Portland General Electric
IOC COMMUNICATIONS TOWER
Radio Frequency Report, Purpose & Need

March, 2019

Prepared By

Telecommunications Consulting
23030 SE Highway 212
Damascus, OR 97089

Executive Summary:

Portland General Electric (PGE) has undertaken a project to construct an Integrated Operations Center (IOC) to replace their existing operations center in downtown Portland. The IOC will house a 24/7 system control center as well as a data center. The need for the new IOC is driven partly by facilities limitations at the existing operations center. An additional driving component is the increasing regulatory requirements for the protection, safety and reliability of the nation's electrical grid.

The IOC will require a robust system to communicate with the outside world as well as internally within the PGE network. In order to accomplish this, several forms and routes for communications will be implemented. This will diversify PGE's communications and act as a failsafe in the case of a communications failure. Public telephone, private mobile radio, private fiber optics and private microwave radio will be employed to accomplish this.

PGE currently operates a private microwave radio network throughout much of Oregon and into Washington. PGE commissioned a "Microwave Path Survey Report – IOC Paths" that would determine a practical location for a communications tower to service the IOC and the required height (attached for reference as Exhibit B). Given that, a tower that services the IOC site must be of sufficient height for at least two microwave paths to have clearance over any obstructions to properly function. The two functioning microwave paths will provide for a diverse route to other PGE communications sites. In addition to the path clearance requirements, the tower must be located within the IOC compound such that access to the tower can be monitored and controlled. The path survey report concluded that the minimum tower height required was 140' and that it could be located within the IOC compound.

The Tualatin Development Code (TDC) suggests that in order to construct a tower over a predetermined height and receive a variance, the proponent must demonstrate the following:

- "It is technically not practical to provide the needed capacity or coverage the tower is intended to provide at a height that meets the TDC requirements. The needed capacity or coverage must be documented with a Radio Frequency report; and
- The collocation report, required as part of the Architectural Review submittal, must document that existing WCFs, or a WCF for which an application has been filed and not denied, cannot be modified to provide the capacity or coverage the tower is intended to provide."

The microwave path survey report demonstrates that it is technically necessary to have a tower with a minimum height of 140' (see Figure 4.0 as an example). Additionally, and as depicted in Figure 3 - 1500' Radius Around IOC Tower, there are no existing WCFs within the 1500 foot search area. Further, any other tower not located within the fenced IOC compound would not provide the level of security required by regulatory agencies.

IOC Background:

Portland General Electric (PGE) provides distribution and transmission services to approximately 40% of Oregon's population making it the state's largest power utility. As such, PGE is mandated to provide reliable and safe power to its customers. Part of that mission is accomplished by operating a 24/7 control center and data center, currently housed in a building in downtown Portland. This existing building has significant limitations that cannot be easily corrected. Coupled with increasing regulatory requirements placed on the operation of the nation's power grid and PGE is now driven to construct a new Integrated Operations Center (IOC).

Part of the function of the IOC will be the monitoring of the Western Interconnect (the western electrical grid) and coordination with other utilities. The coordination with other utilities involves not only verbal communications but various electronic forms as well. The various coordination actions and communications forms are, in part, dictated by the Western Electricity Coordination Council (WECC). WECC is given its authority to oversee the Western Interconnect by the Federal Energy Regulatory Commission (FERC). WECC is responsible for the regional enforcement and compliance monitoring of Reliability Standards for the operation and coordination activities within the Western Interconnect.

IOC Communications:

As the IOC will function as a control center for PGE's electrical operations, several control and monitoring communications circuits (traffic) will be routed to and from the site. Much of these circuits are critical in nature. WECC provides rules for the reliability and routing of these critical circuits. In short, WECC guidelines state that these critical circuits must have diverse routing through multiple forms of communications. Strict rules are also in place to control the security of communications, both physically and electronically.

Due to the importance of the IOC function and the critical communications traffic, PGE will employ several communications formats. A private fiber optic network will be routed in and out of the IOC. For route diversification and backup, microwave radio will also be utilized. The microwave radio will necessitate the construction of a lattice tower to support the parabolic microwave antennas. The tower will also support antennas for PGE's private land mobile radio network (LMR). Their LMR network is not only crucial to communicating with field personnel for power switching functions on a day-to-day basis, but especially in times of outages or emergencies.

The height of the communication tower was determined by a field survey performed for three potential microwave paths in and out of the IOC (Microwave Path Survey Report – IOC Paths).

Path Survey Approach & Results:

The proposed tower location was selected after reviewing several alternatives, and it best meets the objectives: having a workable microwave path to other PGE communications sites, being located inside the secure fence and having the minimum possible height. PGE has existing communications sites to the west on Bald Peak in Yamhill County, to the north at Healy Heights near OHSU and to the northeast on Mount Scott in Happy Valley. Workable microwave paths to these referenced PGE sites will create a link for their own communications network. This, in turn, will establish internally network communications as well as interfaces with other utilities.

The purpose of the field survey was to verify whether there would be an unobstructed path to any of PGE's existing communications sites. The unobstructed path is often referred to as line-of-sight. In general the field investigation found that mature evergreen trees located in close proximity (close-in trees) to the IOC project site will dictate the microwave antenna heights.

Although the required clearance over a potential obstruction is referred to as line-of-sight it is important to understand that just seeing the other end of a microwave path will not provide sufficient clearances for the path to operate correctly. A microwave path is influenced by atmospheric conditions, the earth's curvature and the size of, in most cases, a full 1st Fresnel zone. In microwave propagation models, the Fresnel zone is a cylindrical eclipse between a transmitting antenna and a receiving antenna. The size of the Fresnel zone, or eclipse, is determined by the frequency and distance of the microwave path. The size of the first Fresnel zone can be expressed mathematically [1]:

$$F^1 = 72.1\sqrt{\frac{d_1 d_2}{fD}}$$

Where: F_1 = 1st Fresnel zone in feet
d_1 = Distance from one end of path to point of interest in miles
D = Total length of path in miles
$d_2 = D - d_1$
f = Frequency in GHz

The size of the first Fresnel zone is important to the proper operation of a microwave path. Without sufficient clearances the path will suffer signal degradation due to obstruction loss. Another important path clearance consideration is tree growth. The field investigation found that close-in trees will define the microwave antenna mounting heights. Given that, it is prudent to add a tree growth factor to the clearances over the trees. In this case 20 feet of additional clearance has been added to determine the final antenna mounting heights presented in the path survey report.

[1] GTE Lenkurt Incorporated, "Engineering Considerations for Microwave Communications Systems", Forth Edition.

IOC Tower Location & Height:

Figure 1.0, "IOC Tower Site" depicts the location of the proposed tower. The site was chosen, in part, due to the overall IOC site design. Another important consideration is the tower's proximity to the IOC buildings. Critical electronics will be housed within the IOC buildings. Radio and other electronics will be housed in a pre-fabricated communications shelter near the base of the tower. A fiber optic cable will tie the IOC buildings and the communications shelter together.

The path survey found that the shortest required tower would 140 feet in height. This would provide clearances for the three potential microwave paths out of the IOC. Figure 2.0, "IOC Tower – Potential Microwave Paths" shows the paths emanating from this tower site.

Other factors taken into account for this tower location include the lack of any other tower facilities in the vicinity of the IOC site. Figure 3.0, "1500' Radius Around IOC Tower" shows that the nearest WCF is outside the Tualatin city limits and is therefore not subject to the City's development code. The nearest WCF inside city limits is even farther away to the northeast of the site. Both of these facilities are farther than 1500 feet from the proposed tower, and therefore inappropriate for co-location. This is further shown in the City of Tualatin's document "Existing WCF's with 1500' Buffer Area", which is incorporated in this report by reference.

A final consideration for the tower location is cyber and physical security. This proposed tower will be part of a communications network that will carry information and data vital to the operation of the nation's electrical grid. PGE is mandated by federal regulators to take physical security measures to keep their cyber assets secure. The tower site needs to be located within the IOC secured area.

Final Considerations:

PGE is required to have diverse communications routes in and out of this proposed facility. To meet this requirement PGE will employ various forms of electronic communications. One such form will be the use of microwave radio. The antennas for microwave communications must be supported on a structure, or tower, that will provide for adequate existing and future physical clearances over potential obstructions.

The proposed location for the tower was chosen as it will require the shortest possible tower (140'). The tower location will also allow for physical security that is critical to the IOC site.

The final structural design of the tower will provide for PGE's present and future needs. Because of the heightened security requirements for this site, considerations for additional tower loading from third parties will only be given to police, fire and other emergency services.

FIGURE 1.0
IOC Tower Site

FIGURE 2.0
IOC TOWER – Potential M/W Paths
45 21 59.5 N
122 48 16.9 W

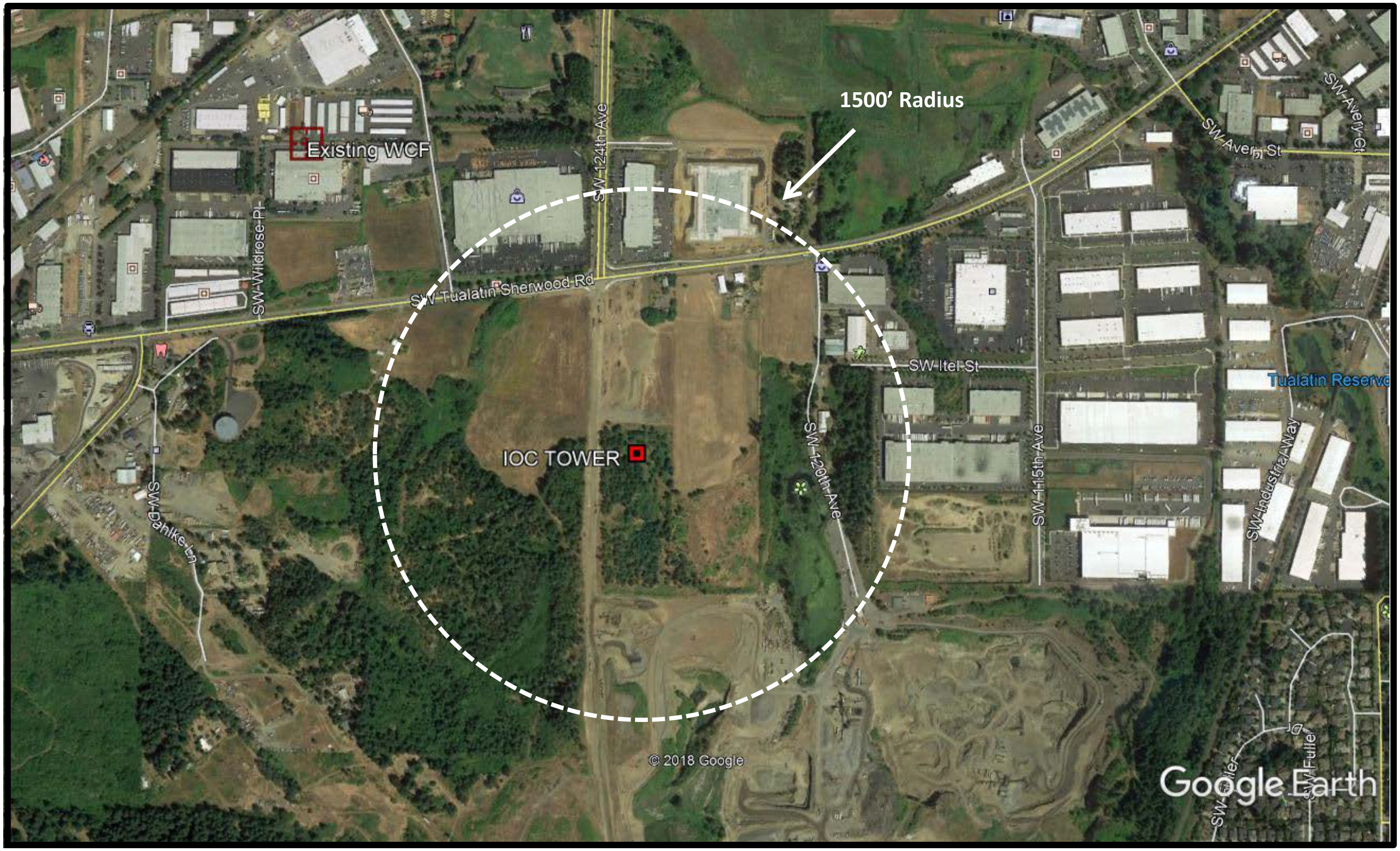

Figure 3.0
1500' RADIUS AROUND IOC TOWER

FIGURE 4.0
Tower Example

EXHIBIT A

Microwave Path Survey Report

Portland General Electric
IOC Paths
P.O. E0010-0000016693

Release 1.0
February, 2019

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GENERAL

STATEMENT OF WORK

The following report summarizes the results of a microwave path survey conducted by Summit Telecom Solutions, Inc. of Damascus, OR for Portland General Electric. Field survey work was performed on January 14th and 18th, 2019, by Mike Bigham.

The survey was undertaken to verify site locations and determine antenna sizes and centerlines required to establish a microwave communications system in conformance with customer requirements and current engineering practices.

SURVEY PROCEDURES

Preliminary path profiles are drawn based on the supplied site coordinates and contour information extracted from the best available topographic mapping. A field site survey is conducted to verify site coordinates and elevations based on North American Datum 1983 (NAD83) and gather information related to the proposed radio equipment and antenna locations, site access, and site development constraints. A field path survey is conducted to verify path profile elevations, measure all natural and manmade potential obstructions and assess the reflective potential of all natural and manmade surfaces. Antenna centerline heights are then calculated for the proposed frequency band by applying suitable clearance criteria based on the propagation characteristics of the geographic area.

Path calculation sheets are generated for each hop, based upon the findings of the field path survey. Antenna sizes and the choice of propagation protection diversity will be chosen to meet the required fade margin and the desired path propagation reliability. Propagation outage and reliability calculations will be based on the Vigants model (ref. "Space Diversity Engineering", BSTJ, 1/75).

DESIGN CRITERIA

Path clearance criteria must be established for each path on the basis of total system performance objectives, economic considerations, and careful analysis of local atmospheric conditions derived from published climatological data, where available, and reported microwave transmission experience pertinent to the area. Antenna heights much greater than actually needed can cause an unwarranted increase in system cost, and on paths with significant ground reflections, it can increase the exposure to multipath and ground reflection signal fading. It is desirable to locate the antennas high enough so that even under severe super-standard atmospheric refractive conditions (surface ducting) there is adequate clearance such that signal entrapment does not significantly degrade the fade margin of the path or generate excessive multipath fade activity. The choice of clearance criteria for a microwave path is a balance between cost and performance.

The path clearance criterion as applied to a given geographic area is a function of the degree and direction of atmospheric beam bending and can conveniently be defined by the equivalent earth radius K factor:

$$K = \frac{Effective\ \ Earth's\ \ Radius}{Actual\ \ Earth's\ \ Radius}$$

The Median Propagation value of K = 4/3 allows the normal microwave horizon to be slightly extended when compared to the optical horizon; however, under certain meteorological conditions (for example, during nighttime super-refractivity usually associated with temperature inversions) the value of K increases to 2 or greater for periods of several minutes to several hours. This increases the path clearance and results in the heavy multipath fade activity seen on some reflective paths and antenna decoupling power fading on others.

CLEARANCE CRITERIA

The criteria used to design a radio path in regions where the X-factor is equal to or less than 1:

- Main to Main:
  - 100% first Fresnel zone radius over K=4/3, or
  - 60% first Fresnel zone radius over K=1, whichever is greater

- Main to Diversity:
  - 60% first Fresnel zone radius over K=4/3 (If Applicable)

The criteria used to design a radio path in regions where the X-factor is greater than 1:

- Main to Main:
  - 100% first Fresnel zone radius over K=4/3, or
  - 30% first Fresnel zone radius over K=2/3, whichever is greater

- Main to Diversity:
  - 60% first Fresnel zone radius over K=4/3 (If Applicable)

MICROWAVE PATH PERFORMANCE CALCULATIONS AND WARRANTIES

The microwave path design models most frequently employed within the industry (e.g., Vigants, and ITU PN-530) provide a reasonably accurate (and therefore usually guaranteed) estimate of the cumulative time a path will be out of service due to random atmospheric multipath fading under normal atmospheric conditions. **These models do not (and cannot) accommodate abnormal, unusual, anomalous, or otherwise unpredictable conditions of weather or atmospheric refractivity**.

MICROWAVE FREQUENCY ENGINEERING / INTER-SYSTEM INTERFERENCE ANALYSIS

Summit Telecom Solutions, Inc. will partner with Micronet Communications, Inc., to provide cost-effective frequency planning and FCC licensing services for radio communications systems (if required). The planning software used, considers specific operating parameters of both the proposed microwave system and the environment microwave systems (license and proposed) to properly consider the interference potential of the new path or system. Parameters and data elements incorporated into the modeling include, but are not limited to, antenna type, antenna height, elevation, antenna radiation pattern, receiver filter performance, terrain, radio modulation, path orientation, receiver threshold, etc. These elements are required to accurately predict specific interfering levels into and from the existing microwave systems. The accuracy of the calculations is ensured by "real time" maintenance of the Micronet point-to-point microwave, earth station, radio equipment, antenna, interference objective, and contact database.

