East Bay Regional Communications System Authority (EBRCSA)

Recommendations Report

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1.0 Introduction

On September 11, 2007, the California counties of Alameda and Contra Costa came together to create a Joint Powers Authority (JPA) named the East Bay Regional Communications System Authority (EBRCSA). The JPA's mission is: "To own, build and operate a state-of-the-art P25 compliant communications system for the public agencies within Alameda and Contra Costa counties."

In order to accomplish this mission both counties have been working together to acquire grant funding from various sources and to date have secured approximately $33 million to begin the build out of a public safety radio communications system to meet their goals.

The fundamental design concept for the East Bay Regional Communications System (EBRCS) was documented by Motorola for Alameda County in a design document dated May 12, 2006. In this design concept, both Contra Costa County and Alameda County are to share an open, standards-based P25 network operating in the 800 MHz band. The system design was intended to support all public safety and local government users in both counties and provide superior interoperability throughout the region.

Based on the design document described above, EBRCSA began working with Motorola to build out the new system. Early in this process EBRCSA recognized that during implementation of a large public safety communications system, requirements for the new system will evolve and that P25 technology would also move forward. To address this changing environment, EBRCSA issued an RFP for consulting services, and as a result a contract was awarded to the Communications Technology team of AECOM, in July of 2008.

AECOM conducted a Needs Analysis of the communications requirements of the EBRCSA member agencies and issued a report to the EBRCSA Board of Directors on December 31, 2008. As a follow on phase, EBRCSA asked AECOM to analyze the original design and to provide recommendations on design changes, schedule and probable costs based on the information gathered during the needs analysis and project changes that have occurred since the December 31, 2008 report. An important goal of this phase is to create an opinion of probable cost for the proposed system, including cost to implement the complete system, as well as recurring costs associated with the system such as management, operations and maintenance.

This report will address five areas associated with the design and probable cost for EBRCS. To begin the process, Section 2 will review the design criteria used in the proposed P25 radio system and microwave designs. Information gathered in the Needs Analysis will be used to help identify any changes to the design criteria required to align them with EBRCSA's current needs. The accuracy of the design criteria is critical since it forms the foundation of efforts to specify, procure, and implement a Project 25 (P25) radio communications system that meets the needs of EBRCSA member agencies, public safety stakeholders and first responders.

Section 3 is a review of the radio traffic and radio coverage analyses provided by Motorola. These analyses were used to determine channel and antenna system requirements for each site in the original system design. As seen in Section 2, changes in the design criteria necessitate changes in the traffic and coverage design of the system. These changes are carefully examined and the results are used to estimate the number of radio channels required to support EBRCSA's member agencies now and into the future. AECOM's recommendations on the size of the wide-area radio communications system are based on an acceptable Grade of Service projected for the busiest hour of any week.

Based on the updated system capacity requirements, the Motorola coverage predictions, site surveys and other site data obtained from EBRCSA, Section 3 will also review the current Motorola coverage design. Changes in the design criteria also can drive changes in coverage design. AECOM's proposed changes to the coverage design in northwestern Alameda County will be examined in this section.

Section 4, New Conceptual System Design and Alternatives documents the new conceptual system design for the East Bay Regional Communications System (EBRCS). This section includes a discussion of the evolution of the system design based on the communications requirements of the thirty-three EBRCSA member agencies and changes in P25 radio technology. Traffic analysis, the frequency plan and coverage analysis of the Alameda Northwest simulcast cell are key technical elements of the updated design and are discussed in Section 4. In addition this section includes examination of two alternatives to the proposed design.

An important aspect of wide area radio system design is the communications backbone used to connect the radio sites together. Section 5 of this report reviews EBRCSA's current site connectivity plan that includes the current Harris Microwave system configuration and compares it to the requirements of the planned wide area P25 radio system. This review will be the basis of recommendations to enhance current planning for the new EBRCS connectivity network.

Physical facilities are the foundation of every radio system design. Section 6 of this report examines the current state of development for the sites proposed and being implemented for the EBRCS and makes recommendations regarding potential upgrades. Site upgrades can contribute significantly to the cost to complete a radio system project and information from this section is used in Section 8, Detailed Cost Analysis.

Section 7 addresses implementation planning and training. Development of a comprehensive migration plan for completion of the system is a key to the success of every radio in the eyes of the end user. This section presents a phased schedule for implementation of the EBRCS that takes into account both technical and financial considerations.

In the planning and implementation of a new radio system one question casts its shadow on all other considerations. That question is "what will this system cost?" Section 7, Detailed Cost Analysis addresses that all important question for the EBRCS. Based on AECOM's composite of actual costs experienced from recent procurements of similar systems, this section of the report provides an itemized opinion of probable system costing for the EBRCS. These itemized costs include life cycle and replacement cost estimates, recommendations on radio user subscriber fees and potential funding alternatives, specifically addressing the ongoing cost of system operations, maintenance and the planned replacement of equipment.

The final section of the report is Section 9, Conclusions and Recommendations. This section provides a summary of the conclusions and recommendations found throughout the report based on our research, analysis and discussions with Alameda and Contra Costa County representatives within EBRCSA.

We wish to thank everyone in both Alameda and Contra Costa Counties who contributed information and direction to this report for their cooperation and support. Everyone we encountered provided us with open access to personnel, facilities and information associated with the EBRCS project. We especially wish to express our thanks and appreciation to Bill McCammon and the EBRCSA committees that supported us for providing advance information, organizing meetings and efficiently responding to our needs in preparing this report. We think the future for the EBRCS is bright.

2.0 Design Criteria

The accuracy of the design criteria is critical since it forms the foundation of efforts to specify, procure, and implement a P25 radio communications system and infrastructure that meets the needs of East Bay Regional Public Safety stakeholders and first responders. It is important to review the design criteria at this point in the project since it has been a number of years since the original design was created and EBRCSA's communications needs and available technologies have changed. In this section we will review the original design criteria and resulting system concept presented by Motorola in 2006 and discuss associated considerations.

Overall it is our opinion that the original EBRCS conceptual system design was solid and did an excellent job meeting the requirements of the EBRCSA member agencies. EBRCSA and Motorola should be commended for creating a system design that will significantly improve communications and interoperability in the East Bay area in a cost effective manner for years to come.

The choice of standards based P25 technology allows EBRCSA to take advantage of the flexibility to cost effectively meet changing requirements provided by P25's open architecture. An excellent example of this flexibility is the ability to interconnect systems. Simulcast systems providing coverage for users in Alameda and Contra Costa Counties are connected while allowing other P25 systems in the San Francisco Bay area, regardless of manufacturer, to be interconnected. The use of 700 and 800 MHz frequencies in the design addresses a key problem in the implementation of many radio systems, namely availability of frequencies to build the system.

The following sections review the original design criteria with an objective to find further improvements to the original design.

2.1 EBRCSA Design Criteria

In the following sections, we will re-state the original Motorola response to the design criteria in the original Alameda County RFP as published in the *East Bay Regional Communications System - Two County Design Document* dated May 12, 2006 and follow it with a discussion of considerations associated with the response.

2.1.1 Coverage Enhancement

"The SmartZone system provides one seamless system for EBRCS agencies to use throughout the two Counties, removing the boundaries caused by the existing disparate systems. Additional coverage enhancements are provided through the addition of repeater sites throughout the Counties to address specific coverage concerns."

Motorola's response to this criterion is a good fit with EBRCSA's communications needs. However, to avoid misunderstandings by users as the system is operated over time, an understanding of how a land mobile radio (LMR) handles roaming (i.e. the handoff of a mobile or portable between simulcast cells and/or standalone sites) should be communicated to the users of the system.

The statement "The SmartZone system provides one seamless system for EBRCS agencies to use throughout the two Counties, removing the boundaries caused by the existing disparate systems" can cause misunderstandings in the user community. P25 systems, such as the SmartZone system proposed by Motorola, can provide continuous coverage over large areas that can improve interoperability between agencies using the system. However, this coverage is hardly "seamless" in all areas. As users move through certain areas served by the system, they can expect to see events that they would not consider "seamless".

Many users will have their expectations of roaming established by their experience with cell phones and roaming in radio systems is significantly different. Due to the small coverage footprint provided by individual cells and other factors in a cellular system, audio for a particular call is provided to all of the cells adjacent to

the active cell which allows a seamless handoff as the phone moves from one cell to the next. The larger coverage footprint provided by an individual simulcast cell or stand alone site in an LMR system combined with scarce frequency resources results makes it less acceptable to provide the audio at all of the adjacent sites. As a result handoffs in a radio system are not “seamless” in the same way as a cell system in all areas.

The most significant of these areas are the boundaries where the user moves from one simulcast cell (a group of sites operating as a simulcast system) or standalone trunking site to another. As the user moves through these areas it is possible to miss a small portion of an on-going conversation as the radio transitions from the original cell or site to the new cell or site. This is due to the fact that it takes the system a finite amount of time to establish the audio on the new cell or site. For talkgroup calls this often is mitigated by the fact that the call audio is already present on the new cell or site due to demand from other parties in the call. This issue is more frequently seen with special calls such as unit to unit calls and telephone interconnect. These types of calls often must be reinitiated after the user transitions to the new cell or site, which can be frustrating to the user.

An excellent way to address this issue is to make available to the end users coverage maps that indicate these “overlap” areas. AECOM recommends that EBRCSA request such maps from Motorola since they have already developed the data required to produce such maps.

2.1.2 Open Architecture Voice and Data Communications Solution

“Motorola will deliver a Public Safety Project 25 trunked voice and data communications system based on ANSI/TIA/EIAA-102 Phase 1 (Project 25) suite of standards.”

At the time of the original system design, this criterion response was appropriate for EBRCSA and reflected the defined and available P25 technology. Over the intervening years, P25 technology has evolved and grown. As a result, a reevaluation of the appropriate P25 technology is in order for EBRCSA.

P25 Phase 2 is a two-slot, 12.5-kHz TDMA solution with a 12.5-kHz Phase 1 control channel for backward compatibility with P25 Phase 1. Phase 2 doubles the traffic handling capacity of a single frequency pair. This increase in channel efficiency is very important in areas like the East Bay area were available frequencies are scarce. For this reason AECOM recommends that the EBRCS be upgraded and implemented as a P25 Phase 2 system.

In section 3 of this report we will reexamine the conceptual design for EBRCSA, starting with traffic analysis and ending with a new conceptual system design that better reflects EBRCSA’s current communications requirements. As part of this examination we will consider the impact of operating the system as a mixed P25 Phase 1 and Phase 2 system. Care was taken to account for both the P25 Phase 1 user equipment already purchased, based on this criterion, and the impact of operating these devices on the size and cost of the EBRCS.

2.1.3 Interoperability

“This project is based upon the Project 25 standard, which provides the greatest flexibility for interoperability for current and future agencies within the two counties. Additionally, this solution would allow interoperability with other Bay Area and State agencies. This design is based on all Public Safety agencies within both Counties joining the system.”

P25 is the standard for interoperability in the U.S and will clearly be the technology of choice for interoperability in the Bay area. This is demonstrated by the EBRCSA’s success in obtaining interoperability related grant funding for the project and the involvement of agencies from the entire San Francisco Bay area in the San Francisco Bay Area Regional Interoperable Communications System (BayRICS) program.

It should be noted that successful communications interoperability for Alameda and Contra Costa Counties will require more than the successful implementation of the EBRCS. If the users are not aware of interoperability

capabilities or do not have access to those capabilities, they will not make use of those capabilities when they are needed most. Interoperability is fundamentally about communicating between people in an agreeable way. This puts an emphasis on the establishment of memorandums of understanding (MOUs) between agencies and creation of standard operating procedures for agency to agency communications when working to improve interoperability. EBRCSA is in a strong position to encourage its member agencies to engage in the planning and training required to provide high quality communications interoperability in the East Bay area.

2.1.4 Radio Communications for all City and County agencies

"The EBRCS solution is tailored for the individual needs of each agency, delivering interoperability and economies through shared resources and information."

This criterion sets the bar very high and in some cases may exceed the capability of the available P25 technologies if some changes are not made in the core conceptual design for the EBRCS. During AECOM's analysis of traffic loading (included in section 3 of this report) for the EBRCS, it became clear that a sixth simulcast cell would be required to handle the required traffic capacity of the current thirty-three member agencies and other agencies that are assumed to be joining the JPA in the near future. This highlights the need to explore the capacity-increasing capabilities of P25 Phase 2.

EBRCSA and Motorola should be commended for the time and effort that has been dedicated to tailoring the solution to the needs of its member agencies. An example of the consideration of the individual needs of each agency is the review that has gone into coverage analysis. Numerous hours and meetings have been invested to make sure that critical areas for each member agency are covered in the evolved system coverage design.

2.1.5 Dispatch solution and cutover process for all EBRCS member agencies

"The EBRCS dispatch solution is tailored to meet the needs of each dispatch center that provides a cutover procedure. It provides either upgrades to CentraCom Gold Elite consoles or new MCC7500 dispatch consoles for each of the dispatch centers."

Motorola's response and installations to date demonstrate that the needs and cutover requirements of each dispatch center have been addressed. In Alameda County, thirty-one dispatch operator positions have received CentraCom Gold Elite upgrades so that they can function with the EBRCS. It should be noted that these upgraded operator positions are currently operating on the existing Alameda County radio system and cutover to the EBRCS has not been started. The IP system upgrade being planned for the EBRCS will impact the cutover plans for these operator positions and associated EBRCSA member agencies.

All other planned operator positions in Alameda and Contra Costa Counties will be implemented using IP-based, Motorola MCC 7500 consoles. Details on planned quantities are included in section 3 of this report. Cut over processes for these operator positions must be coordinated with the radio system cutover plans for each affected member agency.

3.0 Review of Motorola Design

In this section we will conduct a review of the radio coverage and radio traffic analyses provided by Motorola. These analyses were used to determine the site channel and antenna system requirements in the Motorola system design for the EBRCS. The results from these reviews have been incorporated in the new conceptual system design for the EBRCS which is documented in Section 4.0 of this report.

For readers familiar with the AECOM report on the Motorola design commissioned by Contra Costa County will note that the results are similar in this report. This is due to the fact that the majority of the findings in the Contra Costa specific report apply equally to Alameda County.

3.1 System Capacity

The capacity of a radio system to handle the volume of traffic is determined by the number of talk-paths, the number of talk-groups, the number of active users, and the characteristics of the calls (how frequently are calls made, the average length of the call, etc.).

Also affecting the traffic are the nature of special calls made on the system – individual-to-individual (private) calls, status updates, data calls, telephone calls, etc. In a multi-zone system, such as the one described by the Motorola EBRCS design document, the amount of roaming between zones and the percentage of calls that involve more than one zone (termed “wide area” calls) will also impact the capacity of the network.

When we reviewed the system capacity information in the Motorola design document, our first impression was that the projected system usage statistics were too low, resulting in a design that would be inadequate to handle the expected traffic load. This impression results from the assumption in the Motorola report that mobile radio counts can be disregarded assuming each mobile “user” also carries a portable and the assumption that 60% of portable radios will be active during the average busy hour. AECOM’s methodology is based on the number of radios in the inventory which provides a justifiable basis for traffic analysis and results in systems that meet the performance expectations of public safety users.

As we continued to review the system capacity information in the original report we also noted the call parameters used in the original report were significantly different than our standard recommendations for a P25 system. We understand that Motorola used actual traffic statistics from the Alameda County system manager in their analysis. However, our experience with clients operating P25 systems is that call durations and calls per hour per unit are higher when moving to a wide area, digital system from an analog system like the current Alameda County simulcast system.

The AECOM traffic model is different from the Motorola model (we use Erlang C, whereas Motorola states that they use a Monte Carlo model), and we admittedly use some conservative parameters (with justification for public safety clients). However, to provide some perspective, we have reviewed information from a number of our clients of who have been using Motorola SmartZone systems and as a result we have updated our standard metrics for call duration and calls per unit per hour. Our new metrics are a call duration of 4.9 seconds with a call setup overhead of 1 second and a call rate of 1.3 calls per unit during the busy hour. Our experience shows that is an appropriate set of call parameters for a public safety grade, mixed user P25 system like the EBRCS.

AECOM recommends that the capacity of a public safety system be governed by a maximum acceptable call delay of 1 second with a Grade of Service (GOS) for delayed calls of 1% or less during the “busy” hour. (The busy hour is the single hour during a month that experiences the maximum radio traffic. Emergencies, like 9/11 or Hurricane Katrina, are handled by adjusting priority, limiting or eliminating certain categories of calls, etc.) Motorola used the same GOS but 2.5 seconds was used as the maximum acceptable call delay. In our experience, busy queue depths of greater than 1 second generally result in user dissatisfaction with system performance.

Projections of future growth can have a significant impact on calculations of system capacity for a given system. The Motorola assumption of 20% growth over an unspecified number of years and applied to the reduced user count we discussed previously appears to be overly simplistic. It does not reflect the population trends that can differ significant over the two-county area that will be served by the EBRCS.

AECOM generally uses a 15 to 20 year lifespan for a new system. For the EBRCS, AECOM has estimated future growth based on census data and projections for individual regions in Alameda and Contra Costa Counties. This process accounts for differences in growth expected between areas like the Tri-Valley versus Oakland or Richmond. We expect yearly growth rates in the area to range between 0.3 and 1.5 percent project over the 15 year life expectancy of the EBRCS.

The assumptions for roaming and inter-zone (wide area) calls given in Figure 18 of the original Motorola report are now dated and do not reflect changes in the system design that have evolved over time. Up to six standalone trunking sites are included in the current design to enhance coverage. These additional sites will produce a notable change in roaming and wide area call performance in the system. The assumptions of intra-county and inter-county call ratios appear appropriate but will become more complex with the new standalone sites.

From this same figure, it appears that the number of calls within a cell was reduced by the percentage of calls that are going outside of the cell. In a multiple simulcast cell design like EBRCS, calls placed within a cell or standalone site will be carried locally as well as by other cells (or sites) that have users logged into the participating talkgroup. Instead of 90% of the traffic on ALCO East remaining on ALCO East (as shown in the diagram), we believe that the model should consider 100% of the traffic remaining on the home cell.

The net result is that the original EBRCS design is undersized for the intended traffic. This tight environment will force the participating agencies to restrict the use of special features, and maybe even deny use of the system to agencies that would otherwise have been invited to join. This design may also limit the useful life of the system in that you will reach the ceiling for capacity at an early date.

Progress in P25 standards development since the original design offers the potential for a solution that addresses these capacity concerns. P25 standards have been developed in two phases. Phase 1 is an FDMA technology based on one voice or data channel per 12.5-kHz RF channel. Phase I standards are assumed in the original design.

Phase 2 is a time-division multiple access (TDMA) standard based on a two-slot 12.5-kHz channel. This technology will provide one voice channel per 6.25 kHz of spectrum. The advantage of this technology is that it helps conserve precious frequency resources by effectively doubling the capacity of a system. This doubling of talk paths reduces the number of channels needed to provide the required capacity within a given infrastructure design. This means that the EBRCS can be minimally redesigned based on the changes in capacity calculation presented above without significantly increasing the cost of the overall system. In section 4 of this report we will present the technical analysis that supports our capacity design. In section 8 we discuss the analysis that supports our opinion of probable cost.

3.2 Review of Motorola Predicted Coverage

It should be noted that a significant amount of time and effort has been expended by both the EBRCSA member agencies and Motorola to identify and address coverage holes as identified by Motorola coverage predictions. In addition to these efforts, obtaining detailed maps that define the limits of coverage for each simulcast cell and standalone trunking is important to setting the operational expectations of EBRCSA member agencies and the ongoing success of the EBRCS.

The comprehensive updated Motorola coverage map for the EBRCS is shown in Appendix B. This map reflects changes from the original design such as the addition of the Crockett and Niles Canyon sites. We note that this map also still includes sites that have been since removed from the original design such as Rocky Ridge. AECOM recommends that EBRCSA request an updated version of this map from Motorola.

Unfortunately, the full system coverage map discussed above is not particularly useful in planning operational procedures for the system. This is due to the wide area configuration of the proposed network in Alameda and Contra Costa counties.

These cells and sites will operate as independent zones. We presume that many talk-groups, and perhaps some users, will be restricted in their operation to their "home" site. For example, Hayward Police "Main Dispatch" (a fictional talk-group used here to illustrate the issue) may be restricted to ALCO Southwest. So if a HPD officer is monitoring this talk-group, he/she will have to remain within the coverage footprint provided by the sites in the ALCO Southwest simulcast cell. The Motorola map does not show the coverage provided by ALCO Southwest. To be more correct, the Motorola map does not show the *limits* of coverage for the ALCO Southwest cell or any of the other cells or sites. Instead, the maps show a *composite* coverage, which is not what most users will experience – especially as they reach the fringe of their coverage area.

Ideally, we would like to see separate maps for portable usage in light, medium and heavy buildings for each simulcast cell and standalone site. In section 4 of this report, which discusses coverage predictions for the newly defined ALCO Northwest simulcast cell, we will provide examples of the types of coverage maps that we recommend be created for each simulcast cell and standalone site.

4.0 New Conceptual System Design

In this section of the report, we will examine the new conceptual system design for the East Bay Regional Communications System (EBRCS). This examination will include a discussion of the evolution of the system design based on the communications requirements of the thirty-three EBRCSA member agencies and changes in P25 radio technology. It will also include technical information and discussion regarding key technical elements of the new design.

4.1 Evolution of EBRCS Design

The system design described in Motorola's document dated May 12, 2006 was developed in response to a task requiring "a two-county design option" in their contract with Alameda County, which was executed in October 2005. In the design document, Motorola recommended a SmartZone 800 MHz P25 architecture to provide radio coverage to both Alameda County and Contra Costa County. The primary elements of that design were:

- Circuit-Switched P25 Phase 1 Technology
- 5 Simulcast Cells comprised of 30 Repeater Sites
- 1 Stand Alone Repeater Site at Crane Ridge
- 83 New Dispatch Operator Positions
- 94 Upgraded Dispatch Operator Positions
- A Master Site to provide voice switching and management functionality for the cells, sites and consoles

Since the execution of the contract in 2005, EBRCSA and Motorola have been working closely together to refine their understanding of the communications requirements of the member agencies in Alameda and Contra Costa Counties while simultaneously developing sites and implementing equipment. In 2008 AECOM Communications (now AECOM) was retained by EBRCSA to provide consulting services for the EBRCS project. At the end of 2008 AECOM provided a Needs Analysis Report that updated and summarized the communications requirements of the member agencies.

The combined efforts of EBRCSA, Motorola and AECOM have resulted in a new conceptual system design composed of the following primary elements:

- 6 Simulcast Cells comprised of 30 Repeater Sites
- 6 Stand Alone Repeater Sites
- IP Based P25 Phase 2 (TDMA) Technology
- 151 New Dispatch Operator Positions
- 31 Upgraded Dispatch Operator Positions
- A Master Site to provide voice switching and management functionality for the simulcast cells, standalone sites and consoles

This updated conceptual system design reflects the refined understanding of requirements and advances in P25 technology since the original design while staying within the original cost estimates for the overall project.

4.1.1 Site Design Evolution

The six simulcast cells are equally divided between Alameda and Contra Costa Counties in order to provide the required radio coverage for public safety agencies in both counties.

The three simulcast cells in Alameda County (abbreviated ALCO) have the following characteristics:

ALCO East - This simulcast cell consists of four radio sites (with transmitters & receivers) located at Doolan (the "prime" site), Sunol, Patterson Pass (Altamont) and East Dublin BART. Ten channels, or frequency pairs, in the 700 and/or 800 MHz bands will be located at each site. The set of frequencies at each site is identical – hence the term "simulcast".

The “prime” site (Motorola terminology) is the location where simulcast timing (for extremely precise control of the transmit signals) is performed. The “prime” site also houses the “voting comparators”, Motorola term for the equipment used to select the optimum received signal from the sites in a simulcast cell.

ALCO Northwest - This simulcast cell consists of four radio sites located at APL (the “prime” site), UC Berkeley, Skyline Reservoir and Seneca. Sixteen channels, or frequency pairs, in the 700 and/or 800 MHz bands will be located at each site.

ALCO Southwest - The simulcast cell contains seven radio sites located at San Leandro Hills (the “prime” site), Garin, Fremont, Coyote Hills, Hayward, Walpert and Warm Springs BART. Twelve channels will be located at each site. This set of 700 and/or 800 MHz frequencies is identical at all seven sites in the ALCO Southwest cell. The ALCO Southwest set of frequencies are different from the ALCO Northwest cell and from the ALCO East cell.

The three simulcast cells in Contra Costa County (abbreviated CCCO) have the following characteristics:

CCCO West - This simulcast cell consists of four radio sites located at Nichol Knob (the “prime” site), 10900 San Pablo, Pearl Reservoir and Turquoise. Ten channels, or frequency pairs, in the 700 and/or 800 MHz band will be located at each site.

CCCO Central - The simulcast cell contains eight radio sites located at Harbor View in Martinez (the “prime” site), Bald Peak, Alta Mesa Moraga, Kregor, Highland Peak, Peters Ranch, Sidney Drive and Cummings Peak. Ten channels will be located at each site. This set of 700 and 800 MHz frequencies is identical at all eight sites in the CCCO Central cell. The CCCO Central set of frequencies are different from the sets in the other Contra Costa and Alameda County cells.

CCCO East - This simulcast cell is comprised of three radio sites located at Kregor (the “prime” site), Shadybrook, and Los Vaqueros. Seven channels will be used at each of these sites. This set of seven, 700 and/or 800 MHz channels is composed of unique frequencies, used only in this simulcast cell.

In the course of reviewing and implementing the EBRCS, it became apparent that there were areas in both counties that required coverage that could not be provided in a cost effective manner by the planned simulcast cells. These areas shared the characteristic that they were important areas with lower user densities. To address these areas, six standalone trunking sites have been included in the new design. The three sites in Contra Costa County are:

Crockett – This five channel, multi-sited (connected to the voice switch at Alameda County OES in Dublin) standalone trunking site serves the Carquinez Bridge area. The site will be implemented as a cell on wheels (COW) to provide additional communications flexibility for Contra Costa County.

Fire Station 53 - A five channel, multi-sited standalone trunking site that serves the craggy terrain surrounding Old Fire Station 53 in the eastern part of the County.

Marsh Creek- This four channel, multi-sited standalone trunking site is located at the Marsh Creek Detention Facility.

The three sites in Alameda County are:

Crane Ridge – A four channel, multi-sited standalone trunking site serving the mountainous areas in far southeast Alameda County

Gwin – This four channel multi-sited standalone trunking site is located in the Oakland Hills and covers the Caldecott tunnel area.

Niles Canyon – A four channel multi-sited standalone trunking site designed to serve a key transportation corridor through the hills between eastern and western Alameda County.

4.1.2 Dispatch Center Design Evolution

The design of the dispatch centers has also evolved over this time. In the original design over half of the console operator positions were to be upgraded versus replaced with new equipment. This was an excellent strategy that saved cost and obtained upgrades for member agencies while the EBRCS was being implemented. Thirty-nine operator positions in Alameda County were upgraded under this strategy. In reviewing costs in the 2008-2009 timeframe it was discovered that the costs associated with upgrades and new IP-based console operator positions had become effectively equal since the original design was proposed. Based on this information, Alameda and Contra Costa Counties decided that all future console operator positions would be implemented with new equipment.

East Bay area public safety agencies and other EBRCSA member agencies are supported by thirty radio dispatch centers in Alameda and Contra Costa Counties. In the new design, the operator positions at the twenty dispatch centers in Alameda County are a mix of upgraded existing consoles and new IP based consoles. Thirty-nine consoles at seven locations were upgraded to take advantage of existing equipment. The Alameda County dispatch centers included in the new design are:

Oakland Police
Albany Police
Newark Police
Fremont Police
Union City Police
Alameda County Sheriff
San Leandro Police
Alameda City Police
Hayward Police
Berkeley Police
Emeryville Police
East Bay MUD
Pleasanton Police
Piedmont Police
Livermore Police
East Bay Parks
Oakland Fire
Alameda County Office of Emergency Services (OES)
ALCO Fire
UC Berkley

In the ten dispatch centers serving Contra Costa County, each operator position will be installed as a new IP-based console. The Contra Costa County dispatch centers included in the new design are:

COCO Sheriff
Martinez Police
Pleasant Hill Police
Walnut Creek Police
Concord Police
Richmond Police

Pinole Police
Antioch Police
Contra Costa Fire
San Ramon Valley Fire

4.1.3 Infrastructure Design Evolution

Another element of the design of the EBRCS that has changed over time is the move from a circuit based infrastructure to an IP-based packet switching infrastructure. In the original Motorola design document makes repeated references to the advantages of standards based, P25 infrastructure. This implies that the original design for the EBRCSA was IP-based. However, review of the equipment purchased over the last few years and the software contained in that equipment reveals that the current infrastructure and software for the EBRCS is circuit based.

This fact is not a black mark against Motorola. In order to meet scheduled delivery dates for equipment driven by grant funding requirements, Motorola has delivered circuit switched technology to EBRCSA. An upgrade of current equipment to IP-based operation has been planned and funding has been identified. This upgrade is also a foundational step towards the final system element whose evolution we will discuss, that being the air interface.

4.1.4 Air Interface Evolution

Two primary factors have influenced the decision to use time-division multiple access (TDMA) based, P25 Phase 2 technology in the new conceptual design for the EBRCS, increased radio traffic requirements and the availability of 700 MHz frequency resources in Region 6 that serves the Bay area of California. In the traffic analysis section of this report we will show through detailed analysis that the radio traffic requirements for EBRCSA member agencies are significantly greater than previously estimated. TDMA is the most frequency efficient P25 technology, but it alone is not enough to satisfy EBRCSA traffic requirements without the addition of frequency resources. By adding soon to be available 700 MHz frequencies to the design these requirements can be met.

The following two sections summarize key information regarding P25 Phase 2 and the 700 MHz spectrum.

4.1.4.1 P25 Phase 2

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 radio frequency (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 an 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. P25 Phase 2 is a TDMA technology.

P25 standards have been developed in two phases. Phase 1, designated ANSI/TIA/EIA-102, is an FDMA technology based on one voice or data channel per 12.5-kHz RF channel. Phase I standards are basically complete.

Phase 2 has several goals. One goal is to define technology standards that will provide one voice channel per 6.25 kHz of spectrum. The P25 committee is currently finalizing its efforts on a TDMA standard based on a two-slot 12.5-kHz channel. The standard requires that any Phase 2 equipment must be backward-compatible to communicate in Project 25 Phase 1 mode.

Phase 2 will also define IP-based interconnection ("inter-subsystem interface" or ISSI) standards for P25 radio systems. This will allow seamless roaming and wide-area calling across multiple radio systems.

There has been much concern that P25-compliant equipment from various manufacturers is not necessarily interoperable. The P25 standards are purposely vague and leave room for vendors to add proprietary features. This environment does not inspire confidence in public safety agencies that they can purchase equipment for multiple vendors and know that it will all work together.

To help address this unfortunate situation, the National Institute of Standards and Technology (NIST) are working with TIA to develop the P25 Compliance Assurance Program (CAP). A number of testing labs have been established and the first rounds of capability testing have begun. Soon there will be definitive information available to assure that P25 equipment really does interoperate.

4.1.4.2 700 MHz Spectrum

The 700-MHz Public Safety Band was allocated by the FCC in response to the Balanced Budget Act of 1997 (BBA 97). The BBA 97 mandated that, as part of the digital television (DTV) transition, TV broadcasting cease on Channels 60-69, and 24 MHz of the recovered spectrum be allocated to public safety communications.

The FCC originally established the public safety band at 764-776/794-806 MHz. The FCC's decision in August 2007 moved the band to 763-775/793-805 MHz. The FCC adopted rules to provide spectrum efficiency, interoperability and flexibility. The band was a combination of narrowband channels (primarily for voice communications) and wideband channels for data communications. Licensees are allowed to aggregate channels to create wider channels to support TDMA technology and to provide higher data rates.

Channels were allotted in groups of four. This allowed a licensee flexibility to 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.

In Region 6 (Northern California), regional planning committee elected to allot channels in groups of two. This assumes that the dominant technology to be used in the band will be a two-slot TDMA solution (such as Project 25 Phase 2). This method of allotting channels eliminates the problem of "orphaned channels," 12.5-kHz channels left when a licensee implements a 12.5-kHz system in 25-kHz channel allotments and doubles the total number of available channels.

A licensee is allowed to operate at 12.5-kHz efficiency, but only until 2017. 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.

Now we will begin our review of key elements of the new conceptual system design for the EBRCS.

4.2 New Conceptual System Design and Alternatives

4.2.1 Proposed Topology

The foundation for the topology of the new conceptual system design is the network defined in the original Motorola Design report. In creating a new conceptual design it did not make sense to abandon the years of work that went into design, site selection and acquisition and other efforts that have brought the EBRCS to its present stage of development. The key to creating a beneficial new conceptual system design was capturing the changes in requirements that have evolved since the original system design was created. Table 4-1 contains basic site information for the thirty-nine sites considered for use in the new system design.

The first task in defining the conceptual system design was to incorporate changes to the proposed site topology. Three categories of changes to the network design have been identified and included in the design. The categories are:

1. DVRS Site Conversions
2. Coverage Hole Fillers
3. Traffic Loading Driven Changes

4.2.1.1 DVRS Site Conversions

The first category of changes was the conversion of the DVRS site proposed at old Fire Station 53 and Niles Canyon to standalone trunked sites. This change was made to simplify operations for end users communicating in these areas. In order to use a DVRS site, the end user must know that they are outside of the coverage of the main system and manually select the site on their mobile or portable. Once this is accomplished, they can communicate but in a manner different than when they are on the main system. By changing the proposed DVRS sites to multi-sited standalone trunking sites, end users will "roam" onto these sites and communicate in the same manner they do on the main simulcast cells.

4.2.1.2 Coverage Hole Fillers

The second category of design change was the addition of three standalone trunking sites to address holes in system coverage identified by EBRCSA member agencies while reviewing coverage predictions with Motorola. The Crockett site in central Contra Costa County was added to cover the area near the Carquinez Bridge. This high traffic and industrial area cannot be covered by the nearby Cummings Peak site due to hills that create coverage shadows in the area.

The Gwin site in northwest Alameda County was added to cover the Caldecott Tunnel area and enhance coverage in the Oakland Hills. The rough terrain in this area makes it a challenge to cover with a site or sites outside of the immediate area. This area also contains the point of origin for the 1991 Oakland fire.

The Marsh Creek site is located in eastern Contra Costa County. Its primary purpose is to provide coverage for the Marsh Creek Detention Facility. It also provides coverage in areas of northeastern Contra Costa County.

4.2.1.3 Traffic Loading and Coverage Driven Changes

The third category of design changes are changes that result from the analysis of traffic loading and the addressing of coverage issues in areas served by simulcast cells in the original design. As we will discuss in the following sections, changes to the assumptions regarding the number of users and their distribution within Alameda and Contra Costa Counties and heighten awareness of coverage in the northwestern area of Alameda County has resulted in a significant change to the design of the simulcast cell serving western Alameda County. The resulting design is depicted in Figure 4-1.

4.3 Traffic Loading Analysis

In this section, we will discuss the largest single factor contributing to differences between the original Motorola system design for EBRCS and the new conceptual system design, namely traffic loading. We will review the changes in assumptions regarding the number of units to be supported by the EBRCS and the distribution of these units. As we describe the traffic analysis process and results, we will examine two alternatives to the recommended new conceptual system design. Both alternatives are the direct result of changing assumptions regarding the number of units supported by the new system and their distribution.

4.3.1 Radio Counts and Distribution

The traffic analysis process began with the following assumptions regarding the design of the EBRCS:

- Circuit-Switched P25, Phase 1 (FDMA) Technology
- 5 Simulcast Cells comprised of 30 Repeater Sites

- 6 Stand Alone Repeater Sites
- A Master Site to provide voice switching and management functionality for the cells, sites and consoles

These assumption were based on applying the conversion of two proposed DVRS sites to standalone trunking sites described in section 4.2.1.1 and the addition of three “hole filler” sites described in section 4.2.1.2 to the original EBRCS design.

Once the design for the new conceptual design was established, the next key step was to examine traffic loading requirements for the proposed system. A fundamental element of loading requirements for a system is the assumed number of users that will use the system. In the case of the EBRCS, AECOM was asked to make a change to the basis for the number of users from the original Motorola estimate. The new basis is the anticipated system radio count from the EBRCSA Radio Subscriber Fee Status as of April 6, 2009. The resulting radio count assumptions can be seen in Tables 4-2, 4-3 and 4-4. A total of 21,110 radios will be supported by the EBRCS.

4.3.2 Alameda West Simulcast Cell Alternative

As we reviewed the new radio count assumptions, we noticed the large number of Alameda County radios and became suspicious that there might be issues with the traffic capacity that could be supported by the simulcast cell design. To validate this suspicion we proceeded to run an Erlang C analysis of the Alameda West simulcast cell based on the number of users in the radio count assumptions. Based on the user distributions documented in Table 4-5 for Alameda Northwest and Southeast simulcast cells we determined that the proposed Alameda West simulcast cell would be required to support 11,631. Using the call parameter and growth rate projects document in the next section of this report we calculated the need for 33 talkpaths by 2015 and up to 38 talkpaths by 2025. These results were very large considering that they did not take into account any multi-site factors.

Our next step was to determine the maximum channel/talkpath capabilities of Motorola’s P25 system architecture for a simulcast cell. After consulting with multiple Motorola sources, we determined that the maximum number of talkpaths supported by one simulcast cell (or standalone trunking site) was 30 talkpaths for P25 Phase 1 and Phase 2 systems. This maximum talkpath limit is based on the maximum number of simultaneous calls that can be handled by a P25 Phase 1 Control Channel which is common to Phase 1 and Phase 2 systems to support backwards compatibility. This limit meant that it was impractical to implement a single P25 simulcast cell to serve the traffic needs of western Alameda County.

Since the predicted coverage of the originally proposed Alameda West simulcast cell met the needs of the member agencies in the area, a decision was made to develop a solution based on splitting the West simulcast cell into two simulcast cells. The resulting Alameda County northwest and southwest simulcast cells are analyzed in the following sections of this report.

