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VOLUME 2 OF 3
TECHNICAL REPORT

FIRE DEPARTMENT STANDARDS OF RESPONSE COVER REVIEW

PERFORMED BY CITYGATE ASSOCIATES, LLC
in Partnership with The Omega Group and Animated Data

City of Sacramento Fire Department

JULY 20, 2016

CITYGATE ASSOCIATES, LLC
FIRE & EMERGENCY SERVICES

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PART ONE

Standards of Cover Assessment

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SECTION 1—INTRODUCTION AND BACKGROUND

Citygate Associates, LLC's Standards of Response Cover technical review for the City of Sacramento Fire Department (Department) for field deployment functions is presented in this "Volume." Citygate's deployment scope of work and corresponding Work Plan was developed consistent with Citygate's Project Team members' experience in fire administration and deployment planning. Citygate utilizes various National Fire Protection Association (NFPA) publications as best practice guidelines, along with the self-assessment criteria of the Commission on Fire Accreditation International (CFAI).

1.1 DEPLOYMENT PART ORGANIZATION

This "Part" of Volume 2 is structured into the following sections. Volumes 1 (Executive Summary) and 3 (Map Atlas) are separately bound. Part Two of this volume contains an in-depth Community Risk Assessment.

Section 1 Introduction and Background: An introduction to the study and background facts about the Department.

Section 2 Standards of Response Coverage Introduction: An introduction to the Standards of Coverage (SOC) process and methodology used by Citygate in this review.

Section 3 Deployment Goals/Measures and Risk Assessment: An in-depth examination of the City's deployment ability to provide coverage for the community's risks and meet the community's expectations and emergency needs.

Section 4 Staffing and Geo-Mapping Analysis: A review of: (1) the critical tasks that must be performed to achieve the City's desired outcome; and (2) the City's existing fire station locations and possible future locations.

Section 5 Response Statistical Analysis: A statistical data analysis of the City's incident responses and an overall deployment evaluation.

Section 6 SOC Evaluation and Deployment Recommendation: A summary of deployment priorities and an overall deployment recommendation.

Section 7 Next Steps: A summary of deployment short- and long-term next steps.

1.1.1 Goals of Deployment Analysis

As each of the sections mentioned above imparts information, this report will cite findings and make recommendations, if appropriate, that relate to each finding. There is a sequential numbering of all of the findings and recommendations throughout Sections 3 through 6 of this report. To provide a comprehensive summary, a complete listing of all these same findings and

recommendations, in order, is found in the Executive Summary. Sections 6 and 7 of this report bring attention to the highest priority needs and possible next steps.

This document provides technical information about how fire services are deployed across the City, legally regulated, and how the Department currently operates. This information is presented in the form of recommendations and policy choices for the City's leadership to discuss.

1.2 Standards of Response Coverage Scope of Work

The scope of the Standards of Response Coverage review included the following elements:

- Modeling the need and effects of the current fire station locations. Although this is not a study of fire departments adjacent to the City, the study considered the impacts of the City's existing or potential automatic and mutual aid agreements on the City's needs.
- Establishing response time performance goals consistent with best practices and national guidelines from the NFPA and CFAI.
- Using an incident response time analysis program called StatsFD™ to review the statistics of prior historical performance.
- Using a geographic mapping response time measurement tool called FireView™ to measure fire unit driving time coverages.

1.2.1 SOC Study Questions

To prepare and develop this deployment study for the Department, Citygate reviewed computer data, response time analysis, and past performance. As a result, this study addresses the following questions:

- Is the type and quantity of apparatus and personnel adequate for the City's deployment to emergencies?
- What is the recommended deployment to deliver adequate emergency response times, both to the existing areas and new sections as growth continues to occur?

1.3 City Overview

Sacramento has a population of over 480,000 and is a culturally diverse community, consisting of over 35,000 businesses and 97.92 square miles of land and another 2 square miles of water. Additionally, the City provides contract fire protection services for the Natomas Fire Protection District (42 square miles), the Pacific Fire Protection District (3.5 square miles), and the Fruitridge Fire Protection District (1.2 square miles). The services provided by the City to these

fire districts are seamless and the districts receive a level of fire protection service comparable to any other City neighborhood.

As the risk assessment chapter of this report (Part Two) will describe in detail, the Sacramento Fire Department has to protect all of the City's diverse risks from fire and other hazardous emergency events.

The Department consists of 507 personnel operating from 24 fire stations using apparatus ranging from 24 engine companies (pumpers), 9 aerial ladder trucks, 1 rescue company, 15 paramedic ambulances, 4 swift water rescue teams, 2 hazardous materials response teams cross-staffed by engine companies, and wildland fire units cross-staffed by engine companies. The adopted Fiscal Year 2015/2016 budget for the Department is $103,693,995.

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SECTION 2—STANDARDS OF COVERAGE INTRODUCTION

2.1 STANDARDS OF COVERAGE STUDY PROCESSES

The core methodology used by Citygate in the scope of its deployment analysis work is the "Standards of Response Coverage" 5th Edition, which is a systems-based approach to fire department deployment, as published by the CFAI. This approach uses local risk and demographics to determine the level of protection best fitting the City's needs.

The Standards of Response Coverage method evaluates deployment as part of the self-assessment process of a fire agency. This approach uses risk and community expectations on outcomes to help elected officials make informed decisions on fire and emergency medical services deployment levels. Citygate has adopted this methodology as a comprehensive tool to evaluate fire station locations. Depending on the needs of the study, the depth of the components may vary.

Such a systems approach to deployment, rather than a one-size-fits-all prescriptive formula, allows for local determination. In this comprehensive approach, each agency can match local needs (risks and expectations) with the costs of various levels of service. In an informed public policy debate, a governing board "purchases" the fire and emergency medical service levels the community needs and can afford.

While working with multiple components to conduct a deployment analysis is admittedly more work, it yields a much better result than using only a singular component. For instance, if only travel time is considered, and frequency of multiple calls is not considered, the analysis could miss over-worked companies. If a risk assessment for deployment is not considered, and deployment is based only on travel time, a community could under-deploy to incidents.

The Standards of Response Coverage process consists of the following eight parts:

Table 1—Standards of Response Coverage Process Elements

Element	Meaning
1. Existing Deployment Policies	Reviewing the deployment goals the agency has in place today.
2. Community Outcome Expectations	Reviewing the expectations of the community for response to emergencies.
3. Community Risk Assessment	Reviewing the assets at risk in the community. (In this Citygate study, see Part Two—Community Risk Assessment.)
4. Critical Task Study	Reviewing the tasks that must be performed and the personnel required to deliver the stated outcome expectation for the Effective Response Force.
5. Distribution Study	Reviewing the spacing of first-due resources (typically engines) to control routine emergencies.
6. Concentration Study	Reviewing the spacing of fire stations so that building fires can receive sufficient resources in a timely manner (First Alarm assignment or the Effective Response Force).
7. Reliability and Historical Response Effectiveness Studies	Using prior response statistics to determine the percent of compliance the existing system delivers.
8. Overall Evaluation	Proposing Standard of Cover statements by risk type as necessary.

Fire department deployment, simply stated, is about the speed and weight of the attack. Speed calls for first-due, all-risk intervention units (engines, trucks, and/or rescue ambulances) strategically located across a department responding in an effective travel time. These units are tasked with controlling moderate emergencies without the incident escalating to second alarm or greater size, which unnecessarily depletes department resources as multiple requests for service occur. Weight is about multiple-unit response for serious emergencies such as a room-and-contents structure fire, a multiple-patient incident, a vehicle accident with extrication required, or a heavy rescue incident. In these situations, enough firefighters must be assembled within a reasonable time frame to safely control the emergency, thereby keeping it from escalating to greater alarms.

This deployment design paradigm is reiterated in the table below:

Table 2—Fire Department Deployment Simplified

	Meaning	Purpose
Speed of Attack	Travel time of first-due, all-risk intervention units strategically located across a department.	Controlling moderate emergencies without the incident escalating to second alarm or greater size.
Weight of Attack	Number of firefighters in a multiple-unit response for serious emergencies.	Assembling enough firefighters within a reasonable time frame to safely control the emergency.

Thus, small fires and medical emergencies require a single- or two-unit response (engine and specialty unit) with a quick response time. Larger incidents require more crews. In either case, if the crews arrive too late or the total personnel sent to the emergency are too few for the emergency type, they are drawn into a losing and more dangerous battle. The science of fire crew deployment is to spread crews out across a community for quick response to keep emergencies small with positive outcomes, without spreading the crews so far apart that they cannot amass together quickly enough to be effective in major emergencies.

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SECTION 3—CITY DEPLOYMENT GOALS/MEASURES AND RISK ASSESSMENT

3.1 WHY DOES THE DEPARTMENT EXIST AND HOW DOES IT DELIVER THE EXISTING FIRE CREW DEPLOYMENT SERVICES?

3.1.1 Existing Response Time Policies or Goals—Why Does the Agency Exist?

SOC ELEMENT 1 OF 8*

EXISTING DEPLOYMENT POLICIES

**Note: This is an overview of Element 1. The detail is provided on page 18.*

The City has not adopted specific, measureable, and outcome-based response time goals, either in its budget documents or its General Plan Safety Element.

In the 2015-2016 Fire Department budget, the Department reported an average response time measure and went on to say, "A national standard for response times is 5 minutes in an urban enviornment. Response time is defined by 4:00 minutes travel time, plus 1:00 minute turnout time, which is the time from disaptch received till time leaving the station." The source of this national standard statement was not cited.

Another source to look for community response time policies are the Safety Elements of the City's General Plan adopted on March 3, 2015. In the City's General Plan, Goal PHS 2.1.3 under Fire Services states:

- Response Time Standards. The City shall strive to maintain emergency response times that provide optimal fire protection and emergency medical services to the community.

Further in PHS 2.1.4 the plan states:

- Response Units and Facilities. The City shall provide additional response units, staffing, and related capital improvements, including constructing new fire stations, as necessary, in areas where a fire company experiences call volumes exceeding 3,500 in a year to prevent comprising emergency response and ensure optimum service to the community.

As for the timing of adding services, the plan in PHS 2.1.5 states:

- Timing of Services. The City shall ensure that the development of fire facilities and delivery of services keep pace with development and growth of the City.

Nationally recognized standards and best practices call for a time line with several important time measurements that include a definition of response time. Ideally the clock start time is when the 9-1-1 police dispatcher receives the emergency call. The City of Sacramento is a partner in a

best practices-based regional fire dispatch center. In this setting, the Fire Department response clock starts when the fire dispatcher creates an incident in the computerized dispatch system. The time segments for response include dispatch processing, crew alerting and leaving the station (commonly called turnout time), and the actual travel time are measured.

The City and Fire Department also have not identified specific response goals for incidents other than fire and medical emergencies, such as technical rescue and hazardous material responses. These incident type response time goals also are required to meet the Standards of Coverage model for the Commission on Fire Accreditation International (CFAI). In this Standards of Coverage study, Citygate will recommend revised response time goals to include all risks including fire, EMS, hazardous materials, and technical rescue responses. The goals will be consistent with the CFAI systems approach to response.

3.1.2 What Response Goals Have Other Large Departments Adopted?

Prior to approximately the year 2000, it was uncommon for departments to have elected officials adopt response time measures. As fire service accreditation added rigor to the national conversation about deployment, communities began to define and adopt measures. Of the departments that have adopted measures, outside of those who have gained accreditation, many place response time goal measures into the annual budget document to serve as guidelines for the current expense of effort. Other communities have placed them into their General Plan Safety Element.

Based on Citygate's client experience with other large California departments, we have seen:

City of San Jose – Approximately 15 years ago, the Department adopted a formal response time policy by type of risks. The City Council placed in the General Plan Safety Element a 4-minute *travel* time goal. The Department's goals are:

- Arrive in less than 8:00 minutes with appropriate personnel and equipment to all Priority 1 emergencies. This is to be achieved on 80% of incidents. It is measured from the time that a fire department Priority 1 emergency event is created by a fire communications call taker until the time that the first apparatus arrives on scene. It is monitored at the levels of individual battalions and stations to ensure each neighborhood receives appropriate service.
- Arrive in less than 13:00 minutes with appropriate personnel and equipment to all Priority 2 emergencies. This is to be achieved on 80% of incidents. It is measured from the time that a fire department Priority 2 emergency event is created by a fire communications call taker until the time that the first apparatus arrives on scene. It is monitored at the levels of individual battalions and stations to ensure each neighborhood receives appropriate service.

- The second response unit arrival is to be within 10:00 minutes.

City of San Diego – The City of San Diego has multiple measures in its General Plan and Fire Department documents. The City's two key measures are:

- A first responding four-person engine company shall arrive at the scene of an emergency within an average of 5 minutes or less from the time of page received.
- An effective response force will arrive at the scene of an emergency within 9 minutes or less 95 percent of the time from the time of page received.

City of Oakland – In the City's General Plan and budget documents, the Oakland Fire Department identified these response time goals:

- General Plan – Strive to meet a goal of responding to fires and other emergencies within 7 minutes of notification 90 percent of the time.
- Budget Plan – Deliver high quality services when responding to emergency calls within 7 minutes, 90 percent of the time from when Fire Dispatch first receives the call to arrival on-scene.
- Budget Plan – Create 9-1-1 records in the Fire Dispatch system within 90 seconds for the annual call volume of 60,000 emergency calls.

Sacramento Metropolitan Fire District – The District's Board of Directors policy states:

- Distribution of Fire Stations for Initial Response to Built-up Urban-Suburban Areas of Greater than 1,000 People per Square Mile: To treat and transport medical patients and confine small fires to the room of origin, the first-due unit should arrive within 7 minutes, 90 percent of the time from the receipt of the 9-1-1 call. This equates to 1-minute dispatch time, 2 minutes crew turnout time, and 4 minutes travel time spacing for single units.
- Effective Response Force (First Alarm) for Built-up Suburban Areas of Greater than 1,000 People per Square Mile: To treat and transport medical patients and to confine fires near the room of origin, a multiple-unit response of at least 16 personnel should arrive within 11 minutes from the time of 9-1-1 call receipt, 90 percent of the time. This equates to 1-minute dispatch time, 2 minutes crew turnout time, and 8 minutes travel time spacing for multiple units.

City of Stockton – The City's General Plan policy is:

- First-due company is within 4 minutes total travel time, 90 percent of the time.

City of San Bernardino – In the year 2000, the Mayor and Common Council by resolution 2000-113 adopted emergency response time standards, contingent upon the availability of funds. This resolution called for:

- Dispatch processing time to be 60 seconds or less, to 90% of the incidents.
- Crew turnout time to be 60 seconds or less, to 90% of the incidents.
- Travel (drive) time to be less than 5 minutes, to 90% of the incidents.

As the above samples indicate, there are still many diverse approaches and mathematical measures to large agency response time policies. This is because it is an issue for a local government's elected officials to determine in the United States.

3.1.3 Outcome Expectations and Best Practices Response Time Measures

SOC ELEMENT 2 OF 8
COMMUNITY OUTCOME EXPECTATIONS

The Standards of Response Cover Process begins by reviewing existing emergency services outcome expectations. This can be restated as follows: for what purpose does the response system exist? Has the governing body adopted any response performance measures? If so, the time measures used need to be understood and good data collected.

Current best practice nationally is to measure percent completion of a goal (e.g., 90% of responses) instead of an average measure. Mathematically this is called a "fractile" measure.[1] This is because the measure of average only identifies the central or middle point of response time performance for all calls for service in the data set. Using an average makes it impossible to know how many incidents had response times that were way over the average or just over. For example, if a department had an *average* response time of 5 minutes for 5,000 calls for service, it cannot be determined how many calls past the average point of 5 minutes were answered in the 6th minute or way out at 10 minutes. This is a significant issue if hundreds or thousands of calls are answered far beyond the average point. Fractile measures will identify per minute the number of incidents that are reached up to 100%.

More importantly within the Standards of Response Coverage Process, positive outcomes are the goal, and from that crew size and response time can be calculated to allow efficient fire station spacing (distribution and concentrations). Emergency medical incidents have situations with the most severe time constraints. In a heart attack that stops the heart, a trauma that causes severe blood loss, or in a respiratory emergency, the brain can only live 8-10 minutes without oxygen.

[1] A *fractile* is that point below which a stated fraction of the values lie. The fraction is often given in percent; the term percentile may then be used.

Not only heart attacks, but also other events can cause oxygen deprivation to the brain. Heart attacks make up a small percentage; drowning, choking, trauma constrictions, or other similar events have the same effect. In a building fire, a small incipient fire can grow to involve the entire room in 8 to 10 minutes. If fire service response is to achieve positive outcomes in severe emergency medical situations and incipient fire situations, ***all*** responding crews must arrive, size-up the situation, and deploy effective measures before brain death occurs or the fire leaves the room of origin.

Thus, from the time of 9-1-1 receiving the call, an effective deployment system is ***beginning*** to manage the problem within a 7- to 8-minute total response time. This is right at the point that brain death is becoming irreversible and the fire has grown to the point to leave the room of origin and become very serious. Thus, the City needs a first-due response goal within this time frame to give the situation hope for a positive outcome. It is important to note the fire or medical emergency continues to deteriorate from the time of inception, not the time the fire engine actually starts to drive the response route. Ideally, the emergency is noticed immediately and the 9-1-1 system is activated promptly. This step of awareness—calling 9-1-1 and giving the dispatcher accurate information—takes, in the best of circumstances, one minute. Then crew notification and travel time take additional minutes. Once arrived, the crew must walk to the patient or emergency, size-up the situation, and deploy its skills and tools. Even in easy-to-access situations, this step can take two or more minutes. This time frame may be increased considerably due to long driveways, apartment buildings with limited access, multi-storied apartments or office complexes, high rise downtown buildings, or shopping center buildings such as those found in parts of the City.

Unfortunately, there are times that the emergency has become too severe, even before the 9-1-1 notification and/or fire department response, for the responding crew to reverse; however, when an appropriate response time policy is combined with a well-designed system, then only issues like bad weather, poor traffic conditions, or multiple emergencies will slow the response system down. Consequently, a properly designed system will give citizens the hope of a positive outcome for their tax dollar expenditure.

For this report, "total" response time is the sum of the call processing / fire dispatch, crew turnout, and road travel time steps. This is consistent with the recommendations of the CFAI.

Finding #1:	The City Council has not adopted, *in one document, a commonly worded* and complete best-practices-based deployment measure or set of specialty response measures for all-risk emergency responses that includes all the response time segments of dispatch, crew turnout, and travel time, nor a goal statement tied to risks and outcome expectations. The deployment measure should have a second measurement statement to define multiple-unit response coverage for serious emergencies. Making these deployment goal changes will meet the best practice recommendations of the Commission on Fire Accreditation International.

3.2 COMMUNITY RISK ASSESSMENT INTRODUCTION

SOC ELEMENT 3 OF 8
COMMUNITY RISK ASSESSMENT

Risk assessment is a major component of developing a Standards of Cover (SOC) document. A risk assessment identifies the type of incidents a fire department will respond to and what resources and staffing it will need to mitigate the situation.

To better understand risk, it is necessary to define the types and levels of risk a community can encounter. For risk assessment in an SOC study, it is typical to consider low, moderate, high/special, and maximum risk occupancies. Risk also can be classified by probability and consequences. Probability is defined as the likelihood of a fire occurring in an occupancy type. Consequences are defined as the effects of the fire on the property and community.

As part of this project, the City requested an in-depth risk assessment. This comprehensive review is contained in *Part Two* of this study and will not be repeated here.

3.3 COMMUNITY EXPECTATIONS

Even without a currently adopted *specific* response time policy, given the City's historic funding level of fire services and its current General Plan fire policy statements, it is reasonable to assume that residents, employees, and visitors of the City expect an effective level of fire service response. This response should keep time-sensitive events such as serious medical emergencies, fires, and hazardous material releases, from becoming more serious, or worse, catastrophic.

To achieve this, Citygate recommends a best-practices-based goal for the first-due fire department response in an urban risk area to be 7:00 minutes from time of fire dispatch receipt, with a crew of four firefighters. Serious emergencies requiring multiple units and a minimum of

14-15 firefighters, including a Chief Officer, should arrive within 11:00 minutes of 9-1-1 receiving the call for assistance.

3.4 RISK ASSESSMENT RESULT

Upon Citygate's review of the risk assessment data, the City has:

- Urban population densities in many areas.
- Significant building stock ranging from single-family detached homes to high rise and multiple-story residential and business properties.
- Unique commercial and institutional uses such as an airport, schools, and health care facilities.
- Many residential areas that are bordered by open space areas containing quantities of wildland fire fuel types mixed in with the housing.
- Several major highway corridors, major surface street prime arterials, and passenger and cargo rail lines.
- Multiple waterways used not just for cargo movement, but for pleasure boating and water recreation activities.
- Strong automatic aid agreements and resources on several sides of the City.

Based on the above factors, the City has staffed and designed its response system to field an "Effective Response Force" of multiple units to reported serious fires in buildings and wildland areas, and operates paramedic ambulances for emergency medical responses.

The City's multi-unit force (First Alarm) is designed strong enough to stop the escalation of the emergency and keep it from spreading to greater alarms. These "informal" outcomes goals will be the foundation of updated deployment measures as part of this Standard of Response Cover Process.

3.5 EXISTING CITY DEPLOYMENT

3.5.1 Existing Deployment Situation—What the City Has in Place Currently

SOC ELEMENT 1 OF 8*
EXISTING DEPLOYMENT POLICIES
*Note: Continued from page 11.

For positive outcomes to building fires and serious medical emergencies which is consistent with the fire departments budget goal of a 4-minute travel time this study will benchmark the Department's performance against the response time recommendations of NFPA 1710 for career fire service deployment, which are:

- Four (4) minutes travel time for the first-due unit to all types of emergencies
- Eight (8) minutes travel time for multiple units needed at serious emergencies (First Alarm).

The City's current daily staffing plan is:

Table 3—Daily Minimum Staffing per Unit for the City – FY 2015/16

Unit	Minimum	Staff	Extended Minimum
24 Engines @	4	Firefighters/day	92
1 Engine @	3	Firefighters/day	3
9 Ladder Truck Companies @	4	Firefighters/day	36
15 Paramedic Ambulances @	2	Firefighters/day	30
1 Rescue Unit @	4	Firefighters/day	4
Subtotal firefighters			***165***
Emergency Medical Supervisor	1	Per day for command	1
Battalion Chiefs/Command	3	Per day for command	3
		Total	**169**

This daily staffing is adequate for the immediate response fire risk needs presented in most of the built-up urban areas of the City. On days when staffing levels allow, and the threat of wildland fire is serious, or dates with a large amount of waterway-based events, the Department can up staff additional specialty units with crews on focused overtime. However, for the daily staffing statement to be accurate as to adequacy for a building fire, the assumption is that the closest crews are available and all stations are staffed and not already operating on another emergency medical call or fire, which can and does happen. For example, if one engine and ambulance unit are committed to an emergency medical services call, then an adjacent engine company or truck

company must respond. This situation will be evaluated separately in Section 5 of this volume where simultaneous incident workload is analyzed.

The Department has solid automatic aid partnerships with the surrounding fire departments that will send their closest units into the City if the City's units are committed or not as close to other emergencies.

Services Provided

The City funds an "all-risk" fire department providing the people and assets it protects with services that include structure fire, wildland fire, ambulance paramedics, technical rescue, and hazardous materials response as well as other services.

Given these risks, the Department uses a tiered approach of dispatching different types of apparatus to each incident category. The regional fire Communications Center system selects the closest and most appropriate resource types and handles this function. As an example, here are the resources dispatched to common risk types:

Table 4—Resources Sent to Common Risk Types

Risk Type	Minimum Type of Resources Sent	Total Firefighters Sent
1-Patient EMS	1 Engine and 1 Paramedic Ambulance	6 FF
Auto Fire	1 Engine	4 FF
Residential Building Fire	4 Engines, 2 Ladder Trucks, 2 Battalion Chiefs, 1 Ambulance	28 FF
Commercial Building Fire	5 Engines, 3 Ladder Trucks, 2 Battalion Chiefs, 1 Ambulance	36 FF
Wildland Fire	1-2 Engines, 1 Brush Unit and 1 Battalion Chief	9-13 FF
Hazardous Materials and Technical Rescue	First Responding Engine, 1 Specialty Unit, 1 Ambulance, 1 Battalion Chief	11-15 FF

Finding #2: The Department has a standard response dispatching plan that considers the risk of different types of emergencies and pre-plans the response. Each type of call for service receives the combination of engine companies, truck companies, ambulances, specialty units, and command officers customarily needed to handle each type of incident based on experience.

3.5.2 Emergency Unit Staffing

All engine and ladder companies are staffed on a daily basis with a minimum staffing of four firefighters. The daily minimum shift staffing count is 165 firefighters *on firefighting units* plus four supervisors. Per NFPA 1710, a minimum of 14-15 firefighters plus a command chief are required for a typical room and contents fire in a home in a suburban area. For a single-patient emergency medical services event, one fire company plus an ambulance is needed.

While some departments staff three firefighters per unit, larger, highly urban agencies staff four personnel per engine company and ladder truck, as funding allows. There is no question that a four-person team is more time-effective and safer to both the firefighters and the people being served. A four-person team can split into two, two-person teams and, under Occupational Safety and Health Administration (OSHA) regulations, operate safely in hazardous environments. In chaotic incidents, a four-person team allows the Fire Captain or Supervisor to stand-back from the hands-on work and monitor the overall scene for bystander and traffic safety before the police arrive. When a fire engine paramedic must assist the ambulance paramedic with a patient transport to the hospital, a three-person engine crew is still in service to that neighborhood.

Thus, the daily staffing depth of the City is adequate to handle multiple medical emergencies and multiple serious building fires before relying on automatic aid. However, the City does not need to use all of its resources at once. In the automatic aid, closest-unit agreements, a mix of different agencies can be sent based on shortest response times. Doing so leaves other City units available for simultaneous calls for service.

Finding #3:	Minimum apparatus staffing per unit on engine and ladder truck companies at four is a recognized best practice for the City's size and risks.

SECTION 4—STAFFING AND GEO-MAPPING ANALYSIS

4.1 CRITICAL TASK TIME MEASURES—WHAT MUST BE DONE OVER WHAT TIME FRAME TO ACHIEVE THE STATED OUTCOME EXPECTATION?

SOC ELEMENT 4 OF 8
CRITICAL TASK TIME STUDY

Standards of Coverage (SOC) studies use task time information to determine the number of firefighters needed within a timeframe to accomplish the desired fire control objective on moderate residential fires and modest emergency medical rescues. The time it takes to complete one specific task is called an "evolution." These task time evolutions are shown on Table 5 through Table 7 to demonstrate the amount of time the operations require. The following three tables start with the time of fire dispatch notification, and finish with the outcome achieved. These tables are composite tables from Citygate clients in metropolitan departments very similar to Sacramento, with unit staffing at four personnel per engine or ladder truck. These tasks and times are also consistent with national published studies.[2] There are several important themes contained in these tables:

- The evolution test results were obtained at training centers under best conditions; the day was sunny and moderate in temperature. The structure fire response times are from actual events, showing how units arrive at staggered intervals.
- It takes a considerable amount of time after a task is ordered by command to actually accomplish the tasks and arrive at the desired outcome. This is because each task must be completed in order. The fewer the firefighters, the longer some task completion times will be. *Critical steps* are highlighted in ***grey*** in the table.
- Task completion time is usually a function of how many personnel are ***simultaneously*** available. This is desirable so that firefighters can complete some tasks simultaneously.
- Some tasks must be assigned to a minimum of two firefighters to comply with safety regulations. For example, two firefighters are required for searching a smoke-filled room for a victim.

[2] Report on Residential Fireground Field Experiments, National Institute of Standards and Technology Technical Note #1661, April 2010. NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments, 2016 Edition.

Table 5 displays unit and individual duties that are required at a First Alarm fire scene for a typical single-family dwelling fire. This set of duties is taken from typical urban fire departments' operational procedures, which are entirely consistent with the customary findings of other agencies using the Standards of Response Cover process. No conditions existed to override the Occupational Safety and Health Administration (OSHA) 2-in/2-out safety policy which requires that firefighters enter serious building fires in teams of two, while two more firefighters are outside and immediately ready to rescue them should trouble arise.

The following table displays the critical tasks for a department's response to a typical house fire in built-up suburban areas with four engines, two ladder trucks, one ambulance, and two Battalion Chiefs for a minimum force total of **28** personnel.

Scenario: *This was a simulated, two-story residential structure fire with an unknown rescue situation. Responding companies received dispatch information as typical for a witnessed fire. Upon arrival they were told approximately 1,000 square feet of the home was involved in fire.*

Table 5—First Alarm Structure Fire – 28 Firefighters

Structure Fire Incident Tasks	Time from Arrival of First Engine	Total Reflex Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		07:00
First engine on-scene	00:00	
Conditions report	02:37	
Supply line charged	03:00	
Charged line to second floor	03:48	
Rapid Intervention Team established	04:40	11:40
Forced entry	06:09	
First Battalion Chief and second engine arrival	03:38	
Ambulance, third and fourth engine arrival	05:45	
Back-up attack line at door charged	06:15	
Water on fire	07:04	14:04
First ladder truck and second Battalion Chief arrival	07:56	
Primary search for victims	08:10	15:10
Second ladder truck arrival	10:30	
Ladders positioned	11:05	
Utilities secured	12:45	
Positive pressure ventilation	12:32	
Secondary search complete	15:53	22:53
Check for fire extension in hidden spaces	15:58	
Fire out / **incident under control**	**16:45**	**23:45**

The duties in Table 5, grouped together, form an *Effective Response Force or First Alarm assignment*. The above distinct tasks must be performed simultaneously and effectively to achieve the desired outcome; arriving on-scene does not stop the escalation of the emergency. While firefighters accomplish the above tasks, the clock keeps running, which has been running since the emergency first started.

Fire spread in a structure can double in size during its free burn period. Many studies have shown that a small fire can spread to engulf the entire room in less than 4-5 minutes after free burning has started. Once the room is completely superheated and involved in fire (known as flashover), the fire will spread quickly throughout the structure and into the attic and walls. For this reason, it is imperative that fire attack and search commence before the flashover point occurs if the

outcome goal is to keep the fire damage in or near the room of origin. In addition, flashover presents a serious danger to both firefighters and any occupants of the building.

For comparison purposes, Table 6 reviews the tasks needed on a typical auto accident rescue.

Scenario: *The situation modeled was a one-car collision with one patient. The driver required moderate extrication with power tools and the vehicle was upright with no fuel hazards. One engine, one ladder truck, one ambulance, and one Battalion Chief responded with a total of eleven personnel.*

Table 6—Single-Patient Traffic Collision – 8 Firefighters plus an Ambulance and Battalion Chief

Vehicle Extrication Critical Tasks	Time from Arrival of First Engine	Total Reflex Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		07:00
Engine on scene	00:00	
Size up and upgrade to rescue response	00:15	
Initial report	02:00	
Vehicle stabilization initiated	02:00	09:00
Protection firefighting line in place	02:25	
Ambulance, Battalion Chief, and ladder truck arrival	02:00	
Patient assessed, vital signs obtained	03:48	10:48
Door forcibly opened and secured	04:48	
Patient on backboard and removed	05:40	13:50
Patient on gurney	06:00	
Patient under ambulance crew care and depart scene	**07:00**	**14:00**

As another comparison, Table 7 displays the critical tasks needed on a typical cardiac patient, full arrest:

Scenario: *This was a simulated one-patient full arrest indoors. A standard response of one engine and one ambulance responded with a total of six personnel.*

Table 7—Cardiac Arrest – 4 Firefighters plus an Ambulance

Cardiac Arrest Critical Tasks	Time from Arrival of First Engine	Total Reflex Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		7:00
First-due engine on scene	00:00	
Engine crew determine full arrest and start CPR	00:55	7:55
Ambulance on-scene	01:35	
Cardiac monitor attached to patient	02:10	
Auto pulse CPR unit attached	03:18	
Intravenous line placed	03:24	10:24
Bag valve mask ventilation started	03:42	
Epinephrine administered	05:32	12:32
Intubation completed	06:10	13:10
Defibrillate, positive change in patient rhythm	06:53	13:53
Patient on gurney	07:28	
Patient in ambulance	**10:15**	**17:15**

4.1.1 Critical Task Analysis and Effective Response Force Size

What does a deployment study derive from a response time and company task time analysis? The total task completion times (as displayed in the tables) to stop the escalation of the emergency must be compared to outcomes. We know from nationally-published fire service "time vs. temperature" tables that after about 4-5 minutes of free burning, a room fire will grow to the point of flashover. At this point, the entire room is engulfed, the structure becomes threatened, and human survival near or in the fire room becomes impossible. Additionally, we know that brain death begins to occur within 4-6 minutes of the heart having stopped. Thus, the Effective Response Force must arrive in time to stop these catastrophic events from worsening.

The response and task completion times discussed previously show that the residents of the City are able to expect positive outcomes, and have a good chance of survival, in a *serious* fire or medical emergency, *if the neighborhood assigned unit is available to respond*.

Mitigating an emergency event is a team effort *once* the units have arrived. This refers back to the "weight" of response analogy. If too few personnel arrive too slowly, then the emergency will worsen instead of improve. Control of the structure fire incident in the simulation still took 16:45 minutes/seconds after the time of the first unit's arrival, or 23:45 minutes/seconds from fire dispatch notification. The outcome times, of course, will be longer, with less desirable results, if the arriving force is later or smaller.

In the City, the quantity of staffing and the arrival timeframe can be critical in a serious fire. Fires in older and/or multi-story buildings could well require the initial firefighters needing to rescue trapped or immobile occupants. If a lightly-staffed force arrives, it cannot simultaneously conduct rescue and firefighting operations.

Fires and complex medical incidents require that the other needed units arrive in time to complete an effective intervention. Time is one factor that comes from ***proper station placement***. Good performance also comes from ***adequate staffing*** and training. In the critical task measures above, the departments that staff units similar to Sacramento can perform well in terms of time. However, major fires and medical emergencies in which the closest unit is not available to respond still challenge the Department's response system to deliver good outcomes. This factor **must** be taken into account when fire station locations are considered. If fire stations are spaced too far apart, then when one unit has to cover another unit's area, or multiple units are needed, these units can be too far away and the emergency will worsen.

Previous critical task studies conducted by Citygate, the Standard of Response Cover documents reviewed from accredited fire departments, and NFPA 1710 recommendations all arrive at the need for 15+ firefighters arriving within 8 minutes travel at a room and contents structure fire to be able to ***simultaneously and effectively*** perform the tasks of rescue, fire attack, and ventilation. Given that the Department sends *at least* 28 of its own personnel (four engines, two ladder trucks, one ambulance, and two Battalion Chiefs) to an incident involving a working house fire, it is clear that the City and its leaders understand that firefighting units arriving closely together, with adequate staffing, are needed to deliver a positive outcome that protects lives and property by stopping the escalation of the emergency.

A question one might ask is, "If fewer firefighters arrive, *what* from the list of tasks mentioned in Table 5 through Table 7 would not be done?" Most likely, the search team would be delayed, as would ventilation. The attack lines would only consist of two firefighters, which does not allow for rapid movement above the first-floor deployment. Rescue is conducted with only two-person teams; thus, when rescue is essential, other tasks are not completed in a simultaneous, timely manner. It must always be remembered: effective deployment is about the **speed** *(travel time)* and the **weight** *(firefighters)* of the attack.

Twenty-eight initial firefighters can handle a moderate-risk house fire; however, even an Effective Response Force of 28 will be seriously slowed if the fire is above the first floor, in a

low-rise apartment building, or commercial/industrial building. This is where the capability to add personnel to the initial response or to add entire alarms of multiple units becomes important.

Delivering 28 personnel to a moderate risk residential building fire reflects the City's likely goal to confine serious building fires to or near the room of origin, and to prevent the spread of fire to adjoining buildings. This is a typical desired outcome in built-out areas and requires more firefighters more quickly than the typical rural outcome of keeping the fire contained to the building, not room, of origin.

4.2 Distribution and Concentration Studies—How the Location of First-Due and First Alarm Resources Affects the Outcome

SOC Element 5 of 8
Distribution Study

SOC Element 6 of 8
Concentration Study

The City and contract fire district areas are served today by 24 fire stations; one additional station (Station 9) was closed in 1996. Thus, the City currently has 24 engines (pumpers) *in neighborhoods* for first response firefighting. It is appropriate to understand what the existing stations do and do not cover, if there are any coverage gaps needing one or more stations, and what, if anything, to do about them. Additionally, as the City continues to develop, the number and location of additional fire stations that might be necessary must be considered.

In brief, there are two geographic perspectives to fire station deployment:

- **Distribution** – the spreading out or spacing of first-due fire units to stop routine emergencies.
- **Concentration** – the clustering of fire stations closes enough together so that building fires can receive sufficient resources from multiple fire stations quickly. As indicated, this is known as the **Effective Response Force**, or, more commonly, the "First Alarm Assignment"—the collection of a sufficient number of firefighters on scene, delivered within the concentration time goal to stop the escalation of the problem.