MICROWAVE FREQUENCY SELECTION

The interference analysis performed on the microwave system identifies available frequencies considering existing and proposed systems found in the Micronet database. When applicable, an analysis of the systems in the adjacent bands can be done to ensure the microwave system does not receive unwanted threshold degradation. In bands shared with satellite systems, an analysis of potential interference with earth stations and with the geo-stationary satellite orbit can also be done. Additionally, co-located or nearby transmitters already licensed in the required frequency band can be identified in order to reduce the possibility of "bucking" an existing high/low frequency plan that could increase the possibility of receiver overload or reflective interference from a nearby system.

MICROWAVE FREQUENCY COORDINATION AND FCC LICENSING

The majority of microwave bands subject to FCC Rule Part 101 require prior coordination with existing licensees. Summit Telecom Solutions, Inc. will partner with Micronet to perform the frequency coordination and FCC licensing on behalf of the customer (if required). The procedure will include notification of the technical parameters of the proposed system to all existing and proposed licensees in the area and frequency band of operation. Frequency coordination will also be performed with Canadian and Mexican authorities in border areas when necessary. By FCC rule, recipients are given 30 days to respond, or in some cases an expedited response can be requested.

Upon completion of the prior coordination process, documentation required to satisfy FCC Rule Part 101.103 (d) can be prepared on behalf of the customer. This will include any necessary exhibits, including Supplemental Showings required upon submittal of the requested license application. The FCC filing process includes:

- Filing of the FCC Form 601 microwave application upon written approval from the customer and providing an electronic copy of the application to the customer via email.
- Tracking the status of the application until the license is granted by the FCC. Amendments will be handled expeditiously on behalf of the customer for any questions or concerns from the Commission.
- Email notifications to the licensee when the license is granted by the FCC.
- Filing of the required "Completion of Construction" notification with the FCC upon written approval from the licensee and notification of the filing via email.

SPECIAL CONSIDERATIONS

On all microwave radio paths traversing urban areas there exists the possibility of multiple on- and off-path structural reflections which generate long-delayed echoes, as well as "terrain scatter" RF intra- and inter-system interference. Long delayed, low-level echoes have no effect on digital radio performance; however, the terrain scatter mechanism cannot be accurately predicted nor precisely measured without an extensive and expensive field trial. Consequently, this mechanism is specifically excluded from all current industry-wide path survey and frequency coordination performance guarantees.

The structure supporting the microwave antenna can take many forms. The antenna is most often mounted on a tower, but can be mounted on a variety of structures such as roof tripods, penthouse wall, wooden telephone pole or metal monopole. It is recommended that the customer or end user conduct a structural analysis of the support structure to determine if the structure will support the additional loading imposed by the antenna and its mount. The structure must also meet the twist and sway requirements per EIA/ANSI 222G.

Certain geographic areas / frequency bands are restricted due to Radio Astronomy use or DOD and other Government top-secret installations. Even outside the absolute exclusion zone, there are areas where 18 GHz can be cleared by DOD. Coordinators must file applications and wait for the FCC to contact NTIA and NTIA to contact IRAC to analyze these before FCC licenses are granted. If the application is rejected, the proposed microwave link could be subject to redesign with another frequency band.

SYSTEM INFORMATION

SYSTEM DESCRIPTION

Portland General Electric (PGE) has undertaken a project to construct an Integrated Operations Center (IOC) to replace their existing operations center in downtown Portland. The IOC will house a 24/7 system control center as well as a data center. The need for the new IOC is driven partly by facilities limitations at the existing operations center. An additional driving component is the increasing regulatory requirements for the protection, safety and reliability of the nation's electrical grid.

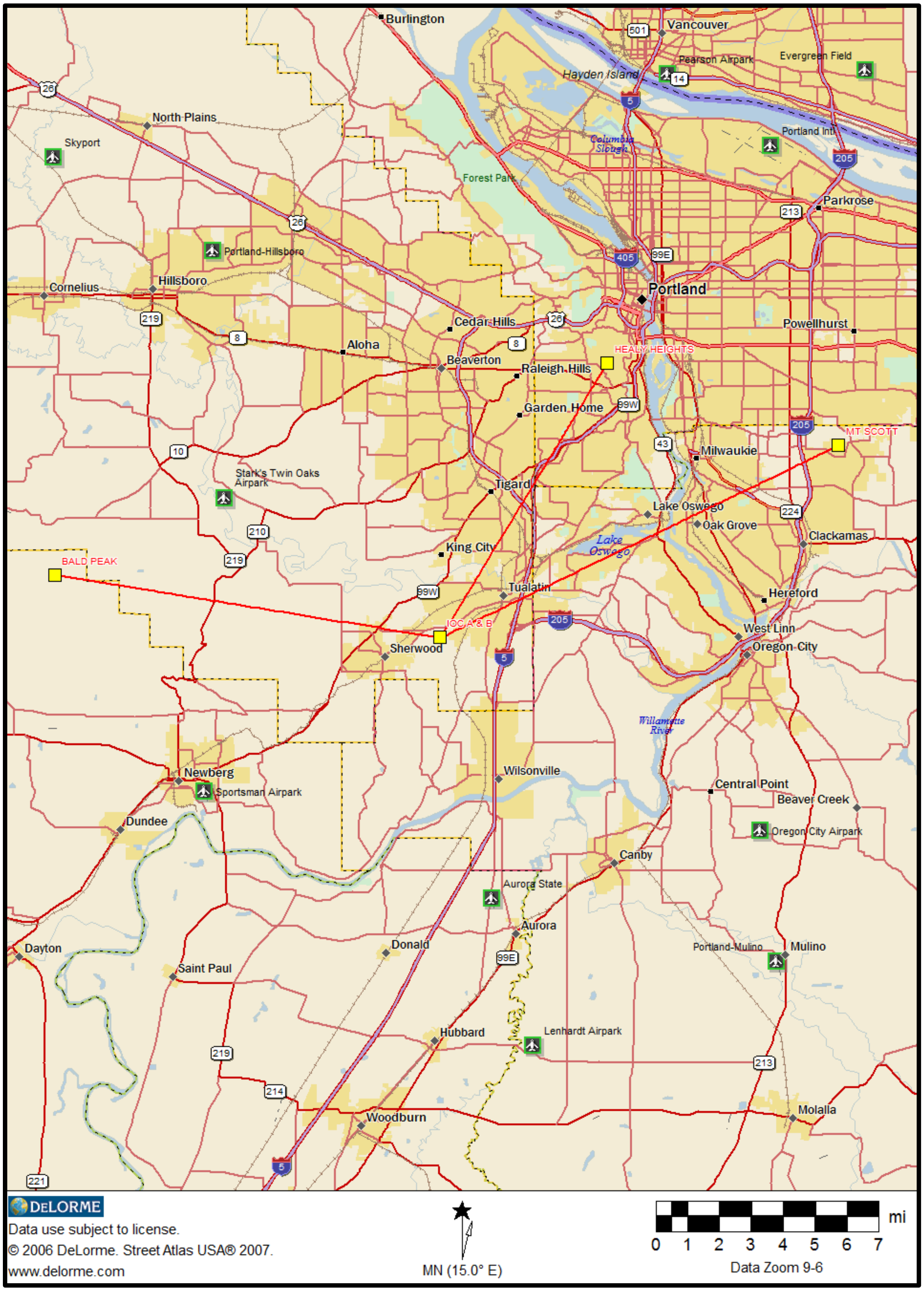
The IOC will require a robust system to communicate with the outside world as well as internally within the PGE network. In order to accomplish this, several forms and routes for communications will be implemented. This will diversify PGE's communications and act as a failsafe in the case of a communications failure. Public telephone, private mobile radio, private fiber optics and private microwave will be employed to accomplish this.

PGE currently operates a private microwave network throughout much of Oregon and into Washington. This report will focus on the technical requirements of microwave communications in and out of the proposed IOC and in particular the antenna mounting heights required. Antenna heights will, in turn, drive the height of any communications tower constructed at the IOC.

The criteria employed in this report for establishing clearance over any potential obstruction is a full 1st Fresnel zone at K=4/3. Additionally, when the path travels over trees, 20' of additional clearance will be added. This will allow the path to function properly over time as the trees grow. Most of the suggested antenna heights in this report are driven by mature trees located near each end of the various paths.

PGE will utilize the Nokia Wavence microwave radio platform.

SYSTEM LAYOUT



SITE INFORMATION

SITE DESCRIPTION – Integrated Operations Center (IOC) – Tower Option A

Customer Supplied Site Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

Note: Discrepancies in verified coordinates and ASR or FCC coordinates may exist. Field coordinates are verified by referencing the tower location to landmarks and points that are depicted on the USGS 7½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Path design utilizes the coordinates and elevations verified in the field.

Field Verified Site Coordinates (NAD 83)		
45°	21’	53.7"N
122°	48’	14.9"N
Elev:	246ft.	75.0m

ASR Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

FCC Licensed Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

Address: Corner of 124th Ave & Tualatin Sherwood Hwy
Tualatin, OR
Washington County

Tower Registration Number: None
Call Sign: None

Tower Considerations:

The tower height is determined by the tallest required antenna mounting height for the three potential paths. As shown in the “Antenna Mounting Considerations” below, the tallest required antenna height is 155 feet AGL. This would suggest that a 160 foot tall self-supporting tower is required to utilize the Option “A” location. This is the minimum height required to achieve a 100% 1st Fresnel zone clearance + tree growth for a K factor = 4/3. Other radio technologies may have different requirements.

Antenna Mounting Considerations:

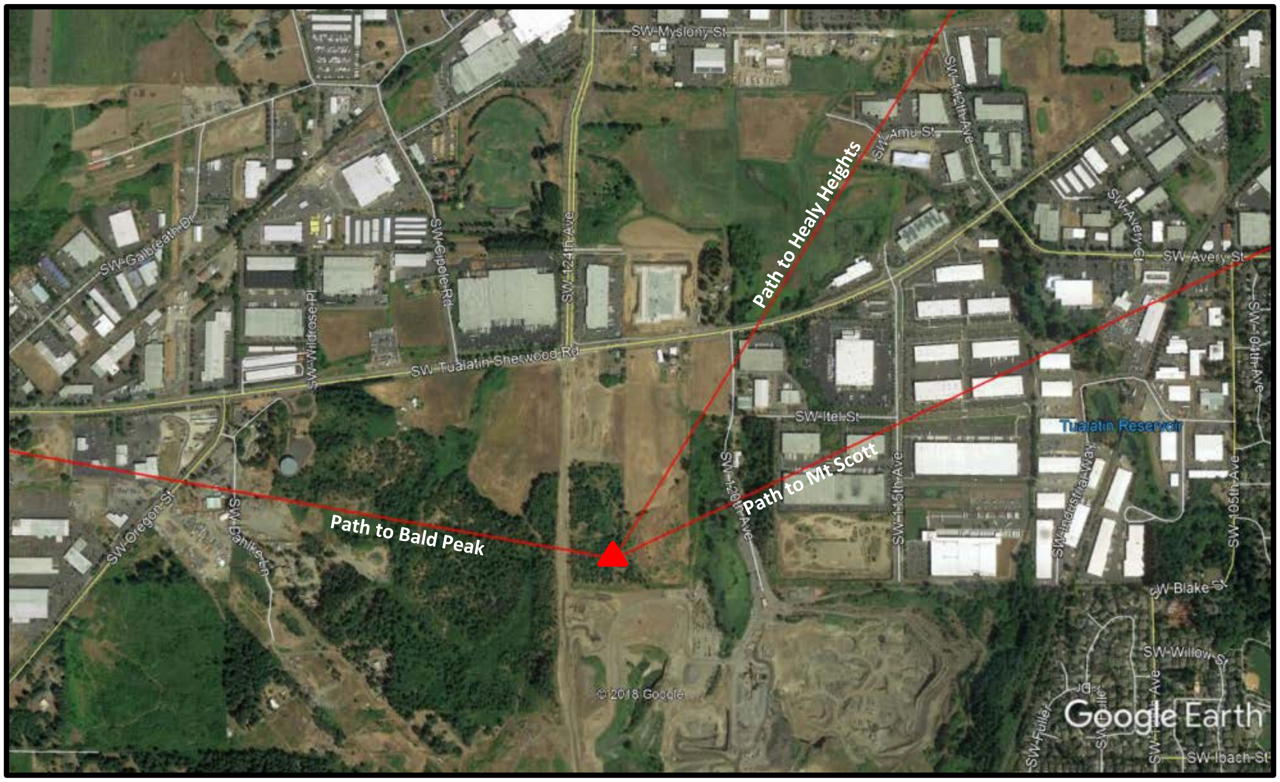
- If the path to Bald Peak was to be licensed to operate at 6.175 GHz the antenna height would need to be 155 feet AGL with a path azimuth of 279.27° and a tilt angle of +1.09°. If licensed at 11.2 GHz the required antenna height would be 150 feet AGL with a path azimuth of 279.27° and a tilt angle of +1.09°.
- The path to Healy Heights would require an antenna mounting height of 55 feet AGL weather licensed at 6.175 GHz or 11.2 GHz. The resultant path azimuth would be 31.24° and a tilt angle of +0.87°.
- Due to the length of the path to Mt Scott, it is prudent to license the path at 6.175 GHz. This would require an antenna mounting height of 130 feet AGL with a path azimuth of 64.17° and a tilt angle of +0.56°.

Transmission Line Considerations:

The transmission line runs for this location are estimated as the site is yet to be constructed.

- The path to Bald Peak at 6.175 GHz will require a run of EW63 that is 205 feet in length. At 11.2 GHz the EW90 run would be 200 feet.
- The path to Healy Heights, whether operating at 6.175 GHz or 11.2 GHz, would require a transmission line run of 105 feet.
- The path to Mt Scott will require a 180 foot run of EW63.

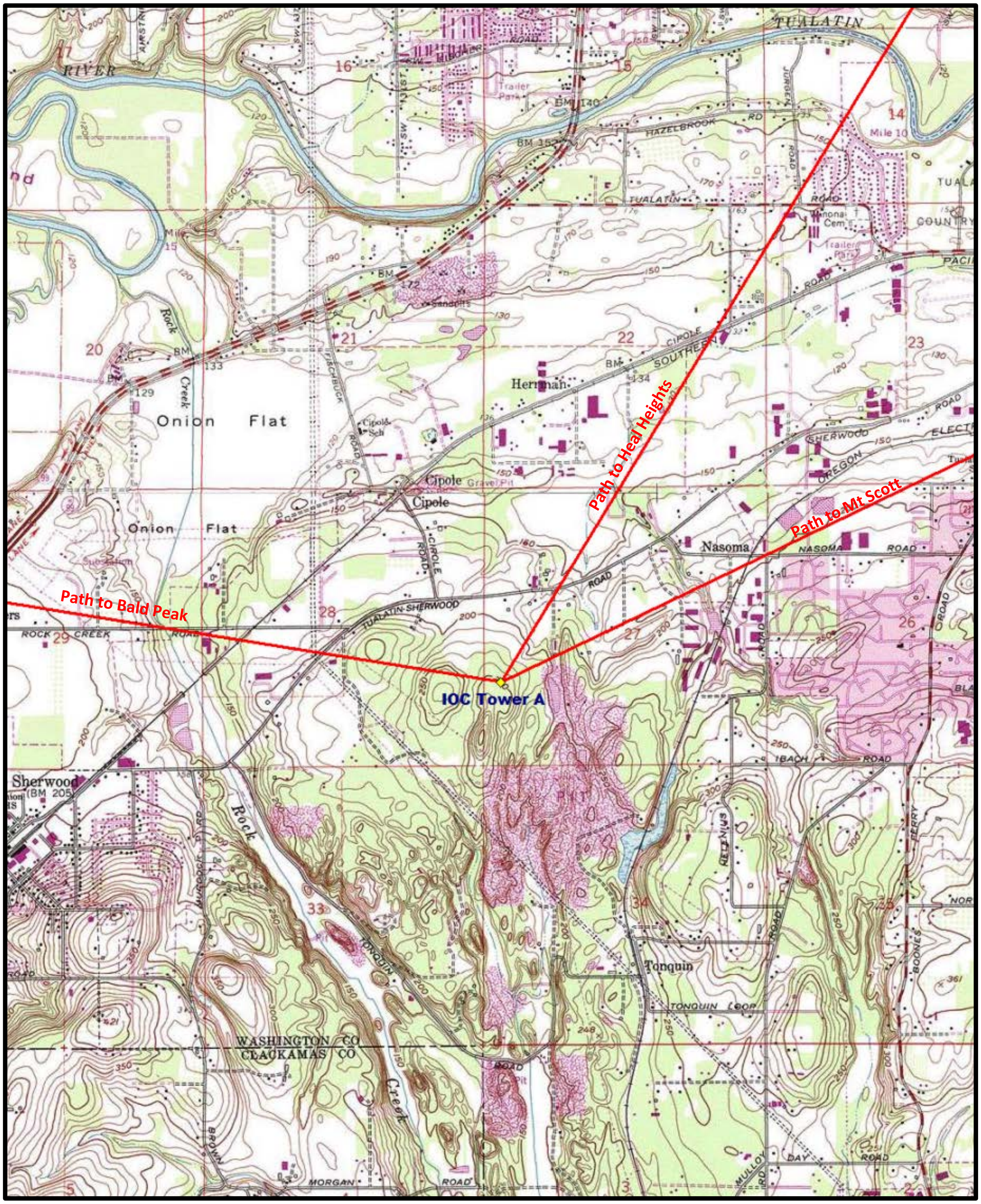
IOC TOWER A – Proposed tower location



IOC TOWER A

Latitude: 45° 21’ 53.7”
Longitude: 122° 48’ 14.8”
Elevation: 246 ft.   75 m

State: Oregon
County: Washington
Map Ref: Google Earth



IOC TOWER A

Latitude: 45° 21' 53.7"
Longitude: 122° 48' 14.8"
Elevation: 246 ft. 75 m

State: Oregon
County: Washington
Map Ref: Sherwood, OR

SITE DESCRIPTION – Integrated Operations Center (IOC) – Tower Option B

Customer Supplied Site Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

Note: Discrepancies in verified coordinates and ASR or FCC coordinates may exist. Field coordinates are verified by referencing the tower location to landmarks and points that are depicted on the USGS 7½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Path design utilizes the coordinates and elevations verified in the field.

