Tillamook County, Oregon

Public Safety Radio System Needs Assessment and System Analysis Report

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Executive Summary

Tillamook County, Oregon (County) maintains multiple land mobile radio (LMR) systems to meet the specific operational needs of County departments, including Emergency Medical Services (EMS), Fire, Public Works and Sheriff. There are separate channels for Fire/EMS, Public Works and Law Enforcement (Sheriff and local police departments). The LMR channels provide voice communications between radio users in the field and Tillamook County Emergency Communications District (Tillamook 911) dispatchers. A microwave radio and fiber optic backhaul system carries radio user voice signals between the LMR repeater sites and the Tillamook 911 dispatch consoles. Tillamook 911 owns and operates the microwave backhaul system. Tillamook Lightwave, a special district that was set up between the County, Tillamook People's Utility District (PUD) and the Port of Tillamook Bay, owns and operates the fiber optic system.

Most of the LMR and microwave backhaul equipment is at end of the product lifecycle[1] and requires replacement. The County is experiencing inadequate radio coverage, as well as system operational and reliability issues.

To address these issues, the County contracted with Federal Engineering, Inc. (***FE***) to assess their existing LMR and microwave radio backhaul systems, identify current and future stakeholder needs and assist in determining the best course of action for the upgrade or replacement of the system. ***FE*** completed this report, the *Needs Assessment and System Analysis Report,* by conducting the following steps:

- Reviewing system documentation and previous studies
- Conducting user interviews and gathering data
- Surveying radio sites
- Modeling existing system coverage
- Analyzing existing system attributes vs. user-stated requirements

[1] The end of a product lifecycle indicates that the technology in use may have reached obsolescence in that major system components lack manufacturer support and repair parts are in limited supply in the marketplace.

Review of System Documentation and Previous Studies

Before meeting with the County and participating agencies, ***FE*** requested and reviewed existing system documentation, including previous studies, FCC licenses, site information, and other documents needed to assess the existing systems. Performing a review of the previous studies and current documentation provided us with a foundation for understanding the status of the radio systems prior to the user interviews.

User Interviews

FE submitted a questionnaire and conducted interviews with County radio system users to obtain input on issues related to the existing systems and to identify radio system needs for the system upgrade. Key issues identified include:

- Stakeholders reported lack of adequate radio coverage on each of the County LMR channels as a major issue that the new system must address. ***FE*** used software to model the existing system coverage which validated the input from the Stakeholders
- Stakeholders reported existing LMR channels can be difficult to use, requiring radio users to know what repeater provides the best coverage for the area they are in and to change channels as they move through the County to access different repeater sites
- Due to the configuration of the existing system, radio users in different areas of the County cannot talk directly to each other

Radio Site Surveys

FE conducted radio site surveys to assess if the existing physical infrastructure can support the LMR and microwave radio system upgrade, and to determine if the County should make any site improvements. Most County radio sites are in good overall condition with sufficient physical space to support new equipment on the tower and in the shelter. However, tower structural analyses are recommended prior to making a determination if additional antennas can be added to the tower.

Two sites have shelters that have limited space available and are in poor condition including one exhibiting signs of water intrusion. The installation of a new shelter at those sites will likely be required to accommodate new radio equipment. In addition, a few remote radio sites require grounding system upgrades.

Key Findings

FE performed an analysis of existing County LMR and microwave radio systems to identify capabilities and vulnerabilities. Some of the key findings are:

- Aging LMR and microwave backhaul equipment, with much of it at end of product lifecycle leaving the County at risk for potential system failures that cannot be repaired
- The backhaul system, connecting most of the LMR sites, needs path redundancy to provide alternate routes to key LMR sites in the event of a primary path failure. If path redundancy is not possible, at a minimum, the link should be protected using a monitored, hot-standby configuration, as are existing spur links
- In order to improve communications between dispatch and the radio users, all transmit/receive LMR sites should be connected to the backhaul network
- The County does not have a network management system that allows maintenance staff to remotely monitor and troubleshoot LMR and microwave radio equipment

Next Steps

Based on the needs assessment and the identification of existing system attributes, issues and vulnerabilities, ***FE*** will analyze alternatives for the upgrade of the County's LMR and microwave radio backhaul systems. We will analyze radio coverage and channel capacity for each alternative, along with the cost, and advantages and disadvantages of each. ***FE***'s forthcoming *Alternatives Analysis and Conceptual Design Report* will include a summary of the analyses, and a recommended solution.

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1. Introduction

1.1 Background

Tillamook County (County) has multiple land mobile radio (LMR) systems to meet specific operational needs of County departments, including the Emergency Medical Services, Fire, Public Works and Sheriff. A microwave radio and fiber optic backhaul system is used to transport voice signals between the LMR system repeaters and dispatch consoles at the Tillamook County Emergency Communications District (Tillamook 911). The microwave backhaul system is owned and operated by Tillamook 911 and the fiber optic backhaul is owned and operated by Tillamook Lightwave, a special district that was set up between the County, Tillamook People's Utility District (PUD) and the Port of Tillamook Bay.

The County contracted with ***FE*** to assess the existing LMR and microwave radio systems, analyze alternatives to upgrade or replace the existing system and provide recommendations for a solution that will address user agency needs. This report, the *Tillamook County Public Safety Radio System Needs Assessment and System Analysis Report*, is the first step in this process.

1.2 Project Approach

FE completed the following steps to produce this document, the *Tillamook County Public Safety Radio System Needs Assessment and System Analysis Report*:

- Reviewed existing LMR and microwave backhaul system documentation
- Submitted a questionnaire to County stakeholders to obtain feedback
- Conducted stakeholder interviews
- Conducted site visits to County LMR and microwave radio sites
- Performed a computer-based radio coverage analysis

FE documented current and future needs based on stakeholder input obtained from the questionnaire and interviews.

2. Existing System Analysis

2.1 Overview

The County has a VHF High Band analog conventional LMR system with countywide channels for the Fire, Public Works and Sheriff, and a General channel that was used by County radio maintenance staff in the past but is now available for reassignment for other purposes. Fire also has single-site repeated tactical (TAC) channels. Table 1 shows the countywide and TAC channels and the radio sites associated with each.

Table 1 – Tillamook County Radio Channels

	County Radio Sites										
Channel	L-190	Mt. Hebo	Neah-kahnie	Cape Meares	Rock-away	South Saddle	Wilson	Justice	Neskowin	Ridge Road	T-Point
Fire Dispatch	x	x	x	x	x				X		
Fire TAC 1			x								
Fire TAC 1A					x						
Fire TAC 2	x										
Fire TAC 3		x									
Fire TAC 3A										x	
Fire TAC 6											x
Fire TAC 6W							x				
Fire TAC 6S						x					
General		x	x	x							x
Public Works		x	x								x
SO	x	x	x	x	x	x	x	x			
SO #2		x	x	x			x				

The Fire Dispatch, General, Public Works, Sheriff's Office (SO) and SO #2 channels use the same radio frequency (RF) frequency pair for all repeaters on the channel and use the same transmit continuous tone coded squelch system (CTCSS)[2] tone to allow radio users in coverage overlap areas of two or more repeaters to hear transmissions from them all. However, each repeater uses a different receive CTCSS tone so that radio users can select the specific repeater site that will provide the best signal quality and to prevent multiple repeaters from "keying up" simultaneously and potentially interfering with each other. As radio users move through the County, they change channels to access different repeater sites. Dispatchers must also select the best radio site for each call and when a call is received from the field must determine which site the radio user called in on and respond using that site.

[2] CTCSS is the generic term but is referred to as private line (PL) by Motorola, channel guard (CG) by Harris and quiet tone (QT) by Kenwood.

A combination of microwave radio, fiber optic cable and VHF High Band control station links are used to connect the dispatch consoles at the Tillamook 911 dispatch center to the repeaters. Tillamook 911 owns and operates the microwave backhaul system and Tillamook Lightwave owns and operates the fiber optic system. Refer to *Section 2.4, Backhaul System*, for additional detail on the backhaul system.

2.2 Tillamook 911 Dispatch

Tillamook 911, located in Tillamook, is the first 9-1-1 Special District in the State and is the primary Public Safety Answering Point (PSAP) for the County. Tillamook 911 dispatches for County Public Works and all law enforcement, fire and emergency medical agencies in the County and is a secondary dispatch center for other agencies operating in the County, as shown in Table 2. As mentioned, Tillamook 911 also owns and operates the microwave backhaul system.

Table 2 – Agencies Tillamook 911 Dispatches

Law	Fire	EMS	Other
Manzanita DPS	Nehalem Bay	Manzanita Ambulance	Oregon Department of Forestry
Rockaway Beach PD	Rockaway Beach	Garibaldi Ambulance	County Public Works
Garibaldi PD	Garibaldi	Tillamook Ambulance	U.S. Coast Guard
Tillamook PD	Bay City	Pacific City Ambulance	State Forestry
Sheriff	Tillamook		Various city public works
County Search and Rescue	Netarts-Oceanside		
State Police (secondary)	Nestucca		
BLM (secondary)			
USFS (secondary)			

Tillamook 911 operates 24 hours per day, 365 days per year, and has four trained dispatchers. Typically, there are 2 dispatchers on duty, but there can be 3 during peak times and one during slow times. The County has an Emergency Operations Center (EOC) at the County Justice Building that has backup dispatch consoles and VHF control stations for access to the Fire Dispatch, Fire TAC 1, 2, 3 and 6, Public Works and SO #2 channels.

2.3 Land Mobile Radio System

2.3.1 Radio Channels

2.3.1.1 Fire

The VHF analog conventional Fire Dispatch channel (154.355 MHz transmit/158.970 MHz receive) is used by the Adventist Health Ambulance Service and the following independent fire departments:

- Bay City
- Garibaldi
- Nehalem Bay
- Nestucca
- Netarts-Oceanside
- Rockaway Beach
- Tillamook

Tillamook 911 pages out the fire departments on the Fire Dispatch channel and then units switch to a repeated TAC channel while enroute to the scene to receive updates and provide status. Depending on the location of the fire, Tillamook 911 may need to page out units from multiple fire departments using different radio sites. Bay City, Garibaldi and Tillamook are paged out on Cape Meares, Nestucca on Mt. Hebo, Netarts/Oceanside on Cape Lookout and Rockaway Beach and Nehalem Bay on Neahkahnie.

Tillamook 911 has access to the Fire Dispatch and TAC channels via the microwave radio/fiber backhaul system or using VHF High Band control links, except for TAC 3A channel at Ridge Road, which is standalone repeater for local communications. Simplex fire ground channels are used once on scene. Refer to *Section 2.4, Backhaul System* for additional detail.

Table 3 shows the radio sites associated with the Fire Dispatch channel and the TAC channels. Refer to *Section 2.3.2, Radio Coverage,* for the coverage provided by each site.

Table 3. Fire Channel Repeater Sites

	Channel								
Repeater Site	**Fire**	**TAC 1**	**TAC 1A**	**TAC 2**	**TAC 3**	**TAC 3A**	**TAC 6**	**TAC 6W**	**TAC 6S**
Neahkahnie Mountain	X	X							
Rockaway Beach	X		X						
Triangulation Point							X		
South Saddle									X
Wilson River								X	

	Channel								
Repeater Site	Fire	TAC 1	TAC 1A	TAC 2	TAC 3	TAC 3A	TAC 6	TAC 6W	TAC 6S
Cape Meares	X								
Cape Lookout (L190)	X			X					
Ridge Road						X			
Mt. Hebo	X				X				
Neskowin	X								

2.3.1.2 General

The VHF High Band analog conventional General channel (154.8375 MHz transmit /157.890 MHz receive) was used in the past by County radio system maintenance staff but is no longer used and is available for use by Fire or the Sheriff. The General channel uses the following sites, listed from North to South. Refer to *Section 2.3.2, Radio Coverage,* for the coverage provided by each site):

- Neahkahnie Mountain
- Triangulation Point
- Cape Meares
- Mt. Hebo

2.3.1.3 Public Works

The VHF High Band analog conventional Public Works channel (153.965 MHz transmit /158.835 MHz receive) operates from the following repeater sites, listed from North to South, for coverage throughout the County (refer to *Section 2.3.2, Radio Coverage,* for the coverage provided by each site):

- Neahkahnie Mountain
- Triangulation Point
- Mt. Hebo

Tillamook 911 has access to the Public Works channel repeaters via a VHF High Band control station.

2.3.1.4 Sheriff

The Sheriff has two VHF High Band analog conventional radio channels, SO (154.725 MHz transmit/158.865 MHz receive) and SO #2 (154.445 MHz transmit/151.0775 MHz receive), which are also the primary channels for the Garibaldi, Manzanita, Rockaway

Beach and Tillamook police departments. The SO channel is the primary channel for all of the law enforcement agencies using the County system and the SO #2 channel is used for backup. The Oregon State Police (OSP) accesses the Sheriff channels for mutual aid operations. The Sheriff and all police departments, except for the Tillamook Police Department, have mobile data terminals (MDTs) using cellular services for the wireless connection.

Table 4 shows the repeater sites used for the SO and SO #2 channels, listed from North to South. Refer to *Section 2.3.2, Radio Coverage*, for the coverage provided by each site.

Table 4. Sheriff Channel Repeater Sites

Repeater Site	SO Channel	SO #2 Channel
Neahkahnie Mountain	X	X
Rockaway Beach City Hall	X	
South Saddle	X	
Wilson River	X	X
Cape Meares	X	X
Cape Lookout (L190)	X	
Mt. Hebo	X	X
County Justice	X	

Tillamook 911 has access to the SO and SO #2 channel repeaters at Neahkahnie, Rockaway Beach, Wilson River, Cape Meares and Mt. Hebo via the microwave radio and fiber backhaul system. The L-190 and South Saddle repeaters are accessed using VHF High Band control stations. The SO repeater at County Justice is standalone for local communications only. Refer to *Section 2.4, Backhaul System*.

The County has installed a voting receiver for the SO channel at the County Courthouse and is considering a second receiver at the Public Works Office in Tillamook to improve portable radio talk-in (portable radio to repeater) coverage. Audio from the voting receiver, along with the receiver audio from the Cape Meares repeater, is routed to a comparator at Cape Meares, which selects the best audio signal and retransmits it on the Cape Meares repeater.

2.3.2 Radio Coverage

FE evaluated existing radio coverage for the Fire, Public Works and Sheriff channels and used the results, along with input from the County stakeholders, to identify areas where additional coverage was needed.

2.3.2.1 Radio Coverage Prediction Software

FE produced the radio coverage maps in this section using ***FEPerformancePro***™ and high-resolution elevation and land use/cover data from the United States Geological Survey (USGS). ***FEPerformancePro***™ uses ATDI's ICS Telecom network planning software which has been used extensively by the Federal Government and validated via field tests. ***FE*** has calibrated this modeling tool and our methodology based on many years of experience and industry-accepted guidelines to deliver the most accurate view of radio coverage possible.

2.3.2.2 Radio Coverage Parameters

The radio coverage prediction studies were conducted using site information provided by the County, such as transmit power levels and antenna make/model and height. In addition, ***FE*** used the technical parameters in Table 5 to model the coverage for the existing County LMR system.

Table 5 – Coverage Study Parameters

Parameter	Description
System Type	Conventional Analog
Frequency Band	VHF High Band
Channel Bandwidth	12.5 kHz
Reliability	95%
Audio Quality	Delivered Audio Quality (DAQ) – 3.4
Talk Paths	Mobile radio talk-out[3] Mobile radio talk-in[4] Portable radio talk-out, on-street Portable radio talk-in, on-street Portable radio talk-out, in light/residential buildings Portable radio talk-in, in light/residential buildings

The coverage displayed on each map indicates the areas predicted to have audio quality greater than or equal to Delivered Audio Quality (DAQ) 3.4. DAQ is a measure of audio quality over a transmission medium, with different levels as shown in Table 6. DAQ 3.4 is the level most commonly used for public safety radio systems.

[3] Repeater to mobile and portable radio.
[4] Mobile and portable radio to repeater.

Table 6 – Delivered Audio Quality Definitions

DAQ Level	Definition
1.0	Unusable. Speech present but not understandable
2.0	Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion
3.0	Speech understandable with slight effort. Requires occasional repetition due to noise or distortion
3.4	Speech understandable without repetition. Some noise or distortion present. DAQ 3.4 is the minimum Channel Performance Criterion (CPC) used for public safety agencies.
4.0	Speech easily understandable. Little noise or distortion
5.0	Perfect. No distortion or noise discernible

Reliability is a measure of confidence in the signals in areas shown as covered on the maps and is based on recommendations from the Telecommunications Industry Association (TIA) TSB-88-D[5] suite of documents. In the case of public safety radio systems, TSB-88-D recommends 95% reliability, which means that users should be able to receive audio at DAQ 3.4 or better in any area that is deemed "covered" at least 95% of the time.

FE used the mobile and portable radio parameters in Table 7 to model radio coverage.

Table 7 – Mobile and Portable Radio Parameters

Parameter	Mobile	Portable
Transmit Power (watts)	50	5
Receive Sensitivity (dBm)	-119	-119
Antenna Location	Roof	Hip
Antenna Gain (dB)	0	0
Body Loss (dB)	N/A	17.6

2.3.2.3 Radio Coverage Workshop

Following the analysis of existing system coverage, ***FE*** conducted a radio coverage workshop with County stakeholders to:

- Review ***FE's*** analysis of existing system
- Identify areas where coverage is insufficient
- Evaluate potential new sites to supplement coverage

[5] TIA TSB-88 Wireless Communications Systems - *Performance in Noise and Interference-Limited Situations*

- Identify a final set of sites that would best meet the County's coverage needs

Results of the existing system analysis are presented below. Analysis of additional sites needed to meet the County's coverage requirements will be presented in the Conceptual Design Report.

2.3.2.4 Radio Coverage Maps

The coverage maps in this section show mobile, on-street portable and in-building portable radio talk-out and talk-in coverage. Mobile radio talk-out and talk-in coverage are about the same because the power output of a VHF mobile radio is typically about the same as the repeater (50 – 100 watts). However, portable radio talk-in coverage will be less than talk-out due to the lower output power of a portable radio (typically 3 – 5 watts) as compared to the repeater. Also shown on the maps, mobile radio coverage exceeds on-street portable radio coverage due to higher radio output power and the use of a higher gain antenna, and on-street portable radio coverage exceeds in-building portable coverage due to the additional signal loss incurred when inside buildings.

The coverage maps use the following colors to model coverage:

- Green - areas where users should be able to communicate using their portable radios when inside light-density and/or residential buildings. For these coverage prediction studies, ***FE*** used 13 dB to represent signal loss inside these types of buildings

- Yellow - areas where users should be able to communicate using their portable radios on the street (on-street portable coverage should also exist in all green areas)

- Purple - areas where users should be able to communicate using their mobile radios (mobile coverage should also exist in all green and yellow areas)

Note: The radio coverage portrayed by the maps in this section may vary from actual system coverage. Computer modeling cannot account for all variables, such as individual radio performance, electrical noise and radio RF interference. General loss factors are used for trees and buildings, but actual signal loss varies based on the type, height and density of the trees and buildings.

In producing the maps, FE assumed that the existing radios perform according to manufacturer specifications. Radio and/or antenna system degradation would negatively affect performance causing actual coverage to be less than that indicated by the maps.

2.3.2.5 Radio Coverage Summary

Table 8 summarizes the general coverage provided by each of the existing County repeater sites.

Table 8 – Summary of Coverage Provided by Existing County Radio Sites

Repeater Site	General Coverage Area
Cape Lookout (L190)	• Good in-building coverage in Tillamook, along central coast, and some in-building coverage in Bay City • Some portable coverage in Garibaldi • Some mobile coverage in Rockaway Beach and Manzanita • Decent mobile coverage along the coast through most of the County's coastline • Mobile coverage along Highway 101 north and south of Tillamook • Mobile coverage along Highway 6 east of Tillamook • Mobile coverage on Highway 130 and Highway 101 in southern County
Cape Meares	• In-building coverage in Tillamook, Bay City, Garibaldi and along the coast in the central County • Some on-street coverage in Rockaway Beach • Some mobile coverage in Manzanita, Nehalem, Wheeler • Some mobile coverage on Highway101 south of Tillamook • Some mobile coverage on Highway 6 heading east of Tillamook (only in west half of County) • Decent mobile coverage on Highway 101 north of Tillamook through Rockaway Beach
Mt. Hebo	• On-street coverage in Tillamook • Some on-street and mobile coverage in Bay City and Garibaldi • Some mobile coverage in Rockaway Beach and Manzanita • Mobile coverage through most of the County south of Tillamook on the major roadways
Neahkahnie Mountain	• Good in-building coverage in Manzanita, Nehalem and Wheeler • Some in-building and on-street coverage in Rockaway Beach • Some mobile coverage in Garibaldi and Bay City • Good coverage along the coast in the northern half of the County • Some mobile coverage along the coast in the southern half of the County • Good mobile coverage on major roadways in northwest corner of County and Foss Road (until the terrain gets mountainous), and Highway 101 south through Tillamook
Neskowin	• No coverage in any of the County's cities • Decent coverage in southern section of County coastline • Good coverage on much of the major roadways in the southern section of the County
Ridge Road	• No coverage in any of the County's cities • Decent coverage in southern section of County coastline • Good coverage on much of the major roadways in the southern section of the County that are nearest to the coast
Rockaway Beach City Hall	• Good in-building coverage in Rockaway Beach • Some on-street and mobile coverage in Manzanita • Decent on-street and mobile coverage along coast in the northern half of the County.

Repeater Site	General Coverage Area
South Saddle	• Decent portable and mobile coverage in areas of the County directly north of the site • Mobile coverage on Highway 6 from the eastern border of the County for approximately 1/3 of the County; once Highway 6 gets farther west into the mountains, the coverage goes away
Triangulation Point	• Some mobile coverage in Tillamook, Bay City, Garibaldi, Rockaway Beach, Wheeler and Nehalem • Some on-street and mobile coverage in Manzanita • Some mobile coverage in eastern sections of Foss Road • Mobile coverage in eastern third and western third of Highway 6; the central third of Highway 6 is not well covered • Mobile coverage on Highway 101 through much of the County
Wilson River	• Some on-street and mobile coverage in Tillamook • Some mobile coverage in Bay City • Coverage on much of Highway 6 throughout the County, although a section directly south of the site is still uncovered • Some mobile coverage in the central part of the County's coastline

2.3.2.6 Results

Figures 1 through 8 show the predicted talk-out and talk-in coverage of the existing Fire Dispatch, Public Works and Sheriff channels. The maps show the composite coverage of all repeaters on each channel. Coverage maps for the Fire TAC channels[6] are included in *Appendix A, Fire TAC Radio Coverage Maps*.

Note: FE produced the existing system coverage maps to identify general areas lacking coverage, which will be used to choose the sites for the system upgrade that will meet the County's radio coverage needs. Our intent was not to depict exact coverage of the existing repeaters/channels. Our goal is to choose a set of sites for the conceptual design that have a high probability of meeting the County's coverage needs. The ultimate responsibility for providing the required coverage will fall on the implementation contractor, as a requirement specified in the Request for Proposals (RFP).

[6] Appendix A also includes the Cape Meares site on the Fire Dispatch channel to show the specific coverage from that site.