To analyze first-due fire unit travel time coverage for this study, Citygate used a geographic mapping tool called *FireView*™ that can measure theoretical travel time over the street network. For this time calculation, Citygate staff uses the base map and street travel speeds calibrated to actual fire company travel times from previous responses to simulate real-world coverage. Using these tools, Citygate ran several deployment tests and measured their impact on various parts of the City. The travel time measure used was 4 minutes over the road network, which is consistent with the Department's budget measure goal and the "benchmark" recommendation in NFPA

1710 to deliver desirable outcomes in critical emergencies. When 90 seconds is added for dispatch time, and 90 seconds for crew turnout times, then the maps effectively show the area covered within 7:00 minutes for the first-due response, and 11:00 minutes for a First Alarm assignment.

4.2.1 Traffic Congestion Impacts

Citygate's team members personally observed the current rush-hour traffic congestion in the City, and others, since the great recession ended. The legacy approach to predict fire apparatus travel times over a street network is insufficient. The approach does not accurately result in response times at peak commute hours because the traditional data set during commute hours is not sufficient.

We thus obtained traffic throughput travel speed data from the company that provides real-time traffic data to internet-based traffic map applications. That company is a multi-national firm called HERE. This is the same data that drives internet-based map views of traffic congestion with red, yellow, and green segments to indicate flow impedance. HERE obtains traffic speed samples from a variety of public and private sources and measures traffic speeds in 15-minute time blocks, between intersections (segments), on a 24/7/365 basis for a rolling 36-month period.

To build the *traffic congestion* time-over-distance maps in this Report, Citygate's model first uses actual fire apparatus travel times averaged over a 24-hour time period for one year. Then traffic speed data is used to build a congested traffic model. Overall, the congestion impacts can be measured in the quantity of streets in the City covered at peak and off-peak hours:

Table 8—Road Mile Coverage for First-Due and First Alarm Units

Measure	Total Public Road Miles	Non-Congested Miles Reached by *Open* Fire Stations	Congested Road Miles	Difference (Miles)
4-minute travel, OPEN Fire Stations	2,336	1,544 *(66% of total public miles)*		**792**
		1,544	989 *(42.3% of open station area)*	**555**
Citygate minimum First Alarm @ 8-minute travel; 3 engines, 1 ladder truck, 1 Battalion Chief	2,336	1,521 *(65.1% of total public miles)*		**815**
		1,521	665 *(28.5% of open station area)*	**856**

As a starting point, only **66%** of the City's public streets are within 4 minutes travel time of an *open* fire station. Of the open fire stations, their travel coverage at commute hours is negatively

impacted by **23.7%**. More importantly, the multi-unit coverage at commute hours is much more severely impacted at **36.6%,** as several units must travel across large sections of the City. The following maps show where this normal and reduced coverage occurs.

4.2.2 Community Deployment Baselines

Map #1 – General Geography, Station Locations, and Risk Measurement Zones

This view shows the existing City fire station locations with the City and contract fire district limits, as well as risk management zones. This is a reference map view for the other map displays that follow. The symbols show the type of fire apparatus in each station, as well as automatic aid partner station locations.

Map #2a – Risk Assessment – High Risk Occupancies

This map plots the locations of higher risk for fire and life safety buildings as described in the risk assessment "Part" of this study. While much of the non-downtown areas are largely residential in zoning, it is important to note that higher risk sites are found in every neighborhood of the City. The highest density of such sites is in downtown and this is where the Department's Effective Firefighting Force of multiple units (First Alarm) should be the strongest.

Map #2b – Risk Assessment – Critical Facilities

Similar to Map #2a, this map plots the location of the identified critical facilities to be protected from fire and other hazards. These facilities are essential to the quality of life and economic operation of California's Capital City.

Map #2c – Risk Assessment – Large Fire Flow Surveyed Buildings

Risk assessment is an effort by the Department to classify properties by potential impact on service demand levels. Building fire risk, separate from the housing areas, was examined by understanding the locations of the higher fire flow buildings as calculated by the Insurance Service Office (ISO) as a measure of how zoning locates the educational, commercial, and industrial uses in the City. These higher fire flow sites (shown in green) are the buildings that must receive a timely and effective First Alarm force to serious fires, thus requiring more firefighters in fewer minutes should a serious fire emerge. Most of these higher fire flow buildings are along the major road corridors.

While most prevalent in the downtown core, City zoning has placed commercial buildings in most all fire station districts and in all four of this study's risk assessment zones. Thus, an Effective Response Force (First Alarm) capability is needed in all areas of the City, with a heavier unit response to the most densely built-up areas downtown.

Map #2d – Risk Assessment – Wildland Fire Threat Zones

As another measure of risk, this map displays the areas in and near the City limits where there is significant exposure to buildings from wildland fires. This map also shows these areas exist along the riverfront and in the pockets elsewhere. Most of the City is not exposed to this threat in a significant manner.

To better serve these areas, the Department has positioned wildfire apparatus in eight of the City's fire stations.

Map #2e – Risk Assessment – Population Density for EMS Incidents

Another risk factor is the population density as there is a direct correlation between population and the demand for emergency medical services. Anything over 5,000 residents per square mile is a very urbanized area. Due to historical zoning decisions, these areas exist not just downtown, but in all of the risk zones in this study. This means that the Department's ambulance system has to be deployed for a significant EMS demand in most areas of the City.

It must also be remembered that this map is for the reported resident, *not employment or tourist* populations, which at some periods of the workday and/or at entrainment venues, add significant EMS risk exposure to the Department's daily and hourly deployment plan.

Map #2f – Risk Assessment – Hazardous Materials Use Sites

Some commercial buildings use or store a significant amount of hazardous materials. Such sites are highly regulated by the Building and Fire Codes and enforcement of the codes is conducted by the Fire Department and Sacramento County Health Department. The location of these sites is mostly in the commercial and industrial zones of the City.

Map #3a – Fire Engine First-Due Unit Distribution at 4-Minute Travel

This map and others to follow show, using light colored green street segments, for uncongested traffic (non-rush-hour) the distribution of City fire engines per a best-practice-recommended response goal of 4 minutes *travel* time. Therefore, the limit of green color per station area is the time an engine could reach within this time ***assuming*** it is in-station and encounters no unusual traffic delays. In addition, the computer mapping tool uses actual fire company speed limits per roadway type. Thus, the green projection is realistic for fire trucks with normal traffic present. The darker green areas are where automatic aid units from adjoining fire departments overlap with City units.

As can be seen there are several small gap areas in the City not within reach of a fire station unit within 4 minutes travel time. A later map will examine these gaps and estimate how many added fire stations would be needed to close the gaps.

Citywide, actual dispatch data *shows* response times to be slower in most all areas of the City. This is due to the effects of the non-grid street design layout, open space areas, freeways that bisect parts of the City, traffic congestion, and simultaneous incident demand at peak hours of the day.

Map #3a – Fire Engine First-Due Unit Distribution at 4-Minute Travel – Traffic Congested*

Next, using data for peak-hour congested traffic, the 4-minute engine coverage is shown as smaller coverage areas. Except for a few areas where there is historically close station spacing, most station areas lose significant coverage during peak traffic congestion hours.

Citygate obtains traffic congestion data for each day's morning and evening rush hours. We look for the mathematical variances and, if they are wide, we produce maps by day of the week, or just morning or evening. Where the variances are small, and thus the congestion patterns are very similar, we use one mid-point congestion period to illustrate the most common impact. In the case of Sacramento, the variance is small and the Friday evening traffic pattern is most illustrative of what occurs during any rush hour period.

Map #3b – Ambulance Unit Distribution at 7-Minute Travel

This map shows a best practice travel time of 7 minutes for an ambulance. When 1 minute is added for crew turnout, this represents an 8-minute time from dispatching the call to arriving on-scene. As can be seen, at this measure, the entire City except for open space pockets and a few hard-to-serve edge areas, is within a 7-minute drive time of a fire station and there is considerable overlap between the City's and Metro Fire's ambulance units. However, as later ambulance workload measures show, this coverage is not maintained during periods of peak ambulance demand.

Map #3b – Ambulance Unit Distribution at 7-Minute Travel – Traffic Congested*

Next, using data for peak-hour congested traffic, the 7-minute ambulance coverage is shown as smaller coverage areas. Except for a few areas where there is historically close station spacing, most station areas lose significant coverage during peak traffic congestion hours. This is especially evident north of downtown across the river in Station 15's area, in closed Station 9's area and in Station 16's area to the south City limits.

The purpose of computer response mapping is to determine and balance station locations. This geo-mapping design is then checked in the study against actual dispatch time data, which reflects the real world. There also should be some overlap between station areas so that a second-due unit can have a chance of an adequate response time when it covers a call in another fire company's first-due area.

Finding #4:	Using the current 24 fire station locations, not including automatic aid stations, only the downtown, most-developed population density areas are within 4 minutes travel time of a fire engine. Traffic congestion has a marked negative impact on unit travel times in all but the core downtown existing fire station service areas.

Map #4 – ISO Coverage Areas

This map displays the Insurance Service Office (ISO) preference that stations cover a 1.5-mile distance response area. Depending on the road network in a department, the 1.5-mile measure usually equates to a 3.5- to 4-minute travel time. However, a 1.5-mile measure is a reasonable indicator of station spacing and overlap. As can be seen, the ISO coverage is similar, but less forgiving on a few edges of the City, than the 4-minute, *non-traffic-congested* travel time measure. This is because a "distance-based" measure cannot account for higher speeds on freeways and primary arterial streets that feed out into the neighborhoods.

This map shows that first-due fire company coverage gaps at the ISO 1.5-mile *distance measure* exist in many areas of the City outside of the downtown and southern I-5 corridor areas.

Map #5a – Concentration (First Alarm Residential) at 8-Minute Travel; Normal and Traffic Congested

This map exhibit shows the Effective Response Force (ERF) *concentration* or massing of fire crews for serious fire or rescue calls. Building fires, in particular, require 15+ firefighters (per NFPA 1710) arriving within a reasonable time frame to work together and effectively to stop the escalation of the emergency. Otherwise, if too few firefighters arrive, or arrive too late in the fire's progress, the result is a greater alarm fire, which is more dangerous to the public and the firefighters.

The concentration map exhibits look at the City's ability to send 4 engine companies, 2 truck companies, 1 ambulance, and 2 Battalion Chief officers to serious, working residential building fires within 8 minutes travel time (11:00 minutes total response time). This measure ensures that a minimum of 28 firefighters can arrive on-scene to work ***simultaneously*** and effectively to stop the spread of a serious building fire.

This map shows in light green *without traffic congestion*, where the City's current fire station system should deliver the initial Effective Response Force during off-peak traffic hours.

As can be seen, given a longer travel time measure of 8 minutes, only some of the City's core areas are covered by the Department's multiple-unit force. As later maps show, the limitation on this coverage is due to the smaller quantity of ladder trucks and chief officer units.

When traffic congestion math is applied, only three small areas shown as dark green can receive this multiple-unit force within 8 minutes of travel.

Finding #5:	Only the City's core areas are within 8 minutes travel time of an Effective Response Force assignment of four engines, two ladder trucks, one ambulance and two Battalion Chiefs, with *no traffic congestion.*

Map #5b – Concentration (First Alarm Commercial) at 8-Minute Travel; Normal and Traffic Congested

Given the size of the buildings and potential for severe fire and life risks, the Department sends an initial force of 5 engine companies, 3 truck companies, 1 ambulance, and 2 Battalion Chief officers to serious, working high-density residential building fires within 8 minutes travel time (11:00 minutes total response time). This measure ensures that a minimum of 36 firefighters can arrive on-scene to work ***simultaneously*** and effectively to stop the spread of a serious building fire.

Given the increased number of units sent to these fires, even fewer areas of the City can receive this force within 8 minutes travel time and almost no areas received this force under traffic congestion pressure.

Map #5c – Concentration (First Alarm Minimum) at 8-Minute Travel; Normal and Traffic Congested

Since the heavier response force currently sent to building fires cannot cover the entire City, this map shows a minimum coverage to a single-family house fire as a Citygate baseline measure. This minimum coverage provides an 8-minute travel time for 3 engines, 1 truck, and 1 chief officer totaling 17 firefighters.

As can be seen, all but three edge areas can receive this force *given normal traffic.* In congested traffic, the coverage significantly reduces to only central areas of the City.

Map #6 – 4 Engines Only at 8-Minute Travel; Normal and Traffic Congested

The next few maps "take apart" the First Alarm force to show a different view of concentration by unit type. This map only shows the 8-minute coverage of four engine companies or 16 firefighters. Here, the green color shows that the areas receiving four engines in 8 minutes travel time *given normal traffic*, cover all but two edge areas of the City.

However, under traffic congestion pressure, the 4-engine coverage reduces to the downtown core and a few areas, especially on the eastern side where the Metro Fire units assist in coverage.

Map #7 – One Battalion Chief at 8-Minute Travel; Normal and Traffic Congested

This map displays the coverage for one Battalion Chief at 8 minutes travel time. Therefore, Map #7 shows the *minimum* City-provided chief officer. As can be seen, even with 3 chief officers on duty, not all the edge areas can be covered *given normal traffic*. With congested traffic, the 1 chief officer reduces coverage to three core areas, including the important downtown.

Finding #6:	The City is too large and has too much traffic congestion for only three command chief officers to cover in 8 minutes travel. The addition of a fourth command chief and relocation of others to balance coverage should be further explored.

Map #8a – One Ladder Truck Coverage at 8-Minute Travel; Normal and Traffic Congested

Map #8a displays the 8-minute travel time coverage for a minimum of one ladder truck. As can be seen, the City's current ladder trucks can cover most of the City to except for two small edges. The coverage is so good, that with traffic congestion the two gaps enlarge, and a small third gap opens up around Station 8. This measure shows that the limiting unit coverage on the entire First Alarm force is mostly due to the Battalion Chief and ambulance unit limits.

Map #8b – Two Ladder Truck Coverage at 8-Minute Travel; Normal and Traffic Congested

Map #8b displays the coverage from two aerial ladder trucks, which is a very hard goal to achieve for most urban fire departments. The coverage shrinks away from the edges of the City, but coverage with two ladder trucks is possible in the downtown and capital areas, exactly where it is most needed.

Finding #7:	The City is too large and has too much traffic congestion for two ladder trucks to cover together in 8 minutes travel. While the second ladder within 8 minutes is a desired asset, it does not need to be on-scene within 8 minutes. As Map #8b measures, most of the highly urbanized areas of the City are covered by two ladder trucks within 8 minutes travel during non-traffic-congested hours. However, the downtown core is covered by two ladder trucks even during traffic congestion periods.

Map #9 – Wildland/Urban Interface Fire Unit Coverage at 8-Minute Travel; Normal and Traffic Congested

Map #9 displays the placement of the wildland apparatus and the resultant coverage at a desirable 8-minute travel goal. Almost the entire City is covered *given normal traffic*. Even when

traffic congestion is considered, most of the wildfire-prone areas of the City are fully or partially covered.

Map #10 – All Incident Locations – 3 Years

The following maps are an overlay of the exact location for all incident types. It is apparent that there is a need for fire services on almost every street segment of the City. The greatest concentration of calls is also where the greatest concentration of City resources is available. Given the City's closest-unit automatic aid partnerships, also shown are the locations outside the City where its units responded.

Map #11 – Emergency Medical Services and Rescue Incident Locations – 3 Years

This map further breaks out only the emergency medical and rescue call locations. With the majority of the calls for service being emergency medical, virtually all areas of the City need emergency medical services in any given year.

Map #12 – All Fire Type Locations – 3 Years

This map identifies the location of all fires in the City for a three-year period. All fires include <u>any</u> type of fire call, from auto to dumpster to building. There are obviously fewer fires than medical or rescue calls. Even given this, it is evident that all first-due engine areas experience fires; the fires are more concentrated where the population is higher and the City's resources are more concentrated. These also happen to be the areas where the building stock is older and less likely to be compliant with current codes.

Map #13 – Structure Fire Locations – 3 Years

Map #13 displays structure fire locations. While the structure fire count is a smaller subset of the total fire count, there are two meaningful findings from this map. First, there are still structure fires in every first-due fire company district. The location of many of the building fires parallels the older and higher risk building types in the City where more significant risk, and the ISO-evaluated buildings, are more common. These areas and buildings are of significant fire and life loss risk to the City. Second, fires in the more complicated building types must be controlled quickly or the losses can be very large.

Map #14 – EMS Incident Location Densities – 3 Years

This map view examines, by mathematical density, where clusters of emergency medical services incident activity occurred. In this set, the darker density color plots the highest concentration of all incidents. This type of map makes the location of frequent workload more meaningful than simply mapping all incident locations, as done in Map #11.

This perspective is important because the deployment system needs an overlap of units to ensure the delivery of multiple units when needed for serious incidents, or to handle simultaneous calls

for service. When this type of map is compared with the concentration of engines in Map #6, the best concentration should be where the greatest density of calls for service occur. This occurs in the core of the City where the fire station spacing is the closest.

Map #15 – Emergency Medical Services and Rescue Incident Location Densities – 3 Years

This map view is similar to Map #14, but includes rescue incidents. When these EMS and rescue hot spots are compared to the location of the Department's ambulances, the locations of the current ambulances *are excellent,* if they are available for dispatch and not already committed to another incident. As Section 5 shows, this occurs frequently during daylight hours.

Map #16 – All Fire Location Densities – 3 Years

This map is similar to Map #12, showing the locations for all types of fires. Again, much of this incident activity occurs in three primary areas, including the downtown core where multiple-unit coverage is the strongest.

Map #17 – Structure Fire Densities – 3 Years

This map shows only the building fire workload by density. While there are small clusters of building fire occurrences, the greatest densities occur southeast of downtown.

4.2.3 Fire Station Area Gap Coverage Analysis

The mapping analysis showed that the current fire station locations only cover 66% of the current City of Sacramento public road system at a 4-minute drive time. Of the 2,336 public street miles, the current fire station locations can cover 2,012 miles (or 90%) in 5:05 minute/seconds of travel time. The challenge then is to determine the number of gaps that are large enough to justify covering in the fifth minute of travel (4:01 to 4:59) to provide an equitable level of responder access to all neighborhoods, while not slowing the time needed to reach 90% of the road miles, as traffic congestion worsens and call for service demand increases.

The next step in this analysis is to look at the size, location, and risks in the gap areas beyond 4-minute coverage. Some gaps will be too small to ever be a candidate for an additional fire station. Other gaps could be the size of an entire fire station area or larger. The gap size information can be combined with a review of the frequency of response activity by adjacent fire companies. If the adjacent fire company that covers the gap is very busy, then the gap may not be just 5 minutes from another fire station, it could be much longer—8 to 10 minutes if the next closest unit is already committed to another emergency.

Map #18a – 4-Minute Travel Gap Analysis Maps

Map #18a was prepared using polygons around each gap area beyond 4 minutes travel time coverage from a fire station. The polygons are lettered in no particular order only for

identification purposes. Citygate evaluated these gaps against population density, multi-unit coverage, and incident volume. Key issues were measured in each gap using GIS mapping:

Some gaps are more understandable because they are at the edges of the City where it is always hard to extend fire station coverage out to 90% of a road network. Other gaps are infill where two or more station areas do not complete coverage at 4 minutes travel time.

Citygate prepared the following data table to evaluate various demographics about each gap in addition to road miles underserved:

- Gap approximate size across in miles.
- Resident population and prior emergency incident demand.
- The overall and building fire risk given the risk assessment criteria used in this study.

A ranking of the strength of adjoining fire companies available to a gap area, based on their travel times currently as well as their Unit-Hour Utilization (UHU) factor which measures their total time on incidents by hour of the day. In Table 10:

- "High" means long travel times and UHU workloads, so the "covering" companies close to the gaps are not as available, especially during daylight hours.
- Citygate then ranked all of the gaps according to what we determined would have the highest need for an additional fire station and crew. Thus, Citygate's #1 priority is based on our estimation of the gaps with the highest *composite* need.

The following table shows all of the gaps, their key measures, sorted by gap identification number in the left column:

Table 9—4-Minute Travel Gaps and Key Measures

Gap Identifier	Population	Non-congested Road Miles	Historical Incidents (7/1/12-6/30/15)
A	29,864	191.9	4,545
B	1,187	1.0	2
C	1,424	1.1	78
D	9,747	17.7	1,206
E	1,227	1.2	80
F	4,009	13.0	1,091
G	1,315	2.1	273
H	14,205	53.4	4,729
I	0	0.9	6
J	3,348	25.8	809
K	0	0.6	3
L	3,728	39.0	800
M	1,345	10.6	1,600
N	1,650	11.0	442
O	10,044	45.8	1,752
P	7,868	24.9	1,005
Q	5,067	11.2	426
R	0	2.2	107
S	2,289	13.4	523
T	12,849	49.3	1,521
U	12,467	44.2	2,965
V	21,520	44.0	1,781
W	12,210	54.7	5,257
X	1,193	7.6	396
Y	0	1.8	17
Z	0	1.8	33
AA	7,082	33.5	1,266

Using several factors, Citygate identified eight gaps significant enough to consider adding fire stations. They are a mix of infill neighborhoods and expanding new construction areas. Citygate suggests the following priorities for adding fire stations:

Table 10—Coverage Gaps and Suggested Order for Adding Stations

Gap ID	Population	Incidents	Road Miles Not Covered at 4-Minute Travel	Risk and Building Fire	Second-Due Unit Travel and UHU %	Deployment Need Fill Order	Type
U (Delta Shores)	12,467	2,965	44	Moderate	High	**1**	**New Const. Underway**
H	14,205	4,729	53.4	Moderate	High	**2**	**Infill**
O	10,044	1,752	45.8	Moderate	High	**3**	**Infill**
AA*	7,082	1,266	33.5	High**	High	**4**	**Restore**
P	7,868	1,005	24.9	Low	Moderate	**5**	**Infill**
X	1,193	396	7.6	Moderate	High	**6**	**Infill**
D	9,747	1,206	17.7	Moderate	High	**7**	**Infill + New Const.**
A**	29,864	4,545	191.9	Low*	High	**8**	**New Const.**
Total	***92,470***	***17,864***	***418.8***				

* This encompasses closed Station 9's area

** Not yet fully developed

The order of adding additional fire stations is complicated with issues other than the population, incidents, and 4-minute covered miles measured by Citygate in this study. The other issues in siting a station are land cost, availability, zoning, environmental, and traffic safety to mention a few. As additional staffing dollars are identified, the quickest way to add a fire company would be to reopen Station 9 in Gap AA. The timing of the other top three infill sites will be determined by City staff as they address all of the siting issues and forward to the City Council Capital Improvement Program (CIP) budget requests as part of the normal budget cycle.

Area "U," which is the Delta Shores Specific Plan Area, is a top priority because it is a large urban development a significant distance from the two nearest fire stations and construction is underway. It is anticipated that Delta Shores, in Phase I, will add approximately 13,000 residents and 1,400 square feet of retail/commercial development. For new construction areas, in general, Citygate recommends that fire stations and crews be online when 50% of a combination of commercial and residential units are given certificates of occupancy for use.

Additionally, the intense development in the proposed Railyards project (Area M on Map #18a) will require an additional fire station and engine company, and perhaps an additional ambulance, given the density of development and that the area is beyond the 4-minute reach of Stations 14 and 15. The additional station and crew should be operational when the Railyards project reaches 50% occupancy of the commercial and residential units.

If the top four Citygate recommended gaps were filled over time with a fire station and at least one fully-staffed engine, as funds allow, the total population receiving improved coverage would amount to 43,798 residents, which is the aggregate size of a modest suburban city. All eight gaps amount to 92,470 residents beyond a desired 4-minute travel time goal.

Over time, if all eight fire stations were to be added, another 17,864 emergencies would receive improved customer service, and 418 miles of public streets would be added to the 4-minute travel time coverage areas.

Finding #8:	At least four to six of the eight gaps identified beyond the adopted 4-minute travel time coverage should strongly be considered for permanent fire stations as economics permit. In addition to the existing four to six infill gaps, the Railyards project also will require a fire station due to its distance from existing fire stations.
Finding #9:	A four-station increase would also add resource depth to the Department at peak hours of the day and when other units are assigned out of their station area for training.

4.2.4 Ambulances vs. Engines as Added Gap Units

The Department operates 2-firefighter ambulances, and could add only ambulances to some of the gap areas. However, they do not replace a full firefighting engine and 4-person crew; they are an adjunct designed to provide medical care and transport patients to hospitals.

Given the spread-out nature of the eight gaps identified, and the need for at least four more fully-staffed fire stations at a minimum, Citygate is of the opinion that only using ambulances to fill the gaps, even on a 24-hour schedule, cannot replace the needed 4 to 6 absent fire engines.

SECTION 5—STATISTICAL ANALYSIS

5.1 HISTORICAL EFFECTIVENESS AND RELIABILITY OF RESPONSE—WHAT STATISTICS SAY ABOUT EXISTING SYSTEM PERFORMANCE

SOC ELEMENT 7 OF 8
RELIABILITY & HISTORICAL RESPONSE EFFECTIVENESS STUDIES

The map sets described in Section 4 show the ideal situation for response times and the responses' effectiveness given perfect conditions with no competing calls, light traffic conditions, units all in place, and no simultaneous calls for service. Examination of the actual response time data provides a picture of how response times are in the "real" world of simultaneous calls, rush hour traffic conditions, units out of position for training, and delayed travel time for events such as periods of severe weather.

5.1.1 Data Set Identification

The Sacramento Fire Department provided incident and apparatus data from its FDM records management system for three fiscal years from 2012/13-2014/15.

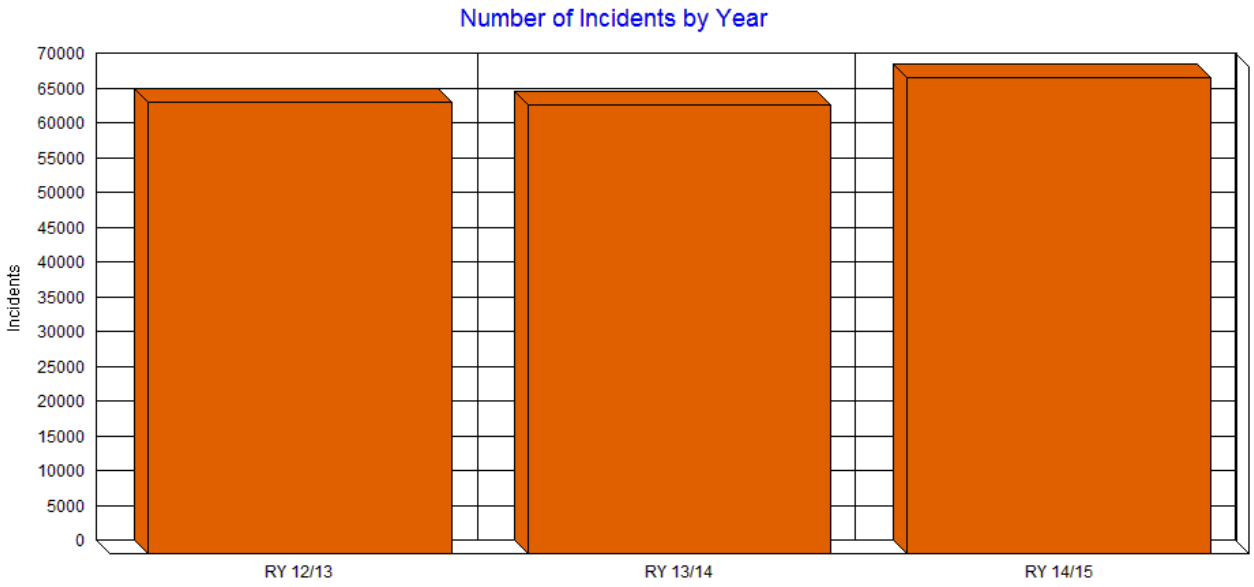
5.2 SERVICE DEMAND

In the Fiscal Year 2014/15 measurement period, the Department responded to and completed an incident report for 68,501 incidents within its jurisdiction. This represents an average daily demand of 188 incidents per day. The percentage of these incidents across three broad categories is as follows: 3% were fire incidents, 68.3% were EMS incidents, and 30.7% were to "Other" incident types.

During this same period, there were 164,310 apparatus responses. This means there was an average of 2.4 apparatus responses per incident.

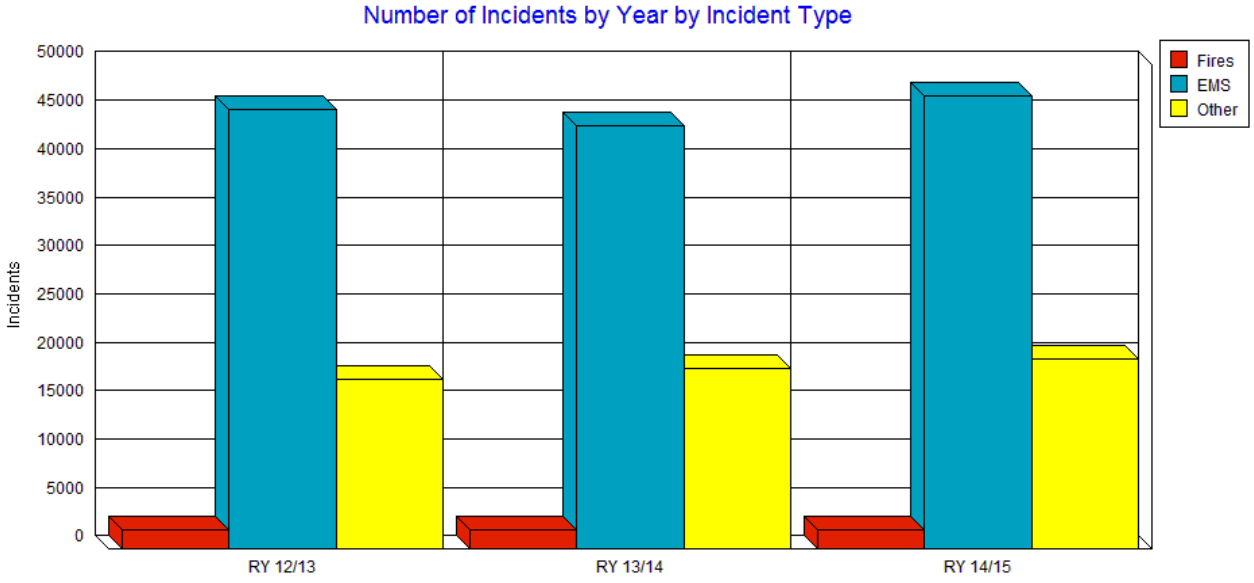
The Department is experiencing slight growth in the number of incidents year to year as indicated in the graph below.

Figure 1—Number of Incidents by Year



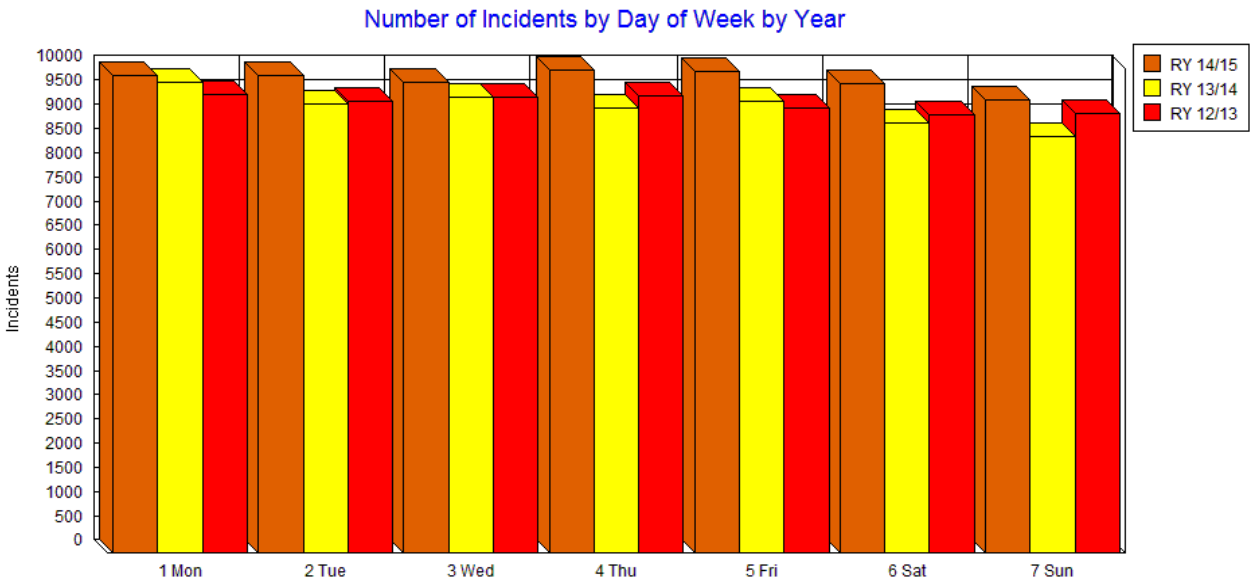
The following figure illustrates the number of incidents by incident type and volume per year:

Figure 2—Number of Incidents by Year by Incident Type



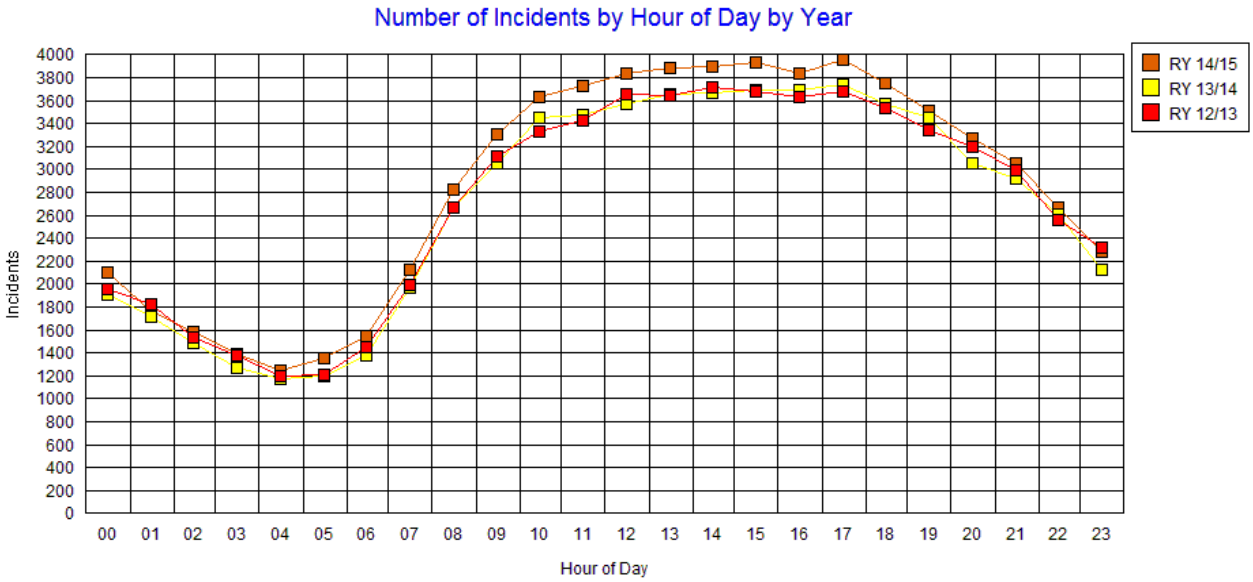
In the next graph, when broken down by day of week, incident activity is close to the same across all seven days of the week.

Figure 3—Number of Incidents by Day of Week by Year



The following displays the breakdown of incidents by hour of the day by year. Notice the activity sharply increases between 6:00 am and 9:00 am, topping out mid-afternoon, but maintains a constant level of activity until 6:00 pm when calls begin to slowly decrease.

Figure 4—Number of Incidents by Hour of Day by Year



The following table shows hourly incident totals by hours of day and day of week in FY 14/15. Green areas have the least activity. Red areas have the heaviest activity. It is evident that the greatest incident activity is in late morning through the early evening hours.