Field Verified Site Coordinates (NAD 83)		
45°	21’	59.5"N
122°	48’	16.9"N
Elev:	235ft.	71.6m

ASR Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

FCC Licensed Coordinates (NAD 83)		
°	’	"N
°	’	"N
Elev:	ft.	m

Address: Corner of 124th Ave & Tualatin Sherwood Hwy
Tualatin, OR
Washington County

Tower Registration Number: None
Call Sign: None

Tower Considerations:

The tower height is determined by the tallest required antenna mounting height for the three potential paths. As shown in the “Antenna Mounting Considerations” below, the tallest required antenna height is 135 feet AGL. This would suggest that a 140 foot tall self-supporting tower is required to utilize the Option “B” location. This is the minimum height required to achieve a 100% 1st Fresnel zone clearance + tree growth for a K factor = 4/3. Other radio technologies may have different requirements.

Antenna Mounting Considerations:

- If the path to Bald Peak was to be licensed to operate at 6.175 GHz the antenna height would need to be 130 feet AGL with a path azimuth of 278.77° and a tilt angle of +1.13°. If licensed at 11.2 GHz the required antenna height would be 125 feet AGL with a path azimuth of 278.77° and a tilt angle of +1.13°.
- The path to Healy Heights would require an antenna mounting height of 75 feet AGL weather licensed at 6.175 GHz or 11.2 GHz. The resultant path azimuth would be 31.71° and a tilt angle of +0.87°.
- Due to the length of the path to Mt Scott, it is prudent to license the path at 6.175 GHz. This would require an antenna mounting height of 135 feet AGL with a path azimuth of 64.64° and a tilt angle of +0.57°.

Transmission Line Considerations:

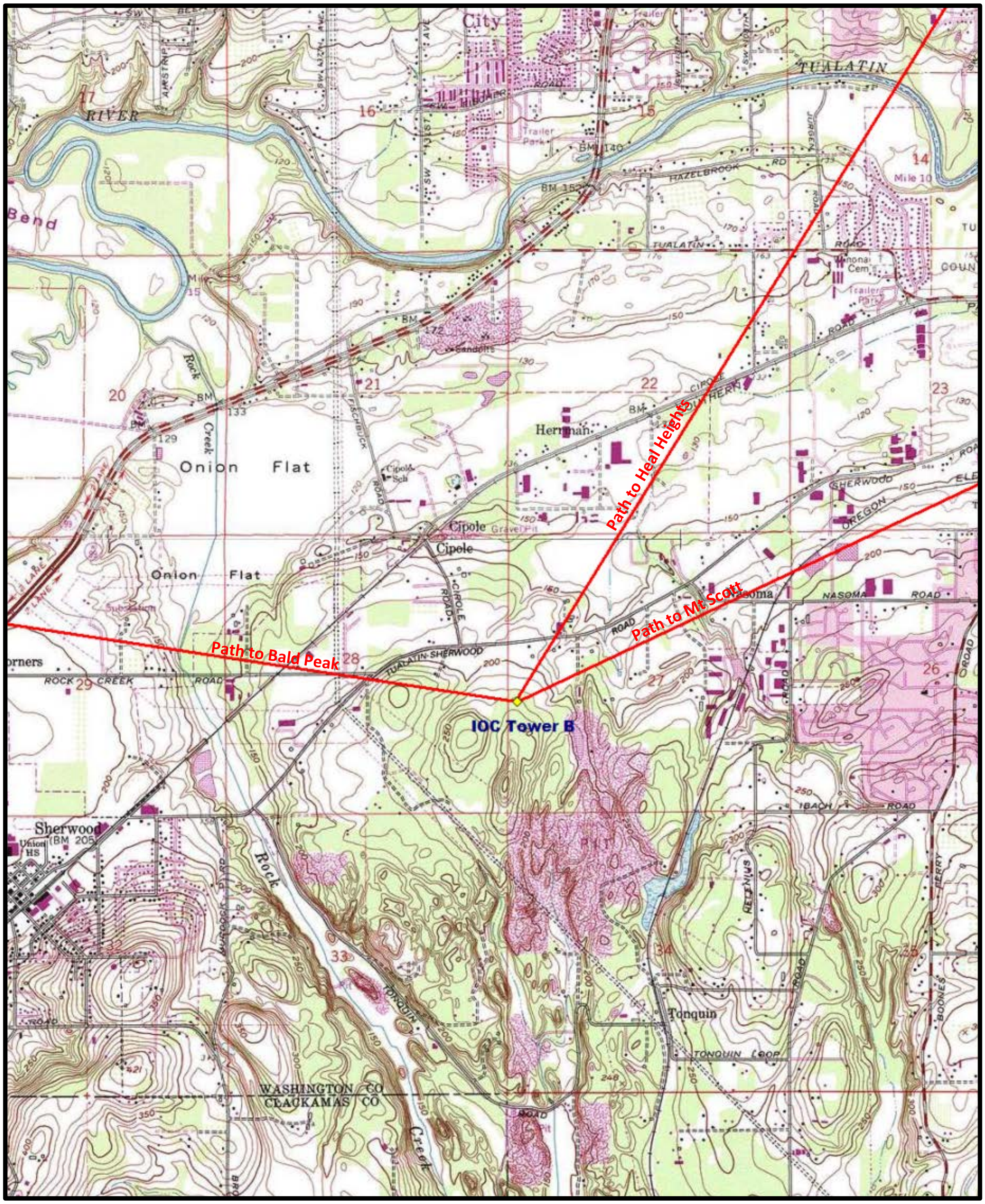
The transmission line runs for this location are estimated as the site is yet to be constructed.

- The path to Bald Peak at 6.175 GHz will require a run of EW63 that is 205 feet in length. At 11.2 GHz the EW90 run would be 200 feet.
- The path to Healy Heights, whether operating at 6.175 GHz or 11.2 GHz, would require a transmission line run of 125 feet.
- The path to Mt Scott will require a 185 foot run of EW63.

IOC TOWER B – Proposed tower location

IOC TOWER B

Latitude: 45° 21’ 59.5”	State: Oregon
Longitude: 122° 48’ 16.9”	County: Washington
Elevation: 235 ft. 71.6 m	Map Ref: Google Earth



IOC TOWER B

Latitude: 45° 21′ 59.5″	State: Oregon
Longitude: 122° 48′ 16.9″	County: Washington
Elevation: 235 ft. 71.6 m	Map Ref: Sherwood, OR

SITE DESCRIPTION – Bald Peak

Customer Supplied Site Coordinates (NAD 83)		
45°	23’	35.4"N
122°	03’	07.3"W
Elev:	1580ft.	481.6m

Note: Discrepancies in verified coordinates and ASR or FCC coordinates may exist. Field coordinates are verified by referencing the tower location to landmarks and points that are depicted on the USGS 7½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Path design utilizes the coordinates and elevations verified in the field.

Field Verified Site Coordinates (NAD 83)		
45°	23’	35.5"N
123°	03’	08.9"W
Elev:	1585ft.	483.1m

ASR Coordinates (NAD 83)		
°	’	"N
°	’	"W
Elev:	ft.	m

FCC Licensed Coordinates (NAD 83)		
45°	23’	35.4"N
122°	03’	07.3"W
Elev:	1580ft.	481.6m

Address: 24350 Bald Peak Road
Newburg, OR
Yamhill County

Tower Registration Number: None
Call Sign: KOV95

Tower Considerations:

The existing tower is a custom built 177’ tall, four legged, self-supporting structure.

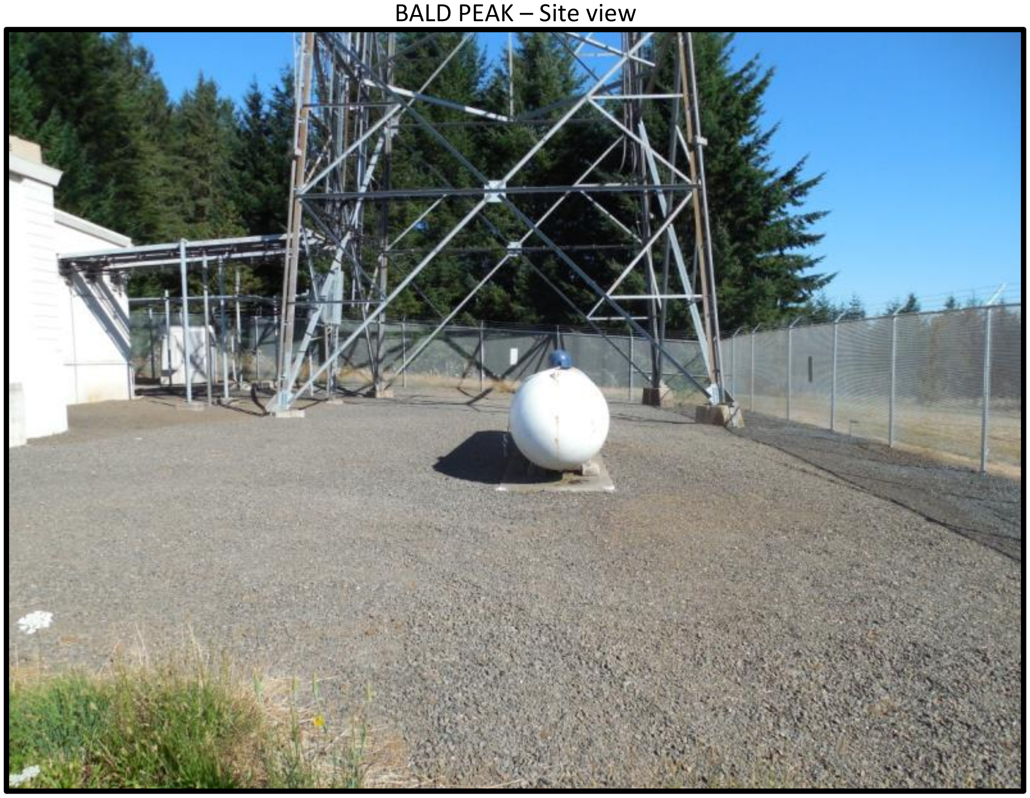
Antenna Mounting Considerations:

- The path to IOC Tower A, whether licensed at 6.175 GHz or 11.2 GHz, would require an antenna height of 120 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 99.09° and a tilt angle of -1.23°.
- The path to IOC Tower B, whether licensed at 6.175 GHz or 11.2 GHz, would require an antenna height of 120 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 98.59° and a tilt angle of -1.26°.

Transmission Line Considerations:

Both paths, to either IOC Tower A and IOC Tower B will have waveguides runs of approximately 170 feet. This applies for either a path licensed at 6.175 GHz or 11.2 GHz.

BALD PEAK – Site view

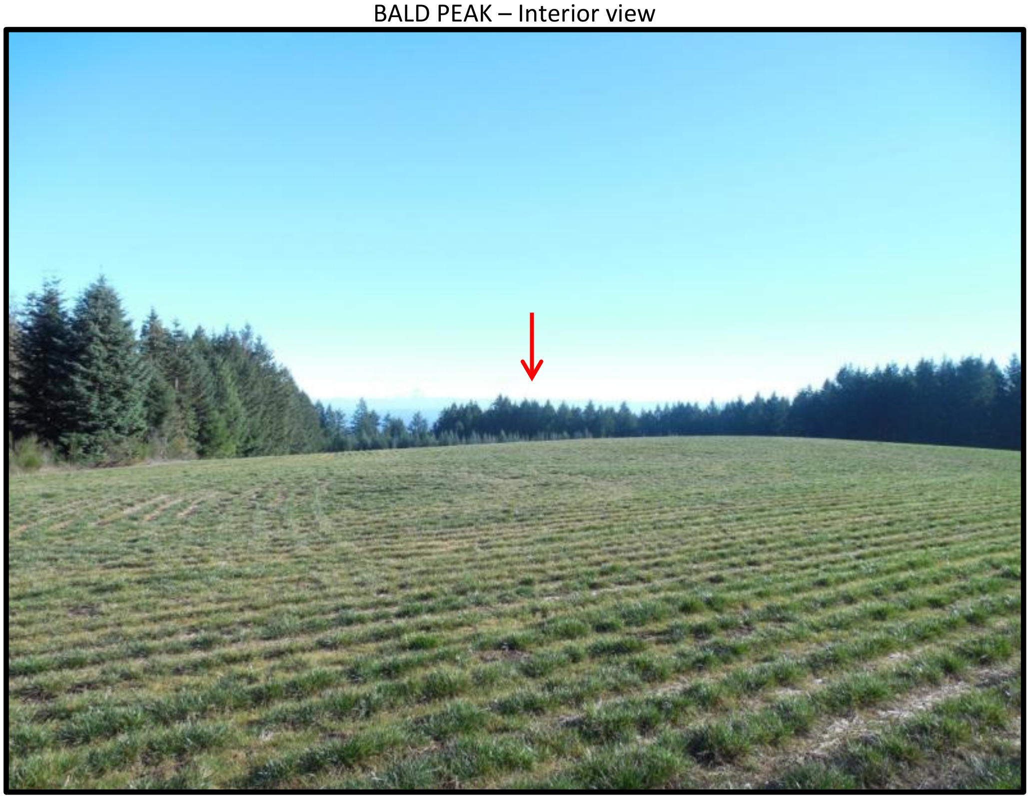


BALD PEAK – Tower and ice bridge view


BALD PEAK – Exterior entry panels


BALD PEAK – Interior entry panel

BALD PEAK – Interior view



BALD PEAK – Paths to IOC A & B

BALD PEAK – Tower view

BALD PEAK

Latitude: 45° 23’ 35.5”	State: Oregon
Longitude: 123° 03’ 09.8”	County: Yamhill
Elevation: 1585 ft. 483.1 m	Map Ref: Google Earth

BALD PEAK

Latitude: 45° 23’ 35.5”
Longitude: 123° 03’ 09.8”
Elevation: 1585 ft.   383.1 m

State: Oregon
County: Yamhill
Map Ref: Dundee, OR

SITE DESCRIPTION – Healy Heights

Customer Supplied Site Coordinates (NAD 83)		
45°	29'	20.4"N
122°	41'	48.3"W
Elev:	1021ft.	311.2m

Note: Discrepancies in verified coordinates and ASR or FCC coordinates may exist. Field coordinates are verified by referencing the tower location to landmarks and points that are depicted on the USGS 7½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Path design utilizes the coordinates and elevations verified in the field.

Field Verified Site Coordinates (NAD 83)		
45°	29'	21.4"N
123°	41'	48.6"W
Elev:	1025ft.	312.4m

ASR Coordinates (NAD 83)		
°	'	"N
°	'	"W
Elev:	ft.	m

FCC Licensed Coordinates (NAD 83)		
45°	29'	20.4"N
122°	41'	48.3"W
Elev:	1021ft.	311.2m

Address: 4711 SW 19th Ave
Portland, OR
Multnomah County

Tower Registration Number: None
Call Sign: WAK240

Tower Considerations:

The existing tower is a custom built 177' tall, four legged, self-supporting structure (similar to Bald Peak).

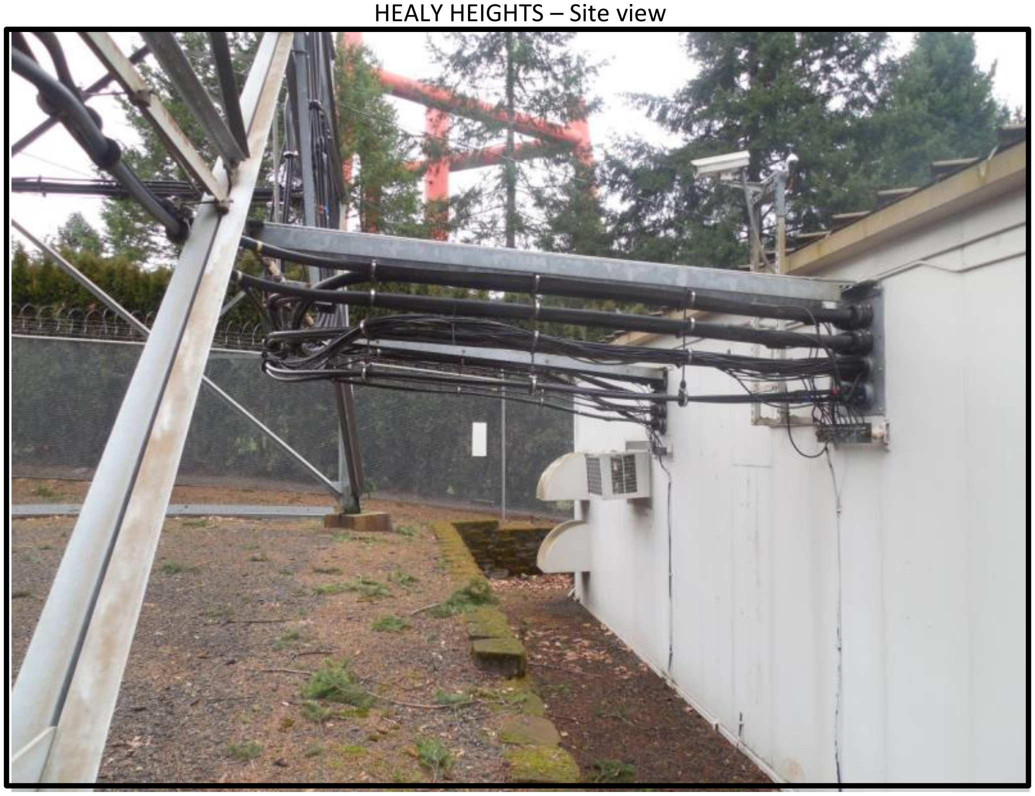
Antenna Mounting Considerations:

- The path to IOC Tower A, whether licensed at 6.175 GHz or 11.2 GHz, would require an antenna height of 135 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 211.32° and a tilt angle of -0.98°.
- The path to IOC Tower B, whether licensed at 6.175 GHz or 11.2 GHz, would require an antenna height of 135 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 211.78° and a tilt angle of -0.98°.

