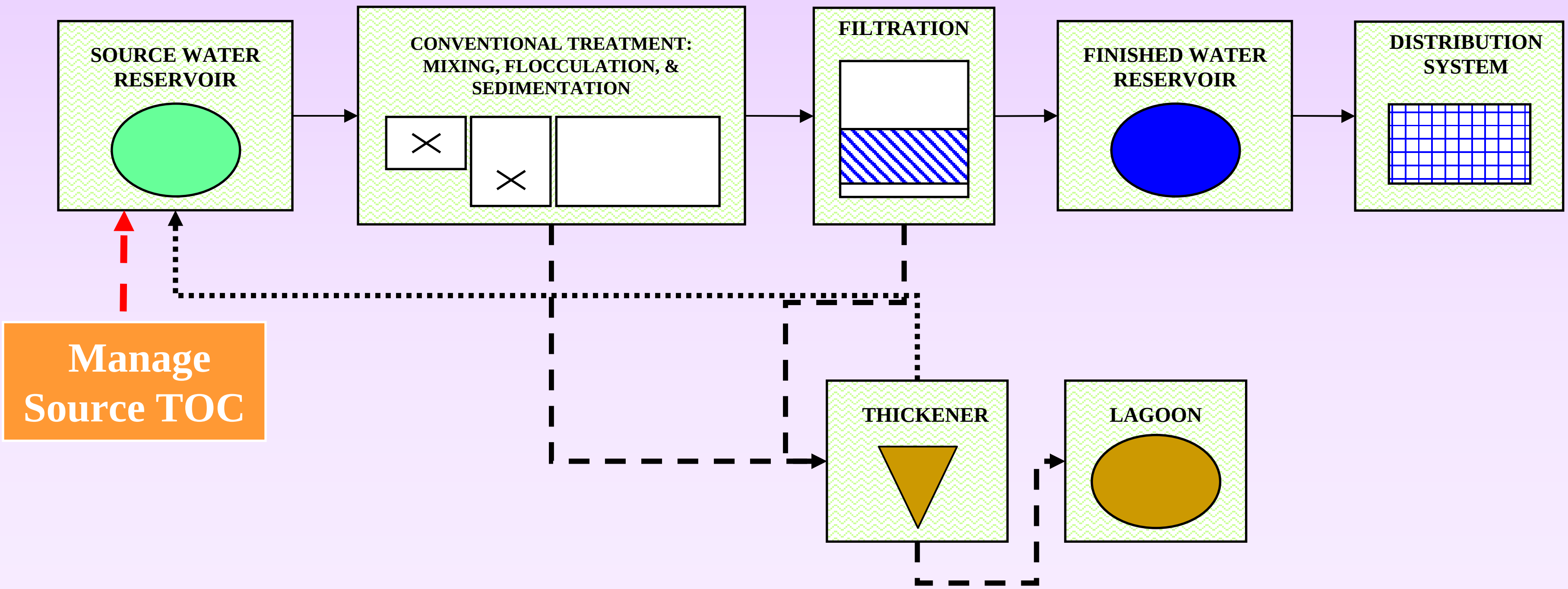
Case study #1: Observations

Surface Water Conventional Treatment: 50 MGD

- Relatively Low Alkalinity Water
- Periodically Elevated Bromide Levels
- Distribution System Water Quality Issues to be Considered with Chloramines:
  - Nitrification, dialysis patients, plumbing materials

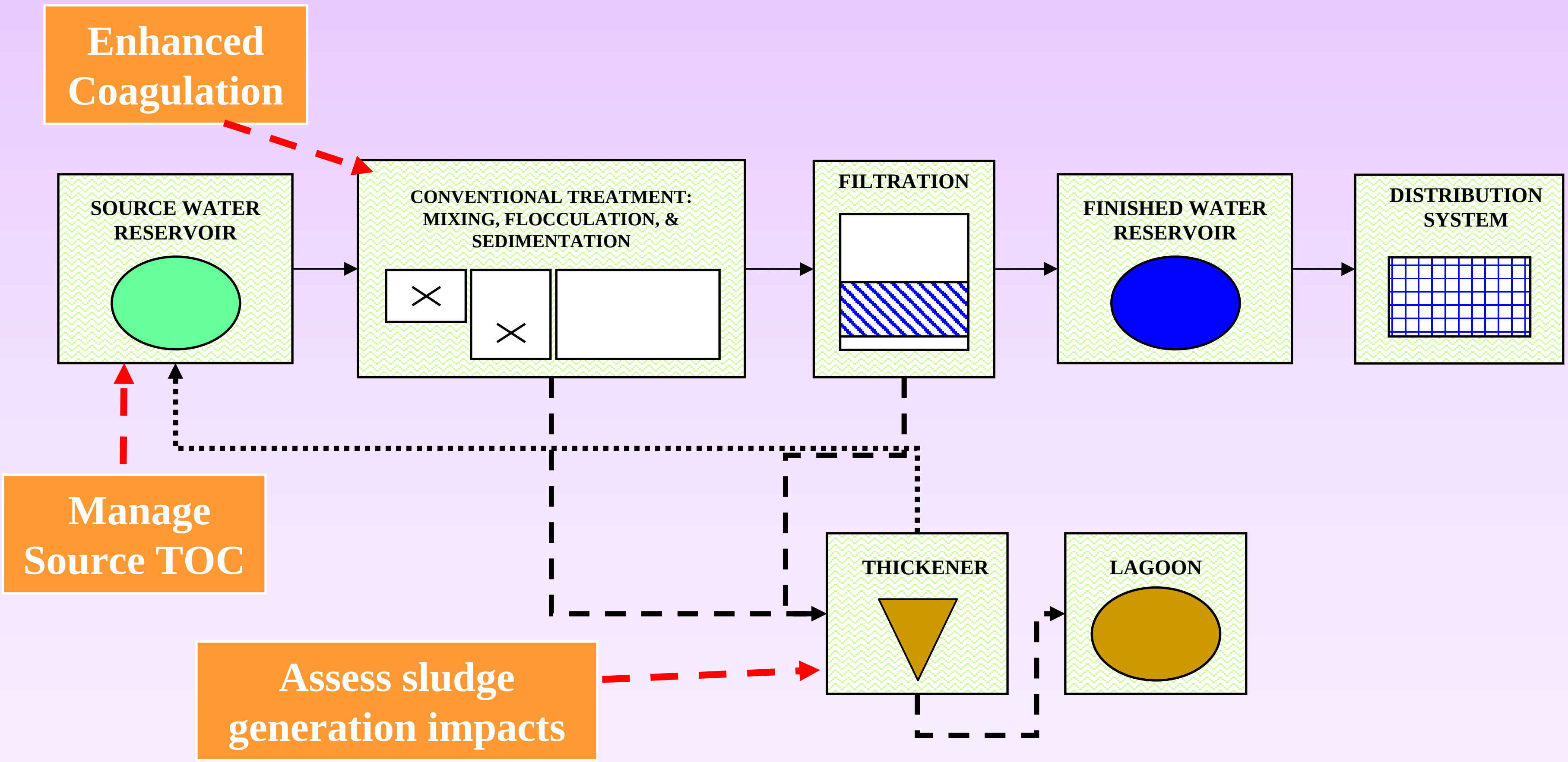
Stage 1 DBPR Case Study #1

Surface Water Conventional Treatment: 50 MGD



Stage 1 DBPR Case Study #1

Surface Water Conventional Treatment: 50 MGD



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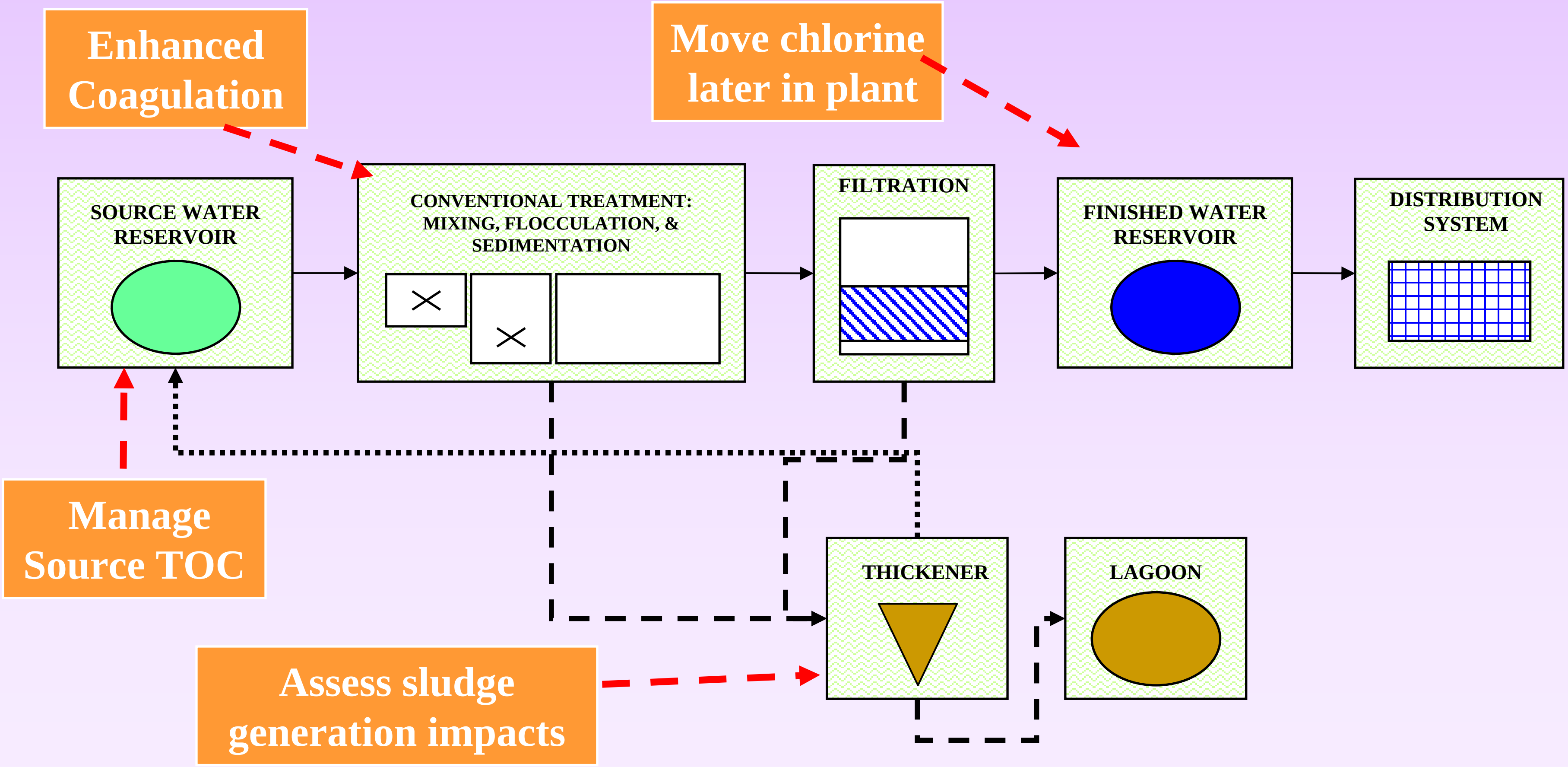
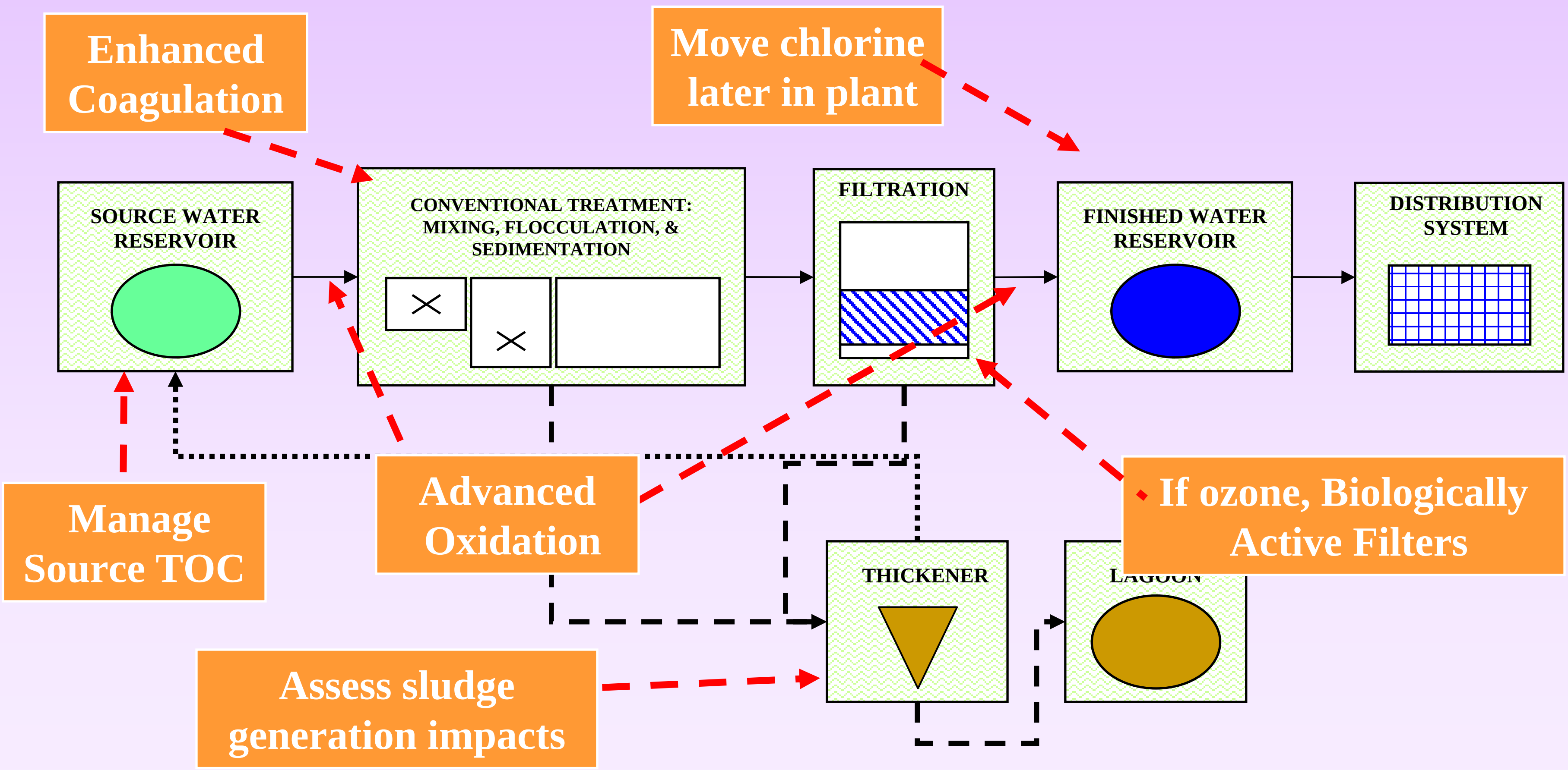
Surface Water Conventional Treatment: 50 MGD



Stage 1 DBPR Case Study #1

Surface Water Conventional Treatment: 50 MGD



Case Study #1: Compliance Strategy Observations

Surface Water Conventional Treatment: 50 MGD

- Reducing Chlorine Contact Time will Reduce Total Disinfection Performance
  - Check Profile and Benchmark
- Bromide Levels may Affect Ozone Retrofit Strategy
  - pH control to limit bromate formation

Case Study #1: Compliance Strategy Observations (cont.)

Surface Water Conventional Treatment: 50 MGD

- Bench and Pilot Test Should be Performed to Demonstrate Advanced Oxidation Techniques (ozone, chlorine dioxide, $KMnO_4$)
- Location of Advanced Oxidants Depends on Other Site-Specific Water Quality Issues:
  - Oxidation demand: organic and inorganic
  - Aesthetic water quality controls: T&O, nuisance algae
  - Effect of contact time

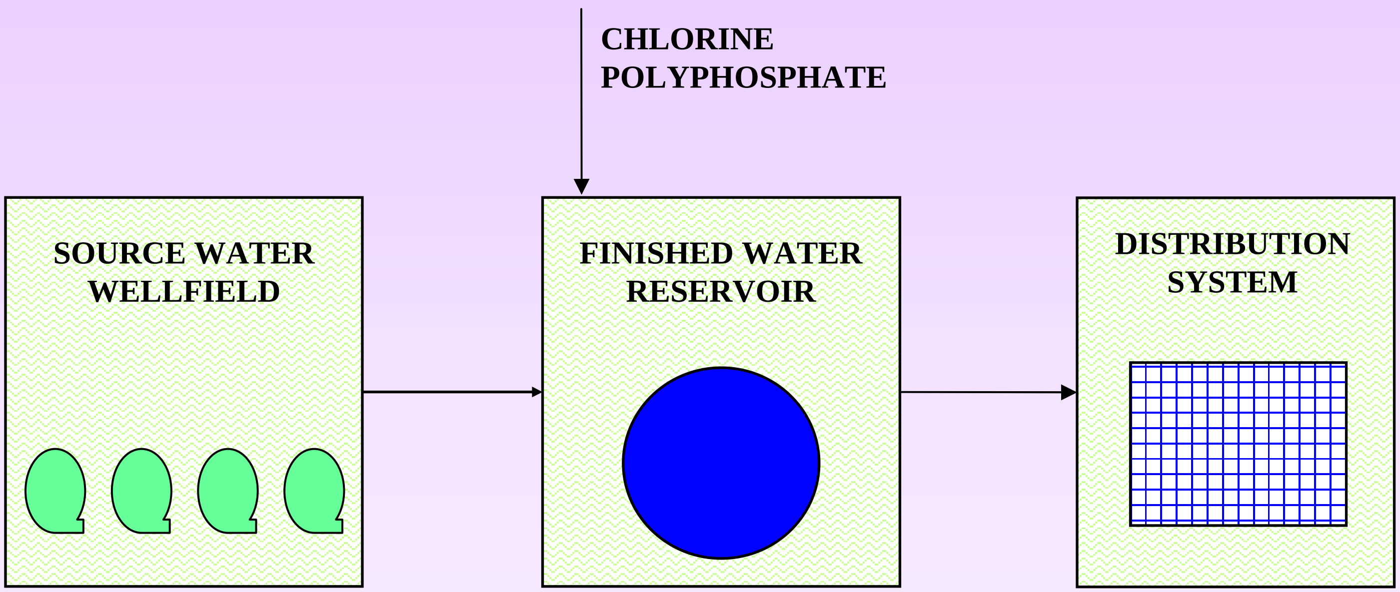
Case Study #1: Compliance Strategy Observations (cont.)

