

SE02629A Mercer Island WT, WA 100-ft Self-Supporting Tower TAEC / T-Mobile

Structural Analysis Report No. 251538.11 January 13, 2025

Analysis and Report by: Harvey Carlisle, S.E. Checked by: Steven Diamond, P.E. Approved by: Harvey Carlisle, S.E.





Mercer Island WT

Report No. 251538.11

January 13, 2025

Introduction

NorthWest Tower Engineering (NWTE) has completed a structural analysis of the 100-foot selfsupporting tower at the water tank site on Mercer Island, Washington. The analysis was performed at the request of Technology Associates EC (TAEC) to determine the ability of the tower to support proposed T-Mobile equipment.

Tower Information

NWTE visited the site on 06-16-15. The tower is a Rohn Industries model SSV-100ft. Tower and foundation drawings were not provided. A Subsurface Exploration Report dated 04-05-12 and a Nondestructive Foundation Mapping report dated 04-17-12 by Tower Engineering Professionals (TEP) were provided. The tower has been structurally modified multiple times. Construction drawings for the original modifications were not provided. Original modifications include the installation of mid bay horizontals at one bay above 40ft and completing the "X" bracing above 80ft for 5 bays. The tower was structurally modified again per NWTE construction drawings dated 05-20-21 (Project No. 211538.09). Modifications consist of installation of mid-bay horizontal bracing between 0'-20' (3 bays) and between 44'-60' (4 bays). NWTE visited the site again on 03-09-22 to make observations of the structural modifications.

Assessed Condition

This analysis was performed to determine the ability of the tower to support the following load conditions:

Elev.	Location	Appurtenance	Tx Line	Tx Line No.
26'	Leg A	(2) GPS	½" Coax	# 26
63'	Leg A	Empty Mount	N/A	N/A
66'	Leg C	10' Omni on 3-ft Stand-off Mount	7/8" Coax	# 20
84'	Leg A,B,C	T-Mobile (3) Commscope FFVV-65C-R3-V1 Panels (3) Nokia AHFIG RRU (3) Nokia AHLOA RRU (1) HCS 2.0 Pendant (3) Site Pro 1 TAM-2U Universal Sliding Tapered Pipe Mount with 8' Pipe	HCS 2.0 Hybrid	# 30
99'	Face C	10ft Face Frame 10ft 2-bay Single Dipole 10ft 4-bay Dual Dipole 4ft Yagi Antenna	(2) 7/8" Coax ¼" coax	# 16,17 #25
99'	Leg B	18" Standoff Mount 10ft 4-bay Dual Dipole	7/8" Coax	# 18
110'	Leg C	10ft Omni Antenna	7/8" Coax	# 19

Existing Appurtenance Configuration



January 13, 2025

Proposed Appurtenance Configuration

All existing antennas and the following:

Elev.	Location	Appurtenance	Tx Line	Tx Line No.
84'	Leg A,B,C	Remove(3) Site Pro 1 TAM-2U Universal Sliding Tapered Pipe Mount with 8' Pipe Retain(3) Commscope FFVV-65C-R3-V1 Panels (3) Nokia AHFIG RRU (3) Nokia AHFIG RRU (1) HCS 2.0 Pendant Proposed (3) Nokia AEHC Panels (86.4') (3) Site Pro 1 VFA8-HD Sector Frames	Retain HCS 2.0 Hybrid Proposed 6x24 Hybrid	# 30 # 31

Antenna center elevations are listed for microwave, yagi, and panel type antennas. Base elevations are listed for other antenna types.

Information on tower geometry, structural member sizes, and existing appurtenances was gathered during NWTE's site visit. Information on proposed appurtenances was provided by TAEC in in preliminary construction drawings dated 01-09-25 and in T-Mobile's RFDS dated 12-20-24.

Steel yield strengths for structural members are assumed standard Rohn as follows:

\triangleright	Pipe Legs	50 ksi
\triangleright	Angle Bracing	36 ksi

The attached drawing shows tower geometry, structural member sizes, existing and proposed antennas, feed lines, and other supported appurtenances.

Wind Load Specifications

A comprehensive structural analysis was performed using the provisions of the current design standard, TIA-222-H, "Structural Standard for Antenna Supporting Structures, Antennas, and Small Wind Turbine Support Structures." This standard is referenced in the 2021 International Building Code (IBC). The minimum basic wind speed of **109 mph** (Vult, 3-second gust) as listed in the standard for Risk Category IV structures at this location was used. A basic wind speed of 30 mph in combination with a design ice thickness of 1" as listed in the TIA-222-H standard was also considered. Exposure Category B (suburban area) was considered. The rigorous topographic factor procedure was used (flat topped hill with crest height, H=365'; slope distance, L=3300'; and distance from crest, x=760'). A base elevation above sea level of 380' was considered.

