ELEVATED WATER STORAGE TANKS

-SELECTION-

-MAINTENANCE-

-WATER AGE AND THM REMOVAL-

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Civil Design Associates, Inc. Engineering Excellence

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Education

B.S. Civil Engineering, 2006–Ohio University, Athens, Ohio

Registration

Professional Engineer in Ohio, Registration No. 74658
Surveyor Intern in Ohio

Field of Expertise

Project Management, Bridge Design and Inspection, Construction Administration, Contract Documents, Municipal Engineering, Pressure and Gravity Piping Design, Surveying, GIS Data Collection

Positions Held

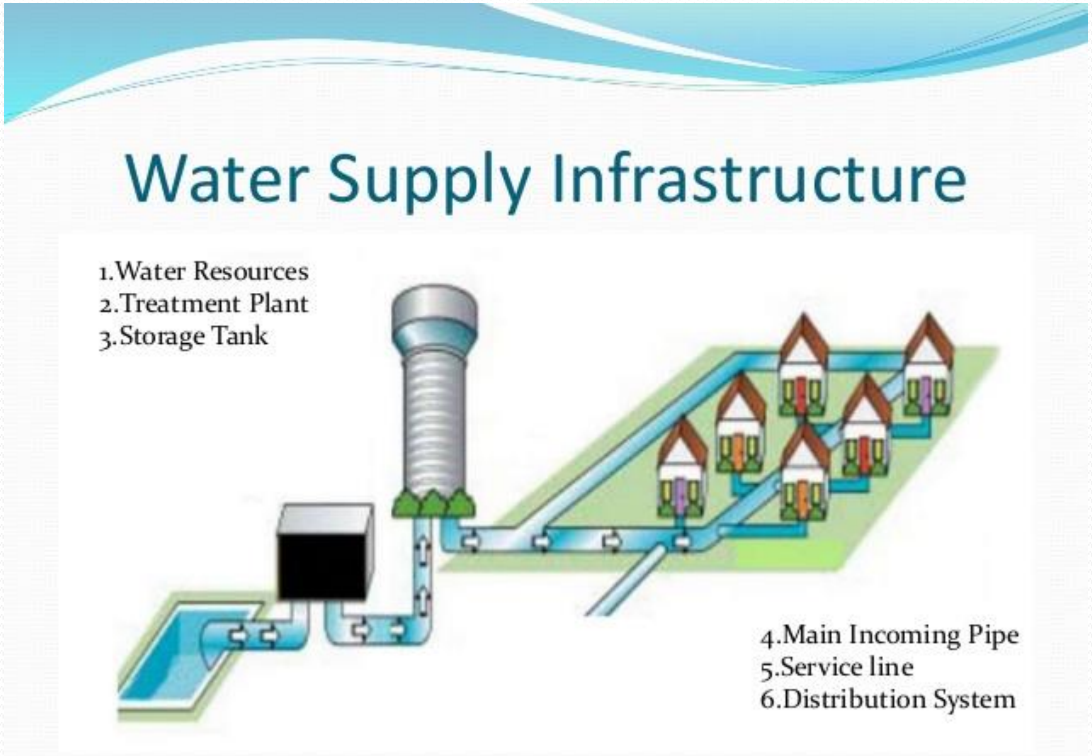
Civil Design Associates, Inc.	2017 – Present	Project Manager
Hocking County Engineer's Office	2016 – 2017	Assistant Engineer
Muskingum County Engineer's Office	2013–2016	Design Engineer, Bridge Program Team Leader
Strand Associates, Inc.®	2006–2013	Project Manager, Engineer, Office Specifier
Ohio Research Institute for Transportation and the Environment (ORITE)	2005–2006	Research Assistant
Basic Systems, Inc.	2001–2004	Engineering Intern