Surface Water Conventional Treatment: 50 MGD

- Location of Advanced Oxidants Depends on Other Site-Specific Water Quality Issues:
  - Compliance with MCLs for bromate or chlorite
  - Compatibility with other treatment objectives: corrosion control, filtration performance
  - Consideration of compliance with future rules

Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



Chlorine dose designed to achieve 4-log virus inactivation

Stage 1 DBPR Case Study #2

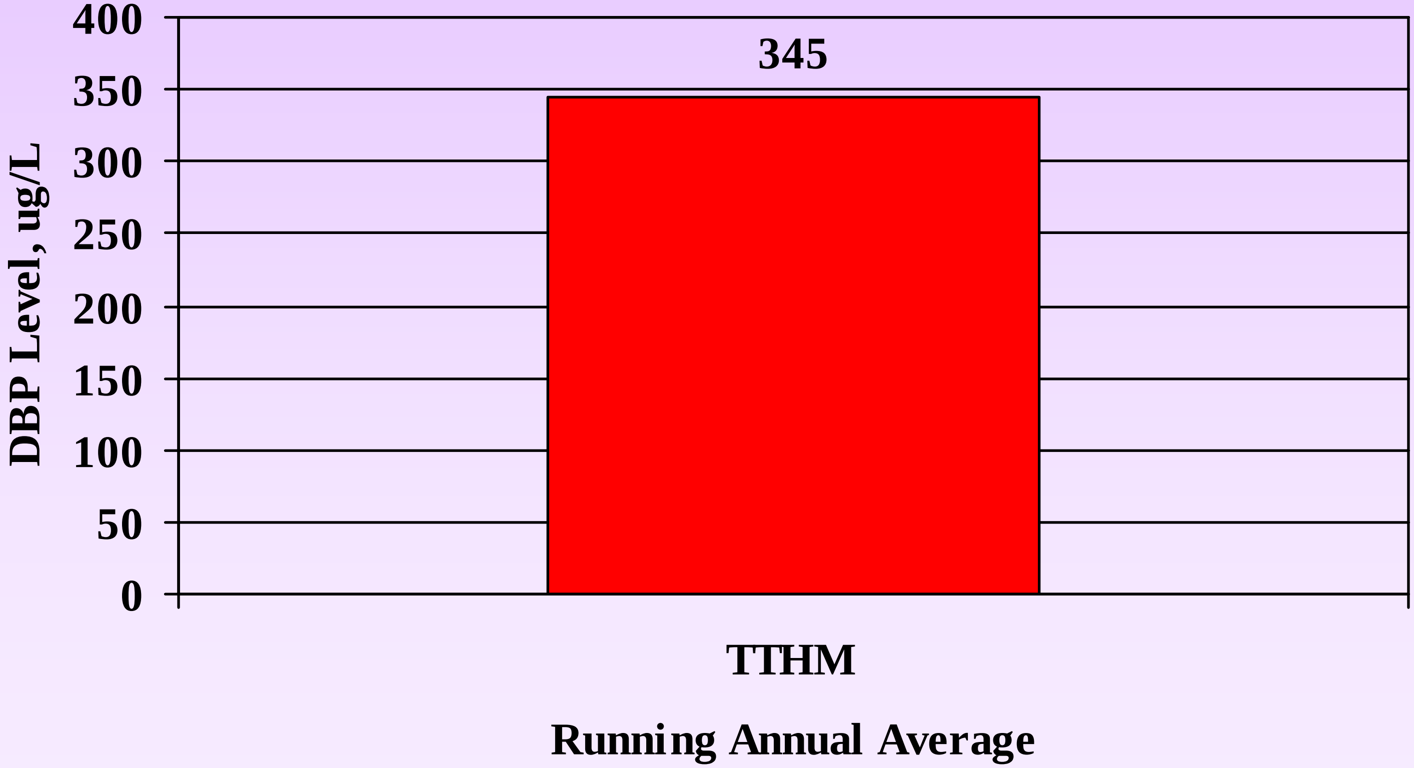
Chlorinated Groundwater: 5 MGD

Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L)	8	6.2	12.4
Bromide (µg/L)	0.50	0.23	0.90
pH	8.1	7.6	8.9
Turbidity (NTU)	?	?	?
Temperature (^{o}C)	17	14	19
Alkalinity (mg/L)	260	175	310
UV-254 (/cm)	0.200	0.120	0.300
SUVA (L/mg-m)	?	?	?
Total Coliform (colonies/100mL)	3	ND	8
Radon (pCi/L)	4200	3600	5000
Arsenic (µg/L)	35	27	42
Color (pcu)	80	75	86

Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



Case Study #2: Observations

Chlorinated Groundwater: 5 MGD

- Need to Collect HAA5 Data
- Multiple Well Sources Provide Source Water Blending Opportunities
- High TOC Groundwater
- Significantly Exceeds TTHM MCL
  - Inference is that HAA5 MCL is likely to be exceeded as well

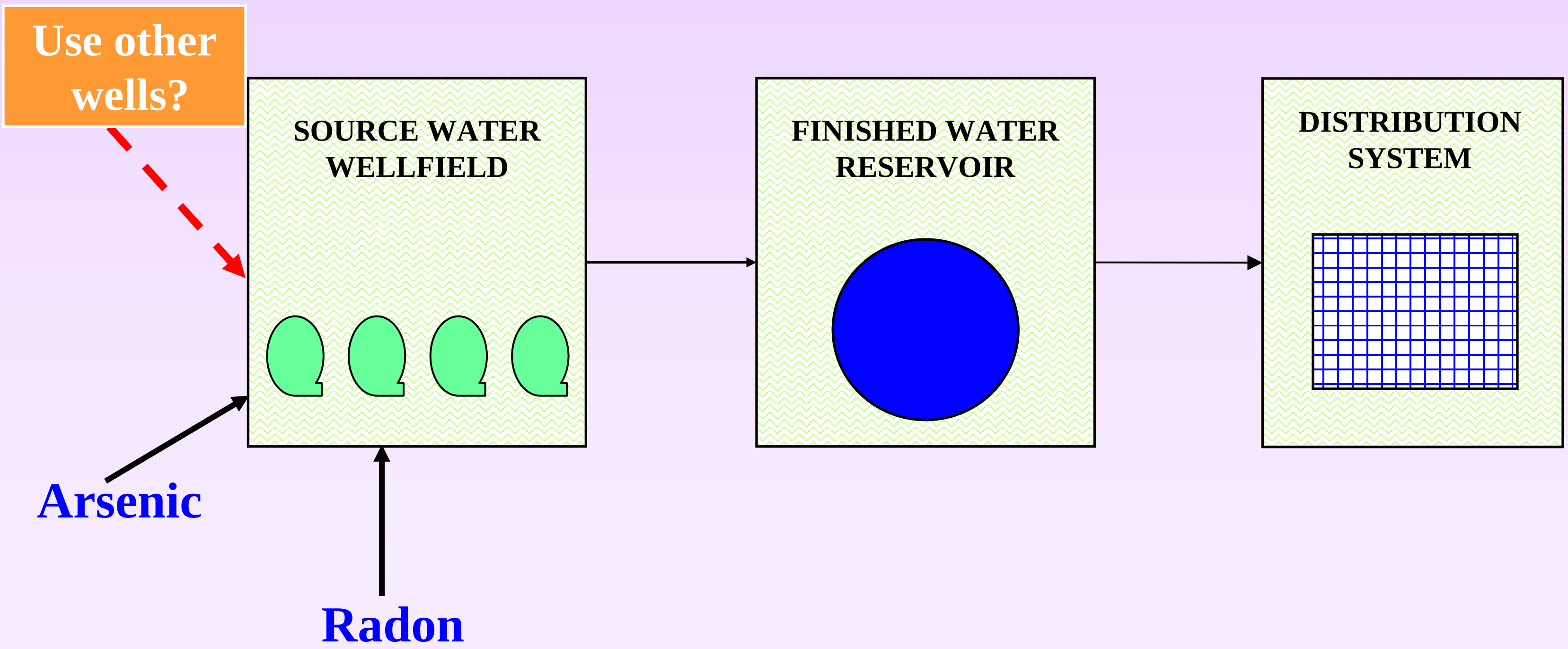
Case Study #2: Observations

Chlorinated Groundwater: 5 MGD

- Arsenic MCL and Potentially, the Future Radon MCL
  - Compliance strategy should consider multiple objectives, not just DBPs
- High Alkalinity Water
- Highly Colored Water
- Significant Levels of Bromide

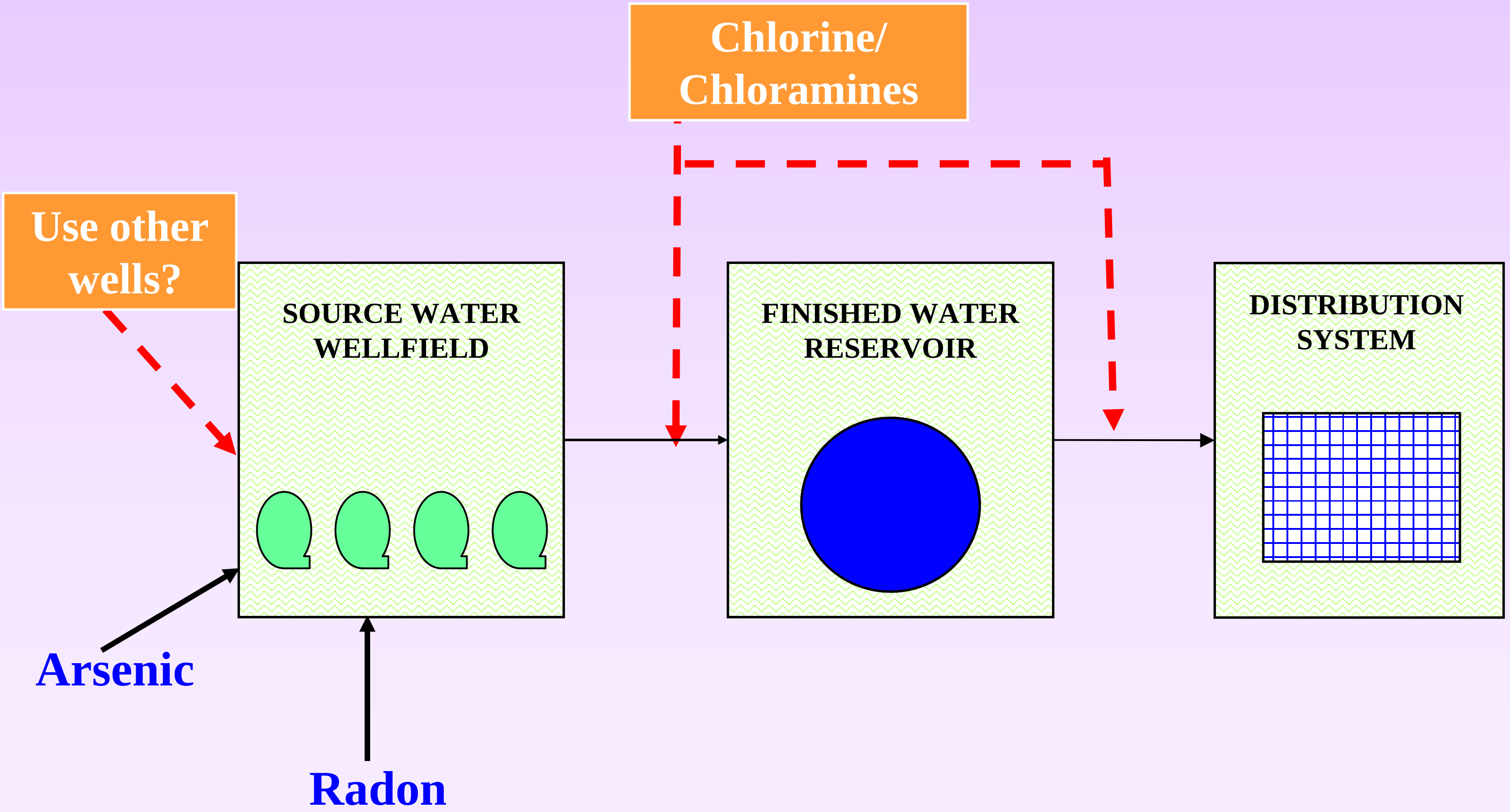
Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



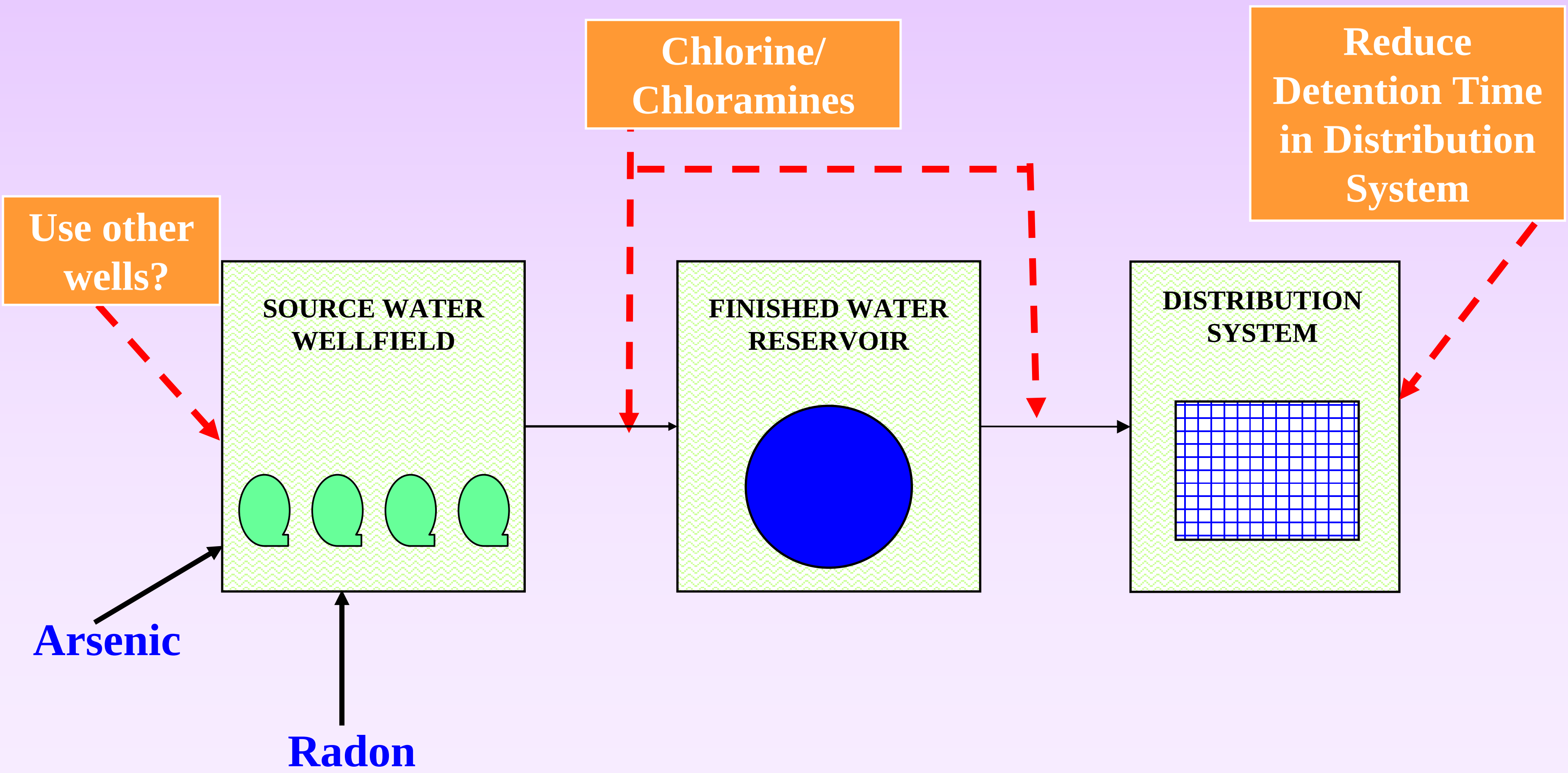
Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