4.3.3 Traffic Analysis of Revised System Design

Once the radio counts were established based on the new Alameda County topology, the distribution of radios across the topology was estimated. Cities and regional member agency users were mapped to the six simulcast cells based on their location in a given county. County wide and region wide member agency users were distributed across all simulcast and standalone sites in the agencies’ operational jurisdiction. These distribution were also weighted based on user densities (i.e. simulcast cells in urban areas received higher percentages of a given groups radios than standalone sites in rural areas). Table 4-5 lists the number of units for each of the participating agencies and the number of these units assigned to each of the systems or sites.

Additional loading for roaming and wide-area (multi-site) calls was added to all sites and simulcast systems by assuming a certain percentage of roamers or wide-area callers from/to adjacent sites. This process is

equivalent to the process used by Motorola (as shown in Figure 18 in the original design document). However, the relationships and percentages of multi-site calls have been adjusted to more accurately represent the relationships between the sites. This adjustment includes retaining 100% of the local calls on the local site and adding the adjacent site load as recommended in the original AECOM report for Contra Costa County.

The percentage of these additional units was applied according to the matrix in Table 4-6. A graphical representation of the assumptions in Table 4-6 can be seen in Figure 4-2

EBRCSA plans to convert the radio system from P25 Phase 1 (12.5-kHz FDMA) to P25 Phase 2 (two-slot 12.5-kHz TDMA with a 12.5-kHz Phase 1 control channel) gradually as agencies purchase Phase 2-capable subscriber units. A Phase 2 system will verify whether all subscribers affiliated with a talk group are capable of TDMA operation. If a Phase 1-only subscriber is affiliated with the talk group, then the system will assign a Phase 1 channel to the talk group. If all subscribers are capable of TDMA operation, it will assign a slot on a TDMA working channel. Table 4-7 summarizes the assumptions regarding the distribution of Phase 1 and Phase 2 subscribers and overall growth on each site or system per year.

The following assumptions are also incorporated:

- Current purchases of Phase 1 only radios were researched and a 7 year useful life was assumed for these radios.
- Only Alameda County has P25 Phase 1 radios
- It was assumed that all radios purchased beginning in 2009 would be P25 Phase 2 capable.
- It was assumed that all P25 Phase 2 capable radios would be upgraded and operational as Phase 2 in 2013.

The loading analysis is based on the Erlang C model. The Erlang C model involves several assumptions:

- The number of units in each site or simulcast system has already been calculated as explained above.
- The analysis is based on all units in inventory. There are no assumptions about the percentage of units active during the busy hour.
- There are 1.3 calls per unit during the busy hour. This value is based on real data from similar public safety systems with several years of loading data.
- The duration of the average call is 4.9 sec. This value, too, is based on real data from operating systems with several years of loading data.
- System (call setup) overhead adds 1 sec to each call. Actual setup time varies based on whether the call is repeated on a standalone site, a simulcast system or multiple sites or systems.
- The maximum allowable call delay is 1 sec.
- The required delayed-call grade of service is 1 percent. That is, no more than 1 percent of calls shall be delayed more than 1 sec during the busy hour.
- The following yearly growth rates were researched and assumed for the traffic analysis:
  - ALCO East Simulcast – 1.5%
  - ALCO Northwest Simulcast – 0.7%
  - ALCO Southwest Simulcast – 0.7%
  - CCCO East Simulcast – 1%
  - CCCO Central Simulcast – 1%
  - CCCO West Simulcast – 0.4%
  - Crane Ridge – 1.5%
  - Crockett – 1%
  - Fire Station 53 – 1%
  - Marsh Creek – 1%
  - Niles Canyon – 0.7%
- The system shall meet capacity needs for 15 years.

- It was assumed that the individually calculated traffic loads and resulting working channel requirements for Phase 1 and Phase 2 users on a given site could be added together to represent the number of working channels at the given site.
- Channel requirements and delayed grades of service over the 15 year life expectancy of the new system were examined to determine the number of channels required in the final conceptual design. The objective was to minimize the total number of channels required while taking into account Phase 1 and Phase 2 traffic loads over time and maintaining public safety grade performance of the system.
- 1 channel per site was added to the number of working channels calculated for a given site to account for the P25 Phase 1 control channel which serves both Phase 1 and 2 working channels.

We have calculated the number of Phase 1 and Phase 2 channels separately then added them together to determine the number of working channels needed, and then added an additional control channel.

Results of the analysis are documented and summarized in Table 4-7. Detailed results from the same analysis are contained in Appendix A.

The following is a summary of the required number of channels at within each simulcast site or at each standalone trunking site:

- New P25 Phase 2 channel requirements:
  - 6 Simulcast Cells
- ALCO East – 10 Ch.
- ALCO Northwest – 16 Ch.
- ALCO Southwest - 12 Ch.
- CCCO East – 7 Ch.
- CCCO Central – 10 Ch.
- CCCO West – 8 Ch.
  - 6 Standalone Sites
- Crane Ridge – 4 Ch.
- Crockett – 5 Ch.
- Fire Station 53 – 3 Ch.
- Marsh Creek – 4 Ch.
- Niles Canyon – 5 Ch.
- Gwin – 4 Ch.

Block Diagrams for the new system and each of the simulcast cells and standalone trunking sites are provided in Appendix C.

4.3.4 Northwest Alameda County Alternative

An important question for EBRCSA that has been present since the beginning of AECOM's involvement with the project has been whether the City of Oakland and other associated agencies would participate in the new system. To address the technical impact of an Oakland decision to not join EBRCSA, AECOM has completed an alternative traffic analysis of the Northwest Alameda County simulcast cell using the following assumptions:

1. Two simulcast cells will be used to cover the western areas of Alameda County. This assumption preserves the flexibility to add capacity to targeted regions in Western Alameda County while reducing costs in the near term by applying only the required resources.
2. The cell will use the same simulcast sites:
   a. APL (Prime)
   b. UC Berkeley
   c. Skyline

d. Seneca

3. The Gwin standalone trunking site will be removed from the design and its users were redistributed to the Northwest ALCO simulcast cell.
4. The number of Oakland users will be reduced from 4360 to 170. 170 radios is ten percent of the 1700 public safety users in Oakland and reflects the anticipated maximum load on the ALCO Northwest simulcast cell for interoperability between Oakland and EBRCSA member agencies.
5. The cities of Emeryville and Piedmont will leave JPA if Oakland does not participate, reducing the loading on the ALCO Northwest cell by 197 units.

Applying the assumptions stated above, we followed the same traffic analysis process that we used for the new conceptual system design that included the Oakland related users. Table 4-8 shows the resulting unit distribution for the ALCO Northwest cell. The number of units support decreased by 4,387 units which means that in this alternative the ALCO Northwest cell is required to support only 48% of the units that the Oakland inclusive simulcast cell is required to handle.

Table 4-9 and Figure 4-3 illustrate the additional loading for roaming and wide-area (multi-site) calls for this scenario. The affect of removing the Gwin site and reallocating its users can be clearly seen in the table and figure. The calculation of resulting traffic loading for this alternative Northwest ALCO simulcast cell design is summarized in Table 4-10. The impact of these changes results in an ALCO Northwest simulcast cell of 10 channels.

The number of console operator positions that the system is required to support is also affected by the assumptions in the alternative. The number of consoles support is decreased by 34 operator positions. Thirty of those positions were planned to support the Oakland Police and Fire Departments (15 operator positions each). The plan also included two console operator positions each for the Emeryville and Piedmont Police Departments.

4.4 Frequency Plan

The EBRCS requires 88 channels as summarized below:

Subsystem	Channels
Alameda East simulcast	10
Alameda Southwest simulcast	12
Alameda Northwest simulcast	16
Contra Costa East simulcast	7
Contra Costa Central simulcast	10
Contra Costa West simulcast	8
Crane Ridge	4
Niles Canyon	5
Gwin	4
Marsh Creek	4
Fire Station 53	3
Crockett	5

The participants in the EBRCSA are licensed for 83 channels in the 800-MHz band. The Region 6 (Northern California) 700-MHz plan allots 57 channels to Alameda County and 40 channels to Contra Costa County. Contra Costa has prepared an 800-MHz license application for eight channels in the rebanded 800-MHz NPSPAC band for the Contra Costa West simulcast subsystem.

The total number of channels allotted and licensed to the EBRCSA participants exceeds the number of channels required, but there are obstacles to assigning channels to the EBRCS. The Region 6 plan allots frequencies at close

distances. Every frequency allotted to Alameda or Contra Costa County has at least one adjacent-channel with an adjoining county. The regional plan states that the frequency allotments are based on an interference-limited basis, not a noise-limited basis. However, the preferred technology for the band is the P25, which is a noise-limited technology. The result is that frequencies allotted to each county are only usable in regions within the county, not across the entire county.

The existing 800-MHz channels are already in use. Cutting over these channels from existing systems to new systems creates additional technical and operational challenges.

Finally, rebanding has not been completed in the Bay area. The FCC has yet to approve the revised 800-MHz regional plan because the Region 6 800-MHz committee decided to repack frequencies. Because of this, licensing new channels or even relocating existing channels in the NPSPAC band is delayed.

We have used the following approach for assigning channels: (1) First, apply for 800-MHz relinquished channels. We are preparing applications for all subsystems, but we will request that the standalone (non-simulcast) trunked sites receive first priority. We believe we are more likely to find a relinquished channel suitable for a standalone site and its relatively small coverage area than we are for a large simulcast system covering half a county. (2) Apply for 700-MHz channels. We are preparing applications for all subsystems here as well, but the priority is on the simulcast subsystems. We have identified the affected co- and adjacent-channel counties and have assigned frequencies to avoid interference. (3) Relicense existing 800-MHz frequencies for use in the EBRCS as needed. This is the last resort if no other frequencies are available.

Table 4-8 outlines the frequency plan, including alternatives. This plan may change as circumstances dictate during the licensing process. In addition to the frequencies listed in Table 4-8, frequencies from existing licenses may be substituted following a careful review for suitability.

The traffic loading analysis yields the number of voice talk-paths required to meet the system goals (e.g., 1% Delayed Call GOS with a maximum acceptable call delay of 1 second during the “busy” hour). For a radio system designed on the basis of P25 Phase 2, which uses time division multiple access (TDMA) with two talk-paths per 12.5 kHz channel, the number of channels required equals the number of talk-paths required divided by two (plus one control channel).

4.5 Northwest Alameda County Coverage Analysis

The purpose of this section is twofold. The first objective is to address a number of key design considerations regarding the Northwest Alameda simulcast cell which is a significant change to the original conceptual design. The second objective is to highlight and provide an example of the increased amount of information that EBRCSA should expect regarding the design of all six simulcast systems in the EBRCS design. All referenced coverage diagrams are contained in Appendix B of this report.

As indicated in the traffic loading analysis section of this report, the western Alameda county region has been split into two regions with associated infrastructure changes to address issues with user density and the ability of the P25 architecture to support that density. The result of that split is a southwest Alameda county region supported by a simulcast system that utilizes the sites in the region identified in the original Motorola design and a new southwest region. Coverage for the northwest region is proposed to be supported by a four site simulcast system plus one standalone trunking site.

The proposed sites for the northwest region are as follows:

ALCO Northwest Simulcast Cell:

1. APL (Prime) -166 W ERP
2. Seneca – 331 W ERP
3. Skyline – 148 W ERP
4. UC Berkeley – 309 W ERP

Standalone Site:

1. Gwin – 25 W ERP

To begin our coverage analysis, we should first look at the coverage maps provided by Motorola, Figure B-1 Wide Area Motorola coverage map and Figure B-2 ALCO NW Region Motorola coverage map. Both maps are based on displaying 95 % reliability coverage for a portable on the street, talk-in at hip level. A common issue with both coverage maps is that they provide only a small part of the coverage picture for a simulcast cell. While it is technically correct to state that coverage is limited by the ability for a portable to talk into the system, it does not represent the entire user experience and does not address the simulcast operation of the system at all. To accurately assess a simulcast system design talk-out coverage predictions are required to characterize the interaction of the transmitters in the proposed coverage area. Beginning with Figure B-3 we have created a set of talk-out coverage predictions to explore a number of different issues that we addressed in the conceptual design of the ALCO Northwest simulcast cell.

The first issue we will address is the question of the coverage capability of the APL site versus the capability of the Glenn Dyer Jail site as part of the Alameda Northwest simulcast cell. This question arises since the two sites are in close proximity and a cost saving can be realized in the microwave system design by eliminating the Glenn Dyer site. However this change would not be acceptable if the coverage provided by use of the APL site is not equal to or better than coverage from the Glenn Dyer site as part of the simulcast cell.

To make this evaluation, we have created two sets of coverage maps for the Alameda Northwest simulcast cell. One set assumes use of the Glenn Dyer site as part of the simulcast cell and the other set assumes the use of the APL site in the cell. Each set contains the following 95 % reliability coverage maps:

1. Mobile Talk Out
2. Portable Outdoors Talk Out at hip level
3. Portable Light Building Talk Out at hip level (8 dB building loss)
4. Portable Medium Building Talk Out at hip level (12 dB building loss)
5. Portable Heavy Building Talk Out at hip level (20 dB building loss)

Talk out coverage predictions were created in order to take into account the unique aspects of a simulcast cell which are related to the transmission of signals from the tower sites. Coverage for a simulcast cell is limited by the talk out capability since call setup and call processing are bi-directional functions for a trunking radio system. This means that the increased transmit power of the mobile radio in comparison to a portable radio does not increase the coverage area for a mobile radio. For system like EBRCS which is design for portable coverage, the use of tower top amplifiers negates the increased coverage performance one would naturally assume for the higher powered mobile radio.

Figures B-3 through B-7 depicts coverage assuming the Glenn Dyer site and Figures B-8 through B-12 assume the APL site. Close examination of the maps reveals that there is virtually no difference in coverage between the two sites as part of the simulcast system. The slight difference in coverage that can be seen in the portable medium and heavy building coverage maps are well within the margins of error in the prediction algorithm. These maps support the case for moving the Glenn Dyer site to APL as part of the Alameda Northwest simulcast cell.

Figure B-13 illustrates another important aspect of a simulcast cell which is the overlap of transmit coverage from sites within the cell. Simulcast cells typically require alignment of signal amplitude and phasing in areas where two or more signals from site transmitters are received by a mobile or portable receiver and the signals are within 12 dB at the receiver. Signals that are greater than 12 dB higher than a competing signal typically capture the receiver. Figure B-13 shows the areas were signals are within the range (i.e. they overlap) when considering the APL and Seneca sites. The areas shown in blue are areas where Motorola should take extra care to make sure that signal time is adjusted to create the best possible coverage.

Figure B-13 is a simplified example of the complex considerations that must be accounted for in the design and alignment of the Alameda Northwest cell. Figure B-14 illustrates the complex coverage environment in the Northwest simulcast cell. Each color represents an area most likely served by a particular transmitter site assuming the timing

delays for each site are set equally. The areas of color transition represent the areas were timing issues have the potential to affect the coverage performance of the simulcast cell. Ideally, these areas should not be allowed in high importance areas and can be repositioned through the adjustment of signal timing delay at the individual transmitters. This type of fine tuning should be expected from the system vendor.

4.6 Consoles

East Bay area public safety agencies are supported by thirty dispatch centers in Alameda and Contra Costa Counties. In the new design, the operator positions at the twenty dispatch centers in Alameda County are a mix of upgraded existing consoles and new IP based consoles. Thirty-one consoles at seven locations were upgraded to take advantage of existing equipment.

The Alameda County dispatch centers included in the new design are:

- Oakland Police
- Albany Police
- Newark Police
- Fremont Police
- Union City Police
- Alameda County Sheriff
- San Leandro Police
- Alameda City Police
- Hayward Police
- Berkeley Police
- Emeryville Police
- East Bay MUD
- Pleasanton Police
- Piedmont Police
- Livermore Police
- East Bay Parks
- Oakland Fire
- Alameda County Office of Emergency Services (OES)
- ALCO Fire
- UC Berkley

In the ten dispatch center serving Contra Costa County, each operator position will be installed as a new IP-based console.

The Contra Costa County dispatch centers included in the new design are:

- COCO Sheriff
- Martinez Police
- Pleasant Hill Police
- Walnut Creek Police
- Concord Police
- Richmond Police
- Pinole Police
- Antioch Police
- Contra Costa Fire
- San Ramon Valley Fire

Table 4-1
EBRCSA Site Data

New Design 2009-08-13	Site Name	City	County	Latitude	Longitude	Elevation (ft AMSL)	Tower Ht (ft AGL)
ALCO Northwest	APL	Oakland	Alameda	37-48-10.7 N	122-16-21.8 W	43	351.0
ALCO Northwest	Glen Dyer Jail	Oakland	Alameda	37-48-00.0 N	122-16-37.2 W	27	178.0
ALCO Northwest	Seneca Reservoir	Oakland	Alameda	37-45-22.7 N	122-09-25.8 W	300	62.0
ALCO Northwest	U.C.-Berkeley	Berkeley	Alameda	37-52-39.6 N	122-14-48.4 W	1087	60.0
ALCO Northwest	Skyline Reservoir WT	Oakland	Alameda	37-49-13.1 N	122-11-05.1 W	1539	100.0
ALCO Southwest	San Leandro Hills (Prime)	San Leandro	Alameda	37-43-26.3 N	122-07-10.4 W	808	144.0
ALCO Southwest	Fremont PD	Fremont	Alameda	37-33-01.0 N	121-58-06.0 W	53	49.0
ALCO Southwest	Garin WT	Hayward	Alameda	37-37-54.0 N	122-01-58.0 W	663	60.0
ALCO Southwest	Warm Springs BART	Fremont	Alameda	37-29-58.0 N	121-56-16.0 W	56	150.0
ALCO Southwest	Coyote Hills	Fremont	Alameda	37-32-25.5 N	122-04-56.4 W	285.4	78.7
ALCO Southwest	Walpert Ridge	Hayward	Alameda	37-39-19.0 N	122-00-08.7 W	1490	102.0
ALCO Southwest	Hayward PD	Hayward	Alameda	37-39-27.0 N	122-05-49.0 W	72	60.0
ALCO East	Doolan Canyon (Prime)	Livermore	Alameda	37-42-38.5 N	121-49-06.5 W	732	60.0
ALCO East	Sunol Ridge	Pleasanton	Alameda	37-37-11.2 N	121-55-21.6 W	2179	102.0
ALCO East	East Dublin BART	Dublin	Alameda	37-42-10.7 N	121-53-48.8 W	335	140.0
ALCO East	Altamont	Livermore	Alameda	37-41-22.6 N	121-37-55.2 W	1638	150.0
CCCO West	Turquoise (Prime)	Hercules	Contra Costa	37-59-35.8 N	122-16-11.4 W	569	60.0
CCCO West	El Cerrito PD	El Cerrito	Contra Costa	37-54-58.7 N	122-18-39.9 W	68.9	40.0
CCCO West	Pearl Ridge Reservoir	Richmond	Contra Costa	37-57-27.2 N	122-18-44.7 W	659.5	60.0
CCCO West	Nichol Knob	Richmond	Contra Costa	37-55-13.0 N	122-22-55.0 W	371	60.0
CCCO Central	Harbor View Reservoir (Prime)	Martinez	Contra Costa	38-00-25.4 N	122-07-35.4 W	229	40.0
CCCO Central	Bald Peak	Berkeley	Contra Costa	37-53-01.1 N	122-13-19.0 W	1886	140.0
CCCO Central	Cummings Peak	Martinez	Contra Costa	38-01-44.8 N	122-11-51.2 W	869	120.0
CCCO Central	Highland Peak	San Ramon	Contra Costa	37-48-53.2 N	121-48-31.2 W	2509	140.0
CCCO Central	Peters Ranch Rd./Apollo	Danville	Contra Costa	37-47-12.6 N	121-59-32.8 W	931	40.0
CCCO Central	Sydney Drive	Walnut Creek	Contra Costa	37-52-02.3 N	122-03-07.5 W	715	45.0
CCCO Central	Kregor Peak	Clayton	Contra Costa	37-56-34.7 N	121-53-27.7 W	1840	150.0
CCCO Central	Alta Mesa Moraga	Moraga	Contra Costa	37-50-10.8 N	122-07-04.9 W	980	45.0
CCCO East	Kregor Peak	Clayton	Contra Costa	37-56-34.7 N	121-53-27.7 W	1840	150.0
CCCO East	Shadybrook Ct	Pittsburg	Contra Costa	38-00-11.8 N	121-56-56.1 W	748	10.0
CCCO East	Los Vaqueros	Livermore	Contra Costa	37-49-01.0 N	121-46-43.7 W	2057	45.0
Crane Ridge	Crane Ridge	Livermore	Alameda	37-36-23.6 N	121-37-14.5 W	2904	59.0
Crockett	Crockett	Crockett	Contra Costa	38-03-22.1 N	122-13-03.8 W	62.3	25.0
Fire Station 53	Old Fire Station 53	Clayton	Contra Costa	37-53-38.0 N	121-47-39.0 W	374	50.0
Gwin	Gwin Reservoir	Oakland	Alameda	37-51-45.7 N	122-13-21.2 W	1367	35.0
Marsh Creek	Marsh Creek	Clayton	Contra Costa	37-53-40.7 N	121-51-47.8 W	741	35.0
Niles Canyon	Niles Canyon	Fremont	Alameda	37-35-53.6 N	121-55-56.7 W	817	30.0

Figure 4-1
EBRCSA Simulcast and Trunking Sites

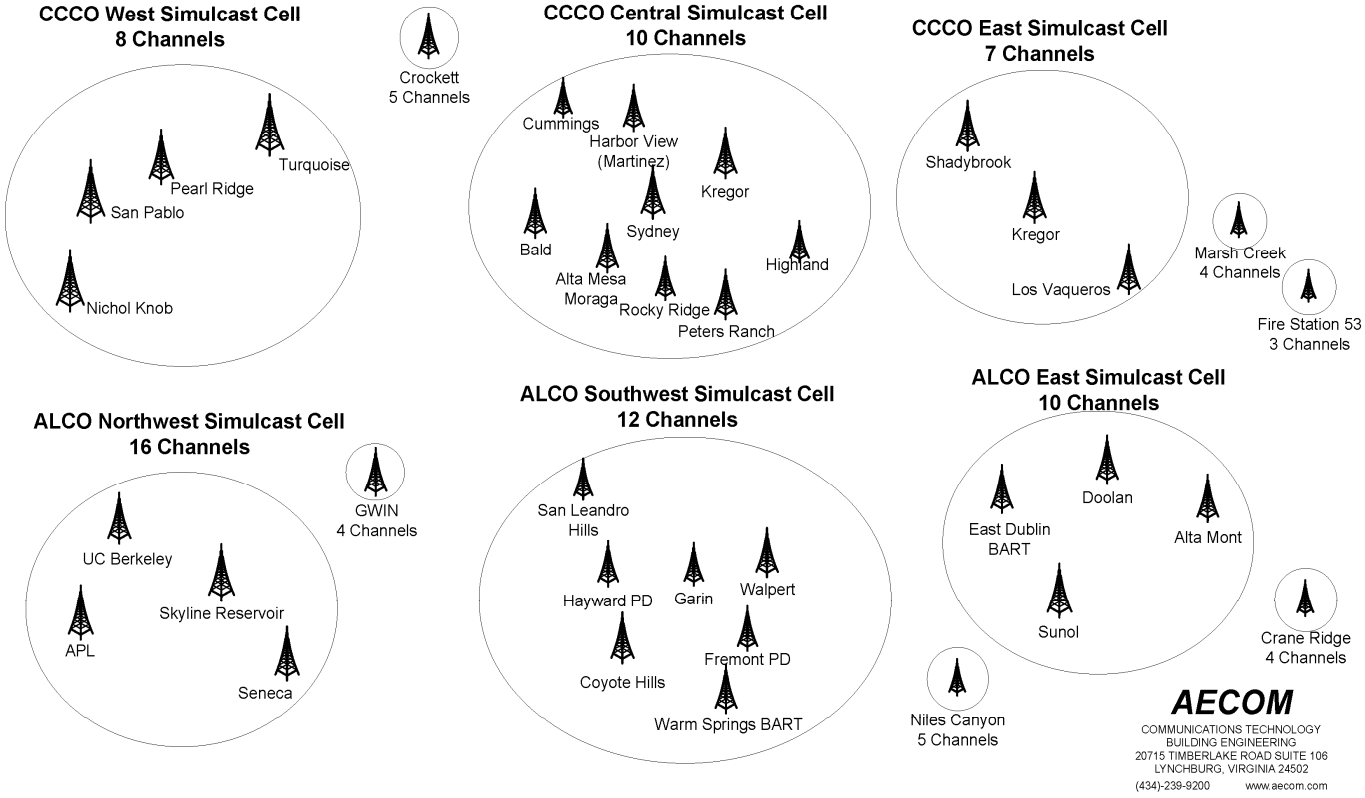

Table 4-2
Alameda County Radio Counts

Agency	Radio Count
Alameda County*	3016
Alameda (City)	529
Albany	83
Berkeley**	750
Dublin	108
Emeryville	100
Fremont	649
Hayward	500
Livermore	461
Newark	263
Oakland**	4360
Piedmont**	97
Pleasanton	361
San Leandro	378
Union City	306
Alameda Total	**11961**

Table 4-3
Contra Costa County Radio Counts

Agency	Radio Count
Contra Costa County*	1485
Antioch	460
Brentwood	130
Clayton	35
Concord	427
Danville	102
El Cerrito	135
Hercules	70
Kensington	18
Lafayette	45
Martinez	107
Moraga	40
Oakley	22
Orinda**	36
Pittsburg	235
Pinole	97
Pleasand Hill	143
Richmond	491
San Pablo	116
San Ramon	85
Walnut Creek	280
Moraga/Orinda Fire**	110
Rodeo-Hercules Fire	30
San Ramon Valley Fire	340
EPRPD (EBR Parks Dept.)	960
Contra Costa Total	**5999**

Table 4-4
Other Member Agencies Radio Counts

Agency	Radio Count
CALTRANS	1000
EBMUD	150
UC Berkeley	1500
Unidentified	500
Other Agency Total 3150	**3150**

Table 4-5
Agency Units and Assigned Systems or Sites

Group	Subscriber Units	Simulcast Systems						Standalone Trunked Sites					
		Alameda Northwest	Alameda Southwest	Alameda East	Contra Costa West	Contra Costa Central	Contra Costa East	Gwin	Niles Canyon	Crane Ridge	Crockett	Marsh Creek	Fire Station 53
Alameda County	3016	754	905	754				151	302	150			
City of Alameda	529	529											
City of Albany	83	83											
City of Berkley	750	750											
City of Dublin	108			108									
City of Emeryville	100	100											
City of Fremont	649		649										
City of Hayward	500		500										
City of Livermore	461			461									
City of Newark	263		263										
City of Oakland	4360	4360											
City of Piedmont	97	97											
City of Pleasanton	361			361									
City of San Leandro	378		378										
City of Union City	306		306										
Contra Costa County	1485				445	445	223				149	149	74
City of Antioch	460						460						
City of Brentwood	130						130						
City of Clayton	35					35							
City of Concord	427					427							
City of Danville	102					102							
City of El Cerrito	135				135								
City of Hercules	70				70								
City of Kensington	18				18								
City of Lafayette	45					45							
City of Martinez	107					107							
City of Moraga	40					40							
City of Oakley	22						22						
City of Orinda	36					36							
City of Pittsburg	235						235						
City of Pinole	97				97								
City of Pleasant Hill	143					143							
City of Richmond	491				491								
City of San Pablo	116				116								
City of San Ramon	85					85							
City of Walnut Creek	280					280							
Moraga-Orinda Fire District	110					110							
Rodeo-Hercules Fire District	30				30								
San Ramon Valley Fire District	340					340							
EBRPD	960	72	96	96	96	48	96	24	96	96	96	96	48
CALTRANS	1000	75	100	100	100	100	100	25	100	100	100	50	50
EBMUD	150	10	15	15	15	15	15	4	15	15	15	8	8
Unidentified	500	38	50	50	50	50	50	13	50	50	50	25	24
UC Berkeley	1500	1500											
Totals	**21110**	**8368**	**3262**	**1945**	**1663**	**2408**	**1331**	**217**	**563**	**411**	**410**	**328**	**204**

Table 4-6
Multi-Site Load

Site/System	Units	Contributing Site												Multi-Site Load Addition	Total Load
		Alameda Northwest	Alameda Southwest	Alameda East	Contra Costa West	Contra Costa Central	Contra Costa East	Crane Ridge	Crockett	Marsh Creek	Niles Canyon	Fire Station #53	Gwin		
		8369	3262	1945	1664	2409	1331	412	410	328	563	205	217		
Alameda Northwest	**8369**		8%		1%								75%	**440**	**8809**
Alameda Southwest	**3262**	8%		9%		1%					50%			**1138**	**4400**
Alameda East	**1945**		5%			3%	1%	75%			50%			**839**	**2784**
Contra Costa West	**1664**	5%				5%			5%					**559**	**2223**
Contra Costa Central	**2409**		1%	3%	5%		5%		75%	5%				**548**	**2957**
Contra Costa East	**1331**			1%		5%				75%		75%		**540**	**1871**
Crane Ridge	**412**			13%										**253**	**665**
Crockett	**410**				1%	5%								**137**	**547**
Marsh Creek	**328**					1%	5%							**91**	**419**
Niles Canyon	**563**		5%	5%										**260**	**823**
Fire Station #53	**205**						5%							**67**	**272**
Gwin	**217**	5%												**418**	**635**
Total	**21115**													**5290**	**26405**

Figure 4-2 Multi-site Assumptions

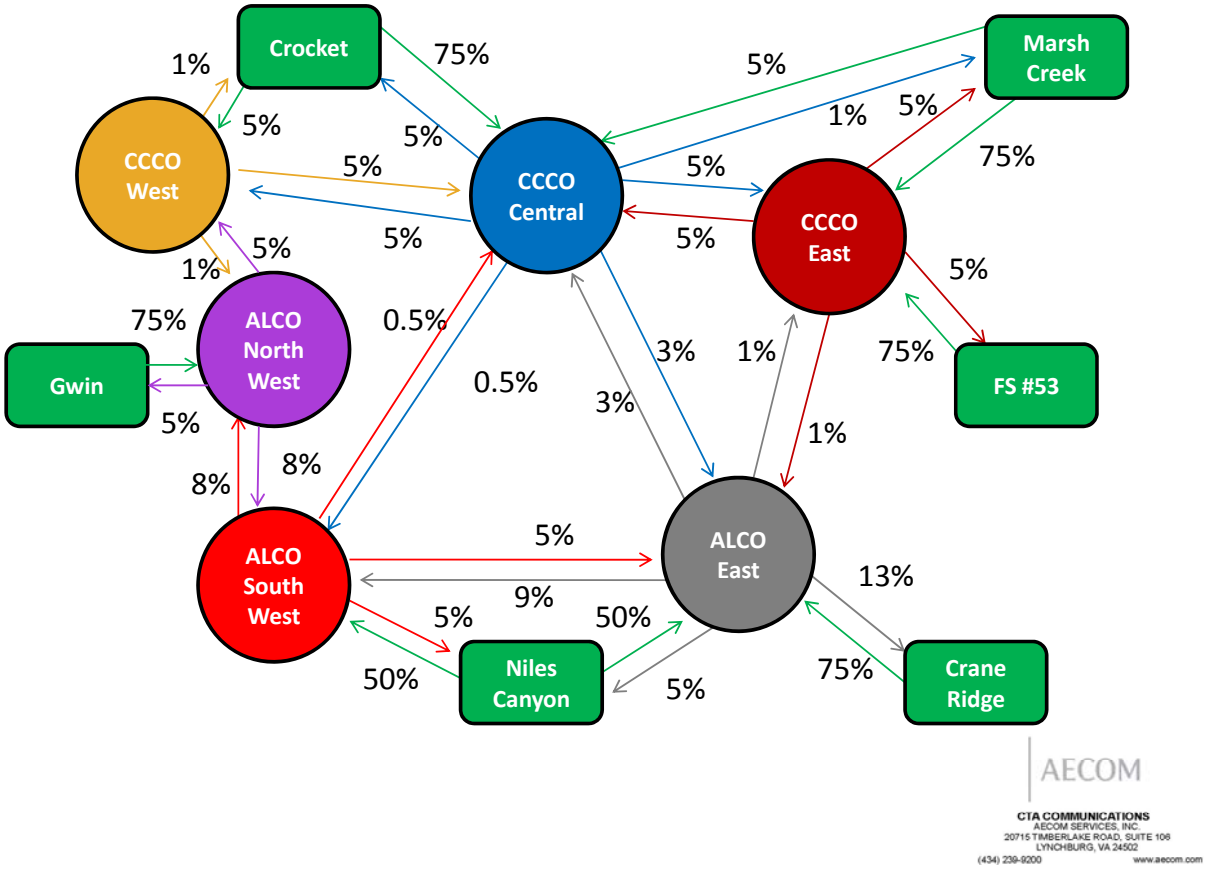

Table 4-7
Traffic Analysis Summary

System or Site	Alameda Northwest						
Yearly Growth Rate	0.7%						
	Unit Distribution		Unit Quantities		Working Channels Required		Total Channels Required
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	4498	0	9	10
2014	0%	70%	0	6341	0	11	12
2015	0%	92%	0	8392	0	14	15
2016	0%	93%	0	8543	0	14	15
2017	0%	94%	0	8695	0	14	15
2018	0%	95%	0	8849	0	14	15
2019	0%	96%	0	9005	0	14	15
2020	0%	97%	0	9162	0	15	16
2021	0%	98%	0	9322	0	15	16
2022	0%	99%	0	9482	0	15	16
2023	0%	100%	0	9645	0	15	16
2024	0%	100%	0	9713	0	15	16
2025	0%	100%	0	9781	0	15	16

System or Site	Alameda Southwest						
Yearly Growth Rate	0.7%						
	Unit Distribution		Unit Quantities		Working Channels		Total Channels
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	14%	30%	625	1339	5	4	10
2013	12%	50%	539	2247	5	6	12
2014	10%	70%	452	3167	5	7	13
2015	8%	92%	364	4192	4	8	13
2016	7%	93%	321	4267	3	8	12
2017	6%	94%	277	4343	3	8	12
2018	5%	95%	233	4420	2	9	12
2019	4%	96%	187	4498	2	9	12
2020	3%	97%	142	4576	1	9	11
2021	2%	98%	95	4656	1	9	11
2022	1%	99%	48	4736	0	9	10
2023	0%	100%	0	4818	0	9	10
2024	0%	100%	0	4851	0	9	10
2025	0%	100%	0	4885	0	9	10

Table 4-7
Traffic Analysis Summary (Continued)

System or Site	Alameda East						
Yearly Growth Rate	1.5%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	20%	0%	565	0	5	0	6
2012	14%	30%	402	860	4	3	8
2013	12%	50%	349	1456	4	4	9
2014	10%	70%	296	2069	4	5	10
2015	8%	92%	240	2759	3	6	10
2016	7%	93%	213	2831	2	6	9
2017	6%	94%	185	2905	2	7	10
2018	5%	95%	157	2979	2	7	10
2019	4%	96%	127	3056	2	7	10
2020	3%	97%	97	3134	2	7	10
2021	2%	98%	66	3213	1	7	9
2022	1%	99%	33	3296	1	7	9
2023	0%	100%	0	3379	0	7	8
2024	0%	100%	0	3429	0	7	8
2025	0%	100%	0	3481	0	7	8

System or Site	Contra Costa West						
Yearly Growth Rate	0.4%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	15%	0%	333	0	4	0	5
2011	20%	0%	446	0	5	0	6
2012	14%	30%	314	672	4	3	8
2013	12%	50%	270	1125	3	4	8
2014	10%	70%	226	1581	2	5	8
2015	8%	92%	181	2087	2	5	8
2016	7%	93%	159	2118	2	5	8
2017	6%	94%	137	2149	1	5	7
2018	5%	95%	115	2180	1	5	7
2019	4%	96%	92	2212	1	6	8
2020	3%	97%	69	2245	1	6	8
2021	2%	98%	46	2277	0	6	7
2022	1%	99%	23	2309	0	6	7
2023	0%	100%	0	2341	0	6	7
2024	0%	100%	0	2351	0	6	7
2025	0%	100%	0	2360	0	6	7

Table 4-7
Traffic Analysis Summary (Continued)

System or Site	Contra Costa Central						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	14%	30%	422	905	4	3	8
2013	12%	50%	366	1524	4	4	9
2014	10%	70%	308	2154	3	5	9
2015	8%	92%	249	2859	3	6	10
2016	7%	93%	220	2919	2	7	10
2017	6%	94%	190	2980	2	7	10
2018	5%	95%	160	3042	2	7	10
2019	4%	96%	129	3105	1	7	9
2020	3%	97%	98	3168	1	7	9
2021	2%	98%	66	3233	1	7	9
2022	1%	99%	33	3299	0	7	8
2023	0%	100%	0	3365	0	7	8
2024	0%	100%	0	3399	0	7	8
2025	0%	100%	0	3433	0	7	8

System or Site	Contra Costa East						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	964	0	4	5
2014	0%	70%	0	1363	0	4	5
2015	0%	92%	0	1809	0	5	6
2016	0%	93%	0	1847	0	5	6
2017	0%	94%	0	1886	0	5	6
2018	0%	95%	0	1925	0	5	6
2019	0%	96%	0	1964	0	5	6
2020	0%	97%	0	2005	0	5	6
2021	0%	98%	0	2045	0	5	6
2022	0%	99%	0	2087	0	5	6
2023	0%	100%	0	2129	0	5	6
2024	0%	100%	0	2151	0	5	6
2025	0%	100%	0	2172	0	5	6

Table 4-7
Traffic Analysis Summary (Continued)

System or Site	Gwin						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	327	0	2	3
2014	0%	70%	0	463	0	3	4
2015	0%	92%	0	614	0	3	4
2016	0%	93%	0	627	0	3	4
2017	0%	94%	0	640	0	3	4
2018	0%	95%	0	654	0	3	4
2019	0%	96%	0	666	0	3	4
2020	0%	97%	0	680	0	3	4
2021	0%	98%	0	694	0	3	4
2022	0%	99%	0	709	0	3	4
2023	0%	100%	0	723	0	3	4
2024	0%	100%	0	730	0	3	4
2025	0%	100%	0	737	0	3	4