Tank Selection

- Location
- Type
- Costs
  - Construction
  - Maintenance

Location of Tank

- Elevation
- Location in System

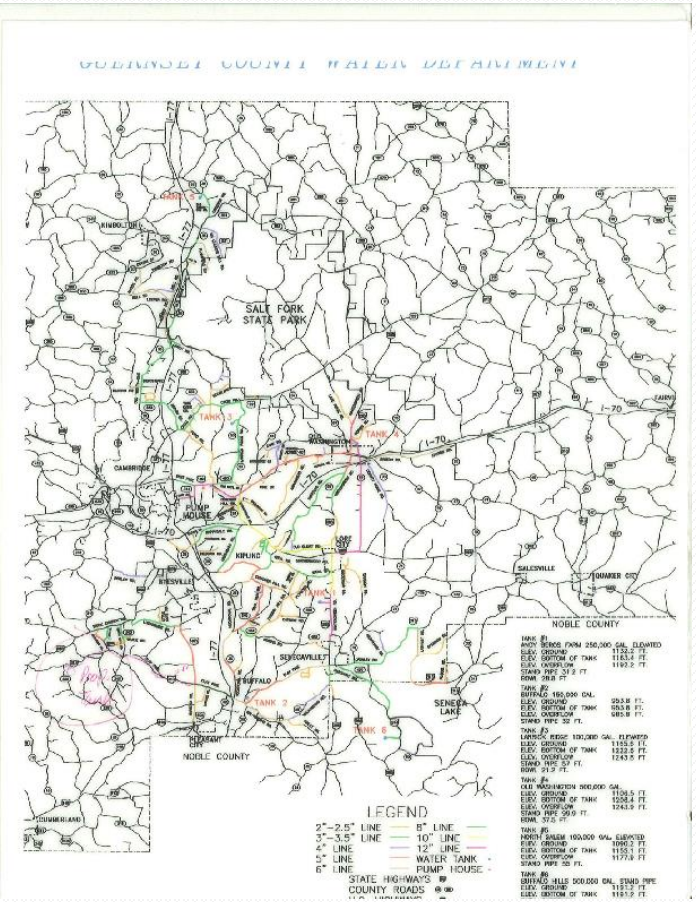


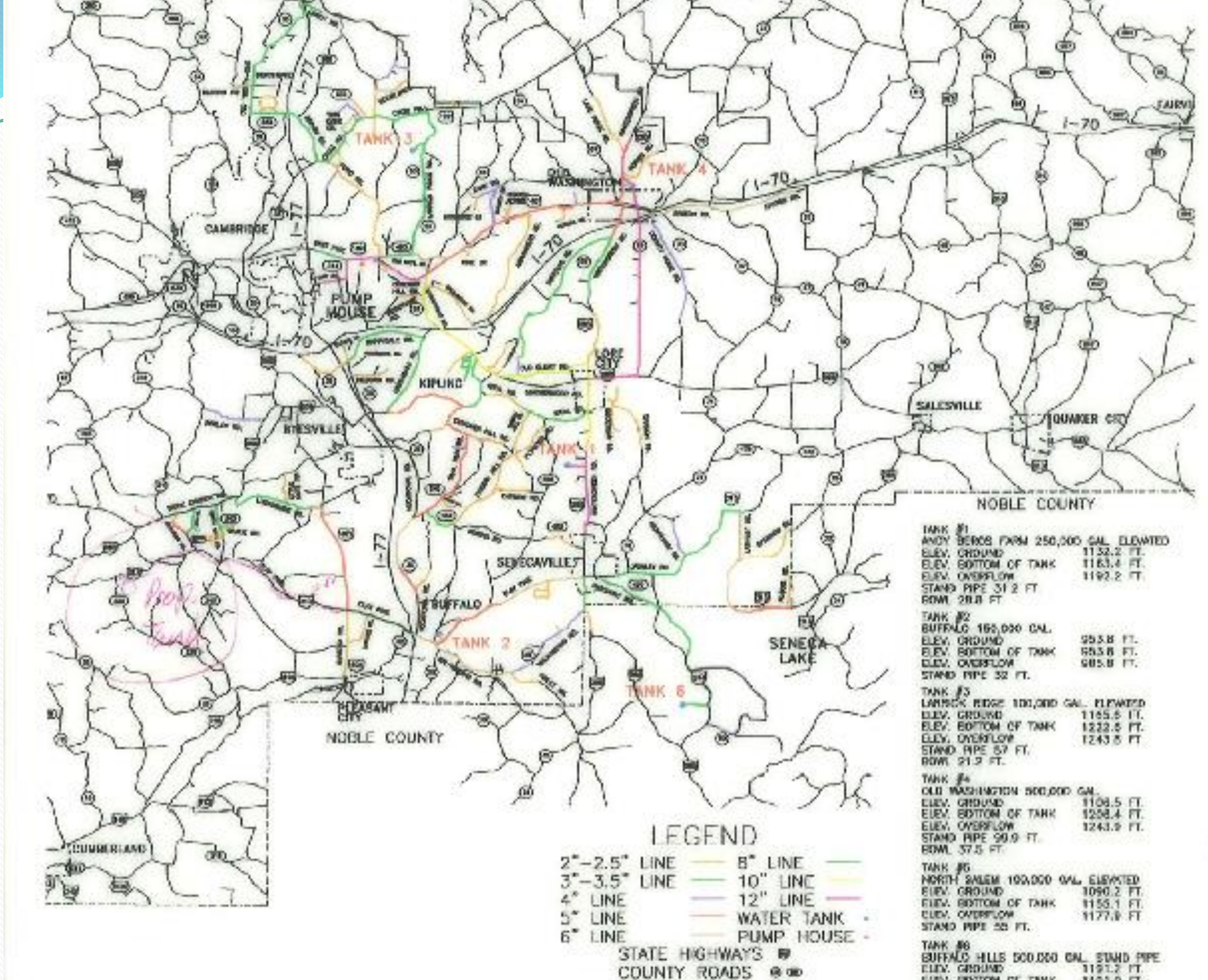
- Elevation
- Tank Site Approx. 1,100 ft
- Service Area Elev. 900-1,000 ft
- Difference of 100 ft
- Pressure 2.31 ft per psi = 43.29 psi
- 35 psi minimum = 80.85 ft