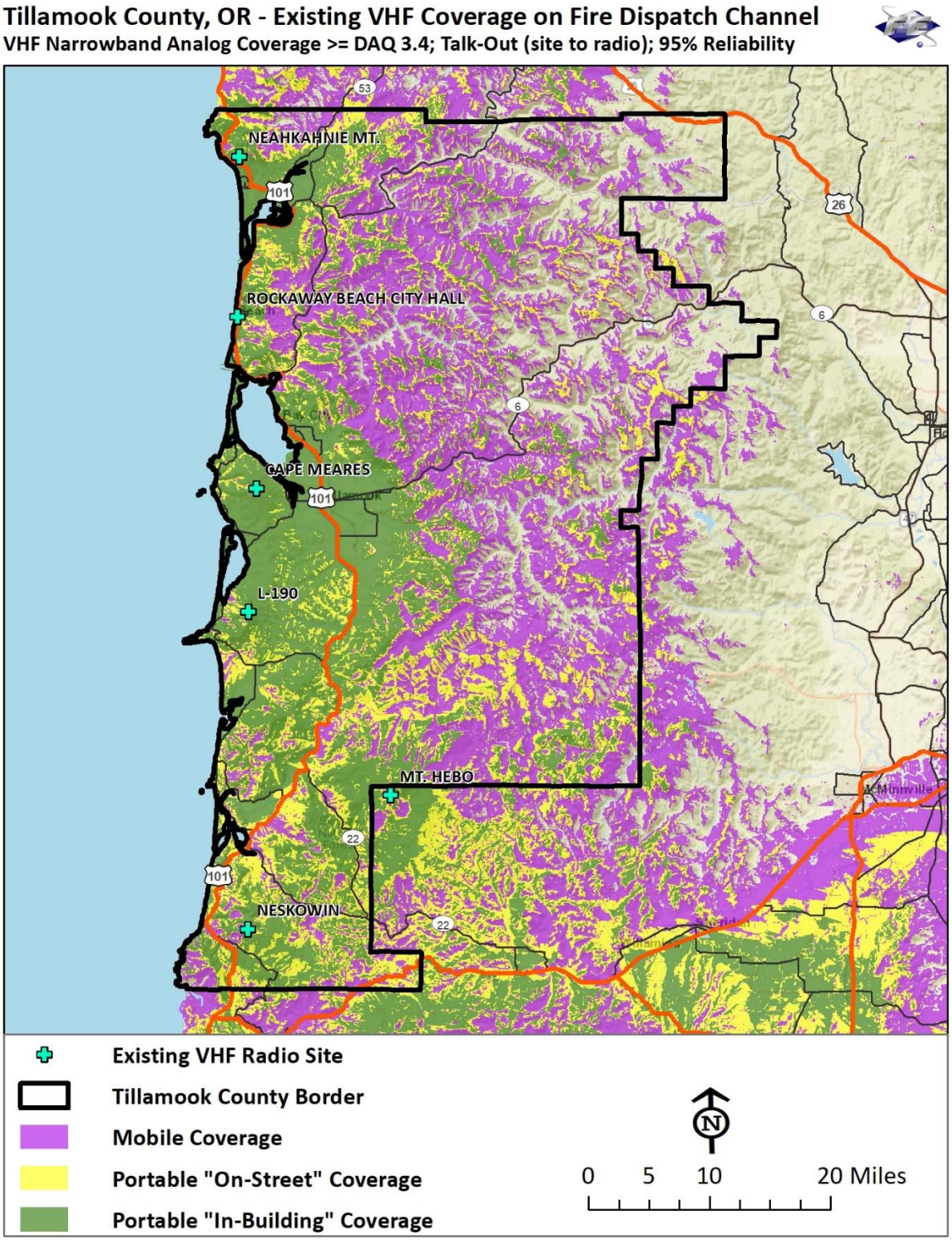


Figure 1 – Fire Dispatch Channel – Existing Radio Coverage– Composite Talk-Out

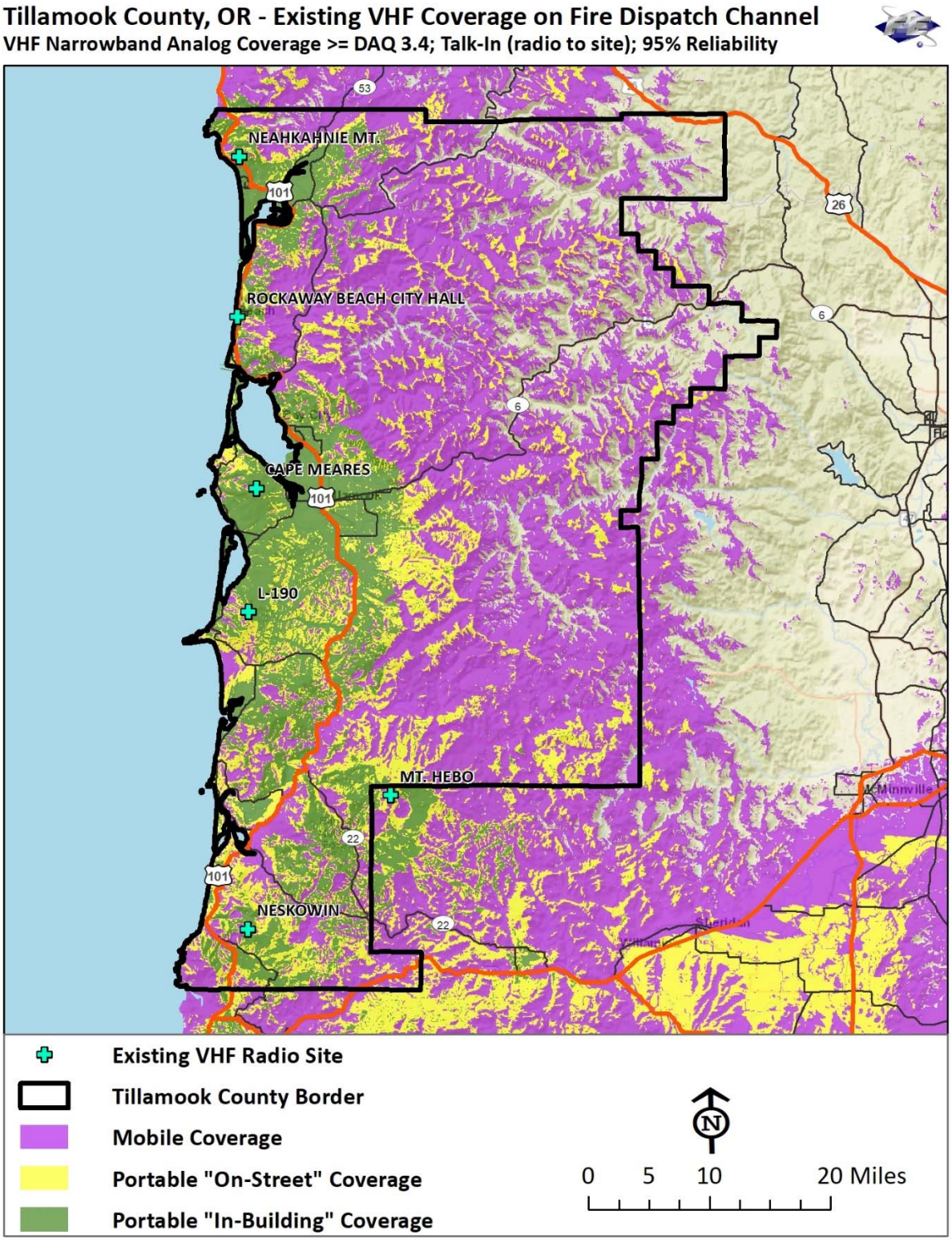


Figure 2 – Fire Dispatch Channel – Existing Radio Coverage – Composite Talk-In

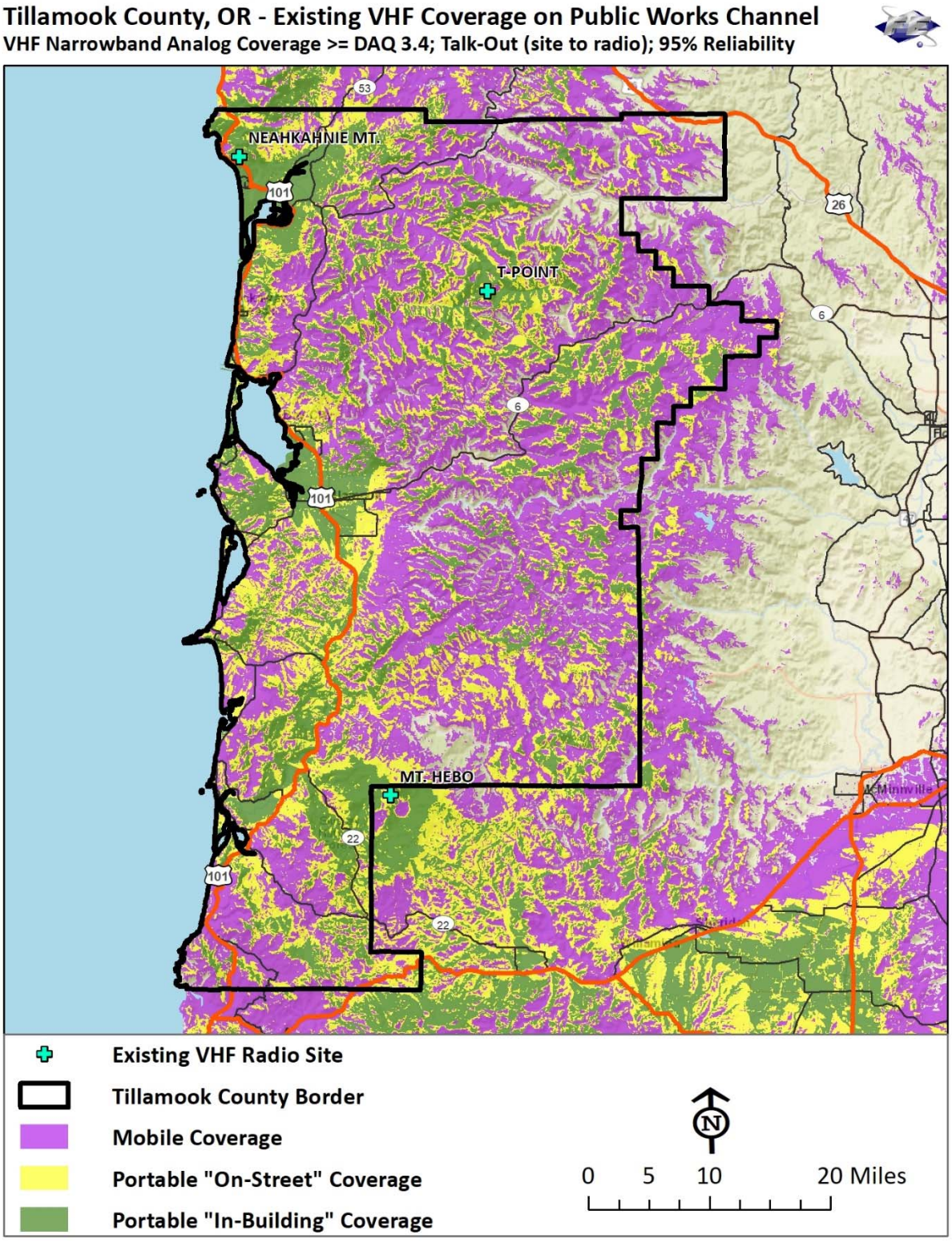


Figure 3 – Public Works Channel – Existing Radio Coverage– Composite Talk-Out

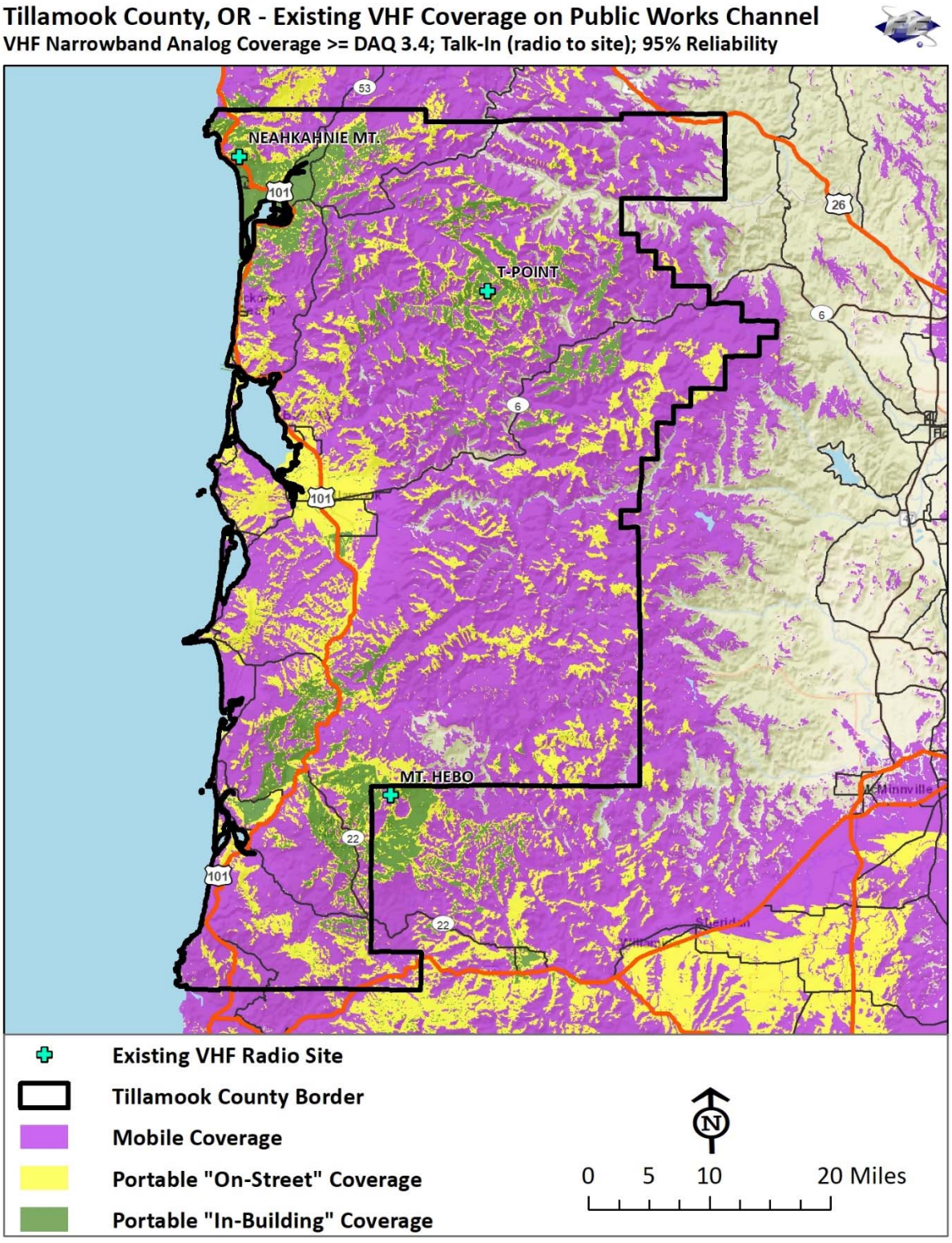


Figure 4 – Public Works Channel – Existing Coverage – Composite Talk-In

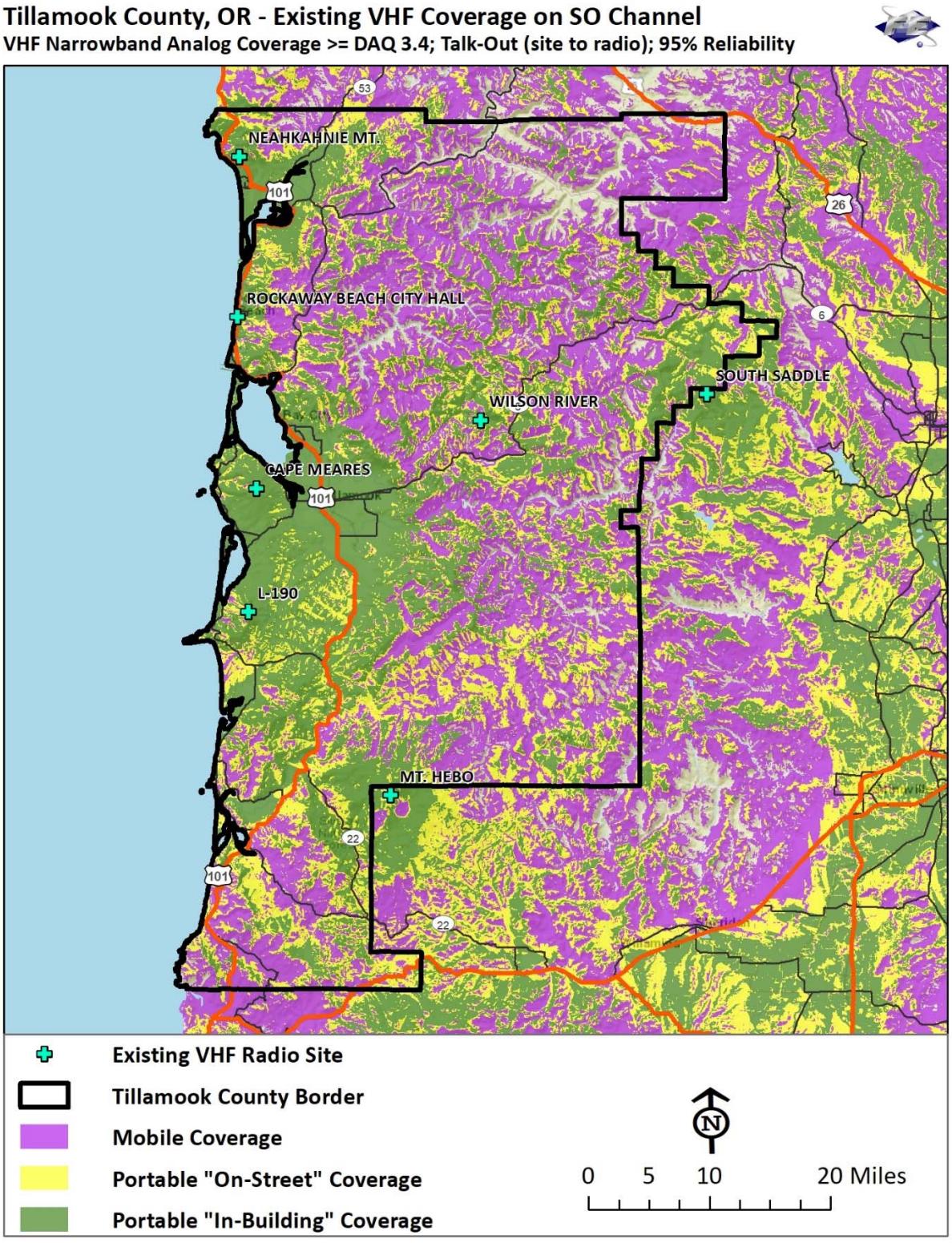


Figure 5 – SO Channel – Existing Radio Coverage – Composite Talk-Out

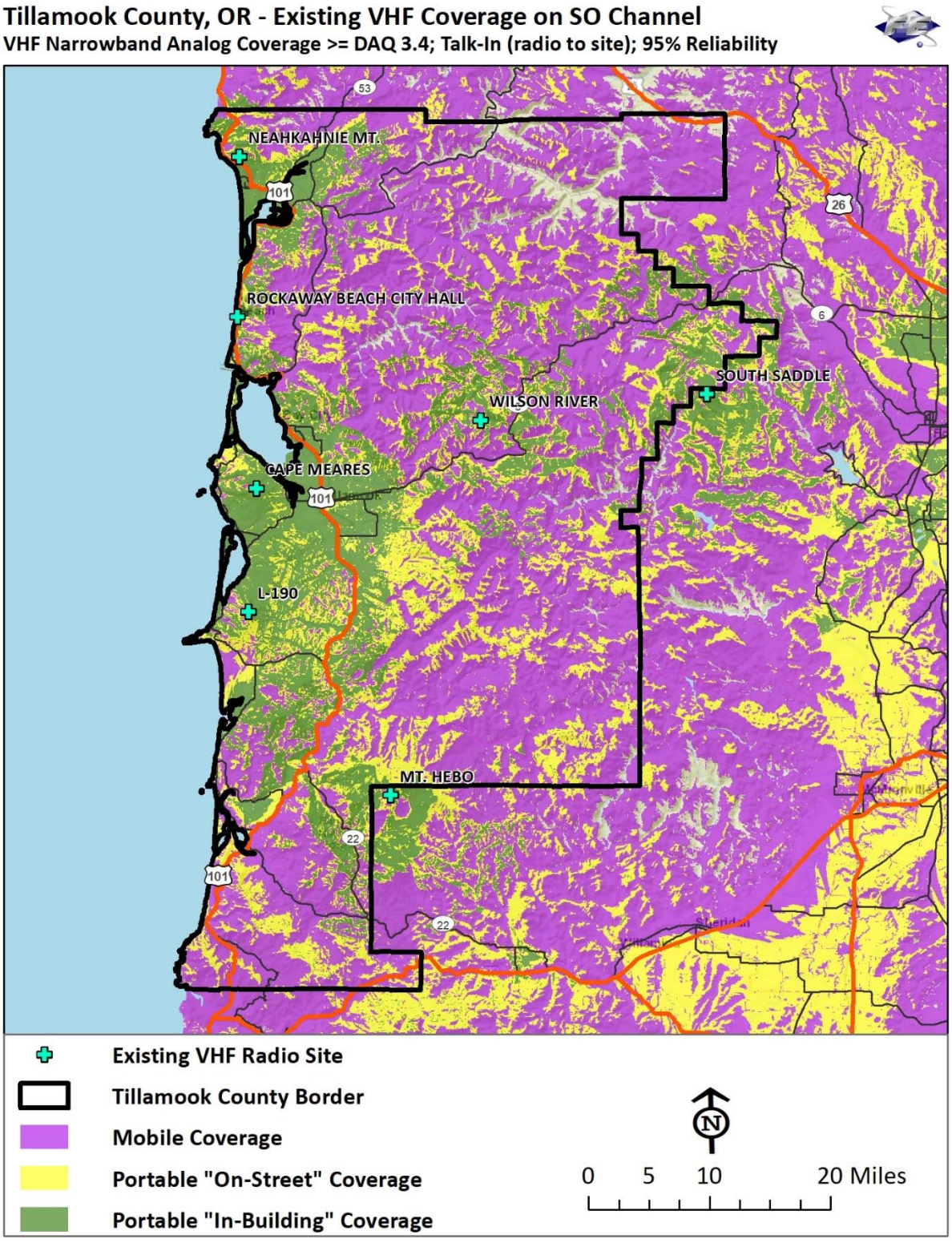


Figure 6 – SO Channel – Existing Radio Coverage – Composite Talk-In

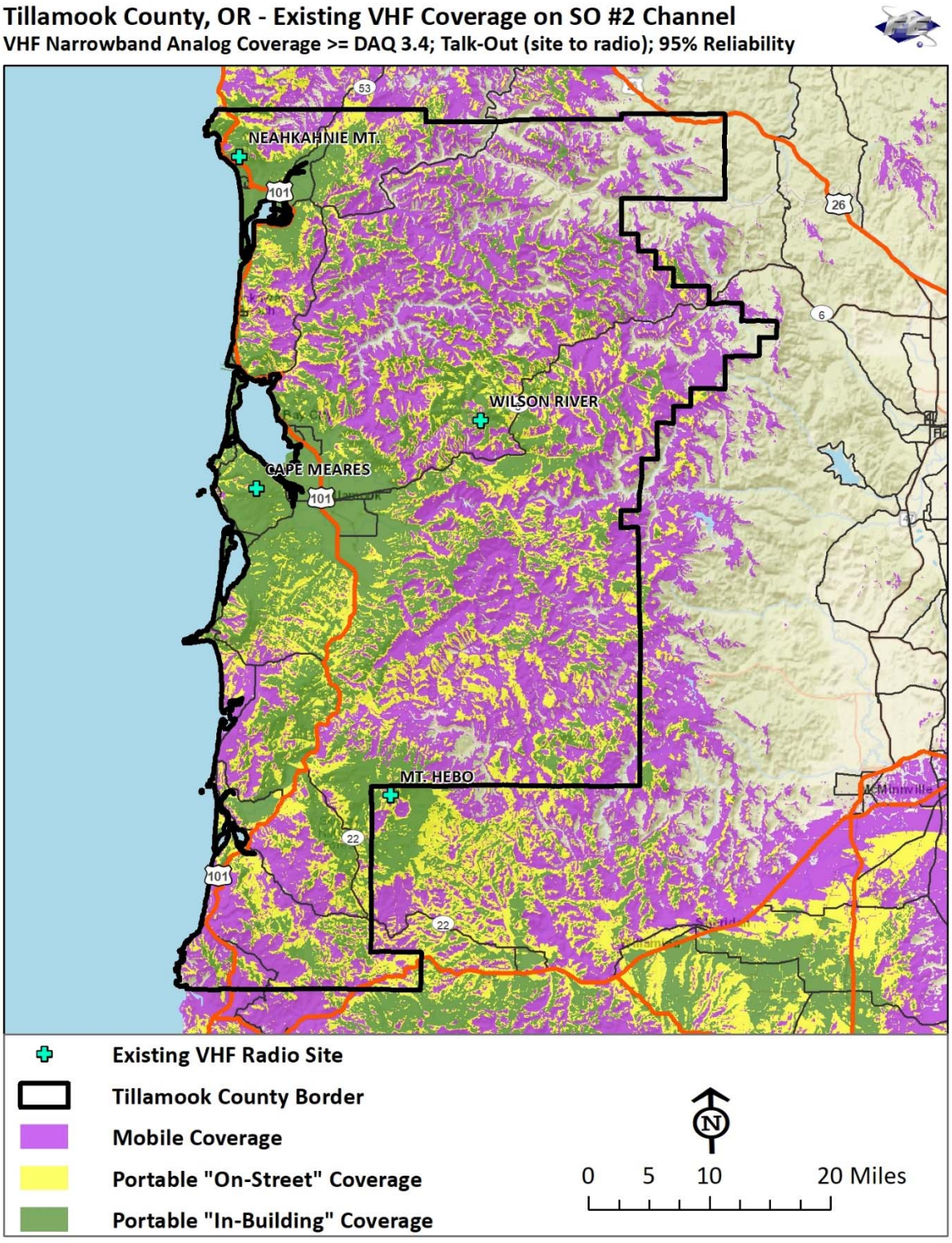


Figure 7 – SO #2 Channel – Existing Radio Coverage – Composite Talk-Out

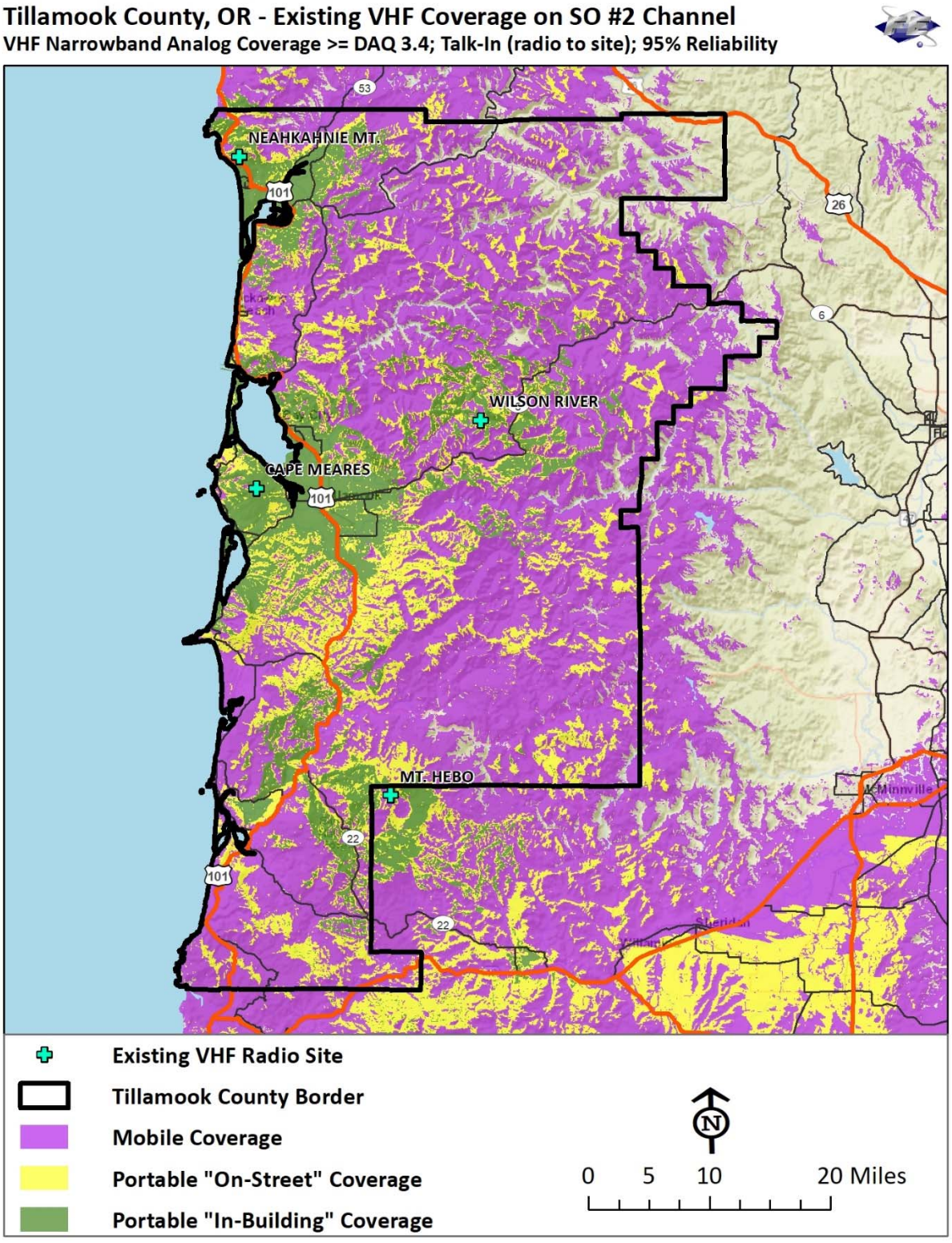


Figure 8 – SO #2 Channel – Existing Radio Coverage – Composite Talk-In

2.3.3 LMR System Assessment

Based on input received from County stakeholders in response to the stakeholder questionnaire and interviews, and through ***FE's*** analysis of existing system documentation and radio coverage, following are issues with the existing system that need to be addressed:

- **Aging Equipment** – The age of the County LMR equipment is 5 to 25 years, with much of it at end-of-life. End-of-life means that the manufacturer is no longer supporting the equipment which makes obtaining replacement parts much more difficult.

- **Inadequate Radio Coverage** – The Fire Dispatch, General, Public Works, SO and SO #2 channels use a different set of repeater sites to provide coverage in the County. However, none of the channels meet stakeholder needs for mobile and in-building and on-street portable in the population centers along the coast and mobile and on-street portable coverage along the main highways heading east (only mobile and on-street portable coverage is needed for the Public Works channel).

- **System Operational Issues** – The Fire Dispatch, General, Public Works, SO and SO #2 channels use the same frequency pair for all repeaters, which can create the following operational issues/difficulties:

    - Radio users need to know what repeater provides the best coverage for the area

    - Radio users must change channels on their radio as they move through the County to access different repeater sites

    - Radio users in the coverage footprint of one repeater site cannot talk directly to radio users in the footprint of another radio site, unless they are in a coverage overlap area of both sites

    - It can be difficult for dispatchers to know what repeater to respond on

    - Dispatchers may need to dispatch the same information on multiple repeater sites

    - If a radio user "keys up" a repeater not knowing that there is an existing incident operating off of an adjacent repeater site, there will be an RF interference issue in the coverage overlap areas of the two sites

