DBP AND DISTRIBUTION SYSTEM
CHLORINE RESIDUAL CONTROL IN
CARLISLE BOROUGH

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Outline

- Project Background and Objectives
- DBP Formation and Control Theory
- DBP Control Study Summary
  - Alternatives Evaluation
  - Recommendations
- Project Design Collaboration
- Construction
- Operation and Results
- Questions and Comments
Project Background

SOURCE: MAPQUEST
Borough of Carlisle water system supplies:
  – Borough and neighboring bulk water customers
  – Serves approximately 20,000 people

WTP permitted capacity of 7 mgd
  – Conventional process with granular media filtration

Source of supply - Conodoguinet Creek

Borough and Staff place a high priority on water quality and quality of service

1st in PA to achieve Partnership for Safe Water Phase IV
Project Location – Demonstrates Root Cause
Staff identified water quality concerns in the system’s West End
- West End is relatively new – sized for demands
  - Primarily warehouse development
- TTHM concentrations very elevated in West End
- Booster chlorination required to maintain residuals
- Mixing required to eliminate stratification
- TTHM concentrations and chlorine residuals are very good in remainder of system
- Stage 1 DBPR compliance (RAA) not a problem
- Stage 2 DBPR projected to be not in compliance
Prior to this project Staff tried to reduce DBP concentrations:
- Valve position and distribution modifications
- Performed a tracer test
- Considered pumping from tank to reduce water age
TTHM LRAA (Stage 1 DBPR Data)

Began using CSC as the West End Tank sample point.
Stage 1 HAA Data

West End/CSC
HAA LRAA (Stage 1 DBPR Data)

Began using CSC as the West End Tank sample point.
Borough’s Fluoride Tracer Test Tells the Story
DBP Formation and Control Theory

CHLORINE + Organic Matter = Disinfection Byproducts!
DBP Formation and Control Theory

DBP Formation

NOM + Cl₂ → DBPs

TIME

Temperature

ph
Proven Approach – Storage Tank Aeration
Well-Designed Storage Tank
Aeration Can Provide TTHM Compliance
Approach – Modification of System Operations

DBP Control via Tank Operating Changes, Aeration

Water Age >> 16 days
(Fluoride Tracer)
Estimated Water Age ~ 32 days

TTHM = 140 - 170 ppb
HAA = 80 – 95 ppb

Projected Water Age Following Operational Changes ~ 7 days
TTHM < 60 ppb
HAA < 50 ppb
DBP Control Study - Summary

- **West End Tank**
  - 2.3 Mgal Standpipe
  - Height to Overflow = 133 feet

- **Floating Storage with Fill/Drain Controlled by WTP**
  - Refill initiated when water level reached 123 feet
  - Cycle occurs approx. two (2) times per day
  - Daily tank turnover approximately 15% (theoretical)
  - Water age much greater – Ref. Fluoride Tracer

- **Existing pumped recirculation system for mixing**
- **Booster chlorination required at tank**
- **Water age and booster chlorine = Elevated DBPs**
DBP Control Study - Summary

- **WTP**
  - Phase IV Partnership
  - Low TOC Effluent
  - Minimal Opportunity to Reduce NOM Cost-Effectively

- **Borough Very Reluctant to Chloraminate**

- **DBP and Chlorine Residual Issues – Localized to West End Area**

- **DBP issues are direct result of excessive water age**

- **Borough Staff Prefer a Localized Approach to Address Distribution System Water Quality**
DBP Control Study - Summary

- TTHM compliance is primary driver
- HAA compliance is also an issue
- The Borough needs to reduce both TTHM and HAA concentrations in the West End for long-term compliance with the Stage 2 DBPR
DBP Control Study – Alternatives Evaluation

- Storage Tank Aeration
- Tank Operation Modifications
- Transmission/Distribution System Modifications
- Alternative Disinfectants
- Biologically Active Carbon/Other Treatment
DBP Control Study – Alternatives Evaluation

