CHAPTER 2: GEOLOGIC HAZARDS

Geologic hazards are generally defined as surficial earth processes that have the potential to cause loss or harm to the community or the environment. The basic elements involved in the assessment of geologic hazards are: 1) underlying geology (including soil types, rock types, groundwater, and zones of weakness like faults, fractures, and bedding); 2) topography; 3) climate; and 4) land use. The geology and types of geologic hazards affecting the City of Coachella General Plan area are discussed in the following sections.

2.1 Physiographic and Geologic Setting

Southern California is divided into distinct geomorphic provinces, that is, regions having their own unique physical characteristics formed by geologic, topographic, and climatic processes. The Coachella General Plan area is located at the boundary of two very distinct provinces. The valley portion of Coachella is part of the Colorado Desert Province, a low-lying basin (up to 240 feet below sea level) that stretches from the San Gorgonio Pass to the Mexican border. In contrast, the northeast corner of the General Plan area reaches up to the base of the Little San Bernardino Mountains, a moderately high range that is the southernmost extension of the Transverse Ranges Province. This province is a region whose characteristic features are a series of generally east-west trending ranges that include the San Gabriel and San Bernardino Mountains. These ranges are called "transverse" because they lie at an oblique angle to the prominent northwesterly structural grain of the southern California landscape, a trend that is aligned with the San Andreas fault. The Transverse Ranges are being intensely compressed by active tectonic forces, therefore they are some of the fastest rising (and fastest eroding) mountains in the world. The boundary of these two provinces is defined by the San Andreas fault, a wide zone of multiple fault strands that also forms the eastern boundary of the basin. Movement along the fault zone has led to the rise of a string of low hills, including those in the northeastern part of the General Plan area.

Elevations across the valley floor, within the General Plan area, range from sea level at the northern end, to about 160 feet below sea level at the southeastern corner, near the community of Thermal. The highest point in the General Plan area is within the northernmost extension of the Mecca Hills, at an elevation of about 1,400 feet above sea level.

The largest drainage in the region, the Whitewater River, crosses the west-central part of the city. The river intermittently drains the surrounding highlands, as well as the Coachella Valley. Streambeds in the surrounding mountains are dry most of the year, and have significant flow only during and immediately after storms, when they carry large amounts of runoff for short periods of time. The Coachella Branch of the All-American Canal (also known as the Coachella Canal) crosses, in a northwesterly direction, the east-central part of the General Plan area, transporting water from the Colorado River to Lake Cahuilla, a man-made storage reservoir located in the city of La Quinta.

Geologically speaking, the valley portion of Coachella is situated at the edge of a broad structural depression known as the Salton Trough. Over the last million years or so, the tectonically subsiding trough has filled with a thick sequence of sediments that now forms the nearly flat valley floor. Although the trough is physically continuous from the San Gorgonio Pass to the Gulf of California, early settlers in the area gave different names to the northern and southern portions: The portion north of the Salton Sea is known as the Coachella Valley or Indio region, and the portion south of the Salton Sea is known as the Imperial Valley.

The sedimentary sequence infilling the trough records the geologic history of the Coachella area. For instance, the Imperial Formation, a geologic unit exposed in Garnet Hill to the north, but occurring predominantly at depth in the valley, is of marine origin, indicating the trough was inundated by sea water in latest Miocene to late Pliocene time (about 6 to 2 million years ago). In the last two million years, these marine sediments were in turn buried by a thick sequence of terrestrial sediments shed from the adjacent highlands. At about the same time, the Colorado River was building its delta at the Gulf of California, effectively forming a dam by depositing sediment at the mouth of the river and turning the trough into a closed basin. The presence of interlayered lakebed sediments in the valley's stratigraphic sequence indicates the basin was periodically inundated with fresh water derived from the Colorado River as it migrated back and forth across its delta. Ancient Lake Cahuilla, the last, and possibly one of the largest of the ancient lakes to occupy the basin, completely evaporated about 400 years ago when the Colorado River again changed course and flowed directly into the Gulf of California. The size of ancient Lake Cahuilla is estimated at over 2,000 square miles, covering most of the basin, including the valley portion of Coachella's General Plan area. In fact, the lake's paleo-shoreline transects the General Plan area, near the base of the hills. The Salton Sea, which formed in 1905 when water from the Colorado River was unintentionally diverted to the basin by man, is considerably smaller by comparison.