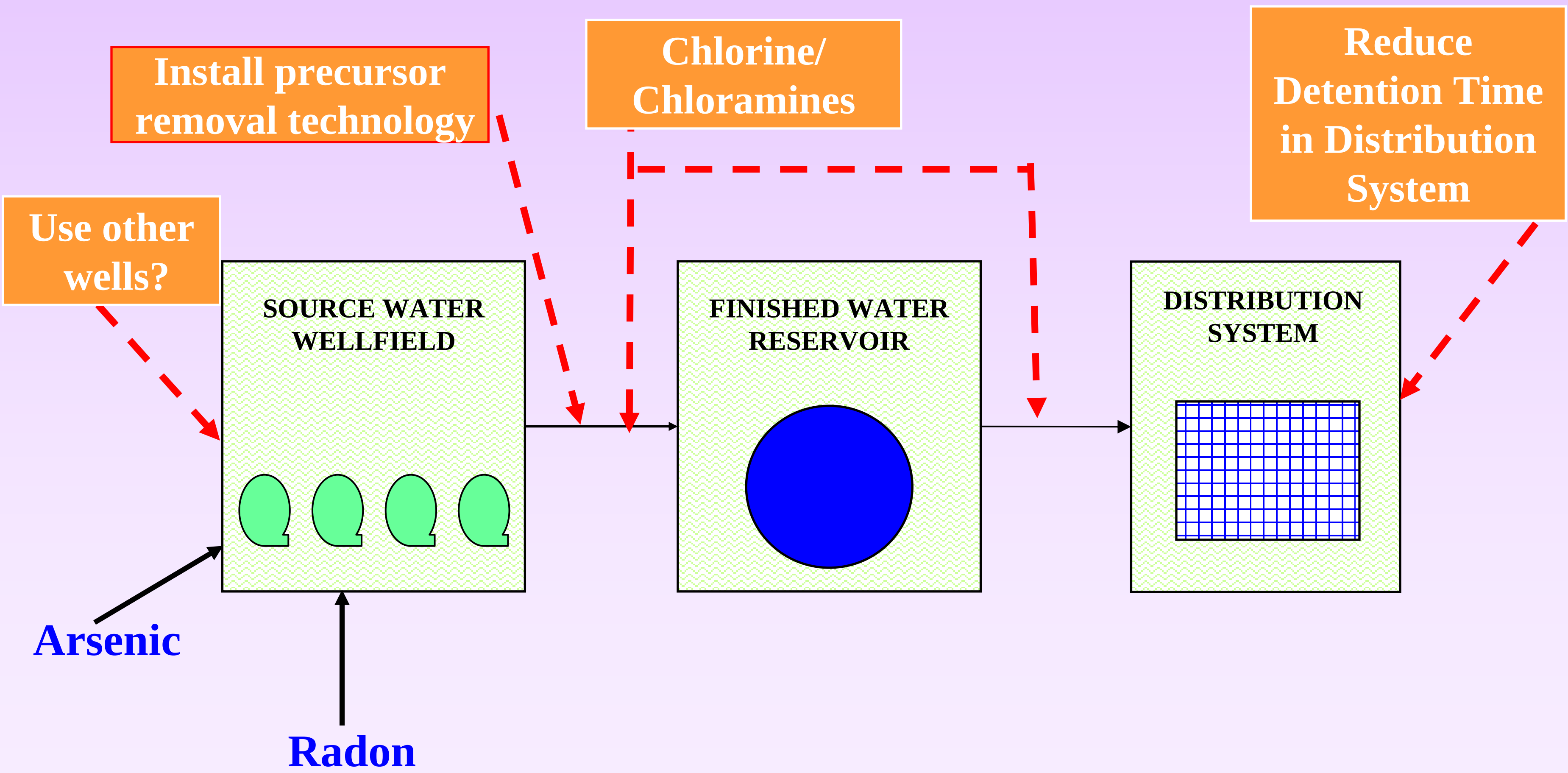
Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



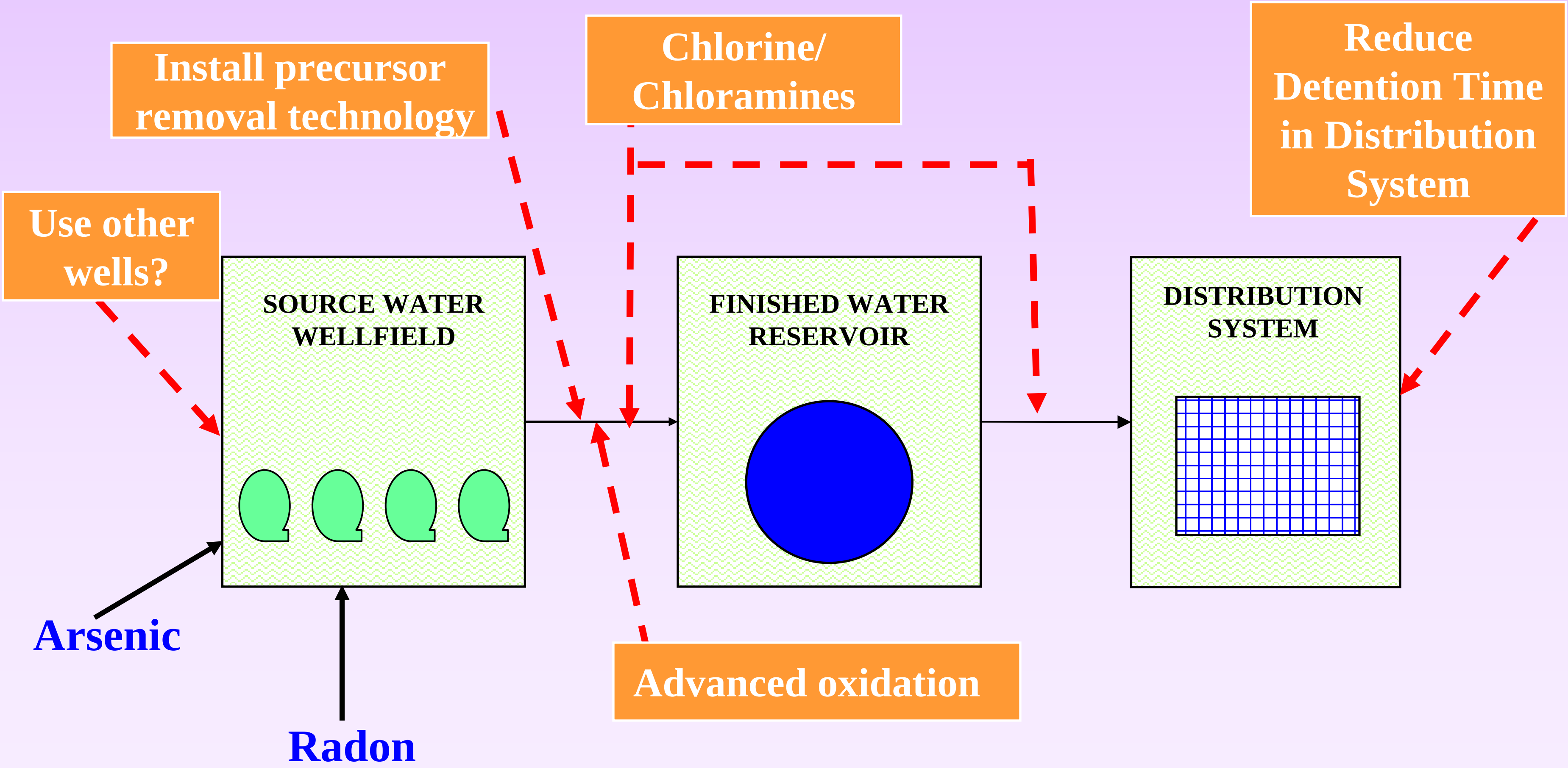
Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



Stage 1 DBPR Case Study #2

Chlorinated Groundwater: 5 MGD



Case Study #2: Compliance Strategy Observations

Chlorinated Groundwater: 5 MGD

- High Organic and Colored Source Water Could:
  - Limit the application of ozone or chlorine dioxide due to byproducts and costs
  - Force high disinfectant residuals in distribution system
- Bromide levels could affect use of chlorine or ozone even after precursor removal

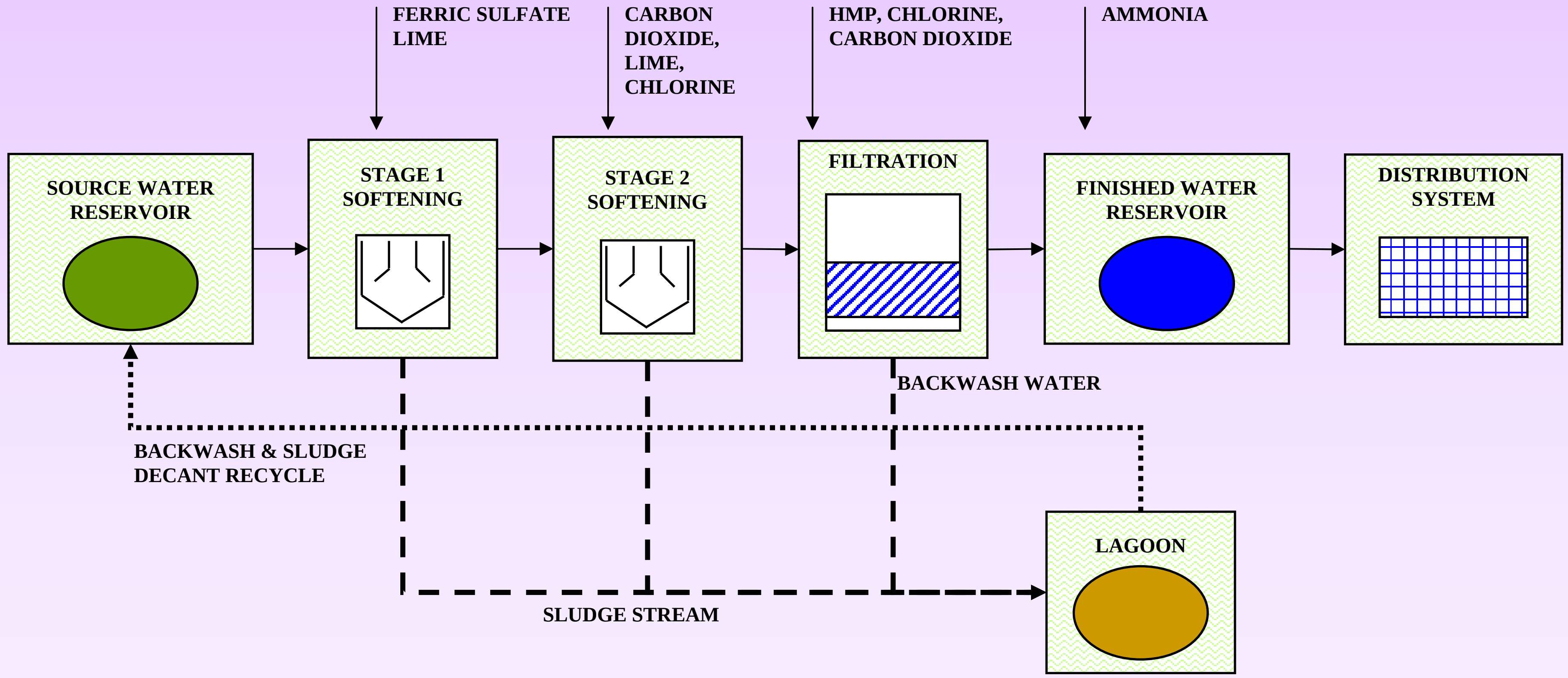
Case Study #2: Compliance Strategy Observations

Chlorinated Groundwater: 5 MGD

- Arsenic and Radon MCLs may Require System to Install Treatment
  - Arsenic control technologies (membranes, anion exchange, activated alumina, coagulation) also benefit DBP precursor control
  - Aeration for radon control raises the pH and may aggravate DBP formation (TTHMs, bromate)
  - Ozone, if feasible, may benefit radon removal

Stage 1 DBPR Case Study #3

River Water 2-Stage Softening: 50 MGD



Stage 1 DBPR Case Study #3

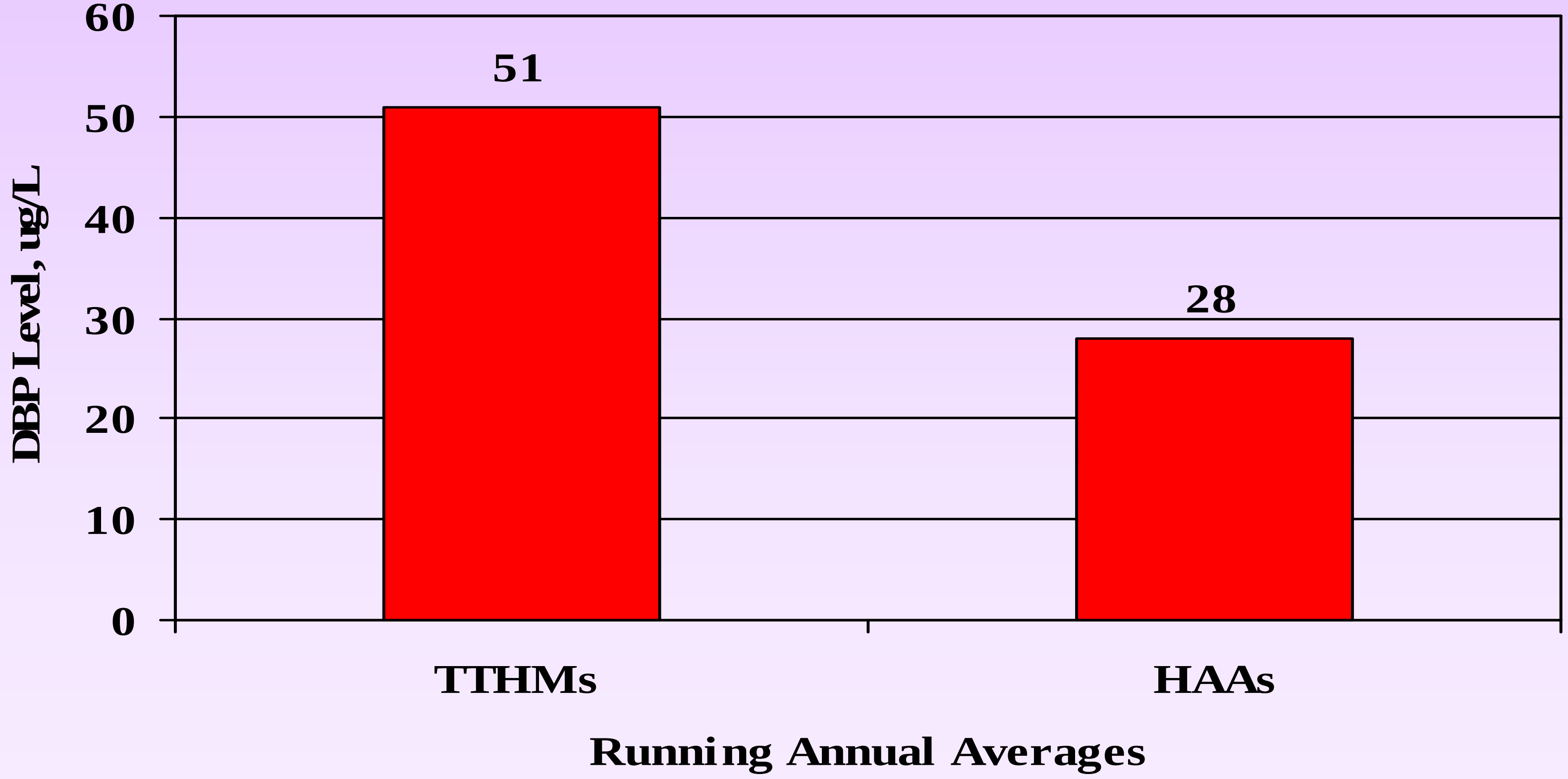
River Water 2-Stage Softening: 50 MGD

Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L)	4.5	2.8	7.1
Bromide (µg/L)	0.08	.05	0.12
pH	7.6	7.2	8.4
Turbidity (NTU)	12	3	50
Temperature (^{o}C)	12	5	22
Hardness (mg/L)	160	110	255
Alkalinity (mg/L)	175	134	240
UV-254 (/cm)	?	?	?
SUVA (L/mg-m)	?	?	?

Stage 1 DBPR Case Study #3

River Water 2-Stage Softening: 50 MGD



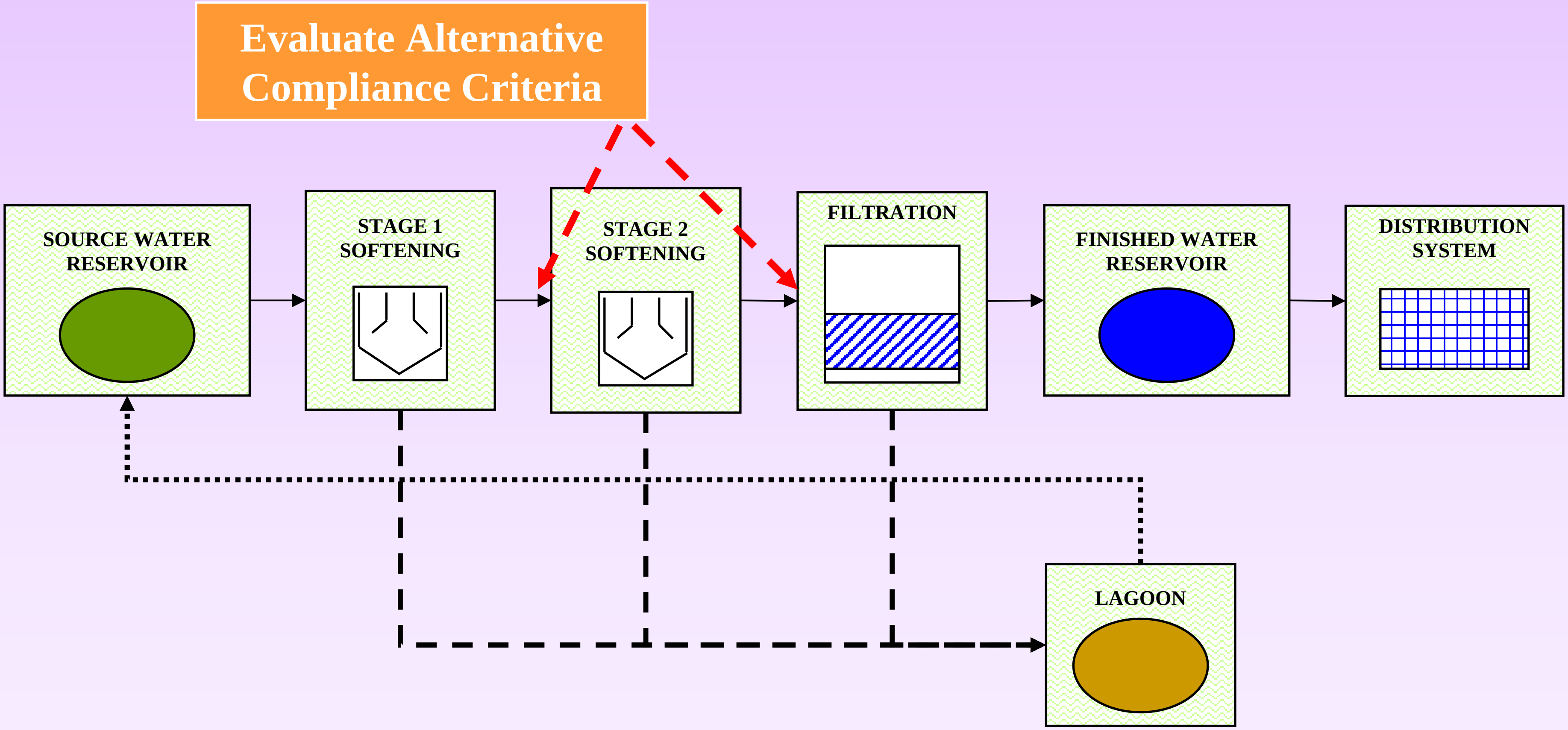
Case Study #3: Observations

River Water 2-Stage Softening: 50 MGD

- Complies with the DBP MCLs and Disinfectant Residual MRDLs
- Average Magnesium Hardness is 16 mg/L
- TOC Values Indicate Enhanced Softening Required
- Low Bromide Source Water
- SUVA Data Needs to be Collected, Including Treated Water SUVA Values