- <u>Other Considerations</u>
- 1. Place to drain overland
- 2. Three feet above 100 YR Flood
- 3. Access for Construction
- 4. Access for Maintenance

Location in System

- Pressure Zones
- Customers Served
- Dead Ends




TANK 3
TANK 4
OLD WASHINGTON
I-70
I-77
CAMBRIDGE
PUMP HOUSE
KIPLING
BYESVILLE
LORE CITY
TANK 1
SALESVILLE
QUAKER CITY
SENECAVILLE
BUFFALO
TANK 2
SENECA LAKE
TANK 6
NOBLE COUNTY
PLEASANT CITY
CUMBERLAND
NOBLE COUNTY
TANK #1
ANDY BEROS FARM 250,000 GAL. ELEVATED
ELEV. GROUND 1132.2 FT.
ELEV. BOTTOM OF TANK 1163.4 FT.
ELEV. OVERFLOW 1192.2 FT.
STAND PIPE 31.2 FT
BOWL 28.8 FT
TANK #2
BUFFALO 165,000 GAL.
ELEV. GROUND 953.8 FT.
ELEV. BOTTOM OF TANK 953.8 FT.
ELEV. OVERFLOW 985.8 FT.
STAND PIPE 32 FT.
TANK #3
LARRICK RIDGE 100,000 GAL. ELEVATED
ELEV. GROUND 1165.5 FT.
ELEV. BOTTOM OF TANK 1222.5 FT.
ELEV. OVERFLOW 1243.5 FT
STAND PIPE 57 FT.
BOWL 21.2 FT.
TANK #4
OLD WASHINGTON 500,000 GAL.
ELEV. GROUND 1108.5 FT.
ELEV. BOTTOM OF TANK 1208.4 FT.
ELEV. OVERFLOW 1243.9 FT.
STAND PIPE 99.9 FT.
BOWL 37.5 FT.
TANK #5
NORTH SALEM 100,000 GAL. ELEVATED
ELEV. GROUND 1090.2 FT.
ELEV. BOTTOM OF TANK 1155.1 FT.
ELEV. OVERFLOW 1177.9 FT
STAND PIPE 55 FT.
TANK #6
BUFFALO HILLS 500,000 GAL. STAND PIPE
ELEV. GROUND 1191.2 FT.
ELEV. BOTTOM OF TANK 1191.2 FT.
LEGEND
2"-2.5" LINE
3"-3.5" LINE
4" LINE
5" LINE
6" LINE
8" LINE
10" LINE
12" LINE
WATER TANK
PUMP HOUSE
STATE HIGHWAYS
COUNTY ROADS