The physical features described above reflect geologic and climatic processes that have affected this region in the last few million years. The physiographic and geologic histories of the Coachella area are important in that they control to a great extent the geologic hazards, as well as the natural resources, within the city. For example, wind-blown sand erosion poses a significant hazard in the Coachella Valley due to funneling of fierce winds through the steep mountain passes. Regional tectonic subsidence of the valley floor, concurrent with uplift of the adjacent mountains, is responsible to a great extent for the rapid deposition of poorly consolidated alluvium that is susceptible to consolidation and/or collapse. On the other hand, the deep alluvium-filled basin, which is bounded by relatively impermeable rock and faults, provides a natural underground reservoir (aquifer) for groundwater, the area's primary source of drinking water.

The Coachella General Plan area is located within a region that is changing rapidly. In fact, this region, which includes San Bernardino and Riverside counties, has the fastest-growing population in all of California. Most of Coachella's valley area is currently developed for growing crops; business districts and densely populated neighborhoods are located almost entirely west of the Whitewater River. The hills in the northeastern part of the area are currently undeveloped. Proposed development is expanding eastward however, and will eventually reach into both the agricultural and hillside areas.

2.2 Earth Units and Their Engineering Properties

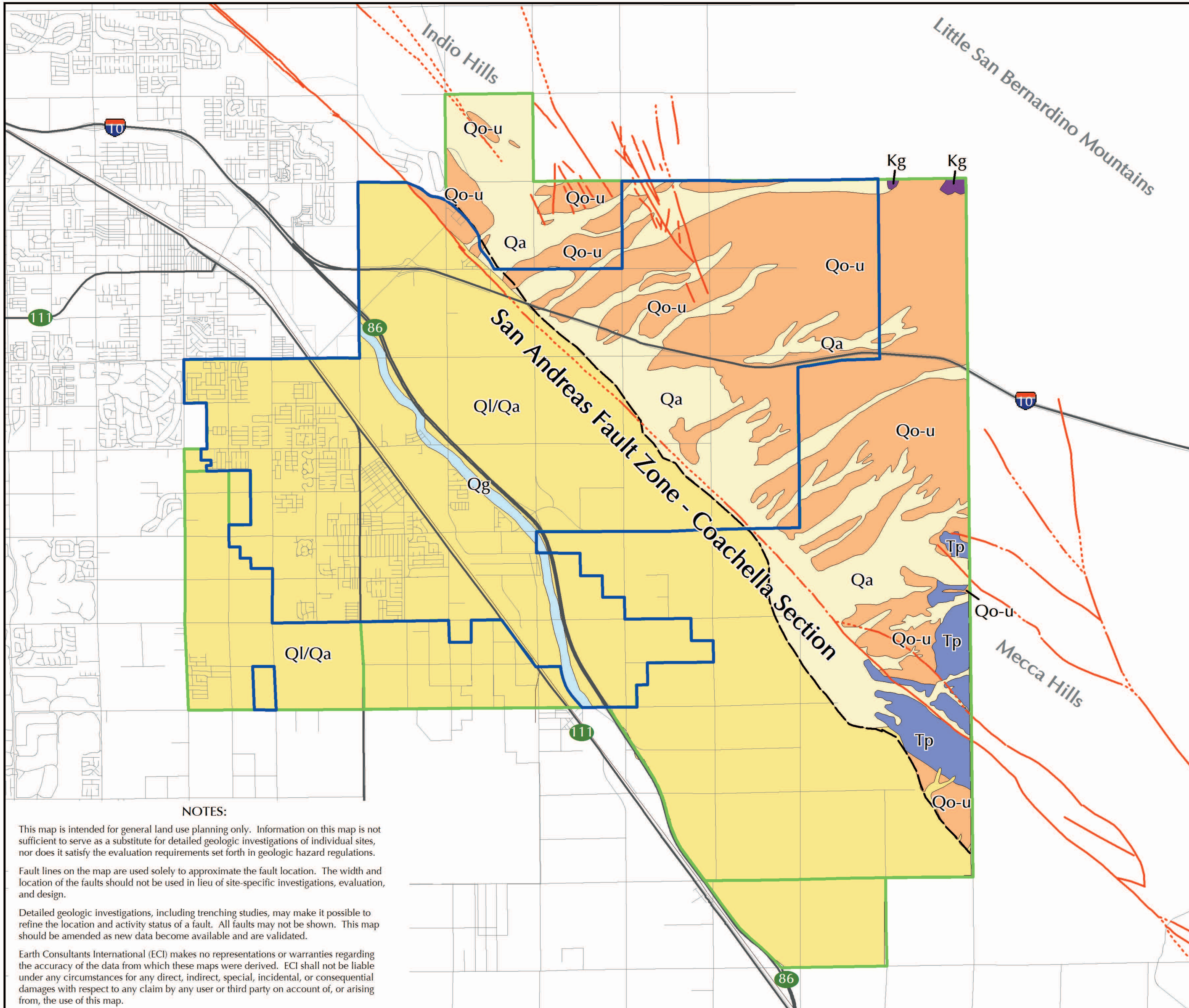
The general distribution of geologic units that are exposed at the surface is shown on the Geologic Map (Plate 2-1a, b). This map is a modified version of that published by Dibblee (2008) and Rogers (1965). The general physical and engineering characteristics of each unit are discussed in the following sections, and summarized on Table 2-1.