- **Storage Tank Aeration**
  - Proven approach for TTHM reduction
  - Can be designed for required % removal
  - Will NOT address HAA concerns
  - Will NOT address water age root cause
  - Will NOT address chlorine residual – booster chlorine required & HAA formation will continue

- **Transmission/Distribution System Modifications**
  - No opportunity for looping
  - Can induce additional flow by CSC site but will not address root cause
- **Tank Operation Modifications (Pumped Storage)**
  - Longer draw cycles
  - Allow discharged water to be used
  - Limit the volume used, if necessary
  - Can reduce water age to 7 days or less

- **Alternative Disinfectants**
  - Viable alternative
  - Last alternative based on Borough preference

- **Biologically Active Carbon/Other Treatment**
  - Effective for HAA reduction
  - Not effective for TTHM reduction

Recommended Approach: Phases/Multi-Faceted

- Minor valve position modifications
- Convert West End Tank to Pumped Storage – Reduce Water Age
- Storage Tank Aeration – If Necessary
Pumped Storage Concerns

• **Reduction in available fire flow**
  – Flow testing with tank online and offline
  – Fire flow >2,500 gpm with tank offline
  – Lag pump activates at low pressure

• **Reduction in stored volume**
  – Existing effective volume only 175,000 gallons of 2.33 Mgal
  – Increases useable volume to 1.8 Mgal
  – Maintains minimum 175,000 gallons available at all times

• **Loss of Utility Power**
Design Criteria

- Maintain pumped recirculation/mixing capability
  - 260 gpm at 30’ TDH, 3 hp
- Reuse chlorine analyzer, etc. as possible
- Provide space for future hypo system, if necessary
- Replace fiberglass structure with precast concrete
- Two (2) booster pumps
  - 400 – 500 gpm at 120’ TDH, 20 hp
- Spray aeration system (bid alternate)
  - 15 hp spray aerator with 2 hp ventilation blower
- Motor operated refill and flow control valve
BPS Control and Operation

- High level start (adjustable)
- Pump maintains preset discharge pressure
- Lag pump starts if minimum pressure not achieved
- Low level pump stop (adjustable)
- Delay following pump down (adjustable)
  - Allow pumped water to be used
- Refill at a controlled rate (adjustable)
- Pumping operations initiated upon completion of fill to high level setpoint
West End Tank Pumped Storage Operation

- Pump Start Level
- Operating Volume
- Pump Stop & Hold Level
- Emergency Storage
West End Tank Project – Site Plan
West End Tank and BPS
Lower Plan – Existing Altitude Valve Vault
Valve/Piping Vault
Main Control Panel
Normal Operating Approach

• Operation
• Emergency/Fireflow
• Power Loss
  – Generator Capable
  – Return to Floating Storage with Emergency Power at WTP
Performance – TTHM Reduction

180
160
140
120
100
80
60
40
20
0

TTHM (ppb)

AUGUST
NOVEMBER
FEBRUARY
MAY

West End Tank Post
CSC Post
Borough Hall Post
West End Tank Pre
Borough Hall Pre

WEST END TANK (CSC) BEFORE PROJECT (2011)
WEST END TANK and CSC AFTER PROJECT (2014/2015)
Performance – HAA Reduction

WEST END TANK (CSC) BEFORE PROJECT (2011)

WEST END TANK and CSC AFTER PROJECT (2014/2015)

Gannett Fleming
Excellence Delivered As Promised
Conclusions

- **Effective water age control**
  - DBP Compliance
  - Chlorine Residual Maintenance
- **Effective collaboration**
  - Successful Project
Select the Right Approach for DBP & Chlorine Control

- WTP Optimization (TOC, chlorination point)
- Disinfection Modification (i.e. modified pre-conceived ideas related to WTP process recycle)
- Disinfectant Type - chloramines
- Tank Aeration
- System Operation and Tank Operation Modifications
QUESTIONS & COMMENTS

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