System or Site	Crockett						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	15%	0%	82	0	3	0	4
2011	20%	0%	110	0	3	0	4
2012	14%	30%	78	167	2	2	5
2013	12%	50%	68	282	2	2	5
2014	10%	70%	57	398	2	2	5
2015	8%	92%	46	529	2	3	6
2016	7%	93%	41	540	1	3	5
2017	6%	94%	35	551	1	3	5
2018	5%	95%	30	562	1	3	5
2019	4%	96%	24	574	1	3	5
2020	3%	97%	18	586	1	3	5
2021	2%	98%	12	598	1	3	5
2022	1%	99%	6	610	1	3	5
2023	0%	100%	0	623	0	3	4
2024	0%	100%	0	629	0	3	4
2025	0%	100%	0	635	0	3	4

Table 4-7
Traffic Analysis Summary (Continued)

System or Site	Niles Canyon						
Yearly Growth Rate	0.7%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	14%	30%	117	251	2	2	5
2013	12%	50%	101	420	1	2	4
2014	10%	70%	85	592	1	3	5
2015	8%	92%	68	784	1	3	5
2016	7%	93%	60	798	1	3	5
2017	6%	94%	52	812	1	3	5
2018	5%	95%	44	827	1	3	5
2019	4%	96%	35	841	1	3	5
2020	3%	97%	26	856	0	3	4
2021	2%	98%	18	871	0	3	4
2022	1%	99%	9	886	0	3	4
2023	0%	100%	0	901	0	3	4
2024	0%	100%	0	907	0	3	4
2025	0%	100%	0	914	0	3	4

System or Site	Crane Ridge						
Yearly Growth Rate	1.5%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	5
2013	0%	50%	0	348	0	2	4
2014	0%	70%	0	494	0	3	5
2015	0%	92%	0	659	0	3	5
2016	0%	93%	0	676	0	3	5
2017	0%	94%	0	694	0	3	5
2018	0%	95%	0	712	0	3	5
2019	0%	96%	0	730	0	3	5
2020	0%	97%	0	749	0	3	4
2021	0%	98%	0	767	0	3	4
2022	0%	99%	0	787	0	3	4
2023	0%	100%	0	807	0	3	4
2024	0%	100%	0	819	0	3	4
2025	0%	100%	0	831	0	3	4

Table 4-7
Traffic Analysis Summary (Continued)

System or Site	Fire Station #53						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	140	0	2	3
2014	0%	70%	0	198	0	2	4
2015	0%	92%	0	263	0	2	4
2016	0%	93%	0	269	0	2	4
2017	0%	94%	0	274	0	2	4
2018	0%	95%	0	280	0	2	4
2019	0%	96%	0	285	0	2	4
2020	0%	97%	0	291	0	2	4
2021	0%	98%	0	297	0	2	4
2022	0%	99%	0	303	0	2	4
2023	0%	100%	0	310	0	2	4
2024	0%	100%	0	313	0	2	4
2025	0%	100%	0	316	0	2	4

System or Site	Marsh Creek						
Yearly Growth Rate	1.0%						
	Unit Distribution		Unit Quantities		Working Channels		Total
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Channels
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	216	0	2	3
2014	0%	70%	0	305	0	2	3
2015	0%	92%	0	405	0	2	3
2016	0%	93%	0	414	0	2	3
2017	0%	94%	0	422	0	2	3
2018	0%	95%	0	431	0	2	3
2019	0%	96%	0	440	0	2	3
2020	0%	97%	0	449	0	3	4
2021	0%	98%	0	458	0	3	4
2022	0%	99%	0	467	0	3	4
2023	0%	100%	0	477	0	3	4
2024	0%	100%	0	482	0	3	4
2025	0%	100%	0	486	0	3	4

Table 4-8
Agency Units and Assigned Systems or Sites
(Northwest Alameda County Alternative)

		Simulcast Systems						Standalone Trunked Sites					
Group	Subscriber Units	Alameda Northwest	Alameda Southwest	Alameda East	Contra Costa West	Contra Costa Central	Contra Costa East	Gwin	Niles Canyon	Crane Ridge	Crockett	Marsh Creek	Fire Station 53
Alameda County	3016	905	905	754					302	150			
City of Alameda	529	529											
City of Albany	83	83											
City of Berkley	750	750											
City of Dublin	108			108									
City of Emeryville	0	0											
City of Fremont	649		649										
City of Hayward	500		500										
City of Livermore	461			461									
City of Newark	263		263										
City of Oakland	170	170											
City of Piedmont	0	0											
City of Pleasanton	361			361									
City of San Leandro	378		378										
City of Union City	306		306										
Contra Costa County	1485				445	445	223				149	149	74
City of Antioch	460						460						
City of Brentwood	130						130						
City of Clayton	35					35							
City of Concord	427					427							
City of Danville	102					102							
City of El Cerrito	135				135								
City of Hercules	70				70								
City of Kensington	18				18								
City of Lafayette	45					45							
City of Martinez	107					107							
City of Moraga	40					40							
City of Oakley	22						22						
City of Orinda	36					36							
City of Pittsburg	235						235						
City of Pinole	97				97								
City of Pleasant Hill	143					143							
City of Richmond	491				491								
City of San Pablo	116				116								
City of San Ramon	85					85							
City of Walnut Creek	280					280							
Moraga-Orinda Fire District	110					110							
Rodeo-Hercules Fire District	30				30								
San Ramon Valley Fire District	340					340							
EBRPD	960	96	96	96	96	48	96		96	96	96	96	48
CALTRANS	1000	100	100	100	100	100	100		100	100	100	50	50
EBMUD	150	14	15	15	15	15	15		15	15	15	8	8
Unidentified	500	50	50	50	50	50	50		50	50	50	25	25
UC Berkeley	1500	1500											
Totals	**16723**	**4197**	**3262**	**1945**	**1663**	**2408**	**1331**	**0**	**563**	**411**	**410**	**328**	**205**

Table 4-9
Contributing Sites and Percent Contribution (Alternative Design)

Cell/Site	Users	ALCO Northwest	ALCO Southwest	ALCO East	CCCO West	CCCO Central	CCCO East	Crane Ridge	Crocket	Marsh Creek	Niles Canyon	Firestation #53	Gwin	Multisite Factor Addition	Net Multi-Site Load
ALCO Northwest	4199	0.0%	8.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	278	4477
ALCO Southwest	3262	8.0%	0.0%	9.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	805	4067
ALCO East	1945	0.0%	5.0%	0.0%	0.0%	3.0%	1.0%	75.0%	0.0%	0.0%	50.0%	0.0%	0.0%	839	2784
CCCO West	1664	5.0%	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	351	2015
CCCO Central	2409	0.0%	0.5%	3.0%	5.0%	0.0%	5.0%	0.0%	75.0%	5.0%	0.0%	0.0%	0.0%	548	2957
CCCO East	1331	0.0%	0.0%	1.0%	0.0%	5.0%	0.0%	0.0%	0.0%	75.0%	0.0%	75.0%	0.0%	540	1871
Crane Ridge	412	0.0%	0.0%	13.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	253	665
Crocket	410	0.0%	0.0%	0.0%	1.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	137	547
Marsh Creek	328	0.0%	0.0%	0.0%	0.0%	1.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	91	419
Niles Canyon	563	0.0%	5.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	260	823
Firestation #53	205	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	67	272
Gwin	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0
Totals	**16728**													**4169**	**20897**

Assuming Oakland Users reduced to 170 from 4360 users
Assuming 217 Gwin users are added to ALCO Northwest
Assuming that Emeryville & Piedmont will leave if Oakland does not join JPA - remove 197 users

Table 4-10
Traffic Analysis Summary (Alternative Design)

System or Site	Alameda Northwest						
Yearly Growth Rate	0.7%						
	Unit Distribution		Unit Quantities		Working Channels Required		Total Channels Required
Year	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	
2010	0%	0%	0	0	0	0	0
2011	0%	0%	0	0	0	0	0
2012	0%	0%	0	0	0	0	0
2013	0%	50%	0	2286	0	6	7
2014	0%	70%	0	3223	0	7	8
2015	0%	92%	0	4265	0	8	9
2016	0%	93%	0	4341	0	8	9
2017	0%	94%	0	4419	0	9	10
2018	0%	95%	0	4497	0	9	10
2019	0%	96%	0	4576	0	9	10
2020	0%	97%	0	4656	0	9	10
2021	0%	98%	0	4737	0	9	10
2022	0%	99%	0	4819	0	9	10
2023	0%	100%	0	4902	0	9	10
2024	0%	100%	0	4936	0	9	10
2025	0%	100%	0	4971	0	9	10

Figure 4-3 Alternate Multi-site Diagram

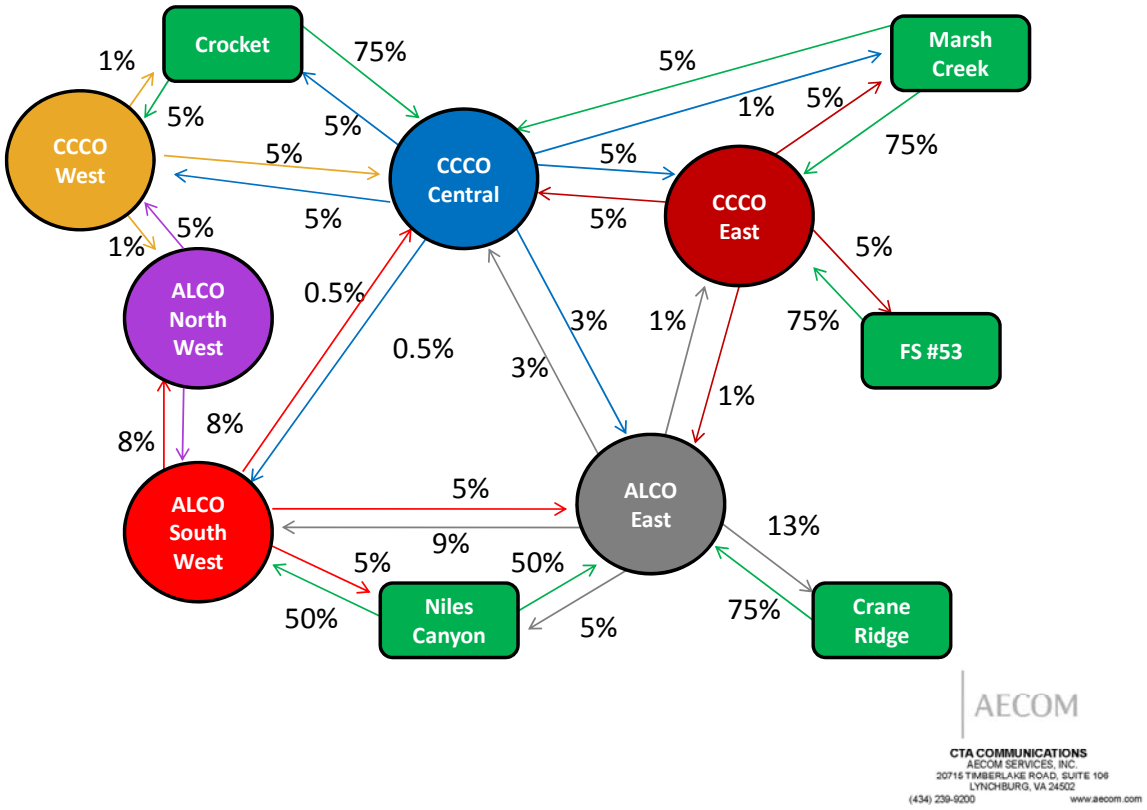

Table 4-11
Alameda County

Dispatch Center	MCC 7500 Positions	Gold Elite Upgrades
Oakland Police	15	0
Albany Police	2	0
Newark Police	0	3
Fremont Police	0	9
Union City Police	0	4
Alameda County Sheriff	5	4
San Leandro Police	0	3
Alameda City Police	0	5
Hayward Police	7	0
Berkeley Police	8	0
Emeryville Police	2	0
East Bay MUD	2	0
Pleasanton Police	5	0
Piedmont Police	2	0
Livermore Police	5	0
East Bay Parks	3	0
Oakland Fire	15	0
Alameda County (EOC)	0	3
ALCO Fire (Sierra Court)	9	0
UC Berkley (Lakeside)	2	0
Total	**82**	**31**

Table 4-12
Contra Costa County

Dispatch Center	MCC 7500 Positions	Gold Elite Upgrades
COCO Sheriff	20	0
Martinez Police	2	0
Pleasant Hill Police	2	0
Walnut Creek Police	6	0
Concord Police	8	0
Richmond Police	6	0
Pinole Police	3	0
Antioch Police	3	0
Contra Costa Fire	7	0
San Ramon Valley Fire	3	0
Total	**60**	**0**

5.0 EBRCSA Connectivity Overview

EBRCSA is in the process of implementing a two-county microwave system designed to support the radio system as well as other needs. The network design is based on the February 2008 East Bay Regional Communications System Design Review Report produced by Interoperable Communications Technical Assistance Program (IAECOMP) and augmented by local experience from both Alameda and Contra Costa Counties. EBRCSA has a contract with Harris Microwave and implementation has been underway for several years which include changes in network design to meet changes in requirements. The Harris design provides for most, but not all, of the connectivity required to support the planned two-county, P25 radio system. AECOM has discovered seven unplanned connections required by the radio system design.

The seven paths are:

1. Rocky Ridge to Alta Mesa Moraga
2. Rocky Ridge to Peters Ranch
3. Kregor Peak to Shadybrook Ct
4. Kregor Peak to Marsh Creek
5. Highland Peak to Old Fire Station 53
6. Highland Peak to Los Vaqueros
7. Sunol Ridge to Niles Canyon

In addition, EBRCSA is planning to use existing microwave systems (Contra Costa County, City of Oakland, City of Hayward and East Bay Regional Parks) and leased T1 backhaul to complete the connectivity requirements of the P25 radio system. Table 5-1 documents all 73 required point to point connections and current plans for meeting those needs. The information presented in this section is based on the best information available to AECOM at the time of the review and is subject to change.

5.1 Connectivity Network

The required connectivity network design, as illustrated in FIGURE 5-1 (Microwave, RF and Dispatch Sites), incorporates both equipment and path redundancy. Review of this network design and conversations with County personnel in both counties reveals that existing microwave paths were used (where possible) within the design configuration.

The high level architecture of this network consists of five topological rings. Each county is served by a main ring and a number of smaller rings. The smaller rings provide increased reliability in critical areas as identified by the maintenance organizations in each county.

5.1.1 Contra Costa County Main Ring

In Contra Costa County, the main ring utilizes many of the same sites as the existing Contra Costa County microwave network. The main ring consists of the following sites:

- Alameda OES
- Rocky Ridge
- Bald Mountain
- Cummings Peak
- Pine St. (Martinez)
- 40 Glacier
- Kregor Peak
- Highland Peak

5.1.2 Contra Costa County West Ring

A recently purchased ring serving the western part of the county consists of the following sites:

- Bald Mountain
- Cummings Peak
- Turquoise
- Pearl Ridge
- Richmond
- Nichol Knob
- El Cerrito PD

5.1.3 Alameda County Main Ring

The main ring consists of the following sites:

- Alameda OES
- East Dublin BART
- Doolan
- Sunol Ridge
- Newark PD
- Coyote Hills
- San Leandro Hills
- Oakland PD
- APL
- UC Berkeley
- Lakeside
- Bald Mtn
- Rocky Ridge

5.1.4 Alameda County San Leandro Ring

The San Leandro area is served by a ring which also shares a path with the Hayward/Newark ring serving the Hayward/Newark area in southwest Alameda County. The San Leandro ring consists of the following sites:

- San Leandro Hills
- San Leandro Communications Center
- Hayward PD
- Coyote Hills

5.1.5 Alameda County Hayward/Newark Ring

The Hayward/Newark ring consists of the following sites and is also served by a ring which also shares a path:

- Hayward PD
- Coyote Hills
- Newark PD
- Sunol Ridge
- Walpert Ridge
- Hesperian
- Garin

5.2 Designed Microwave Path Review

Due to the size of the network, two additional figures were created to enhance understandability of the design. Figure 5-2 (Alameda County Office of Emergency Services (EOS) Area Detail) focuses on the network near the Master Site. The Master site is a significant location for the operation of the P25 radio system. It houses the Zone Controller which provides centralized call control, voice switching and other functions for Motorola wide area systems.

Virtually every voice call passes through the voice switching function at the Master site. This importance is supported in the design by having the Alameda OES site included as part of each county's main loop. The passive microwave repeater site at the Santa Rita Jail is noteworthy since all but one of the hops connecting directly to the Alameda OES pass through Santa Rita.

The topology of the network in the Northwestern Alameda County area is depicted in Figure 5-3 (Northwest Alameda County Area Detail). Both the APL and Lakeside sites support a significant number of spurs for public safety dispatch centers. We recommend that the network design in this area be reevaluated with the goal of creating path redundancy (i.e. a possible ring) for the dispatch centers in this high population area.

Review of the overall design indicates that at least 35 proposed microwave sites are not ring protected. These sites are linked to a ring in close proximity via hot standby microwave spurs. Equipment redundancy included in the design improves link reliability where path redundancy was not provided.

The design put forth in FIGURE 5-1 is conducive to utilizing mesh switching technologies such as Multi Protocol Label Switching (MPLS) or Asynchronous Transfer Mode (ATM) with PNNI (Private Network-to-Network Interface). A network availability design goal of 99.999% is appropriate for this public safety network and is achievable with a mesh switching technology. With mesh technology actual circuit Mean Time between Outage (MTBO) becomes a derivative of path availability, equipment Mean Time between Failures (MTBF) and the switching technology utilized. A proper formulation of these three design criteria will maximize the network MTBO.

5.3 Proposed Connectivity Network

The current Harris design utilizes a 16 hop Alameda County ring. To increase the ring network reliability and circuit availability the ring should be split into two rings by adding an additional hop with two microwave RF channels between San Leandro Hills and Rocky Ridge, reference FIGURE 5-4. Also, for the same purpose, the Contra Costa County ring should be split into two rings by adding one additional microwave RF channel from Cummings Peak to Bald Mountain.

All Simulcast Prime sites should be incorporated within a ring to increase reliability via path redundancy, as shown in FIGURE 5-4.

The mobile radio infrastructure design utilizing the Harris designed Alameda County ring will require a minimum of 44 DS1's if routed via a SONET UPSR microwave network. This would use up over half of the available bandwidth of the Alameda County microwave ring, with only 40 DS1's remaining. The actual data rate requirement for each of the ALCO Northwest Simulcast Sites is only 320 kbps and the remaining simulcast sites will be 256 kbps or less. This means that for all sites the actual total data rate required is 12.520 Mbps or the equivalent of 9 DS1's. If MPLS or ATM technologies were utilized for R1 thru R4, as shown in FIGURE 5-4, 9 DS1's would be all that is required for the mobile radio connectivity within R2 and R4. This would free up an additional 35 DS1's, for a total of 75 spare DS1's to utilize for other applications.

A centralized alarm and provisioning management platform and surveillance center is recommended for the entire microwave network. Since there are many segmented microwave links within the microwave network, this will be critical in the troubleshooting of equipment failures and degradation within the network. All network alarms for all connectivity equipment should be routed to a central network alarm manager with a redundant backup server. This will facilitate the capability of providing reports on the network performance. Centralized circuit provisioning and monitoring is essential, especially with a MPLS or ATM network. Multiple equipment alarm management systems may be layered into a high order network management system such as HP Open View.

Each site should have the remote capability to perform diagnostics and provisioning of all multiplexer nodes and microwave equipment of any other site within the network. This access may be accomplished within the network via an internal microwave LAN or external IP WAN. Both Alameda County and Contra Costa County should have the capability to monitor, provision, and perform diagnostic functions of all microwave and multiplex/switching equipment at

each site in their area. We were not able to verify the existence or extent of these capabilities based on the information provided to us at the time of this report.

The microwave network capacity design of this network is significantly higher than the data rate required for the backhaul of this P25 system. Approximately seventy-four percent of the paths in this network are designed for 24.6 Mbps (16T1) bandwidth and forty-three percent designed for 156.5 Mbps (OC3 + 1DS1) bandwidth. With careful consideration of bandwidth requirements this network has the potential to support a broadband wireless data technology, such as LTE, to serve public safety in both counties.

6.0 Site Assets Evaluation

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

A. Site Development
B. Equipment Enclosures
C. Emergency Generators and Site Power
D. New Towers
E. Alarms

6.1 Site Development

The following is a list of site construction elements which must be addressed for new tower sites and for upgrading any existing radio sites.

A. In general, the site should be clean and properly cleared of vegetation and debris. 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 SUV-type vehicles on a regular basis. The road must be in passable condition or capable of being repaired without undue expense. We consider four inches of standard road paving gravel, such as #57 size (or comparable) aggregate to be an acceptable covering material and recommend it for all sites. We do not recommend any extensive grading, paving, 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 gravel. There should be ample room for a turn-around area and parking for two full-size pickup trucks.

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

D. Structural and wind loading analysis of existing towers, antenna structures, and foundations are typically required to determine if they are acceptable when specified equipment is mounted on them. Standard TIA-222-G which became effective January 1, 2006 has increased tower structural requirements. As a result, AECOM recommends that when a new load is added to an existing structure that it be analyzed against this standard. If the loading is not acceptable, the tower or antenna structure 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 utilized. Any existing fencing should be rust-free, in good repair, well grounded, and have a double gate. Access to the fenced radio site shall be regulated using locking devices.

F. Geotechnical investigations, including borings for tower foundations, shall be performed before designing and building any new towers or other structures. The Owner customarily provides these studies.

G. The grounding system at a radio site must consist of the following:
   - Halo ground system inside building
   - Buried ground system for building and tower
   - Tower and fence grounding

- Ground rods and test wells
- Surge suppression devices

The grounding system of all communications equipment installations must follow industry standard grounding specifications.

6.2 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 equipment 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, AECOM 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. Provision of fire detection/suppression equipment varies according to client preferences and can vary by facility. At a minimum, we recommend fire/smoke detection and security equipment to provide notification to operators of an emergency or intrusion. Each site will require a manual CO2 fire extinguisher. Automatic release of fire suppression agents may be provisioned at remote radio sites or facilities not typically manned 24 hours a day. Some clients feel that loss of equipment in case of fire is difficult to prevent and opt not to install the suppression equipment.

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.

6.3 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. AECOM will usually specify outdoor generators with weatherproof enclosures and block heaters where generators do not exist or are not acceptable. Generators must be capable of remote start/stop from designated dispatch centers. To ensure dependability of power to radio equipment, 48 V DC power systems with battery back-up (minimum of 2 hours emergency uptime) is required for all fixed network equipment. A battery backup with an emergency uptime of 8-12 hours would be preferred.

6.4 New Towers

New towers may be needed to replace structures that are incapable of holding the antennas necessary for the radio system or which do not provide the height above ground level needed for sufficient radio coverage from the radio site. All new towers will be specified with extra loading capacity for future antennas.

6.5 Alarms

AECOM 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 both communications centers. The following alarm points are recommended:

A. Intrusion alarm from door switch
B. Building temperature alarm
C. Generator fuel level alarm

D. Automatic transfer switch alarm
E. Generator abnormal alarm
F. Generator run alarm
G. Loss of utility power supply
H. Charger failure
I. DC bus voltage
J. UPS alarm
K. HVAC alarm
L. Tower lighting alarm
M. Fire suppression system deployment
N. 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.

6.6 Site Assets Summary

Table 6-1 contains a list of the radio sites in the EBRCS system design. This list was compiled by combining the technical data gathered by AECOM during the Needs Analysis, discussions with EBRCSA leadership and member agencies, discussions with Motorola and any additional information that AECOM was able to gather from the FCC Database. The table contains a list of those sites selected for the new radio system.

The table is sorted by County and Region and provides a list of those sites that AECOM anticipates will be simulcast versus standalone. The simulcast/standalone determination was based on the new conceptual system design. In addition, information is provided that describes the type of site, number of channels and connectivity.

The table also contains the site name and the Latitude and Longitude for the site in degrees, minutes and seconds format. The remaining columns provide an overview of current site conditions. Numbers less than one in these columns indicated that the required task at the site is less than AECOM's standard assumption for the category. Each of these categories was factored into our cost to complete considerations for each site.

6.7 Site Improvements

The brief site improvement descriptions below are a high-level overview of the types of work needed to improve upon EBRCSA radio sites at each of the selected locations. These site improvements have been factored into the site development costs in our opinion of probable cost.

6.7.1 Alameda County - East Radio Sites

Doolan (Prime)

No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades, Towers, or Alarm System work is required. A tower analysis should be performed if installation of a 700 MHz antenna system is required.

Sunol

No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades, Towers, or Alarm System work is required.

Patterson Pass (Altamont)

This is a green field site requiring a new shelter, improved access and electrical service work. A new shelter has been purchased and a new 150' monopole tower has been installed. The access road and parking area are to be improved. Electrical service from the pole to the shelter is being improved.

East Dublin BART
A new shelter has been purchased and a 20 ft tower extension is needed. Work is required on the electrical service at the site including a generator and a 48 V, DC power system. Fencing and a fire suppression system is recommended for the new shelter.

Crane Ridge
A new generator, commercial power improvements, a new ground system and upgraded HVAC have been recently completed at this site.

6.7.2 Alameda County - Northwest Radio Sites

Glenn Dyer/APL (Prime)
Radio system equipment is currently installed at the Glenn Dyer site. AECOM recommends relocating this site to the Alameda Power and Light (APL) Building. The APL site shares a generator with the building. AECOM recommends installation of an independent generator and a tower analysis.

Seneca
The site needs a new 60 ft. tower and a new shelter to support the EBRCS requirements. A geotechnical survey is recommended prior to installation of the new tower. As part of the shelter installation, the site will need a generator and fuel tank installed. The new generator and fuel tank will need a new foundation and grounding system.

UC Berkeley
EBRCSA is investigating a move of the currently planned Lawrence Berkeley Labs site to the UC Berkeley site. The UC Berkeley site requires a 60 ft new tower, a new shelter and associated utilities work. The new shelter should include required upgrades to commercial power, a new generator and a 48 V DC power system. Development of the site including geotechnical surveys, ground preparation, parking and fencing is required. An existing tower and shelter on the site is not adequate for a public safety communications site.

Skyline
This is an FAA site and tower. The plan is to use the existing tower (no structural analysis is planned) and install a new building for the EBRCS. The new building requires upgrades to commercial power, a new generator and a 48 V, DC power system. No grading, fencing or other facilities upgrades are required.

Gwin
No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades, or Towers are required. Alarm system work is required.

6.7.3 Alameda County - Southwest Radio Sites

Fremont PD
A 20' Extension needs to be added to the existing tower. A tower analysis is required for the extension. The commercial electrical service at the site requires minor work to support the new 48 V, DC power system and to connect to the new generator. Alarm system work is required.

Garin
A 20' Extension needs to be added to the existing tower. A tower analysis is required for the extension. A new small shelter (8’ X 16’) has been installed at the site. An upgrade to the existing commercial electrical service is required. Site is owned by the City of Hayward.

San Leandro Hills (Prime)
This site has already been installed. An upgrade of the current commercial electrical service to an 800 Amp service is underway. Site grounding is being improved and a structural analysis of the state tower to support microwave dishes has been completed.

Warm Springs BART
This site is being built in conjunction with the construction of a new BART station. A new 150 ft monopole and a new 10x20 shelter (including a generator and 48 v, DC power system) are being added to the site.

Coyote Hills
Alameda GSA has purchased a new shelter for the site. New commercial service, grounding, generator, electrical distribution and HVAC work is underway. A tower analysis to include the installation of a new 700 MHz antenna system is recommended.

Walpert
No Site Development, Equipment Enclosures, Emergency Generators, or Towers are required. A Motorola contract is in place for a new shelter and generator. The commercial power at the site is being upgraded from 100 to 200 Amps. Alarm System work is required. A structural analysis of the existing tower is recommended. The site is owned by City of Hayward.

Hayward PD
Alarm system work is required. A structural analysis of the existing tower is recommended. For purposes of cost estimation it has been assumed that a generator and a 48 V, DC power system is required to address power issues at the site. The site is owned by City of Hayward.

Niles Canyon
This is a Greenfield site and a location for this site has not been identified. It has been assumed that a new tower and shelter will be required. It has also been assumed that site development and systems such as alarm systems, generators and 48 V, DC power systems will be required.

6.7.4 Contra Costa County - Central Radio Sites

Harbor View Martinez (Prime)
A lease agreement is being negotiated with the Martinez Police Department for the use of this site. A tower analysis is recommended for the existing tower before new EBRCS antenna systems are mounted. Alarm system work is required. An upgrade to existing commercial power, a generator and a 48 V, DC power system is required. It has been assumed that grounding and HVAC upgrades will also be required.

Cummings
No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades or Towers are required. Alarm system work is required.

Kregor
This site is utilized in both the Contra Costa Central and East simulcast cells. No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades or Towers are required. Alarm system work for the Central simulcast cell is required.

Sydney
This is a green field site with an existing Water Tower that needs a new tower solution. Space on the site is limited by the wooden water tank and close proximity of residential neighborhood. EBRCSA is investigating possible use of PGE electrical tower adjacent to the site. It has been assumed that a new 30 foot tower and a shelter with associated electrical systems (Generator, 48 V, DC power system, etc.) are required based on uncertainty regarding the electrical tower and site conditions.

Bald
This site is “Site ready” and new microwave equipment has already been installed. New microwave dishes are to be mounted. LMR equipment will be installed at a later date. Alarm system work is required. For cost estimation purposes it has been assumed that a tower structural analysis and site grounding will be required.

Peters Ranch
This is a Greenfield site located of the same property as an existing water tower. It has been assumed that a new tower (30 ft. monopole) and shelter will be required. It has also been assumed that site development and systems such as alarm systems, generators and 48 V, DC power systems will be required.

Highland
A new tower and shelter are in the process of being installed. Commercial power and alarm system work is required at the site.

Alta Mesa Moraga
The site is currently being used by commercial wireless providers. It has been assumed that a new 30 foot tower and a shelter with associated electrical systems (Generator, 48 V, DC power system, etc.) are required. An alarm system is needed at the site. Upgrades to existing commercial power and fencing are also required.

Crockett-COW
A location for this site has not been identified. Contra Costa County and EBRCSA are planning to implement the site as a Cell-site On Wheels (COW) with a 90ft crank up tower.

6.7.5 Contra Costa County - East Radio Sites

Kregor
This site is utilized in both the Contra Costa Central and East simulcast cells. No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades or Towers are required. Alarm system work for the East simulcast cell is required.

Shadybrook
A tower analysis of the four 16 ft monopoles will be required to determine if they are suitable for EBRCS use. An existing shelter on the site will require an alarm system, a new generator and a 48 V, DC power system. An upgrade to the existing commercial electrical service is also required.

Los Vaqueros
This is a Greenfield site and a location for this site has not been identified. It has been assumed that a new tower and shelter will be required. It has also been assumed that site development and systems such as alarm systems, generators and 48 V, DC power systems will be required.

Marsh Creek
This site is located at the Marsh Creek Detention Center. A new tower and shelter are required. Site development and systems such as alarm systems, generators and 48 V, DC power systems are also required.

Fire Station 53
This site is located at the old Contra Costa County Fire, Fire Station 53 building. A new 35 ft. monopole tower is required at the site. An upgrade to existing commercial power and a new small shelter with associated systems (alarm systems, generators and 48 V, DC power systems, etc.) are also required.

6.7.6 Contra Costa County - West Radio Sites

Turquoise

No Site Development, Equipment Enclosures, Site Power Upgrades, Towers, or Alarm System work is required. For cost estimation purposes it has been assumed that a back-up generator and upgrades to existing commercial power will be required.

El Cerrito PD (10900 San Pablo)

No Site Development, Equipment Enclosures, Emergency Generators, Site Power Upgrades, Towers, or Alarm System work is required.

Pearl

No Site Development, Equipment Enclosures, Emergency Generators, Towers, or Alarm System work is required. We have assumed that some commercial power and site grounding work may be required at this site.

Nichol Knob (Prime)

No Site Development, Equipment Enclosures, Emergency Generators, Towers, or Alarm System work is required. We have assumed that some commercial power work may be required at this site.

7.0 Migration and Training Plans

7.1 Migration Schedule

The schedule presented in the section represents the current plan for implementation of the EBRCS. This plan considers the work already completed by the EBRCSA, logistical requirements of EBRCSA member agencies and financial considerations. The following schedule was developed in coordination with the EBRCSA Executive Director:

Milestone	Completion Date
Master Site Installation	2006
Microwave installation	June 2010
IP Upgrade	June 2010
West Contra Costa Cell	June 2010
Eastern Alameda County Cell	September 2010
Northwestern Alameda County cell	June 2011
Southwestern Alameda County Cell	December 2011
Contra Costa Central Cell	June 2012
Contra Costa Eastern Cell	December 2012
Stand Alone Sites	2013- 2015

7.2 Implementation/Migration Plan

This section describes the methodology in transitioning EBRCSA member agencies from the current mix of VHF, UHF and 800 MHz radio systems to a two county wide 700/800 MHz P25, Phase 2 system. AECOM recommends a phased approach to the implementation plan. The transition will be accomplished in phases beginning with Phase 0 and ending with Phase 7. The Implementation Plan will take approximately 5 years to fully execute.

The migration of the current systems in Alameda and Contra Costa Counties from the present mix of technologies to a P25 compliant 700/800 MHz system is a large undertaking and requires a multi-phased approach. A phased approach combined with a good understanding of the current radio systems will help to maintain interoperability and operational effectiveness throughout the implementation process. Each of the phases is listed below and is described in detail in subsequent sections of this report. It should also be noted that most of the phases will overlap with one another.

Phase 0 - Network Implementation
Phase 1 - Contra Costa West
Phase 2 - Alameda East
Phase 3 - Alameda Northwest
Phase 4 - Alameda Southwest
Phase 5 - Contra Costa Central
Phase 6 - Contra Costa East
Phase 7 - Standalone Sites

Phase 0, Network Implementation: Phase 0 will create a foundation for the successful implementation and cutover of member agencies in each geographical region as they come into service in Alameda and Contra Costa Counties. Ideally, technical elements such as area wide completion of the microwave network and the IP Upgrades can be completed before the first region begins cutover. Realistically, it is critical that these tasks be completed in a region before cutover in order to minimize the impact to public safety communications on the EBRCS after it is placed in service.

Equally important are the planning efforts included in Phase 0. It is critical to establish the fleet map before starting the first cutover. This effort involves determining the plan for assigning both individual and group ID within the EBRCS.

This is a significant task for a large two county system and will require integration of both EBRCSA and BayRICS requirements. Failure to do such planning can result in large scale reprogramming of radios which is financially and logistically unfeasible.

Phases 1-6, Regional Cutovers: The cutover of each region will be based primarily on the completion of the simulcast system serving the region but many other significant tasks are also required. Without the installation and/or distribution of radios and operational consoles to support them, the completion of the simulcast system will not be sufficient for most member agencies to cutover to the new system. In the following section we will identify the member agencies that will utilize the system in a region, summarize the technical efforts required to complete the system in the region and review the logistical steps required for the successful cutover of the region.

Phase 7, Standalone Sites: In the final phase of the project, sites designed to fill holes in coverage will be implemented. At the beginning of this phase most of the EBRCSA member agencies will be utilizing the network as their primary means of radio communications and interoperability. The installation of these sites will have much less impact on radio communications than in the previous phases. The need or lack of need for these sites will become much clearer as the phase begins and adjustments can be made at that time.

7.2.1 Phase 0: Network Implementation

System Management is a large part of Network Implementation. Member agencies need to be aware of how the physical systems, user radios, and other assets will be managed in a two county shared communications environment.

A. System Programming

System infrastructure including the Master site, dispatch centers, connectivity network, and tower sites all require configuration and programming. This is most effectively accomplished from a “master plan”. The plan is set up according to JPA objectives but flexibly accommodates member agency requirements. We envision this task be directed from central location (either EBRCSA or Alameda and Contra Costa Counties) by an “expert” with peer personnel in each region. Representatives must be established for individual or groups of member agencies.

Examples of system programming controls include important characteristics such as:

- Fleet map
- Talk groups
- Channel
- Names and aliases
- Wide area operation
- County, district, region calling structure

B. User Radio Programming

Similar to the infrastructure side, user radios require programming. This is similar to channel programming in today’s radios. This activity will be done on a much more frequent basis than system programming. Therefore, personnel will need to be available at the county level to perform this task. It is not a difficult activity, but people need to be trained and managers need to plan for the costs of manpower including employee salary and benefits.

User radio programming will present unique issues for EBRCSA because member agencies are responsible for their user equipment. Guidelines and requirements for radio programming should be established by the Operations Committee. These requirements must be enforced through the management systems for the infrastructure.

Over the air programming (OTAR) included with modern systems, greatly eases the task of maintaining radio programming. The task is handled on a batch basis via radio link without requiring users to bring radios to the shop. This saves time and cost. Radio programming controls characteristics such as:

- Access permissions for each radio on the system
- Radio settings; channels and talkgroups
- Radio feature characteristics

C. Advanced Features

Systems planned for the EBRCS offer advanced features, some of which may be new and useful to member agencies. As expected, time and effort is required of the administrative staff to set up these features on the system and radios. Some of the more important features are listed below:

- Telephone interconnect - access the telephone system from a radio – useful in areas of poor cellular coverage
- User priority – the ability to prioritize access to the system in time of system congestion
- Emergency button – single button alert to dispatch of officer emergency situation
- Conventional channel talk groups - the ability to share a conventional channel without having to listen to unrelated traffic
- Encryption – prevents eavesdropping on communications – useful for SWAT teams
- Individual call – the ability to call a single user for a private conversation
- Text message – one-to one short messages - similar to cellular service

7.2.2 Implementation Considerations

These considerations apply to Phase 1 –7. The migration is very complex and must be carefully planned in order to appear substantially seamless to the users. Motorola should be required to develop detailed transition and cutover plans that include these elements:

- Frequency/channel plan
- Size of migrating contingent
- Capacity of the phase to absorb users
- Interference aspects
- Inclusion of new users after project phase is completed
- Location of installation and maintenance facilities
- Phased and orderly timeline
- Talk-group Development
- Installation Schedule
- Removal and Disposition of Existing Equipment (including reuse)
- Transition Schedule
- Decommissioning and Disposition of Legacy Sites & Equipment

During the transition of a particular area, cut-over will be by agency. Detailed transition/cutover plans will need to be developed that will address these and other issues. The plans must be in compliance with the established schedule.