Table 11—Hourly Incident Totals by Hours of Day and Day of Week

Hour	1 Mon	2 Tue	3 Wed	4 Thu	5 Fri	6 Sat	7 Sun	Total
00:00-00:59	285	272	244	285	272	369	373	2,100
01:00-01:59	226	223	211	240	232	305	329	1,766
02:00-02:59	220	213	185	206	222	266	267	1,579
03:00-03:59	201	162	187	190	202	226	224	1,392
04:00-04:59	182	173	145	200	184	174	184	1,242
05:00-05:59	186	190	187	205	193	187	204	1,352
06:00-06:59	238	222	224	231	226	193	218	1,552
07:00-07:59	346	304	329	303	314	278	249	2,123
08:00-08:59	413	456	427	433	417	342	340	2,828
09:00-09:59	490	493	485	534	453	435	417	3,307
10:00-10:59	554	560	534	533	519	504	428	3,632
11:00-11:59	572	550	553	581	545	470	454	3,725
12:00-12:59	544	562	574	587	540	516	511	3,834
13:00-13:59	580	582	553	566	585	536	485	3,887
14:00-14:59	531	600	568	602	571	509	522	3,903
15:00-15:59	540	597	566	570	596	521	545	3,935
16:00-16:59	580	577	534	549	557	512	529	3,838
17:00-17:59	619	632	601	574	564	503	470	3,963
18:00-18:59	546	507	519	552	554	542	533	3,753
19:00-19:59	512	466	483	492	521	537	497	3,508
20:00-20:59	449	470	466	454	483	515	439	3,276
21:00-21:59	432	424	436	432	449	442	434	3,049
22:00-22:59	344	333	388	379	403	441	382	2,670
23:00-23:59	288	297	327	299	358	396	322	2,287
Total	**9,878**	**9,865**	**9,726**	**9,997**	**9,960**	**9,719**	**9,356**	**68,501**

A detailed review of the types of properties to which the Fire Department responds finds, in summary, that of the 68,501 incidents in a year, 51% occurred in residential dwelling units of all types. Another 21% occurred on roads, highways, and parking areas. The remaining 28%

occurred across a variety of commercial, industrial, and open space properties. Given that, in most cities, the predominant land use type is residential, these incident locations in Sacramento are normal.

Finding #10: The highest volume hours for incidents span from 8 am through 8 pm, and even later on Friday and Saturday. Given this, where additional units are needed, they could be peak-hour ambulances for 12 hours per day for at least 5-6 days per week.

5.2.1 Simultaneous Incident Demand

Simultaneous incidents are incidents that begin when other incidents have already been underway. In Sacramento during 2014/15, 94.63% of incidents occurred while one or more other incidents were underway. Here is the percentage of simultaneous incidents broken-down by number of simultaneous incidents:

Table 12—Simultaneous Incident Activity

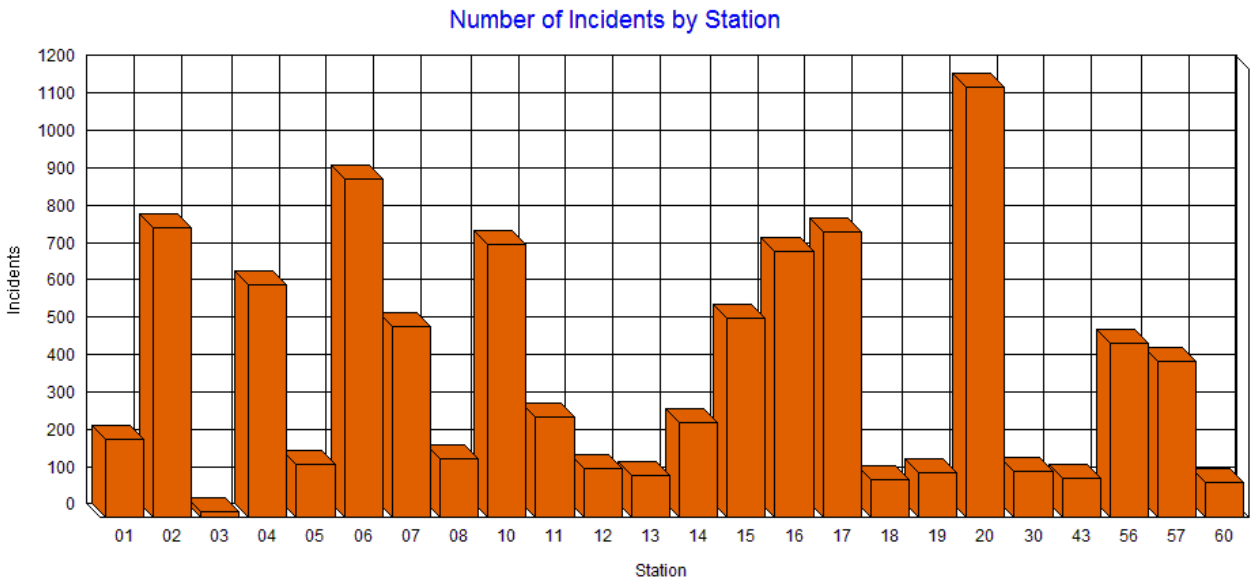
Number of Simultaneous Incidents	Percentage
1 or more	94.63%
2 or more	82.09%
3 or more	64.87%
4 or more	46.32%
5 or more	29.93%
6 or more	17.54%
7 or more	09.29%
8 or more	04.52%
9 or more	01.98%
10 or more	00.88%

In a large city, simultaneous incidents in different station areas have very little operational consequence. However, when simultaneous incidents occur within a single station area, there can be significant delays in response times.

Figure 5 illustrates the number of single-station simultaneous incidents by station area in 2014/15. Station 20, Station 06, and Station 02 have the greatest number of in-station area

simultaneous incidents. Station 03 has the fewest number of in-station-area simultaneous incidents.

Figure 5—Number of Simultaneous Incidents by Station



5.3 Response Time Analysis

Once the types of incidents are quantified, incident analysis shifts to the time required to respond to those incidents. Fractile breakdowns track the percentage (and count the number) of incidents meeting defined criteria, such as the first apparatus to reach the scene within progressive time segments.

5.3.1 Response Time Performance

A person calling 9-1-1 measures the speed of fire department response from the time assistance is requested until the assistance arrives. This measurement is called "Call to First Apparatus Arrival" (or "Call to Arrival"). Police and sheriff's departments, under state law, act as a Public Safety Answering Point (PSAP) for 9-1-1 calls. All 9-1-1 calls for fire service in the City are routed to the Sacramento Police Communications Center. Upon a quick evaluation, fire, EMS, and other rescue calls are routed to the Sacramento Regional Fire/EMS Communications Center for processing and crew dispatching. This center handles all fire service dispatching in the County and allows for a coordinated, closest unit response, regardless of jurisdiction of incident origin.

Based on national best practices, and our large client experience, Citygate's response time test goal is for the 90% Call to Arrival measure to be 7:00 minutes (or 420 seconds). This is made up of three component parts:

Table 13—Response Time Components

Time Component	Minutes	Description
Call Processing Time	90 seconds	Receive, determine need, alert crew
Turnout Time	90 seconds	Notify, don required protective gear, get moving
Travel Time	4 minutes	Drive to scene
Call to Arrival	**7:00 minutes/seconds**	**Time from Fire Dispatch receipt to first unit arrival**

There are three fundamental measurements of operational performance: Call Processing, Turnout Time, and Travel Time.

- Call Processing begins when a request for assistance is first received and ends when the dispatch center communicates the location and nature of the emergency to responders.
- Turnout begins with responder notification and ends when the fire apparatus begins "wheels turning" to the scene of the emergency.
- Travel begins with "wheels turning" and ends when the apparatus arrives at the scene of the emergency.

Each of these basic measurements is calculated as the amount of time it takes to reach 90% compliance. If we use Call Processing as an example, we select a set of incidents and calculate the amount of time it takes for 90% of requests for assistance to be dispatched to one or more apparatus.

Two additional measurements are: (1) "Dispatch to Arrival," which is 90% compliance from time of *one or two* apparatus being notified to respond to the time they arrive; and (2) "Call to Arrival," which is 90% compliance from the receipt of the request for assistance at fire dispatch until the first apparatus arrives on the scene.

Also measured is the performance of a team of apparatus commonly called a "First Alarm" but more properly known in fire service deployment as an Effective Response Force (ERF). This team is dispatched to serious or high risk incidents such as building and wildland fires or technical rescues. It is a best practice to measure "ERF Travel" from the first apparatus in the ERF to start "wheels turning" until the last apparatus necessary to establish the ERF team arrives on the scene. Thus, there are six types of response time performance outlined below to meet best practices as recommended by the NFPA and the Commission on Fire Accreditation International:

1. Call Processing
2. Turnout
3. Travel
4. Dispatch to Arrival
5. Call to Arrival
6. ERF Travel

Information on each performance category is provided below. The following performance measurements are based on apparatus response data timestamps from 7/1/2012 to 6/30/2015. Only "in-jurisdiction" fire and EMS incidents (where no mutual or auto aid was provided/given) were used for this analysis.

The times are shown in minutes and seconds and show the amount of time necessary for 90% of Priority 1 incidents to be handled. The number in parenthesis to the right of the time is the number of incidents used to perform the calculation. This number represents fire/EMS incidents with first arriving apparatus having call processing performance meeting outlier specifications. Outlier specifications eliminate times that are unrealistically too low or too high.

5.3.2 Call Processing Performance

Table 14—Call Processing Analysis (90% Baseline Performance in 2014/15)

Battalion	Time (Incidents)
Department-Wide	**02:24** (46,504)
Battalion 01	02:25 (15,281)
Battalion 02	02:23 (17,533)
Battalion 03	02:24 (13,690)

Finding #11: National best practices as recommended by NFPA 1710 are for call processing to be 90 seconds, 90% of the time, and 120 seconds, 99% of the time. The call sorting processing and crew alerting requires additional time, and is currently taking 144 seconds for 90% of calls.

5.3.3 Turnout Performance

Table 15—Turnout Time Analysis (90% Baseline Performance in 2014/15)

Battalion	Time (Incidents)
Department-Wide	**01:55** (42,113)
Battalion 01	01:53 (13,860)
Battalion 02	01:55 (15,905)
Battalion 03	01:57 (12,348)

Station design can profoundly affect turnout time. However, other factors such as location confirmation, gearing-up, and other essential and non-essential response preparations can have an effect on turnout time.

Finding #12: National best practices recommend turnout time to be 80 seconds for fires and 60 seconds for EMS incidents. Given station design and the legal requirement to don protective clothing before responding, Citygate finds, across a large set of clients, that a realistic goal is for turnout time to be 90 seconds to 90% of the emergent incidents. Sacramento is just under a 2-minute goal and to be commended for its performance close to a best-practices-based goal.

5.3.4 Travel Time Performance

Given the size of the City of Sacramento and a desirable goal to have every neighborhood have equitable access to fire and emergency medical services, the following travel times are reported by fire station areas and thus provide correlation to the GIS mapping projections.

Table 16—Travel Time Analysis (90% Baseline Performance in 2014/15)

Battalion/Station	Time (Incidents)
Department-Wide	**05:55** (39,552)
Battalion 01	05:23 (13,054)
Station 01	04:27 (1,322)
Station 02	04:31 (2,175)
Station 04	05:20 (2,340)
Station 05	05:30 (1,033)
Station 06	05:07 (2,641)
Station 08	06:18 (1,191)
Station 12	05:30 (1,089)
Station 14	06:35 (1,263)
Battalion 02	**05:53** (15,027)
Station 07	06:01 (1,955)
Station 10	05:52 (2,540)
Station 11	05:59 (1,590)
Station 13	06:02 (1,099)
Station 16	05:47 (2,391)
Station 56	05:24 (2,212)
Station 57	05:41 (2,115)
Station 60	06:29 (1,125)
Battalion 03	**06:30** (11,471)
Station 03	10:24 (143)
Station 15	07:18 (2,248)
Station 17	05:38 (2,380)
Station 18	06:28 (944)
Station 19	05:53 (872)
Station 20	05:42 (2,929)
Station 30	07:08 (1,020)
Station 43	06:45 (935)

Finding #13: In the 2014/15 measurement period, the Department had a 90% travel time Citywide of 5:55 minutes/seconds. This travel time is 1:55 minutes longer than national best practice publications for metro/urban areas. This travel time is fairly consistent across urbanized areas of the City, and none of the Battalions or station areas in Sacramento met a 4-minute goal.

5.3.5 Fire Crew Dispatch to Arrival Time Performance

The Department's current budget document performance measure for fire crew dispatch to arrival of the first crew on scene is 5 minutes to 90% of the fire and EMS incidents. As shown in the table below, no station areas were under a 5-minute, 90% Department goal, and only two areas downtown (where stations are spaced closely together) were under 6 minutes:

Table 17—Crew Dispatch to Arrival Time Analysis (90% Baseline Performance in 2014/15)

Battalion/Station	Time (Incidents)
Department-Wide	**06:57** (46,340)
Battalion 01	06:25 (15,236)
Station 01	05:42 (1,441)
Station 02	05:32 (2,711)
Station 04	06:17 (2,610)
Station 05	06:30 (1,254)
Station 06	06:09 (3,309)
Station 08	07:26 (1,267)
Station 12	06:37 (1,179)
Station 14	07:34 (1,465)
Battalion 02	**06:54** (17,455)
Station 07	07:02 (2,441)
Station 10	06:51 (3,068)
Station 11	07:13 (1,717)
Station 13	07:18 (1,176)
Station 16	06:42 (3,047)
Station 56	06:27 (2,446)
Station 57	06:40 (2,371)
Station 60	07:32 (1,189)
Battalion 03	**07:33** (13,649)
Station 03	12:09 (162)
Station 15	08:23 (2,464)
Station 17	06:32 (3,064)
Station 18	07:44 (1,011)
Station 19	07:08 (964)
Station 20	06:37 (3,754)
Station 30	08:04 (1,221)
Station 43	08:18 (1,009)

Finding #14:	As measured from crew dispatch to the first unit arrival, none of the City's fire station areas perform under the Department's goal of 5 minutes. This is because: crew turnout times realistically take more than 1 minute; and large station areas, absent sufficient station coverage, require travel times longer than 4 minutes. Traffic congestion also negatively impacts travel time results.

5.3.6 Call to Arrival Time Performance

This measure combines the steps of dispatch processing, crew notification with turnout, and travel time to 90% of the fire and EMS incidents. Citygate's recommended goal for this "total response time" is 7:00 minutes/seconds. As shown in the table on the following page, only one station area downtown (where stations are spaced closely together) is under a 7:00 minute/second, 90% Citygate-recommended goal:

Table 18—Fire Dispatch Receipt to *Arrival* Time Analysis (90% Baseline Performance in 2014/15)

Battalion/Station	Time (Incidents)
Department-Wide	**08:24** (47,089)
Battalion 01	**07:52** (15,495)
Station 01	07:13 (1,455)
Station 02	06:53 (2,771)
Station 04	07:45 (2,650)
Station 05	07:53 (1,277)
Station 06	07:32 (3,379)
Station 08	08:53 (1,276)
Station 12	08:01 (1,185)
Station 14	09:04 (1,502))
Battalion 02	**08:19** (17,737)
Station 07	08:25 (2,493)
Station 10	08:19 (3,125)
Station 11	08:31 (1,733)
Station 13	08:41 (1,185)
Station 16	08:05 (3,108)
Station 56	07:51 (2,486)
Station 57	08:08 (2,408)
Station 60	09:01 (1,199)
Battalion 03	**09:00** (13,857)
Station 03	13:10 (163)
Station 15	09:52 (2,491)
Station 17	08:00 (3,121)
Station 18	09:02 (1,021)
Station 19	08:35 (974)
Station 20	08:08 (3,837)
Station 30	09:26 (1,232)
Station 43	09:39 (1,018)

Finding #15: Due to longer dispatch and travel times, with the current quantity of fire stations, the Department only has one station area performing better than a Citygate-recommended Call Receipt to Arrival time of 7:00 minutes/seconds.

5.3.7 First Alarm (Effective Response Force) Performance to Building Fires

In the Department, the response plan is for four engines, two ladder trucks, one ambulance, and two Battalion Chiefs for a minimum force total of **28** personnel. The desired travel time goal in NFPA 1710 for career fire departments in urban areas is that the last unit arrive within 8 minutes *travel time* to 90% of the First Alarms.

Table 18 is the 90% ERF travel for 170 incidents with a travel time of less than 30 minutes to eliminate mutual aid responses outside of the City. Fire engines, ladder trucks, and the ambulance all arrived on scene inside the City for these incidents. In some rural areas in the contracted fire protection districts, or due to simultaneous incident demand, some units had atypical travel times and were not included in this count. Also, not all fires are serious enough for all of the units to be needed, so the resultant ERF count is small and not as statistically significant. Thus, the following table only aggregates ERF measures by Battalion areas:

Table 18—Travel Time for ERF Incidents (90% Baseline Performance in 2014/15)

Battalion	Time (Incidents)
Department-Wide	**23:24** (51)
Battalion 01	20:00 (9)
Battalion 02	23:24 (29)
Battalion 03	18:29 (11)

It is not always possible for 7 units, including limited quantity units such as ladders and ambulances, to all arrive to serious fires within 8 minutes travel. A few occurrences of the last unit being delayed in arrival in the table above can distort the overall performance. Citygate reviewed the arrival times of all the individual units and found that on these serious incidents, 4-5 units arrive in most of the urbanized areas within 8-9 minutes travel time, which is close to best practice recommendations. Given that the City staffs engines and ladder units with 4 firefighters each, if a combination of three engines and one ladder all arrive in less than 9 minutes, then 16 firefighting personnel are on scene which meets the NFPA 1710 minimum of 15+ firefighters.

5.3.8 Engine and Ambulance Workload Capacity Analysis

Due to the simultaneous incident rates measured in this study and the lengthy travel times in many areas approaching 6 minutes, this section of incident measures presents demand on units by the hour of day it occurs, and determines if the peak-hour demand is so high that response times suffer because units must cross the City to cover for overly busy units.

In the tables to follow, the different colors illustrate the variation in demand; the lowest rates of activity are green, progressing up to yellow, and finally red which indicates the greatest quantity of incidents or rate of activity. The following tables depict a Unit-Hour Utilization (UHU)

summary. The percentage listed is the percentage likelihood a particular unit is assigned to a 9-1-1 incident at any given hour. This number considers not only the number of emergency incidents, but also the duration time of the incidents. The busiest units are listed first.

In the tables to follow, it is important to consider the ideal maximum utilization percentage on a firefighting unit. During the 9-hour daytime work period, when crews on a 24-hour shift need to also pay attention to apparatus checkout, station duties, training, public education, and paperwork, plus required physical training and meal breaks, understanding all of the factors that go into a fire crew duty shift, Citygate recommends the maximum commitment UHU per hour should not exceed 30%. Beyond that, the most important element to suffer will be training hours.

There is a need to gain maximum economic efficiency out of an expensive to staff unit. For a dedicated unit, such as an ambulance or low acuity squad working *less than* a 24-hour shift, such as an 8- to 12-hour shift, then UHU can rise to 40-50% at a maximum. At that UHU level, peak-hour squad crews must then have additional duty days for training only, and not responding to incidents, in order to meet their annual continuing education and training hours requirements. Citygate recommends that an ambulance crew on a 24- to 48-hour shift also should not be worked above 30% UHU and, if done so for most of their core workday hours, their training and other commitments to departmental duties will suffer.

The following tables present the engine and ambulance UHU measures by Battalion. For brevity, the ladder truck and Battalion Chief UHU measures are <u>not</u> presented as they do <u>not</u> approach critical concern levels.

5.3.9 Battalion 1 – Unit-Hour Utilization – Medic Units

In Battalion 1, medic units M2, M1, and M6 have the highest demand percentage.

Table 19—FY 14/15 Unit-Hour Utilization in Battalion 1 – Medic Units

Hour	M2	M1	M6	M12	M8
00:00	38.93%	23.87%	19.74%	17.25%	13.96%
01:00	40.27%	27.25%	20.71%	13.09%	9.95%
02:00	31.99%	21.18%	16.19%	14.22%	14.10%
03:00	21.21%	13.45%	15.71%	9.82%	9.10%
04:00	21.33%	12.13%	15.38%	12.88%	6.30%
05:00	25.30%	13.89%	15.79%	14.98%	10.59%
06:00	27.39%	19.21%	16.21%	18.98%	14.24%
07:00	32.32%	29.97%	32.22%	24.44%	20.72%
08:00	50.30%	43.95%	36.84%	40.77%	25.20%
09:00	53.30%	46.00%	48.75%	44.13%	34.53%
10:00	54.91%	49.16%	48.22%	46.82%	27.80%
11:00	62.81%	53.14%	50.86%	49.47%	37.22%
12:00	55.95%	56.23%	55.84%	48.95%	36.56%
13:00	63.65%	53.56%	57.14%	45.91%	35.80%
14:00	61.01%	53.33%	49.19%	51.24%	32.24%
15:00	61.24%	62.12%	50.14%	51.74%	34.32%
16:00	62.87%	50.34%	51.43%	48.55%	37.28%
17:00	59.97%	52.15%	50.94%	50.24%	40.17%
18:00	56.45%	50.60%	46.60%	39.04%	29.10%
19:00	52.14%	38.22%	39.14%	42.41%	27.21%
20:00	47.45%	42.85%	36.15%	34.18%	24.01%
21:00	45.88%	37.44%	33.62%	33.00%	20.95%
22:00	40.36%	29.77%	29.77%	23.26%	17.03%
23:00	35.64%	27.43%	25.14%	23.09%	14.77%
Overall	**45.94%**	**37.80%**	**35.90%**	**33.27%**	**23.88%**
Responses	**6,209**	**5,132**	**5,577**	**4,366**	**3,168**

5.3.10 Battalion 1 – Unit-Hour Utilization – Engines

In Battalion 1, engines E2, E4, and E6 are the busiest apparatus.

Table 20—FY 14/15 Unit-Hour Utilization in Battalion 1 – Engines

Hour	E2	E4	E6	E14	E1	E8	E12	E5
00:00	12.30%	8.41%	8.08%	6.53%	4.69%	4.01%	3.83%	3.82%
01:00	16.41%	8.70%	6.23%	4.71%	6.73%	4.53%	3.64%	3.63%
02:00	12.67%	8.33%	5.56%	6.70%	6.32%	5.37%	3.84%	4.86%
03:00	5.23%	4.74%	4.58%	4.27%	4.56%	3.39%	3.76%	2.41%
04:00	6.06%	4.58%	4.39%	6.30%	3.23%	2.61%	3.58%	2.48%
05:00	4.12%	6.01%	6.42%	5.63%	3.01%	3.40%	4.78%	3.02%
06:00	4.85%	7.37%	4.12%	5.81%	4.05%	3.91%	4.29%	2.97%
07:00	8.38%	8.95%	10.48%	10.24%	5.64%	5.46%	11.07%	6.26%
08:00	12.42%	10.73%	15.79%	11.48%	9.02%	7.25%	7.50%	7.88%
09:00	13.06%	15.94%	15.97%	12.29%	9.69%	9.86%	8.03%	6.63%
10:00	11.90%	16.50%	12.56%	12.57%	10.01%	9.65%	9.88%	7.07%
11:00	12.99%	17.21%	13.86%	12.96%	9.54%	9.41%	9.18%	6.37%
12:00	14.33%	16.74%	15.42%	11.69%	9.91%	9.24%	8.56%	9.81%
13:00	20.11%	19.75%	21.99%	14.99%	12.77%	14.11%	10.56%	10.23%
14:00	18.87%	17.37%	17.77%	15.34%	12.68%	10.08%	11.05%	9.20%
15:00	20.69%	18.97%	19.61%	13.88%	12.10%	9.29%	14.19%	10.64%
16:00	15.93%	18.35%	14.95%	12.94%	10.07%	11.56%	10.55%	9.13%
17:00	15.19%	15.14%	15.50%	11.46%	11.23%	13.89%	9.51%	8.54%
18:00	14.77%	14.54%	13.16%	12.13%	7.48%	9.57%	8.40%	6.59%
19:00	14.57%	13.00%	14.62%	10.41%	8.73%	8.09%	7.36%	8.29%
20:00	13.84%	11.90%	12.51%	10.63%	9.22%	6.75%	7.68%	6.34%
21:00	12.59%	9.94%	11.14%	11.09%	7.26%	7.23%	7.04%	6.15%
22:00	11.73%	8.23%	11.76%	8.60%	7.39%	5.19%	5.11%	5.11%
23:00	11.94%	7.91%	10.08%	5.98%	6.09%	4.31%	4.31%	4.48%
Overall	**12.71%**	**12.06%**	**11.94%**	**9.94%**	**7.98%**	**7.42%**	**7.40%**	**6.33%**
Responses	**4,385**	**3,873**	**4,686**	**2,972**	**2,572**	**2,213**	**2,129**	**2,229**

5.3.11 Battalion 2 – Unit-Hour Utilization – Medic Units

In Battalion 2, medic units M56, M11, and M10 have the highest demand percentage.

Table 21—FY 14/15 Unit-Hour Utilization in Battalion 2 – Medic Units

Hour	M56	M11	M10	M7
00:00	34.33%	22.99%	20.03%	22.99%
01:00	24.88%	18.70%	19.22%	23.96%
02:00	24.47%	24.16%	18.64%	15.31%
03:00	25.42%	19.18%	16.58%	17.16%
04:00	19.95%	16.49%	13.63%	13.11%
05:00	21.50%	19.30%	16.16%	18.49%
06:00	31.12%	29.66%	19.38%	19.69%
07:00	37.74%	34.60%	25.19%	26.71%
08:00	48.13%	36.75%	32.32%	31.21%
09:00	45.81%	47.18%	37.67%	32.36%
10:00	55.39%	46.17%	43.55%	40.68%
11:00	57.86%	45.33%	38.09%	35.96%
12:00	58.31%	48.64%	40.74%	37.67%
13:00	47.93%	40.39%	40.18%	34.06%
14:00	62.15%	50.65%	41.67%	41.74%
15:00	55.31%	49.21%	43.88%	41.25%
16:00	54.12%	52.23%	45.33%	41.98%
17:00	60.60%	53.07%	45.90%	38.73%
18:00	52.19%	47.46%	38.05%	36.60%
19:00	47.17%	44.41%	40.25%	37.40%
20:00	51.40%	46.27%	41.09%	31.72%
21:00	43.93%	31.04%	32.16%	31.74%
22:00	40.80%	29.65%	28.05%	28.37%
23:00	34.01%	26.12%	22.21%	25.54%
Overall	**43.10%**	**36.65%**	**31.67%**	**30.19%**
Responses	**5,377**	**3,859**	**3,949**	**3,954**

5.3.12 Battalion 2 – Unit-Hour Utilization – Engines

In Battalion 2, engines E57, E56, and E10, are the most active.

Table 22—FY 14/15 Unit-Hour Utilization in Battalion 2 – Engines

Hour	E57	E56	E10	E16	E7	E11	E13	E60
00:00	11.83%	11.28%	8.35%	8.14%	7.58%	7.29%	4.58%	5.44%
01:00	9.29%	7.02%	9.10%	6.69%	6.19%	4.74%	4.30%	4.75%
02:00	7.42%	8.40%	8.29%	5.66%	4.82%	4.63%	4.42%	3.47%
03:00	7.37%	7.89%	5.82%	6.21%	4.43%	3.14%	4.71%	4.36%
04:00	6.26%	7.60%	7.16%	4.37%	4.98%	3.98%	4.12%	2.77%
05:00	7.10%	10.81%	6.42%	3.57%	4.68%	4.64%	4.50%	4.79%
06:00	9.08%	7.28%	6.63%	6.93%	4.78%	4.89%	5.82%	3.52%
07:00	10.67%	11.37%	11.21%	11.57%	7.60%	7.93%	4.91%	6.20%
08:00	11.06%	13.38%	12.45%	11.10%	11.73%	9.04%	8.42%	8.05%
09:00	16.08%	9.48%	13.61%	12.82%	8.37%	11.90%	11.61%	8.33%
10:00	16.95%	14.49%	14.61%	11.97%	14.03%	11.45%	9.88%	9.10%
11:00	13.79%	12.91%	13.91%	10.14%	11.56%	13.22%	9.85%	7.71%
12:00	14.76%	15.41%	13.56%	13.01%	12.30%	12.65%	10.56%	10.42%
13:00	19.81%	15.01%	16.94%	11.33%	13.50%	13.04%	11.88%	15.56%
14:00	19.99%	19.10%	16.17%	15.52%	14.48%	14.79%	12.50%	11.90%
15:00	18.49%	19.57%	16.80%	14.47%	15.21%	10.63%	13.82%	11.68%
16:00	16.46%	16.23%	15.20%	13.00%	12.75%	10.51%	9.55%	12.03%
17:00	14.80%	17.67%	12.92%	11.98%	11.05%	11.24%	10.02%	9.76%
18:00	17.94%	16.01%	14.28%	14.23%	13.73%	12.93%	9.58%	9.28%
19:00	16.50%	17.46%	16.24%	12.58%	13.77%	11.02%	11.10%	8.13%
20:00	13.57%	13.32%	14.90%	15.20%	10.59%	10.55%	6.97%	8.44%
21:00	11.98%	14.13%	13.56%	11.85%	12.84%	9.46%	6.91%	5.54%
22:00	12.76%	14.13%	12.51%	11.71%	11.19%	6.70%	4.86%	5.44%
23:00	10.65%	10.90%	10.63%	8.60%	9.06%	5.55%	4.33%	5.56%
Overall	**13.11%**	**12.95%**	**12.14%**	**10.53%**	**10.05%**	**9.00%**	**7.88%**	**7.59%**
Responses	**3,527**	**3,713**	**4,027**	**3,583**	**3,122**	**2,472**	**1,954**	**1,999**

5.3.13 Battalion 3 – Unit-Hour Utilization – Medic Units

In Battalion 3, the busiest medic units are M20, M17, and M43.

Table 23—FY 14/15 Unit-Hour Utilization in Battalion 3 – Medic Units

Hour	M20	M17	M43	M19
00:00	34.71%	25.65%	25.39%	11.20%
01:00	26.54%	26.17%	18.98%	7.61%
02:00	24.92%	18.01%	16.73%	7.51%
03:00	21.45%	19.65%	16.62%	5.61%
04:00	20.26%	18.97%	16.47%	5.47%
05:00	23.67%	22.36%	18.90%	5.28%
06:00	28.88%	23.72%	24.88%	6.22%
07:00	37.75%	33.25%	33.57%	10.77%
08:00	43.81%	39.63%	39.63%	20.05%
09:00	44.80%	45.02%	41.83%	25.05%
10:00	50.58%	45.09%	37.16%	34.91%
11:00	60.32%	41.90%	47.63%	32.19%
12:00	52.70%	52.87%	54.41%	36.14%
13:00	59.69%	46.40%	39.72%	38.47%
14:00	52.48%	46.09%	52.17%	33.15%
15:00	59.24%	45.71%	43.73%	35.70%
16:00	49.86%	45.67%	50.03%	38.16%
17:00	57.01%	43.77%	48.34%	27.62%
18:00	53.38%	48.20%	43.91%	31.68%
19:00	47.57%	39.05%	44.64%	26.53%
20:00	52.41%	41.22%	36.67%	28.03%
21:00	49.17%	35.70%	37.86%	22.80%
22:00	44.53%	31.41%	31.48%	15.73%
23:00	38.26%	28.52%	30.63%	13.19%
Overall	**43.08%**	**36.00%**	**35.47%**	**21.63%**
Responses	**5,522**	**3,942**	**3,660**	**3,168**

5.3.14 Battalion 3 – Unit-Hour Utilization – Engines

In Battalion 3, the busiest engines are E20, E15, and E17.

Table 24—FY 14/15 Unit-Hour Utilization in Battalion 3 – Engines

Hour	E20	E15	E17	E18	E19	E30	E43	E3
00:00	10.39%	10.43%	9.85%	4.07%	4.12%	4.86%	4.21%	0.90%
01:00	8.47%	9.62%	6.84%	3.51%	2.55%	3.57%	1.66%	0.46%
02:00	7.25%	8.95%	5.45%	2.35%	2.58%	2.75%	1.76%	0.28%
03:00	6.82%	6.68%	4.97%	2.74%	3.10%	5.15%	1.90%	0.75%
04:00	7.34%	8.85%	5.63%	1.80%	2.55%	2.84%	2.03%	1.23%
05:00	6.87%	7.12%	7.06%	2.62%	4.99%	2.76%	2.06%	1.00%
06:00	6.53%	7.38%	7.13%	5.78%	2.43%	3.70%	4.60%	1.23%
07:00	11.82%	10.21%	9.96%	5.08%	3.63%	5.92%	3.98%	2.02%
08:00	14.55%	10.45%	14.89%	7.20%	5.66%	10.57%	4.52%	1.62%
09:00	11.86%	10.60%	13.11%	8.57%	9.23%	5.76%	4.51%	2.25%
10:00	11.75%	12.12%	12.79%	8.21%	8.88%	5.73%	4.25%	1.57%
11:00	12.28%	16.50%	12.41%	8.91%	9.56%	7.12%	6.25%	2.19%
12:00	17.53%	17.25%	15.57%	10.60%	9.76%	6.31%	5.80%	3.17%
13:00	20.13%	16.61%	21.47%	12.28%	12.35%	12.54%	9.39%	5.10%
14:00	15.41%	18.88%	15.32%	10.21%	9.41%	6.24%	7.31%	1.75%
15:00	19.09%	18.90%	15.01%	12.34%	14.15%	9.71%	9.60%	3.57%
16:00	16.50%	17.00%	13.07%	8.97%	7.99%	9.18%	7.49%	3.59%
17:00	15.48%	17.84%	11.16%	9.48%	8.90%	8.34%	6.42%	2.11%
18:00	19.01%	17.60%	17.84%	9.33%	8.76%	6.92%	8.06%	4.15%
19:00	18.12%	15.78%	18.75%	9.16%	7.27%	10.12%	6.67%	3.40%
20:00	19.44%	18.25%	13.88%	9.54%	8.07%	7.63%	5.22%	2.50%
21:00	17.61%	14.94%	12.30%	7.78%	5.82%	6.65%	6.60%	3.56%
22:00	17.48%	11.86%	9.22%	4.79%	5.86%	5.74%	6.02%	3.41%
23:00	11.37%	12.82%	9.11%	5.61%	3.51%	5.32%	3.98%	2.88%
Overall	**13.46%**	**13.19%**	**11.78%**	**7.12%**	**6.71%**	**6.48%**	**5.18%**	**2.28%**
Responses	**4,639**	**3,448**	**3,841**	**1,854**	**1,814**	**1,660**	**1,245**	**538**

The following table shows all of the ambulances in one table:

Table 25—FY 14/15 Unit Hour Utilization for All Ambulances

Hour	M2	M56	M20	M1	M11	M17	M6	M43	M12	M10	M7	M8	M19
00:00	38.93%	34.33%	34.71%	23.87%	22.99%	25.65%	19.74%	25.39%	17.25%	20.03%	22.99%	13.96%	11.20%
01:00	40.27%	24.88%	26.54%	27.25%	18.70%	26.17%	20.71%	18.98%	13.09%	19.22%	23.96%	9.95%	7.61%
02:00	31.99%	24.47%	24.92%	21.18%	24.16%	18.01%	16.19%	16.73%	14.22%	18.64%	15.31%	14.10%	7.51%
03:00	21.21%	25.42%	21.45%	13.45%	19.18%	19.65%	15.71%	16.62%	9.82%	16.58%	17.16%	9.10%	5.61%
04:00	21.33%	19.95%	20.26%	12.13%	16.49%	18.97%	15.38%	16.47%	12.88%	13.63%	13.11%	6.30%	5.47%
05:00	25.30%	21.50%	23.67%	13.89%	19.30%	22.36%	15.79%	18.90%	14.98%	16.16%	18.49%	10.59%	5.28%
06:00	27.39%	31.12%	28.88%	19.21%	29.66%	23.72%	16.21%	24.88%	18.98%	19.38%	19.69%	14.24%	6.22%
07:00	32.32%	37.74%	37.75%	29.97%	34.60%	33.25%	32.22%	33.57%	24.44%	25.19%	26.71%	20.72%	10.77%
08:00	50.30%	48.13%	43.81%	43.95%	36.75%	39.63%	36.84%	39.63%	40.77%	32.32%	31.21%	25.20%	20.05%
09:00	53.30%	45.81%	44.80%	46.00%	47.18%	45.02%	48.75%	41.83%	44.13%	37.67%	32.36%	34.53%	25.05%
10:00	54.91%	55.39%	50.58%	49.16%	46.17%	45.09%	48.22%	37.16%	46.82%	43.55%	40.68%	27.80%	34.91%
11:00	62.81%	57.86%	60.32%	53.14%	45.33%	41.90%	50.86%	47.63%	49.47%	38.09%	35.96%	37.22%	32.19%
12:00	55.95%	58.31%	52.70%	56.23%	48.64%	52.87%	55.84%	54.41%	48.95%	40.74%	37.67%	36.56%	36.14%
13:00	63.65%	47.93%	59.69%	53.56%	40.39%	46.40%	57.14%	39.72%	45.91%	40.18%	34.06%	35.80%	38.47%
14:00	61.01%	62.15%	52.48%	53.33%	50.65%	46.09%	49.19%	52.17%	51.24%	41.67%	41.74%	32.24%	33.15%
15:00	61.24%	55.31%	59.24%	62.12%	49.21%	45.71%	50.14%	43.73%	51.74%	43.88%	41.25%	34.32%	35.70%
16:00	62.87%	54.12%	49.86%	50.34%	52.23%	45.67%	51.43%	50.03%	48.55%	45.33%	41.98%	37.28%	38.16%
17:00	59.97%	60.60%	57.01%	52.15%	53.07%	43.77%	50.94%	48.34%	50.24%	45.90%	38.73%	40.17%	27.62%
18:00	56.45%	52.19%	53.38%	50.60%	47.46%	48.20%	46.60%	43.91%	39.04%	38.05%	36.60%	29.10%	31.68%
19:00	52.14%	47.17%	47.57%	38.22%	44.41%	39.05%	39.14%	44.64%	42.41%	40.25%	37.40%	27.21%	26.53%
20:00	47.45%	51.40%	52.41%	42.85%	46.27%	41.22%	36.15%	36.67%	34.18%	41.09%	31.72%	24.01%	28.03%
21:00	45.88%	43.93%	49.17%	37.44%	31.04%	35.70%	33.62%	37.86%	33.00%	32.16%	31.74%	20.95%	22.80%
22:00	40.36%	40.80%	44.53%	29.77%	29.65%	31.41%	29.77%	31.48%	23.26%	28.05%	28.37%	17.03%	15.73%
23:00	35.64%	34.01%	38.26%	27.43%	26.12%	28.52%	25.14%	30.63%	23.09%	22.21%	25.54%	14.77%	13.19%
Overall	**45.94%**	**43.10%**	**43.08%**	**37.80%**	**36.65%**	**36.00%**	**35.90%**	**35.47%**	**33.27%**	**31.67%**	**30.19%**	**23.88%**	**21.63%**
Responses	**6,209**	**5,377**	**5,522**	**5,132**	**3,859**	**3,942**	**5,577**	**3,660**	**4,366**	**3,949**	**3,954**	**3,168**	**3,168**

Finding #16: While some engines reach 20% Unit-Hour Utilization workloads, no engines approach a Citygate recommended threshold of 30%. At peak hours of the day, while many engines are busy with EMS events, adding engines into existing stations at this time is not yet necessary.