- **RF Site Interference** – Based on feedback received from the County, there is a severe RF interference issue at Cape Meares, and to a lesser extent at Neahkahnie and South Saddle. There are various types of RF interference (i.e. co-channel, adjacent channel and receiver desensitization) that can render a channel inoperable (short or long term) or can reduce the coverage from a County repeater, requiring stronger than normal signal levels to overcome the RF interference.

- **Limited Remote System Management Capability** –The County does not have a network management system that allows maintenance staff to remotely monitor or troubleshoot LMR equipment.

2.4 Backhaul System

2.4.1 Overview

The microwave radio and fiber optic backhaul system provides connectivity between Tillamook 911 and the Fire, General, Public Works and Sheriff channel repeaters. Tillamook 911 owns and operates the microwave backhaul system. Tillamook Lightwave, an intergovernmental agency special district that was set up between the County, Tillamook People's Utility District (PUD) and the Port of Tillamook Bay, owns and operates the fiber optic system. Figure 9 is a logical diagram of the County backhaul system. Yellow lines are microwave links, blue lines are fiber optic links and red lines are VHF control station links.

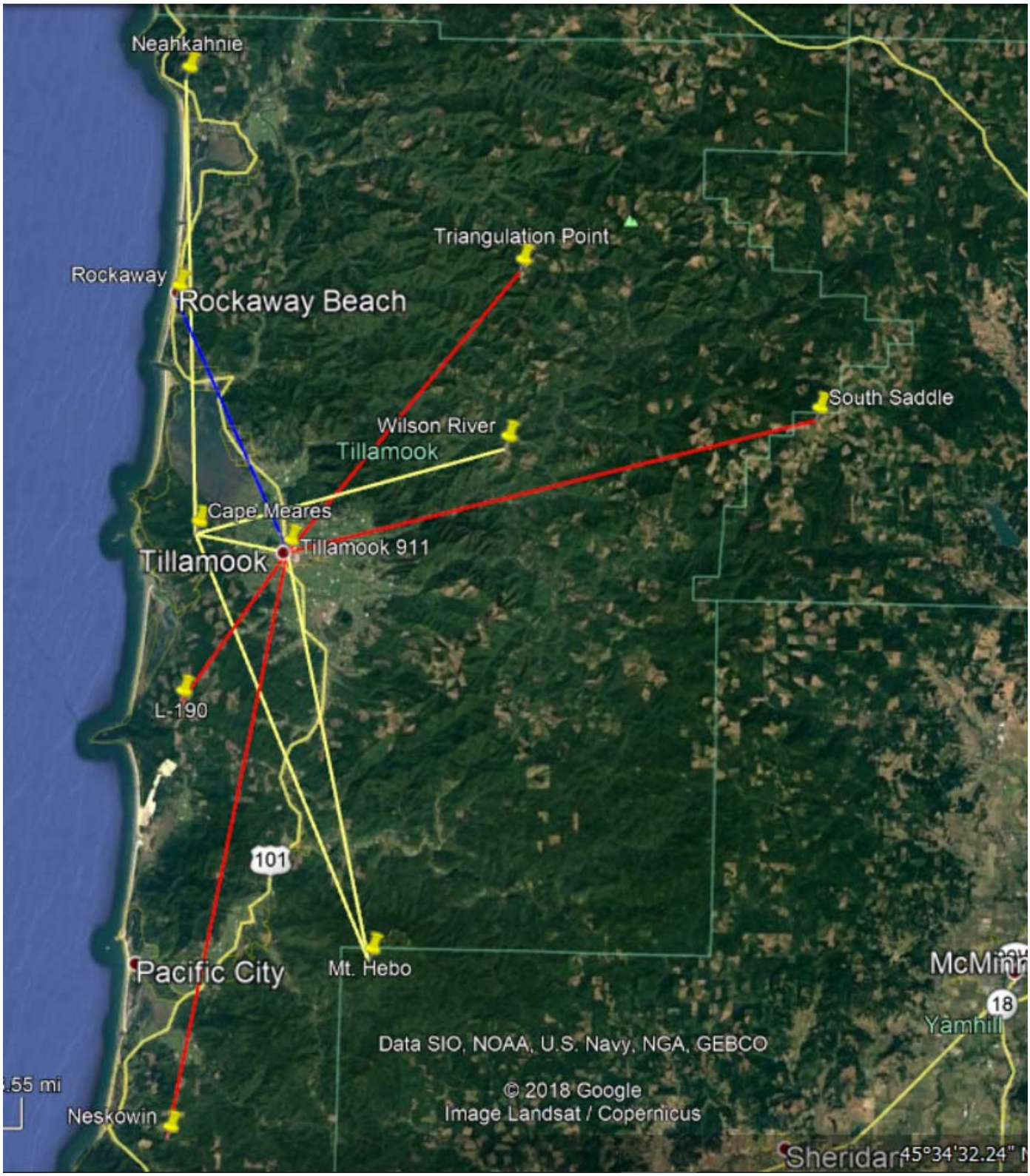


Figure 9 – Tillamook County Backhaul System

The microwave backhaul system utilizes Aviat Constellation time division multiplexed (TDM) system radios. Microwave links on the ring between Tillamook 911, Cape Meares and Mt. Hebo are non-protected and spur links are hot standby. The Tillamook Lightwave fiber optic system provides connectivity between Tillamook 911 and the SO, Fire and Fire TAC 1A channel repeaters at Rockaway Beach.

Tillamook 911 uses VHF control stations to access the following repeaters:

- Fire Dispatch, Fire TAC 2 and SO channel repeaters at L-190
- Fire TAC 6S and SO channel repeaters at South Saddle
- Fire TAC 6, General and Public Works channel repeaters at Triangulation Point
- General and Public Works channel repeaters at Mt. Hebo
- General and Public Works channel repeaters at Neahkahnie
- General channel repeater at Cape Meares

The EOC has backup VHF control stations to access the Fire Dispatch, Fire TAC 1, 2, 3 and 6, Public Works and SO #2 channels.

Establishing a reliable control link between the VHF control stations and repeaters requires a radio path with sufficient clearance above all terrain (i.e. hills and mountains). If a control link is blocked by terrain, RF signal refraction and/or reflections from mountains or buildings are required to establish communications, which typically leads to a much higher incidence of path fades or outages. Major path fades or outages result in loss of communications, which appear as a radio coverage issue or system outage to radio users in the field.

FE produced radio path profiles from Tillamook 911 to each of the repeater sites listed above to determine if the radio paths provided sufficient clearance above the terrain. As can be seen in Figures 9 through 14 the VHF links to Neahkahnie, South Saddle and Triangulation Point are blocked by terrain.

