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Water Tank Structural Analysis Report

Terra Consulting Group Project #: 54-1540 REV 1

October 29, 2024

<u>Site Information</u>	PSLC: Site Name: MDG Location No. Carrier Name: Address:	237385 Willard Water Tank - A 5000309199 Verizon Wireless 512 E. Jackson Street Willard, MO 65781 GREENE COUNTY
	Latitude:	37.299261°
	Longitude:	-93.418025°
Structure Information	Tower Type:	124-Ft Water Tank

FUZE ID # 16947572

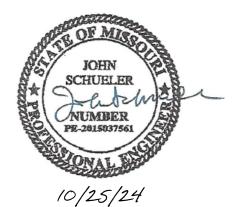
Analysis Results

Water Tank:

Sufficient

Report Prepared By: Matthew Wozniak, P.E. <u>mattw@terraltd.com</u>

Matthew Wozniak



Executive Summary:

The objective of this report is to determine the capacity of the water tank tower at the subject facility to support the final wireless telecommunications configuration, per the applicable codes and standards. Any modification listed under Sources of Information was assumed completed and was included in this analysis.

Sources of Information:

Document Type	Remarks
Radio Frequency Data Sheet (RFDS)	Verizon RFDS, FUZE # 16947572, dated October 2, 2024
Mapping Report	Hightower Solutions, dated August 28, 2013
Structural Analysis Report	Destek Engineering, dated December 31, 2013
Water Tank Drawings	Caldwell Tanks, inc., #E-3975, May, 1996

Analysis Criteria:

Water Tank Analysis:		
Codes and Standards:	ANSI AWWA D100-11	
Wind Parameters:	Basic Wind Speed, V: Importance Factor: Wind Exposure Category: Gust Effect Factor:	90 mph 1.15 C 1.0
Seismic Parameters:	S₅: S1:	0.176 0.1





Final Loading Configuration:

The following equipment has been considered for the analysis of the tower:

Mount Elevation (ft)	Equipment Elevation (ft)	Quantity	Manufacturer	Model	Feedlines (in)	Status	Carrier
		3	Ericsson	AIR6419			
		6	Commscope	NHH-65C-R2B	(2) 1 5 /0"		
120	127	3	Ericsson	4890	(3) 1-5/8"	Added	VZW
		3	Ericsson	4490	Hybrid		
		3	-	RVZDC-6627-PF-48			
		3	Kathrein Scala	80010692V01	(10) 1-5/8"		
120	107	3	Triasx	TMA2061F1V1-1	Coax	Deteined	Othor
120	127	4	Antel	BSA-185065/10CF	(Esimated from	Retained	Other
		1	Antel	BXA-185063/9CF	Photos)		
		3	-	Panel Antenna			
102	102	3	-	Panel Antenna	(2) Use wird	Deteined	Othor
102	102	6	-	RRH	(3) Hybrid	Retained	Other
		1	-	Dish			

Standard Conditions:

- 1. The Standard of Care for all Professional Engineering Services performed by Terra Consulting Group under this project will be the skill and care used by members of the Consultant's profession practicing under similar circumstances at the same time and in the same locality.
- 2. All engineering services are performed on the basis that the information provided to Terra Consulting Group and used in this analysis is current and correct. The existing equipment loading has been applied at locations determined from the supplied documentation. Any deviation from the loading locations specified in this report shall be communicated to Terra Consulting Group to verify deviation will not adversely impact the analysis.
- 3. The water tank was properly fabricated, installed and maintained in good condition in accordance with its original design and manufacturer's specifications. The structural analysis was performed assuming no physical deterioration has occurred to any of the structural components. No allowance was made for members or bolts that are corroded, damaged, bent, loose or missing. The analysis assumes all bolts are torqued to a snug-tight condition defined by AISC.
- 4. The structural analysis of the water tank was performed according to the minimum design loads recommended by the Reference Standard. The mount analysis does not imply to meet any serviceability criteria such as twist, sway and deflections. If more restrictive design criteria for wind, ice, deflections or serviceability are required, then Terra Consulting Group should be notified.
- 5. All member connections are assumed to have been designed to meet or exceed the load carrying capacity of the connected member unless otherwise specified in this report.
- 6. All services are performed, results obtained, and recommendations made in accordance with generally accepted engineering principles and practices. Terra Consulting Group is not responsible for the conclusion, opinions, and recommendations made by others based on the information supplied.
- 7. Structural Steel Grades have been assumed as follows, if applicable, unless otherwise noted in this analysis:

0	HSS Tube	ASTM A500 Gr. B)
0	Pipe	ASTM A53 (Gr.B)
0	Plate	ASTM A36
0	Bolts	ASTM A325

Discrepancies between in-field conditions and the assumptions listed above may render this analysis invalid unless explicitly approved by Terra Consulting Group.