Finding #17: Ten (10) of the City's 15 ambulances exceed a Citygate recommended 30% Unit-Hour Utilization rate for most of the daylight hours seven days a week. In Battalion 1, four ambulances exceed 30%; in Battalions 2 and 3, three ambulances per Battalion exceed 30%.

Finding #18: The workload on the ten busiest ambulances is past the critical saturation point and crew effectiveness, training, and availability for incidents suffers. Reliever ambulances are needed for peak hours of the day as soon as possible in all three Battalions.

SECTION 6—SOC EVALUATION AND RECOMMENDATIONS

6.1 OVERALL EVALUATION

SOC ELEMENT 8 OF 8
OVERALL EVALUATION

The Department serves a very diverse land use pattern with a geographically challenging and limited road network in some areas. Population drives service demand and development brings population. The outer areas of the City and especially the contract fire districts have slightly slower response times typical of less developed suburban areas of California. While the City and now the state-mandated Fire Code has required fire sprinklers even in dwellings, it will be many more decades before enough buildings are replaced or remodeled using automatic fire sprinklers. For the foreseeable future, the City will need both a first-due firefighting unit and Effective Response Force (First Alarm) coverage in all parts of the City, consistent with current best practices, if the risk of the fire is to be limited to only part of the inside of the affected building.

The Department is not meeting its budget goal of "*4:00 minutes travel time, plus 1:00 minute turnout time*." The reality is instead of a 5:00 minute/second response time from crew notification, the actual Citywide performance is 06:57 minutes/seconds or 1:57 longer. Citygate submits there are four principal reasons for this situation: (1) too few stations; (2) traffic congestion; (3) high workload rates on many key companies; and (4) some fire station areas that are too large.

6.1.2 The Path Ahead

If the City wants to provide the three outcomes below, the City will have to increase its deployment of fire crews by adding at least 4 to 6 key missing fire stations, and increase the number of ambulances at peak hours of the day in all three Battalion areas. The three outcomes are:

- Provide equitable response times to all similar risk neighborhoods
- Provide for depth of response when multiple incidents occur
- Provide for a concentration of response forces in the core for high-risk venues.

If the City chooses <u>not</u> to adopt these three policy goals for fire services delivery, then it should adopt a travel time goal that it can afford, understanding that longer response times will mean the most time-sensitive emergencies could experience worse than desired outcomes.

6.1.3 Additional Ambulances

During the timeframe of this study the Department added two more full-time ambulances at Stations 30 and 57 and their impact is not measured in this study. However, there are other

neighborhood coverage needs for those units; they were not added only to lower workload on the busiest units in each Battalion area.

This study identified that too many ambulances are at or past desirable emergency incident commitment capacity (measured as unit hour utilization or UHU) for too many contiguous hours during the crew's core work shift. Citygate recommends as a *first* step, to add three peak-hour (part-time) ambulances which will lower the utilization demand on the busiest ambulances, along with other strategies the Department is pursing to lower hospital wait times and provide for alternative treatments for non-emergency patients. Even with three added peak-hour ambulances, some ambulances will still have utilizations above 30% per hour at times, but not for as many hours at a stretch, opening up time for other fire service duties and training.

The impact of the three added ambulances can immediately be measured and the alternative work schedules adjusted as needed during a trial period. If, after a trial period, enough workload is not removed from the overworked units, then additional units, even 24-hour-based units, may be needed. However, that cannot be determined until the added impact of three peak-hour ambulances is observed along with the impacts, if any, of other strategies to reduce the time spent on EMS incidents.

6.1.3 Overall Deployment Recommendations

Based on the technical analysis and findings contained in this Standards of Coverage study, Citygate offers the following overall deployment recommendation:

Recommendation #1: **Address Emergency Medical Services Workload by Adding Peak-Hour Ambulances:**

1.1 Add at least three peak-hour ambulances Monday through Saturday, one in each of the three Battalions. Measure the workload reductions on the busiest units and adjust the additional ambulance hours as needed.

1.2 The ambulance system should be deployed using full- and part-time units to deliver transport services where needed to patients, within 8 minutes travel time, or 11:00 minutes/seconds total response time from fire dispatch receiving the call for assistance.

Recommendation #2:	**<u>Address Service Gaps by Adding Fire Stations and Resources:</u>** **2.1** Identify the funding and timing to restore closed Fire Station 9 and add a fire station in the Delta Shores expansion area along with at least two other infill fire stations in the larger service gaps areas. **2.2** As fire stations are added and incident volumes and severity increase, the Department can explore/consider adding a fourth field Battalion Chief position per day. **2.3** When the Railyards project reaches 50% occupancy of the commercial and residential units, add a fire station and engine inside the project area.
Recommendation #3:	**<u>Adopt Updated Best Practice City Council Deployment Measures Policy:</u>** The City's elected officials should adopt updated, complete performance measures to direct fire crew planning and to monitor the operation of the Department. The measures of time should be designed to deliver outcomes that will save patients medically salvageable upon arrival; and to keep small, but serious fires from becoming greater alarm fires. With this is mind, Citygate recommends the following measures:

3.1 Distribution of Fire Stations: To treat medical patients and control small fires, the first-due unit should arrive within 7:00 minutes/seconds, 90% of the time from the receipt of the 9-1-1 call in the regional fire dispatch center. This equates to a 90-second dispatch time, 90-second company turnout time, and a 4-minute drive time in the most populated areas. The ambulance system should be deployed within 8:00 minutes travel time or 11:00 minutes total response time from fire dispatch receiving the call for assistance.

3.2 Multiple-Unit Effective Response Force for Serious Emergencies: To confine residential fires near the room of origin, to stop wildland fires to under three acres, and to treat multiple medical patients at one incident, a multiple-unit response force of a minimum of four engines, two ladder trucks, one ambulance, and two Battalion Chiefs totaling 28 personnel should arrive within 11:00 minutes/seconds from the time of 9-1-1 call receipt in fire dispatch, 90% of the time. This equates to 90-seconds dispatch time, 90 seconds company turnout time, and 8 minutes drive time spacing for multiple units in the most populated areas.

3.3 Hazardous Materials Response: Provide hazardous materials response designed to protect the community from the hazards associated with uncontrolled release of hazardous and toxic materials. The fundamental mission of the Fire Department response is to minimize or halt the release of a hazardous substance so it has minimal impact on the community. It can achieve this with a travel time in urban to suburban areas for the first company capable of investigating a HazMat release at the operations level within 4 minutes travel time or less than 90% of the time. After size-up and scene evaluation is completed, a determination will be made whether to request additional resources from the Department's hazardous materials team.

3.4 Technical Rescue: Respond to technical rescue emergencies as efficiently and effectively as possible with enough trained personnel to facilitate a successful rescue. Achieve a travel time for the first company in urban to suburban areas for size-up of the rescue within 4 minutes travel time or less, 90% of the time. Assemble additional resources for technical rescue capable of initiating a rescue within a total response time of 11:00 minutes/seconds, 90% of the time. Safely complete rescue/extrication to ensure delivery of patient to a definitive care facility.

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SECTION 7—NEXT STEPS

7.1 NEXT STEPS

The purpose of a Standards of Cover study is to compare the City's current performance against the local risks to be protected and nationally recognized best practices. This analysis of performance forms the base from which to make recommendations for changes, if any, in fire station locations, equipment types, staffing, and headquarters programs.

As one step, the City Council should adopt updated and best-practices-based response time goals for the City and provide accountability for the Fire Department personnel to meet those standards. The goals identified in Recommendation #3 meet the City's risk and emergency outcome needs and correlate to national best practices. Measurement and planning as the City continues to evolve over time will be necessary for the City to meet these goals. Citygate recommends that the City's next steps be to work through the issues identified in this study over the following time lines:

7.1.1 Short-Term Steps

- Absorb the policy recommendations of this fire services study and adopt updated City performance measures to drive the deployment of firefighting and emergency medical resources.
- Restore funding for a fire engine and crew at closed Fire Station 9.
- Require fire stations be added inside the Delta Shores and Railyards new project areas.
- Develop the costs and a timeline for a minimum of two additional infill fire stations.

7.1.2 Long-Term Steps

- Monitor the effect of growth and traffic congestion on incident demand volume at peak hours of the day.
- If traffic congestion continues to decay response times, even with additional ambulances and fire crews, then more peak-hour and 24-hour ambulances and perhaps engines will become necessary to maintain response times to critical events.

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PART TWO

Community Risk Assessment

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SECTION 8—COMMUNITY RISK ASSESSMENT

8.1 COMMUNITY RISK ASSESSMENT INTRODUCTION

SOC ELEMENT 3 OF 8
COMMUNITY RISK ASSESSMENT

The third element of the Standards of Coverage (SOC) process is a community risk assessment or analysis. The objective of a community risk assessment is to:

1. Identify the hazards with potential to adversely impact the community or jurisdiction
2. Quantify the probability of occurrence for each identified hazard
3. Identify and evaluate factors likely to influence impact severity for each identified hazard
4. Determine overall risk by hazard.

A *Hazard* is broadly defined as a situation or condition that can cause or contribute to harm. Hazard examples include fire, medical emergency, vehicle collision, earthquake, flood, etc. *Probability* is the likelihood of occurrence of a particular hazard, and *impacts* or *consequences* are the adverse effects that a hazard occurrence has on people, property, and/or the community as a whole. *Risk* is broadly defined as the *probability of hazard occurrence* in combination with the *likely severity of resultant impacts*, and *Risk Vulnerability* is a measure of the probability of the existing deployment model's ability to protect against or mitigate a specific hazard.

8.2 RISK ASSESSMENT METHODOLOGY

The methodology employed by Citygate to assess and quantify community risk as an integral element of an SOC study incorporates the following elements:

1. Identification of geographic risk assessment sub-zones (risk zones) appropriate for the community or jurisdiction
2. Identification of the fire and non-fire natural and human-caused hazards with potential to adversely impact the community or jurisdiction
3. Determination of *probability of future occurrence* for each hazard by risk zone considering historical service demand and the probability of occurrence criteria described in Table 26.

Table 26—Probability of Occurrence Criteria

Probability Score	Description	Criteria
1	Very Low	Less than 10% probability of occurrence within next 12 months
2	Low	10% - 25% probability of occurrence within next 12 months
3	Moderate	26% - 75% probability of occurrence within next 12 months
4	High	76% - 90% probability of occurrence within next 12 months
5	Very High	Greater than 90% probability of occurrence within next 12 months

4. Identification and evaluation of appropriate *impact severity factors* for each hazard by risk zone using agency/jurisdiction-specific data and information and the impact severity factor score criteria described in Table 27 and throughout this risk assessment.

Table 27—Impact Severity Factor Score Criteria

Risk Factor Score	General Factor Description
1	Risk factor ***negligibly*** contributes to increased overall impact severity, or significantly contributes to reducing overall impact severity
2	Risk factor ***minimally*** contributes to increased overall impact severity, or contributes moderately to reducing overall impact severity
3	Risk factor ***moderately*** contributes to increased overall impact severity
4	Risk factor ***significantly*** contributes to increased overall impact severity
5	Risk factor ***seriously*** contributes to increased overall impact severity

5. Calculation of *overall risk score* for each hazard by multiplying the sum of *impact factor scores* by the *probability of occurrence* score for each risk zone.

6. Determination of overall *Risk Rating* by risk zone based on overall risk score as described in Figure 6 and Table 28.

Figure 6 illustrates the methodology used to quantify overall risk for each hazard by risk zone.

Figure 6—Overall Risk Calculation Flowchart

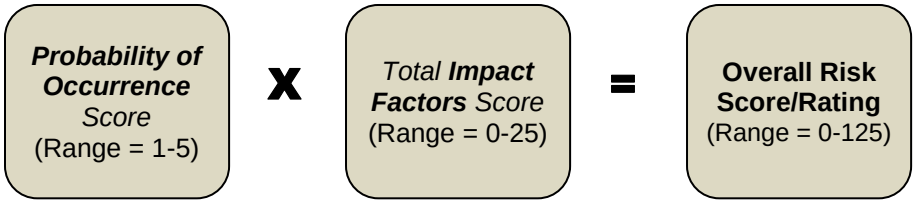


Table 28 shows overall *Risk Rating* by risk zone based on overall risk score.

Table 28—Overall Risk Rating

Overall Risk SCORE	Overall Risk RATING
0 - 31	LOW
32 - 62	MODERATE
63 - 94	HIGH
95 - 125	VERY HIGH

Citygate used multiple data sources for this study to understand the risks to be protected in Sacramento as follows:

- U.S. Census Bureau population data and demographics
- Insurance Services Office (ISO) building fire flow and construction data
- City of Sacramento Geographical Information Systems (GIS) data
- City of Sacramento 2035 General Plan and Zoning documents
- 2011 City of Sacramento Local Hazard Mitigation Plan (LHMP) Annex to the Sacramento County LHMP Update
- Trends of historical incident response data.

8.3 Risk Assessment Summary

Citygate's evaluation of the various risks likely to adversely impact Sacramento yields the following conclusions:

1. Sacramento has differing population densities within the City.
2. Sacramento's population is projected to grow by over 33% over the next 20 years

3. Sacramento has a mix of residential, commercial, office, and industrial buildings typical of a large western metropolitan city
4. Sacramento has a vast transportation network including highways and other primary vehicle transportation routes, railways, mass transportation modes, and airports
5. The City of Sacramento has varying levels of risk relative to nine hazards specifically relating to fire department services as follows:
    a. Building Fire Risk
    b. Wildland Fire Risk
    c. Emergency Medical Service Risk
    d. Hazardous Materials Risk
    e. Technical Rescue Risk
    f. Transportation Risk
    g. Maritime Risk
    h. Earthquake/Seismic Activity Risk
    i. Flood Risk

For this analysis, six risk assessment zones were established in collaboration with the Department's Project Team as shown in Figure 7.

Figure 7—Risk Assessment Zones

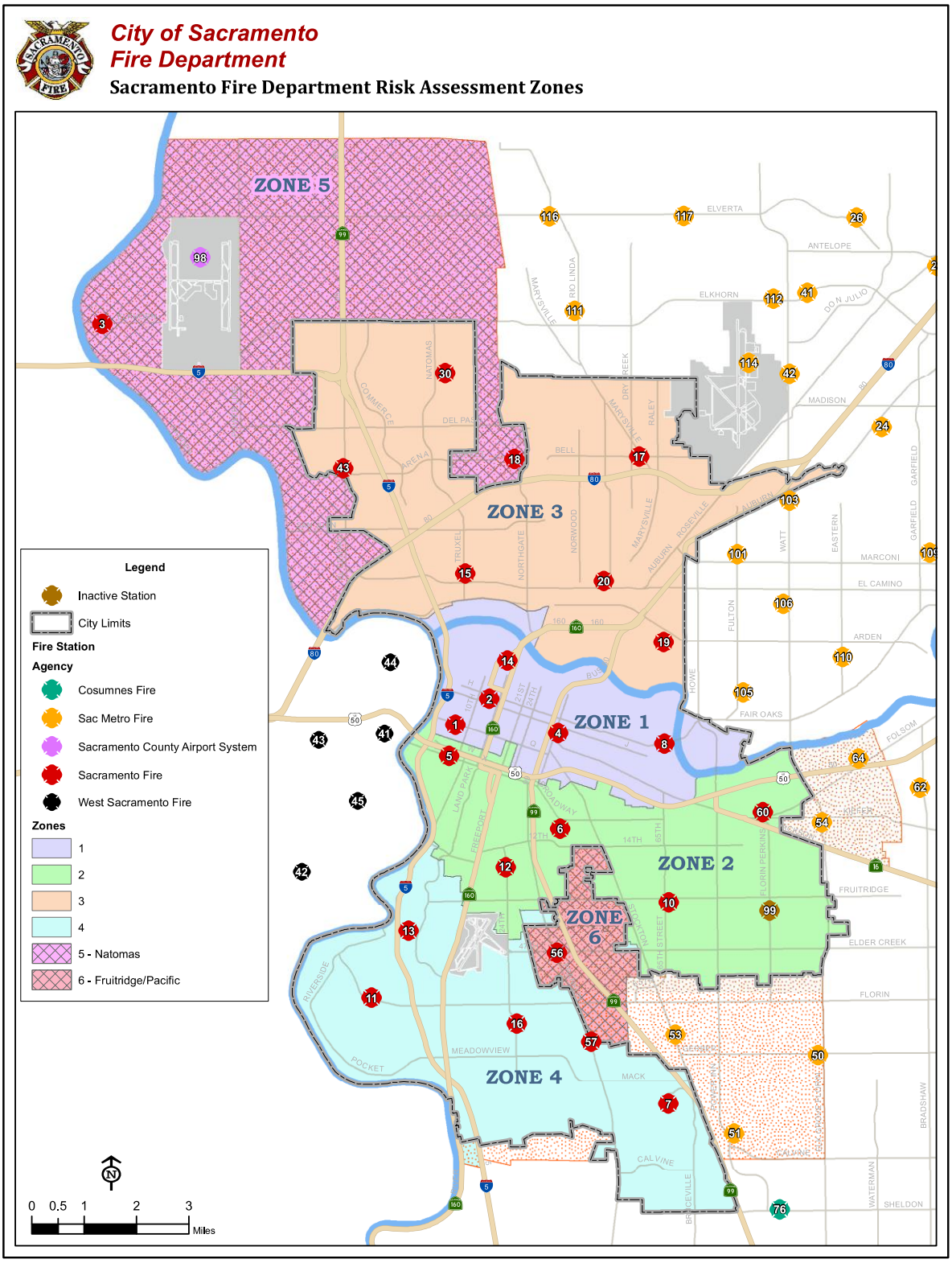


Table 29 summarizes Sacramento's overall risk by hazard and risk zone.

Table 29—Overall Risk Summary by Hazard and Risk Zone

Risk	Risk Assessment Zone					
	1	2	3	4	5	6
Building Fire	High	Moderate	Moderate	High	Low	Moderate
Wildland Fire	Moderate	Moderate	Moderate	Low	Low	Low
EMS	High	High	High	High	High	High
Hazardous Material	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Technical Rescue	Moderate	High	Moderate	High	Moderate	Low
Transportation	High	High	High	High	High	High
Maritime	Low	Low	Low	Low	Low	Low
Earthquake/Seismic Activity	Low	Low	Low	Low	Low	Low
Flood	Low	Low	Moderate	Moderate	Moderate	Moderate

The following sections will describe the risk analysis process and risk factors used to determine overall risk as shown in Table 29 in more detail.

8.4 COMMUNITY DEMOGRAPHICS[3]

8.4.1 City of Sacramento

Table 30 summarizes key demographic data for the City of Sacramento.

Table 30—City of Sacramento Demographics

Demographic	2000	2013	Percentage
Population	**407,018**	**471,477**	
Under 5 years	29,066	34,135	7.2%
5 – 19 years	94,192	93,747	19.9%
20 – 64 years	237,317	291,407	61.8%
Over 65 years	46,443	52,188	11.1%
Median age	32.8	33.7	
Housing Units	**163,957**	**193,273**	
Owner-Occupied	77,514	85,886	44.4%
Renter-Occupied	77,067	91,442	47.3%
Employment			
Labor Force[1]	N/A	227,700	46.9%[2]
Employment[1]	N/A	214,800	94.3%
Ethnicity			
White	196,549	163,722	34.7%
Hispanic/Latino	87,974	128,152	27.2%
Black/African American	62,968	65,373	13.9%
Asian	67,635	86,357	18.3%
Other	8,108	27,873	5.9%
Education (age 25 and over)			
High School Graduate	54,716	76,861	20.5%
Undergraduate Degree	39,609	62,330	19.0%
Graduate Degree	21,433	31,721	10.4%
Birthplace			
U.S.	324,459	368,339	78.1%
Foreign-Born	82,616	103,138	21.9%

[1] October 2015 data - California Employment Development Department
[2] Based on estimated 2014 population of 485,200
Source: U.S. Census Bureau; State Employment Development Department; Sacramento Area Council of Governments (SACOG)

[3] No detailed demography data available for Natomas or Pacific Fruitridge Fire Protection Districts

8.5 GROWTH AND DEVELOPMENT

8.5.1 City of Sacramento

Overview

The City of Sacramento's 2035 General Plan[4] envisions Sacramento as "*the most livable city in America.*" As the state's capital city, Sacramento will continue to play its traditional role in the region as the primary center of government, employment, and culture. Downtown Sacramento will be vibrant with arts, culture, entertainment, and a 24-hour population; and the City's economy will continue to strengthen, diversify, and play a larger role in the global economy with a broad range of jobs in all industry sectors, including those related to small and local businesses.

The General Plan further envisions the following themes:

- Every neighborhood will be a desirable place to live because of its walkable streets, extensive tree canopy, range of housing choices, mixed-use neighborhood centers, great schools, parks and recreation facilities, and easy access to Downtown and jobs.
- Sacramento will be linked to the rest of the region by an extensive, efficient, and safe network of roadways, bridges, mass transit, bikeways, pedestrian trails, and sidewalks. It will be linked to the rest of California and the world by an international airport, conventional and high-speed passenger rail, interstate highways, and high-speed communication systems.
- Sacramento will continue to celebrate its cultural and ethnic diversity and ensure the equitable treatment of all neighborhoods and groups.
- Sacramento will protect its historic and cultural resources and its natural environment and will increase access to its riverfront and open spaces for the enjoyment of its growing population.
- Sacramento will promote the health and well-being of the community and will plan for the long-term safety of its citizens.
- Sacramento will be a model of sustainable development in its planning, its use of urban heat island reduction measures, and its conservation of energy, water, and other natural resources.

[4] Sacramento 2035 General Plan (March 2015)

Land Use and Future Development

The City's General Plan land use policies include:

- Regulating population and building intensity to not more than 640,400 population and 390,100 employees by 2030
- Promoting and facilitating infill development
- Requiring annexation prior to providing City services
- Planning for future growth in Special Study Areas
- Preserving and enhancing neighborhoods as a basic unit
- Protecting established neighborhoods
- Promoting complete and well-structured neighborhoods that promote livability and safety for residents of all ages and cultures
- Promoting development of strategically located mixed-use neighborhood centers
- Preserving and enhancing Sacramento's riverfronts as signature features.

The General Plan also provides policy direction for specific communities in the form of Community Plans. The 2035 General Plan includes ten Community Plans as follows:

- Arden Arcade (AA)
- Central City (CC)
- East Sacramento (ES)
- Fruitridge Broadway (FB)
- Land Park (LP)
- North Natomas (NN)
- North Sacramento (NS)
- Pocket (P)
- South Area (SA)
- South Natomas (SN)

In addition, the General Plan identifies five Special Study Areas adjacent to current City boundaries that are of interest to the City for planning purposes:

- Arden Arcade Study Area

- East Study Area
- Fruitridge Florin Study Area
- Natomas Joint Vision Study Area
- Town of Freeport Study Area

Projected Growth Figure 8 illustrates the City's Community Planning Areas.

Figure 8—City of Sacramento Community Planning Areas

INTRODUCTION

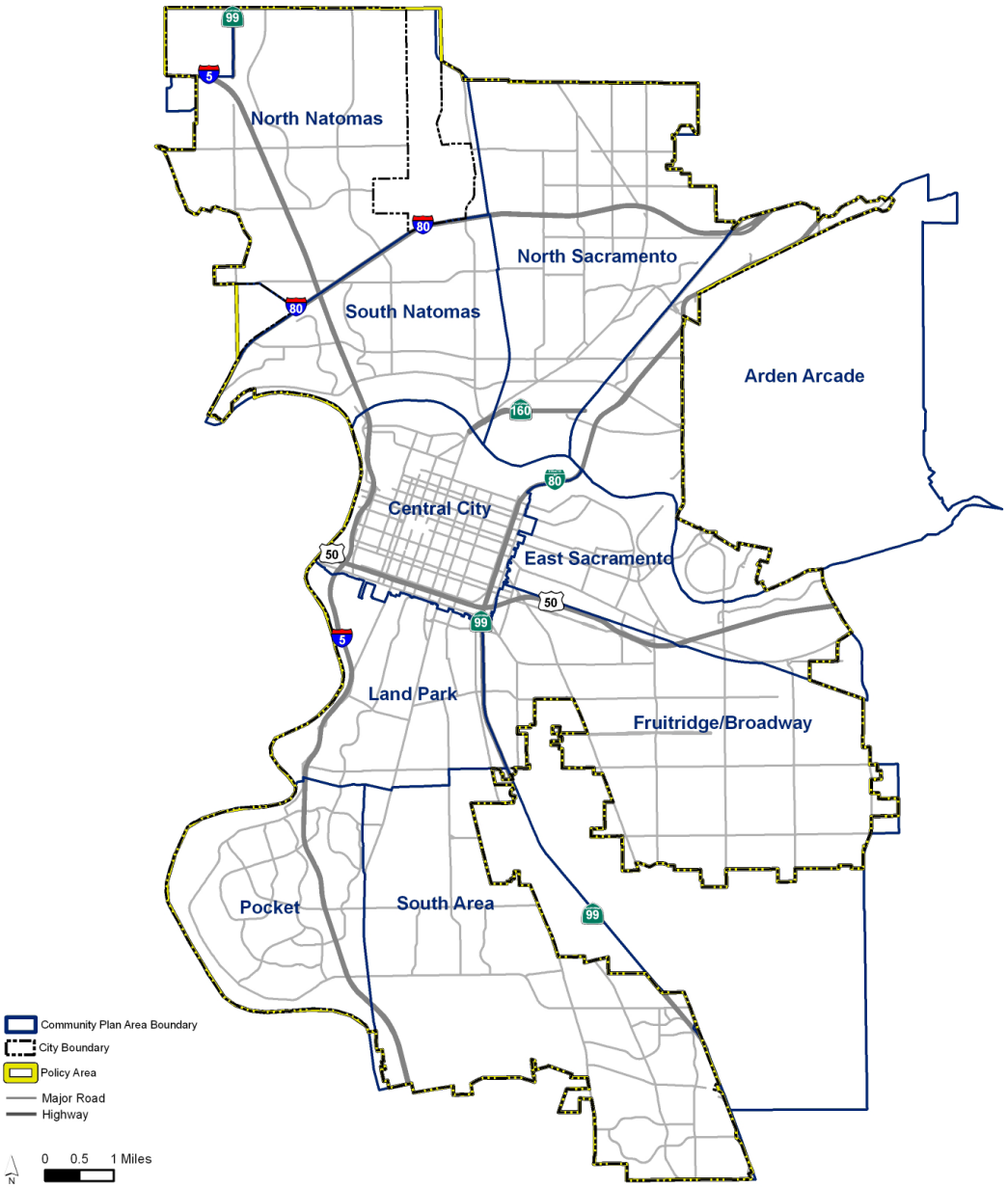


Figure CP-1
Community Plan Boundaries

Adopted March 3, 2015 | Page 3-3

Table 31 summarizes key growth projections for the City of Sacramento.

Table 31—Projected Growth – City of Sacramento

Growth Factor	2012	2035	Projected Growth (Units)	Projected Growth (Percentage)
Population	467,467	629,000	161,533	**34.55%**
Housing Units	192,351	260,699	68,348	**35.53%**
Employment	299,732	386,214	86,482	**28.85%**

Source: U.S. Census Bureau; City of Sacramento; SACOG

Table 32 summarizes projected City housing and employment growth by Planning Area.

Table 32—Projected Growth by Planning Area

Community Planning Area	2012		2035		Growth (Units)		Growth (Percentage)	
	Housing Units	Employment	Housing Units	Employment	Housing Units	Employment	Housing Units	Employment
Arden Arcade	5,854	24,876	9,158	29,044	3,304	4,168	56.44%	16.76%
Central City	20,282	114,808	44,501	139,328	24,219	24,520	119.41%	21.36%
East Sacramento	15,562	21,633	18,493	27,403	2,931	5,770	18.83%	26.67%
Fruitridge/Broadway	23,294	48,174	29,585	63,321	6,291	15,147	27.01%	31.44%
Land Park	13,212	12,863	15,431	13,691	2,219	828	16.80%	6.44%
North Natomas	22,849	21,529	36,242	43,184	13,393	21,655	58.62%	100.59%
North Sacramento	19,575	18,766	23,349	20,947	3,774	2,181	19.28%	11.62%
Pocket	20,895	4,976	21,552	5,918	657	942	3.14%	18.93%
South Area	33,150	19,639	43,115	26,516	9,965	6,877	30.06%	35.02%
South Natomas	17,678	12,468	19,273	16,862	1,595	4,394	9.02%	35.24%
Total	**192,351**	**299,732**	**260,699**	**386,214**	**68,348**	**86,482**	**35.53%**	**28.85%**

Source: Community Development Department, City of Sacramento

8.5.2 Natomas Fire Protection District

Overview

The Natomas Fire Protection District borders the north and western portions of the City of Sacramento, extending west out to the Sacramento River, and North to the Sacramento County Line. The fire district covers approximately 42 square miles of land. A peninsula of land, called the panhandle, previously extended into the City limits, and was developed out as an industrial park. The "handle" portion of the panhandle, which is still undeveloped land, was recently annexed by the City of Sacramento, leaving the industrial park as an unincorporated island

within the City limits. The Sacramento International Airport sits in the middle of the district, but operates its own fire protection.

Land Use and Future Development

Land use within the District is predominantly agricultural and open space with the exception of the Teal Bend Golf Club and the Sacramento International Airport, which is owned and operated by the County of Sacramento with its own fire department providing fire and aircraft crash/fire services within the airport property boundaries.

It had been assumed since the early 1980s that if the Natomas area were to be ultimately urbanized, it would occur under the guidance and leadership of the City; however, the City has now abandoned plans to annex the area and has recognized the County's interest in becoming the "urbanizer" of the area. In 2010, the County Board of Supervisors directed staff to create a Special Planning Area overlay for Natomas, and initiated efforts to move the Urban Services Boundary (USB) and Urban Policy Area (UPA) to allow for development. In 2011, the Board of Supervisors created a Natomas Joint Vision Overlay for the area and recognized the likelihood for future urbanization.

In December of 2014, the Sacramento Metropolitan Fire District (Metro Fire) filed an Application for Sphere of Influence Amendment and Annexation Request with the Sacramento LAFCo to amend its sphere of influence to include the portion of the Natomas Fire Protection District service area within the unincorporated area of the Natomas community. Subsequently, Metro Fire withdrew its request prior to a LAFCo decision and the Sacramento Fire Department entered into negotiations with the County for a three-year service contract extension with a mutually-agreeable one-year extension. Future fire protection services for this area beyond June 2019 are uncertain.

8.5.3 Pacific-Fruitridge Fire Protection District

Overview

The Pacific-Fruitridge Fire Protection District, located adjacent to the south-central area of the City of Sacramento along State Route 99, encompasses 4.6 square miles with a population of approximately 46,000,[5] and is surrounded by the City except on the southeast side. Prior to formation in 2006 through a consolidation of the former Pacific and Fruitridge Fire Protection Districts, the consolidated District has contracted for fire protection services from the City since its creation. An independent special district, the Pacific-Fruitridge Fire Protection District is governed by a seven-member Board of Directors elected by District voters to staggered 4-year terms.

[5] Ibid

Prior to consolidation in 2006, the Fruitridge Fire Protection District first contracted with the City for fire protection services in 1984, followed by the Pacific Fire Protection District in 1991. With each of these service contracts, the City absorbed the District personnel and assumed control of the respective District facility(s), fire apparatus, and related equipment. The consolidated District passes through its revenue less any District-specific expenditures such as a biennial fiscal audit.

Land Use and Future Development

Land use within the District is predominantly urban residential and commercial, with some industrial uses in the south and western areas of the District. The District is essentially built-out with the exception of some potential minor future infill. The District is also fully within the City of Sacramento's sphere of influence.

8.6 PRIOR RISK STUDIES

The federal Disaster Mitigation Act of 2000 (DMA2000), which amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), emphasizes the need for state and local entities to closely coordinate disaster planning and mitigation efforts to reduce the severity of disaster impacts. In addition to continuing the requirement for a state mitigation plan as a condition of federal disaster assistance, DMA2000 creates a similar requirement for local entities and creates incentives for increased coordination and integration of mitigation activities among local jurisdictions.

The September 2011 City of Sacramento Annex (Annex F) to the Sacramento County Local Hazard Mitigation Plan (LHMP) Update (December 2010) identifies 19 hazards as shown in Table 34. The LHMP utilizes the criteria shown in Table 33 for hazard rankings.

Table 33—Hazard Ranking Criteria in Sacramento County LHMP

Criteria	Description
Frequency of Occurrence	
Highly Likely	Near 100 percent probability within the next year
Likely	10-100 percent probability within the next year, or at least one chance within the next 10 years
Occasional	1-10 percent probability within the next year, or at least one chance within the next 100 years
Unlikely	Less than 1 percent probability in the next 100 years
Spatial Extent	
Limited	Less than 10 percent of the planning area
Significant	10-50 percent of the planning area
Extensive	50-100 percent of the planning area
Potential Magnitude	
Catastrophic	More than 50 percent of the planning area affected
Critical	25-50 percent of the planning area affected
Limited	10-25 percent of the planning area affected
Negligible	Less than 10 percent of the planning area affected
Significance (Subjective)	
Low	
Medium	
High	

Table 34—City of Sacramento Hazard Summary

Hazard		Frequency of Occurrence	Spatial Extent	Potential Magnitude	Significance
1	Agricultural Insects/Pests	Occasional	Limited	Limited	Low
2	Bird Strike	Occasional	Limited	Negligible	Low
3	Dam Failure	Occasional	Extensive	Catastrophic	High
4	Drought	Occasional	Extensive	Critical	Medium
5	Earthquake	Occasional	Limited	Critical	Low
6	Earthquake: Liquefaction	Occasional	Limited	Critical	Low
7	Flood: 100/200/500-year	Likely	Critical	Critical	High
8	Flood: Localized Storm	Highly Likely	Significant	Critical	High
9	Landslide	Unlikely	Limited	Negligible	Low
10	Levee Failure	Likely	Significant	Catastrophic	Medium
11	River/Stream Erosion	Likely	Limited	Limited	Medium
12	Severe Weather: Extreme Heat	Likely	Significant	Critical	Medium
13	Severe Weather: Fog	Likely	Limited	Limited	Medium
14	Severe Weather: Freeze	Occasional	Limited	Limited	Low
15	Severe Weather: Heavy Rain/Storms	Likely	Significant	Critical	High
16	Severe Weather: Tornado	Unlikely	Limited	Limited	Low
17	Subsidence	Likely	Limited	Limited	Low
18	Volcano	Unlikely	Limited	Catastrophic	Low
19	Wildfire	Occasional	Significant	Limited	Medium

Source: September 2011 City of Sacramento LHMP Annex

8.6.1 Values at Risk[6]

Table 35 summarizes the relative value of real property and buildings within the City of Sacramento by land use category. This data should only be used as a guideline to overall values in the City as the values do not necessarily reflect current market or replacement value due to the assessment limitations of Proposition 13. It is also important to note that in the event of a disaster, the value of the infrastructure or improvements to the land is generally of more concern

[6] City of Sacramento Annex to 2010 County of Sacramento LHMP (September 2011)

or exposure to risk. This data is of value in identifying the general value of property at risk within the City.