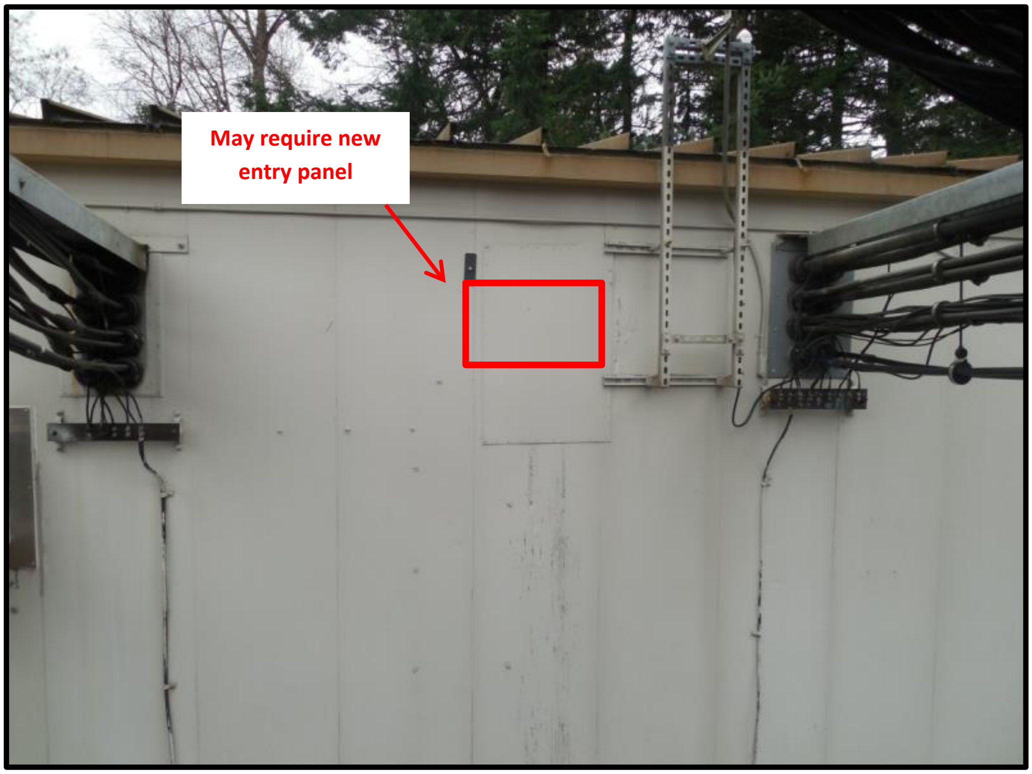
Transmission Line Considerations:

Both paths, to either IOC Tower A and IOC Tower B will have waveguides runs of approximately 195 feet. This applies for either a path licensed at 6.175 GHz or 11.2 GHz.

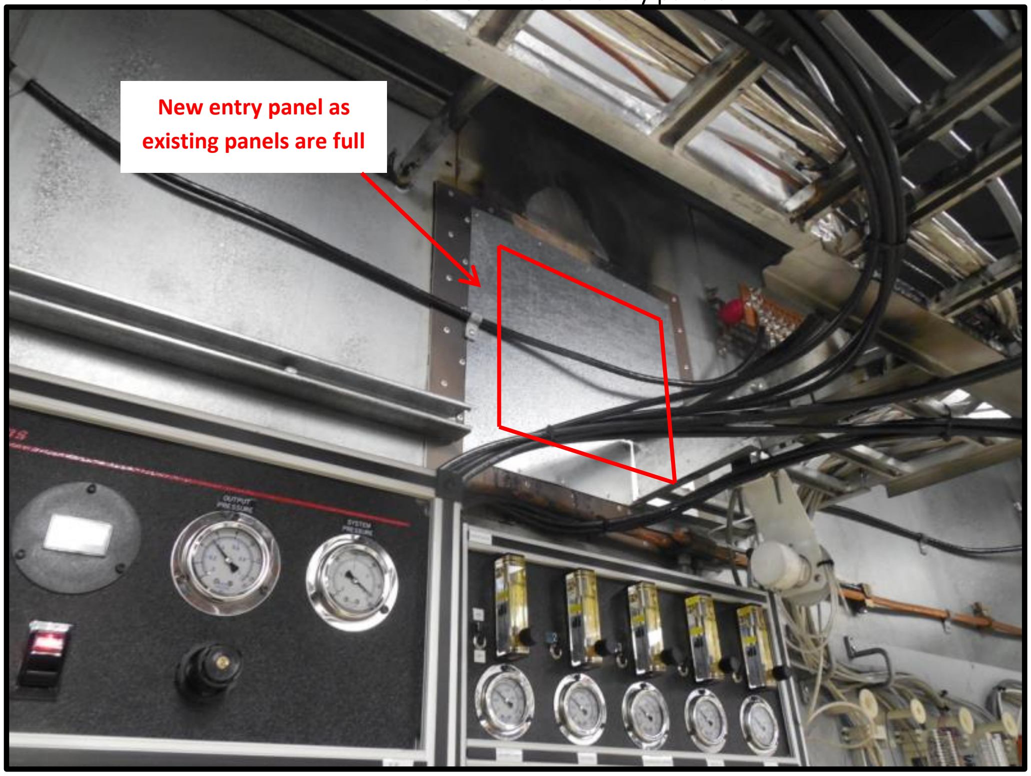
HEALY HEIGHTS – Site view



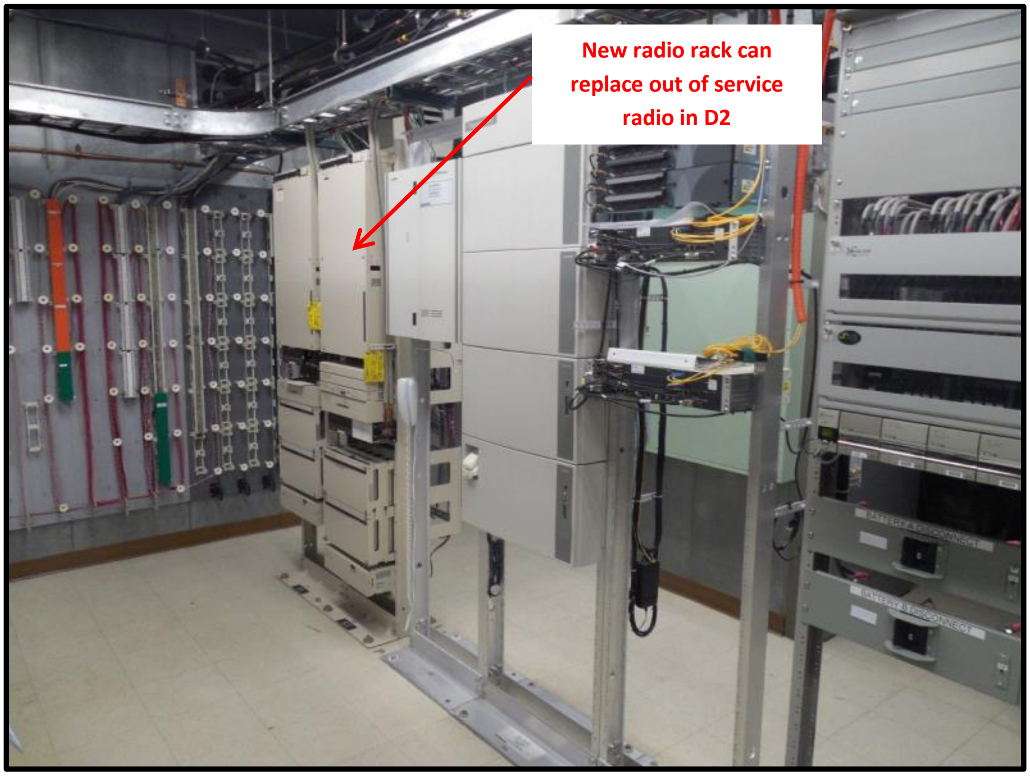
HEALY HEIGHTS – View of ice bridges



HEALY HEIGHTS – Exterior entry panels

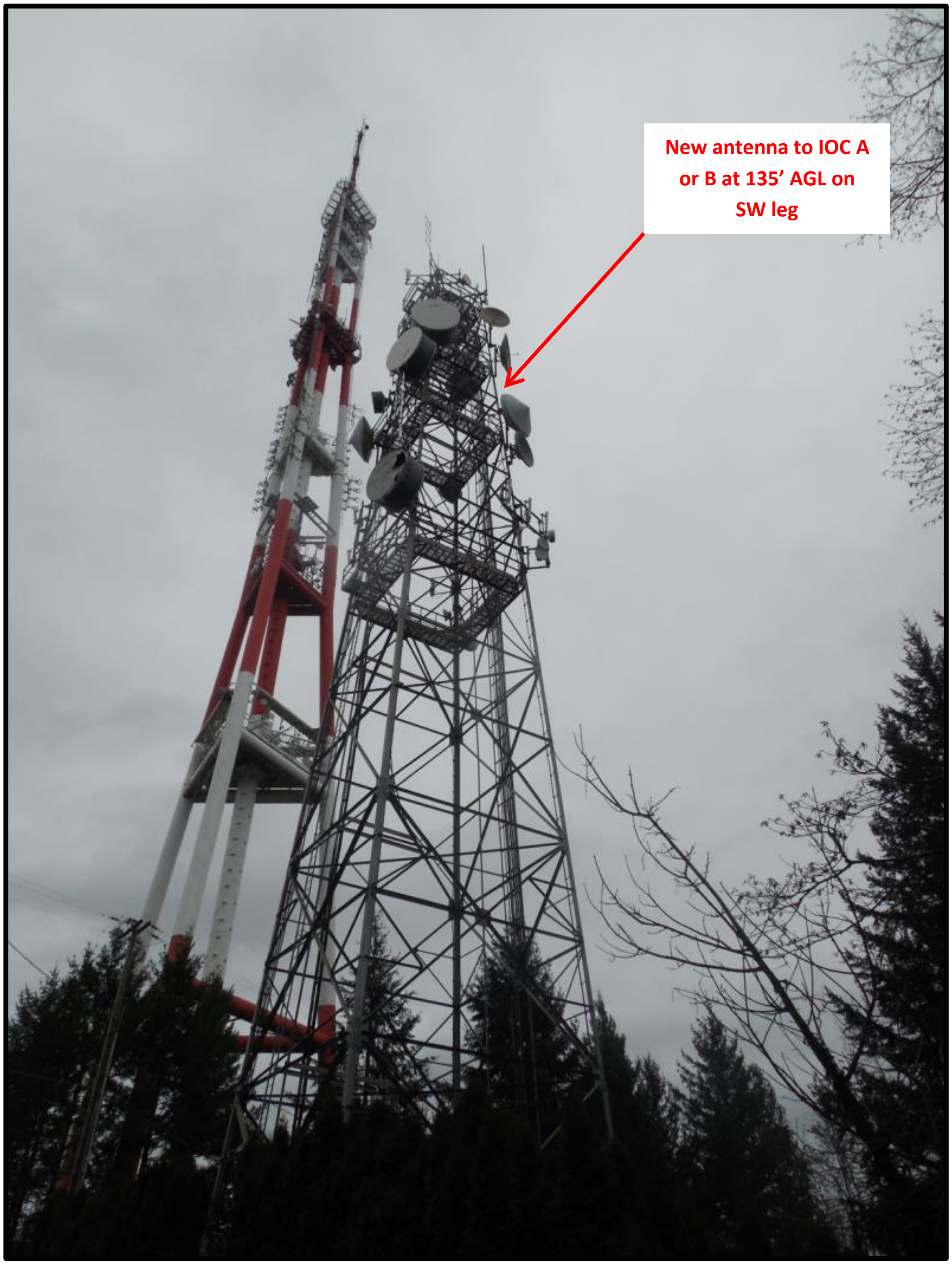


HEALY HEIGHTS – Interior entry panels



HEALY HEIGHTS – Interior view

HEALY HEIGHTS – Paths to IOC A & B



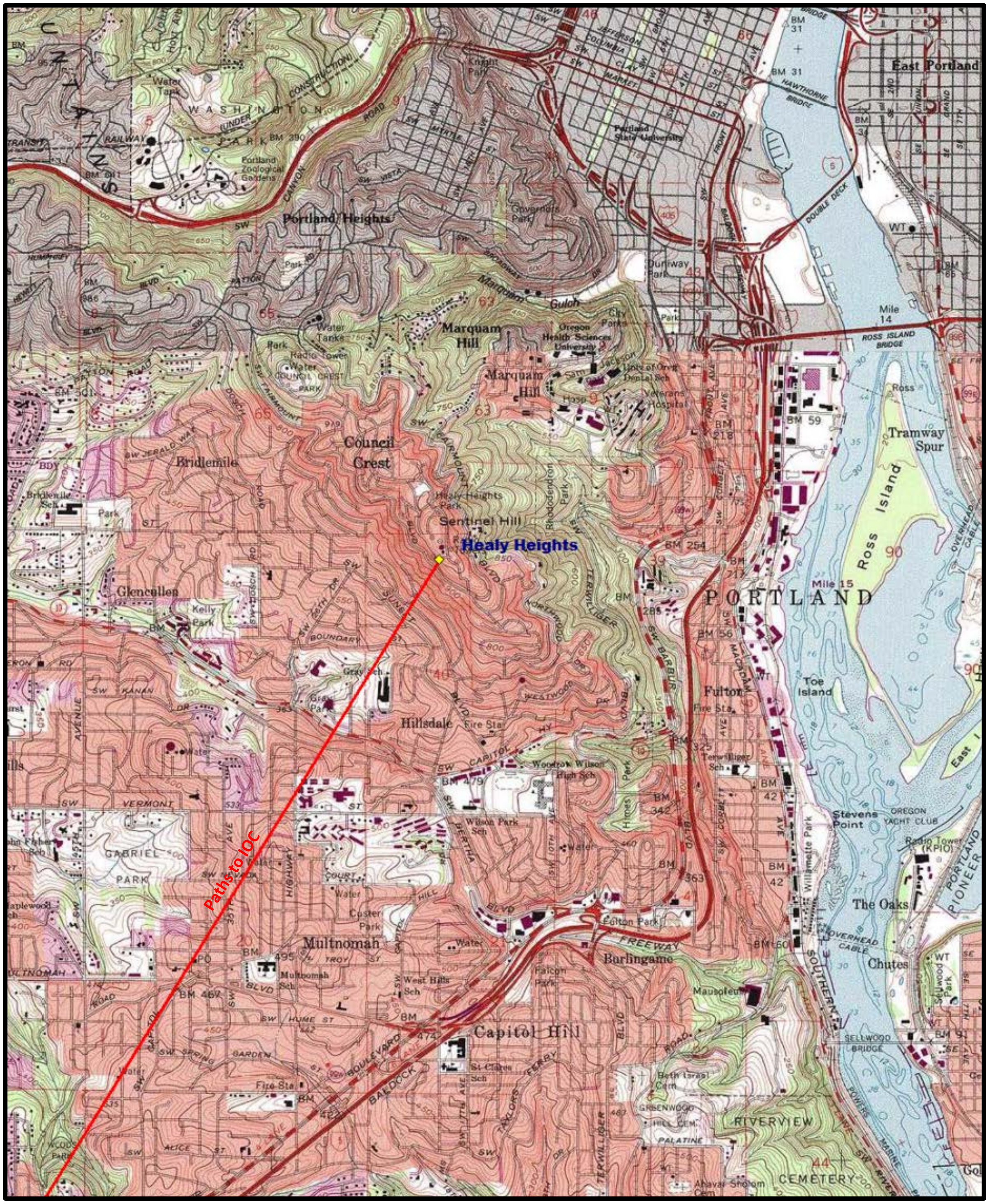
HEALY HEIGHTS – Tower view

HEALY HEIGHTS

Latitude: 45° 29' 21.4"
Longitude: 122° 41' 48.6"
Elevation: 1025 ft.   312.4 m

State: Oregon
County: Multnomah
Map Ref: Google Earth

Summit Telecom Solutions, Inc.



