CTA COMMUNICATIONS, INC

CTA COMMUNICATIONS, Inc.
CONSULTANTS

FINAL

Needs Assessment Report

LARIMER COUNTY
COMMITTED TO EXCELLENCE

LARIMER COUNTY, COLORADO

FEBRUARY 17, 2006

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EXECUTIVE SUMMARY

ABSTRACT

Two-way radio communication capabilities in Larimer County are characterized by poor coverage in mountainous areas, a lack of interoperability between public safety agencies that have moved to 800 MHz, channel crowding and congestion, and inadequate capacity for emergencies. These major deficiencies compounded by operational concerns currently inhibit public safety personnel from efficient operations and interoperability. This current state of communications is inefficient at best and potentially dangerous at worst. The analysis performed by CTA Communications has resulted in a technically and operationally efficient and cost effective recommendation that all public safety and non-public safety entities within Larimer County participate in a Hybrid Radio System. The Hybrid System solution allows the County to immediately start implementing an 800 MHz trunked radio system east of the foothills by joining the Consolidated Communications Network of Colorado (CCNC) while maintaining VHF coverage with the existing County system to allow a graceful transition of Larimer County from VHF conventional to 800 MHz trunked. With the introduction of trunked technology to the County through this solution, agencies can establish separate talkgroups, interoperate with County public safety agencies, Fort Collins, Loveland and the Colorado State Patrol, and can enjoy private communications without having to wait for a clear channel. 800 MHz portable and mobile coverage is already provided east of the foothills through the CCNC. The recommended design plan is to establish 800 MHz mobile coverage to the main roadways in mountainous areas in four phases and transition all agencies from VHF to 800 MHz over a seven-year period before the FCC mandate to convert all VHF wideband equipment to narrowband is enforced.

BACKGROUND

In May of 2005, CTA Communications, Inc. was contracted by Larimer County to help develop a plan for improving mobile radio communications on the County's public safety infrastructure. This plan takes into consideration the next generation, mission critical radio communication technologies and the existing radio systems in Larimer County.

Larimer County is the seventh largest County in Colorado based on population. The estimated population in 2004 was 283,000 which is about a 3% increase from 2003. The County encompasses 2,640 square miles that includes the Roosevelt National Forest and the Rocky Mountain National Park. Major communities include Berthoud, Estes Park, Fort Collins, Loveland, Timnath and Wellington.

The County currently provides radio communications support in the VHF band for County Government agencies that include the Sheriff's Office, Road and Bridge, Parks and Open Lands, Landfill as well as volunteer organizations such as search and rescue and volunteer fire departments. User requirements for each County agency were analyzed for an operational period of fifteen years. Through the needs assessment process, CTA partnered with the County and its users to identify existing radio system problems and future requirements. CTA examined existing equipment, property, facilities and has analyzed solutions to meet future needs. CTA recommended a system design (including radio propagation, radio communications system, paging, and facilities) that meets countywide requirements and overcomes the various limitations that may be present, such as funding and scheduling. CTA has also provided budgetary turnkey cost estimates for the implementation of the preliminary design.

CURRENT COMMUNICATIONS ENVIRONMENT WITHIN LARIMER COUNTY

Public Safety Answering Points (PSAP)

The Public Safety Answering Points (PSAP) for Larimer County consists of five (5) locations. They include the Larimer County Sheriffs Office (LCSO), Fort Collins Police Department, Estes Park Police Department, Colorado State University (CSU) and Loveland Police Department. The Loveland PSAP was not visited during the site surveys. All of the PSAP's that we surveyed use the same CAD and radio dispatch equipment.

Larimer County VHF Radio System

CTA surveyed the following seven (7) radio sites: Buckhorn Mountain, Prospect Mountain, Justice Center, Horsetooth Mountain, Cactus Hill, Deadman Mountain, and the Larimer County Sheriffs Office. Larimer County has an eight (8) channel, conventional VHF analog radio system with a microwave backhaul system for supporting County public safety and public service departments.

Fairgrounds and Events Center UHF Trunked Radio System

There is a four-channel Motorola UHF trunked radio system that was installed at the Fairgrounds and Events Center. The radio system provides coverage for the fairgrounds and within the exhibition buildings and the Budweiser Events center. The trunked radio system does not interface with the Larimer County PSAP for dispatch operations.

Consolidated Communications Network of Colorado (CCNC)

The Consolidated Communications Network of Colorado (CCNC) Digital Trunked Radio System (DTRS) is a State and participant owned multi-site dedicated public safety wireless communications system using 800 MHz and 700 MHz for both voice and data (data is a future implementation). The design of the DTRS is based on the APCO Project 25 trunking standard and provides wide area interoperable communications to local governments and public safety groups. It should be noted that the "DTRS is designed to provide mobile radio communication coverage on major State highways to the participant. Portable radio coverage is not guaranteed and will vary from location to location.

Northern Colorado Regional Communications Network (NCRCN)

The Northern Colorado Regional Communications Network (NCRCN) was created before the CCNC was formed. The NCRCN consist of a board of local public safety and public service agencies in Larimer County that have combined resources to establish an APCO 16, Motorola SMARTZONE 800 MHz trunked radio communications system in the local area. All equipment was purchased by the NCRCN. The NCRCN has recently joined the CCNC and has upgraded their 800 MHz system to a P25 compliant radio system. They continue to be a separate organization from the CCNC. Sites have already been established through the NCRCN and the CCNC to provide 800 MHz coverage to Fort Collins, Loveland, Estes Park, and northeastern Larimer County.

Sites that belong to the NCRCN have been connected to the CCNC zone controller located at the Platte River Power Authority. In the mountainous areas, coverage is almost non-existent with the exception of Estes Park.

CURRENT COMMUNICATIONS PROBLEMS WITHIN LARIMER COUNTY

During the personal interviews, CTA surveyed radio users from several departments to determine the extent to which radio system problems effect their operations. These problems can be categorized as follows:

- Coverage Issues – VHF radio coverage is poor in mountainous areas and in the extreme northern and southern regions of the County. Existing coverage will further shrink as the existing radio equipment is replaced by new narrowband capable equipment as mandated by the FCC (the deadline is January 1, 2013).

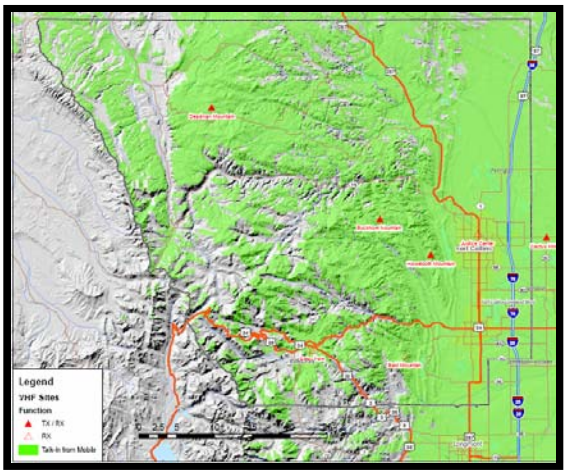
- Lack of interoperability between the VHF and 800 MHz Systems in Larimer County (Colorado State Patrol, Fort Collins and Loveland)

- Channel Congestion – most all County agencies have experienced channel congestion during different times of the day or during certain events.

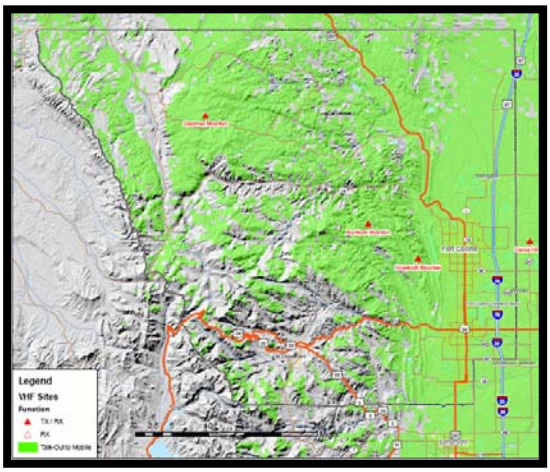
CURRENT COVERAGE OF THE COUNTY VHF RADIO SYSTEM

Our VHF coverage analysis of the County's radio system shows that the major problem areas are west of the foothills. The radio system is both talk-in and talk-out limited. In some areas, the radio operator can receive messages from dispatch but may not be able to transmit back to dispatch. In other situations, dispatch tries to call back a radio operator with information or performs a status check and the radio operator does not hear the dispatch call. This is because the Sheriff's Office Channel 2, 3, 4 and the EMS North channels are transmission steered based on the position that the radio operator was last voted by the receive site. After a certain amount of time has elapsed, the transmission channel will revert back to the home site before dispatch calls back to the radio operator. This causes the "hit or miss" effect when dispatch is trying to locate a radio operator.

Existing VHF Mobile Talk-In Coverage



Existing Mobile VHF Talk-Out Coverage



RADIO SYSTEM ALTERNATIVES

CTA Communications investigated six alternatives for implementing a countywide radio communications system. Each alternative was considered according to its ability to meet the requirements developed in this study and to correct the problems identified in the interviews. Once each alternative was identified, we then estimated a Rough Order of Magnitude (ROM) cost for each alternative to help with the decision process. *(The ROM cost figures for Alternatives 2 through 6 were based on providing 95% on-the-street portable coverage in mountainous areas.)* We then presented these alternatives to the County with the associated estimated ROM costs for each during the Cost Benefit Meeting on August 26, 2005. The following alternatives were considered:

Alternative 1 Do Nothing
Alternative 2 VHF Conventional Simulcast Radio System
Alternative 3 VHF Trunked Simulcast Radio System
Alternative 4 Join CCNC/NCRCN 800 MHz Radio System
Alternative 5 Hybrid System – 800 MHz Trunked/ VHF Conventional
Alternative 6 Hybrid System – 800 MHz Trunked/ VHF Trunked

After these alternatives were identified, we factored in the County's feedback during the Impact Analysis process. Larimer County user rankings identifying the most desirable features and characteristics were numerically evaluated against each alternative's ability to deliver the capability. The weighted-rankings were used to help narrow down the most suitable alternative for Larimer County.

RECOMMENDED RADIO SYSTEM CONFIGURATION

The continued rate of growth expected over the next 15 years in Larimer County will certainly result in a corresponding increase in radio traffic for first responders, public safety and public service units. This will result in the critical problems listed above to become unbearable and potentially life threatening for the public safety and public service radio system users of Larimer County.

Based on the results of the Impact Analysis and discussions with County personnel, CTA recommends Alternative 5 (Hybrid System) as the best solution to alleviate the critical problems residing with the existing VHF radio system. We further recount implementing mobile coverage in the mountains for all the main roadways. This will provide the required communications while reducing the number of sites required for 800 MHz in mountainous areas thus reducing the total cost.

The Hybrid System solution allows the County to immediately start implementing an 800 MHz trunked radio system east of the foothills by joining the Consolidated Communications Network of Colorado (CCNC) while maintaining VHF coverage with the existing County system to allow a graceful transition of agencies from VHF conventional to 800 MHz trunked. With the introduction of trunked technology to the County through this solution, agencies can establish separate talkgroups, interoperate with other 800 MHz users (County, State, Fort Collins and Loveland), and can enjoy private communications without having to wait for a clear channel. It also provides a means to transition from VHF to 800 MHz over a seven-year period before the FCC mandate to convert all VHF wideband equipment to narrowband is enforced.

The Hybrid System also provides: required in-building radio coverage east of the foothills; advanced radio features; interference mitigation; channel congestion mitigation; and enhanced radio dispatch operations. Limited mobile data capabilities are currently available through the voice network of the CCNC radio system. This capability may include silent dispatch, status messaging, and limited mug shot capability. A dedicated mobile data capability will be implemented by the CCNC in the future. This capability is still being defined by the CCNC. This solution consolidates all radio users within the County under one radio system. Our solution recommendation provides the following core attributes:

- Enables interoperability within the County for all users
- Enables interoperability outside of the County for all users
- Provides improved coverage for all users

- Provides improved system capacity for all users
- Maximizes Cost Savings for the County

RECOMMENDED RADIO SYSTEM IMPLEMENTATION

CTA recommends that the radio system be built in four phases. The first phase can be accomplished within one year and would begin by procuring 800 MHz subscriber units to operate on the existing CCNC network in Larimer County. Additional repeaters would then be added to existing sites to provide capacity for 80% of the County's operations east of the foothills. The current VHF system will remain operational for the paging system, the Road and Bridge Department, Parks and Opens Lands and the 20% of Sheriff's Office operations that take place in the mountainous areas while 800 MHz sites are being built. Sheriff's Office and other County department vehicles may require a VHF and 800 MHz mobile radio at the interim to access both frequency bands in the County. Approximately 218 mobile radios in the 800 MHz band will need to be procured for the Sheriff's Office vehicles.

The next phases will add sites in the mountainous areas to provide mobile coverage to the main roadways. The County's VHF voice system will stay operational until all proposed sites are built. Completion of site construction and commissioning should be before January 1, 2013, which is the FCC deadline to have all VHF equipment converted to narrowband. (If the County does not complete the build out of 800 MHz sites in the mountainous areas before January 1, 2013, the County will have to replace all wideband VHF infrastructure and radios with narrowband versions as required by the FCC narrowband mandate. This was estimated at approximately $1,347,000.) Transition of all remaining County departments from VHF to 800 MHz will take place once 800 MHz is established in the mountainous part of the County. Approximately 170 mobile radios in the 800 MHz band will need to be procured for the remaining County vehicles (Road and Bridge, Parks and Open Lands, Landfill, and other County departments). A residual narrowband VHF capability will be required indefinitely for the County digital paging system and interoperability between Larimer County Wild Land Fire and the US Forest Service. The following four phases are recommended for the system implementation:

<u>Phase 1</u>

- Add three (3) additional channels to Horsetooth Mountain
- Add two (2) channels to Buckhorn Mountain
- Add one (1) channel to Bald Mountain
- Upgrade console CEB at the Sheriff's Office PSAP and connect to Platte River Power Authority

- Add 800 MHz subscriber units to CCNC network for primary operation east of the foothills
- Add Pole Mountain microwave site and connectivity to Buckhorn Mountain and Bull Mountain (this phase is currently fully funded)

Phase 2

- Implement a five-channel radio site at an established FM radio tower site near Black Mountain.

Phase 3

- Implement a five-channel radio site at Middle Bald Mountain
- Transition remaining VHF subscribers to 800 MHz

Phase 4A

- Implement an optional site at Kinikinik for enhancing Poudre River Canyon coverage.

Phase 4B

- Implement an optional site at Mummy Range for enhancing western central Larimer County coverage.

ESTIMATED RADIO SYSTEM COSTS

Estimates were developed for the major categories of equipment as they apply to the system preliminary design. The equipment, installation, non-fixed equipment and vendor service cost information were obtained from historical CTA Communications cost files and vendor pricing of comparable projects. These costs were compared and weighted in order to derive an average "list price" type for a turnkey system. Professional consulting fees and post-warranty maintenance costs are excluded.

Estimate of Probable Cost:

COST ELEMENT	HIGH ESTIMATE	LOW ESTIMATE
PHASE 1	$ 176,769	$ 133,700
NON-FIXED UNITS (COUNTY)	$ 2,846,100	$ 2,846,100
NON-FIXED UNITS (VOLUNTEER)	$ 661,100	$ 661,100
PHASE 2	$ 1,103,050	$ 904,051
PHASE 3	$ 1,157,669	$ 962,830
PHASE 4A	$ 1,016,120	$ 828,225
PHASE 4B	$ 898,593	$ 760,894
TOTAL	**$ 7,859,401**	**$ 7,096,900**

RECOMMENDATIONS

Before the County starts moving personnel to 800 MHz and begins implementation of sites, we recommend that the County survey the existing coverage of the CCNC in Larimer County. It is important to document areas where the existing 800 MHz sites provide good, poor or no coverage at all to the Larimer County users. This independent method of coverage testing can also be used for future site planning to prevent the County from spending funds for sites that are not necessary or after each new site is commissioned to ensure acceptable coverage is achieved.

As sites are developed and are made operational, we recommend that coverage testing be performed to document the extent of the new area of coverage before implementing additional sites. Site development can be adjusted based on final coverage results. CTA can provide independent coverage testing services using our RaCE coverage evaluation tool. RaCE provides end-to-end testing of your radio system and provides results such as Delivered Audio Quality (DAQ) scoring, signal strength measurements, and GPS position. Results are plotted on a map to show where radio coverage either provides passing, failing or marginal audio quality.

Additional project savings can be realized if Larimer County specifies, procures, and implements the following on a separate and competitive basis:

- new sites (physical facilities) work
- non-fixed subscriber units (radios)
- microwave

CTA commends Larimer County for embarking upon the current path of building a new radio communications system. We encourage all those participating in this two-way communications project to embrace the recommended solution and provide all Larimer County public safety and public service personnel the improved communications that is critically needed.

1.0 INTRODUCTION

In May of 2005, CTA Communications, Inc. was contracted by Larimer County to help develop a plan for improving mobile radio communications on the County's public safety infrastructure. This plan takes into consideration the next generation, mission critical radio communication technologies and the existing radio systems in Larimer County.

The communications plan in this study includes the following:

- Initialization Meeting
- Site Surveys
- Personal interviews with County agencies
- Existing coverage analysis
- Alternative solution analysis
- Development of a preliminary communications system design that is highly adaptable for County Government Agencies and volunteer organizations
- Estimated budgetary turnkey system costs

Larimer County is the seventh largest County in Colorado based on population. The estimated population in 2004 was 283,000 which is about a 3% increase from 2003. The County encompasses 2,640 square miles that includes the Roosevelt National Forest and the Rocky Mountain National Park. Major communities include Berthoud, Estes Park, Fort Collins, Loveland, Timnath and Wellington.

The County currently provides radio communications support in the VHF band for County Government agencies that include the Sheriff's Office, Road and Bridge, Parks and Open Lands, Landfill as well as volunteer organizations such as search and rescue and volunteer fire departments. User requirements for each County agency were analyzed for an operational period of fifteen years. Through the needs assessment process, CTA partnered with the County and its users to identify existing radio system problems and future requirements. CTA examined existing equipment, property, facilities and have analyzed solutions to meet future needs and recommended a system design (including radio propagation, radio communications system, paging, and facilities) that meets countywide requirements and overcomes the various limitations that may be present, such as funding and scheduling. CTA has also provided budgetary turnkey cost estimates for the implementation of the preliminary design.

This report is structured in nine sections:

SECTION 1 INTRODUCTION – This section introduces the study.

SECTION 2 CURRENT COMMUNICATIONS ENVIRONMENT UPDATE - This section describes the current radio systems in Larimer County, its status, problems and current coverage analysis.

SECTION 3 REGULATORY ISSUES – This section describes the current regulatory or standards-related issues that will have an impact on planning a land mobile radio (LMR) system in Larimer County.

SECTION 4 SYSTEM FUNCTIONAL REQUIREMENTS – This section describes the system functional requirements for a new radio system to be shared by the various County public safety departments.

SECTION 5 ANALYSIS OF ALTERNATIVES – This section describes the analysis of alternative solutions for improving Larimer County's radio communications.

SECTION 6 PRELIMINARY SYSTEM DESIGN – This section describes the preliminary design of the recommended radio system for Larimer County's radio communications.

SECTION 7 FACILITIES FOR RADIO SITES – This section describes the facility requirements for the County's new radio system.

SECTION 8 COSTING – This section discusses the cost of the recommended preliminary system design.

SECTION 9 CONCLUSIONS AND RECOMMENDATIONS – This section summarizes CTA's recommendations for Larimer County's radio communications.

2.0 CURRENT COMMUNICATIONS ENVIRONMENT UPDATE

This section of our study documents the existing dispatch and radio communication systems in Larimer County. APPENDIX A provides all tables and figures in this report. APPENDIX B includes CTA's Site Observation Records, Initialization Meeting Record, and Interview Records. These records were created as a result of meeting with County personnel and CTA surveying radio sites and Public Safety Answering Points (PSAP) in June 2005. Descriptions of the current communications systems are given, and communications sites and PSAPs are identified. Present radio channel allocations are also provided. Refer to TABLE 2-1 for a listing of current public safety frequencies utilized in Larimer County. The non-fixed radio equipment (mobiles, portables, etc.) inventory estimates for the various agencies and departments are shown in TABLE 2-2. The inventory estimate is based on our survey information obtained directly from County radio system users.

2.1 Overview of the Larimer County 911 Communications

The Public Safety Answering Points (PSAP) for Larimer County consists of five (5) locations. Four (4) of the five (5) locations were visited by CTA during the week of June 06, 2005. The Loveland PSAP was not visited during the site surveys. All of the PSAPs use some of the same equipment vendors and models as each other; therefore, they have a lot of similarities. The following information was recorded during our visit:

2.1.1 Larimer County PSAP

The main PSAP for Larimer County is at the Larimer County Sheriffs Office (LCSO) on Midpoint Drive located at the east central side of the county.

This PSAP serves the following public-safety agencies:

- Larimer County Sheriffs Office
- Timnath-Wellington Law Enforcement
- Emergency Services
- Search & Rescue
- Dive Team

- Volunteer Fire / EMS
- Air Life
- State / County Parks

The Communication Center is equipped with a total of eight (8) positions with six (6) of the eight (8) used for dispatch/call-taker positions and the other two (2) positions are used only for call-taker positions. Each dispatch position has a total of five (5) monitors while the call-taker position has two (2) monitors. The dispatch positions have Centracom Gold Elite radio console positions that are interconnected into the Central Electronics Bank (CEB) audio switch located in the equipment room. The PSAP uses Plant Equipments VESTA Automatic Number Identification and Automatic Location Identification (ANI/ALI) software with the Plant Equipment MAARS (Modular ANI ALI Retrieval System) hardware. The 9-1-1 telephone service is provided by Qwest and the county uses a Centrex system.

The county utilizes the Tiburon Computer Aided Dispatch (CAD) and Records Management System (RMS) / Jail Management System (JMS), and uses 9-1-1 Maverick mapping software that interfaces with Tiburon. The city of Fort Collins GIS department handles all of the data inputs and software upgrades for the mapping software. The county is wireless Phase I deployed and wireless Phase II compliant. The CAD system also interfaces into National Crime Information Center (NCIC) and Colorado Crime Information Center (CCIC) databases. Though the county doesn't use mobile data, it has the capability of adding mobile data for future use into the CAD system.

The county uses a three-and-a-half year old NICE Digital Voice Logging (DVL) recorder that has a 32 channel capacity and records onto DVD's.

2.1.2 Fort Collins Police Department PSAP

The Public Safety Answering Point (PSAP) for the city of Fort Collins is at the Fort Collins Police Department (FCPD) on LaPorte Avenue. The city of Fort Collins is on the statewide Motorola 800 MHz SMARTNET 6.3 radio system.

This PSAP serves the following public-safety agencies:

- Fort Collins Police Department
- Ambulance services
- Platt River Fire
- Timnath-Wellington Fire/Ambulance
- Poudre Fire Authority

The Communication Center is equipped with a total of nine (9) positions with seven (7) of the nine (9) used for dispatch/call-taker positions and the other two (2) positions are used only for call-taker positions, and one (1) supervisor position. The dispatch positions have Centracom Gold Elite radio console positions that are interconnected into the Central Electronics Bank (CEB) audio switch located in the equipment room. The PSAP uses Plant Equipments VESTA ANI/ALI software with the Plant Equipment MAARS hardware. The 9-1-1 telephone service is provided by Qwest.

Fort Collins utilizes the Tiburon CAD and RMS/JMS system, and uses 9-1-1 Maverick mapping software that interfaces with Tiburon. The city of Fort Collins GIS department handles all of the data inputs and software upgrades for the mapping software. The city is wireless Phase I and Phase II deployed. The CAD system also interfaces into NCIC and CCIC databases.

The city uses a NICE Digital Voice Logging (DVL) recorder that records onto DVD's.

2.1.3 Estes Park Police Department PSAP

The Public Safety Answering Point (PSAP) for Estes Park is at the Estes Park Police Department (EPPD) on MacGregor Ave., located at the southwest side of the county.

This PSAP serves the following public-safety agencies:

- Estes Park Police Department
- Estes Park Volunteer Fire Department
- Ambulance services

- Area Park Rangers
- Six (6) Larimer County Sheriff Deputies that operate in the Estes Park area.
- Glen Haven Volunteer Fire Department
- Local utility providers after business hours

The Communication Center is equipped with a total of four (4) positions with three (3) of the four (4) used for dispatch/call-taker positions and the other position is used only as a call-taker position. The dispatch positions have Centracom Gold Elite radio console positions that are interconnected into the Central Electronics Bank (CEB) audio switch located in the equipment room. The town uses Metrocall for paging the ambulance services, fire departments, and the utility providers. The PSAP uses Plant Equipments VESTA ANI/ALI software with the Plant Equipment MAARS hardware. The 9-1-1 telephone service is provided by Qwest. There are a total of seven (7) 9-1-1 trunk lines, four (4) admin lines, and five (5) ring down lines coming into the PSAP. Also, Estes Park uses a PBX system inside the building.

The town utilizes the Tiburon CAD and RMS/JMS 7.2 system, and uses 9-1-1 Maverick mapping software that interfaces with Tiburon. The town is wireless Phase I and Phase II deployed. The CAD system also interfaces into NCIC and CCIC databases.

The town uses a NICE Digital Voice Logging (DVL) recorder that records onto DVD's.

Estes Park has two (2) channels assigned to the Ambulance Service, two (2) channels for the volunteer fire departments, and Estes Park Police Department has three (3) channels (car-to-car, Repeat, & TAC channel). Estes Park is experiencing coverage problems in some of the following areas: Pinewood Springs, Sections of Big Elk Rd, Star Mtn., and the Blue Mtn. Area.

Estes Park utilizes a mobile data system, but the current mobile data system design only provides 40% coverage in the town of Estes Park. The town is currently working on a new system layout that will improve the mobile data coverage.

Estes Park is using Alvarion fixed equipment on the 2.4 GHz frequency spectrum that meets the 802.11b standards.

2.1.4 Colorado State University (CSU) Dispatch

The CSU dispatch center has a total of two (2) positions that both have dispatch/call-taker capabilities. The dispatch center is located on Meridian Ave on the campus.

Each position has a Motorola Centracom Gold Elite radio console that is interconnected to the Motorola Central Electronics Bank (CEB) in the equipment room.

The PSAP uses the Tiburon CAD and RMS/JMS system, and uses 9-1-1 Maverick mapping software that interfaces with Tiburon. The CAD system also interfaces into NCIC and CCIC databases.

The PSAP uses Plant Equipments VESTA ANI/ALI software with the Plant Equipment MAARS hardware. The 9-1-1 telephone service is provided by Qwest. The PSAP uses a PBX system on the campus. The PSAP also uses a Dictaphone Digital Logging Recorder.

2.2 Overview of the Larimer County Radio Systems

CTA surveyed the following seven (7) radio sites: Buckhorn Mountain, Prospect Mountain, Justice Center, Horsetooth Mountain, Cactus Hill, Deadman Mountain, and the Larimer County Sheriffs Office.

Larimer County has an eight (8) channel, conventional VHF analog radio system with a microwave backhaul system for supporting the County public safety and public service departments. There is a voter receiver system in place for the sites that have receive only channels.

The following information was recorded during the surveys:

2.2.1 Buckhorn Mountain

Buckhorn Mountain site contains the following radio channels and base station modules:

- EMS-North Simplex – Motorola MSR-2000
- LCSO 2 Transmit – Motorola MTR-2000
- LCSO 4 (FIRENET) Simplex – Motorola MTR-2000
- LCSO 2 Receive – Motorola MTR-2000
- LCSO 3 Receive – Motorola MTR-2000
- Road & Bridge Transmit & Receive – Motorola MTR-2000
- Paging – MSR-5000

There is a microwave radio link located at this site and it includes:

A link to Horsetooth Mtn. – Alcatel MDR-6000, 16 x T1 channel capacity, 6 GHz

2.2.2 Prospect Mountain

Prospect Mountain site contains the following radio channel and base station module:

Paging – MSR-2000

There is a fiber link backhaul from this site that is managed by Platt River Power Authority.

2.2.3 Justice Center

Justice Center site contains the following radio channels and base station modules:

- LCSO 2 Receive – Motorola MTR-2000

- LCSO 3 Receive – GE MASTR II Auxiliary Receiver
- LCSO 4 (FIRENET) Receive – GE MASTR II Auxiliary Receiver

There are two (2) microwave radio links located at this site and they include:

- A link to Cactus Hill – Alcatel MDR-4000e, 2 x DS-3 channel capacity, 6 GHz
- A link to Horsetooth Mtn. – Alcatel MDR-6000, 4 x T1 channel capacity, 6 GHz

2.2.4 Horsetooth Mountain

Horsetooth Mountain site contains the following radio channels and base station modules:

- LCSO 1 Transmit & Receive – Motorola MTR-2000
- LCSO 2 Receive – Motorola MTR-2000
- LCDTF Transmit & Receive – Kenwood TKR-720/N/A
- LCSO 3 Simplex – Motorola MTR-2000
- LCSO 2 Transmit – Motorola MTR-2000
- LCSO 4 (FIRENET) Simplex – Motorola MTR-2000
- Paging – Motorola MTR-2000

There are three (3) microwave radio links located at this site and they include:

- A link to the Sheriffs Office – Alcatel MDR-4000e, 1 x DS-3 channel capacity, 6 GHz
- A link to Buckhorn Mtn. – Alcatel MDR-6000, 16 x T1 channel capacity, 6 GHz
- A link to the Justice Center – Alcatel MDR-6000, 4 x T1 channel capacity, 6 GHz

2.2.5 Cactus Hill

Cactus Hill site contains the following radio channels and base station modules:

- Road & Bridge Simplex – Motorola MTR-2000
- LCSO 2 Receive – Motorola MTR-2000
- LCSO 2 Transmit – Motorola MSR-2000 with 250 watt power amp
- Paging – Motorola MTR-2000
- EMS-North Simplex – MSR-2000
- National Law Enforcement Channel (NLEC) Simplex – GE MASTR II
- LCSO 4 (FIRENET) Simplex – Motorola MSF-5000
- LCSO 3 Simplex – Motorola MSF-5000

There are three (3) microwave radio links located at this site and they include:

- A link to the Sheriffs Office – Alcatel MDR-4000e, 2 x DS-3 channel capacity, 6 GHz
- A link to the Justice Center – Alcatel MDR-4000e, 2 x DS-3 channel capacity, 6 GHz
- A link to Deadman Mountain – Lynx SC.2, 1 x T1 channel capacity, 2.4 GHz

2.2.6 Deadman Mountain

Deadman Mountain site contains the following radio channels and base station modules:

- LCSO 2 Transmit – GE MASTR II
- LCSO 2 Receive – GE MASTR II Auxiliary Receive
- LCSO 4 (FIRENET) Simplex – GE MASTR II
- National Law Enforcement Channel (NLEC) Simplex – GE MASTR II
- Paging – Motorola MSR-2000
- EMS-North Simplex – Motorola MSR-2000
- Road & Bridge Transmit & Receive – Motorola MTR-2000

There is a microwave radio link located at this site and it includes:

A link to Cactus Hill – Lynx SC.2, 1 x T1 channel capacity, 2.4 GHz

2.2.7 Larimer County Sheriffs Office (LCSO)

LCSO site contains the following radio channels and base station modules:

- LCSO 2 Transmit (backup base) – Motorola MTR-2000
- LCSO TAC1 Simplex – Motorola MTR-2000
- DTR1 Control Station – Motorola ASTRO XTL-5000 Consolette
- DTR2 Control Station – Motorola ASTRO XTL-5000 Consolette
- LCSO 1 Control Station – Motorola ASTRO XTL-5000 Mobile Radio
- Greeley Police Control Station – Motorola ASTRO-5000 Mobile Radio
- NCPSCA/Ft. Collins PD Control Station – Motorola ASTRO-5000 Mobile Radio
- U.S. Customs Aircraft Control Station – Motorola ASTRO-5000 Mobile Radio
- FBI Control Station – Motorola ASTRO-5000 Mobile Radio
- Weld. Co. Sheriff Control Station – Motorola ASTRO-5000 Mobile Radio
- Loveland Police Control Station – Motorola ASTRO-5000 Mobile Radio
- DEA Control Station – Motorola ASTRO-5000 Mobile Radio

There are two (2) microwave radio links located at this site and they include:

- A link to Cactus Hill – Alcatel MDR-4000e, 2 x DS-3 channel capacity, 6 GHz
- A link to Horsetooth Mtn. – Alcatel MDR-4000e, 1 x DS-3 channel capacity, 6 GHz

Additionally, there are six (6) Raytheon / JPS-Communications SNV-12 voters located at this site for the following channels: 1) NLEC, EMS-North, LCSO 2 Receive, LCSO 2 Transmit, LCSO 3, and LCSO 4. Larimer County has an ACU-1000 modular interconnect system located at this site for the purpose of establishing interoperability with surrounding radio systems.

2.2.8 Fairgrounds and Events Center UHF Trunked Radio System

There is a four-channel Motorola UHF trunked radio system that was installed at the Fairgrounds and Events Center. The radio system provides coverage for the fairgrounds and within the exhibition buildings and the Budweiser Events center. The trunked radio system does not interface with the Larimer County PSAP for dispatch operations

2.2.9 Consolidated Communications Network of Colorado (CCNC)

The Consolidated Communications Network of Colorado (CCNC) Digital Trunked Radio System (DTRS) is a State and participant owned multi-site dedicated public safety wireless communications system using 800 MHz and 700 MHz for both voice and data (high-speed data is a future implementation). The design of the DTRS is based on the APCO Project 25 trunking standard and provides wide area interoperable communications to local governments and public safety groups.

The CCNC is "a nonprofit corporation advisory panel of member Participants, which makes recommendations and advises on the orderly operation of DTRS." The CCNC provides benefits and services to its participants that include the following:

- An 800 MHz digital FM signal
- Multiple system redundancies with backup power
- A wide range of talkgroups
- Auto affiliation and de-affiliation
- Electronic identification on all transmissions
- Microwave back-bone system reliability
- Encryption availability
- System security
- Radio interoperability
- 24-hour a day system monitoring. [1]

[1] Consolidated Communications Network of Colorado, www.ccncinc.org. This site provides information concerning the Consolidated Communications Network of Colorado (CCNC).

It should be noted that the "DTRS is designed to provide mobile radio communication coverage on major State highways to the participant. Portable radio coverage is not guaranteed and will vary from location to location. However, the system is provided as is and neither the CCNC nor the State of Colorado makes any guarantee, either express or implied, as to a specific level of coverage." [1]

2.2.10 Northern Colorado Regional Communications Network (NCRCN)

The Northern Colorado Regional Communications Network (NCRCN) was created before the state's CCNC was formed. The NCRCN consist of a board of local public safety and public service agencies in Larimer County that have combined resources to establish an APCO 16, Motorola SMARTZONE 800 MHz trunked radio communications system in the local area. All equipment was purchased by the NCRCN. The NCRCN has recently joined the CCNC and has upgraded their 800 MHz system to a P.25 compliant radio system. They continue to be a separate organization from the CCNC.

Sites have already been established through the NCRCN and the CCNC to provide 800 MHz coverage to Fort Collins, Loveland, Estes Park, and northeastern Larimer County. Sites that belong to the NCRCN have been connected to the CCNC zone controller provided by a Homeland Security Grant and is located at the Platte River Power Authority. In the mountainous areas, coverage is almost non-existent with the exception of Estes Park.

If Larimer County wants to join the NCRCN, a formal request to the CCNC is required. Once the request is made, the CCNC will perform a capacity analysis to determine whether additional channels at sites are required. If the County considers joining the NCRCN, a site in the Thompson Canyon to improve coverage would be requested of the County.

2.3 Larimer County Radio System Problems

This subsection describes the deficiencies found in the existing two-way radio systems used by the public safety and public service departments in Larimer County. During the personal interviews, CTA surveyed radio users from several County departments to determine the extent to which these deficiencies effect their operations. At the end of this subsection is a table that ranks these problems in order of severity.

2.3.1 Radio Users Surveyed

APPENDIX B contains the Interview Records of the radio users whom CTA surveyed. These records cite some of the specific problems each group has with the radio system. The following is a list of the departments considered in this study, most of whom provided us with operational considerations and problems that they are encountering with the existing radio systems during the face-to-face interviews and through additional written survey responses:

- Sheriff's Office Detention
- Sheriff's Office 9-1-1 Center
- Sheriff's Office Fairgrounds and Events Center
- Sheriff's Office Patrol
- Sheriff's Office Investigations
- Parks and Open Lands
- Road and Bridge
- Landfill

2.3.2 Problem Summary

During the interview process, CTA handed out a problem assessment table to be filled out by each department that was interviewed. The problem assessment table listed fifteen possible radio system problems for each department to rank from 0 (no problem) to 5 (critical concern). APPENDIX C provides copies of the filled out problem assessment table from each department that we interviewed.

TABLE 2-3 summarizes the ranked problem areas from each department, in order of reported severity, identified as a result of the interviews and surveys conducted by CTA. The list of defined problem areas is described as:

A. Limited Coverage -- Dead spots regularly occur, particularly between dispatcher and user.

B. Mobile to Mobile -- Users cannot talk between mobile units more than a short distance.

C. Channel Crowding -- Too many users on the channel; user cannot gain access when the situation requires communications with other units or with the dispatcher.

D. Channel Congestion -- Too many unrelated functions using the channel; user tends to turn volume down unless they specifically need to call someone, and thus cannot be reached.

E. Not Portable Based -- Portable units cannot generally and reliably be used in the system, particularly indoors.

F. Foreign Interference -- Other users in other locations interfere and step on the local users, forcing repeated messages, or overriding critical communications.

G. Local Interference -- Local users regularly step on other local users, either within or outside of the jurisdiction, forcing repeated messages, or overriding critical communications.

H. Reliability -- Frequent breakdowns of old or poorly maintained equipment, generally infrastructure equipment.

I. Lack of Interoperability -- The system does not allow users the ability to communicate between agencies within the jurisdiction.

J. Capacity -- The system has insufficient capacity to support traffic associated with peak or emergency conditions.

K. Cumbersome Operation -- The user needs to learn the characteristics of the system in order to operate on it, which causes difficulty if the user is in a high-pressure situation. The system does not have a grab the microphone and talk configuration.

L. Dispatcher Access -- For whatever reason, the dispatcher or the user cannot gain access to each other on a routine basis. Either the user must compete for the dispatcher's time, or the configuration is such that the dispatcher has no way to contact the user (private band operation).

M. Maintainability -- Maintenance is inadequate on user equipment (including consoles and desk top units); regularly need to return to get the same thing fixed.

N. Lack of Regional Interoperability -- The system does not allow users the ability to communicate between agencies outside of the jurisdiction. Use of private band systems causes regional interoperability problems as well.

O. Lack of Ability to Support New Technologies – The system infrastructure cannot readily support new technologies such as digital voice, AVL, Mobile Data etc.

2.3.3 Radio User Dissatisfaction

As a measure of the relative dissatisfaction of current users with their current systems, we have calculated the average numerical ranking for the above problems. Four rankings appear in TABLE 2-3, the first column representing the overall score for all departments, the second column for Public Safety only, the third column for Public Service (all other government departments), and the fourth column for the Fairgrounds and Events Center since this is a separate campus UHF trunked radio system. The scale ranges from 0 (highly satisfied) to 5 (highly dissatisfied).

Therefore, using the Public Safety scale, we note that the top eight problems on the list center around basic coverage related issues, interoperability, interference and channel capacity.

In the overall column that includes the Public Service departments, we see that interoperability, channel crowding, congestion, and interference, are all symptomatic of work groups that are forced to share channels.

2.4 Current Coverage of County Radio Systems

CTA was commissioned in this study to provide estimates of the current County radio coverage. This involves producing coverage maps for the existing tower sites operating in the VHF band. In addition to computer modeling estimates, this analysis takes into account information learned from County personnel, site survey observations, and user inputs on specific coverage problem areas.

During the personal interviews with the County agencies on the week of June 6, 2005, we asked each agency to circle coverage problem areas on a map of Larimer County. The map in FIGURE 2-1 provides a consolidation of the problem coverage areas that we obtained during these interviews. (We note that Road and Bridge did not have any present problems to report concerning the new high band VHF system since they were in the process of transitioning from their low band radio system.) We have used this map as part of our existing coverage analysis along with the coverage maps that was produced for the County's existing radio sites. In this subsection, we will discuss the County's existing coverage.

We suggest that the County may use the results of this analysis for the following purposes.

1. Use the maps to visually explain approximately where County radio users may, or may not expect to talk in on their radios.

2. Explain the impact on radio operations caused by coverage deficiencies.

3. Use the recommendations to justify radio system improvement.

CTA used computer modeling tools to estimate where transmissions from mobile and portable radios are likely to reach the network of radio towers with sufficient signal levels to be intelligible at dispatch. Our model utilizes receive path parameters including your tower site locations, antenna heights, antenna gains and patterns, circuit losses, receiver sensitivity, and typical environmental noise.

Transmitter parameters include typical power and antenna characteristics for a typical model of your VHF mobile and portable radios. We factor in the USGS National Elevation Dataset (NED) terrain data, USGS land use data, and where appropriate we insert building loss to compute and display expected coverage in map format.

Computer propagation modeling is a statistical estimate, and our computer generated studies shows where there is a *statistical* probability of coverage in a particular service area. While our predictions have proven to be reasonably accurate when averaged over an *area*, say a square quarter mile, the statistical margin of error becomes quite large when the sample size becomes small. In other words, our predictions will hold true for a neighborhood in Fort Collins, but are likely to be inaccurate for a particular street corner. This is the nature of coverage models.

Propagation prediction variability is derived from three basic sources:

1. The medium itself changes seasonally, daily, hourly, and sometimes by the minute, due to changes in atmospherics, weather, water content of vegetation, and intervening man-made objects (vehicles, construction, even aircraft). For a portable based system, the medium is affected also by where you wear your radio, the angle your body is with respect to the fixed radio site, how close you are to other objects, and even whether you are in an air conditioned location or outside and have perspired.

2. The influence of noise and interference in the VHF band affect the usability, and therefore the *perceived* radio system coverage. Our computer modeling and calculation process can only consider noise in an overall context. Point noise sources and intermodulation effects are outside the domain of computer propagation modeling.

3. Models are only an approximation of actual radio propagation. A number of useful models have been developed (i.e. Longley-Rice, Okumura, Anderson 2D, etc.). Each model has strengths and weaknesses depending on terrain, frequency bands, coverage area, etc. Although these models serve well, they are at best predictive tools. Actual field experience often identifies situations where a given model is less accurate in predicting system performance.

We describe some of the more dominant limitations below:

- Land-use Data. We use local clutter loss attenuation values in our model. The land use data is provided from the USGS and characterizes general land-use mapping differentiating between urban, residential, forest lands, crop lands, etc. over 200 meter square grids.

  Based on TIA/EIA TSB88A recommendations (SECTION 6.4) and CTA experience, the effect on radio propagation is determined by land use data and a dB loss assigned.

  Two sources of uncertainty arise from this process. First, although the USGS data is under constant development, changes in the land use patterns since the data was provided are missing. New construction can have a significant impact on propagation but may not be included in the data. Second, the data is developed by the USGS from aerial photogrametric analysis, and does not have sufficient resolution to account for individual buildings, or clusters of heavy buildings.

- Terrain Database. Our modeling uses the USGS National Elevation Database 1-second database, which means that an elevation data point is established every second of arc (approximately 100 feet). Although this elevation data base is the best currently available, large elevation changes over small areas may not be completely captured.

- Portable Configuration. To best portray your operating conditions, we modeled portable radios keyed at the head level. From a propagation standpoint, this is a more favorable situation than portables at the waist level keyed by a speaker/microphones on the shoulder. In the latter case, portables would experience several additional dB of path loss due to body absorption.

- Noise and Interference. Radio system design only generally takes into account the effects on voice intelligibility from co-channel and adjacent channel interference. Both steady and transient external noise conditions such as electric equipment, auto ignition systems, commercial and government radio, can all affect the performance of your radio equipment.

Nevertheless, although propagation predictions are not precise, computer propagation analysis can reveal useful information about the expected performance of radio in your area. A significant and consistent difference between predicted coverage and that experienced by your users could point out an installation problem or a deterioration that has occurred since the system was installed.

We note that users generally remark on poor coverage experiences and seldom remark on excellent coverage, and therefore we suggest that in the absence of a comprehensive radio measurement program, user experiences should be considered in the aggregate (give more weight to consistent multiple sources of coverage problems in an area than you would to a single individual).

2.4.1 Coverage Maps and Observations

We have observed that about 80% of the County's radio operation occurs east of the foothills. This area consists of both flat and rolling hills with light buildings making up the majority of construction. Some medium building structures also exist in the cities of Fort Collins and Loveland. Located west of the foothills are the Roosevelt National Forest and the Rocky Mountain National Park. This area consists of rugged terrain with high mountain peaks and low river canyons. Approximately 20% of the County's radio operation occurs in this area.

For this analysis, we use no additional loss for mobile and portable radios on the street. Light buildings are represented by a 12 dB loss in our modeling for VHF. Light buildings include typical single family residences and similarly constructed commercial buildings. Medium buildings are represented by a 20 dB loss in our modeling. Medium buildings include low office buildings and shopping centers and multi-story wood frame apartments.

To understand which channels are located at each site, we have devised a matrix for both receive and transmit channels. A receive site matrix is portrayed in TABLE 2-4 and a transmit site matrix is portrayed in TABLE 2-5. These tables reveal which frequencies have equipment in the same places.

FIGURE 2-2 is a composite map of the current talk-in mobile coverage for the Larimer County Sheriff's Office Channel 2 (LCSO 2). This map is based on a 100-watt mobile radio.

FIGURE 2-3 is a composite map of the current talk-in portable on the street coverage for LCSO 2. This map is based on a 5-watt portable radio. The LSCO 2 channel is the main dispatch channel for the Sheriff's Office. Talk-in coverage is based on voted receivers placed at the following sites:

- Bald Mountain
- Buckhorn Mountain
- Cactus Hill
- Deadman Mountain
- Estes Park
- Horsetooth Mountain
- Justice Center

FIGURE 2-2 shows that talk-in coverage is poor or non-existent in the following major areas:

- Poudre River Canyon
- Thompson Canyon
- Laramie River Valley
- Route 36 leaving Estes Park
- South Fork River
- Chambers Lake area
- Route 80c (from Laramie River Road)
- Route 74e (to Red Feather Lakes from Livermore)
- Rocky Mountain National Park
- Many coverage holes in the far north and south areas of the County

FIGURE 2-3 shows how the portable on the street coverage area is reduced in the mountainous areas. There is good coverage east of the foothills. Talk-in coverage is more reliable near the receive site in mountainous areas. Talk-in portable coverage is limited by the 5-watt transmitter, signal loss due to body absorption, and poor antenna gain on the portable. Noise and interference can be another factor in some locations.

FIGURES 2-4 and 2-5 shows portable talk-in coverage for light and medium buildings. Portable in-building coverage is important in heavily populated areas where the public safety radio users are required to enter into buildings on a daily basis. These figures show poor in-building coverage in populated areas east of the foothills.

FIGURE 2-6 shows a composite of mobile talk-out coverage. This figure shows the same coverage problems as FIGURE 2-2 except that talk-out coverage in Estes Park does not exist.

Based upon discussions with radio users concerning the existing coverage problems and our analysis of the coverage using our coverage model, we conclude that the County radio system is both talk-in and talk-out limited. We also believe that because the radio system setup uses transmission steering based on the best voted radio signal at the receive sites; this can present some operational problems that may be interpreted as coverage problems.

For example, dispatch tries to call back a radio operator with information or performs a status check and the radio operator does not hear the dispatch call. This is because the Sheriff's Office Channel 2, 3, 4 and the EMS North channels are transmission steered based on the position that the radio operator was last voted by the receive site. After a certain amount of time has elapsed, the transmission channel will revert back to the home site before dispatch calls back to the radio operator.

To solve this, the dispatcher will need to select different sites until the radio user is found. This then becomes a "hit or miss" operation. Also in the poor or non-existent coverage areas, a portable radio user may hear the dispatch message but will not be able to talk back to the dispatcher because of the talk-in limitation imposed by a lower power portable.

3.0 REGULATORY ISSUES

There are several significant regulatory or standards-related issues that will impact the planning of a land mobile radio (LMR) system:

- Migration to Digital Technology
- Narrowbanding of LMR Frequencies below 512 MHz
- The 700-MHz Public Safety Band
- The 800-MHz Rebanding Plan
- The 4.9-GHz Band

Each of these issues will directly affect the technology that will be available to Larimer County.

3.1 Migration to Digital Technology

The migration to digital modulation technology is not, strictly speaking, a regulatory issue. The Federal Communications Commission (FCC) has not mandated the use of digital modulation in any LMR band except for the new 700-MHz public safety band. However, digital modulation has been encouraged by several regulatory proceedings. This migration is driven by several factors:

- rapid growth of wireless communications technologies and services, which has created an increased demand for radio frequency (RF) spectrum;
- the need for improved security of voice communications;
- the need to transfer more and more varieties of data; and
- the availability of increased computing power for mobile and portable radio equipment.

For decades, LMR systems have utilized analog frequency modulation (FM) voice technology. The first trunked systems were based on analog modulation. More recently, the major vendors of trunked radio systems have offered dual-mode systems, supporting both analog and digital modulation. In 2004, the largest trunked radio system manufacturer, Motorola, announced it would stop shipping new dual-mode radio systems in favor of its all-digital product line. Motorola's largest competitor, M/A-COM, still continues to offer dual-mode systems.

Most conventional radio systems are still analog, but digital systems are increasing in number.

3.1.1 Digital Communications Techniques

One of the primary advantages of digital communications is the ability to improve spectrum efficiency by increasing the number of communication paths or circuits per RF bandwidth. In LMR systems, there are two main techniques for accomplishing this: frequency-division multiple access (FDMA) and time-division multiple access (TDMA).