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Analysis Method

A three-dimensional finite element model of the tower was created using *tnxTower Version* 8.2.1.0 (Tower Numerics, 2023). This computer software program calculates and distributes wind and ice loads in the model. It calculates the resulting forces (required strength) in all structural members and determines tower deflections and foundation loads. Required strength of each structural member is compared to each member's design strength determined using the TIA-222-H standard.

Analysis Results

The following ratios of required strength to design strength for the tower's structural members were found:

Elevation (ft)	Member	Existing Configuration Maximum % Capacity	Proposed Configuration Maximum % Capacity
	Leg	70	87
100 - 0	Diagonal	43	67
	Horizontal	13	16

MEMBER DEMAND-CAPACITY RATIO

The attached tables contain more detailed lists of member forces and capacities. Capacities of all structural members were found to be adequate.

Calculations show anchor bolts and bolts in leg splice and bracing connections to be adequate. Welds, plates, and other elements of the connections are assumed to develop the full strengths of the members.

According to the TEP foundation mapping report, each leg of the tower rests on a concrete pier. Pier dimensions are listed as approximately 2'-6" square at top and 3'-6" square at bottom with a depth of 11'-6". Calculations confirm that the foundations are adequate.

Seismic calculations were performed using the equivalent lateral force procedure in accordance with the TIA-222-H standard. Seismic forces were distributed over the height of the tower in accordance with the TIA-222-H standard. Resulting values for shear forces in the tower were then calculated at multiple levels and compared with shear forces generated from wind loads. Wind load was found to govern over the full height of the structure.

Conclusion

The tower meets the requirements of the TIA-222-H standard for the antenna configurations considered. Structural modifications are not required.

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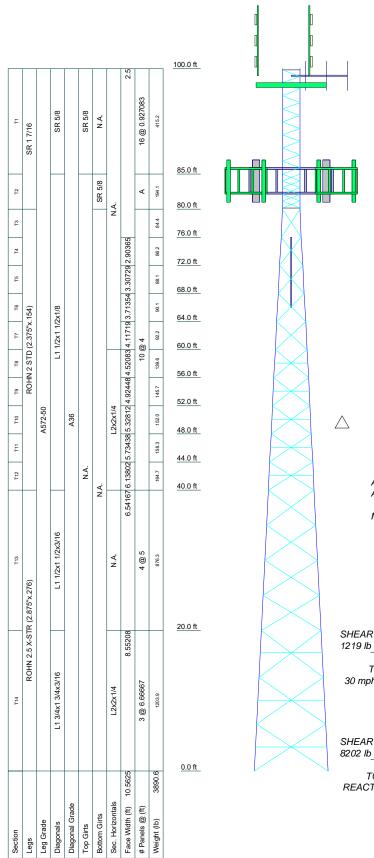
January 13, 2025

Conditions of Analysis

The analysis performed and the conclusions contained herein are based on the following assumptions:

- The tower has been properly installed and maintained.
- Steel grades for structural members are as listed above.
- Any deficiencies noted during the field visit have been or will be corrected.
- No x-ray, subsurface excavation, or other similar examination of the tower, foundation system, or welded connections was conducted. For portions of the tower and foundation system that were not visually accessible, no determination regarding the condition or adequacy was made.
- All structural components of the tower including, but not limited to, structural members (legs, bracing, etc.), connection components (gusset plates, welds, bolts), and foundations are in good condition.
- Feed lines are arranged as shown in the attached cross section.
- Existing and proposed T-Mobile antennas and equipment will be installed on new sector frames.

Deviations to these assumptions may affect the analysis results.