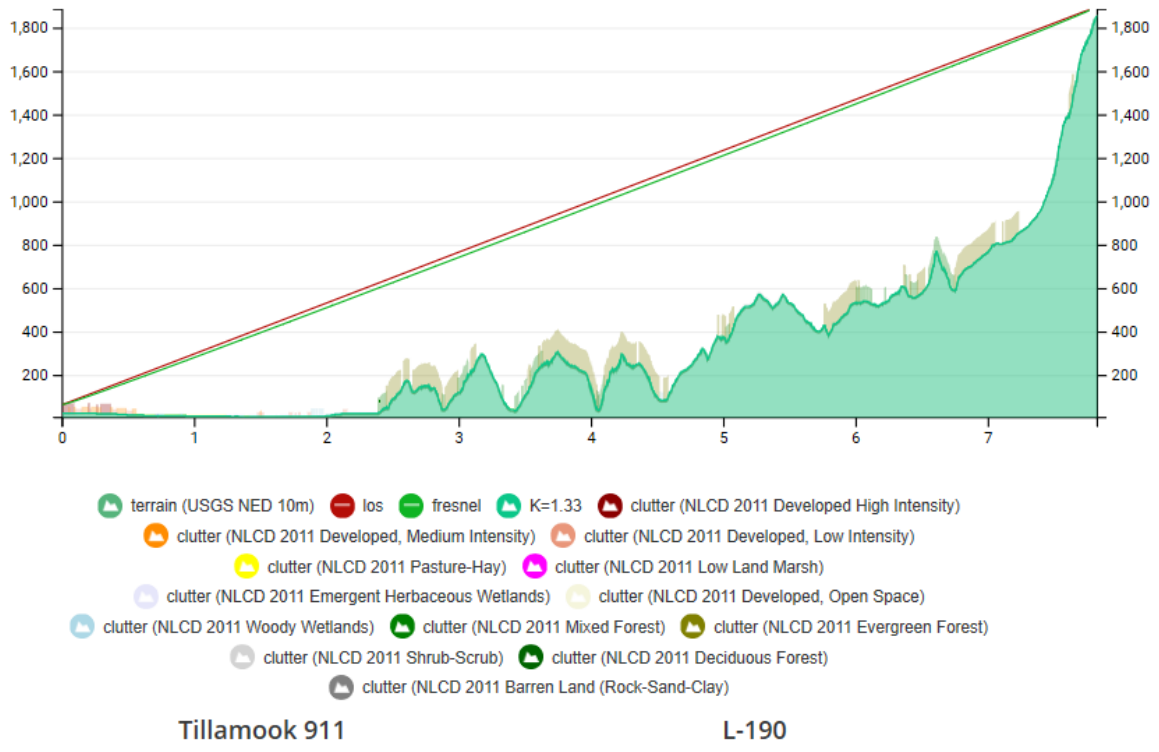


Figure 9 – Radio Path Profile – Tillamook 911 to L-190

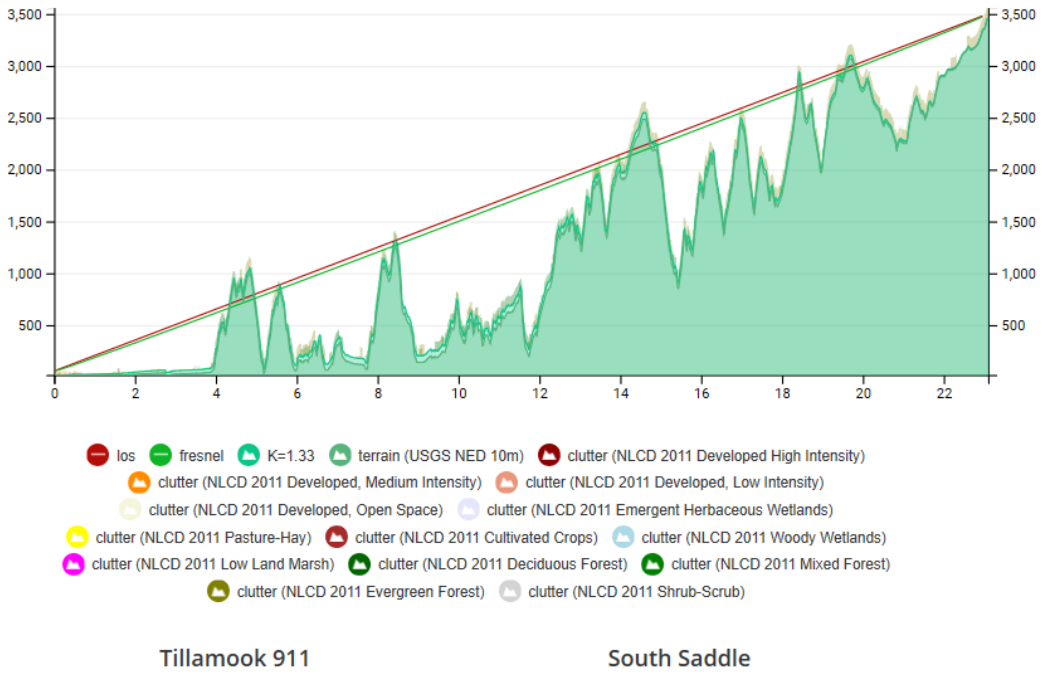


Figure 10 – Radio Path Profile – Tillamook 911 to South Saddle

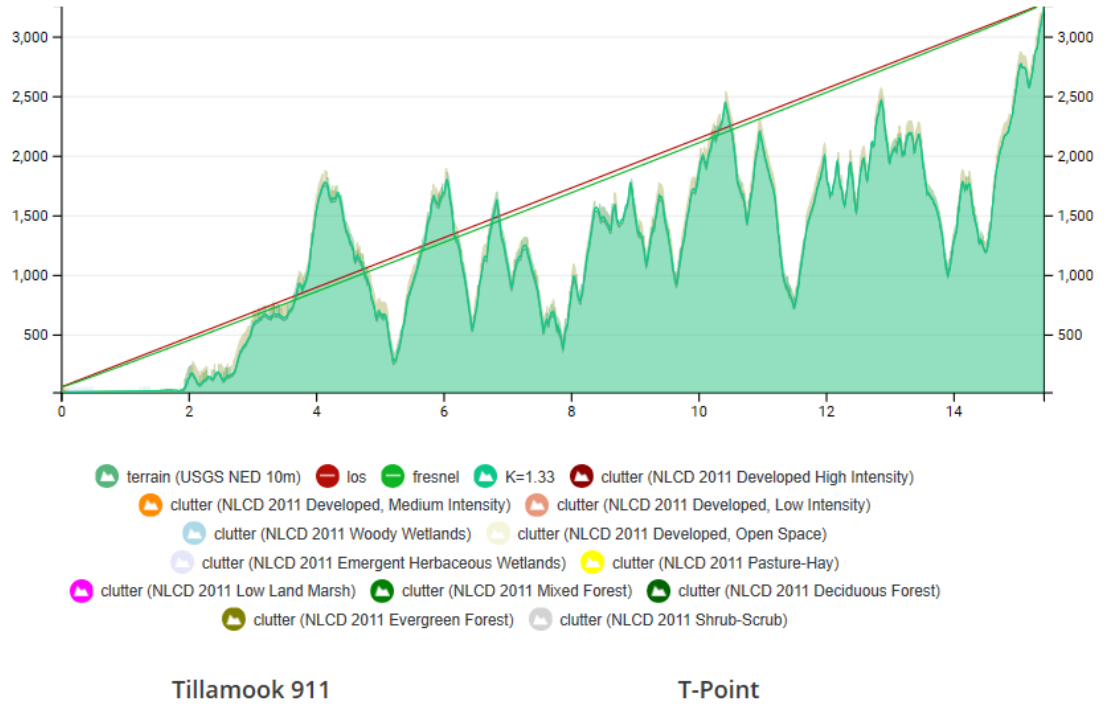


Figure 11 – Radio Path Profile – Tillamook 911 to Triangulation Point

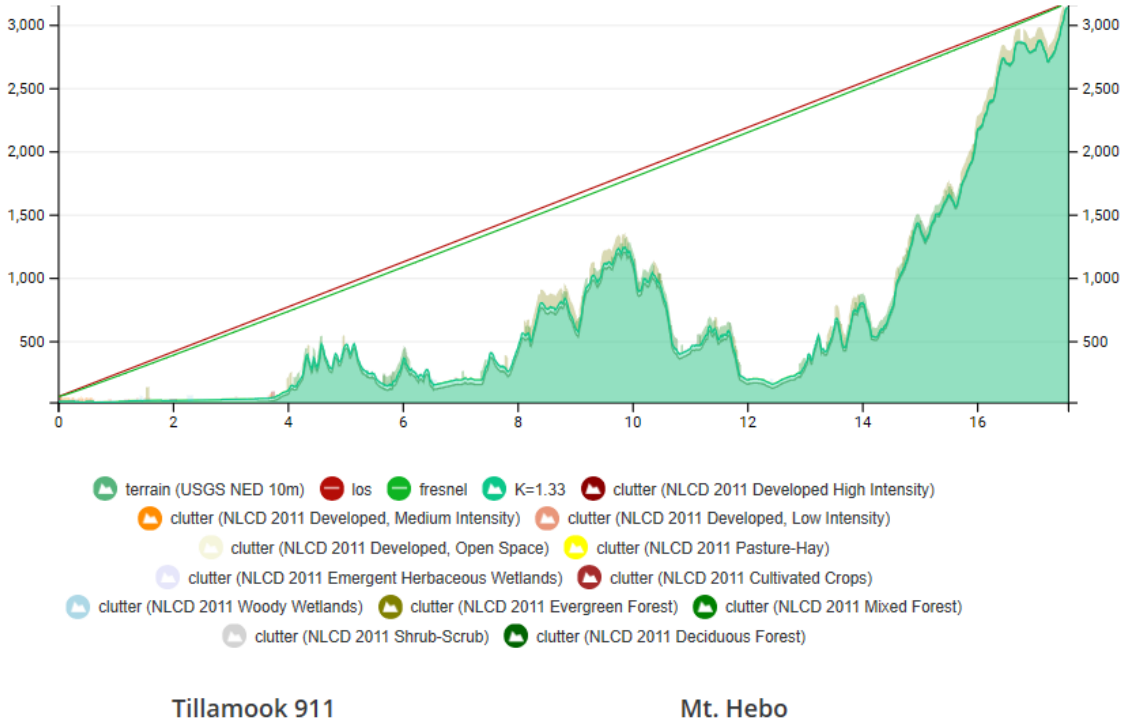


Figure 12 – Radio Path Profile – Tillamook 911 to Mt. Hebo

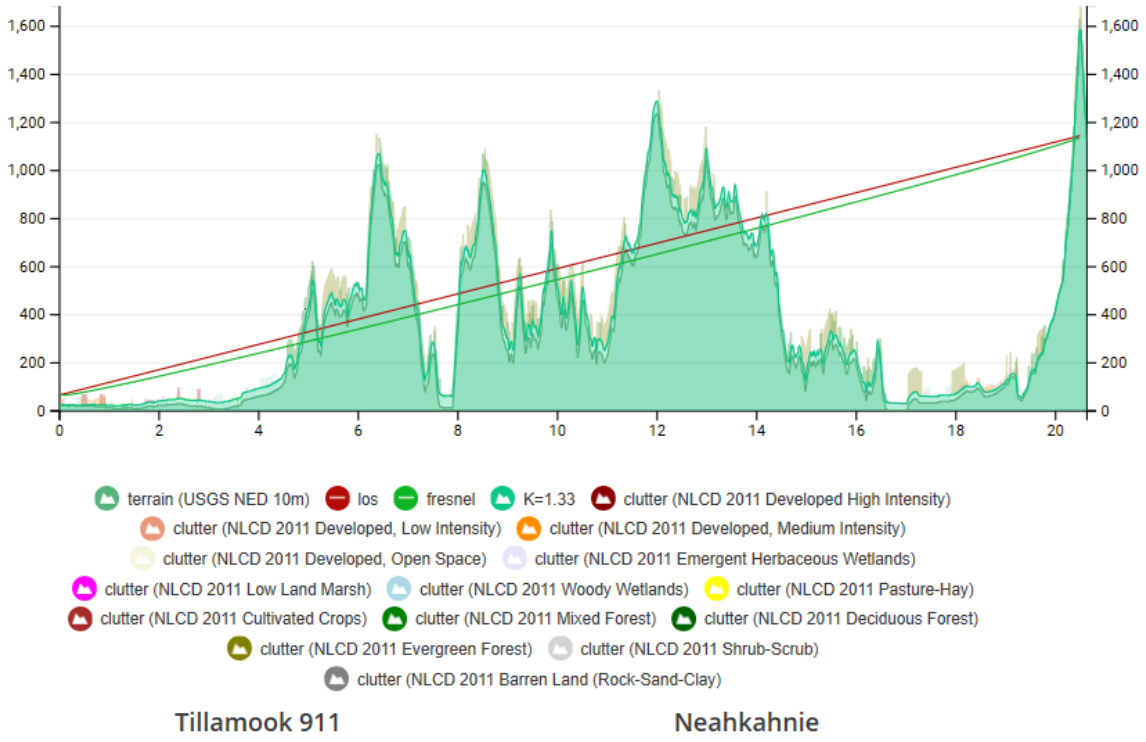


Figure 15 – Radio Path Profile – Tillamook 911 to Neahkahnie

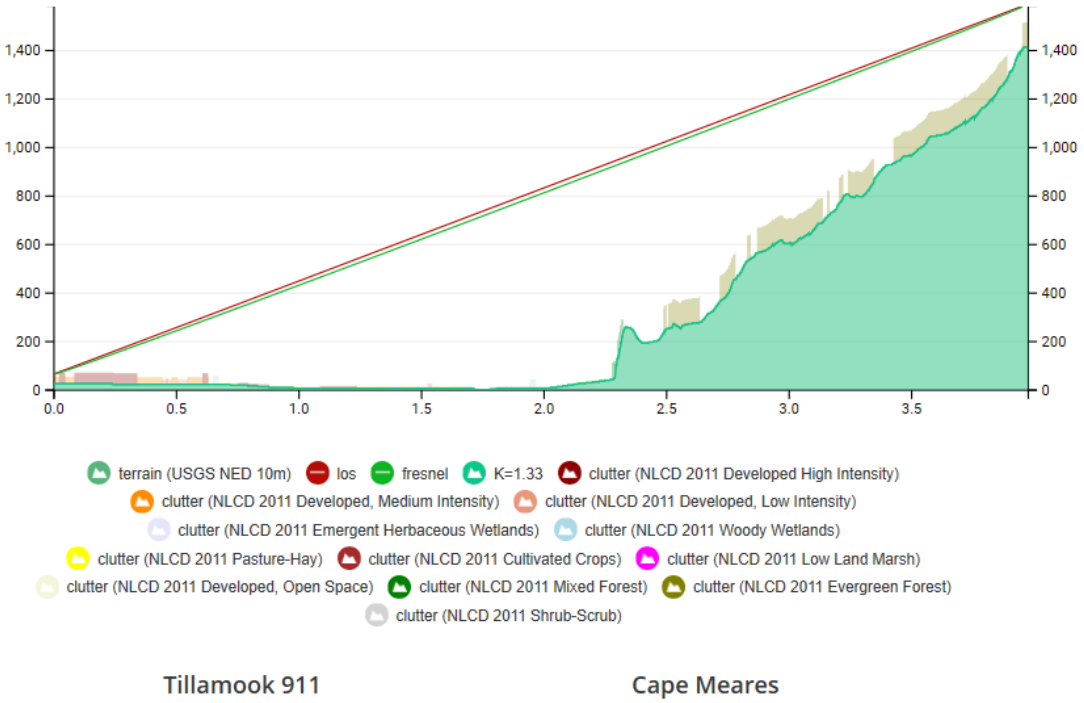


Figure 16 – Radio Path Profile – Tillamook 911 to Cape Meares

2.4.2 Backhaul System Assessment

Based on input received from County stakeholders in response to the stakeholder questionnaire and interviews, and ***FE's*** analysis of existing system documentation and existing microwave and VHF backhaul links, following are issues that need to be addressed:

- **Aging Equipment** – Most of the County's microwave backhaul equipment has reached end-of-life, with parts no longer available from the manufacturer. Tillamook 911 secured parts from Tri-Met in Portland when they replaced their system but getting replacement parts will continue to be more difficult.

- **Key Sites Not on Backhaul** – The L-190, South Saddle and Triangulation Point sites are not on the County backhaul system and rely on less reliable VHF links from control stations at Tillamook 911 for access to Fire, Public Works and SO repeaters. VHF control links are also used to access General and Public Works repeaters at Mt. Hebo, Neahkahnie and Cape Meares. *As* shown in *Section 2.4, Backhaul System*, the VHF paths from Tillamook 911 to Neahkahnie, South Saddle and Triangulation Point are blocked by terrain.

- **Limited Path Redundancy** – The County has established a microwave ring between Tillamook 911, Cape Meares and Mt. Hebo but the remaining backhaul sites do not have a secondary path to protect against a primary path failure

- **Limited Remote System Management Capability** – Tillamook 911 has an alarm system to monitor the microwave radio system. However, the County does not have a network management system that allows maintenance staff to remotely monitor or troubleshoot microwave radio equipment.

- **Older Technology** – The County's microwave backhaul system uses time division multiplexed (TDM) technology. The trend for public-safety systems is to transition from older TDM-based systems to internet protocol (IP)/multi-protocol labeling system (MPLS) systems offering additional bandwidth and flexibility to allow sharing between multiple agencies/entities while maintaining priority and bandwidth guarantees for critical traffic

2.5 Radio Site Assessment

FE conducted site surveys to the County radio sites shown in Figure 17, to confirm the site coordinates, elevation and tower heights, and to collect information on:

- Access road condition
- Tower and shelter condition
- Physical site security
- Grounding/lightning protection
- Tower and shelter space
- Power systems
- Needed site improvements
- Equipment inventory
- Heating, ventilating and air conditioning (HVAC)

FE assessed the feasibility of re-using the sites in a new system and found that many of the radio towers should support new antennas, however some of the equipment shelters and buildings housing the equipment require upgrades or replacement. Several sites have limited shelter and/or tower space and many will likely require upgrades to the electrical grounding systems, HVAC and/or emergency backup power systems. The assessment did not include tower structural analyses or tower climbs. Table 9 is a list of sites surveyed, including coordinates, ground elevation, and tower height.

Table 9 – County Radio Sites Surveyed

Site Name	Latitude	Longitude	Elevation (feet)	Tower Height (feet)	Comments
Neahkahnie Mountain	45°44'37.89"N	123°56'27.85"W	1563	30	
Rockaway Beach City Hall	45°36'36.01"N	123°56'39.17"W	20	45	5' tripod on 40' building
Cape Meares	45°27'57.68"N	123°55'15.29"W	1414	190	
L-190	45°21'43.94"N	123°55'48.78"W	1856	50	
Ridge Road	45°13'10.69"N	123°58'14.18"W	195	30 (pole)	
Neskowin	45° 5'43.15"N	123°55'51.72"W	1620	30 (pole)	
Mt. Hebo	45°12'28.46"N	123°45'36.27"W	3149	60	
Wilson River	45°31'23.60"N	123°39'10.38"W	2312	100	
T-Point	45°37'53.50"N	123°38'38.07"W	3290	30	
South Saddle	45°32'42.22"N	123°22'54.56"W	3484	40 (current) 180 (new)	
Tillamook 911	45°27'21.50"N	123°50'26.33"W	28	125	
County Justice	45°25'29.94"N	123°48'18.24"W	42	70	
County Courthouse	45°27'24.29"N	123°50'29.46"W	30	70	30' tower on 40' building

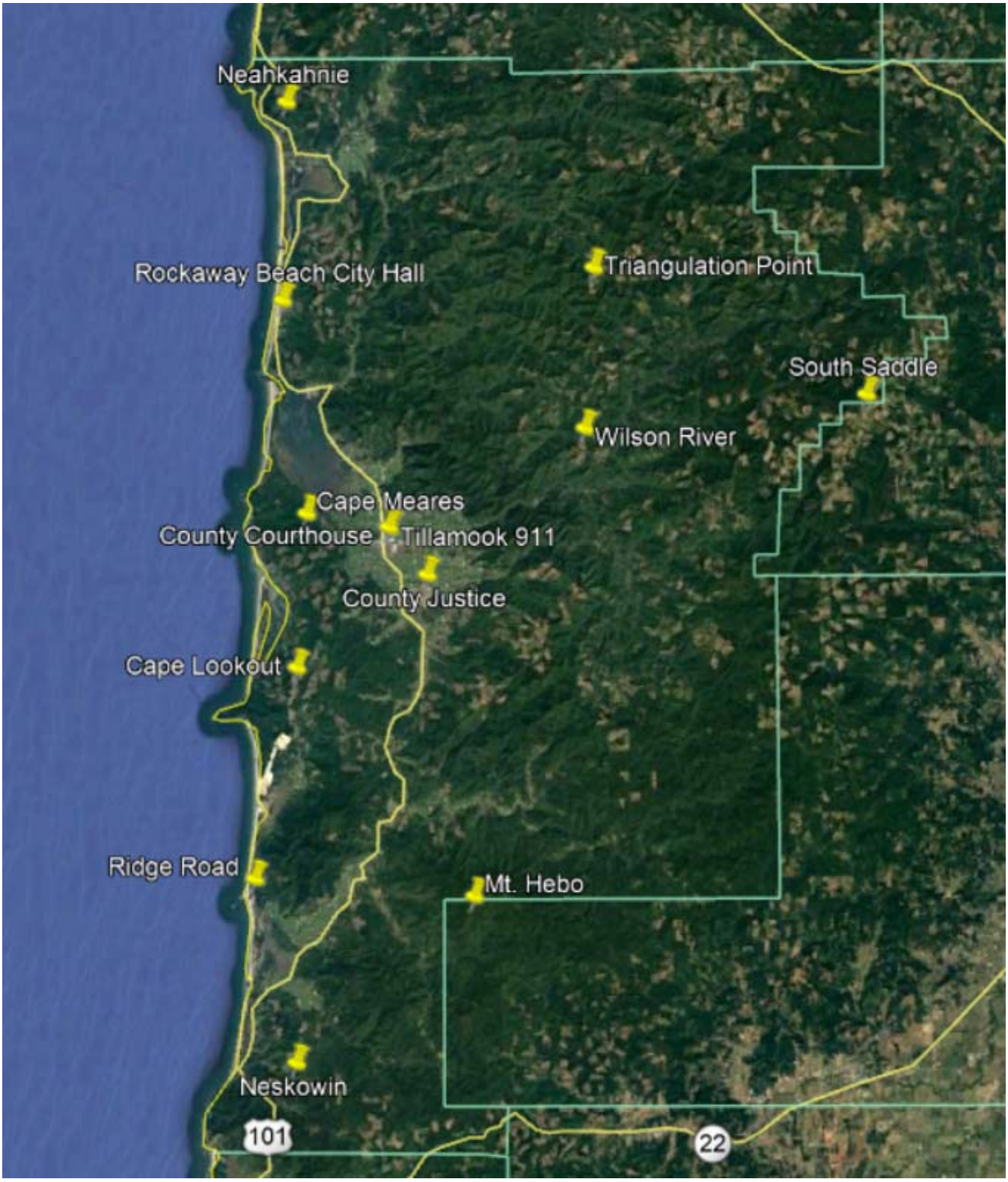
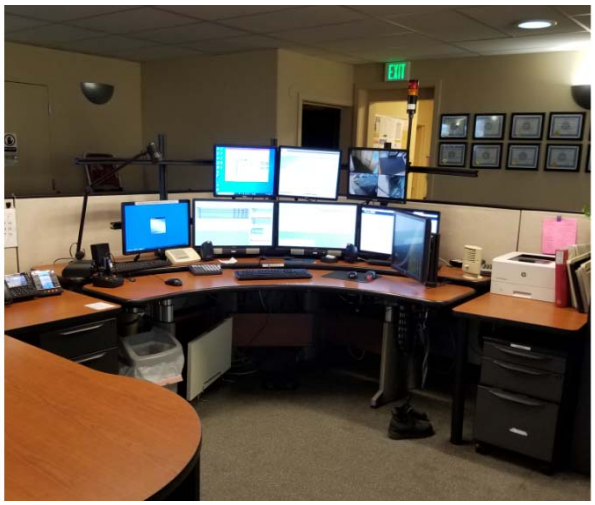


Figure 17 – Tillamook County LMR Radio Sites

2.5.1 Tillamook 911

Tillamook 911, located at 2311 3rd St in Tillamook, Oregon, houses the only PSAP in the County and is a secure site with card access, security cameras, and external lighting. The facility has HVAC, commercial AC power and a 125 hp CAT diesel generator.

Tillamook 911 has four Motorola MCC 5500 radio console positions, a VESTA 911 phone system with three ShoreTel internet protocol (IP) phones and a Stancil server-based logging recorder running on Windows Server 2012, which records analog voice for the radio system and digital IP for the phone system. Tillamook 911 also has six scaled-down Motorola MIP 5000 radio console positions for the incident command team which are bridged into their dispatch console radios and also has Motorola MIP 5000 consoles at the Adventist Health Tillamook and ambulance quarters in Manzanita, Garibaldi, Tillamook and Pacific City. A Zetron Model 25 paging system provides two-tone paging on the Fire Dispatch channel.



The radio, microwave, information technology (IT) equipment and dispatch console central electronics are in a 12' x 26' equipment room on the first floor, adjacent to the dispatch floor. Grounding updates may be required as there is no evidence of an interior halo, and all metal objects do not appear grounded. The equipment room houses eight standard 19” racks and two 4-post server cabinets with the equipment shown in Table 10 and has additional space for new equipment racks.

Table 10 – 911 Dispatch Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Harris Constellation microwave radio to Mt. Hebo
	Harris Constellation microwave radio to Cape Meares
	RFS dehydrator system
Rack 2	Microwave multiplex equipment
	Cisco network equipment (2800 Series, 1800 Series, and 2900 Series routers and switches)
Rack 3	Harris Intraplex Access Server (quantity - 4)
	AdTran networking equipment
	RAD Ipmux-24 equipment (Rockaway)
Rack 4	IT Cabinet, with Stancil logging recorder on Windows Server 2012

Rack/Cabinet	Equipment/Description
Rack 5	IT Cabinet, with UPS
Rack 6	Motorola Console Electronics
Rack 7	State Forestry, Motorola MTR2000
	Fire TAC 6A, Motorola ASTRO Consolette
	SO #2, Motorola MTR2000
	USCG, Motorola ASTRO Consolette
	OSP, Motorola ASTRO Consolette
Rack 8	Fire TAC 1, Motorola MTR2000
	Fire TAC 2, Motorola MTR2000
	Public Works (Backup), Motorola ASTRO Consolette
	Fire Dispatch (spare), Motorola MTR2000
	Tillamook PD 1, Motorola SLR8000
	Tillamook PD Dispatch, Motorola SLR8000
Rack 9	Motorola MIP 5000 Gateways (quantity - 16)
	Linksys SR224R 24-port switch
	ASTRON RM-35A power supply
	Dual Control Head, Kenwood KRK-3HD
	NorthStar Batteries (quantity - 2)
Rack 10	DC Power Supply, Eltek Flatpack 1500
	DC Power Supply, Batteries (quantity - 8)

Tillamook 911 has a 125’ monopole tower on the west side of the building, approximately 30’ from the building, with an ice bridge to support the transmission lines. The tower and ice bridge appear in good condition with no visual rusting or noticeable structural issues. The tower is fairly loaded with multiple antennas and dishes at different heights (from 30’ to 125’), but does have some space for new antennas, but a structural analysis would be needed prior to installation of any new antennas to verify that the maximum tower loading is not exceeded. The tower grounding system appears consistent with industry standards.

2.5.2 Cape Meares

The County leases space from SBA Communications Corporation at the Cape Meares radio site for the SO, SO #2 and Fire Dispatch channel equipment. The remote mountaintop site is approximately 7.5 miles west of Tillamook and a four-wheel drive (4WD) vehicle is required to access the site. The site is well secured, with a 100' x 190' chain link fence, fence lock, external lighting, security cameras and door alarms. This compound has eight equipment shelters of varying dimensions and other outdoor cabinets and has additional space within and outside the compound for additional structure(s).

The Cape Meares site has a 12' x 28' prefabricated, single room shelter that is partitioned into two sections by a chain-link fence and gate. The County's section is approximately 10'x12' on the north side of the shelter. The shelter is in good condition but may require minor grounding updates to comply with industry standards. The shelter has an HVAC system, commercial AC power and a 60 kW Cummins diesel backup generator (in a separate shelter).

There are nine equipment racks in the front part of shelter for other tenants, including Coast Guard, Vanir Broadband, KAIK, KTMK, KTCB, KDEP, and Pacificorp. The County section in the back has eight equipment racks, which includes Tillamook PUD, NOAA, and HAM radio equipment, as shown in Table 11. The County section has room for one more rack, but the other larger section has room for multiple racks. The shelter houses multiple racks of equipment as shown in Table11.

Table 11 – Cape Meares Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	County VHF combiner, Telewave pre-selectors and combiner (Model M101-150-5TR19SP)
Rack 2	County SO repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County SO #2 repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Fire Dispatch repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	Tillamook PUD Repeater, Motorola XPR8300 (Backup)
	Tillamook PUD Repeater, Motorola MTR3000
	County Fiber (Wave), Cisco SG300, Adva FSP 150CC
	County Courthouse Backup Data Server, Synology DS2015X5
	County UPS, Tripplite (Smart Online UPS)
Rack 3	County SO receiver, Motorola GPW8000 with MLC 8000 analog comparator
	County router, MikroTik RouterBoard RB3011 Ui AS-RM
	NOAA Equipment, Digi LR54, Cisco 1841
	NOAA Motorola CDM750, UHF, Armstrong NWR FMX-100B

Rack/Cabinet	Equipment/Description
Rack 4	Tillamook 911 Microwave radio, Harris Constellation, Neahkahnie
	Tillamook 911 Microwave radio, Harris Constellation, Wilson
	County DATARADIO Paragon3-UHF (to be removed)
Rack 5	Tillamook 911 Microwave radio, Harris Constellation, Mt. Hebo
	Tillamook 911 Microwave radio, Harris Constellation, Tillamook 911
Rack 6	County Multiplex Equpment, Intraplex Access Server
	Tillamook PUD Equipment, Cisco 2800 and 2900 Series
	County Dehydrator, RFS
Rack 7	County DC rack, Eltek Flatpack 1500
	County batteries (quantity – 8), Powersafe 12V155FS
Rack 8	HAM Radio, GE Cabinet, KA7AHV
Nine Racks on non-County side	Coast Guard, Vanir Broadband, KAIK, KTMK, KTCB, KDEP, and Pacificorp

The Cape Meares site has a 190', 4-leg, self-supporting tower that appears in good condition. While the tower is heavily loaded with many antennas and microwave dishes, there is available space at different heights, however, a structural analysis will be needed prior to the installation of any new antennas. All shelters and outdoor cabinets at this site have antennas and transmission lines on this tower. The County's receive antenna is at 180' and their transmit antenna is at 150'. There is a 15' ice bridge between the tower and shelter that appears in good condition. The tower grounding system appears consistent with industry standards with evidence of a single point ground system and tower ground ring. Minor grounding system upgrades may be needed, such as adding a tower ground bar.

There is a nearby tower that could be a potential obstruction to radio communications.

2.5.3 County Justice/Jail Facility

The County Justice Facility, in an industrial area at 5995 Long Prairie Road in Tillamook, houses the Tillamook County Sheriff's Department and Jail and serves as the backup 911 PSAP and Emergency Operations Center (EOC). The building requires card access and has security cameras and external lighting. The facility has HVAC, commercial AC power and a 200 kW Katolight backup generator with 1000-gallon Liquefied Petroleum Gas (LPG) tank.

The County's IT equipment and central electronics for the dispatch consoles are located in a 6' x 13' equipment room on the first floor. The room has limited space for a new equipment rack. Grounding upgrades may be needed, as there is no evidence of an interior halo, and all metal objects are not grounded. The equipment room houses three standard 19" racks with equipment as shown in Table 12.

Table 12 – County Justice Facility Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Motorola CENTRACOM Gold Elite card cages
	3COM 12-port switch
	APC Back-UPS 600
Rack 2	SO repeater, Kenwood TKR-750
	SO #2 control station, Kenwood mobile with Zetron tone remote adapter Model 250
	Fire Dispatch control station, Kenwood mobile with Zetron tone remote adapter Model 250
	Fire TAC1 control station, Kenwood mobile with Zetron tone remote adapter Model 250
	Fire TAC2 control station, Kenwood mobile with Zetron tone remote adapter Model 250
	Fire TAC3 control station, Kenwood mobile with Zetron tone remote adapter Model 250
	Fire TAC6 control station, Kenwood mobile with Zetron tone remote adapter Model 250
	PW/Siren control station, Kenwood mobile with Zetron tone remote adapter Model 250
Rack 3	IT equipment, including ADVA FSP 150CC, Cisco 2900, Eaton Evolution 3000 UPS

The EOC is approximately 20' x 30' and houses six operator positions, a large conference table and chairs and multiple television/monitors. Three operator positions are equipped with the Motorola CENTRACOM Gold Elite dispatch consoles and the other three positions are equipped with phone and/or mobile radio. There is also an Iridium satellite phone in the EOC.

There is a 70' monopole tower on the northwest side of the facility, approximately 5' from the building, with an ice bridge to support the transmission lines. The tower and ice bridge appear in good condition with no visual rusting or structural issues. The tower is heavily loaded with 20 antennas at heights from 12' to 63'. The tower has some available antenna space; however, a structural analysis would be needed prior to installation of any new antennas. The tower grounding system appears consistent with industry standards.

