

Appendix P

WyoLink VHF-57 Solution

WyoLink VHF-57 is one possible solution that maximizes the use of existing or planned WyDOT-only sites to achieve the target WyoLink goal of 95% mobile coverage statewide, except for Yellowstone National Park area. Appendix P is a refinement of previous coverage analysis work documented in Appendix O - Site Selection that examined various combinations of optimized site selections for both the VHF and 800 MHz bands including mobile and portable coverage plots.

There are three (3) component documents in Appendix P. They are:

- Assumptions and Results
- Exhibit 1 - WyDOT 57 Sites
- Exhibit 2 - Mobile Talk-in VHF-57 Coverage

Assumptions and Results

This document covers the engineering assumptions made in determining the actual modeled parameters for equipment performance and the overall coverage results of 94.6% for the mobile talk-in path for a DAQ of 3.0 using the selected group of 57 WyDOT sites.

Exhibit 1 - WyDOT 57 Sites

Exhibit 1 is a table listing the 57 WyDOT sites used for the coverage analysis. Of importance to the WyoLink Project, the Exhibit includes the WyDOT site name, latitude and longitude in both degrees-minutes-seconds and decimal degrees, elevation and antenna height.

Exhibit 2 - Mobile Talk-in VHF-57 Coverage

Exhibit 2 shows the resulting coverage plot. It depicts DAQ 4.0 coverage of 85.9% in green, DAQ 3.4 coverage of 92.6% in blue, DAQ 3.0 coverage of 94.6% in orange, and the remaining 5.4% of subpar (DAQ below 3.0) coverage in white. The coverage plot is overlaid on a map of Wyoming showing county borders, highways, and the tower sites.

WyoLink VHF-57 Radio Coverage Analysis Engineering Assumptions Used and Results

Assumptions:

- Center Frequency: 156 MHz
- Cable Type: Assumed to be 7/8" Helix© Decibel Products LDF5-50A or equivalent.
- Cable Loss assumed to be: ~ 0.45 dB /100 ft at 156 MHz.
- Datum of the latitude and longitude was indicated as NAD 87
- Latitude and longitude values are all provided in decimal format.
- Output power and ERP are in units of watts.
- Height is in feet.
- Maps represent the coverage of every tower layered on top on each other.
- Base/repeater effective gain for talk-in is calculated as:

$$\text{Base/repeater effective gain (in dBw)} = \begin{aligned} & [(\text{antenna gain}) - (\text{cavity and connector losses}) + \\ & (\text{receiver multi-coupler gains}) - (\text{coax loss})] \end{aligned}$$

Where:

- Cavity and connector losses are assumed to be 2.5 dB for the VHF solution.
- The receiver multi-coupler amplifier for the 156 MHz system has 13 dB effective gain (assumes a TX/RX 42-33-01-08N or equivalent).
- Coax loss = $[(\text{antenna height} + 20' \text{ of coax from tower to equipment})/100'] \times [\text{cable loss}/100']$
- Base/repeater antenna gain is estimated to be 6 dB for the VHF solutions with reference to a ½ wave dipole in an omni-directional orientation.
- Mobile ERP is 15.44 dBw

- Mobile ERP is calculated as:

$$\text{Mobile ERP (in dBw)} = 10 \times \log_{10}(\text{output power}) - [(\text{connector losses}) - (\text{coax loss}) + (\text{antenna gain})]$$

where the values in brackets is effectively 0 dB.

- with reference to a ½ wave dipole used to represent the gains and losses associated with the mobile environment beyond the output power of the mobile transmitter. This accounts for the antenna gain, connector losses, cable losses, the effects of light bars, and the effect of high-speed travel on bending of the antenna, when applicable, etc. Light bars or similar devices will be present on vehicles in each grouping, therefore worst case scenario is assumed.
- Mobile output power is assumed to be 35 watts for the VHF solution.
- All receiver sensitivities are assumed to be 0.35 V.
- A 10.2 dB value was used as the threshold value to achieve 95% tile reliability for mobile coverage.
- Selected WYDOT sites for analysis are contained in Exhibit 1.

Results:

The percent coverage results for Exhibit 2 are shown below:

Map	Group	Path	DAQ 4.0*	DAQ 3.4*	DAQ 3*	Remaining Unacceptable Coverage	Number of sites/ systems contributing to the coverage
			Green	Blue	Orange	White	
Task 5.4.2, Exhibit 2	WyoLink VHF-57 Sites	Talk-in	85.9%	92.6%	94.6%	5.4%	57