HEALY HEIGHTS

Latitude: 45° 29’ 21.4”	State: Oregon
Longitude: 122° 41’ 48.6”	County: Multnomah
Elevation: 1025 ft. 312.4 m	Map Ref: Lake Oswego, OR

SITE DESCRIPTION – Mt Scott

Customer Supplied Site Coordinates (NAD 83)		
45°	27’	07.4"N
122°	32’	50.3"W
Elev:	1050ft.	320.0m

Note: Discrepancies in verified coordinates and ASR or FCC coordinates may exist. Field coordinates are verified by referencing the tower location to landmarks and points that are depicted on the USGS 7½ minute topo maps for the area. GPS readings may also be used to supplement the USGS topo data. Path design utilizes the coordinates and elevations verified in the field.

Field Verified Site Coordinates (NAD 83)		
45°	27’	07.3"N
123°	32’	51.3"W
Elev:	1057ft.	322.2m

ASR Coordinates (NAD 83)		
45°	27’	07.4"N
122°	32’	50.3"W
Elev:	1050ft.	320.0m

FCC Licensed Coordinates (NAD 83)		
45°	27’	07.4"N
122°	32’	50.3"W
Elev:	1050ft.	320.0m

Address: 9790 SE Eastview Drive
Happy Valley, OR
Clackamas County

Tower Registration Number: 1219562
Call Sign: KOV94

Tower Considerations:

The existing tower is a custom built 160’ tall, four legged, self-supporting structure.

Antenna Mounting Considerations:

- The path to IOC Tower A would require an antenna height of 130 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 244.36° and a tilt angle of -0.71°.
- The path to IOC Tower B would require an antenna height of 130 feet AGL due to available antenna mounting locations. This will result in a path azimuth of 244.82° and a tilt angle of -0.72°.

Transmission Line Considerations:

Both paths, to either IOC Tower A and IOC Tower B will have waveguides runs of approximately 175 feet.

MT SCOTT – Site view

MT SCOTT – View of ice bridges

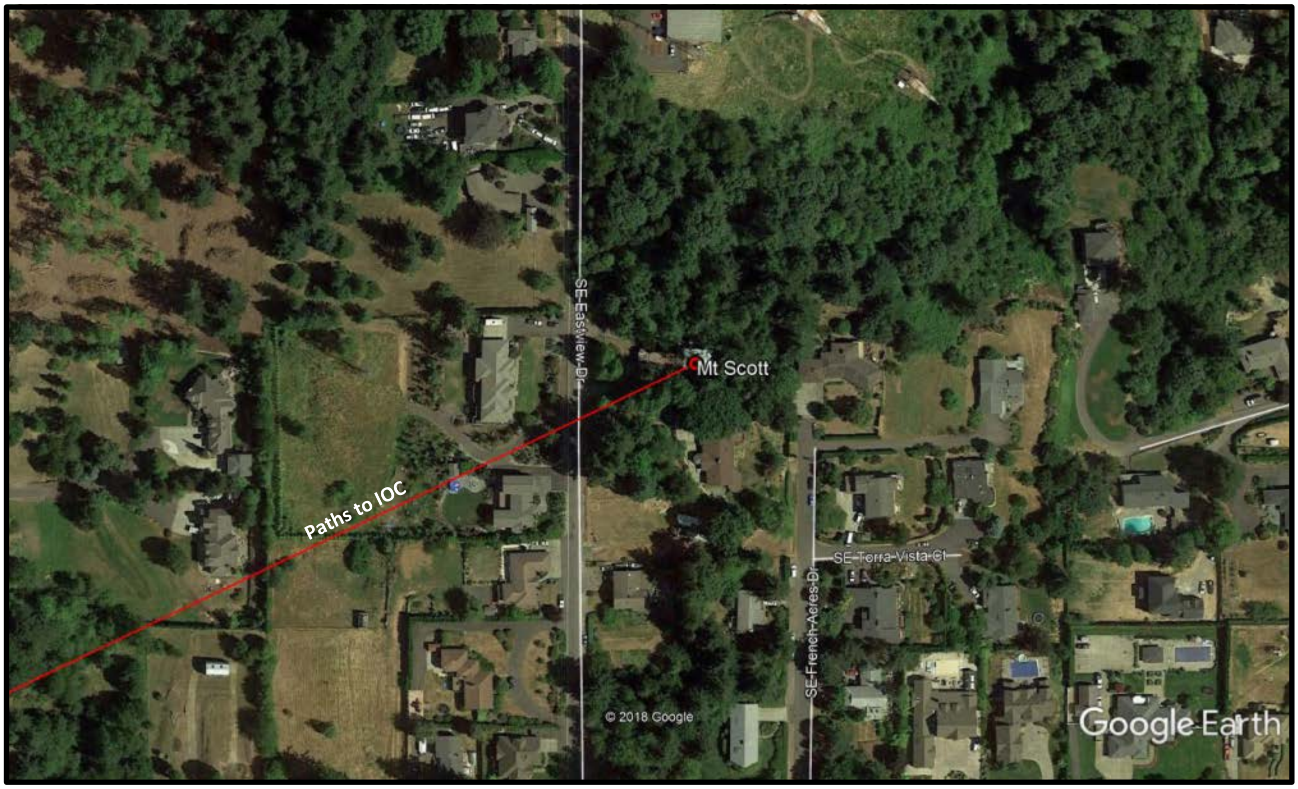

MT SCOTT – Exterior entry panel


MT SCOTT – Interior entry panel

MT SCOTT – Interior view

MT SCOTT – Paths to IOC A & B

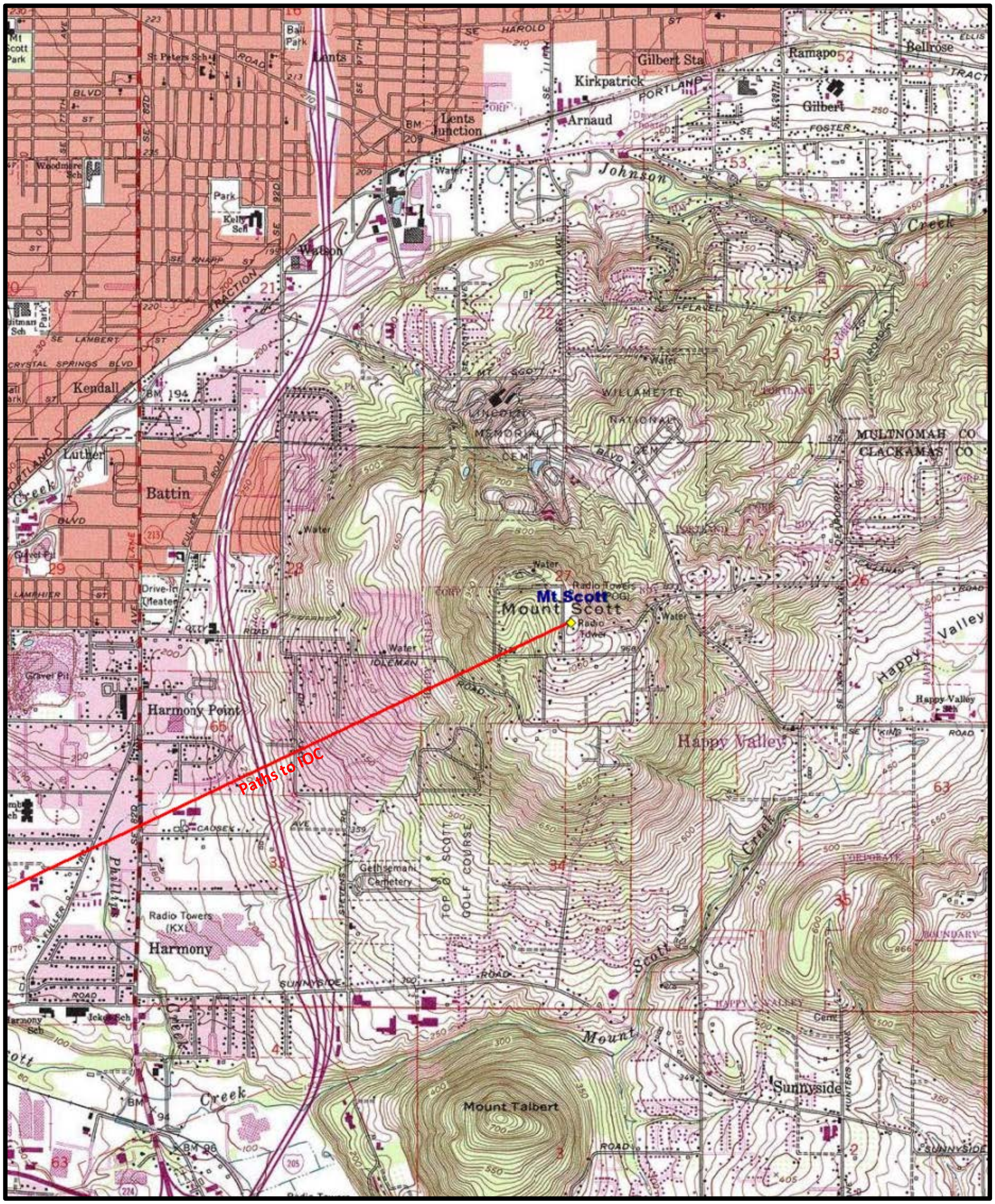
MT SCOTT – Tower view



MT SCOTT

Latitude: 45° 27’ 07.3”
Longitude: 122° 32’ 51.3”
Elevation: 1057 ft.   322.2 m

State: Oregon
County: Clackamas
Map Ref: Google Earth



MT SCOTT

Latitude: 45° 27' 07.3"
Longitude: 122° 32' 51.3"
Elevation: 1057 ft. 322.2 m

State: Oregon
County: Clackamas
Map Ref: Gladstone, OR

PATH INFORMATION

PATH DESRIPTIONS

IOC (A) to Bald Peak

Path Length: 12.24 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Bald Peak.

PATH DESRIPTIONS

IOC (A) to Bald Peak

Path Length: 12.24 Miles

Frequency Band: 11.2 GHz

Path Climate Considerations:
The path is located in a region that is referred to as "average" radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as "Temperate Maritime" with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Bald Peak.

PATH DESRIPTIONS

IOC (B) to Bald Peak

Path Length: 12.20 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as "average" radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as "Temperate Maritime" with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Bald Peak.

PATH DESRIPTIONS

IOC (B) to Bald Peak

Path Length: 12.20 Miles

Frequency Band: 11.2 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Bald Peak.

PATH DESRIPTIONS

IOC (A) to Healy Heights

Path Length: 10.05 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses varying and broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Healy Heights.

PATH DESRIPTIONS

IOC (A) to Healy Heights

Path Length: 10.05 Miles

Frequency Band: 11.2 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses varying and broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Healy Heights.

PATH DESRIPTIONS

IOC (B) to Healy Heights

Path Length: 9.97 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as "average" radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as "Temperate Maritime" with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses varying and broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Healy Heights.

PATH DESRIPTIONS

IOC (B) to Healy Heights

Path Length: 9.97 Miles

Frequency Band: 11.2 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses varying and broken terrain that generally rises in elevation with distance. Trees along the path dominate the terrain and effectively block any specular ground reflections. Trees near the IOC end of the path dictate the antenna mounting height. Trees and available tower space control the mounting height at Healy Heights.

PATH DESRIPTIONS

IOC (A) to Mt Scott

Path Length: 13.85 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

General Path Description:
This path displays high-low tendencies. The path crosses varying terrain that generally rises in elevation with distance. Trees along the path dominate the terrain. Trees on a hilltop near mid-path control the antenna mounting height at IOC. Trees and available tower space control the mounting height at Mt Scott.

PATH DESRIPTIONS

IOC (B) to Mt Scott

Path Length: 13.83 Miles

Frequency Band: 6.175 GHz

Path Climate Considerations:
The path is located in a region that is referred to as “average” radio propagation. Average annual temperatures range from 45° F to 55°F. Crane refers to rainfall in this region as “Temperate Maritime” with annual rainfall approaching 36 inches.

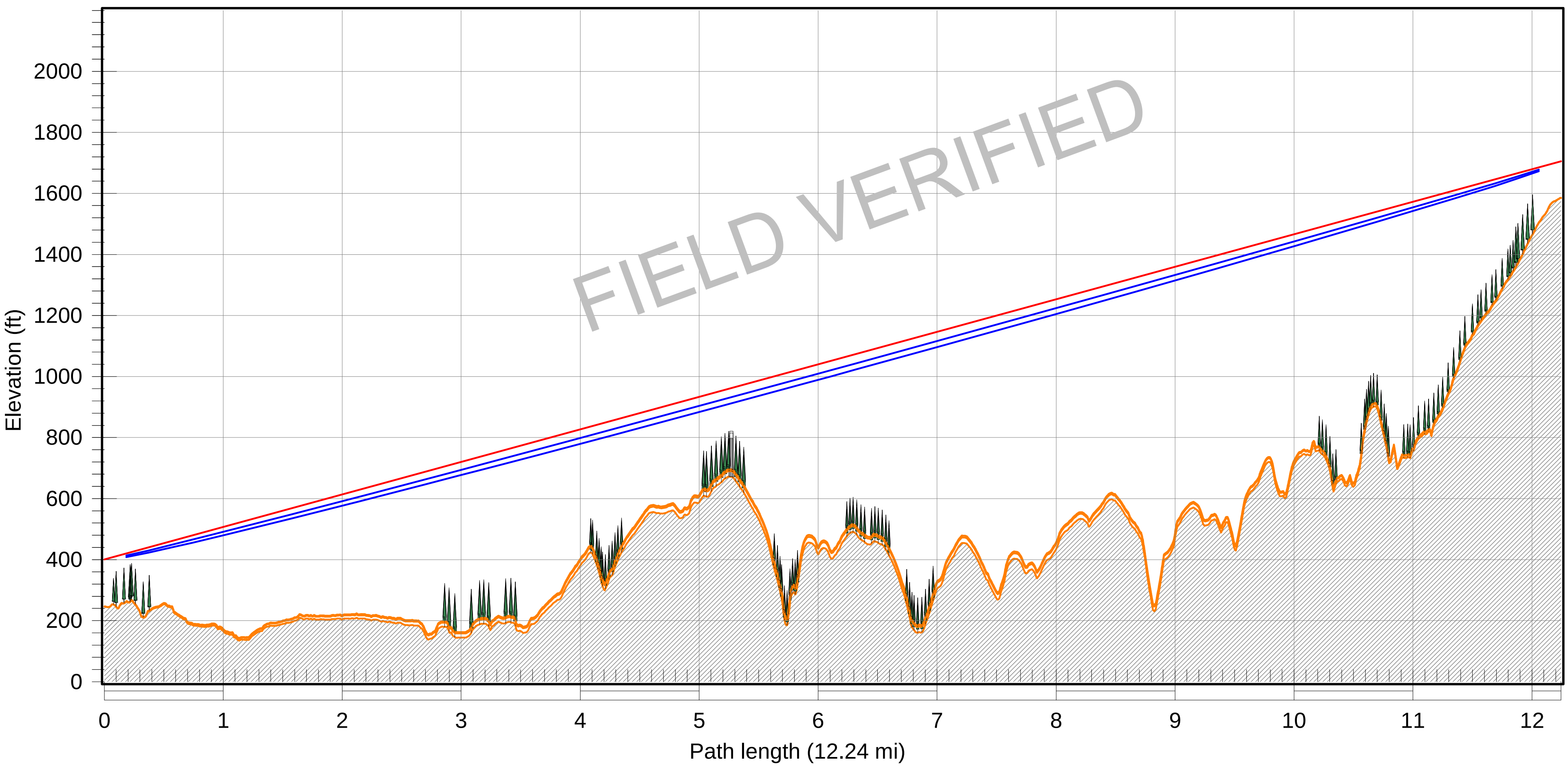
General Path Description:
This path displays high-low tendencies. The path crosses varying terrain that generally rises in elevation with distance. Trees along the path dominate the terrain. Trees close to the IOC end control the antenna mounting height there. Trees and available tower space control the mounting height at Mt Scott.