2.2.1 River Channel Deposits (map symbol: Qg)

This unit comprises unconsolidated alluvium recently deposited by the Whitewater River. Consisting of crudely bedded sand, silt, gravel, boulders, and debris deposited by floodwaters, these sediments are highly susceptible to erosion, reworking, and burial by future flooding. Construction is generally not allowed in regulated flood control channels, nevertheless roadways, bridges, or pipelines may need to cross these areas out of necessity.

Geologic Map

Coachella, California



NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Fault lines on the map are used solely to approximate the fault location. The width and location of the faults should not be used in lieu of site-specific investigations, evaluation, and design.

Detailed geologic investigations, including trenching studies, may make it possible to refine the location and activity status of a fault. All faults may not be shown. This map should be amended as new data become available and are validated.

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Symbols

- Fault; solid where location known, dashed where approximate, dotted where concealed. (For more information refer to Plates 1-1 and 1-2)
- Approximate location of eastern shoreline of ancient Lake Cahuilla
- Geologic Contact
- Coachella City Boundary
- Coachella Planning Area Boundary

For Geologic Unit Descriptions
See Plate 2-1b

N W E S

Scale: 1:72,000

6000 0 6000
Feet

2000 0 2000
Meters

Base Map: From City of Coachella.
Sources: Modified from Dibblee (2008) and Rogers (1965, reprinted 1992); faults from Quaternary fault and fold database for the United States, accessed April 2010, from USGS web site: http//earthquakes.usgs.gov/regional/qfaults; location of main San Andreas fault from Petra (2006-2007).

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Plate 2-1a

Geologic Unit Descriptions

Surficial Sediments

Qg	River Channel Deposits: Sand, gravel, and boulders within the modern Whitewater River channel (Holocene)
Ql/Qa	Lake and Distal Fan Deposits: Fine-grained sand, silt, and clay of the valley floor (Holocene)
Qa	Alluvial Fan and Stream Deposits: Sand, silt, and gravel filling active drainages within the Indio and Mecca Hills, and forming gently sloping fans at the valley margin (Holocene)