In an FDMA system, spectrum efficiency is improved by dividing the existing RF channel into two (or more) narrower channels with one voice channel for each RF channel. In a TDMA system, spectrum efficiency is improved by dividing the channel into two or more time slots with one voice channel per time slot. For example, most existing stations in the VHF and UHF bands operate on 25-kHz channels. Under the FCC's narrowbanding plan, licensees can either convert their systems to operate in 12.5-kHz channels (the FDMA solution) or continue to use a two-slot TDMA solution in 25-kHz channels. In either case, the spectrum efficiency mandate is achieved by creating two voice channels per 25 kHz of spectrum instead of one.

3.1.2 Advantages of Digital Technology

3.1.2.1 Increased Capacity

As explained above, the main potential advantage of digital technology is the increased capacity generated by improved spectrum efficiency. Creating two or four voice channels per 25 kHz of spectrum doubles or quadruples capacity.

3.1.2.2 Signal Recovery

An analog repeater simply retransmits the signal it receives (along with noise and interference), while a digital repeater performs error correction on the received signal and retransmits it, removing noise and interference in the process.

A similar process takes place in the mobile or portable radio. The subscriber unit performs error correction on the received signal, providing better audio quality in weak-signal areas at the fringes of the coverage area. The drawback to this is that, to the user, there is no sense of signal degradation at the fringes. Audio simply disappears suddenly at the limits of radio coverage. Conversely, analog voice quality experiences a gradual degradation as the user approaches the fringes of the coverage area and thus provides the user some warning that they may soon be out of range.

3.1.2.3 Encryption

Although analog encryption schemes are still available for conventional radio systems, trunked radio system vendors only offer digital encryption. Digital encryption is more secure than analog encryption and does not reduce understandability as older methods did.

Even without encryption, digital systems provide some protection against casual eavesdropping because most scanners cannot decode digital signals. However, because there are digital scanners capable of decoding and tracking trunked digital radio systems, encryption is the only way to ensure security.

3.1.2.4 Mobile Data

Digital modulation schemes offer the potential for improvements in data rates for mobile data applications. Currently, most LMR vendors offer a data rate of 19.2 kbps per 25-kHz channel. This meets the FCC regulatory requirements for narrowbanding in the VHF and UHF bands and for the new narrowband channels in the 700-MHz public safety band. However, we believe that significant increases are possible in the future.

Most attention is now focused on the wideband channels in the 700-MHz band and the new 4.9-GHz public safety band. The FCC has mandated data rates of 384 kbps per 150-kHz channel in the 700-MHz band. The 4.9-GHz band is allocated especially for wideband data transfer at the incident scene. The channel plan is designed for commercial data standards like IEEE 802.11. The major LMR vendors are busy preparing products for these bands. The market for these products is new, so it will be a while before mature product lines are widely available.

3.1.3 Disadvantages of Digital Technology

3.1.3.1 Cost

The costs associated with digital technology have been significantly higher than with analog technology. However, digital equipment prices continue to drop. We expect that eventually the difference in price between analog and digital systems will no longer be an issue. At the present time, digital infrastructure equipment like repeaters and voters is about ten percent more expensive than comparable analog or dual-mode equipment, while digital subscribers can be 30 to 50 percent more expensive than analog subscriber units.

3.1.3.2 Interoperability

Interoperability remains a challenge for everyone, but especially for digital radio systems. Consider the following:

Analog conventional radio systems offer true over-the-air compatibility—unless the systems are in different frequency bands.

Trunked radio systems from different vendors do not provide over-the-air compatibility with neighboring systems. In order to provide communications between dissimilar systems, radio vendors must provide patches or other fixes that allow users to talk with each other on an as-needed basis. The alternative is to specify direct over-the-air compatibility with neighboring systems, which typically results in a sole-source procurement.

Even trunked radio systems from the same vendor may not be able to communicate with each other. New subscribers may be able to communicate on older systems, but the older subscriber units may not work on the new systems. This provides "halfway" compatibility.

Digital radio systems have an inherent latency—the time it takes to translate an analog voice signal into a digital format and then translate it back to analog voice at the receiver. This latency can be minimized within a single radio system, but when two systems are patched together, the analog-to-digital-to-analog conversion is performed twice rather than once, doubling overall latency and causing greater difficulty for field personnel.

These problems continue to make interoperability with adjacent jurisdictions using diverse systems and frequency bands a serious technical and operational challenge.

3.1.4 Project 25

The Association of Public-Safety Communications Officials International (APCO), in conjunction with the Telecommunications Industry Association (TIA) and others, initiated APCO Project 25 (P25) to promote a single non-proprietary set of standards for digital radio communications. The purpose of the standards was two-fold:

to improve interoperability between law enforcement agencies; and
to provide greater competition and cost savings in the procurement of radio equipment.

The P25 standards are being developed in three phases. Phase I, designated ANSI/TIA/EIA-102, is an FDMA technology based on one voice or data channel per 12.5-kHz RF channel. The Phase I standards are nearly complete. When vendors speak of P25 compatibility, Phase I is usually what they are talking about.

Phase II, still in the early stages of development, has several goals. One goal is to define technology standards that will provide one voice channel per 6.25 kHz of spectrum.

It will accomplish this by taking a two-pronged approach: an FDMA standard based on a 6.25-kHz RF channels and TDMA standards based on a four-slot 25-kHz channel or a two-slot 12.5-kHz channel. The standard requires that any Phase II equipment must be backward-compatible to communicate in Project 25 Phase I mode.

Phase II will also define IP-based interconnection standards for infrastructure equipment such as repeaters, controllers and consoles. As it stands now in Phase I, subscriber equipment from a variety of manufacturers can be mixed, but infrastructure equipment, such as repeaters, controllers and consoles, cannot. Once you purchase infrastructure equipment from a single manufacturer, you are locked in to that manufacturer for system upgrades or expansion.

Phase III, also known as Project 25/34, defines the requirements for wideband high-speed data standards. Work on these standards has continued under the auspices of Project MESA, a combined effort of the Project 25 Group and a European group. This effort has produced TIA-902, a wideband data standard which the FCC has proposed for use on the wideband interoperability channels in the 700-MHz band.

3.1.5 TSB-88

Prior to the development of digital modulation technologies, analog radio systems were designed based on a large body of empirical knowledge. Engineers were able to draw upon years of collective experience in the propagation characteristics of analog radio systems, translating acceptable communications to signal level targets. This is not the case with the new digital technologies.

In the case of digital technologies, each modulation technique may have different characteristics, and each vendor's product may have different error correction capabilities. Because of this, very little information has been published on digital propagation outside of information published by vendors on their unique products and coverage philosophies.

In an effort to fill the need for a common reference point in the field of digital radio propagation, the Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA) released Telecommunications Systems Bulletin 88 (TSB-88), *Wireless Communications Systems - Performance in Noise and Interference-Limited Situations -Recommended Methods for Technology-Independent Modeling, Simulation, and Verification*. Although not a true regulatory (FCC-inspired) action, TSB-88 and its latest revisions have already had an impact on the design of two-way radio systems.

TSB-88 is a beginning step, or basic guideline, for defining and predicting digital/narrowband propagation. It defines many of the elements of radio system coverage in common terms. There are sections devoted to service area, testing methodology, propagation models, reliability, noise and frequency coordination. It is not a standard, but has achieved "quasi-standard" status in that no other document or statement on the subject exists. Once there is more experience in actual field performance of digital systems, these lessons can be applied to the provisions of TSB-88.

The design of any radio system involves a certain degree of risk. As the vendor's engineers approach the project, they must account for this risk factor in the overall system design. A system designed with an overly optimistic propagation model runs the risk of not meeting the coverage requirements of the purchaser. A design that is overly conservative can reduce this risk to negligible levels, but the price of the system may be exorbitant.

The latest revision of TSB-88, TSB-88-B, takes a very conservative approach to radio propagation and system design. This encourages a design that provides reduced risk for the vendor but possibly higher expense for the customer.

CTA recommends and will assist Larimer County in designing a radio system considering the provisions of TSB-88-B. However, designing the system to meet all of the actual and implied recommendations of TSB-88-B may lead to an over designed system and excessive costs. Because of its "quasi-standard" status, the issue of TSB-88 "compliance" will be an issue in any liability or conflict situation. We recommend that TSB-88-B be taken into consideration during the design of the system but that the provisions of TSB-88-B be applied appropriately to the unique needs of Larimer County.

3.2 Narrowbanding of LMR Spectrum below 512 MHz

The FCC began in 1992 a proceeding to increase spectrum efficiency in the Private LMR (PLMR) bands below 512 MHz. The "Refarming Proceeding", as it became known, introduced major changes in these bands.

3.2.1 New Narrowband Channels

The FCC created new narrowband channels in the 150-174 (VHF High), 421-430, 450-470 and 470-512 MHz (UHF) bands.

In the VHF high band, where existing 25-kHz (wideband) channels were spaced at 15 kHz, new narrowband channels were created 7.5 kHz from existing channels. The new channels may only be licensed for bandwidths of 12.5 kHz or less.

In the UHF bands, where existing 25-kHz channels were spaced 25 kHz apart, new channels were created at 12.5 kHz and 6.25 kHz from existing channels. The channels 12.5 kHz from existing channels are available for licensing at 12.5-kHz or less bandwidths and those 6.25 kHz from existing channels are available for licensing at 6.25-kHz or less bandwidths.

The new channels are available for licensing now. However, incumbents are still operating at the old 25-kHz bandwidths on adjacent channels, creating the potential for interference to the new channels.

3.2.2 Narrowband Equipment Requirements

All new LMR equipment placed on the market today must be capable of operating at a spectrum efficiency of one voice channel per 12.5 kHz of channel bandwidth. This can be accomplished by using either FDMA technology, transmitting a single voice channel in 12.5-kHz RF channel, or TDMA technology, transmitting two voice channels in a 25-kHz RF channel. (For data transmitting equipment, the efficiency standard is 4800 bps per 6.25-kHz of channel bandwidth.)

The FCC's ultimate goal is one voice channel per 6.25-kHz channel, but the FCC has stayed the deadline for meeting this requirement as it considers the state of technology and narrowband migration.

Although new equipment must be capable of operating in more efficient modes, licensees are still allowed to operate this equipment at the old wideband efficiency standard of one voice channel per 25 kHz of channel bandwidth.

At the time these rules were adopted, the FCC believed that the congested conditions in the refarming bands would provide a "natural inducement" for users to migrate to narrowband equipment. However, since the rules were enacted, very few incumbents have migrated to the narrower bandwidths, so the FCC has reconsidered its decision that the migration be wholly voluntary.

3.2.3 Deadline for Wideband Equipment Manufacture

Recently, the FCC decided to set deadlines for migration to greater spectrum efficiency. As a result, the FCC decided to prohibit manufacture and importation of equipment capable of operating at one voice channel per 25 kHz of bandwidth after January 1, 2011.

3.2.4 Deadline for Migration

The FCC also updated the rules to set a fixed deadline for all users to transition to 12.5 kHz operation. The deadline for conversion to 12.5 kHz efficiency is January 1, 2013 for all licensees. After that date, all licensees in the bands 150-512 MHz must operate at one voice channel per 12.5 kHz of bandwidth. Users may still use 25 kHz channels as long as the spectrum efficiency standard is met.

The FCC has not yet set a deadline for conversion to 6.25 kHz efficiency.

3.2.5 Deadline for Wideband Applications

At the same time, the FCC set January 1, 2011 as the deadline for applications for new wideband licenses and modifications to existing wideband licenses.

This allows users flexibility to maintain and expand existing systems until two years before the migration deadline.

3.2.6 Trunking in the VHF and UHF Bands

As part of the Refarming Proceeding, the FCC established rules for trunking in the 150-174 and 450-470 MHz bands. The rules allow trunking as long as concurrence is obtained from affected licensees within 70 miles of the proposed trunked station. The term "affected licensees" refers to stations with assigned frequencies 15 kHz or less from a proposed trunked station with 25-kHz bandwidth, 7.5 kHz or less from a proposed trunked station with 12.5-kHz bandwidth and 3.75 kHz or less from a proposed trunked station with 6.25-kHz bandwidth. In lieu of concurrence, an applicant may provide an engineering study that demonstrates that the proposed station interference contour does not overlap the affected licensee's service territory. Rules for trunking below 512 MHz require so much coordination with neighboring licensees that they make the implementation of trunking systems in these bands quite difficult.

3.2.7 Impact of Narrowbanding on Larimer County's Communications

With its decision to set deadlines for the transition to 12.5-kHz operation, the FCC has provided much-needed clarity to the narrowbanding issue. Larimer County may legally continue to operate its existing 25-kHz VHF and UHF systems until 2013. County agencies need to be aware that eventually all of their equipment will need to be upgraded to narrowband as required by the FCC. This will require all base stations, subscriber radios and digital pagers to be replaced with narrowband capable units. County agencies should also be aware that replacement of their analog wideband equipment with analog narrowband equipment will reduce their overall coverage area and in-building coverage. This reduction is equivalent to reducing the overall system gain by as much as 3 dB (equivalent to 50% reduction in system gain). The FCC's decision provides sufficient time to plan for the transition.

If the County's existing wideband radio system is adequate, it may make sense to maintain it as is until the transition date is closer.

However, major new investments in equipment should be based on more spectrum efficient technologies.

3.3 The 700-MHz Public Safety Band

3.3.1 Balanced Budget Act

The Balanced Budget Act of 1997 mandated that television broadcasting be terminated on channels 60 to 69 (746 to 806 MHz) by December 31, 2006. The Act directed the FCC to allocate 24 MHz of the spectrum from these channels to public safety users. However, provisions were added that would allow incumbent broadcasters to continue broadcasting in this spectrum if any of three factors are true:

1. A station of one of the four major networks (ABC, CBS, NBC and Fox) is not yet broadcasting a digital television signal in a specific market and has exercised due diligence to meet construction deadlines;

2. Digital-to-analog signal converters are not readily available in a market; or

3. More than fifteen percent of the households in a market are not capable of receiving digital television programming by cable or over-the-air (47 U.S.C. 309(j)(14)(B) [Communications Act of 1934, as amended]).

These exceptions may delay significantly the availability of spectrum for public safety users in some areas. Because of the slow pace of the transition, some in Congress have recognized the need to do more to expedite the transition and free this spectrum for public safety communications, but no significant action has yet been taken.

3.3.2 Objectives

In response to the Balanced Budget Act of 1997, the FCC established a new public safety land mobile radio band at 764-776/794-806 MHz.

The FCC has adopted rules for this spectrum with three basic concerns in mind:

A. Efficiency. The FCC seeks to promote spectrum efficiency in the band by requiring an aggressive standard of one voice channel, or one data channel of 4800 bps, per 6.25 kHz of bandwidth. The FCC has not mandated a specific technology for meeting this requirement, but all systems licensed for this band must use some form of digital modulation. By 2015, all equipment manufactured and marketed for use in the 700-MHz band must meet the 6.25-kHz efficiency mandate, and no new applications for systems operating at 12.5-kHz efficiency will be accepted. By 2017, all systems in the band must operate at 6.25-kHz efficiency.

B. Interoperability. The FCC has set aside a significant portion of the band (2.6 MHz) for interoperability. Although the FCC has refrained from mandating standards for the rest of the band, it has mandated Project 25 Phase I as the standard for use on the narrowband interoperability channels.

C. Flexibility. The FCC has recognized that by mandating the adoption of specific technology standards, it may actually inhibit the acceptance of more advanced and spectrum-efficient technology. Therefore, it has chosen to allow the market to drive the technology. In that light, it has provided flexibility in the licensing of frequencies in the 700-MHz band. The band is divided into 960 narrowband 6.25-kHz channels and 120 wideband 50-kHz channels.

A licensee may aggregate two or four narrowband channels to create a single 12.5- or 25-kHz channel, as long as the overall spectrum efficiency is one voice channel, or one data channel of 4800 bps, per 6.25 kHz.

A licensee may aggregate two or three wideband channels to create a single 100- or 150-kHz channel with the requirement that the overall spectrum efficiency be at least 384 kbps per 150 kHz.

3.3.3 State Licenses

Recognizing the need of states for frequencies across a wide geographic area, the FCC has issued state licenses for 192 narrowband channels. These licenses are not subject to the regional planning process. The license grants require states to provide "substantial service" to their populations by specific deadlines. If the deadlines are not met, the licenses will be modified accordingly. Frequencies that are unused will revert to the general use spectrum to be administered by regional planning committees.

3.3.4 Regional Planning Committees

The 700-MHz band will be administered by regional planning committees in the same fashion as the 800-MHz NPSPAC band has been. The regions are the same as at 800-MHz with a few exceptions (Michigan and Connecticut). Regional planning committees are in various stages of forming and preparing plans for approval by the FCC. The only plan approved so far is Region 5, Southern California. Region 24, Missouri, is close, but no other plans have been approved. Until the regional plans have been approved, no licenses will be issued to local public safety users.

3.3.5 Availability

We expect the 700-MHz band to become widely available in the coming years. Delays in the implementation of digital television services will create difficulties and delays for public safety users. In areas without television stations in the 700-MHz band, spectrum will be available much sooner. In these areas, availability depends upon having a regional plan finalized and approved by the FCC. Unfortunately, the delays in availability will probably be the longest in the most populous areas of the country.

The major vendors have already produced "dual-band" subscriber units capable of operation in both the 700- and 800-MHz bands. To this point, however, none of the major radio system vendors has produced 700-MHz radio systems, although several have made commitments to do so.

The lack of a viable product line may create further delays for anyone seeking to use the band.

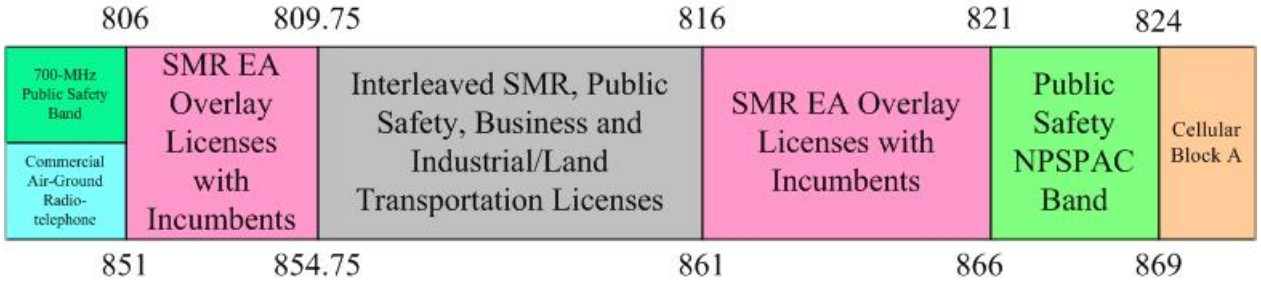
3.4 The 800-MHz Rebanding Plan

In 2001, in response to documented interference issues, Nextel Communications proposed a drastic realignment of the 800-MHz band. After extensive debate and comment, the FCC in 2004 adopted a rebanding plan.

3.4.1 The Current Situation

3.4.1.1 Existing Frequency Allocations at 800-MHz

The 800-MHz band has evolved over the years to produce the arrangement we have today, as illustrated below. The segments 806-809.75/851-854.75 and 816-821/861-866 MHz are licensed geographically by Economic Areas (EAs) to the Specialized Mobile Radio (SMR) Service. However, there are still some incumbent public safety and other licensees in these bands who were grandfathered when the EA licenses were auctioned.



The segment 809.75-816/854.75-861 MHz is allocated to four categories of users (SMR, Public Safety, Business, and Industrial/Land Transportation), with the different categories interleaved.

The segment 821-824/866-869 MHz, known as the NPSPAC band, is allocated solely to Public Safety.

Above 824 and 869 MHz are the cellular blocks A and B. Below 806 MHz is the new 700-MHz Public Safety band and its remaining incumbent TV stations. The band 849-851 MHz is the Commercial Air-Ground Radiotelephone Service.

3.4.1.2 Interference Mechanisms

In recent years there have arisen more and more reports of interference to 800-MHz public safety radio systems from Specialized Mobile Radio (SMR), Enhanced SMR (ESMR) and cellular telephone systems (collectively referred to as Commercial Mobile Radio Services [CMRS]) in the 800-MHz bands. The following is a summary of the interference mechanisms involved.

In the early days of the 800-MHz band, SMRs and other radio systems were generally designed to the same parameters: They were designed to cover as much territory with as few sites as possible. This led to systems with sites located at high elevations and operating at high power levels. Coverage for such systems is limited only by the strength of the signal compared to thermal noise of the receiver. Therefore such systems are called “noise-limited” systems.

In order to serve the greatest number of customers possible, modern cellular and ESMR systems are designed to reuse the limited number of channels available as often as possible. An individual cell is designed to cover a smaller territory, so sites are located at lower elevations with lower powers. Coverage areas of cells tend to overlap and receivers are designed to function in an environment in which interference from adjacent cells is common. These kinds of systems are considered “interference-limited” because their range is limited not by signal-to-noise ratio but by interference from adjacent cells.

When noise-limited and interference-limited systems are operated in close proximity (by frequency and geography) the potential for interference increases, especially to the noise-limited systems such as most public safety users operate. The problem is exacerbated by the high duty-cycles of SMR systems.

There are three main categories of interference involved:

A. Intermodulation

Intermodulation is caused by undesired mixing of two or more frequencies. This mixing produces signals at frequencies that are the combination of sums and differences of the frequencies being mixed. Intermodulation can take place in transmitters or receivers or elsewhere and creates unwanted signals that block desired signals. This is especially a problem when the desired signal is weak as in traditional noise-limited systems.

B. Receiver Desensitization

Receiver desensitization (or "desense") is caused when a nearby strong signal overloads the "front-end" amplifier of a receiver, reducing the gain of the amplifier in the radio, thereby inhibiting the ability to receive the desired signal. The effect to the user is the creation of "holes" in radio system coverage. A mobile or portable operating near an ESMR site will simply not be able to hear calls from its own system.

C. Transmitter Sideband Noise

Transmitter sideband noise is produced by the modulation of the carrier frequency. Modulation produces frequencies above and below the carrier. The FCC sets limits as to how much energy can be transmitted beyond the limits of a channel, but when a transmitter is nearby, sideband noise can override the weaker desired signal.

3.4.2 The FCC Rebanding Plan

The text of the FCC's rebanding plan was released August 6 and published in the Federal Register on November 22, 2004. On December 22, the FCC released another Order clarifying issues raised by Rebanding Order.

This is a summary of the plan:

- All non-Nextel incumbents will be relocated from the 806-809/851-854 MHz General Category band. These licensees will be relocated to former Nextel channels in the 809.75-816/854.75-861 MHz band.

- The NPSPAC band will be moved from 821-824/866-869 MHz to the new NPSPAC band at 806-809/851-854 MHz. In most instances, NPSPAC licensees will simply change frequencies by 15 MHz.

- Existing Public Safety systems and non-cellular Business, Industrial and Land Transportation (B/ILT) and SMR systems operating on interleaved channels between 809-816/854-861 MHz will continue to operate on those channels.

- Nextel will relocate all of its 800-MHz operations to the 817-824/862-869 MHz band, and will vacate all channels it now uses in the 806-817/851-862 MHz band segment. Public safety agencies and later critical infrastructure industries (CII) will have exclusive access to all channels vacated by Nextel in the interleaved portion of the band below 817/862 MHz for a limited number of years.

- The FCC has created an Expansion Band at 815-816/860-861 MHz. Incumbent Public Safety licensees will be given the option to relocate from this band to avoid potential interference from the new ESMR band above 817/862 MHz.

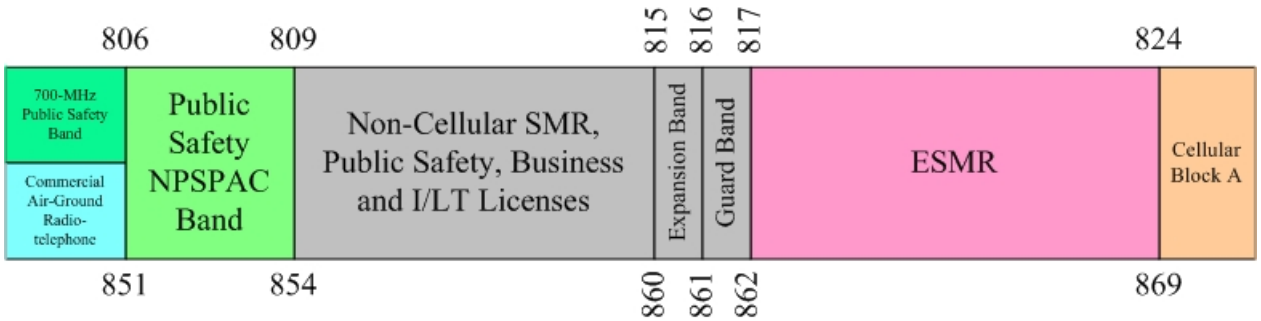
- The FCC has also created a Guard Band at 816-817/861-862 MHz. Any 800 MHz licensee may relocate to this spectrum, but will be afforded less protection from interference than licensees in the lower part of the 800-MHz band.

- Non-Nextel ESMR operations below 816/861 MHz may stay where they are, but will be subject to a stringent non-interference obligation.

- Nextel will receive 10 MHz of spectrum at 1910-1915/1990-1995 MHz.

- All costs for all licensees affected by band reconfiguration will be paid up front by Nextel.

Below is an illustration of the 800-MHz band allocations after the transition is completed. In certain parts of the country, most notably border areas and areas served by SouthernLINC, the plan is different.



3.4.3 Rebanding Management

In the Rebanding Order, the FCC ordered the five largest stakeholders in the 800-MHz band to select a Transition Administrator (TA) to oversee the process. The selection team chose BearingPoint, a management consulting firm, and its partners, Squire, Sanders & Dempsey L.L.P, and Baseline Telecom, Inc.

The TA will oversee the administrative and financial aspects of the band reconfiguration, provide accountability for the reconfiguration process, and help facilitate the band reconfiguration occurring with minimal disruption to licensees, particularly public safety entities. It will also authorize the disbursement of funds for band reconfiguration and resolve funding disputes through mediation.

3.4.4 Timetable

The reconfiguration of the 800-MHz band will be performed on the basis of the 55 NPSPAC Public Safety Planning Regions. On January 31, 2005, The TA provided the FCC with a schedule outlining the sequence in which regions will be reconfigured.

The schedule is based on four reconfiguration "waves". Colorado is included in Wave 1. Wave 1 was scheduled to begin on June 27, 2005. Each wave begins with the voluntary negotiation period for licensees on channels 1-120 (806-809/851-854 MHz). Voluntary negotiations for NPSPAC licensees in Wave 1 are scheduled to begin in February 2006. The waves are staggered by three months, so Wave 2 will begin on October 3, 2005, Wave 3 will begin January 3, 2006 and Wave 4 will begin April 3, 2006.

The schedule is supposed to provide for completion of band reconfiguration within 36 months of the beginning of reconfiguration of the first region. The FCC has mandated that within 18 months, Nextel must have relocated all non-Nextel incumbents in the 806-809/851-854 MHz band and begun negotiations with all NPSPAC licensees in the first 20 regions.

The 36 month deadline is extremely aggressive and there are many reasons to believe that it will be extended, especially in border regions where reconfiguration cannot begin until new spectrum-sharing agreements can be reached with Canada and Mexico.

3.4.5 Regional Timetable

The FCC will release a public notice 30 days before the official beginning of band reconfiguration for each region. That will initiate a three-month voluntary negotiation period during which Nextel and licensees will seek to come to a retuning agreement, including costs and schedule. If no agreement is reached during that time, there will be a three-month mandatory negotiation period overseen by the TA. If no agreement is reached at that time, the matter will be referred for resolution to the TA and then possibly to the FCC.

3.4.6 Application Freeze

During the transition period, when the TA announces the beginning of the transition for a particular NPSPAC region, there will be a temporary freeze on new 800 MHz license applications within 70 miles of that region. The freeze will begin 30 days before the voluntary negotiations period and end 30 days after the mandatory negotiations period—a total of eight months.

3.5 The 4.9 GHz Band

3.5.1 Band Plan

In 2003, the FCC established rules for the 4.9 GHz Public Safety Band. The band is divided into 18 channels with bandwidths of 1 or 5 MHz. The purpose of this band is primarily to provide public safety users with spectrum for broadband communications applications.

The spectrum can be used for data, voice, video, wireless local area networks, or any number of high-speed digital technologies. It is intended for mobile use, while temporary fixed use is allowed. The FCC envisions this band's use for the implementation of incident scene networks and wireless "hot spots" for high-speed data transfers of things like maps, building layouts, emergency medical service files, and wanted or missing person images.

Recently, changes were made to the rules for the 4.9 GHz band in order to allow the use of the IEEE 802.11 (Wi-Fi) series of standards. It is hoped that this will make available a wider range of products for use in the band and will leverage the economies of scale to lower equipment prices.

3.5.2 Licensing and Coordination

A license will be issued to any public safety entity, and allow the entity to operate base, mobile or temporary fixed units throughout its legal jurisdictional area of operation. Applications must be made directly to the FCC; there is no frequency coordination necessary and no fees. Permanent, fixed, point-to-point services are allowed on a secondary, non-interfering basis, but require a separate site license.

The spectrum is licensed on a shared basis, i.e., all users are licensed to all channels. Licensees must coordinate with each other to use the band. The FCC gave 700 MHz regional planning committees the option to establish regional plans for the use of the 4.9 GHz spectrum.

Since the availability of the band and the development technologies to use it are so recent, the FCC agreed to give the planning committees extended time to prepare plans for the coordinated use of the band. We encourage Larimer County to apply for a 4.9 GHz license. There are no deadlines to implementing a system. This band may provide the County an opportunity to implement an inexpensive high-speed mobile data network.

4.0 SYSTEM FUNCTIONAL REQUIREMENTS

In this section, we will describe the requirements for the new radio system to be shared by the various countywide agencies.

4.1 Overview of System Requirements

The radio system must provide two-way communications between dispatchers and mobile and portable radio units, and between the mobile and portable radio units themselves. Two-way radio communications may include both voice and data traffic.

The Larimer County radio service area is defined as the area within the geopolitical boundaries of the County. Radio coverage is required for mobile radios, portable radios (in-building), and control stations throughout the service area.

This list of system requirements has been used as a starting point to develop the system design alternatives, which in turn was used as a basis for developing budgetary cost estimates. This is a feasibility study addressing the proposed alternatives: the intent is not to have a fully designed system at this point, but only to make sure that each system design concept is generally feasible, operationally appropriate, and economically sensible for the County.

4.2 Target System Requirements

This section describes the target system functional requirements for a countywide radio system. The majority of County agencies independently rated each of these requirements by applying a weight factor from 0 to 5 for each of the attributes. The rankings indicate the relative importance of each attribute to the department. TABLE 4-1 provides the final weight factor results for each attribute listed. Independent ranking of the requirements by each participating County agency is provided in APPENDIX D. The specific requirements are defined in the following sections.

4.2.1 Coverage

For coverage east of the foot hills, the system shall provide a signal availability of 95 percent to/from all in-building portables (mounted at the hip level) and 95 percent to/from mobile radios, with coverage evenly distributed over the service area for all operational functions. The goal is to provide coverage with no dead spots.

For coverage in mountainous areas west of the foot hills, mobile coverage shall be provided on all major roadways.

4.2.2 Dispatch Operational Concept

The system shall continue to support dispatch operations from the Sheriff's Office Communications Center, where 9-1-1 call-takers and radio dispatchers are located.

Normal operations shall be conducted from a centralized dispatch location, where access to all talk-groups and agencies shall be provided by use of computer-controlled CRT consoles. The growth capability shall be provided by expansion of the computer database, and by the installation of remote dispatch consoles for Larimer County agencies, if required by the individual agency.

4.2.3 Flexibility in Personnel Allocation

The system shall provide the ability to shift personnel to support different radio groups depending on workload. Communications must be tied to the individual's work, not to the individual. The Larimer County emergency contingency plans should be aided, not constrained, by the communications system.

4.2.4 Survivability

The system shall be designed to survive in severe weather or emergency conditions.

If dispatch points are shifted from their primary to a backup location, radio control shall be available at the backup location to the same degree it was available at primary dispatch.

4.2.5 Capacity

The system shall have enough channels or talk groups to prevent channel over-crowding (having to wait for busy channels to clear). The system shall provide sufficient capacity so that the current routine, peak, and emergency overcrowding conditions will be alleviated.

- Routine Capacity: Alleviate crowded conditions with various channels at various times. This is true for both voice and data, and may include shifting some voice traffic to mobile data, and increasing data throughput.

- Peak and Emergency Capacity: Provide reserve for peak and emergency situations. The system shall allow priority calls for critical users when the system approaches full loading.

- Growth capacity: To the year 2021 (Voice and data).

- Goal: Radio system to handle routine traffic at 30 percent capacity, peak traffic at 60 to 95 percent capacity, and emergency traffic through prioritized radio usage.

4.2.6 Mobile Data

A separate radio system installation shall support a mobile data network either concurrently with the new radio system installation or in the future. The data platform shall include the following features:

- Support of the Police NCIC inquiry requirements.

- Universal data access: Access to centrally located information (databases), access to graphics, access to the District's LAN to the same extent as provided land based users (taking into consideration mobile bandwidth).

- Data call capability: Transmit data messages to talk-groups, individual units, or all units on the system ("all calls").

- Local computing capability: Smart terminal in vehicle for more flexibility, while retaining standard forms for routine operations.

- Mobile data capability for all field personnel.

- Other capabilities:

    - Faxing/printing (at offices, in vehicles)
    - Access to map information
    - Access to scanned images
    - Ability to transfer reports via RF

4.2.7 Automatic Vehicle Location

The system shall support automatic vehicle location (AVL).

4.2.8 Alphanumeric Paging

The system shall support alphanumeric paging for County personnel.

4.2.9 Future Expansion

The system shall be capable of future expansion of both the number of channels and the number of sites. System design shall incorporate expansion to the level of usage predicted for the next 15 years with only the addition of non-fixed equipment. No replacement of fixed equipment shall be required.

The proposed system shall be capable of advanced digital technology applications as described above.

4.2.10 Intercommunications

The system shall provide portable-to-portable, vehicle-to-vehicle, and vehicle-to/from-portable communications.

Emergency: Allow respondents from other agencies and the surrounding area to talk together during an emergency when they are a common team.

Provide the ability to move anywhere in the coverage area and communicate using the same radio with the same access protocol, and without needing to know where the calling or called unit is located.

Implementation of a mobile data capability shall provide the ability to send messages to anyone anywhere in the coverage area at any time regardless of whether the field person has checked in (registered with the system) or not.

4.2.11 Interoperability

The radio system shall allow continued or improved interoperability with Fort Collins, Loveland, Colorado State Police, Estes Park, Jackson County, Boulder County, Weld County, and Laramie County, WO.

Provide interoperability with the Forest Service and State Police.

4.2.12 Interference Immunity

The new system shall eliminate inter-site (co-channel) and skip (other users) interference.

4.2.13 Power Backup

All fixed radio equipment shall require backup power with automatic transfer, capable of handling 100 percent loading of radio equipment. An uninterruptible power system (UPS) shall be required for computer control equipment.

4.2.14 Maintainability

The radio system shall be designed for a mean-time-to-repair of not more than two hours.

4.2.15 Reliability

The radio system and equipment must be designed such that single-mode failures do not perceptibly impact the routine operations of the system. Current radios, which are generally aged and becoming unreliable, shall be replaced by reliable new equipment.

The following requirements shall apply to failure conditions:

- Channel failure: no operating impact due to failed voice or data channel.
- Primary power failure: On-line Uninterruptible Power Supply (UPS) backup shall be supplied for all fixed communications equipment. An emergency generator shall be supplied for primary power backup lasting at least 72 hours minimum.
- Console failures:
    - Console terminal failure: use reserve console.
    - Console common equipment failure: dispatchers operate co-located radio control station.
    - Communications Center failure: Revert to local dispatch at the designated backup dispatch facility.

4.2.16 System Operational Transparency

The radio system shall transmit/receive from multiple sites, with switching operations transparent to the radio user. System operation shall be logical, with the focus on whom the user wants to call rather than where they are located.

4.2.17 Console Features

All consoles shall be public-safety grade with keyboard, mouse, trackball, and/or touch-screen CRT operation, to include the following features:

- Capability for paging
- Ability to support computer-aided dispatch (CAD)
- Audible/visual cues for acknowledgment of calls transmitted
- Audible/visual cues to announce incoming emergency calls
- Instant-Call Recorders
- Logging Recorder
- Head set with microphone
- Foot pedal transmit button
- Cross-patching to the County telephone system
- Cross-patching to other radio systems (800 MHz, UHF, etc.)
- Dedicated telephone line access or microwave link to the base station repeaters (to prevent downtime with leased telephone lines)

There should be limited/controlled personnel access to console area to reduce distractions around dispatchers.

4.2.18 Emergency Access

The system shall provide universal emergency access throughout the County. Emergency calls shall have the highest priority and shall be given exclusive use of the channel during the duration of the emergency situation. Routine radio traffic shall be allowed to continue uninterrupted on other channels.

4.2.19 Initial Cost

The initial cost to Larimer County is a prime concern in the evaluation of the proposed alternatives. Trade-offs between cost and capability will be examined and presented in this report.

4.2.20 No Internal Congestion

The system shall have enough channels or talk groups to allow groups or departments with different functions to have their own channel or talk group, without interfering with or being interfered by other non-related groups or functions.

4.2.21 Long Term Cost

Long-term cost to Larimer County is a prime concern in the evaluation of the proposed alternatives. Long-term costs associated with leasing and ownership of the systems will be examined in this study.

4.2.22 Encryption (selected units only)

To prevent unauthorized release of confidential information, the system shall provide encrypted communications for designated law enforcement and possibly other required personnel. Encryption shall be DES or equivalent, as required by the agencies.

4.2.23 Competitive Procurement Process

The radio equipment shall be procured using open, non-restrictive, competitive specifications. Award is to be based on the most cost-effective system meeting the County's operational and functional requirements.

4.2.24 Operational Boundary Flexibility

Changes in County agency operational boundaries shall be transparent to radio users. The radio system shall allow any group or department to operate with full communications capability within the service area (i.e., County borders).

4.2.25 Commonality of Equipment

A single vendor shall install and supply all required LMR equipment. As much as possible, non-fixed equipment shall be similar in operation and maintenance requirements. Goal: minimize spare parts inventory and requirement for training on multiple system equipment.

4.2.26 Telephone Access

System shall provide authorized radio users ability to make telephone calls (without dispatch assistance) when system capacity is available.

4.2.27 Monitoring

Supervisors shall have ability to monitor communications.

4.2.28 Training

System vendor shall provide formal training for supervisors, dispatchers, field users, and maintenance technicians.

4.2.29 Additional Non-Fixed Radio Features

- Emergency call capability
  - Call back
  - Status (Fire and Rescue)
  - Number of talkgroups

- Number of systems
- Unit identification on each radio
- Call alert, select call, or paging from dispatch
- Audible tones to acknowledge successful/failed calls during push-to-talk
- Priority break-in for dispatchers to relay emergency information if users are on a talk-around channel
- Priority scan of talk groups
- Small, lightweight portables
- Capability to add a lapel mike to portables
- Intrinsically-safe operation for select portables (e.g., Fire and Rescue)
- Remote enable/disable

4.2.30 Cost Effectiveness

As much as possible, system procurement and implementation shall occur on a phased basis, intending to stagger costs over several years. The radio system shall be designed to meet operational needs while remaining within the Larimer County fiscal constraints. High, mid- and low-tier radio equipment with decreasing levels of feature sets matched to the particular using group shall be provided. Re-use of existing equipment where practical is desired.

5.0 RADIO SYSTEM ALTERNATIVES

A major step in the system design process was to identify communications systems alternatives that would satisfy the majority of County's requirements. CTA devised a list of requirements in SECTION 4 to be used as a starting point for identifying several design alternatives. These alternatives would then be analyzed based on meeting the requirements and resolving existing radio system problems. We then list here both the advantages and disadvantages of each alternative. From this analysis, we have selected the best candidate for further development into a conceptual design, which is described in more detail in SECTION 6.

5.1 Existing Countywide Radio System Problems

To help determine the right solution for a countywide radio system, CTA first identified a list of existing radio system problems in SECTION 2. These problems can be categorized as follows:

A. FCC Narrowband Mandate

In less than eight years, the current VHF equipment must be replaced with all new narrowband capable radio equipment (from 25 kHz to 12.5 kHz) as mandated by the FCC. The County will be required to procure all new base stations, subscriber radios and pagers that are narrowband capable. VHF subscribers should be aware that moving to an analog narrowband capable system will be equivalent to reducing the overall system gain by as much as 3 dB (50% reduction in signal strength) thus shrinking the existing coverage area. Any existing coverage problems will go from bad to worse. The County will have to come up with the funds to replace this equipment while dealing with the fact that their radio coverage will be degraded.

B. Interoperability between VHF and 800 MHz systems

Currently, 800 MHz systems are deployed by the State, Fort Collins and Loveland in Larimer County. Larimer County dispatch has some patching capabilities to talk to Fort Collins PD, Loveland PD and other agencies.

Interagency politics at higher levels does not allow Larimer County dispatch to utilize the patching capability for interoperability.

Valley Sergeants have 800 MHz radios but are only allowed to use the mutual aid channels (Fort Collins and Loveland will not allow use of talkgroups for interoperability). An ACU 1000 was installed to provide interoperability between VHF and the local 800 MHz systems. Interagency politics also does not allow its use with their 800 MHz radio systems because of the concern that their system will be loaded down. Interoperability between other agencies outside of the County is a concern. Messages from different agencies are relayed through a dispatcher. Cell phones are used as backup to resolve interoperability problems.

C. Channel Congestion

Most all County agencies have experienced channel congestion during different times of the day or during certain events. The channel congestion can be overwhelming and may cause confusion. During an emergency situation, this could also be a problem. This problem may get worse as the County grows in population and the numbers of subscribers increase.

D. Coverage Issues

In the mountainous areas, VHF coverage for the Sheriff's Office is hit or miss. Radio coverage in the mountainous areas is also poor in the extreme northern and southern parts of the County. Subscribers may be able to hear radio communications from dispatch but they cannot communicate back to dispatch. The alphanumeric paging system experiences the same coverage problems as the voice radio system. Estes Park dispatches for Larimer County due to poor coverage from the County radio system. This causes patrolman to switch back and forth between dispatchers.

Our VHF coverage analysis of the County's radio system shows that the major problem areas are west of the foothills. The radio system is both talk-in and talk-out limited. In some areas, the radio operator can receive messages from dispatch but may not be able to transmit back to dispatch. In other situations, dispatch tries to call back a radio operator with information or performs a status check and the radio operator does not hear the dispatch call.

This is because the Sheriff's Office Channel 2, 3, 4 and the EMS North channels are transmission steered based on the position that the radio operator was last voted by the receive site. After a certain amount of time has elapsed, the transmission channel will revert back to the home site before dispatch calls back to the radio operator. This causes the "hit or miss" effect when dispatch is trying to locate a radio operator.

As mentioned in the discussion concerning the FCC narrowband mandate, VHF subscribers will experience a reduction in coverage area based on converting their analog wideband systems to analog narrowband.

5.2 Alternative Solutions

CTA Communications investigated seven alternatives for implementing a countywide radio communications system. Each alternative was considered according to its ability to meet the requirements listed in SECTION 4 and correct the problems listed above. Once each alternative was identified, we then estimated a Rough Order of Magnitude (ROM) cost for each alternative to help with the decision process. We then presented these alternatives to the County with the associated estimated ROM costs for each during the Cost Benefit Meeting on August 26, 2005. The following alternatives were considered:

Alternative 1 Do Nothing
Alternative 2 VHF Conventional Simulcast Radio System
Alternative 3 VHF Trunked Simulcast Radio System
Alternative 4 Join CCNC/NCRCN 800 MHz Radio System
Alternative 5 Hybrid System – 800 MHz Trunked/ VHF Conventional
Alternative 6 Hybrid System – 800 MHz Trunked/ VHF Trunked

5.2.1 Alternative 1 Do Nothing

In this alternative the County would continue to operate and maintain their existing radio systems.

The FCC has mandated the conversion of all VHF and UHF equipment to narrowband. In this alternative, the County would be required to convert their radio systems to narrowband.

The deadline after which manufacturers will discontinue building wideband VHF and UHF radio equipment is January 1, 2011. The deadline to completely convert to narrowband is January 1, 2013.

If the County decided not to move forward with a new communications system solution, the County must take action to comply with the FCC regulations to move to narrowband.

The following actions must be taken:

- Replace all aging antennas and cables
- Replace all wideband repeaters and base stations by January 1, 2013
- Replace all wideband non-fixed equipment (mobiles, portables and control stations)
- Replace all wideband digital pagers

The estimated ROM cost for this alternative is approximately $1,347,000.

Advantages:

- Low cost.
- There are no operational advantages.

Disadvantages:

- Conversion of VHF/UHF equipment to narrowband will require total replacement of base stations, subscriber units and pagers.
- Radio traffic in individual VHF systems will increase causing existing congestion to go from bad to worse.
- No interoperability improvement between existing 800 MHz systems.
- VHF area coverage will further degrade as sites are converted to narrowband.

5.2.2 Alternative 2 VHF Conventional Simulcast Radio System

This alternative considers installing a conventional VHF simulcast system using the existing infrastructure with the addition of channels, sites, and microwave equipment to enhance capacity and the radio service coverage area.

The system will utilize the existing paging system and voice channels licensed to the County along with the addition of channels to improve capacity. Dispatch and subscriber operations will appear to be seamless since simultaneous transmissions will take place at each site. The dispatcher will not have to be concerned with the location of the subscriber when transmitting a dispatch message. If the simulcast solution is P25 (digital), simulcast sites are required to be close together. This means that many new sites will be required for proper operation.

The estimated ROM cost for this alternative is approximately $14,500,000.
Advantages:

- Provides seamless VHF mobile coverage (Simulcast)
- Improves dispatch operations
- Promotes interoperability with VHF user groups
- Improves channel congestion.
- County has full control of the radio system.

Disadvantages:

- High cost coverage solution if P25 simulcast, requires many sites.
- Requires a large number receive sites to balance the talk-in coverage area with the talk-out coverage area for portable operations.
- Does not totally eliminate channel congestion.
- Many new sites are required in the National Forest. Site approval will be difficult through the Forest Service.
- No interoperability improvements with the local 800 MHz systems.

5.2.3 Alternative 3 VHF Trunked Simulcast Radio System

This alternative considers installing a trunked VHF simulcast system using the existing infrastructure with the addition of channels, sites, and microwave equipment to enhance capacity and the radio service area coverage. The system will utilize the existing paging system and voice channels licensed to the County. The existing voice channel licenses will need to be modified for a trunked radio system application. Additional VHF trunked channels would need to be obtained from the FCC to provide sufficient capacity for all County agencies.

The trunked radio system will allow the segregation of County agencies and departments into separate talk-groups rather than these groups being placed on separate radio channels. Instead, a pool of radio channels will be accessible by all radio users through the trunked radio system controller. Dispatch and subscriber operations will appear to be seamless since simultaneous transmissions will take place at each site. The dispatcher will not have to be concerned with the location of the subscriber when transmitting a dispatch message. If the simulcast solution is P25 (digital), simulcast sites are required to be close together. This means that many new sites will be required for proper operation.

The estimated ROM cost for this alternative is approximately $23,500,000.

Advantages:

- Provides seamless VHF mobile coverage (Simulcast)
- Improves Dispatch Operations
- Allows each agency or department to operate on talk groups rather than competing for clear channel.
- Promotes Interoperability with VHF User Groups
- Eliminates Channel Congestion
- The County keeps full control of system

Disadvantages:

- High cost coverage solution. If P25 simulcast, requires many sites.
- Requires many receive sites to balance the talk-in coverage area with the talk-out coverage area for portable operations.
- Many new sites are required in the National Forest. Site approval will be difficult through the Forest Service.
- No Interoperability Improvements with 800 MHz Users
- VHF trunked licenses are difficult to obtain.

5.2.4 Alternative 4 Join CCNC/NCRCN 800 MHz Radio System

CCNC is the Consolidated Communications Network of Colorado, the users group for the Colorado Digital Trunked Radio System (DTRS).

The CCNC network is made up of member networks provided by the State of Colorado and other local government entities statewide. One of the member networks is the Northern Colorado Regional Communications Network (NCRCN). The NCRCN was established by the City of Loveland, the City of Fort Collins, the Poudre R-1 School District, the Poudre Fire Authority and the Northern Colorado Water Conservancy District.

In this alternative, Larimer County would join the CCNC to establish an 800 MHZ trunked P25 radio system that provides 95% coverage in mountainous areas for portable on-the-street and mobile operations. The coverage criteria would be 95% for areas east of the foothills for portable operation in medium and light buildings. Joining the CCNC would allow the County to implement a state-of-the-art 800 MHz P25 trunked radio system using the state's radio system contract. Sites have already been established through the NCRCN and the CCNC to provide 800 MHz coverage to Fort Collins, Loveland, Estes Park, and all eastern Larimer County. Sites that belong to the NCRCN have become part of the CCNC and have been connected to the CCNC zone controller located at the Platte River Power Authority. The County would add 800 MHz channels and repeaters at select CCNC/NCRCN sites to provide sufficient capacity east of the foothills. In mountainous areas, coverage is almost non-existent with the exception of Estes Park.

If the County joins the CCNC, the County will be responsible for proper maintenance and repair of its radio equipment. This assures that the County's radios are in optimal operating order and will not have an adverse impact on other participant's use of the DTRS. The County's maintenance capabilities and training levels will need to be reviewed by the CCNC Technical Committee to assure the service provider understands and can comply with DTRS standards, guidelines, and protocols, and is "qualified" to service the Participant's radio equipment.