	IOC Tower - A	Bald Peak
Latitude	45 21 53.70 N	45 23 35.50 N
Longitude	122 48 14.90 W	123 03 08.90 W
True azimuth (°)	279.27	99.09
Vertical angle (°)	1.09	-1.22
Elevation (ft)	246.00	1585.00
Antenna model	VHLP6-6W-6WH/B (TR)	VHLP6-6W-6WH/B (TR)
Antenna gain (dBi)	39.30	39.30
Antenna height (ft)	155.00	120.00
TX line model	EW63	EW63
TX line unit loss (dB/100 ft)	1.47	1.47
TX line length (ft)	205.00	170.00
TX line loss (dB)	3.01	2.50
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.00	2.00
RX filter loss (dB)	2.60	2.60
Frequency (MHz)	6175.00	
Polarization	Vertical	
Path length (mi)	12.25	
Free space loss (dB)	134.17	
Atmospheric absorption loss (dB)	0.17	
Net path loss (dB)	66.66	66.66
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR61-L1024A30-227	95MPR61-L1024A30-227
Emission designator	30M0D7W	30M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	140.00	
C factor	0.26	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	7.435E-003	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 227	31.50	31.50	-60.50	-60.50	65.39	65.90	-35.16	-35.16	25.34	25.34	25.34	25.34
512 206	**31.50**	**31.50**	**-63.70**	**-63.70**	**65.39**	**65.90**	**-35.16**	**-35.16**	**28.54**	**28.54**	**28.54**	**28.54**
256 183	32.50	32.50	-67.10	-67.10	66.39	66.90	-34.16	-34.16	32.94	32.94	32.94	32.94
128 161	32.50	32.50	-70.10	-70.10	66.39	66.90	-34.16	-34.16	35.94	35.94	35.94	35.94
64 136	32.50	32.50	-73.00	-73.00	66.39	66.90	-34.16	-34.16	38.84	38.84	38.84	38.84
32 113	32.50	32.50	-74.90	-74.90	66.39	66.90	-34.16	-34.16	40.74	40.74	40.74	40.74
16 90	32.50	32.50	-78.30	-78.30	66.39	66.90	-34.16	-34.16	44.14	44.14	44.14	44.14
4 43	32.50	32.50	-89.00	-89.00	66.39	66.90	-34.16	-34.16	54.84	54.84	54.84	54.84

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 227	99.9978	99.9978	99.9995	99.9995			99.9989	99.9989
512 206	**99.9990**	**99.9990**	**99.9997**	**99.9997**			**99.9995**	**0.0006**
256 183	99.9996	99.9996	99.9999	99.9999			99.9998	0.0003
128 161	99.9998	99.9998	99.9999	99.9999			99.9999	0.0001
64 136	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
32 113	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
16 90	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
4 43	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000

Multipath fading method - Vigants - Barnett



IOC Tower - A	
Latitude	45 21 53.70 N
Longitude	122 48 14.90 W
Azimuth	279.27°
Elevation	246 ft ASL
Antenna CL	155.0 ft AGL

Frequency (MHz) = 6175.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

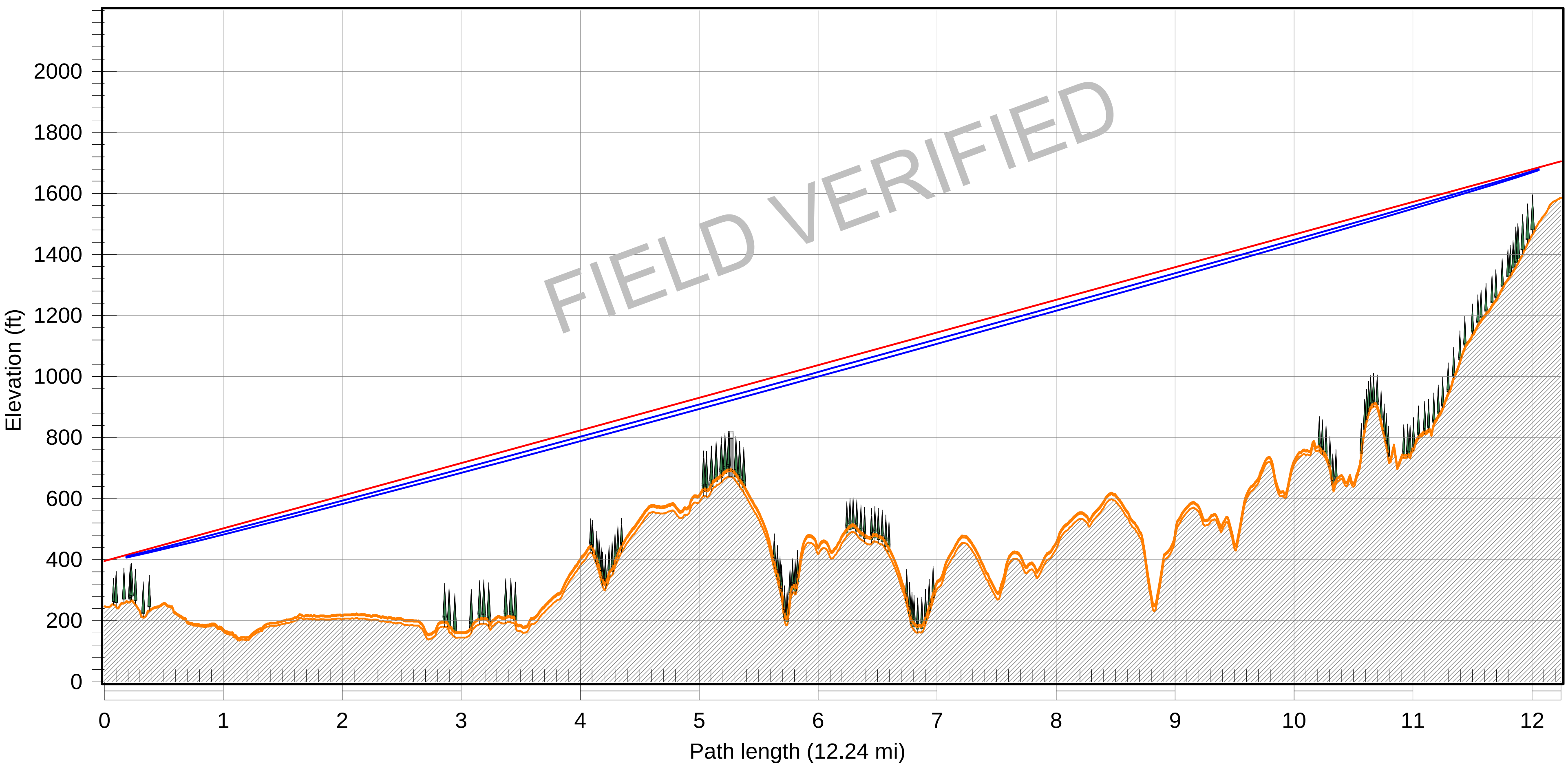
Bald Peak	
Latitude	45 23 35.50 N
Longitude	123 03 08.90 W
Azimuth	99.09°
Elevation	1585 ft ASL
Antenna CL	120.0 ft AGL

	IOC Tower - A	Bald Peak
Latitude	45 21 53.70 N	45 23 35.50 N
Longitude	122 48 14.90 W	123 03 08.90 W
True azimuth (°)	279.27	99.09
Vertical angle (°)	1.09	-1.23
Elevation (ft)	246.00	1585.00
Antenna model	HP8-107-P1A (TR)	HP8-107-P1A (TR)
Antenna gain (dBi)	46.40	46.40
Antenna height (ft)	150.00	120.00
TX line model	EW90	EW90
TX line unit loss (dB/100 ft)	3.08	3.08
TX line length (ft)	200.00	170.00
TX line loss (dB)	6.16	5.24
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.70	2.70
RX filter loss (dB)	2.90	2.90
Frequency (MHz)	11200.00	
Polarization	Vertical	
Path length (mi)	12.25	
Free space loss (dB)	139.34	
Atmospheric absorption loss (dB)	0.31	
Net path loss (dB)	64.65	64.65
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR11-L1024A40-294	95MPR11-L1024A40-294
Emission designator	40M0D7W	40M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	140.00	
C factor	0.26	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	1.349E-002	
Polarization	Vertical	
Rain region	Portland, Oregon	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 294	30.00	30.00	-58.50	-58.50	67.14	68.06	-34.65	-34.65	23.85	23.85	23.85	23.85
512 267	**31.00**	**31.00**	**-61.70**	**-61.70**	**68.14**	**69.06**	**-33.65**	**-33.65**	**28.05**	**28.05**	**28.05**	**28.05**
256 238	32.00	32.00	-65.10	-65.10	69.14	70.06	-32.65	-32.65	32.45	32.45	32.45	32.45
128 207	32.50	32.50	-68.10	-68.10	69.64	70.56	-32.15	-32.15	35.95	35.95	35.95	35.95
64 179	32.50	32.50	-71.00	-71.00	69.64	70.56	-32.15	-32.15	38.85	38.85	38.85	38.85
32 145	32.50	32.50	-73.40	-73.40	69.64	70.56	-32.15	-32.15	41.25	41.25	41.25	41.25
16 115	32.50	32.50	-76.80	-76.80	69.64	70.56	-32.15	-32.15	44.65	44.65	44.65	44.65
4 55	32.50	32.50	-87.50	-87.50	69.64	70.56	-32.15	-32.15	55.35	55.35	55.35	55.35

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 294	99.9944	99.9944	99.9986	99.9986	99.9998	99.9998	99.9971	99.9971
512 267	**99.9979**	**99.9979**	**99.9995**	**99.9995**	**99.9999**	**99.9999**	**99.9989**	**0.0018**
256 238	99.9992	99.9992	99.9998	99.9998	99.9999	99.9999	99.9996	0.0007
128 207	99.9997	99.9997	99.9999	99.9999	99.9999	99.9999	99.9998	0.0002
64 179	99.9998	99.9998	99.9999	99.9999	99.9999	99.9999	99.9999	0.0001
32 145	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
16 115	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
4 55	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000

Multipath fading method - Vigants - Barnett
Rain fading method - Crane



IOC Tower - A	
Latitude	45 21 53.70 N
Longitude	122 48 14.90 W
Azimuth	279.27°
Elevation	246 ft ASL
Antenna CL	150.0 ft AGL

Frequency (MHz) = 11200.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

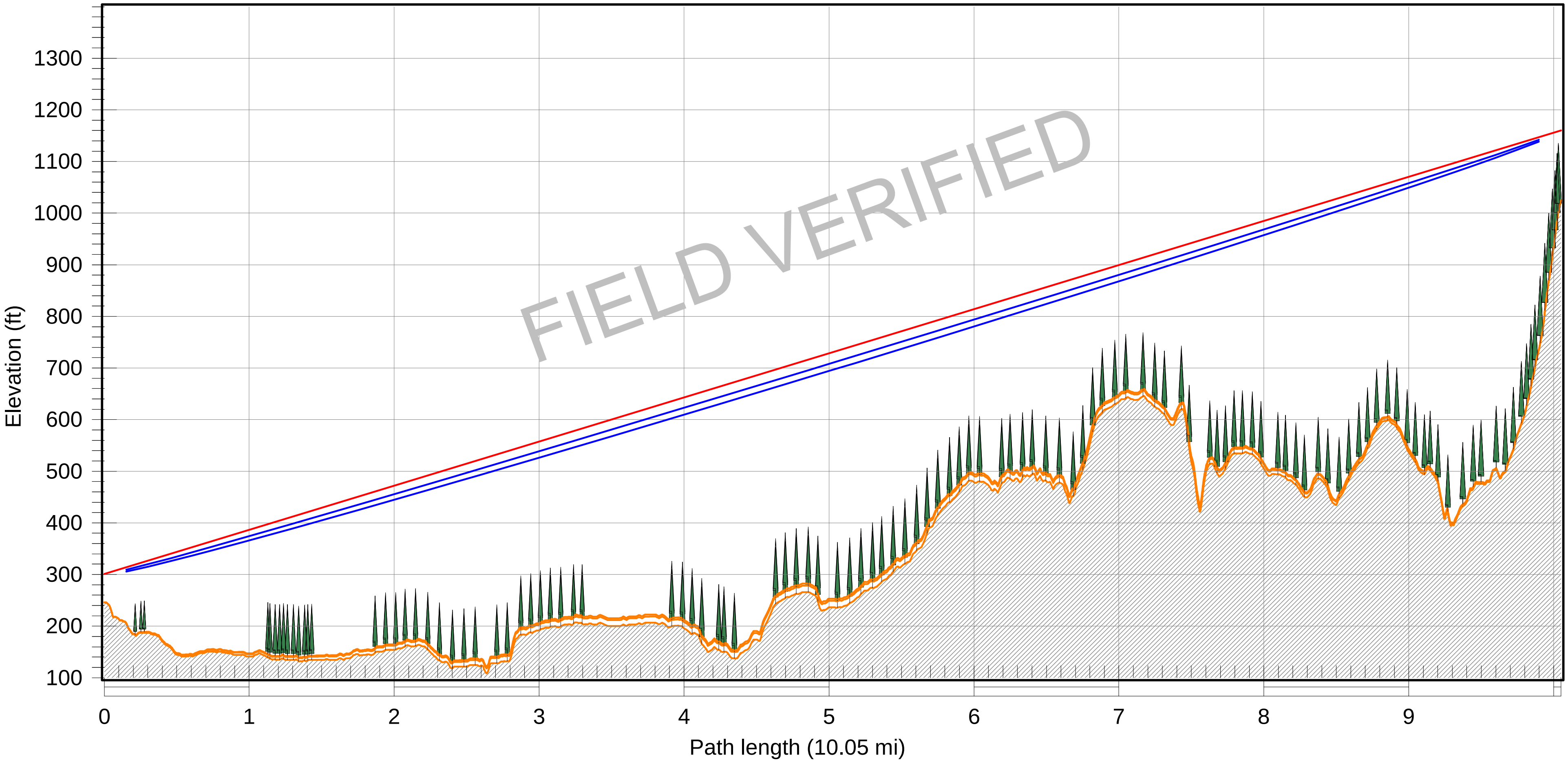
Bald Peak	
Latitude	45 23 35.50 N
Longitude	123 03 08.90 W
Azimuth	99.09°
Elevation	1585 ft ASL
Antenna CL	120.0 ft AGL

	IOC Tower - A	Healy Heights
Latitude	45 21 53.70 N	45 29 21.40 N
Longitude	122 48 14.90 W	122 41 48.60 W
True azimuth (°)	31.24	211.32
Vertical angle (°)	0.87	-0.98
Elevation (ft)	246.00	1025.00
Antenna model	HP8-107-P1A (TR)	VHLP6-11W-6WH/A (TR)
Antenna gain (dBi)	46.40	44.00
Antenna height (ft)	55.00	135.00
TX line model	EW90	EW90
TX line unit loss (dB/100 ft)	3.08	3.08
TX line length (ft)	105.00	195.00
TX line loss (dB)	3.23	6.01
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.70	2.70
RX filter loss (dB)	2.90	2.90
Frequency (MHz)	11200.00	
Polarization	Vertical	
Path length (mi)	10.05	
Free space loss (dB)	137.63	
Atmospheric absorption loss (dB)	0.26	
Net path loss (dB)	63.12	63.12
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR11-L1024A40-294	95MPR11-L1024A40-294
Emission designator	40M0D7W	40M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	95.45	
C factor	0.43	
Average annual temperature (°F)	47.56	
Fade occurrence factor (Po)	1.227E-002	
Polarization	Vertical	
Rain region	Portland, Oregon	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 294	30.00	30.00	-58.50	-58.50	70.07	64.89	-33.12	-33.12	25.38	25.38	25.38	25.38
512 267	**31.00**	**31.00**	**-61.70**	**-61.70**	**71.07**	**65.89**	**-32.12**	**-32.12**	**29.58**	**29.58**	**29.58**	**29.58**
256 238	32.00	32.00	-65.10	-65.10	72.07	66.89	-31.12	-31.12	33.98	33.98	33.98	33.98
128 207	32.50	32.50	-68.10	-68.10	72.57	67.39	-30.62	-30.62	37.48	37.48	37.48	37.48
64 179	32.50	32.50	-71.00	-71.00	72.57	67.39	-30.62	-30.62	40.38	40.38	40.38	40.38
32 145	32.50	32.50	-73.40	-73.40	72.57	67.39	-30.62	-30.62	42.78	42.78	42.78	42.78
16 115	32.50	32.50	-76.80	-76.80	72.57	67.39	-30.62	-30.62	46.18	46.18	46.18	46.18
4 55	32.50	32.50	-87.50	-87.50	72.57	67.39	-30.62	-30.62	56.88	56.88	56.88	56.88

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 294	99.9964	99.9964	99.9992	99.9992	99.9999	99.9999	99.9982	99.9982
512 267	**99.9986**	**99.9986**	**99.9997**	**99.9997**	**99.9999**	**99.9999**	**99.9993**	**0.0011**
256 238	99.9995	99.9995	99.9999	99.9999	99.9999	99.9999	99.9997	0.0004
128 207	99.9998	99.9998	99.9999	99.9999	99.9999	99.9999	99.9999	0.0001
64 179	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0001
32 145	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
16 115	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
4 55	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000

Multipath fading method - Vigants - Barnett
Rain fading method - Crane



IOC Tower - A	
Latitude	45 21 53.70 N
Longitude	122 48 14.90 W
Azimuth	31.24°
Elevation	246 ft ASL
Antenna CL	55.0 ft AGL