DESIGNED APPURTENANCE LOADING

TYPE	ELEVATION	TYPE	ELEVATION
Mast 10'x1"	110	Commscope FFVV-65C-R3 (T-Mobile)	84
Small Yagi	99	Commscope FFVV-65C-R3 (T-Mobile)	84
Face Frame	99	Commscope FFVV-65C-R3 (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
10' Dipole Antenna with Mount	99	AHLOA RRU (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Nokia AEHC (T-Mobile)	86	Nokia AHFIG (T-Mobile)	84
Site Pro 1 VFA8-HD V-Frame	84	HCS 2.0 Pendant (T-Mobile)	84
(T-Mobile)		Mast 10'x1"	66
Site Pro 1 VFA8-HD V-Frame	84	3-ft Stand-Off Mount	66
(T-Mobile)		3-ft Stand-Off Mount	63
Site Pro 1 VFA8-HD V-Frame (T-Mobile)	84	GPS	21 - 11

SYMBOL LIST

MARK	SIZE	MARK	SIZE
A 5	@ 0.966667		

MATERIAL STRENGTH

G	RADE	Fy	Fu	GRADE	Fy	Fu
A572	-50	50 ksi	65 ksi	A36	36 ksi	58 ksi

TOWER DESIGN NOTES

Tower is located in King County, Washington.
 Tower designed for Exposure B to the TIA-222-H Standard.
 Tower designed for a 109 mph basic wind in accordance with the TIA-222-H Standard.

Tower is also designed for a 30 mph basic wind with 1.00 in ice. Ice is considered to increase in thickness with height.

5. Deflections are based upon a 60 mph wind.

6. Tower Risk Category IV.

- 7. Topographic Category 5 with Crest Height of 365'
- 8. TOWER RATING: 86.5%

ALL REACTIONS ARE FACTORED

4.

MAX. CORNER REACTIONS AT BASE: DOWN: 57223 lb SHEAR: 5419 lb

UPLIFT: -48900 lb SHEAR: 4605 lb

AXIAL 25287 lb



TORQUE 322 lb-ft 30 mph WIND - 1.0000 in ICE

> AXIAL 9212 lb

MOMENT 495355 lb-ft

TORQUE 2597 lb-ft REACTIONS - 109 mph WIND

NWT

NorthWest Tower Engineering			
3426 Broadway Suite 302	Project: Proposed, V =	109 mph & 30 mph with	1" Ice
Everett, WA 98201	Client: TAEC/ T-Mobile	Drawn by: Steven Diamond	App'd:
E Phone: 425 258 4248	Code: TIA-222-H	Date: 01/13/25	Scale: NTS
FAX: 425 258 4289	Path:	e bolie ANAnsheist 100-8 SS Mercer Island, WA Processed 251528, 11 an	Dwg No. E-1

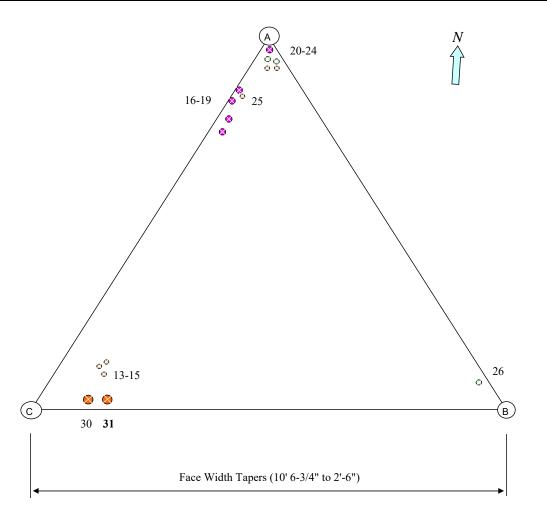


NorthWest Tower Engineering 3426 Broadway Suite 302 Everett, WA 98201 Phone: 425-258-4248

Job Name:	100-ft SS, Mercer Island	Page:	A-1
Project Number:	251538.11	Date:	1/8/2025
Client Name:	TAEC / T-Mobile	By:	SD/HC

	EXISTING FEEDLINES				
Coax Number	Coax Description	Termination Elevation	Coax Key		
1-12	removed	N/A	N/A		
13-15	(3) 1/4" Coax (Dead)	80'	٥		
16-19	(4) 7/8" Coax	99',110'	۲		
20	7/8" Coax	66'	0		
21-22	(2) 1/2" Coax (Dead)	98', 62'	0		
23-24	(2) 3/8" Coax (Dead)	62'	٥		
25	1/4" Coax	99'	٥		
26	1/2" Coax	21'	٥		
27-29	removed	N/A	N/A		
30	HCS 2.0 Hybrid Cable	84'	8		

PROPOSED FEEDLINES T-Mobile					
31 6x24 Hybrid Cable 84'					



Job

Project

Client

NorthWest Tower Engineering 3426 Broadway Suite 302 Everett, WA 98201 Phone: 425 258 4248 FAX: 425 258 4289