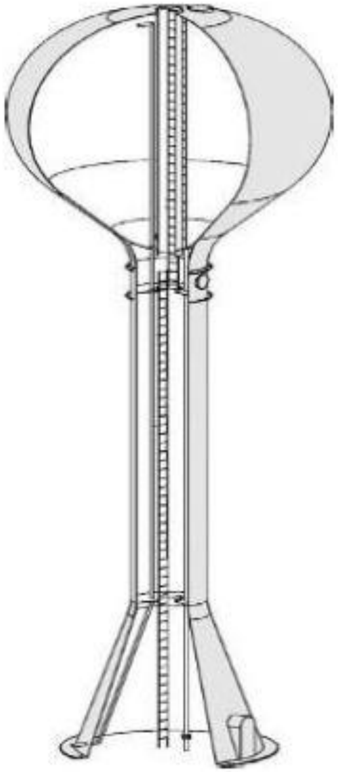
Types of Tanks

- Stand Pipe
- Multi-leg
- Composite
- Pedisphere
- Fluted Column

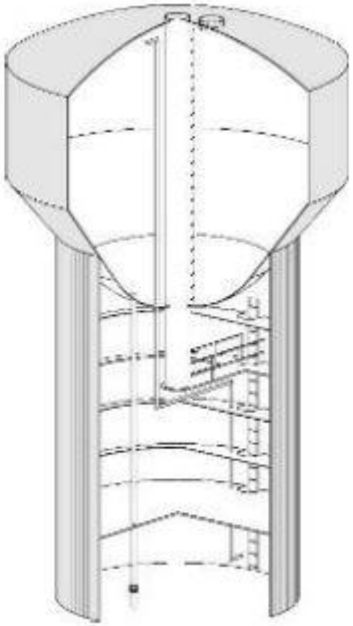
Reconditioned water tower showing City's new logo.

New elevated water storage tank.

Single Pedestal



Gallons	Diameter	Head Range
75,000	27'-0"	25'-0"
100,000	30'-0"	26'-0"
125,000	32'-0"	29'-6"
150,000	34'-0"	31'-4"
200,000	37'-6"	34'-0"
250,000	44'-0"	31'-0"
500,000	55'-6"	37'-6"

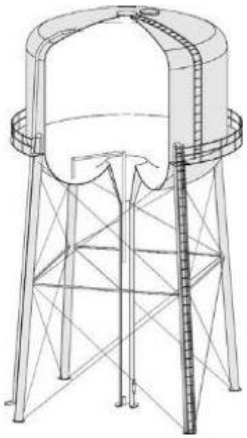


Fluted Column

Gallons	Diameter	Head Range
250,000	42'-0"	30'-4"
300,000	44'-0"	30'-8"
400,000	44'-0"	39'-6"
500,000	50'-0"	37'-6"

Fluted Column Tanks are available in sizes up to two million gallon capacity

TORO



Gallons	Diameter	Head Range
250,000	42'-0"	30'-4"
300,000	44'-0"	30'-8"
400,000	44'-0"	39'-6"
500,000	50'-0"	37'-6"

Double Ellipsoidal

Gallons	Diameter	Head Range
75,000	30'-0"	16'-0"
100,000	30'-0"	20'-8"
125,000	30'-0"	25'-5"
150,000	32'-0"	28'-0"
200,000	36'-0"	28'-3"

Sizing Case Study

New Holland, Ohio
Population 801
342 Customers

100,000 Gallon 122Ft
Multi-leg (Circa 1939)

Elevations 840-870 Ft

Sizing Case Study

	Present Conditions	Future Conditions
Firm Supply (gallons)	216,000	228,000
Maximum Day Demand (gallons)	196,000	228,000
Fire Fighting Demand (gallons)	180,000	180,000
Peak Hour Demand (gallons)	49,000	57,000
Total Supply (gallons)	216,000	228,000
Total Demand (gallons)	425,000	465,000
Storage Required (gallons)	**209,000**	**237,000**