Upper Ocotillo Conglomerate

Qo-u	Upper Ocotillo Conglomerate: Sand, gravel, and boulders, gray, widely exposed in the Indio and Mecca Hills (late Pleistocene to early Holocene)

Palm Spring Formation

Tp	Palm Spring Formation: Arkosic sandstone, light pinkish-gray, with interbedded siltstone and red clays, exposed in southeastern part of the Planning Area, in the Mecca Hills (Pliocene)

Crystalline Rocks

Kg	Plutonic rocks of variable composition, including quartz monzonite and quartz diorite, exposed in the Little San Bernardino Mountains (Cretaceous)

River sediments are highly compressible, so bridge supports and roadway embankments need to extend through the unconsolidated sediments, onto firm ground. Foundation elements, roadways, and culverts placed in the river will be susceptible to scour from floodwaters or to damage from boulders carried by fast-moving waters.

2.2.2 Lake and Distal Fan Deposits (map symbol: Ql/Qa)

Unconsolidated sediments forming the upper part of the valley fill consist predominantly of variable mixtures of fine-grained sand, silt, and clay. Lenses of medium- to coarse-grained sand and gravels occur locally. These sediments were derived intermittently from prehistoric lakes that once occupied the valley floor, from fine-grained sediments that washed down from the mountains, and from periodic flooding of the Whitewater River before it was confined to its man-made channel. Wind-blown sand also occurs intermittently. The uppermost layers of the valley fill are Holocene in age (deposited in the last 11,000 years).

From an engineering perspective, these deposits are compressible in the upper few feet and will erode easily if subjected to concentrated water flow. Permeability is high except where interbedded silt or clay layers retard the downward percolation of water; in fact, shallow clay layers have created local perched water conditions in areas that are heavily irrigated. The potential for expansive soils is generally low, except where lake deposits of silt and clay are within or just below the depth of structural foundation elements. These deposits are suitable for fill materials, however clay-rich sediments should not be placed in foundation areas if possible.

Figure 2-1: Geologic Units in the Coachella Area. The sands in the foreground are alluvial deposits reworked by the wind; the hills in the middle are comprised of the Upper Ocotillo Conglomerate, whereas the mountains in the far distance consist of crystalline rocks.

2.2.3 Alluvial Fan and Stream Deposits (map symbol: Qa)

This unit consists of young (Holocene-aged) crudely bedded silt, sand, and gravel deposited in active drainages within the adjacent low hills, eventually spreading out as a series of small, coalescing fans at the valley margin. The fan surfaces are relatively smooth and support a network of shallow, ephemeral streams. Towards the valley, these deposits become increasingly finer grained, transitioning into the alluvial and lakebed sediments forming the valley floor.

How and where these deposits were laid down have a significant bearing on the engineering properties of these materials. Young near-surface alluvium often has organic debris, and is typically deposited rapidly by flash floods. As a result, the engineering issues affecting these geologically young deposits are: 1) compressibility, which occurs when additional loads are applied, and 2) collapse (hydroconsolidation) upon introduction of irrigation water if the deposit is dry. Being unconsolidated, the young alluvium is also highly susceptible to erosion. Alluvial deposits also have moderate to high permeability. Alluvial sediments are suitable for use as fill once the organic materials and oversized rocks are removed; however, they typically require the addition of water to achieve compaction. Stability of manufactured slopes is generally good, provided the slope is protected from erosion.

2.2.4 Upper Ocotillo Conglomerate (map symbol: Qo-u)

The Ocotillo Conglomerate is present both northeast and southwest of the San Andreas fault. In the valley, southwest of the fault, it is part of the thick sequence of sediments filling the Salton Trough. Beneath Coachella, Ocotillo sediments overlie older marine and non-marine deposits, and are buried beneath the younger fan and lake deposits described above. Because of its stratigraphic position, this formation is considered to be late Pleistocene to early Holocene in age (Popenoe, 1959). This unit is considerably thicker in the basin (Dibblee, 1954), where it is the primary water-bearing formation (aquifer) beneath Coachella, supplying domestic water to the area (California Department of Water Resources, 1964). Northeast of the San Andreas fault, this unit has been tectonically uplifted relative to the valley and is widely exposed in Coachella's hills, where it forms a relatively smooth surface that has been incised to various degrees by numerous streams conveying storm water from the Little San Bernardino Mountains to the valley.