Existing, V =109 mph & 30 mph with 1" Ice

Designed by Steven Diamond

Section Capacity Table

Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	${}^{\phi P_{allow}}_{lb}$	% Capacity	Pass Fail
T1	100 - 85	Leg	1 7/16	1	-6794.62	55181.80	12.3	Pass
••	100 00	Diagonal	5/8	12	-1028.38	3721.20	27.6	Pass
		Top Girt	5/8	6	-146.28	4197.96	3.5	Pass
T2	85 - 80	1						
12	85 - 80	Leg	1 7/16	57	-12522.70	67675.80	18.5	Pass
		Diagonal	L1 1/2x1 1/2x1/8	66	1320.46	9175.78	14.4	Pass
							42.2 (b)	
		Bottom Girt	5/8	59	-216.90	4197.96	5.2	Pass
T3	80 - 76	Leg	ROHN 2 STD (2.375"x.154)	93	-13529.40	36808.30	36.8	Pass
		Diagonal	L1 1/2x1 1/2x1/8	98	-1447.63	8844.59	16.4	Pass
		-					43.2 (b)	
T4	76 - 72	Leg	ROHN 2 STD (2.375"x.154)	102	-16651.50	36808.30	45.2	Pass
		Diagonal	L1 1/2x1 1/2x1/8	107	-1171.21	8546.46	13.7	Pass
		Diagonal	E1 1/2X1 1/2X1/0	107	11/1.21	0540.40	37.7 (b)	1 435
T5	72 69	Lag	BOIN 2 STD (2 275" + 154)	111	18520.00	36807.80	50.3	Deeg
15	72 - 68	Leg	ROHN 2 STD (2.375"x.154)	111	-18529.90			Pass
		Diagonal	L1 1/2x1 1/2x1/8	116	-1061.06	8207.04	12.9	Pass
							32.1 (b)	
T6	68 - 64	Leg	ROHN 2 STD (2.375"x.154)	120	-20943.40	36808.30	56.9	Pass
		Diagonal	L1 1/2x1 1/2x1/8	126	-1017.08	7836.20	13.0	Pass
							31.8 (b)	
T7	64 - 60	Leg	ROHN 2 STD (2.375"x.154)	129	-22897.00	36808.30	62.2	Pass
		Diagonal	L1 1/2x1 1/2x1/8	135	-1060.70	7428.20	14.3	Pass
		Diugonai	ET DERI DERIO	155	1000.70	/ 120.20	32.3 (b)	1 400
T8	60 - 56	Leg	ROHN 2 STD (2.375"x.154)	138	-24678.90	44897.70	55.0	Pass
10	00 - 30							
		Diagonal	L1 1/2x1 1/2x1/8	144	-1065.55	6953.73	15.3	Pass
			~ ~ ~ ~ //				32.8 (b)	
		Secondary Horizontal	L2x2x1/4	146	427.99	28582.70	1.5	Pass
							6.9 (b)	
T9	56 - 52	Leg	ROHN 2 STD (2.375"x.154)	150	-26415.60	44919.20	58.8	Pass
		Diagonal	L1 1/2x1 1/2x1/8	156	-1061.12	6315.40	16.8	Pass
		e					32.3 (b)	
		Secondary Horizontal	L2x2x1/4	158	458.11	28582.70	1.6	Pass
				100	100111	200021/0	7.4 (b)	1 400
T10	52 - 48	Leg	ROHN 2 STD (2.375"x.154)	162	-28204.70	44935.90	62.8	Pass
110	52 - 40		· · · · · · · · · · · · · · · · · · ·					
		Diagonal	L1 1/2x1 1/2x1/8	168	-1050.17	5710.57	18.4	Pass
							32.1 (b)	_
		Secondary Horizontal	L2x2x1/4	170	489.15	28582.70	1.7	Pass
							7.9 (b)	
T11	48 - 44	Leg	ROHN 2 STD (2.375"x.154)	174	-29926.20	44953.30	66.6	Pass
		Diagonal	L1 1/2x1 1/2x1/8	180	-1061.67	5181.11	20.5	Pass
		-					32.3 (b)	
		Secondary Horizontal	L2x2x1/4	182	518.99	28582.70	1.8	Pass
		y					8.4 (b)	
T12	44 - 40	Leg	ROHN 2 STD (2.375"x.154)	186	-31669.70	44967.00	70.4	Pass
112	44 - 40							
		Diagonal	L1 1/2x1 1/2x1/8	192	-1045.48	4712.02	22.2	Pass
							31.9 (b)	
		Secondary Horizontal	L2x2x1/4	194	-549.23	25125.30	2.2	Pass
							8.9 (b)	
T13	40 - 20	Leg	ROHN 2.5 X-STR (2.875"x.276)	198	-39849.50	74429.90	53.5	Pass
		Diagonal	L1 1/2x1 1/2x3/16	204	-1107.39	4000.42	27.7	Pass
T14	20 - 0		ROHN 2.5 X-STR (2.875"x.276)	225	-47071.60	87455.80	53.8	Pass
	•	Diagonal	L1 3/4x1 3/4x3/16	231	-1479.42	3968.11	37.3	Pass
		Secondary Horizontal	$L_{1,3/4x1,3/4x3/10}$ L2x2x1/4	231	-816.33	22539.30	3.6	Pass
		Secondary Horizofilal	LZAZA1/4	233	-010.33	22339.30		1 488
							13.2 (b)	
							Summary	
						Leg (T12)	70.4	Pass
						Diagonal	43.2	Pass