Assumed - 2 hour fire flow 1,500 gpm
Peak Demand 25% of max. day demand

Tank Costs

Tank Type	Tank Size (Gallons)	Average Construction Costs	24-Year Maintenance Costs	Total Costs
Pedisphere	150,000	$580,000	$168,000	$748,000
Pedisphere	200,000	$662,500	$201,000	$863,500
Pedisphere	250,000	$745,000	$237,000	$982,000
Multilegged	150,000	$470,000	$186,000	$656,000
Multilegged	200,000	$530,000	$199,000	$729,000
Multilegged	250,000	$617,500	$241,000	$858,500
Composite	150,000	$850,000	$128,000	$978,000
Composite	200,000	$925,000	$149,000	$1,074,000
Composite	250,000	$995,000	$171,000	$1,166,000
Glass-Lined	150,000	$495,000	$5,100	$500,100
Glass-Lined	200,000	$615,000	$5,100	$620,100
Glass-Lined	250,000	$715,000	$5,100	$720,100

Source: Caldwell Tanks, HydroDynamics Company, Phoenix Fabricators and Erectors

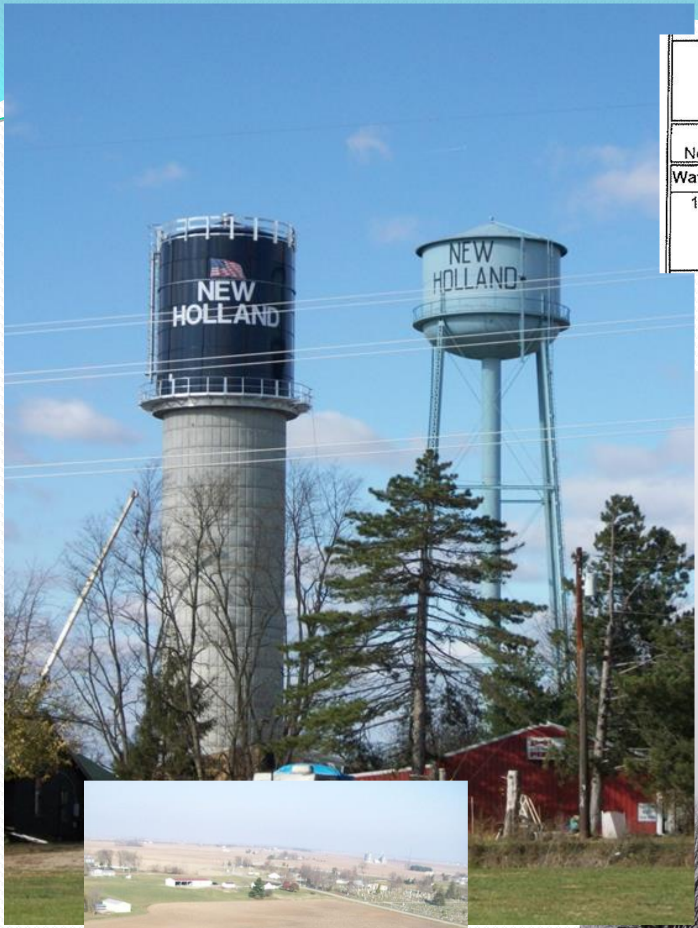
Table 5.04-1 Opinion of Probable Cost (WST)

Alternative Ranking

Alternative	Construction Cost		Present Worth of Maintenance		Present Worth		Average Annual Equivalent Cost	
	Cost	Rank	Cost	Rank	Cost	Rank	Cost	Rank
150,000 Gallon Pedisphere	$580,000	4	$168,000	6	$748,000	6	$49,817	6
200,000 Gallon Pedisphere	$662,500	7	$201,000	10	$863,500	8	$57,509	8
250,000 Gallon Pedisphere	$745,000	9	$237,000	11	$982,000	10	$65,401	10
150,000 Gallon Multilegged	$470,000	1	$186,000	8	$656,000	3	$43,690	3
200,000 Gallon Multilegged	$530,000	3	$199,000	9	$729,000	5	$48,551	5
250,000 Gallon Multilegged	$617,500	6	$241,000	12	$858,500	7	$57,176	7
150,000 Gallon Composite	$850,000	10	$128,000	4	$978,000	9	$65,135	9
200,000 Gallon Composite	$925,000	11	$149,000	5	$1,074,000	11	$71,528	11
250,000 Gallon Composite	$995,000	12	$171,000	7	$1,166,000	12	$77,656	12
150,000 Gallon Glass-Lined	$495,000	2	$5,100	1	$500,100	1	$33,307	1
200,000 Gallon Glass-Lined	$615,000	5	$5,100	1	$620,100	2	$41,299	2
250,000 Gallon Glass-Lined	$715,000	8	$5,100	1	$720,100	4	$47,959	4