Table 35—Property Values – City of Sacramento

Land Use	Buildings	Land Value	Building Value
Agricultural	2	$2,876,955	$338,789
Care/Health	147	$64,900,508	$741,106,902
Church/Welfare	446	$72,453,537	$391,496,143
Industrial	1,823	$577,365,076	$1,543,578,041
Miscellaneous	1,018	$49,166,867	$99,284,450
No Data	3	$816,191	$2,197,468
Office	1,610	$1,043,061,457	$3,986,194,313
Public/Utilities	226	$21,558,220	$73,655,981
Recreational	77	$38,171,708	$124,496,858
Residential	127,083	$7,297,516,660	$18,001,708,739
Retail/Commercial	2,451	$1,073,600,018	$1,926,371,152
Vacant	217	$732,218,713	$17,882,675
Total	**135,103**	**$10,973,705,910**	**$26,908,311,511**

Source: 2010 Secured Property Tax Roll Data, Sacramento County Assessor's Office

Significant assets within Sacramento include, but are not necessarily limited to, a range of properties and infrastructure including City-owned property, critical facilities and infrastructure, key resources, and cultural and natural resources. Table 36 summarizes key City assets and their value.

Table 36—Key Assets – City of Sacramento

Asset	Type[1]	Replacement Value	Hazard Exposure
Administration Buildings	EF	$133,512,000	Earthquake, Flood
CCL Buildings and Assets	EF	$346,099,237	Earthquake, Flood
DOT Buildings	EF	$13,428,342	Earthquake, Flood
Economic Development Assets	EF	$5,065,156	Earthquake, Flood
Fire Department Facilities	EF	$44,256,144	Earthquake, Flood
Fleet Vehicles	T&L	$30,697,829	Earthquake, Flood
General Services Assets	EF	$49,480,859	Earthquake, Flood
Library Facilities	EF	$95,864,075	Earthquake, Flood
Parking Structures	T&L	$185,735,887	Earthquake, Flood
Parks and Recreation Buildings	EF	$71,904,104	Earthquake, Flood
Police Department Facilities	EF	$59,176,630	Earthquake, Flood
SHRA Buildings	EF	$705,167	Earthquake, Flood
SRDTF Buildings	EF	$1,345,246	Earthquake, Flood
Transportation Buildings	EF	$1,667,057	Earthquake, Flood
Utilities Facilities and Assets	EF	$593,917,054	Earthquake, Flood
	Total	**$1,632,854,787**	

[1] EF=Essential Facilities; T&L=Transportation and Lifeline Facilities
Source: Sacramento City Annex to 2010 Sacramento County LHMP (September 2011)

Critical facilities are defined as any facility, including a structure, infrastructure, property, equipment, or service that is adversely affected during a hazard occurrence may result in severe consequences to public health and safety or interrupt essential services and operations for the community at any time before, during, or after the hazard occurrence. The City of Sacramento has 910 designated critical facilities in two categories as shown in Table 37.

Table 37—Critical Facilities – City of Sacramento

Critical Facility Category[1]	Type of Facility	Number
ESF	Airport	1
ESF	Arena	1
ESF	Bus Terminal	6
ESF	Convention Center	1
ESF	Emergency Evacuation Shelter	76
ESF	Fire Station	21
ESF	General Acute Care Hospital	6
ESF	Government Facilities	29
ESF	Light Rail Stop	36
ESF	Medical Health Facility	97
ESF	Police Facility	3
ESF	Stadium	2
ESF	Train Station	1
ESF	Water Treatment Plant	2
KR	Adult Day Care	11
KR	Adult Education Facility	4
KR	Adult Residential Facility	119
KR	Alternative Education Facility	2
KR	Assisted Living Facility	1
KR	Charter School	14
KR	Children's Home	2
KR	College/University	4
KR	Community Day School	4
KR	Day Care Facility	158
KR	Group Home	19
KR	Hotel	17
KR	Independent Study School	1
KR	Infant Center	14
KR	Jail	1
KR	Private Elementary School	18
KR	Private K-12 School	9
KR	Private High School	7
KR	Public Continuation High School	4
KR	Public Elementary School	83
KR	Public Middle School	13
KR	Public High School	11
KR	Residential Care/Elderly	70
KR	School-Age Day Care	41
KR	Social Rehabilitation Facility	1
	Total	**910**

[1] ESF=Essential Services Facilities; KR=Key Resource
Source: Sacramento City Annex to 2010 Sacramento County LHMP (2011)

8.6.2 Historic and Cultural Resources

The City of Sacramento has 111 registered federal historic sites, state landmarks, and key points of interest within 29 Historic Districts, with 10 historic district surveys currently in process, one adopted survey, and two Special Planning Districts.

8.6.3 Economic Assets

Table 38 summarizes the top nine public and private employers within the City of Sacramento.

Table 38—Top Sacramento City Employers

Employer	Employees[1]	Location	Industry/Type
Public Sector			
State of California	66,792	Central City	State Government
Sacramento County	13,933	Central City	Local Government
UC Davis Health Center[2]	6,339	East Broadway	Healthcare
Los Rios Community College District	6,000	Arden Arcade	Education
City of Sacramento	4,695	Central City	Local Government
Private Sector			
Kaiser Permanente	5,374	Arden Arcade	Healthcare
Sutter Health	4,274	Central City	Healthcare
Wells Fargo	2,380	Central City	Financial Services
The McClatchy Company	1,410	Central City	Publishing
Total	**111,197**		

[1] Number of Full-Time Equivalent (FTEs) employees in the City of Sacramento
Source: Sacramento City Annex to 2010 Sacramento County LHMP (2011)

8.7 HAZARD IDENTIFICATION

Citygate utilizes prior risk studies where available, fire and-non-fire hazards as identified by the Commission on Fire Accreditation International (CFAI), and agency/jurisdiction-specific data and information to identify the hazards to be evaluated for this study.

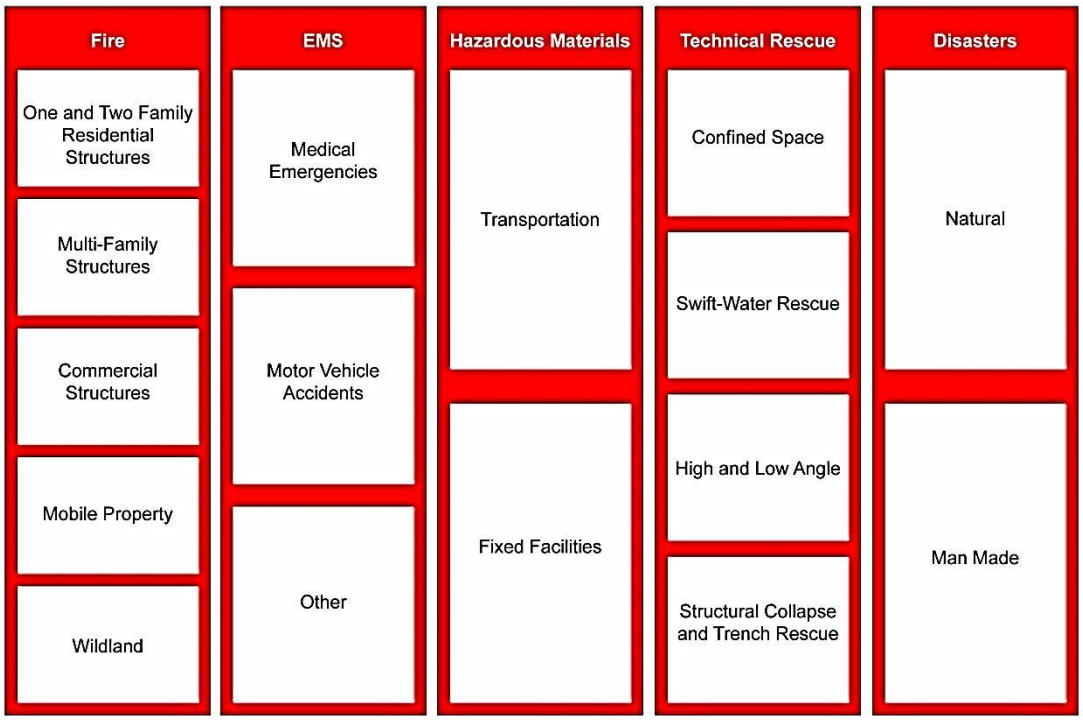
The primary hazards identified in the 2011 Sacramento City Annex to the 2010 Sacramento County Local Hazard Mitigation Plan, as they relate to Fire Department services, include:

1. Dam Failure
2. Flood
3. Earthquake

4. Landslide
5. Levee Failure
6. Severe Weather: Extreme Heat
7. Severe Weather: Heavy Rain/Storms
8. Wildfire

Due to low significance, landslide risk is not included in this analysis. Figure 9 summarizes the fire and non-fire hazards established by CFAI.

Figure 9—CFAI Fire and Non-Fire Hazards



Source: CFAI Standards of Cover (5th Edition)

Following are the risks evaluated for this study based on the hazards identified in the 2011 City of Sacramento LHMP Annex and fire and non-fire hazards identified by CFAI as they relate to services provided by the Sacramento Fire Department:

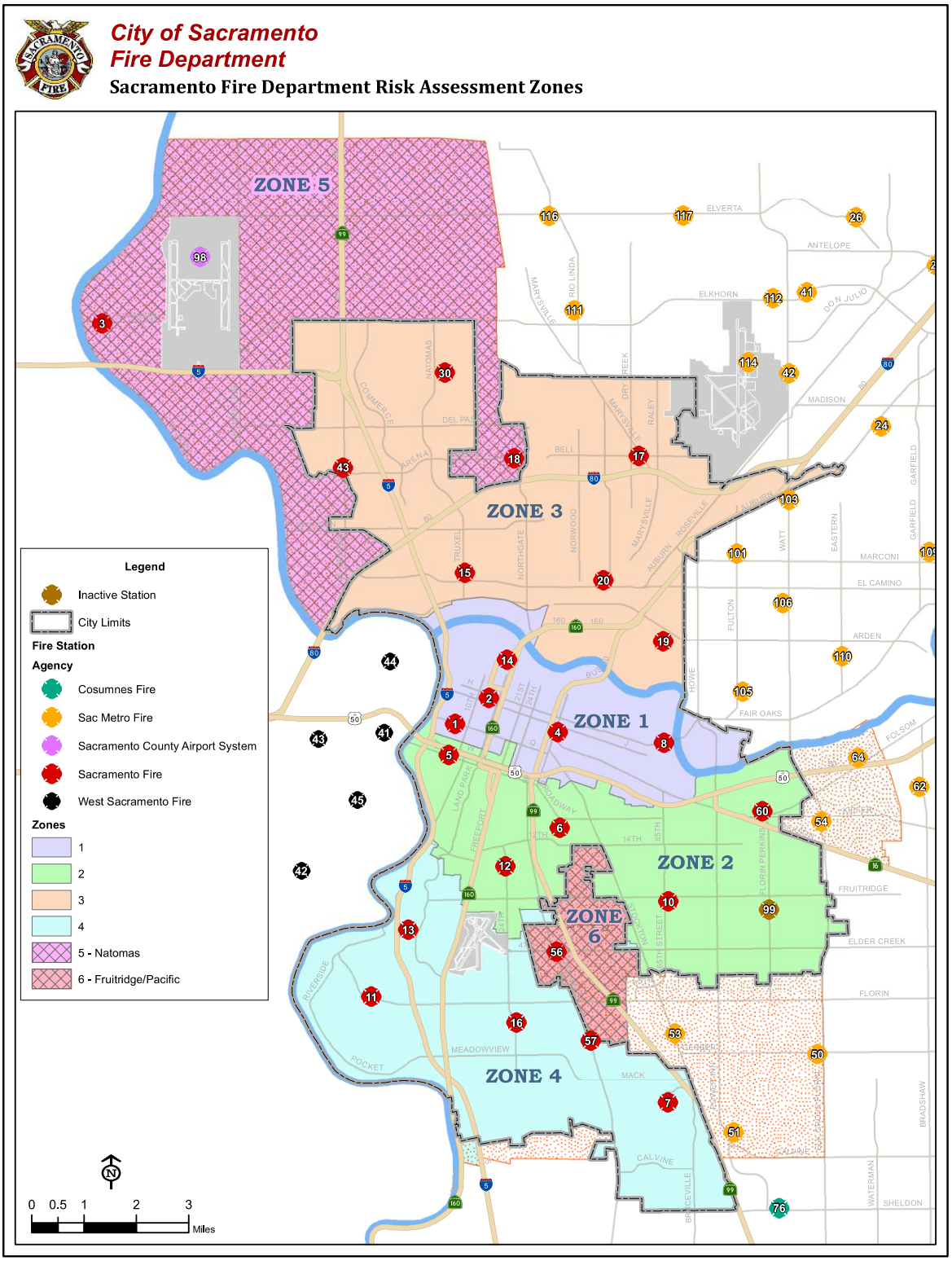
7. Building Fire Risk
8. Wildland Fire Risk
9. Emergency Medical Services (EMS) Risk
10. Hazardous Materials Risk

11. Technical Rescue Risk
12. Transportation Risk
13. Maritime Fire Risk
14. Earthquake / Seismic Activity
15. Flood

8.8 RISK ASSESSMENT ZONES

As shown earlier, in collaboration with the Department's Project Team, six risk assessment zones were identified for this analysis as shown in Figure 10.

Figure 10—Sacramento Risk Assessment Zones



8.9 PROBABILITY OF OCCURRENCE

As cited earlier, *probability of occurrence* refers to the likely future occurrence of a hazard or risk over a specific time period. Since the CFAI Agency Accreditation process requires *annual* review of an agency's risk assessment and baseline performance measures, Citygate recommends using the 12 months following completion of a SOC study as an appropriate period for the probability of occurrence evaluation. Table 39 describes the criteria used in evaluating the probability of future occurrence for each hazard or risk as also discussed in Table 26.

Table 39—Probability of Occurrence Criteria

Probability Score	Description	Criteria
1	Very Low	Less than 10% probability of occurrence within next 12 months
2	Low	10% - 25% probability of occurrence within next 12 months
3	Moderate	26% - 75% probability of occurrence within next 12 months
4	High	76% - 90% probability of occurrence within next 12 months
5	Very High	Greater than 90% probability of occurrence within next 12 months

8.10 RISK FACTORS

Elements to be considered in a community risk assessment include factors that influence service demand, service capacity, probability of hazard occurrence, and severity of impacts or consequences of a hazard occurrence relative to life, property, the environment, and overall community resilience.

In conducting a community risk assessment, Citygate examines prior risk studies, community demographics including current and projected population, land use, future development potential, employment, and building occupancy data as available, prior service demand data, and risk-specific service capacity.

8.11 SERVICE CAPACITY

Service capacity refers to the size of an agency's daily response force; the size, types, and condition of its response fleet and any specialized equipment; core and specialized performance competencies; resource distribution and concentration; availability of automatic and/or mutual aid; and any other agency-specific factors influencing its ability to meet current and prospective future service demand relative to the risks to be protected.

8.12 Building Fire Risk

One of the primary hazards in any community is building fire. Citygate used available data from the City of Sacramento, the U.S. Census Bureau, and the Insurance Services Office (ISO) to assist in identifying and quantifying the City's building fire risk.

8.12.1 Building Risk Categories

CFAI identifies five building risk categories as follows:

Low Risk Occupancies – includes detached garages, storage sheds, outbuildings, and similar buildings that pose a relatively low risk of harm to humans or the community if damaged or destroyed by fire.

Moderate Risk Occupancies – includes detached single-family or two-family dwellings, mobile homes, commercial and industrial buildings less than 10,000 square feet without a high hazard fire load, aircraft, railroad facilities, and similar buildings where loss of life or property damage is limited to the single building.

High Risk Occupancies – includes apartment/condominium buildings, commercial and industrial buildings more than 10,000 square feet without a high hazard fire load, low-occupant load buildings with high fuel loading or hazardous materials, and similar occupancies with potential for substantial loss of life or unusual property damage or financial impact.

Special Risk Occupancies – includes single or multiple buildings that require an Effective Response Force (ERF) greater than what is appropriate for the risk which predominates the surrounding area such as apartment/condominium complexes more than 25,000 square feet, Critical Infrastructure/Key Resource (CIKR) facilities, commercial/industrial occupancies with fire flows greater than 3,500 GPM, vacant/abandoned buildings, buildings with required fire flow exceeding available water supply, and similar occupancies with high-life hazard or large fire loss potential.

Maximum Risk Occupancies – includes buildings or facilities with unusually high risk requiring an ERF involving a significant augmentation of resources and personnel, and where a fire would pose the potential for a catastrophic event involving large loss of life and/or significant economic impact to the community.

8.12.2 Building Fire Risk Factors

Table 40 illustrates the probability and consequences for each of the building fire risk categories. As cited earlier, *probability* is the likelihood of a fire occurring in a particular occupancy type, and *consequences* are the probable adverse impacts that the fire will have on people, property, and the community.

Table 40—Building Fire Probability/Consequence Matrix

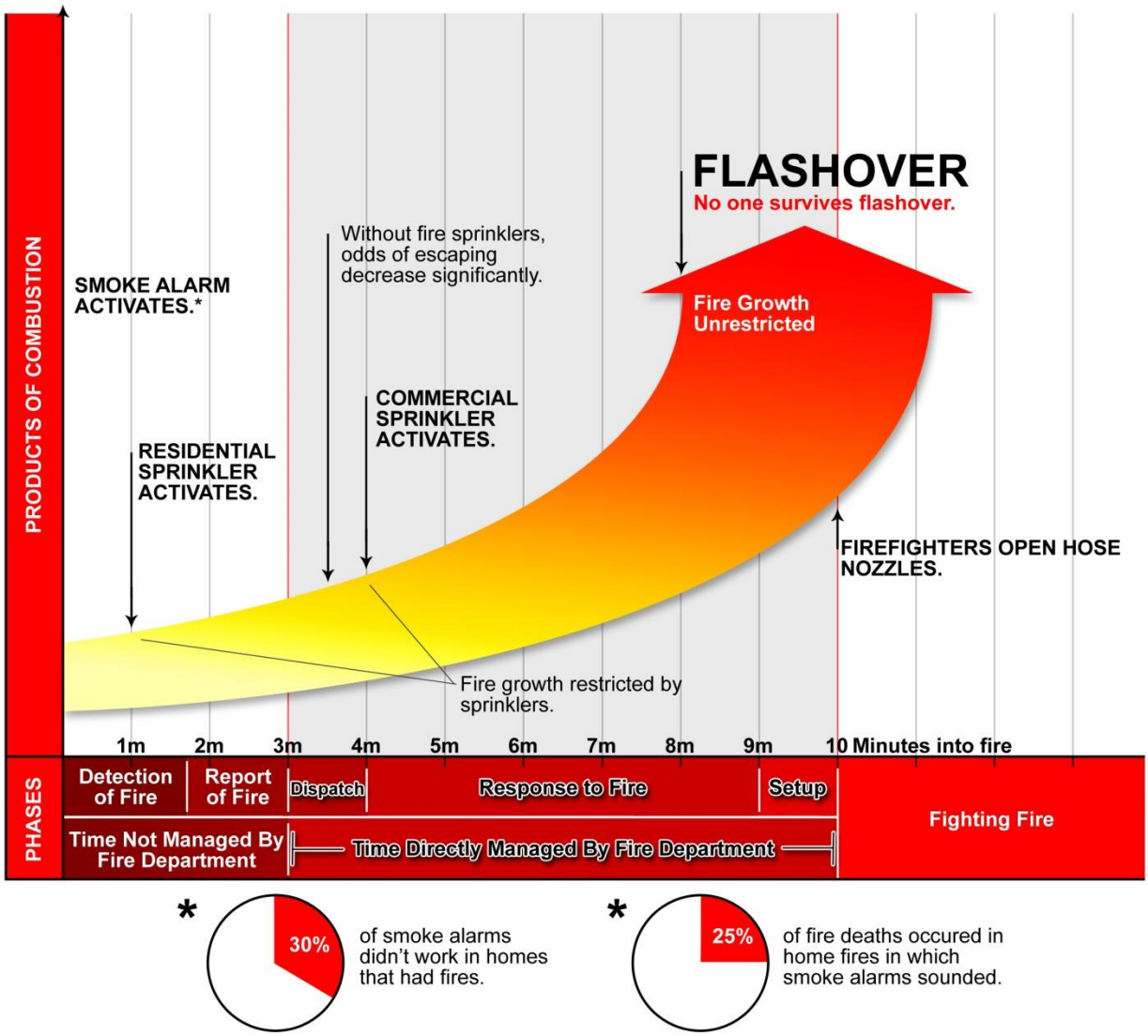
	Low Consequence	High Consequence
High Probability	**Moderate Risk** (***High*** Probability) (***Low*** Consequence)	**Maximum Risk** (***High*** Probability) (***High*** Consequence)
Low Probability	**Low Risk** (***Low*** Probability) (***Low*** Consequence)	**High/Special Risk** (***Low*** Probability) (***High*** Consequence)

Source: CFAI Standards of Cover, 5th Edition

Resource deployment (distribution/concentration), staffing, and response time are three critical factors influencing favorable outcomes for building fire risk. Figure 11 illustrates the progression timeline of a building fire, and shows that a response time[7] of 7:00 minutes or less is necessary to stop a building fire before it reaches flashover, which is the point at which the entire room erupts into fire after all of the combustible objects in that room have reached their ignition temperature. Survivability of a human in a room after flashover is extremely unlikely.

[7] Time interval from time of receipt of 9-1-1 call to initiation of suppression actions

Figure 11—Building Fire Progression Timeline



Source: http://www.firesprinklerassoc.org

Building Inventory

Sacramento has a mix of building occupancies typical of a large metropolitan city. Table 41 summarizes the inventory of higher risk use categories, as defined by CFAI,[8] by risk zone.

[8] High, Special, and Maximum risk categories only

Table 41—Building Occupancy Inventory by Use Classification / Risk Category

Occupancy Classification		Risk Zone 1	2	3	4	5	6	Total	Risk Category[1]
Assembly	A-1 Theater	11	2	3	2	0	0	**18**	Maximum
	A-2 Bar/Restaurant	239	91	94	54	1	25	**504**	High
	A-3 Public Assembly	67	87	82	51	0	21	**308**	High
	A-4 Indoor Sports	4	2	2	1	0	0	**9**	Maximum
	A-5 Outdoor	2	2	2	0	0	0	**6**	High
Education	Schools, Day Care	42	77	82	97	0	18	**316**	High
Factory	F-1 Moderate Risk	24	84	53	9	0	10	**180**	High
	F-2 Moderate Risk	5	18	12	3	0	3	**41**	High
Hazardous	H-1 Explosion Hazard	1	2	1	1	0	0	**5**	Special
	H-2 Accelerated Burn	1	3	4	0	0	2	**10**	Special
	H-3 High Hazard	7	20	3	0	0	3	**33**	Special
	H-4 Health Hazard	5	4	9	2	0	1	**21**	Special
	H-5 Semi-Conductor	0	1	1	0	0	0	**2**	Special
Institutional	I-1 Assisted Living	5	1	1	7	0	2	**16**	Special
	I-2 Hospital/SNF	11	8	1	8	0	1	**29**	Special
	I-2.1 Ambulatory	3	0	3	1	0	1	**8**	Special
	I-3 Restrained	5	5	1	1	0	0	**12**	Special
	I-4 Day Care	1	1	2	2	0	0	**6**	Special
Residential	R-1 Hotel/Motel	40	19	28	8	1	5	**101**	High
	R-2 Multi-Family	739	330	359	135	0	37	**1,600**	High
	R-3.1 Group Care ≤ 6	3	19	29	80	0	8	**139**	High
	R-4 Care Facility > 6	40	19	28	8	1	5	**101**	High
	Total	**1,255**	**795**	**800**	**470**	**3**	**142**	**3,465**	

[1] CFAI Risk Category
Source: City of Sacramento

Table 42 further summarizes building inventory by risk category.

Table 42—Building Inventory Summary by Risk Zone[9]

Risk Category	Risk Zone						Total
	1	2	3	4	5	6	
High	1,201	746	769	445	3	132	**3,296**
Special	39	45	26	22	0	10	**142**
Maximum	15	4	5	3	0	0	**27**
Total	**1,255**	**795**	**800**	**470**	**3**	**142**	**3,465**

Source: Sacramento Fire Department

Table 43 summarizes Sacramento's building inventory by building risk category percentage per risk zone.

Table 43—Building Occupancy Risk Category Percentage Summary[8]

Risk Category	Risk Zone						Total
	1	2	3	4	5	6	
High	36.44%	22.63%	23.33%	13.50%	0.09%	4.00%	**100.00%**
Special	27.46%	31.69%	18.31%	15.49%	0.00%	7.04%	**100.00%**
Maximum	55.56%	14.81%	18.52%	11.11%	0.00%	0.00%	**100.00%**
Total	**36.22%**	**22.94%**	**23.09%**	**13.56%**	**0.09%**	**4.10%**	**100.00%**

Source: Sacramento Fire Department

[9] High, Special, and Maximum risk building occupancies only from Table 41

Figure 12 illustrates the distribution of the high-risk building occupancies described above, with the exception of R-2 multi-family residential occupancies shown separately in Figure 13.

Figure 12—High Risk Occupancies

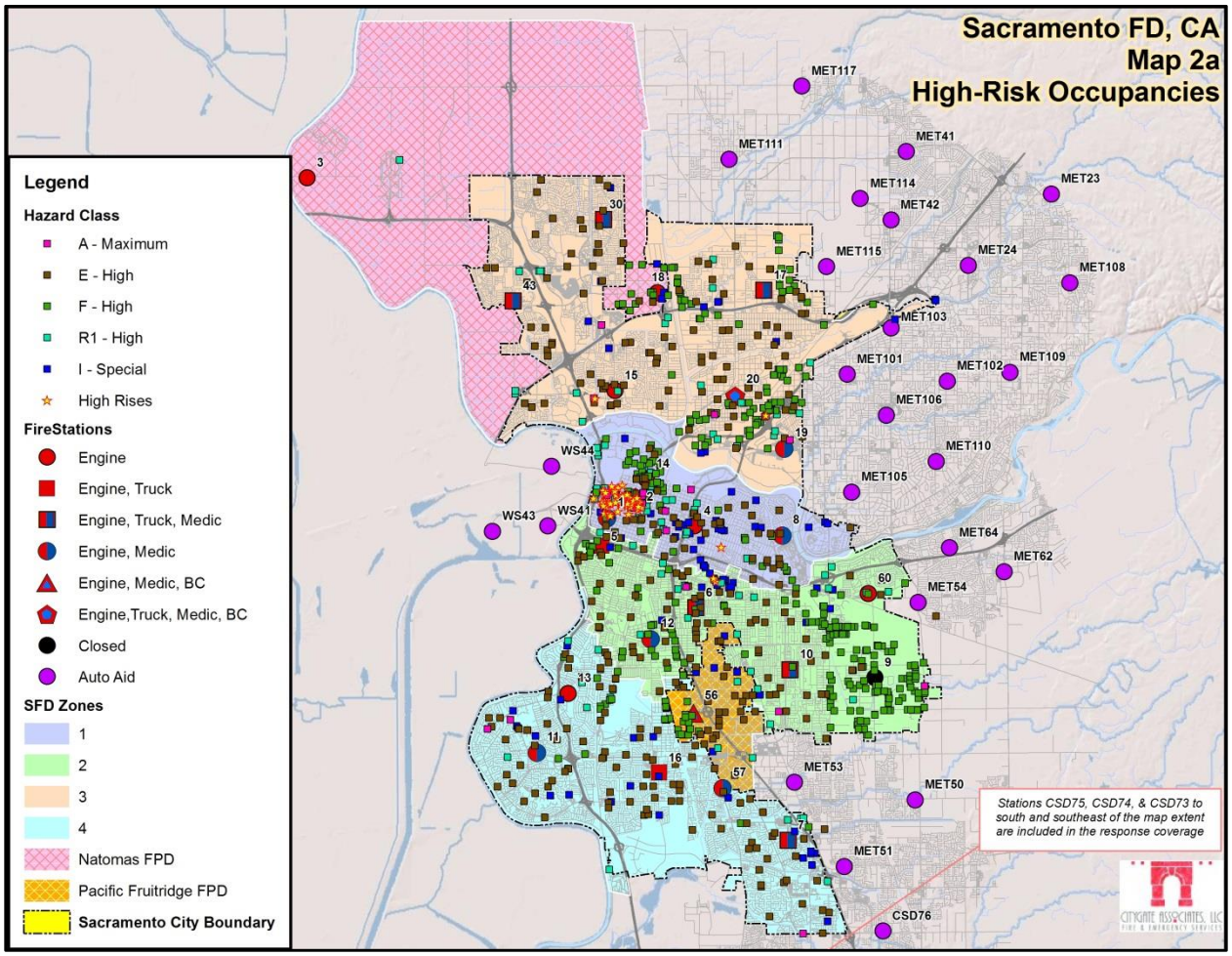
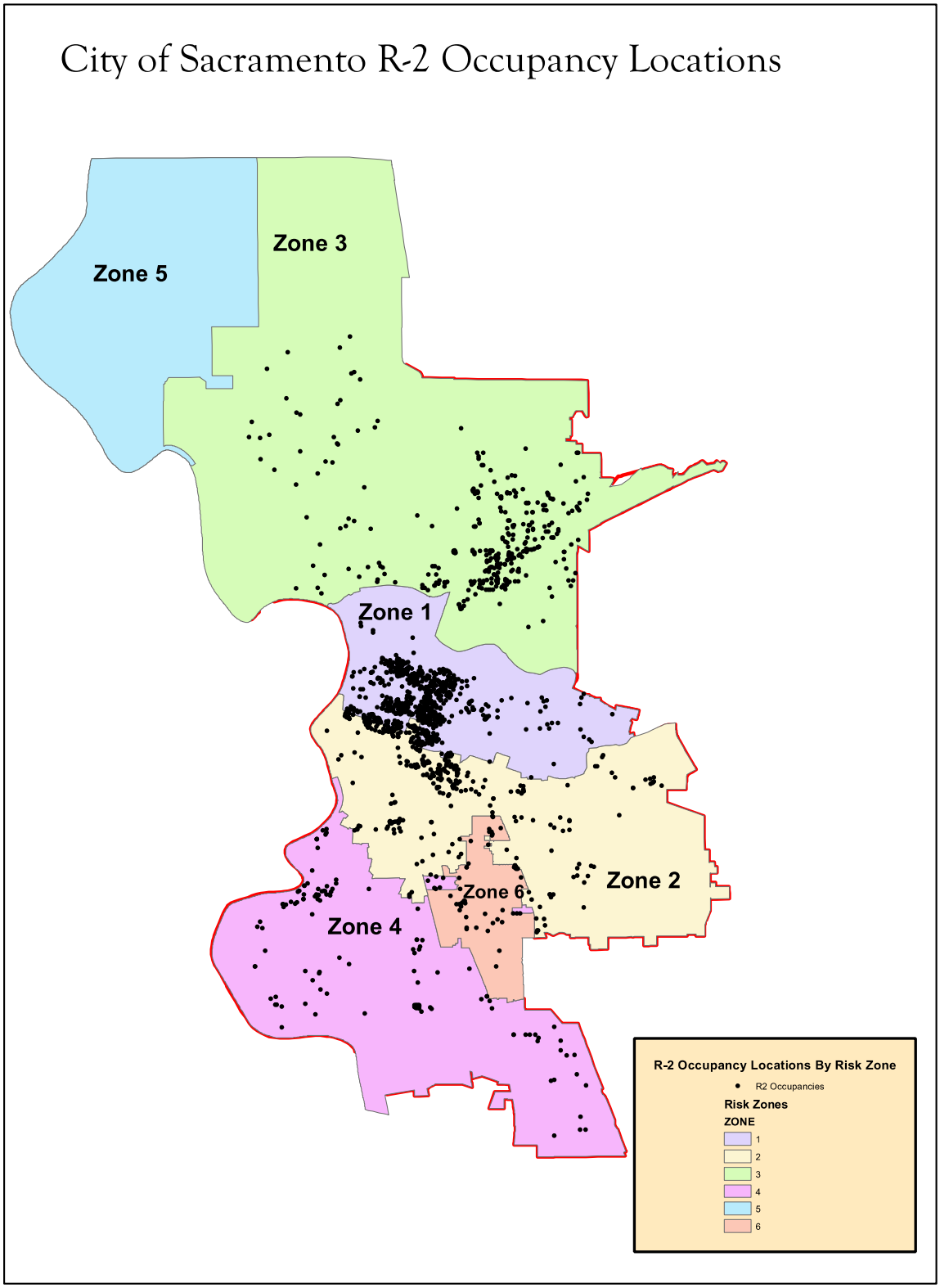


Figure 13—R-2 Multi-Family/Apartment Occupancies



High Rise Buildings

High-rise buildings present unique fire risks, particularly as they relate to the number of potential building occupants, the time required to evacuate those occupants in the event of an emergency, and the time required to get firefighters and fire suppression equipment to the floor(s) involved in fire. A high-rise building is defined by the California Building Code as any building having floors used for human occupancy more than 55 feet above the lowest floor having building access, except hospitals,[10] and by the California Health and Safety Code and California Fire Code as any building having floors used for human occupancy located more than 75 feet above the lowest level having building access, except hospitals.[11]

Sacramento has 53 high-rise buildings eight stories or more in height, which exceed the reach of the Department's aerial devices as shown in Table 44 and Figure 12.

Table 44—High-Rise Buildings

Building Type	Risk Zone						Total
	1	2	3	4	5	6	
High-Rise	49	2	2	0	0	0	**53**

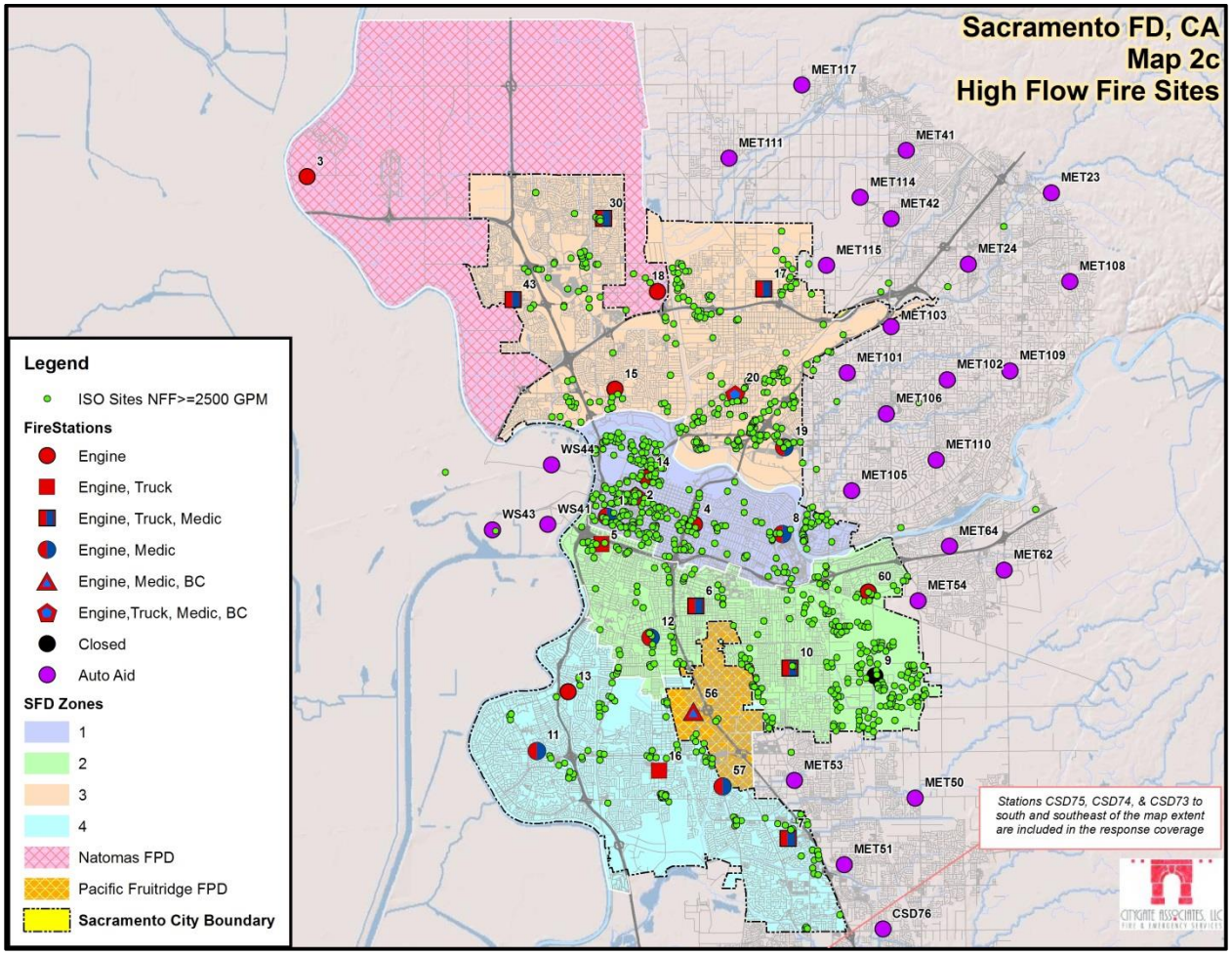
Source: City of Sacramento

High Fire Flow Requirements

One of the factors used by Insurance Services Office (ISO) is "Needed Fire Flow" (NFF), which is the amount of water that would be required in gallons-per-minute (GPM) if the building were seriously involved in fire. For Sacramento, the ISO database identifies 4,324 buildings evaluated, of which 2,066 have a needed fire flow of less than 1,500 GPM, 1,792 have a needed fire flow of 1,500-3,000 GPM, 388 have a needed fire flow of 3,000-5,000 GPM, and 78 have a needed fire flow of more than 5,000 GPM as shown in Figure 14.