Analysis Results:

Component	Utilization %	Pass/Fail						
Water Tank Structure	See Recommendations	Pass						
Structure Rating – (Controlling Utilization of all Components) Sufficient								

Recommendation:

Based on the ANSI AWWA D100 and Section 3403 of the 2018 IBC, an increase in wind loads of less than 10% and an increase in gravity load of less than 5% is considered acceptable. Based on this, the relatively small gravity loads produced by Verizon Wireless' proposed equipment are negligible compared to the overall water tank structure. The wind loads produced by Verizon Wireless' proposed equipment and existing equipment of the other carriers exceeds 10% compared to the overall water tank structure.

Per the tank drawings by Caldwell Tanks, Inc. from May of 1996, the water tank structure was designed for a base moment due to seismic forces of 7001320 ft-lbs and a base moment due to wind forces of 3781760 ft-lbs. The design base shear due to wind is 51930 lbs and 69620 lbs due to seismic. The design base moment due to seismic forces is 85% greater than the design base moment due to wind. Although the wind forces exceed the original design wind forces by greater than 10%, the original tank design was controlled by the seismic forces. The increased wind forces are less than the original seismic design forces and therefore are considered acceptable.

The water tank was designed for a total vertical load 2822420 lbs. The percentage increase of vertical loads due to the weight of the additional VZW and other carrier equipment is less than 1% and is negligible compared to the overall water tank structure.

Considering the small percentage increase in base moment and vertical load compared to the original water tank design reactions, it is our opinion that the existing water tank has sufficient capacity to support the proposed loading.

ANSI/ASSP rigging plan review services compliant with the requirements of ANSI/TIA 322 are available for a Construction Class IV site or other, if required. Separate review fees will apply.

Attachments:

1. Analysis Calculations



237385 / Willard Water Tank-A Terra Project : 54-1540 Rev 1 10/29/2024

Water Tank Stability Check

Wind Load Calculations (AWWA D100-11)

Pw: G:	Wind Pressure Gust Effect Factor	= =	qz * G * Cf 1.0	>=	30 * Cf		(psf)	AWWA Section 3.1.4 AWWA Section 3.1.4
G. Cf:	Force coefficient	-	Flat		F	1.0		AWWA Section 5.1.4
CI.	Force coefficient	-						
		=	Cylindrical		С	0.6		AWWA Table 2
		=	Double Curve		DC	0.5		
z:	Height above Grade	ft						AWWA Section 3.1.4
Kz:	Velocity Pressure	=	2 01*/-	(-~)^(2 (~)			ASCE7-15 or
	Coefficient at z	-	2.01*(z/	28)~(2/u)			AWWA Table 3
			Kz(min) <= Kz	<=2.0)1			
I:	Importance Factor	=	1.15					AWWA Section 3.1.4
V:	Basic Wind Speed	=	90	mph				Figure 1, Page 14-18
	Wind Exposure	=	С					
qz:	Velocity Pressure	=	0.00256 * Kz*	I*V ²				AWWA Section 3.1.4
Top of Toplu		_	100.67	C+				
Top of Tank:		=	123.67	ft				



Tank Area

Me	mber	# of Members	Length or Diameter (ft)	(‡) Width	(‡) Depth	(t) Area	C/L Elev. (ft)	Kz	Shap	oe/Cf	qz (psf)	Pw (psf)	Wind Load (k)	Base Moment (kip ft)
Tank	Тор	1	43.3	12	12	457.8	118.67	1.31	DC	0.5	31.29	15.64	7.16	849.88
Tank	Body	1	43.3	13	13	562.9	105.17	1.28	С	0.6	30.50	18.30	10.30	1083.45
Tank	Bottom	1	43.3	12	12	538.6	87.9267	1.23	DC	0.5	29.37	15.00	8.08	710.41
Tank Legs		5	99	1.5	1.5	743	49.50	1.09	С	0.6	25.99	18.00	13.37	661.57
Riser Cone		1	6.75	10	10	68	83.00	1.22	С	0.6	29.02	18.00	1.22	100.85
Riser		1	77	3.5	3.5	270	38.5	1.09	С	0.6	25.99	18.00	4.85	186.76
Horizontal 1		5	26.5	0.67	0.67	88.3775	49.5	1.09	F	1	25.99	30.00	2.65	131.24
Diagonal 1	1.25"	10	54	0.1	0.1	56.16	74.25	1.19	С	0.6	28.35	18.00	1.01	75.06
Diagonal 2	1.5"	10	54	0.13	0.13	67.5	24.75	1.09	С	0.6	25.99	18.00	1.22	30.07
Handrail		1	45	0.67	0.67	30.015	99	1.26	F	1	30.12	30.12	0.90	89.49
	ent, over flow e, etc)						78.73						5.08	399.59
Totals:													55.83	4318.36