The upper portion of the Ocotillo Conglomerate, namely that part of the formation exposed in the low hills in eastern Coachella, has been described as a weakly consolidated, light tan to grayish, crudely bedded, coarse sand, gravel, and boulder deposit (Proctor, 1968; Dibblee 1954 and 2008). The unit represents an older alluvial fan built with detritus shed from the nearby mountains. Bedding in the formation dips gently southwestward, generally about 3 to 10 degrees. Steep dips, reversed dips, and localized folding are present where active fault traces traverse the hills.

General engineering characteristics of the Ocotillo Conglomerate include erosion susceptibility, compressibility, and collapse upon the addition of landscape water if the unit is very dry. Boulders can also be a hindrance to earthwork or foundation construction. Positive aspects are good permeability, low expansion potential, and generally good stability in engineered slopes due to the lack of well-developed bedding or weak clay beds. These sediments are suitable for fill materials, provided boulders are removed or placed in deeper fills as directed by a geotechnical engineer. Boulders should not be placed near finished grades.

2.2.5 Palm Spring Formation (map symbol: Tp)

In the valley, alluvial and lacustrine (lake) deposits of the Palm Spring Formation are buried beneath the Ocotillo Conglomerate and are estimated to be over 5,000 feet thick (California Department of Water Resources, 1964). This unit is exposed however, in the Mecca Hills, where it has been elevated by the San Andreas fault. In contrast to the Ocotillo Conglomerate, hills underlain by the Palm Spring Formation have been eroded into a rugged badlands topography, displaying serrated ridges and deeply incised drainages. This unit is moderately lithified and is finer-grained than the Ocotillo Conglomerate, consisting primarily of light pinkish gray arkosic (quartz-rich) sandstone and pebbly sandstone, with a lesser amount of siltstone and red clay interbeds. Sandstone beds are commonly thick and internally massive. Based on fossil correlations, this formation is estimated to be Pliocene (2.6 to 5.3 million years old) in age (Dibblee, 1954; Popenoe, 1959). This unit has been severely deformed by faults of the San Andreas system, resulting in intense folding, shearing, and slippage along weak, clayey bedding planes (Sylvester and Damte, 1999). Erosion of the Palm Spring Formation in the Mecca Hills has made it a popular location for viewing exposures of the San Andreas fault.

Because the unit is moderately lithified, compressibility and collapsibility are generally not a concern. The unit is not water-bearing (California Department of Water Resources, 1964), therefore permeability is likely to be poor overall. Its expansion potential will be highly variable, ranging from low in sandy zones to moderately high in siltstone and clays. Slope stability is also variable, but due to the intense deformation, presence of clay-rich beds, shearing, faulting, and highly variable bedding orientations, the potential for localized slope failures in manufactured slopes is high, and would most likely require remedial grading. This unit is suitable for fill materials, although mixing sand and clay can be difficult from an earthwork-construction point of view.

2.2.6 Crystalline Rocks (map symbol: Kg)

The oldest geologic unit in the Coachella area consists of very hard, crystalline rock that forms the surrounding mountains and the bottom of the basin. Rock classifications are based primarily on genesis, texture, and mineral composition. Because crystalline rocks are usually highly variable in texture and mineralogy, often grading from one type to another, the units are typically named by the dominant rock type. Based on genesis alone, rocks underlying Coachella are plutonic, meaning that the rocks crystallized from the molten state deep within the Earth's crust. Plutonic rocks generally have large grains that can easily be seen without magnification, and often have a spotted appearance. The rock forming the mountains east of Coachella is light-colored and has a mineral assemblage that most closely aligns with quartz monzonite or quartz diorite (Dibblee, 2008). Most of this rock crystallized from a magma that was emplaced over 65 million years ago (Cretaceous age).