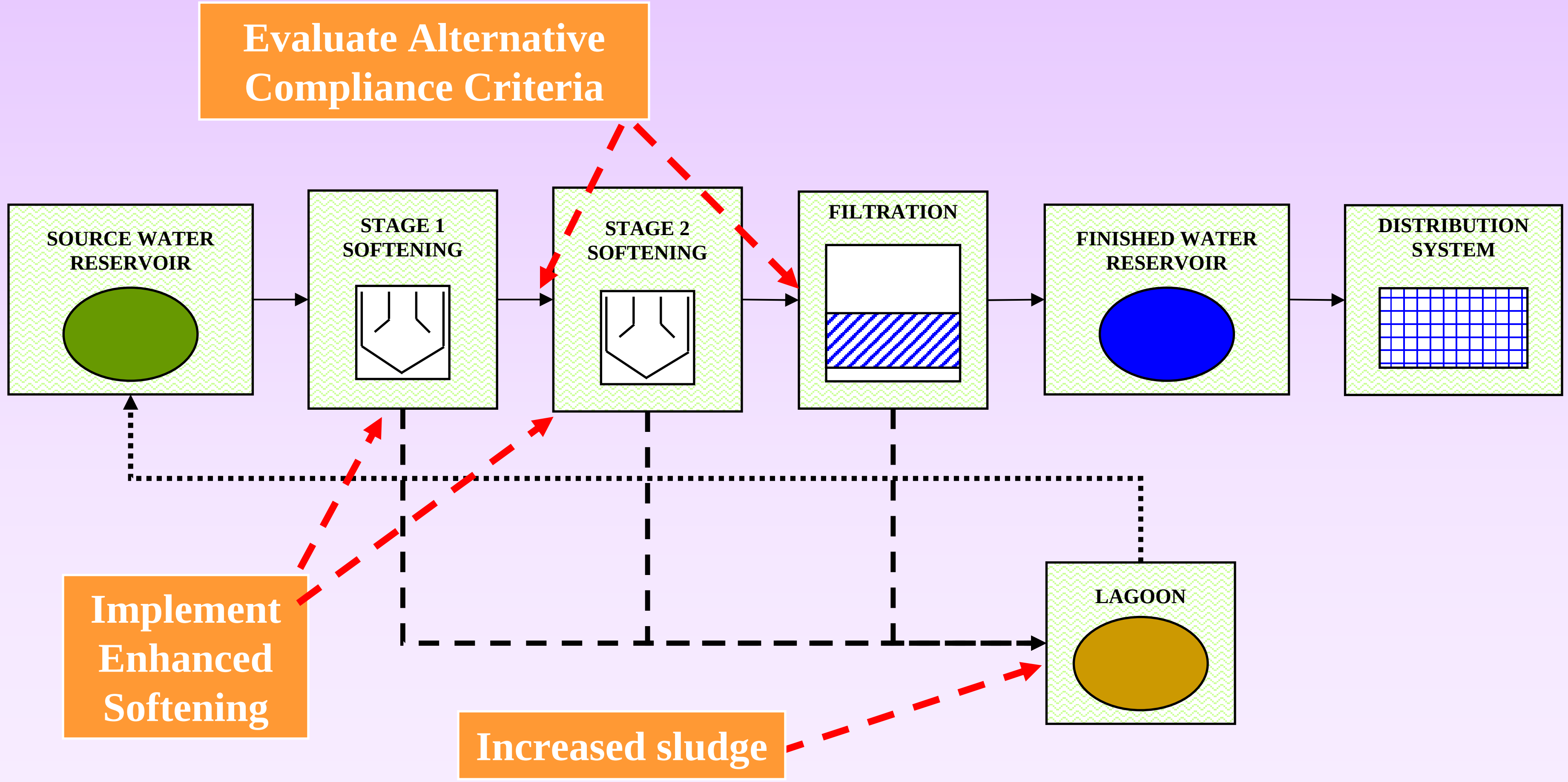
Stage 1 DBPR Case Study #3

River Water 2-Stage Softening: 50 MGD



Stage 1 DBPR Case Study #3

River Water 2-Stage Softening: 50 MGD



Case Study #3: Compliance Strategy Observations

River Water 2-Stage Softening: 50 MGD

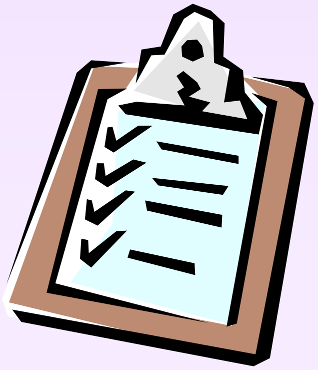
- Source and Treated Water Monitoring Should be Initiated to Evaluate the Plant's Ability to Meet Alternative Compliance Criteria
- Jar Testing will be Necessary to Determine Potential Compliance with the Treated Water SUVA Alternative Compliance Criteria
- Lime Dosages for this Plant Minimally Could Be:
  - 100 mg/L $Ca(OH)_2$: Reduce alkalinity to ≤60 mg/L
  - 135 mg/L $Ca(OH)_2$: Remove 10 mg/L magnesium

Workshop

Consider Solutions for Each System's Problems

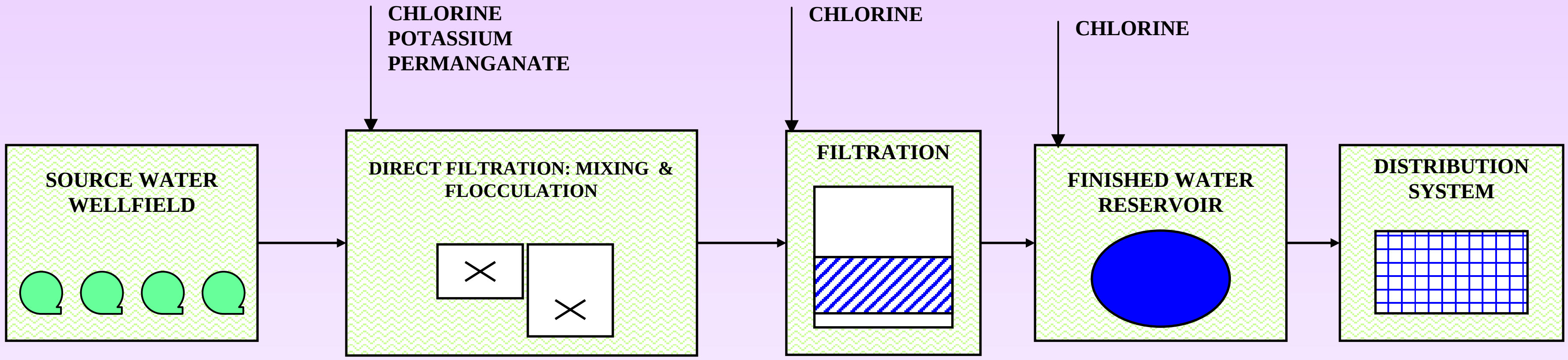
Outline (cont.)

- Case Studies - Workshop
  - Groundwater, iron removal, 10 MGD,
    TOC = 2 mg/L
  - Surface water, direct filtration plant, 50 MGD
    TOC = 2.1 mg/L
  - Surface water, conventional treatment plant, 50 MGD, TOC = 10 mg/L
- Summary



Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



Stage 1 DBPR Case Study #4

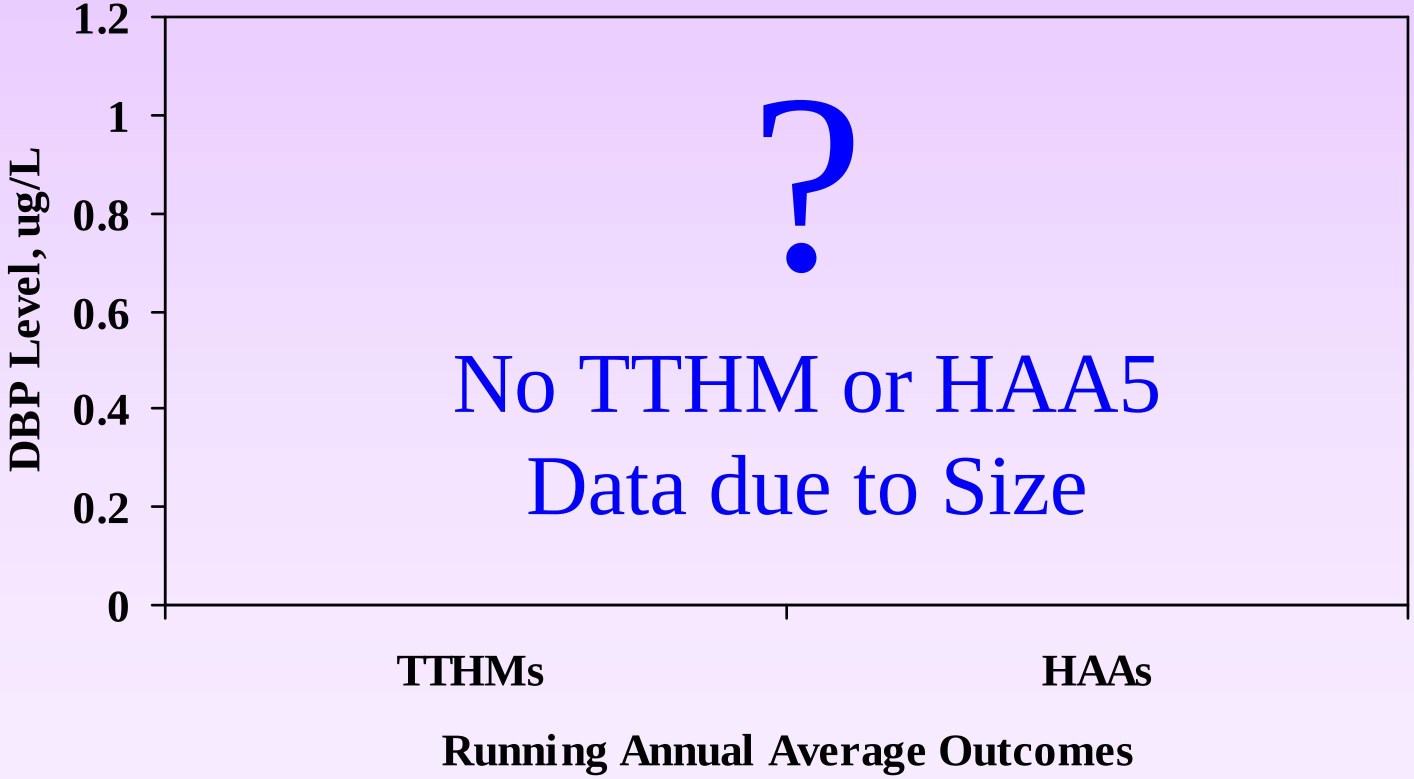
Groundwater w/ Iron & Manganese Removal: 2 MGD

Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L) *	2	2	2
Bromide (μg/L)	?	?	?
pH	6.7	6.2	7.5
Turbidity (NTU)	0.10	0.12	0.08
Temperature (^{o}C)	13	9	16
Alkalinity (mg/L)	85	68	102
Iron (mg/L)	0.6	0.4	2.0
Manganese (mg/L)	0.1	0.05	0.3
UV-254 (ohms/cm)	?	?	?
Arsenic (μg/L)	< 50	< 50	< 50
* One TOC Sample Collected as Part of Groundwater Survey			

Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



Case Study #4: Observations

Groundwater w/ Iron & Manganese Removal: 2 MGD

- Good Bacterial Quality for a Disinfected Groundwater
- Essential to Collect DBP Data
- Unknown DBP Precursor Water Quality
  - Bromide, UV254, SUVA, TOC

Case Study #4: Observations

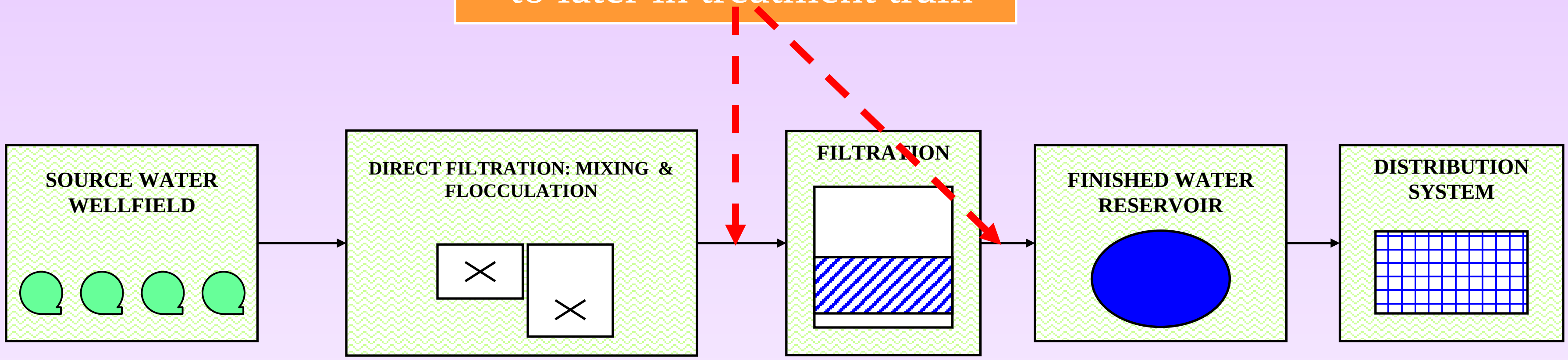
Groundwater w/ Iron & Manganese Removal: 2 MGD

- Low Level Arsenic Measures Unavailable
- Radon Sampling has not been Performed
- Iron and Manganese are Elevated:
  - Co-occurs with arsenic, but existing treatment may already be effective for arsenic control
  - Oxidation & removal strategy for iron/manganese must be incorporated with overall compliance strategy

Stage 1 DBPR Case Study #4

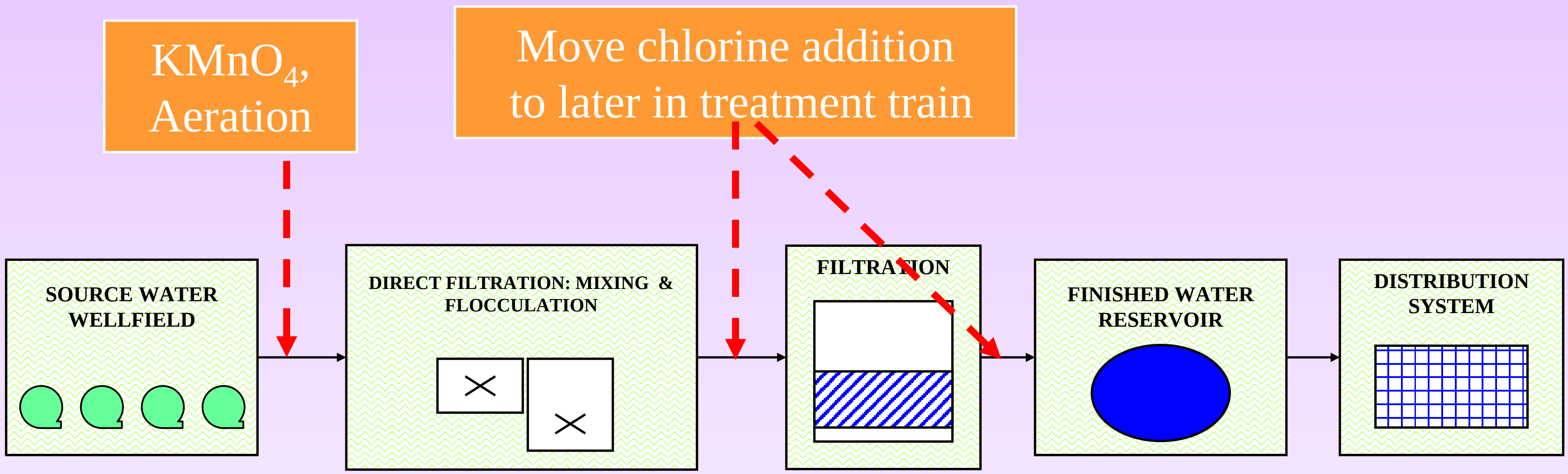
Groundwater w/ Iron & Manganese Removal: 2 MGD