[10] California Building Code Section 10-28.030 (2013 Edition)
[11] California Health and Safety Code Section 13210; California Fire Code Section 202 (2013 Edition)

Figure 14—ISO High Fire Flow Sites



This is a significant amount of firefighting water to deploy, and a major fire at any one of these buildings would require a significant commitment of the Department's on-duty force. Using a generally accepted figure of 50 gallons-per-minute per firefighter on large building fires, a fire in a building requiring 2,000 gallons-per-minute would require 40 firefighters, which is more than the Department's current initial Effective Response Force (ERF) of 28-36 firefighters for structure fires.

Critical Facilities

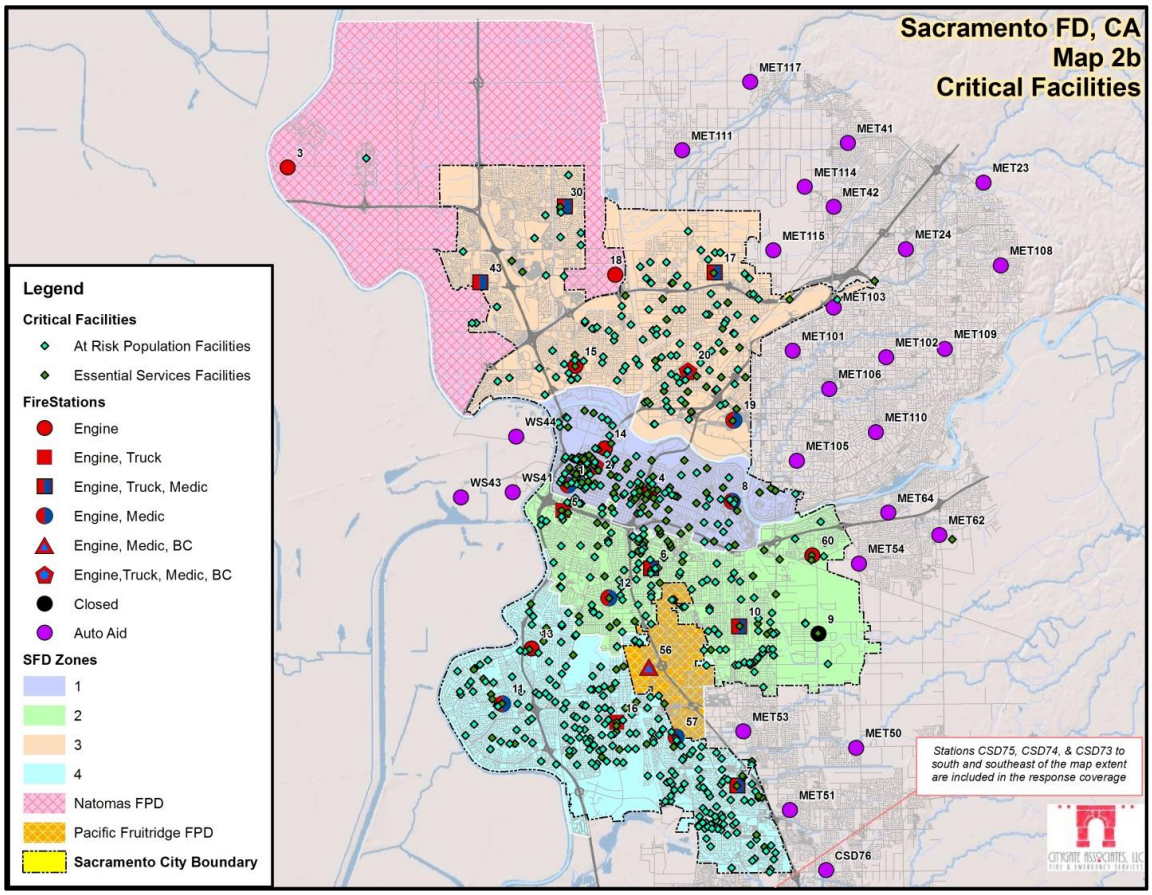
Sacramento's 2011 Annex to the Sacramento County LHMP identifies 895 critical facilities[12] as shown in Table 45 and Figure 15.

Table 45—Critical Facilities

Critical Facility Category	Risk Zone						Total
	1	2	3	4	5	6	
Essential Services	108	53	44	63	0	1	**269**
Key Resources	83	144	154	242	1	2	**626**
Total	**191**	**197**	**198**	**305**	**1**	**3**	**895[1]**

[1] This amount differs from the 910 noted in Table 37 due to a lack of specific locations identified for 15 facilities
Source: City of Sacramento Annex to Sacramento County LHMP (Table F.4)

Figure 15—Critical Facilities[1]



[1] At Risk Population Facilities are the same as Key Resources Facilities as noted in Table 45

[12] Essential public services and at-risk populations

Water Supply and Distribution System[13]

A reliable public water system providing adequate volume, pressure, and flow duration in close proximity to all buildings is a critical factor influencing a community's building fire impact severity. The City of Sacramento Department of Utilities relies on three sources for its potable water supply: the Sacramento and American Rivers, and local groundwater.

The Utilities Department manages and maintains the City's water distribution system, which includes two water treatment plants, 29 wells, and 10 storage reservoirs. The water system is capable of providing 386 million gallons per day distributed through approximately 1,600 miles of transmission and distribution system mains, with a storage capacity of 89.4 million gallons. The water supply system includes 15,348 fire hydrants with a flow capacity of 3,000 gallons per minute or more throughout most of the City.[12] The City's Water Supply Master Plan[12] identifies areas within Arden-Arcade, Central City, East Sacramento, and Executive Airport/Meadowview where older 4-inch to 6-inch pipelines are recommended for replacement with larger diameter pipe.

Buildings with Automatic Fire Sprinkler Systems

The City has approximately 12,000 buildings, exclusive of single-family dwelling units, protected by automatic fire sprinkler systems, although no data was available to quantify these by risk type or zone.

Building Fire Service Capacity

Sacramento's service capacity for building fire risk consists of a minimum daily on-duty response force of 169 personnel staffing 49 apparatus from 24 fire stations. The Department's Effective Response Force (ERF) for a residential building fire is four engines, two ladder trucks, one ambulance, and two Battalion Chiefs for a total of 28 personnel. For a commercial building fire, the ERF includes one additional engine and one additional ladder truck for a total of 36 personnel. In addition, the Department has automatic aid or mutual aid agreements with adjacent fire agencies, and is also a signatory to the Sacramento County Mutual Aid Agreement.

8.12.3 Building Fire Service Demand

Over the past 3 years, there were a total of 1,018 building fires comprising 0.51% of total service demand over the same time period, and resulting in estimated property damage/loss of $37.8 million. Of those 1,018 building fire incidents, 235 (23.7%) resulted in an ERF[14] arriving at the

[13] City of Sacramento Water Supply Master Plan (July 2013)
[14] ERF = 4 engines, 2 trucks, 1 ambulance, 1 Battalion Chief

incident from the initial dispatch. Table 46 summarizes building fire service demand for Sacramento by risk zone.

Table 46—Building Fire Service Demand

Risk Zone	FY 2012/13	FY 2013/14	FY 2014/15	Total
1	49	56	65	**170**
2	73	78	62	**213**
3	80	84	81	**245**
4	109	91	87	**287**
5	3	3	2	**8**
6	34	27	34	**95**
Total	**348**	**339**	**331**	**1,018**
Percent of Total Service Demand	0.53%	0.53%	0.48%	**0.51%**

8.12.4 Building Fire Risk Analysis

Table 47 summarizes Citygate's analysis of Sacramento's building fire risk. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 48 on the following page.

Table 47—Building Fire Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		High-Risk Occupancies	Critical Facilities	Fire Protection Systems	Water Supply	Service Capacity			
1	**5**	5	2	3	3	2	**15**	**75**	**High**
2	**5**	2	2	3	2	2	**11**	**55**	**Moderate**
3	**5**	2	2	3	3	2	**12**	**60**	**Moderate**
4	**5**	2	3	3	3	2	**13**	**65**	**High**
5	**3**	0	0	3	3	3	**9**	**27**	**Low**
6	**5**	2	1	3	3	1	**10**	**50**	**Moderate**

As Table 47 illustrates, the City's building fire risk is ***High*** in risk zones 1 and 4, reflecting a high probability of occurrence in combination with moderate to high impact severity factor scores for percentage of high-risk occupancies and critical facilities, and the percentage of these facilities protected by automatic fire protection systems, water supply, and building fire service

capacity. The City's building fire risk in ***Moderate*** in risk zones 2, 3, and 6 reflecting lower impact severity factor scores. The building fire risk for zone 5 is ***Low*** reflecting a lower probability of occurrence combined with lower impact severity factor scores.

Table 48—Building Fire Impact Severity Factor Scoring Guide

Impact Severity Factor	Score	Scoring Guidelines
High-Risk Occupancies[1]	**0**	Less than 1% of buildings are high-risk occupancies
	1	Less than 5% of buildings are high-risk occupancies
	2	Less than 10% of buildings are high-risk occupancies
	3	Less than 15% of buildings are high-risk occupancies
	4	Less than 20% of buildings are high-risk occupancies
	5	More than 20% of buildings are high-risk occupancies
Built-In Fire Protection Systems	**0**	More than 95% of high-risk occupancies AND critical facilities have automatic fire sprinkler system AND monitored detection/alarm system
	1	More than 90% of high-risk occupancies AND critical facilities have automatic fire sprinkler system AND monitored detection/alarm system
	2	More than 80% of high-risk occupancies AND critical facilities have automatic fire sprinkler system AND local fire detection/alarm system
	3	More than 75% of high-risk occupancies AND critical facilities have automatic fire sprinkler system AND local fire detection/alarm system
	4	More than 50% of high-risk occupancies AND critical facilities buildings have automatic fire sprinkler system
	5	Less than 50% of high-risk occupancies AND critical facilities have automatic fire sprinkler system
Critical Facilities[2]	**0**	Less than 1% of buildings are critical facilities
	1	Less than 5% of buildings are critical facilities
	2	Less than 10% of buildings are critical facilities
	3	Less than 15% of buildings are critical facilities
	4	Less than 20% of buildings are critical facilities
	5	More than 20% of buildings are critical facilities
Water Supply[3]	**0**	More than 95% of buildings have Needed Fire Flow[2] (NFF) available within 300 ft.
	1	More than 90% of buildings have Needed Fire Flow[2] (NFF) available within 300 ft.
	2	More than 75% of buildings have Needed Fire Flow[2] (NFF) available within 300 ft.
	3	More than 50% of buildings have Needed Fire Flow[2] (NFF) available within 500 ft.
	4	More than 50% of buildings have Needed Fire Flow[2] (NFF) available within 1000 ft.
	5	Less than 50% of buildings have Needed Fire Flow[2] (NFF) available within 1000 ft.
Service Capacity[4]	**0**	ERF for all building fire risk, meeting minimum recommended annual training, available within 10:10 min. total response time @ 90% (NFPA 1710)
	1	ERF for 90% of building fire risk, meeting minimum recommended annual training, available within 11:00 min. total response time @ 90% (NFPA 1720-Suburban)
	2	ERF for 90% of building fire risk, meeting minimum recommended annual training, available within 15:00 min. total response time @ 90% (NFPA 1720-Rural)
	3	ERF for 90% of building fire risk, meeting minimum recommended annual training, available within 20:00 min. total response time @ 90%
	4	ERF for 80% of building fire risk available within 25:00 min. total response time @ 90%
	5	ERF for less than 80% of building fire risk not available, or available within total response time exceeding 25:00 min. @ 90%

[1] CFAI High, Special, or Maximum occupancy risk category
[2] As defined by the jurisdiction/agency
[3] Needed Fire Flow as determined by the Insurance Services Office (ISO)
[4] Effective Response Force (ERF) – number of personnel required to apply Needed Fire Flow and perform other necessary critical tasks as determined by fire agency

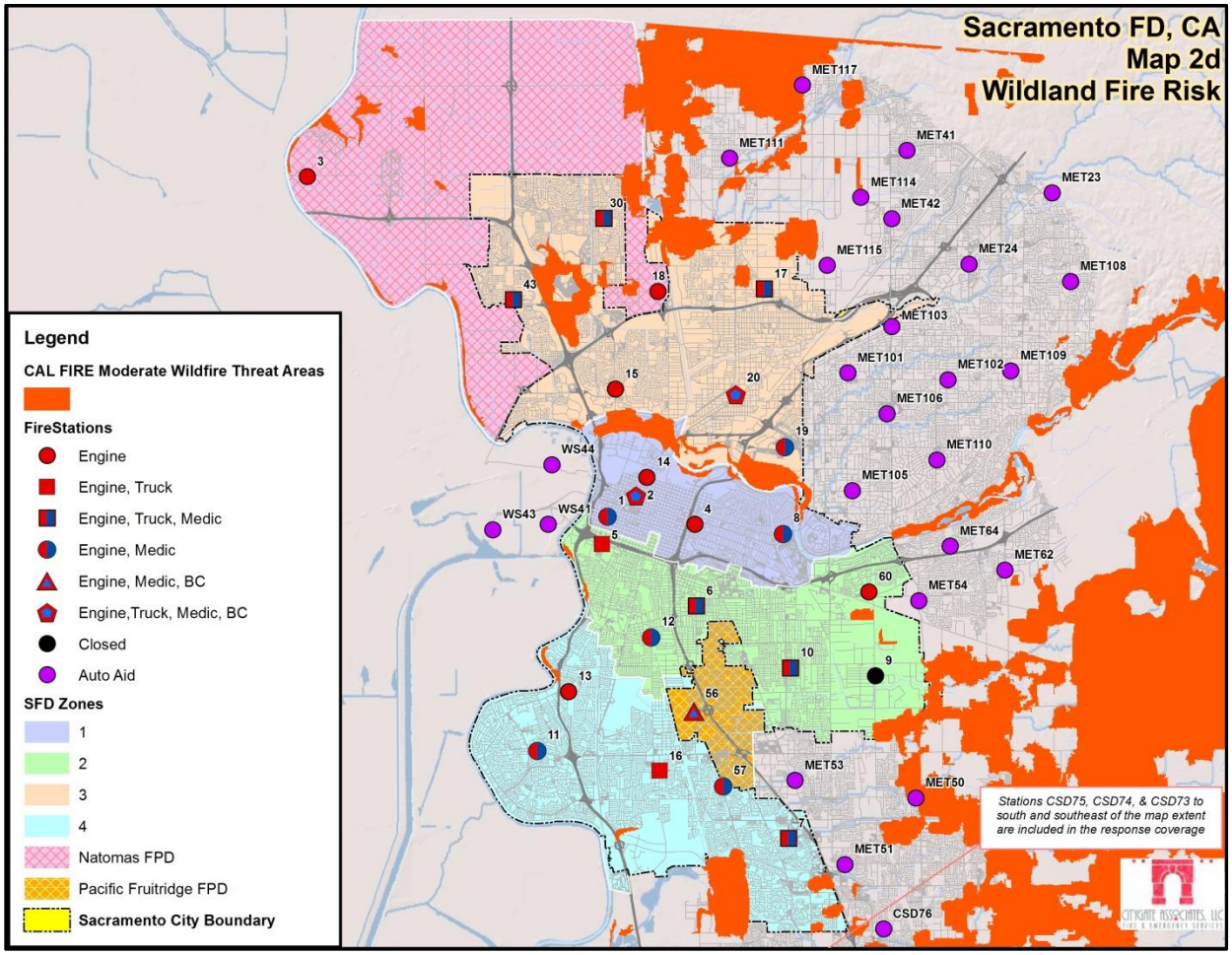
8.13 WILDLAND FIRE RISK

8.13.1 Fire Hazard Severity Zones

The California Department of Forestry and Fire Protection (CAL FIRE) designates *Moderate*, *High*, and *Very High* wildland Fire Hazard Severity Zones (FHSZ) throughout the state based on analysis of multiple wildland fire hazard factors and modeling of potential wildland fire behavior for State Responsibility areas (SRA) where CAL FIRE has fiscal responsibility for wildland fire protection. CAL FIRE also identifies recommended *Moderate*, *High*, and *Very High* FHSZs for Local Responsibility Areas (LRA) where a local jurisdiction bears the fiscal responsibility for wildland fire protection, including cities. CAL FIRE has identified the following areas of the City of Sacramento as having ***Moderate*** wildland fire hazard severity risk as shown in Figure 16.

- Open space areas generally bounded by Interstate 5, North Park Drive, Gateway Park Boulevard, and Interstate 80
- Open space areas generally bounded by Sorento Way, Ascot Avenue, Patrol Road, and Main Avenue
- Open space adjacent to Sunset Lawn Cemetery
- American River Parkway
- Sacramento River Bike Trail
- Open space in the Chicory Bend area
- Open space in the I-5 / Cosumnes River Boulevard area
- Open space southwest of Cosumnes River Boulevard / Franklin Boulevard
- Open space in the southwest corner of the City northwest of State Route 99 and Sheldon Road
- Open space on the eastern edge of the City between Jackson Road and Morrison Creek

Figure 16—Wildland Fire Hazard Severity Zones



8.13.2 Wildland Fire Risk Factors

Wildland fire behavior is predominantly influenced by fuel, weather, and topography. Wildland fuels in Sacramento consist of a mix of annual grasses and weeds, brush, and deciduous and evergreen trees. Once ignited, wildland fires can burn intensely and contribute to rapid fire spread under the right fuel, weather, and topographic conditions.

Wildland fuel factors influencing fire intensity and spread include fuel type (vegetation species), height, arrangement, density, and fuel moisture. Weather elements such as temperature, relative humidity, wind, and lightning also affect wildland fire potential and behavior. High temperatures and low relative humidity dry out wildland fuels creating a situation where fuel will more readily ignite and burn more intensely. Wind is the most significant weather factor influencing wildland fire behavior; higher wind speeds increase fire spread and intensity. The annual wildland fire season in Sacramento County, when wildland fires are most likely to occur due to fuel and weather conditions, is generally from late spring through fall due to a predominant climate

pattern of low annual rainfall, hot and dry summers, and moderate winds through the Sacramento Valley. Wildland fire risk during drought conditions is even greater. Sacramento's generally flat topography has a negligible influence on wildland fire behavior and spread.

Another significant wildland fire risk factor is the good water supply immediately available for suppression in wildland fire-prone or high-risk areas.

8.13.3 Wildland Fire History

Within the past several years, there have been numerous urban and wildland fires within Sacramento County. In Sacramento City, grass fires are the main wildland fire concern. Grass fires are an annual threat during the dry summer and fall months, especially within recreational areas such as the American River Parkway. Significant historical wildland fires include:

- 1985 – Several spot fires burned into one large fire in the Bushy Lake area behind Cal Expo. The University Avenue section of Sacramento, just to the east of the 1985 fire area, is heavily populated and could be affected by a similar fire along this stretch of the American River Parkway.
- 1992 – A wildland fire occurred by Northgate Boulevard along the American River Parkway and extended into a commercial building.
- 2002 – The Sierra fire (September 2002) affected 500 acres in the eastern suburbs of Sacramento. Within the communities of Loomis and Granite Bay (Placer County), the fire destroyed six structures and threatened two schools. One hundred homes were evacuated, and more than 1,000 homes in both communities were threatened.
- 2014 – A 100-acre fire along the American River Parkway near Cal Expo on July 4 resulted in the evacuation of a waterpark, the cancellation of a sold-out professional soccer game, and the delay of the largest pyrotechnical display in the region.

  2015 – More than 70 wildland fire incidents occurred along the American River Parkway.

8.13.4 Wildland Fire Service Capacity

The Department's Response Plan for vegetation/wildland fires includes two engines/patrols. In addition, the Department has a minimum daily on-duty response force of 169 personnel staffing 49 apparatus from 24 fire stations. The Department also has automatic aid or mutual aid agreements with adjacent fire agencies, and is a signatory to the Sacramento County Mutual Aid Agreement. This service capacity is appropriate to minimize Sacramento's impact severity for current and anticipated near-future wildland fire risk.

8.13.5 Wildland Fire Service Demand

Over the most recent three-year period evaluated by Citygate for this study, there were a total of 1,601 vegetation-related fires in Sacramento, comprising 0.81% of total service demand over the same time period as shown in Table 49.

Table 49—Wildland Fire Service Demand

Risk Zone	FY 2012/13	FY 2013/14	FY 2014/15	Total
1	108	112	93	**313**
2	114	88	100	**302**
3	200	198	155	**553**
4	91	71	61	**223**
5	19	23	26	**68**
6	48	44	50	**142**
Total	**580**	**536**	**485**	**1,601**
Percent of Total Service Demand	0.89%	0.83%	0.71%	**0.81%**

Source: Fire Department incident records

8.13.6 Wildland Fire Risk Analysis

Table 50 summarizes Citygate's analysis of the wildland fire risk for Sacramento based on evaluation of five wildland impact severity factors for each risk assessment zone. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 51 on the following page.

Table 50—Wildland Fire Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		Wildland Fuels	Weather	Topography	Water Supply	Service Capacity			
1	**4**	1	5	0	2	1	**9**	**36**	**Moderate**
2	**4**	1	5	0	2	1	**9**	**36**	**Moderate**
3	**4**	1	5	0	2	1	**9**	**36**	**Moderate**
4	**2**	1	5	0	2	1	**9**	**18**	**Low**
5	**2**	1	5	0	2	1	**9**	**18**	**Low**
6	**2**	1	5	0	2	1	**9**	**18**	**Low**

Sacramento's wildland fire risk is ***Moderate*** for risk zones 1, 2, and 3, reflecting moderately high probability of occurrence in combination with low to high impact severity factor scores for

wildland vegetative fuels, weather factors, topography, water supply, and wildland fire service capacity. The City's wildland fire risk is ***Low*** for risk zones 4, 5, and 6 reflecting a lower probability of occurrence.

Table 51—Wildland Fire Impact Severity Factor Evaluation Criteria[1]

Impact Severity Factor	Score	Scoring Guidelines
Flammable Vegetation	0	No identified wildland fire hazard fuels risk[2] within 1 mile of ≥90% of exposed values at risk[3]
	1	No identified wildland fire hazard fuels risk[2] within 1/2 mile of ≥90% of exposed values at risk[3]
	2	No identified wildland fire hazard fuels risk[2] within ¼ mile of ≥75% of exposed values at risk[3]
	3	No identified wildland fire hazard fuels risk[2] within 1000 ft. of ≥75% of exposed values at risk[3]
	4	No identified wildland fire hazard fuels risk[2] within 500 ft. of ≥50% of exposed values at risk[3]
	5	Identified wildland fire hazard fuels risk[2] within 500 ft. of ≥25% of exposed values at risk[3]
Weather	0	Multiple high fire weather factors[4] occur concurrently ≤ average of 15 days per year
	1	Multiple high fire weather factors[4] occur concurrently ≤ average of 30 days per year
	2	Multiple high fire weather factors[4] occur concurrently ≤ average of 45 days per year
	3	Very high fire weather factors[5] occur concurrently ≤ average of 30 days per year
	4	Very high fire weather factors[5] occur concurrently ≤ average of 45 days per year
	5	Very high fire weather factors[5] occur concurrently> average of 45 days per year
Topography	0	Average slope ≤5%; no topographic features[6] present within 1/2 mile of ≥90% of exposed values at risk[3]
	1	Average slope ≤5%; no topographic features[6] present within 1/4 mile of ≥90% of exposed values at risk[3]
	2	Average slope ≤5%; no topographic features[6] present within 1/8 mile of ≥75% of exposed values at risk[3]
	3	Average slope ≤10%; no topographic features[6] present within 1/4 mile of ≥90% of exposed values at risk[3]
	4	Average slope ≤10%; no topographic features[6] present within 1/8 mile of ≥75% of exposed values at risk[3]
	5	Average slope >10% and/or topographic features[6] present within 1/8 mile of >25% of exposed values at risk[3]
Water Supply	0	Public water supply ≥1,000 GPM within 500 ft. of ≥90% of exposed values at risk[3]
	1	Public water supply ≥750 GPM within 500 ft. of ≥90% of exposed values at risk[3]
	2	Public water supply ≥750 GPM within 500 ft. of ≥75% of exposed values at risk[3]
	3	Public water supply ≥500 GPM within 500 ft. of ≥75% of exposed values at risk[3]
	4	Public or private water supply ≥500 GPM within 1000 ft. of ≥75% of exposed values at risk[3]
	5	Public or private water supply <500 GPM; or >1000 ft. of >25% of exposed values at risk[3]
Response Capacity	0	ERF[6] for *all* wildland fire risk, meeting minimum recommended annual training, available with response time ≤15:00 min. @ 90%
	1	ERF[6] for ≥90% of wildland fire risk, meeting minimum recommended annual training, available with response time ≤15:00 min. @ 90%
	2	ERF[6] for ≥90% of wildland fire risk, meeting minimum recommended annual training, available with response time ≤20:00 min. @ 90%
	3	ERF[6] for ≥75% of wildland fire risk, meeting minimum recommended annual training, available with response time ≤30:00 min. @ 90%
	4	ERF[6] for ≥50% of wildland fire risk available with response time ≤30:00 min. @ 90%
	5	ERF[6] for ≥50% of wildland fire risk not available, or available with response time >30:00 min. @ 90%

[1] Significant wildland fire incident requiring multiple-alarm resources and impacting multiple values at risk
[2] State or locally identified moderate, high, or very high wildland fire hazard risk zones
[3] Values at risk includes occupied buildings, critical Infrastructure/key resources (CIKR), and vulnerable populations
[4] High Fire Weather Factors include temperature >90° F., relative humidity <25%, wind >5 mph
[5] Very High Fire Weather Factors include temperature >95° F., relative humidity <15%, wind >10 mph
[6] Includes box canyon, chimney, ridge, saddle
[7] Effective Response Force (ERF) – number of personnel required to apply appropriate fire flow and perform other critical tasks necessary to prevent fire from impacting other values at risk

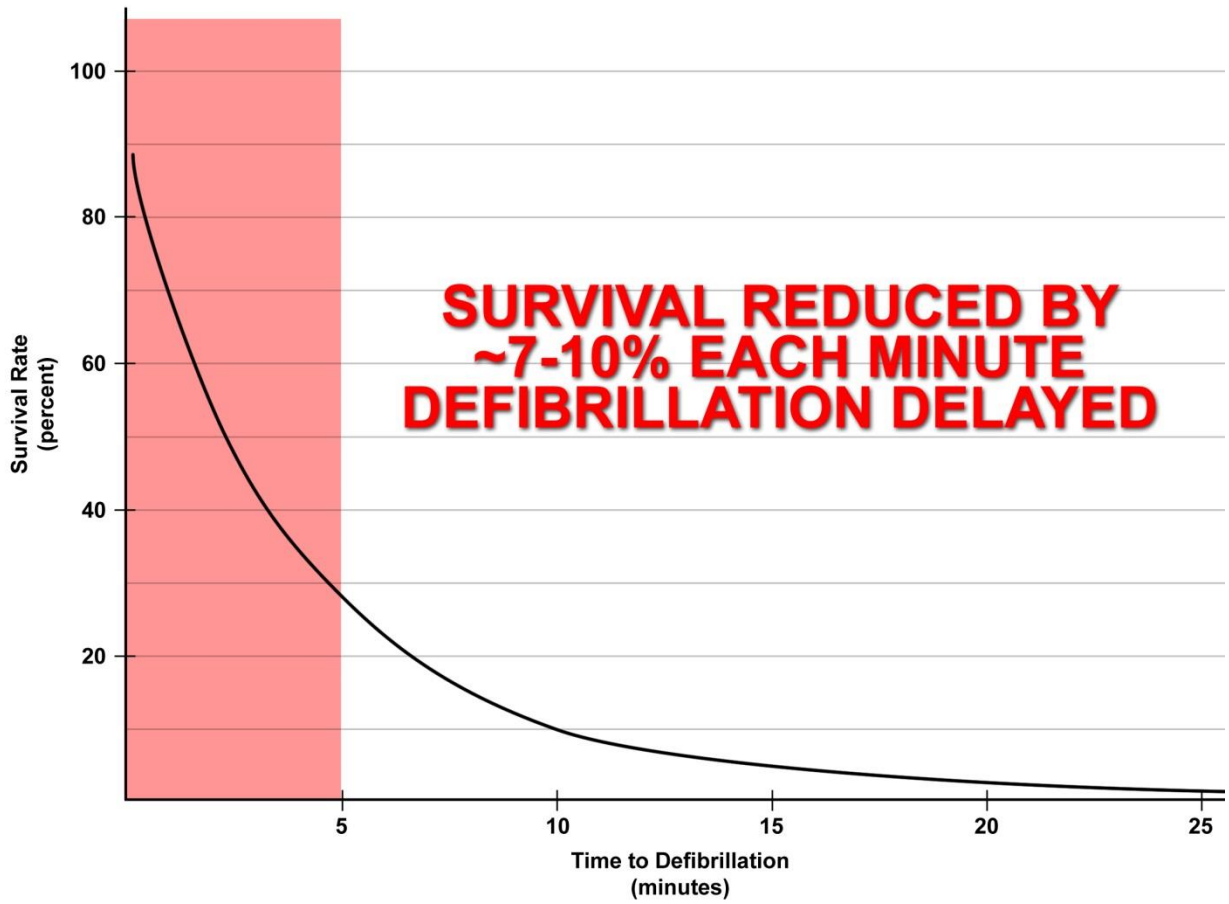
8.14 EMERGENCY MEDICAL SERVICES RISK

8.14.1 EMS Risk Factors

Emergency medical services (EMS) risk in most communities is predominantly a function of population density, demographics, vehicle traffic, violence, and health insurance coverage. Relative to population demographics, EMS risk tends to be higher among poorer, older, less educated, and uninsured populations. As would be expected, EMS risk is also higher in communities or segments of communities with higher rates of violence. EMS risk is also higher in those areas of a community with high vehicle traffic loads, particularly those areas with high traffic volume travelling at higher speeds. The City has a well laid out street network system with major arterial streets and collectors approximately every mile for arterials and one-half mile for collectors.

EMS risk can also be categorized as either a medical emergency resulting from a health-related condition or event, or a traumatic injury. One serious medical emergency is cardiac arrest or some other emergency where there is an interruption or blockage of oxygen to the brain. Figure 17 illustrates the reduced survivability of a cardiac arrest victim as time to defibrillation increases. While early defibrillation is one factor in cardiac arrest survivability, other factors can influence survivability as well, such as early CPR and pre-hospital Advanced Life Support (ALS) interventions.

Figure 17—Survival Rate vs. Time of Defibrillation

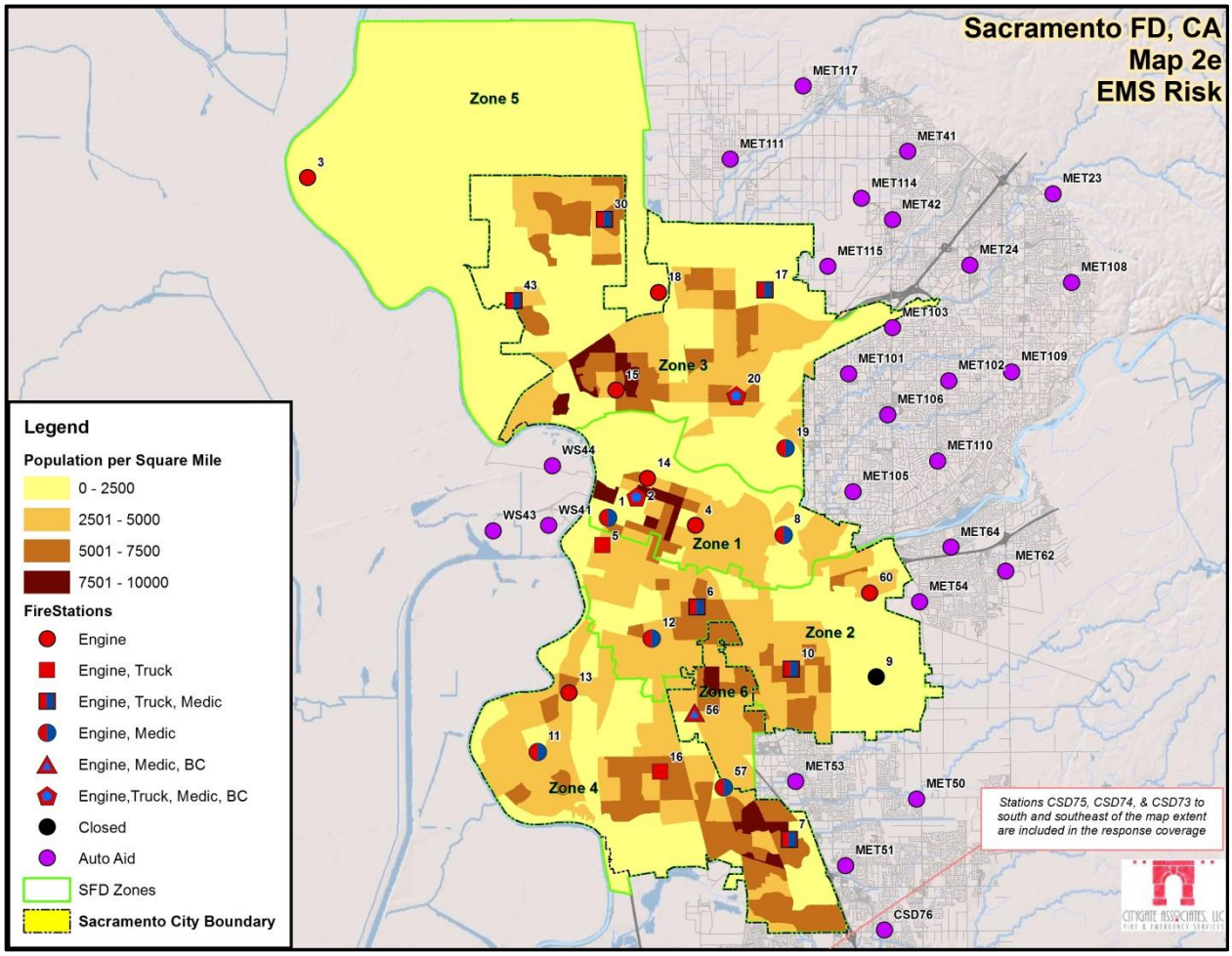


Source: www.suddencardiacarrest.org

8.14.2 Population Demographics

Figure 18 shows Sacramento's population densities in increments of 2,500 persons per square mile. As cited above, population density is a primary risk factor affecting EMS service demand. As Figure 18 illustrates, higher EMS service demand would be expected in the darker shaded areas of the City.

Figure 18—Population Density



According to 2014 U.S. Census Bureau estimates, 7.2% of Sacramento's population is under 5 years of age and 11.1% is 65 and older. In addition, 19.3% of Sacramento residents 18 years of age and older are below poverty level, and 15% of residents have no health insurance coverage. Also contributing to Sacramento's EMS risk are five highways carrying more than 900,000 vehicles daily, including 78,000 per hour at peak volume.

8.14.3 EMS Risk Service Capacity

Sacramento's service capacity for EMS risk consists of a minimum daily on-duty response force of 169 personnel staffing 49 apparatus from 24 fire stations, including 15 Advanced Life Support (ALS) medic ambulances. In Sacramento, all calls for medical assistance receive the closest Fire Department unit response in addition to a Department ALS transport ambulance. All Department response personnel are trained to either the Emergency Medical Technician (EMT) level capable of providing Basic Life Support (BLS) pre-hospital emergency medical care, or Paramedic level capable of providing ALS pre-hospital emergency medical services. All Sacramento fire apparatus are staffed with a minimum of four personnel except for Engine 3 with three personnel, including at least one paramedic on each apparatus on most days. Ambulances are staffed with at least one paramedic and one Emergency Medical Technician (EMT). This level of response provides a minimum of five firefighters to every EMS-related call for service. Air ambulance services are available from CalSTAR and REACH Air Medical Services in Sacramento.