2.5.4 L-190

The L-190 site (also known as Cape Lookout) is a non-County site approximately 12 miles southwest of Tillamook, that houses equipment for the SO, Fire Dispatch, Fire TAC 2 and Siren Tone (activates siren for Barney reservoir) channels. The County has a 10-year ground lease from Stimson Timber Company. L-190 is a remote mountaintop site requiring 4WD vehicle access. Physical site security is minimal, with no perimeter fence or security cameras. However, the shelter is locked and has a door alarm activated.

Oregon Department of Transportation (ODOT) has a small shelter at the site, and the County has a 12' x 20' prefabricated, single room shelter that appears in good condition and has an HVAC system. The shelter has a grounding system, but minor upgrades may be needed to bring the site up to industry standards, including the grounding of all metal objects in the shelter. The shelter has two empty racks and there is space for new equipment racks. The shelter currently houses six standard 19" open racks for County equipment as shown in Table 13.

Table 13 – L-190 Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Empty
Rack 2	Empty
Rack 3	DEM Sirens, Kenwood TKR-740 w/ TPL RXR Series RF PA
Rack 4	County Fire TAC2 repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Spare TAC2 repeater, Kenwood TKR-740
Rack 5	County Fire Dispatch repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
Rack 6	County SO repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
Battery Bank	Batteries (quantity – 12), Trojan T-105

L-190 is a DC site with no commercial AC power. A 16 kW Generac generator (primary source) and solar power system (secondary source) provide power to a 12 volt battery bank. The site has a 1,000-gallon LPG tank that provides fuel to the generator.

The County has a 50', 3-leg, self-supporting tower for the County and ODOT antennas that is approximately 10' from the shelter, with an ice bridge to support the transmission lines. The tower and ice bridge appear in good condition with no visual rusting or structural issues. The County has their receive antenna at 50' and their transmit antenna at 35'. The tower has available space, but there are surrounding trees that could impact LMR coverage and/or microwave paths. All tower legs appeared to be grounded to a tower ground ring, however, a tower ground bar (TGB) was not installed.

2.5.5 Mt. Hebo

Mt. Hebo is a remote mountaintop site approximately 28 miles south of Tillamook that requires a 4WD vehicle to access the compound. Mt. Hebo is a very busy site shared by many tenants including Tillamook County, Tillamook PUD, National Oceanic and Atmospheric Administration (NOAA), Yamhill County, Forest Service and Civil Air Patrol. The County has repeaters for the SO, SO #2, Fire Dispatch, Fire TAC 3 and Public Works channels at the site.

The Mt. Hebo site has a single-room, 12' x 20' concrete shelter with land available for expansion, if needed. There is no perimeter fence at this site, but the shelter is locked and has cameras, door alarms, and exterior lighting. The shelter has commercial AC power and an HVAC system. The County has a 10 kW Kohler backup generator with two 500-gallon LPG tanks, and a 12 volt backup battery bank. The backup generator has its own 8' x 10' shelter approximately 30 yards from the equipment shelter.

There are 13 equipment racks in the shelter and open space for new equipment racks. The shelter is in good condition but may require minor grounding upgrades to comply with industry standards. Table 14 shows the equipment mounted in each rack.

Table 14 – Mt. Hebo Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Tillamook 911 Microwave radio, Harris Constellation
Rack 2	Tillamook 911 Microwave radios (quantity – 2), Harris Constellation
	County dehydrator, RFS
Rack 3	County multiplex equipment, Intraplex Access Server
	County DATARADIO Paragon3-UHF (to be removed)
Rack 4	County DC battery rack, Eltek Flatpack 1500
	County batteries, (quantity – 8), Powersafe 12V155FS
Rack 5	NOAA equipment, NWR-G100
Rack 6	Yamhill County repeater, Kenwood TKR 850
	Yamhill County battery modules BM-48-4
	Yamhill County repeater, Tait TB8100
Rack 7	County SO #2 repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	Forest Service repeater, Daniels P25
	Tillamook PUD repeater, Motorola XPR8300
	Tillamook PUD router, Cisco 2900 Series
	Tillamook PUD repeater, Motorola MTR3000
Rack 8	County SO repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Fire Dispatch repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Fire TAC3 repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County PW Repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
Rack 9	County combiner rack, Telewave M101150-5TR19SP
Rack 10	County UHF link, Kenwood TKR-850 (Channel Hebo 300)
	County UHF duplexer, BpBr Model WP-678
	Emergency Management Repeater, GE MASTR II
Rack 11	Empty; single battery at the bottom
Rack 12	Empty; County Dehydrator at the bottom, Andrew Model MT050B-81315
Rack 13	Civil Air Patrol, Motorola Cabinet

The Mt. Hebo site has a 60’, 4-leg, self-supporting tower on a 30’ x 30’ foundation approximately 8’ from the shelter, with an ice bridge to support the transmission lines. The tower has some visual rusting but no noticeable structural issues and the ice bridge appears in good condition with no noticeable structural issues. The County has their receive antenna at 45', transmit A antenna at 32’ and transmit B antenna at 16' on different legs. The tower is fairly loaded, but there is available space for new antennas and no potential obstructions that could degrade LMR coverage or a new microwave path. A structural analysis would be needed prior to installation of any new antennas. The tower grounding system appears consistent with industry standards as there is evidence of a single point ground system, tower ground bar and tower ground ring.

2.5.6 Neahkahnie Mountain

Oregon Rural Wireless Television manages the Neahkahnie Mountain radio site, which on Oregon State Parks managed land in the Oswald West State Park approximately 30 miles north of Tillamook. A 4WD vehicle is needed to access the site. Neahkahnie Mountain is a very busy site shared by many tenants including Tillamook County, Tillamook PUD, NOAA, Oregon State Police (OSP), and the KGW, KATU, and KOPB broadcast stations. The County has repeaters for the SO, SO #2, Fire Dispatch, Health, Fire TAC 1 (North), Public Works, and General North channels at the site.

The Neahkahnie Mountain site has a 12' x 16' concrete shelter with two rooms separated by a chain-link gate for different tenants. There is no perimeter fence or exterior lighting, but the shelter is locked and has cameras and door alarms. The shelter has an exhaust fan and heater for HVAC and commercial AC power, with a 100 kW LPG generator that provides backup power for the County site and a nearby commercial carrier site. The County also has a 12 volt backup battery bank. The shelter is very crowded with limited space for additional equipment and is in poor condition with signs of water intrusion and rust on doorways. Major grounding upgrades are needed to comply with industry standards. The shelter houses multiple racks of equipment as shown in Table 15. The County's radio equipment in Racks 1 through 5 is in the first narrow room (8.5' x 16') and the County's battery bank and other tenants' racks (6 – 11) are in the second larger room (3.5' x 16').

Table 15 – Neahkahnie Mt. Equipment Inventory

Rack/ Cabinet	Equipment/Description
Rack 1	County VHF combiner rack, Telewave Preselectors and Combiner Model M101-150-5TR19SP
Rack 2	County SO repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Fire Dispatch repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Health North repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Fire TAC1 (North) repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County Public Works repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	County General North repeater, Kenwood TKR-750 (Not in service)
Rack 3	Combiner cavities (quantity - 2)
	Tillamook PUD repeater, Motorola MTR3000
	Tillamook PUD router, Cisco 2900 Series

Rack/ Cabinet	Equipment/Description
	County SO #2 repeater, Kenwood TKR-740 w/ TPL RXR Series RF PA
	Tillamook PUD repeater, Motorola XPR8300 (backup, not in service)
Rack 4	Tillamook 911 Microwave link, Harris Constellation
	County Intraplex Access Server
	County router, Cisco 2800 Series
	County DATARADIO Paragon3-UHF (to be removed)
Rack 5	County DC power rack, Eltek Flatpack 1500
	County DC-DC converter, Newmar 48-12-30 RM
	County dehydrator, RFS
	County batteries (quantity – 4), Powersafe 12V155FS
Battery Bank	County batteries (quantity – 10), Trojan
Rack 6	NOAA equipment
Rack 7	Broadcast equipment, KGW
Rack 8	Broadcast equipment, KATU
Rack 9	Broadcast equipment, KOPB
Rack 10	OSP radio equipment
Rack 11	OSP power equipment

Neahkahnie Mountain has an “H-Frame” tower consisting of two 30’ wooden utility poles with multiple cross-braces in between them that is heavily loaded with limited space for new antennas. There are at least a dozen antennas mounted at the top and a dozen cellular amplifiers at the 5’ and 10’ levels. The County’s VHF High Band antenna is at 30’, approximately halfway in between the poles and the Tillamook 911 microwave antenna is roof-mounted on a 5’ metal pipe. There is a 10’ ice bridge between the shelter and tower.

This site is very busy with other antenna structures surrounding the shelter, including multiple Rohn light-duty towers, wooden poles and metal poles. These structures, along with surrounding trees, are potential obstructions for LMR coverage or microwave paths. All of the towers are heavily loaded, with limited space for new antennas. A structural analysis will be needed for all of these structures prior to installation of any new antennas. Grounding upgrades may be required for the primary H-Frame tower as it did not appear to have a tower ground bar or tower ground ring.

2.5.7 Neskowin

Neskowin is a remote mountaintop site approximately 33 miles south of Tillamook that requires a 4WD vehicle to access the site. The County leases space from Hancock Forest Management for their Fire Dispatch repeater, which is the only radio equipment at the site. The repeater equipment is installed in an outdoor cabinet and the antenna is installed on a 30' wooden utility pole. The outdoor cabinet is approximately 60" High x 25" wide x 34" deep and houses the equipment in Table 16.

Neskowin is a DC site with no commercial AC power. A solar power system (primary source) and wind generator (secondary source) provide power to a 12 volt battery bank. The solar panels are approximately 3' from the cabinet and the wooden pole is approximately 3' on the other side of the cabinet. There is a small ice bridge between the cabinet and the pole. Grounding upgrades may be required to the cabinet, ice bridge, and tower appurtenances.

Table 16 – Neskowin Equipment Inventory

Rack/Cabinet	Equipment/Description
Outdoor Cabinet	County Fire Dispatch repeater, Kenwood TKR-750
	County duplexer, Sinclair Model Q2222E
	County solar controller, Tri Star
Separate Toolbox	County batteries (quantity – 2) in cabinet, four additional batteries in separate toolbox

The site has no perimeter fence, exterior lighting or security cameras. There is additional land at the site, but there are trees all around that would be potential obstructions to LMR coverage and/or microwave radio paths. The County's antenna is mounted at approximately 20' and there is little space available for new antennas, with three other items mounted on the pole. The County advises that the yagi antenna used for a supervisory control and data acquisition (SCADA) system could be removed.

2.5.8 Ridge Road

Ridge Road is a County-owned site in a heavily-wooded area near Cape Kiwanda in the outskirts of Pacific City, approximately 23 miles southwest of Tillamook that houses a County repeater for the Fire TAC 3A channel. The site is accessed by a dirt road, but a 2WD vehicle may reach the site all year round.

The TAC 3A repeater is the only equipment at the site and is installed in an outdoor cabinet, mounted on a 30' utility wooden pole. The site has commercial AC power but does not have any secondary power sources. The outdoor cabinet is approximately 30" High x 25" wide x 34" deep and houses the equipment listed in Table 17.

The site has no perimeter fence, exterior lighting or security cameras. There is no additional land at the site for new shelters or towers, and there are many trees that would be potential obstructions to LMR coverage and/or microwave radio paths. The County's antenna is mounted at the top of the 30' pole and the pole has limited space for new antennas. There is small solar panel mounted on the pole at 18' that is not in use and could be removed.

Table 17 – Ridge Road Equipment Inventory

Rack/Cabinet	Equipment/Description
Outdoor Cabinet	County Fire TAC 3A repeater, Kenwood TKR-750
	County duplexer, Sinclair Model Q2222E
	County power supply, Duracomm

2.5.9 Rockaway Beach

The County has SO, Fire Dispatch and Fire TAC 1A repeaters at Rockaway Beach City Hall at 276 US-101 in Rockaway Beach, which is approximately 15 miles northwest of Tillamook. Rockaway Beach City Hall is a secure site with card access, security cameras and external lighting and has HVAC, commercial AC power and a 100 kW diesel backup generator.

The County's radio equipment is located in 4' x 4' chain link cage in a corner of a 20' x 30' mechanical room on the second floor. The cage currently houses two standard 19" open racks for County repeaters as shown in Table 18.

Table 18 – Rockaway Beach Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	County Fire Dispatch repeater, Kenwood TKR-740
	County channel controller, Kenwood (Not in service)
	County SO repeater, Kenwood TKR-740
	County Fire TAC 1A repeater, Kenwood TKR-740
	County power distribution, Duracomm
	County Fire Dispatch TPL RXR Series RF PA
	County SO TPL RXR Series RF PA
	County TAC1 TPL RXR Series RF PA
Rack 2	County VHF combiner rack, Telewave Dual Isolator (Qty. 3), Model T-1560
	County VHF preselector, Telewave Model TPCP-1544CSP
	County VHF receiver Distribution Panel, Telewave Model TWR4-150-12
	County Power Supply, Astron Model RM-50M-BB
	County 12V battery (quantity – 1), Napa Legend75 Model 9848

There is no space in the cage for additional racks, however there is additional space in the mechanical room for expansion. Grounding upgrades may be required as there is no evidence of an interior halo, and all metal objects do not appear grounded.

There is a 5' tripod on the roof of the 40' City Hall building. Access to roof was not available during site survey but based on inspection from the ground the antenna structure appears in good condition. The County has two antennas at same level on the tripod and there is no space on existing tripod for additional antennas; however, the County advises that other areas of building roof are available for other structure(s). The distance between the antenna mount structure and the equipment room is approximately 40'. The grounding system may require upgrades, but rooftop access is needed to confirm.

2.5.10 South Saddle

South Saddle is a remote mountaintop site in the Tillamook State Forest approximately 40 miles east of Tillamook, that requires a 4WD vehicle for site access. The site is a very busy, shared by many tenants including Tillamook County, Northwest Gas, West Oregon Electric Coop, Forest Grove, Stimson and BLM. The County has SO and Fire TAC 6S repeaters at the site.

There is a 10' x 18' concrete shelter at the site, with no perimeter fence or exterior lighting. However, the shelter is locked and there are cameras and door alarms. The shelter has an HVAC system and commercial AC power, with a Kohler backup generator and two 500-gallon LPG tanks. The shelter is very crowded with limited space for additional equipment and is in poor condition and will need grounding system upgrades to comply with industry standards. The shelter currently houses multiple racks and cabinets as shown in Table 19.

Table 19 – South Saddle Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Empty
Rack 2	Northwest Gas equipment
Rack 3	Northwest Gas equipment
Rack 4	Northwest Gas equipment
Rack 5	Other Tenant equipment
Rack 6	Other Tenant equipment
Rack 7	Other Tenant equipment
Rack 8	Other Tenant equipment
Rack 9	County power supply, Astron

Rack/Cabinet	Equipment/Description
	County SO repeater, Kenwood TKR-750
	County Fire TAC 6S repeater, Kenwood TKR-750
	County duplexer, Telewave TPRD-1544C
	County duplexer, Sinclair Q2220E
Rack 10 (cabinet)	West OR Electric Coop equipment
Rack 11 (cabinet)	Forest Grove equipment
Rack 12	Stimson and BLM equipment
Rack 13	County Transportation equipment

South Saddle has three self-supported towers, including a 3-leg, 40' Rohn light-duty tower, a 3-leg, 40' medium-duty tower, and a 30' 4-leg, medium-duty tower. The County has a receive antenna at 40' and a transmit antenna at 30' on the 3-leg, 40' medium-duty tower. The 4-leg, 30' medium-duty tower has several LMR antennas and large microwave antennas mounted on it and the 40' Rohn light-duty tower is loaded with other tenants' antennas. All three towers are heavily loaded, with limited space for new antennas. A structural analysis will be needed prior to installation of any new antennas. Grounding upgrades may be needed as the three towers did not appear to have a tower ground bar or tower ground ring.

The County advises that a new site is being constructed adjacent to the existing site and will include a new 180' self-supported tower and equipment shelter (dimensions unknown). At the time of the site survey, there was evidence of excavation and site work in progress. There is a nearby abandoned site (with tower and shelter) that could be a potential obstruction, however, the County advises that the site is planned for demolition.

2.5.11 Tillamook County Courthouse

The County has an SO channel receiver and SO, Fire Dispatch and Fire TAC 1A repeaters at the Tillamook County Courthouse at 201 Laurel Avenue in Tillamook. The County Courthouse requires card access and has security cameras and external lighting. The County Courthouse building has an HVAC system, commercial AC power and a Cummins backup generator with 1000-gallon diesel tank.

The County's radio equipment is located in a 15' x 15' equipment room on the bottom floor (below ground), which has space for new equipment racks. Grounding upgrades may be needed as there is no evidence of an interior halo and all metal objects do not appear grounded. The equipment room houses seven 4-post open frame server racks with the equipment shown in Table 20.

Table 20 – Tillamook County Courthouse Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	County IT equipment
Rack 2	County IT equipment
Rack 3	County IT equipment
	County SO receiver, Motorola GPW8000 with MLC 8000 Analog Comparator
Rack 4	County IT equipment
Rack 5	County IT equipment
Rack 6	County IT equipment
Rack 7	County IT equipment

There is a 3-leg, 30' Rohn light-duty, guyed tower on the roof of the 40' County Courthouse. Roof access was not available during site survey due to work in progress, but based on inspection from a distance, the tower appears in good condition. The County has a single receive antenna at 30' on the tower and there are two other antennas mounted at 15' that other departments use. There is limited space on the tower for additional antennas and a structural analysis will be required prior to installation of any new antennas. The tower is approximately 40' from the equipment room. The tower grounding system may require upgrades, but roof access is needed to confirm. The County advises that other areas of the roof are available for other structures.

2.5.12 Triangulation Point

Triangulation Point (also called T-Point) is remote mountaintop site in the Tillamook State Forest, approximately 28 miles northeast of Tillamook and has repeaters for the Fire TAC 6, Public Works, Health Department and General East channels. The County Transportation and Emergency Management departments also have equipment at this site. A 4WD vehicle is needed for site access.

T-Point is on leased land managed by Oregon Department of Forestry. Physical site security is minimal, with no perimeter fence, exterior lighting or security cameras. However, the shelter is locked and has door alarm activated. The County has an 8' x 12' single-room, military electrical shelter that appears in good condition. The shelter currently houses three standard 19" open racks for County repeaters as shown in Table 21.

Table 21 – T-Point Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	County PW repeater, Kenwood TKR-750
	County Health repeater, Kenwood TKR-750
	County Fire TAC 6 repeater, Kenwood TKR-750
	County General East repeater, Kenwood TKR-750
	County combiner, Telewave preselectors TPCP-1543C and TPCP-1544C, Compact Distribution Panel TWR8-150-1R
Rack 2	County Transportation repeater, Kenwood NEXEDGE
	County Transportation duplexer, Telewave TPRD-4544, VHF
Rack 3	Emergency Management repeater, Motorola Radius GR1225 with Decibel Duplexer

T-Point is a DC power site with no commercial AC power, with a 6 kW gasoline generator, two variable output wind turbine generators and four 3' x 6' solar panels that provide power to a 12 volt battery bank. The shelter does not have HVAC and grounding system upgrades may be needed to meet industry standards. All metal objects did not appear to tie to the grounding system. The three racks currently installed have open space and there is space for new equipment racks within the shelter.

The T-Point site has three 30' Rohn light-duty, 3-leg, self-supported towers, installed on three corners of the shelter. The County has a receive antenna at 20' on one of the towers

and a transmit antenna at 15’ on another tower at the opposite corner of the shelter. This configuration provides approximately 5’ and 15’ of vertical and horizontal separation, respectively. All three towers have multiple antennas, so there is limited space for new antennas. A structural analysis will be needed prior to installation of any new antennas. Grounding upgrades may be needed as the towers did not appear to have a tower ground bar or tower ground ring. There is space available at the site for new towers and/or shelters, but there are trees all around that would be potential obstructions to LMR coverage and/or microwave radio paths.

2.5.13 Wilson River

The County leases space at the Wilson River site from the Oregon Department of Transportation on agreement between ODF/ODOT on ODF managed land. The Wilson River site is in the Tillamook State Forest, approximately 15 miles northeast of Tillamook and requires a 4WD vehicle for site access. The site houses equipment for Tillamook PUD, Oregon DOC, ODOT and OSP. The County has SO, SO #2 and Fire TAC 6W channels at the site.

The Wilson River site is well secured with a 60' x 60' chain link fence, fence lock, external lighting, security cameras and door alarms. There is additional space for new towers and/or shelters.

The site has a 12’ x 28’ prefabricated, single room shelter that appears in good condition. The shelter has an HVAC system and commercial AC power, with a Kohler backup generator (in a separate, adjacent shelter) and a 1,000-gallon LPG tank. The shelter grounding system appears consistent with current industry standards, with an interior halo, and all racks, equipment, and metal objects tied to a single point ground system. The shelter currently has ten racks and a battery bank installed. Two racks are currently empty, and there is open space for new equipment racks. The standard 19” open racks have the following equipment installed as shown in Table 22.

Table 22 – Wilson River Equipment Inventory

Rack/Cabinet	Equipment/Description
Rack 1	Tillamook 911 Microwave radio, Harris Constellation to Cape Meares
	County multiplex equipment, Intraplex Access Server
	County DATARADIO Paragon3-UHF (to be removed)
Rack 2	County DC-DC converters, Newmar Model 48-12-15 RM (Qty. 2), and Model 48-1000RM
	County router, Cisco 1700 Series
	Tillamook PUD repeater, XPR8300 (backup)
	County Fire TAC 6W repeater, Kenwood TKR-750
	County SO repeater, Kenwood TKR-750
	County SO #2 repeater, Kenwood TKR-750
	Tillamook PUD router, Cisco 2900 Series
	Tillamook PUD repeater, MTR3000
Rack 3	Empty
Rack 4	County combiner rack, Telewave multicoupler TMC155X5X511501, Combiner M108-150-5TRM
Rack 5	Oregon DOC repeater, Harris MASTR III UHF
Rack 6	OSP repeaters (quantity – 2), Harris MASTR III VHF
Rack 7	OSP/ODOT Netguardian/Coastcom Wideband IAD
Rack 8	Empty
Rack 9	Empty
Rack 10	County battery rack, C&D Sageon II Power System
Battery Bank	County batteries, C&D Technologies ms-endur II, Qty. 24, model AT-19P

Wilson River has a 100', 3-leg, self-supporting tower to support the antennas for the multiple tenants. The tower has some visual rusting but no other noticeable structural issues. The tower is approximately 20' from the shelter, with an ice bridge to support the transmission lines. The ice bridge appears in good condition with no noticeable structural issues. The County has their receive antenna at 60' and transmit A and B antennas at 35' on different legs. The tower has space for additional antennas and there are no potential obstructions around the site. A structural analysis will be needed prior to installation of any new antennas. The tower grounding system appears consistent with industry standards as there is evidence of a single point ground system, tower ground bar and tower ground ring.

3. Needs Assessment

FE submitted a questionnaire to County radio system users to obtain feedback related to the ability of the Fire, Public Works and Sheriff channels to meet their operational requirements, and to identify needed improvements. ***FE*** then interviewed stakeholders from the County departments and other agencies in the County using the County radio system to expand on or clarify their responses to the questionnaire. Following is a summary of the information obtained in response to the questionnaire and interviews.

3.1 Radio Coverage

Stakeholders reported poor radio coverage for all County radio channels, which is primarily due to the mountainous terrain and dense trees throughout substantial portions of the County. As expected, portable on-street coverage is worse than mobile coverage and portable in-building coverage is almost non-existent throughout much of the County. The sections below describe the coverage needs and existing problem areas for the Fire, Public Works and Sheriff radio channels.

3.1.1 Required Radio Coverage

The Adventist Health Ambulance Service, fire departments, public works and law enforcement agencies operating on the County radio system require mobile and on-street portable radio coverage throughout the County. In addition, the Adventist Health Ambulance Service, fire departments and law enforcement agencies would like improved in-building portable radio coverage in the population centers. Table 23 identifies the primary focus areas for radio coverage.