Move chlorine addition to later in treatment train



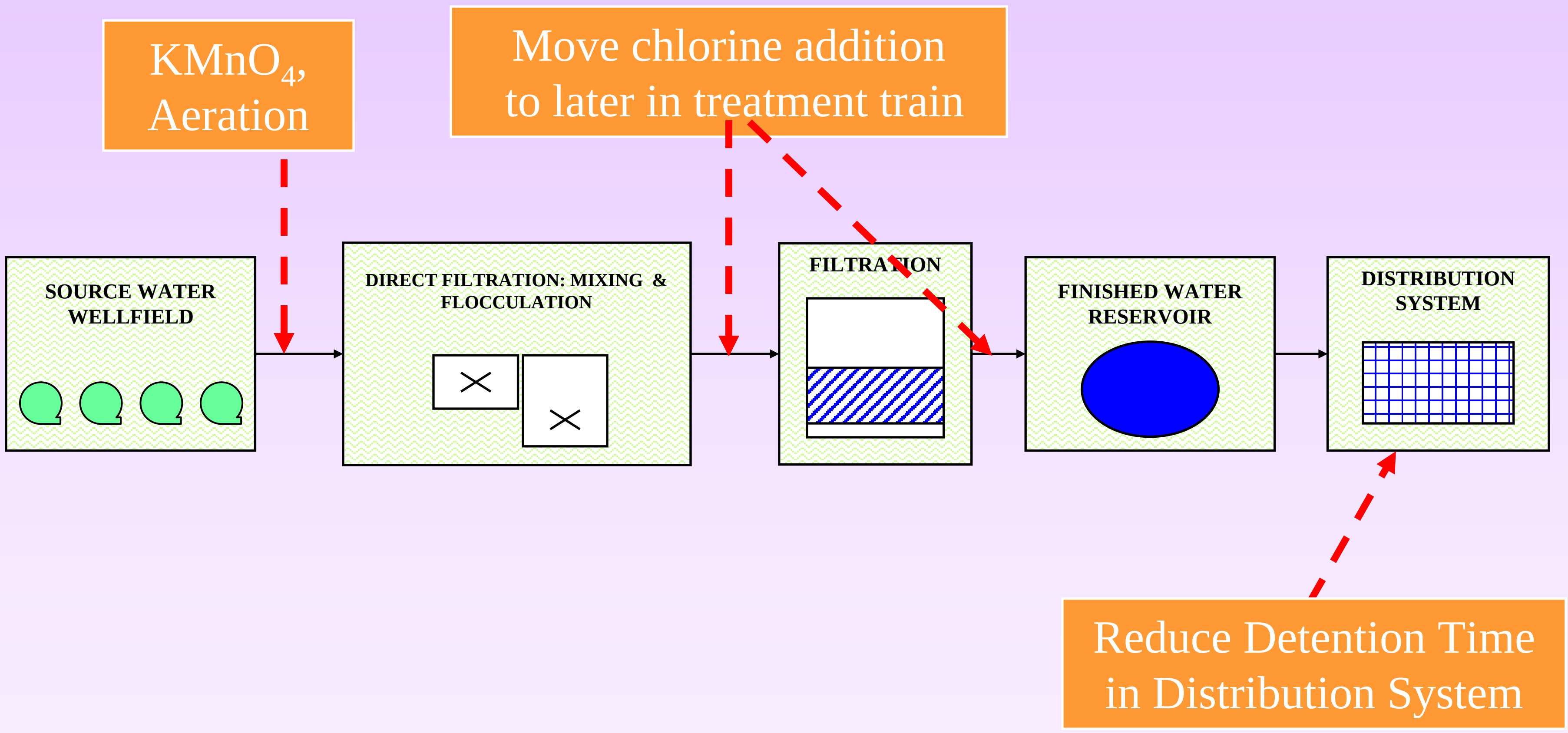
Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



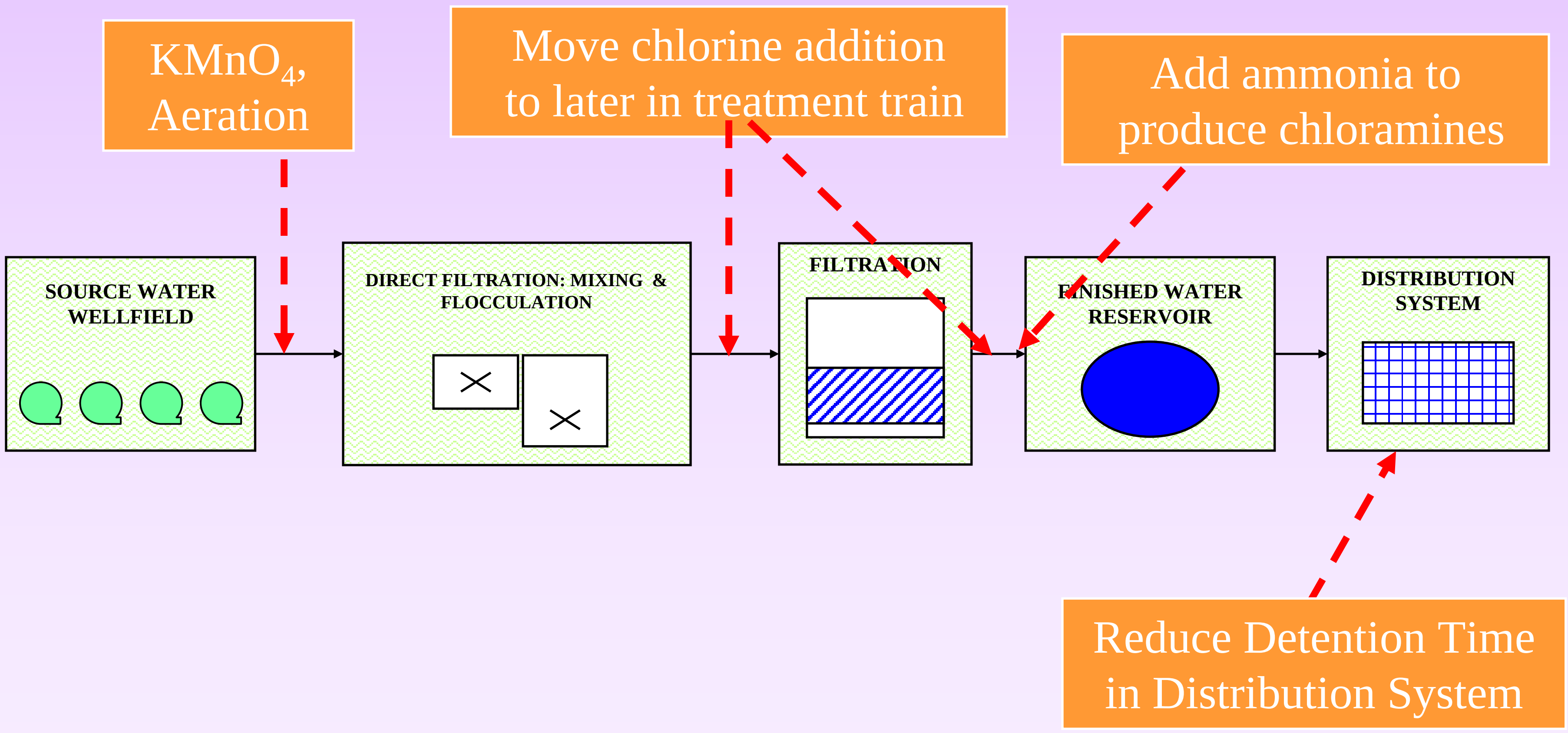
Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



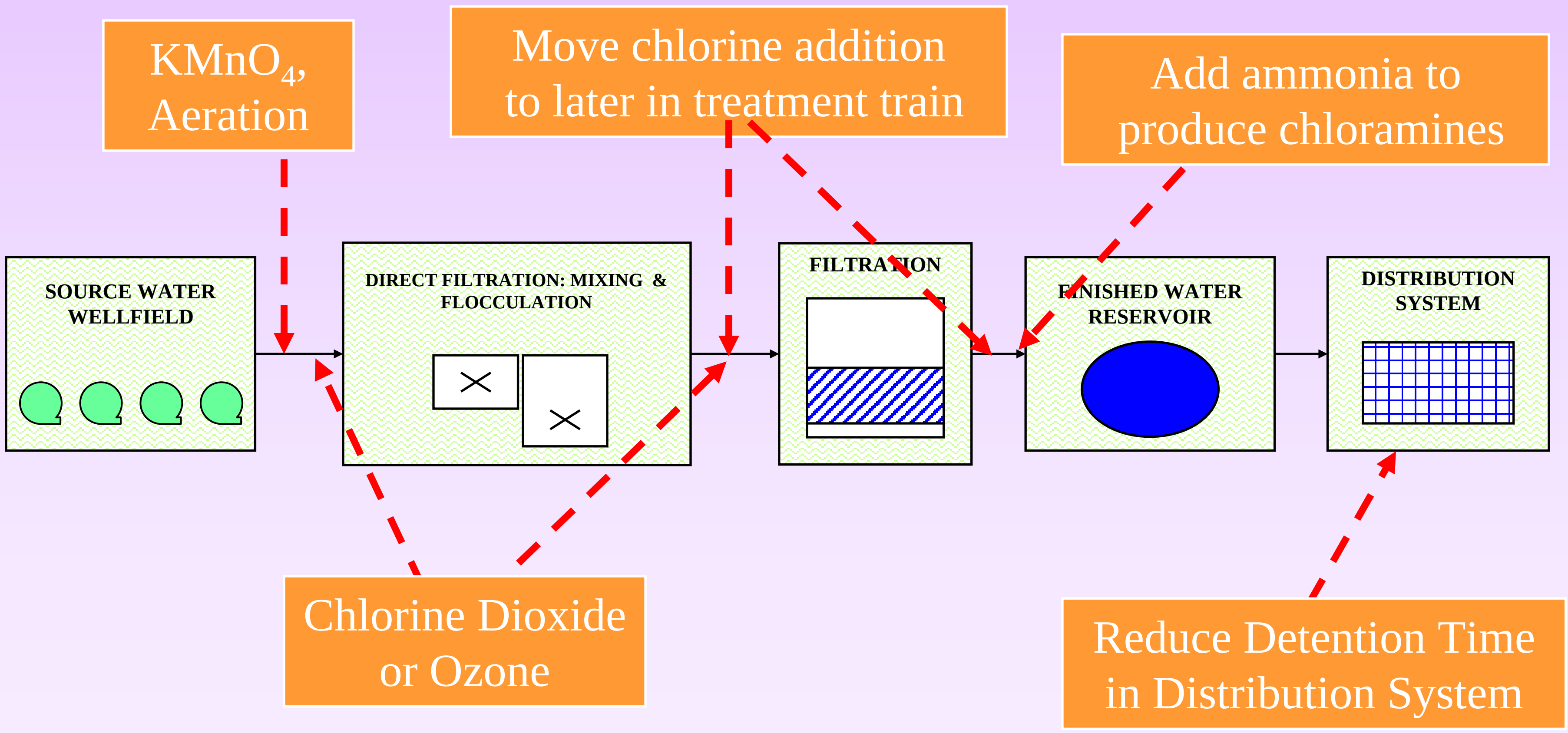
Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



Stage 1 DBPR Case Study #4

Groundwater w/ Iron & Manganese Removal: 2 MGD



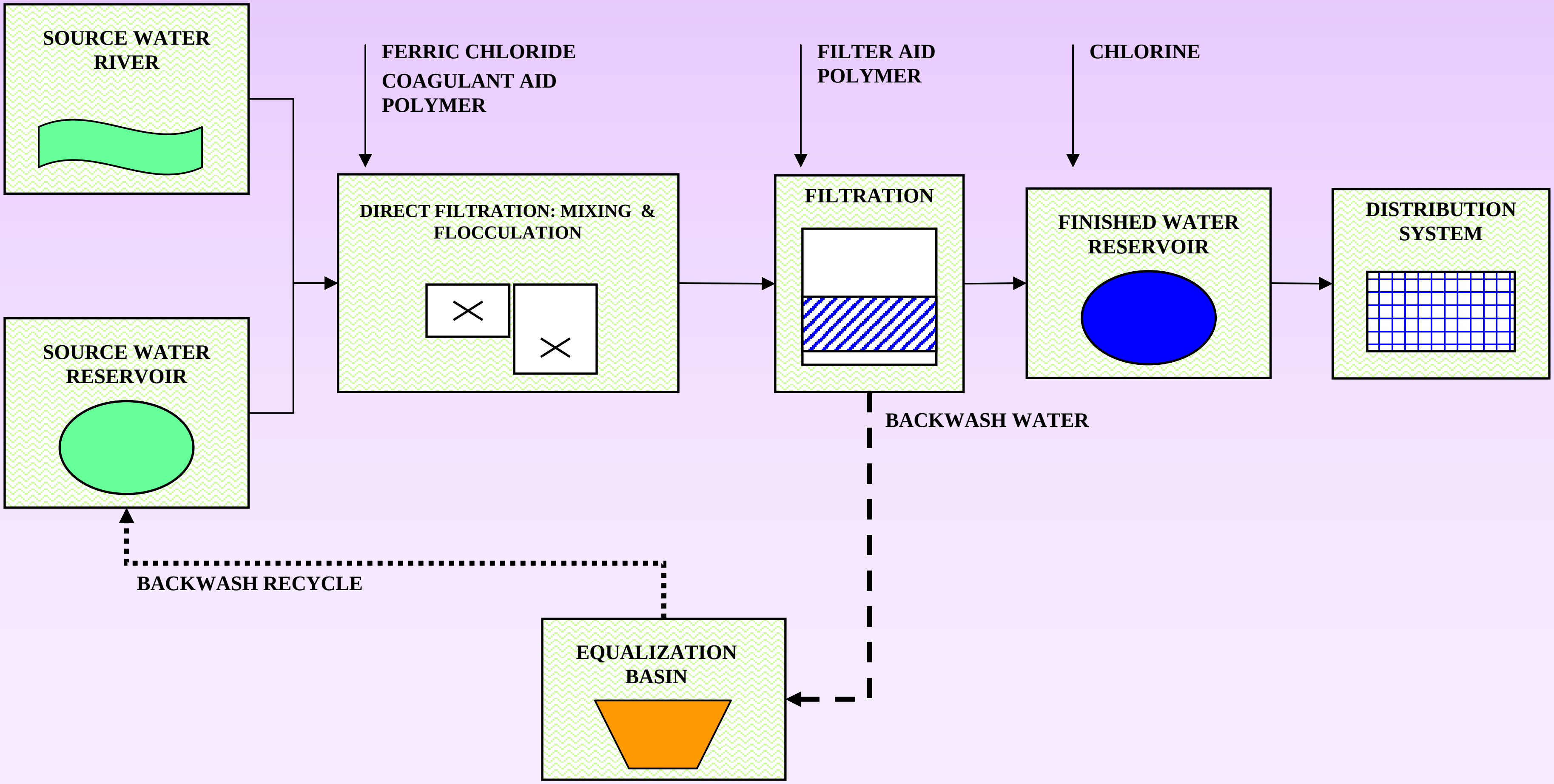
Case Study #4: Compliance Strategy Observations

Groundwater w/ Iron & Manganese Removal: 2 MGD

- Manage ClO_2 dosage to stay within chlorite MCL
- Manage chlorine contact time prior to ammonia to control DBPs
- Critical to collect HAA5 data
- Sedimentation basins could be constructed to manage arsenic removal

Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



Stage 1 DBPR Case Study #5

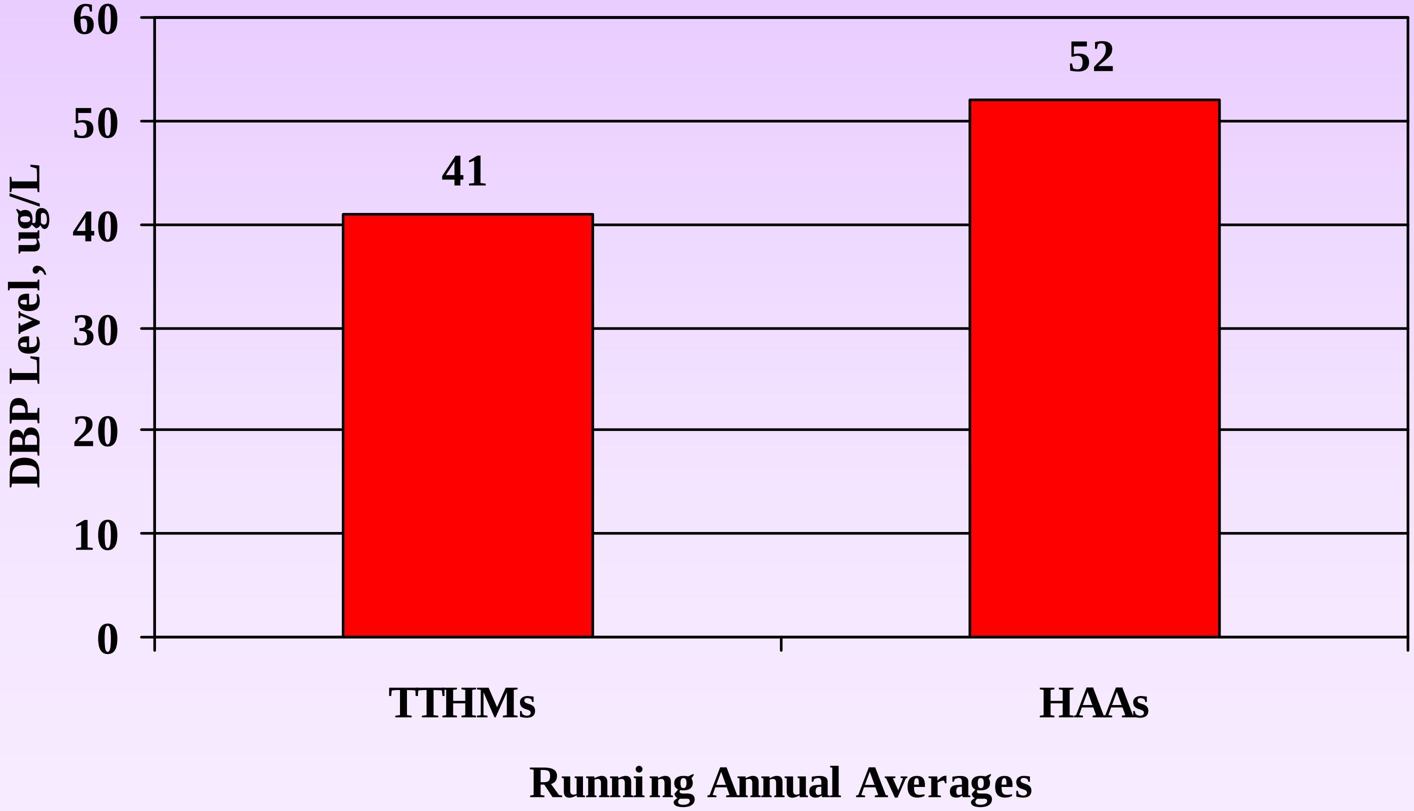
Surface Water Direct Filtration: 50 MGD

Blended Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L)	2.1	0.7	4.2
Bromide (µg/L)	0.22	0.15	0.35
pH	7.1	6.3	9.2
Turbidity (NTU)	6	1	27
Temperature (^{o}C)	9	4.1	17
Alkalinity (mg/L)	42	8	65
UV-254 (/cm)	0.045	0.028	0.136
SUVA (L/mg-m)	2.7	1.8	4.6
Total Coliform (colonies/100mL)	23	ND	105
Cryptosporidium (oocyst/100L)	ND	ND	ND
Giardia (cysts/100 L)	ND	ND	44
Viruses (plaque/100L)	ND	ND	ND