The transition and cutover plans should also be in compliance with the phased schedules as approved. We expect that agencies will begin cutover as each area is brought up to the desired coverage level of 95%. In addition, it is possible that minimal “outside the phase” construction may be required to accommodate operational concerns.

After the transition and cutover plans are approved, Motorola should be required to update and revise these plans as necessary when conditions change, and in no case less than semi-annually. The updated and

revised plans should be submitted for approval by the Executive Director and/or the Operations and Finance Committees.

Motorola will work with the Operations Committee in a series of meetings and review cycles to minimize the impact of transition and cutover on each member agency, while bringing that agency on-line in an expedient manner consistent with the agency's operational situation.

Test Plan Development

The design specification will include the acceptance plan requirements and the preparation of the test plan. The Operations Committee will need to review and approve Motorola's test procedures, which are prepared in response to the acceptance test specification. This is an important step to enforce compliance with the design specifications in accordance with the contract. AECOM envisions that testing will include Factory Staging, as well as field tests after completion of implementation. The test procedures should be provided well in advance of each planned test event. In addition, independent testing may be desirable to confirm the acceptance test results.

Acceptance Inspection and Testing

The acceptance phase entails the period beginning with the LMR subsystems and other major component staging tests, includes inspection of the installation at each site, and ends with the acceptance after cutover. We would expect that acceptance testing and cutover will be accomplished in each region. Additional tests will be performed for the acceptance of each region. These tests would demonstrate inter-area communications, roaming and other wide-area functions. Finally, there would be testing to demonstrate inter-zone communications and uniform functionality and operations on a statewide scale.

Staging Tests

In general, staging is done at Motorola's facility. Since major elements of the overall system have been installed, the following requirements should be applied to major system components such as the Contra Costa East simulcast system before they are shipped to EBRCSA.

A written analysis of punch list items identified during these tests should be prepared. AECOM recommends that both the Operations and Finance Committees provide representation at the staging tests.

We encourage some of the acceptance testing to be done in a staging area, such that design problems are identified while Motorola can easily address them.

Facility and Infrastructure Inspections

Each site must be inspected to determine that the equipment and facilities are installed in a professional and competent manner. Items requiring attention will then be documented in an inspection punch list. The vendor will be required to resolve each punch list item prior to beginning the field acceptance tests.

Acceptance Tests

Acceptance testing in each region will need to be closely monitored and overseen. These tests will address three specific test areas:

1. Fixed Infrastructure
2. Interference
3. Coverage

Motorola will be responsible for the actual testing of the fixed infrastructure and interference. AECOM recommends that the Operations Committee require the test setup to be adequate and appropriate, and that testing is done according to the acceptance test plan and detailed procedures. AECOM further recommends

that each test team be composed of at least two members – one from EBRCSA and one from Motorola. EBRCSA personnel will witness the infrastructure tests, and will spot check specific equipment tests to determine that devices tested in the factory or shop have been properly documented.

Coverage Acceptance Testing

AECOM recommends that coverage testing be done independently using AECOM's **Radio Coverage Evaluator** (**RaCE**[SM]) to perform delivered audio quality (DAQ) based testing. DAQ measures system coverage performance the same way users do, by the quality of the sound they hear coming from the speaker. Other popular coverage testing methods including received signal strength indication (RSSI) and bit error rate (BER) depend on correlations between measured values and the quality of the audio signal.

AECOM's patented RaCE[SM] (U.S. Patent # 7,522,978 B2) provides non-invasive, end-to-end, two-way evaluation of communications systems using automated voice test calls to measure DAQ understandability. These voice test calls are made while simultaneously measuring RSSI and BER received at the mobile test radio. A key advantage of RaCE[SM] is the fact that this technology minimizes the human subjectivity present in traditional voice quality coverage testing. AECOM has overcome these common voice testing barriers by providing an impartial, automated method for coverage testing that dramatically reduces the number of personnel and the time required to perform the test. RaCE[SM] automated voice coverage testing not only provides a consistent, reliable, repeatable evaluation, but it also provides our engineers with the data needed to analyze EBRCS coverage the way users will be using it – with the human voice.

Test Report

Motorola should be required to provide the draft test results within one week after completion of the acceptance tests. The project management team will analyze the results, and provide a written report recommending acceptance or rejection of the tests or any portion of the tests.

During acceptance test time, the vendor generally will be pressed with many alignment and minor implementation tasks. In turn, the owner typically feels a strong pressure by users for acceptance and to get it operational.

We consider it critically important to conduct the acceptance tests in a calm, methodical way, rejecting pressures by either the vendor or user community to expedite any aspect of the acceptance process. This requires a strong project manager on the EBRCSA's side, who can deal not only with Motorola but also with member agency personnel.

Thirty-Day Operational Tests

We recommend that the design specification include a mandatory 30-day operational test to evaluate performance reliability in each area prior to acceptance.

During this time, no adjustments or repairs would be allowed without permission from EBRCSA, and all failures and problems would be documented and analyzed. Operations Committee personnel will need to be available to monitor the thirty-day tests, and observe cutover.

Review Record (As-Built) Drawings

At the completion of implementation for each region, Motorola will provide as-built drawings. This documentation must be reviewed to prove to the project management team's satisfaction that the format and content is sufficient to enable qualified technicians to maintain the system in a straightforward and competent manner.

Monitor/Coordinate Training

The types and levels of training are covered in Section 7.3. It is critical that the Operations Committee not only review Motorola's training plans, but also monitor the training as it is administered to ensure its adequacy and completeness.

EBRCS Wide Testing

At the completion of the construction and implementation of all areas within a region, additional tests will be performed to demonstrate compliance with the design specifications. Region-wide communications between areas should be demonstrated. Communications with and between other regions should be demonstrated.

Automatic roaming within the region (between areas) as well as to and from adjacent regions should also be part of these tests. Uniform functionality and compatibility of subscriber equipment within the region, as well as with the standards for the system, should be part of the final acceptance test in each region.

7.2.3 Phase 1: CCCO West

The first area scheduled to become operational in the EBRCS is the Contra Costa West region. The simulcast cell serving the region is scheduled for completion in June 2010. The Turquoise, El Cerrito PD, Pearl Ridge and Nichol Knob sites are installed. Contra Costa County has submitted applications for 800 MHz NPSPAC frequencies. A key milestone in this phase will be obtaining the licenses from the FCC.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of El Cerrito
2. City of Hercules
3. City of Kensington
4. City of Pinole
5. City of Richmond
6. City of San Pablo
7. Rodeo/Hercules Fire

In addition, cutover planning should also include users in the western Contra Costa area from the following member agencies:

1. Contra Costa County (Sheriff, Fire and others)
2. CALTRANS
3. EBMUD
4. East Bay Parks

Two planned dispatch centers are located in this region, Richmond and Pinole. Our understanding is that the Richmond dispatch center will not immediately move to the EBRCS. The Pinole dispatch center has grant funding in place and must be included in the cutover plans for the city.

Dispatch support for county-wide (Contra Costa County Sheriff's Department and Contra Costa Fire) and area-wide (CALTRANS, EBMUD and East Bay Parks) will first be addressed in this phase. If at all possible, the dispatch centers for these agencies should be established in Phase 1. Provisions for supporting users on the EBRCS and existing systems will be required until all users in a member agency are cutover to the EBRCS.

7.2.4 Phase 2: ALCO East

The Alameda County East region is scheduled to become operational in December 2010. Equipment has already been installed at the Doolan and Sunol sites and each site requires the installation of two additional channels. The Patterson Pass and East Dublin BART sites are being developed and upgraded. Radio

equipment for these sites has not been ordered. AECOM is working on behalf of EBRCSA to license 700 and 800 MHz frequencies for the simulcast system.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of Dublin
2. City of Livermore
3. City of Pleasanton
4. Alameda County (Sheriff, Fire and others)
5. CALTRANS
6. EBMUD
7. EB Parks

Four dispatch centers are located in this region. Five operator positions each have been ordered for the Livermore and Pleasanton Police Departments dispatch centers. Three consoles have been upgraded at the Alameda County Office of Emergency Services in Dublin. Eight Alameda County Fire Department consoles have been upgraded in the dispatch center at Lawrence Livermore Labs. Nine new operator positions are planned when ALCO Fire moves its dispatch center to Sierra Court.

7.2.5 Phase 3: ALCO NW

The Alameda County Northwest region is scheduled to become operational in June 2011. New prime site equipment is required at the APL site to create the ALCO Northwest simulcast cell. Equipment currently located at the Glenn Dyer Jail will be moved to APL to complete the site. A similar move will be required for equipment located at the Lawrence Berkeley National Lab (LBNL) site to the UC Berkeley site upon completion of the Berkeley site. The Skyline and Seneca sites are being developed and upgraded. The APL, Skyline and UC Berkeley sites will each require the addition of six channels if all projected member agencies join the system. Radio equipment for the Seneca site has not been ordered. AECOM is working on behalf of EBRCSA to license 700 and 800 MHz frequencies for the simulcast system.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of Alameda
2. City of Albany
3. City of Berkley
4. City of Emeryville
5. City of Oakland
6. City of Piedmont
7. UC Berkeley
8. Alameda County (Sheriff, Fire and others)
9. CALTRANS
10. EBMUD
11. EB Parks

Nine dispatch centers are located in this region. The City of Oakland has two dispatch centers each to be equipped with 15 new operator positions, Oakland Police and Fire. The dispatch centers for Albany, Emeryville, UC Berkeley and Piedmont Police will each receive two new operator positions. The City of Berkeley Police will receive a major installation of eight new operator positions. Five operator positions have been upgraded in the City of Alameda's dispatch center and must be cutover to the EBRCS as part of Alameda's user cutover. East Bay MUD's dispatch center (two new operator positions) will be installed during this phase if it has not already been installed.

7.2.6 Phase 4: ALCO SW

The seven site simulcast system to serve the Southwest region of Alameda County is scheduled for completion in December 2011. AECOM is working on behalf of EBRCSA to license 700 and 800 MHz

frequencies for the simulcast system. All sites are receiving varying degrees of upgrades to their electrical distribution and backup systems. The Garin, Warm Springs BART, Coyote Hills and Walpert sites are getting new shelters. Twenty foot tower extensions are being added to the Fremont PD and Garin sites. Tower structural analysis is recommended for the San Leandro Hills and Hayward PD sites.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of Fremont
2. City of Hayward
3. City of Newark
4. City of San Leandro
5. City of Union City
6. Alameda County (Sheriff, Fire and others)
7. CALTRANS
8. EBMUD
9. EB Parks

The southwestern Alameda County region is served by seven dispatch centers operated by EBRCSA member agencies. Five of these dispatch centers have Motorola Gold Elite consoles which have been upgraded to operate on the new EBRCS. A cutover plan must be generated for all of these dispatch centers as part of the cutover process for their respective member agencies. The Newark PD and San Leandro Hills dispatch centers each have three upgraded consoles. Four console operator positions have been upgraded in the Alameda County Sheriff's and Union City PD dispatch centers. The largest number of upgraded console operator positions (9) is located in the Freemont PD dispatch center.

Three dispatch centers in the region are scheduled to receive new Motorola MCC 7500 console operator positions. The Alameda County Sheriff's dispatch center will receive five new operator positions in addition to the four upgraded positions. The Hayward PD dispatch center will receive seven new operator positions. The East Bay Parks dispatch center is scheduled to receive three new operator positions which may be installed prior to this phase to support their distributed user base.

7.2.7 Phase 5: CCCO Central

The largest region in terms of the number of sites and member agencies served is Contra Costa Central. This region is scheduled for completion in June 2012. AECOM is working on behalf of EBRCSA to license 700 and 800 MHz frequencies for the simulcast system. The Sydney and Peters Ranch sites are greenfield sites which will require extensive planning and development. At the opposite end of the spectrum are the Cummings, Kregor, and Bald sites which are "site ready" to receive radio equipment. A new tower and shelter are in the process of being installed at the Highland site. The Harbor View and Alta Mesa Moraga sites require extensive site work before equipment can be installed.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of Clayton
2. City of Concord
3. City of Danville
4. City of Lafayette
5. City of Martinez
6. City of Moraga
7. City of Orinda
8. City of Pleasant Hill
9. City of San Ramon
10. City of Walnut Creek
11. Moraga/Orinda Fire District
12. San Ramon Valley Fire

13. Contra Costa County (Sheriff, Fire and others)
14. CALTRANS
15. EBMUD
16. East Bay Parks

The six dispatch centers in this region will all receive new MCC 7500 console operator positions. The Contra Costa County Sherriff's dispatch center will receive twenty operator positions. It is likely that a number of those positions will be operational before this phase to support the users in the West Contra Costa region. Martinez PD and Pleasant Hill will each receive two operator positions in their dispatch centers. The other major dispatch operations in Concord and Walnut Creek will receive eight and six new positions respectively. Seven new operator positions are also scheduled for Contra Costa Fire.

7.2.8 Phase 6: CCCO East

The last region to come on line in the EBRCS is Contra Costa East. This region is scheduled for completion in December 2012. AECOM is working on behalf of EBRCSA to license 700 and 800 MHz frequencies for this three site simulcast system. The Kregor site is "site" ready for installation of radio equipment and microwave equipment is already installed. Shadybrook requires significant development. A location for the Los Vaqueros site has not been finalized.

Details for the cutover of the following member agencies must be planned in this phase:

1. City of Antioch
2. City of Brentwood
3. City of Oakley
4. City of Pittsburg
5. Contra Costa County (Sheriff, Fire and others)
6. CALTRANS
7. EBMUD
8. East Bay Parks

The Antioch and San Ramon Valley FD dispatch centers will both receive three new MCC 7500 console operator positions.

7.2.9 Phase 7: Standalone Sites

The final phase of implementation for the EBRCS will be the implementation of the standalone trunking sites. These sites are designed to fill in coverage in areas that are not covered by the simulcast systems. These sites will be installed over the years 2013- 2015. AECOM has submitted applications for 800 MHz frequencies for these six sites on behalf of EBRCSA.

Three of the sites are located in Alameda County. The Crane Ridge site requires electrical systems upgrades including a generator and HVAC work. A location for the Niles Canyon site has not been identified. This site will serve a key transportation corridor between east and west Alameda County. The Gwin site in northwestern Alameda County is designed to cover areas in the Oakland Hills. It will require site upgrades and a generator.

In Contra Costa County, the Crockett site is intended to serve the industrial area near the Solano Bridge. A location for this site has not been identified. A plan is in place to implement the site as a COW (Cell-site On Wheels) with a 90ft crank up tower. Two sites lie in the eastern part of the County. The site at the Marsh Creek Detention Facility requires a new tower and shelter. The site at Fire Station 53 also requires a new shelter and a 35ft monopole tower.

7.3 Training

With the design and implementation of a large, two county, P25 radio system, training is paramount to the success of the system. This section discusses the training needs required for the successful implementation of the EBRCS.

7.3.1 Field User Training

It is important that every radio user is trained in the proper use of the radio. Although P25 trunked radios are not overly complex, they will be "different" from what most of the users throughout Alameda and Contra Costa Counties are currently using, and offer many new features to the users. Because of the differences, explicit steps and purposeful actions must be taken to ensure that the field users are trained.

This may be particularly challenging for the EBRCSA since member agencies are responsible for the purchase of their own user gear. We recommend that the JPA work with the member agencies and the P25 radio vendors to create field user training programs in alignment with the recommendations in this section of the report. The collective strength of the member agencies will encourage the radio vendors to participate in the process and create a body of lessons learned information for the end users of the EBRCS. These programs will need to be in place for the duration of the full system implementation to support all member agencies before cutover to the new system.

Training for field radio users should utilize a train-the-trainer approach. Trainers from each agency in the localities would attend this training. Then the agency trainers will train their personnel on all shifts. These trainers will then train new personnel as they are added, as well as provide refresher training.

User training should consist of a brief system overview, basic radio operation for all the radio features utilized for mobiles and portables, as well as which talk groups or channels to use and when they should be used. The users should understand the relationship between the base stations and the coverage areas. They will need to be familiar with trunking operation as well. It is recommended that each member agency have one user train-the-trainer session. The agencies' radio administrator should attend this training and a lead person from each department which will operate radios on the new system. These individuals would then be responsible for training the users in their respective agencies.

Refer to TABLE 7-1 which summarizes the recommended training.

7.3.2 Dispatcher / Operator Training

It is also important that dispatchers receive training on the new radio system and / or console. Formal user training for dispatchers will make the users knowledgeable and comfortable with their communications tools.

If the existing consoles will be utilized on the new radio system, dispatchers will still need to be trained on the new features and functionality, as well as on the new radio system itself. Since the dispatch centers are connected to the microwave system, they will need to learn the operation of a backup radio.

It is important for the console vendor to provide the initial training to every dispatcher. Console operation can be more complicated for a P25 trunked system than for the analog conventional systems that many dispatchers are currently using. Vendor-provided training allows questions to be fully answered and explained, and can provide for a more thorough initial training. When every dispatcher receives training from the vendor, this ensures a thorough foundation for the dispatch operations. Subsequent dispatcher training for new personnel or for refresher training is then accomplished through agency-provided train-the-trainer.

It is recommended that every dispatcher receive operator training. Operator training is conducted on-site on the agency's consoles. There should be two to three people per available console used for training. At a minimum, there should be three to four training sessions per member agency to accommodate all shifts and

people's work schedules. The exact number of training sessions required depends upon the number of dispatchers for each agency.

Refer to TABLE 7-1 which summarizes the recommended training.

7.3.3 Administration Training

Administration and management of a P25 radio system is complex. A successful implementation of the EBRCS will require careful planning of operations at the county level, across member agencies, and for area wide interoperability.

We would recommend that there will be at least two and possibly three system-wide administrators who are responsible for the radio system. It is envisioned that there will be at minimum an administrator per County. In addition we would recommend an administrator at the JPA level who has overall responsibility for the system.

Each county administrator would be responsible for radio operations and management in their county. They would work with the agencies in their jurisdiction to determine the local talk groups per agency, assign individual IDs to each radio, and determine the mobile and portable programming including the features and functionality for radio operation. They would also be able to generate reports on radio system usage for the County or member agencies.

The EBRCSA level administrator would be responsible for coordinating efforts with the county administrators and could serve as a backup for the county administrators. The EBRCSA administrator would also be responsible for coordination with other JPA level administrators or a BayRICS level administrator as BayRICS is implemented and operated.

Radio System Administration Training is very important for the successful implementation of the system. It provides the administrators with the knowledge necessary for planning the operations of the system, as well as the knowledge of how to use the tools required for implementation, such as the database computers and radio programming. Since system-wide planning is important, Administration Training should be early in the implementation schedule. This allows the administrators to appropriately plan for the system as it is being built. It is recommended that this course be held at the factory where all the features and functionality can be demonstrated on a fully-functional system, since their own system may not be implemented. While travel expenses will be incurred, this expense is offset by having a satisfactory training experience.

It is recommended that all administrators attend an Administration Course. This course is typically one week long. Motorola may also offer additional courses (two – three days in duration, typically) that go into more detail on the underlying databases and management tools for the P25 radio system. It is recommended that at minimum the EBRCSA administrator attend such additional courses.

The microwave system is an important piece of the P25 radio system. Both county microwave administrators and the EBRCSA administrator should take a Network Management course on the new Harris Stratex microwave system.

Refer to TABLE 7-1 which summarizes the recommended training.

7.3.4 Maintenance Training

Modern trunked radio systems consist of sophisticated, state-of-the-art, digitally controlled communications equipment. A program of preventative maintenance will be essential to keep it running dependably.

Alameda and Contra Costa Counties are currently self-maintained will continue to be so. Maintenance shop personnel will require special training, and development of expertise in other disciplines may be necessary.

Radio system maintenance courses can be two weeks in length for overall systems maintenance, with base station and mobile / portable maintenance course being typically one week.

Maintenance training is also needed on the new microwave equipment for both counties maintenance shops. This should include training on the network management alarm and diagnostic equipment, the multiplex node equipment, and the microwave radio equipment.

Refer to TABLE 7-1 which summarizes the recommended training.

TABLE 7-1
TRAINING NEEDS

Training Needed	Who Should Attend	Where	Number of Attendees	# of Sessions	Comments
P25 Radio Sytem Training					
Field User Training - Train-the-Trainer	Person responsible for training from every agency, and Administrators	On-Site	At least 1 from every member agency + Administrators	Minimum of 1 per County	These people will then train all users in their agencies
Operator/Console Training	All dispatchers	On-Site	All dispatchers	3 (minimum) per Dispatch Center	2 - 3 dispatchers / console for training. Number of sessions is determined by the number of people to be trained and the number of consoles available for training. Optional for administrators to attend.
System Administration Training	EBRCSA Administrator & County Administrators	Factory	2-3 Administrators	1	Required for all who will administer the radio system
System Manager Training	EBRCSA Administrator & County Administrators	Factory	2-3 Administrators	1	Indepth on the management tools and databases
Alarm and Diagnostic Training	Administrators, Maintenance personnel	Factory or On-Site	2-3 Administrators + 1 maintenance person per qualified service shop	1	Required for all who will manage and operate the system
System Maintenance Training	Administrators, if technical, Maintenance personnel	Factory	2-3 Administrators (if technical) + 1 maintenance person per qualified service shop	1	Required for all who will maintain this equipment
Base Station / Repeater Training	Maintenance personnel	Factory	At least 1 maintenance person per county service shop	1	Required for all who will maintain this equipment
Mobile/ Portable Training (Optional)	Maintenance personnel	Factory	At least 1 maintenance person per county service shop	1	Required for all who will maintain this equipment
Microwave Radio System Training					
Network Management - Provisioning and Alarms	Administrators	Factory	2-3 Administrators	1	Required for all who will administer a local microwave system and alarms
Network Management Alarm and Diagnostic Training	Local Administrator	Factory	2-3 Administrators	1	Required for all who will monitor or manage a local microwave system alarms in a maintenance environment
Microwave Radio Equipment MaintenanceTraining	Maintenance personnel	Factory	1 MW maintenance person from each county	1	Required for all who will maintain this equipment
Multiplexer Node Training	Maintenance personnel	Factory	1 MW maintenance person from each county	1	Required for all who will maintain this equipment

8.0 Detailed Cost Analysis

8.1 Radio Systems Cost Estimate

In order to produce a viable and complete estimate for the EBRCSA project, the estimate was created using three distinct paths:

- Full System Estimate
- System Replacement and Contribution
- Cost to Complete Estimate

Some description is needed to clarify these approaches. The Full System Estimate is created first to produce an estimated value of the project and the associated costs. This estimate is based on the anticipated costs to purchase the system as if nothing existed at this time. This is done to create a starting point in the process and, importantly, these figures are used to anticipate future costs, and these numbers are used in the cost allocation models to be described later. This estimate will be shown below.

The System Replacement Estimates were calculated based on the Full System Estimate. The goal is to estimate the costs the community can expect to bear in fifteen years when replacing the system; and the contributions needed to be set aside by the users to off-set these anticipated costs.

The Cost to Complete Estimate is also based on the Full System Costs but then several factors are applied to the figures. Over the last three year period the Joint Powers Authority (JPA) has moved ahead with many of the items that will be needed in the system and has worked hard to obtain grant and other funding for the project. These items include contracts with Motorola and Harris Stratex for radio and microwave infrastructure, site acquisition and upgrades by Alameda and Contra Costa Counties, installation of infrastructure at many locations in the two county area and financial support through COPS, SHSGP and UASI grants and an earmark. The Cost to Complete Estimate reflects the anticipated costs to obtain the initial system after the items already accounted for are removed from the costs. This estimate will be shown below.

The Full System Estimate and the Cost to Complete Estimate were developed for the major categories of equipment as they apply to the Conceptual System Design for the EBRCSA Project that is described in this report. In brief overview, the System Estimate is applied to the results of the combined efforts of EBRCSA, Motorola and AECOM with a new conceptual system design composed of the following primary elements:

- Six Simulcast Cells comprised of 30 Repeater Sites
- Six Stand Alone Repeater Sites
- IP Based P25 Phase II (TDMA) Technology
- 151 New Dispatch Operator Positions
- 31 Upgraded Dispatch Operator Positions
- A Master Site to provide voice switching and management functionality for the cells, sites and consoles

First, the various costs for this system are compared and weighted in order to derive an average "list price" type of estimate. Estimates reflect expected list pricing.

8.2 Opinions of Probable Costs Radio System

Included in this section are tables reflecting our opinion of the probable costs of the project. These display tables contain elements and categories that drive the reflected cost estimate.

Elements and categories in these tables include:

A. List Estimate
   Items and categories of equipment are applied to the List Costs database that AECOM has created.

B. Negotiated Estimate
We have adjusted the List Costs for the effect of negotiating with a sole source vendor or system integrator. The Lists Costs are reduced by the percentages that we have typically seen in this type procurement.

C. Competitive Estimate
Estimates are further reduced to reflect the cost reduction we have seen in highly competitive procurements.

8.3 Cost Element Categories

These are Categories of equipment that make up the system design and costs. Each of these costs elements are discussed further in this document.

A. Radio Infrastructure
The estimate display for Radio Infrastructure contains several cost elements. These are generally the fixed equipment contained at the transmission and control sites. This includes transmitters, receivers, repeaters, antennas, multicouplers and combiners, voters, and simulcast equipment.

The following assumptions and elements are included:

The number of transmitters and other equipment is based on the number of channels expected to be in use in the expected overall system size for the Year 2025.

Specialized equipment is included for the basic systems.

B. Microwave
This includes microwave radios, microwave antennas, waveguide and other cabling, orderwire, loop and hot standby switches, and DC power supplies; as well as the equivalent costs expected for fiber connectivity.

All of the trunked tower sites are interconnected as a two-countywide communications network through a combination of microwave radio links and leased T1 paths.

The network backbone also interconnects the dispatch operations, radio system administration and maintenance functions, and the public safety information systems such as CAD and records.

The connectivity network is estimated to interconnect the radio sites with the Master Site, Dispatch Centers, and to various other locations within the two county area. This telecommunications subsystem will provide the latest state-of-the-art technology and allow for expansion to accommodate future needs.

C. Physical Facilities
This category is perhaps the most difficult to identify. Contained here are towers, foundations, geotechnical surveys, tower analysis, site clearing, access road paving, security fencing, lighting, shelters, generators, UPS power supplies, HVAC, solar power, utilities connections, and grounding.

The existing facilities at a number of tower site locations have been evaluated. The different sites are in various levels of readiness. The sites will require some development before they are ready to support a system of this complexity. Section 6 of this report provides information regarding the assumed development and upgrades for the sites in the EBRCS. Much of the system's reliability will rely on the sites' condition.

D. Non Fixed Equipment
In this project estimate, the category of Non Fixed equipment applies to the back-up, desk-top control stations employed in the dispatch centers as back up for the console equipment.

E. Vendor Services
Purchasing a communications system is a complex and detailed process. Some of the effort on the part of a major radio retailer and/or a systems integrator would be to outsource those efforts not part of their core business. As would be expected in the outsourcing, the price for the service is escalated with pass through fees and administrative add-ons, as well as risk factors for unanticipated activities.

In the cost estimate there is a category for Vendor Services. This accounts for the expenses experienced by the Vendor to perform procedures for professional engineering, design, project management, and their own verification of performance for these elements to match your requirements.

F. Spares – Non Fixed
This cost element is a simple 1% factor of the value of the Control Stations used as back up for the consoles.

G. Spares - Infrastructure
This cost element is a simple 1% factor of the value of the Fixed Infrastructure costs; including consoles.

H. Contingency
In a project of this size and complexity unexpected occurrences and expenditures will be required. All of the estimates and all of the proposals will be predicated on such terms as “normal soils conditions”, that there will be no zoning appeals and/or delays, suitable access will be available, and other such codicils. While successful and detailed negotiations can assist in protecting the EBCSRA project; there will be the unexpected. In our experience a viable cost element for contingencies set aside should be 10% of the project without the non-fixed element.

8.4 Radio System Cost Summaries

The Radio and Microwave systems estimates are shown in Table 8-1. This wide area design utilizes multiple tower site configurations in various areas of both counties to balance user mobility with adequate channel capacity.

This system includes:

- IP Based P25 Phase II Technology with a system Master Site to provide voice switching and management functionality for the cells, sites and consoles
- Six Simulcast Cells comprised of 30 Repeater Sites
- Six Stand Alone Repeater Sites
- New and Upgraded Dispatch Operator Positions

Radio Systems: FINANCIAL STRATEGY FOR SYSTEM REPLACEMENT AND CONTRIBUTION

The East Bay Regional Communications System Authority (EBRCSA) requires a forecast of the on-going costs for the radio systems in order to make valid decisions on the approach to maintaining and sustaining these systems. The challenge here is to accurately forecast the maintenance and system equipment replacement expenses and to determine how those expenses should be allocated to each of the participating member agencies. The model described herein should not be interpreted as limiting future activities of the Authority to explore alternative funding opportunities, or improved methods of financing system sustainability.

We have applied the following assumptions to our analysis:

- Fees for operations and maintenance support and for future equipment replacement should be billed to the participant member agencies monthly.

- The sustainability model must provide for scheduled replacement of fixed equipment.

- Infrastructure (fixed core equipment) should be replaced on a fifteen year lifecycle.

- A fund will be established for deposit of funds for future fixed equipment replacement. This account should be an interest bearing account. Interest should accrue for application towards future equipment replacement costs. The funds should only be used for equipment replacement purposes or as directed by the Authority.

- Annual budgeted expenses for the System will vary but EBRCSA will strive to balance the fee structure over many years and will make budget projections to help agencies forecast budgetary needs.

- The Replacement and O&M costs should be apportioned equally to all participating member agencies based on their participation ratio.

- O&M services for the systems infrastructure are to be performed by Alameda County GSA, Contra Costa County IT, and Motorola. The fixed equipment that makes up the radio systems infrastructure is inclusive of the dispatch consoles.

- Individual member agencies will be responsible for replacement costs for subscriber equipment requiring lifecycle replacement.

- O&M and programming services for subscriber equipment will be the responsibility of the member agencies.

- Individual member agencies will be responsible for replacement of accessories such as battery chargers, carrying cases, and lapel microphones.

As needs dictate individual member agencies may make additional purchases of subscriber equipment as approved by the EBRCSA Executive Director. These purchases will be at the expense of the individual member agency. However, the expectation is that when additional radios are added the agency participation ratio on which fees will be based shall be adjusted.

The basic cost sharing factor is to be the participation ratio for each individual participating agency. This is a simple calculation of the number of subscriber units authorized for use by that agency compared to the total number of subscriber units authorized system wide. This ratio is used throughout the estimates.

The cost forecasts will require modification as real time system operation information is gained in the coming years. At this time, however, we must rely on experience gained in other environments and make many assumptions as to the cost factors.

8.5 Fixed Infrastructure O&M Costs – Radio and Consoles

The sustainability model that follows assumes that all participating member agencies are equally responsible for the costs associated with maintaining the core system components and that these costs should be apportioned based on the participation ratio.

Fixed (Core System) Maintenance

This estimate was created using a past experience method. The cost factors associated with infrastructure O&M costs include contracts parts usage and spare parts. This category is inclusive of spare parts, tools, instruments and other equipment required to service the fixed infrastructure. Dispatch console systems are calculated as part of this category. All consoles are considered.

The cost projections are based on information known today. Actual costs may be different and will require analysis and adjustment as part of the annual budget process. These costs will become part of the annual budget.

Table 8-2 displays the estimate to maintain the radio and microwave systems for the second through the fifth years of service. The first year is included as warranty service in the initial estimates. The costs are then compared to the number of users and the participation ratio is applied.

This produces a system maintenance user contribution of $15.25 per unit, per month.

Fixed Replacement

EBRCSA should anticipate that the core equipment will be replaced during the fifteen years life time expressed herein. To calculate this anticipated expense we have taken the cost estimate for the Fixed Infrastructure – Radio (including consoles), Microwave, Spares, and Services; and added an inflation factor of 1.75% compounded for fifteen years. This produced a 15-year Fixed Replacement cost estimate of $85,176,700. Additionally, we calculated the interest that might accrue to funds deposited over this same period estimating a conservative 2.0% monthly rate of return on deposits made quarterly. Interest earned on these funds has the effect of decreasing the overall capital investment that might otherwise be required to replace equipment at the end of its lifecycle. The member agency participation ratio is applied to the annual installment.

AECOM recommends that EBRCSA update these forecasts annually and adjust the cost recovery fees as necessary to account for fluctuation in rates of inflation, interest, or expected future cost for fixed equipment replacement.

Today's analysis projects a need to save $85,176,700 to cover future replacement costs and that to do so will require quarterly deposits of $1,219,700 apportioned according to the agency participation ratio.

This produces a system replacement user contribution of $19.25 per unit, per month. Finally through this analysis we conclude that in order to recover costs for radio systems infrastructure maintenance, replacement of fixed equipment on a 15-year lifecycle, and to provide subscriber maintenance services, EBRCSA will need to collect a monthly subscriber fee of $34.50. In addition, individual agencies will remain ultimately responsible for their future subscriber equipment replacement costs.

8.6 Cost to Complete Estimate

As stated above the Cost to Complete Estimate is based on the Full System Estimate costs described after several reductions are applied to the estimate. During the last three years EBRCSA has obtained many of the items that are needed in the system; and have also obtained grant and other funding for the project that have already been applied to the required infrastructure. The Cost to Complete Estimate reflects the anticipated costs to obtain the initial system after these items are removed for the costs.

In this estimate as well the major categories of equipment apply to the System Design for the EBRCSA Project. The various costs required to complete this system are compared and weighted in order to derive an average "list price" type of estimate as in the previous estimates. Estimates reflect expected list pricing.

Elements and categories shown in the Cost to Complete include:

- List Estimate
- Negotiated Estimate
- Competitive Estimate

The Categories of equipment that make up the system design and costs are:

- Radio Infrastructure
- Microwave
- Physical Facilities
- Non Fixed Equipment
- Vendor Services
- Install and Test Previous Equipment
- Spares – Non Fixed
- Spares - Infrastructure
- Contingency

- Phase 2 System Software and Hardware Upgrade

8.7 Radio System Cost Summaries

The Radio and Microwave Cost to complete estimates are shown in Table 8-3.

TABLE 8-1
OPINION OF PROBABLE COST
FULL SYSTEM ESTIMATE

	LIST ESTIMATE		NEGOTIATED ESTIMATE		COMPETITIVE ESTIMATE	
RADIO INFRASTRUCTURE	100%	$ 26,754,800	85%	$ 22,741,600	75%	$ 20,066,100
MICROWAVE	100%	$ 20,302,900	90%	$ 18,272,600	90%	$ 18,272,600
RADIO CONSOLE	100%	$ 7,487,600	85%	$ 6,364,500	75%	$ 5,615,700
PHYSICAL FACILITIES	100%	$ 9,329,000	85%	$ 7,929,700	75%	$ 6,996,800
NON-FIXED EQUIPMENT	100%	$ 975,000	90%	$ 877,500	90%	$ 877,500
VENDOR SERVICES	100%	$ 11,497,400	85%	$ 9,772,800	75%	$ 8,623,100
PHASE 1 SYSTEM SOFTWARE UPGRADE	100%	$ -	90%	$ -	90%	$ -
PHASE 2 SYSTEM SOFTWARE & HARDWARE UPGRADE	100%	$ -	90%	$ -	90%	$ -
SPARES - NON FIXED	100%	$ 9,800	100%	$ 9,800	100%	$ 9,800
SPARES - INFRASTRUCTURE	100%	$ 638,700	100%	$ 638,700	100%	$ 638,700
CONTINGENCY	100%	$ 6,387,400	90%	$ 5,748,700	80%	$ 5,109,900
TOTAL		**$ 83,382,600**		**$ 72,355,900**		**$ 66,210,200**

TABLE 8-2
OPINION OF PROBABLE COST
FULL SYSTEM MAINTENANCE ESTIMATE

	LIST ESTIMATE	NEGOTIATED ESTIMATE	COMPETITIVE ESTIMATE
LMR MAINTENANCE COST			
YEAR 2	$ 3,170,700	$ 3,113,000	$ 3,042,000
YEAR 3	$ 3,268,300	$ 3,211,400	$ 3,140,400
YEAR 4	$ 3,369,100	$ 3,313,100	$ 3,241,900
YEAR 5	$ 3,472,600	$ 3,417,700	$ 3,346,500
MICROWAVE MAINTENANCE COST			
YEAR 2	$ 322,800	$ 290,600	$ 290,600
YEAR 3	$ 329,400	$ 296,400	$ 296,400
YEAR 4	$ 335,700	$ 302,100	$ 302,100
YEAR 5	$ 342,200	$ 308,000	$ 308,000
TOTAL	**$ 14,610,800**	**$ 14,252,300**	**$ 13,967,900**

TABLE 8-3
OPINION OF PROBABLE COST
COST TO COMPLETE SYSTEM ESTIMATE

COST ELEMENTS	LIST ESTIMATE			NEGOTIATED ESTIMATE			COMPETITIVE ESTIMATE		
RADIO INFRASTRUCTURE	100%	$	18,484,100	85%	$	16,266,000	75%	$	14,787,300
MICROWAVE	100%	$	2,044,900	90%	$	2,044,900	90%	$	1,859,000
RADIO CONSOLE	100%	$	4,703,100	85%	$	4,138,700	75%	$	3,762,500
PHYSICAL FACILITIES	100%	$	3,990,200	90%	$	3,990,200	90%	$	3,627,500
NON-FIXED EQUIPMENT	100%	$	975,000	85%	$	804,400	75%	$	731,300
VENDOR SERVICES	100%	$	6,035,300	85%	$	5,311,000	75%	$	4,828,200
INSTALL & TEST PREVIOUS EQUIPMENT	100%	$	2,328,000	100%	$	2,328,000	100%	$	2,328,000
SPARES - NON FIXED	100%	$	9,800	100%	$	9,800	100%	$	9,800
SPARES - INFRASTRUCTURE	100%	$	268,200	100%	$	268,200	100%	$	268,200
CONTINGENCY	100%	$	3,750,000	90%	$	3,375,000	80%	$	3,000,000
TOTAL		**$**	**42,588,600**		**$**	**38,536,200**		**$**	**35,201,800**
FUTURE REQUIREMENTS	**LIST**			**NEGOTIATED**			**COMPETITIVE**		
PHASE 2 SYSTEM SOFTWARE & HARDWARE UPGRADE	100%	$	5,200,000	100%	$	5,200,000	100%	$	5,200,000

9.0 Conclusions & Recommendations

As a result of the reviews and design efforts that serve as a foundation for this report, we have concluded that the original EBRCS conceptual system design was fundamentally sound. Like many other projects of similar scope, refinement of the design to address capacity and coverage issues are required to successfully fulfill the requirements of the EBRCSA's member agencies. This fact should not take away from the praise that should be given to the leadership of the EBRCSA for its foresight, vision and success in funding such a large project. Motorola should also be recognized for their willingness to work so closely with EBRCSA since the beginning of the project.