The addition of infrastructure east of the foothills will be minimal since sites belonging to the CCNC and NCRCN already exist. Current DTRS sites within Larimer County are:

Site Name	# NCRCN base stations	# other base stations
Prospect Peak	0	5 (State of Colorado)
Drake	3	0

Site Name	# NCRCN base stations	# other base stations
Loveland	6	0
Poudre Valley Hospital	7	0
Buckhorn Mtn	3	5 (State of Colorado)
Horsetooth Mtn	9	1 (BOR)
Bald Mtn	6	2 (BOR, DOE)

800 MHz DTRS coverage in Larimer County is enhanced by other numerous radio sites in Weld and Boulder counties.

In areas west of the foothills, many new sites will be required to provide 95% portable on-the-street coverage. The County is currently adding a site at Bull Mountain through a grant that would provide additional coverage in the northwestern corner of the County. The grant includes microwave connectivity and equipment for 800 MHz. The county currently has an application filed with the US Forest Service to build a new site on Middle Bald Mountain. The County also has an agreement in place to provide free use of the FM radio station site at Black Mountain. These sites may not provide sufficient 800 MHz coverage in the National Forest. The County may need to add other 800 MHz sites to meet the 95% portable on the street coverage requirements in the National Forest. Sites that are built out for 800 MHz coverage will be connected to the CCNC. The County would be required to maintain all sites that they construct. Through the CCNC, the County will be able access to the 800 MHz radio network statewide.

All new subscriber equipment would be required for participating agencies. This alternative will enable the County to interoperate seamlessly with Fort Collins, Loveland and the Colorado State Police. In addition to the County moving operations to the CCNC, the County would continue operating its VHF paging system through the radio dispatch consoles. The CCNC Board will have to review the County's capacity requirements and needs before giving the approval to add subscribers, adding 800 MHz channels, adding sites and connecting a central electronics bank (CEB) located at the sheriff's office to the CCNC.

The estimated ROM cost for this alternative is approximately $25,670,000.

Advantages:

- Provides countywide 800 MHz portable on-the-street and mobile Coverage

- Provides advanced trunking features.
- Technology allows an efficient method of segregating agencies through the use of talk groups.
- Improves dispatch operations.
- Connection into CCNC allows for dispatch backup capabilities at Fort Collins and Loveland.
- Provides seamless interoperability with Fort Collins, Loveland and Colorado State Police.
- Provides statewide interoperability.
- Eliminates channel congestion.
- Easier to obtain grant dollars for a P25 solution.

Disadvantages:

- Very high cost coverage solution (many new sites required for countywide 95% portable coverage).
- NCRCN $50/Unit/Year fee for use of NCRCN infrastructure plus yearly maintenance cost for new 800 MHz sites.
- Many new sites are required in the National Forest. Site approval will be difficult through the Forest Service.
- Lose over-the-air of interoperability with Forest Service, National Park and other VHF user groups
- Lose control of radio system

5.2.5 Alternative 5 Hybrid System – 800 MHz Trunked/ VHF Conventional

The hybrid system in this alternative is a combination of Alternatives 2 and 4. This alternative takes advantage of the existing CCNC/NCRCN 800 MHz coverage east of the foothills for the 80% of the County's radio operation and adds a simulcast VHF conventional system for its remaining 20% of operations in mountainous areas. The County would add 800 MHz channels and repeaters at select CCNC/NCRCN sites to provide sufficient capacity. For VHF portable and mobile coverage in mountainous areas, the County would use existing sites and add new sites for enhancing VHF coverage. This solution requires fewer sites for 800 MHz in mountainous areas for 95% on the street portable coverage and takes advantage of VHF propagation characteristics in a rugged terrain.

The estimated ROM cost for this alternative is approximately $16,700,000.

Advantages:

- Provides solid 800 MHz coverage east of foothills.
- Provides advanced trunking features for 80% of the County's operation.
- Technology allows an efficient method of segregating agencies through the use of talk groups for 80% of operations.
- Improves dispatch operations
- Connection into CCNC allows for dispatch backup capabilities at Fort Collins and Loveland.
- Promotes Interoperability with both 800 MHz and VHF User Groups
- Improves VHF coverage in the mountains.
- Eliminates channel congestion.
- Lower cost coverage solution.

Disadvantage:

- Requires NCRCN user fee ($50/Unit/Year)
- Site approval may be difficult through the Forest Service for new VHF sites.
- VHF requires a large number receive sites to balance the talk-in coverage area with the talk-out coverage area for portable operations
- Select users may need two radios in vehicles.

5.2.6 Alternative 6 Hybrid System – 800 MHz Trunked/ VHF Trunked

The hybrid system in this alternative is a combination of Alternatives 3 and 4. This alternative takes advantage of the existing CCNC/NCRCN 800 MHz coverage east of the foothills for the 80% of the County's radio operation and adds a simulcast VHF trunked system for its remaining 20% of operations in mountainous areas. The County would add 800 MHz channels and repeaters at select CCNC/NCRCN sites to provide sufficient capacity. For VHF portable and mobile coverage in mountainous areas, the County would use existing sites and add new sites for enhancing VHF coverage. This solution requires fewer sites for 800 MHz in mountainous areas for 95% on the street portable coverage and takes advantage of VHF propagation characteristics in a rugged terrain.

The estimated ROM cost for this alternative is approximately $21,500,000.

Advantages:

- Provides solid 800 MHz coverage east of foothills.
- Provides advanced trunking features for both 800 MHz and VHF operations.
- Technology allows an efficient method of segregating agencies through the use of talk groups for both 800 MHz and VHF operations.
- Improves dispatch operations.
- Connection into CCNC allows for dispatch backup capabilities at Fort Collins and Loveland.
- Promotes interoperability with both 800 MHz and VHF user groups.
- Improves VHF coverage in the mountains.
- Eliminates channel congestion.
- Lower cost coverage solution.

Disadvantage:

- Requires NCRCN user fee ($50/Unit/Year).
- Site approval will be difficult through the Forest Service for new VHF sites.
- VHF requires a large number receive sites to balance the talk-in coverage. area with the talk-out coverage area for portable operations.
- Select users may need two radios in vehicles.
- Higher cost solution than Alternative 6.

5.3 Alternatives Analysis

CTA assessed the ability of each radio system alternative to meet the requirement established in SECTION 4 and assigned a value to each requirement from 0 (required function/attribute does not exist) to 5 (95 percent of the function/attribute is available) as shown in TABLE 5-1. We then multiplied this assessment value times the County voted weighted factor for each requirement established in TABLE 4-1 to determine the highest ranked alternative.

Comparison of the weighted-ranked results shows that the hybrid system discussed in Alternative 5 ranked the highest over all other alternatives.

The main factors that caused Alternative 5 to rank the highest are the initial cost and the cost effectiveness of this alternative.

During the Cost Benefit Meeting held on August 26, 2005, CTA recommended Alternative 5 as the best solution for the County based on the following:

- Robust VHF Coverage in Mountains
- Robust 800 MHz Coverage in Populist Areas
- Maximizes Interoperability in all Areas
- Eliminates Channel Congestion
- Moderate Cost Solution
- Potential of a Phased Implementation

The County further analyzed the six alternatives that were presented by CTA. On October 3, 2005, the County concurred with the hybrid solution that allows for a combination of 800 MHz through the CCNC and conventional VHF. Upon a more detailed investigation, it was determined that the County should keep the existing VHF system in place while phasing in 800 MHz countywide and transitioning VHF radio users to 800 MHz. Instead of implementing 95 percent portable on the street coverage in the mountains for 800 MHz, only mobile coverage will be established for all the main roadways. This will reduce the number of sites required for 800 MHz in mountainous areas thus reducing the total cost.

CTA recommends a phased approach for transitioning completely to 800 MHz over the next seven years before the County's VHF equipment has to be converted from wideband to narrowband as mandated by the FCC. In SECTION 6, we will discuss the preliminary design of the hybrid system based on a phased approach.

6.0 PRELIMINARY SYSTEM DESIGN

After taking into account the analysis of alternatives and discussions with County personnel concerning the design path for a countywide radio system, both CTA Communications and the County conclude that the hybrid alternative provides the best path for designing a new radio system. The hybrid system solution requires the County to join the CCNC. This will allow the County to continue using its VHF radio system while implementing a state-of-the-art 800 MHz P25 trunked radio system using the State's radio system contract. Sites have already been established through the NCRCN and the CCNC to provide 800 MHz coverage to Fort Collins, Loveland, Estes Park, and all of eastern Larimer County. Sites that belong to the NCRCN have been connected to the CCNC zone controller located at the Platte River Power Authority. In this section, we will discuss the radio system design based on existing 800 MHz sites and building new 800 MHz radio sites west of the foothills while retaining the current VHF radio system. The goal of this approach is based on providing 800 MHz mobile coverage to the main roadways in mountainous areas and 95 percent portable coverage east of the foothills in medium and light buildings and for on the street portable operations.

This alternative can be implemented in several phases. The first phase would begin by procuring 800 MHz subscriber units to operate on the existing CCNC network in Larimer County. Additional repeaters would then be added to existing sites to provide capacity for 80% of the County's operations east of the foothills. The current VHF system will remain operational for the paging system, the Road and Bridge Department, Parks and Opens Lands and the 20% of Sheriff's Office operations that take place in the mountainous areas while 800 MHz sites are being built. The Sheriff's Office and other County department vehicles may require a VHF and 800 MHz mobile radio at the interim to access both frequency bands in the County while 800 MHz coverage is being established west of the foothills. Approximately 218 mobile radios in the 800 MHz band will need to be procured for the Sheriff's Office vehicles.

The next phases will add sites in the mountainous areas over a number of years to provide mobile coverage on the main roadways. The County's VHF voice system will stay operational until all proposed sites are built. Once these sites are built, an additional 170 mobile radios in the 800 MHz band will need to be procured for the remaining County vehicles (Road and Bridge, Parks and Open Lands, Landfill, and other County departments).

Completion of site construction and commissioning should be before January 1, 2013, which is the FCC deadline to have all VHF equipment converted to narrowband. (If the County does not complete the build out of 800 MHz sites in the mountainous areas before January 1, 2013, the County will have to replace all wideband VHF infrastructure and radios with narrowband versions as required by the FCC narrowband mandate. This was estimated at approximately $1,347,000 in Alternative 1.) The VHF transmitters for the digital paging system will be the only part of the existing VHF system to be converted to narrowband.

6.1 Design Process Overview

The required quantities of channels, loading requirements, coverage, and connectivity are covered in this report. The design for the countywide communications system considers the following factors:

- Present and future requirements
- Performance
- Area Coverage
- Interoperability
- Capacity
- Connectivity between sites
- Reliability
- Maintainability
- Cost

We have followed a logical, sequential approach to analyzing the proposed solutions, summarized as follows:

- Identified existing communication systems problems
- Established the system requirements.
- Established and defined the minimum present and estimated future requirements independent of the present system capability.
- Developed the interoperability requirements both within and outside of Larimer County.
- Established and defined the minimum requirements for availability, maintainability, reliability, and survivability.

6.2 Major System Design Requirements

Before developing the conceptual design, we will first summarize the major design goals based on what has been learned from the needs assessment process with Larimer County and its participating agencies. These are the objectives that must be met for a successful project.

The entire list of system requirements is defined in SECTION 4 of this report.

- System capacity must support current operations and be expandable well into the future. Capacity impacts user load and channel space under routine, peak load and emergency circumstances.
- Provide 800 MHz mobile coverage to the main roadways in mountainous areas.
- Provide 95 percent 800 MHz portable coverage east of the foothills for on the street operations and in medium and light buildings operations.
- Provide mobile-to-mobile, mobile-to-portable, portable-to-portable and mobile/portable-to-dispatch intercommunications.
- Provide emergency call and emergency access capability.
- Provide communications security with digital encryption capability.
- Provide local interoperability for Larimer County departments, Fort Collins, Loveland, Estes Park, Colorado State Police, Jackson County, Boulder County, Weld County, Laramie County, WY, and Larimer County public safety and public service agencies.
- Maintain VHF conventional communications capability to provide interoperability communications with emergency respondents using VHF equipment.

6.2.1 Interoperability

The system must support interoperability by integrating communications for local law enforcement, firefighters, EMS, public services and other local, state and federal public safety organizations.

It will also have to accommodate the communications systems of neighboring public safety agencies, so that units from one locality can talk with their colleagues in another locality.

The system must be APCO P25 compliant and provide interoperability with the CCNC and the NCRCN.

The system must provide a patching capability to VHF control stations to interoperate with the Forest Service, Bolder County and other VHF user groups.

6.2.2 Service Dependability Criteria

Service dependability is made up of four critical elements: availability, reliability, maintainability, and survivability.[2]

Availability: The user must have communications available both when and where needed. In a two-way radio system, availability is composed of two elements -- coverage availability and channel availability.

Radio coverage must be provided to the level commensurate with the users' requirements. For the Larimer County radio system, this has been tentatively specified as 95 percent portable coverage to/from buildings east of the foothills and on street level in the unincorporated portions of Larimer County plus 95 percent mobile coverage on the main roadways in mountainous areas.

[2] Cardwell & Brush, "Meeting the Challenge of Assuring Dependable Telecommunications in the 90's," IEEE Communications June 1990.

Channel availability is a function of the channel loading, the number of users, the number of functions, and the frequency and duration of system access. The FCC dictates channel loading in some systems. However, it is flexible within certain limitations. A trunked system design is based on a FCC criterion of 100 units per channel to obtain licensing.

Reliability: The system and equipment must be designed such that single-mode failures do not perceptibly impact routine operations of the system.

A crucial system component of reliability is equipment redundancy. Key system elements, particularly control system elements, must either be redundant, or they must have bypass or alternate circuitry to enable operation when those elements fail.

Elements such as microwave should have redundancy (hot standby or loop configuration), and AC power should be backed up by an uninterruptible power supply (UPS) and sufficient emergency generator capacity.

Maintainability: The system and equipment must be configured such that a reasonably equipped and trained service shop can maintain it with a mean time to repair not exceeding two to four hours.

This requires adequate alarms and remote diagnostics; effective preventive maintenance procedures; documentation that is complete, understandable and usable; test equipment that is standard and accurately calibrated; and a spare board and parts program that supports the repair of any conceivable failure or combination of failures.

Survivability: The system must be designed to accommodate natural and man-made assaults on its operational status, and retain functional capability. The system must be designed to localize and contain failures, such that a failure in one area does not destroy the operational capability in other areas. Further, the system must be designed to fail gracefully, with each succeeding level of failure affecting operations to a greater degree.

6.3 Coverage Design and Propagation Analysis

Our first step in the technical design process is to establish the area of coverage for all agencies that will be operating on the new radio system. This requires an understanding of the service coverage area that includes in building and on-the-street coverage areas for portable radio operations as well as mobile communication areas. Discussions with the County concerning problem coverage areas have helped establish these service coverage areas and will be addressed in the following subparagraphs.

6.3.1 Service Coverage Areas

The service coverage area is that area within which the radio system is required to provide a specified level of service at a specified level of reliability. The service area for this design is defined by the political boundaries of Larimer County.

In our preliminary system design, the coverage area includes all areas within County boundaries. The radio system shall provide two-way radio coverage, base-to-mobile and mobile-to-mobile throughout the main roadways west of the foothills. Also, the system shall provide base-to-portable and portable-to-portable coverage achieving at least 95 percent availability within light, and medium buildings throughout the established service coverage area east of the foothills.

The in-building service areas are defined as follows:

Light Buildings: Light buildings include single-family houses, duplexes, town houses, stores and office structures of less than three stories, constructed of brick veneer, frame or block, and other buildings with similar radio signal penetration characteristics contained within the boundaries of Larimer County. These structures are characterized by a loss of 8 dB at 800 MHz.

Medium Buildings: Medium buildings include small-to-medium size apartment buildings, commercial buildings, enclosed shopping centers, schools and others with similar radio signal penetration characteristics contained within the boundaries of Larimer County. These structures are characterized by a loss of 12 dB at 800 MHz.

We consider light buildings to be the predominant building type in Larimer County, while there are some medium buildings located in Fort Collins and Loveland. There are a few buildings meeting the criteria of "heavy" that are scattered throughout the rest of the County. Coverage within these buildings as required will be achieved with in-building antenna/amplifier systems.

6.3.2 Communications Towers and Sites

For designing a system that provides the required coverage, we started with the existing 800 MHz radio sites owned by the CCNC, NCRCN, and the County that are located with Larimer County. These sites are currently connected to the Zone 3 Zone Controller. The existing location of these sites is shown in FIGURE 6-1. We also provide locations of proposed sites for mountain coverage. These are also shown in FIGURE 6-1. We note that the County has started development of the Bull Mountain tower site located in the northwestern corner of the County. This site will become part of the CCNC. This development is funded by a state grant and will provide 800 MHz coverage. Additional VHF radio equipment can be added at County expense. We also note that there are other CCNC sites in Boulder County that may provide some mobile coverage to the southwestern border of the County.

6.3.3 Coverage Parameters

The basis of this coverage estimate is a computer-generated coverage prediction program using CTA Communications in-house facilities. These predictions are based on knowledge of radio signal propagation, and the factors that affect the signal as it travels through the air, over different terrain types, through different vegetation types, into and around buildings and other obstacles. Parameters affecting the predictions include:

- Transmitter power
- Line losses
- Antenna gain(s)
- Antenna height(s)
- Receiver sensitivity
- Terrain levels

- Tree or foliage type and density
- Atmospheric conditions
- Radio Frequency Noise
- Portable configuration (handheld at head level, attached to belt using lapel speaker/mic with antenna)

The coverage predictions for the 800 MHz band is based on the Longley Rice model.

A one-second, digitized terrain database for the County was used for determining the elevation features used in the prediction. For the 800 MHz coverage predictions, a 12-dB signal attenuation factor was used for medium building loss, and an 8-dB signal attenuation factor was used light building loss.

Location and antenna height details of the existing and new tower sites are provided in TABLE 6-1. The effective radiated power (ERP) that affects the propagation analysis for the fixed and non-fixed equipment is also listed.

6.3.4 Radio System Coverage Estimates

The following steps were taken to complete the propagation analyses for Larimer County:

- Existing radio sites were located on a map for 800 MHz.
- A propagation analysis was run on each of these sites.
- Additional sites were identified for enhanced coverage
- The coverage contours were combined from plots of the individual sites. This final plot shows if adequate coverage is provided for outdoor, light building and medium building coverage scenarios (east of foothills).
- Tower-top amplifiers were used in the 800 MHz analyses to provide balance between talk-in and talk-out coverage for 800 MHz portables.
- After analyzing 800 MHz coverage at the existing sites, additional sites were added to fill in coverage holes.

We note that our coverage estimates are conservative and that the actual coverage may well exceed what is predicted on the maps presented in this section.

These maps do not show coverage from other state sites located outside of the County borders that may contribute to the overall coverage. Because of the difficult terrain in the western part of County, it is not feasible and cost effective to provide portable coverage to the whole County. Therefore, the goal is to provide mobile coverage to most of the main roadways west of the foothills and portable coverage east of the foothills. This does not include the Rocky Mountain National Park since this is patrolled by the Park Rangers using a different radio system.

As discussed in SECTION 5, we recommended that site construction be done in phases over the next seven years. This will allow the transition to 800 MHz from VHF before having to replace all wideband VHF equipment with narrowband equipment. Therefore, we have divided this analysis into phases to correspond with the recommended site construction sequence.

CTA analyzed coverage of the existing CCNC and NCRCN sites. Since many of these sites are close together and provide overlapping coverage, we did include every site in the design. For Phase 1, we focused on five CCNC sites as the baseline for this design. They include Buckhorn Mountain, Drake Mountain, Horsetooth Mountain, Bald Mountain and Prospect Mountain. The mobile coverage prediction for these sites is shown in FIGURE 6-2. FIGURES 6-3, 6-4 and 6-5 show portable coverage predictions for on the street, light building and medium building.

Seeing that adequate 800 MHz coverage is provided east of the foothills, CTA then identified areas for new sites to provide mobile coverage to the main roadways in the mountainous area. As mentioned before, Bull Mountain will be the first County/CCNC site to provide 800 MHz coverage in the mountainous terrain. This site should be completed by summer of 2006. This is also considered as part of Phase 1. FIGURE 6-6 shows the composite mobile coverage prediction when this site is completed. The County will need to pursue development of other sites in the mountains to provide the required mobile coverage. Establishing these new sites will include site approval through the Forest Service, the purchase of land, site and road construction and the construction of a tower at each site.

Phase 2 focuses on the use of an existing FM radio tower site located near Black Mountain. This established site will need little development and does not require approval from the Forest Service. FIGURE 6-7 shows the composite mobile coverage prediction for when this site is added.

Phase 3 focuses on site approval by the Forest Service for Middle Bald Mountain. This site is currently not approved by the Forest Service and may take up to five years before any implementation can take place. The Middle Bald Mountain coordinates were identified by the County as a location that can provide coverage in some areas along the Poudre River Canyon. FIGURE 6-8 shows the composite coverage prediction for when this site is added. We note that the existing and the proposed sites shown on the map do not provide total coverage along Route 36 south of Estes Park. Review of the CCNC coverage map on their Web site shows Route 36 covered by other sites outside of the County. This was confirmed through discussions with the DTRS Project Manager.

Phases 4A and 4B will be optional based on coverage testing results to determine if additional coverage is needed for west central Larimer County. FIGURE 6-9 shows the composite coverage prediction for the addition of sites at Kinikinik and Mummy Range.

Based on the analysis of these coverage plots, we have estimated that a minimum of two new sites in addition to Bull Mountain will need to be constructed for mobile coverage in the mountainous terrain. We have estimated two new optional sites (Phase 4A and 4B) for western central Larimer County if results from coverage testing require these additions. Concerning the coverage in the Big Thompson River Canyon and along Route 36, we would recommend that the County test the current 800 MHz coverage to determine whether additional coverage is required. Overall, a minimum of eight sites (combination of new and existing) has been estimated for mobile and portable coverage.

6.4 Multi-site Coverage Design

The CCNC DTRS design is based on the Motorola ASTRO 25 system. The radio network in Larimer County and throughout the State uses a multi-site configuration (as apposed to a simulcast configuration) for wide area coverage.

Each site has a separate set of 800 MHz channels and provides coverage to specific areas within the State of Colorado. The State is currently divided into three zones. Each zone is set up with a zone controller that supports a number of radio sites. The "third zone" controller resides at the Platte River Power Authority in Fort Collins where the existing sites for the CCNC and NCRCN in Larimer County are connected. This is also where Larimer County will connect all new 800 MHz sites and the County PSAP for dispatch operations. Radio units can be programmed to roam within Larimer County and the State of Colorado and still have access to the radio network. Access to the radio network will depend upon coverage from sites designated as part of the CCNC.

As discussed in the last subsection, CTA recommends that the radio system be built in four phases. FIGURE 6-10 shows a site connectivity diagram of the Hybrid System depicting existing site connectivity and future connectivity to new sites. FIGURE 6-11 shows a block diagram of the final system configuration once the County transitions fully to 800 MHz. The following four phases are recommended for the system implementation:

A. Phase 1

This phase starts with the County joining the CCNC. Coverage analysis shows that five existing sites can provide coverage east of the foothills and include some coverage in the Big Thompson River Canyon and in Estes Park. We recommend that the Horsetooth Mountain site be used as the prime site for operations since it provides the most coverage. Bald and Buckhorn Mountain sites will provide additional coverage while roaming out of range of Horsetooth Mountain. The last part of this phase connects the Bull Mountain site to the CCNC. The County has already funded the implementation of the microwave connectivity to this site. The following implementation steps are recommended for this phase:

- Add three (3) additional channels to Horsetooth Mountain
- Add two (2) channels to Buckhorn Mountain
- Add one channel to Bald Mountain
- Upgrade console CEB at the Sheriff's Office PSAP and connect to Platte River Power Authority
- Add 800 MHz subscriber units to CCNC network for primary operation east of the foothills

- Add Pole Mountain microwave site and connectivity to Buckhorn Mountain and Bull Mountain (this phase is currently fully funded)

B. Phase 2

The County currently has an agreement to implement radio equipment at an established FM radio tower site near Black Mountain. The following implementation steps are recommended:

- Add shelter, generator and utilities
- Add remote site equipment for five channels
- Add microwave connectivity between Black Mountain and Pole Mountain microwave site

C. Phase 3

Planning for this phase will need to start immediately in order to get site approval from the Forest Service within the next five years. The following implementation steps are recommended for this phase:

- Obtain site approval for Middle Bald Mountain site from the Forest Service
- Acquire land for site development
- Develop site and add tower, shelter, generator and utilities
- Add remote site equipment for five channels.
- Add microwave connectivity between Black Mountain and Middle Bald Mountain
- Transition remaining VHF subscribers to 800 MHz

D. Phase 4A

This phase is for developing an optional site at Kinikinik for enhancing Poudre River Canyon coverage. The following implementation steps are recommended for this phase:

- Obtain site approval from the Forest Service
- Acquire land for site development
- Develop sites and add tower, shelter, generator and utilities

- Add remote site equipment for five channels
- Add leased T1 connectivity

E. Phase 4B

This phase is for developing an optional site at Mummy Range for enhancing western central Larimer County coverage. The following implementation steps are recommended for this phase:

- Obtain site approval from the Forest Service
- Acquire land for site development
- Develop sites and add tower, shelter, and solar power
- Add two conventional mutual aid channels
- Add microwave connectivity to between Middle Bald Mountain and Mummy Range

As sites are developed and are made operational, we recommend that coverage testing be performed to document the extent of the area coverage before implementing additional sites. Site development can be adjusted based on final coverage results. CTA can provide independent coverage testing services using our RaCE coverage evaluation tool. RaCE provides end-to-end testing of your radio system and provides results such as Delivered Audio Quality (DAQ) scoring, signal strength measurements, and GPS position. Results are plotted on a map to show where radio coverage either provides passing, failing or marginal audio quality.

6.4.1 Coverage Enhancements

As sites are built out in the mountainous areas and coverage from these sites is tested, results may show a lack of coverage in areas where difficult terrain exists (e.g. Poudre River Canyon and Big Thompson River Canyon). The number of sites required to fill in these coverage gaps and the cost of a large scale radio site development may be too high for the small areas that needs additional coverage. There are existing technologies that can be used to enhance coverage in areas with difficult terrain without having to engage in a massive site development.

Mobile relay sites and transportable/mobile repeater stations are two such technologies that can help enhance coverage in these difficult terrain areas.

6.4.1.1 Mobile Relay

Mobile relays consist of special control stations that extend the coverage area of an existing site by receiving and rebroadcasting the signals from a repeater site to a subscriber unit, and from a subscriber unit to a repeater site. This technology can be used to extend coverage into small areas with difficult terrain in place of multi-channel repeater sites as long as there is overlapping coverage from a repeater site. Difficult areas such as the Poudre River Canyon and the Big Thompson River Canyon can benefit by this technology. Sites can be placed in strategic locations to extend coverage from existing repeaters into these difficult areas.

6.4.1.2 Transportable and Mobile Repeater Stations

A transportable or mobile repeater station can be used in areas where the 800 MHz system does not cover, in locations where there is a temporary need for additional capacity, and in situations where a critical LMR site may not be accessible for ground operations.

The mobile repeater station is envisioned as packaged in a transportable container, with the capability to be vehicle driven, vehicle towed, or helicopter dropped into a temporary location. The platform should be designed to be rugged, contain a generator, erectable tower, and fuel tanks. At least 5 trunked channels should be made available.

6.5 Digital Linkages

The County PSAP and new radio sites will be connected via digital links. Digital links are typically one of the following: digital microwave, owned fiber optic links, leased fiber optic links, or leased T-1 circuits.

Digital microwave is the medium of choice for interconnection of the new radio sites for the following reasons:

- Control
  The system and links are under the complete control of the owner. Leased links or circuits are subject to economic or other priorities established by the owners. This applies to service interruptions, priority of restoration of service, and circuit degradation.

- Reliability
  Microwave links are designed for reliability on the order of 99.9995% or better, which translates into outages of less than one minute per year. These outages are related to atmospheric conditions (at these frequency bands the conditions result from tropospheric anomalies, rather than storm conditions) distributed over the year with typical outages seldom exceeding several seconds in length. Fiber optic links are subject to fiber damage from storms or construction, and when this happens the outage is on the order of hours or days. Leased circuits are subject to all of these outage mechanisms plus power loss.

- Cost
  For circuits exceeding several thousand feet, microwave typically costs less than fiber links. Microwave costs include the initial construction and maintenance. Fiber costs include initial construction, maintenance, and the cost of right-of-way. While initial costs will approximately equal-out for a five to ten mile link, right-of-way costs become dominant at fairly short distances. Leased T-1 circuits typically exceed the cost of microwave at the four-to seven-year point, depending on distance, demand, and commercial rates.

- Utilization
  Excess capacity in a microwave link may be used for other purposes, such as mobile data circuits between various points in the region. While this capability is also available for fiber links, it is not for T-1 circuits.

  If it is part of a competitive procurement process, and if it is well defined in the specification, market pressure will provide the most cost-effective solution.

6.6 Microwave Subsystem

6.6.1 Subsystem Description

The County currently has a microwave system deployed for connectivity between the VHF sites. The County also provides microwave connectivity to Buckhorn Mountain and Horsetooth Mountain for the 800 MHz radio system used by the CCNC and NCRCN. As the County begins to deploy 800 MHz sites west of the foothills, they will need to expand connectivity out to the new sites. A digital microwave system can be implemented to interconnect most of the new sites as a more reliable alternative to leased T1 lines. Currently, the County has already planned to extend microwave connectivity to the new Bull Mountain site that will be completed by summer of 2006. Since this site cannot be reached directly from the County's existing sites, a microwave tower site at Pole Mountain in Wyoming has been located that will provide connectivity to Bull Mountain and other sites planned for northern Larimer County. FIGURE 6-12 shows the physical layout of the proposed microwave subsystem in its completed state based on the coverage design discussed previously.

The digital microwave layout consists of a spur configuration and uses the 6 GHz band for all hops. The spur configuration is designed using hot-standby microwave radios to provide equipment redundancy. An optional loop is shown by installing a hop between Middle Bald Mountain and Buckhorn Mountain. This can be considered after Phase 3 for additional capacity and path reliability.

6.6.2 Microwave Path Profiles

Path profiles between sites for the microwave path were reviewed for feasibility. FIGURES 6-13 through 6-19 illustrates the path profiles for the planned and proposed microwave links. The profiles are based on the microwave dish elevations given in TABLE 6-2. These path estimates were developed using the CTA Communications' one-second-terrain database. TABLES 6-3 to 6-9 also show the path reliability calculations for each path.

We note that the link between Buckhorn Mountain and Pole Mountain is 42.97 miles. The length of this hop limits the size of the radio to a 4DS1 model at 6 GHz using a 6' antenna. Our proposed design will require all four T1 links provided by this hop. If additional microwave capacity is required in the future to the proposed radio sites, a hop between Buckhorn Mountain and Middle Bald Mountain can be implemented to provide an additional 8 DS1s at 6 GHz using a 6' antenna. The path profile for this hop is shown in FIGURE 6-20. The path reliability calculations for this hop is provided in TABLE 6-10.

It is essential that, prior to implementing any microwave path, the microwave vendor conduct a physical path survey to verify that the required clearances are maintained.

6.7 Intercommunications and Interoperability Design

6.7.1 Intercommunications within the Coverage Area

All agencies within the County using 800 MHz will be compatible and capable of communicating with one another. During the transition from VHF to 800 MHz, intercommunications between VHF and 800 MHz users inside of the County becomes an operational issue of how best to enable cross-band communications. To enable seamless communications, a percentage of radio users will be required to be equipped with a VHF and 800 MHz radio. VHF radios will be used in the majority of locations west of the foothills while 800 MHz is being implemented. As 800 MHz coverage becomes available in these areas, the radio user can then completely switch over to 800 MHz. The cross band patch feature will be available at the dispatch level if use of this feature is required to patch a VHF user to an 800 MHz user.

6.7.2 Dispatch and Tactical Communications

All public safety agencies that operate under the 800 MHz trunked radio system will be dispatched over their designated dispatch talkgroups.

The VHF dispatch channel used by the Sheriff's Office will remain operational with 800 MHz dispatch talkgroups while 800 MHz coverage is being implemented west of the foothills. The Centracom Gold Elite dispatch consoles will have the capability to dispatch to 800 MHz and VHF at the same time or by separate talkgroup or VHF channel. For tactical operations, each public safety agency will have specific talkgroups programmed into their radios. Development of a fleetmap for each public safety agency using trunked radios will be required during the implementation phase of the countywide radio system.

6.7.3 Interoperability between County Agencies and with Surrounding Areas

The County and its Cities and Towns must maintain its ability to communicate between law enforcement, fire departments, public service departments and with all surrounding jurisdictions for mutual aid response. Routine cooperation with Weld County, Boulder County, Jackson County and Laramie County, WY for mutual aid is critical. Mutual aid response with the State Highway Patrol and these jurisdictions must be planned for.

Roaming into jurisdictions outside of the County for mutual aid will require cooperation between public safety agencies within the County and the adjacent jurisdictions. For outside jurisdictions that roam into the County for mutual aid that do not have 800 MHz trunked radio systems that tie into the CCNC, patches to VHF can be made as long as a VHF control station for that jurisdiction is tied into the County dispatch console. The dispatchers will be able to patch cooperating channels to the appropriate 800 MHz talkgroups. Patches should only be used on a temporary basis. Permanent patches may have an impact on system loading. Technical solutions will be employed to facilitate the operational changes. Surrounding jurisdictions and important channels will be wired into the dispatch center making them available for patching. These technical options are available to help satisfy this requirement:

A. Utilize assigned Mutual Aid analog conventional 800 MHz channels. (Provides communications with all 800 MHz equipment.) This has been provided by the CCNC and NCRCN at the existing 800 MHz sites.

B. Over-the-air access can be granted to the non-county agencies as well as counties with compatible 800 MHz radio systems.

C. For jurisdictions that do not have 800 MHz radio systems, response (supervisory) vehicles may need to retain VHF mobile radios to operate on the adjacent jurisdiction's channels. The installation of additional radios is not recommended on a wide-scale basis, but may provide a cost-effective solution in certain situations.

D. Provide a few portable radios in response vehicles that will operate on the adjacent jurisdiction's channels.

A mix of the above techniques will satisfy the requirements for the County.

6.8 Paging System

The VHF paging channel will need to continue its operation after the VHF voice system is discontinued. The wideband paging transmitters will be replaced by a narrowband version during the 800 MHz implementation. This needs to be completed before January 1, 2013. Once the Road and Bridge Department completely moves over to 800 MHz, the VHF voice system at Cactus Hill and Deadman Mountain sites will no longer be needed and the County can choose to dismantle these two sites. Since these two sites are used for the current paging system, the County would need to move the paging transmitters to other locations. The construction of the Middle Bald Mountain site in the future can be used to replace the Deadman Mountain site. The Sheriff's Office location can also be used to replace the Cactus Hill site.

6.9 Public Safety Answering Point (PSAP)

The proposed system design assumes the reuse of Centracom Gold Elite dispatch consoles at the Sheriff's Office PSAP. The Sheriff's Office PSAP currently accommodates six (6) dispatch and call-taker positions. Upgrades to the existing Central Electronics Bank (CEB) may be required for interconnection with the CCNC zone controller located at the Platte River Power Authority. VHF operations through the existing dispatch consoles will continue as 800 MHz connectivity PSAP is made. Once this connectivity is completed, the Sheriff's Office PSAP will have the capability to monitor 800 MHz communications from Fort Collins, Loveland and the State Highway Patrol. Proper programming will also allow Fort Collins, Loveland and the Sheriff's Office to act as backup PSAPs since all will be on the same radio network.

6.10 Fairgrounds and Events Center UHF Trunked Radio System

The existing Fairgrounds and Events Center UHF Trunked Radio System does not have a link to the Sheriff's Office PSAP for dispatch capabilities. We recommend that a link between the Events Center and the PSAP be installed. This can be either a fiber line, leased lined or a RF link. If coverage between the Events Center and the Sheriff's Office is good, the County can connect a UHF trunked control station at the Larimer County Sheriff's Office to a BIM card in the CEB to provide a RF link to the Events Center radio system. This would be the most cost effective method. A Yagi antenna to the control station should be installed and pointed towards the Event Center. A dispatch talkgroup should be programmed into all law enforcement radios used at the Events Center. This will allow dispatch calls to be made directly between the PSAP and the Events Center without the patrolman on duty having to carry two radios.

6.11 Mobile Data System

The overall ranking of requirements that was provided by County agencies in SECTION 4 showed that mobile data terminal technology as part of their requirements would be nice to have and could enhance operations. Although coverage, interoperability and capacity in the current radio system seem to be the number one priorities, the County should still plan for a future mobile data system. The CCNC does have a future requirement to implement high-speed data as part of the statewide network. This network may not be implemented until the next five years.

In this network, data would be shared over wide areas. In the interim, the CCNC voice system does provide a slow data capability using the voice channels. The data rate is available at 9600 bps. If a mobile data terminal is used with the same voice radio, then all voice radio traffic will have priority over data traffic. A separate data radio can be used on a separate talkgroup for mobile data applications to alleviate contention between voice and data on the same radio. This light data capability can be used for status messaging, silent dispatch, or small mug shots. Our recommendation is for the County to actively monitor the CCNC plan for providing a faster data service to Larimer County. Once implemented, this high-speed data capability will be available to all County agencies just as the voice network (the CCNC data capability does not include automatic vehicle location (AVL) capability at this time).

The ability to fulfill the need for an independent high-speed mobile data network in the County will be affected mainly by cost. Since cost may be an issue in establishing a private mobile data system, the interim solution for high-speed data is to use commercial services provided to the County. Like cellular services, commercial mobile data services are limited to highly populated areas. Therefore, commercial mobile data use will generally be limited to areas east of the foothills. Once the State implements a high-speed wide area mobile data capability in Larimer County, the County then can consider joining this network and terminate commercial mobile data services.

For the purpose of this report, we have provided in this subsection an explanation of the technology options that are available to construct a solution for mobile data.

All countywide agencies can realize the benefits of a carefully designed mobile data system. For Public Safety, these include silent dispatch, and direct access to local, state, and federal information systems. Field reporting enables workers to more accurately and efficiently complete needed paperwork on-the-scene. Non-public safety workers can access County information where and when it is needed using wireless technology. This saves return trips to the office and supports paperless operations. Information can include maps, GIS databases, ordinances, and a variety of information available on the County intranet.

6.11.1 System Functions

Law enforcement and fire departments can implement mobile data dispatch. This allows direct transfer of 9-1-1 and CAD incident information to the Mobile Data Computer (MDC) of the assigned responding officer. This is sometimes called "silent dispatch" in that it cuts down on the verbal communication required to dispatch a call and improves information accuracy. Common mobile data dispatch functions include:

- Incident dispatch
- Unit status, all unit status
- Self-initiated incident
- Messaging

Law enforcement should have access to national and state information databases. Queries are performed directly from the officer's MDC.

Shifting the query method from voice to data reduces dispatcher workload and sometimes can return information to the officer more quickly. Connections to these networks from the vehicles are usually through an interface with the CAD system.

Mobile access to the County 911 RMS can improve efficiency for the Sheriff's Office and fire department personnel. Officers can query master name, address, property, and vehicle indices to view outstanding warrants, civil papers, arrest records, citations, inmate records, and other information.

If the County were to implement field reporting, incident information can be completed in the field, electronically sent through the approval process and is collected in the RMS. This improves information accuracy, reduces missed information, streamlines the approval process, and makes information widely accessible sooner.

AVL can also be implemented for both public safety and non-public safety groups. The uses will be different for the two groups. Law enforcement and fire departments can interface AVL for mapping functions. AVL and mapping can also be used in the dispatch center for location-based incident assignment.

Non-public safety departments can improve operations using AVL. The unit location application would be outside the dispatch center mapping system. Instead, non-public safety departments would use Internet-based applications separate from the public safety system. For example, an office supervisor would go to a web-style application on a PC to determine the location of a worker, and then would assign that worker based on current location to respond to a service call.

Based on our experience with AVL, we suggest operating AVL as a separate system rather than over the voice radio system. Depending on how often units are polled for unit location, the over-the-air messaging involved can present significant loading to the radio system.

CTA has found mobile email integrated with office email to be a costly extra in terms of expense and system complexity. The County should carefully evaluate the need for office-integrated email before including it.

The types of mobile data applications suitable for the County have been described above. The descriptions are intended to give the County a feel for what is available. Detailed selection of applications and usage by the various departments will be required prior to system procurement.

6.11.2 Mobile Data Computers

The use of mobile data in the County will require varying mobile computer types depending on the department. These requirements may include the semi-rugged laptop such as the Panasonic Toughbook, the more portable large screen tablet computer, or the very portable PDA format.

Law Enforcement and Fire can most appropriately use a laptop docked in the vehicles. These laptops should be a semi-rugged variety able to withstand daily use. We have seen practical computer selection range from commercial units to semi-rugged units able to withstand shock and spills. If the units are repeatedly removed from the vehicles, units that are more rugged should be used. External floppy disk or CD drives can help prevent unauthorized software loading. Auxiliary dome lights may be mounted for night use.

The actual MDCs can make up a significant portion of the mobile data cost for County agencies (Mobile data computers and data radio cost approximately $12,000). If the County were to provide mobile data capabilities to its agencies, the County could procure enough MDCs for a single shift, and use a checkout system to reduce costs.

Fleet software maintenance must be considered in mobile data design. Computers need periodic application and database updates. Two methods can be employed: manual updates and over-the-air updates.

Manual updates involve either going to the vehicles or bringing in the laptops to install software. This method is simple but can be inconsistent and time consuming. The primary RF service can also be used for updates, keeping in mind the bandwidth limitations.

We do note that many of the County buildings already provide wireless LAN capabilities. This capability could be used to transfer large files (such as software upgrades) to MDCs during refueling and off hours.

Either of these over-the-air MDC maintenance methods requires the addition of servers and software to manage the exchange of information to the MDC fleet. The wireless LAN method also requires a second RF modem in each laptop. These ideas are presented for the County's future consideration.

The public service departments have different needs than public safety. Instead of CAD information, they need wireless access to information traditionally found on the office intranet. This includes utility maps, building plans, codebooks, ordinances, Geographic Information System (GIS) data, and other information. Access to this information requires a mobile server connection to the County intranet.

Some departments may need the large screen size of a laptop for map display, but the portability of a handheld device. Some of the newer "tablet" type PCs would be ideal for meeting these needs.

Other public service departments and many of the public safety supervisors may desire the portability of handheld PDAs and can use the smaller display size. Supervisors and service organizations could make use of scheduling applications to set up follow up appointments. Law Enforcement and Fire management may also find PDA's useful for RMS and state/federal queries.

6.11.3 Wireless LAN 802.11

Wireless high-speed data applications are generally served via the 802.11 "hotspot" deployment systems. The County currently has a wireless LAN installed in some County buildings. This technology can be further deployed by installing local base stations in strategically accessible Basic Service Area (BSA) such as Sheriff's Office patrol vehicle parking lots and garages. This type of deployment allow for in vehicle transfer of incident reports and downloading of graphic intensive data such as photos, video and maps. "802.11g" offers data speeds up to 54 Mbps in the 2.4 GHz frequency band and "802.11a" provides the same data rate at 4.9 GHz.

The maximum throughput rate of all 802.11 standards is determined by the distance from the client to the access point as shown in TABLE 6-11.

A single Extended Service Set (ESS) should be deployed to limit difficulties incurred when transitioning between Basic Service Set (BSS) areas of multiple ESS's. Single BSS access points would be deployed at each "hot spot". If multiple IP subnets are used in the same ESS, roaming between BSS areas will require re-initialization of the client (laptop).

Access security will require client software that implements strong cryptographic protection. Wired Equivalent Privacy (WEP) is not useful for protecting against determined unauthorized access.

WEP does not protect users from one another. To address the shortcomings of WEP for authentication, a solution should be implemented such as the Extensible Authentication Protocol (EAP).

The 802.11 suite of standards is a continuing evolution. If the County decides to install hot spots throughout the County, the wireless LAN would reflect the most current innovations. These innovations include 802.11i which recommends a series of fixes for WEP and MiMAX (IEEE 802.16-2004) for improved reliability.

6.12 Capacity Analysis and Design

When designing a trunked radio system, building in the capacity to handle the anticipated future traffic on the system should be a primary goal. By properly sizing the system for use 15 years into the future, the user benefits by having the capability to operate under routine, peak, and emergency conditions without major operational differences. In observing the usage of trunked radio systems installed by each of the major vendors, we have found that communications systems serving public safety operations have predictable use patterns and loading requirements.

6.12.1 Traffic Loading Definitions

To help the reader understand the radio traffic analysis, some basic definitions are provided:

A. Erlang

A traffic engineering term used to measure the communications load for a circuit or set of circuits. One Erlang is defined as one person speaking continuously. For the purpose of this analysis, 1 Erlang is equivalent to 1 call lasting 3600 seconds in a 1-hour period.

B. Erlang C Model

Derived from the assumption that all requested calls are held in a queue that cannot be immediately assigned a radio channel. The Erlang C formula is based on the following assumptions:

- Calls arrive randomly as characterized by a Poisson distribution.
- Calls are served in order of arrival.
- Blocked calls are delayed.
- Blocked calls are placed in a queue with an infinite length.
- Top of queue is granted next available channel.
- Infinite number of requests.
- All users (including blocked) can request a channel at any time.
- Probability of a user occupying a channel is exponentially distributed (longer calls are less likely to occur).

- There are a finite number of channels available in the trunking pool.

- Busy Hour occurs at the same time for all subscribers.

C. Grade of Service (GOS)

GOS is a measure of the ability of a user to access a trunked system without delay (i.e., without going into a queue) during the busiest hour of radio operation. It is expressed as the probability of being delayed (0% is good, 100% is very busy)

D. Delayed Call GOS

The probability that a delayed call is forced to wait more than the maximum acceptable call delay (*t* seconds).

6.12.2 Traffic Loading Model

A trunked LMR system design goal is to deliver a specific call capacity at a GOS conducive to clear, reliable communications. The busy hour is based on user demand at the busiest operational hour during a week.

GOS is usually given as the likelihood that a call is blocked, or the likelihood that a call is experiencing a delay greater than a certain queuing time.

The traffic loading model that CTA has developed is based on a transmission trunked LMR system that has a formal queue. If a radio channel is not available immediately, the call request may be delayed until a channel becomes available.

This type of radio system trunking is called "Blocked Calls Delayed Trunking," and its measure of GOS is defined as "the probability that a call is blocked after waiting a specific length of time in the queue."

For Blocked Calls Delayed Trunking, an Erlang C formula is used to determine the probability that a call is blocked and is a measure of the GOS for a trunked LMR system that provides queuing for blocked calls.

The CTA traffic loading model is based on the parameters that require an Erlang C statistic to be used for traffic intensity calculations. The Erlang C model assumes that traffic requests obey a Poisson distribution, which implies exponentially distributed call inter-arrival times. Furthermore, the Erlang C model assumes a large number of channels and a large number of users with similar calling patterns.

The loading model takes the subscriber data inputs (number of radio subscriber units in the Larimer County inventory) and calculates the number of radio channels needed to provide sufficient capacity in a trunked architecture.

The number of radio channels is determined by using a Delayed Call GOS for the busiest hour of 1% and a maximum acceptable call delay of 1 second. A Delayed Call GOS of 1% means that 1 out of 100 calls may experience a delay more than 1 second. This is a generally accepted standard for public safety trunked radio systems.

6.12.3 Loading Considerations for Trunked Public Safety Systems

Typically, a radio system has three distinct levels of loading: routine operation, peak operation, and emergency (extraordinary) operation. Each has its own concerns and considerations that must be addressed in the system design. For this report, capacity design is based on peak operations, also known as the busy hour.

The radio system must have the capacity to alleviate crowded channel conditions during routine operations. Peak loading (busy hour) is typically seen during shift changes, but may occur at other times as well. The system should provide reserve capacity for peak operation hours. The system should allow priority calls for critical users when the system approaches full loading.

Emergency loading levels are reached during both planned and unplanned incidents that require multiple emergency responders or a massive mobilization of assets. Loading typically exceeds system capabilities and is handled through a system of priorities assigned to each user. It may also be necessary to suspend some system functions, such as private call, during emergencies.

The overall design goal for the radio system is to handle traffic during the busiest hour of the day and emergency traffic through prioritized radio usage.

Projected system growth must also be addressed in the loading analysis. The system should be designed to handle anticipated growth over the life of the system. This ability to expand typically includes predicted growth for 10 to 15 years following final system acceptance.

6.12.4 Existing Capacity for CCNC Sites

TABLE 6-12 provides a list of the five existing CCNC and NCRCN sites that we chose to provide coverage in eastern Larimer County and Estes Park. Included in the table is the current number of channels and the maximum capacity in Erlangs that each site can currently support. The maximum Erlangs is based on a Delayed Call GOS of 1% with a maximum call delay of 1 second. This means that 1 out of 100 calls during the busiest hour may be delayed for more than 1 second. In the next subsections, we will add the estimated traffic for Larimer County that may access each site to determine additional channels that my be required when Larimer County agencies are added to the radio network.

6.12.5 System Loading for the 800 MHz Trunked System

Existing trunked systems provide an excellent source for call data statistics since each call is logged in the system manager database. The following profiles have been derived from other related CTA public safety trunked radio projects:

- Law Enforcement: Standard Call-Seconds/Unit = 4 Seconds, Voice Calls/Hour/Unit = 6
- Fire and EMA: Standard Call-Seconds/Unit = 6 Seconds, Voice Calls/Hour/Unit = 2
- Supervisory/Administrative: Standard Call-Seconds/Unit = 7 Seconds, Voice Calls/Hour/Unit = 6
- Other: Standard Call-Seconds/Unit = 10 Seconds, Voice Calls/Hour/Unit = 2

- Working Channel Call Overhead (digital) = 1. Second. This includes .5 seconds for access time and .5 seconds for digital processing (also known as latency).
- The maximum acceptable call delay is one second.

The radio traffic loading analysis performed by CTA is based on the number of radio units on duty during the busiest hour and not the total number of units in the inventory. Busy Hour percentages are allocated to the total number of public safety and non-public safety radio users to reduce the total inventory to the actual responding personnel. These percentages (which are the assumed percentage of radios used during the busiest hour) are applied to the number of subscribers to take into account that a 100 % response rate is not valid, and that responding units will use either mobiles or portables but not necessarily both at the same time.