Table 23. Primary Focus Areas for Radio Coverage

Population Centers	Highways	Other
North County (Brighton, Manzanita, Nehalem and Wheeler)	Highway 53 from Highway 101 north to the County border	Miami Foley Road, Foss Road Northfork Road along Nehalem River Short Sands/Smugglers Cove
Central County (Bay City, Garibaldi, Netarts, Oceanside, Rockaway Beach and Tillamook)	Highway 6 from Highway 101 east to the County border Highway 131 Whiskey Creek/Cape Lookout Highway	Bayocean Spit Trask River Road to Recreation/County Park area (approximately 15 miles east of Tillamook) Browns Camp to recreation area 10 miles northeast of South Saddle

Population Centers	Highways	Other
		Diamond Mill ATV recreation area 10 miles east of Triangulation Point
South County (Beaver, Cloverdale, Hebo, Neskowin and Pacific City)	Highway 22 south from Highway 101 to Highway 130 Highway 130 southeast from Highway 101 to the County border Blaine Road/Upper Nestucca River Road from Highway 101 to County Border	Sandlake Road
Countywide	Highway 101 through the County	

3.1.2 Existing System Problem Areas

Table 24 shows existing radio coverage problem areas as reported by the fire departments and law enforcement agencies operating on the County radio system, understanding that the coverage problem areas vary for the Fire, Public Works and Sheriff channels, because each channel uses a different subset of the County radio sites.

Table 24. Existing Radio System Problem Areas

North County	Central County	South County
Highway 101 north of Manzanita near the County border	Some areas of Garibaldi	Beach from Pacific City north to Cape Lookout Road
Highway 53 from the intersection of Highway 53/Lucky Lane north to the County border	Northern half of Bay City is poor from L190, but covered well by Cape Meares	Along Highway 858
Miami Foley Road from Highway 53 south to Highway 101	Beach area west of Tillamook Bay is poor from L190, but good from Neahkahnie	Neskowin
Rockaway Beach area	The beach area in Oceanside	Spotty on Highway 101 from Neskowin to Lincoln County border
Recreation area approximately 8 miles northeast of Triangulation Point	Recreation area about 15 miles east of Tillamook	
	Highway 6	
	Recreation area approximately 1 mile east of South Saddle (near Washington County border)	

3.2 Channel Capacity

FE posed questions in the questionnaire and during the stakeholder interviews to obtain feedback regarding channel usage and congestion to determine whether the County has enough radio channels to support operations. Overall, channel capacity does not seem to be an issue most of the time, however, the SO and Fire channels can experience congestion at peak call times such as holiday weekends and during seasonal tourism periods.

3.2.1 Sheriff

Stakeholders from the Sheriff and local police departments reported that the existing SO and SO #2 channels are sufficient and no additional channels are needed. However, the buildout of the SO #2 channel for countywide coverage would be beneficial so that the channel could be used for special events, thus freeing up the SO channel for normal operations.

It was mentioned that better radio channel discipline could reduce channel loading, especially during tourist season and random peak periods in the offseason.

3.2.2 Fire/EMS

Overall, it seems that channel congestion is not a major issue, however, stakeholders expressed the need for the Fire Dispatch channel to be countywide and said that a countywide Fire/EMS TAC channel would be helpful for water rescues and two-alarm fires as units are responding from different parts of the County.

Fire and EMS are dispatched on the Fire Dispatch channel and are then moved to a command TAC channel based on their location. Incident operations is assigned to a simplex channel, which works well to limit congestion on the command TAC channels. Channel congestion can be an issue when there is more than one incident in the same area of the County and operations stays on the command TAC channel.

3.2.3 Public Works

Public Works did not express the need for additional channels.

3.3 Interoperability

Interoperability can sometimes be a technical issue, when agencies that need to talk to each other are on different frequency bands or use different system types (i.e. analog conventional and digital trunked). There are ways to address these issues, but they can

be challenging. In response to the questionnaire and during the interviews, respondents mentioned that most agencies/departments operating in the County are on the VHF band and operate on conventional systems. Therefore, interoperability is made possible by:

- County departments programming other departments/agencies channels in their mobile and portable radios and vice versa
- Lending portable radios to other agencies responding to an incident

Following is additional stakeholder input regarding interoperability:

- The capability to interoperate is included in the radio programming, but there is no training on how to use the radio in this fashion other than direct knowledge. Training is key, along with and updated maintenance schedule to confirm frequency/PL changes across agencies
- The County depends on outside agencies having the County frequencies in their radios
- Some console patching is used
- There is no countywide channel for use in Tillamook County

3.4 System Reliability

Stakeholders were asked questions about existing system reliability. Following are their responses for both the microwave backhaul and LMR systems.

3.4.1 Microwave Backhaul

Following are comments received from stakeholders regarding microwave radio backhaul system reliability:

- Occasionally there are microwave backhaul outages due to transmit/receive part failure
- There have been some weather related low received signal level (RSL) issues, especially with on the Cape Meares to Neahkahnie path
- The microwave backhaul is reaching end-of-life so will need to be replaced. As antennas/equipment are replaced, we note improvements

- Cape Meares has a lot of "noise" so getting away from that "noise" would be helpful

3.4.2 Land Mobile Radio Systems

Overall the LMR system has been reliable, but following are specific comments from County stakeholders:

- Much of the equipment has reached end-of-life
- The eastern sites have access issues in the winter
- Recently the Fire Dispatch channel repeater at Cape Meares was not providing coverage to fire units for paging, then last week it was offline entirely
- There have been outage issues with the Public Works repeaters at Triangulation Point and Neahkahnie

3.5 Other

Following are other issues raised by County stakeholders:

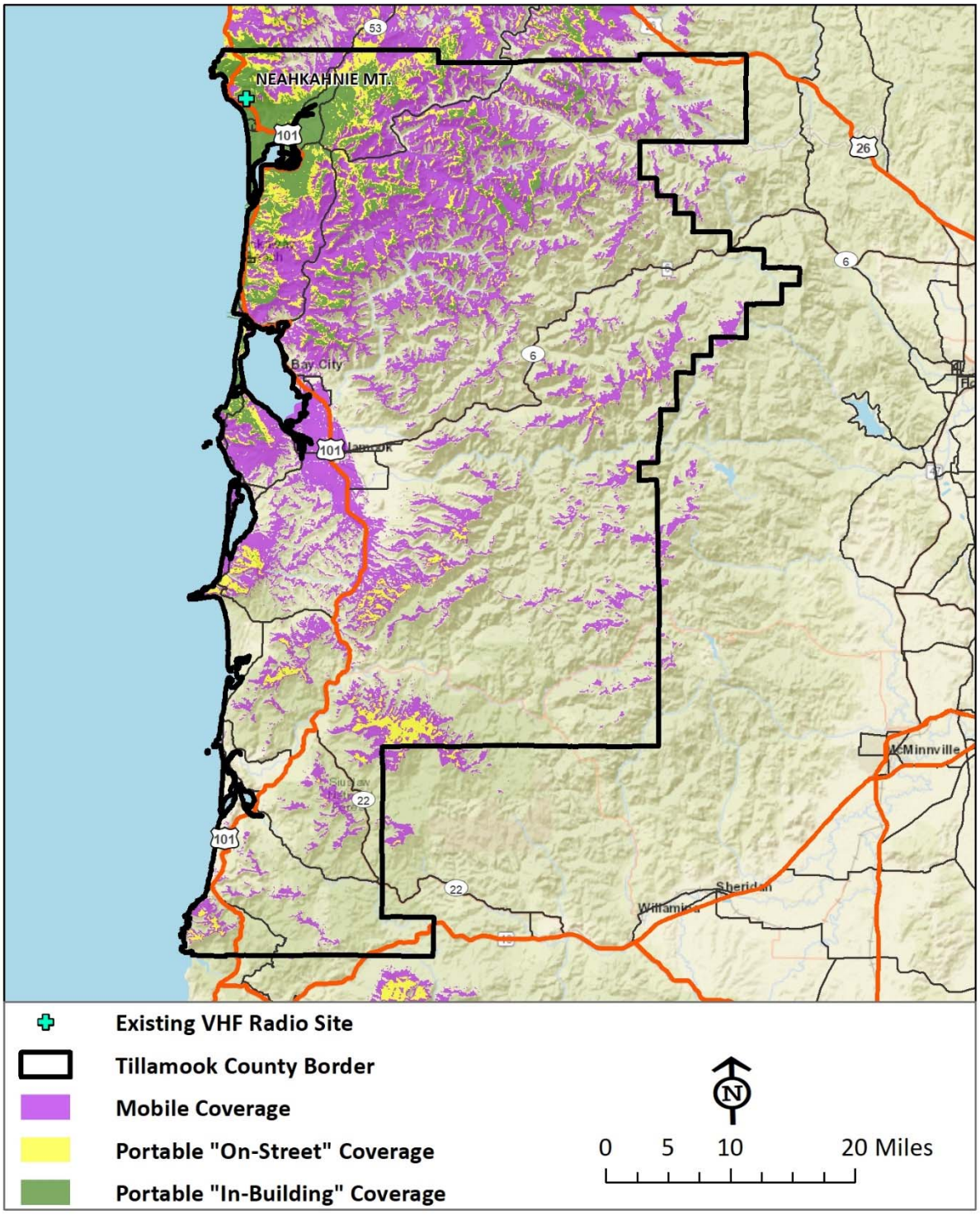
- County has an alarm system for the microwave backhaul system and the L-190 site is tied into Verizon for alarms, but other than that County maintenance staff do not have the ability to remotely monitor and troubleshoot LMR and MW equipment
- Sheriff stakeholders mentioned that the ability to encrypt radio traffic would be nice, but is not required
- The existing system can be difficult to use, especially for new field users. It requires some time to become familiar enough with the radio system to know what repeater provides the best coverage in each area.
- Since the system is a series of individual repeaters using the same frequency pair, dispatchers must switch channels based on where radio users are in the County. Radio users operating on different repeaters cannot talk directly to each other
- Public Works stakeholders said that the ability to track their vehicles would increase safety and productivity

- A centrally managed system would be ideal, where all have County departments utilize the same vendor for scheduled radio maintenance. Although LMR is an important tool, radio maintenance is often neglected

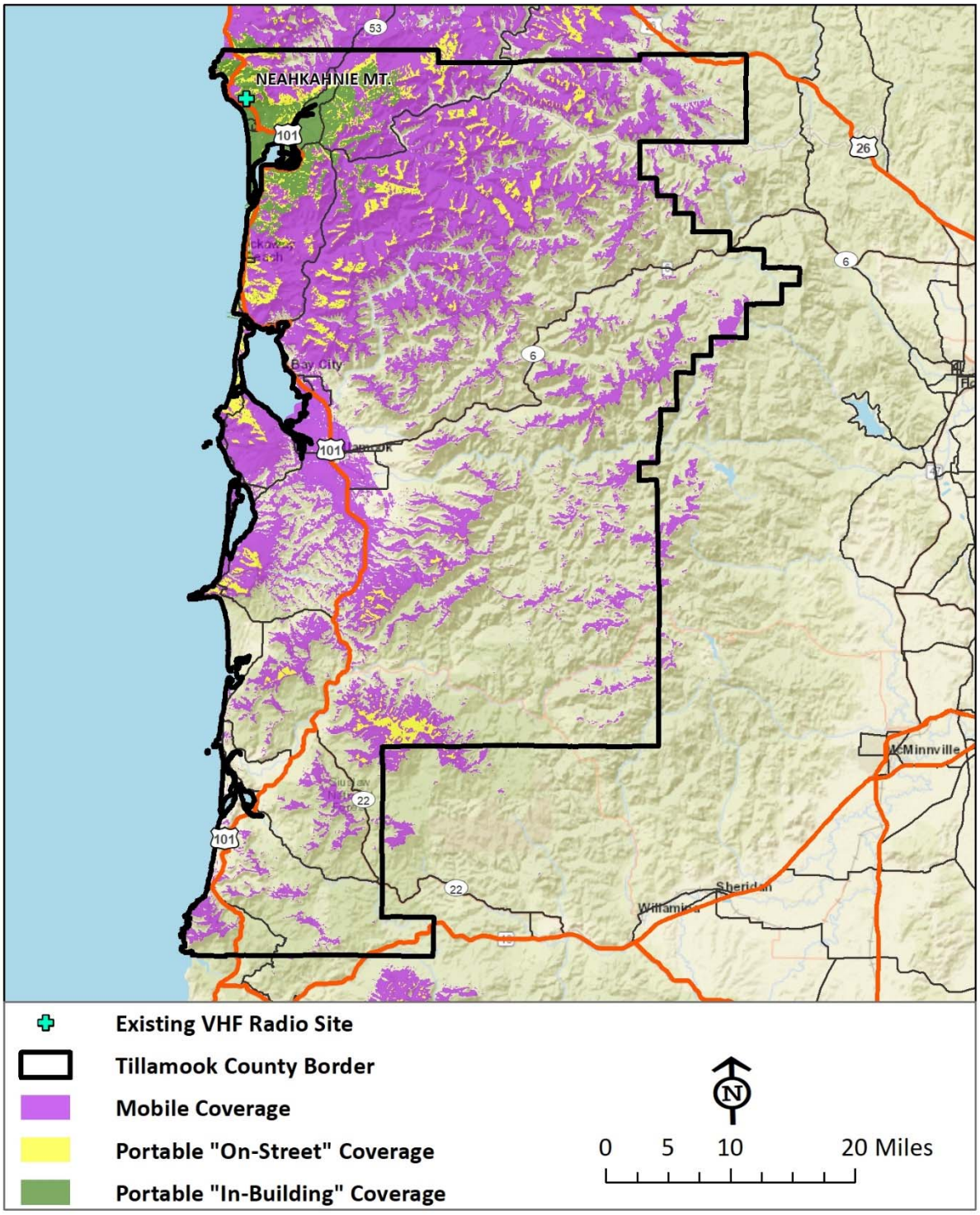
Appendix A - Fire TAC Radio Coverage Maps

This appendix contains individual radio coverage maps for the Fire TAC radio repeaters.

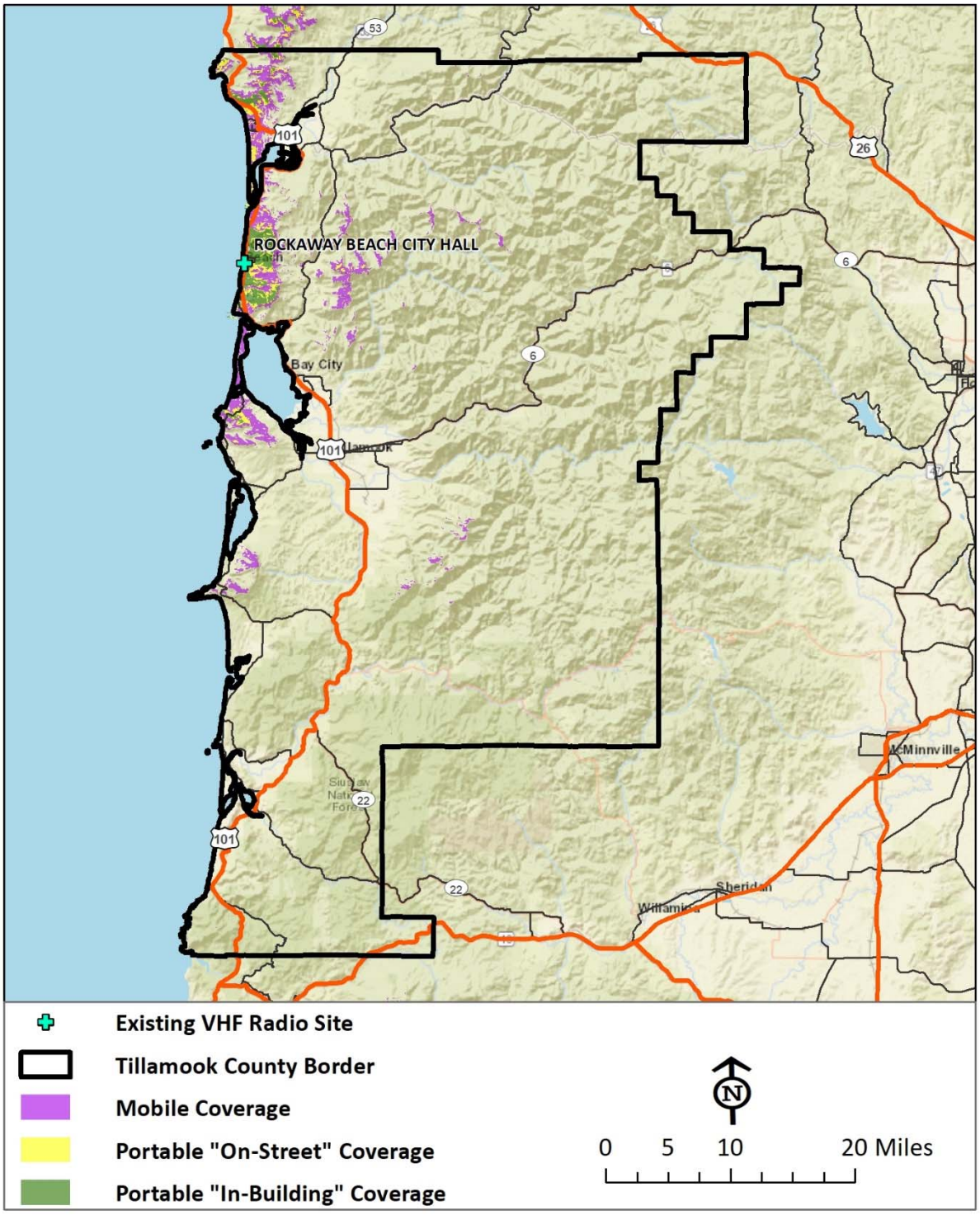
Tillamook County, OR - Existing VHF Coverage on Fire TAC1 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



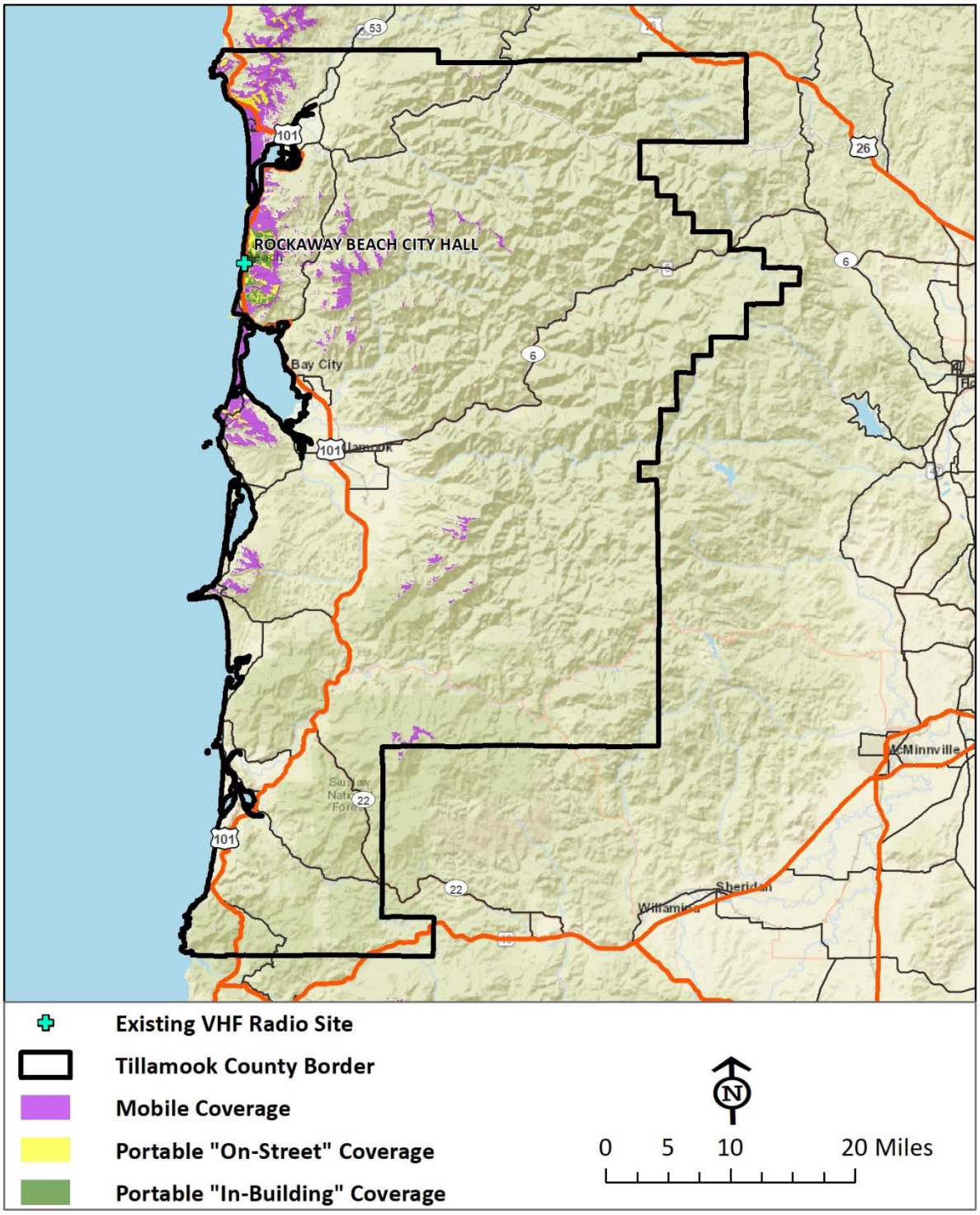
Tillamook County, OR - Existing VHF Coverage on Fire TAC1 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



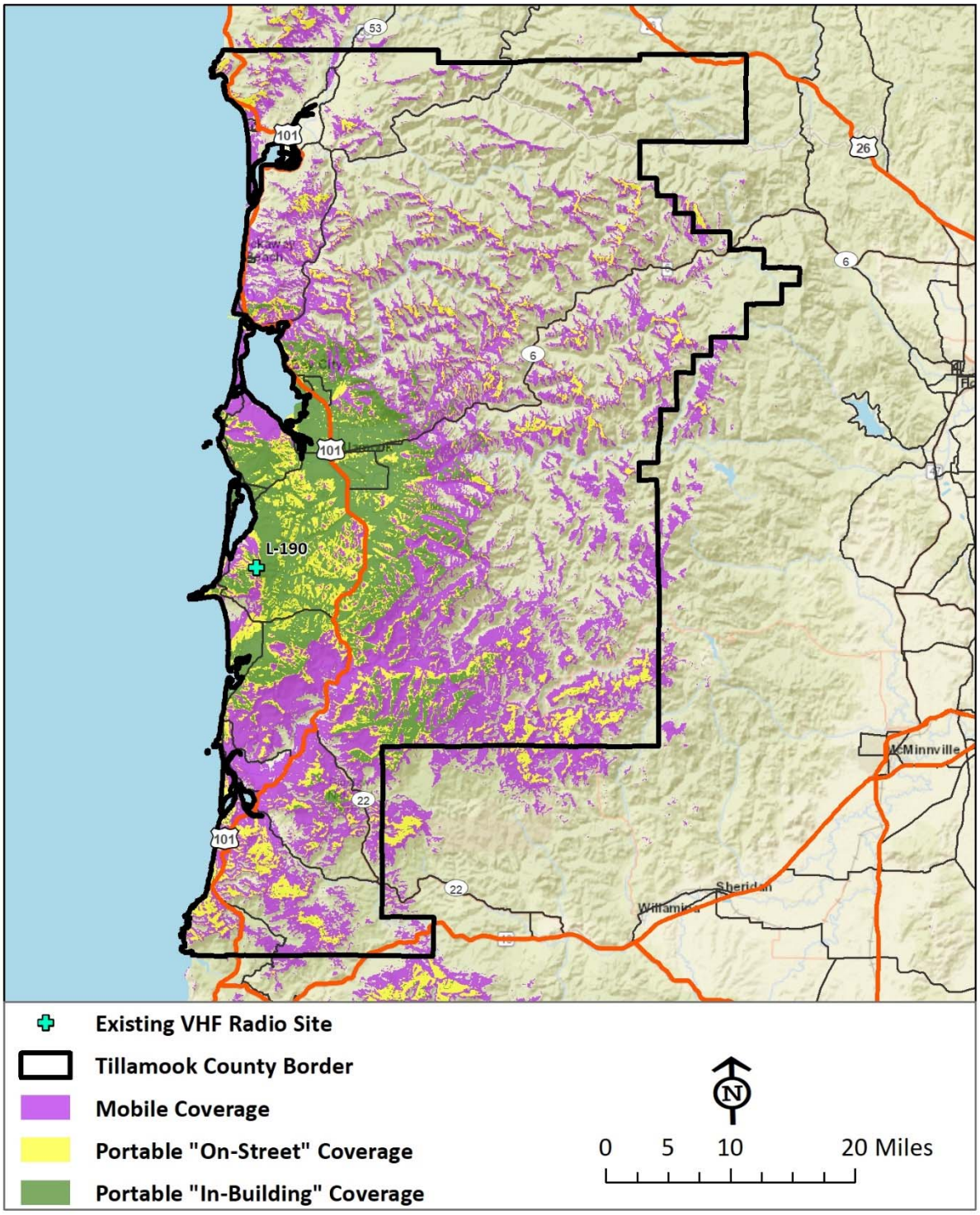
Tillamook County, OR - Existing VHF Coverage on Fire TAC1A Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