Advances in P25 technology since the EBRCS project began in 2006 are proving to be very beneficial for the EBRCSA. The advent of IP based technology allows EBRCSA to leverage knowledge gained from member agency Information Technology (IT) to provide high quality service and maintenance for the radio network at reduced costs. P25 Phase 2 TDMA technology (available in 2012) increases the traffic capacity available in the network without the need for additional frequency resources which are scarce in the Bay Area. This additional capacity helps EBRCSA meet the increasing demand for service from its member agencies while keeping costs in control.

We also have concluded that the original budget estimates for the EBRCS project were appropriate and accurate. Our opinion of the probable cost to complete the project, included in this report, supports this conclusion. The estimate takes into account the purchases and efforts already completed and those that must still be made to fully realize the new conceptual system design. When the cost to complete is combined with the amount expended to date, the sum falls well within the accuracy that could be expected in the original budget estimates. This is an excellent outcome which correctly anticipated changes that could not be foreseen at the beginning of the project.

Our cost estimation efforts also support the conclusion that the planned User-Based Subscriber Fee is a good approach to funding operations, maintenance and capital improvements for the anticipated 15 year life of the new EBRCS system. The per user fee information calculated in this report demonstrates that the final user fee determined by the EBRCSA Board of Directors is in line with those we have seen for projects of similar scope.

The progress we have seen on the EBRCS is impressive and we believe that the future of the system will be bright. The EBRCS will demonstrably improve communications for member agencies and improve interoperability in the East Bay area for years to come.

9.1 Recommendations

This section makes recommendations on a roadmap for a radio system that will meet the needs of the EBRCSA member agencies and that will provide interoperability with the East Bay area and with BayRICS. The scope of work for the project required AECOM to:

1. Review and evaluate proposed Motorola system design.
2. Establish a technical roadmap for full interoperability.
3. Provide a cost to complete analysis to the EBRCSA, leveraging the equipment already purchased, installed and/or staged by EBRCSA to contain cost.
4. Review the proposed conceptual design and provide comments and recommendations based on technology and trend shifts that have occurred in the public safety communications industry.

Because EBRCSA is part of the Bay Area Super Urban Area Security Initiative (SUASI), the goals and vision of the SUASI must be incorporated into the technical roadmap that is developed for the counties of Alameda and Contra Costa.

The recommendations in this section are substantiated by the analysis and documentation provided in the prior sections of this report. EBRCSA should continue to develop consensus among members of EBRCSA to implement

the detailed design of the state of the art P25 Phase 2 radio system as described in this report. Further, EBRCSA should request updated coverage and new simulcast overlap area maps from Motorola. This request should include a request for separate portable usage in light, medium and heavy building maps for each simulcast cell and standalone site.

EBRCSA should develop and adopt detailed plans, assuming a 15 year life span, including projected replacement costs, and census driven growth predictions prior to executing a phased approach to implementing the two county 700/800 MHz P25 Phase 2 system. The design adopted by EBRCSA should also include each of the recommendations which follow below.

Phases of this project should be based on the implementation and cutover of an entire simulcast cell and/or individual stand alone sites. Eight phases will be required to complete the process in 5 years and phases may overlap. Independent coverage testing should be completed at the end of each phase. A mandatory 30-day operational test to evaluate the performance reliability in each region prior to acceptance should be included in the project specification. Roaming tests should also be conducted in adjacent cells, as completed, and in the system as whole once complete.

The JPA should work with the member agencies and the P25 radio vendors to create field user training programs. Train-the-trainer sessions should be completed for each member agency. The recipients of this training would then serve their agencies in training the users of each department.

A minimum of two system administrators should be assigned who will be responsible for day to day administration of the radio system. To address operation considerations, however, we recommend there be a minimum of one administrator per County, and one representative of the EBRCSA.

It is recommended that EBRCSA upgrade current P25 equipment to IP-based technology as soon as possible. In order to meet EBRCSA operational requirements and FCC narrow banding requirements the EBRCS must be Phase 2 compliant in 2012.

Beginning immediately, all radios purchased for operation on the EBRCS must be capable of upgrade to P25 Phase 2 operation. P25 Phase 1 radios will have a significant impact on system loading. We recommend that incentives be created for replacing P25 Phase 1 radios as soon as possible. These incentives should account for the investments made by the member agencies. We also recommend limiting the number of Phase 1 only radios operating on the system after 2014 and prohibiting Phase 1 operations after 2019.

It is of utmost importance that EBRCSA re-license the 800 MHz frequencies for existing simulcast systems and acquire 700 MHz licenses as soon as possible upon acceptance of the recommended system design. EBRCSA should continue to pursue licensing of 700 MHz and 800 MHz relinquished frequencies, recognizing the use of new frequencies will make the process of cutover easier for member agencies.

Section 6 of this report summarizes the upgrades needed for sites within EBRCSA to include access, power, shelters, towers, etc. EBRCSA should continue existing site upgrades already scheduled and in progress, as well as, any upgrades necessary prior to the build out of the P25 Phase 2 network.

EBRCSA should implement AECOM's recommendations to upgrade the microwave system to provide additional redundancy. Implementation of the microwave network design described in this report will improve reliability for the wide area network by decreasing network latency and provides path redundancy (i.e. a ring) for the dispatch centers in the Alameda County area.

Establishment of a centralized alarm, provisioning management platform, and surveillance center for the entire microwave network is critical for overall system performance and reliability. Centralized circuit provisioning and monitoring is essential, especially with a MPLS or ATM network. Multiple equipment alarm management systems may be layered into a high order network management system such as HP Open View.

This network has the potential to support a broadband wireless data technology, such as LTE, to serve public safety in both counties. Careful consideration of bandwidth requirements and further evaluation may be required prior to future implementation of a data network.

EBRCSA should continue development of financial plans for funding the completion of the radio system and on-going maintenance costs. AECOM recommends that EBRCSA update budget forecasts annually and adjust the cost recovery fees as necessary to account for fluctuation in rates of inflation, interest, or expected future cost for fixed equipment replacement. EBRCSA should continue to aggressively look for grant funding opportunities to pay for the completion of the EBRCSA P25 radio system. The EBRCSA has done a good job to date of securing assets and funding while meeting operational and financial models.

EBRCSA should make a determination on the status of the City of Oakland's participation in EBRCSA as soon as possible. This will facilitate future budget and project planning that will address any impacts the City of Oakland's decision may have upon EBRCSA.

The EBRCSA has done an outstanding job of planning for and implementing a P25 system to fulfill the communications and interoperability requirements of its member agencies while minimizing the financial impact to those agencies. By accepting the recommendations of this report, EBRCSA will be able to build on the success they have already achieved and deliver a state of the art P25 Phase 2 TDMA network to meeting the communications requirements of the public safety community in Alameda and Contra Costa Counties for many years into the future.

Appendix A Site by Site Analysis

Erlang C Calculator Basic Version - ALCO East

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.5%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**2889**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	2932	**20%**	586	**0%**	0	**1.3**	**4.9**	5.9	762.32	4497.7	**5**	1.2494	0.97%	52.96%	0.513%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**5**	**6**
2012	2976	**14%**	417	**30%**	893	**1.3**	**4.9**	5.9	541.632	3195.6	**4**	0.8877	1.37%	59.01%	0.807%	1160.64	6847.8	**6**	3	1.9022	1.44%	49.93%	0.717%	**7**	**8**
2013	3021	**12%**	363	**50%**	1511	**1.3**	**4.9**	5.9	471.276	2780.5	**4**	0.7724	0.85%	57.87%	0.491%	1963.65	11585.5	**8**	4	3.2182	1.91%	44.46%	0.848%	**8**	**9**
2014	3066	**10%**	307	**70%**	2146	**1.3**	**4.9**	5.9	398.58	2351.6	**4**	0.6532	0.47%	56.71%	0.268%	2790.06	16461.4	**10**	5	4.5726	2.09%	39.86%	0.834%	**9**	**10**
2015	3112	**8%**	249	**92%**	2863	**1.3**	**4.9**	5.9	323.648	1909.5	**3**	0.5304	1.78%	65.80%	1.169%	3721.952	21959.5	**12**	6	6.0999	2.52%	36.79%	0.927%	**9**	**10**
2016	3159	**7%**	221	**93%**	2938	**1.3**	**4.9**	5.9	287.469	1696.1	**2**	0.4711	8.98%	77.17%	6.932%	3819.231	22533.5	**13**	7	6.2593	1.34%	31.90%	0.427%	**9**	**10**
2017	3206	**6%**	192	**94%**	3014	**1.3**	**4.9**	5.9	250.068	1475.4	**2**	0.4098	6.97%	76.37%	5.323%	3917.732	23114.6	**13**	7	6.4207	1.63%	32.79%	0.533%	**9**	**10**
2018	3254	**5%**	163	**95%**	3091	**1.3**	**4.9**	5.9	211.51	1247.9	**2**	0.3466	5.12%	75.56%	3.869%	4018.69	23710.3	**13**	7	6.5862	1.97%	33.72%	0.663%	**9**	**10**
2019	3303	**4%**	132	**96%**	3171	**1.3**	**4.9**	5.9	171.756	1013.4	**2**	0.2815	3.47%	74.73%	2.595%	4122.144	24320.6	**13**	7	6.7557	2.37%	34.70%	0.823%	**9**	**10**
2020	3353	**3%**	101	**97%**	3252	**1.3**	**4.9**	5.9	130.767	771.5	**2**	0.2143	2.07%	73.89%	1.533%	4228.133	24946.0	**14**	7	6.9294	1.31%	30.17%	0.394%	**9**	**10**
2021	3403	**2%**	68	**98%**	3335	**1.3**	**4.9**	5.9	88.478	522.0	**1**	0.1450	14.50%	86.51%	12.544%	4335.422	25579.0	**14**	7	7.1053	1.60%	31.08%	0.496%	**8**	**9**
2022	3454	**1%**	35	**99%**	3419	**1.3**	**4.9**	5.9	44.902	264.9	**1**	0.0736	7.36%	85.47%	6.290%	4445.298	26227.3	**14**	7	7.2853	1.94%	32.04%	0.622%	**8**	**9**
2023	3506	**0%**	0	**100%**	3506	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4557.8	26891.0	**14**	7	7.4697	2.35%	33.06%	0.778%	**7**	**8**
2024	3559	**0%**	0	**100%**	3559	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4626.7	27297.5	**14**	7	7.5826	2.64%	33.70%	0.889%	**7**	**8**
2025	3612	**0%**	0	**100%**	3612	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4695.6	27704.0	**15**	8	7.6956	1.40%	29.00%	0.407%	**8**	**9**

Enter data in the highlighted cells only. Adjust the number of channels until the delayed-call GOS meets system requirements, typically 1 percent for a public-safety system. You can determine the number of channels required for each group by adjusting the number of channels in the row for each group. All users and calls are totalled on the bottom row. Adjusting the number of channels in that row gives you the requirement for the entire system. Additional rows can easily be inserted by copying and inserting an existing row.

The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - ALCO Northwest

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**0.7%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**8505**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	8565	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	8624	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	8685	**0%**	0	**50%**	4343	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	5645.25	33307.0	**16**	8	9.2519	3.12%	31.86%	0.994%	**8**	**9**
2014	8746	**0%**	0	**70%**	6122	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	7958.86	46957.3	**21**	11	13.0437	2.95%	25.96%	0.766%	**11**	**12**
2015	8807	**0%**	0	**92%**	8102	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	10533.172	62145.7	**26**	13	17.2627	3.42%	22.74%	0.777%	**13**	**14**
2016	8869	**0%**	0	**93%**	8248	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	10722.621	63263.5	**26**	13	17.5732	4.12%	23.97%	0.988%	**13**	**14**
2017	8931	**0%**	0	**94%**	8395	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	10913.682	64390.7	**27**	14	17.8863	3.04%	21.34%	0.649%	**14**	**15**
2018	8993	**0%**	0	**95%**	8543	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	11106.355	65527.5	**27**	14	18.2021	3.68%	22.51%	0.829%	**14**	**15**
2019	9056	**0%**	0	**96%**	8694	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	11301.888	66681.1	**28**	14	18.5225	2.73%	20.06%	0.548%	**14**	**15**
2020	9119	**0%**	0	**97%**	8845	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	11499.059	67844.4	**28**	14	18.8457	3.32%	21.19%	0.703%	**14**	**15**
2021	9183	**0%**	0	**98%**	8999	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	11699.142	69024.9	**28**	14	19.1736	4.01%	22.40%	0.899%	**14**	**15**
2022	9248	**0%**	0	**99%**	9156	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	11902.176	70222.8	**29**	15	19.5063	3.02%	20.01%	0.605%	**15**	**16**
2023	9312	**0%**	0	**100%**	9312	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	12105.6	71423.0	**29**	15	19.8397	3.66%	21.17%	0.776%	**15**	**16**
2024	9377	**0%**	0	**100%**	9377	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	12190.1	71921.6	**29**	15	19.9782	3.96%	21.67%	0.858%	**15**	**16**
2025	9443	**0%**	0	**100%**	9443	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	12275.9	72427.8	**29**	15	20.1188	4.28%	22.20%	0.950%	**15**	**16**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - ALCO Southwest

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**0.7%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**4447**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	4478	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	4509	**14%**	631	**30%**	1353	**1.3**	**4.9**	5.9	820.638	4841.8	**5**	1.3449	1.31%	53.82%	0.703%	1758.51	10375.2	**8**	4	2.8820	1.03%	42.00%	0.434%	**9**	**10**
2013	4541	**12%**	545	**50%**	2271	**1.3**	**4.9**	5.9	708.396	4179.5	**5**	1.1610	0.72%	52.17%	0.374%	2951.65	17414.7	**11**	6	4.8374	1.20%	35.19%	0.423%	**11**	**12**
2014	4573	**10%**	457	**70%**	3201	**1.3**	**4.9**	5.9	594.49	3507.5	**5**	0.9743	0.34%	50.54%	0.173%	4161.43	24552.4	**13**	7	6.8201	2.54%	35.08%	0.891%	**12**	**13**
2015	4605	**8%**	368	**92%**	4237	**1.3**	**4.9**	5.9	478.92	2825.6	**4**	0.7849	0.90%	57.99%	0.520%	5507.58	32494.7	**16**	8	9.0263	2.55%	30.67%	0.782%	**12**	**13**
2016	4637	**7%**	325	**93%**	4312	**1.3**	**4.9**	5.9	421.967	2489.6	**3**	0.6916	3.58%	67.62%	2.419%	5606.133	33076.2	**16**	8	9.1878	2.95%	31.52%	0.930%	**11**	**12**
2017	4670	**6%**	280	**94%**	4390	**1.3**	**4.9**	5.9	364.26	2149.1	**3**	0.5970	2.43%	66.55%	1.619%	5706.74	33669.8	**17**	9	9.3527	1.73%	27.36%	0.475%	**12**	**13**
2018	4702	**5%**	235	**95%**	4467	**1.3**	**4.9**	5.9	305.63	1803.2	**2**	0.5009	10.03%	77.56%	7.781%	5806.97	34261.1	**17**	9	9.5170	2.02%	28.13%	0.569%	**11**	**12**
2019	4735	**4%**	189	**96%**	4546	**1.3**	**4.9**	5.9	246.22	1452.7	**2**	0.4035	6.77%	76.29%	5.169%	5909.28	34864.8	**17**	9	9.6847	2.35%	28.94%	0.681%	**11**	**12**
2020	4768	**3%**	143	**97%**	4625	**1.3**	**4.9**	5.9	185.952	1097.1	**1**	0.3048	30.48%	88.88%	27.088%	6012.448	35473.4	**17**	9	9.8537	2.73%	29.78%	0.812%	**10**	**11**
2021	4802	**2%**	96	**98%**	4706	**1.3**	**4.9**	5.9	124.852	736.6	**1**	0.2046	20.46%	87.39%	17.881%	6117.748	36094.7	**17**	9	10.0263	3.16%	30.67%	0.968%	**10**	**11**
2022	4835	**1%**	48	**99%**	4787	**1.3**	**4.9**	5.9	62.855	370.8	**0**	0.1030	0.00%	101.76%	0.000%	6222.645	36713.6	**18**	9	10.1982	1.91%	26.65%	0.508%	**9**	**10**
2023	4869	**0%**	0	**100%**	4869	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	6329.7	37345.2	**18**	9	10.3737	2.22%	27.46%	0.610%	**9**	**10**
2024	4903	**0%**	0	**100%**	4903	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	6373.9	37606.0	**18**	9	10.4461	2.37%	27.79%	0.658%	**9**	**10**
2025	4938	**0%**	0	**100%**	4938	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	6419.4	37874.5	**18**	9	10.5207	2.52%	28.15%	0.709%	**9**	**10**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - CCCO Central

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**3043**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	3073	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	3104	**14%**	435	**30%**	931	**1.3**	**4.9**	5.9	564.928	3333.1	**4**	0.9259	1.58%	59.39%	0.936%	1210.56	7142.3	**6**	3	1.9840	1.74%	50.63%	0.880%	**7**	**8**
2013	3135	**12%**	376	**50%**	1568	**1.3**	**4.9**	5.9	489.06	2885.5	**4**	0.8015	0.96%	58.15%	0.561%	2037.75	12022.7	**9**	5	3.3396	0.80%	38.31%	0.307%	**9**	**10**
2014	3167	**10%**	317	**70%**	2217	**1.3**	**4.9**	5.9	411.71	2429.1	**3**	0.6747	3.36%	67.43%	2.263%	2881.97	17003.6	**11**	6	4.7232	1.02%	34.51%	0.351%	**9**	**10**
2015	3198	**8%**	256	**92%**	2942	**1.3**	**4.9**	5.9	332.592	1962.3	**3**	0.5451	1.91%	65.96%	1.260%	3824.808	22566.4	**13**	7	6.2684	1.35%	31.95%	0.433%	**10**	**11**
2016	3230	**7%**	226	**93%**	3004	**1.3**	**4.9**	5.9	293.93	1734.2	**2**	0.4817	9.35%	77.31%	7.229%	3905.07	23039.9	**13**	7	6.4000	1.59%	32.67%	0.518%	**9**	**10**
2017	3263	**6%**	196	**94%**	3067	**1.3**	**4.9**	5.9	254.514	1501.6	**2**	0.4171	7.20%	76.47%	5.504%	3987.386	23525.6	**13**	7	6.5349	1.85%	33.43%	0.620%	**9**	**10**
2018	3295	**5%**	165	**95%**	3130	**1.3**	**4.9**	5.9	214.175	1263.6	**2**	0.3510	5.24%	75.62%	3.963%	4069.325	24009.0	**13**	7	6.6692	2.16%	34.20%	0.737%	**9**	**10**
2019	3328	**4%**	133	**96%**	3195	**1.3**	**4.9**	5.9	173.056	1021.0	**1**	0.2836	28.36%	88.57%	25.119%	4153.344	24504.7	**13**	7	6.8069	2.50%	35.00%	0.877%	**8**	**9**
2020	3361	**3%**	101	**97%**	3260	**1.3**	**4.9**	5.9	131.079	773.4	**1**	0.2148	21.48%	87.54%	18.806%	4238.221	25005.5	**14**	7	6.9460	1.33%	30.25%	0.403%	**8**	**9**
2021	3395	**2%**	68	**98%**	3327	**1.3**	**4.9**	5.9	88.27	520.8	**1**	0.1447	14.47%	86.50%	12.514%	4325.23	25518.9	**14**	7	7.0886	1.57%	30.99%	0.485%	**8**	**9**
2022	3429	**1%**	34	**99%**	3395	**1.3**	**4.9**	5.9	44.577	263.0	**0**	0.0731	0.00%	101.25%	0.000%	4413.123	26037.4	**14**	7	7.2326	1.83%	31.76%	0.583%	**7**	**8**
2023	3463	**0%**	0	**100%**	3463	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4501.9	26561.2	**14**	7	7.3781	2.14%	32.55%	0.697%	**7**	**8**
2024	3498	**0%**	0	**100%**	3498	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4547.4	26829.7	**14**	7	7.4527	2.31%	32.97%	0.763%	**7**	**8**
2025	3533	**0%**	0	**100%**	3533	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	4592.9	27098.1	**14**	7	7.5273	2.50%	33.38%	0.833%	**7**	**8**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - CCCO East

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**1935**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	1954	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	1974	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	1994	**0%**	0	**50%**	997	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1296.1	7647.0	**7**	4	2.1242	0.66%	43.76%	0.291%	**4**	**5**
2014	2014	**0%**	0	**70%**	1410	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1832.74	10813.2	**8**	4	3.0037	1.30%	42.88%	0.559%	**4**	**5**
2015	2034	**0%**	0	**92%**	1871	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2432.664	14352.7	**9**	5	3.9869	2.33%	42.76%	0.997%	**5**	**6**
2016	2054	**0%**	0	**93%**	1910	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2483.286	14651.4	**10**	5	4.0698	0.99%	36.60%	0.362%	**5**	**6**
2017	2075	**0%**	0	**94%**	1951	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2535.65	14960.3	**10**	5	4.1556	1.13%	37.14%	0.421%	**5**	**6**
2018	2095	**0%**	0	**95%**	1990	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2587.325	15265.2	**10**	5	4.2403	1.29%	37.67%	0.487%	**5**	**6**
2019	2116	**0%**	0	**96%**	2031	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2640.768	15580.5	**10**	5	4.3279	1.48%	38.24%	0.564%	**5**	**6**
2020	2137	**0%**	0	**97%**	2073	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2694.757	15899.1	**10**	5	4.4164	1.68%	38.81%	0.652%	**5**	**6**
2021	2159	**0%**	0	**98%**	2116	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2750.566	16228.3	**10**	5	4.5079	1.91%	39.42%	0.754%	**5**	**6**
2022	2180	**0%**	0	**99%**	2158	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2805.66	16553.4	**10**	5	4.5982	2.17%	40.03%	0.867%	**5**	**6**
2023	2202	**0%**	0	**100%**	2202	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2862.6	16889.3	**10**	5	4.6915	2.45%	40.67%	0.998%	**5**	**6**
2024	2224	**0%**	0	**100%**	2224	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2891.2	17058.1	**11**	6	4.7384	1.04%	34.60%	0.360%	**6**	**7**
2025	2246	**0%**	0	**100%**	2246	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	2919.8	17226.8	**11**	6	4.7852	1.11%	34.88%	0.389%	**6**	**7**

Enter data in the highlighted cells only. Adjust the number of channels until the delayed-call GOS meets system requirements, typically 1 percent for a public-safety system. You can determine the number of channels required for each group by adjusting the number of channels in the row for each group. All users and calls are totalled on the bottom row. Adjusting the number of channels in that row gives you the requirement for the entire system. Additional rows can easily be inserted by copying and inserting an existing row.

The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - CCCO West

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**0.4%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**2258**	**15%**	339	**0%**	0	**1.3**	**4.9**	5.9	440.31	2597.8	**4**	0.7216	0.67%	57.37%	0.384%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**4**	**5**
2011	2267	**20%**	453	**0%**	0	**1.3**	**4.9**	5.9	589.42	3477.6	**5**	0.9660	0.33%	50.47%	0.167%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**5**	**6**
2012	2276	**14%**	319	**30%**	683	**1.3**	**4.9**	5.9	414.232	2444.0	**4**	0.6789	0.54%	56.96%	0.308%	887.64	5237.1	**5**	3	1.4547	1.79%	54.83%	0.979%	**7**	**8**
2013	2285	**12%**	274	**50%**	1143	**1.3**	**4.9**	5.9	356.46	2103.1	**3**	0.5842	2.30%	66.40%	1.526%	1485.25	8763.0	**7**	4	2.4342	1.35%	46.12%	0.622%	**7**	**8**
2014	2294	**10%**	229	**70%**	1606	**1.3**	**4.9**	5.9	298.22	1759.5	**2**	0.4887	9.60%	77.40%	7.429%	2087.54	12316.5	**9**	5	3.4212	0.93%	38.85%	0.362%	**7**	**8**
2015	2304	**8%**	184	**92%**	2120	**1.3**	**4.9**	5.9	239.616	1413.7	**2**	0.3927	6.45%	76.15%	4.908%	2755.584	16257.9	**10**	5	4.5161	1.93%	39.48%	0.764%	**7**	**8**
2016	2313	**7%**	162	**93%**	2151	**1.3**	**4.9**	5.9	210.483	1241.8	**2**	0.3450	5.07%	75.54%	3.833%	2796.417	16498.9	**10**	5	4.5830	2.12%	39.93%	0.847%	**7**	**8**
2017	2322	**6%**	139	**94%**	2183	**1.3**	**4.9**	5.9	181.116	1068.6	**1**	0.2968	29.68%	88.76%	26.348%	2837.484	16741.2	**10**	5	4.6503	2.32%	40.38%	0.938%	**6**	**7**
2018	2331	**5%**	117	**95%**	2214	**1.3**	**4.9**	5.9	151.515	893.9	**1**	0.2483	24.83%	88.04%	21.861%	2878.785	16984.8	**11**	6	4.7180	1.01%	34.48%	0.348%	**7**	**8**
2019	2341	**4%**	94	**96%**	2247	**1.3**	**4.9**	5.9	121.732	718.2	**1**	0.1995	19.95%	87.31%	17.419%	2921.568	17237.3	**11**	6	4.7881	1.12%	34.89%	0.391%	**7**	**8**
2020	2350	**3%**	71	**97%**	2280	**1.3**	**4.9**	5.9	91.65	540.7	**1**	0.1502	15.02%	86.59%	13.006%	2963.35	17483.8	**11**	6	4.8566	1.24%	35.30%	0.436%	**7**	**8**
2021	2359	**2%**	47	**98%**	2312	**1.3**	**4.9**	5.9	61.334	361.9	**0**	0.1005	0.00%	101.72%	0.000%	3005.366	17731.7	**11**	6	4.9255	1.36%	35.72%	0.486%	**6**	**7**
2022	2369	**1%**	24	**99%**	2345	**1.3**	**4.9**	5.9	30.797	181.7	**0**	0.0505	0.00%	100.86%	0.000%	3048.903	17988.5	**11**	6	4.9968	1.50%	36.15%	0.543%	**6**	**7**
2023	2378	**0%**	0	**100%**	2378	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	3091.4	18239.3	**11**	6	5.0665	1.65%	36.58%	0.604%	**6**	**7**
2024	2388	**0%**	0	**100%**	2388	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	3104.4	18316.0	**11**	6	5.0878	1.70%	36.71%	0.623%	**6**	**7**
2025	2397	**0%**	0	**100%**	2397	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	3116.1	18385.0	**11**	6	5.1069	1.74%	36.83%	0.642%	**6**	**7**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - Firestation 53

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**274**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	277	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	280	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	282	**0%**	0	**50%**	141	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	183.3	1081.5	**3**	2	0.3004	0.37%	63.28%	0.235%	**2**	**3**
2014	285	**0%**	0	**70%**	200	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	259.35	1530.2	**3**	2	0.4250	0.97%	64.63%	0.630%	**2**	**3**
2015	288	**0%**	0	**92%**	265	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	344.448	2032.2	**4**	2	0.5645	0.28%	55.86%	0.156%	**2**	**3**
2016	291	**0%**	0	**93%**	271	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	351.819	2075.7	**4**	2	0.5766	0.30%	55.98%	0.169%	**2**	**3**
2017	294	**0%**	0	**94%**	276	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	359.268	2119.7	**4**	2	0.5888	0.33%	56.09%	0.183%	**2**	**3**
2018	297	**0%**	0	**95%**	282	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	366.795	2164.1	**4**	2	0.6011	0.35%	56.21%	0.197%	**2**	**3**
2019	300	**0%**	0	**96%**	288	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	374.4	2209.0	**4**	2	0.6136	0.38%	56.33%	0.213%	**2**	**3**
2020	303	**0%**	0	**97%**	294	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	382.083	2254.3	**4**	2	0.6262	0.41%	56.45%	0.229%	**2**	**3**
2021	306	**0%**	0	**98%**	300	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	389.844	2300.1	**4**	2	0.6389	0.44%	56.57%	0.247%	**2**	**3**
2022	309	**0%**	0	**99%**	306	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	397.683	2346.3	**4**	2	0.6518	0.47%	56.69%	0.265%	**2**	**3**
2023	312	**0%**	0	**100%**	312	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	405.6	2393.0	**4**	2	0.6647	0.50%	56.82%	0.285%	**2**	**3**
2024	315	**0%**	0	**100%**	315	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	409.5	2416.1	**4**	2	0.6711	0.52%	56.88%	0.295%	**2**	**3**
2025	318	**0%**	0	**100%**	318	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	413.4	2439.1	**4**	2	0.6775	0.54%	56.94%	0.306%	**2**	**3**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values.

Erlang C Calculator Basic Version - Crockett

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**595**	**15%**	89	**0%**	0	**1.3**	**4.9**	5.9	116.025	684.5	**3**	0.1902	0.10%	62.11%	0.063%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**3**	**4**
2011	601	**20%**	120	**0%**	0	**1.3**	**4.9**	5.9	156.26	921.9	**3**	0.2561	0.24%	62.81%	0.149%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**3**	**4**
2012	607	**14%**	85	**30%**	182	**1.3**	**4.9**	5.9	110.474	651.8	**3**	0.1811	0.09%	62.02%	0.054%	236.73	1396.7	**3**	2	0.3880	0.76%	64.23%	0.487%	**5**	**6**
2013	613	**12%**	74	**50%**	307	**1.3**	**4.9**	5.9	95.628	564.2	**2**	0.1567	1.14%	73.17%	0.833%	398.45	2350.9	**4**	2	0.6530	0.47%	56.71%	0.267%	**4**	**5**
2014	619	**10%**	62	**70%**	433	**1.3**	**4.9**	5.9	80.47	474.8	**2**	0.1319	0.82%	72.86%	0.594%	563.29	3323.4	**4**	2	0.9232	1.56%	59.36%	0.927%	**4**	**5**
2015	625	**8%**	50	**92%**	575	**1.3**	**4.9**	5.9	65	383.5	**2**	0.1065	0.54%	72.55%	0.391%	747.5	4410.3	**5**	3	1.2251	0.89%	52.74%	0.472%	**5**	**6**
2016	632	**7%**	44	**93%**	588	**1.3**	**4.9**	5.9	57.512	339.3	**1**	0.0943	9.43%	85.77%	8.084%	764.088	4508.1	**5**	3	1.2523	0.98%	52.98%	0.518%	**4**	**5**
2017	638	**6%**	38	**94%**	600	**1.3**	**4.9**	5.9	49.764	293.6	**1**	0.0816	8.16%	85.58%	6.980%	779.636	4599.9	**5**	3	1.2777	1.06%	53.21%	0.565%	**4**	**5**
2018	644	**5%**	32	**95%**	612	**1.3**	**4.9**	5.9	41.86	247.0	**1**	0.0686	6.86%	85.40%	5.859%	795.34	4692.5	**5**	3	1.3035	1.15%	53.44%	0.615%	**4**	**5**
2019	651	**4%**	26	**96%**	625	**1.3**	**4.9**	5.9	33.852	199.7	**1**	0.0555	5.55%	85.21%	4.727%	812.448	4793.4	**5**	3	1.3315	1.25%	53.70%	0.674%	**4**	**5**
2020	657	**3%**	20	**97%**	637	**1.3**	**4.9**	5.9	25.623	151.2	**1**	0.0420	4.20%	85.01%	3.570%	828.477	4888.0	**5**	3	1.3578	1.36%	53.94%	0.732%	**4**	**5**
2021	664	**2%**	13	**98%**	651	**1.3**	**4.9**	5.9	17.264	101.9	**1**	0.0283	2.83%	84.82%	2.400%	845.936	4991.0	**5**	3	1.3864	1.47%	54.20%	0.799%	**4**	**5**
2022	670	**1%**	7	**99%**	663	**1.3**	**4.9**	5.9	8.71	51.4	**1**	0.0143	1.43%	84.61%	1.208%	862.29	5087.5	**5**	3	1.4132	1.59%	54.45%	0.867%	**4**	**5**
2023	677	**0%**	0	**100%**	677	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	880.1	5192.6	**5**	3	1.4424	1.73%	54.72%	0.944%	**3**	**4**
2024	684	**0%**	0	**100%**	684	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	889.2	5246.3	**5**	3	1.4573	1.80%	54.86%	0.986%	**3**	**4**
2025	691	**0%**	0	**100%**	691	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	898.3	5300.0	**6**	3	1.4722	0.43%	46.42%	0.200%	**3**	**4**

Enter data in the highlighted cells only. Adjust the number of channels until the delayed-call GOS meets system requirements, typically 1 percent for a public-safety system. You can determine the number of channels required for each group by adjusting the number of channels in the row for each group. All users and calls are totalled on the bottom row. Adjusting the number of channels in that row gives you the requirement for the entire system. Additional rows can easily be inserted by copying and inserting an existing row.

The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - Marsh Creek

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**443**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	447	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	452	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	456	**0%**	0	**50%**	228	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	296.4	1748.8	**3**	2	0.4858	1.40%	65.30%	0.915%	**2**	**3**
2014	461	**0%**	0	**70%**	323	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	419.51	2475.1	**4**	2	0.6875	0.57%	57.04%	0.322%	**2**	**3**
2015	466	**0%**	0	**92%**	429	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	557.336	3288.3	**4**	2	0.9134	1.51%	59.27%	0.893%	**2**	**3**
2016	470	**0%**	0	**93%**	437	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	568.23	3352.6	**4**	2	0.9313	1.61%	59.44%	0.956%	**2**	**3**
2017	475	**0%**	0	**94%**	447	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	580.45	3424.7	**5**	3	0.9513	0.31%	50.35%	0.156%	**3**	**4**
2018	480	**0%**	0	**95%**	456	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	592.8	3497.5	**5**	3	0.9715	0.34%	50.52%	0.171%	**3**	**4**
2019	485	**0%**	0	**96%**	466	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	605.28	3571.2	**5**	3	0.9920	0.37%	50.70%	0.188%	**3**	**4**
2020	489	**0%**	0	**97%**	474	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	616.629	3638.1	**5**	3	1.0106	0.40%	50.86%	0.204%	**3**	**4**
2021	494	**0%**	0	**98%**	484	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	629.356	3713.2	**5**	3	1.0314	0.44%	51.04%	0.223%	**3**	**4**
2022	499	**0%**	0	**99%**	494	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	642.213	3789.1	**5**	3	1.0525	0.48%	51.22%	0.244%	**3**	**4**
2023	504	**0%**	0	**100%**	504	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	655.2	3865.7	**5**	3	1.0738	0.52%	51.40%	0.266%	**3**	**4**
2024	509	**0%**	0	**100%**	509	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	661.7	3904.0	**5**	3	1.0845	0.54%	51.50%	0.278%	**3**	**4**
2025	514	**0%**	0	**100%**	514	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	668.2	3942.4	**5**	3	1.0951	0.56%	51.59%	0.290%	**3**	**4**

Enter data in the highlighted cells only. Adjust the number of channels until the delayed-call GOS meets system requirements, typically 1 percent for a public-safety system. You can determine the number of channels required for each group by adjusting the number of channels in the row for each group. All users and calls are totalled on the bottom row. Adjusting the number of channels in that row gives you the requirement for the entire system. Additional rows can easily be inserted by copying and inserting an existing row.