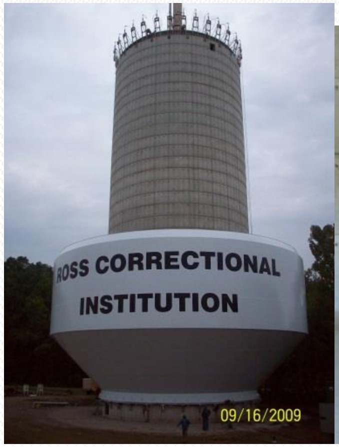
No.	Description	Quantity	Unit	Mid Atlantic Storage Systems, Inc. 1551 Robinson Road Washington Court House, OH 43160 Unit Price	Total Price	Caldwell Tanks, Inc. 4000 Tower Road Louisville, KY 40219 Unit Price	Total Price
Water Storage Tank							
1.	150,000-GAL Composite Water Storage Tank, INCL Site Work, 12-IN Water Line, and Demolition of Existing Tank	1	LS	$ 793,298.00	$ 793,298.00	$ 998,977.00	$ 998,977.00

Bids February 2012



Composite Tank Consideration

-Welded or Glass Lined
-Security
-Maintenance Cost
-Storage
-Valve Room
-Ladder Location



Drain Options

Maintenance

-Inspection - Generally every 5 years AWWA G200 (2010)

-Cleaning - Disinfection one of three methods found in
AWWA C652-11 Disinfection of Water Storage Facilities (2011)

-Painting - every 10-15 years
Painting Largest Cost typically $8-$18 per square foot

Applicable Standards

AWWA MANUAL M42 - Steel Water-Storage Tanks

• ANSI/AWWA D100, Standard for Welded Carbon Steel Tanks for Water Storage.
• ANSI/AWWA D102, Standard for Coating Steel Water-Storage Tanks.
• ANSI/AWWA D103, Standard for Factory-Coated Bolted Carbon Steel Tanks for Water Storage.
• ANSI/AWWA D104, Standard for Automatically Controlled, Impressed Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks.
• ANSI/AWWA D106, Standard for Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks.

• ANSI/AWWA D107, Standard for Composite Elevated Tanks for Water Storage.
• ANSI/AWWA D108, Standard for Aluminum Dome Roofs for Water Storage Facilities.
• ANSI/AWWA C652, Standard for Disinfection of Water-Storage Facilities.

Tank Reconditioning Reynoldsburg, Ohio

Reconditioned water tower showing City's new logo.

Additional cost for fluted Column ~$229,500 (41.6 %) = $12,079 per year over 19 yrs.

1 Million Gallon Fluted Column 92 Ft. to Overflow
Built in 1989
Reconditioned in 2008 (19 years)
Existing Exterior Coating - 2 coat urethane
Existing Interior Coating – 2 Coat Epoxy
Cost to Refinish

Exterior:

Prep.	$99,000
Shrouding	$50,000
Zinc, Urthane, Floro-Polymer	$180,000

Ext. Total $329,000 (60%)

Interior:

Prep. Zinc with 2 coats Epoxy

Int. Wet	$158,000
Int. Dry	$65,000 (12%)

Total $223,000 (40%)

Grand Total $552,000

$29,053 per year over 19 yrs.