TABLE 6-13 provides an estimate of Larimer County radio users that may access the radio sites throughout the County. This table shows estimated busy hour radio use for each County agency. Each agency's busy hour is assumed to be the same hour. Our busy hour estimates show that out of 1748 possible radio units at the end of 15 years (including 1% growth each year), 337 radio units will be accessing the radio network throughout the County during the same busy hour. This equates to a total load of 2.9132 Erlangs countywide. We estimate that 80% of this load will occur primarily on sites east of the foothills and 20% on sites west of the foothills.

We selected sites based on providing portable coverage for on the street, light and medium buildings. This was discussed in SECTION 6.3. The best sites include Bald Mountain, Buckhorn Mountain and Horsetooth Mountain. We selected Horsetooth Mountain as the primary site for providing capacity for 80% of the operations east of the foothills. This site provides the best coverage for eastern Larimer County. Based on results of our Erlang C calculations for loading on the Horsetooth Mountain site, we conclude that the County would need to add three additional channels to the Horsetooth Mountain site to provide adequate capacity for the next 15 years (this does not account for the State or the NCRCN adding other users other than Larimer County).
This would require a channel upgrade from nine to twelve channels. This estimate is based on what capacity the Horsetooth Mountain site can currently support plus the addition of County subscribers to the radio network over the next fifteen years.

Since Horsetooth Mountain would be the primary site, we also estimated that 25% of this traffic would access Bald Mountain and 60% would access Buckhorn Mountain. This is based on radio units roaming in and out of the Horsetooth Mountain coverage area. Our Erlang C calculations for loading on these two sites show that the County should add one additional channel to Bald Mountain and two additional channels to Buckhorn Mountain. For Drake and Prospect Mountain sites, we estimate that a small amount of County traffic will hit these sites. We do not recommend additional channels for these two sites. See TABLE 6-14 for channel calculation results.

For the new sites that need to provide coverage west of the foothills, the State typically likes to see sites with a minimum of five channels. In some areas of the County, five channels may be more than adequate. A five-channel site will provide a maximum capacity of 1 Erlang, which is equivalent to 120 radio units operating on the system for 1 hour with a profile of 6 calls/hour/unit and a call duration of four seconds. This is based on a 1% delayed Call GOS. Therefore, new sites at Bull Mountain, Black Mountain, Middle Bald Mountain, and Kinikinik are each estimated with 5 channels. This provides plenty of capacity for 20% of the County's radio operation plus and additional units from the Colorado State Patrol. The Mummy Range site is located in a remote area of the County and may only be powered by a solar cell. This limits this site to only using conventional mutual aid channels. We have estimated two channels for this site. See TABLE 6-14 for channel calculation results.

6.13 Licensing of 800 MHz Channels

Before implementation can take place for each site, it will be necessary to first identify available 800 MHz channels to provide the required capacity for the County's radio traffic. Site implementation should not commence until the 800 MHz channels are identified. Identification of the 800 MHz channels starts with the regional coordinator. Once all of the channels are identified, a license application package can be developed and submitted to the regional coordinator for approval. When the application is approved, the regional coordinator will forward the application to APCO. After APCO is satisfied with the application, it is then forwarded to the FCC for processing. Since the new sites will become part of the CCNC, the State will have the responsibility for finding the 800 MHz channels.

7.0 FACILITY DEVELOPMENT

Investment in completely new trunked radio systems is usually accompanied by new or fully dedicated facilities to house the equipment. New systems can require specifically located new sites for optimal coverage and sometimes new and larger facilities. The facility guidelines described in this section apply to any Larimer County sites to augment County coverage for the CCNC.

Existing sites to be used in the new radio system will require varying degrees of upgrading. The following issues are addressed for existing radio sites and new sites:

A. Site Development

B. Equipment Enclosures

C. Emergency Generators and Site Power

D. New Towers

E. Alarms

7.1 Site Development

The following is a list of elements which must be addressed for the upgrade of any existing radio sites or when designing and developing new radio sites:

A. In general, the site should be clean and properly cleared of vegetation. This includes grubbing and leveling of the area and providing a clearing of a 10-foot-wide path from any guyed towers to their guy anchor points.

B. The site must be accessible to normal sedan-type vehicles on a regular basis. The road must be in passable condition or capable of being repaired without undue expense. We consider four (4) inches of standard road paving gravel, such as #57 size (or comparable) aggregate to be an acceptable covering material and recommend it for all the sites.

We do not recommend any extensive grading, culverts, etc. The road should be able to be maintained free of washouts and dry, except possibly after heavy downpours. In cases of heavy downpours, it is acceptable for water to cover part of the road for a short period of time. The area inside the equipment enclosure fencing should be covered with a weed barrier fabric and gravel. There should be ample room for parking and a turn-around area for two full-size pickup trucks.

C. Foundations for the equipment building and for the tower and guy anchors would be required if new shelters and/or towers are installed.

D. The system vendor will be required to provide a structural and wind-loading analysis of existing towers and foundations with their equipment mounted on them to determine if they are acceptable. If the loading is not acceptable, the tower will have to be replaced or strengthened. All new towers will be specified with extra loading capability for future antennas.

E. Fencing is needed to enclose the site and to enclose the guy anchor points individually where a guyed tower is located. Any existing fencing should be rust-free, in good repair, well grounded, and have a double-swing gate. Access to the fenced radio site shall be regulated using locking devices.

F. Geo-technical investigations including borings for tower foundations shall be performed before designing and building any new towers.

G. The grounding system at a radio site must consist of a minimum of the following:

- Halo ground system inside building
- Buried ground system for building and tower
- Tower and fence grounding equipment
- Ground rods and test wells
- Surge suppression devices

7.2 Equipment Enclosures

Varying degrees of work will have to be performed, which may include part of the following:

A. The equipment building or room must be of sufficient size to hold the radio plus provide room for any future expansion. The building or room must be in good condition and provide protection to the equipment from vermin and water damage. In the event that new shelters are needed, CTA Communications recommends pre-fabricated enclosures, which are currently furnished by several manufacturers. This type of building represents the best economic alternative to on-site construction, which is generally more expensive. The enclosures would be delivered to the site fully assembled with electrical wiring and lighting already installed. Access to the equipment enclosure shall be regulated using locking devices.

B. Sufficient fire suppression equipment is needed at each site to limit the loss of equipment in case of fire. Fire or smoke detection and security equipment must provide notification to operators of an emergency or intrusion. An automatic release of fire suppression agents should occur at remote radio sites or facilities not typically manned 24 hours a day.

C. The heating, ventilation, and air conditioning (HVAC) system must be capable of accommodating the equipment's heat dissipation. Dual-redundant HVAC units are recommended for each site because of the sensitivity of the radio equipment to fluctuations in temperature and humidity.

D. A twenty-five pair telephone termination must be brought into sites that need a new shelter or where an equipment enclosure exists but does not have the twenty-five pair telephone termination. OCEM, for example, will require a 25 pair minimum cable between the existing facility and the new shelter housing the new system equipment.

7.3 Emergency Generators and Site Power

The main power transformer at each site must have adequate size and be in good condition. Transformer sizes at existing sites must be able to accommodate the increased heating and building loads.

There should also be an emergency generator to pick up the entire load in case of a power outage on the main feeder. CTA Communications will usually specify outdoor generators with weatherproof enclosures and block heaters where generators do not exist or are not acceptable.

To ensure dependability of power to radio equipment, uninterruptible power supplies (UPS) will be required for all fixed network equipment. DC power with ample battery back-up will be used for some classes of equipment or for some locations where AC power back-up is impractical.

7.4 New Towers

New towers may be needed to replace structures which are incapable of holding the antennas necessary for the new radio system or which do not provide the height above ground level needed for sufficient radio coverage from the radio site.

7.5 Alarms

CTA Communications recommends that a comprehensive alarm system be installed for facilities, in addition to other radio alarm points, which are required by the radio system. These alarms should be wired to a local enunciator (non-audible, light only) at each site and also be sent back to the communications center. The following alarm points are recommended:

- Intrusion alarm from door switch
- Building temperature alarm
- Generator fuel level alarm
- Automatic transfer switch alarm
- Generator abnormal alarm

- Generator run alarm
- Loss of utility power supply
- Charger failure
- DC bus voltage
- UPS alarm
- HVAC alarm
- Tower lighting alarm
- Fire suppression system deployment
- Channel Bank equipment
- Microwave Alarms
- Spare alarm points

Note: An integrated alarm system for radio and site alarms is also acceptable. The selected vendor should recommend an alarm scheme categorizing alarms transmitted to the consoles as either major or minor. The vendor should present the alarm scheme as part of their overall proposal.

8.0 ESTIMATED BUDGETARY TURNKEY SYSTEM COSTS

Estimates were developed for the major categories of equipment as they apply to the system preliminary design as described in SECTION 6. The equipment, installation, non-fixed equipment and vendor service cost information were obtained from historical CTA Communications cost files and vendor pricing of comparable projects. These costs were compared and weighted in order to derive an average "list price" type for a turnkey system.

The contract prices are recommended for planning and budgetary purposes only. The following cost tables pertaining to the phased implementation of the Hybrid radio system design are described in the subsections below:

TABLE 8-1 Estimate of Probable Cost: Phase 1 Larimer County Infrastructure

TABLE 8-2 Estimate of Probable Cost: Larimer County Non-Fixed Units

TABLE 8-3 Estimate of Probable Cost: Phase 2 Larimer County Infrastructure

TABLE 8-4 Estimate of Probable Cost: Phase 3 Larimer County Infrastructure

TABLE 8-5 Estimate of Probable Cost: Phase 4A Larimer County Infrastructure

TABLE 8-6 Estimate of Probable Cost: Phase 4B Larimer County Infrastructure

TABLE 8-7 Estimate of Probable Cost: Larimer County Hybrid System Project

8.1 Hybrid System

In SECTION 5, CTA determined that the best solution for a countywide radio system is a Hybrid System that combines 800 MHz coverage from the CCNC radio sites and VHF coverage from the County's existing radio system. Once the County has built sites to provide 800 MHz mobile coverage west of the foothills, the County can transition agencies from VHF to 800 MHz. We have developed a phased approach for implementing 800 MHz sites while maintaining VHF coverage with the existing radio system over a seven year period.

This coincides with the time that the County must convert its wideband VHF equipment to narrowband. In the next subsections, we will describe each phase with its associated costs.

8.1.1 Phase 1 Implementation

Phase 1 of the implementation will take place in the first year after receiving County approval for the Hybrid solution. Phase 1 adds three (3) 800 MHz trunked repeaters to the Horsetooth Mountain site, one (1) 800 MHz trunked repeater to Bald Mountain, and two (2) 800 MHz trunked repeaters to Buckhorn Mountain. At this point, the County can begin procuring 800 MHz radios for the Sheriff's Office for operations east of the foothills. TABLE 8-1 describes the estimated range of equipment costs and services ($133,700 - $176,769) that the County can expect for this phase. The non-fixed equipment cost will be described in the next subsection.

Phase 1 also connects the Bull Mountain site to the CCNC via a microwave link at Pole Mountain in Wyoming to Buckhorn Mountain. The cost for this microwave connectivity is not included in this estimate since the County has already secured the funds for this implementation through a State grant and is in the process of completing the installation by next summer.

TABLE 8-1 includes estimates for fixed equipment, systems engineering, installations and program management for adding capacity to three sites. The following cost considerations were applied to this estimate:

- Fixed equipment costs are based on CTA Communications historical data.
- Three (3) 800 MHz trunked repeaters at Horsetooth Mountain
- One (1) 800 MHz trunked repeater at Bald Mountain
- Two (2) 800 MHz trunked repeater at Buckhorn Mountain
- Upgrade to Central Electronics Bank

8.1.2 LMR Non-Fixed Radio Equipment

The non-fixed estimate is displayed in TABLE 8-2 for each County agency. The estimate is based on County agencies purchasing the non-fixed units today.

The non-fixed equipment represents a large portion of the costs of the system. The estimate includes full warranty for the first year of operation and installation. Included with the estimate is the yearly usage fee to the NCRCN for each agency. This will be a reoccurring cost each year for each agency that operates on the NCRCN owned sites. This cost must be planned for by each County agency.

Since non-fixed equipment represents a large portion of the cost of a system, the following assumptions for non-fixed equipment were made:

- All law enforcement agencies mobile and portable units are mid-tier, digital radios.
- Fire, EMS, and other public service departments using mobile and portable units are agency-tier, digital radios.
- All desktop control stations are mid-tier, digital radios

Non-fixed mid-tier and agency-tier units are described below:

- <u>Mid-Tier Units</u>
  Mid-Tier units are public safety grade portable or mobile radios, which include only those features necessary for fulfilling the particular mission of the public safety agency. These units typically provide groups or subgroups necessary for routine operation, with the capability of being dynamically regrouped by the dispatcher as required. Mid-Tier Units are typically assigned to front-line or patrol personnel.

- <u>Agency-Tier Units</u>
  Agency-units are economically priced, limited feature mobile or portable radios. The emphasis is on cost control through reduction in features. These units may be limited in the groups and subgroups available. Agency-units are typically assigned to personnel who are mainly interested in communicating with each other or with their office. Agency-Tier units are expected to be a less-expensive model. It is desired that the mid- and agency-tier radios be from the same family of radios. The intent is to allow one model/type of accessory, such as battery, shoulder microphone or antenna, to work on both mid and agency-tiers.

The estimate includes, for mobile and desktop radios, all installation, initial programming, and one (1) year of warranty. The portable estimates include initial programming, two (2) batteries, a shoulder microphone, a carrying case, a single desk charger, and 1/40th of a multi-charger unit.

8.1.3 Phase 2 Implementation

Phase 2 of the Hybrid System implementation will take place in the second year. This phase adds a remote 800 MHz radio site at Black Mountain. The County will use an existing FM tower for the microwave and 800 MHz antennas. This phase estimates the addition of a shelter to house both the microwave and 800 MHz radio equipment.

TABLE 8-3 includes an estimated range of costs ($904,051 - $1,103,050) for fixed equipment, systems engineering, installations and program management. The following cost considerations were applied to this estimate:

- Fixed Equipment costs are based on CTA Communications historical data.
- Physical facility work at Black Mountain site to add a shelter for 800 MHz and microwave equipment.
- Five (5) 800 MHz trunked repeaters at Black Mountain
- Remote site controller.
- One channel bank.
- Microwave links installed at Pole Mountain and Black Mountain
- One remote alarm terminal

8.1.4 Phase 3 Implementation

Phase 3 of the Hybrid System implementation will take place within five years depending on how fast a site can be approved through the Forest Service. This phase involves the development of the Middle Bald Mountain site. The Middle Bald Mountain site will replace the Deadman Mountain site. The Forest Service is requiring the County to remove its systems from this site but has not provided a deadline for removing the equipment.

TABLE 8-4 includes an estimated range of costs ($962,830 - $1,157,669) for fixed equipment, systems engineering, installations and program management.

The following cost considerations were applied to this estimate:

- Fixed Equipment costs are based on CTA Communications historical data.
- Physical facility work at Middle Bald Mountain and Moose Mountain sites to add shelters, towers, access roads, parking, fencing, utilities and grounding for 800 MHz and microwave equipment.
- Five (5) 800 MHz trunked repeaters
- One VHF paging transmitter
- One remote site controller
- One channel bank
- Microwave links installed between Middle Bald Mountain and Black Mountain
- One remote alarm terminal

8.1.5 Phase 4 Implementation

Phase 4 of the Hybrid System implementation will take place within seven years. This is an optional phase based on results from coverage testing of sites installed in Phases 1 through 3. If coverage results are unfavorable, then the County should plan to get site approval through the Forest Service. This phase is divided into two sub-phases; Phase 4A and Phase 4B. Phase 4A constructs a new site at Kinikinik to enhance coverage in the Poudre River Canyon. Phase 4B constructs a new solar powered site at a location on Mummy Range to enhance coverage in western central Larimer County.

TABLE 8-5 includes an estimated range of costs ($828,225 - $1,016,120) for Phase 4A fixed equipment, systems engineering, installations and program management. The following cost considerations were applied to this estimate:

- Fixed Equipment costs are based on CTA Communications historical data.
- Physical facility work at Kinikinik to add a shelter, tower, access road, parking, fencing, utilities and grounding for 800 MHz equipment.
- Five (5) 800 MHz trunked repeaters
- One remote site controller

- One channel bank
- One remote alarm terminal

TABLE 8-6 includes an estimated range of costs ($760,894 – 898,593) for Phase 4B site development, fixed equipment, systems engineering, installations and program management.

The following cost considerations were applied to this estimate:

- Fixed Equipment costs are based on CTA Communications historical data.
- Physical facility work at Mummy Range to add a shelter, tower, access road, parking, fencing, solar power system and grounding for 800 MHz equipment.
- Two (2) 800 MHz conventional repeaters
- One channel bank
- One remote alarm terminal

8.1.6 Larimer County Hybrid System Project Cost

TABLE 8-7 provides the total cost range ($7,080,300 - $7,837,574) for all four phases of the Hybrid System Project including inflation over the seven year implementation period. The non-fixed cost is based on procuring mobiles, portables and control stations within the next year. The total cost does not include the NCRCN fees for each non-fixed unit.

8.2 Items Not Contained In the Estimate

The following cost items are not included in the estimate:

- Estimates for physical facility development do not include any costs associated with obtaining, permitting or zoning the sites or properties.
- Radio dispatch consoles and call-taking equipment.
- CAD equipment for the 9-1-1 Emergency Communications Center.
- Temporary transition costs.

- CTA fees.
- Yearly maintenance cost for each new site.

8.3 Procurement Recommendations

Since this system is a P25 solution, several advantages can be realized: potential of Homeland Security grants; potential to have multiple vendor radios work within the system allowing the opportunity to purchase a full range of subscriber units from very low cost/low tier to the high cost/high tier units.

Additional project saving can be realized if Larimer County specifies, procures, and implements the microwave system and physical facility work for the new sites on a separate and competitive basis.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

In May of 2005, Larimer County contracted with CTA Communications to investigate their two-way radio communications situation, to identify current problem areas and alternative solutions, and to develop a plan for a countywide, two-way radio communications system.

Two-way radio communication capabilities in Larimer County are characterized by poor coverage in mountainous areas, a lack of interoperability between public safety agencies that have moved to 800 MHz, channel crowding and congestion, and inadequate capacity for emergencies. These major deficiencies compounded by operational concerns currently inhibit public safety personnel from efficient operations and interoperability. This current state of communications is inefficient at best and potentially dangerous at worst.

9.2 Recommendations

The continued rate of growth expected over the next 15 years in Larimer County will certainly result in a corresponding increase in radio traffic for first responders. This will result in the critical problems listed above to become unbearable and potentially life threatening for the public safety radio system users of Larimer County.

CTA recommends Alternative 5 (Hybrid System) as the best solution for alleviating these critical problems. The Hybrid System solution allows the County to immediately start implementing an 800 MHz trunked radio system by joining the Consolidated Communications Network of Colorado (CCNC). With the introduction of trunked technology to the County through this alternative, County departments (both public safety and public service) can establish separate talkgroups and can enjoy private communications without having to wait for a clear channel. It also provides a means to transition from VHF to 800 MHz over a seven-year period before the FCC mandate to convert all VHF wideband equipment to narrowband is enforced.

Established 800 MHz sites (NCRCN & CCNC) currently provide coverage east of the foothills with the capacity to start migrating County public safety agencies onto the State's radio network. This will provide the interoperability that is needed with Fort Collins, Loveland and the Colorado State Highway Patrol. The County may be required by the CCNC to add more channels to select sites in order to accommodate radio traffic over the next ten to fifteen years. We have estimated a total of six additional channels for the existing sites (three for Horsetooth Mountain, two at Buckhorn Mountain, and one at Bald Mountain).

The current VHF radio system should remain operational while implementing 800 MHz coverage throughout the western part of the County. This will provide coverage support for departments such as the Sheriff's Office, Road & Bridge, Parks and Open Lands, the volunteer fire departments and other departments that depend on coverage in the mountainous part of the County while 800 MHz coverage is being established. The goal of implementing 800 MHz sites in the mountainous terrain is to provide mobile coverage to the main roadways. As the County completes the implementation of 800 MHz coverage west of the foothills, the County can then transition completely from their VHF voice radio system. A residual narrowband VHF capability will be required indefinitely for the County digital paging system and interoperability between Larimer County Wild Land Fire and the US Forest Service.

Completion of the transition from VHF to 800 MHz will provide for seamless interoperability between all public safety and public service radio users in the County including Fort Collins, Loveland and the Colorado State Patrol. Although, implementation can take place all at once, we have recommended a phased approach to allow time for site approval by the Forest Service and time to obtain the funds necessary to develop each new site.

The Hybrid System also provides: required in-building radio coverage east of the foothills; advanced radio features; interference mitigation; channel congestion mitigation; and enhanced radio dispatch operations. Limited mobile data capabilities are currently available through the voice network of the CCNC radio system. This capability may include silent dispatch, status messaging, and limited mug shot capability. A dedicated mobile data capability will be implemented by the CCNC in the future. The hybrid solution consolidates all radio users within the County under one radio system.

Our solution recommendation provides the following core attributes:

- Enables interoperability within the County for all users
- Enables interoperability outside of the County for all users
- Provides improved coverage for all users
- Provides improved system capacity for all users
- Maximizes Cost Savings for the County

9.3 Implementation Strategy

Before the County starts moving personnel to 800 MHz and begins implementation of sites, we recommend that the County survey the existing coverage of the CCNC in Larimer County. It is important to document the areas where the existing 800 MHz sites provide good, poor or no coverage at all to the Larimer County users. This independent method of coverage testing can also be used for future site planning to prevent the County from spending funds for sites that are not necessary or after each new site is commissioned to ensure acceptable coverage is achieved.

Additional project savings can be realized if Larimer County specifies, procures, and implements the following on a separate and competitive basis:

- new sites (physical facilities) work
- non-fixed subscriber units (radios)
- microwave

CTA commends Larimer County for embarking upon the current path of building a new radio communications system. We encourage all those participating in this two-way communications project to embrace the recommended solution and provide all Larimer County public safety and public service personnel the improved communications that is critically needed.

APPENDIX A TABLES AND FIGURES

TABLE 2-1
CURRENT LARIMER COUNTY VHF FREQUENCIES

Call Sign	Channel Name	Tx Frequency (MHz)	Rx Frequency (MHz)	Site Name	Location (DD-MM-SS.S) Lat. (N)	Lon. (W)
-	EMS-North - Simplex	155.34000	155.34000	Buckhorn Mtn.	40-37-01.45	105-19-38.86
KRY907	LCSO 2 - Transmit	155.13000	-	Buckhorn Mtn.	40-37-01.45	105-19-38.86
WSW826	LCSO 4 (Firenet) - Simplex	154.38500	154.38500	Buckhorn Mtn.	40-37-01.45	105-19-38.86
-	LCSO 2 - Receive	-	154.71000	Buckhorn Mtn.	40-37-01.45	105-19-38.86
-	LCSO 3 - Receive	-	155.56500	Buckhorn Mtn.	40-37-01.45	105-19-38.86
KJS781	Roads & Bridge Repeater	151.10750	158.03250	Buckhorn Mtn.	40-37-01.45	105-19-38.86
WNPU412	Paging	159.10500	-	Buckhorn Mtn.	40-37-01.45	105-19-38.86
WNPU412	Paging	159.10500	-	Prospect Mtn.	40-21-37.0	105-31-13.1
-	LCSO 2 - Receive	-	154.71000	Justice Center	40-35-18.96	105-04-46.42
-	LCSO 3 - Receive	-	155.56500	Justice Center	40-35-18.96	105-04-46.42
-	LCSO 4 (Firenet) - Receive	-	154.38500	Justice Center	40-35-18.96	105-04-46.42
WPMY334	LCSO 1 - Repeater	155.67000	159.15000	Horsetooth Mtn.	40-32-54.38	105-11-53.60
-	LCSO 2 - Receive	-	154.71000	Horsetooth Mtn.	40-32-54.38	105-11-53.60
WPPG295	LCDTF-Drug task force	159.45000	151.01000	Horsetooth Mtn.	40-32-54.38	105-11-53.60
WPAJ312	LCSO 3 - Simplex	155.56500	155.56500	Horsetooth Mtn.	40-32-54.38	105-11-53.60
WPAJ312	LCSO 2-Transmit	155.13000	-	Horsetooth Mtn.	40-32-54.38	105-11-53.60
WPAV871	LCSO 4 (Firenet) - Simplex	154.38500	154.38500	Horsetooth Mtn.	40-32-54.38	105-11-53.60
WPMY334	Pager	159.10500	-	Horsetooth Mtn.	40-32-54.38	105-11-53.60
KJS781	Road & Bridge - Simplex	155.03250	155.03250	Cactus Hill	40-34-51.31	104-54-23.18
-	LCSO 2 - Receive	-	154.71000	Cactus Hill	40-34-51.31	104-54-23.18
KQZ831	LCSO 2 - Transmit	155.13000	-	Cactus Hill	40-34-51.31	104-54-23.18
WNPU412	Paging	159.10500	-	Cactus Hill	40-34-51.31	104-54-23.18
	EMS-N-Simplex	155.34000	155.34000	Cactus Hill	40-34-51.31	104-54-23.18
KQZ831	NLEC-Simplex	155.47500	155.47500	Cactus Hill	40-34-51.31	104-54-23.18
WSW826	LCSO 4 (Firenet) - Simplex	154.38500	154.38500	Cactus Hill	40-34-51.31	104-54-23.18
KNIG839	LCSO 3 - Simplex	155.56500	155.56500	Cactus Hill	40-34-51.31	104-54-23.18
KNAK317	LCSO 2 - Transmit	155.13000	-	Deadmans Mtn.	40-49-48.14	105-45-06.70
-	LCSO 2 - Receive	-	154.71000	Deadmans Mtn.	40-49-48.14	105-45-06.70
KNAI722	LCSO 4 (Firenet) - Simplex	154.38500	154.38500	Deadmans Mtn.	40-49-48.14	105-45-06.70
KNIG839	NLEC - Simplex	155.47500	155.47500	Deadmans Mtn.	40-49-48.14	105-45-06.70
WNPU412	Paging	159.10500	-	Deadmans Mtn.	40-49-48.14	105-45-06.70
-	EMS-North-Simplex	155.34000	155.34000	Deadmans Mtn.	40-49-48.14	105-45-06.70
WNSP896	Road & Bridge Repeater	151.12250	159.20250	Deadmans Mtn.	40-49-48.14	105-45-06.70

TABLE 2-2
LARIMER COUNTY NON-FIXED RADIO UTILIZATION

Item	AGENCY	INITIAL QUANTITIES 2005		
		MOB	PORT	STNS
	Larimer County			
1	Sheriff's Office Investigatons	22	23	0
2	Sheriff's Office Detention Center	17	108	3
3	Sheriff's Office Emergency Services	20	30	0
4	SO Fairgrounds & Event Center	0	102	3
5	Sheriff's Office Patrol	129	198	0
6	Health Department	0	16	0
7	Parks and Open Lands	53	72	9
8	Road and Bridge Department	99	25	3
9	Land Fill	11	6	3
10	Coroner/DA	7	5	0
11	Community Corrections	0	3	0
12	Estes Park PD*	10	31	3
	Total	**368**	**619**	**24**
	Volunteer Fire Departments			
	Rist Canyon	13	25	1
1	Livermore	11	17	2
2	Crystal Lake	6	6	0
3	Red Feather Lakes	12	27	1
4	Glacier View	6	6	0
5	Poudre Canyon	12	40	2
6	Glen Haven	11	24	1
7	Allens Park	6	6	0
8	Big Elk	8	27	1
9	Pinewood	7	20	1
10	Big Thompson Canyon	6	6	0
11	Estes Park	26	55	1
12	Sheriff's Office Search & Rescue	30	68	4
13	**Total**	**154**	**327**	**14**

Notes:
MOB-Mobile Radio
PORT-Portable Radio
STNS-Desktop or Control Station
* Not a County entity

TABLE 2-3
PROBLEM ASSESSMENT TABLE

	Problem	Weighted Overall Rank	Public Safety Rank	Public Service Rank	Fairgrounds & Events Center
A	Limited Coverage	2.38	3	2	0
B	Mobile to Mobile	2.5	3	2.5	0
G	Local Interference	2.13	3	1	0
I	Lack of Interoperability	2.75	3	1	5
J	Capacity	2.75	3	1	5
N	Lack of Regional Interoperability	2.75	3	1	5
C	Channel Crowding	2.63	2.4	2.5	4
D	Channel Congestion	2.75	2.2	3.5	4
H	Reliability	1.38	2	0.5	0
M	Maintainability	1.13	1.8	0	0
E	Not Portable Based	1.13	1.4	1	0
O	Lack of Ability to Support New Technologies	0.75	1.2	0	0
F	Foreign Interference	0.63	0.8	0.5	0
K	Cumbersone Operation	1	0.8	0	4
L	Dispatcher Access	2	0.8	3.5	5

The numerical coefficients of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill his mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

TABLE 2-4
RECEIVE SITES

	CHANNELS						
SITE	LCSO 1	LCSO 2	LCSO 3	LCSO 4	EMS-North	NLEC	R & B
Buckhorn Mtn.		X	X	X	X		X
Justice Center		X	X	X			
Horsetooth Mtn.	X	X	X	X			
Cactus Hill		X		X	X	X	X
Deadmans Mtn.		X		X	X	X	X
Bald Mtn.		X	X				
Estes Park		X					
Prospect Mtn.							

TABLE 2-5
TRANSMIT SITES

	CHANNELS							
SITE	LCSO 1	LCSO 2	LCSO 3	LCSO 4	EMS-North	NLEC	R & B	PAGING
Buckhorn Mtn.		X		X	X		X	X
Justice Center								
Horsetooth Mtn.	X	X	X	X				X
Cactus Hill		X	X	X	X	X	X	X
Deadmans Mtn.		X		X	X	X	X	X
Bald Mtn.								
Estes Park								
Prospect Mtn.								X

TABLE 4-1
LARIMER COUNTY
RANKING OF REQUIREMENTS

	Attribute	Ranking
1	Coverage	4.60
2	Dispatch Operational Concept	2.7
3	Flexibility in Personnel Allocation	2.9
4	Survivability	4.1
5	Capacity	3.9
6	Mobile Data	2.3
7	Automatic Vehicle Location	2
8	Alphanumeric Paging	3.3
9	Future Expansion	3.7
10	Intercommunications	4
11	Interoperability	3.6
12	Interference Immunity	3.3
13	Power Backup	3.7
14	Maintainability	3.9
15	Reliability	4.6
16	System Operational Transparency	3.3
17	Console Features	3.1
18	Emergency Access	3.6
19	Initial Cost	2.9
20	No Internal Congestion	3.6
21	Long Term Cost	3
22	Encryption	2.6
23	Competitive Procurement Process	2.6
24	Operational Boundary Flexibility	3.3
25	Commonality of Equipment	3.1
26	Telephone Access	1.7
27	Monitoring	3.1
28	Training	3.6
29	Additional Non-Fixed Radio Features	3
30	Cost Effectiveness	2.9

Rankings:

0: Attribute is **not important** to the user.
1: Attribute is **minimally important** to the user.
2: Attribute is **nice to have**, could enhance operations.
3: Attribute is **useful**, will promote more efficient day to day operation.
4: Attribute is **quite important**, lack could result in degradation of mission, injury, or loss of property.
5: Attribute is **critical**; lack generally will result in injury, loss of property, or degradation of mission.

Instructions:

1. Rank each attribute by its importance to your agency's mission
2. Use the scale described above.
3. Please return this form to:
   David Pociluyko
   CTA Communications
   P.O.Box 4579
   Lynchburg, VA 24502
4. If you have any questions, please call David Pociluyko at (434) 239-9200.

TABLE 5-1
ALTERNATIVES ANALYSIS

		CTA Assessment						Laimer County Ranking	Weighted-Ranked Results					
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
	Attribute	Do Nothing	VHF Conv System	VHF Trunked Radio System	800 MHz CCNC/ NCRCN	800 MHz Hybrid Conv	800 MHz Hybrid Trunked		Do Nothing	VHF Conv System	VHF Trunked Radio System	800 MHz CCNC/ NCRCN	800 MHz Hybrid Conv	800 MHz Hybrid Trunked
1	Coverage	2	4	4	4	4	4	4.6	9.2	18.4	18.4	18.4	18.4	18.4
2	Dispatch Operational Concept	4	4	4	5	5	5	2.7	10.8	10.8	10.8	13.5	13.5	13.5
3	Flexibility in Personnel Allocation	2	3	5	5	5	5	2.9	5.8	8.7	14.5	14.5	14.5	14.5
4	Survivability	3	5	5	5	5	5	4.1	12.3	20.5	20.5	20.5	20.5	20.5
5	Capacity	2	3	5	5	5	5	3.9	7.8	11.7	19.5	19.5	19.5	19.5
6	Mobile Data	0	0	0	5	5	5	2.3	0	0	0	11.5	11.5	11.5
7	Automatic Vehicle Location	0	0	0	0	0	0	2	0	0	0	0	0	0
8	Alphanumeric Paging	4	4	4	4	4	4	3.3	13.2	13.2	13.2	13.2	13.2	13.2
9	Future Expansion	2	5	5	5	5	5	3.7	7.4	18.5	18.5	18.5	18.5	18.5
10	Intercommunications	2	4	4	5	5	5	4	8	16	16	20	20	20
11	Interoperability	3	3	3	5	5	5	3.6	10.8	10.8	10.8	18	18	18
12	Interference Immunity	3	3	3	5	5	5	3.3	9.9	9.9	9.9	16.5	16.5	16.5
13	Power Backup	3	5	5	5	5	5	3.7	11.1	18.5	18.5	18.5	18.5	18.5
14	Maintainability	3	5	5	5	5	5	3.9	11.7	19.5	19.5	19.5	19.5	19.5
15	Reliability	2	5	5	5	5	5	4.6	9.2	23	23	23	23	23
16	System Operational Transparency	2	5	5	5	5	5	3.3	6.6	16.5	16.5	16.5	16.5	16.5
17	Console Features	5	5	5	5	5	5	3.1	15.5	15.5	15.5	15.5	15.5	15.5
18	Emergency Access	3	3	5	5	5	5	3.6	10.8	10.8	18	18	18	18
19	Initial Cost	5	3	3	1	4	2	2.9	14.5	8.7	8.7	2.9	11.6	5.8
20	No Internal Congestion	2	3	5	5	5	5	3.6	7.2	10.8	18	18	18	18
21	Long Term Cost	4	3	3	1	4	4	3	12	9	9	3	12	12
22	Encryption	0	0	5	5	5	5	2.6	0	0	13	13	13	13
23	Competitive Procurement Process	0	5	5	5	5	5	2.6	0	13	13	13	13	13
24	Operational Boundary Flexibility	2	5	5	5	5	5	3.3	6.6	16.5	16.5	16.5	16.5	16.5
25	Commonality of Equipment	3	5	5	5	5	5	3.1	9.3	15.5	15.5	15.5	15.5	15.5
26	Telephone Access	0	0	0	0	0	0	1.7	0	0	0	0	0	0
27	Monitoring	3	3	3	4	5	5	3.1	9.3	9.3	9.3	12.4	15.5	15.5
28	Training	2	5	5	5	5	5	3.6	7.2	18	18	18	18	18
29	Additional Non-Fixed Radio Features	3	3	5	5	5	5	3	9	9	15	15	15	15
30	Cost Effectiveness	5	4	3	1	3	2	2.9	14.5	11.6	8.7	2.9	8.7	5.8
	WEIGHTED SUM **********								**249.7**	**363.7**	**407.8**	**425.3**	**451.9**	**443.2**

CTA Assessment:
0 - Required Function/Attribute does not exist
1 - Available but totally insufficient for the County's needs
2 - Generally inadequate for the County's needs, unacceptable alternative

3 - Marginally adequate for the County's needs, approximately 60% functionality

4 - Reasonably adequate for the County's needs, a good alternative

5 - 95% of Function/Attribute available, excellent alternative
N/A - Desired Function/Attribute that is not applicable to the system

Larimer Rankings:
0 - Attribute is not important to the user.
1 - Attribute is minimally important to the user
2 - Attribute is nice to have, could enhance operations.

3 - Attribute is useful, will promote more efficient day to day operation.

4 - Attribute is quite important, lack could result in degradation of mission, injury, or loss of property.

5 - Attribute is critical; lack generally will result in injury, loss of property, or degradation of mission.

TABLE 6-1
800 MHz RADIO SITES IN LARIMER COUNTY

SITE NAME	LATITUDE (dd-mm-ss.s) (N)	LONGITUDE (dd-mm-ss.s) (W)	SITE ELEVATION (ft AMSL)	800 MHz ANTENNA HEIGHT (ft AGL)	800 MHz ANTENNA TYPE	800 MHz ERP (W)
Existing 800 MHz Sites						
Buckhorn Mtn.	40-37-01.45 N	105-19-38.86 W	8,288	70	OMNI	155
Horsetooth Mtn.	40-32-54.38 N	105-11-53.60 W	7,133	68	OMNI	54
Bald Mtn.	40-21-20.9 N	105-15-49.0 W	7,094	141	OMNI	53
Prospect Mtn.	40-21-37.0 N	105-31-13.1 W	8,962	70	OMNI	55
Poudre Valley Hospital	40-34-17.9 N	105-03-22.9 W	4,953	78	OMNI	54
Drake	40-25-49.9 N	105-20-24.9 W	6,227	20	OMNI	150
1250 N Wilson Ave	40-24-24.9 N	105-06-25.9 W	5,058	95	OMNI	51
410 East 5th Street	40-23-43.9 N	105-05-19.9 W	4,970	60	OMNI	150
5300 Frontage Road	40-26-50.9 N	104-59-16.9 W	5,042	60	OMNI	150
New 800 MHz Sites						
Black Mountain	40-52-36.4 N	105-41-45.5 W	9,715	189	OMNI	155
Bull Mountain	40-56-50.3 N	105-55-31.5 W	9,212	60	OMNI	155
Middle Bald Mountain	40-45-56.8 N	105-42-27.8 W	10,926	60	OMNI	155
Kinikinik	40-42-12 N	105-44-10 W	9,022	100	OMNI	155
Mummy Range	40-34-48 N	105-43-24 W	11,801	100	OMNI	155

TABLE 6-2

LARIMER COUNTY MICROWAVE RADIO SYSTEM PATH SUMMARY

	Transmit Site					Receive Site			Radio			Antenna		
Path ID	Site ID	Site Name	North Latitude	West Longitude	Elevation (ft)	Site ID	Site Name	Distance (mi)	Capacity	Configuration	Center Freq. (GHz)	Centerline (ft)	Azimuth (°)	Diameter (ft)
A	S01	Sheriff's Office	40-33-47.3	105-01-57.88	4,901	S02	Horsetooth Mtn	8.78	1 DS3	MHSB	6.7	40	263.41	4
A	S02	Horsetooth Mtn	40-32-54.38	105-11-53.60	7133	S01	Sheriff's Office	8.78	1 DS3	MHSB	6.7	52	83.3	4
B	S02	Horsetooth Mtn	40-32-54.38	105-11-53.60	7133	S03	Buckhorn Mtn	8.28	16 DS1	MHSB	6.7	50	304.9	4
B	S03	Buckhorn Mtn	40-37-01.45	105-19-38.86	8288	S02	Horsetooth Mtn	8.28	16 DS1	MHSB	6.7	50	124.82	4
C	S03	Buckhorn Mtn	40-37-01.45	105-19-38.86	8288	S04	Pole Mtn	42.97	4 DS1	MHSB	2.4	50	352.07	6
C	S04	Pole Mtn	41-14-01.7	105-26-28.6	8832	S03	Buckhorn Mtn	42.97	4 DS1	MHSB	2.4	50	171.99	6
D	S04	Pole Mtn	41-14-01.7	105-26-28.6	8832	S05	Bull Mtn	32.08	8 DS1	MHSB	2.4	50	232.13	6
D	S05	Bull Mtn	40-56-50.3	105-55-31.5	9212	S04	Pole Mtn	32.08	8 DS1	MHSB	2.4	40	51.81	6
E	S04	Pole Mtn	41-14-01.7	105-26-28.6	8832	S06	Black Mtn	27.99	8 DS1	MHSB	6.7	40	208.45	6
E	S06	Black Mtn	40-52-36.4	105-41-45.5	9715	S04	Pole Mtn	27.99	8 DS1	MHSB	6.7	100	28.29	6
F	S06	Black Mtn	40-52-36.4	105-41-45.5	9715	S07	Middle Bald Mtn	7.68	8DS1	MHSB	6.7	40	184.6	4
F	S07	Middle Bald Mtn	40-45-56.8	105-42-27.8	10934	S06	Black Mtn	7.68	8DS1	MHSB	6.7	50	4.59	4
G	S07	Middle Bald Mtn	40-45-56.8	105-42-27.8	10934	S08	Mummy Range	12.84	4DS1	MHSB	6.7	40	183.67	4
G	S08	Mummy Range	40-34-48	105-43-24	11795	S07	Middle Bald Mtn	12.84	4DS1	MHSB	6.7	50	3.66	4
H	S07	Middle Bald Mtn	40-45-56.8	105-42-27.8	10934	S03	Buckhorn Mtn	22.45	8 DS1	MHSB	6.7	50	117.07	6
H	S03	Buckhorn Mtn	40-37-01.45	105-19-38.86	8288	S07	Middle Bald Mtn	22.45	8 DS1	MHSB	6.7	50	297.32	6

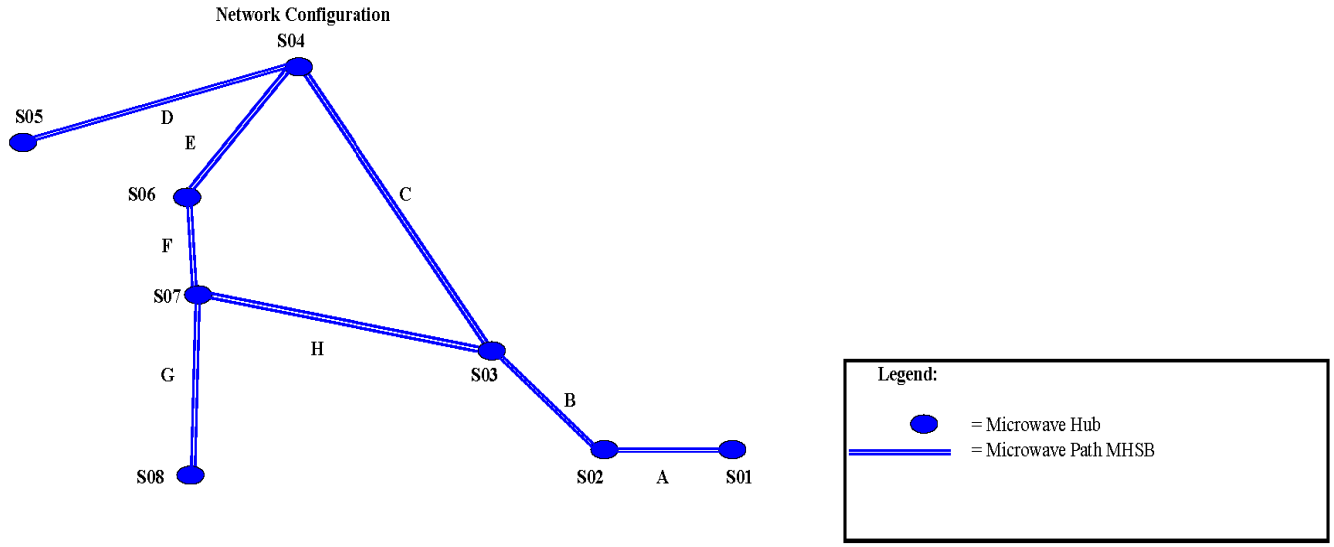


TABLE 6-3
Microwave Path Availability Path A

CTA Communications									Path Loss and Fade Margin Calculations
Lynchburg, Virginia									for Line-of-Sight Microwave Systems
									Version 1.95
Project:	Larimer County, Colorado								
Radio Capacity:	16 DS1					Date:	12/01/05		
Protection Type:	MHSB					Rev Date:			
Frequency Band (GHz):	6.525-6.875					Engineer:	Harold Wyatt		
Center Frequency (GHz):	6.700					Approved:			
Site Name		Sheriffs Office					Horsetooth Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	33	47.3		N	40	32	54.4
Longitude	W	105	01	57.9		W	105	11	53.6
Elevation AMSL (ft)			4901	ft				7133	ft
Azimuth			263.41	deg				83.30	deg
Path Length (miles)					8.77	mi			
Free Space Loss					131.98	dB			
Atmospheric Absorption					0.13	dB			
Antenna Center Line			40	ft.				52	ft.
Transmission Line Length			80	ft.				82	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.09	dB				1.12	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					138.31	dB			
Transmitter Power					21	dBm			
Antenna Type			Standard					Standard	
Antenna Size			4	ft				4	ft
Antenna Gain			36.3	dB				36.3	dB
Effective Radiated Power (EIRP)			54.21	dB				54.18	dB
Total Antenna Gains					72.6	dB			
TOTAL GAINS					93.6	dB			
Unfaded Received Signal Level (RSL)					-44.7	dBm			
Receive Threshold @ 10^{-6} BER					-74.5	dBm			
Dispersive Fade Margin					50.0	dB			
Flat Fade Margin					29.8	dB			
Composite Fade Margin					29.7	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00000314				
Outage Time, Non-Diversity					22.7	sec/yr			
One-Way Availability					99.999928	%			
One-Way Objective					99.999000	%			

TABLE 6-4
Microwave Path Availability Path B

CTA Communications								Path Loss and Fade Margin Calculations	
Lynchburg, Virginia								for Line-of-Sight Microwave Systems	
								Version 1.95	
Project:	Larimer County, Colorado								
Radio Capacity:	8 DS1					Date:	12/01/05		
Protection Type:	MHSB					Rev Date:			
Frequency Band (GHz):	6.525-6.875					Engineer:	Harold Wyatt		
Center Frequency (GHz):	6.700					Approved:			
Site Name		Buckhorn Mountain					Horsetooth Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	37	01.5		N	40	32	54.4
Longitude	W	105	19	38.9		W	105	11	53.6
Elevation AMSL (ft)			8288	ft				7133	ft
Azimuth			124.82	deg				304.90	deg
Path Length (miles)					8.29	mi			
Free Space Loss					131.49	dB			
Atmospheric Absorption					0.12	dB			
Antenna Center Line			50	ft.				50	ft.
Transmission Line Length			80	ft.				80	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.09	dB				1.09	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					137.79	dB			
Transmitter Power					21	dBm			
Antenna Type		Standard					Standard		
Antenna Size			4	ft				4	ft
Antenna Gain			36.3	dB				36.3	dB
Effective Radiated Power (EIRP)			54.21	dB				54.21	dB
Total Antenna Gains					72.6	dB			
TOTAL GAINS					93.6	dB			
Unfaded Received Signal Level (RSL)					-44.2	dBm			
Receive Threshold @ 10^{-6} BER					-77.5	dBm			
Dispersive Fade Margin					64.0	dB			
Flat Fade Margin					33.3	dB			
Composite Fade Margin					33.3	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00000117				
Outage Time, Non-Diversity					8.4	sec/yr			
One-Way Availability					99.999973	%			
One-Way Objective					99.999000	%			

TABLE 6-5
Microwave Path Availability Path C

CTA Communications									Path Loss and Fade Margin Calculations
Lynchburg, Virginia									for Line-of-Sight Microwave Systems
									Version 1.95
Project:	Larimer County, Colorado								
Radio Capacity:	4 DS1					Date:	12/01/05		
Protection Type:	MHSB					Rev Date:			
Frequency Band (GHz):	6.525-6.875					Engineer:	Harold Wyatt		
Center Frequency (GHz):	6.700					Approved:			
Site Name		Buckhorn Mountain					Pole Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	37	01.5		N	41	14	01.7
Longitude	W	105	19	38.9		W	105	26	28.6
Elevation AMSL (ft)			8288	ft				8832	ft
Azimuth			352.07	deg				171.99	deg
Path Length (miles)					42.97	mi			
Free Space Loss					145.79	dB			
Atmospheric Absorption					0.64	dB			
Antenna Center Line			50	ft.				50	ft.
Transmission Line Length			80	ft.				80	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.09	dB				1.09	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					152.60	dB			
Transmitter Power					32	dBm			
Antenna Type		Standard					Standard		
Antenna Size			6	ft				6	ft
Antenna Gain			38.8	dB				38.8	dB
Effective Radiated Power (EIRP)			67.71	dB				67.71	dB
Total Antenna Gains					77.6	dB			
TOTAL GAINS					109.6	dB			
Unfaded Received Signal Level (RSL)					-43.0	dBm			
Receive Threshold @ 10^{-6} BER					-86.0	dBm			
Dispersive Fade Margin					67.0	dB			
Flat Fade Margin					43.0	dB			
Composite Fade Margin					43.0	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00001755				
Outage Time, Non-Diversity					127.0	sec/yr			
One-Way Availability					99.999597	%			
One-Way Objective					99.999000	%			

TABLE 6-6
Microwave Path Availability Path D

CTA Communications								Path Loss and Fade Margin Calculations	
Lynchburg, Virginia								for Line-of-Sight Microwave Systems	
								Version 1.95	
Project:	Larimer County, Colorado								
Radio Capacity:	8 DS1					Date:	12/01/05		
Protection Type:	MHSB					Rev Date:			
Frequency Band (GHz):	6.525-6.875					Engineer:	Harold Wyatt		
Center Frequency (GHz):	6.700					Approved:			
Site Name		Bull Mountain					Pole Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	56	50.3		N	41	14	01.7
Longitude	W	105	55	31.5		W	105	26	28.6
Elevation AMSL (ft)			9212	ft				8832	ft
Azimuth			51.81	deg				232.13	deg
Path Length (miles)					32.09	mi			
Free Space Loss					143.25	dB			
Atmospheric Absorption					0.48	dB			
Antenna Center Line			40	ft.				50	ft.
Transmission Line Length			70	ft.				80	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			0.95	dB				1.09	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					149.77	dB			
Transmitter Power					31	dBm			
Antenna Type		Standard					Standard		
Antenna Size			6	ft				6	ft
Antenna Gain			38.8	dB				38.8	dB
Effective Radiated Power (EIRP)			66.85	dB				66.71	dB
Total Antenna Gains					77.6	dB			
TOTAL GAINS					108.6	dB			
Unfaded Received Signal Level (RSL)					-41.2	dBm			
Receive Threshold @ 10^{-6} BER					-77.5	dBm			
Dispersive Fade Margin					64.0	dB			
Flat Fade Margin					36.3	dB			
Composite Fade Margin					36.3	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00003383				
Outage Time, Non-Diversity					244.8	sec/yr			
One-Way Availability					99.999224	%			
One-Way Objective					99.999000	%			