Stage 1 DBPR Case Study #5

Surface Water (Reservoir) Direct Filtration: 50 MGD



Case Study #5: Observations

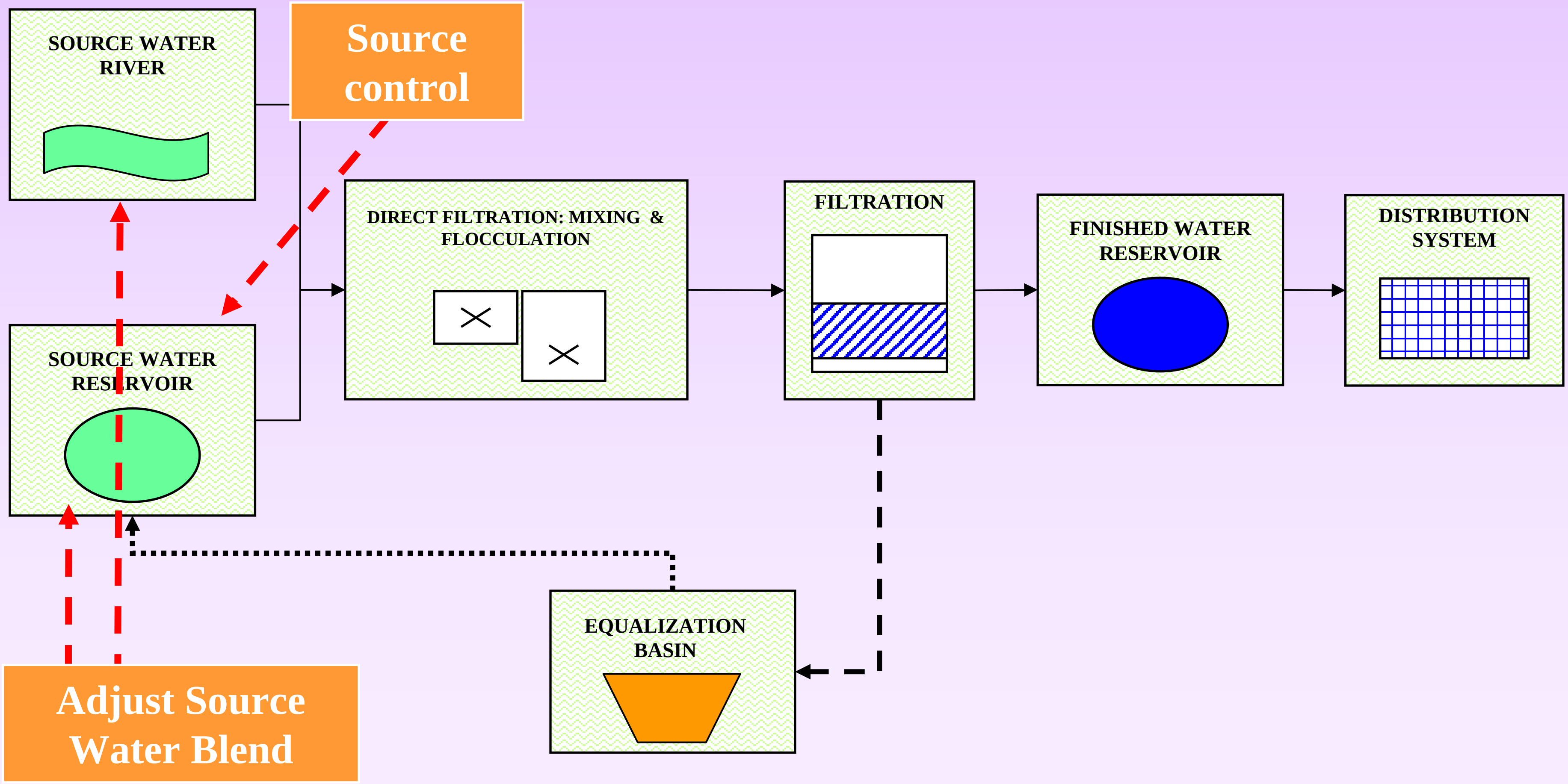
- Elevated Bromide Levels
- Relatively Low TOC and Alkalinity
- Enhanced Coagulation is NOT Required, but SUVA Indicates TOC Removal Possible
- Plant Already Meets Stage 1 DBPR MCLs
- Plant Would NOT Meet Stage 2 LRAA MCLs
- Currently Blend Source Waters ~ 50:50

Case Study #5: Observations

- Reservoir Source has Higher TOC and Seasonal Algae
  - Leads to T&O problems
- Increased Reliance on Reservoir Supply in Future due to Increase Demand
- Future Water Quality may Cause Higher TTHMs and HAA5 in Distribution System

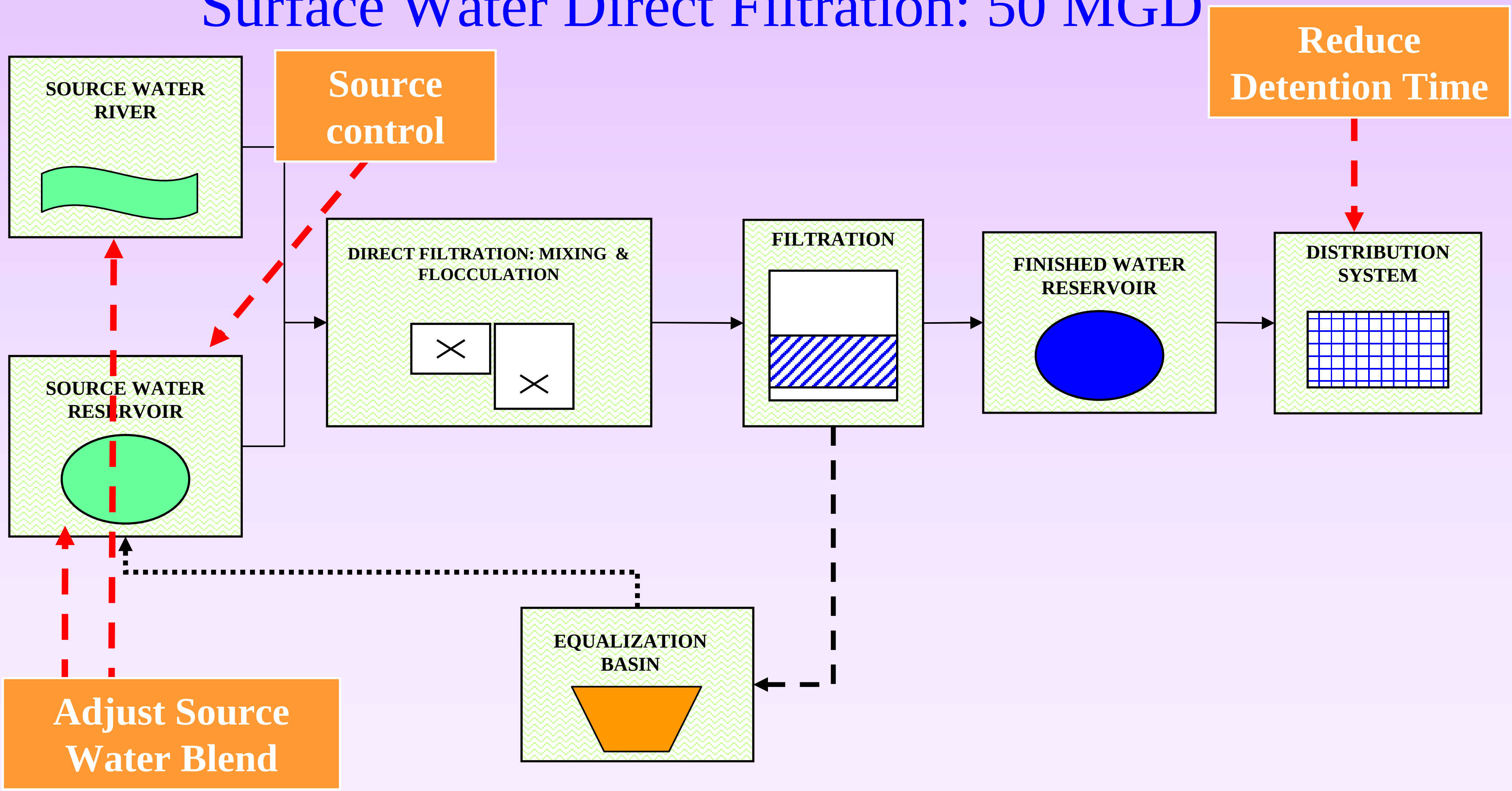
Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



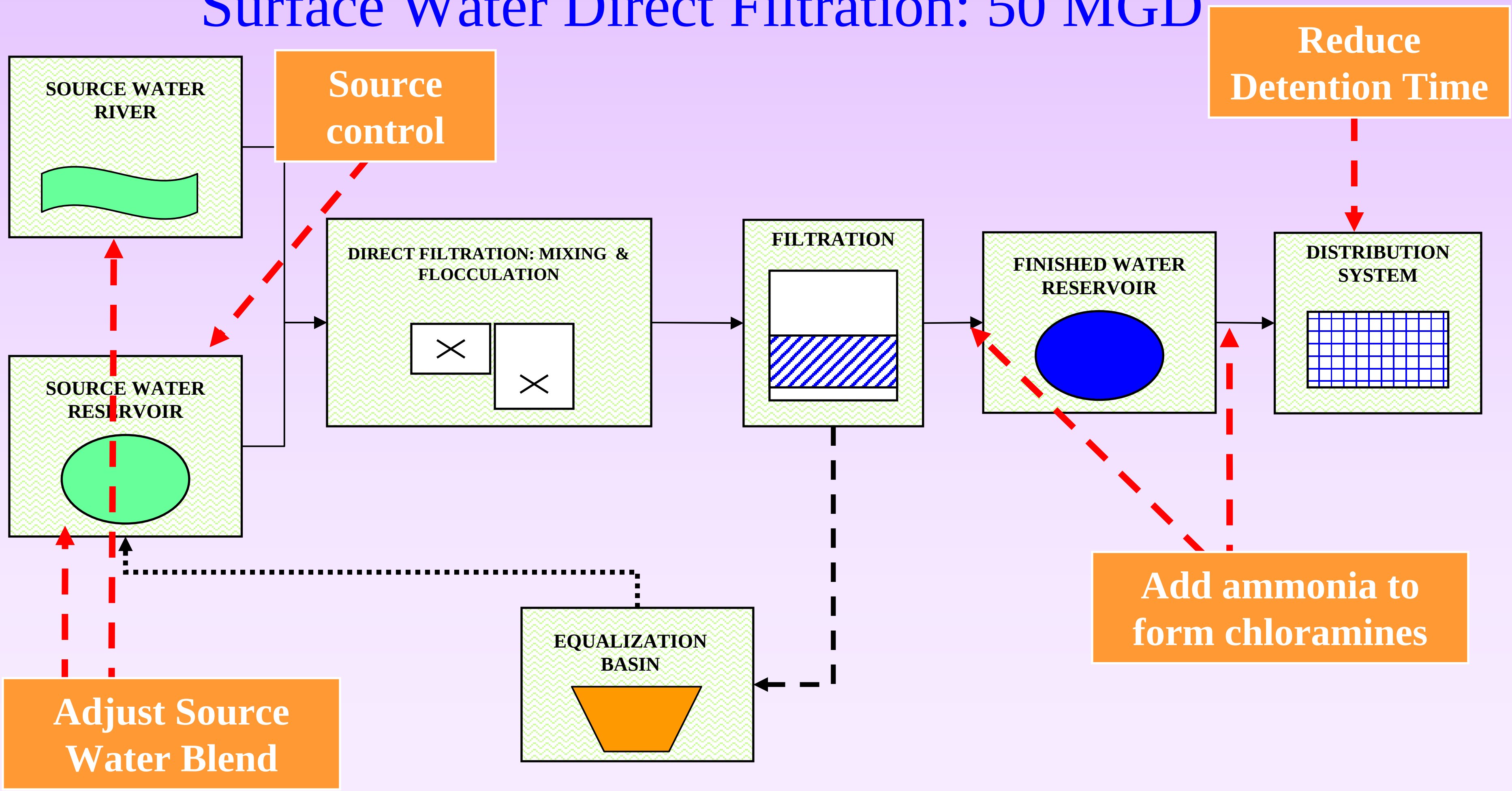
Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



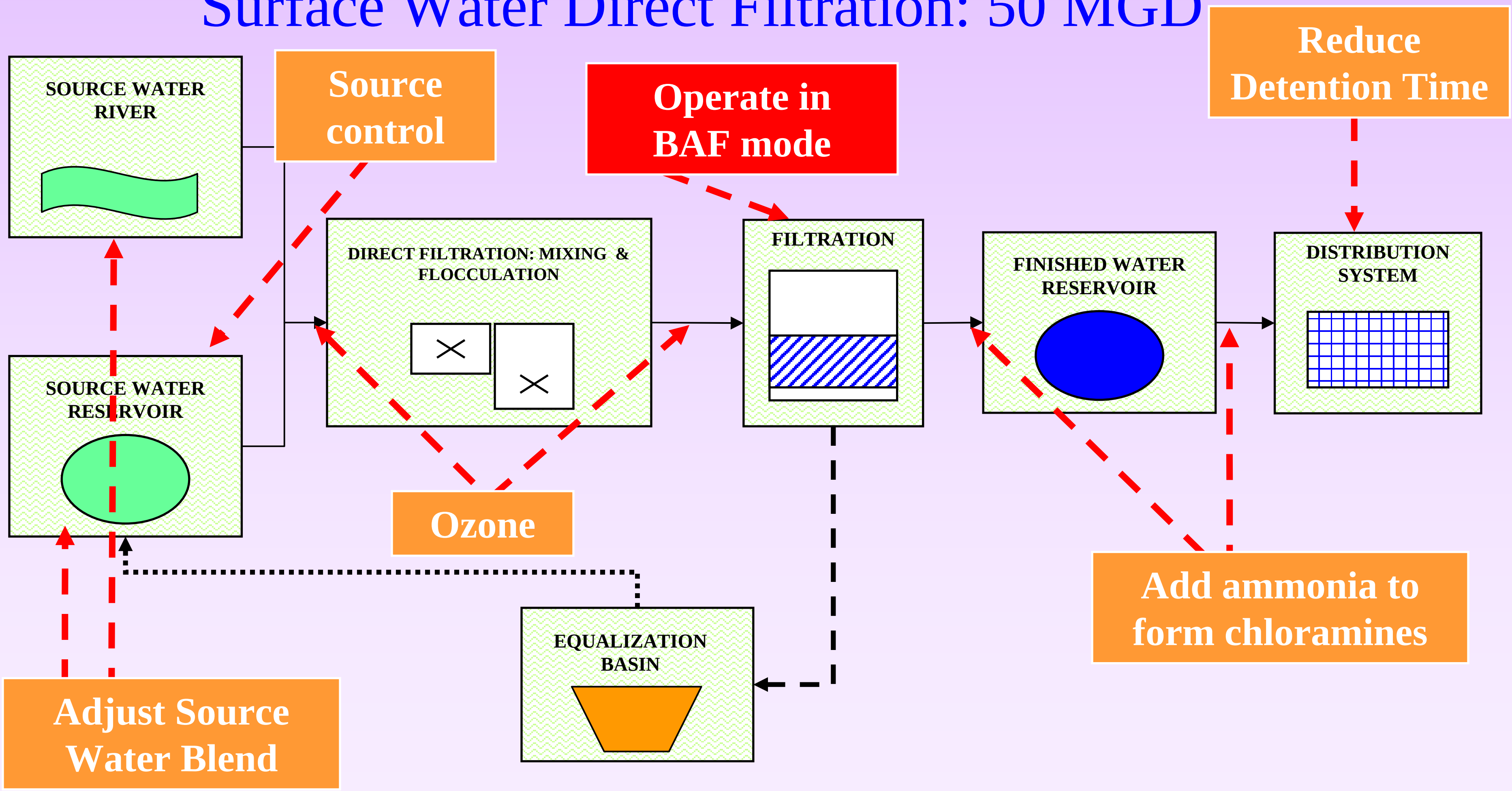
Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