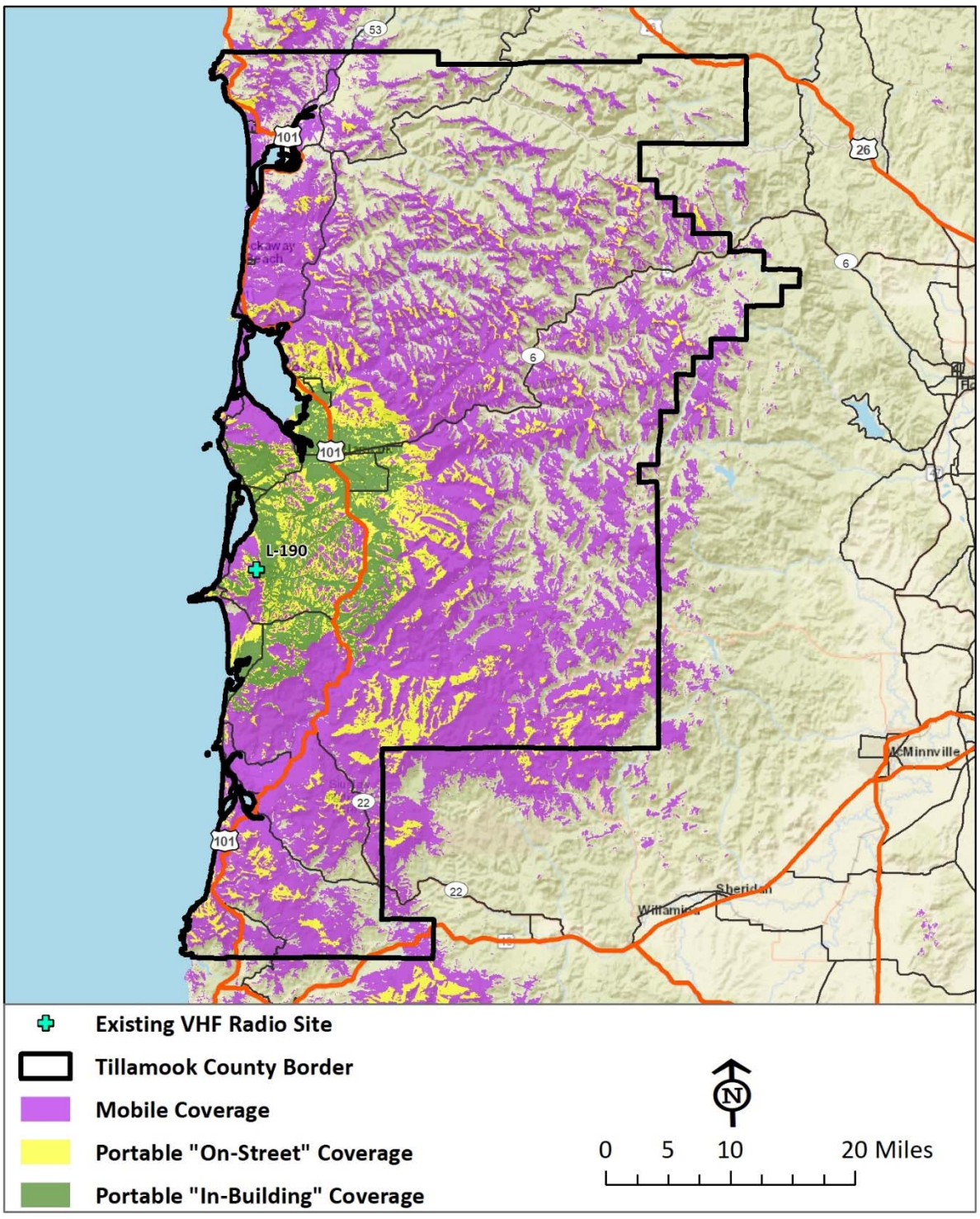
Tillamook County, OR - Existing VHF Coverage on Fire TAC1A Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



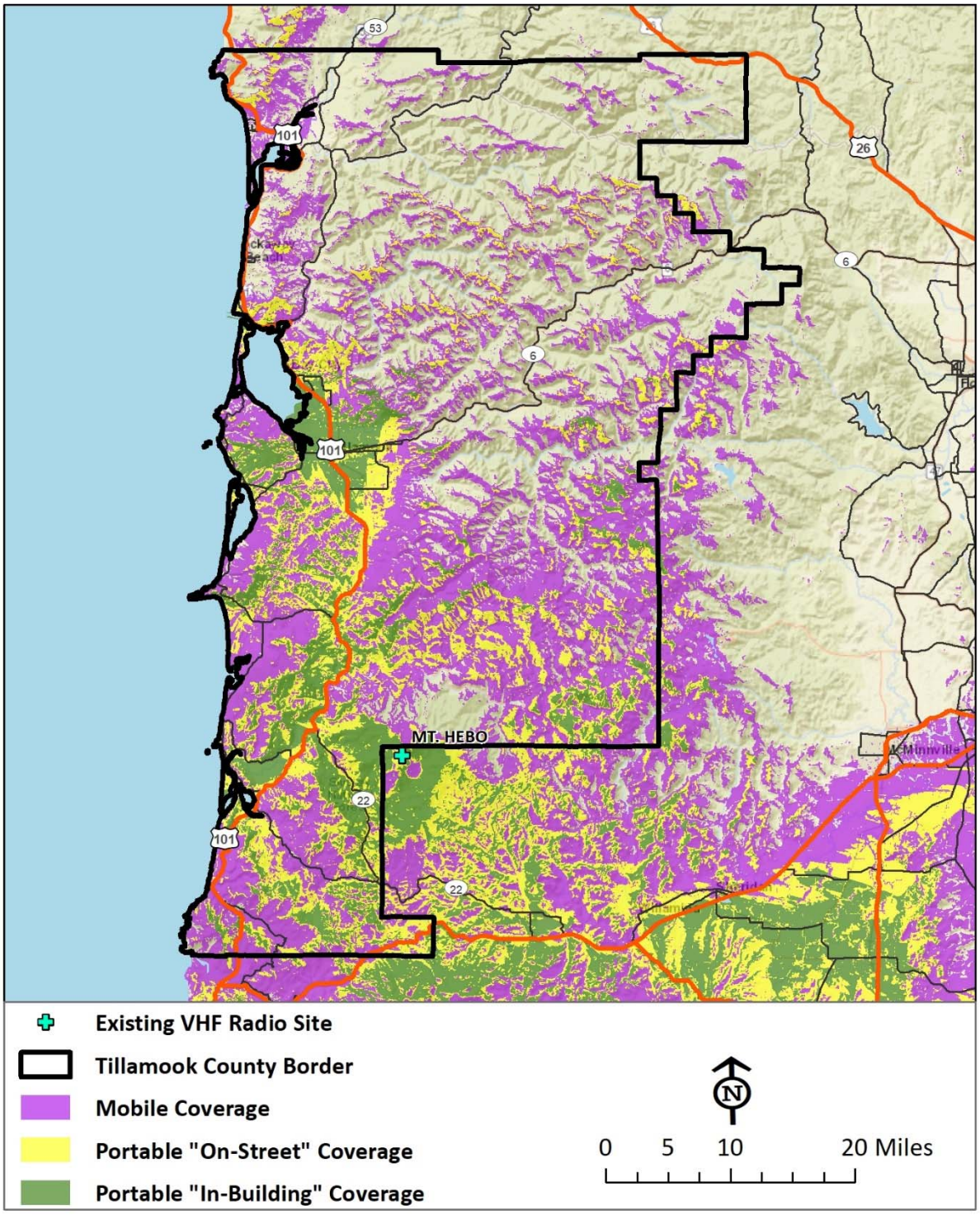
Tillamook County, OR - Existing VHF Coverage on Fire TAC2 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



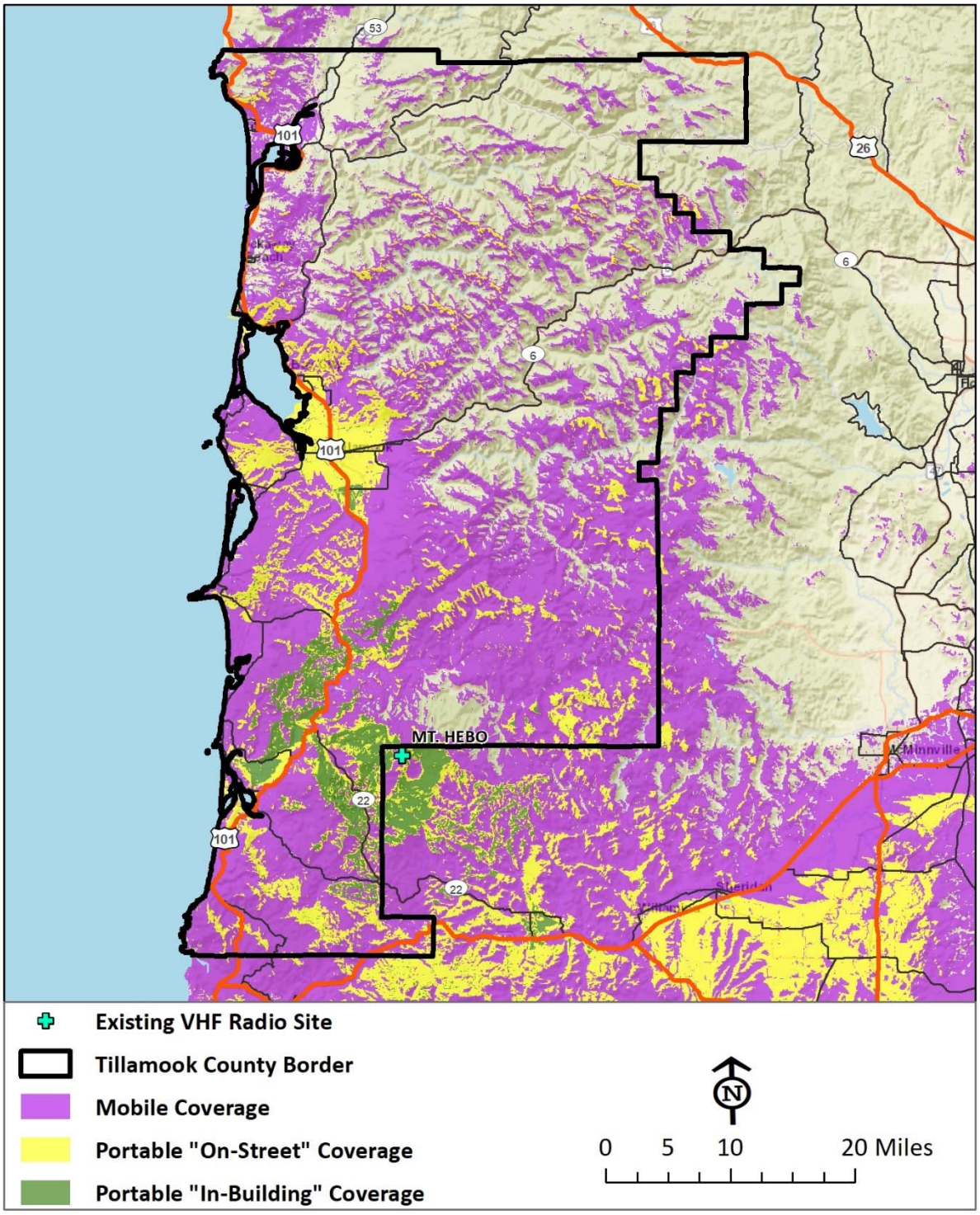
Tillamook County, OR - Existing VHF Coverage on Fire TAC2 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



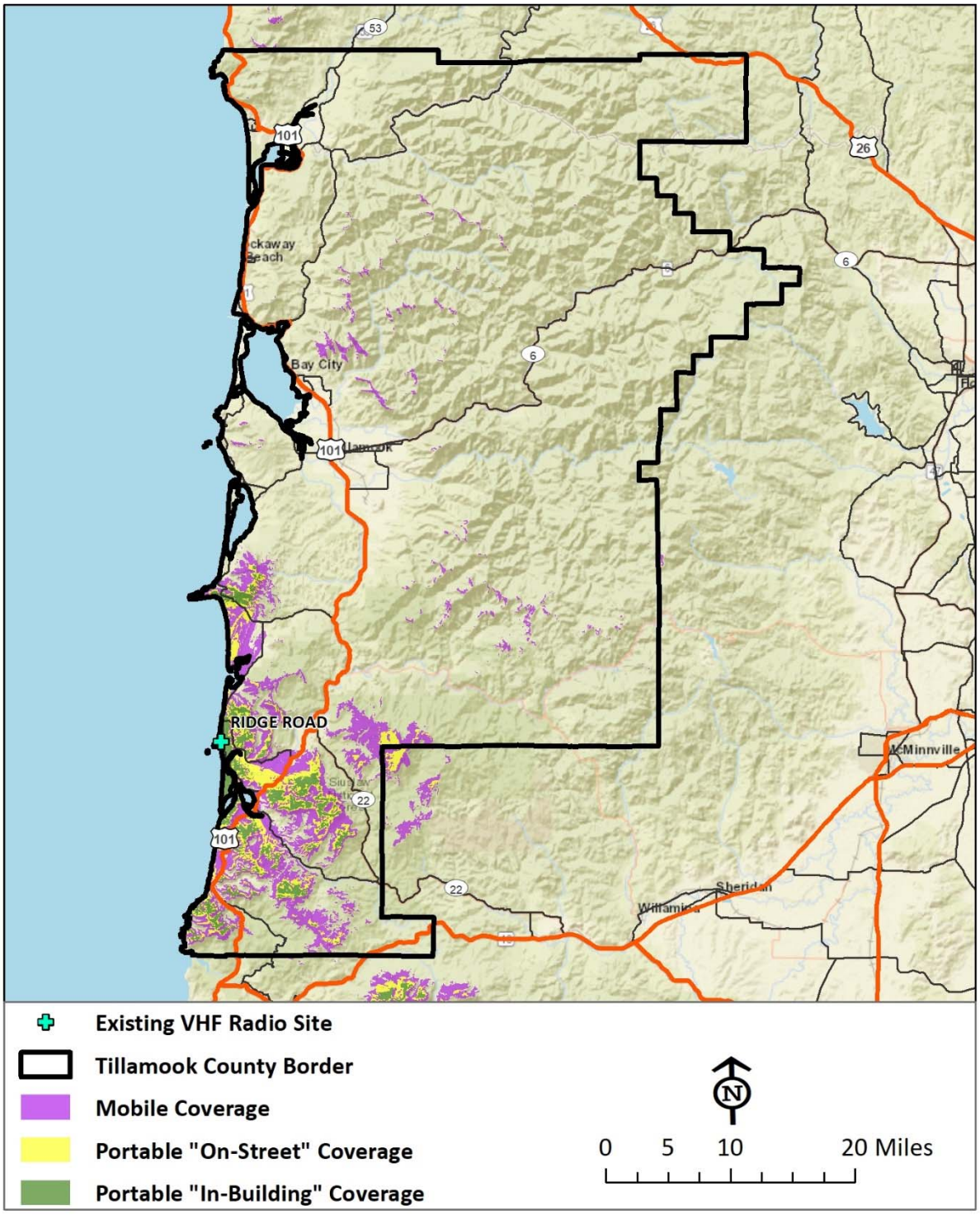
Tillamook County, OR - Existing VHF Coverage on Fire TAC3 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



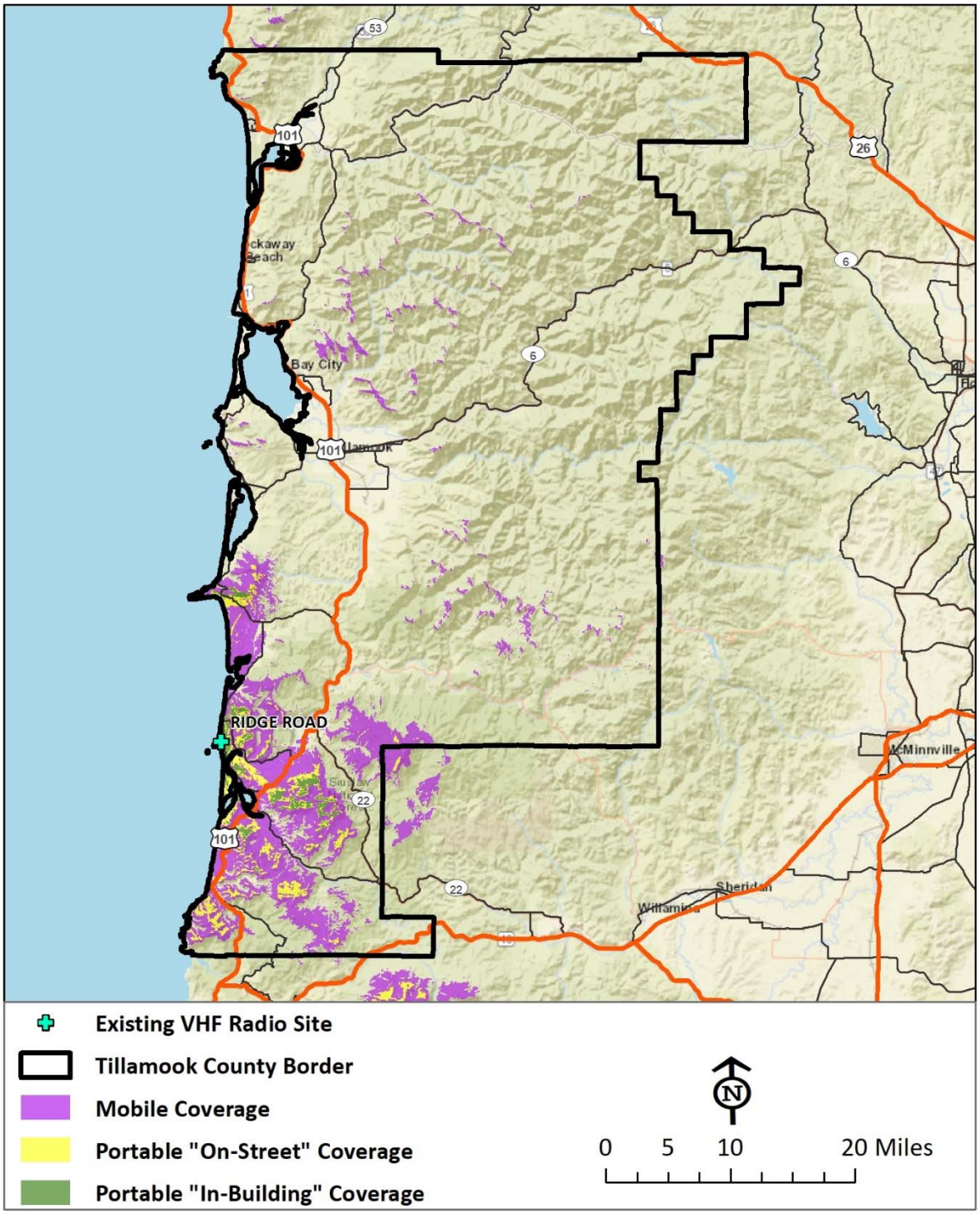
Tillamook County, OR - Existing VHF Coverage on Fire TAC3 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



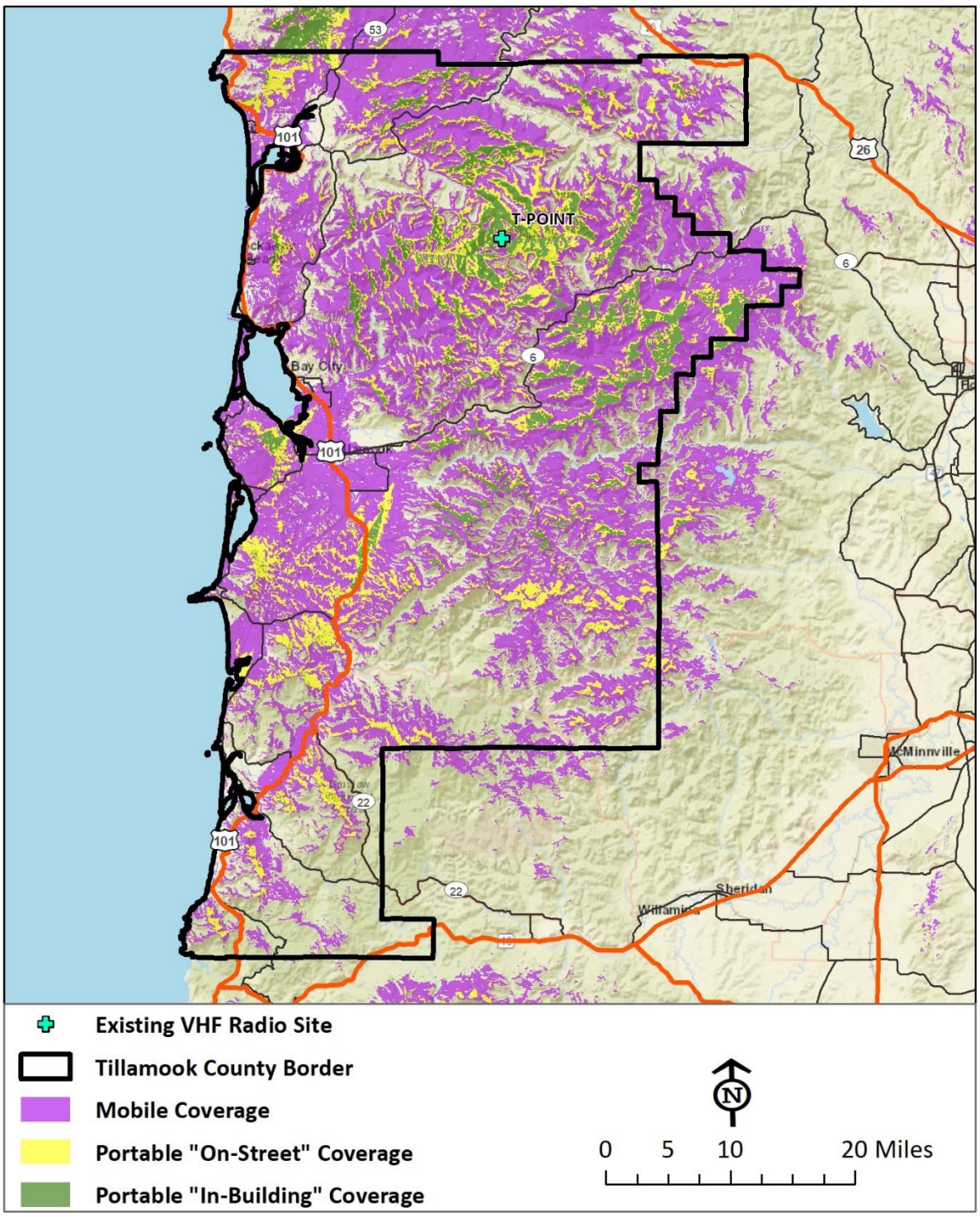
Tillamook County, OR - Existing VHF Coverage on Fire TAC3A Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