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Antennas										Wind	Directio	on	80	٥					
Manufacturer	Antennna	#	Ht	W	D	Frontal Area	Side Area	Wt / unit	Total Wt	AZ	Project Area	TL Project Area	Elev.	Shape	Cf	dz	ΡW	Wind Load	Moment
			(in)	(in)	(in)	(sf)	(sf)	(lbs)	(lbs)	٥	(sf)	(sf)	(ft)			(psf)	(psf)	(k)	(kip ft)
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	40	4.05	4.05	127	F	1	31.7	31.7	0.13	16.32
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	160	2.71	2.71	127	F	1	31.7	31.7	0.09	10.92
ERICSSON	AIR6419	1	31.3	16.1	9.8	3.5	2.13	71	71	280	4.02	4.02	127	F	1	31.7	31.7	0.13	16.20
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	40	9.12	18.24	127	F	1	31.7	31.7	0.58	73.52
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	160	6.0	12.1	127	F	1	31.7	31.7	0.38	48.69
COMMSCOPE	NHH-65C-R2B	2	96.0	11.9	7.1	7.9	4.73	51.6	103	280		18.14	127	F	1	31.7	31.7	0.58	73.12
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	40	2.36	2.36	127	F	1	31.7	31.7	0.07	9.51
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	160	1.38	1.38	127	F	1	31.7	31.7	0.04	5.56
ERICSSON	4490	1	20.6	15.7	7.0	2.25	1.00	68.4	68.4	280	2.45	2.45	127	F	1	31.7	31.7	0.08	9.88
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	40	2.38	2.38	127	F	1	31.7	31.7	0.08	9.59
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	160	1.40	1.40	127	F	1	31.7	31.7	0.04	5.64
ERICSSON	4890	1	20.6	15.7	7.2	2.25	1.03	69.5	69.5	280	2.46	2.46	127	F	1	31.7	31.7	0.08	9.92
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	40	3.75	3.75	127	F	1	31.7	31.7	0.12	15.12
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	160	2.59	2.59	127	F	1	31.7	31.7	0.08	10.44
RAYCAP	RVZDC-6627-PF-48	1	28.9	15.7	10.3	3.16	2.07	32	32	280	3.68	3.68	127	F	1	31.7	31.7	0.12	14.83
GENERIC PANE	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	70	12.51	12.51	102	F	1	30.3	30.3	0.38	38.67
GENERIC PANE	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	190	7.86	7.86	102	F	1	30.3	30.3	0.24	24.30
GENERIC PANE	6'x2'	1	72.0	24.0	8.0	12.00	4.00	50	50	310	10.78	10.78	102	F	1	30.3	30.3	0.33	33.32
GENERIC PANE	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	70	4.78	4.78	102	F	1	30.3	30.3	0.14	14.78
GENERIC PANE	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	190	3.42	3.42	102	F	1	30.3	30.3	0.10	10.57
GENERIC PANE	3'x1.5'	1	36.0	18.0	8.0	4.50	2.00	40	40	310	4.42	4.42	102	F	1	30.3	30.3	0.13	13.66
GENERIC PANE	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	70	2.23	4.46	102	F	1	30.3	30.3	0.14	13.79
GENERIC PANE	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	190	2.09	4.18	102	F	1	30.3	30.3	0.13	12.92
GENERIC PANE	RRH	2	24.0	12.0	9.0	2.00	1.50	50	100	310	2.43	4.86	102	F	1	30.3	30.3	0.15	15.02
GENERIC PANE	DISH	1	26.0	26.0	12.0	4.7	2.17	40	40	90	5.00	5.00	102	F	1	30.3	30.3	0.15	15.46
KATHREIN SCAL	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	20	7.95	7.95	127	F	1	31.7	31.7	0.25	32.04