tnxTower	Job	100-ft SS Mercer Island, WA 251538.11	Page 2 of 2
NorthWest Tower Engineering 3426 Broadway Suite 302	Project	Existing, V =109 mph & 30 mph with 1" Ice	Date 15:04:48 01/13/25
Everett, WA 98201 Phone: 425 258 4248 FAX: 425 258 4289	Client	TAEC/ T-Mobile	Designed by Steven Diamond

Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	ϕP_{allow} lb	% Capacity	Pass Fail
						(T3) Secondary Horizontal (T14)	13.2	Pass
						Top Girt (T1)	3.5	Pass
						Bottom Girt (T2)	5.2	Pass
						Bolt Checks RATING =		Pass Pass

Program Version 8.2.1.0 - 9/11/2023 File:P:/Projects 2025/251538.11 100ft SSV Mercer Island, WA TAEC, T-Mobile AN/Analysis/100-ft SS Mercer Island, WA Existing 251538.11.eri

Job

Project

Client

NorthWest Tower Engineering 3426 Broadway Suite 302 Everett, WA 98201 Phone: 425 258 4248 FAX: 425 258 4289

TAEC/ T-Mobile

Proposed, V =109 mph & 30 mph with 1" Ice

Designed by Steven Diamond

Section Capacity Table

Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	${}^{\phi P_{allow}}_{lb}$	% Capacity	Pass Fail
T1	100 - 85	Leg	1 7/16	1	-7000.22	55181.80	12.7	Pass
		Diagonal	5/8	12	-1143.50	3721.20	30.7	Pass
		Top Girt	5/8	6	-146.94	4197.96	3.5	Pass
T2	85 - 80	Leg	1 7/16	57	-15054.20	67675.80	22.2	Pass
12	05 00	Diagonal	L1 1/2x1 1/2x1/8	66	1913.91	9175.78	20.9	Pass
		Diagonai	ET HEAT HEATING	00	1715.71	9119.10	61.2 (b)	1 455
		Bottom Girt	5/8	59	-260.75	4197.96	6.2	Pass
Т3	80 - 76	Leg	ROHN 2 STD (2.375"x.154)	93	-16480.80	36808.30	44.8	Pass
15	80 - 70	Diagonal	L1 1/2x1 1/2x1/8	98	-2259.40	8844.59	25.5	Pass
		Diagonal	L1 1/2X1 1/2X1/8	90	-2239.40	0044.39	23.3 66.7 (b)	r ass
T4	76 - 72	Lag	BOIN 2 STD (2 275" 154)	102	-20693.50	36808.30	56.2	Pass
14	/0 - /2	Leg	ROHN 2 STD (2.375"x.154)					
		Diagonal	L1 1/2x1 1/2x1/8	107	-1753.50	8546.46	20.5	Pass
							57.3 (b)	-
T5	72 - 68	Leg	ROHN 2 STD (2.375"x.154)	111	-23179.70	36807.80	63.0	Pass
		Diagonal	L1 1/2x1 1/2x1/8	116	-1577.59	8207.04	19.2	Pass
							47.3 (b)	
T6	68 - 64	Leg	ROHN 2 STD (2.375"x.154)	120	-26222.10	36808.30	71.2	Pass
		Diagonal	L1 1/2x1 1/2x1/8	126	-1437.53	7836.20	18.3	Pass
							45.4 (b)	
T7	64 - 60	Leg	ROHN 2 STD (2.375"x.154)	129	-28612.10	36808.30	77.7	Pass
		Diagonal	L1 1/2x1 1/2x1/8	135	-1441.76	7428.20	19.4	Pass
		8					43.7 (b)	
T8	60 - 56	Leg	ROHN 2 STD (2.375"x.154)	138	-30783.70	44897.70	68.6	Pass
10	00 00	Diagonal	L1 1/2x1 1/2x1/8	144	-1403.66	6953.73	20.2	Pass