Example Estimate Calculation

1,000,000 Gallon Fluted Column 65.3 Ft Dia., 40 Ft Tall Tank, 92 Ft overflow

<u>Interior Surface Area:</u>

Walls = Circumference x Height =8,206 SF

Floor and Ceiling = 2 $x\ A = \pi r^2$ = 6,698 SF

Int. Total =14,904 SF

Interior Estimate **$10 per SF** = $149,040

Bid Price (9 bidders) $158,000 = **$10.60 per SF**

<u>Exterior Surface Area:</u>

Bowl

Walls = Circumference x Height =8,206 SF

Roof = A=πr^2 = 3,349 SF

Total =11,555 SF

Column

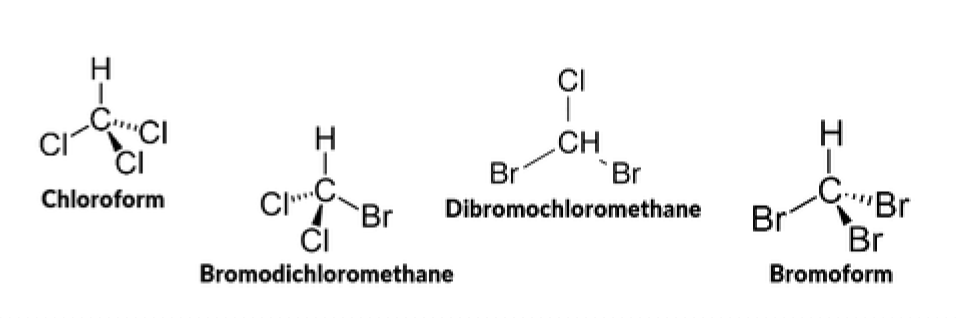
Circumference x Height $\prod 50FT\ x\ (92FT - 40FT)$ = 8,168 SF

Exterior Total = 19,723 SF

Exterior Estimate w/ Containment $16 per SF = 19,723 SF x $16/SF = $315,568

Bid Price (9 bidders) $329,000 = **$16.68 per SF**

Water Age and THM Reduction



Trihalomethanes - THMs

-Identified in 1974

-Disinfectants/Disinfection Byproducts (DBPs) – Natural Organic Matter (NOM)

-THMs are formed by chemical reaction of chlorine and NOM

-Chlorine Sources:

Gaseous Chlorine, Sodium Hypochlorite, Calcium Hypochlorite, Chloramine, and Chlorine Dioxide

-Other factors:

Water Temperature, detention time, High pH, High bromide levels, High chlorine dosage

-Types of THMs (Henry's Constant "capacity for volatilization"

Compound	Henry's Constant @ 20 deg. C
Chloroform (most common)	170
Bromodichloromethane	118
Dibromochloromethane	47
Bromoform	35

THM Removal

-Before disinfection

Precursor Removal (reduces disinfection demand)

- -Oxidation (ozone or chlorine dioxide)
- -Clarification (Coagulation, Settling, and Filtration)
- -Adsorption (Activated Carbon)

-After disinfection

- -Tank Operation
- -Aeration
- -Mixing
- -Adsorption

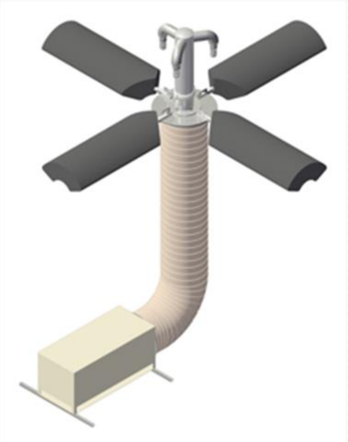
THM Removal, continued

- -Aeration (Chloroform is predominant THM)
  - -Mixing
  - -Adsorption
  - -Headspace
  - -Ventilation
- -Information Needed for Design
  - -Historical Flow
  - -Residence Time
  - -THM data for the tank
- -Considerations
  - -Water Quality (pH, alkalinity, free chlorine residual)
  - -Haloacetic Acids (HAA)

THM Removal, continued

-Aeration (20 -70% reduction possible)
  - -Mixing
    - Flow Rate -Water Age
    - Tank Turn Over - Water Age
    - Water Depth - Stagnate areas
  - -Adsorption
  - -Headspace (4-5 feet surface and spray aeration)
    - Unsaturated Air to absorb THMs
    - Distance between nozzle for transfer
  - -Ventilation (fresh air exchange rate)