Frequency (MHz) = 11200.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

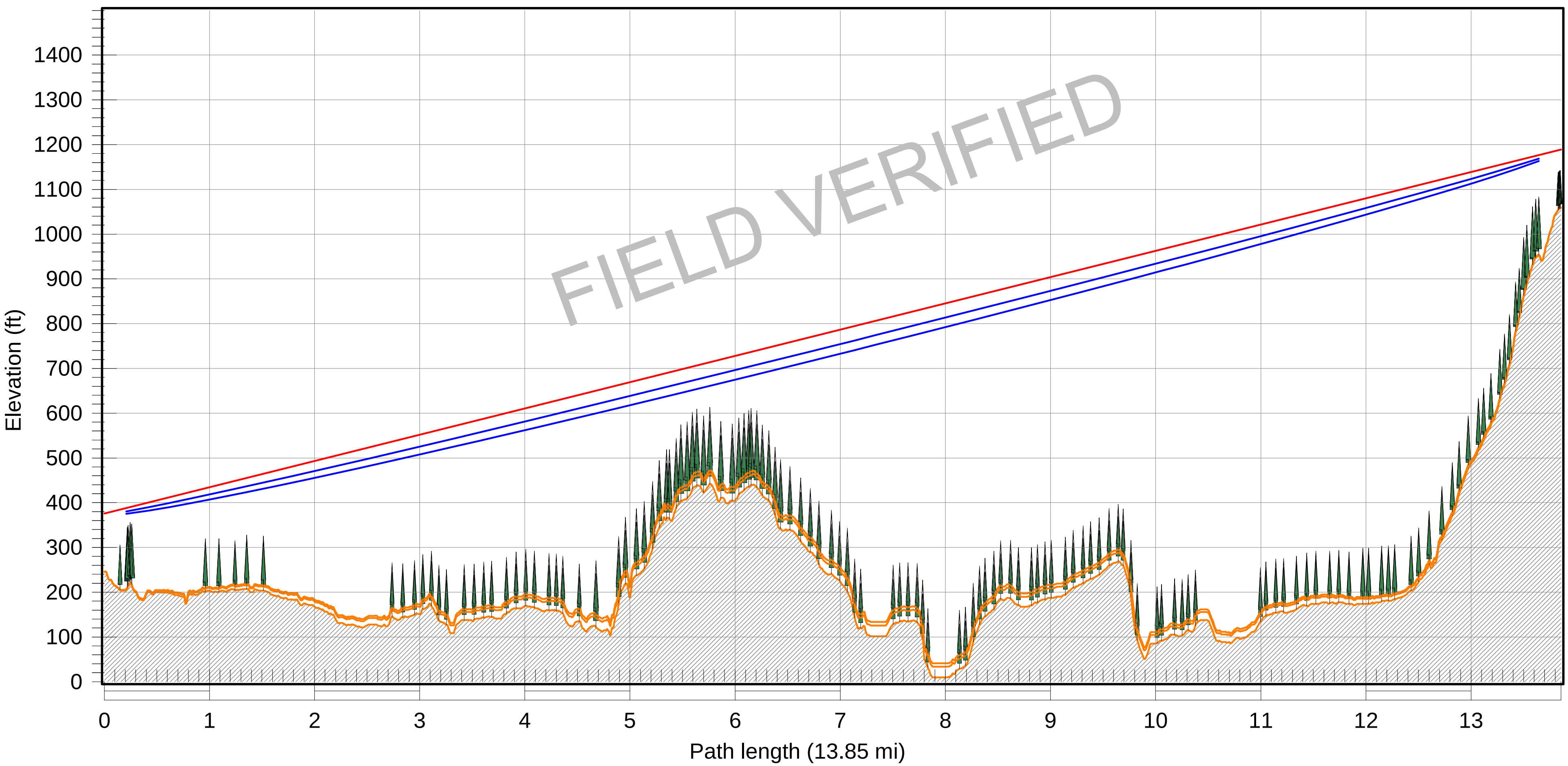
Healy Heights	
Latitude	45 29 21.40 N
Longitude	122 41 48.60 W
Azimuth	211.32°
Elevation	1025 ft ASL
Antenna CL	135.0 ft AGL

	IOC Tower - A	Mt Scott
Latitude	45 21 53.70 N	45 27 07.30 N
Longitude	122 48 14.90 W	122 32 51.30 W
True azimuth (°)	64.17	244.36
Vertical angle (°)	0.56	-0.71
Elevation (ft)	246.00	1057.00
Antenna model	HP8-59-D3A (TR)	VHLP6-6W-6WH/B (TR)
Antenna gain (dBi)	41.50	39.30
Antenna height (ft)	130.00	130.00
TX line model	EW63	EW63
TX line unit loss (dB/100 ft)	1.47	1.47
TX line length (ft)	180.00	175.00
TX line loss (dB)	2.65	2.57
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.00	2.00
RX filter loss (dB)	2.60	2.60
Frequency (MHz)	6175.00	
Polarization	Vertical	
Path length (mi)	13.86	
Free space loss (dB)	135.25	
Atmospheric absorption loss (dB)	0.19	
Net path loss (dB)	65.26	65.26
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR61-L1024A30-227	95MPR61-L1024A30-227
Emission designator	30M0D7W	30M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	96.98	
C factor	0.42	
Average annual temperature (°F)	47.21	
Fade occurrence factor (Po)	1.736E-002	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 227	31.50	31.50	-60.50	-60.50	67.95	65.83	-33.76	-33.76	26.74	26.74	26.74	26.74
512 206	**31.50**	**31.50**	**-63.70**	**-63.70**	**67.95**	**65.83**	**-33.76**	**-33.76**	**29.94**	**29.94**	**29.94**	**29.94**
256 183	32.50	32.50	-67.10	-67.10	68.95	66.83	-32.76	-32.76	34.34	34.34	34.34	34.34
128 161	32.50	32.50	-70.10	-70.10	68.95	66.83	-32.76	-32.76	37.34	37.34	37.34	37.34
64 136	32.50	32.50	-73.00	-73.00	68.95	66.83	-32.76	-32.76	40.24	40.24	40.24	40.24
32 113	32.50	32.50	-74.90	-74.90	68.95	66.83	-32.76	-32.76	42.14	42.14	42.14	42.14
16 90	32.50	32.50	-78.30	-78.30	68.95	66.83	-32.76	-32.76	45.54	45.54	45.54	45.54
4 43	32.50	32.50	-89.00	-89.00	68.95	66.83	-32.76	-32.76	56.24	56.24	56.24	56.24

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 227	99.9963	99.9963	99.9991	99.9991			99.9983	99.9983
512 206	**99.9982**	**99.9982**	**99.9996**	**99.9996**			**99.9992**	**0.0009**
256 183	99.9994	99.9994	99.9998	99.9998			99.9997	0.0005
128 161	99.9997	99.9997	99.9999	99.9999			99.9998	0.0002
64 136	99.9998	99.9998	99.9999	99.9999			99.9999	0.0001
32 113	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
16 90	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
4 43	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000

Multipath fading method - Vigants - Barnett



IOC Tower - A	
Latitude	45 21 53.70 N
Longitude	122 48 14.90 W
Azimuth	64.17°
Elevation	246 ft ASL
Antenna CL	130.0 ft AGL

Frequency (MHz) = 6175.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

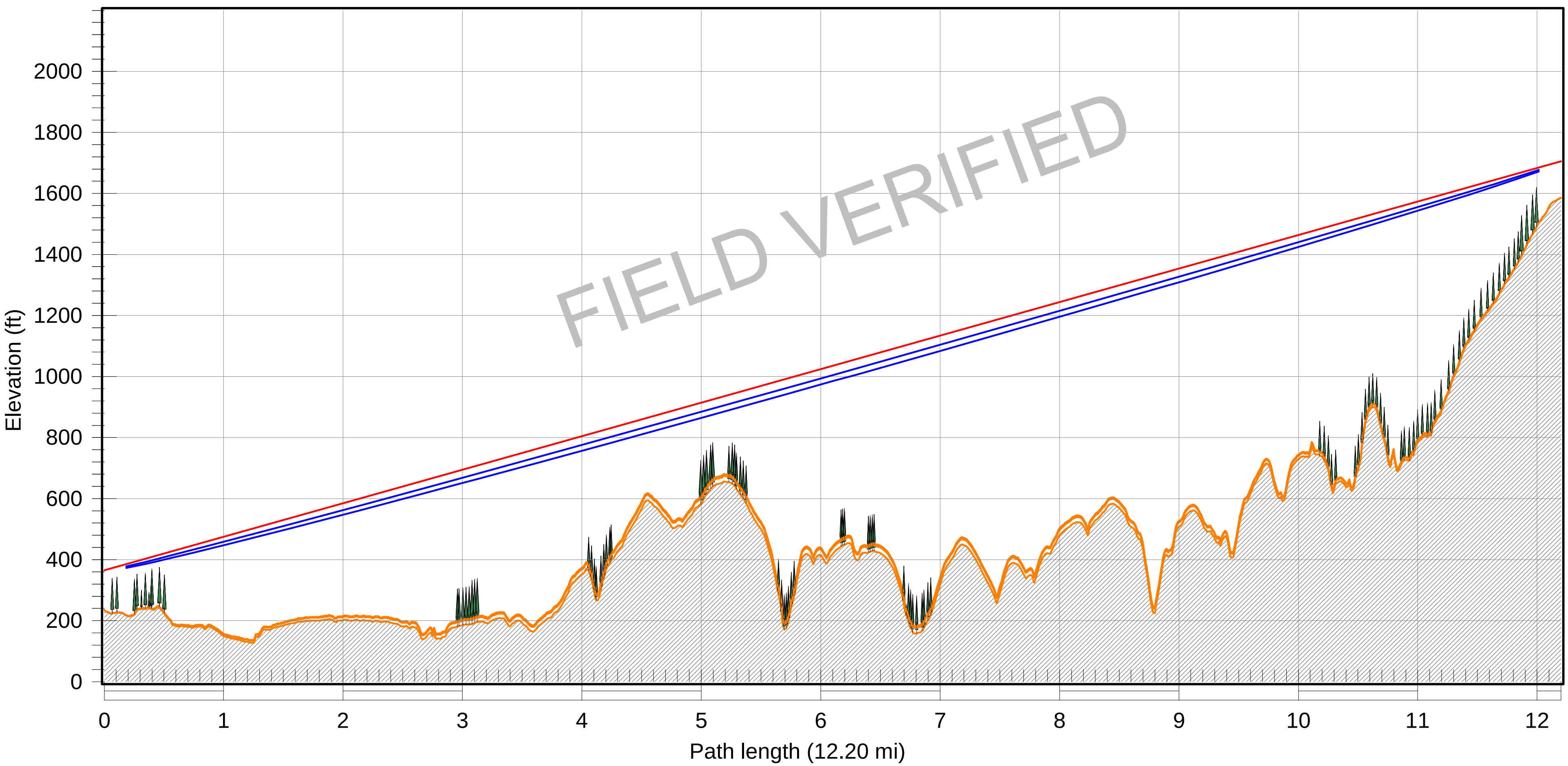
Mt Scott	
Latitude	45 27 07.30 N
Longitude	122 32 51.30 W
Azimuth	244.36°
Elevation	1057 ft ASL
Antenna CL	130.0 ft AGL

	IOC Tower - B	Bald Peak
Latitude	45 21 59.50 N	45 23 35.50 N
Longitude	122 48 16.90 W	123 03 08.90 W
True azimuth (°)	278.77	98.59
Vertical angle (°)	1.13	-1.26
Elevation (ft)	235.00	1585.00
Antenna model	VHLP6-6W-6WH/B (TR)	VHLP6-6W-6WH/B (TR)
Antenna gain (dBi)	39.30	39.30
Antenna height (ft)	130.00	120.00
TX line model	EW63	EW63
TX line unit loss (dB/100 ft)	1.47	1.47
TX line length (ft)	180.00	170.00
TX line loss (dB)	2.65	2.50
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.00	2.00
RX filter loss (dB)	2.60	2.60
Frequency (MHz)	6175.00	
Polarization	Vertical	
Path length (mi)	12.20	
Free space loss (dB)	134.14	
Atmospheric absorption loss (dB)	0.17	
Net path loss (dB)	66.26	66.26
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR61-L1024A30-227	95MPR61-L1024A30-227
Emission designator	30M0D7W	30M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	140.00	
C factor	0.26	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	7.355E-003	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 227	31.50	31.50	-60.50	-60.50	65.75	65.90	-34.76	-34.76	25.74	25.74	25.74	25.74
512 206	**31.50**	**31.50**	**-63.70**	**-63.70**	**65.75**	**65.90**	**-34.76**	**-34.76**	**28.94**	**28.94**	**28.94**	**28.94**
256 183	32.50	32.50	-67.10	-67.10	66.75	66.90	-33.76	-33.76	33.34	33.34	33.34	33.34
128 161	32.50	32.50	-70.10	-70.10	66.75	66.90	-33.76	-33.76	36.34	36.34	36.34	36.34
64 136	32.50	32.50	-73.00	-73.00	66.75	66.90	-33.76	-33.76	39.24	39.24	39.24	39.24
32 113	32.50	32.50	-74.90	-74.90	66.75	66.90	-33.76	-33.76	41.14	41.14	41.14	41.14
16 90	32.50	32.50	-78.30	-78.30	66.75	66.90	-33.76	-33.76	44.54	44.54	44.54	44.54
4 43	32.50	32.50	-89.00	-89.00	66.75	66.90	-33.76	-33.76	55.24	55.24	55.24	55.24

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 227	99.9980	99.9980	99.9995	99.9995			99.9990	99.9990
512 206	**99.9991**	**99.9991**	**99.9998**	**99.9998**			**99.9995**	**0.0005**
256 183	99.9997	99.9997	99.9999	99.9999			99.9998	0.0003
128 161	99.9998	99.9998	99.9999	99.9999			99.9999	0.0001
64 136	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
32 113	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
16 90	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
4 43	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000

Multipath fading method - Vigants - Barnett



IOC Tower - B	
Latitude	45 21 59.50 N
Longitude	122 48 16.90 W
Azimuth	278.77°
Elevation	235 ft ASL
Antenna CL	130.0 ft AGL

Frequency (MHz) = 6175.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

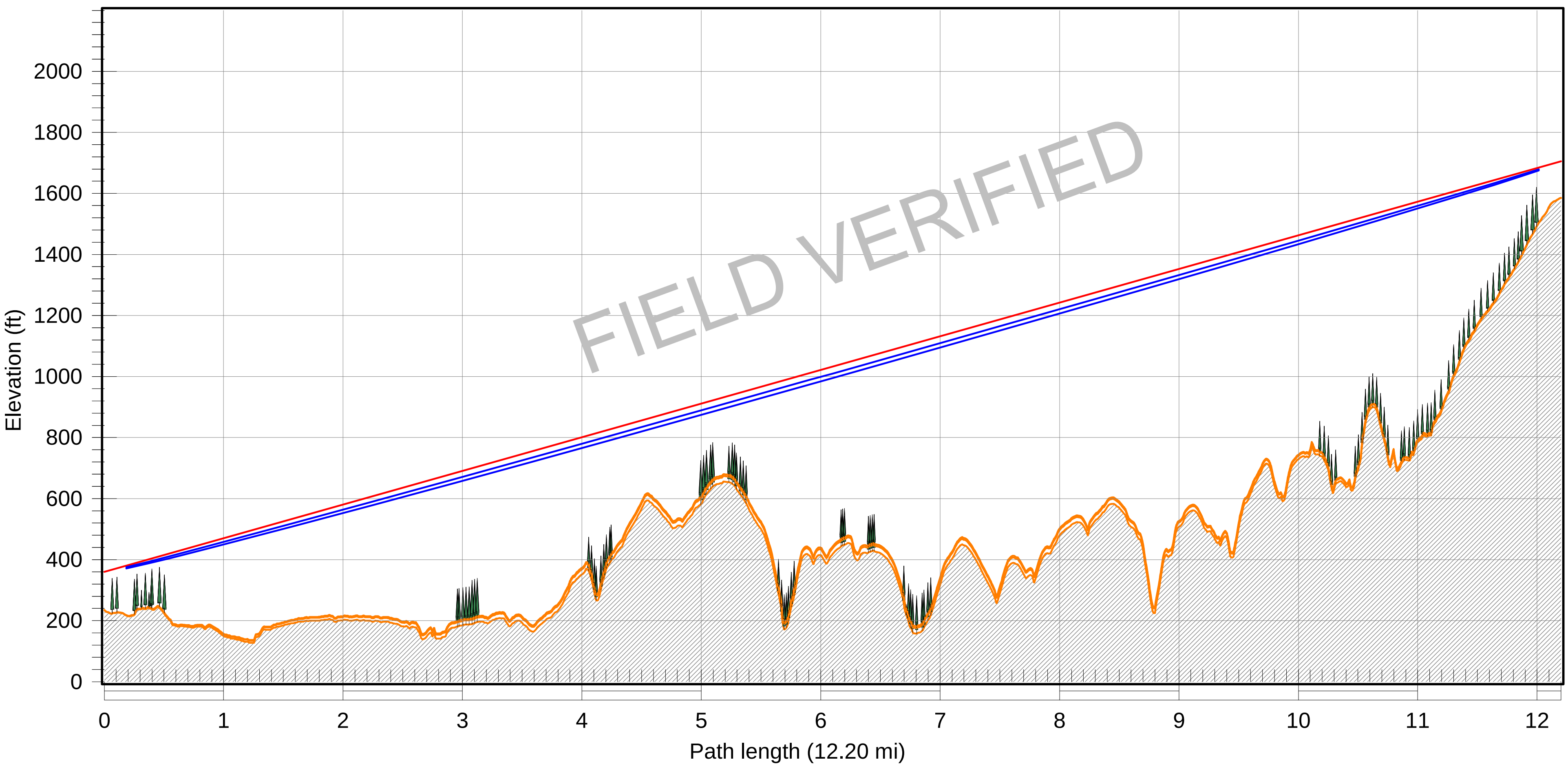
Bald Peak	
Latitude	45 23 35.50 N
Longitude	123 03 08.90 W
Azimuth	98.59°
Elevation	1585 ft ASL
Antenna CL	120.0 ft AGL