Outcrops of crystalline rock are rare in the General Plan area, occurring only in the northeast corner, at the base of the Little San Bernardino Mountains. Adjacent to the mountains it is most likely present in the shallow subsurface, buried by variable thicknesses of alluvium. In the valley, the crystalline rocks are deeply buried below the thousands-of-feet thick sequence of sediments.

Crystalline rock is very hard where not highly weathered, cannot be excavated easily, and in some cases must be blasted. It is typically non-water bearing and has low to moderately low permeability, except where joints and fractures provide avenues for water to move in and around the rock mass. Crystalline rocks provide strong foundation support and are generally non-expansive. Slope stability is generally good, however these rocks contain fractures and cooling joints that may locally serve as planes of weakness along which slope instability can occur. Very steep roadcuts are most vulnerable to this type of failure.

2.3 Geologic Hazards in the Coachella Area

2.3.1 Landslides and Slope Instability

Developments that encroach upon the edge of natural slopes may be impacted by slope failures. Even if a slope failure does not reach the adjacent property, the visual impact will generally cause alarm to homeowners. Although slope failures tend to affect a relatively small area (as compared to an earthquake or major flood), and are generally a problem for only a short period of time, the dollar losses can be high. Homeowner's insurance policies typically do not cover land slippage, and this can add to the anguish of the affected property owners.

A significant portion of the General Plan area encompasses the northern extension of the Mecca Hills, and the northeastern corner reaches up to the base of the Little San Bernardino Mountains. Hillside areas within and adjacent to Coachella are currently uninhabited, however future land uses identified for these areas include low density residential development. Consequently, slope stability remains a potential hazard.

2.3.1.1 *Types of Slope Failures*

Slope failures occur in a variety of forms, and there is usually a distinction made between **gross failures** (sometimes also referred to as "global" failures) and **surficial failures**. Gross failures include deep-seated or relatively thick slide masses, such as landslides, whereas surficial failures can range from minor soil slips to destructive mud or debris flows. Failures can occur on natural or man-made slopes. Most failures of man-made slopes occur on older slopes built at slope gradients steeper than those allowed by today's grading codes. Although infrequent, failures can also occur on newer, graded slopes, generally due to poor engineering or poor construction. Furthermore, slope failures often occur as elements of interrelated natural hazards in which one event triggers a secondary event, such as earthquake-induced landsliding, fire-flood sequences, and storm-induced mudflows.

Gross Failures

Landslides are movements of relatively large landmasses, either as nearly intact bedrock blocks, or as jumbled mixes of bedrock blocks, fragments, debris, and soils. Landslide materials are commonly porous and very weathered in the upper portions and along the margins of the slide. They may also have open fractures and joints. The head of the slide may have a graben (pull-apart area) that has been filled with soil, and bedrock blocks and fragments.

The potential for slope failure is dependent on many factors and their interrelationships. Some of the most important factors include slope height, slope steepness, shear strength and orientation of weak layers in the underlying geologic unit, as well as pore-water pressures. Joints and shears, which weaken the rock fabric, allow water to infiltrate the rock mass. This in turn results in increased and deeper weathering of the rock, increased pore pressures, increased plasticity of weak clays that may be present in the rock, and increased weight of the landmass. Geotechnical engineers combine these factors in calculations to determine if a slope meets a minimum standard of safety. The generally accepted standard is a factor of safety of 1.5 or greater (where 1.0 is equilibrium, and less than 1.0 is failure). Natural slopes, graded slopes, or graded/natural slope combinations must meet these minimum engineering standards where they have the potential to impact planned homes, subdivisions, or other types of developments.