Sacramento has seven hospitals with emergency room facilities, including Kaiser Permanente Hospital, Kaiser Permanente South Sacramento Medical Center, Mercy General Hospital, Methodist Hospital of Sacramento, Sutter Medical Center Sacramento, and UC Davis Medical Center. UC Davis Medical Center is also a Level 1 Trauma Center, and Kaiser Permanente South Sacramento is a Level II Trauma Center.

This service capacity is insufficient to meet the City's current and anticipated near-future EMS risk due to the extended wait times at area hospitals' emergency rooms during peak demand hours.

8.14.4 EMS Risk Service Demand

Table 52 summarizes Sacramento's EMS service demand over the previous 3 years, which is 67.7% of total service demand over the same period.

Table 52—EMS Service Demand

Risk Zone	FY 2012-13	FY 2013-14	FY 2014-15	Total
1	8,430	8,624	9,357	**26,411**
2	9,029	8,902	9,126	**27,057**
3	12,141	12,227	13,125	**37,493**
4	10,386	10,397	10,802	**31,585**
5	558	588	624	**1,770**
6	3,346	3,165	3,308	**9,819**
Total	**43,890**	**43,903**	**46,342**	**134,135**
Percent of Total Service Demand	67.45%	68.04%	67.65%	**67.71%**

Source: City of Sacramento Fire Department incident records

8.14.5 EMS Risk Analysis

Table 53 summarizes Citygate's EMS risk analysis for Sacramento. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 54 on the following page.

Table 53—EMS Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		Population Density	Demographics	Vehicle Traffic	Pre-Hospital EMS Capacity	Hospital Emergency Care Capacity[1]			
1	**5**	4	2	5	1	4	**16**	**80**	**High**
2	**5**	3	2	5	1	4	**15**	**75**	**High**
3	**5**	3	2	5	1	4	**15**	**75**	**High**
4	**5**	3	2	5	1	4	**15**	**75**	**High**
5	**5**	1	2	5	2	4	**14**	**70**	**High**
6	**5**	4	2	5	0	4	**15**	**75**	**High**

[1] Hospital Emergency Care Capacity scores reflect wait times for emergency room care during peak demand periods

As Table 53 illustrates, Sacramento's EMS risk is ***High*** across all six risk zones reflecting a high probability of occurrence in combination with moderate demographic risk factors, high vehicle

traffic risk factors, a very good pre-hospital EMS capacity, and good hospital emergency care capacity impacted by extended wait times during peak demand periods.

Table 54—EMS Impact Severity Factor Evaluation Criteria

Impact Severity Factor	Score	Scoring Guidelines
Population Density	0	Average population density less than 500 per square mile
	1	Average population density less than 1,000 per square mile
	2	Average population density less than 2,500 per square mile
	3	Average population density less than 5,000 per square mile
	4	Average population density less than 10,000 per square mile
	5	Average population density greater than 10,000 per square mile
Population Demographics	0	Less than 5% of population under age 10, over age 65, or below federal poverty level
	1	Less than 10% of population under age 10, over age 65, or below federal poverty level
	2	Less than 20% of population under age 10, over age 65, or below federal poverty level
	3	Less than 30% of population under age 10, over age 65, or below federal poverty level
	4	Less than 40% of population under age 10, over age 65, or below federal poverty level
	5	More than 40% of population under age 10, over age 65, or below federal poverty level
Vehicle Traffic	0	No freeway or highway traffic; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	1	One or more two-lane highways; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	2	One or more multiple-lane highways; no seasonal snow, ice, or dense fog
	3	Single multiple-lane highway; limited high-speed arterial traffic; minimal seasonal snow, ice, or dense fog
	4	Multiple multiple-lane highways; moderate high-speed arterial traffic; moderate seasonal snow, ice, or dense fog
	5	Multiple multiple-lane freeways; heavy high-speed arterial traffic; heavy seasonal snow, ice, or dense fog
Pre-Hospital Service Capacity	0	ALS[1] services available within 6:00 min. total response time[3] @ 90%
	1	ALS[1] services available within 8:00 min. total response time[3] @ 90%
	2	ALS[1] services available within 10:00 min. total response time[3] @ 90%
	3	ALS[1] or BLS[2] services available within 12:00 min. total response time[3] @ 90%
	4	ALS[1] or BLS[2] services available within 15:00 min. total response time[3] @ 90%
	5	ALS[1] or BLS[2] services not available, or not available within 15:00 min. total response time[3] @ 90%
Hospital Emergency Care Capacity	0	Primary ER within 10 min. travel time @ 90%; secondary ER within 20 min. travel @ 90%; trauma center within 30 min. travel @ 90%
	1	Primary ER within 15 min. travel @ 90%; secondary ER within 30 min. travel @ 90%; trauma center within 40 min. travel @ 90%
	2	Primary ER within 15 min. travel @ 90%; secondary ER within 30 min. travel @ 90%; trauma center within 45 min. travel @ 90%
	3	Primary ER within 20 min. travel @ 90%; secondary ER within 35 min. travel @ 90%; trauma center within 60 min. travel @ 90%
	4	Primary ER within 25 min. travel @ 90%; secondary ER within 45 min. travel @ 90%; trauma center within 60 min. travel @ 90%
	5	Primary ER not within 25 min. travel @ 90%; secondary ER not within 45 min. travel @ 90%; trauma center not within 60 min. travel @ 90%

[1] Advanced Life Support (ALS)
[2] Basic Life Support (BLS)
[3] Response Time – time from receipt of 9-1-1 call to arrival of initial response resource

8.15 Hazardous Materials Risk

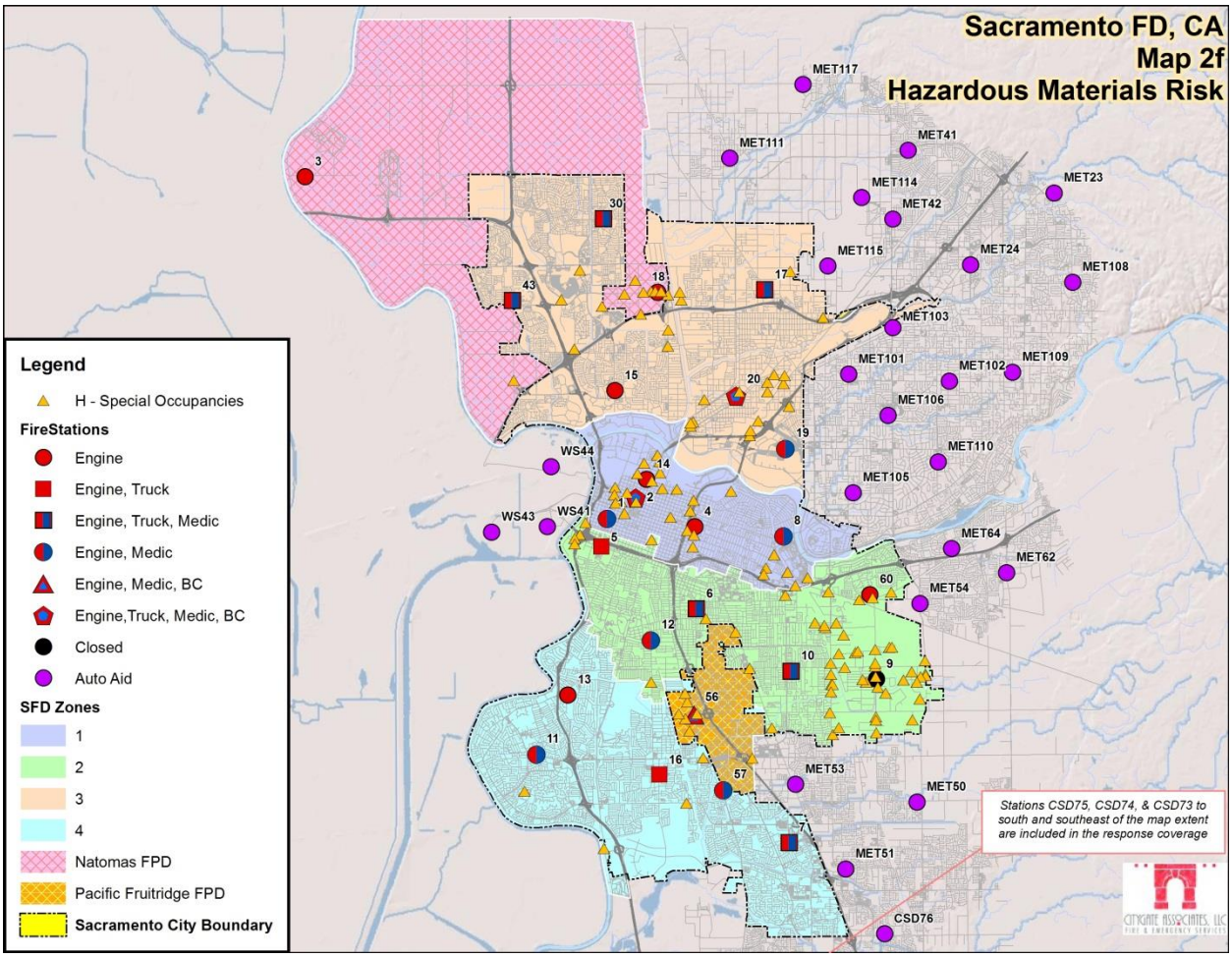
8.15.1 Hazardous Materials Risk Factors

Hazardous material risk factors include fixed facilities that store, use, or produce hazardous chemicals, or produce hazardous waste; underground pipeline(s) that transport hazardous materials; and aircraft, railroad, and vehicle transportation of hazardous materials.

Other hazardous material risk factors include at-risk populations and related demographics, service capacity, historic service demand, emergency evacuation planning and effectiveness, and presence and effectiveness of mass emergency notifications system(s).

Sacramento has 147 hazardous occupancies as classified by the California Building Code. Additionally, the Certified Unified Program Agency (CUPA) for Sacramento County identifies 53 occupancies with active California Accidental Release Program (CalARP) permits, and 16 sites requiring a tiered permit as shown in Figure 19. In addition, there are 3,551 active or potential hazardous waste generator sites, 454 sites with aboveground or underground hazardous material storage tanks, and 2,905 sites with a hazardous material business plan. CUPA facilities are permitted and operated under California Health and Safety Code and Fire Code regulations.

Figure 19—Hazardous Materials Sites



As Figure 19 illustrates, hazardous material sites are located throughout the City but are most prevalent in risk zones 1, 2, and 3.

In addition to the fixed facility hazardous materials risk discussed above, Sacramento also has significant transportation-related hazardous material risk as a result of its extensive road transportation network including multiple freeways and arterial roadways with heavy daily truck traffic volume, multiple railway routes with heavy daily cargo traffic, and 76 miles of underground high pressure natural gas pipelines.

Table 55 summarizes the average annual daily truck traffic for the Sacramento's five highways.

Table 55—Average Annual Daily Truck Traffic

Route	Crossing	AADT[1]	Truck AADT by Axles				% Truck AADT by Axles			
			2	3	4	5+	2	3	4	5+
I-5	I St.	16,993	3,959	1,020	459	11,555	23.30%	6.00%	2.70%	68.00%
Hwy. 16	Hwy. 50	4,950	1,544	1,386	594	1,426	31.20%	28.00%	12.00%	28.80%
Hwy. 50	Hwy. 99	7,901	3,998	1,237	571	2,095	50.60%	15.66%	7.23%	26.51%
Hwy. 80	Hwy. 5	7,851	2,543	1,021	393	3,894	32.40%	13.00%	5.00%	49.60%
Hwy. 99	Fruitridge	11,986	3,718	805	397	7,066	31.02%	6.72%	3.31%	58.95%
	Total	**49,681**	**15,762**	**5,469**	**2,414**	**26,036**	**31.73%**	**11.01%**	**4.86%**	**52.41%**

[1] Average Annual Daily Trips
Source: California Department of Transportation

8.15.2 Hazardous Materials Service Capacity

The Department operates two CalOES Type-1 Hazardous Materials Response Teams from Station 30 in north Sacramento and Station 7 in south Sacramento. Both units are cross-staffed as needed with a minimum of eight on-duty Hazardous Materials Specialists. Additional hazardous materials response resources are available through the regional mutual aid system. This service capacity is sufficient to minimize Sacramento's current and anticipated near-future hazardous materials risk exclusive of a major disaster event.

8.15.3 Hazardous Material Service Demand

Table 56 summarizes Sacramento's hazardous material service demand over the previous three years, which is 0.35% of total service demand over the same period.

Table 56—Hazardous Material Risk Service Demand

Risk Zone	FY 2012-13	FY 2013-14	FY 2014-15	Total
1	44	51	47	**142**
2	65	57	51	**173**
3	69	75	58	**202**
4	43	42	50	**135**
5	5	7	8	**20**
6	13	11	10	**34**
Total	**239**	**243**	**224**	**706**
Percent of Total Service Demand	0.36%	0.38%	0.32%	**0.35%**

Source: City of Sacramento Fire Department incident records

8.15.4 Hazardous Materials Risk Analysis

Citygate's analysis of hazardous material risk for Sacramento is summarized in Table 57. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 58 on the following page.

Table 57—Hazardous Material Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		Vulnerable Populations	Fixed Facilities	Trans. Risk	Service Capacity	Evacuation Capability			
1	**4**	3	1	4	1	3	**12**	**48**	**Moderate**
2	**4**	3	1	4	0	3	**11**	**44**	**Moderate**
3	**4**	3	1	4	0	3	**11**	**44**	**Moderate**
4	**4**	3	1	4	0	3	**11**	**44**	**Moderate**
5	**4**	0	1	3	0	3	**7**	**28**	**Low**
6	**4**	3	1	3	0	3	**10**	**40**	**Moderate**

As Table 57 shows, Sacramento's hazardous material risk is ***Moderate*** for risk zones 1, 2, 3, 4, and 6 reflecting a moderately high probability of occurrence combined with low to moderate impact severity factor scores for vulnerable populations, percentage of fixed hazardous material sites, transportation risk, hazardous material response capacity, and emergency evacuation capability. The City's hazardous material risk is ***Low*** for risk zone 5, reflecting a lower percentage of vulnerable populations.

Table 58—Hazardous Material Impact Severity Factor Evaluation Criteria[1]

Impact Severity Factor	Score	Scoring Guidelines
Vulnerable Populations	0	Less than 5% of population under age 10 and/or over age 65
	1	Less than 10% of population under age 10 and/or over age 65
	2	Less than 20% of population under age 10 and/or over age 65
	3	Less than 30% of population under age 10 and/or over age 65
	4	Less than 40% of population under age 10 and/or over age 65
	5	More than 40% of population under age 10 and/or over age 65
Fixed Hazardous Material Facility Risk	0	Less than 1% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
	1	Less than 2.5% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
	2	Less than 5% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
	3	Less than 7.5% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
	4	Less than 10% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
	5	More than 10% of occupancies require hazardous material operating permit or Hazardous Material Business Plan
Transportation Hazardous Material Risk	0	Less than 100 AADT[2] truck traffic; no railway freight traffic; no air cargo traffic
	1	Less than 1,000 AADT[2] truck traffic; less than 3 daily freight train movements; less than 10 tons annual air cargo
	2	Less than 5,000 AADT[2] truck traffic; less than 10 daily freight train movements; less than 50 tons annual air cargo
	3	Less than 25,000 AADT[2] truck traffic; less than 25 daily freight train movements; less than 100 tons annual air cargo
	4	Less than 50,000 AADT[2] truck traffic; less than 50 daily freight train movements; less than 500 tons annual air cargo
	5	More than 50,000 AADT[2] truck traffic; more than 50 daily freight train movements; more than 500 tons annual air cargo
Service Capacity	0	Type-I HazMat Team available within 15 min. @ 90%; all response personnel trained to HazMat FRO[3]
	1	Type-I HazMat Team available within 20 min. @ 90%; all response personnel trained to HazMat FRO[3]
	2	Type-II HazMat Team available within 30 min. @ 90%; all response personnel trained to HazMat FRO[3]
	3	Type-II HazMat Team available within 45 min. @ 90%; more than 75% of response personnel trained to HazMat FRO[3]
	4	Type-III HazMat Team available within 60 min. @ 80%; more than 50% of response personnel trained to HazMat FRO[3]
	5	Type-III HazMat Team not available within 60 min. @ 80%; less than 50% of response personnel trained to HazMat FRO[3]
Evacuation Capability	0	Evacuation plan adopted and functionally exercised at least every 12 months; multiple EMNS[4] able to effectively notify more than 90% of residents/businesses within 15 mins.; EMNS tested at least every 12 months
	1	Evacuation plan adopted and functionally exercised at least every 18 months; EMNS[4] able to effectively notify more than 75% of residents/businesses within 15 mins.; EMNS tested at least every 18 months
	2	Evacuation plan adopted and evaluated at least every 18 months; EMNS[4] able to effectively notify more than 75% of residents/businesses within 30 mins.; EMNS tested at least every 24 months
	3	Evacuation plan evaluated at least every 24 months; EMNS[4] able to effectively notify more than 50% of residents/businesses within 30 mins.; EMNS tested at least every 24 months
	4	Evacuation plan not evaluated; EMNS[4] unable to effectively notify at least 50% of residents/businesses within 30 mins. and/or not tested
	5	No evacuation plan and/or no EMNS[4] available

[1] Incident requiring multiple resources and impacting multiple values at risk (e.g., freight/tank truck collision, freight train derailment, earthquake, explosion, weapon of mass destruction, etc.)
[2] Average Annual Daily Trips (AADT)
[3] First Responder Operational (FRO)
[4] Emergency Mass Notification System (EMNS)

8.16 TECHNICAL RESCUE RISK

8.16.1 Technical Rescue Risk Factors

Technical rescue risk factors include construction activity, heavy industrial activity, confined spaces such as tanks and underground vaults, bodies of water and rivers or streams, urban flooding, transportation volume, and other factors that may create a need for technical rescue skills and/or equipment. Sacramento also has approximately 23 miles of popular recreation area along the Sacramento and American rivers.

8.16.2 Technical Rescue Service Capacity

The Sacramento Fire Department has a Type-1 Heavy Rescue unit at Station 20 in the north-central section of the City. This unit is cross-staffed by Station 20 personnel as needed with a minimum of eight personnel capable of conducting low-angle and high-angle rope rescue; structural collapse search and rescue, confined space rescue, swiftwater rescue, and trench rescue. The Department also has a marine program capable of deploying swiftwater rescue boats from Stations 2, 5, 8, and 11. Boat 5 is moored at Miller Park on the Sacramento River, and also has firefighting capabilities.

The Department is the host agency for California Urban Search and Rescue (US&R) Task Force 7, one of eight California-based national US&R resources sponsored by the Federal Emergency Management Agency (FEMA) and coordinated and managed in California by the Governor's Office of Emergency Services. Each US&R Task Force consists of specially trained and equipped members capable of performing complex search, rescue, medical, and other highly technical search and rescue functions. Other regional technical rescue resources are also available through the mutual aid system.

This service capacity is adequate to minimize Sacramento's current and anticipated near-future technical rescue impact severity exclusive of a major regional disaster event.

8.16.3 Technical Rescue Service Demand

Over the most recent 3-year period evaluated for this study, there were 253 rescue incidents in Sacramento comprising 0.12% of total service demand over the same period as shown in Table 59.

Table 59—Technical Rescue Service Demand

Risk Zone	FY 2012-13	FY 2013-14	FY 2014-15	Total
1	39	41	41	**121**
2	14	15	12	**41**
3	12	16	13	**41**
4	9	10	11	**30**
5	7	3	2	**12**
6	4	3	1	**8**
Total	**85**	**88**	**80**	**253**
Percent of Total Service Demand	0.13%	0.13%	0.12%	**0.12%**

Source: City of Sacramento Fire Department incident records

8.16.4 Technical Rescue Risk Analysis

Table 60 summarizes Citygate's technical rescue risk analysis for Sacramento. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 61 on the following page.

Table 60—Technical Rescue Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		Construction Activity	Industrial Activity	Water Risk	Traffic Volume	Service Capacity			
1	**4**	4	2	4	5	0	**15**	**60**	**Moderate**
2	**4**	2	5	4	5	0	**16**	**64**	**High**
3	**4**	3	3	4	5	0	**15**	**60**	**Moderate**
4	**4**	4	3	4	5	0	**16**	**64**	**High**
5	**3**	1	1	4	5	0	**11**	**33**	**Moderate**
6	**3**	2	1	1	5	0	**9**	**27**	**Low**

As Table 60 illustrates, Sacramento's technical rescue risk is ***High*** for risk zones 2 and 4, reflecting a moderately high probability of occurrence in combination with low to high impact severity factor scores for construction activity, industrial/manufacturing activity, water rescue risk, traffic volume, and technical rescue service capacity. The City's technical rescue risk is ***Moderate*** for risk zones 1, 3, and 5, and ***Low*** for risk zone 6, reflecting a lower probability of occurrence and/or lower impact severity factor scores.

Table 61—Technical Rescue Impact Severity Factor Evaluation Criteria[1]

Impact Severity Factor	Score	Scoring Guidelines
Construction Activity	0	No significant construction activity other than single-family dwellings, remodels, etc.
	1	Some light new construction activity
	2	Moderate light commercial/infrastructure construction activity
	3	Some heavy commercial/industrial/infrastructure construction activity
	4	Moderate heavy commercial/industrial/infrastructure/high-rise construction activity
	5	Significant heavy commercial/industrial/infrastructure/high-rise construction activity
Industrial/Manufacturing Activity	0	No industrial/manufacturing activity
	1	Some light industrial/manufacturing activity
	2	Moderate light industrial/manufacturing activity
	3	Some heavy industrial/manufacturing activity
	4	Moderate heavy industrial/manufacturing activity
	5	Significant heavy industrial/manufacturing activity
Water Rescue	0	No water rescue risk
	1	Minimal water rescue risk; one or more small bodies of non-swiftwater; minimal recreation activity
	2	Minor water rescue risk; one or more small bodies of non-swiftwater; minor recreation activity
	3	Moderate water rescue risk; one or more bodies of non-swiftwater; moderate recreation activity
	4	High water rescue risk; one or more bodies of swiftwater; high recreation activity
	5	Very high water rescue risk; multiple swift waterways; coastal waterfront; very high recreation activity
Traffic Volume	0	No freeway or highway traffic; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	1	One or more two-lane highways; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	2	One or more multiple-lane highways; no seasonal snow, ice, or dense fog
	3	Single multiple-lane highway; limited high-speed arterial traffic; minimal seasonal snow, ice, or dense fog
	4	Multiple multiple-lane highways; moderate high-speed arterial traffic; moderate seasonal snow, ice, or dense fog
	5	Multiple multiple-lane freeways; heavy high-speed arterial traffic; heavy seasonal snow, ice, or dense fog
Service Capacity	0	US&R[2] Type-1 (Heavy) Team / Type-1 swiftwater/flood S&R[3] Team available within 30 min. @ 90%
	1	US&R[2] Type-1 (Heavy) Company / Type-1 swiftwater/flood S&R[3] Team available within 45 min. @ 90%
	2	US&R[2] Type-2 (Medium) Company / Type-2 swiftwater/flood S&R[3] Team available within 60 min. @ 90%
	3	US&R[2] Type-3 (Light) Company / Type-3 swiftwater/flood S&R[3] Team available within 75 min. @ 90%
	4	US&R[2] Type-4 (Basic) Company / Type-4 swiftwater/flood S&R[3] Team available within 90 min. @ 90%
	5	Technical Rescue capability / swiftwater/flood S&R[3] capability not available within 90 min. @ 90%

[1] Significant technical rescue incident requiring multiple resources
[2] Urban Search and Rescue
[3] Search and rescue

8.17 TRANSPORTATION RISK

8.17.1 Transportation Risk Factors

Transportation risk factors include motor vehicle, railway, watercraft, and aircraft use in and through Sacramento.

Primary Transportation Routes

There are approximately 57 miles of interstate and state freeways and highways in the City and two fire district areas carrying more than 900,000 vehicles daily with more than 75,000 per hour at peak traffic volume as shown in Table 62. Sacramento also has 22 miles of Light Rail transit line, approximately 33 miles of commercial railway, and approximately 3,000 miles of surface streets with over 700 signalized intersections, approximately 175 of which are equipped for traffic pre-emption by emergency vehicles.

Table 62—Average Annual Daily Traffic Volume

Route	Crossing	AADT[1]	Peak-Hour Volume
I-5	Richards Blvd.	209,000	15,800
Hwy. 16	Folsom Blvd.	57,000	5,600
Hwy. 50	Howe Ave.	268,000	25,000
Hwy. 80	Raley Blvd.	143,000	11,000
Hwy. 99	12th Ave.	235,000	20,600
	Total	**912,000**	**78,000**

[1] Average Annual Daily Trips
Source: California Department of Transportation (2014)

Rail Services and Mass Transportation

Amtrak provides passenger rail services via the Sacramento–San-José Capitol Corridor and Seattle–Los-Angeles Coast Starlight routes. The Sacramento Regional Transit District operates 67 transit bus routes and 38.6 miles of light rail service covering a 418-square-mile service area throughout Sacramento County, with annual ridership exceeding 26 million passengers. Both light rail and bus ridership averages approximately 50,000 passengers each on weekdays. Long-term plans call for the expansion of the light rail system to the Sacramento International Airport.

Multiple Union Pacific (UP) and Burlington Northern Santa Fe (BNSF) tracks carry heavy daily railway cargo traffic into and through Sacramento from all directions, with more than 300 daily train movements.[15]

Airports

The Sacramento Executive Airport, owned and operated by the Sacramento County Airport System, is located three miles south of downtown Sacramento on the east side of Freeport Boulevard between Fruitridge Avenue and Florin Road and supports approximately 87,000 general aviation flights and 25,000 tons of cargo annually, or an average of approximately 300 flights per day.

The Sacramento International Airport, located northwest of the City north of Interstate 5, serves approximately 9 million passengers, over 100,000 flights, and nearly 7,000 tons of cargo annually. It is also owned and operated by the Sacramento County Airport System, and has its own fire department.

8.17.2 Transportation Risk Service Capacity

Sacramento's service capacity for transportation risk consists of a minimum daily on-duty response force of 169 personnel staffing 49 apparatus from 24 strategically located fire stations. In addition, the Department has automatic aid and mutual aid agreements with adjacent fire agencies, and is also a signatory to the Sacramento County Mutual Aid Agreement. Combined with its specialized technical rescue capabilities from Station 20, this service capacity is appropriate to mitigate Sacramento's transportation risk exclusive of a disaster event.

[15] Federal Railroad Administration data

8.17.3 Transportation Risk Service Demand

Over the most recent 3-year period evaluated for this study, there were 9,734 transportation-related incidents in Sacramento comprising 4.91% of total service demand over the same period as shown in Table 63.

Table 63—Transportation Risk Service Demand

Risk Zone	FY 2012/13	FY 2013/14	FY 2014/15	Total
1	635	680	739	**2,054**
2	793	763	812	**2,368**
3	851	874	1,090	**2,815**
4	499	493	545	**1,537**
5	94	99	102	**295**
6	212	213	240	**665**
Total	**3,084**	**3,122**	**3,528**	**9,734**
Percent of Total Service Demand	4.74%	4.84%	5.15%	**4.91%**

Source: City of Sacramento Fire Department incident records

8.17.4 Transportation Risk Analysis

Table 64 summarizes Citygate's analysis of Sacramento's transportation risk. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 65 on the following page.

Table 64—Transportation Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Total Risk Factors Score	Overall Risk Score	Risk Rating
		Vehicle Traffic Volume	Aircraft Traffic Volume	Railway Traffic Volume	Disaster Risk	Service Capacity			
1	**5**	5	3	5	3	1	**17**	**85**	**High**
2	**5**	5	3	5	3	1	**17**	**85**	**High**
3	**5**	5	3	5	3	1	**17**	**85**	**High**
4	**5**	5	3	5	3	1	**17**	**85**	**High**
5	**5**	5	5	3	3	1	**17**	**85**	**High**
6	**5**	5	3	3	3	1	**15**	**75**	**High**

Table 64 shows that Sacramento's transportation risk is ***High*** across all six risk zones reflecting a high probability of occurrence, high vehicle traffic volume, moderate to high aircraft and railway traffic volume, moderate disaster risk, and very good transportation risk service capacity.

Table 65—Transportation Risk Impact Severity Factor Evaluation Criteria[1]

Impact Severity Factor	Score	Scoring Guidelines
Vehicle Traffic Volume	0	No freeway or highway traffic; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	1	One or more two-lane highways; no high-speed arterial traffic; no seasonal snow, ice, or dense fog
	2	One or more multiple-lane highways; no seasonal snow, ice, or dense fog
	3	Single multiple-lane highway; limited high-speed arterial traffic; minimal seasonal snow, ice, or dense fog
	4	Multiple multiple-lane highways; moderate high-speed arterial traffic; moderate seasonal snow, ice, or dense fog
	5	Multiple multiple-lane freeways; heavy high-speed arterial traffic; heavy seasonal snow, ice, or dense fog
Aircraft Traffic Volume	0	No passenger, cargo, or military aircraft operations
	1	No commercial passenger or cargo aircraft operations; less than 5,000 general aviation flights annually
	2	Less than 500,000 passengers; less than 50,000 general aviation flights; less than 5,000 annual cargo tons
	3	Less than 1 million passengers; less than 100,000 general aviation flights; less than 10,000 annual cargo tons
	4	Less than 5 million passengers; less than 250,000 general aviation flights; less than 20,000 annual cargo tons
	5	More than 5 million passengers; more than 250,000 general aviation flights; more than 20,000 annual cargo tons
Railway Traffic Volume	0	No railway passenger or freight services
	1	Average of less than 10 daily train movements
	2	Average of less than 25 daily train movements
	3	Average of less than 100 daily train movements
	4	Average of less than 250 daily train movements
	5	Average of more than 250 daily train movements
Disaster Risk	0	No known active fault/historical earthquake activity within 100 miles
	1	No historical earthquake activity greater than 3.0 magnitude within 100 miles within the previous 25 years
	2	No historical earthquake activity greater than 4.0 magnitude within 100 miles within the previous 25 years
	3	No historical earthquake activity greater than 5.0 magnitude within 100 miles within the previous 25 years
	4	No historical earthquake activity greater than 6.0 magnitude within 100 miles within the previous 25 years
	5	Historical earthquake activity greater than 6.0 magnitude within 100 miles within the previous 25 years
Service Capacity	0	ALS available within 6 min. @ 90%; technical rescue available within 30 min. @ 90%
	1	ALS available within 8 min. @ 90%; technical rescue available within 45 min. @ 90%
	2	ALS available within 10 min. @ 90%; technical rescue available within 60 min. @ 90%
	3	ALS or BLS available within 12 min. @ 90%; technical rescue available within 75 min. @ 90%
	4	ALS or BLS available within 15 min. @ 90%; technical rescue available within 90 min. @ 90%
	5	ALS or BLS not available within 12 min. @ 90%; technical rescue not available within 75 min. @ 90%

[1] Multiple-victim incident requiring multiple resources (e.g., earthquake, explosion, flooding, etc.)

8.18 MARITIME RISK

8.18.1 Maritime Risk Factors

Maritime risk factors include watercraft storage and use in and through Sacramento.

Waterways

The Sacramento River is the primary navigable waterway through Sacramento, and forms the western boundary of much of the City. The largest river in California, it originates in the Klamath Mountains near Mount Shasta in northern California and flows 445 miles south to the Sacramento-San Joaquin River Delta and ultimately into San Francisco Bay. Average flow through Sacramento is about 28,000 cubic feet per second, making it a popular recreational boating waterway.

The American River also bisects the City from east to west, converging with the Sacramento River just north of downtown. Average flow for the river through Sacramento is about 3,600 cubic feet per second, making it a popular recreational waterway for rafts, kayaks, canoes, rowboats, and smaller motorboats. Motorboats are limited to a maximum speed of 5 miles per hour on the American River.

The recreational use of the waterways has also contributed to an increase in drowning incidents resulting in Sacramento experiencing one of the highest levels of fatalities in the region.

In 2015, 28 deaths due to drowning occurred in rivers within Sacramento County (16 in the Sacramento River and 12 in the American River). These statistics have remained largely unchanged since 1960 as the Sacramento Region has averaged 8 deaths per year. A national per capita fresh water-drowning rate of 3.043 deaths per one million people is provided by the World Health Organization. The County of Sacramento's population in 2015 is 1,501,335 which results in an estimate of 4.57 persons annually. The 55-year average is nearly double that figure and the 2015 death count is nearly 6 times the national average.

Marinas

The Sacramento Marina is the largest off-river marina in the Sacramento area. Located on the Sacramento River on the east side of Miller Park just south of the U.S. 50 Bridge, it has 475 covered berths that can accommodate vessels up to 50 feet in length. Open 24 hours per day, 365 days a year, it is also where the City's fireboat and the Police Department boats are berthed.

Riverbank Marina is the second largest private boat marina on the Sacramento River. Located on the north bank of the river along Garden Highway west of Interstate 5, it has 175 covered/uncovered berths accommodating vessels up to 50 feet in length.

There are no marinas on the American River.

8.18.2 Maritime Fire Risk Service Capacity

Sacramento's service capacity for maritime risk consists of a fireboat berthed at Sacramento Marina that is cross-staffed by on-duty personnel from Station 5 at Broadway and 8th Street, approximately one mile from the marina. In addition, the Department has three rigid inflatable boats (RIBs) at Station 2 (I Street/13th Street), Station 8 (H Street/Carlson Drive), and Station 11 (Florin Road/Havenside Drive). The RIBs are cross-staffed with on-duty station personnel also trained as Swiftwater Rescue Technicians (SRT), and are transported by trailer to pre-designated launch sites as needed. Sacramento's service capacity for maritime risk includes a minimum daily on-duty response force of 24 personnel staffing four boats from four strategically located fire stations (2, 5, 8, and 11). In addition, the Department has automatic aid and mutual aid agreements with adjacent fire agencies, and is also a signatory to the Sacramento County Mutual Aid Agreement.

The City of West Sacramento Fire Department also operates a fireboat from its Station 41 on the west side of the Sacramento River just south of Interstate 80, and a RIB from its Station 45 approximately 1.5 miles south of Station 41.

Combined with the specialized technical rescue capabilities from Station 20, this combined service capacity is appropriate to mitigate Sacramento's maritime risk.

8.18.3 Maritime Risk Service Demand

Over the most recent 3-year period evaluated for this study, there were 75 transportation-related incidents in Sacramento comprising .04% of total service demand over the same period as shown in Table 66.

Table 66—Maritime Risk Service Demand

Risk Zone	FY 2012/13	FY 2013/14	FY 2014/15	Total
All	**36**	**20**	**19**	**75**
Percent of Total Service Demand	0.06%	0.03%	0.03%	**0.04%**

Source: City of Sacramento Fire Department incident records

8.18.4 Maritime Risk Analysis

Table 67 summarizes Citygate's analysis of Sacramento's maritime risk. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 68 on the following page.

Table 67—Maritime Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Risk Factors Score	Overall Risk Score	Risk Rating
		Waterways	Waterfront Recreation	Values at Risk	Service Demand	Service Capacity			
1	**1**	3	2	0	0	1	**6**	**6**	**Low**
2	**1**	3	1	3	0	1	**8**	**8**	**Low**
3	**1**	3	2	2	0	1	**8**	**8**	**Low**
4	**1**	3	3	0	0	0	**6**	**6**	**Low**
5	**1**	3	1	0	0	2	**6**	**6**	**Low**
6	**1**	0	0	0	0	1	**1**	**1**	**Low**

Table 67 shows that Sacramento's maritime risk is ***Low*** across all six risk zones reflecting a very low probability of occurrence in combination with moderate risk waterways, low to moderate waterfront recreation risk, low to moderate maritime values at risk, very low service demand, and very good maritime service capacity.