THM Removal, continued



-Aeration (20 -70% reduction possible)

-Time of Year (Spring, Summer, and Fall)

-Types of Systems

1. Spray Aeration Min. 5 Foot headspace

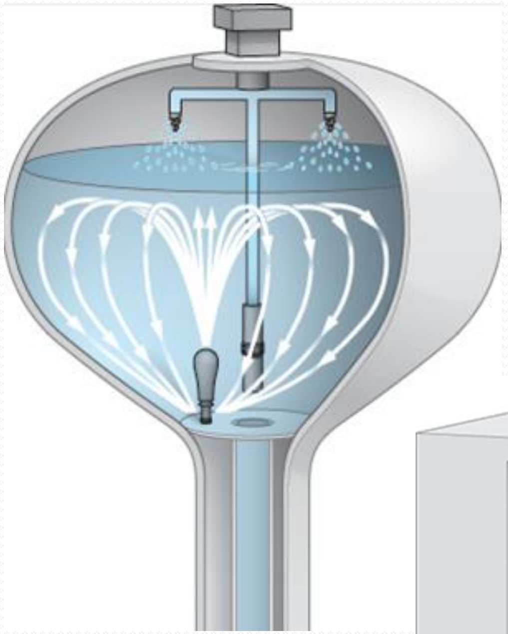
Draw water from bottom of tank spray from nozzle

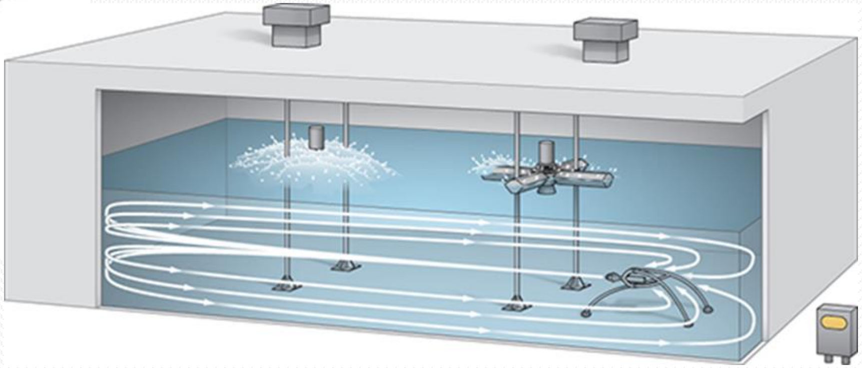
Droplet size

Travel Distance

Water Temperature

Ice Formation, typically spray not operated in Winter





THM Removal, continued

Diffused Aeration – Min 4-Ft headspace
Tiny Bubbles
Air Bubble Size
Air to Water Ratio
Depth of Water Above the Diffuser
Detention Time
Water Temperature
Geometry of Tank (Baffling)

THM Removal, continued

Effects on Residual

"Chlorine and chloramine are more stable in water than THMs, and we have seen little to no loss of residual in our in-tank aeration installations. In side-by-side measurements, we measured roughly 10% reduction in residual chlorine in a system that removed 50% of TTHMs. At pH levels lower than 7, we expect a greater fraction of residual chlorine to exist in the form of hypochlorous acid, which is slightly volatile. Therefore, we generally expect more residual chlorine to be lost due to aeration in low-pH systems." - Pax Water Technologies

THM Removal, continued

Summary and Recommendations from AWWA
-Aeration can be successful
-Haloacetic Acids may increase
-Disinfection byproducts precursors at plant
-Water System BMPs
    -Exercise Tanks, Reduce Water Age,
    Control CL Residuals, Clean Tanks,
    Perform Routine Hydrant Flushing
-Monitor water quality for pH, stability, and CL residuals

THANK YOU

CONTACT INFORMATION

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References:
1. White Paper on Aeration to Reduce Trihalomethanes, AWWA Ohio Section Technology Committee November 30,2013
2. Gerard Tanks sizing charts 1540 East 11th St. Concordia, KS 669 01 Phone: 785-243-3895
3. www.paxwater.com
4. www.medoraco.com SolarBee