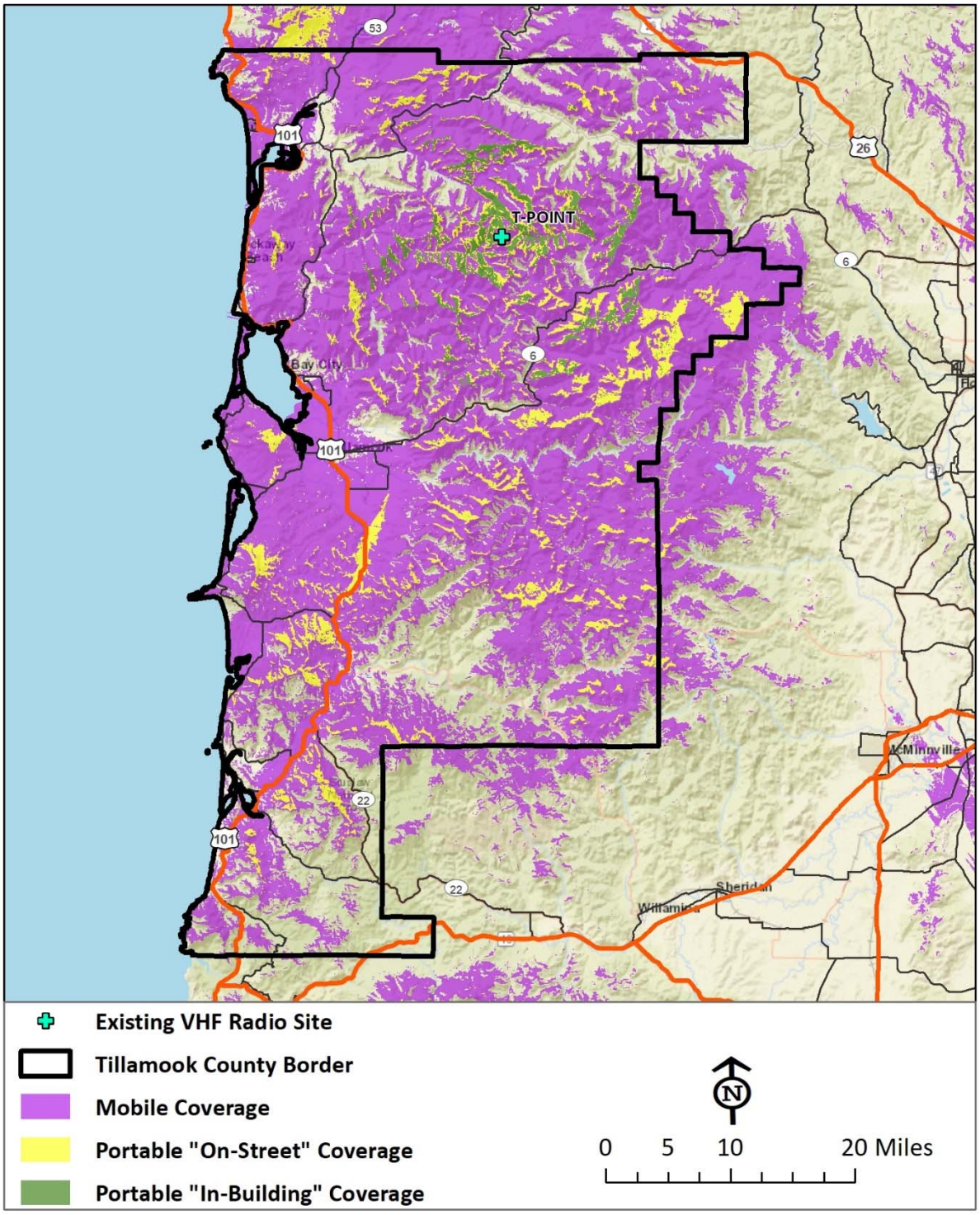
Tillamook County, OR - Existing VHF Coverage on Fire TAC3A Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



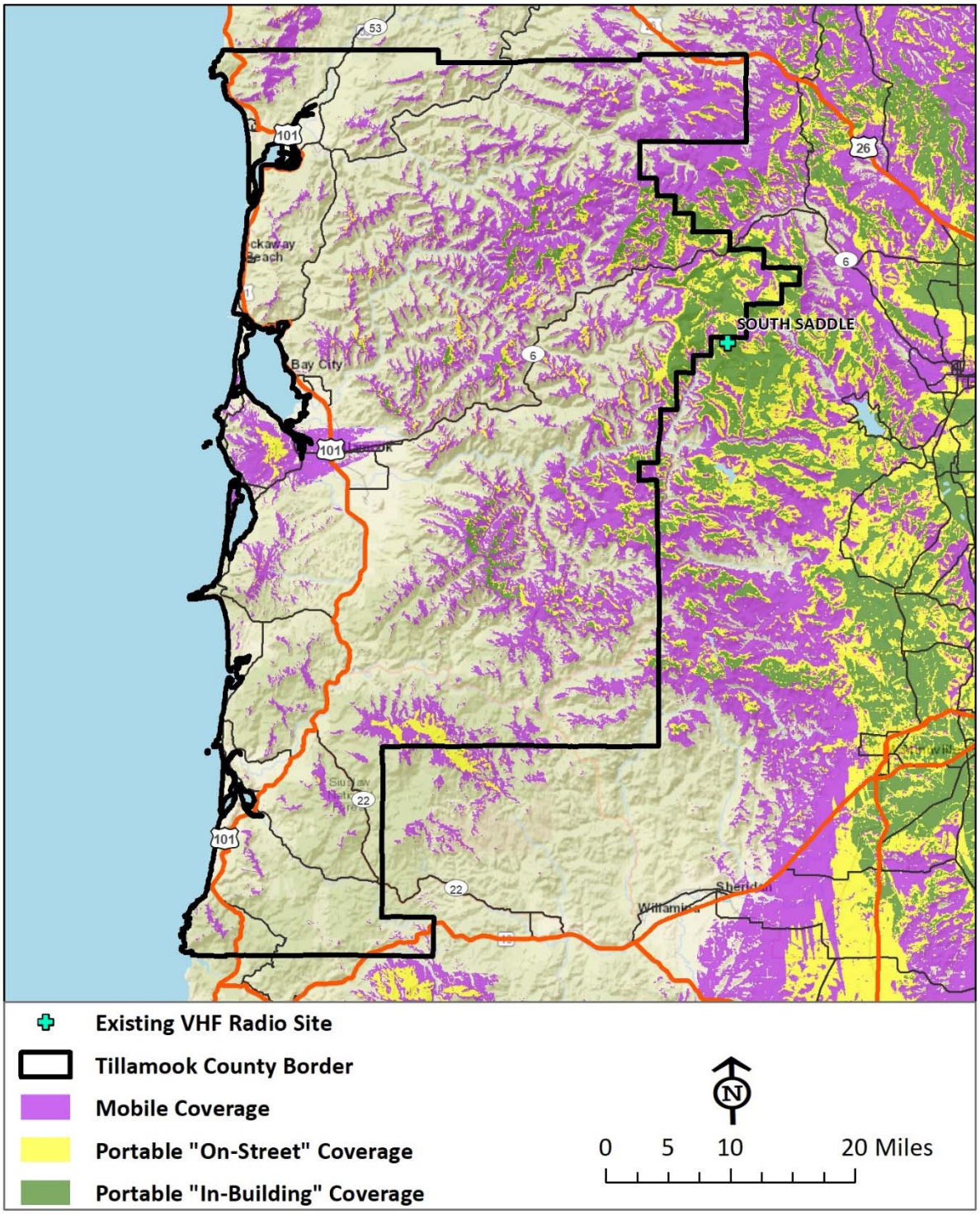
Tillamook County, OR - Existing VHF Coverage on Fire TAC6 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



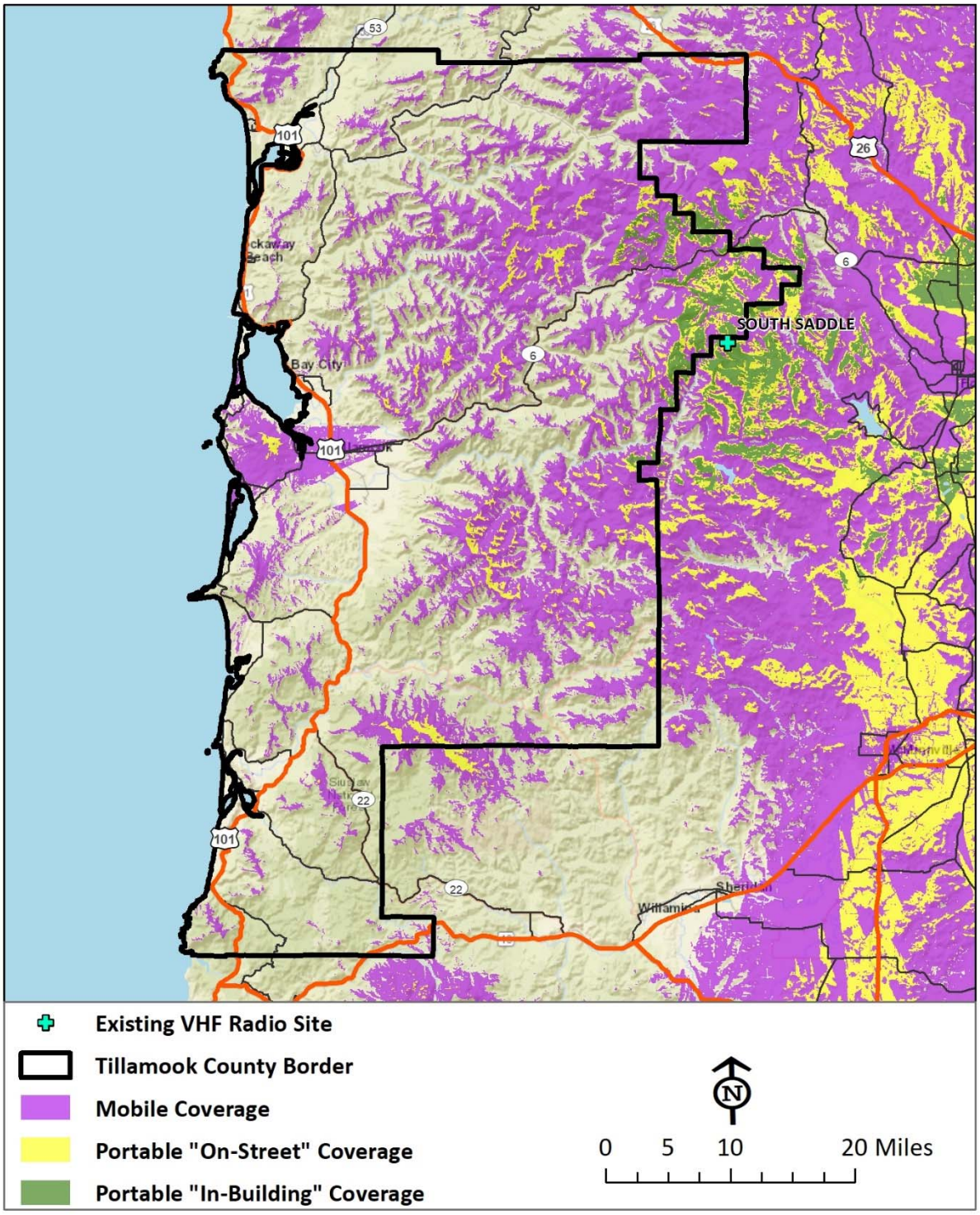
Tillamook County, OR - Existing VHF Coverage on Fire TAC6 Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



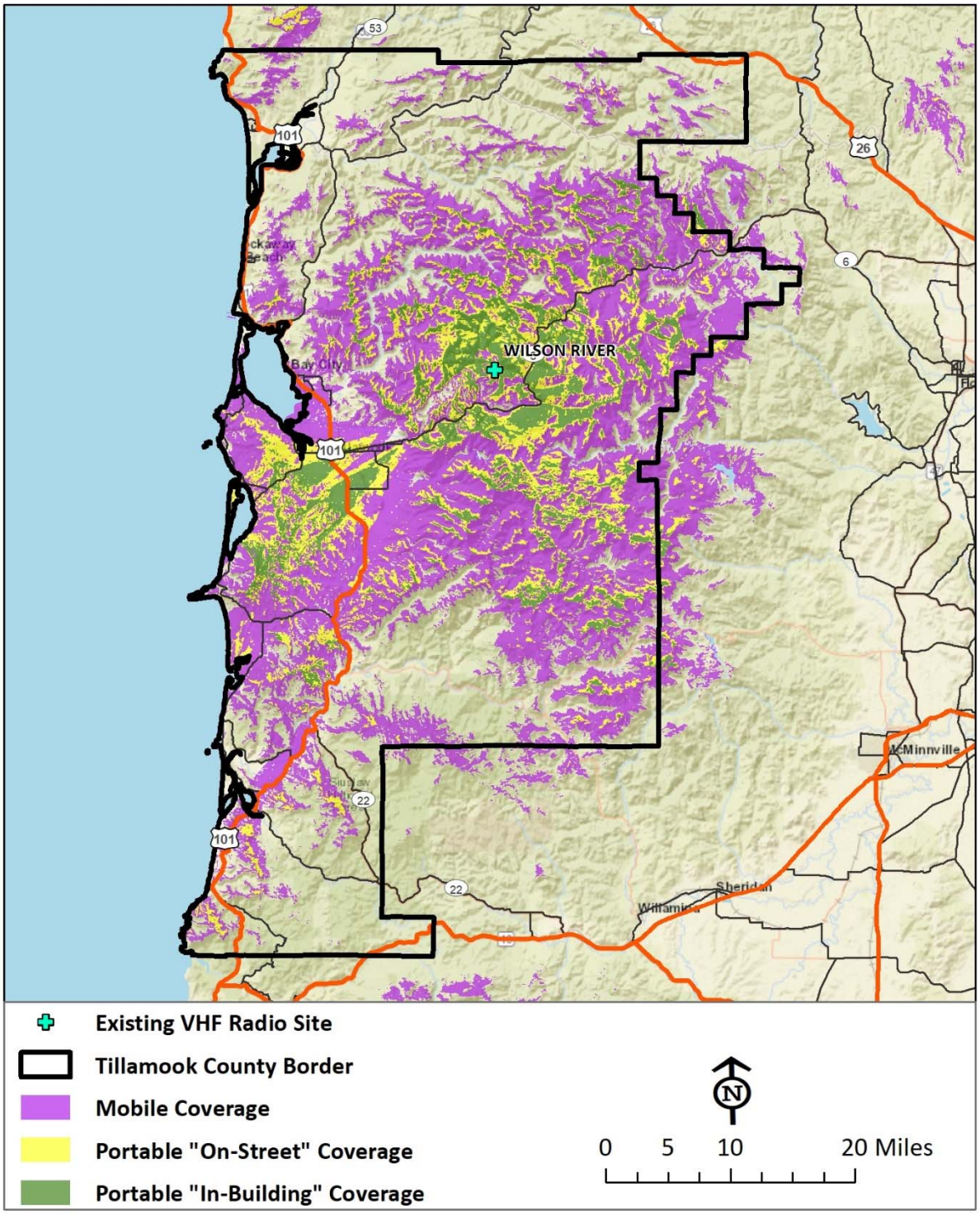
Tillamook County, OR - Existing VHF Coverage on Fire TAC6S Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



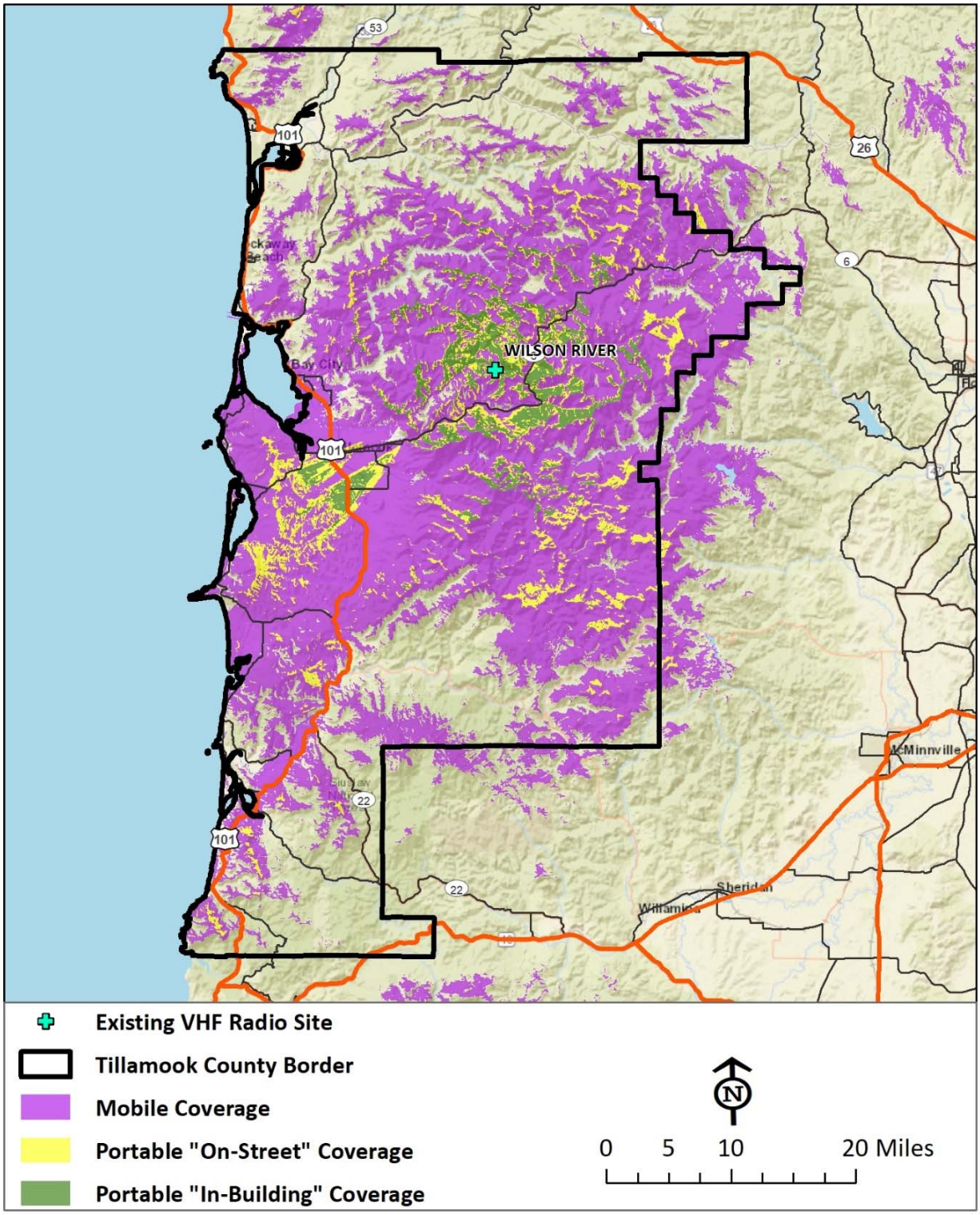
Tillamook County, OR - Existing VHF Coverage on Fire TAC6S Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



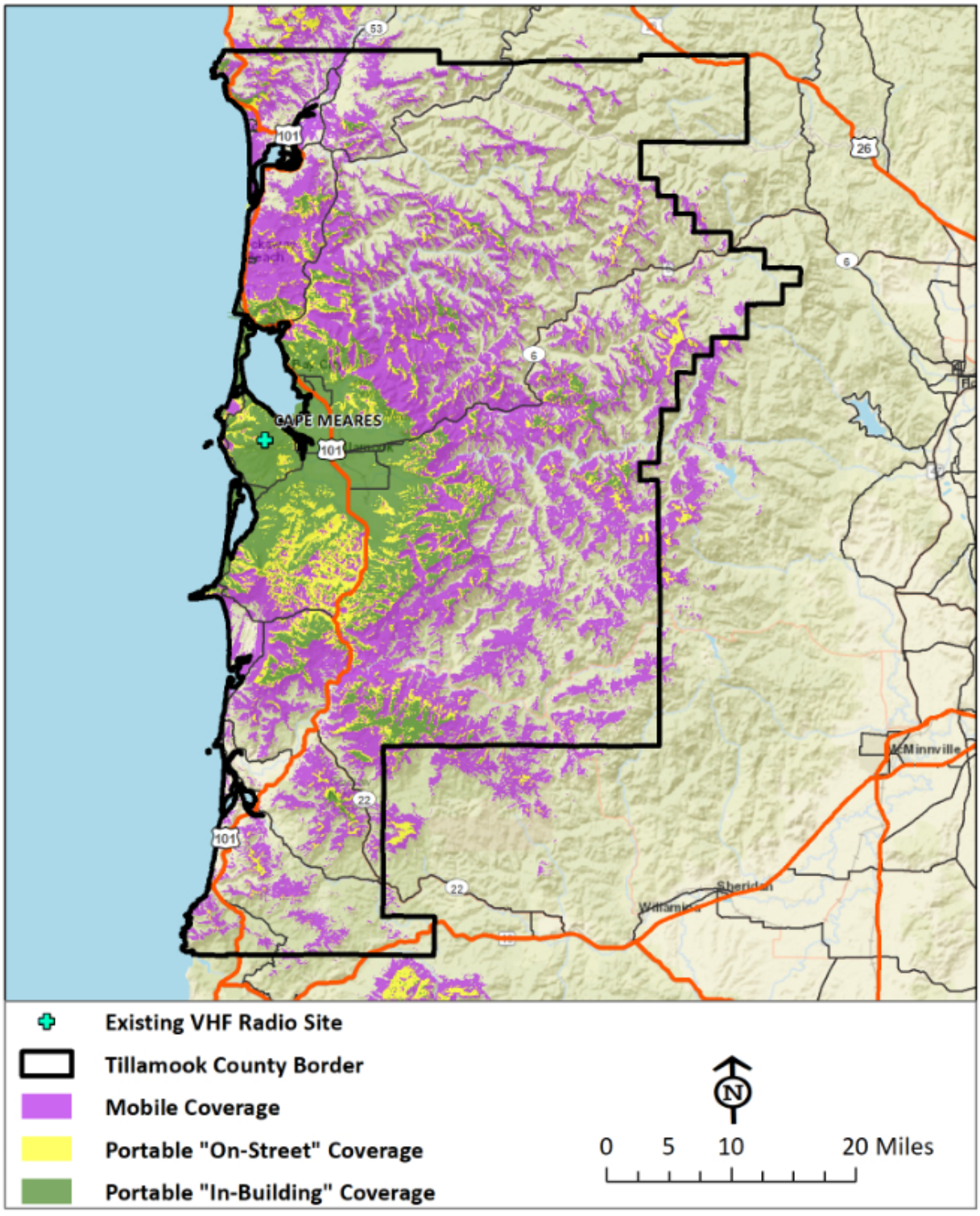
Tillamook County, OR - Existing VHF Coverage on Fire TAC6W Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



Tillamook County, OR - Existing VHF Coverage on Fire TAC6W Channel
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability



Tillamook County, OR - Existing Fire Dispatch Coverage from Cape Meares
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-Out (site to radio); 95% Reliability



Tillamook County, OR - Existing Fire Dispatch Coverage from Cape Meares
VHF Narrowband Analog Coverage >= DAQ 3.4; Talk-In (radio to site); 95% Reliability