Table 68—Maritime Risk Impact Severity Factor Evaluation Criteria[1]

Impact Severity Factor	Score	Scoring Guidelines
Waterways	0	One or more non-swift waterways navigable only by non-motorized vessels
	1	One or more waterways navigable only by non-motorized vessels
	2	One or more waterways navigable by non-commercial motorized vessels up to 20 feet in length
	3	One or more waterways navigable by non-commercial motorized vessels up to 50 feet in length
	4	One or more navigable waterways serving commercial non-container cargo vessels
	5	One or more navigable waterways serving container cargo and/or combustible liquid tanker vessels
Waterfront Recreation	0	Annual average less than 100 persons/day; peak use less than 250 persons/day
	1	Annual average less than 250 persons/day; peak use less than 500 persons/day
	2	Annual average less than 500 persons/day; peak use less than 1,000 persons/day
	3	Annual average less than 1,000 persons/day; peak use less than 2,500 persons/day
	4	Annual average less than 2,500 persons/day; peak use less than 5,000 persons/day
	5	Annual average more than 2,500 persons/day and/or peak use more than 5,000 persons/day and/or recreation areas include swiftwater or coastal waterfront
Values at Risk	0	No private or commercial marinas serving more than 3 vessels less than 25 feet in length
	1	One or more private or commercial marinas with less than 50 berths serving vessels up to 30 feet in length
	2	One or more private or commercial marinas with less than 250 berths serving vessels up to 40 feet in length
	3	One or more private or commercial marinas with more than 250 berths serving vessels 40 feet or more in length
	4	One or more ports serving commercial non-container cargo vessels
	5	One or more ports serving container cargo and/or combustible liquid tanker vessels
Service Demand	0	Maritime service demand comprises less than .25% of total service demand over previous 3 years
	1	Maritime service demand comprises less than .50% of total service demand over previous 3 years
	2	Maritime service demand comprises less than 1% of total service demand over previous 3 years
	3	Maritime service demand comprises less than 5% of total service demand over previous 3 years
	4	Maritime service demand comprises less than 10% of total service demand over previous 3 years
	5	Maritime service demand comprises more than 10% of total service demand over previous 3 years
Service Capacity	0	Maritime fire suppression AND water rescue available within 10 minutes response time @ 90%
	1	Maritime fire suppression AND water rescue available within 15 minutes response time @ 90%
	2	Maritime fire suppression AND water rescue available within 20 minutes response time @ 90%
	3	Maritime fire suppression AND water rescue available within 30 minutes response time @ 90%
	4	Maritime fire suppression AND water rescue available within 45 minutes response time @ 90%
	5	No maritime fire suppression or water rescue capability, or response time greater than 45 minutes @ 90%

[1] Significant maritime event requiring multiple resources and/or impacting multiple maritime values at risk

8.19 EARTHQUAKE/SEISMIC ACTIVITY RISK

An *earthquake* is a sudden, rapid shaking of the ground caused by the breaking and shifting of rock beneath the earth's surface or along fault lines. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free causing the ground to shake. Most earthquakes occur at the boundaries where the plates meet, commonly called faults; however, some earthquakes occur in the middle of plates.

A *fault* is a fracture in the earth's crust along which movement has occurred either suddenly during earthquakes or slowly during a process called creep. Cumulative displacement may be tens or even hundreds of miles as movement occurs over geologic time. Although fault lines are often represented as linear, most fault lines can be very intricate with multiple fractures along curved, complex paths. Fault displacement episodes are generally small, usually less than several feet, and are commonly separated by tens, hundreds, or thousands of years. Damage associated with fault-related ground rupture is normally confined to a fairly narrow band along the trend of the fault. Structures are often not able to withstand fault rupture and utilities crossing faults are at risk of damage. Fault displacement involves forces so great that it is generally not feasible (structurally or economically) to design and build structures to accommodate this rapid displacement.

Liquefaction is the phenomenon that occurs when ground shaking causes loose, saturated soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength. Lateral spreads develop on gentle slopes and entail the sidelong movement of large masses of soil as an underlying layer liquefies. Loss of bearing strength results when the soil supporting structures liquefies and causes structures to collapse. The larger the earthquake magnitude, and the longer the duration of strong ground shaking, the greater the potential there is for liquefaction to occur.

The effect of an earthquake on the earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally, total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli Intensity (MMI) scale developed in 1931. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects. The MMI value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than magnitude because intensity refers to the effects actually experienced at a particular place. The lower numbers of the intensity

scale deal with the manner in which people feel the earthquake. The higher numbers of the scale are based on observed structural damage.

Most people are familiar with the Richter scale, a method of rating earthquakes based on strength using an indirect measure of released energy. The Richter scale is logarithmic. Each one-point increase corresponds to a 10-fold increase in the amplitude of the seismic shock waves and a 32-fold increase in energy released. An earthquake registering 7.0 on the Richter scale releases over 1,000 times more energy than an earthquake registering 5.0.

Peak ground acceleration (PGA) is a measure of the strength of ground movement. Rapid ground acceleration results in greater damage to structures. PGA is used to project the risk of damage from future earthquakes by showing earthquake ground motions that have a specified probability (10%, 5%, or 2%) of being exceeded in 50 years return period. Therefore, these values are often used for reference in construction design, and in assessing relative hazards when making economic and safety decisions.

8.19.1 Earthquake Risk Factors[16]

Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, gas, communication, and transportation. Earthquakes may also cause collateral emergencies including dam and levee failures, seiches, hazardous materials releases, fires, avalanches, and landslides. The degree of damage from an earthquake depends on many interrelated factors including: magnitude, focal depth, distance from the causative fault, source mechanism, duration of shaking, high rock accelerations, type of surface deposits or bedrock, degree of consolidation of surface deposits, presence of high groundwater, topography, and the design, type, and quality of building construction.

Faults

California is seismically active because it sits on the boundary between two of the earth's tectonic plates. Most of the state—everything east of the San Andreas Fault—is on the North American Plate. The cities of Monterey, Santa Barbara, Los Angeles, and San Diego are on the Pacific Plate, which is constantly moving northwest past the North American Plate. The relative rate of movement is about two inches per year. The San Andreas Fault is considered the boundary between the two plates, although some of the motion is taken up on faults as far away as central Utah. Active faults have experienced displacement in historic time, suggesting that future displacement may be expected. Inactive faults show no evidence of movement in recent geologic time, suggesting that these faults are dormant.

[16] Source: Sacramento County Local Hazard Mitigation Plan Update, September 2011

Geological literature indicates that no major active faults transect Sacramento County; however, there are several subsurface faults in the Delta. The Midland fault, buried under alluvium, extends north of Bethel Island in the Delta to the east of Lake Berryessa and is considered inactive but possibly capable of generating a near 7.0 (Richter Scale) earthquake. This figure is speculative based on an 1895 earthquake measuring 6.9 on the Richter Scale with an epicenter possibly in the Midland Fault vicinity. However, oil and gas companies exploring the area's energy potential have identified several subsurface faults, none of which show any recent surface rupture. A second, presumably inactive, fault is in the vicinity of Citrus Heights near Antelope Road. This fault's only exposure is along a railroad cut where offsetting geologic beds can be seen. Neither the lateral extent of the trace, the magnitude of the offset, nor the age of faulting has been determined. To the east, the Bear Mountain fault zone trends northwest to southeast through Amador and El Dorado Counties. Geologists believe this series of faults has not been active in historic time. Table 69 identifies known faults in close proximity to Sacramento County.

Table 69—Historically Active Faults in the Vicinity of Sacramento County

Fault	Distance from Sacramento (Miles)	Historical Seismicity	Probable Intensity (Richter Scale)
San Andreas	80	1906 (8.25)	7.5
Vaca	35	1892 (6.5-7.0)	6.0
Hayward	60	1836, 1868 (7.25)	6.5-7.0
Calaveras	50	1861 (6.5-7.0)	6.5-7.0
Concord-Green Valley	45	1955 (5.4)	6.0
Midland	20	Circa 1895	6.9
Dunnigan Hills	18	Unknown	6.0
Foothill Fault System	25	1975	6.0

Source: Sacramento County Local Hazard Mitigation Plan, September 2011

Seismic Activity History

A generally accepted axiom among emergency management planners is that earthquakes will occur where they have occurred previously. While Sacramento County has experienced relatively little seismic activity, faulting in neighboring regions, especially the San Francisco Bay Area and the Sierra Nevada, suggests that the County could be affected by future ground motion originating elsewhere.

The greatest amount of ground shaking experienced in the County occurred on **April 21, 1892**, when an earthquake shook Yolo County between Winters and Vacaville. While the damage in

Yolo County was severe, the damage in Sacramento County was substantially less. Damage to buildings in Sacramento was limited to statuary falling from building tops and cracks in chimneys.

The **1906** San Francisco earthquake generated little shaking in Sacramento County and damage locally was limited to minor cracks in a local post office and jail.

A **December 16, 1954** earthquake near Fairview Peak, Nevada measured 7.1 on the Richter Scale. The earthquake caused some damage in Sacramento, while virtually no damage occurred in Reno, Nevada.

On **August 1, 1975**, a moderate earthquake (magnitude 5.7) occurred near Oroville on the Cleveland Hills fault. This earthquake was felt in Sacramento County, although no direct damage was reported.

Sacramento County suffered little damage from the **October 17, 1989** Loma Prieta earthquake, which was felt over an area covering 400,000 square miles from Los Angeles to the California-Oregon border. The earthquake measured 7.1 on the Richter Scale; the epicenter was located along the San Andreas fault beneath the Santa Cruz Mountains, about 60 miles southeast of San Francisco. In contrast to Sacramento County, the San Francisco Bay Area region suffered over $6 billion in property damage and 62 lives were lost. The Loma Prieta earthquake resulted in a federal disaster declaration for the area around San Francisco, including Sacramento County.

Ground Shaking

Ground shaking is motion that occurs as a result of energy released during a fault rupture. The damage or collapse of buildings and other structures caused by ground shaking is among the most serious seismic hazards. Damage to structures from this vibration, or ground shaking, is caused by the transmission of earthquake vibrations from the ground to the structure. The intensity of shaking and its potential impact on buildings is determined by the physical characteristics of the underlying soil and rock, building materials and construction methods, earthquake magnitude and location of epicenter, and the character and duration of ground motion. Much of the County is located on alluvium, which increases the amplitude of the earthquake wave. Ground motion lasts longer and waves are amplified on loose, water-saturated materials than on solid rock. As a result, structures located on alluvium typically suffer greater damage than those located on solid rock.

Seismic Structural Safety

Older buildings constructed before building codes were established, and even newer buildings constructed before earthquake-resistant provisions were included in the codes, are the most likely to sustain damage from an earthquake. One-story and two-story wood-frame buildings are considered to be the most structurally resistant to earthquake damage. Older masonry buildings

without seismic reinforcement (unreinforced masonry) are the most susceptible to the type of structural failure that causes injury or death.

Sacramento has some very old buildings very susceptible to damage from an earthquake. Many of these structures are multi-family housing units with "soft story" construction that is very susceptible to collapse in an earthquake. A soft story building is a multi-story building in which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in places where a shear wall would normally be required for stability as a matter of earthquake engineering design. A typical soft story building is an apartment building of three or more stories located over a ground level with large openings, such as a parking garage or series of retail businesses with large windows.

Buildings are classified as having a "soft story" if that level is less than 70% as stiff as the floor immediately above it, or less than 80% as stiff as the average stiffness of the three floors above it. Soft story buildings are vulnerable to collapse in a moderate to severe earthquake in a phenomenon known as soft story collapse. The inadequately braced level is relatively less resistant than surrounding floors to lateral earthquake motion, so a disproportionate amount of the building's overall side-to-side drift is focused on that floor. Subject to disproportionate lateral stress, and less able to withstand the stress, the floor becomes a weak point that may suffer structural damage or complete failure, which in turn results in the collapse of the entire building.

Soft story failure was responsible for nearly half of all homes that became uninhabitable in California's Loma Prieta earthquake of 1989, and was projected to cause severe damage and possible destruction of 160,000 homes in the event of a more significant earthquake in the San Francisco Bay Area. Citygate was unable to locate any data relating to soft story building locations for this study.

The susceptibility of a structure to damage from ground shaking is also related to the underlying foundation material. A foundation of rock or very firm material can intensify short-period motions that affect low-rise buildings more than taller flexible buildings. A deep layer of water-logged soft alluvium can cushion low-rise buildings, but it can also accentuate the motion in tall buildings. The amplified motion resulting from softer alluvial soils can also severely damage older masonry buildings.

Other potentially dangerous conditions include, but are not limited to: building architectural features that are not firmly anchored, such as parapets and cornices; roadways, including column and pile bents and abutments for bridges and overcrossings; and aboveground storage tanks and their mounting devices. Such features could be damaged or destroyed during strong or sustained ground shaking.

Liquefaction Potential

Liquefaction is a process whereby soil is temporarily transformed to a fluid form during intense and prolonged ground shaking. In Sacramento County, the Delta and areas of downtown Sacramento are at risk to liquefaction. The Delta sits atop a blind fault system on the western edge of the Central Valley. Moderate earthquakes in 1892 near Vacaville and in 1983 near Coalinga demonstrate the seismic potential of this structural belt. The increasing height of the levee system has prompted growing concern about the seismic stability of the levees. The concern is based on the proximity of faulting, the nature of the levee foundations, and the materials used to build the levees. Many levees consist of uncompacted weak local soils that may be unstable under seismic loading. The presence of sand and silt in the levees and their foundations indicates that liquefaction is also a possibility.

Settlement

Settlement can occur in poorly consolidated soils during ground shaking. During settlement, the soil materials are physically rearranged by the shaking to result in a less stable alignment of the individual minerals. Settlement of sufficient magnitude to cause significant structural damage is normally associated with rapidly deposited alluvial soils or improperly founded or poorly compacted fill. These areas are known to undergo extensive settling with the addition of irrigation water, but evidence due to ground shaking is not available.

Other Earthquake Impact Severity Factors

Other factors influencing the impact severity of an earthquake event include the percentage of area affected, percentage of the affected area population sustaining injuries or death, property damage, percentage of critical facilities/services affected, and long-term community-wide impacts including adverse economic/employment and essential government services.

8.19.2 Earthquake Risk Service Capacity

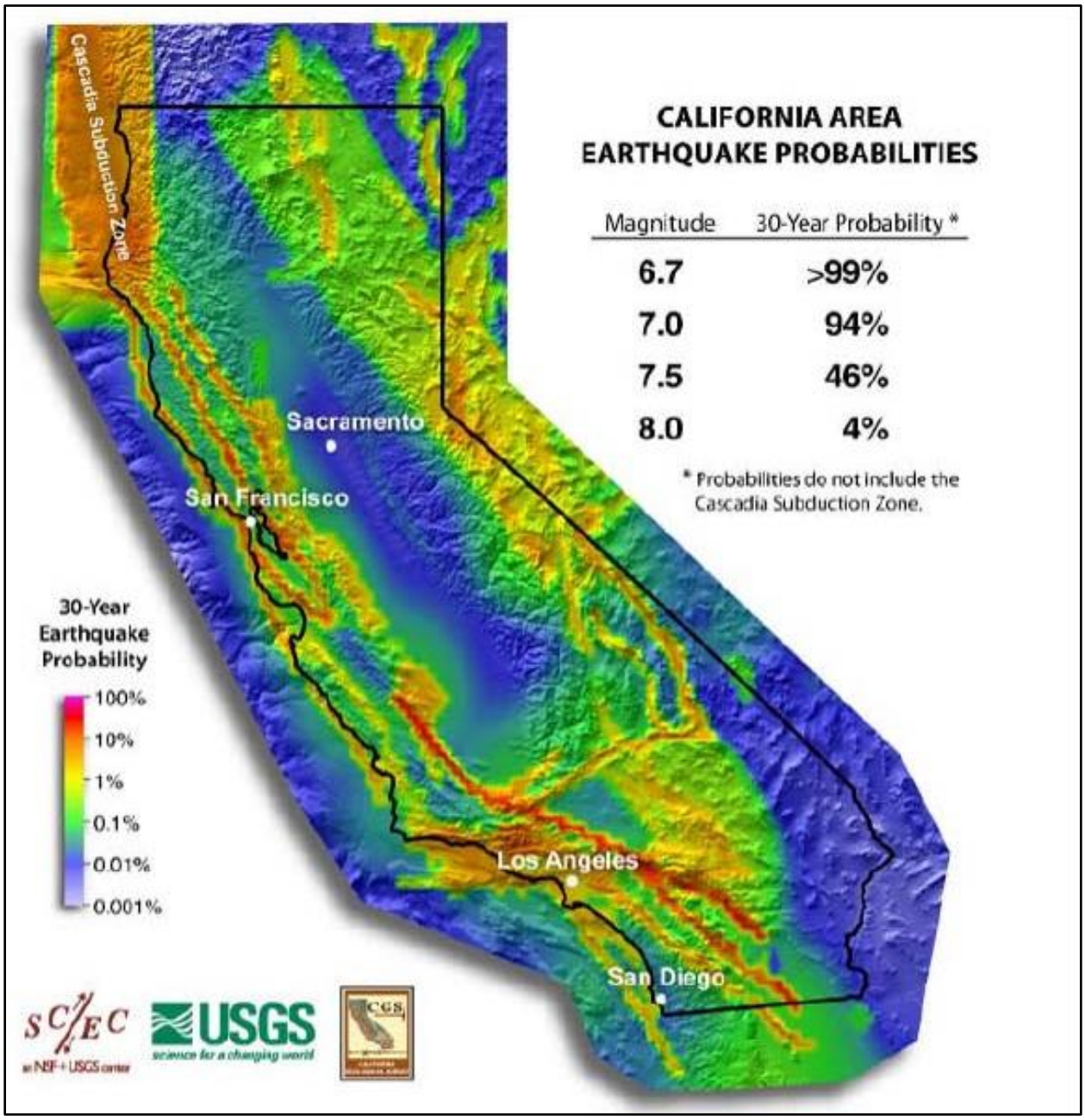
Sacramento's service capacity for earthquake risk consists of a minimum daily on-duty response force of 169 personnel staffing 49 apparatus from 24 strategically located fire stations. In addition, the Department has automatic aid and mutual aid agreements with adjacent fire agencies, and is also a signatory to the Sacramento County Mutual Aid Agreement. Combined with its specialized technical rescue capabilities from Station 20, this service capacity is appropriate to minimize Sacramento's earthquake impact severity exclusive of a widespread large magnitude event.

8.19.3 Probability of Occurrence

Sacramento County's Safety Element notes that there is a high potential that the area will be subject to at least moderate earthquake shaking one or more times over the next century. As discussed above, Sacramento County could be affected by earthquake activity from several local

and regional fault systems. In 2008, the United States Geological Survey (USGS) and the California Geological Survey (CGS) released the time-dependent version of the Uniform California Earthquake Rupture Forecast (UCERF II) model. These were the first statewide peer-reviewed forecasts and Next Generation Attenuation (NGA) ground motion prediction efforts undertaken. The UCERF II results have helped to reduce the uncertainty in estimated 30-year probabilities of strong ground motions in California. The UCERF map shown in Figure 20 indicates that Sacramento County has a relatively low risk of earthquake occurrence.

Figure 20—California Earthquake Probability



8.19.4 Earthquake Risk Analysis

Table 70 summarizes Citygate's analysis of Sacramento's earthquake risk. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 71 on the following page.

Table 70—Earthquake Risk Analysis Summary

Risk Zone	Probability of Occurrence[1]	Impact Severity Factors					Risk Factors Score	Overall Risk Score	Risk Rating
		Percentage of Area Potentially Affected	Potential Injuries / Fatalities	Potential Property Damage	Percentage of Critical Facilities Affected	Potential for Long-Term Impacts			
1	**1**	2	2	4	4	4	**16**	**16**	**Low**
2	**1**	2	2	4	4	4	**16**	**16**	**Low**
3	**1**	2	2	4	4	4	**16**	**16**	**Low**
4	**1**	2	2	4	4	4	**16**	**16**	**Low**
5	**1**	2	2	4	4	4	**16**	**16**	**Low**
6	**1**	2	2	4	4	4	**16**	**16**	**Low**

[1] Magnitude 6.0 or greater event

Table 70 shows that Sacramento's earthquake risk is ***Low*** across all six risk zones reflecting a very low probability of occurrence; low percentage of area affected and potential injuries/fatalities; and high potential property damage, percentage of critical facilities affected, and potential for long-term community-wide impacts.

Table 71—Earthquake Risk Impact Severity Factor Evaluation Criteria

Impact Severity Factor	Score	Scoring Guidelines
Area Impacted	1	Less than 1% of risk zone likely impacted
	2	1% -10% of risk zone likely impacted
	3	11% - 25% of risk zone likely impacted
	4	26% - 50% of risk zone likely impacted
	5	More than 50% of risk zone likely impacted
Injuries / Fatalities	1	Less than 1% of population within risk zone likely to be injured or killed
	2	1% - 10% of population within risk zone likely to be seriously injured or killed
	3	11% - 25% of population within risk zone likely to be seriously injured or killed
	4	26% - 50% of population within risk zone likely to be seriously injured or killed
	5	More than 50% of population within risk zone likely to be seriously injured or killed
Property Damage	1	Less than 1% of assessed value subject to probable damage
	2	1% - 10% of assessed value subject to probable damage
	3	11% - 25% of assessed value subject to probable damage
	4	26% - 50% of assessed value subject to probable damage
	5	More than 50% of assessed value subject to probable damage
CIKR[1]	1	No probable CIKR[1] impacts within risk zone
	2	Probable impacts to 1% - 10-% of CIKR[1] within risk zone
	3	Probable impacts to 11% - 25% of CIKR[1] within risk zone
	4	Probable impacts to 26% - 50% of CIKR[1] within risk zone
	5	Probable impacts to more than 50% of CIKR[1] within risk zone
Mid-Term / Long-Term Community Impacts	1	No probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	2	Negligible probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	3	Minor probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	4	Moderate probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	5	Major probable mid-term and/or long-term economic or other impacts adversely affecting community resilience

[1] Critical infrastructure/key resources

8.20 FLOOD RISK[17]

Flooding is the rising and overflowing of a body of water onto normally dry land. Floods are among the costliest natural disasters in terms of human hardship and economic loss nationwide. History clearly highlights floods as the most frequent natural hazard impacting Sacramento County. Sacramento County is susceptible to three types of flood events: riverine, flash, and localized storm water flooding. The area is also at risk from flooding caused by levee or dam failure. Regardless of the type of flood, the cause is often the result of severe weather and excessive rainfall, either in the immediate flood area or upstream reach.

Riverine flooding occurs when a watercourse exceeds its "bank-full" capacity, and is the most common type of flood event. Riverine flooding occurs as a result of prolonged rainfall that is combined with saturated soils from previous rain events, or combined with snowmelt, and is characterized by high peak flows of moderate duration and by a large volume of runoff. Riverine flooding occurs in river systems whose tributaries drain large geographic areas and can include many watersheds and sub-watersheds. The duration of riverine floods varies from a few hours to many days. Factors that directly affect the amount of flood runoff include the amount, intensity, and distribution of precipitation; soil moisture content; channel capacity; seasonal variation in vegetation; snow depth; and water-resistance of the surface due to urbanization. In Sacramento County, riverine flooding can occur anytime during the normal rainfall season from October through April. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions.

Flash flooding describes localized flooding involving a large volume of water over a short time period, generally less than four hours. In contrast to riverine flooding, this type of flood usually results from a heavy rainfall over a relatively small drainage area. Precipitation of this sort usually occurs in the spring and summer. Dam failures also result in flash flooding.

Localized storm water flooding problems are often caused by flash flooding, severe weather, or an unusual amount of rainfall. Flooding from these intense weather events usually occurs in areas experiencing an increase in runoff from impervious surfaces associated with development and urbanization as well as inadequate storm drainage systems.

Cloudburst storms, sometimes lasting as long as three hours, occur over Sacramento County anytime from late spring to early fall, and they may occur as an extremely severe sequence within a general winter rainstorm. Cloudbursts are high-intensity storms that can produce peak flow equal to or somewhat greater than those of general rainstorms in portions of the County.

[17] Source: Sacramento County Local Hazard Mitigation Plan Update, September 2011

Flooding from cloudbursts is characterized by high peak flow, short duration flood flow, and small runoff volume.

8.20.1 Floodplains

A floodplain is the area that is inundated during a flood event. It is often physically discernible as a broad, flat area created by prior floods. The larger the floodplain, the greater the area at risk for flooding. The Federal Emergency Management Agency (FEMA), through its National Flood Insurance Program (NFIP), has created a Flood Insurance Rate Map (FIRM) that identifies and designates Special Flood Hazard Areas (SFHA) subject to a 1% chance of inundation in any given year. This 1% annual chance flood is also referred to as the base flood, or 100-year flood. Moderate Flood Hazard Areas (MFHA) are identified as those areas between the limits of the base flood and the 0.2% annual chance (or 500-year) flood. Areas of minimal flood hazard are those areas outside of the SFHA and higher in elevation than the MFHA.

Historically, Sacramento County has always been vulnerable to flooding because of its relatively flat terrain and number of watercourses that traverse the County. According to the 2008 Flood Insurance Study for the County, flooding can occur in the Sacramento County planning area anytime from October through April. Flooding results from prolonged heavy rainfall and is characterized by high peak flows of moderate duration and by a large volume of runoff. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions.

8.20.2 Sacramento County Watersheds

Sacramento County encompasses multiple rivers, streams, creeks, and associated watersheds. Sacramento County watersheds include numerous watersheds contained within the County as well as several watersheds that drain into Sacramento County from Placer, El Dorado, or Amador Counties.

The three primary rivers in Sacramento County are the Sacramento, American, and Cosumnes Rivers. The Sacramento and American Rivers and several tributaries to the east, north, and west all flow toward the City of Sacramento. The watersheds of these two main rivers drain most of northern California and part of southern Oregon for a total of approximately 26,000 square miles. The Cosumnes River flows southwesterly through the southern portion of the County and into the Delta region.

When the Sacramento River reaches peak capacity, the American River and other tributaries that flow into the Sacramento River cannot flow at a normal rate. These conditions result in “backflows” which cause tributaries to overflow and flood local areas. The Sacramento River is also affected by ocean tides that periodically raise and lower the water level. High tides that occur simultaneously with flooding conditions could increase the rate of flooding.

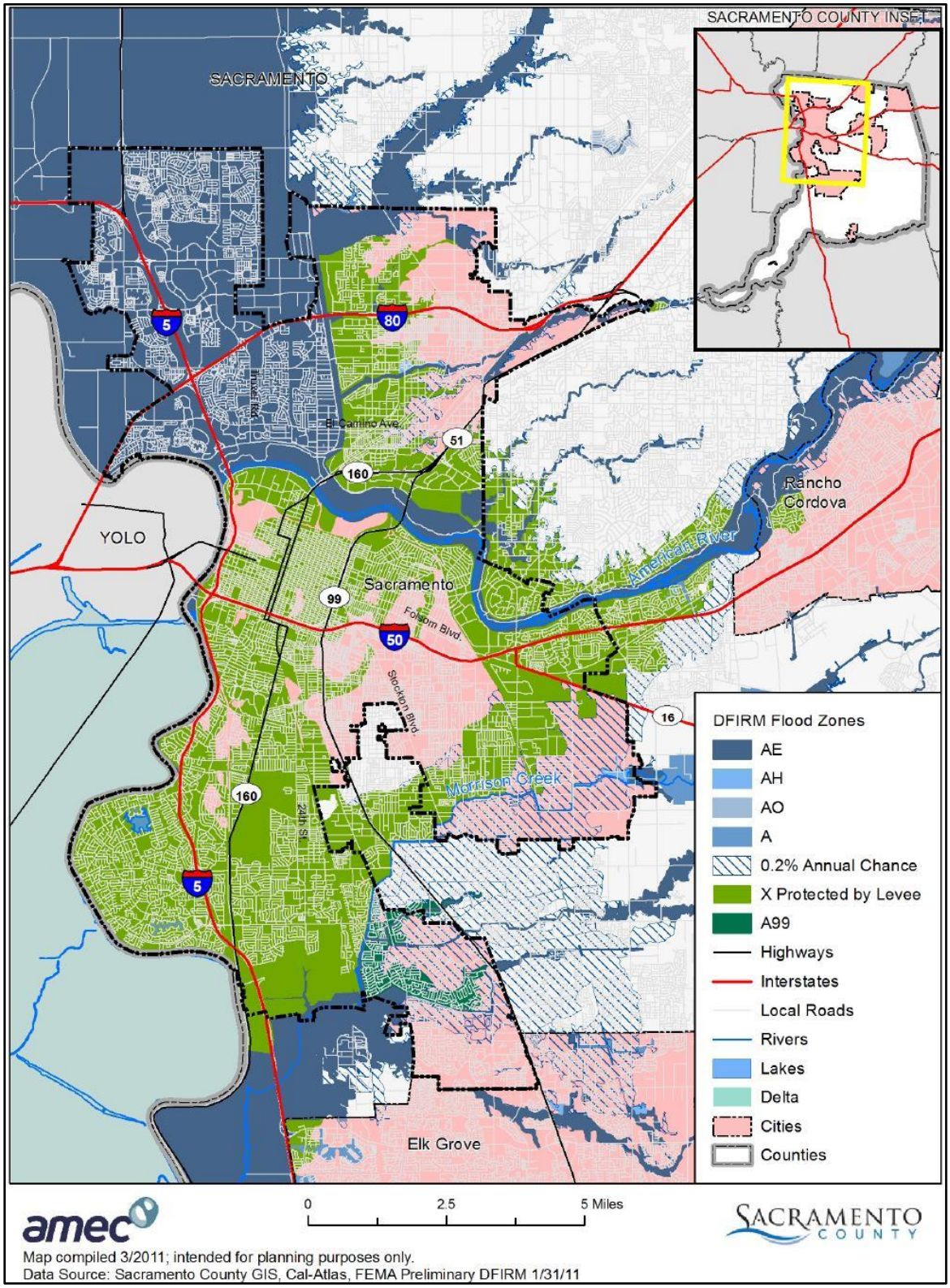
High water levels along the Sacramento and American Rivers are a common occurrence in the winter and early spring months due to increased flow from storm runoff and snowmelt. An extensive system of dams, levees, overflow weirs, drainage pumping plants, and flood control bypass channels strategically located on the Sacramento and American Rivers has been established to protect the area from flooding. These facilities control floodwaters by regulating the amount of water passing through a particular reach of the river. The amount of water flowing through the levee system can be controlled by Folsom Dam on the American River and the reserve overflow area of the Yolo Bypass on the Sacramento River. However, flood problems in Sacramento County are still quite a concern, especially since the flood of 1986. Numerous areas of the County are still subject to flooding by the overtopping of rivers and creeks, levee failures, and the failure of urban drainage systems that cannot accommodate large volumes of water during severe rainstorms.

High flows on the Cosumnes River are less frequent, as the river is essentially dam free and has little in the way of flow regulation. Flooding along the river, such as in 1997, has been due to high water coupled with the failure of non-standard, poorly constructed private levees.

8.20.3 Flood-Prone Areas

As cited earlier, FEMA's Flood Insurance Rate Map (FIRM) delineates 100-year, 200-year, and 500-year floodplains and specific flood risk zones within these floodplains as shown in Figure 21.

Figure 21—Sacramento Flood Hazard Zones



8.20.4 Flood History

Substantial river flooding in northern California occurred in 1937, 1938, 1940, 1943, 1945, 1950, 1952, 1955, 1956, 1958, 1962, 1963, 1964, 1967, 1969, 1986, 1995, 1997, and 2006. Floods on Dry Creek (American River Stream Group) have occurred with similar frequency.

The October 1962 floods on Dry and Robla Creeks spread from 800 feet to approximately 1 mile wide. The flood of October 1962 was the largest that has been recorded at the Roseville gaging station, located on Dry Creek upstream of Sacramento County. Damage in the October 1962 flood was approximately $50,000. The resultant high water was within 2 feet of the top of the levee on the southern side of Robla Creek and along the Magpie Creek diversion channel. Floodwaters form Magpie Creek bypassed the upper portion of the diversion levee and flowed into lower Magpie Creek. Similar, less-severe floods occurred in 1955, 1958, February 1962, 1967, 1969, 1970, and 1973.

Other creeks in the American River Stream Group have wide floodplain boundaries. A large flood on Arcade and Cripple Creeks occurred in October 1962, with resulting damages of approximately $10,000. The 1986 and 1995 floods caused significantly more damage.

Large portions of the Morrison Creek Stream Group area were flooded in 1952, 1955, 1958, 1962, and 1963. During the 1955 flood, overflow from the Cosumnes and Mokelumne Rivers caused inundation of the Beach-Stone Lake area, thus creating high backwater conditions on streams of the Morrison Creek Stream Group. Damage was estimated at $213,000 in the Morrison Creek Stream Group area as a result of the 1955 floods and at $204,000 from the 1958 flood. The floods of 1962 and 1963 caused an estimated $161,000 in damage. The Morrison Creek Stream Group experienced lesser flooding in 1967 and 1969.

In the Morrison Creek Stream Group Basin, the most recent flooding occurred in 1982, February 1986, and January 1995. That flood had the largest peak flow recorded on Morrison Creek.

Floods on the Cosumnes River occurred in 1950, 1955, 1958, 1962, 1964, 1986, and 1997 with the events of 1986 and 1997 being most severe. These two floods ripped gaping holes in the levee system.

In total, floods have accounted for 20 state and federal disaster declarations in Sacramento County since 1950.

8.20.5 Probability of Occurrence

Riverine flooding is the most significant natural hazard that Sacramento County faces. The Sacramento area has a good working knowledge of the 100-year flood; however, the statistical outlier flood is not as well quantified. Sacramento is not just at high risk of flooding, but is at low risk of catastrophic flooding.

In addition, there are many urban streams, channels, canals, and creeks that serve the drainage needs of the County. There is significant threat of flooding in large areas of the County from several of these streams. Many of these streams are prone to rapid flooding with little notice.

With respect to the localized storm water flood issues, the potential for flooding may increase as storm water is channelized due to land development. Such changes can create localized flooding problems in and outside of natural floodplains by altering or confining natural drainage channels. Urban storm drainage systems have a finite capacity. When rainfall exceeds this capacity or systems clog, water accumulates in the street until it reaches a level of overland release. With increasing urbanization of the Sacramento County planning area, combined with older infrastructure, this type of flooding will continue to occur during heavy rains.

The term "100-year flood" is misleading. It is not a flood that will occur once every 100 years. Rather, it is the flood elevation (or depth) that has a 1% chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. In summary, the 100-year flood is the flood that has a 1% chance in any given year of being equaled or exceeded.

8.20.6 Flood Risk Analysis

Table 72 summarizes Citygate's analysis Sacramento's flood risk. The scoring for the Impact Severity Factors referenced in the table below is explained in Table 73 on the following page.

Table 72—Flood Risk Analysis Summary

Risk Zone	Probability of Occurrence	Impact Severity Factors					Risk Factors Score	Overall Risk Score	Risk Rating
		Potential Area Impacted	Potential Injuries / Fatalities	Potential Property Damage	Percent of Critical Facilities Affected	Long-Term Impacts			
1	**1**	5	3	5	5	5	**23**	**23**	**Low**
2	**1**	5	3	4	4	4	**20**	**20**	**Low**
3	**2**	5	2	5	5	4	**21**	**42**	**Moderate**
4	**2**	4	3	3	3	3	**16**	**32**	**Moderate**
5	**2**	5	2	5	5	4	**21**	**42**	**Moderate**
6	**2**	4	3	4	4	4	**19**	**38**	**Moderate**

Table 72 shows that Sacramento's flood risk is ***Low*** in risk zones 1 and 2, and ***Moderate*** for the other four risk zones. These risk ratings reflect a very low to low probability of occurrence; high percentage of area affected; moderate risk of injury or death; moderate to high potential property damage; moderate to high percentage of critical facilities affected; and moderate to high potential for long-term community-wide impacts.

Table 73—Flood Risk Impact Severity Factor Evaluation Criteria

Impact Severity Factor	Score	Scoring Guidelines
Area Impacted	1	Less than 1% of risk zone subject to probable flooding
	2	1% -10% of risk zone subject to probable flooding
	3	11% - 25% of risk zone subject to probable flooding
	4	26% - 50% of risk zone subject to probable flooding
	5	More than 50% of risk zone subject to probable flooding
Injuries / Fatalities	1	Less than 1% of population within risk zone likely to be injured or killed
	2	1% - 10% of population within risk zone likely to be seriously injured or killed
	3	11% - 25% of population within risk zone likely to be seriously injured or killed
	4	26% - 50% of population within risk zone likely to be seriously injured or killed
	5	More than 50% of population within risk zone likely to be seriously injured or killed
Property Damage	1	Less than 1% of assessed value subject to probable damage
	2	1% - 10% of assessed value subject to probable damage
	3	11% - 25% of assessed value subject to probable damage
	4	26% - 50% of assessed value subject to probable damage
	5	More than 50% of assessed value subject to probable damage
CIKR[1]	1	No probable CIKR[1] impacts within risk zone
	2	Probable impacts to 1% - 10-% of CIKR[1] within risk zone
	3	Probable impacts to 11% - 25% of CIKR[1] within risk zone
	4	Probable impacts to 26% - 50% of CIKR[1] within risk zone
	5	Probable impacts to more than 50% of CIKR[1] within risk zone
Mid-Term / Long-Term Community Impacts	1	No probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	2	Negligible probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	3	Minor probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	4	Moderate probable mid-term and/or long-term economic or other impacts adversely affecting community resilience
	5	Major probable mid-term and/or long-term economic or other impacts adversely affecting community resilience

[1] Critical infrastructure/key resources