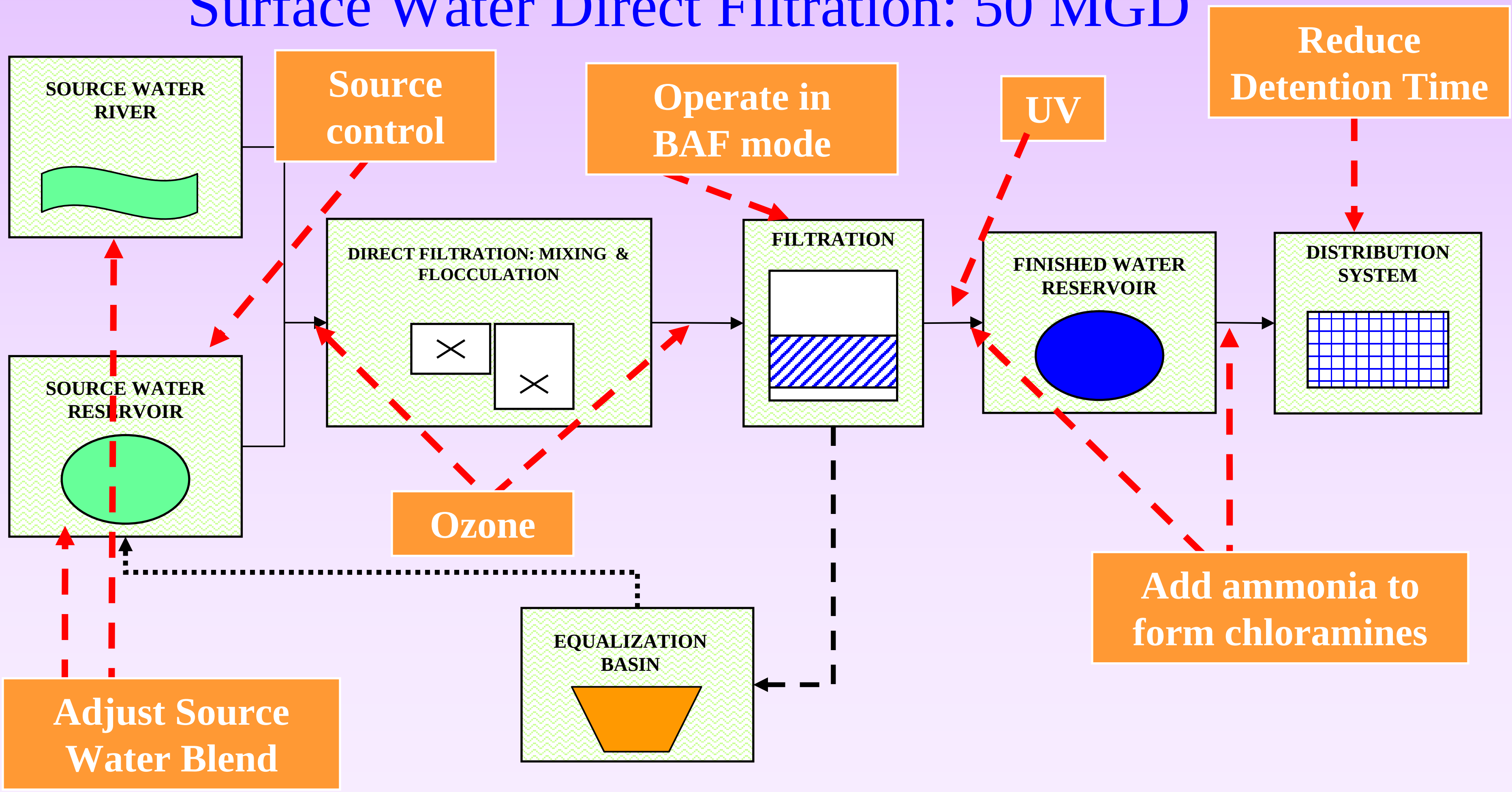
Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



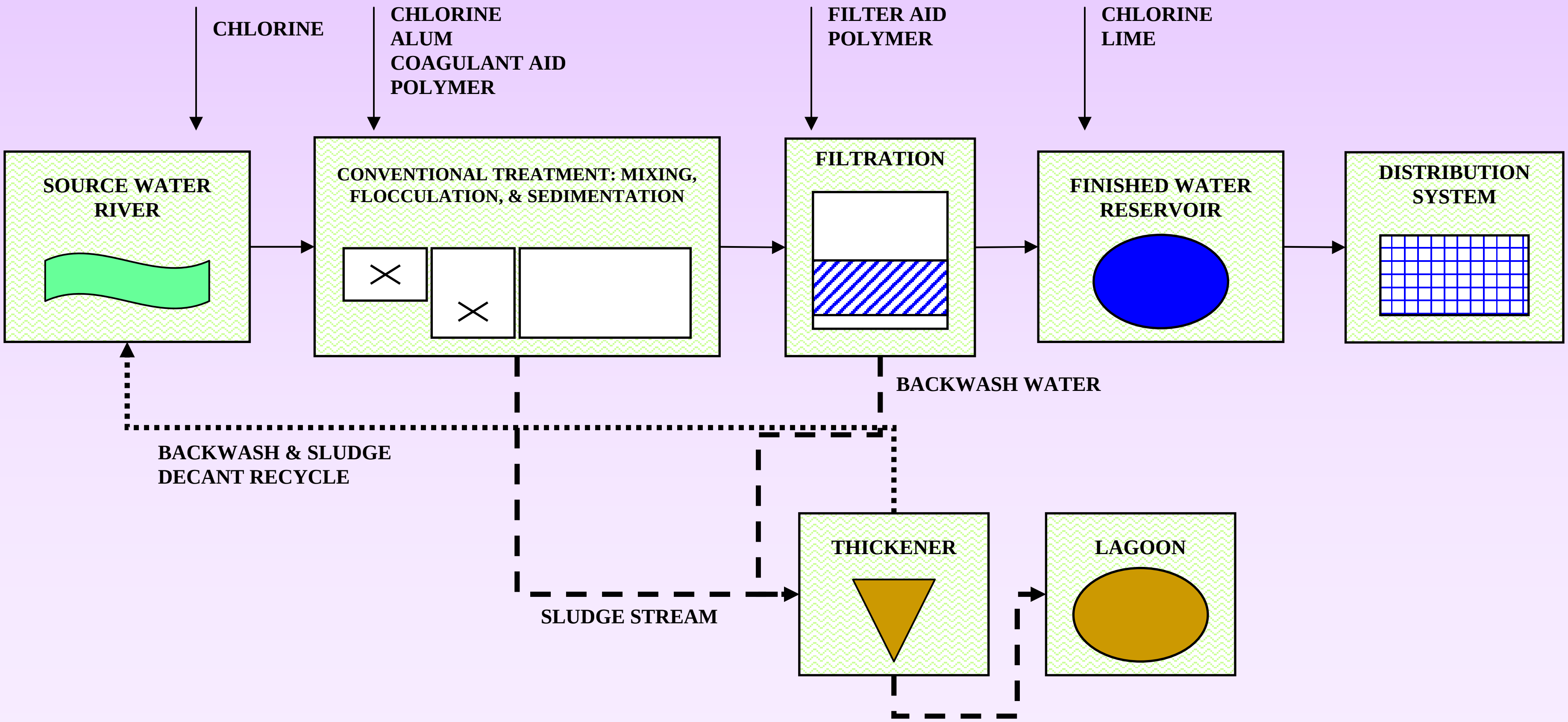
Stage 1 DBPR Case Study #5

Surface Water Direct Filtration: 50 MGD



Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



Stage 1 DBPR Case Study #6

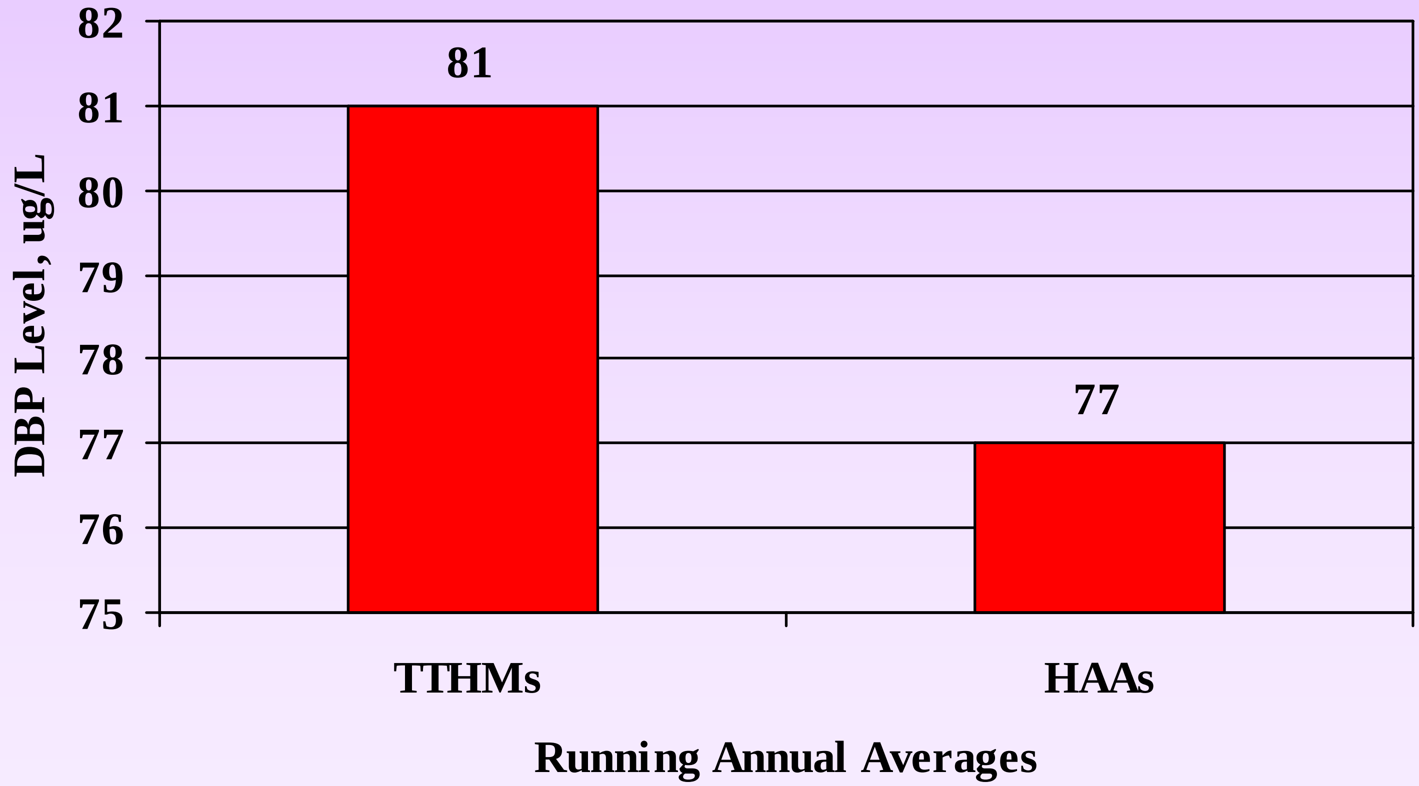
Surface Water (River) Conventional Treatment: 50 MGD

Influent Water Quality

Parameter	Average	Minimum	Maximum
TOC (mg/L)	10	3.6	22
Bromide (µg/L)	0.1	0.05	0.25
pH	6.8	6.2	7.5
Turbidity (NTU)	68	23	>1000
Temperature (^{o}C)	12	4.1	26
Alkalinity (mg/L)	23	12	55
UV-254 (/cm)	0.095	0.032	0.256
SUVA (L/mg-m)	7.5	4.1	16.0
Total Coliform (colonies/100mL)	1,250	800	37,000
Cryptosporidium (oocyst/100L)	25	ND	420
Giardia (cysts/100 L)	42	ND	680
Viruses (plaque/100L)	?	?	?

Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



Case Study #6: Observations

Surface Water (River) Conventional Treatment: 50 MGD

- High TOC Source Water
- Periodically Elevated Bromide
- Enhanced Coagulation is Required
- High SUVA Indicates TOC Removal by Coagulation is Promising
- Exceeds the TTHM MCL Marginally, but Significantly Above the HAA5 MCL

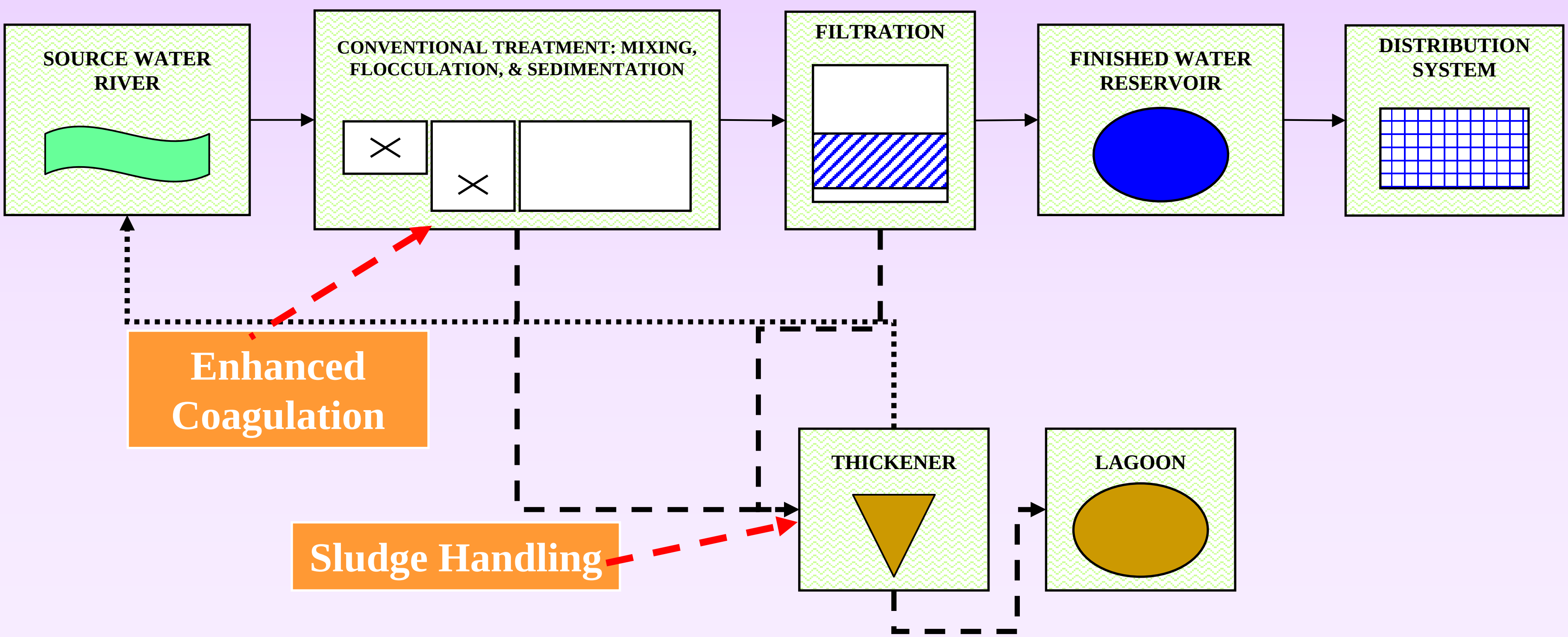
Case Study #6: Observations

Surface Water (River) Conventional Treatment: 50 MGD

- Treatment Challenges from Source Water Quality:
  - Poor microbiological quality (High coliform bacteria, *Giardia*, and *Cryptosporidium*)
  - Low alkalinity can limit coagulation performance
  - High turbidity events can overload processes
  - Seasonal trend has cold temperature, low alkalinity, and high turbidity coinciding

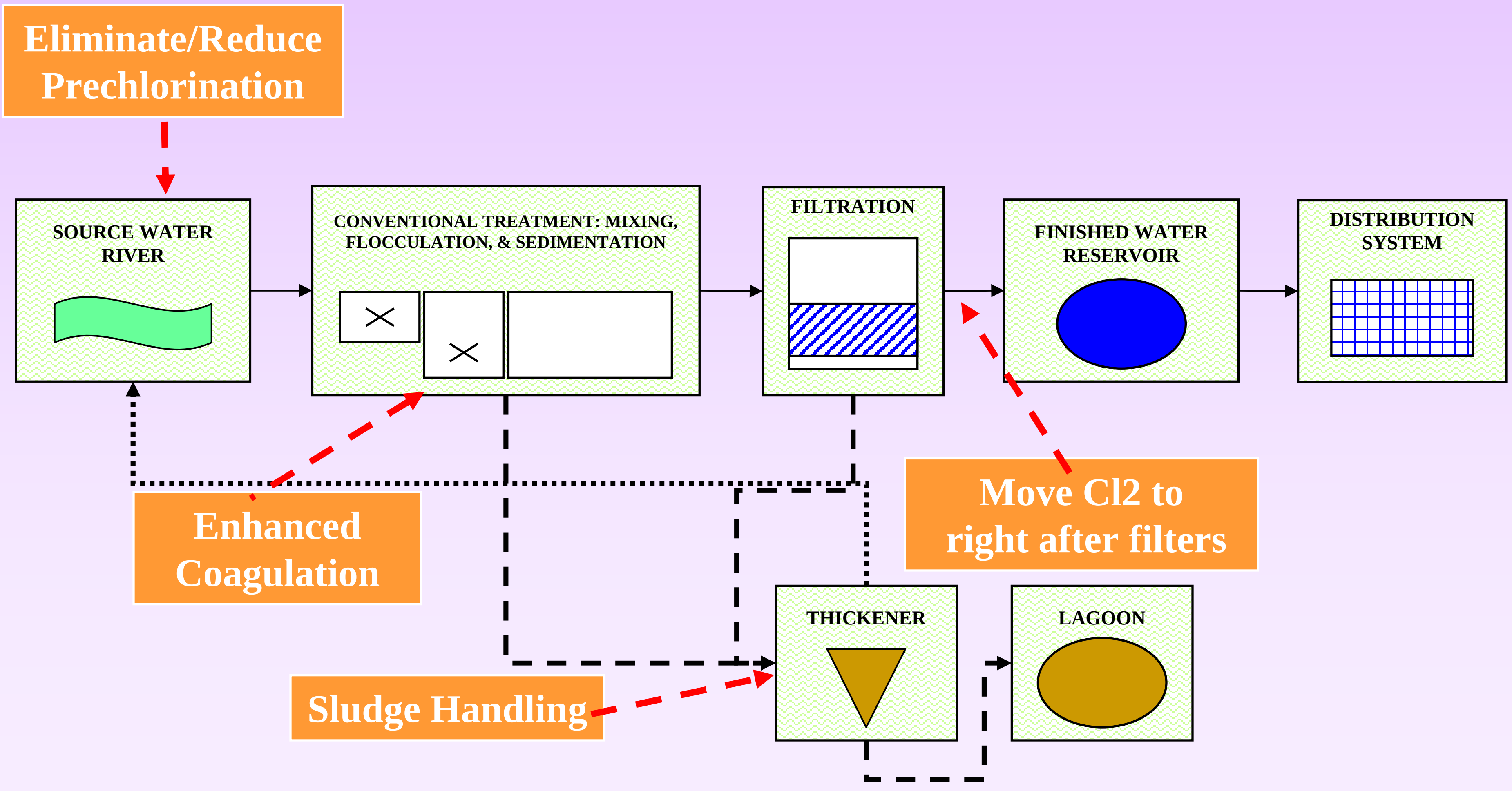
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