The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - Niles Canyon

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**0.7%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**873**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	879	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	885	**14%**	124	**30%**	266	**1.3**	**4.9**	5.9	161.07	950.3	**2**	0.2640	3.08%	74.51%	2.293%	345.15	2036.4	**4**	2	0.5657	0.28%	55.87%	0.158%	**4**	**5**
2013	891	**12%**	107	**50%**	446	**1.3**	**4.9**	5.9	138.996	820.1	**1**	0.2278	22.78%	87.73%	19.985%	579.15	3417.0	**5**	3	0.9492	0.31%	50.33%	0.154%	**4**	**5**
2014	898	**10%**	90	**70%**	629	**1.3**	**4.9**	5.9	116.74	688.8	**1**	0.1913	19.13%	87.19%	16.682%	817.18	4821.4	**5**	3	1.3393	1.28%	53.77%	0.690%	**4**	**5**
2015	904	**8%**	72	**92%**	832	**1.3**	**4.9**	5.9	94.016	554.7	**1**	0.1541	15.41%	86.64%	13.350%	1081.184	6379.0	**6**	3	1.7719	1.04%	48.84%	0.506%	**4**	**5**
2016	910	**7%**	64	**93%**	846	**1.3**	**4.9**	5.9	82.81	488.6	**1**	0.1357	13.57%	86.37%	11.722%	1100.19	6491.1	**6**	3	1.8031	1.12%	49.10%	0.552%	**4**	**5**
2017	917	**6%**	55	**94%**	862	**1.3**	**4.9**	5.9	71.526	422.0	**1**	0.1172	11.72%	86.10%	10.093%	1120.574	6611.4	**6**	3	1.8365	1.22%	49.38%	0.604%	**4**	**5**
2018	923	**5%**	46	**95%**	877	**1.3**	**4.9**	5.9	59.995	354.0	**1**	0.0983	9.83%	85.83%	8.439%	1139.905	6725.4	**6**	3	1.8682	1.32%	49.64%	0.657%	**4**	**5**
2019	930	**4%**	37	**96%**	893	**1.3**	**4.9**	5.9	48.36	285.3	**1**	0.0793	7.93%	85.55%	6.780%	1160.64	6847.8	**6**	3	1.9022	1.44%	49.93%	0.717%	**4**	**5**
2020	936	**3%**	28	**97%**	908	**1.3**	**4.9**	5.9	36.504	215.4	**0**	0.0598	0.00%	101.02%	0.000%	1180.296	6963.7	**6**	3	1.9344	1.55%	50.20%	0.778%	**3**	**4**
2021	943	**2%**	19	**98%**	924	**1.3**	**4.9**	5.9	24.518	144.7	**0**	0.0402	0.00%	100.68%	0.000%	1201.382	7088.2	**6**	3	1.9689	1.68%	50.50%	0.848%	**3**	**4**
2022	949	**1%**	9	**99%**	940	**1.3**	**4.9**	5.9	12.337	72.8	**0**	0.0202	0.00%	100.34%	0.000%	1221.363	7206.0	**6**	3	2.0017	1.81%	50.78%	0.918%	**3**	**4**
2023	956	**0%**	0	**100%**	956	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1242.8	7332.5	**6**	3	2.0368	1.96%	51.08%	0.999%	**3**	**4**
2024	963	**0%**	0	**100%**	963	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1251.9	7386.2	**7**	4	2.0517	0.55%	43.23%	0.239%	**4**	**5**
2025	969	**0%**	0	**100%**	969	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1259.7	7432.2	**7**	4	2.0645	0.57%	43.32%	0.247%	**4**	**5**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - Crane Ridge

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.5%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	Total Units	Phase I Units	Phase I Units	Phase II Units	Phase II Units	Calls/ Hour/ Unit	Average Call Length (sec)	Total Average Call Length (sec)	Calls/ Hour	Traffic Load (call-sec/hr)	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Calls/ Hour	Traffic Load (call-sec/hr)	Working Talk Paths	Working Channels	Traffic Load (erlangs)	Queuing Grade of Service (Erlang C)	Delayed Call Probability	Delayed-Call Grade of Service	Total Working Channels	Total Channels
2010	**716**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	727	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	738	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	749	**0%**	0	**50%**	375	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	486.85	2872.4	**4**	2	0.7979	0.95%	58.12%	0.552%	**2**	**3**
2014	760	**0%**	0	**70%**	532	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	691.6	4080.4	**5**	3	1.1335	0.65%	51.93%	0.337%	**3**	**4**
2015	771	**0%**	0	**92%**	709	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	922.116	5440.5	**6**	3	1.5112	0.49%	46.73%	0.228%	**3**	**4**
2016	783	**0%**	0	**93%**	728	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	946.647	5585.2	**6**	3	1.5514	0.55%	47.05%	0.260%	**3**	**4**
2017	795	**0%**	0	**94%**	747	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	971.49	5731.8	**6**	3	1.5922	0.63%	47.37%	0.297%	**3**	**4**
2018	807	**0%**	0	**95%**	767	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	996.645	5880.2	**6**	3	1.6334	0.71%	47.71%	0.337%	**3**	**4**
2019	819	**0%**	0	**96%**	786	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1022.112	6030.5	**6**	3	1.6751	0.80%	48.05%	0.383%	**3**	**4**
2020	831	**0%**	0	**97%**	806	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1047.891	6182.6	**6**	3	1.7174	0.90%	48.39%	0.433%	**3**	**4**
2021	843	**0%**	0	**98%**	826	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1073.982	6336.5	**6**	3	1.7601	1.00%	48.74%	0.490%	**3**	**4**
2022	856	**0%**	0	**99%**	847	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1101.672	6499.9	**6**	3	1.8055	1.13%	49.12%	0.555%	**3**	**4**
2023	869	**0%**	0	**100%**	869	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1129.7	6665.2	**6**	3	1.8515	1.27%	49.50%	0.628%	**3**	**4**
2024	882	**0%**	0	**100%**	882	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1146.6	6764.9	**6**	3	1.8792	1.36%	49.74%	0.676%	**3**	**4**
2025	895	**0%**	0	**100%**	895	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	1163.5	6864.7	**6**	3	1.9068	1.45%	49.97%	0.726%	**3**	**4**

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The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Erlang C Calculator Basic Version - Gwin

Project Title	East Bay Regional Comm. System
Comm. No.	60091361
Originator	James Collum
Reviewer	
Reviewer	
Date	
Revision Date	August 10, 2009

Call Overhead (sec)	**1.0**
Allowable Call Delay (sec)	**1.0**
Yearly Growth Rate	**1.0%**
Target Grade of Service	**1%**

									Phase I Units							Phase 2 Units									
Year	**Total Units**	**Phase I Units**	**Phase I Units**	**Phase II Units**	**Phase II Units**	**Calls/ Hour/ Unit**	**Average Call Length (sec)**	**Total Average Call Length (sec)**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Calls/ Hour**	**Traffic Load (call-sec/hr)**	**Working Talk Paths**	**Working Channels**	**Traffic Load (erlangs)**	**Queuing Grade of Service (Erlang C)**	**Delayed Call Probability**	**Delayed-Call Grade of Service**	**Total Working Channels**	**Total Channels**
2010	**620**	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2011	626	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2012	632	**0%**	0	**0%**	0	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	0	0.0	**0**	0	0.0000	0.00%	100.00%	0.000%	**0**	**0**
2013	639	**0%**	0	**50%**	320	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	415.35	2450.6	**4**	2	0.6807	0.55%	56.97%	0.311%	**2**	**3**
2014	645	**0%**	0	**70%**	452	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	586.95	3463.0	**5**	3	0.9619	0.32%	50.44%	0.164%	**3**	**4**
2015	652	**0%**	0	**92%**	600	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	779.792	4600.8	**5**	3	1.2780	1.06%	53.21%	0.565%	**3**	**4**
2016	658	**0%**	0	**93%**	612	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	795.522	4693.6	**5**	3	1.3038	1.15%	53.45%	0.616%	**3**	**4**
2017	665	**0%**	0	**94%**	625	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	812.63	4794.5	**5**	3	1.3318	1.26%	53.70%	0.674%	**3**	**4**
2018	671	**0%**	0	**95%**	637	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	828.685	4889.2	**5**	3	1.3581	1.36%	53.94%	0.733%	**3**	**4**
2019	678	**0%**	0	**96%**	651	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	846.144	4992.2	**5**	3	1.3867	1.48%	54.20%	0.800%	**3**	**4**
2020	685	**0%**	0	**97%**	664	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	863.785	5096.3	**5**	3	1.4156	1.60%	54.47%	0.873%	**3**	**4**
2021	692	**0%**	0	**98%**	678	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	881.608	5201.5	**5**	3	1.4449	1.74%	54.74%	0.951%	**3**	**4**
2022	699	**0%**	0	**99%**	692	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	899.613	5307.7	**6**	3	1.4744	0.43%	46.44%	0.201%	**3**	**4**
2023	706	**0%**	0	**100%**	706	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	917.8	5415.0	**6**	3	1.5042	0.48%	46.67%	0.223%	**3**	**4**
2024	713	**0%**	0	**100%**	713	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	926.9	5468.7	**6**	3	1.5191	0.50%	46.79%	0.234%	**3**	**4**
2025	720	**0%**	0	**100%**	720	**1.3**	**4.9**	5.9	0	0.0	**0**	0.0000	0.00%	100.00%	0.000%	936	5522.4	**6**	3	1.5340	0.52%	46.91%	0.246%	**3**	**4**

Enter data in the highlighted cells only. Adjust the number of channels until the delayed-call GOS meets system requirements, typically 1 percent for a public-safety system. You can determine the number of channels required for each group by adjusting the number of channels in the row for each group. All users and calls are totalled on the bottom row. Adjusting the number of channels in that row gives you the requirement for the entire system. Additional rows can easily be inserted by copying and inserting an existing row.

The values for call overhead, allowable call delay, calls per unit per hour and average call length are standard Communications Technology values

Appendix B Coverage Predictions

0 1.42 2.84 mi
1 inch = 1.42 miles @ 1/90000

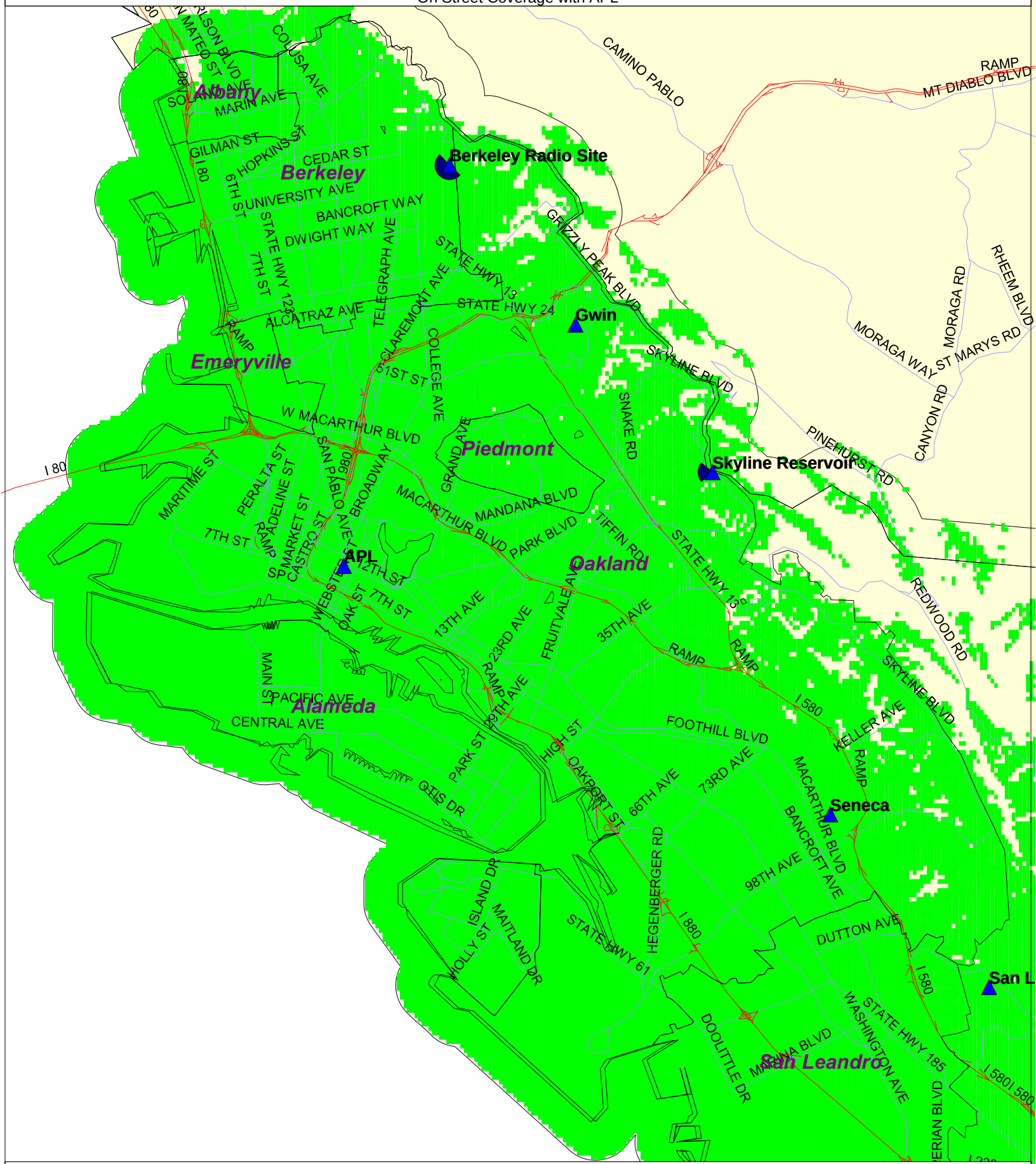
EBRCS 95% Portable On-Hip Street Level Inbound Coverage (Light Green 95% Purple 90% and Light Blue is DVRS Coverage)

Wednesday, February 25 2009 3.40 Build 3671

Job Id : 756221706.35.000.2.5

Portion(s) Of GIS Source Data Provided By ESRI, Inc.

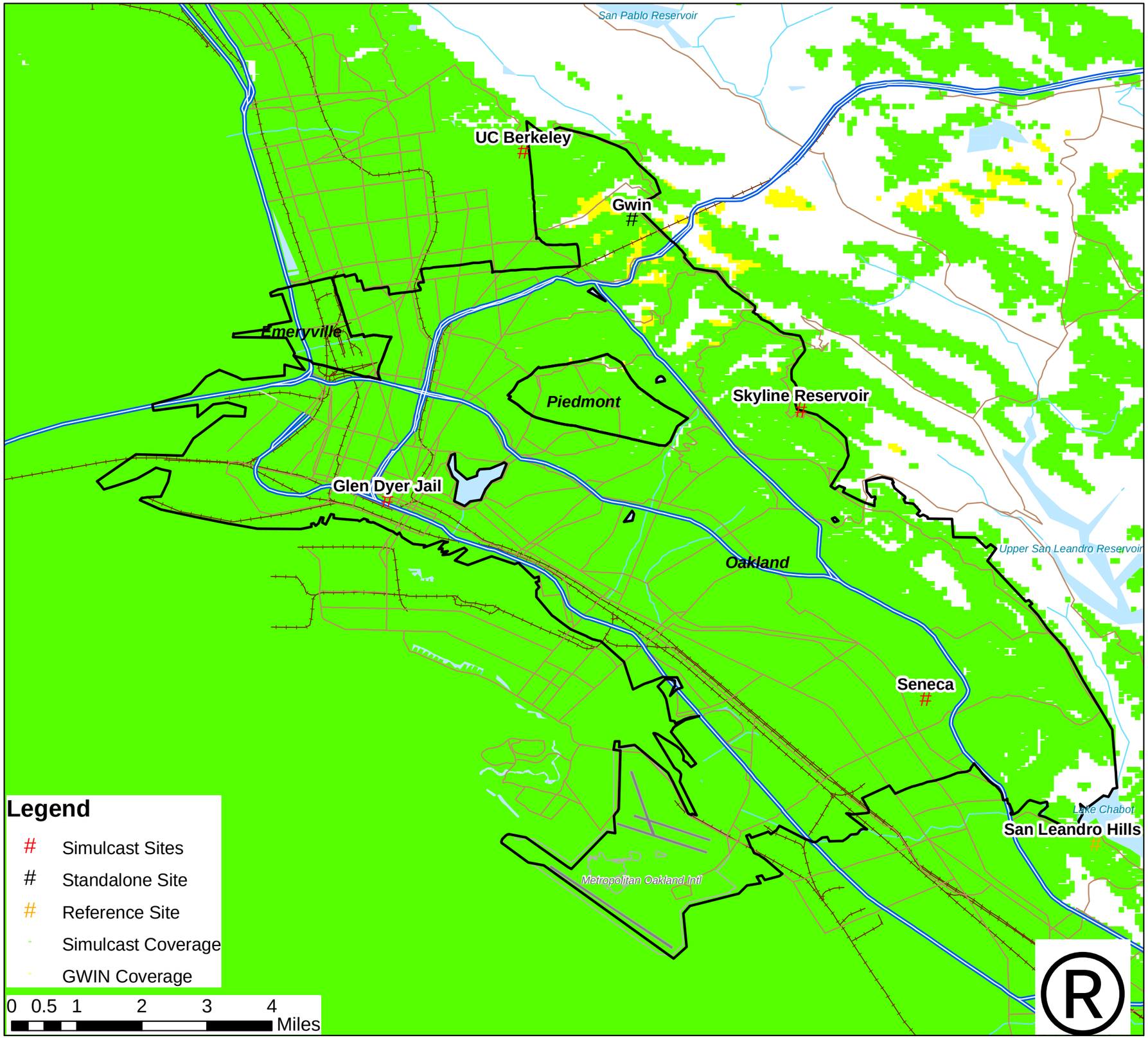
ALCO West Cell 95% Portable On-Hip Inbound
On Street Coverage with APL



0 1.57 3.14 mi
1 inch = 1.57 miles @ 1/99612

Projection World_Mercator
Center Point 37:47:45.22 N 122:13:49.76 W

Thursday, October 08 2009 3.40 Build 3671 Job Id : 108697022.12.000.5.4



Appendix B-3 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Mobile
Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: Glen Dyer Jail
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:

M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-3 Proposed EBRCS Northwest ALCO Mobile Coverage.pdf

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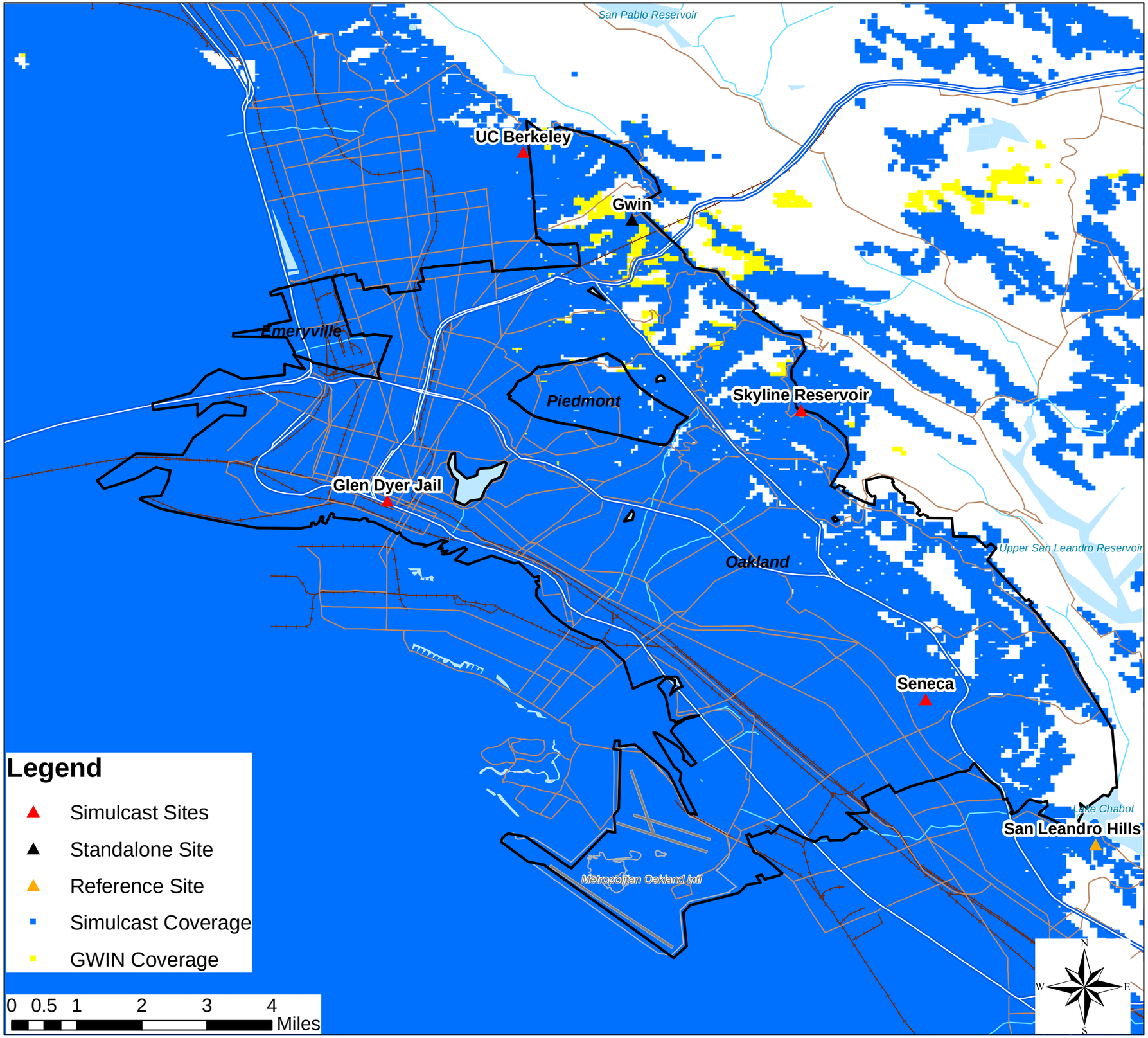

Appendix B-4 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Outdoors Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: Glen Dyer Jail
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

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Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-4 Proposed EBRCS Northwest ALCO Portable Outdoors Coverage.pdf

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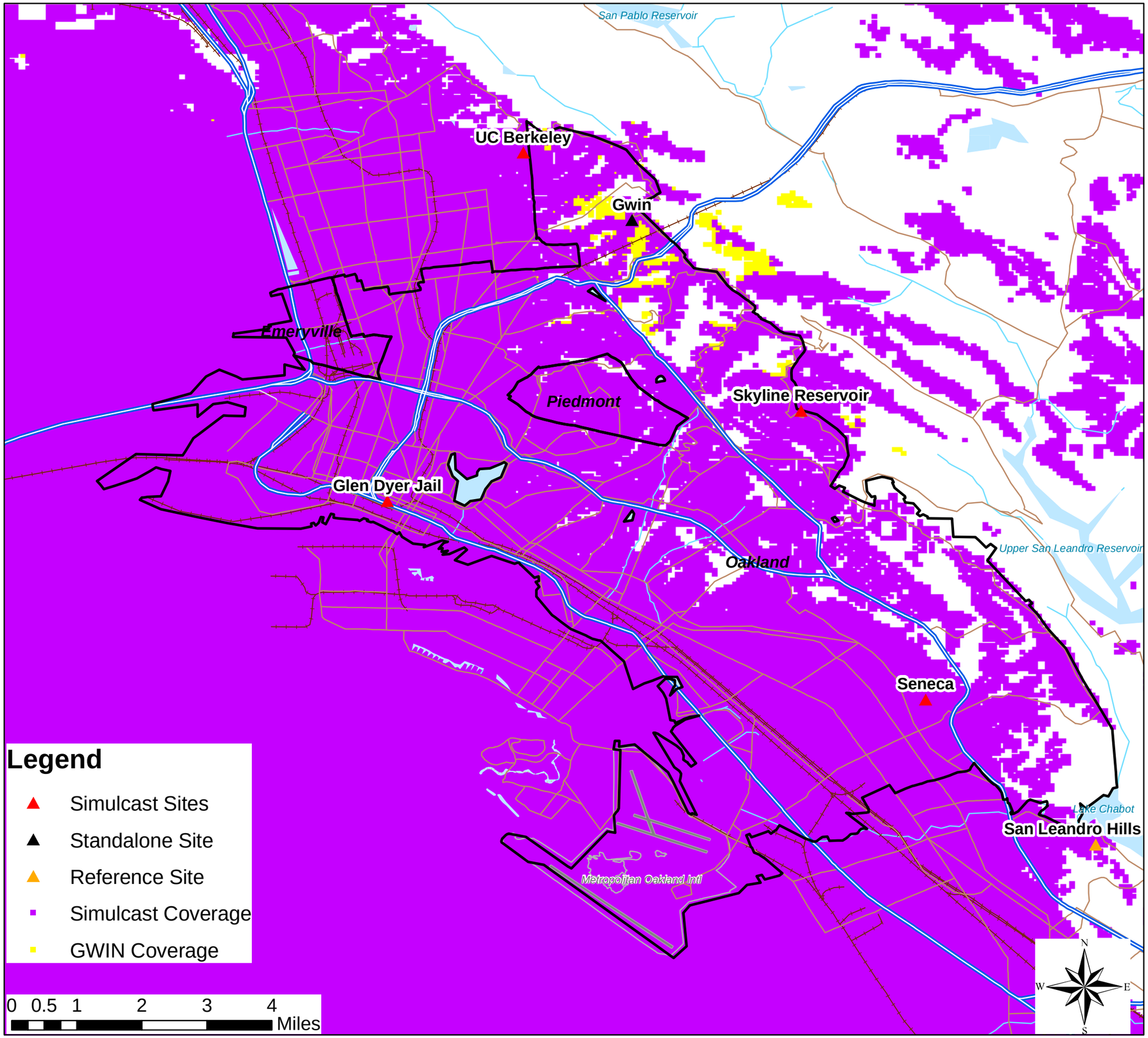

Appendix B-5
Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Light
Building Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: Glen Dyer Jail
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-5 Proposed EBRCS Northwest ALCO Light Bldg Coverage.pdf

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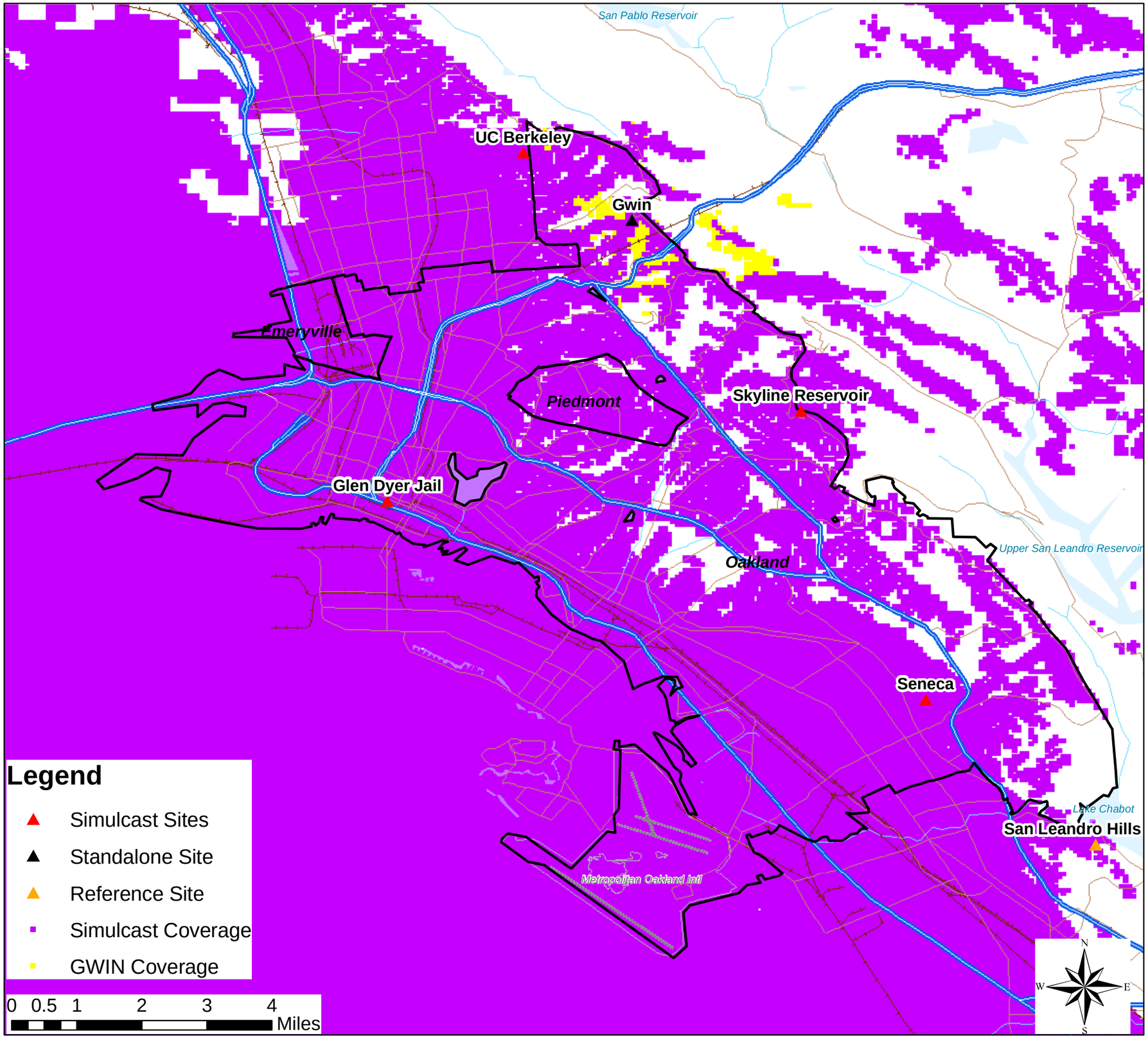

Appendix B-6 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Medium Building Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: Glen Dyer Jail
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-6 Proposed EBRCS Northwest ALCO Medium Bldg Coverage.pdf

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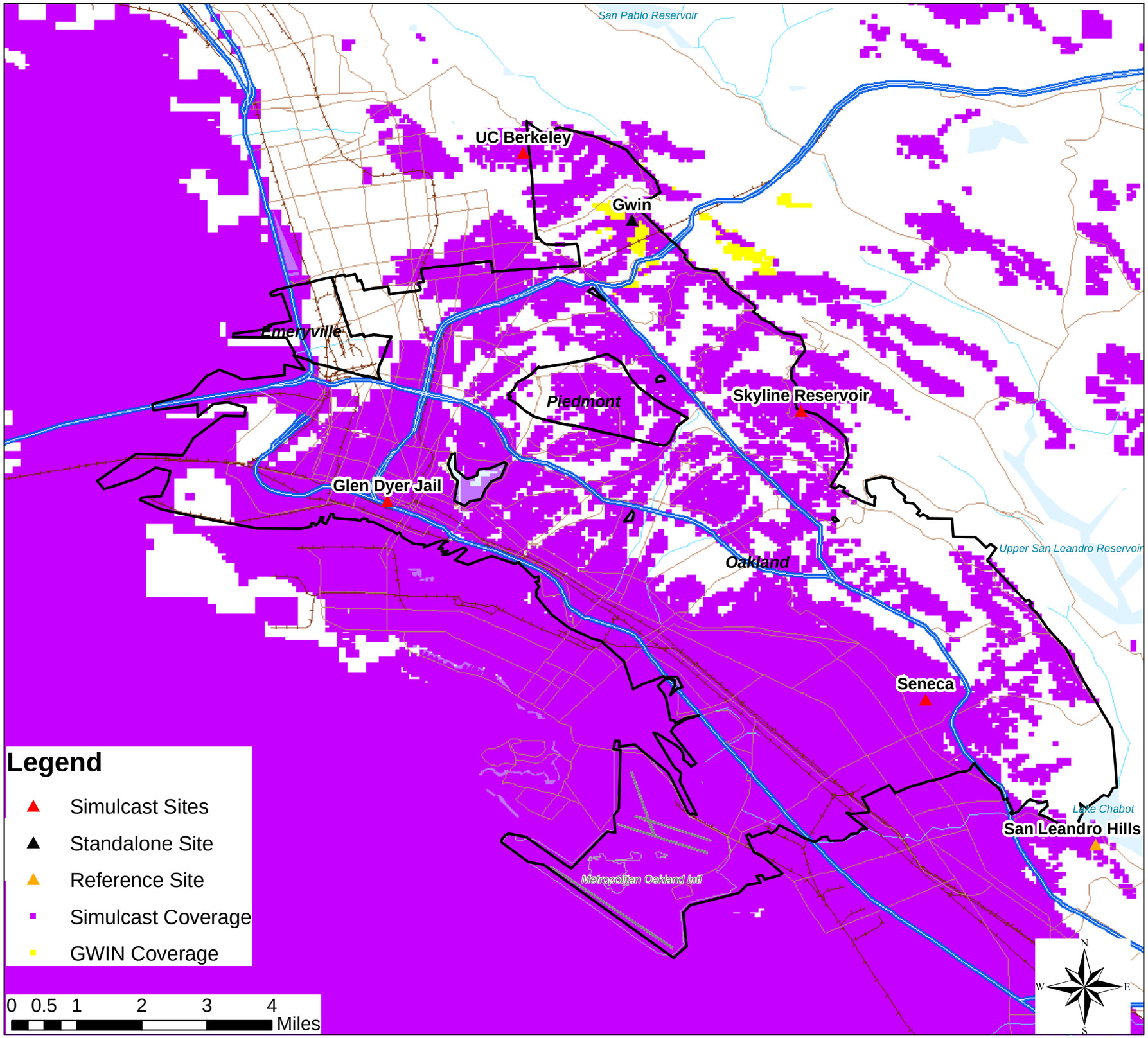

Appendix B-7
Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Heavy Building Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: Glen Dyer Jail
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-7 Proposed EBRCS Northwest ALCO Heavy Bldg Coverage.pdf

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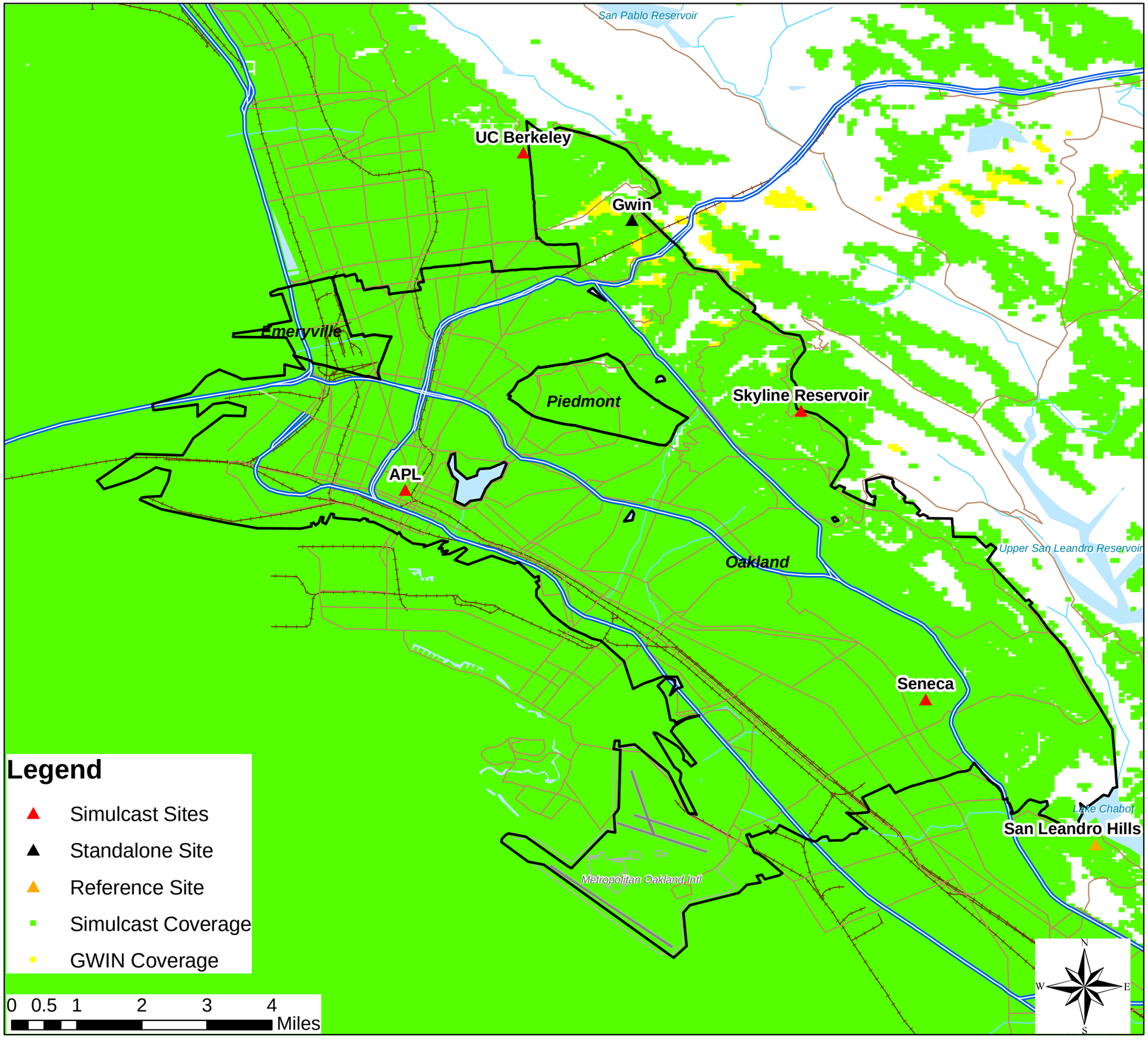

Appendix B-8
Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Mobile
Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-8 Proposed EBRCS Northwest ALCO Mobile Coverage.pdf