KATHREIN SCAL	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	140	7.95	7.95	127	F	1	31.7	31.7	0.25	32.04
KATHREIN SCAL	80010692V01	1	103.2	11.8	6.0	8.5	4.30	73.2	73.2	260	8.46	8.46	127	F	1	31.7	31.7	0.27	34.10
GENERIC PANEI	TMA2061F1V1-1	1	14.3	7.9	5.2	0.8	0.51	50	50	20	0.8	0.8	127	F	1	31.7	31.7	0.03	3.39
GENERIC PANE	TMA2061F1V1-1	1	14.3	7.9	5.2	0.8	0.51	50	50	140	0.84	0.84	127	F	1	31.7	31.7	0.03	3.39
GENERIC PANEI	TMA2061F1V1-1	1	14.3	7.9	5.2	0.78	0.51	50	50	260	0.78	0.78	127	F	1	31.7	31.7	0.02	3.14
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	20	2.04	2.04	127	F	1	31.7	31.7	0.06	8.22
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	140	2.04	2.04	127	F	1	31.7	31.7	0.06	8.22
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	260	2.63	2.63	127	F	1	31.7	31.7	0.08	10.60
ANTEL	BSA-185065/10CF	1	60.2	6.3	2.0	2.63	0.84	9.1	9.1	260	2.63	2.63	127	F	1	31.7	31.7	0.08	10.60
ANTEL	BXA-185063/9CF	1	48.8	6.1	3.2	2.07	1.08	10	10	20	1.97	1.97	127	F	1	31.7	31.7	0.06	7.94
																To	tals	5.690	675.45

Antenna Mount Areas

Member	#	Length or Diam.	W	D	Project Area	TL Pr Ar	Elev.	Shape	Cf	dz	Pw	Antenna Cover	Wind Load	Moment
		(in)	(in)	(in)	(sf)	(sf)	(ft)			(psf)	(psf)	(%)	(k)	(kip ft)
VZW Corral	1	288	12	12	24	24	123	F	1	31.5	31.5	5.0%	0.72	88.41
VZW Mount Pipes	21	102	2.88	2.88	2.04	42.84	127	С	0.6	31.7	19.0	30.0%	0.57	72.52
Carrier Mount Pipes	10	96	2.38	2.38	1.59	15.8667	102	С	0.6	30.3	18.2	40.0%	0.17	17.66
	-			-	-					-		Totals	1.46	178.59

Wt / ft lb	Wt Ib
3.66	88
4.75	848
7.58	606

Cables														
Cables	Quantity	Quantity in Wind	Width Exp. To Wind	Shap	e /Cf	Cable Length	CL Elev	Projected Area	Wt	qz	Pw	Tl Wt.	Wind Load	Moment
		Willa	(in)			(ft)	(ft)		(lb/ft)	(psf)	(psf)	(lb)	(k)	(k ft)
VZW Cables	3	2	1.625	С	0.6	127	63.5	34.3958333	0.82	27.4	18.0	312.42	0.619	39.31
Other	3	1	1.625	С	0.6	102	51	13.8125	0.82	26.2	18.0	250.92	0.249	12.68
Other	10	3	1.625	С	0.6	127	63.5	51.59375	0.82	27.4	18.0	1041.4	0.929	58.97



110.97

1.796

Total Appurtanence Loading

	Wind Load	Moment
	(k)	(k ft)
Pipe Mounts	1.46	178.59
Antennas	5.69	675.45
Cables	1.80	110.97
Totals	8.95	965.01

Tank Loads						
Wind Load	Moment					
(k)	(k ft)					
55.83	4318.36					

Total Moment					
Wind Load	Moment				
(k)	(k ft)				
64.78	5283.372				

Totals

Percentage Increase in Lateral Force on Tank	Total / Tanks Loads	116.0%			
Percentage Increase in Moment on Tank	Total / Tanks Loads	122.3%			
* Maximum increase per ANSI AWWA D100 and Section 2402 of 2015 IPC					

116.0%	/ 110% *	=	105.5%
122.3%	/ 110% *	=	111.2%

Sufficient

* Maximum increase per ANSI AWWA D100 and Section 3403 of 2015 IBC

Base Seismic Moment from Original Tank Design:	7001320 ft-lbs
Required Base Moment from Wind Forces:	5283372 ft-lbs