* Excludes Yellowstone Park Area

WYOMING RADIO COVERAGE ANALYSIS
WyoLink VHF-57 Solution
Exhibit 1

SAIC #	FE ID	WyDOT Site Name	Latitude D-M-S	Longitude D-M-S	Elevation (feet)	RX side talk-in gains (dB)	SAIC Filename	Antenna Height (feet)	Latitude Decimal	Longitude Decimal
1	1	1st Divide	41° 16' 56"	110° 46' 51"	7633	16.14	NEWSALECSKKR571Evanston	60	41.282	-110.781
2	2	9 Mile Hill	41° 52' 51.9"	107° 19' 21"	7723	16.14	NEWWYDOTKXM897Rawlins	60	41.881	-107.323
3	3	77 Hill	42° 50' 38.9"	104° 37' 0.9"	5630	16.05	NEWWYDOTWSB705Lusk	80	42.844	-104.617
4	4	Aspen Mountain	41° 25' 33.9"	109° 7' 40"	8659	16.05	NEWWYDOTKJL508RockSprings	80	41.426	-109.128
5	6	Baggs Hill	41° 0' 20.8"	107° 37' 18.8"	6686	15.94	NEWPHWNS957BAGGS	105	41.006	-107.622
6	8	Casper Mountain	42° 44' 52"	106° 18' 8.9"	8091	15.87	NEWWYDOTWJZ333Casper	120	42.748	-106.303
7	9	Cedar Mountain	44° 29' 51"	109° 9' 10"	7779	15.87	NEWXCEDARMOUNTAIN	121	44.498	-109.153
8	10	Copper Mountain	43° 26' 9.9"	107° 59' 58"	8200	16.05	NEWWYDOTWQE460Shoshoni	80	43.436	-107.999
9	11	Dead Indian Hill	44° 45' 18"	109° 22' 28"	8535	16.05	NEWWYDOTWPEV313Cody	80	44.755	-109.374
10	12	Delaney Rim	41° 33' 50.9"	108° 16' 58.9"	7549	16.05	NEWWYDOTWPM672Wamsutter	80	41.564	-108.283
11	13	Hogsback/Hogsback Ridge	42° 19' 33"	110° 19' 8"	9018	16.05	NEWWYDOTWPPQA276LaBaege	80	42.326	-110.319
12	14	Jade Mountain	42° 24' 4.9"	107° 57' 30.9"	8191	16.32	NEWWYDOTWPF966JefferyCity	20	42.401	-107.959
13	15	Jim Creek Hill	44° 35' 58.9"	106° 45' 34.2"	4948	16.05	NEWWYDOTKNDJ412Sheridan	80	44.599	-106.759
14	16	Morton Hill	42° 50' 25"	105° 19' 59"	5558	15.60	NEWXMORTONHILL	180	42.840	-105.333
15	17	Mount Pisgah	43° 59' 37"	104° 9' 0"	6400	16.05	NEWWYDOTKNDJ413NewCastle	80	43.994	-104.150
16	18	Muddy Gap Hill	42° 21' 15.8"	107° 29' 21.1"	6929	16.05	NEWWYDOTWNNQ676MuddyGap	80	42.354	-107.489
17	19	Oyster Ridge	41° 47' 24.9"	110° 30' 29"	7775	16.05	NEWWYDOTKNDJ409Kemmerer	80	41.790	-110.508
18	20	Pine Ridge	42° 20' 46.9"	105° 2' 10"	4645	16.32	NEWXPINERIDGE	20	42.346	-105.036
19	21	Pumpkin Buttes	43° 43' 57"	105° 53' 0"	5990	16.05	NEWWYDOTKNDJ411Gillette	80	43.733	-105.883
20	23	Sherman (Beacon) Hill	41° 15' 42"	105° 25' 53"	8770	15.91	NEWWYDOTKWL375CheyenneLaramie	112	41.262	-105.431
21	24	Shirley Mountain	42° 9' 51.8"	106° 34' 36.8"	8990	16.05	NEWWYDOTKWL374MedicineBow	80	42.164	-106.577
22	25	Snow King/Jackson (two sites)	43° 27' 8"	110° 45' 11"	8005	16.05	NEWWYDOTKNDJ410Jackson	80	43.452	-110.753
23	26	Torchlite Hill	44° 22' 54.9"	107° 59' 17.1"	4335	15.96	NEWXTORCHLITEHILL	100	44.382	-107.988
24	27	Virgin Hill	42° 3' 34.9"	104° 41' 45.9"	5484	15.87	NEWWYDOTWRA452Wheatland	120	42.060	-104.696
25	28	Windy Ridge	43° 29' 57.9"	109° 41' 16.9"	9896	16.05	NEWWYDOTWNCHE615WindyRidge	80	43.499	-109.688
26	30	Warren Peak	44° 30' 11.9"	104° 31' 18.9"	5665	16.05	NEWWYDOTKNIP999Sundance	80	44.503	-104.522
57	31/44	Sage Junction/Twin Buttes	41° 50' 55.9"	110° 50' 52"	7660	16.05	NEWWYDOTWPM673Sage	80	41.849	-110.848