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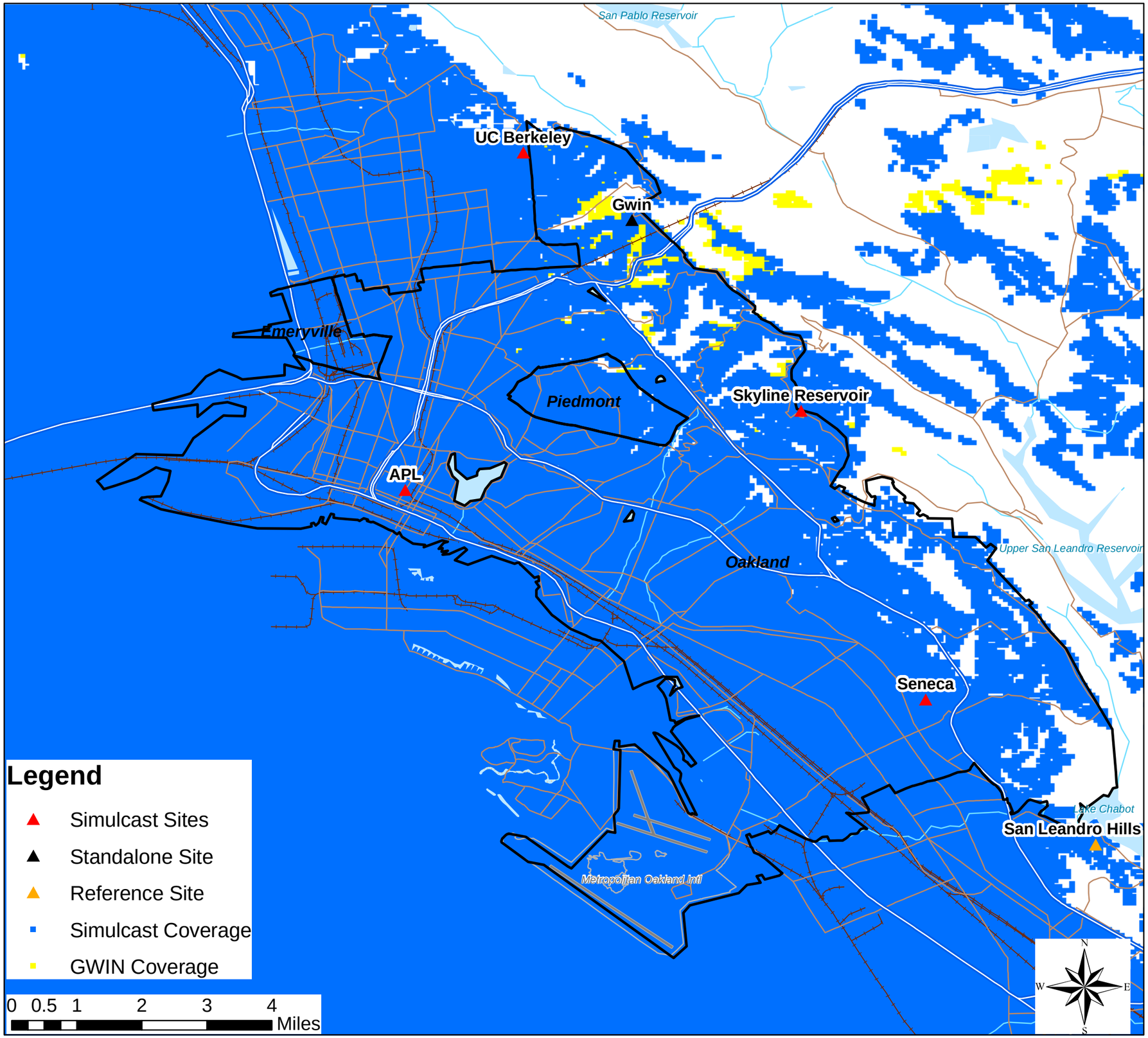

Appendix B-9 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Outdoors Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-9 Proposed EBRCS Northwest ALCO Portable Outdoors Coverage.pdf

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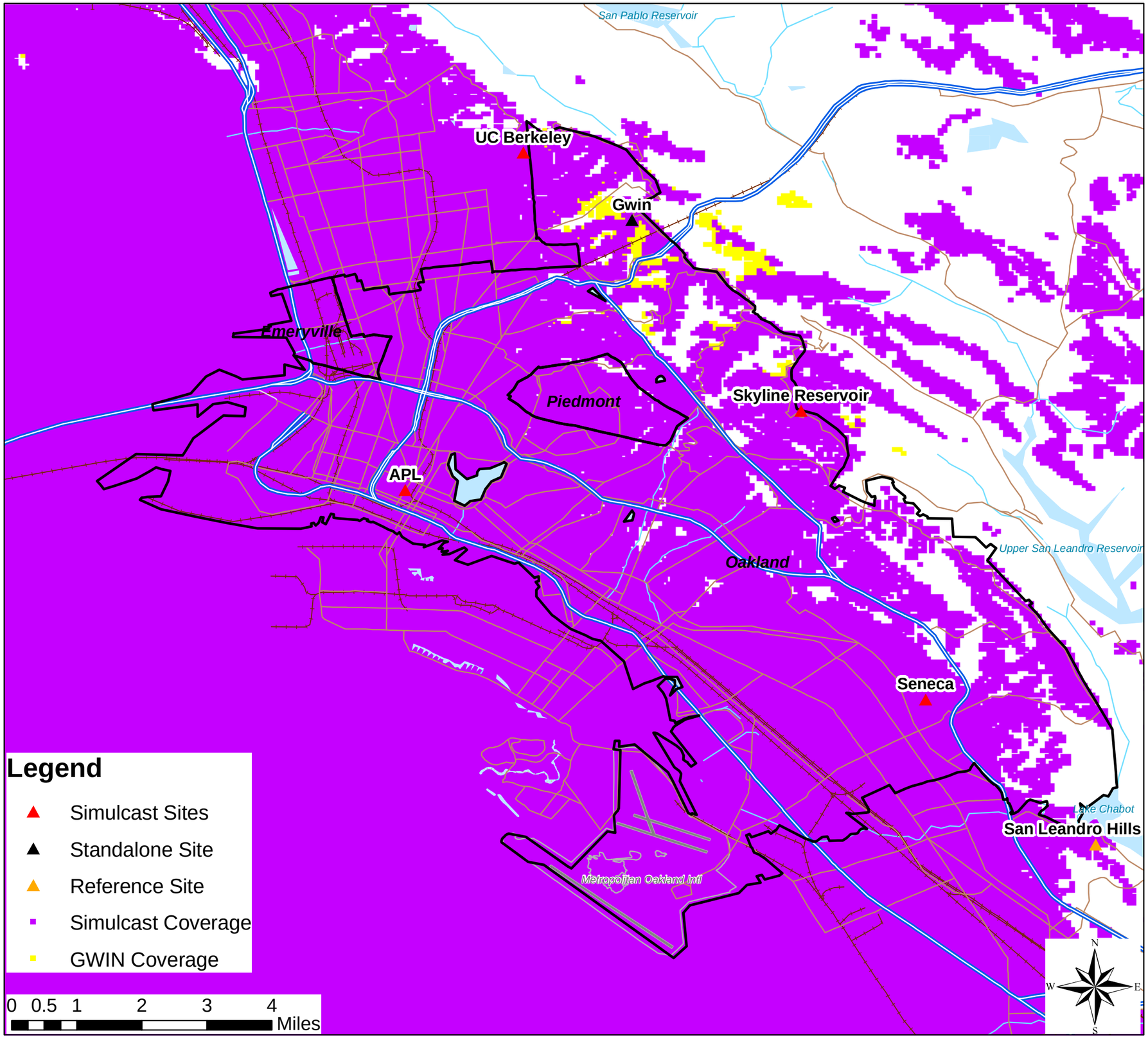

Appendix B-10 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Light Building Coverage Prediction (Base to Portable) 800MHz Prediction Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-10 Proposed EBRCS Northwest ALCO Portable Light Bldg Coverage.pdf

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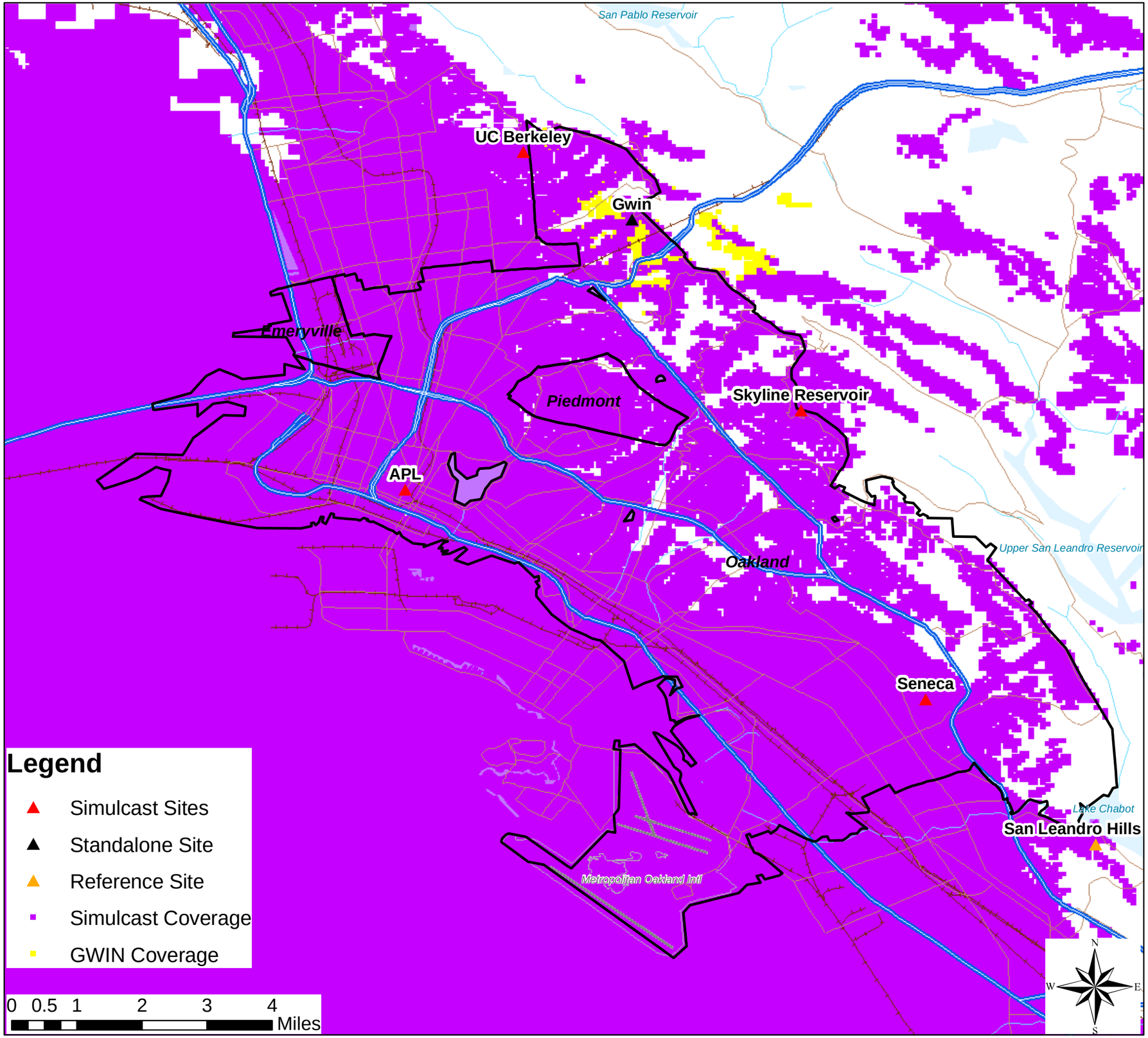

Appendix B-11
Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Medium Building Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-11 Proposed EBRCS Northwest ALCO Portable Medium Bldg Coverage.pdf

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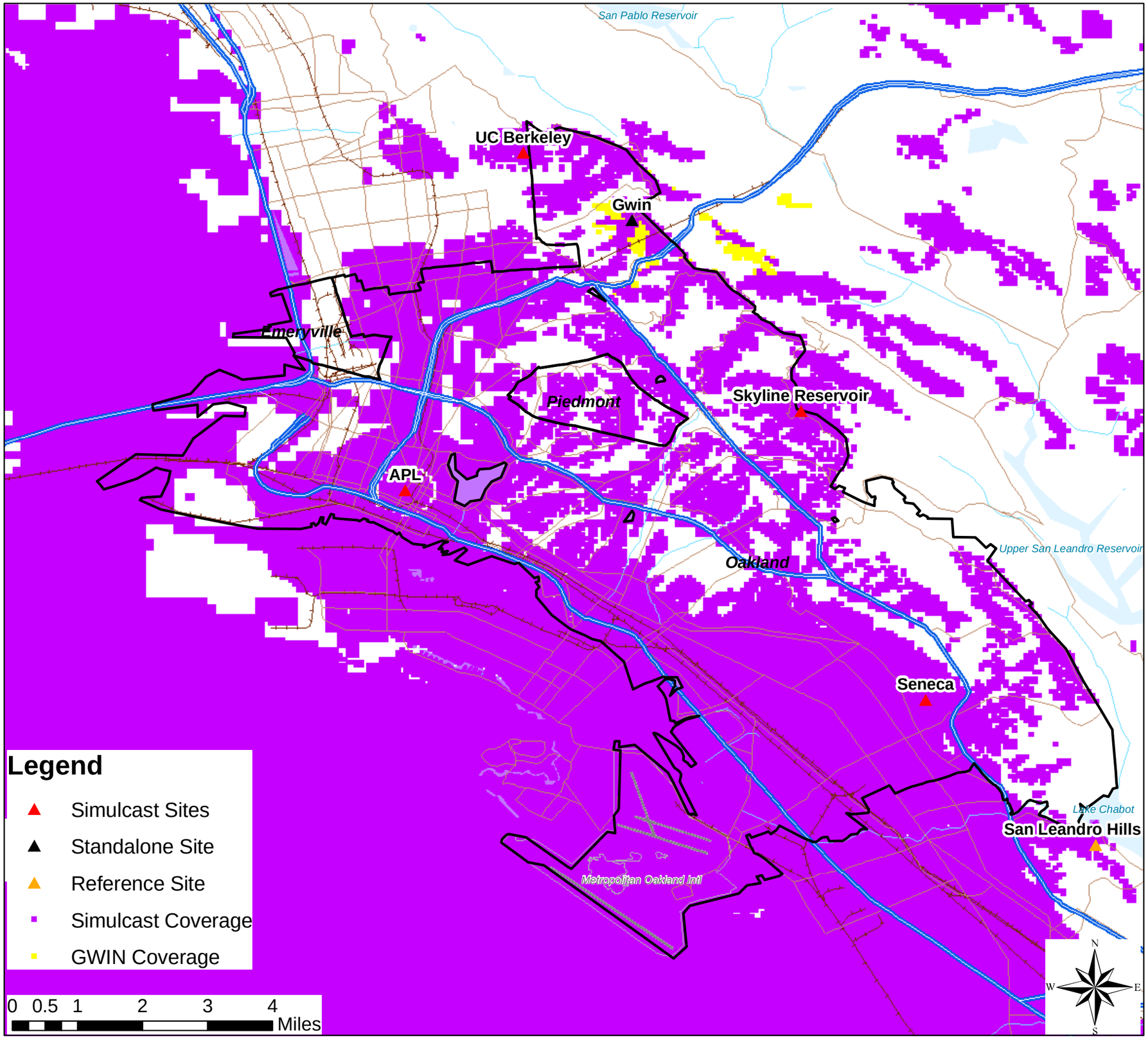

Appendix B-12 Proposed EBRCS Northwest ALCO Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Heavy Building Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Standalone Site: GWIN

San Leandro Hills site is shown for reference only and it's coverage is not shown in this coverage prediction.

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 28 October 2009

Checked: HWW 29 October 2009

Approved: JFC 29 October 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-12 Proposed EBRCS Northwest ALCO Portable Heavy Bldg Coverage.pdf

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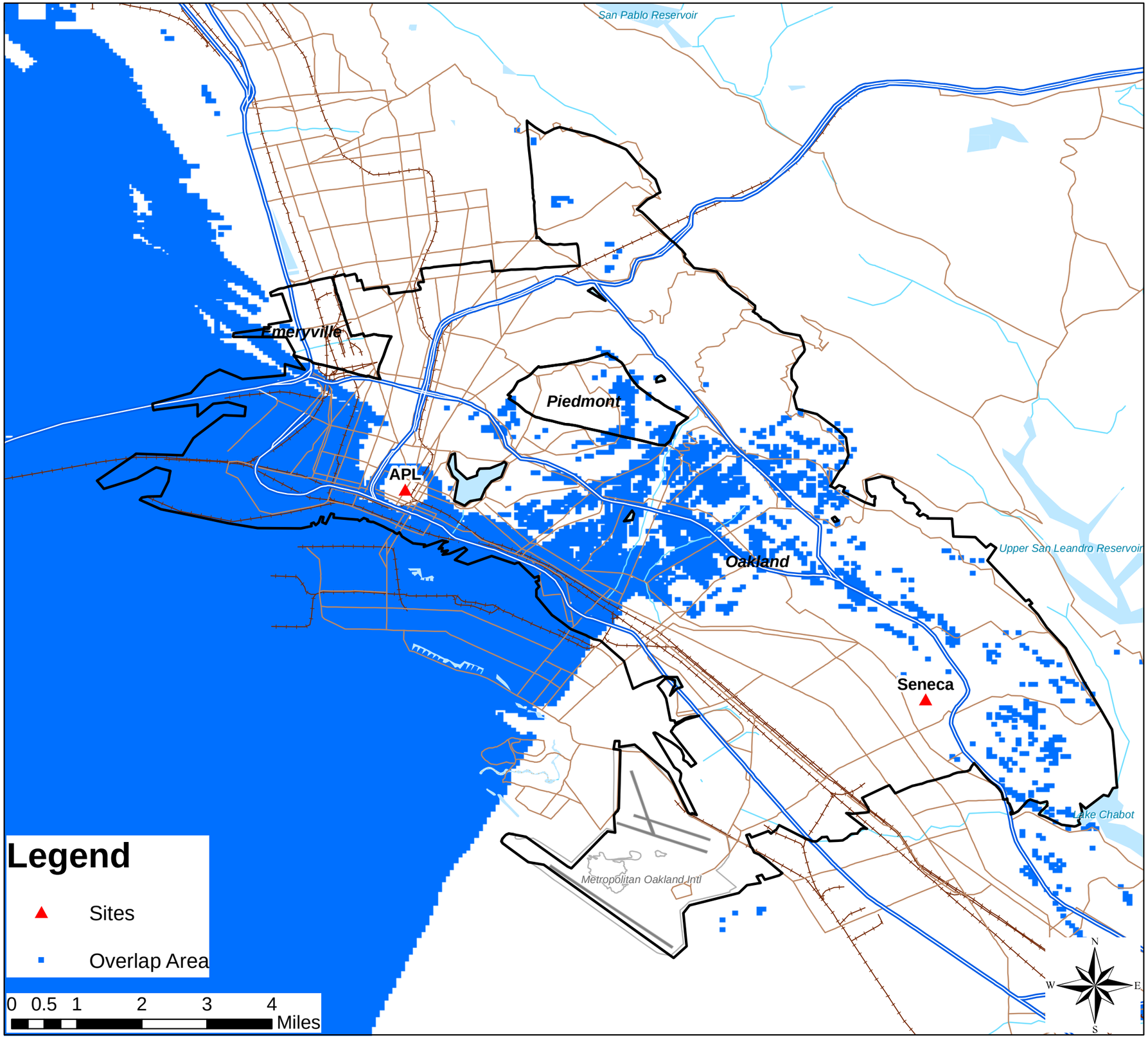

Appendix B-13
Proposed EBRCS
Northwest ALCO
APL-Seneca
Overlap Coverage

Client: City of Oakland
Commission No. 20177A

Proposed System Portable on
Street Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Seneca

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 23 September 2009

Drawn: TRM 30 October 2009

Checked: HWW 02 November 2009

Approved: JFC 02 November 2009

File Name:
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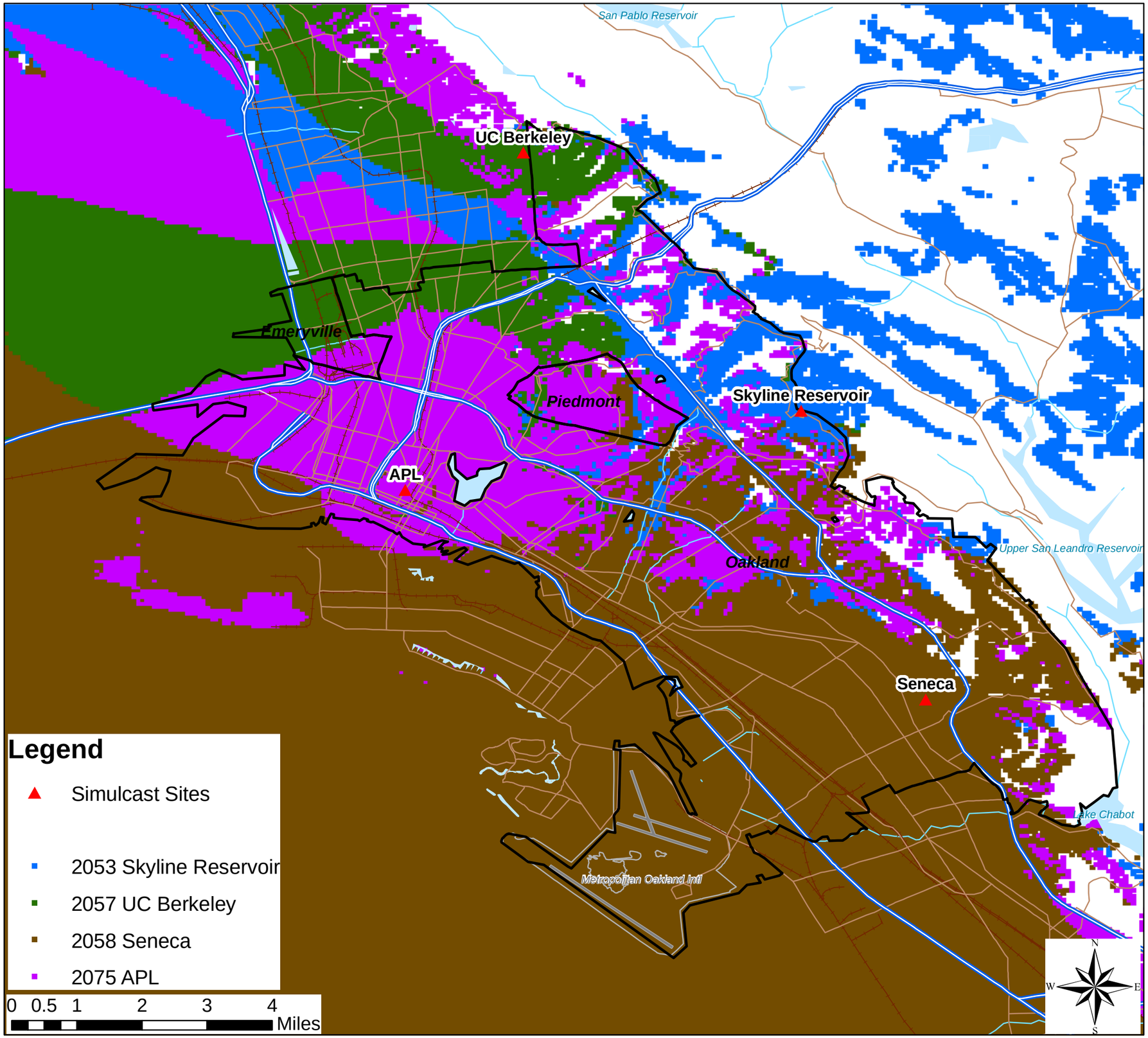

Appendix B-14
Proposed EBRCS
Northwest ALCO
Each Site Coverage

Client: City of Oakland

Commission No. 20177A

Proposed System Portable Outdoors
Coverage Prediction
(Base to Portable) 800MHz Prediction
Based on FCC License

Simulcast Sites: APL
Skyline Reservoir
Seneca
UC Berkeley

Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters, USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to interference, multi-path fading, and other random effects.

Design: JFC 18 August 2009

Drawn: TRM 30 October 2009

Checked: HWW 02 November 2009

Approved: JFC 02 November 2009

File Name:
M:\Projects\Radio Projects\60091361_20175 EBRCSA\Task 000B Phases II & III Cost & Spec\ Job Files\Technical Data\CTA P-CALA\ Arcview Maps\Appendix B-14 Proposed EBRCS Northwest ALCO Each Site Coverage.pdf

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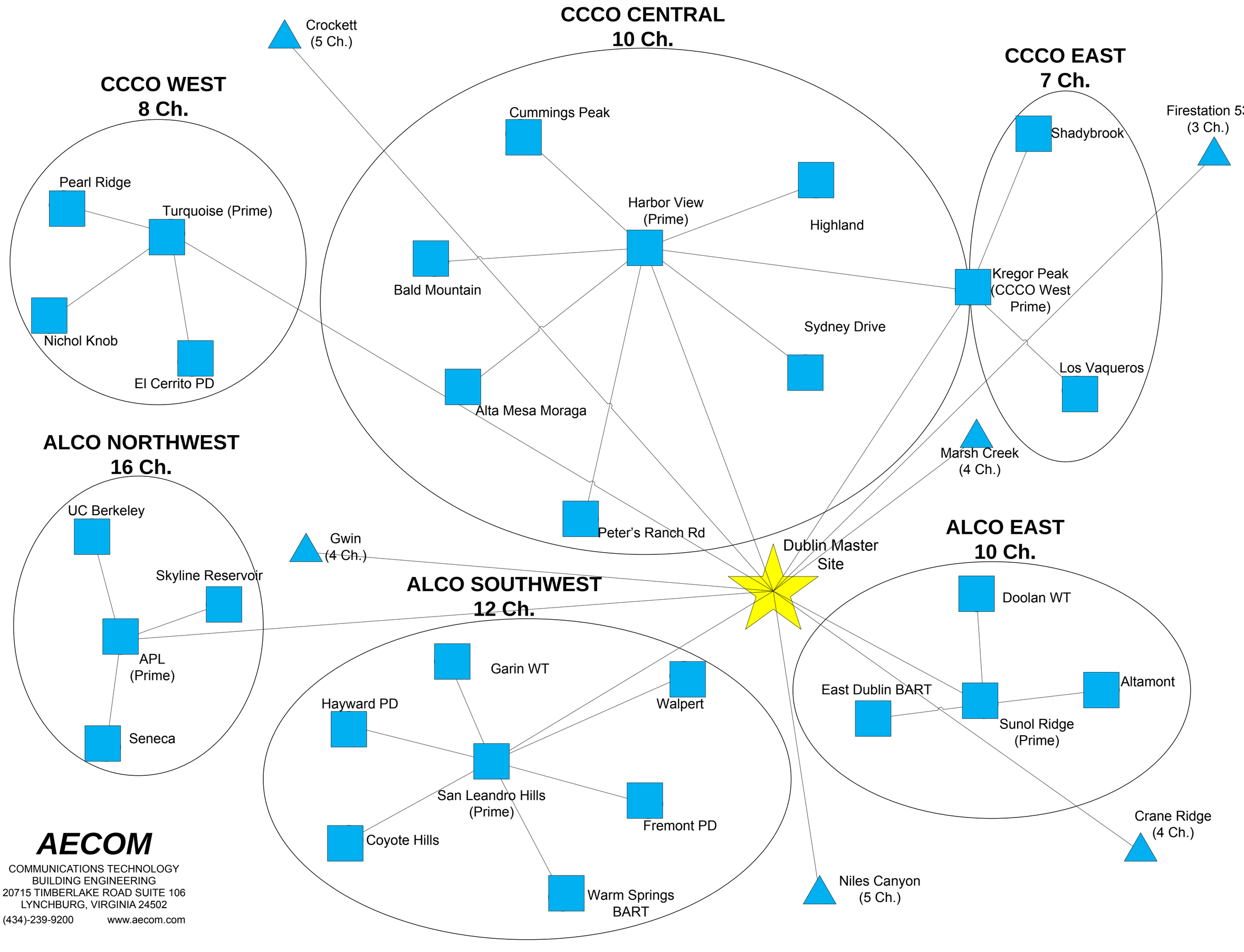
Appendix C High Level Block Diagrams

Appendix C-1 System Diagram



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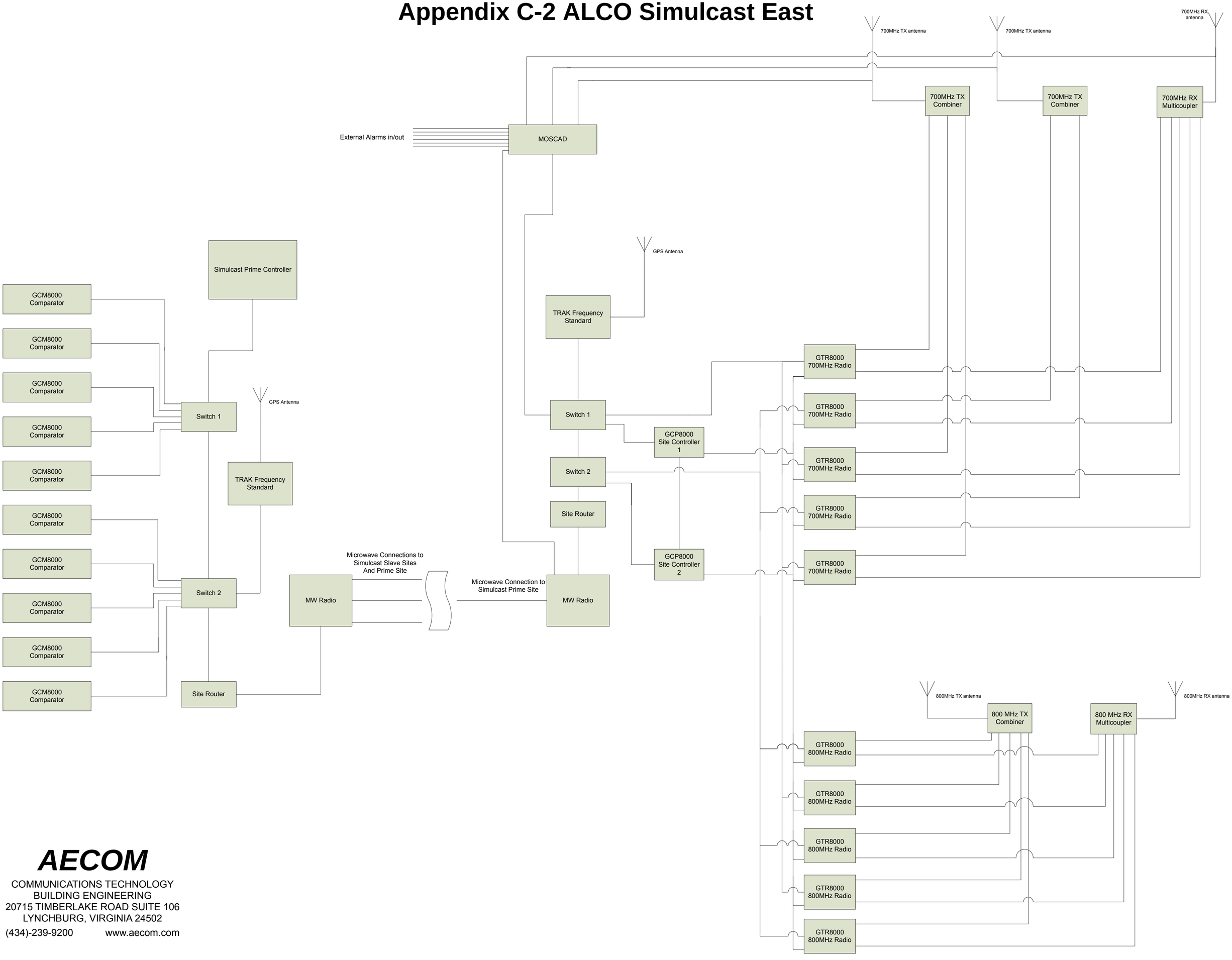
Appendix C-2 ALCO Simulcast East



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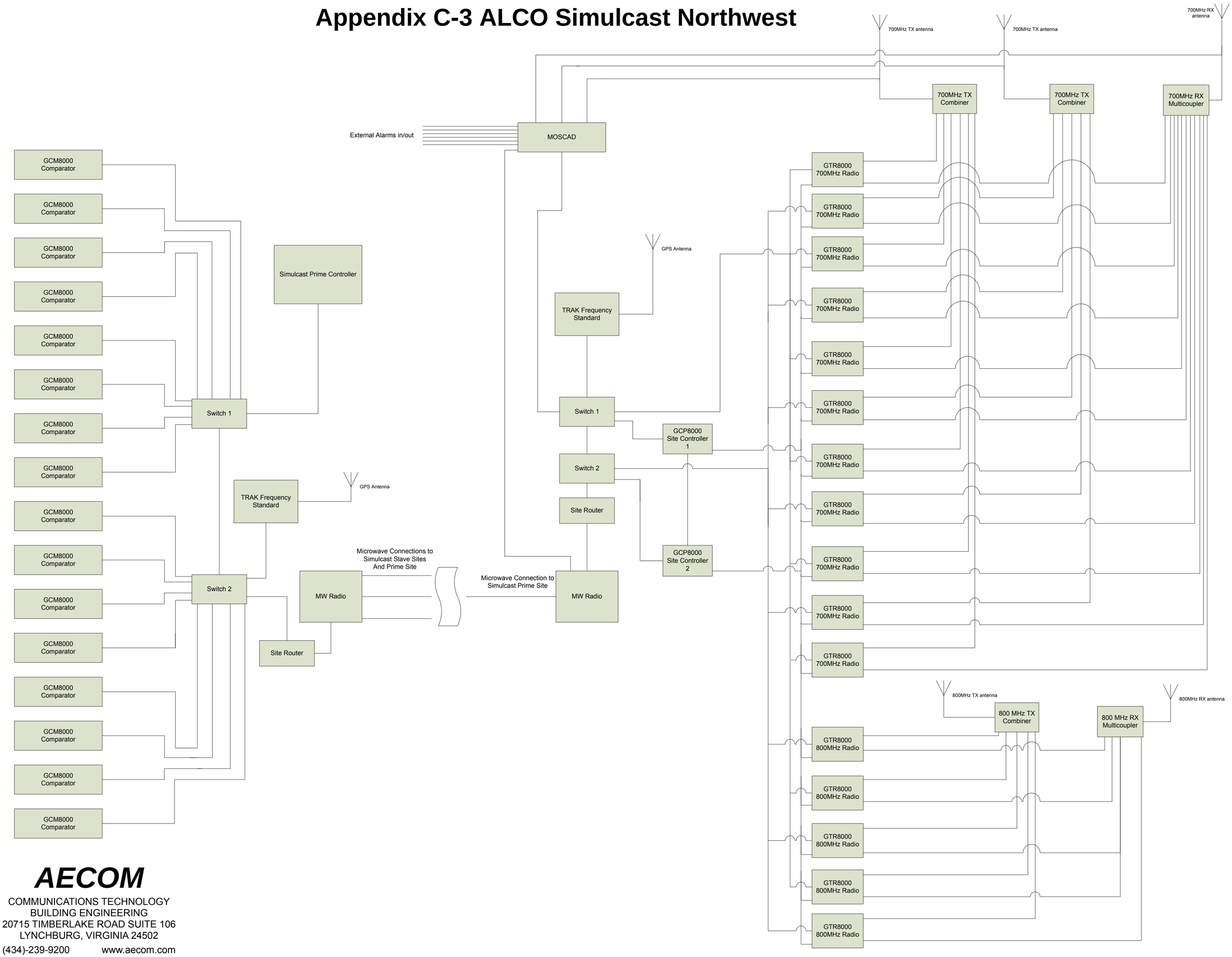
Appendix C-3 ALCO Simulcast Northwest



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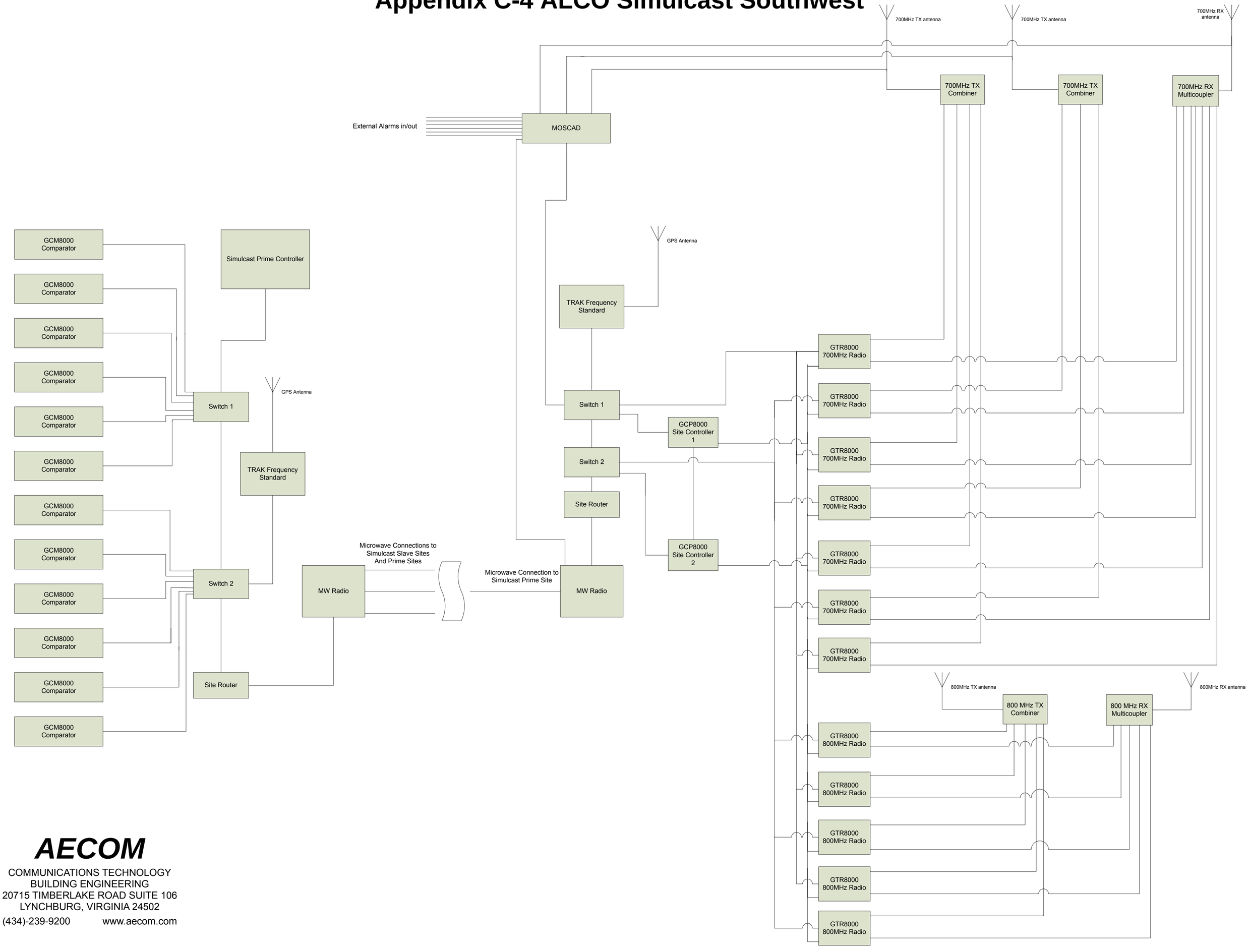
Appendix C-4 ALCO Simulcast Southwest