TABLE 6-7
Microwave Path Availability Path E

CTA Communications									Path Loss and Fade Margin Calculations
Lynchburg, Virginia									for Line-of-Sight Microwave Systems
									Version 1.95
Project:	Larimer County, Colorado								
Radio Capacity:	8 DS1					Date:	12/01/05		
Protection Type:	MHSB					Rev Date:			
Frequency Band (GHz):	6.525-6.875					Engineer:	Harold Wyatt		
Center Frequency (GHz):	6.700					Approved:			
Site Name		Black Mountain					Pole Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	52	36.4		N	41	14	01.7
Longitude	W	105	41	45.5		W	105	26	28.6
Elevation AMSL (ft)			9715	ft				8832	ft
Azimuth			28.29	deg				208.45	deg
Path Length (miles)					28.00	mi			
Free Space Loss					142.06	dB			
Atmospheric Absorption					0.42	dB			
Antenna Center Line			100	ft.				40	ft.
Transmission Line Length			130	ft.				70	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.77	dB				0.95	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					149.20	dB			
Transmitter Power					31	dBm			
Antenna Type		Standard					Standard		
Antenna Size			6	ft				6	ft
Antenna Gain			38.8	dB				38.8	dB
Effective Radiated Power (EIRP)			66.03	dB				66.85	dB
Total Antenna Gains					77.6	dB			
TOTAL GAINS					108.6	dB			
Unfaded Received Signal Level (RSL)					-40.6	dBm			
Receive Threshold @ 10^{-6} BER					-77.5	dBm			
Dispersive Fade Margin					64.0	dB			
Flat Fade Margin					36.9	dB			
Composite Fade Margin					36.9	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00001974				
Outage Time, Non-Diversity					142.8	sec/yr			
One-Way Availability					99.999547	%			
One-Way Objective					99.999000	%			

TABLE 6-8
Microwave Path Availability Path F

CTA Communications							Path Loss and Fade Margin Calculations		
Lynchburg, Virginia							for Line-of-Sight Microwave Systems		
									Version 1.95
Project:	Larimer County, Colorado								
Radio Capacity:	8 DS1				Date:	12/01/05			
Protection Type:	MHSB				Rev Date:				
Frequency Band (GHz):	6.525-6.875				Engineer:	Harold Wyatt			
Center Frequency (GHz):	6.700				Approved:				
Site Name		Black Mountain					Middle Bald Mountain		
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	52	36.4		N	40	45	56.8
Longitude	W	105	41	45.5		W	105	42	27.8
Elevation AMSL (ft)			9715	ft				10934	ft
Azimuth			184.60	deg				4.59	deg
Path Length (miles)					7.68	mi			
Free Space Loss					130.83	dB			
Atmospheric Absorption					0.11	dB			
Antenna Center Line			40	ft.				50	ft.
Transmission Line Length			70	ft.				80	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			0.95	dB				1.09	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					136.99	dB			
Transmitter Power					21	dBm			
Antenna Type		Standard					Standard		
Antenna Size			4	ft				4	ft
Antenna Gain			36.3	dB				36.3	dB
Effective Radiated Power (EIRP)			54.35	dB				54.21	dB
Total Antenna Gains					72.6	dB			
TOTAL GAINS					93.6	dB			
Unfaded Received Signal Level (RSL)					-43.4	dBm			
Receive Threshold @ 10^{-6} BER					-77.5	dBm			
Dispersive Fade Margin					64.0	dB			
Flat Fade Margin					34.1	dB			
Composite Fade Margin					34.1	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00000077				
Outage Time, Non-Diversity					5.6	sec/yr			
One-Way Availability					99.999982	%			
One-Way Objective					99.999000	%			

TABLE 6-9
Microwave Path Availability Path G

CTA Communications								Path Loss and Fade Margin Calculations	
Lynchburg, Virginia								for Line-of-Sight Microwave Systems	
								Version 1.95	
Project:	Larimer County, Colorado								
Radio Capacity:	4 DS1				Date:	12/01/05			
Protection Type:	MHSB				Rev Date:				
Frequency Band (GHz):	6.525-6.875				Engineer:	Harold Wyatt			
Center Frequency (GHz):	6.700				Approved:				
Site Name	Mummy Range					Middle Bald Mountain			
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	34	48.0		N	40	45	56.8
Longitude	W	105	43	24.0		W	105	42	27.8
Elevation AMSL (ft)			11795	ft				10934	ft
Azimuth			3.66	deg				183.67	deg
Path Length (miles)					12.85	mi			
Free Space Loss					135.30	dB			
Atmospheric Absorption					0.19	dB			
Antenna Center Line			50	ft.				40	ft.
Transmission Line Length			80	ft.				70	ft.
Transmission Line Type			Elliptical Waveguide					Elliptical Waveguide	
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.09	dB				0.95	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					141.53	dB			
Transmitter Power					21	dBm			
Antenna Type			Standard					Standard	
Antenna Size			4	ft				4	ft
Antenna Gain			36.3	dB				36.3	dB
Effective Radiated Power (EIRP)			54.21	dB				54.35	dB
Total Antenna Gains					72.6	dB			
TOTAL GAINS					93.6	dB			
Unfaded Received Signal Level (RSL)					-47.9	dBm			
Receive Threshold @ 10^{-6} BER					-86.0	dBm			
Dispersive Fade Margin					67.0	dB			
Flat Fade Margin					38.1	dB			
Composite Fade Margin					38.1	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00000145				
Outage Time, Non-Diversity					10.5	sec/yr			
One-Way Availability					99.999967	%			
One-Way Objective					99.999000	%			

TABLE 6-10
Microwave Path Availability Path H

CTA Communications									Path Loss and Fade Margin Calculations
Lynchburg, Virginia									for Line-of-Sight Microwave Systems
									Version 1.95
Project:	Larimer County, Colorado								
Radio Capacity:	8 DS1				Date:	12/01/05			
Protection Type:	MHSB				Rev Date:				
Frequency Band (GHz):	6.525-6.875				Engineer:	Harold Wyatt			
Center Frequency (GHz):	6.700				Approved:				
Site Name	Buckhorn Mountain					Middle Bald Mountain			
	Hem.	Deg.	Min.	Sec.		Hem.	Deg.	Min.	Sec.
Latitude	N	40	37	01.5		N	40	45	56.8
Longitude	W	105	19	38.9		W	105	42	27.8
Elevation AMSL (ft)			8288	ft				10934	ft
Azimuth			297.32	deg				117.07	deg
Path Length (miles)					22.45	mi			
Free Space Loss					140.15	dB			
Atmospheric Absorption					0.34	dB			
Antenna Center Line			50	ft.				50	ft.
Transmission Line Length			80	ft.				80	ft.
Transmission Line Type		Elliptical Waveguide					Elliptical Waveguide		
Transmission Line Loss			1.36	dB/100 ft				1.36	dB/100 ft
Transmission Line Loss Calculated			1.09	dB				1.09	dB
Jumper or Flex Loss			0.5	dB				0.5	dB
Radome Loss			0.5	dB				0.5	dB
Misc/Common Line Pads			0	dB				0	dB
Transmit ACU Loss			1	dB				1	dB
Receive ACU Loss			1	dB				1	dB
TOTAL PATH LOSSES					146.66	dB			
Transmitter Power					28	dBm			
Antenna Type		Standard					Standard		
Antenna Size			6	ft				6	ft
Antenna Gain			38.8	dB				38.8	dB
Effective Radiated Power (EIRP)			63.71	dB				63.71	dB
Total Antenna Gains					77.6	dB			
TOTAL GAINS					105.6	dB			
Unfaded Received Signal Level (RSL)					-41.1	dBm			
Receive Threshold @ 10^{-6} BER					-77.5	dBm			
Dispersive Fade Margin					64.0	dB			
Flat Fade Margin					36.4	dB			
Composite Fade Margin					36.4	dB			
Climate Factor					1				
Terrain Roughness Factor					140	ft			
Temperature					45	deg F			
C Factor					0.2622				
Non-Diversity Outage Probability					0.00001130				
Outage Time, Non-Diversity					81.8	sec/yr			
One-Way Availability					99.999741	%			
One-Way Objective					99.999000	%			

TABLE 6-11
IEEE 802.11 Throughput Rates

DISTANCE	802.11b	802.11a	802.11g	802.11g CTS*	802.11g RTS/CTS*
Feet	Mbps	Mbps	Mbps	Mbps	Mbps
10	5.8	24.7	24.7	14.7	11.8
50	5.8	19.8	24.7	14.7	11.8
100	5.8	12.4	19.8	12.7	10.6
150	5.8	4.9	12.4	9.1	8
200	3.7	0	4.9	4.2	4.1
250	1.6	0	1.6	1.6	1.6
300	0.9	0	0.9	0.9	0.9

TABLE 6-12
EXISTING CCNC AND NCRCN SITE RADIO TRAFFIC LOADING

Location	City/County	Existing Channels*	Max Radios @ Busy Hour**	Max Erlangs @ Busy Hour***
Buckhorn Mtn.	Fort Collins	8	327	2.7250
Horsetooth Mtn.	Fort Collins	9	400	3.3335
Bald Mtn.	Loveland	8	327	2.7250
Prospect Mtn.	Estes Park	5	120	1.0000
Drake Mountain	Loveland	3	22	0.1835

* Number of voice channels plus one control channel

** Maximum number of radios supported in 2006 using a profile of 6 calls/hour/user with a 4 second call duration

*** Maximum Erlangs that can be supported during the busiest hour using a 1% Delayed call GOS with a 1 second maximum delay

TABLE 6-13
LARIMER COUNTY RADIO USAGE

Operational Group	Percentage of Growth per Year	Number of Years Projected	Mobiles	Portables	Desktops	Total Current Users	Projected Additional Units	Projected Total Units	Busy Hour Impact of Mobiles	Busy Hour Impact of Portables	Busy Hour Impact of Desktops	Number of Units During Busy Hour	Average Calls/Hour/ Unit	Average Seconds/ Call	Working Channel Call Overhead (Seconds)	Average Call Length (Seconds)	Total Call-Seconds	Calls/ Second	Offered Load (Erlangs)
Sheriff's Office Investigatons	1.00%	15	22	23	0	45	7	52	0%	32%	100%	9	2	10.0	1	11.0	99.0	0.0050	0.0550
Sheriff's Office Detention Center	1.00%	15	17	108	3	128	21	149	0%	32%	100%	44	6	4.0	1	5.0	220.0	0.0733	0.3667
Sheriff's Office Emergency Services	1.00%	15	20	30	0	50	8	58	32%	32%	100%	19	6	4.0	1	5.0	95.0	0.0317	0.1583
SO Fairgrounds & Event Center	1.00%	15	0	102	3	105	17	122	0%	0%	0%	0	7	3.8	1	4.8	0.0	0.0000	0.0000
Sheriff's Office Patrol	1.00%	15	129	198	0	327	53	380	66%	5%	100%	110	6	4.0	1	5.0	550.0	0.1833	0.9167
Health Department	1.00%	15	0	16	0	16	3	19	0%	10%	100%	2	2	10.0	1	11.0	22.0	0.0011	0.0122
Parks and Open Lands	1.00%	15	53	72	9	134	22	156	0%	32%	100%	37	6	4.0	1	5.0	185.0	0.0617	0.3083
Road and Bridge Department	1.00%	15	99	25	3	127	20	147	32%	10%	100%	43	7	6.0	1	7.0	301.0	0.0836	0.5853
Land Fill	1.00%	15	11	6	3	20	3	23	20%	0%	100%	6	2	10.0	1	11.0	66.0	0.0033	0.0367
Coroner/DA	1.00%	15	7	5	0	12	2	14	10%	10%	100%	1	2	10.0	1	11.0	11.0	0.0006	0.0061
Community Corrections	1.00%	15	0	3	0	3	0	3	0%	100%	100%	3	2	10.0	1	11.0	33.0	0.0017	0.0183
Forest Service	1.00%	15	0	0	0	0	0	0	0%	0%	0%	0	14	7.0	1	8.0	0.0	0.0000	0.0000
Estes Park PD	1.00%	15	10	31	3	44	7	51	66%	0%	0%	8	6	4.0	1	5.0	40.0	0.0133	0.0667
Rist Canyon VFD	1.00%	15	13	25	1	39	6	45	20%	5%	0%	4	2	6.0	1	7.0	28.0	0.0022	0.0156
Livermore VFD	1.00%	15	11	17	2	30	5	35	20%	5%	0%	4	2	6.0	1	7.0	28.0	0.0022	0.0156
Crystal Lake VFD	1.00%	15	6	6	0	12	2	14	20%	5%	0%	2	2	6.0	1	7.0	14.0	0.0011	0.0078
Red Feather Lakes VFD	1.00%	15	12	27	1	40	6	46	20%	5%	0%	4	2	6.0	1	7.0	28.0	0.0022	0.0156
Glacier View VFD	1.00%	15	6	6	0	12	2	14	20%	5%	0%	2	2	6.0	1	7.0	14.0	0.0011	0.0078
Poudre Canyon VFD	1.00%	15	12	40	2	54	9	63	20%	5%	0%	5	2	6.0	1	7.0	35.0	0.0028	0.0194
Glen Haven VFD	1.00%	15	11	24	1	36	6	42	20%	5%	0%	4	2	6.0	1	7.0	28.0	0.0022	0.0156
Allens Park VFD	1.00%	15	6	6	0	12	2	14	20%	5%	0%	2	2	6.0	1	7.0	14.0	0.0011	0.0078
Big Elk VFD	1.00%	15	8	27	1	36	6	42	20%	5%	0%	3	2	6.0	1	7.0	21.0	0.0017	0.0117
Pinewood VFD	1.00%	15	7	20	1	28	5	33	20%	5%	0%	3	2	6.0	1	7.0	21.0	0.0017	0.0117
Big Thompson Canyon VFD	1.00%	15	6	6	0	12	2	14	20%	5%	0%	2	2	6.0	1	7.0	14.0	0.0011	0.0078
Estes Park VFD	1.00%	15	26	55	1	82	13	95	20%	5%	0%	9	2	6.0	1	7.0	63.0	0.0050	0.0350
Sheriff's Office Search & Rescue	1.00%	15	30	68	4	102	16	118	20%	5%	0%	11	2	6.0	1	7.0	77.0	0.0061	0.0428
Total	1.00%	15	522	946	38	1506	242	1748				337				6.0		0.4892	2.9132

TABLE 6-14
SITE CHANNEL CALCULATIONS

Location	City/County	Existing Channels*	Max Radios @ Busy Hour**	Max Erlangs @ Busy Hour***	Additional Larimer Radio Units @ Busy Hour	Larimer Erlangs @ Busy Hour	State + Larimer Total Erlangs	Required Channels
Buckhorn Mtn.	Fort Collins	8	327	2.7250	162	1.3500	4.075	10
Horsetooth Mtn.	Fort Collins	9	400	3.3335	270	2.2500	5.5835	12
Bald Mtn.	Loveland	8	327	2.7250	68	0.5665	3.2915	9
Prospect Mtn.	Estes Park	5	120	1.0000	11	0.0915	1.0915	5
Drake Mountain	Loveland	3	22	0.1835	2	0.0165	0.2000	3
Bull Mtn	Larimer	---	---	---	67	0.5585	1.0000	5
Black Mtn	Larimer	---	---	---	67	0.5585	1.0000	5
Middle Bald Mtn	Larimer	---	---	---	67	0.5585	1.0000	5
Kinikinik	Larimer	---	---	---	67	0.5585	1.0000	5

* Number of voice channels plus one control channel

** Maximum number of radios supported in 2006 using a profile of 6 calls/hour/user with a 4 second call duration

*** Maximum Erlangs that can be supported during the busiest hour using a 1% Delayed call GOS with a 1 second maximum delay

TABLE 8-1
ESTIMATE OF PROBABLE COST - PHASE 1
LARIMER COUNTY INFRASTRUCTURE

COST ELEMENT	HIGH ESTIMATE	LOW ESTIMATE
RADIO INFRASTRUCTURE	$ 137,030	$ 102,800
MICROWAVE	$ -	$ -
PHYSICAL FACILITIES	$ -	$ -
SERVICES	$ 24,665	$ 18,500
CONTENGENCY	$ 13,703	$ 11,000
SPARES - FIXED	$ 1,370	$ 1,400
TOTAL	**$ 176,769**	**$ 133,700**

TABLE 8-2
ESTIMATE OF PROBABLE COST
LARIMER COUNTY NON-FIXED UNITS

Item	AGENCY	INITIAL QUANTITIES 2005			COST ESTIMATE	NCRCN FEE/YEAR
		MOB	PORT	STNS		
	Larimer County					
1	Sheriff's Office Investigatons	22	23	0	$ 175,200.00	$ 2,250.00
2	Sheriff's Office Detention Center	17	108	3	$ 476,100.00	$ 6,400.00
3	Sheriff's Office Emergency Services	20	30	0	$ 192,000.00	$ 2,500.00
4	Sheriff's Office Patrol	129	198	0	$ 1,254,600.00	$ 16,350.00
5	Health Department	0	16	0	$ 24,000.00	$ 800.00
6	Parks and Open Lands	53	72	9	$ 240,500.00	$ 6,700.00
7	Road and Bridge Department	99	25	3	$ 211,800.00	$ 6,350.00
8	Land Fill	11	6	3	$ 42,500.00	$ 1,000.00
9	Coroner/DA	7	5	0	$ 47,400.00	$ 600.00
10	Community Corrections	0	3	0	$ 10,800.00	$ 150.00
11	Sheriff's Office Search & Rescue	30	68	4	$ 171,200.00	$ 5,100.00
	Total	**388**	**554**	**22**	**$ 2,846,100.00**	**$ 48,200.00**
	Volunteer Fire Departments					
	Rist Canyon	13	25	1	$ 63,600.00	$ 1,950.00
1	Livermore	11	17	2	$ 53,700.00	$ 1,500.00
2	Crystal Lake	6	6	0	$ 23,900.00	$ 600.00
3	Red Feather Lakes	12	27	1	$ 65,000.00	$ 2,000.00
4	Glacier View	6	6	0	$ 23,900.00	$ 600.00
5	Poudre Canyon	12	40	2	$ 89,800.00	$ 2,700.00
6	Glen Haven	11	24	1	$ 58,900.00	$ 1,800.00
7	Allens Park	6	6	0	$ 23,900.00	$ 600.00
8	Big Elk	8	27	1	$ 58,600.00	$ 1,800.00
9	Pinewood	7	20	1	$ 46,500.00	$ 1,400.00
10	Big Thompson Canyon	6	6	0	$ 23,900.00	$ 600.00
11	Estes Park	26	55	1	$ 129,400.00	$ 4,100.00
	Total	**124**	**259**	**10**	**$ 661,100.00**	**$ 19,650.00**

Notes:
MOB-Mobile Radio
PORT-Portable Radio
STNS-Desktop or Control Station

TABLE 8-3
ESTIMATE OF PROBABLE COST - PHASE 2
LARIMER COUNTY INFRASTRUCTURE

COST ELEMENT	LIST ESTIMATE	LOW ESTIMATE
RADIO INFRASTRUCTURE	$ 448,812	$ 336,600
MICROWAVE	$ 100,000	$ 100,000
PHYSICAL FACILITIES	$ 297,800	$ 268,000
SERVICES	$ 152,390	$ 114,300
CONTENGENCY	$ 84,661	$ 67,700
SPARES - FIXED	$ 8,466	$ 8,500
INFLATION (1 YEAR)	$ 10,921	$ 8,951
TOTAL	**$ 1,103,050**	**$ 904,051**

TABLE 8-4
ESTIMATE OF PROBABLE COST - PHASE 3
LARIMER COUNTY INFRASTRUCTURE

COST ELEMENT	HIGH ESTIMATE	LOW ESTIMATE
RADIO INFRASTRUCTURE	$ 360,392	$ 270,300
MICROWAVE	$ 100,000	$ 100,000
PHYSICAL FACILITIES	$ 390,300	$ 351,300
SERVICES	$ 155,663	$ 116,700
CONTENGENCY	$ 86,479	$ 69,200
SPARES - FIXED	$ 8,648	$ 8,600
INFLATION (5 YEARS)	$ 56,187	$ 46,730
TOTAL	**$ 1,157,669**	**$ 962,830**

TABLE 8-5
ESTIMATE OF PROBABLE COST - PHASE 4A
LARIMER COUNTY INFRASTRUCTURE

COST ELEMENT	HIGH ESTIMATED	LOW ESTIMATE
RADIO INFRASTRUCTURE	$ 360,392	$ 270,300
MICROWAVE	$ -	$ -
PHYSICAL FACILITIES	$ 374,300	$ 336,900
SERVICES	$ 132,245	$ 99,200
CONTENGENCY	$ 73,469	$ 58,800
SPARES - FIXED	$ 7,347	$ 7,300
INFLATION (7 YEARS)	$ 68,367	$ 55,725
TOTAL	**$ 1,016,120**	**$ 828,225**

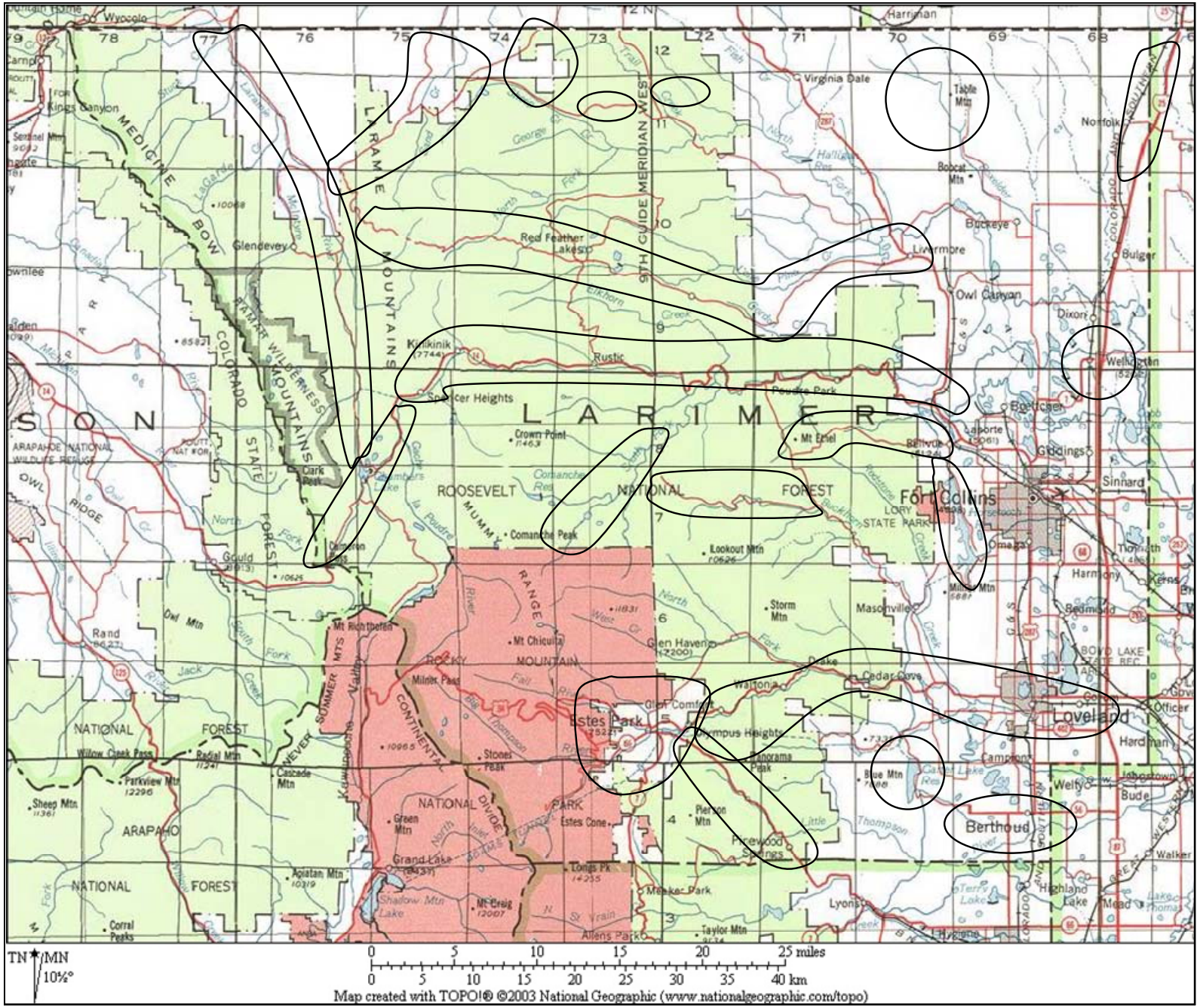
TABLE 8-6
ESTIMATE OF PROBABLE COST - PHASE 4B
LARIMER COUNTY INFRASTRUCTURE

COST ELEMENT	HIGH ESTIMATE	LOW ESTIMATE
RADIO INFRASTRUCTURE	$ 208,116	$ 156,100
MICROWAVE	$ 100,000	$ 100,000
PHYSICAL FACILITIES	$ 341,600	$ 307,400
SERVICES	$ 116,949	$ 87,700
CONTENGENCY	$ 64,972	$ 52,000
SPARES - FIXED	$ 6,497	$ 6,500
INFLATION (7 YEARS)	$ 60,459	$ 51,194
TOTAL	**$ 898,593**	**$ 760,894**

TABLE 8-7
ESTIMATE OF PROBABLE COST
LARIMER COUNTY HYBRID SYSTEM PROJECT

COST ELEMENT	HIGH ESTIMATE	LOW ESTIMATE
PHASE 1	$ 176,769	$ 133,700
NON-FIXED UNITS (COUNTY)	$ 2,846,100	$ 2,846,100
NON-FIXED UNITS (VOLUNTEER)	$ 661,100	$ 661,100
PHASE 2	$ 1,103,050	$ 904,051
PHASE 3	$ 1,157,669	$ 962,830
PHASE 4A	$ 1,016,120	$ 828,225
PHASE 4B	$ 898,593	$ 760,894
TOTAL	**$ 7,859,401**	**$ 7,096,900**

FIGURE 2-1
CONSOLIDATED COVERAGE PROBLEMS



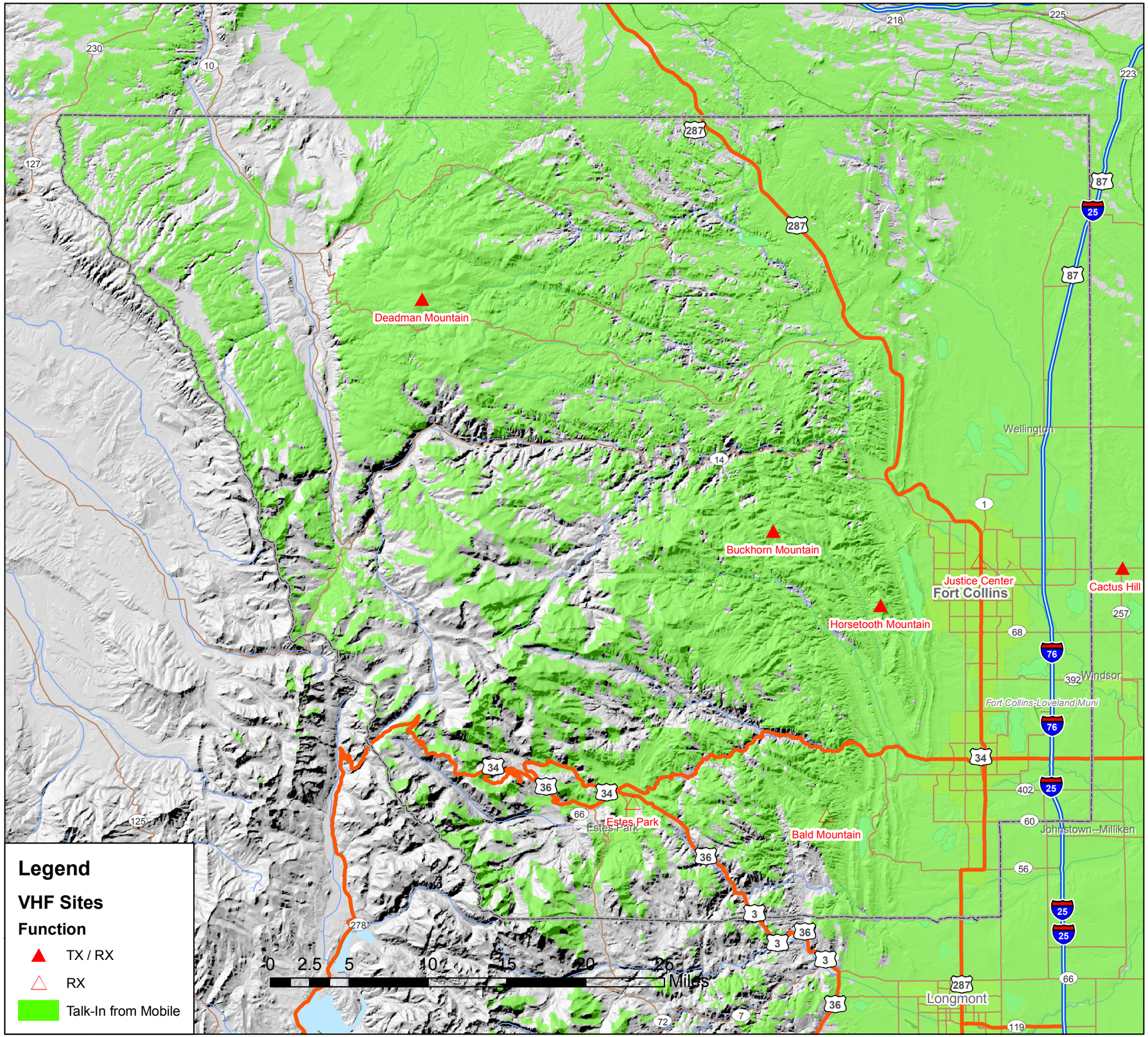


Figure 2-2
VHF Wideband Talk-In from Mobile

Client
Larimer County, Colorado

Description
Projected VHF Coverage

Commission No. 20079

Scale 1 inch equals 6.2 miles

Data Sources and Notes:

Geographical Data from ESRI, Inc.

Elevation Data from the USGS National Elevation Dataset

Projection: Lambert Conformal Conic
NAD 1983 StatePlane Colorado
North FIPS 0501 Feet

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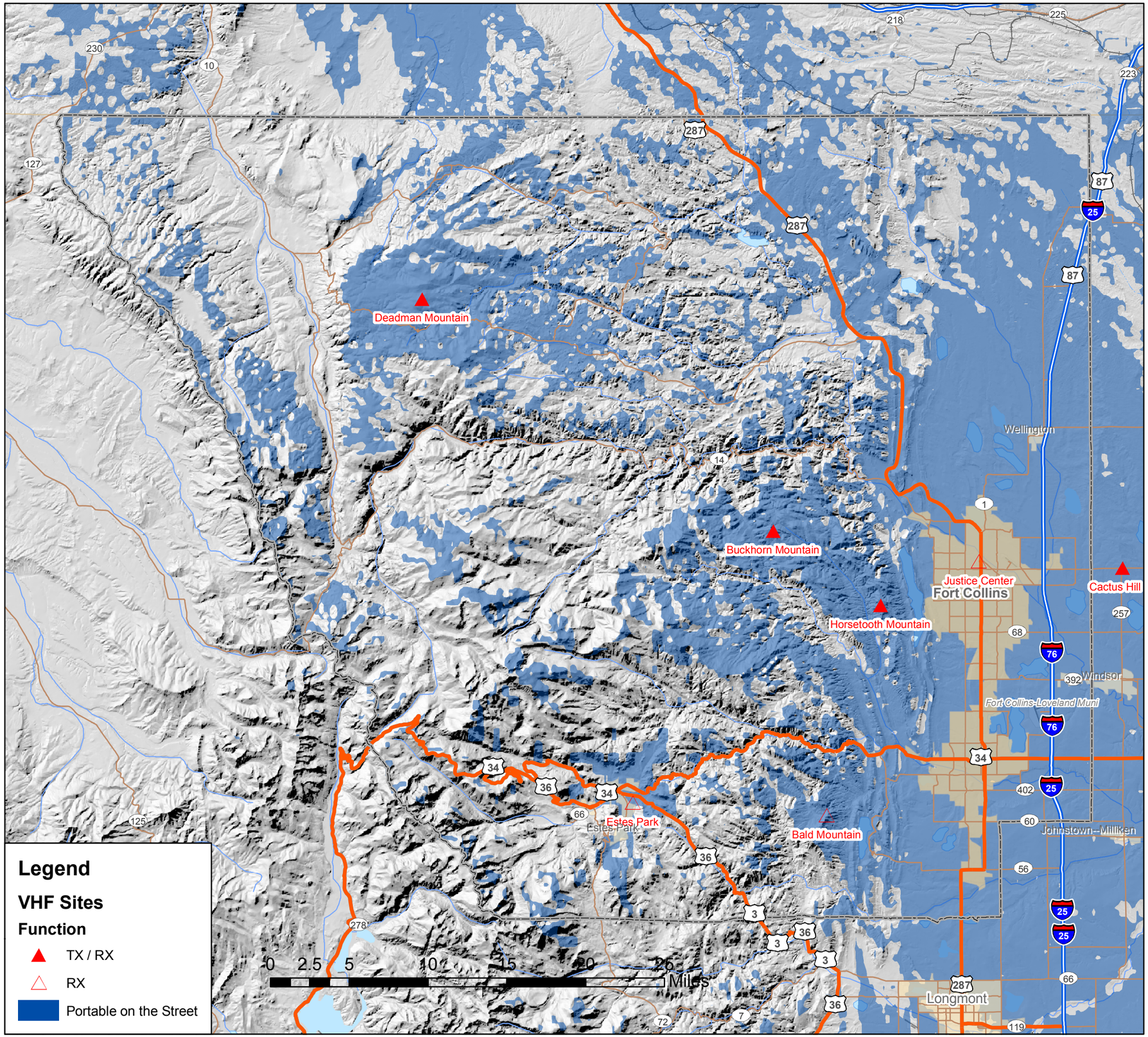

Figure 2-3
VHF Wideband Talk-In from Portable on the Street

Client
Larimer County, Colorado

Description
Projected VHF Coverage

Commission No. 20079

Scale 1 inch equals 6.2 miles

Data Sources and Notes:

Geographical Data from ESRI, Inc.

Elevation Data from the USGS National Elevation Dataset

Projection: Lambert Conformal Conic
NAD 1983 StatePlane Colorado
North FIPS 0501 Feet

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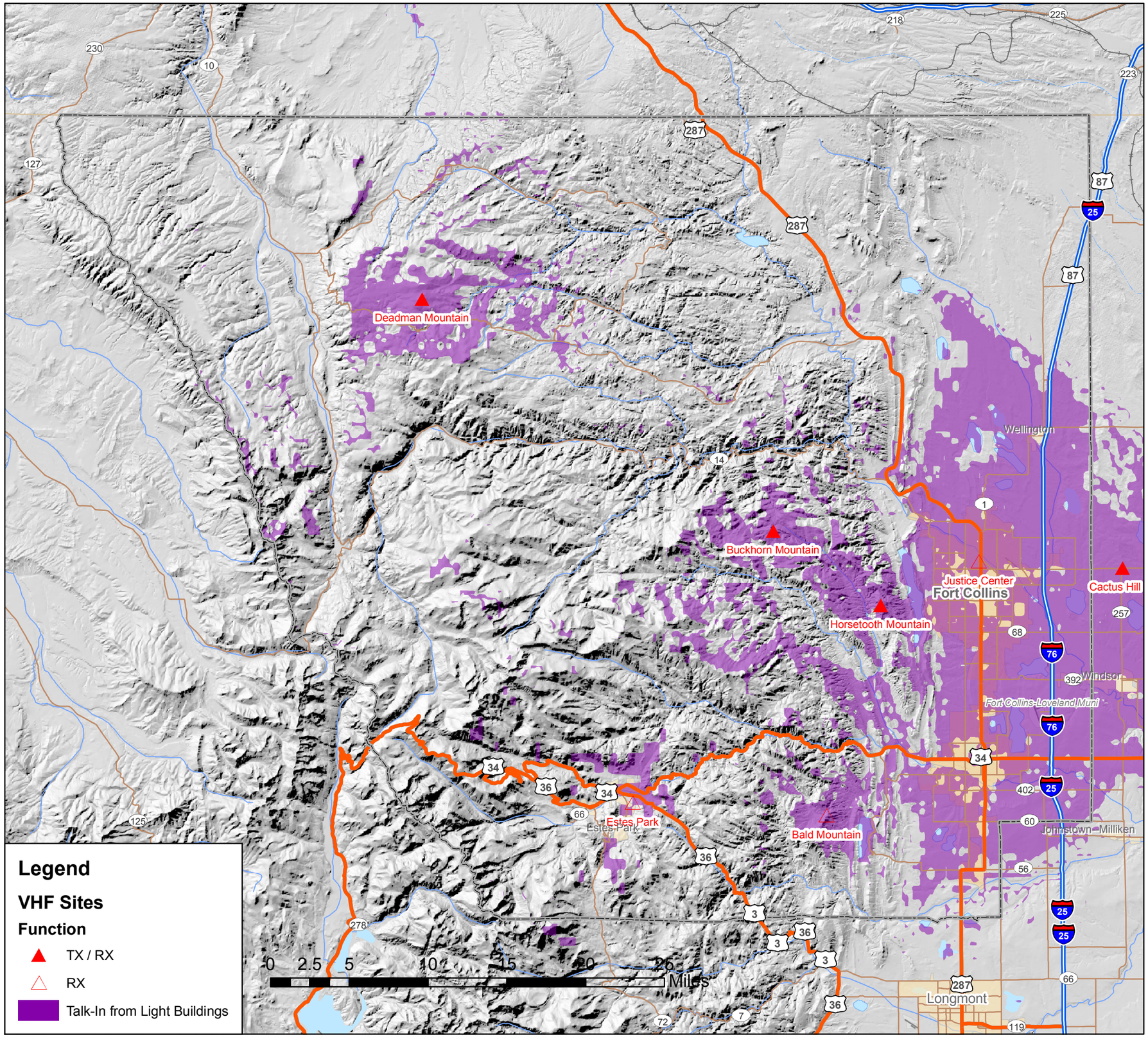

Figure 2-4
VHF Wideband Talk-In from Portable in Light Buildings

Client
Larimer County, Colorado

Description
Projected VHF Coverage

Commission No. 20079

Scale 1 inch equals 6.2 miles

Data Sources and Notes:

Geographical Data from ESRI, Inc.

Elevation Data from the USGS National Elevation Dataset

Projection: Lambert Conformal Conic
NAD 1983 StatePlane Colorado
North FIPS 0501 Feet

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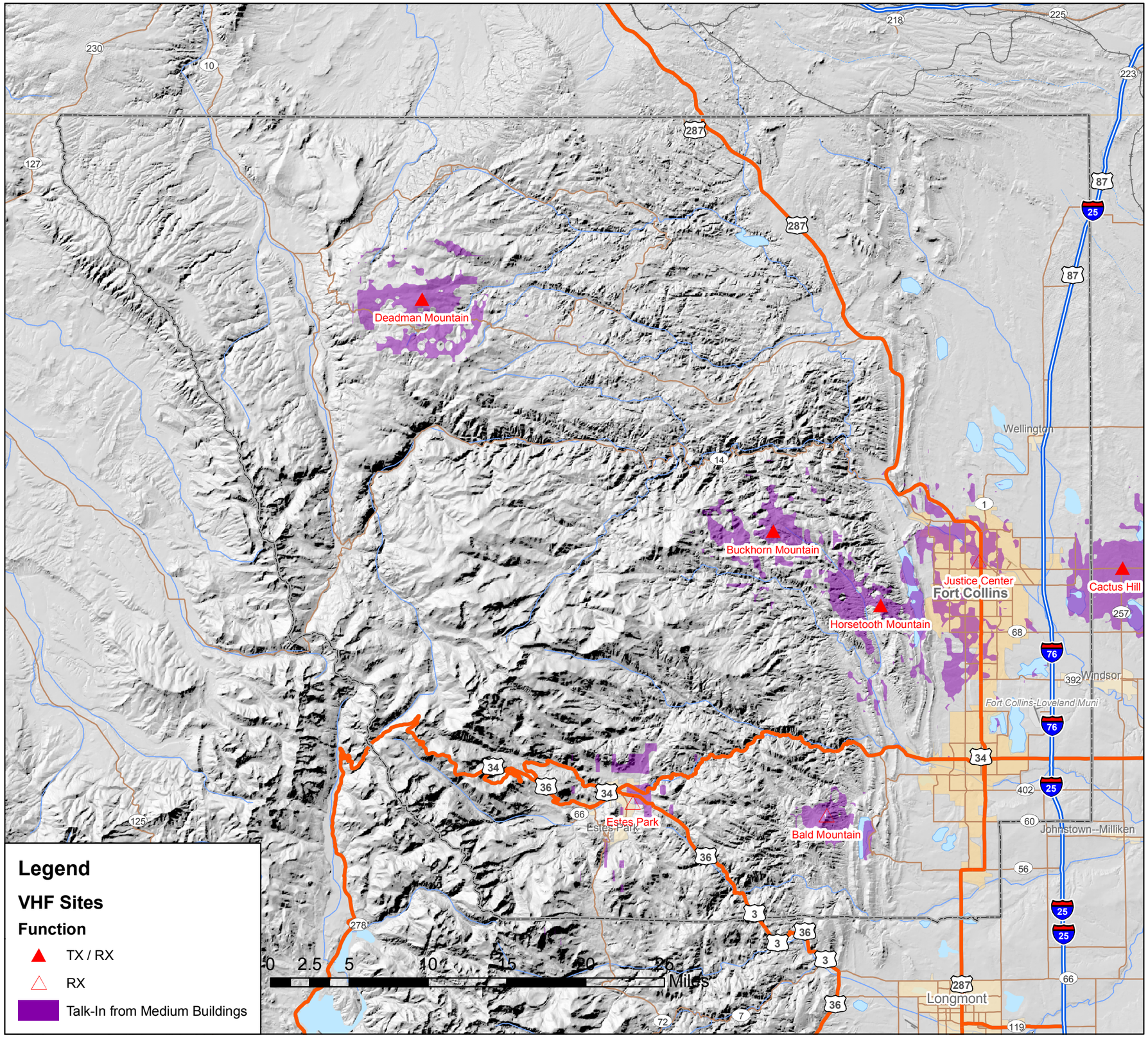

Figure 2-5
VHF Wideband Talk-In from Portable in Medium Buildings

Client
Larimer County, Colorado

Description
Projected VHF Coverage

Commission No. 20079

Scale 1 inch equals 6.2 miles

Data Sources and Notes:

Geographical Data from ESRI, Inc.

Elevation Data from the USGS National Elevation Dataset

Projection: Lambert Conformal Conic
NAD 1983 StatePlane Colorado
North FIPS 0501 Feet

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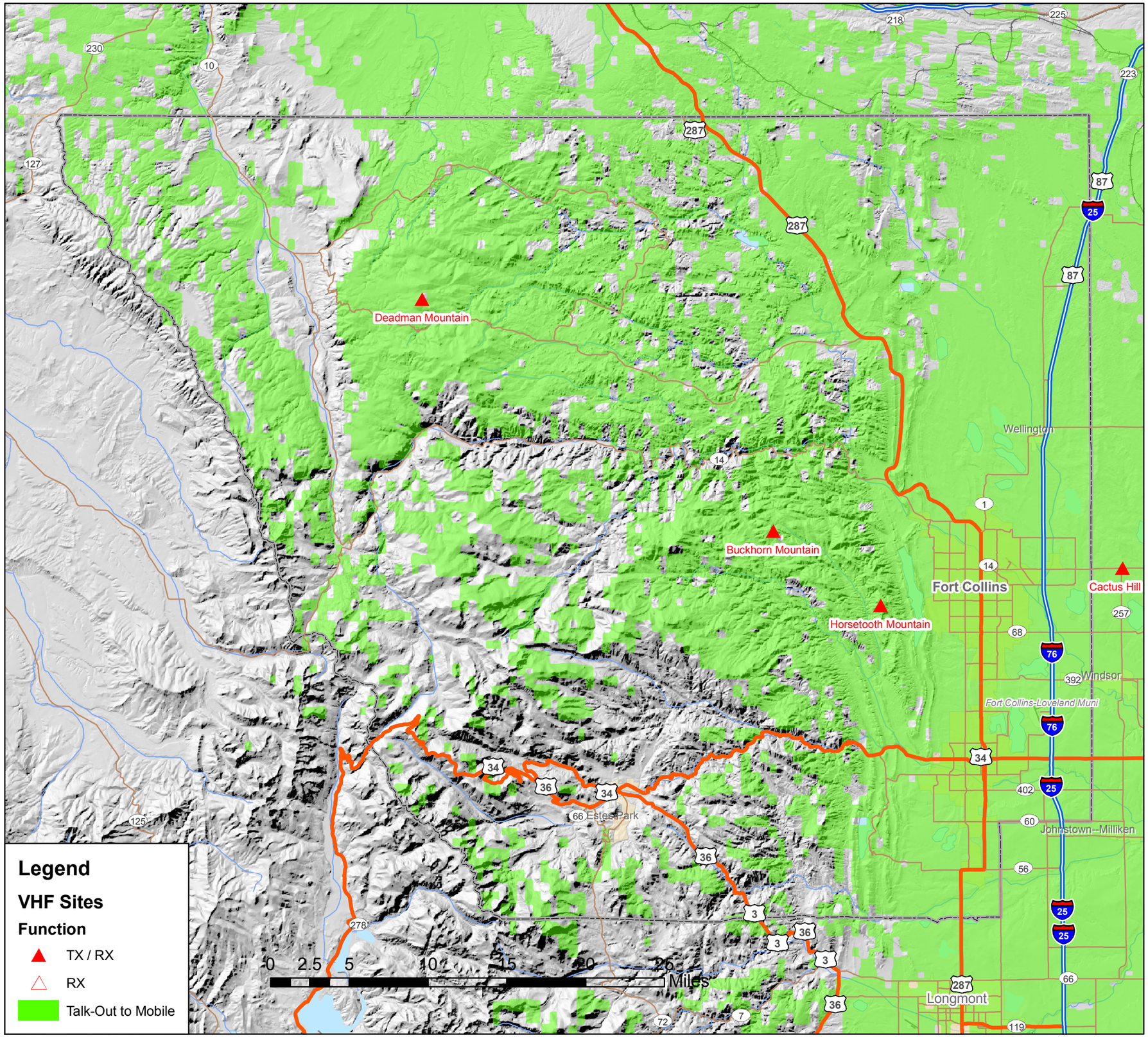

Figure 2-6
VHF Wideband
Talk-Out to Mobile

Client
Larimer County, Colorado

Description
Projected VHF Coverage

Commission No. 20079

Scale 1 inch equals 6.2 miles

Data Sources and Notes:

Geographical Data from ESRI, Inc.

Elevation Data from the USGS
National Elevation Dataset

Projection: Lambert Conformal Conic
NAD 1983 StatePlane Colorado
North FIPS 0501 Feet

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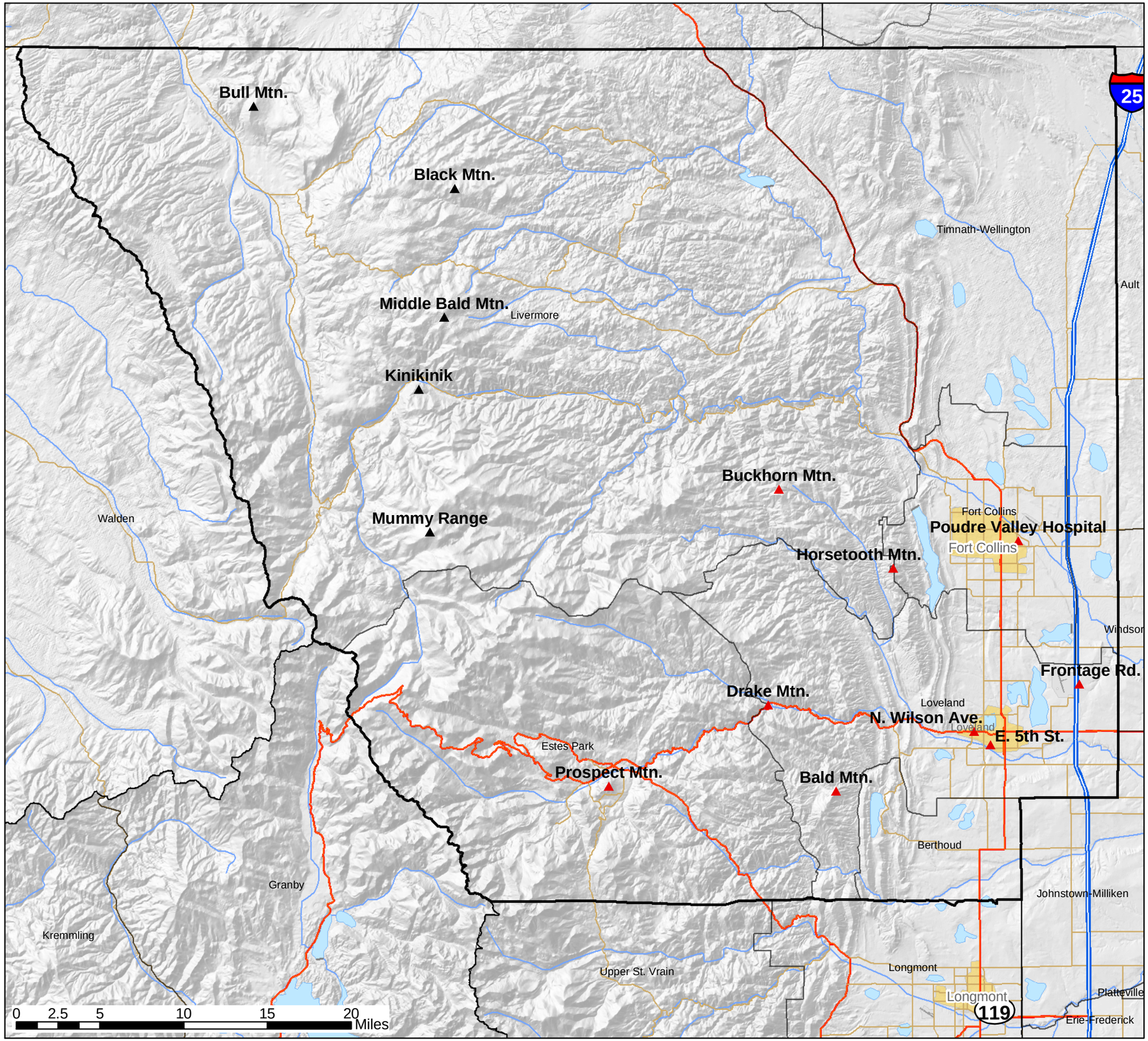

FIGURE 6-1
EXISTING 800MHZ & NEW RADIO SITES

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Existing 800 MHz and new radio sites.