	IOC Tower - B	Bald Peak
Latitude	45 21 59.50 N	45 23 35.50 N
Longitude	122 48 16.90 W	123 03 08.90 W
True azimuth (°)	278.77	98.59
Vertical angle (°)	1.13	-1.26
Elevation (ft)	235.00	1585.00
Antenna model	HP8-107-P1A (TR)	HP8-107-P1A (TR)
Antenna gain (dBi)	46.40	46.40
Antenna height (ft)	125.00	120.00
TX line model	EW90	EW90
TX line unit loss (dB/100 ft)	3.08	3.08
TX line length (ft)	175.00	170.00
TX line loss (dB)	5.39	5.24
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.70	2.70
RX filter loss (dB)	2.90	2.90
Frequency (MHz)	11200.00	
Polarization	Vertical	
Path length (mi)	12.20	
Free space loss (dB)	139.31	
Atmospheric absorption loss (dB)	0.31	
Net path loss (dB)	63.85	63.85
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR11-L1024A40-294	95MPR11-L1024A40-294
Emission designator	40M0D7W	40M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	140.00	
C factor	0.26	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	1.334E-002	
Polarization	Vertical	
Rain region	Portland, Oregon	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 294	30.00	30.00	-58.50	-58.50	67.91	68.06	-33.85	-33.85	24.65	24.65	24.65	24.65
512 267	**31.00**	**31.00**	**-61.70**	**-61.70**	**68.91**	**69.06**	**-32.85**	**-32.85**	**28.85**	**28.85**	**28.85**	**28.85**
256 238	32.00	32.00	-65.10	-65.10	69.91	70.06	-31.85	-31.85	33.25	33.25	33.25	33.25
128 207	32.50	32.50	-68.10	-68.10	70.41	70.56	-31.35	-31.35	36.75	36.75	36.75	36.75
64 179	32.50	32.50	-71.00	-71.00	70.41	70.56	-31.35	-31.35	39.65	39.65	39.65	39.65
32 145	32.50	32.50	-73.40	-73.40	70.41	70.56	-31.35	-31.35	42.05	42.05	42.05	42.05
16 115	32.50	32.50	-76.80	-76.80	70.41	70.56	-31.35	-31.35	45.45	45.45	45.45	45.45
4 55	32.50	32.50	-87.50	-87.50	70.41	70.56	-31.35	-31.35	56.15	56.15	56.15	56.15

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 294	99.9954	99.9954	99.9989	99.9989	99.9998	99.9998	99.9976	99.9976
512 267	**99.9982**	**99.9982**	**99.9996**	**99.9996**	**99.9999**	**99.9999**	**99.9991**	**0.0015**
256 238	99.9994	99.9994	99.9998	99.9998	99.9999	99.9999	99.9997	0.0006
128 207	99.9997	99.9997	99.9999	99.9999	99.9999	99.9999	99.9998	0.0002
64 179	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0001
32 145	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
16 115	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
4 55	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000

Multipath fading method - Vigants - Barnett
Rain fading method - Crane



IOC Tower - B	
Latitude	45 21 59.50 N
Longitude	122 48 16.90 W
Azimuth	278.77°
Elevation	235 ft ASL
Antenna CL	125.0 ft AGL

Frequency (MHz) = 11200.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

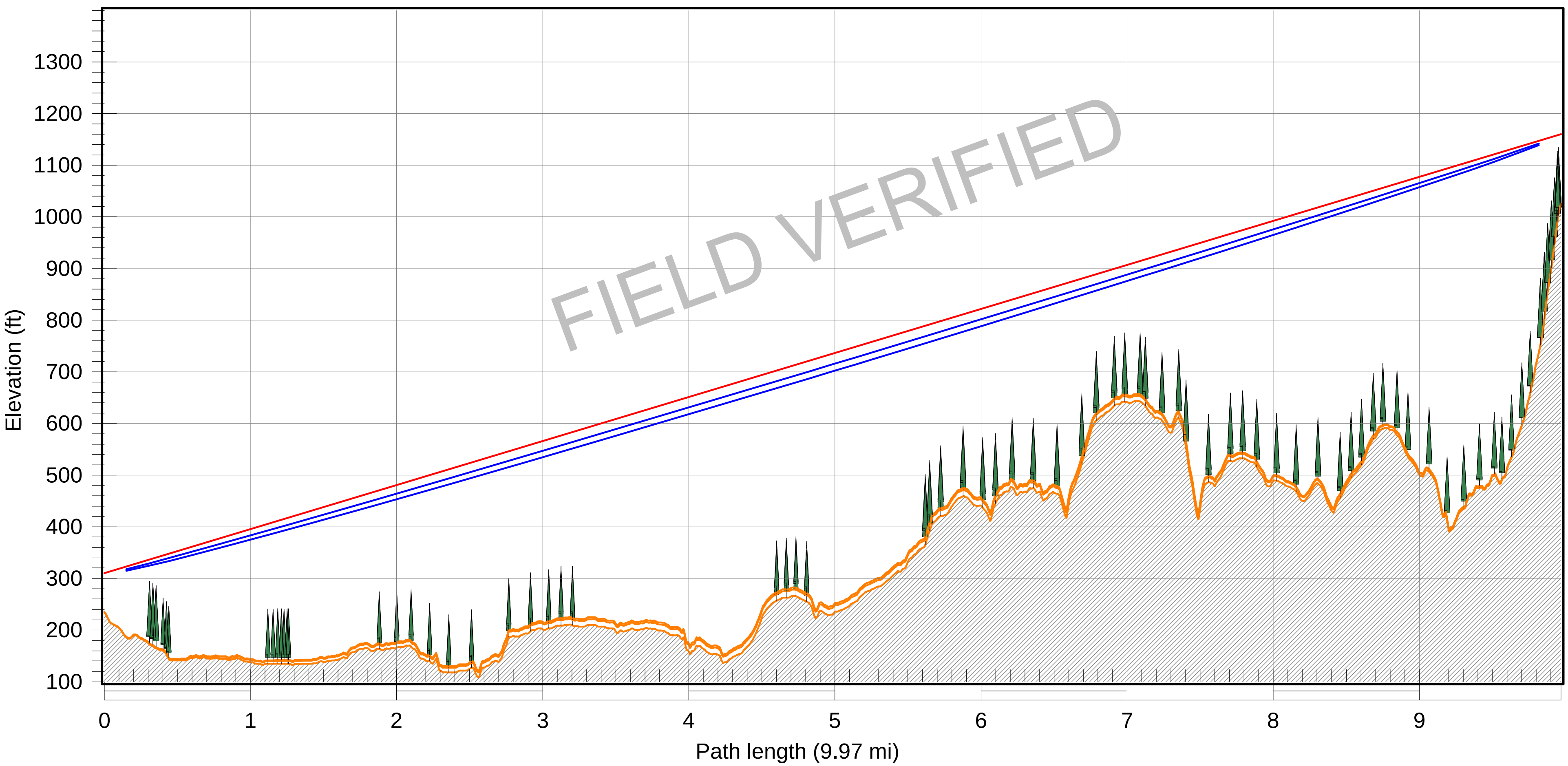
Bald Peak	
Latitude	45 23 35.50 N
Longitude	123 03 08.90 W
Azimuth	98.59°
Elevation	1585 ft ASL
Antenna CL	120.0 ft AGL

	IOC Tower - B	Healy Heights
Latitude	45 21 59.50 N	45 29 21.40 N
Longitude	122 48 16.90 W	122 41 48.60 W
True azimuth (°)	31.71	211.78
Vertical angle (°)	0.87	-0.98
Elevation (ft)	235.00	1025.00
Antenna model	HP8-107-P1A (TR)	VHLP6-11W-6WH/A (TR)
Antenna gain (dBi)	46.40	44.00
Antenna height (ft)	75.00	135.00
TX line model	EW90	EW90
TX line unit loss (dB/100 ft)	3.08	3.08
TX line length (ft)	125.00	195.00
TX line loss (dB)	3.85	6.01
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.70	2.70
RX filter loss (dB)	2.90	2.90
Frequency (MHz)	11200.00	
Polarization	Vertical	
Path length (mi)	9.97	
Free space loss (dB)	137.56	
Atmospheric absorption loss (dB)	0.25	
Net path loss (dB)	63.67	63.67
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR11-L1024A40-294	95MPR11-L1024A40-294
Emission designator	40M0D7W	40M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	70.79	
C factor	0.64	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	1.766E-002	
Polarization	Vertical	
Rain region	Portland, Oregon	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 294	30.00	30.00	-58.50	-58.50	69.45	64.89	-33.67	-33.67	24.83	24.83	24.83	24.83
512 267	**31.00**	**31.00**	**-61.70**	**-61.70**	**70.45**	**65.89**	**-32.67**	**-32.67**	**29.03**	**29.03**	**29.03**	**29.03**
256 238	32.00	32.00	-65.10	-65.10	71.45	66.89	-31.67	-31.67	33.43	33.43	33.43	33.43
128 207	32.50	32.50	-68.10	-68.10	71.95	67.39	-31.17	-31.17	36.93	36.93	36.93	36.93
64 179	32.50	32.50	-71.00	-71.00	71.95	67.39	-31.17	-31.17	39.83	39.83	39.83	39.83
32 145	32.50	32.50	-73.40	-73.40	71.95	67.39	-31.17	-31.17	42.23	42.23	42.23	42.23
16 115	32.50	32.50	-76.80	-76.80	71.95	67.39	-31.17	-31.17	45.63	45.63	45.63	45.63
4 55	32.50	32.50	-87.50	-87.50	71.95	67.39	-31.17	-31.17	56.33	56.33	56.33	56.33

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 294	99.9942	99.9942	99.9986	99.9986	99.9999	99.9999	99.9971	99.9971
512 267	**99.9978**	**99.9978**	**99.9995**	**99.9995**	**99.9999**	**99.9999**	**99.9989**	**0.0018**
256 238	99.9992	99.9992	99.9998	99.9998	99.9999	99.9999	99.9996	0.0007
128 207	99.9996	99.9996	99.9999	99.9999	99.9999	99.9999	99.9998	0.0002
64 179	99.9998	99.9998	99.9999	99.9999	99.9999	99.9999	99.9999	0.0001
32 145	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
16 115	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000
4 55	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	99.9999	0.0000

Multipath fading method - Vigants - Barnett
Rain fading method - Crane



IOC Tower - B	
Latitude	45 21 59.50 N
Longitude	122 48 16.90 W
Azimuth	31.71°
Elevation	235 ft ASL
Antenna CL	75.0 ft AGL

Frequency (MHz) = 11200.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

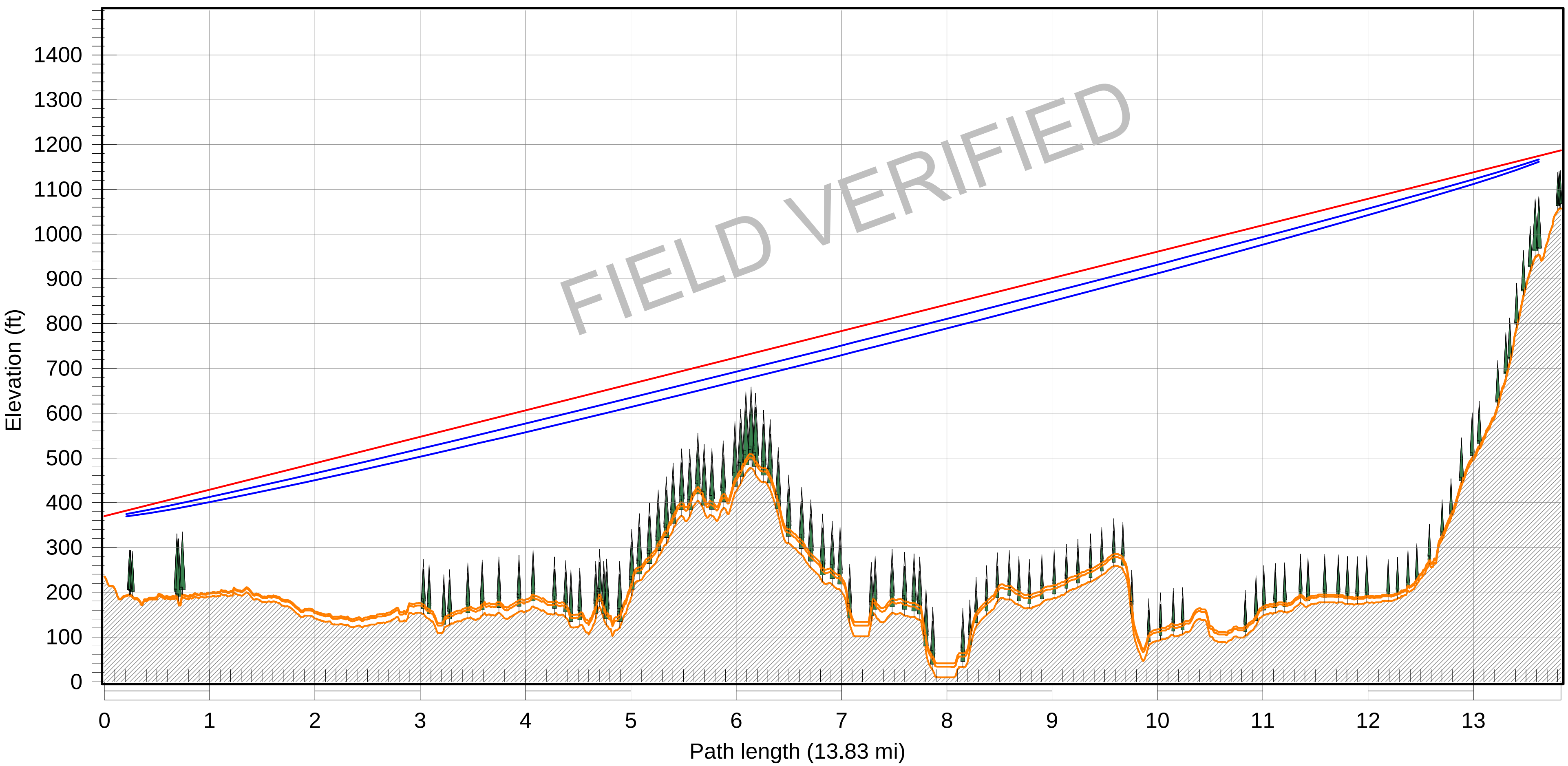
Healy Heights	
Latitude	45 29 21.40 N
Longitude	122 41 48.60 W
Azimuth	211.78°
Elevation	1025 ft ASL
Antenna CL	135.0 ft AGL

	IOC Tower - B	Mt Scott
Latitude	45 21 59.50 N	45 27 07.30 N
Longitude	122 48 16.90 W	122 32 51.30 W
True azimuth (°)	64.64	244.82
Vertical angle (°)	0.57	-0.72
Elevation (ft)	235.00	1057.00
Antenna model	HP8-59-D3A (TR)	VHLP6-6W-6WH/B (TR)
Antenna gain (dBi)	41.50	39.30
Antenna height (ft)	135.00	130.00
TX line model	EW63	EW63
TX line unit loss (dB/100 ft)	1.47	1.47
TX line length (ft)	185.00	175.00
TX line loss (dB)	2.72	2.57
Connector loss (dB)	0.40	0.40
TX filter loss (dB)	2.00	2.00
RX filter loss (dB)	2.60	2.60
Frequency (MHz)	6175.00	
Polarization	Vertical	
Path length (mi)	13.83	
Free space loss (dB)	135.23	
Atmospheric absorption loss (dB)	0.19	
Net path loss (dB)	65.31	65.31
Configuration	HSB (1:10) - Stacking	HSB (1:10) - Stacking
Radio model	95MPR61-L1024A30-227	95MPR61-L1024A30-227
Emission designator	30M0D7W	30M0D7W
Climatic factor	1.00	
Terrain roughness (ft)	89.38	
C factor	0.47	
Average annual temperature (°F)	48.51	
Fade occurrence factor (Po)	1.920E-002	

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
1024 227	31.50	31.50	-60.50	-60.50	67.88	65.83	-33.81	-33.81	26.69	26.69	26.69	26.69
512 206	**31.50**	**31.50**	**-63.70**	**-63.70**	**67.88**	**65.83**	**-33.81**	**-33.81**	**29.89**	**29.89**	**29.89**	**29.89**
256 183	32.50	32.50	-67.10	-67.10	68.88	66.83	-32.81	-32.81	34.29	34.29	34.29	34.29
128 161	32.50	32.50	-70.10	-70.10	68.88	66.83	-32.81	-32.81	37.29	37.29	37.29	37.29
64 136	32.50	32.50	-73.00	-73.00	68.88	66.83	-32.81	-32.81	40.19	40.19	40.19	40.19
32 113	32.50	32.50	-74.90	-74.90	68.88	66.83	-32.81	-32.81	42.09	42.09	42.09	42.09
16 90	32.50	32.50	-78.30	-78.30	68.88	66.83	-32.81	-32.81	45.49	45.49	45.49	45.49
4 43	32.50	32.50	-89.00	-89.00	68.88	66.83	-32.81	-32.81	56.19	56.19	56.19	56.19

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
1024 227	99.9959	99.9959	99.9990	99.9990			99.9980	99.9980
512 206	**99.9980**	**99.9980**	**99.9995**	**99.9995**			**99.9990**	**0.0010**
256 183	99.9993	99.9993	99.9998	99.9998			99.9996	0.0006
128 161	99.9996	99.9996	99.9999	99.9999			99.9998	0.0002
64 136	99.9998	99.9998	99.9999	99.9999			99.9999	0.0001
32 113	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
16 90	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
4 43	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000

Multipath fading method - Vigants - Barnett



IOC Tower - B	
Latitude	45 21 59.50 N
Longitude	122 48 16.90 W
Azimuth	64.64°
Elevation	235 ft ASL
Antenna CL	135.0 ft AGL

Frequency (MHz) = 6175.0
K = 1.33, 1.00
%F1 = 100.00, 60.00

Mt Scott	
Latitude	45 27 07.30 N
Longitude	122 32 51.30 W
Azimuth	244.82°
Elevation	1057 ft ASL
Antenna CL	130.0 ft AGL