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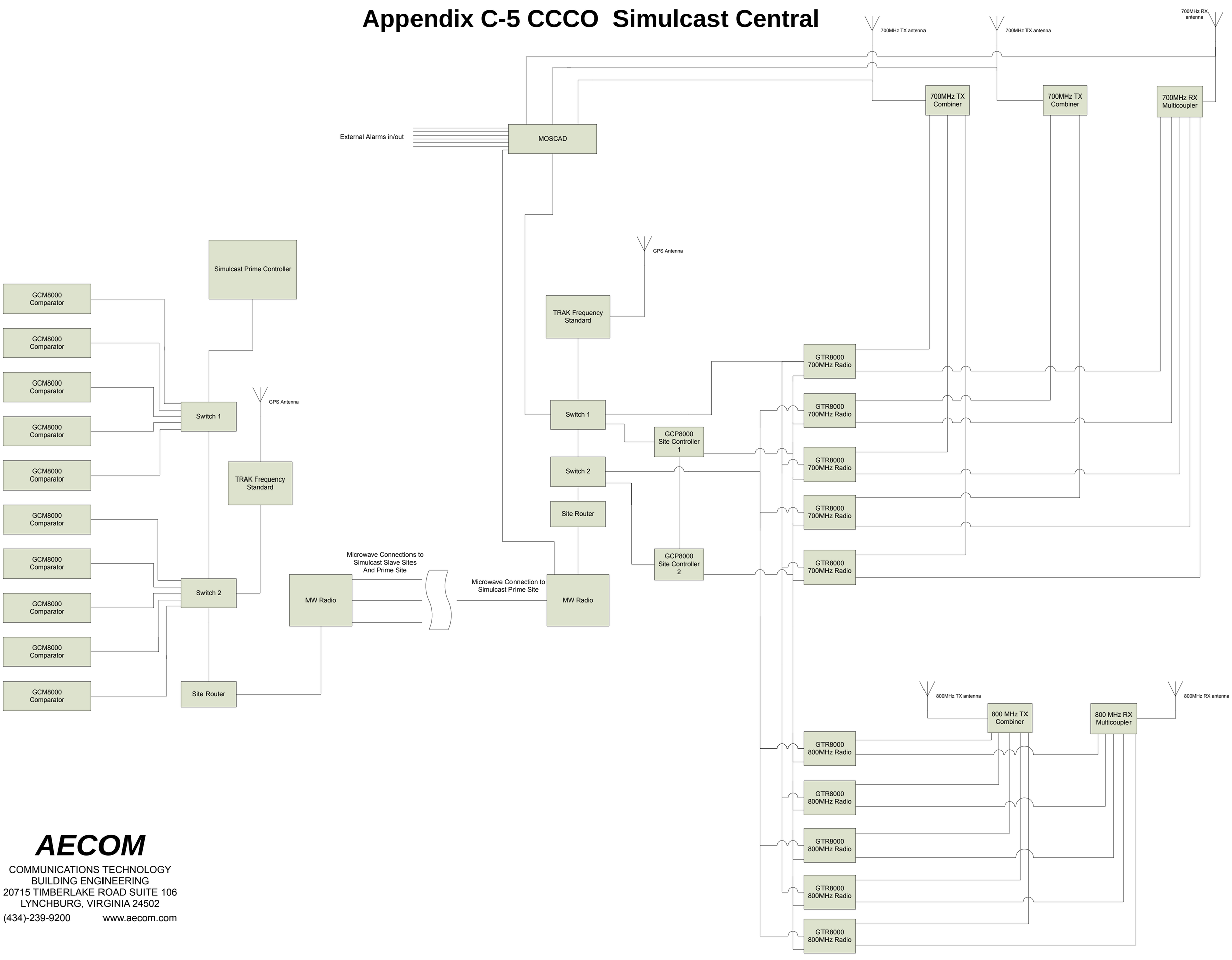
Appendix C-5 CCCO Simulcast Central



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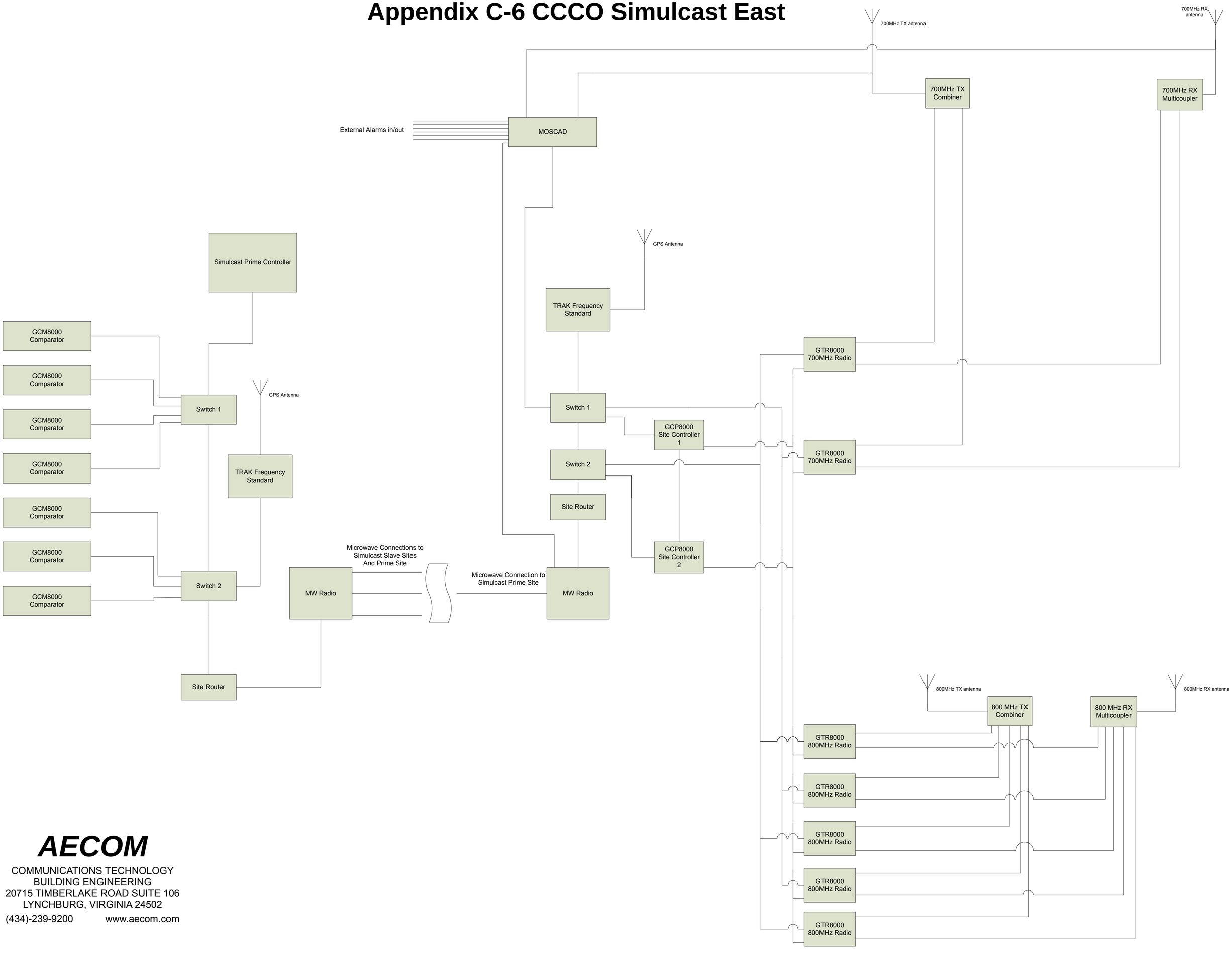
Appendix C-6 CCCO Simulcast East



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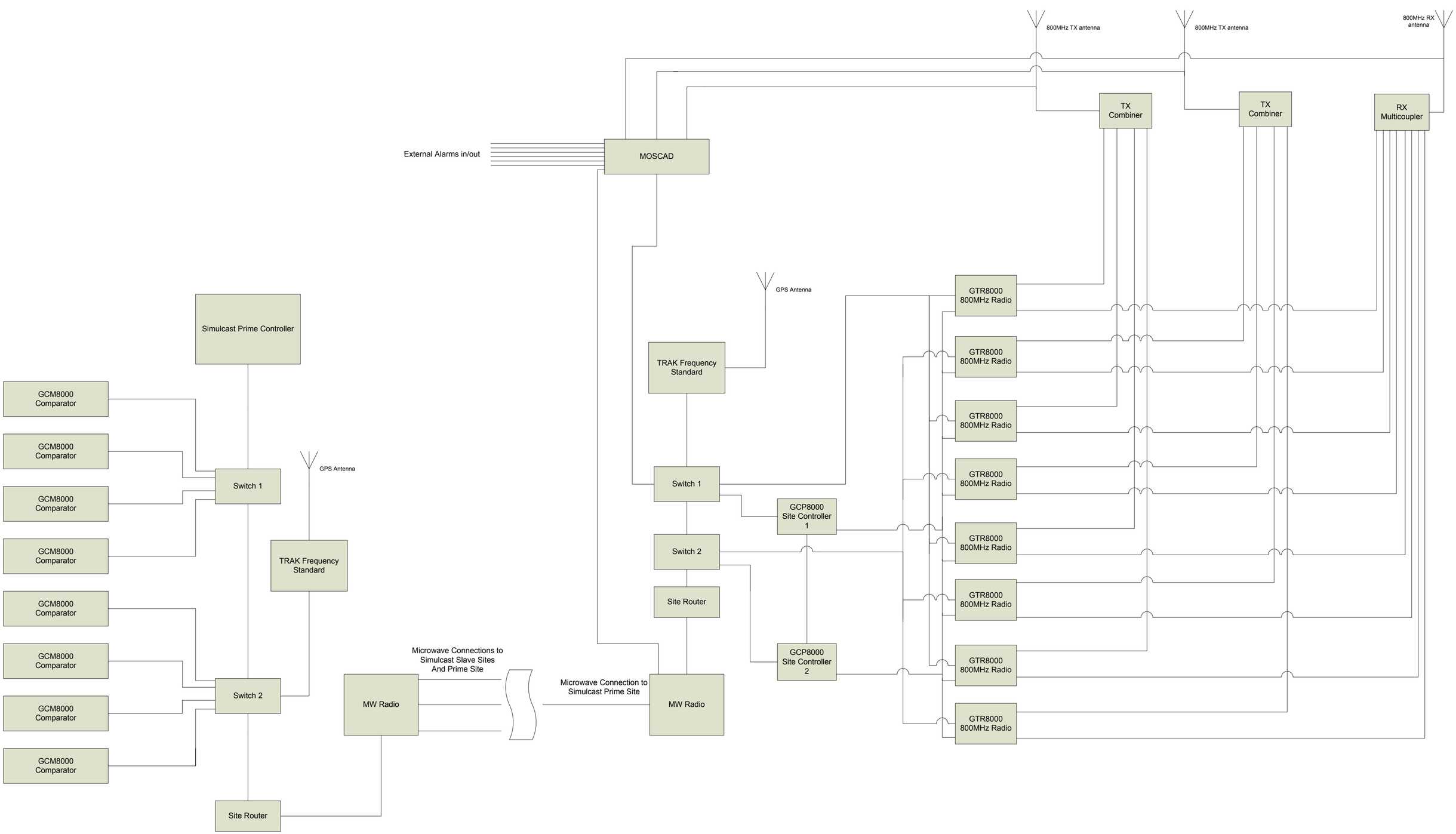
Appendix C-7 CCCO Simulcast West



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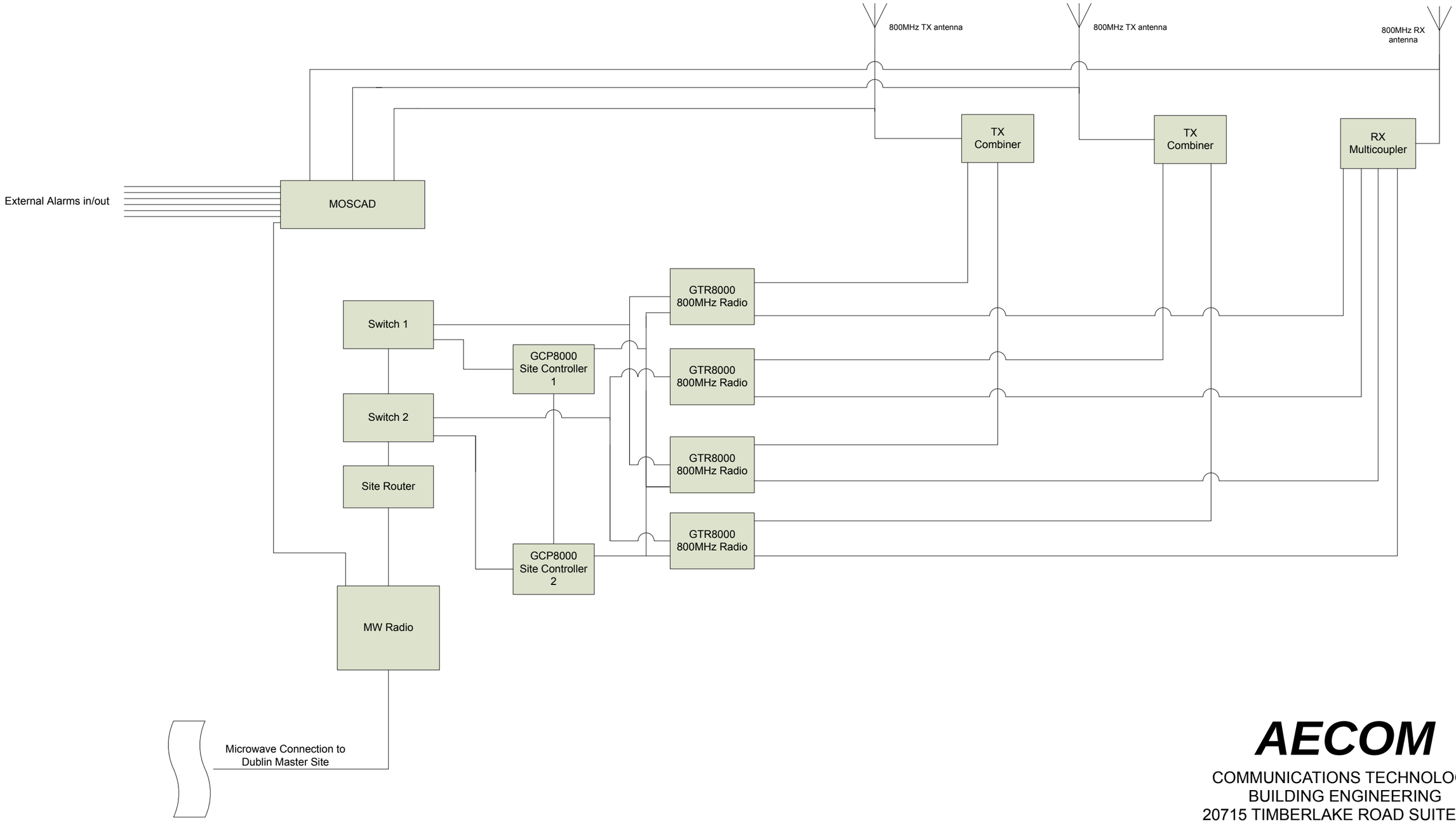
Appendix C-8 Crane Ridge



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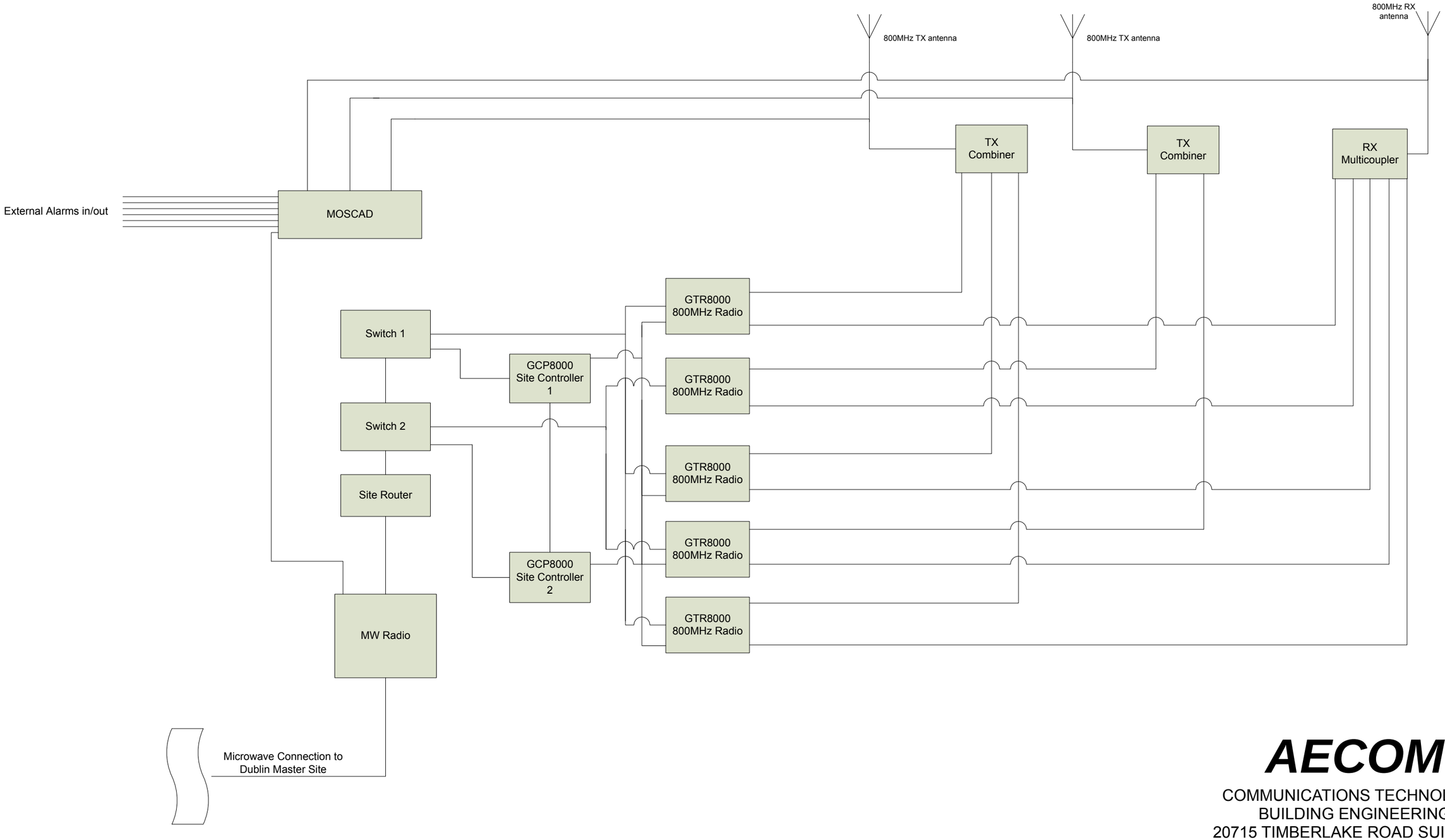
Appendix C-9 Crocket



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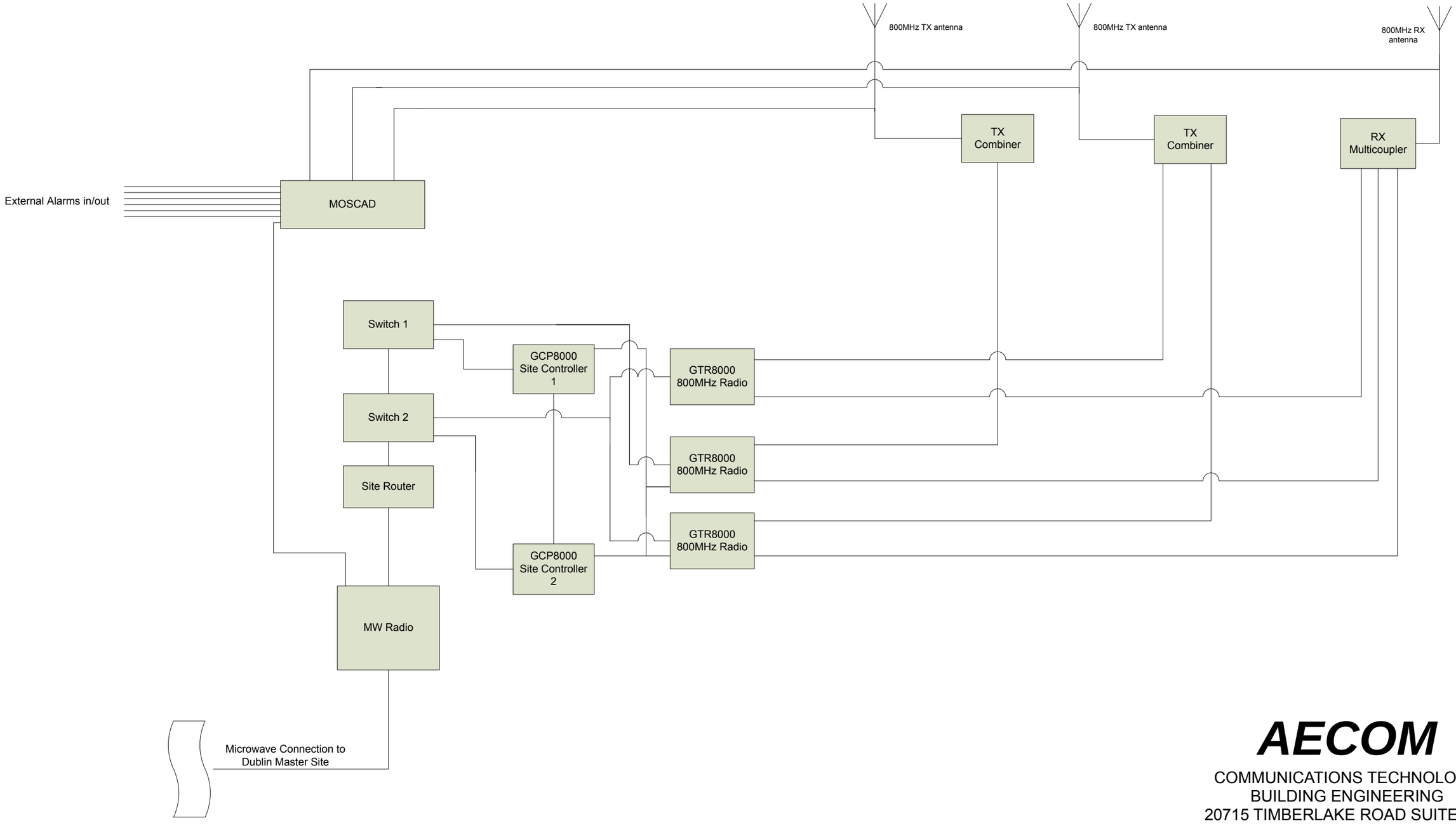
Appendix C-10 Fire Station 53



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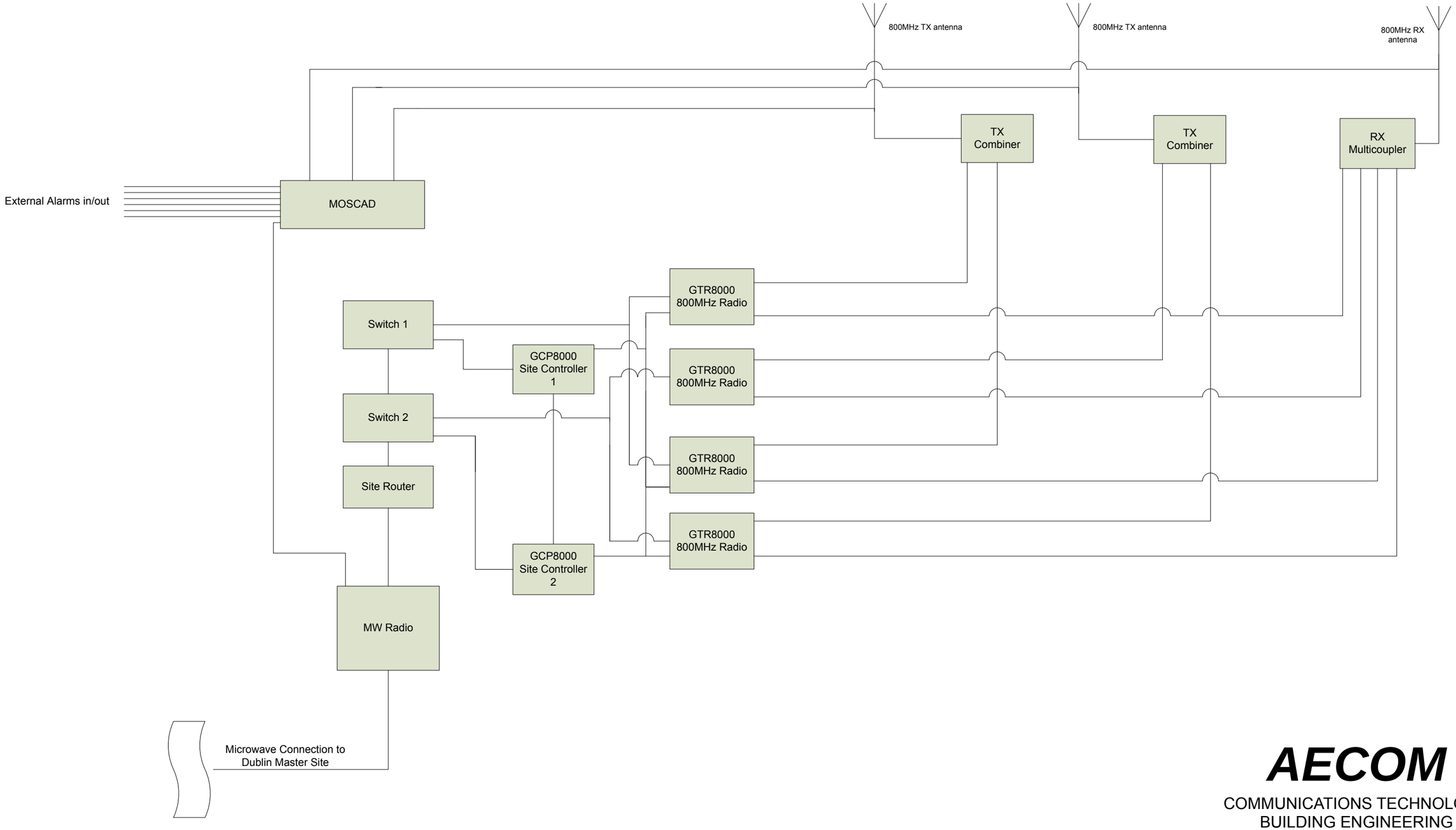
Appendix C-11 GWIN



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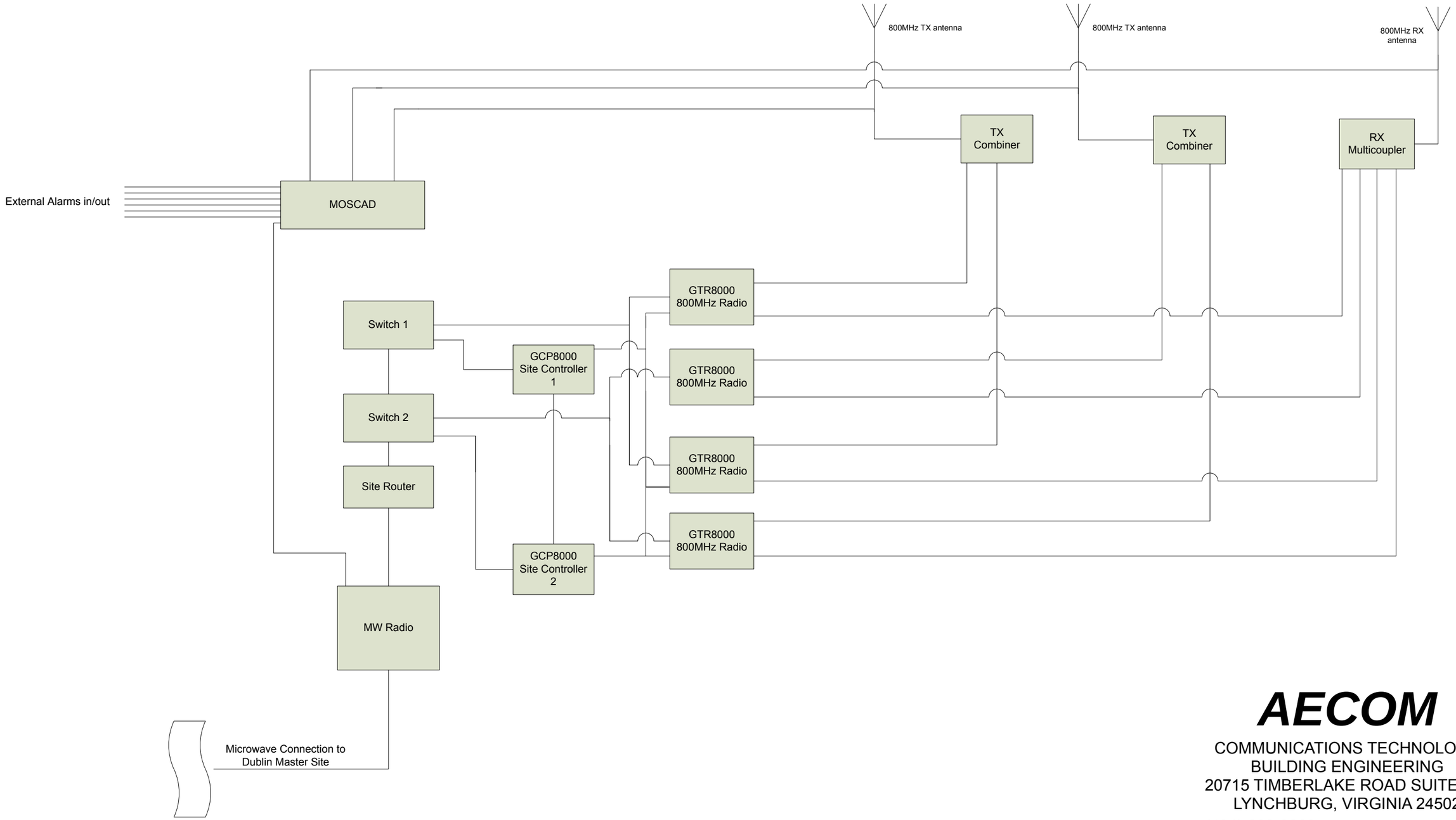
Appendix C-12 Marsh Creek



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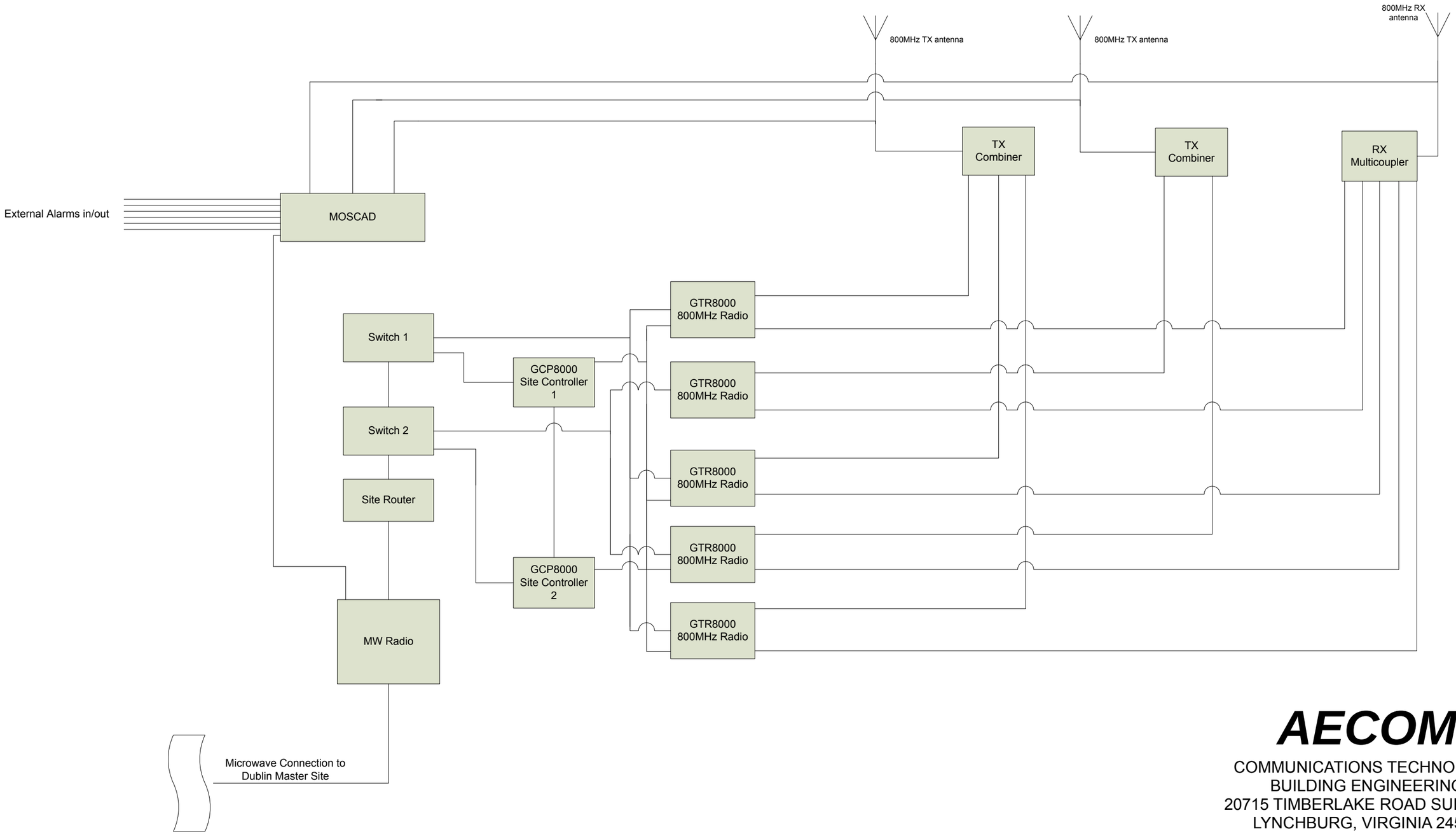
Appendix C-13 Niles Canyon



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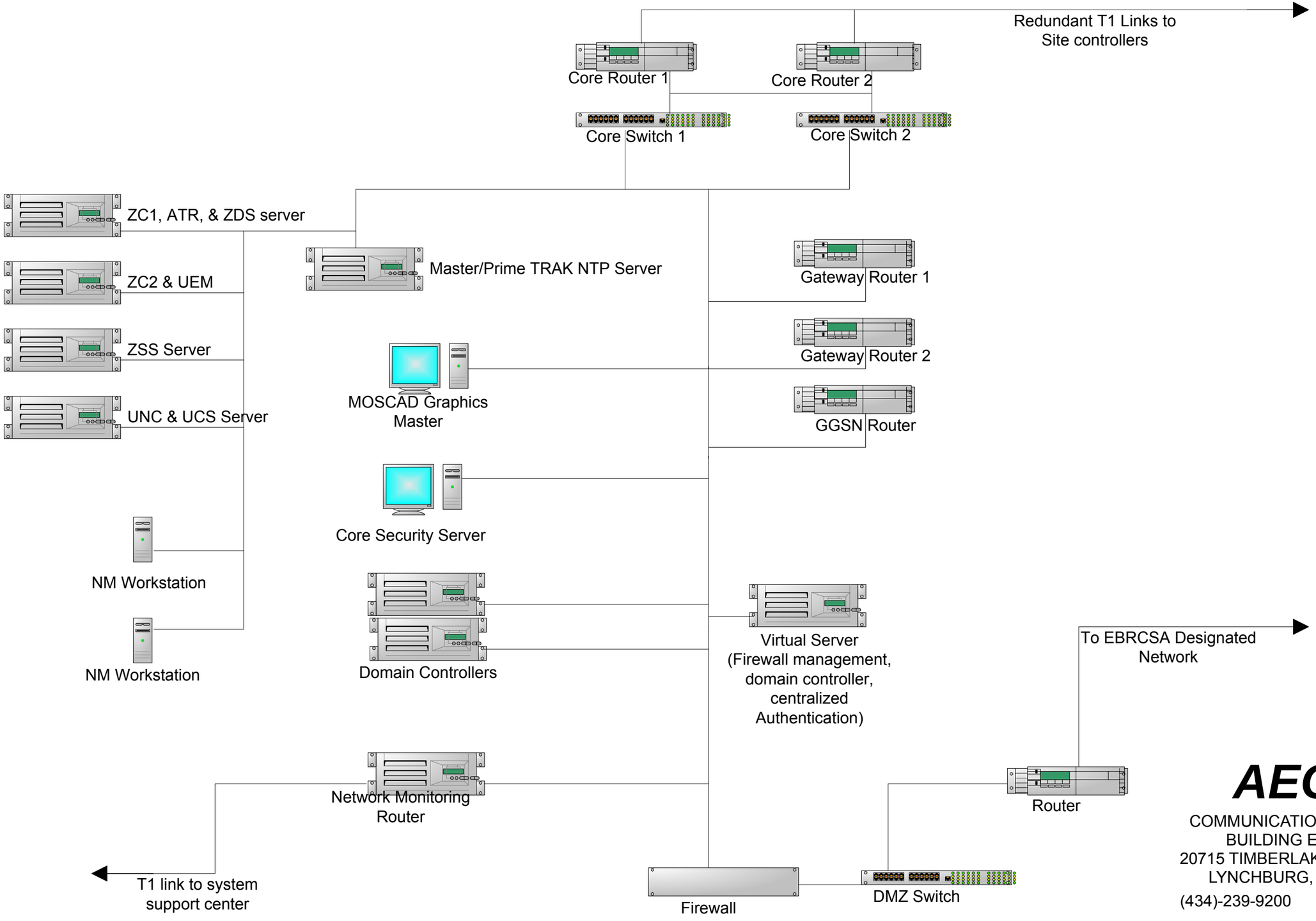
Appendix C-14 Master Site



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