		Diagonai	ET NEXT NEXTO	111	1105.00	0705.15	43.3 (b)	1 400
		Secondary Horizontal	L2x2x1/4	146	533.87	28582.70	1.9	Pass
		Secondary Horizontar	L2X2X1/4	140	555.07	20502.70	8.6 (b)	1 455
Т9	56 - 52	Leg	ROHN 2 STD (2.375"x.154)	150	-32839.90	44919.20	73.1	Pass
19	50 - 52							
		Diagonal	L1 1/2x1 1/2x1/8	156	-1373.18	6315.40	21.7	Pass
		0 1 1 1	10.0.1/4	150	5(0.52	20502 70	41.6 (b)	P
		Secondary Horizontal	L2x2x1/4	158	569.53	28582.70	2.0	Pass
		_					9.2 (b)	_
T10	52 - 48	Leg	ROHN 2 STD (2.375"x.154)	162	-34932.70	44935.90	77.7	Pass
		Diagonal	L1 1/2x1 1/2x1/8	168	-1329.19	5710.57	23.3	Pass
							40.7 (b)	
		Secondary Horizontal	L2x2x1/4	170	605.83	28582.70	2.1	Pass
							9.8 (b)	
T11	48 - 44	Leg	ROHN 2 STD (2.375"x.154)	174	-36904.90	44953.30	82.1	Pass
		Diagonal	L1 1/2x1 1/2x1/8	180	-1320.99	5181.11	25.5	Pass
		8					40.2 (b)	
		Secondary Horizontal	L2x2x1/4	182	640.02	28582.70	2.2	Pass
				102	0.0002	200021/0	10.3 (b)	1 400
T12	44 - 40	Leg	ROHN 2 STD (2.375"x.154)	186	-38878.10	44967.00	86.5	Pass
112	44 - 40	Diagonal	L1 1/2x1 1/2x1/8	192	-1279.48	4712.02	27.2	Pass
		Diagonal	L1 1/2X1 1/2X1/8	192	-12/9.46	4/12.02	39.0 (b)	Pass
			12.2.1/4	105	(74.04	25125.20		р
		Secondary Horizontal	L2x2x1/4	195	-674.24	25125.30	2.7	Pass
T12	10 20	¥.		100	17000 10	7 4420.00	10.9 (b)	P
T13	40 - 20		ROHN 2.5 X-STR (2.875"x.276)	198	-47928.10	74429.90	64.4	Pass
		Diagonal	L1 1/2x1 1/2x3/16	204	-1285.25	4000.42	32.1	Pass
T14	20 - 0		ROHN 2.5 X-STR (2.875"x.276)	225	-55636.40	87455.80	63.6	Pass
		Diagonal	L1 3/4x1 3/4x3/16	231	-1598.62	3968.11	40.3	Pass
		Secondary Horizontal	L2x2x1/4	234	-964.87	22539.30	4.3	Pass
							15.6 (b)	
							Summary	
							Summary	
						Leg (T12)	86.5	Pass

taxTowar	Job		Page
tnxTower		100-ft SS Mercer Island, WA 251538.11	2 of 2
NorthWest Tower Engineering	Project		Date
3426 Broadway Suite 302		Proposed, V =109 mph & 30 mph with 1" Ice	15:00:24 01/13/25
Everett, WA 98201	Client		Designed by
Phone: 425 258 4248 FAX: 425 258 4289		TAEC/ T-Mobile	Steven Diamond

Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	${}^{{ m }{ m $	% Capacity	Pass Fail
						(T3) Secondary Horizontal (T14)	15.6	Pass
						Top Girt (T1)	3.5	Pass
						Bottom Girt (T2)	6.2	Pass
						Bolt Checks RATING =		Pass Pass

Program Version 8.2.1.0 - 9/11/2023 File:P:/Projects 2025/251538.11 100ft SSV Mercer Island, WA TAEC, T-Mobile AN/Analysis/100-ft SS Mercer Island, WA Proposed 251538.11.eri