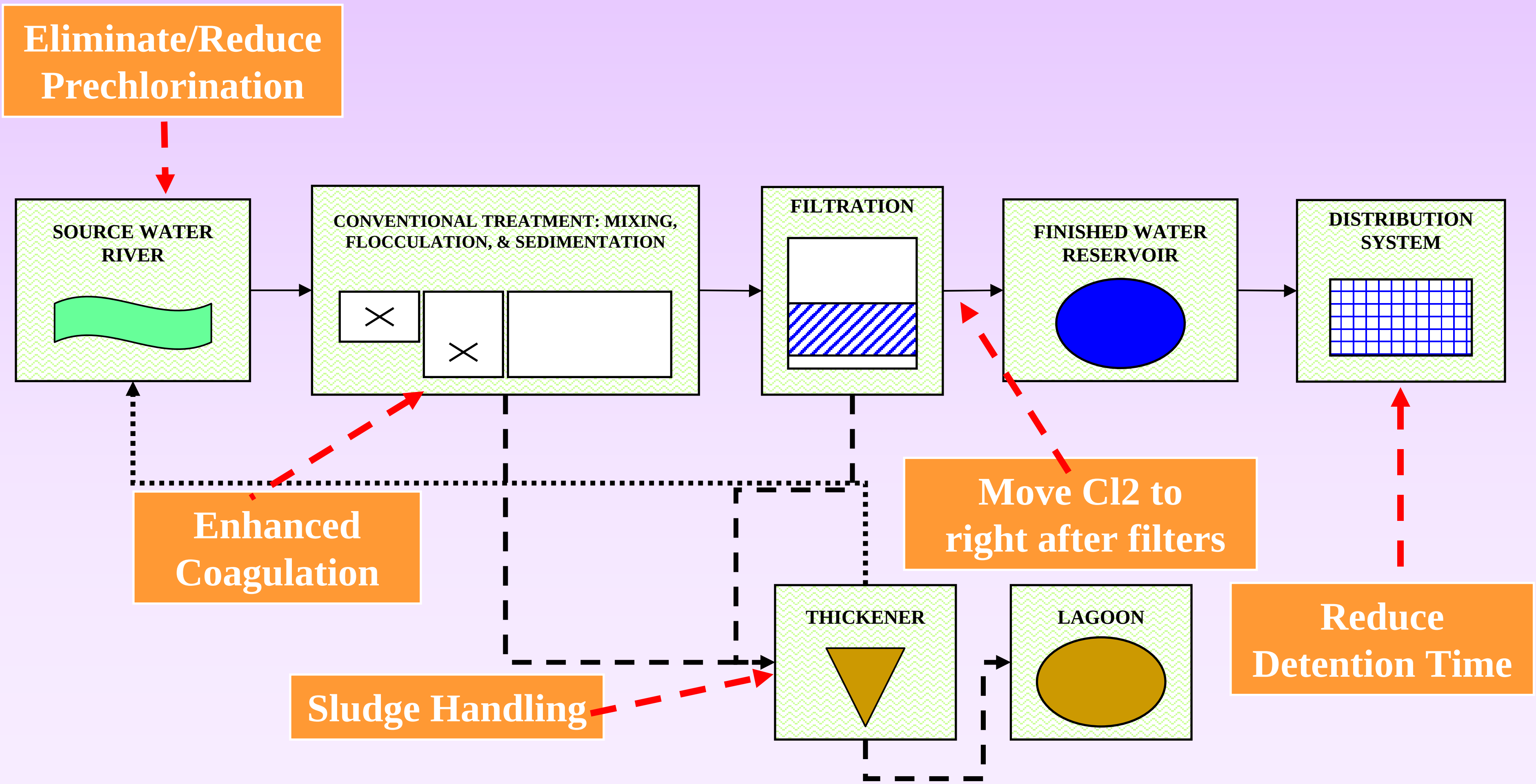
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



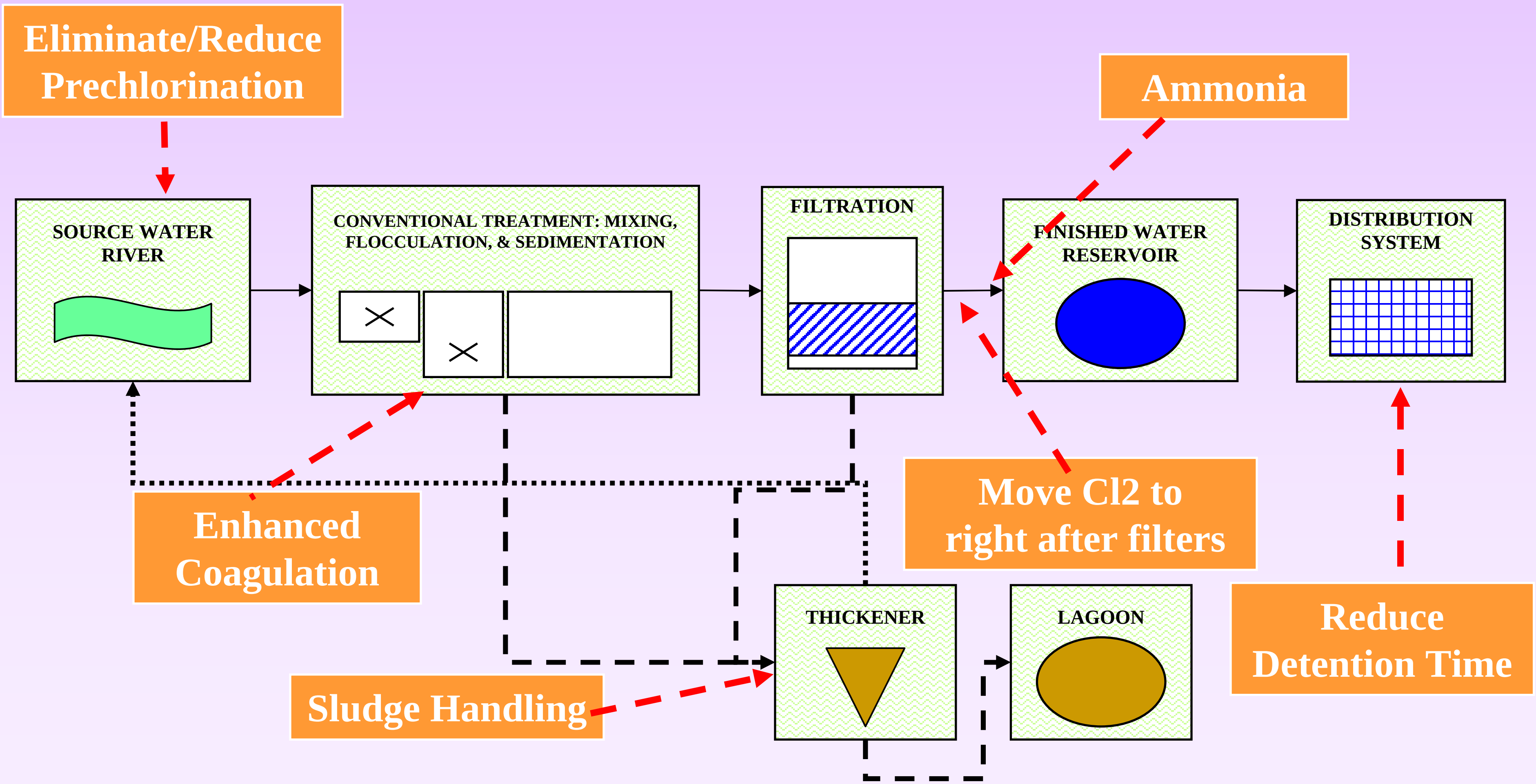
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



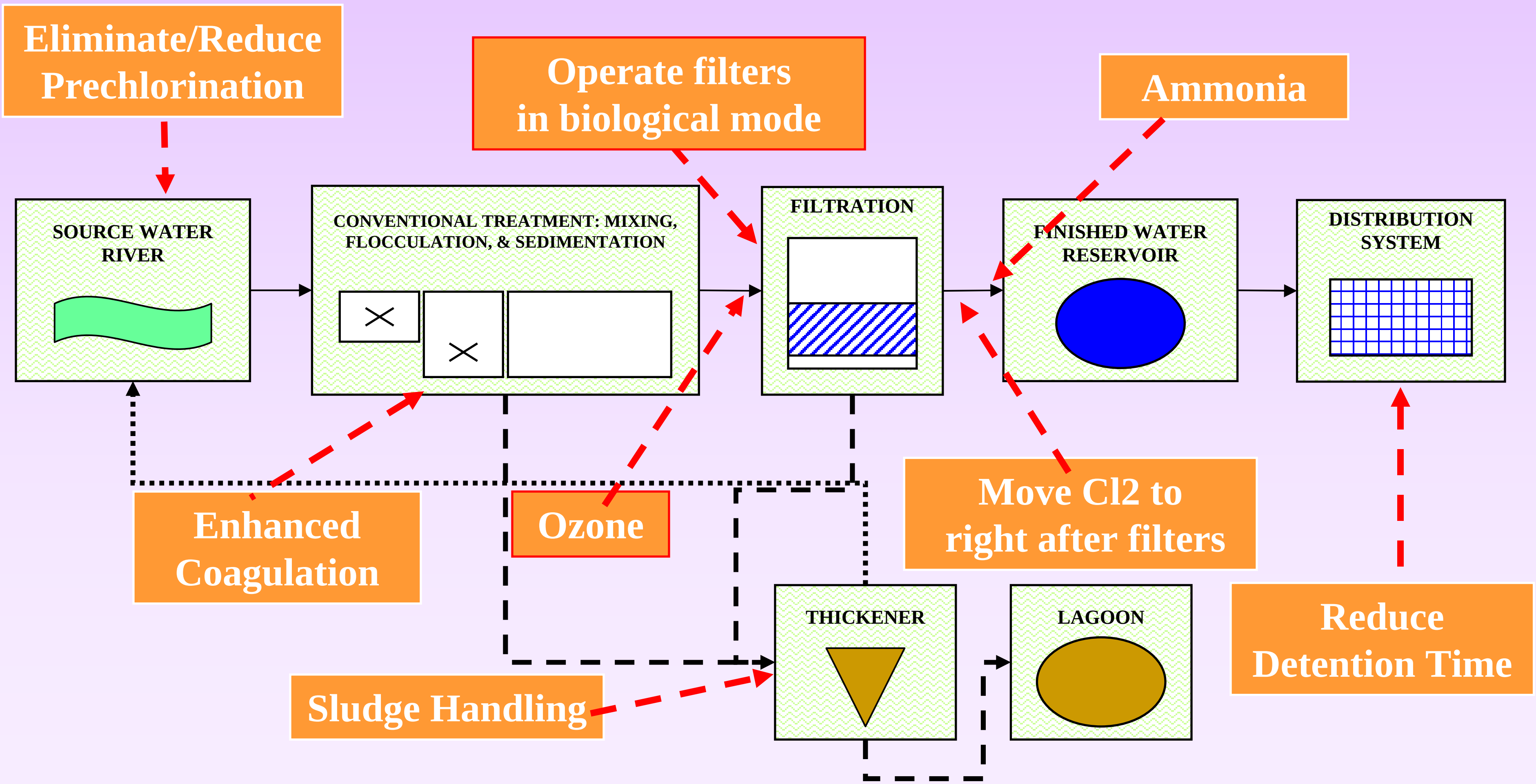
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



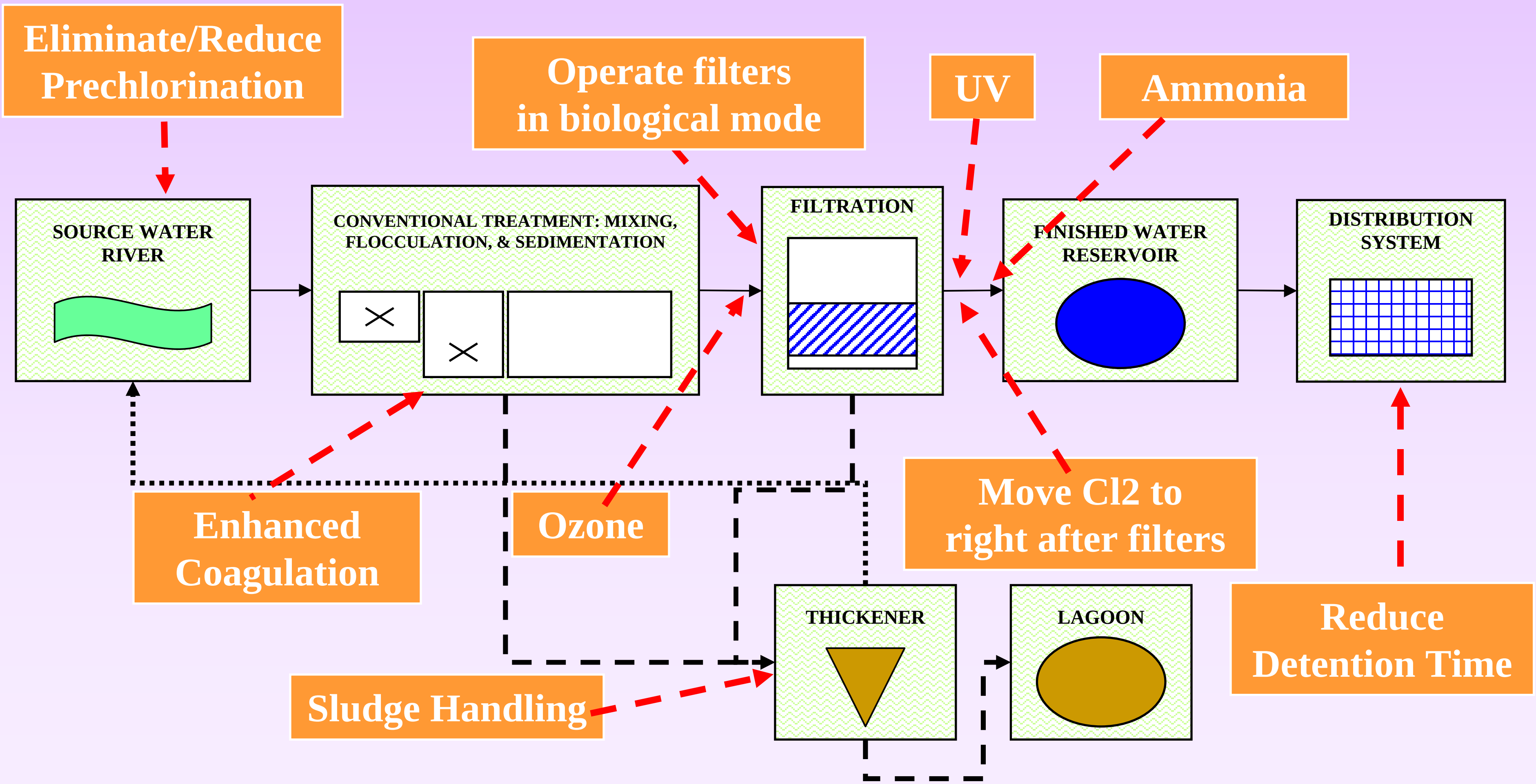
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



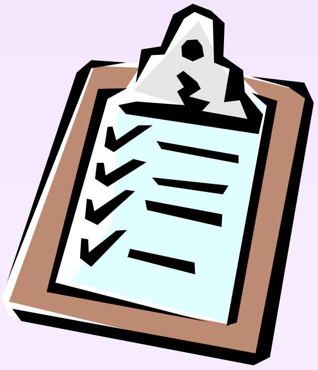
Stage 1 DBPR Case Study #6

Surface Water (River) Conventional Treatment: 50 MGD



Outline (cont.)

- Case Studies - Breakout Groups
  - Groundwater, iron removal, 10 MGD, TOC = 2 mg/L
  - Surface water, direct filtration plant, 50 MGD TOC = 2.1 mg/L
  - Surface water, conventional treatment plant, 50 MGD, TOC = 10 mg/L
- Summary



Summary

- Your “Tool Kit” Contains Many Options
- There are Multiple “Right” Solutions
- Changing One Parameter Can Impact Many Others
  - Look for interactions in water quality and treatment objectives
- Compliance May Be Costly

Summary (cont.)

- Operational Issues Associated with Your Solution(s) Must be Carefully Assessed
  - Bench or pilot test as practicable
  - Learn from others’ experiences
- Understand the Implications of the Changes you Make for Meeting Other Regulations
- CONSIDER FUTURE REGULATORY CHANGES

Things to Consider

- Test for all Nine Bromine and Chlorine-Containing HAA Species
- Track Levels of Brominated THMs and HAAs

Things to Consider