5283372 ft-lbs < 7001320 ft-lbs

JOB NUMBER: E-3975 DATE :04/09/95 INPUT BY :TLR CHECKED BY: 6 -20-96

DOME HEAD (LBS)	7900.
TOP KNUCKLE (LBS)	15190.
STRAIGHT SHELL (LBS)	17360.
BOTTOM KNUCKLE (LDS)	15220.
BOTTOM TAIL (LBS)	5920.
CONE SECTION (LDS)	2410.
TEN & COMP RINGS (LBS)	
INCERT FLATES (LRS)	3000.
BALCONY GIRDER (LES)	1680.
COLUMNE (LES)	53090.
STRUTS (LPS)	2390.
TIE RODS (LBS)	7510.
RISER RODS (LBS)	770.
BASE PLATES (LBS)	2010.
RISER (LBS)	14610.
SMALL FIECES (LBS)	1220.
	144 - 1444 - 1 644 - 1644 - 1644 - 1844 - 1854 - 1854 - 1854 - 1855 - 1855 - 1855 - 1855 - 1855 - 1855 - 1855 - 1
TOTAL STEEL WEIGHT (LRS)	156490.
WEIGHT OF WATER (LES)	2636570.
WEIGHT OF SNOW (LBS)	29360.

VERTICAL LOADS

TOTAL WEIGHT ON BASE

2822420

COLUMN FOUNDATION DESIGN LOADS

TOTAL	VER	TICAL	LOVINE	۸T	BUGE	OF	COLUMNS
ny 1991 9996 4996 4999 49	** **** **** ****		944 9924 9424 144 4 4444 5 <i>4</i> 44 4		*** **** **** 24** **** **		184 ****= -**** >***> 4784 *8*4 7974 797
μ <u>Λ</u>	TER	(LRS)				1	357490.
STE	- <u>F. (</u>	(LBS)					133180.
SM	<u>)₩ (</u>	LBG)					29360.

MOMENTS AND SHEARS AT BASE

WIND MOMENT (FT-LES)	3781760.
WIND SHEAR (LBS)	51930.
SEISMIC MOMENT (FT-LRS)	7001320.
SEISMIC SHEAR (LBS)	69620.

OF MICO ATE OF MISSO REGISTES JERREL L. SHAFFER NUMBER GNEE E Jule 29 46



ASCE Hazards Report

Standard: ASCE/SEI 7-16

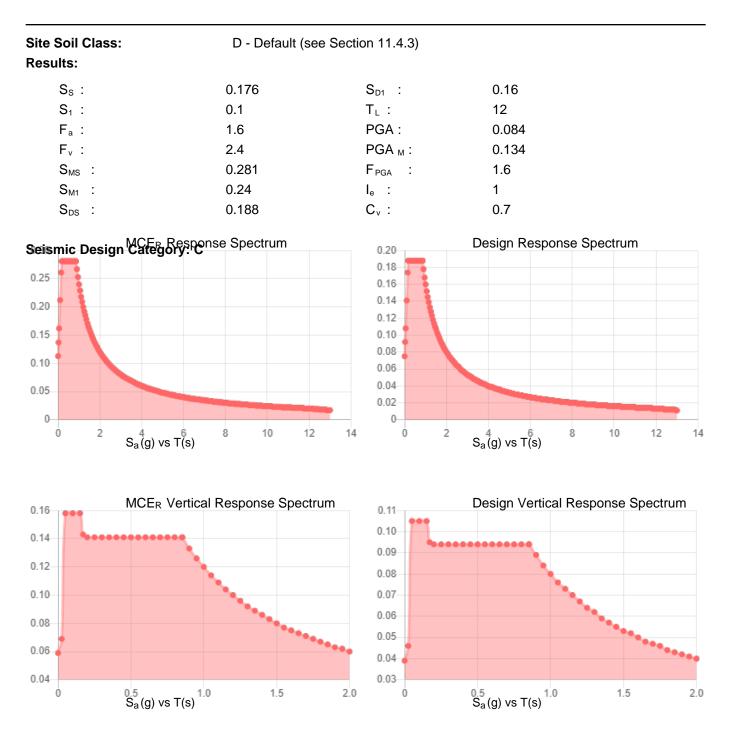
Risk Category: II

Soil Class:

y: II D - Default (see Section 11.4.3) Latitude: 37.299261 Longitude: -93.418025 Elevation: 1239.9757962277806 ft (NAVD 88)

Dennis St Pleasant Hope righton Goodnight Kime St W Mo-C GREENE Walnut Grove 1251 ft Nillard Lester St Ash Groy E Walnut Ln New Melville R Coope Park Springfield Halltown w Ln Hill St eb St Republic c Battle field





Data Accessed:

Thu Jul 25 2024

Date Source:

USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.



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