27	46	Kismet Peak	43° 5' 57.9"	110° 15' 25.9"	8375	15.96	NEWXKISMETPEAK	100	43.099	-110.257
28	47	Banner Ridge	44° 36' 29"	106° 55' 23.1"	5602	15.96	NEWXBANNERIDGE	100	44.608	-106.923
29	51	Church Buttes	41° 24' 55"	110° 4' 54.8"	7040	15.96	NEWXCHURCHBUTTES	100	41.415	-110.082
30	52	Divide Hill	44° 32' 56"	107° 42' 59"	7325	15.96	NEWXDIVIDEHILL	100	44.549	-107.716
31	53	Flat Top	42° 49' 41"	105° 3' 20.1"	5537	15.96	NEWXFLATTOP	100	42.828	-105.056
32	56	Lonetree	43° 23' 30.9"	105° 23' 58.9"	5277	15.96	NEWXLONETREE	100	43.392	-105.400
33	58	Rozet Hill	44° 20' 26"	105° 14' 48.9"	4813	15.97	NEWXROZETHILL	98	44.341	-105.247
34	60	Strouss Hill	41° 29' 17.9"	106° 2' 57.8"	7970	15.96	NEWXSTROSSHILL	100	41.488	-106.049
35	62	Torrington	42° 5' 21.9"	104° 10' 40"	4104	15.96	NEWXTORRINGTON	100	42.089	-104.178
36	63	Tisdale Divide	44° 14' 0.9"	106° 42' 0"	5330	15.96	NEWXTISDALEDIVIDE	100	44.234	-106.700
37	64	Waltman Hill	43° 2' 13.9"	107° 17' 17.1"	6434	15.96	NEWXWALTMANHILL	100	43.037	-107.288
38	65	North Albin	41° 28' 36.9"	104° 6' 6.1"	5368	15.96	NEWXNORTHALBIN	100	41.477	-104.102
39	66	Russell Hill/Pine Bluff	41° 15' 29"	104° 6' 16.9"	5345	15.96	NEWXPINEBLUFFSRUSSELLHILL	100	41.258	-104.105
40	67	85 South	41° 1' 17"	104° 47' 8.8"	6277	15.96	NEWX85SOUTH	100	41.021	-104.786
41	68	Whitcomb Hill/ County Line	41° 39' 1"	104° 54' 6.1"	6035	15.96	NEWXWHITCOMBHILLCOUNTYLINE	100	41.650	-104.902
42	69	Ruby Knolls	41° 50' 17"	107° 46' 20.9"	7183	15.96	NEWXRUBYKNOLLSROSYKNOB	100	41.838	-107.773
43	70	North Flattop	41° 13' 17"	107° 49' 58"	7823	15.96	NEWXNORTHFLATTOP	100	41.221	-107.833
44	71	Geneva Summit	42° 19' 59"	111° 8' 12.1"	7013	15.96	NEWXGENEVASUMMIT	100	42.333	-111.137
45	72	Salt Pass (new)	42° 29' 20"	110° 53' 34"	8102	15.96	NEWXSALTPASSNEW	100	42.489	-110.893
46	73	Narrow Hill	42° 51' 34.9"	110° 56' 31.9"	7064	15.96	NEWXNARROWSHILL	100	42.860	-110.942
47	74	Rendezvous Peak	43° 35' 49.9"	110° 52' 12"	9815	15.96	NEWXRENDEZVOUSPEAK	100	43.597	-110.870
48	75	Riverton	42° 59' 0"	108° 29' 4.9"	5019.685	16.19	NEWXRIVERTON	49.87008	42.983	-108.485
49	76	Diverion Dam	43° 13' 41.9"	109° 0' 29.1"	5157	15.96	NEWXDIVERSIONDAM	100	43.228	-109.008
50	77	Cedar Ridge	43° 40' 14"	108° 15' 41"	5185	15.96	NEWXCEDARRIDGE	100	43.671	-108.261
51	78	Rattlesnake Ridge	44° 4' 0"	107° 51' 50"	4669	16.28	NEWXRATTLESNAKERIDGE	30	44.067	-107.864
52	80	McCullough Peaks	44° 35' 13.9"	108° 51' 6"	6549	16.19	NEWXMCCULLOUGHPEAKS	49	44.587	-108.852
53	81	3 Mile Hill	44° 8' 22.9"	108° 49' 18.9"	6726	16.01	NEWX3MILEHILL	89	44.140	-108.822
54	82	Tisdale Mountain	43° 30' 41"	106° 35' 9.9"	5810	15.96	NEWXTISDALEMOUNTAIN	100	43.511	-106.586
55	83	NW Campbell County	44° 51' 0"	105° 51' 51.8"	4185	15.96	NEWXNWCAMPBELLCOUNTY	100	44.850	-105.864
56	84	South Pass	42° 34' 4"	108° 40' 19.9"	8234	15.96	NEWXSOUTHPASS	100	42.568	-108.672

VHF Mobile Talk-In
 57 WYDOT Site Solution Set
 Exhibit 2, Task 5.4.2