Legend

- ▲ Proposed Sites
- ▲ Existing Sites

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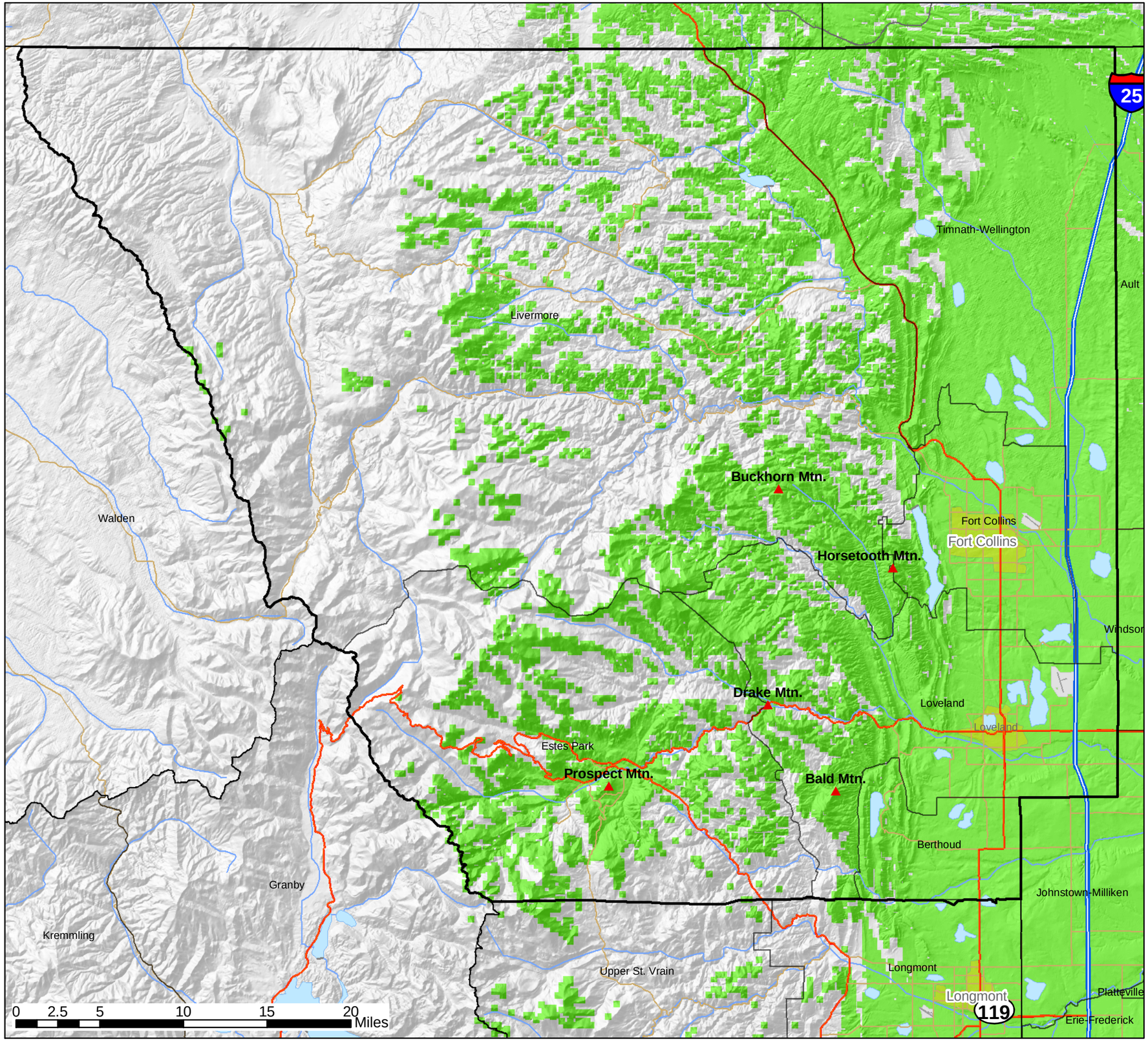

FIGURE 6-2
EXISTING CCNC 800 MHz MOBILE COVERAGE PHASE 1

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out mobile coverage for existing sites.

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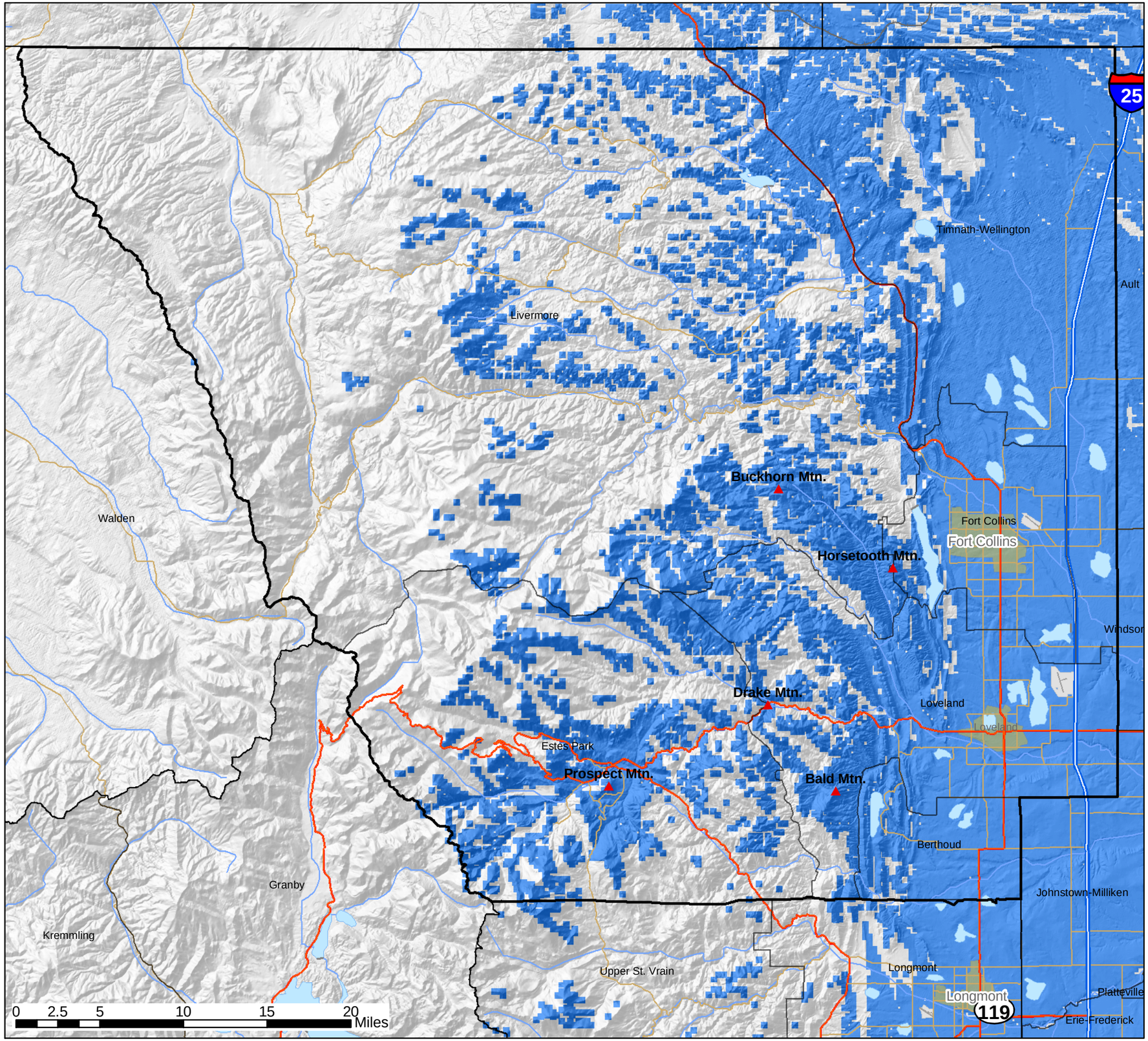

FIGURE 6-3
EXISTING CCNC
800 MHz PORTABLE
COVERAGE
PHASE 1

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out portable coverage for existing on street sites.

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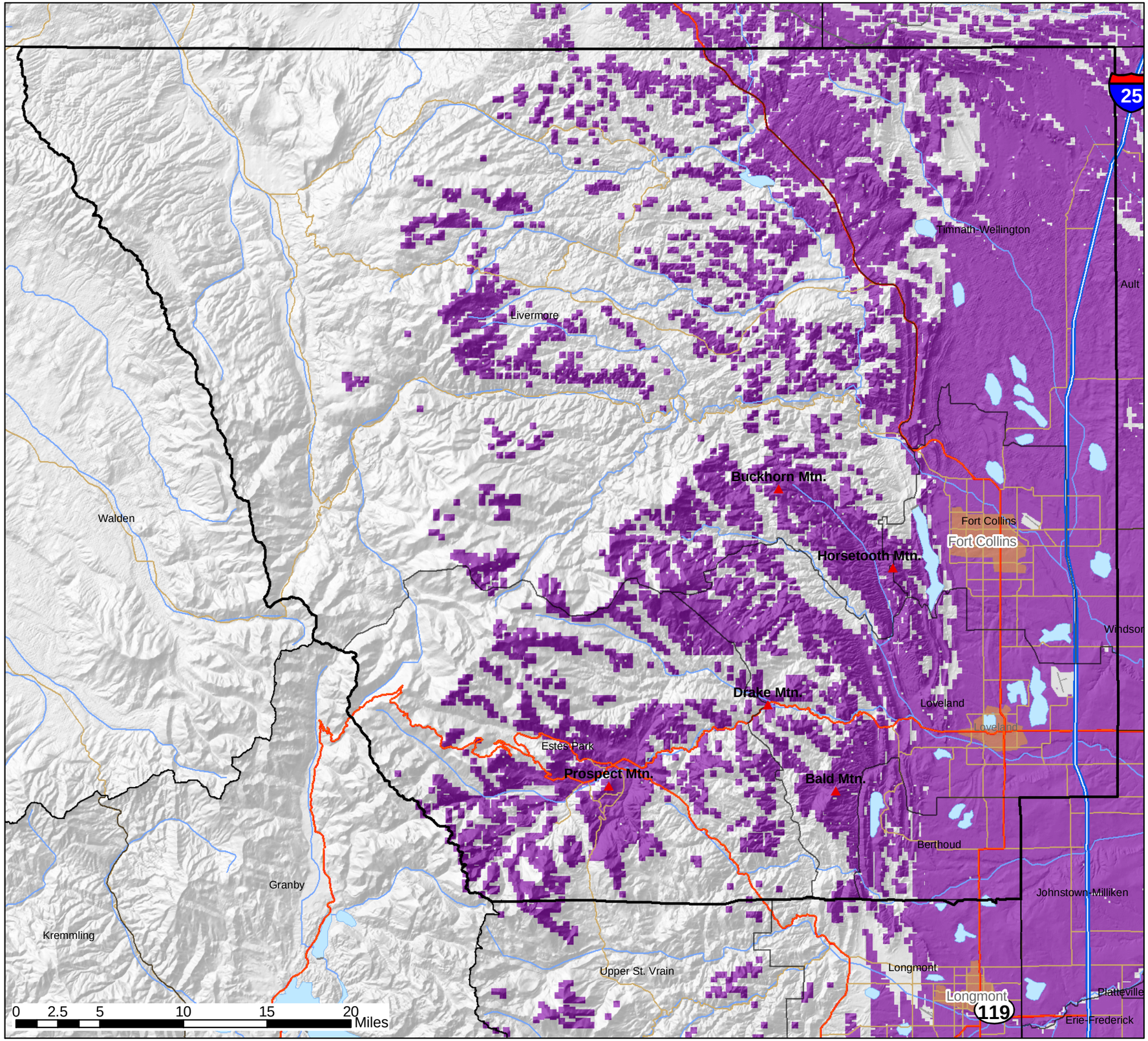

FIGURE 6-4
EXISTING CCNC
800 MHz PORTABLE
COVERAGE
PHASE 1

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out portable coverage for existing in light building sites.

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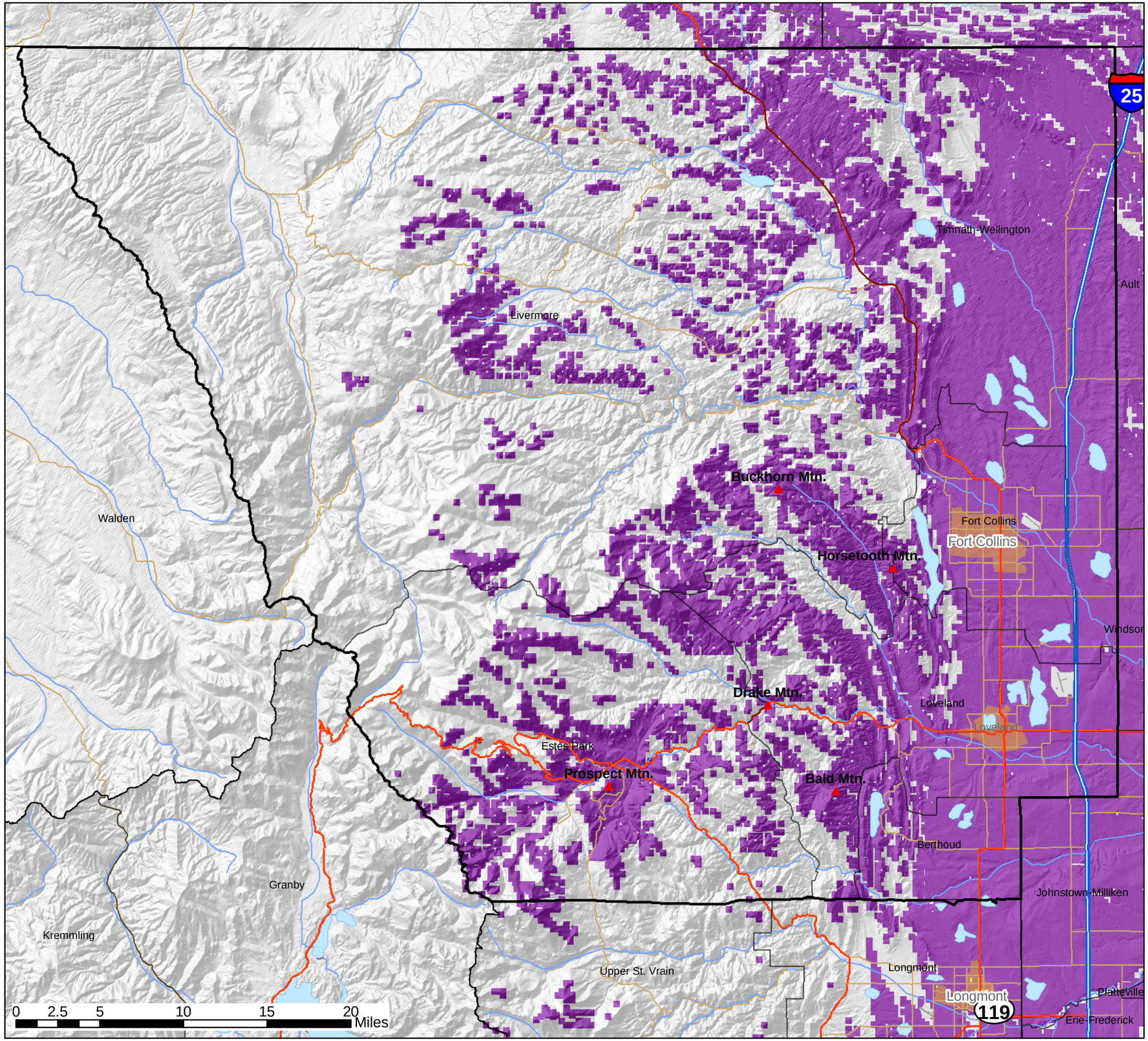

FIGURE 6-5
EXISTING CCNC
800 MHz PORTABLE
COVERAGE
PHASE 1

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out portable coverage for existing in medium building sites.

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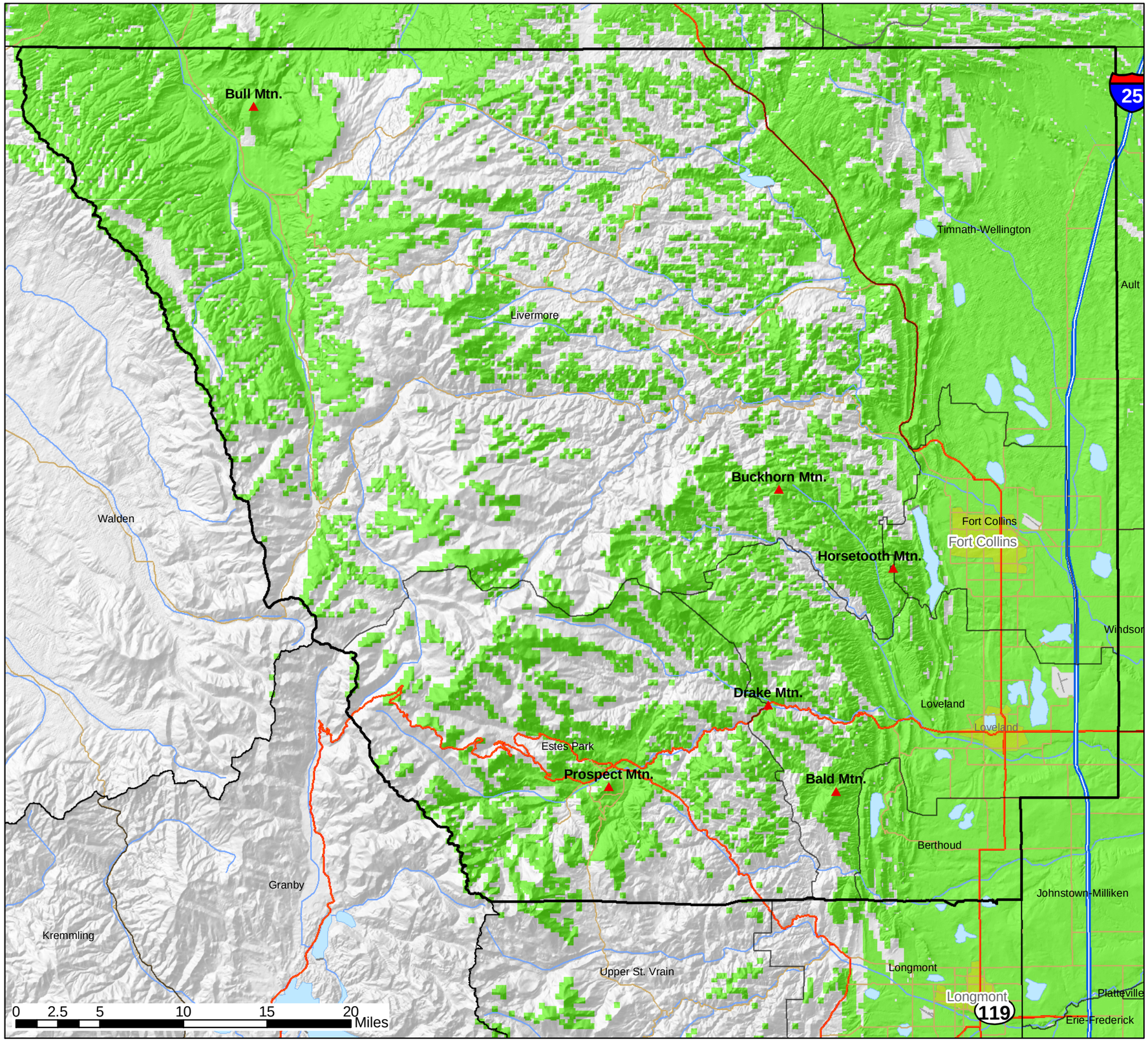

FIGURE 6-6
800 MHz MOBILE COVERAGE
PHASE 1

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out mobile coverage for proposed Bull Mtn. plus existing CCNC sites.

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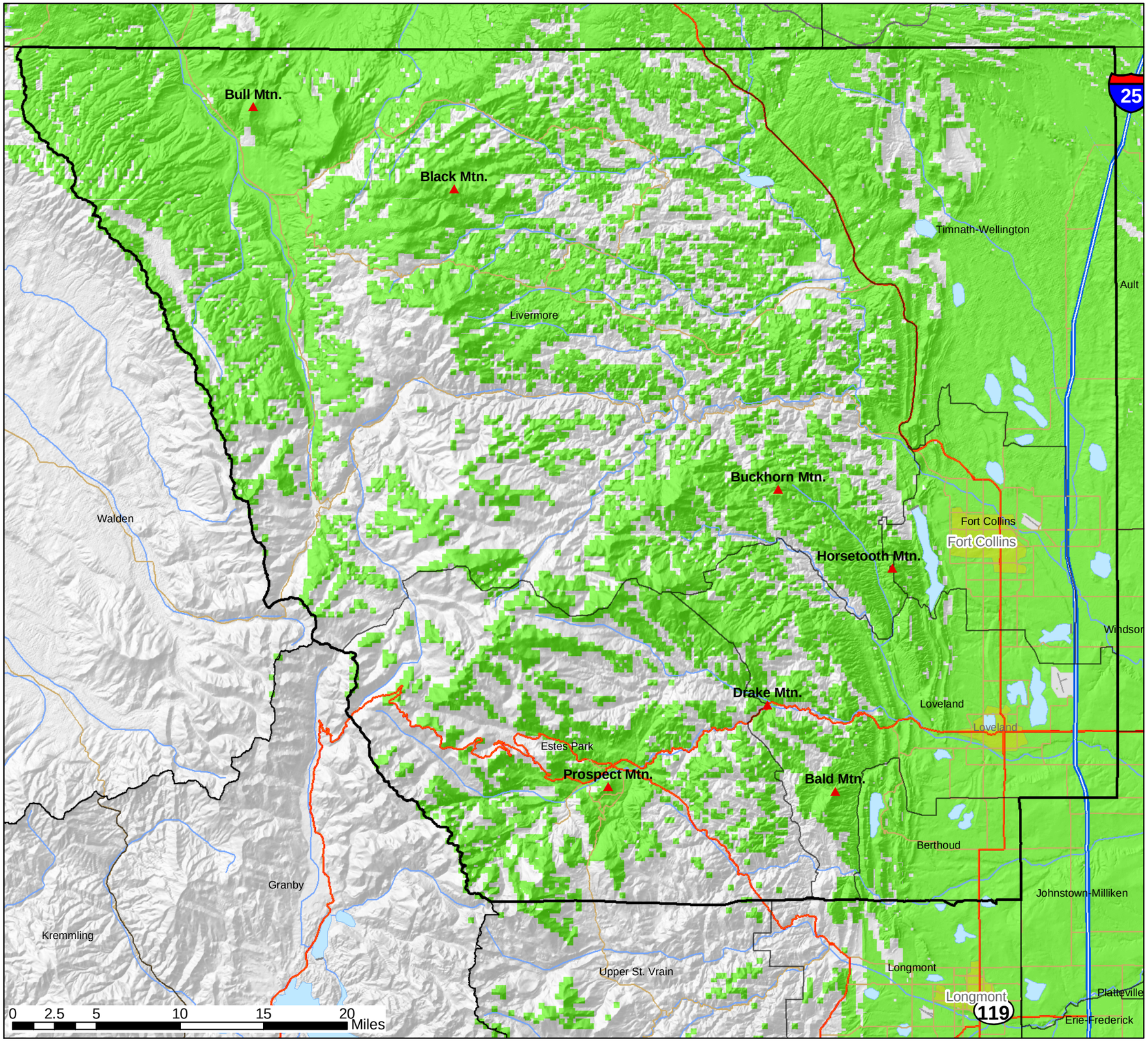

FIGURE 6-7
800 MHz MOBILE COVERAGE
PHASE 2

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out mobile coverage for proposed Black Mtn. plus existing CCNC sites.

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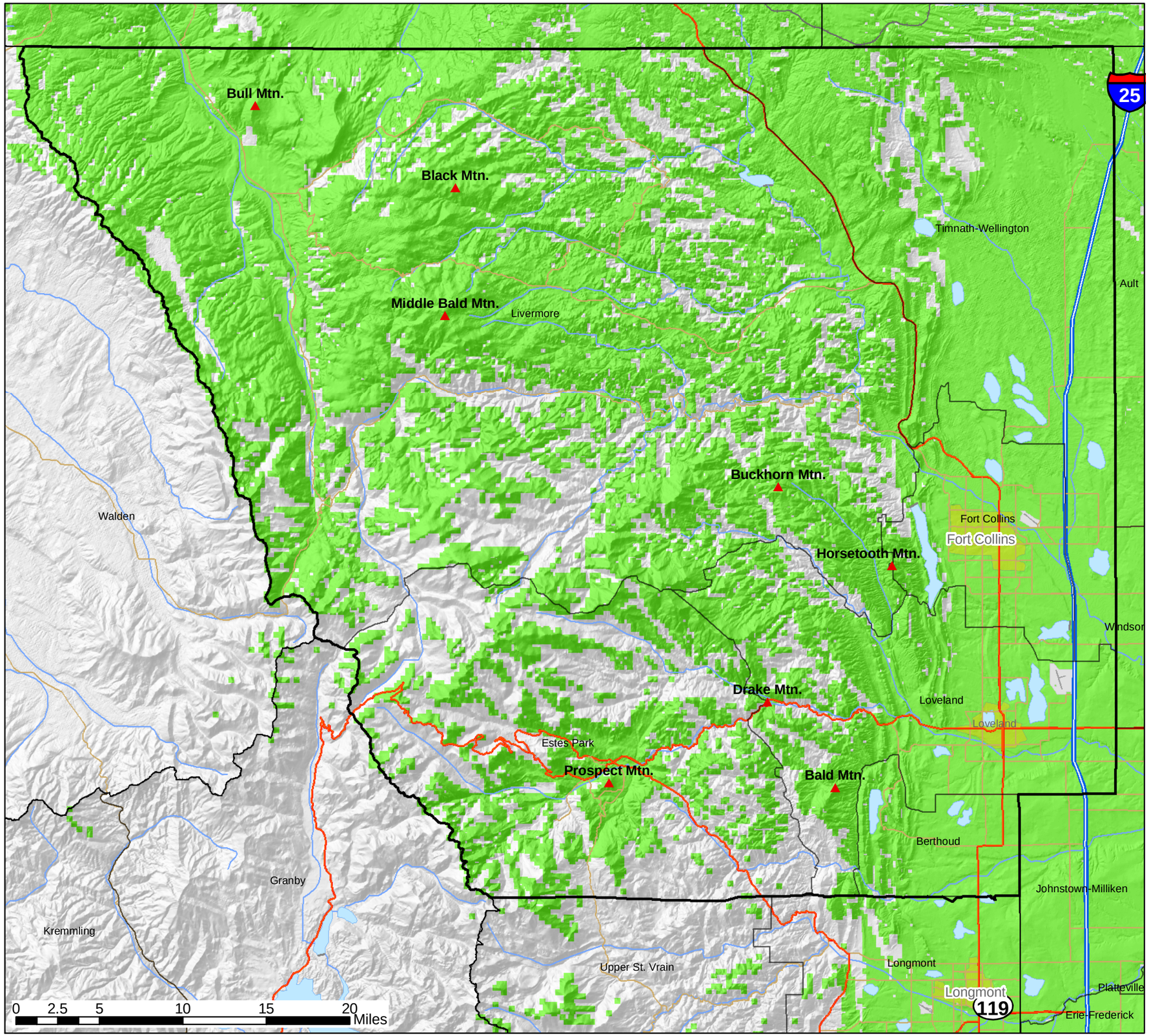

FIGURE 6-8
800 MHz MOBILE COVERAGE
PHASE 3

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.8 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out mobile coverage for proposed Middle Bald Mtn. plus existing CCNC sites.

"Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or indeterminate variables."

Design:

Drawn: TRM - 30 November 2005

Checked:

Approved:

File Name:

M:\Files\20079 Larimer\Coverage\
Figure 6-8.mxd

Revised:

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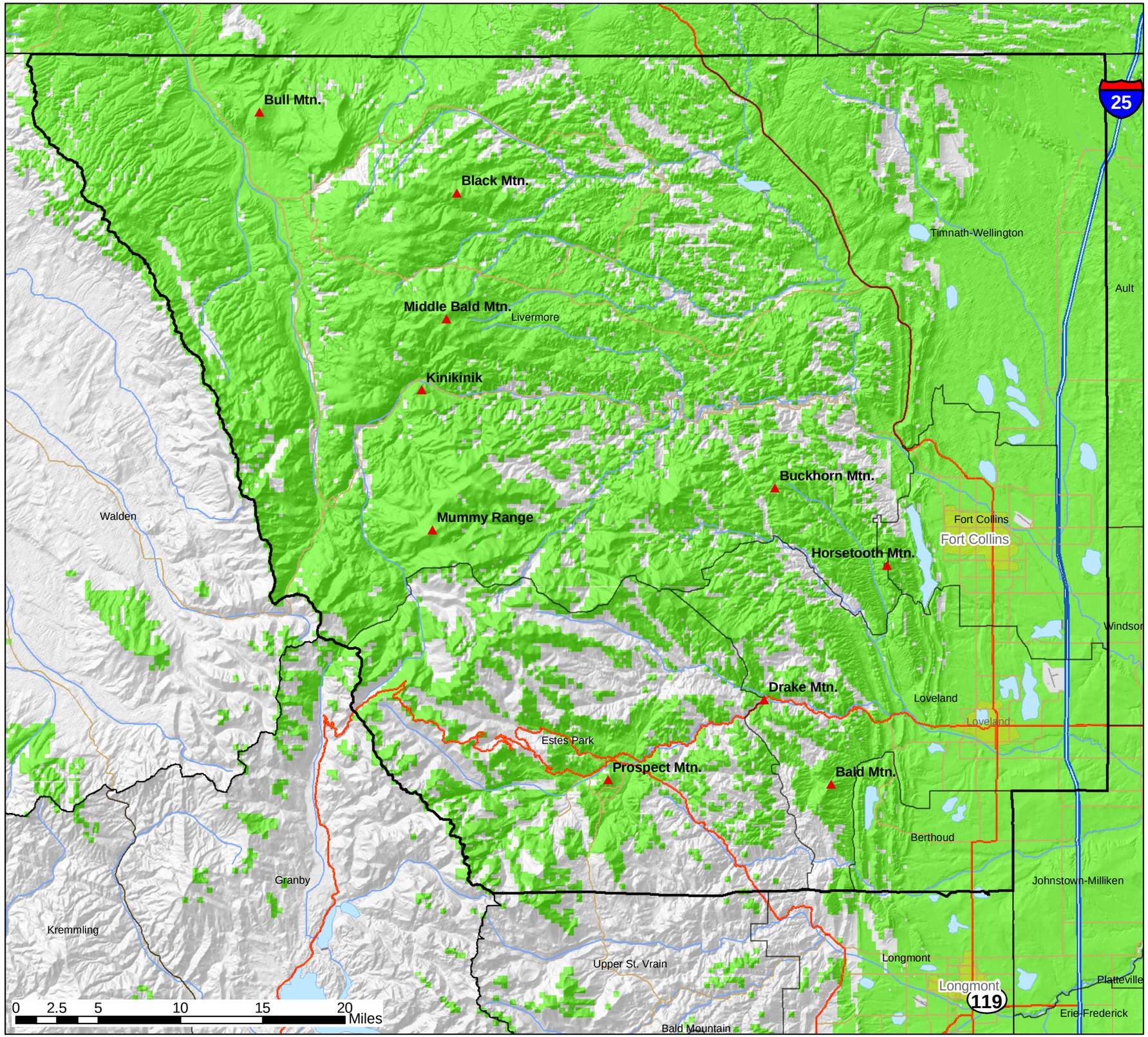

FIGURE 6-9
800 MHz MOBILE COVERAGE
PHASE 4A & 4B

Client: Larimer County

Commission No. 20079

Scale 1 inch equals 5.9 miles

Data Sources and Notes:
Coverage prediction for 800 MHz talk-out mobile coverage for proposed Kinikinik and Mummy Range plus existing CCNC sites.

"Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or indeterminate variables."

Design:

Drawn: TRM - 30 November 2005

Checked:

Approved:

File Name:

M:\Files\20079 Larimer\Coverage\
Figure 6-9.mxd

Revised:

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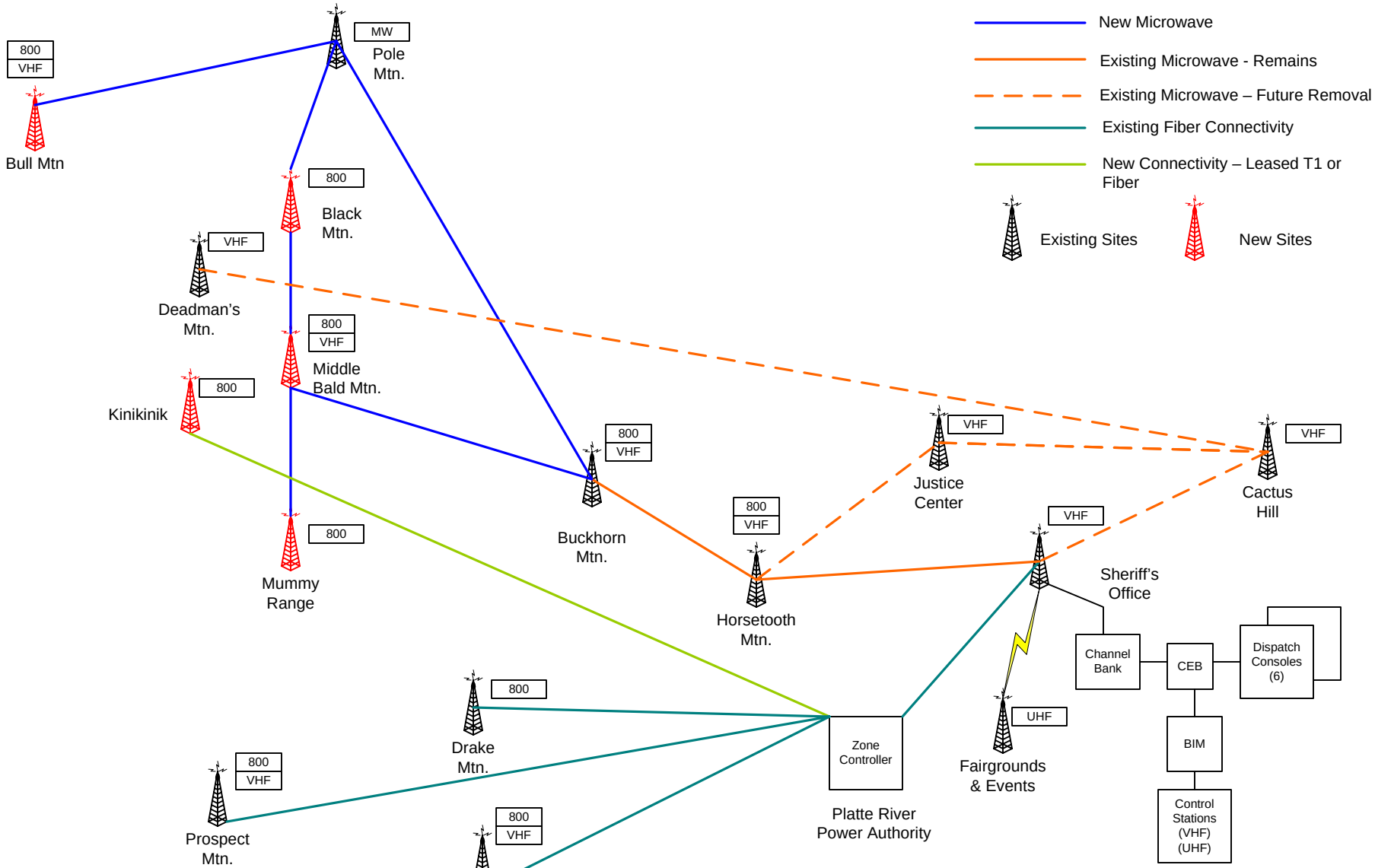

NAME		DATE
DESIGN:	JDP	11/28/05
DRAWN:	NJD	11/28/05
CHECKED:	JDP	11/28/05
APPROVED:	CSG	11/28/05

REVISION DATE('S):

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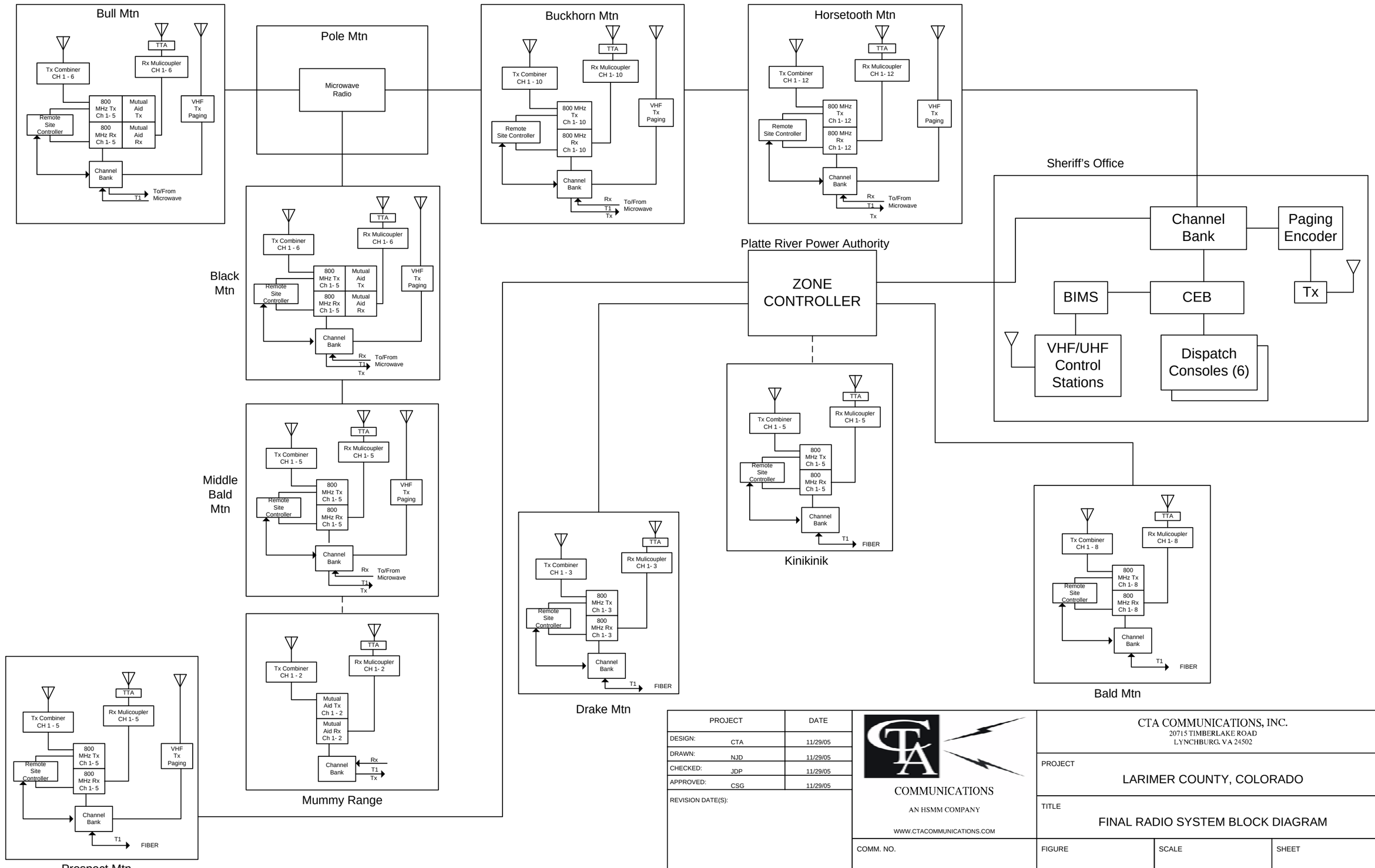
CTA COMMUNICATIONS, INC.
20715 TIMBERLAKE ROAD
LYNCHBURG, VA 24502

PROJECT: LARIMER COUNTY, COLORADO

TITLE: HYBRID SYSTEM SITE CONNECTIVITY

COMM NO.	DWG. NO.	SCALE	PAGE
20079	6-10	N/A	1 of 1

M:\FILES\20079\CADD\PRELIMINARY RADIO SYSTEM DESIGN.VSD



PROJECT		DATE
DESIGN:	CTA	11/29/05
DRAWN:	NJD	11/29/05
CHECKED:	JDP	11/29/05
APPROVED:	CSG	11/29/05
REVISION DATE(S):		

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CTA COMMUNICATIONS, INC.
20715 TIMBERLAKE ROAD
LYNCHBURG, VA 24502

PROJECT
LARIMER COUNTY, COLORADO

TITLE
FINAL RADIO SYSTEM BLOCK DIAGRAM

COMM. NO.	FIGURE	SCALE	SHEET
20079	6-11	N/A	1 OF 1

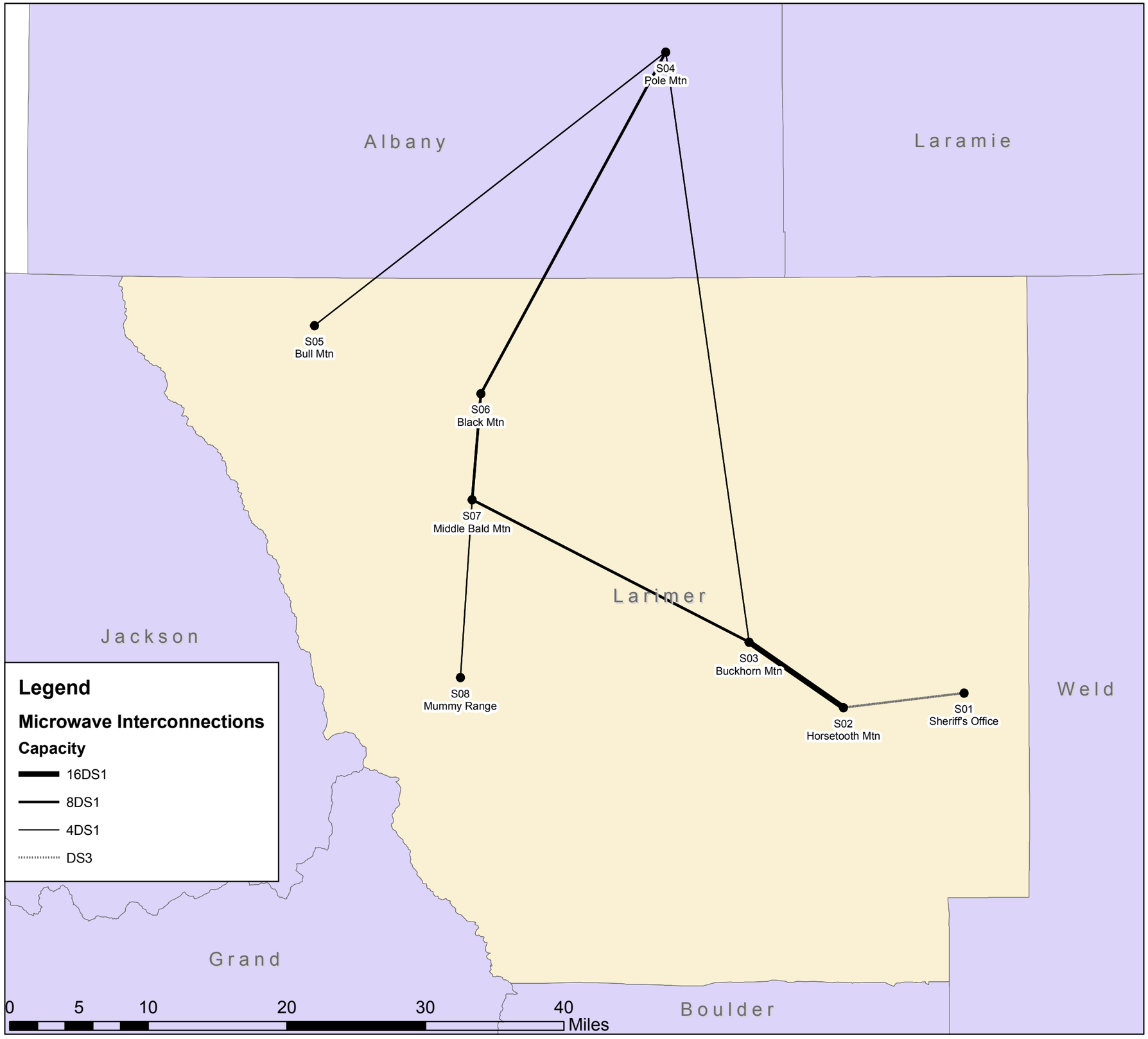

Figure 6-12
Microwave System

Client
Larimer County, Colorado

Description
Microwave Interconnection Drawing

Commission No. 20079

Scale 1 inch equals 7.0 miles

Data Sources and Notes:

County Shapes provided from ESRI.

Microwave System design from Table 6-2

Projection Information
NAD 1983 StatePlane Colorado North
FIPS 0501 Feet
Projection: Lambert Conformal Conic

Design:	JDP - 22 November 2005
Drawn:	MJL - 28 November 2005
Checked:	MJL - 7 December 2005
Approved:	JDP - 7 December 2005

File Name:
M:\FILES\20079 Larimer Co\cadd \Figure 6-12_rev_1.pdf

Revised:
Revised DS3 connection symbol to better distinguish between types of connections.

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Figure 6-13
Sheriffs Office to Horsetooth Mountain

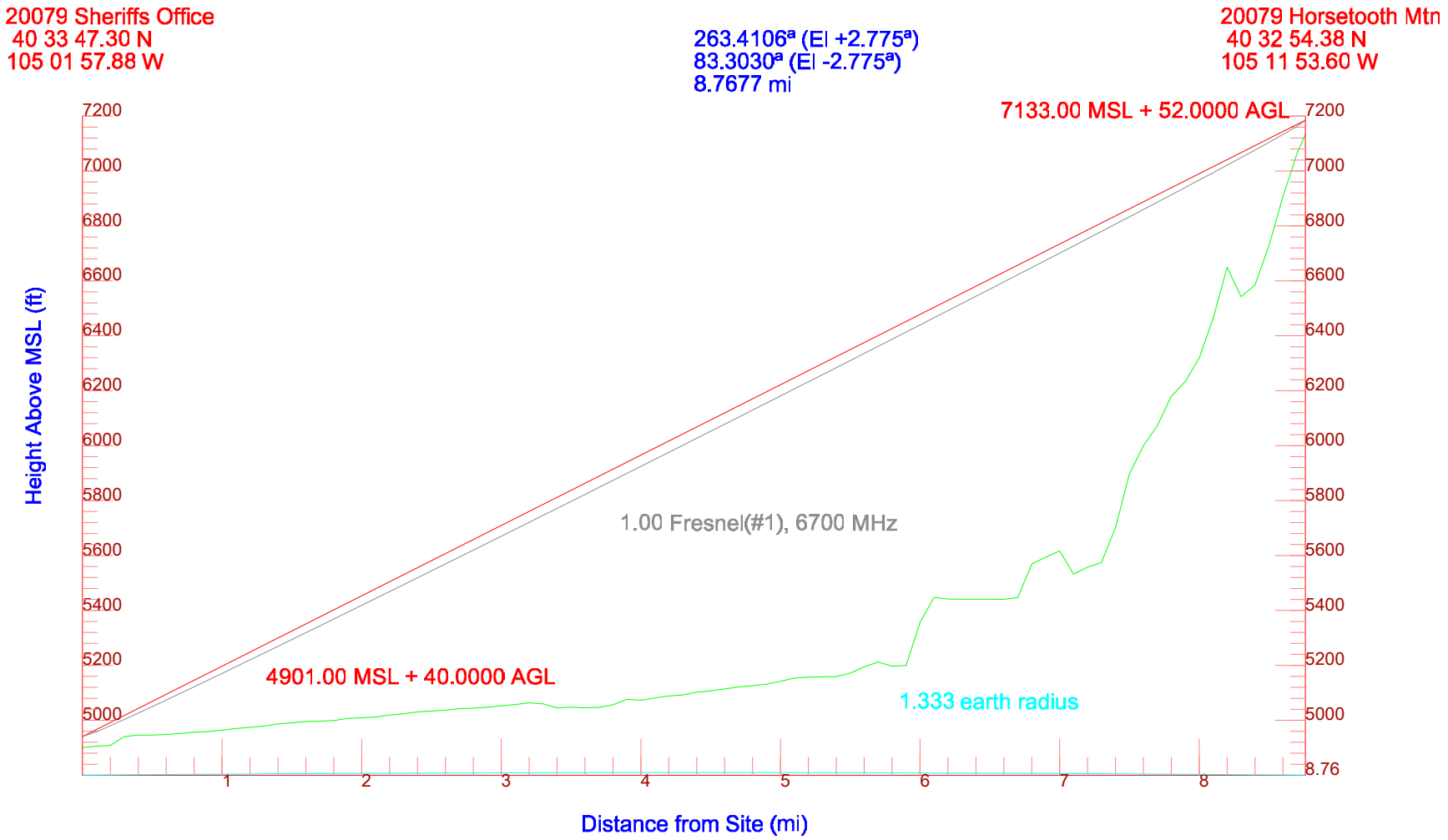


Figure 6-14
Buckhorn Mountain to Horsetooth Mountain

Figure 6-15
Pole Mountain to Buckhorn Mountain

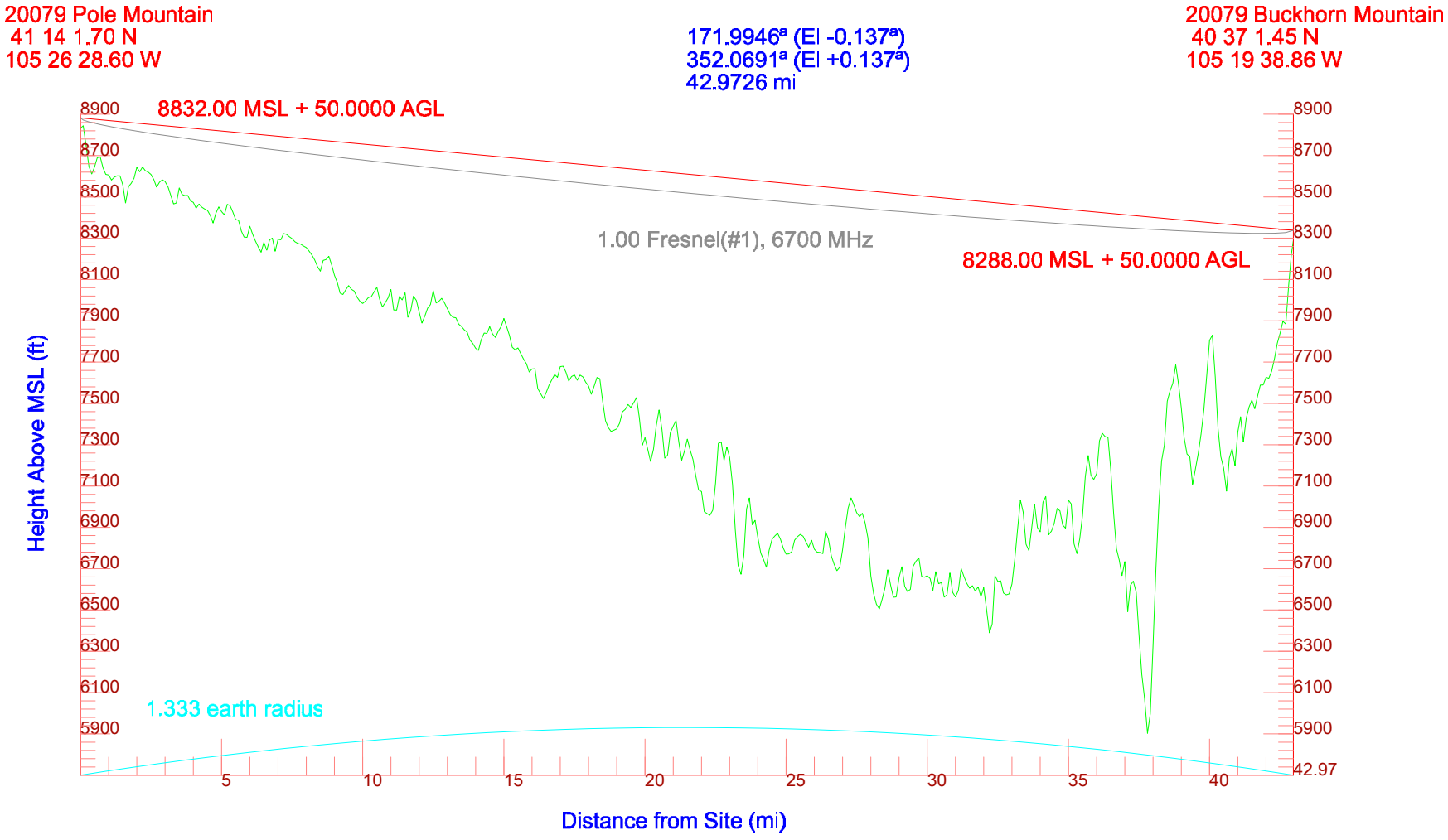


Figure 6-16
Pole Mountain to Bull Mountain

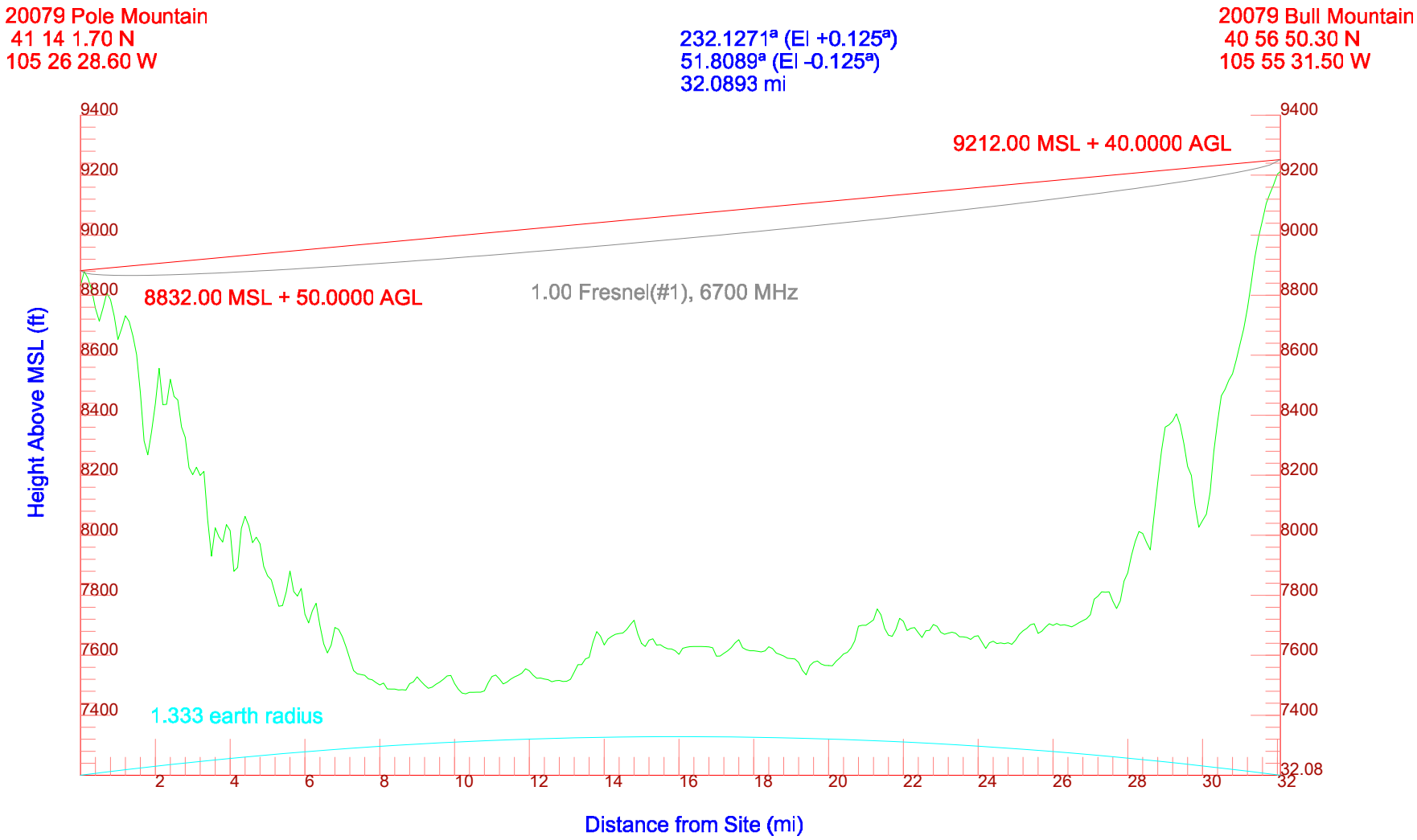


Figure 6-17
Pole Mountain to Black Mountain

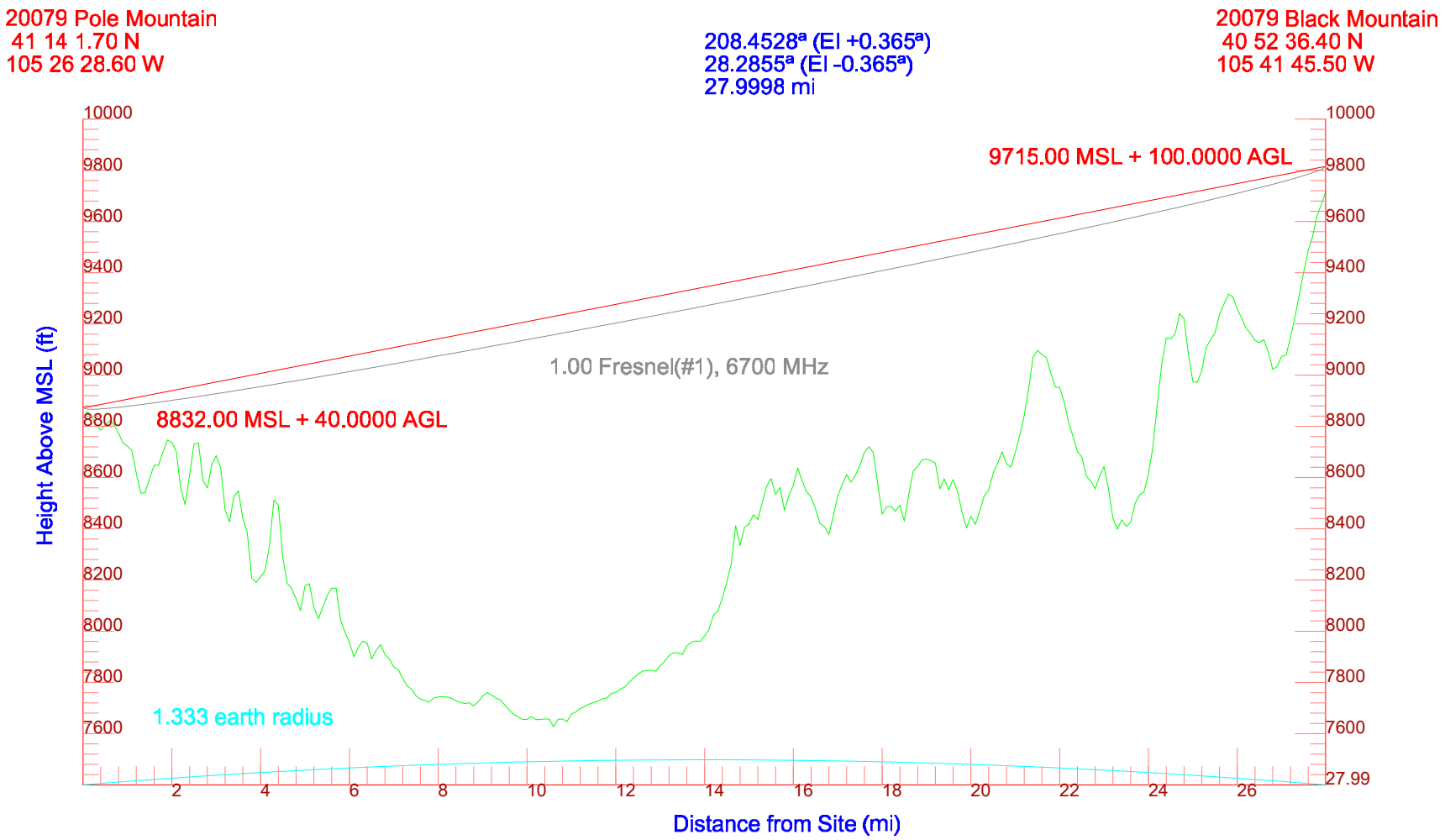


Figure 6-18
Middle Bald Mountain to Black Mountain

Figure 6-19
Middle Bald Mountain to Mummy Range

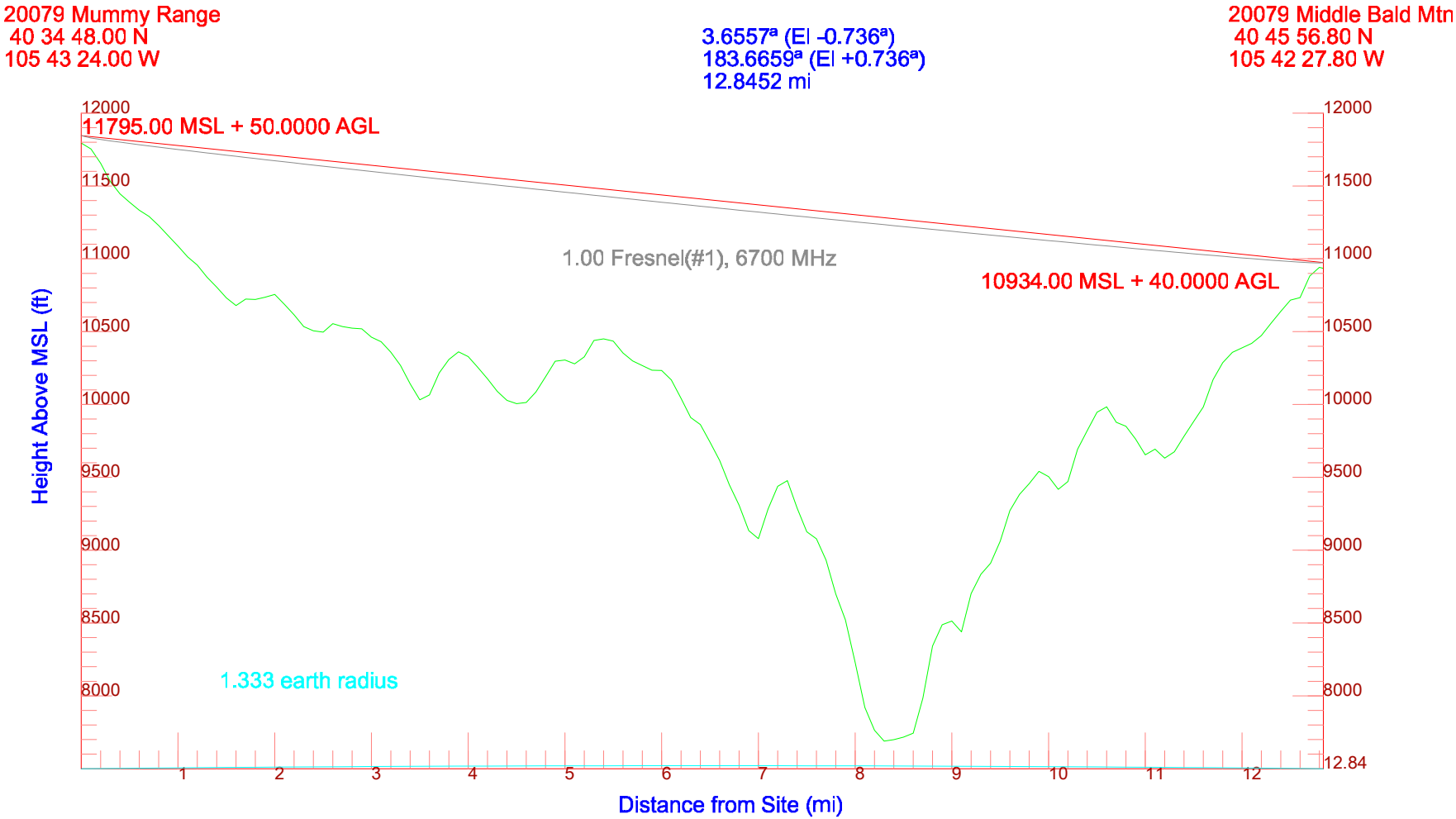
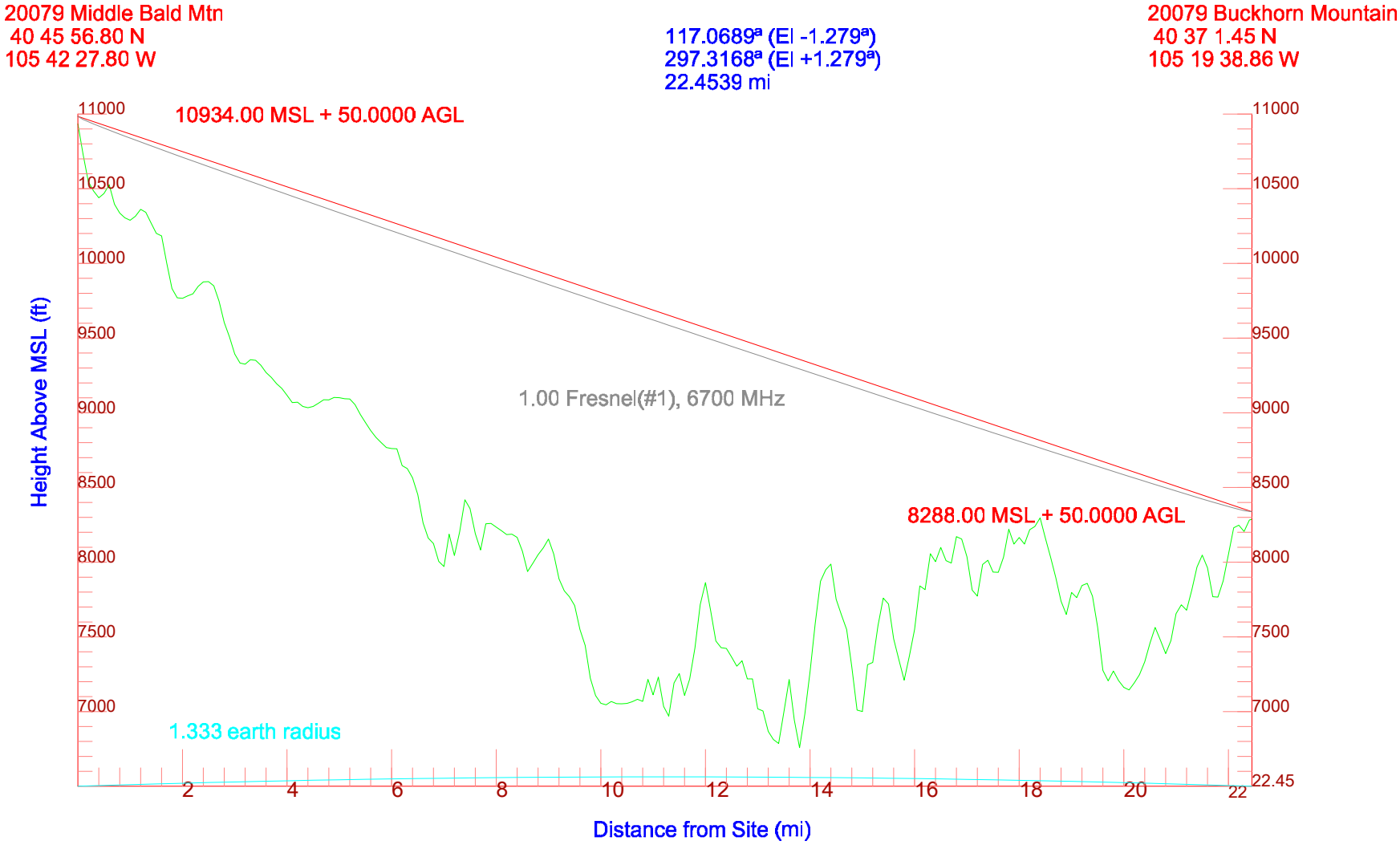


Figure 6-20
Middle Bald Mountain to Buckhorn Mountain



APPENDIX B INITIALIZATION MEETING, INTERVIEW RECORDS, AND SITE SURVEY RECORDS

INITIALIZATION MEETING

INTERVIEW RECORDS

SITE SURVEY RECORDS

INITIALIZATION MEETING RECORD

Meeting Date: June 6, 2005

Meeting Location: Larimer County Courthouse
200 West Oak Street
Fort Collins, CO 80522

Attendees: Representatives from (attendance sheets attached):

David Rowe – Technical Communications
LT Timothy B. Palmer – Sheriff's Office
Drew Davis – Road and Bridge
Jim Alderden - Sheriff's Office
William Nelson – Sheriff Operations Major
Janelle Henderson – Health Department, Environment Health Spec.
Robert H. Nielson – Larimer County Solid Waste
Mark Pfaffinger – IMS, technical Support Manager

CTA Communications:

Cheryl Giggetts (Project Manager)
David Pociluyko (Project Engineer)
Jonathan Farrar (Communications Specialist)

1. The meeting was convened at 9:00 a.m. on Monday, June 6th. Mr. David Rowe opened the meeting with welcoming remarks and introduced the project and the CTA team.

2. Cheryl Giggetts and David Pociluyko discussed the goals of the Larimer County radio communications project.

The following items were discussed:

- CTA will be looking at what the County needs for a new radio system. This will start with existing radio site surveys, PSAP observations and individual interviews.

The interviews will address the current situation, current problems and future requirements. After the interviews are completed, we will provide interview records to the County for review. Once the County provides back their comments, CTA will finalize the interview record.

- A Radio Usage Survey form was provided to the County to be distributed to the different agencies. This form will also be provided during the interviews. The survey will help CTA determine the initial number of radios in each agency, the estimated growth rate for 5, 10 and 15 years, and problems experienced in the radio system. The information provided will help CTA design a radio system that will not be over grown in 15 years. This includes the number channels required to prevent channel overcrowding.

- A problem assessment table was provided for the County agencies to fill out. Each agency has different problems and needs. The table is provided with a list of problems that each agency will rank using a scale from 0 – 5 (0 not a problem, 5 being the worst case). CTA will review the list of problems from the different agencies and will come up with options that will help alleviate the problem.

- CTA will perform an existing coverage analysis of your current radio system. The site surveys will provide the data needed for the coverage analysis. We will provide this analysis as a deliverable to the County. CTA will also use this analysis to determine where new sites need to be placed for providing 95% coverage throughout the County.

- CTA will identify several design alternatives. We will look at both the design and cost to help the County make a decision on the right solution. Advantages, disadvantages, and costs of each solution will be used in formulating our recommendations.

- The project schedule provided tells every step that we will take in order to get to the final design and recommendations. The next opportunity on the schedule is the Cost Benefit Meeting. This will occur around the mid August time frame. We will discuss the options, cost and trade offs during this meeting. The County may make changes at this time based on the options presented.

- We will provide a draft report to the County after the Cost Benefit Meeting. The County will have five (5) days to review and get comments back to CTA.

- After the final report is delivered, CTA will present the final design to the County during the Executive Presentation Meeting.

3. The following items were discussed by all participants:

- The engineering analysis conducted in the study will determine the following:
  - The type of system that CTA will recommend
  - Potential options
  - Number of sites and channels
  - Number of radios
  - Interoperability methodology
  - Microwave design
  - CTA will find out where the existing sites are located and will look at site reuse

- For mobile data, CTA will look at both fiber and microwave technology to accommodate both voice and data.

- CTA does not have a vendor preference. The system design will be based on functionality and County requirements.

- County Vision and Goals:

- Modern up-to-date radio system
- Move forward – been waiting since the early 90s for a radio system
- Have not received any clear path from consultants
- No business case
- Need to motivate Forest Service to approve site development
  - The County does not have a good relationship with local managers
  - The Sheriff's Office does have a good relationship
  - Focus is on fire mitigation
  - NEPA Study – no personnel to review studies

- Forest Service is happy with their coverage. They own three (3) sites. Larimer County uses two (2) of their sites.

- Proposal has been accepted for the County to build two (2) additional sites.

- Key areas that don't have coverage have not been improved in 20 years.
- Need one system that meets the County's needs instead of multiple systems.
- Interoperability is difficult. Don't use patching that much. ACU-1000 was used with the Fort Collins 800 MHz system and crashed their system.
- The Health Department is funded by a grant to buy eight (8) 800 MHz radios. Still waiting for a recommendation for what to buy.
- The volunteer fire department is poorly funded. They are buying low budget radios. Some departments have tactical frequencies of their own. The Sheriff's Office provides dispatch service for the fire departments. Boulder County and Estes Park also provide dispatch services for some of the County fire departments.
- Colorado has run out of 800 MHz frequencies. Planning is now based on dual band sites using 700 MHz.
- The 800 MHz rebanding is in Wave 4. Rebanding will probably not provide any new 800 MHz frequencies.
- Using 6 GHz microwave on all but one site. One site uses 2 GHz.
- The voting system is old and needs to be upgraded.
- The Dead Man Mountain Site uses solar power. All other sites have backup power but no UPS.
- Aging base stations are failing which is a common problem. Base station models are GE MASTR II and Motorola MTR-2000.
- There is no mobile data service at this time. Technology of choice is either through Verizon or Motorola (802.11 Hot Site).
- Sheriff's Office cars are equipped with laptops without a RF solution. Laptops are used for field reports.

- The Sheriff's Office received a grant to rebuild their reporting system. Would like to use 802.11 Hot Site.

- The County CAD system is new. The CAD vendor is Tiburon.

- The County has a contract with RCC to look into the consolidation of PSAPs.

- There has been a wait and see approach to technology in the County.

This record was prepared by:

CTA Communications, Inc.

Signature on File

Joseph D. Pociluyko
Project Engineer

Enclosure: Sign In Sheets
cc: Cheryl S. Giggetts

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CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Larimer County Detention**
File Name:	**Larimer County Detention Interview Record.doc**
Date of Interview:	**June 8, 2005**
Location of Interview:	**Larimer County Courthouse** **200 West Oak Street** **Fort Collins, CO 80522**
Persons Interviewed:	**Major Justin Smith** **LT James Wacker** **Brandon Ohrns – Detention Service Manager** **LT Pat McCosh**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

<u>Organization and Responsibilities</u>

1. The Detention Center is responsible for the transportation and housing of prisoners.

<u>Present Situation</u>

1. Prisoners are transported to a central location in Denver most of the time. Long distance transport of prisoners is not done very often. Main areas of operation that require the use of radios are the Justice Center, the Detention Center and the immediate area between the two (2) centers. Portable radios are used on all floors within the centers. Pagers are also used by many Detention personnel. Other communications include access to Fort Collins and detention transportation units. Cell phones are considered the best method of communications.

2. There are two (2) channels that are used inside of the centers. One is a repeated channel and the other a simplex channel. The simplex channel can reach from one end of the building to half of the other side of the building. A bi-directional amplifier system is used inside of the centers to provide in-building coverage.

3. The portable radios used in the detention centers are equipped with a Unit ID (unique feature for Detention) and an Emergency Button feature. The Unit ID helps identify the radio user, gives the radio administrator the ability to turn off a radio if it gets stolen by a prisoner, and allows the administrator to check if a radio is turned on or off.

4. The location of an assignment determines what type of radio is used. A total of one hundred and ten radios are used between the Justice Center and the Detention Center. The deputies use about 65 of these radios and civilians use about 45 radios of these radios. Additionally, there are about 10 more transportation units with radios that have Detention Center and Patrol channels. There is a fleet of eight (8) ASU buses. These buses have the same radio needs as Patrol. The ASU is stocked primarily with cell phones and about 5 radios.

5. Interoperability is required between Fort Collins PD, fire and medical. The Justice Center has 800 MHz portables to contact Fort Collins.

6. Growth in the next ten years:

- Grow from 550 beds to 800+ beds
- Build out another 1000 bed site
- Communication needs will change

<u>Present Problems</u>

1. There is a problem with inhibiting a radio if a prisoner gets a hold of one.

2. There is no ability to communicate with radios between the Justice Center and Detention Center. Phones are used instead.

3. Patrol radios do not have the Unit ID feature and can overpower DC radios when patrol deputies call in on DC channels.

4. There is a problem with channel congestion during certain hours of the day. At any time, 50 people can be added to the Detention Center. At lunch time, there are so many functions going on at one time. The channel congestion can be overwhelming and may cause confusion. An emergency situation could also be a problem.

5. Emergency button activation on a portable silences all radio communications.

6. When the repeated DC channel is unavailable and the simplex DC channel must be used, there is a problem with communicating from one side of the Detention Center building to another side of the building.

Future Requirements

1. Need an extra channel to improve channel capacity.

2. Need the ability to communicate with the State 800 MHz system.

3. Require 30 more deputies on staff.

4. It would be helpful to have the Automatic Vehicle Location (AVL) feature available on all Transportation vehicles.

5. Encryption may be feature that will be needed.

6. GPS feature for tracking personnel.

7. Ability to communicate between the Justice Center and Detention Center.

8. Improve BDA system for in-building coverage.

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. Corrected draft was returned to CTA Communications on June 29, 2005.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Detention - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Estes Park Police Department PSAP**
File Name:	**Estes Park PD - INTRVW.doc**
Date of Interview:	**June 9, 2005**
Location of Interview:	**Estes Park Police Department** **170 MacGregor Ave.** **Estes Park, CO 80517**
Persons Interviewed:	**Cherie Bartram – Support Services Manager** **Bruce G. Walters – Communications Supervisor**
CTA Interviewer:	**David Pociluyko** **Jon Farrar**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. Provide dispatch services for the Estes Park Police Department, Larimer County Sheriff's Office, Rocky Mountain National Park rangers, local fire departments, and utilities.

Present Situation

1. The following radio systems are deployed on Prospect Mountain site for coverage in Estes Park:

   - Fire Department – Two (2) licensed channels
   - Ambulance Service - Two (2) licensed channels
   - Police Department – One (1) Repeated and one (1) tactical channel

2. The ambulance service and fire department are dispatched to the Rocky Mountain National Park when required. Dispatch services are provided to Estes Park Utilities and the Rocky Mountain National Park rangers after hours. Also dispatch for Larimer County Sheriff's office and Glen Haven Fire Department since the County does not have radio coverage in the Estes Park area.

3. Estes Park PD currently has eight (8) vehicles. The radio inventory includes 10 mobiles, 15 portables, 16 auxiliary portables, one (1) desktop console, three (3) dispatch desktops, and eight Sheriff's Office radios.

4. Metro Call paging service is used for police, fire and power utilities.

5. The Estes Park PD has mobile data capability (802.11B) through a private wireless service (Anywhere Network Solutions).

Present Problems

1. No radio unit ID or emergency button enabled on radios.

2. Private mobile data network only provides coverage in 40% of the area.

3. Cost is a concern for a new radio system.

4. Problem coverage areas include Pinewood Springs, Star Mountain and the Blue Mountain area.

Future Requirements

1. Looking to join the combined communication center with the County.

2. Mobile data capability with improved coverage.

3. Improve problem coverage

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. There were no corrections returned to CTA Communications.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Estes Park PD - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Fairgrounds and Events Center**
File Name:	**Fairgrounds & Events - INTRVW.doc**
Date of Interview:	**June 8, 2005**
Location of Interview:	**Larimer County Courthouse** **200 West Oak Street** **Fort Collins, CO 80522**
Persons Interviewed:	**Tim Palmer**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. Assigned as Director of Security and Traffic at the County Fairgrounds and Event Center. Responsible for hiring officers from Loveland PD, Estes Park PD, Windsor PD, and the Sheriff's Office for patrolling an event.

Present Situation

1. The County Fairgrounds and Event Center was opened approximately two (2) years ago. The compound consists of several major buildings to include an Events Center, Exhibition Building, Indoor Arena, Livestock Pavilion, and Outdoor Arena. Buildings are constructed with steal and concrete. The County Fairgrounds and Event Center is used for hockey games, concerts and family shows. The County contracted a private contractor to manage the construction of the facility (Global Spectrum).

Global Spectrum subcontracted a radio vendor (Call Com) to install a campus radio system for the center's radio communications. The radio system is a four (4) channel, Motorola, UHF trunked radio system. The system includes 100 portable radios and three (3) desktop radios. The system is not used on a 24 hour basis. Currently, the license for the four (4) UHF channels is owned by Call Com (non public safety band). The County recently applied for a license to obtain five (5) of their own UHF channels. In the near future, the County will swap licenses and return the four (4) channels back to Call Com.

2. Main radio system users are fulltime staff, maintenance personnel, management, and concessions.

3. There are no known system failures or problems. Radio coverage is well beyond the fairgrounds.

4. A bidirectional antenna system is installed to provide indoor coverage for VHF and 800 MHz.

5. The portable radios are Motorola 1250LS models. Each radio is programmed with 16 talkgroups used by law enforcement, EMS, fire, maintenance, operations, events staff, ticketing & box office, building management, concessions and security. All of these users have their own talkgroup. All talkgroups have the same priority. Officers on duty are all given a campus radio. This is the only radio they carry. During an event, ushers can switch to the police talkgroup and request for help if an incident is occurring. A VHF desktop radio is also resident in order to talk to dispatch and the Sheriff's Office.

6. The growth of events and activities may require 200 active radios on the system at one time. An additional 30 radios have already been rented.

Present Problems

1. Have not experienced any emergencies that would require bringing in help from fire and police. The concern is that an emergency plan has not been tested using the campus radio system.

2. There is no cross connection between the campus radio system and the County radio system. Do not have the capability to talk to the County dispatch or other radio systems using the campus system.

3. The design of the radio system did not consider the needs of all other agencies on campus. The system experiences busy signals during major events.

4. Not enough officers from the Sheriff's Office participate in patrolling an event.

5. Call Com (Vendor responsible radio system installation) owns the current FCC license. They are also still holding the password for the campus system transmitters.

Future Requirements

1. Direct connection from dispatch to the campus radio system. This includes a direct patch to the Sheriff's Office radio system.

2. Prioritize talkgroups.

3. Add a fifth channel to increase system capacity.

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. There were no corrections returned to CTA Communications.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Fairgrounds & Events - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Larimer County Department of Health and Environment**
File Name:	**Health Department - INTRVW.doc**
Date of Interview:	**June 7, 2005**
Location of Interview:	**Larimer County Sheriff's Office** **2405 Midpoint Dr.** **Fort Collins, CO 80525**
Persons Interviewed:	**Adrienne LeBailly, MD – Director** **Janelle Henderson – Environmental Health Specialist**
CTA Interviewer:	**Cheryl Giggetts** **David Pociluyko**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. The Larimer County Department of Health and Environment consists of a Community Health Division and Environmental Health Division. Major areas of operation include Fort Collins, Loveland, and Estes Park.

   The Community Health Division oversees the following areas:

   - Clinical services
   - Communicable Disease Prevention and Control
   - Immunization Services
   - Family Planning
   - Nutrition Education and Supplementation for Women, Infants, Children
   - Children with Special Needs

The Environmental Health Division oversees the following areas:

- Restaurant Inspections
- School Inspections
- Camp Inspections
- Water Quality Program
- Emergency Response
  - Spills
  - Bioterrorism Threats
  - Floods
  - Plane Crashes
- Air Quality Program
- Solid Waste Program
- Environmental Planning
- Zoonotic Disease Monitoring

Present Situation

1. The County Health Department does not currently own any radios. Other local health departments and the Colorado Department of Public Health and Environment have recently implemented 800 MHz radios as their primary emergency radio communication system. In order to be interoperable with state and local health departments, funds from two (2) Emergency Preparedness Grants have been earmarked for the purchase of (8) portable radios. The State has issued clear guidance that these should be 800 MHz radios.

2. Radios will not be designated for day-to-day use or assigned to individuals. Radios will primarily be used during an emergency.

3. Currently using cell phones and alphanumeric pagers. Health Department personnel are contacted either by cell phone or pager. There are currently 24 pagers, 20 regular cell phones, and 24 PDA cell phones assigned.

4. Provide technical advice to emergency responses. One person is on call 24/7. During the day, the Health Department office receives a phone call from Sheriff's Dispatch. After hours, Sheriff's Dispatch sends out a page.

Present Problems

1. Information Management Services has not permitted the purchase of the grant-funded 800 MHz radios by the Health Department at this time. Radios purchased by the grant money need to be compatible with other health departments. The Health Department has already lost 25% of its radio grant funding because of this delay and the grants will expire in August of 2005. The radios must be ordered by the end of June, 2005, to receive them by August 31, otherwise the funds will be lost entirely.

Future Requirements

1. Need radios compatible with other local and state health departments. Radios also need to be programmed with the nine (9) public health talk groups and one Northeast Region mutual aid talk group, at a minimum.

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. Corrected draft was returned to CTA Communications on July 5, 2005.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Health Department - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Larimer County Landfill**
File Name:	**Larimer County Landfill Interview Record DRAFT.doc**
Date of Interview:	**June 8, 2005**
Location of Interview:	**Larimer County Courthouse** **200 West Oak Street** **Fort Collins, CO 80522**
Persons Interviewed:	**Robert H. Nielson**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. Assigned as Solid Waste Manager. Manage operations at the County Landfill. The County Landfill is setup to receive all refuse in Larimer County.

Present Situation

1. Communicate on a VHF radio system. The main transmitter is located at the County Courthouse. The radio system operates on the same frequency as Road and Bridge and Engineering and Fleet Services.

2. The Landfill radio inventory includes seven (7) mobile radios, six (6) portable radios, and three (3) base stations. There are two (2) gatehouses at the County Landfill equipped with base stations. The majority of communications take place at the Landfill compound. Channels 1 (Courthouse Base Station) and 2 (Simplex) are the main channels used.

Present Problems

1. Experience channel congestion from other agencies that share Channel 1. Attempt to talk over the congested channel.

2. There is no capability on the radio system to talk to police if an incident occurs.

3. There is a coverage problem at the Landfill compound when using the simplex Channel 2.

Future Requirements

1. Need a direct connection to the Sheriff's Office dispatch.

2. Need to have interoperability with Road and Bridge.

3. Require the radio system to allow segregation of talk channels.

4. Need the capability to talk to the Landfill compound from anywhere in the County.

Additional Comments

None.

The draft of this record was sent to David S. Rowe on June 24, 2005. There were no corrections returned to CTA Communications.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Landfill - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Larimer County Parks and Open Lands**
File Name:	**Parks & Open Lands - INTRVW.doc**
Date of Interview:	**June 8, 2005**
Location of Interview:	**Larimer County Courthouse** **200 West Oak Street** **Fort Collins, CO 80522**
Persons Interviewed:	**Dan Rieves – Manager** **Mark Caughlan - Manager**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. Manage the open space and outdoor recreational areas in Larimer County including Horsetooth Reservoir, Horsetooth Mountain Park, Carter Lake, Flatiron Reservoir, Pinewood Reservoir, Ramsay-Shockey Open Space, Devil's Backbone Open Space, Rimrock Open Space, Fossil Creek Reservoir Regional Open Space, and Soderberg Open Space. Operate as law enforcement arm of the county's Parks and Open Lands agency. The agency is divided into two (2) districts; Blue Mountain and Horsetooth. Seventy people use radios between the two (2) districts.

Present Situation

1. Majority of radio use is for the ranger program. Parks and Open Lands operate on two channels in the VHF band. One channel is repeated and the other is simplex. The agency is dispatched through the Sheriff's Office PSAP. The agency also has access to the Fire Net channel and three (3) Sheriff's Office channels.

2. The agency has 60 portables, 60 vehicles with mobiles and four (4) boats with mobiles. Radios are predominately used in the park areas. The Sheriff's Office channels are used during an emergency. The Parks and Open Lands channels are used 95% of the time. Nine channels are programmed on the radios. Other channels include Wildlife Division, weather and marine (scanned). Pagers are used with the Sheriff's Office VHF paging system. Cell phones are used for county business calls. Fixed base stations are used at the visitor centers.

3. The radio system repeater is used for communicating between districts. Radio coverage is pretty good.

4. Growth rate is expected to be 10% over the next five (5) years. The County may manage two (2) new reservoirs.

Present Problems

1. During the day on weekends, radio channel congestion is a problem.

2. Experience static and channel bleed over problems.

3. Lose Horstooth repeater twice a year.

4. Cell coverage is unreliable in the foot hills.

Future Requirements

1. Add more channels to reduce channel congestion.

2. Capability that allows communications with ambulance service.

3. Capability to send alphanumeric pages. This will help decrease radio traffic and cell phone time.

4. Mobile Data capability to reduce channel traffic.

5. Automatic Vehicle Location (AVL) capability.

6. Encryption would be useful.

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. Corrected draft was returned to CTA Communications on June 30, 2005.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Parks & Open Lands - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Larimer County Sheriff's Office Patrol**
File Name:	**Larimer County Patrol Interview Record DRAFT.doc**
Date of Interview:	**June 9, 2005**
Location of Interview:	**Larimer County Courthouse** **200 West Oak Street** **Fort Collins, CO 80522**
Persons Interviewed:	**Michael Brooks – Patrol Sergeant** **Earl Fawcett – Deputy Sheriff** **LT Andy Josey - Investigations**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

<u>Present Situation</u>

1. The County Patrol Supervisor maintains constant intercommunications between all entities within the County Sheriff's Office. Communications occur on the Sheriff's Office VHF radio system using Channel 1 (repeated), Channel 2 (repeated), and Channel 3 (data channel). Cell phones are also used only by the Patrol supervisors.

2. Investigations use radios infrequently. When radios are used, the car radio is used while driving and a portable radio during an investigation. Nextel is used for surveillance. Satellite phones are used where cell coverage is not available. There is no mobile data function equipment provided to personnel.

3. The Patrol Deputy performs police work, search and rescue, fire fighting, river rescue, and handling of hazardous materials (plane crashes in the mountains). Mode of travel includes horseback, snow cat, and on foot (using snow shoes).

   a. Currently using a Motorola SPECTRA, after turning in a faulty EF Johnson radio. The radio is capable of being programmed with 42 channels, 32 channels are currently programmed into the radio.

   b. Periodically have to communicate with Jackson County, Albany County, and Laramie County, WO. Use Wyoming mutual aid channels.

   c. Forest Service channel is used most of the time in the northern part of the County because of coverage problems.

   d. A satellite phone is used since cellular communications is non existent.

   e. For search and rescue at Cactus Hill, radio coverage is about 90%.

   f. The number of law enforcement radio calls is increasing because of the population and recreation growth in the mountainous areas.

Present Problems

1. County Sheriff's Office Patrol:

   a. The County Patrol experiences coverage dead spots in canyon areas (Route 34), Berthoud area, and County road 8 and 8E. Southern and Western areas have poor coverage.

   b. The County Patrol cannot use Sheriff's Office radios at the County Fairground and Events Center. Use of special trunked UHF radios is required.

   c. The Horsetooth area coverage is bad for tactical operations. Can see other Patrol Officers with radios from a distance but cannot communicate with them.

   d. Interoperability between other agencies is a problem. Cell phones are used as a backup.

   e. There is poor coverage in Justice Center.

2. Investigations:

   a. There is an inability to talk to local police. Cannot talk to other agencies during a pursuit.

   b. There is poor cell coverage in the mountainous areas.

3. Patrol Deputy:

   a. There is poor coverage in the mountainous areas. Cannot be contacted 92% of the time by radio. Can hear radio communications from dispatch but cannot communicate back to dispatch.

   b. EF Johnson Pack Set was turned in because it did not work properly in the field. Had the same problem with a Motorola SPECTRA. Scan rate has been a problem also – too slow. The programmer did not understand how to program in the radio set features.

   c. Radios are handed out with no training.

   d. Concerned that the delay caused by cross patching other radio systems can cause lives.

   e. Dispatch is not hearing radio communications from law enforcement in the Berthoud area.

Future Requirements

1. County Sheriff's Office Patrol:

   a. Need the capability to scan channels in Fort Collins and Loveland (both cities are on 800 MHz).

   b. Improve poor coverage areas.

   c. The green silo in Berthoud is a good place for a repeater.

2. Investigations:

   a. Combine PSAPs at Fort Collins, Loveland, Berthoud, and the Sheriff's Office into a central dispatch location (one hand doesn't know what the other hand is doing).

   b. Add more channels to reduce channel sharing.

   c. Need a radio that can easily be concealed.

   d. Mobile Data capability. Use PDAs with cellular capability instead of using a big bulky laptop.

   e. Encryption would be useful.

3. Patrol Deputy:

   a. Radios need to be user friendly. Standard training class should be provided to understand the radio feature set.

   b. Need AVL capability for locating patrolman. Dispatch does not have a clue where patrolman are located.

   c. Need quick access to all agency radio systems.

Additional Comments

None.

The draft of this record was sent to Dave Rowe on June 24, 2005. Corrected draft was returned to CTA Communications on June 29, 2005.

M:\FILES\20079 Larimer Co\interview\FINAL Interview Records\Patrol - INTRVW.doc

CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Road and Bridge Department**
File Name:	**Larimer County Road & Bridge Interview Record FINAL.doc**
Date of Interview:	**June 9, 2005**
Location of Interview:	**Larimer County Courthouse 200 West Oak Street Fort Collins, CO 80522**
Persons Interviewed:	**Drew Davis – Manager, Technical and Support Services**
CTA Interviewer:	**David Pociluyko**

The following points were conveyed to CTA during this interview:

Organization and Responsibilities

1. The Road and Bridge Department consists of 64 full time employees. Thirty additional personnel are added during the off time season (April 1 – October 30). The department is responsible for maintaining all County roads.

Present Situation

1. The Road and Bridge Department is currently in transition from VHF low band (43 MHz) to VHF high band. The low band VHF is shared with the Landfill Department. The VHF band became available after Fort Collins moved to 800 MHz. Four (4) frequencies are being used in this band; two (2) sets of repeater pairs are repeated and two (2) are simplex. A remote base is located at Cactus Hill and repeaters are located on Buckhorn and Dead Man Mountain.

2. Communication areas are countywide with exception of Rocky Mountain National Park. Road work is performed in all forest locations under a Forest Service contract arrangement.

3. The agency currently has 29 portables and 99 mobiles. Mobiles are installed in all vehicles and moving equipment. Senior managers are all assigned to a portable. Cell phones are used for private calls. The County paging system is used for receiving alphanumeric pages.

4. Work projects are organized by teams. At least one portable and a mobile are sent out with a team. Larger teams may include up to 17 trucks. A crew that grades a road will include a portable, pickup truck, water truck, and road grader (each vehicle includes a mobile).

5. The Cingular EDGE Network is used for mobile data needs (for receiving emails and transmitting files). The service is $80/month/unit. The network card for the laptop is $400.

6. Interoperate with the Sheriff's Office and with fire departments. Fire Net (154.385 MHz) is being programmed in all radios to contact Sheriff's Office dispatch or fire. Cell phones are mostly used for interoperability.

Present Problems

1. There are no present problems to report concerning the new radio system since the Road and Bridge Department has never operated on VHF high band.

2. Current low band coverage is spotty in the northeast.

3. There is no transmitter or receive site in the Estes Park area.

4. CB style chatter is heard on the low band channel from the Landfill site.

Future Requirements

1. Need radio coverage a quarter of a mile on each side of the road.

2. Need AVL system for agency accountability.

3. Would like to have three (3) simplex channels, three (3) working channels, and one (1) data channel for AVL.

4. It would be nice to have a corporate mobile data network.

5. Radio features:

- Unit ID – For identifying individual portables and vehicles with mobiles
- Emergency Button
- Channel Scan

6. Radio Talk Groups:

- North and South TG
- Management TG
- Hauling and Placing TG
- Two working channel TG

7. Being able to contact the Sheriff's Office dispatch is important.

8. Need a telephone interconnect through the radio system.

9. Spread Spectrum capability installed at satellite sites.

Additional Comments

None.

The draft of this record was sent to David S. Rowe on June 24, 2005. There were no corrections returned to CTA Communications.

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CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**Sheriff's Office Emergency Services**
File Name:	**Larimer County SO Emergency Services Interview Record FINAL.doc**
Date of Interview:	**June 6, 2005**
Location of Interview:	**Larimer County Sheriff's Office** **2405 Midpoint Dr.** **Fort Collins, CO 80525**
Persons Interviewed:	**Kevin Johnston** **William Nelson** **Don Griffith**
CTA Interviewer:	**Cheryl Giggetts** **David Pociluyko**

The following points were conveyed to CTA during this interview:

<u>Organization and Responsibilities</u>

1. Emergency Services consists of four (4) Sheriff's Office personnel. Responsibilities involve the suppression of wild land fires, search and rescue, water rescue and coordinating a posse. Operations include working heavily with the Volunteer Fire Department. Responsible for communicating with multiple agencies on multiple frequencies in the western part of the County (80% of the time spent in less populated areas). Areas of operation include camp sites, fishing areas, hunting areas and some skiing areas. The first of May through November is the prime time for emergency services.

Present Situation

1. Emergency Services consist of the following teams:

   - Dive Rescue Team - 40 members
   - Larimer County Search and Rescue (SAR) - 70 members
   - Larimer County Posse - 15 to 20 members

   Dive Rescue and SAR buy their own radios. The Country provides radios to the Posse. Twenty Pack Sets and twenty portables are available for distribution.

2. The Sheriff's Office radio system is a voter based system that operates on the VHF band. The primary radio site for operations is located at Buckhorn. Horse Tooth and Dead Man Mountain are two other radio site locations used for communications. Emergency Services use the following channels:

   - One (1) Fire Net channel
   - Three (3) Search and Rescue (SAR) channels
   - Three (3) FERN channels
   - One (1) Mountain Rescue channel
   - One (1) TAC 1 channel

   The SWAT Team also uses the TAC 1 channel and has multiple users. Emergency Services will determine which FERN channels are to be used in the field. A "Dive Call" will use the Fire Net channel. A "Fire Call" involves the coordination of a lot of agencies and radio frequencies.

3. Portable radios are used in the field and work pretty well except in some of the rough terrain areas. A bus is used as a command post and includes two (2) radios; an 800 MHz radio (communications with Fort Collins, Loveland and State frequencies) and UHF radio (communications with the Forest Service).

4. Emergency Services uses the Sheriff's Office VHF alphanumeric paging system. Users include EMS, Dive Team, SAR, Posse, and the Northern Volunteer Fire Departments.

5. Emergency Services works closely with the Volunteer Fire Departments in the northern and southern parts of the County and along Interstate 25.

Each Fire Department has approximately 6 portable radios and 6 mobile radios. A total of 120 fire pagers are also used with the paging system.

The Northern Fire Departments include the following:

- Rist Canyon
- Livermore
- Crystal Lake
- Red Feather Lakes
- Glacier View
- Poudre Canyon

The Southern Fire Departments include the following:

- Glen Haven
- Allens Park
- Big Elk
- Pinewood
- Big Thompson Canyon
- Estes Park

Fire Departments along the Interstate include the following:

- Wellington
- Poudre
- Loveland
- Berthoud

6. Interoperate with Rocky Mountain National Park Police and Forest Service Police.

7. There is no planned growth in Emergency Services. The Volunteer Fire Departments are experiencing a lack of growth and participation.

Present Problems

1. Radio channel congestion is experienced by Emergency Services. Thirty percent of the congestion would be resolved if proper radio discipline was used.

2. Cell phone coverage is not dependable.

3. Radio coverage in the extreme northern and southern parts of the County is poor. The alphanumeric paging system experiences the same coverage problems as the voice radio system.

4. Experience radio interference from Washington County (East) and Golden County (South). Also experience interference on the TAC 1 channel from Denver.

5. Voice dispatch cannot be made during an alphanumeric page transmission.

6. Received a lot of 800 MHz radios through Homeland Security Grant. The Sheriff's Office is only allowed to use mutual aid channels on their 800 MHz radios with Fort Collins and Loveland.

7. There is a problem with reliable dispatch service during busy hours.

8. The Dead Man Mountain site has experienced failures in the past. Calls can be affected on a cloudy day (primary power is solar power).

Future Requirements

1. Need a method for making phone calls in the mountainous areas (Satellite phones are currently used).

2. Need more channels to reduce congestion.

3. Need laptop capability in the field.

4. Need a new command post.

Additional Comments

None.

The draft of this record was sent to David S. Rowe on June 24, 2005. No corrections were returned to CTA Communications.

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CTA COMMUNICATIONS
FINAL INTERVIEW RECORD

Organization/Agency:	**County Patrol and Communications Manager**
File Name:	**Larimer County SO Lieutenant & Comm Mgr Interview Record FINAL.doc**
Date of Interview:	**June 7, 2005**
Location of Interview:	**Larimer County Sheriff's Office** **2405 Midpoint Dr.** **Fort Collins, CO 80525**
Persons Interviewed:	**LT Ken Elliot** **LT Robert Cook** **Diane Webber – Communications Manager**
CTA Interviewer:	**Cheryl Giggetts** **David Pociluyko**

The following points were conveyed to CTA during this interview:

<u>Organization and Responsibilities</u>

1. The County Patrol consists of four 4 Patrol Lieutenants, 40 Detectives and 14 SWAT Team Deputies. The County Patrol is responsible for patrolling 1/3 of the valley area (Berthoud to County line), I25 corridor, Red Feather area, and Estes Park. Also provide backup support in the mountainous areas.

2. The Larimer Communications Center is responsible for dispatch to the Sheriff's Office Patrol, Emergency Services, Search & Rescue, Dive Team, Volunteer Fire/Ambulance Teams, Air Life, State Patrol and State/County Parks.

Present Situation

1. The following assignments impact the Sheriff's Office VHF radio system:

   - Traffic Unit (5)
   - Wellington substation (4)
   - Estes Park substation (6)
   - School Resource Officer (1)
   - Reserve Unit (14)

2. The following channels are used by the Sheriff's Office:

   - Channel 1 – Data channel for checking license plates and background checks
   - Channel 2 – Dispatch Channel
   - Channel 3 – Checking warrants and dispatch additional information
   - TAC 1 – Used by SWAT Team and Emergency Services
   - Fire Net – Wild Land Fires

3. All patrolman use portable and mobile radios. The SWAT Team uses a head set communications system (Peltour Head Set System). All are provided with a car and a mobile radio. Mobile radios are not provided to the reserve units. 800 MHz scanners are used in supervisory vehicles to monitor radio traffic in Fort Collins and Loveland.

4. There are 8 dispatch positions located at the Sheriff's Office PSAP. There are 16 dispatch personnel assigned to the PSAP. Larimer County dispatchers handle all calls. Dispatch positions are not divided into separate fire and law enforcement positions. Area PSAPs are currently divided by fire districts instead of law enforcement districts. There is a countywide CAD system that includes Fort Collins. County and Fort Collins dispatchers can view each others call notes. Loveland is considering joining the County CAD network. The County currently has a contract with the Town of Wellington and Berthoud to provide dispatch services. Boulder County dispatches some of the fire groups in Larimer County.

5. Parks and Open Lands have the ability to switch over to the Sheriff's Office frequencies for interoperability. The use of cell phones is also used for interoperability.

6. The State Patrol uses a statewide 800 MHz radio system. They work all traffic accidents within Larimer County. State Patrol cars are equipped with VHF radios to talk directly to Larimer County. Larimer County provides dispatch services to the State Patrol since 800 MHz coverage is very poor in the County.

Present Problems

1. Reliable coverage is the biggest concern. In the mountainous areas, coverage is hit or miss. Estes Park dispatches for Larimer County due to poor coverage from the County radio system. This causes patrolman to switch back and forth between dispatchers.

2. Larimer County Sheriff's Office is short 21 Patrol Officers. Five were added last year.

3. There are so many different radio systems along the I25 corridor that are dispatched from different PSAPs. Multiple PSAPs are sometimes involved in incidents on the east side of I25.

4. Interoperability between other agencies outside of the County is a concern. Messages from different agencies are relayed through a dispatcher.

5. Valley Sergeants have 800 MHz radios but are only allowed to use the mutual aid channels (Fort Collins and Loveland will not allow use of talkgroups for interoperability). An ACU-1000 was installed for interoperability with the 800 MHz radio systems. Political figures do not allow its use with their radio systems because of the concern that their system will be loaded down.

6. Interoperability with Loveland ceased when they moved to 800 MHz. There is a 60 minute delay before Fort Collins and Loveland relays information to Larimer County dispatch concerning an incident.

7. There is a problem with getting approval from the Forest Service for new radio sites in the National Forest. NEPA Study approval is a long process through the Forest Service.

8. Have problems with congested channels during emergencies and increased call load during summertime.

9. Fire district coverage is useless in most county areas.

10. There is problem with missing calls on a channel when another channel is setup as a priority channel.

11. PSAPs are divided by fire districts rather than law enforcement districts. As a result, PSAPs are handling calls that are out of their jurisdiction.

12. Dispatch has difficulty in getting problems with the equipment resolved by the technicians. Radio technicians need so much detailed information when a problem occurs. The dispatchers don't have the time or the manpower to watch all of the screens in order to catch the problem. Unless the radio technicians are sitting at a radio screen in dispatch when the problem occurs, they have a difficult time trouble shooting it. Then they need to know which officers had the problems, were they on their portable radio or mobile radio, where were they at the time the problem occurred, were they near tall buildings, etc.

13. Dispatch has some patching capabilities to talk to Fort Collins PD, Loveland PD and other agencies. The political figures at those agencies will not allow Larimer County dispatch to utilize the patching capability.

Future Requirements

1. Need 25 additional reserve units.

2. Dispatch by law enforcement personnel would be beneficial.

3. Recommend the area be divided by law enforcement districts for dispatch rather than fire districts.

4. Need to be able to monitor 800 MHz radio traffic in Fort Collins and Loveland.

5. Need 95% coverage on I25 and all main roads in the mountainous areas.

6. Need the following radio features:

    - Encryption for the SWAT Team
    - Emergency Button
    - Radio ID
    - Automatic Vehicle Location (AVL) – CAD currently has this feature

7. Need additional channels to reduce channel congestion.

8. Need mobile data system for mug shots and silent dispatch capability.

Additional Comments

1. The County has huge officer safety issues that occur daily bringing frustration to both dispatchers and street officers. When dispatch attempts to communicate with Emergency Services personnel or any of the volunteer fire and ambulance departments, it's nearly impossible to reach them in some areas of the County. "When we have an emergency situation, we MUST have reliable radio coverage to adequately serve our crews and the public."

The draft of this record was sent to David S. Rowe on June 24, 2005. No comments were returned to CTA Communications.

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CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Buckhorn Mountain

Site Type: LMR / Microwave

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/07/2005

Name of Observer: Jonathan Farrar

File Name: OBHM06072005B.doc

Latitude: 40-37-01.5 North

Longitude: 105-19-38.9 West

Elevation 8,362 Feet (MSL)

The following observations were made at this site:

General Information:

- Site is located on top of Buckhorn Mountain.
- The access road to the tower off of the main road is unpaved.
- The main road leading to the site is difficult to travel during the winter months because of snow and ice.
- FCC Call Signs include: KRY907, WSW826, KJS781, and WNPU412.

Physical Description, Site:

Rating: ☐Great ☐Good ☒Average ☐Poor

- Site is co-located with other occupants.
- Several shelters and towers are located at this site.
- There is no fencing at this site.

Physical Description, Shelter:

Rating: ☐Great ☐Good ☒Average ☐Poor

- Concrete block shelter with a poured concrete floor.
- There are two (2) rooms inside this shelter with only one (1) entry into the shelter.
- Wooden A-framed roof.

Physical Description, Tower:

Rating: ☐Great ☐Good ☐Average ☒Poor

- Tower height is approximately 100 ft. (AGL)
- Self-supporting, galvanized steel tower
- Tower was due for replacement last year.

Tower Ground System: Tower grounding was not observed.

Radio Equipment:

The following radio equipment is installed at this site:

- Motorola MSR-2000 (100 W) base station for EMS-North Simplex
    - RG-8/U cable from the base station to Motorola cavity
    - 1/4” coax cable from cavity to a Polyphaser
    - 7/8” coax cable from polyphaser to antenna
- Motorola MTR-2000 (100 W) base station for LCSO 2 Transmit
    - RG-8A/U cable from the base station to a 1/2” LDF4-50A coax cable that has a polyphaser connected to it
    - 7/8” LDF5-50A coax cable from the polyphaser to the antenna
- Motorola MTR-2000 (100 W) base station for LCSO 4 (FIRENET) simplex channel
    - RG-8A/U cable from the base station to a 1/2” LDF4-50A coax cable that has a polyphaser connected to it
    - 7/8” LDF5-50A coax cable from the polyphaser to the antenna
- Motorola MTR-2000 base station for LCSO 2 Receive
    - RG-8A/U cable from the base station to a Telewave, Inc. tuned cavity
    - RG-8A/U cable from the tune cavity that connects to a polyphaser
    - 7/8” LDF5-50A coax cable from the polyphaser to the antenna
- Motorola MTR-2000 base station for LCSO 3 Receive
    - RG-8A/U cable from the base station to a Telewave, Inc. tuned cavity
    - RG-8A/U cable from the tune cavity that connects to a polyphaser
    - 7/8” LDF5-50A coax cable from the polyphaser to the antenna
- Motorola MTR-2000 (100 W) base station for Road & Bridge Transmit & Receive (VHF)
    - RG-8A/U cable from the base station to the duplexer
    - RG-8A/U cable from the duplexer that is connected to a polyphaser
    - 1/2” LDF4-50A coax cable from the polyphaser to the antenna
- MSR-5000 (100 W) base station for Paging
    - LMR 600 (1/2” diameter) coaxial cable from the base station that connects to a polyphaser
    - LMR 600 (1/2” diameter) coaxial cable from the polyphaser to the antenna

The following microwave equipment is installed at this site:

- Alcatel MDR-6000 6 GHz digital radio
    - Aligned site is Horsetooth Mtn.
    - FCC MW call sign is WPNB968

Channel Pairs:

LCSO 2	Tx: 155.1300 MHz Rx: 154.7100 MHz
LCSO 4	Tx: 154.3850 MHz Rx: 154.3850 MHz
LCSO 3	Rx: 155.5650 MHz
EMS-North	Tx: 155.3400 MHz Rx: 155.3400 MHz
Road & Bridge	Tx: 151.1075 MHz Rx: 155.0325 MHz
Paging	Tx: 159.1050 MHz

Power, Backup Power:

Electric Utility Provider is Poudre Valley Rural Electric Association

Generator:

- 20 kW Kohler Power Systems generator and one (1) 350 gallon LPG tank

Transfer Switch:

- Kohler Power System Automatic Transfer Switch (ATS)

Uninterruptible Power Supply (UPS):

- There are no UPS systems installed at this site.

DC Battery System:

- Two (2) Power Conversion Products TwinPack Plus redundant dc chargers.
    - 50 Amps, 120/210 Input Volts, -48 Output Volts
- One (1) Power Conversion Products SD2 System Status/Control Panel dc converter
- Three (3) year-old Absolyte GNB battery plant with five (5) stacks
    - 160 Amps/Hours

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☐Average ☒Poor

- At the time of this survey there was a #2 AWG unshielded, stranded halo ground system being installed. None of the fixed equipment was grounded to this system. The microwave radio was already grounded to another ground system that was in the shelter. Polyphaser coax protectors are used on the transmission cables and a surge suppressor is installed at this site.

HVAC Description:

- Mitsubishi Electric PK-24AG Mr. Slim wall mount unit.

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Cactus Hill

Site Type: LMR / Microwave

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/08/2005

Name of Observer: Jonathan Farrar

File Name: OCTH06072005A.doc

Latitude: 40-34-51.3 North

Longitude: 104-54-23.2 West

Elevation 5,210 Feet (MSL)

The following observations were made at this site:

General Information:

- Site is located west of Larimer County in Weld County.
- Site is located off of Highway 14
- Driveway to site is unpaved.
- Cactus Hill helps provide radio coverage for the east portion of the county

Physical Description, Site:

Rating: ☐Great ☐Good ☒Average ☐Poor

- Graveled lot.
- Three (3) towers (one (1) owned by FAA).
- Two (2) shelters (one (1) owned by FAA).
- Four (4') feet tall cattle fence located around the site with a double-swing gate at the entrance.

Physical Description, Shelter:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Concrete block shelter with a poured concrete floor.
- Limited space available for installation of new equipment.

Physical Description, Tower:

Rating: ☐Great ☒Good ☐Average ☐Poor

- There are a total of three (3) towers located at this site.
- The county is on two (2) towers – 40' and 20'

Tower Ground System: Tower grounding was not observed.

Radio Equipment:

The following radio equipment is installed at this site:

- Motorola MTR-2000 (100 W) base station for Road & Bridge
  - ¼" cable from the base station
  - ½" cable to the antenna
- Motorola MTR-2000 Auxiliary Receiver base station for LCSO 2
  - ¼" cable from the base station
  - ½" cable to the antenna
- Motorola MSR-2000 (250 W) base station for LCSO 2 Transmit
  - ¼" cable from the base station
  - ½" cable to the antenna
- Motorola MSR-5000 (100 W) base station for NLEC simplex channel
  - RG-214/U cable from the base station that connects to a tune cavity
  - RG-214/U cable from the tune cavity to the duplexer
  - ½" coax cable to the antenna
- GE MASTR II (100 W) base station for NLEC
  - RG-214/U cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.
- Motorola MSF-5000 (100 W) base station for LCSO4 channel
- FCC LMR Call Signs include: KJS781, KQZ831, WNPU412, WSW826, WPCI694, and KNIG839.

The following microwave equipment is installed at this site:

- LYNX sc.2 spread spectrum, 2.4 GHz Spread Spectrum radio
  - Aligned site is Deadmans Mtn.
- Alcatel MDR-4000e 6 GHz Licensed radio
  - Aligned site is Midpoint (Sheriffs Office)
- Alcatel MDR-4000e 6 GHz Licensed radio
  - Aligned site is Justice Center

- Puregas 550 Air Dryer dehydrator
- FCC MW Call Signs include: WNTV655, WHI504, and WNTJ866

Channel Pairs:

LCSO 2	Tx: 155.1300 MHz Rx: 154.7100 MHz
LCSO 3	Tx: 155.5650 MHz
LCSO 4	Tx: 154.3850 MHz Rx: 154.3850 MHz
NLEC	Tx: 155.4750 MHz Rx: 155.4750 MHz
EMS-North	Tx: 155.3400 MHz Rx: 155.3400 MHz
Road & Bridge	Tx: 155.0325 MHz Rx: 155.0325 MHz
Paging	Tx: 159.1050 MHz

Power, Backup Power:

Electric Utility Provider is Poudre River Electric Authority

Generator:

- 35 kW Cummins Power Generator located at this site with one (1) 145 gallon tank.

Transfer Switch:

- GE Zenith Controls

Uninterruptible Power Supply (UPS):

- There are not UPS systems installed at this site.

DC Battery System:

- Two (2) Power Conversion Products TwinPack Plus redundant dc chargers.
    - 50 Amps, 120/210 Input Volts, -48 Output Volts
- One (1) Power Conversion Products SD2 System Status/Control Panel dc converter
- Three (3) year-old Absolyte GNB battery plant with five (5) stacks
    - 160 Amps/Hours

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☐Average ☒Poor

- None of the County equipment is grounded.

HVAC Description:

- International Comfort Products PGAA30D1KS
    - 90000 BTUs
    - Located outside

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Deadmans Mountain

Site Type: LMR / Microwave

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/08/2005

Name of Observer: Jonathan Farrar

File Name: ODMM06082005B.doc

Latitude: 40-49-48.1 North

Longitude: 105-45-06.7 West

Elevation 10,800 Feet (MSL)

The following observations were made at this site:

General Information:

- Site is located on top of Deadmans Mountain
- Must have a tracked vehicle (i.e., Sno-cat) to gain access to the site between October and July.
- Road leading up the mountain is paved, but the access road leading to the mountain is unpaved.
- Deadmans Mountain helps provide radio coverage for the northwest portion of the county
- FCC Call Signs include: KNAK317, KNAI722, KNIG839, WNPU412, and WNSP896.

Physical Description, Site:

Rating: ☒Great ☐Good ☐Average ☐Poor

- Site is co-located with AT&T.
- A shelter and a fire tower are located at this site.

- Chain-link, barb wire fence is located around the fire tower.
- Site is solar powered because of its location.

Physical Description, Shelter:

Rating: ☒Great ☐Good ☐Average ☐Poor

- Concrete block shelter with a poured concrete floor.
- Shelter is broken up into two sections, one (1) side of the shelter houses all of the radio equipment and the other side houses all of the batteries for the site.
- On the radio equipment side of the building there is wood installation to protect it from the extreme cold weather conditions.

Physical Description, Tower:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Tower height is approximately 80 ft. (AGL)
- Steel frame fire tower with stairs.
- Volunteers use this fire tower during the summer months.

Tower Ground System: Tower grounding was not observed.

Radio Equipment:

The following radio equipment is installed at this site:

- GE MASTR II (100 W) base station for LCSO 2 transmit channel
  - RG-214/U cable from the base station that connects to a selective cavity filter.
  - RG-214/U cable from the selective cavity filter to a duplexer.
  - RG-214/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.
- GE MASTR II Auxiliary Receiver base station for LCSO 2 receive channel
  - RG-214/U cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to another RG-214/U cable.
  - RG-214/U cable that connects to a ½" LDF4-50A coax cable that connects to the antenna.
- GE MASTR II (100 W) base station for LCSO 4 (FIRENET) simplex channel
  - RG-214/U cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.
- GE MASTR II (100 W) base station for NLEC simplex channel
  - RG-214/U cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.
- Motorola MSR-2000 (100 W) base station for Paging
  - RG-214/U cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that

connects to the antenna.

- Motorola MSR-2000 (100 W) base station for EMS-North simplex channel
  - ¼" FSJ1-50A heliax cable from the base station that connects to a duplexer.
  - RG-214/U cable from the duplexer that connects to another RG-214/U cable.
  - RG-214/U cable connects to a ½" LDF4-50A coax cable that connects to the antenna.
- Motorola MTR-2000 (100 W) base station for Road & Bridge repeater channel
  - 10 AWG Ultralink jumper cable from the Motorola/Radio Frequency Systems duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.

The following microwave equipment is installed at this site:

- LYNX sc.2 spread spectrum, 2.4 GHz Spread Spectrum radio
  - Aligned site is Cactus Hill
  - 47 Mile Hop
  - Tx Freq: 2.410 GHz Rx Freq: 2.453 GHz
  - Tx Power: 29.3 dBm
  - Power Configuration: -48 vdc
  - Channel Capacity: 1 x T1
  - Channel Bank Manufacturer: Wescom

Channel Pairs:

LCSO 2	Tx: 155.1300 MHz Rx: 154.7100 MHz
LCSO 4	Tx: 154.3850 MHz Rx: 154.3850 MHz
NLEC	Tx: 155.4750 MHz Rx: 155.4750 MHz
EMS-North	Tx: 155.3400 MHz Rx: 155.3400 MHz
Road & Bridge	Tx: 151.1225 MHz Rx: 159.2025 MHz
Paging	Tx: 159.1050 MHz

Power, Backup Power:

Main Panel Electric Panel:

- There is no electric power provider for this site because of its location on the mountain. Power is provided via batteries and solar power.
- Electrical Panel Designation: A) Total Spaces: 24 B) # of Spaces Used: 7
- Power Rating: 125 Amps, 120/240 Volts

Generator:

- There is a mobile Honda generator that is used to provide power for the lights and heaters when persons are at the site. This generator isn't really used to provide any power to the radio equipment.

Transfer Switch:

- None

Uninterruptible Power Supply (UPS):

- There are no UPS systems installed at this site.

DC Battery System:

- Eight (8) year old battery system installed at this site that can last up to 40 no sun days.

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☐Average ☒Poor

- None of the County equipment is grounded.

HVAC Description:

- No cooling system put into place because of the site location.

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Horsetooth Mtn.

Site Type: LMR / Microwave

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/06/2005

Name of Observer: Jonathan Farrar

File Name: OHTM06062005A.doc

Latitude: 40-32-54.9 North

Longitude: 105-11-53.6 West

Elevation 7,177 Feet (MSL)

The following observations were made at this site:

General Information:

- Site is located west of the city of Fort Collins.
- The access road to the site is in need for improvements because it has been washed out numerous times. A 4-wheel drive vehicle is needed to gain access to the top of the mountain to the radio site.

Physical Description, Site:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Co-located site with NCRCN 800 MHz radio system.
- Several towers are located at this site.

- There is no fencing around the site; however, there is a gate at the beginning of the access road.
- Mountain bike riders and runners use the access road, therefore people go up and down this mountain all of the time for recreational purposes.

Physical Description, Shelter:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Concrete block shelter with a poured concrete floor.
- Limited space available for installation of new equipment.

Physical Description, Tower:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Galvanized steel tower.
- Three (3) legged self-supporting tower.
- Tower height is 80'
- There is a transmission line ladder mounted on the tower and climbing pegs.

Tower Ground System: There is a #4 AWG stranded, unshielded pigtail on each tower leg that terminates into the earth. It is not known what type of grounding system is buried underneath the site.

Radio Equipment:

The following radio equipment is installed at this site:

- Motorola MTR-2000 (100 W) repeater for LCSO 1
  - 10 AWG jumper cable from the repeater to the Motorola duplexer
  - ½" coax cable to the antenna
- Motorola MTR-2000 Auxiliary Receiver base station for LCSO 2
  - RG-6/U ultra flex cable from the dB Products dB4062 duplexer to the coax line.
  - ½" cable to the antenna
- Kenwood TKR-720/N/A (100 W) repeater for LCDTF
  - ½" coax cable from the Telewave TPCD-1554 duplexer to the antenna
- Motorola MTR-2000 Auxiliary Receiver base station for LCSO 3
  - RG-6/U cable from the base station that connects to the coax cable
  - ½" coax cable to the antenna
- Motorola MTR-2000 (100 W) base station for LCSO 2 Transmit
  - RG-6/U cable from the base station that connects to a duplexer.
  - RG-6/U cable from the duplexer that connects to a ½" LDF4-50A coax cable that connects to the antenna.

- Motorola MTR-2000 (100 W) base station for LCSO 4 Transmit
    - ½" heliax jumper cable from the duplexer to the coax lightning protector
    - ½" coax cable from the coax lightning protector to the antenna.
- Motorola MTR-2000 (100 W) base station for Paging
    - ½" heliax jumper cable from the duplexer to the coax lightning protector
    - ½" coax cable from the coax lightning protector to the antenna.

- FCC LMR Call Signs include: WPMY334, WPPG295, WPAJ312, WPAV871, and WPMY334

The following microwave equipment is installed at this site:
- Alcatel MDR-4000e 6 GHz Licensed radio
    - Aligned site is Midpoint (Sheriffs Office)
- Alcatel MDR-4000e 6 GHz Licensed radio
    - Aligned site is Justice Center
- Alcatel MDR-6000 6 GHz Licensed radio
    - Aligned site is Buckhorn Mtn.
- Puregas 550 Air Dryer dehydrator
- FCC MW Call Signs include: WPNB967 and WPNB968

Channel Pairs:

LCSO 1	Tx: 155.6700 MHz Rx: 159.1500 MHz
LCSO 2	Tx: 155.1300 MHz Rx: 154.7100 MHz
LCSO 3	Tx: 155.5650 MHz Rx: 155.5650 MHz
LCSO 4	Tx: 154.3850 MHz Rx: 154.3850 MHz
LCDTF	Tx: 159.4500 MHz Rx: 151.0100 MHz
Paging	Tx: 159.1050 MHz

Power, Backup Power:

Electric Utility Provider is Poudre Valley Rural Electric Association

Generator:
- 30 kW Onan generator located at this site with one (1) 350 gallon liquid propane tank.
    - Generator is located inside the shelter.

Transfer Switch:

- There is a Automatic Transfer Switch (ATS) located at this site.

Uninterruptible Power Supply (UPS):

- There are not UPS systems installed at this site.

DC Battery System:

- Two (2) Power Conversion Products TwinPack Plus redundant dc chargers.
    - 50 Amps, 120/210 Input Volts, -48 Output Volts
- One (1) Power Conversion Products SD2 System Status/Control Panel dc converter
- Three (3) year-old Absolyte GNB battery plant with five (5) stacks
    - 160 Amps/Hours

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☒Average ☐Poor

- There is a #10 AWG solid copper halo located near the floor of the shelter. The equipment racks are connected to the halo ground. There are Polyphaser coax protectors on the transmission coax lines.

HVAC Description:

- There are two (2) (redundant) HVAC units mounted on the outside of the shelter.

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Justice Center

Site Type: LMR Receive Only / Microwave

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/07/2005

Name of Observer: Jonathan Farrar

File Name: OJCR06072005D.doc

Latitude: 40-35-18.9 North

Longitude: 105-04-46.4 West

Elevation 5,174 Feet (MSL)

The following observations were made at this site:

General Information:
- Site is located in downtown Ft. Collins.
- Must have a security officer escort you to the penthouse of the building where the equipment is located.

Physical Description, Site:
Rating: ☐Great ☒Good ☐Average ☐Poor
- Equipment is located inside the Justice Center and the antennas are mounted on the roof and building.
- Building is approximately six (6) stories tall with only five (5) stories being used.

Physical Description, Shelter:
Rating: ☐Great ☐Good ☐Average ☐Poor
- Fixed equipment is located inside the building in the penthouse area.

Physical Description, Tower:

Rating: ☐Great ☐Good ☐Average ☐Poor

- There is no tower located at this site.
- LMR and Microwave antennas are mounted on the roof.

Tower Ground System:

N/A

Radio Equipment:

The following radio equipment is installed at this site:

- Motorola MTR-2000 base station for LCSO 2 Receive
    - Ultra link 10 AWG cable from the base station that is connected to the Telewave receiver distribution panel
    - Ultra link 10 AWG cable from the receiver distribution panel to a selective cavity filter (multicoupler).
    - RG-213/U cable from the multicoupler to a polyphaser.
    - RG-213/U cable from the polyphaser to the antenna.
- GE MASTR II Auxiliary Receiver base station for LCSO 3 Receive
    - RG-213/U cable from the base station that is connected to the Telewave receiver distribution panel
    - Ultra link 10 AWG cable from the receiver distribution panel to a selective cavity filter (multicoupler).
    - RG-213/U cable from the multicoupler to a polyphaser.
    - RG-213/U cable from the polyphaser to the antenna.
- GE MASTR II Auxiliary Receiver base station for LCSO 4 (FIRENET) Receive
    - Ultra link 10 AWG cable from the base station that is connected to the Telewave receiver distribution panel
    - Ultra link 10 AWG cable from the receiver distribution panel to a selective cavity filter (multicoupler).
    - RG-213/U cable from the multicoupler to a polyphaser.
    - RG-213/U cable from the polyphaser to the antenna.

The following microwave equipment is installed at this site:

- Alcatel MDR-6000 6 GHz digital radio
    - Aligned site is Horsetooth Mtn.
- Alcatel MDR-4000e 6 GHz digital radio
    - Aligned site is Cactus Hill.
- FCC MW call sign is WPRU948

Channel Pairs:

LCSO 2	Rx: 154.7100 MHz
LCSO 3	Rx: 155.5650 MHz
LCSO 4	Rx: 154.3850 MHz

Power, Backup Power:

Electric Utility Provider is Poudre Valley Rural Electric Association

Generator:

- Larimer County radio equipment is on the building generator system

Transfer Switch:

- See generator notes above.

Uninterruptible Power Supply (UPS):

- There are no UPS systems installed at this site.

DC Battery System:

- Two (2) Goodall redundant dc chargers.

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☐Average ☐Poor

- Not observed

HVAC Description:

- The penthouse HVAC system is part of the building HVAC system and was not observed.

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Prospect Mountain

Site Type: Paging

Site Address: -

Site Telephone Number: Unknown

Date of Observation: 06/09/2005

Name of Observer: Jonathan Farrar

File Name: OPPM06092005A.doc

Latitude: 40-21-37.0 North

Longitude: 105-31-13.1 West

Elevation 8,962 Feet (MSL)

The following observations were made at this site:

General Information:
- Unpaved access road leading to site.
- Several vendors are located on top of the mountain, and the mountain is privately owned.
- Larimer County has permission to be on this site at this point in time.
- FCC Call Sign includes: WNPU412.

Physical Description, Site:
Rating: ☐Great ☒Good ☐Average ☐Poor
- Site is co-located with other occupants.
- Several shelters and towers are located at this site.
- There is no fencing at this site.

Physical Description, Shelter:

Rating: ☐Great ☐Good ☒Average ☐Poor

- Aluminum shelter that was used by the Bureau of Recreation, and then donated to Estes Park and the County.

Physical Description, Tower:

Rating: ☐Great ☒Good ☐Average ☐Poor

- Tower height is approximately 40 ft. (AGL)
- Self-supporting, galvanized steel tower

Tower Ground System: Tower grounding was not observed.

Radio Equipment:

The following radio equipment is installed at this site:

- Motorola MSR-2000 (100 W) base station for Paging
    - RG-214/U cable from the base station to a polyphaser coax protector
    - 1/2" LDF4-50A coax cable from the coax protector to the antenna

Channel Pairs:

Paging Tx: 159.1050 MHz

Power, Backup Power:

Electric Utility Provider is Estes Park Light and Power Department

Generator:

- None

Transfer Switch:

- None

Uninterruptible Power Supply (UPS):

- None

DC Battery System:

- None

Grounding, Lightning Protection Description:

Rating: ☐Great ☐Good ☐Average ☒Poor

- None

HVAC Description:

- One wall mount unit.

CTA COMMUNICATIONS
SITE OBSERVATION RECORD

Name of Site: Sheriff's Office (Midpoint)

Site Type: LMR / Microwave / Dispatch

Site Address:

Site Telephone Number: Unknown

Date of Observation: 06/07/2005

Name of Observer: Jonathan Farrar

File Name: OSOE06072005B.doc

Latitude: 40-33-47.7 North

Longitude: 105-01-58.0 West

Elevation 4,900 Feet (MSL)

The following observations were made at this site:

General Information:

- Radio equipment is located on the second floor of the Sheriff's Office.
- Visitors must sign in and receive a badge in order to receive access to the inside of the building.
- The county jail is located next to the Sheriff's Office.
- Site is located in a suburban area and the roads are all paved.
- Dispatch, voter, control, and consolette equipment are located at this site.
- The County radio offices are located at the Sheriff's Office.

Physical Description, Tower:

Rating: ☒Great ☐Good ☐Average ☐Poor

- Tower height is approximately 20 ft. and is located on top of the roof of the building.
- The height above ground level is approximately 5,000 ft.
- Four (4) legged self-supporting tower.

Tower Ground System: Each tower leg has a #2/0 AWG stranded, unshielded wire (pig tail) that is clamped to the tower and exothermically welded to the #2/0 AWG ground ring for the tower located on the roof.

Radio Equipment:

The following radio equipment is installed at this site:

- Six (6) Raytheon / JPS Communications SNV-12 Voters
  - NLEC
  - LCSO 2 – In
  - LCSO 2 – Out
  - EMS-North
  - LCSO 3
  - LCSO 4
- One (1) JPS Communications ACU-1000 Interoperability device
- Eight (8) Motorola ASTRO XTL-5000 Digital Mobile Radios:
  - LCSO 1
  - Greeley Police
  - NCPSCA / Ft. Collins
  - U.S. Customs Aircraft
  - FBI
  - Weld Co. Sheriff
  - Loveland Police
  - DEA
- Two (2) Motorola ASTRO XTL-5000 Digital Consolettes:
  - Allows connectivity into the state 800 MHz Digital Trunked Radio System (DTRS)
    - DTRS 1
    - DTRS 2
- One (1) Motorola DeskTrac control station for LCSO 1 at Horsetooth Mtn.
- Eight (8) Central Electronics Bank (CEB) card cages with power supplies
- Motorola MTR-2000 (100 W) base station for LCSO TAC 1
  - ¼" Cablewave jumper cable.
- Motorola MTR-2000 (100 W) base station for LCSO 2 Transmit (back up)
  - ¼" Cablewave jumper cable.
- Two (2) Zetron Model 2200 paging terminals
- One (1) Zetron Series 2000 standby control unit
- Four (4) Zetron line transfer units
- One (1) black box modem

The following microwave equipment is installed at this site:

- Alcatel MDR-4000e, 6 GHz Licensed Microwave Radio
  - Aligned site is Cactus Hill

- Alcatel MDR-4000e, 6 GHz Licensed Microwave Radio
    - Aligned site is Horsetooth Mtn.
- RFS Cablewave Systems dehydrator
- One (1) Alcatel TSM-2500 Fault Monitoring System for the Microwave system (Alarm)
- FCC MW Call Signs include: WPNB967, WNTV655, and WHI504

Power, Backup Power:

Electric Utility Provider is Poudre Valley Rural Electric Association

Generator:

- There is a 180 kW generator located at this site for the building.

Transfer Switch:

Transfer switch was not observed because of its location in the building, but there is one used for the generator.

Uninterruptible Power Supply (UPS):

- No UPS system is used at this site on the radio equipment.

DC Battery System:

- Redundant SAFT NIFE – SMR 48/25M dc chargers are located in the equipment room.
    - 75 Amps, 190-265 Input Volts, -48 Output Volts
- SAFT NIFE 4131-68-40377 dc converter
- Four (4) batteries are connected in a series

Grounding, Lightning Protection Description:

Rating: ☐Great ☒Good ☐Average ☐Poor

- #2/0 AWG stranded, unshielded Halo ground located near the ceiling. The Halo ground is connected to the ground bus bar, and there is not a cut (break) in the Halo ring. Each rack is grounded with a #2 AWG shielded, stranded ground wire that connects to the ground bus bar. The MTR-2000 base stations are not grounded to the rack ground. The ASTRO consolette's and mobile radios are grounded to the rack ground via #6 AWG shielded, stranded ground wires. #2/0 AWG shielded, stranded ground wire that connects to the ground bus bar terminates underneath the floor.

HVAC Description:

- The building uses a Carrier HVAC system.

APPENDIX C PROBLEM ASSESSMENT RECORDS

Detention Center

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	2
B	Mobile to Mobile	4
C	Channel Crowding	4
D	Channel Congestion	
E	Not Portable Based	1.
F	Foreign Interference	0
G	Local Interference	2
H	Reliability	1
I	Lack of Interoperability	5
J	Capacity	1.
K	Cumbersone Operation	1.
L	Dispatcher Access	3 ?
M	Maintainability	5
N	Lack of Regional Interoperability	? yes
O	Lack of Ability to Support New Technologies	?

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Investigations

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	4
B	Mobile to Mobile	4
C	Channel Crowding	2
D	Channel Congestion	3
E	Not Portable Based	0
F	Foreign Interference	0
G	Local Interference	2
H	Reliability	3
I	Lack of Interoperability	5
J	Capacity	4
K	Cumbersone Operation	4
L	Dispatcher Access	0
M	Maintainability	3
N	Lack of Regional Interoperability	5
O	Lack of Ability to Support New Technologies	5

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Landfill

Robert Nielsen
June 8, 2005

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	Ø
B	Mobile to Mobile	2
C	Channel Crowding	4
D	Channel Congestion	4
E	Not Portable Based	2
F	Foreign Interference	1
G	Local Interference	2
H	Reliability	1
I	Lack of Interoperability	2
J	Capacity	2
K	Cumbersone Operation	Ø
L	Dispatcher Access	2
M	Maintainability	Ø
N	Lack of Regional Interoperability	2
O	Lack of Ability to Support New Technologies	Ø

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

: Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Parks + Open Lands 6/8/05

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	2
B	Mobile to Mobile	2
C	Channel Crowding	2
D	Channel Congestion	2
E	Not Portable Based	2
F	Foreign Interference	2
G	Local Interference	3
H	Reliability	2
I	Lack of Interoperability	1
J	Capacity	1
K	Cumbersone Operation	Ø
L	Dispatcher Access	Ø
M	Maintainability	1
N	Lack of Regional Interoperability	2
O	Lack of Ability to Support New Technologies	1

Buried T.V. Cables.

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Road & Bridge

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	4
B	Mobile to Mobile	3
C	Channel Crowding	~~0~~ 1
D	Channel Congestion	3
E	Not Portable Based	?
F	Foreign Interference	?
G	Local Interference	?
H	Reliability	?
I	Lack of Interoperability	?
J	Capacity	?
K	Cumbersone Operation	~~5~~ ?
L	Dispatcher Access	5
M	Maintainability	?
N	Lack of Regional Interoperability	0
O	Lack of Ability to Support New Technologies	?

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

LARIMER COUNTY, CO

Sheriff Patrol

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	1-2
B	Mobile to Mobile	0-1
C	Channel Crowding	2
D	Channel Congestion	3
E	Not Portable Based	0
F	Foreign Interference	0
G	Local Interference	3
H	Reliability	0
I	Lack of Interoperability	?
J	Capacity	3
K	Cumbersone Operation	0
L	Dispatcher Access	1
M	Maintainability	0
N	Lack of Regional Interoperability	?
O	Lack of Ability to Support New Technologies	?

The numerical rating of severity of the problem are defined as:

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2 : Occasionally a problem, affects some operations but is generally worked around.

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5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Sheriffs Office
Diane Webber

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating
A	Limited Coverage	5
B	Mobile to Mobile	4
C	Channel Crowding	2
D	Channel Congestion	2
E	Not Portable Based	5
F	Foreign Interference	2
G	Local Interference	5
H	Reliability	4
I	Lack of Interoperability	4
J	Capacity	2
K	Cumbersone Operation	0
L	Dispatcher Access	0
M	Maintainability	0
N	Lack of Regional Interoperability	4
O	Lack of Ability to Support New Technologies	?

The numerical rating of severity of the problem are defined as:

0 : No problem identified.

1 : Identified problem, currently not of concern. May become a concern in the future.

2 : Occasionally a problem, affects some operations but is generally worked around.

3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

4 : Frequently a problem, frequently affects operations, compromises the ability of the user to fulfill their mission.

5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

Tim Palmer June 8, 2005

LARIMER COUNTY, CO

Problem Assessment Table

	Problem	Rating	
A	Limited Coverage	0	
B	Mobile to Mobile	0	
C	Channel Crowding	4	Peak Events
D	Channel Congestion	4	
E	Not Portable Based	0	
F	Foreign Interference	0	
G	Local Interference	0	
H	Reliability	0	
I	Lack of Interoperability	5	
J	Capacity	5	
K	Cumbersone Operation	4	- Lack of Feature turned on
L	Dispatcher Access	5	
M	Maintainability	0	
N	Lack of Regional Interoperability	5	
O	Lack of Ability to Support New Technologies	0	

The numerical rating of severity of the problem are defined as:

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3 : Regularly a problem, operations are routinely affected to the extent there is a loss of operational efficiency.

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5 : Critical concern, usually affects operations, potential compromise to safety of user or of citizen.

APPENDIX D INDEPENDENT RANKING OF THE REQUIREMENTS

LARIMER COUNTY
RANKING OF ATTRIBUTES
COUNTY AGENCY: Health and Environment

	Attribute	Ranking
1	Coverage	4
2	Dispatch Operational Concept	0
3	Flexibility in Personnel Allocation	2
4	Survivability	4
5	Capacity	3
6	Mobile Data	0
7	Automatic Vehicle Location	0
8	Alphanumeric Paging	2
9	Future Expansion	3
10	Intercommunications	4
11	Interoperability	4
12	Interference Immunity	1
13	Power Backup	1
14	Maintainability	2
15	Reliability	4
16	System Operational Transparency	3
17	Console Features	0
18	Emergency Access	3
19	Initial Cost	3
20	No Internal Congestion	2
21	Long Term Cost	3
22	Encryption	1
23	Competitive Procurement Process	2
24	Operational Boundary Flexibility	3
25	Commonality of Equipment	2
26	Telephone Access	1
27	Monitoring	3
28	Training	3
29	Additional Non-Fixed Radio Features	2
30	Cost Effectiveness	2

Rankings:

0: Attribute is **not important** to the user.
1: Attribute is **minimally important** to the user.
2: Attribute is **nice to have**, could enhance operations.
3: Attribute is **useful**, will promote more efficient day to day operation.
4: Attribute is **quite important**, lack could result in degradation of mission, injury, or loss of property.
5: Attribute is **critical**; lack generally will result in injury, loss of property, or degradation of mission.

Instructions:

1. Rank each attribute by its importance to your agency's mission.
2. Use the scale described above.
3. Please return this form to:
   David Pociluyko
   CTA Communications
   P.O.Box 4579
   Lynchburg, VA 24502
4. If you have any questions, please call David Pociluyko at (434) 239-9200.

Wm Nelson
498-5105

LARIMER COUNTY
RANKING OF ATTRIBUTES
COUNTY AGENCY:

	Attribute	Ranking
1	Coverage	5
2	Dispatch Operational Concept	5
3	Flexibility in Personnel Allocation	4
4	Survivability	5
5	Capacity	4
6	Mobile Data	2
7	Automatic Vehicle Location	2
8	Alphanumeric Paging	5
9	Future Expansion	4
10	Intercommunications	5
11	Interoperability	5
12	Interference Immunity	4
13	Power Backup	5
14	Maintainability	5
15	Reliability	5
16	System Operational Transparency	5
17	Console Features	5
18	Emergency Access	5
19	Initial Cost	4
20	No Internal Congestion	5
21	Long Term Cost	4
22	Encryption	4
23	Competitive Procurement Process	4
24	Operational Boundary Flexibility	4
25	Commonality of Equipment	4
26	Telephone Access	2
27	Monitoring	4
28	Training	4
29	Additional Non-Fixed Radio Features	4
30	Cost Effectiveness	4

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4. If you have any questions, please call David Pociluyko at (434) 239-9200.

ATTN Rowe

LARIMER COUNTY
RANKING OF ATTRIBUTES
COUNTY AGENCY:

	Attribute	Ranking
1	Coverage	
2	Dispatch Operational Concept	
3	Flexibility in Personnel Allocation	
4	Survivability	
5	Capacity	
6	Mobile Data	
7	Automatic Vehicle Location	
8	Alphanumeric Paging	
9	Future Expansion	
10	Intercommunications	
11	Interoperability	
12	Interference Immunity	
13	Power Backup	
14	Maintainability	
15	Reliability	
16	System Operational Transparency	
17	Console Features	
18	Emergency Access	
19	Initial Cost	
20	No Internal Congestion	
21	Long Term Cost	
22	Encryption	
23	Competitive Procurement Process	
24	Operational Boundary Flexibility	
25	Commonality of Equipment	
26	Telephone Access	
27	Monitoring	
28	Training	
29	Additional Non-Fixed Radio Features	
30	Cost Effectiveness	

FROM: Blue Mt District Parks & OPGMO

Rankings:

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Instructions:

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   CTA Communications
   P.O.Box 4579
   Lynchburg, VA. 24502
4. If you have any questions, please call David Pociluyko at (434) 239-9200.

Mike Brooks, Patrol

LARIMER COUNTY
RANKING OF ATTRIBUTES
COUNTY AGENCY:

	Attribute	Ranking
1	Coverage	5
2	Dispatch Operational Concept	3
3	Flexibility in Personnel Allocation	3
4	Survivability	5
5	Capacity	5
6	Mobile Data	3
7	Automatic Vehicle Location	4
8	Alphanumeric Paging	5
9	Future Expansion	5
10	Intercommunications	4
11	Interoperability	4
12	Interference Immunity	4
13	Power Backup	5
14	Maintainability	5
15	Reliability	5
16	System Operational Transparency	3
17	Console Features	3
18	Emergency Access	4
19	Initial Cost	1
20	No Internal Congestion	3
21	Long Term Cost	1
22	Encryption	2
23	Competitive Procurement Process	0
24	Operational Boundary Flexibility	2
25	Commonality of Equipment	3
26	Telephone Access	2
27	Monitoring	3
28	Training	3
29	Additional Non-Fixed Radio Features	2
30	Cost Effectiveness	0

Rankings:

0: Attribute is **not important** to the user.
1: Attribute is **minimally important** to the user.
2: Attribute is **nice to have**, could enhance operations.
3: Attribute is **useful**, will promote more efficient day to day operation.
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5: Attribute is **critical**; lack generally will result in injury, loss of property, or degradation of mission.

Instructions:

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2. Use the scale described above.
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   CTA Communications
   P.O.Box 4579
   Lynchburg, VA 24502
4. If you have any questions, please call David Pociluyko at (434) 239-9200.

LARIMER COUNTY
RANKING OF ATTRIBUTES
COUNTY AGENCY: SHERIFF

	Attribute	Ranking
1	Coverage	5
2	Dispatch Operational Concept	3
3	Flexibility in Personnel Allocation	3
4	Survivability	5
5	Capacity	4
6	Mobile Data	3
7	Automatic Vehicle Location	1
8	Alphanumeric Paging	3
9	Future Expansion	4
10	Intercommunications	5
11	Interoperability	4
12	Interference Immunity	4
13	Power Backup	5
14	Maintainability	5
15	Reliability	5
16	System Operational Transparency	3
17	Console Features	5
18	Emergency Access	5
19	Initial Cost	2
20	No Internal Congestion	4
21	Long Term Cost	2
22	Encryption	3
23	Competitive Procurement Process	1
24	Operational Boundary Flexibility	4
25	Commonality of Equipment	3
26	Telephone Access	3
27	Monitoring	5
28	Training	4
29	Additional Non-Fixed Radio Features	4
30	Cost Effectiveness	2

Rankings:

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   CTA Communications
   P.O.Box 4579
   Lynchburg, VA 24502
4. If you have any questions, please call David Pociluyko at (434) 239-9200.

LARIMER COUNTY RANKING OF ATTRIBUTES
COUNTY AGENCY: SOLID WASTE

	Avg	Bob Turner	Steve Harem	Rocky Sanks	Total
1 Coverage	3	4	2	4	10
2 Dispatch Operational Concept	1	1	2	1	3
3 Flexibility in Personnel Allocation	2	3	1	3	5
4 Survivability	1	2	1	4	4
5 Capacity	3	4	3	4	8
6 Mobile Data	1	2	1	3	4
7 Automatic Vehicle Location	1	1	1	3	3
8 Alphanumeric Paging	1	1	2	3	4
9 Future Expansion	2	3	2	4	6
10 Intercommunications	2	4	2	4	7
11 Interoperability	1	1	0	2	2
12 Interference Immunity	3	3	3	5	8
13 Power Backup	2	2	2	4	5
14 Maintainability	2	3	2	4	6
15 Reliability	3	3	4	5	9
16 System Operational Transparency	2	3	3	3	7
17 Console Features	1	1	1	3	3
18 Emergency Access	1	1	1	4	3
19 Initial Cost	3	5	4	3	10
20 No Internal Congestion	3	4	3	5	9
21 Long Term Cost	3	5	4	3	10
22 Encryption	1	2	1	3	4
23 Competitive Procurement Process	3	5	2	3	8
24 Operational Boundary Flexibility	3	4	3	4	8
25 Commonality of Equipment	2	3	2	3	6
26 Telephone Access	1	1	2	3	4
27 Monitoring	2	3	3	3	7
28 Training	3	3	4	4	8
29 Additional Non-Fixed Radio Features	2	2	2	3	5
30 Cost Effectiveness	3	5	3	3	9

RA
COUNTY

	Attribute	Ranking
1	Coverage	5
2	Dispatch Operational Concept	5
3	Flexibility in Personnel Allocation	4
	Survivability	5
5	Capacity	4
	Mobile Data	3
7	Automatic Vehicle Location	3
8	Alphanumeric Paging	5
9	Future Expansion	4
10	Intercommunications	4
11	Interoperability	4
12	Interference Immunity	4
13	Power Backup	5
14	Maintainability	5
15	Reliability	5
16	System Operational Transparency	4
17	Console Features	5
18	Emergency Access	3
19	Initial Cost	3
20	No Internal Congestion	3
21	Long Term Cost	4
22	Encryption	3
23	Competitive Procurement Process	3
24	Operational Boundary Flexibility	3
25	Commonality of Equipment	3
26	Telephone Access	3
27	Monitoring	3
28	Training	5
29	Additional Non-Fixed Radio Features	5
30	Cost Effectiveness	4

Rankings:

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