Table 2-1: Engineering Characteristics of the Geologic Units that Crop Out in the Coachella General Plan Area
(Refer to Plate 2-1 for the areal distribution of these units in the study area)

Geologic Unit / Engineering Characteristics	River Channel Deposits (Qg)	Distal Fan and Lake Deposits (Ql/Qa)	Alluvial Fan and Stream Deposits (Qa)	Upper Ocotillo Conglomerate (Qo-u)	Palm Spring Formation (Tp)	Crystalline Rocks (Kg)
Compressibility	Highly compressible.	Compressible in the upper few feet. Collapse may be a concern locally.	High in stream channels; moderate to high on alluvial fans, especially near the ground surface. If dry may be subject to collapse upon the addition of irrigation water.	Compressible in the upper few feet.	Generally not compressible or collapsible.	Not compressible or collapsible.
Expansion Potential	Low.	Low to moderately high, depending on the amount of silts and clays at or just below foundation grades.	Low.	Low.	Highly variable; low to moderately high.	Low.
Slope Stability	Poor.	Good for manufactured slopes.	Good, except where natural slopes are oversteepened by stream erosion. Moderate to good in cut slopes on alluvial fans. Surficial instability could contribute to debris flows.	Good except where natural slopes are oversteepened by stream erosion. Good in cut slopes except where fault deformation is present. Surficial instability could contribute to debris flows.	Moderate to poor. Cut slopes will likely need remedial grading. Surficial instability may contribute to debris flows.	Good.
Erosion / Sedimentation Potential	Very high.	Moderate to high when subjected to concentrated water flow.	High.	High, especially if subjected to concentrated water flow.	Moderate. More erosion-resistant than the younger units, but still susceptible if subjected to concentrated water flow.	Very low.
Permeability	High.	High, except where silt and clay-rich layers retard the downward percolation of water.	Moderate to high.	High.	Low.	Low.
Ease of Excavation	Easy.	Easy.	Easy.	Easy.	Easy.	Difficult to very difficult where unweathered. May require blasting.
Suitability of Fill	Generally good after organics, debris, and oversize rocks are removed.	Good, however, rich-clay soils should not be placed near foundation elements.	Good, provided vegetation and oversized rocks are removed.	Good, provided that vegetation and oversized rocks are removed.	Good, however, mixing sands and clays may be difficult. Clay-rich fill should not be placed at or near foundation elements.	Good for weathered, decomposed rock. Poor for unweathered rock.

Slopes adjacent to areas where the risk of economic losses from landsliding is small, such as parks and roadways, are sometimes allowed a lesser factor of safety, at the discretion of the local reviewing agency.

The geologic units in the Coachella General Plan area are generally resistant to landsliding and no existing landslides have been mapped here. Nevertheless, grading cuts in the Palm Spring Formation could result in localized slope failures due to tectonic deformation and the presence of weak, clay beds. The Ocotillo Conglomerate, which is more widespread in the hillside areas, is generally more stable in a gross sense, but more susceptible to erosion. All hillside areas are susceptible in various degrees to surficial failures, some of which may result in debris flows.

Surficial Failures

Surficial failures are too small to map at the scale used in Plate 2-1, however they may be present locally in hillside areas, typically occurring in drainage swales, and in accumulated sediments near the base of steep slopes. Surficial failures, predominantly soil slips, occur throughout mountainous areas during winters of particularly heavy and/or prolonged rainfall. The types of surficial instability most likely to occur in the Coachella area are described below.

Soil slip failures are generated by strong winter storms, and are widespread in mountainous areas, particularly after winters with prolonged and/or heavy rainfall. Failures occur on canyon sideslopes, and in soils that have accumulated in swales, gullies and ravines. Slope steepness has a strong influence on the development of soil slips, with most slips occurring on slopes having gradients between about 27 and 56 degrees (Campbell, 1975).

Slopes within this range of gradients are present in the higher hills and mountains within and above the Coachella General Plan area (see Plate 2-2).

Debris flows are the most dangerous and destructive of all types of slope failure. A debris flow (also called mudflow, mudslide, and debris avalanche) is a rapidly moving slurry of water, mud, rock, vegetation and debris. Larger debris flows are capable of moving trees, large boulders, and even cars. This type of failure is especially dangerous as it can move at speeds as fast as 40 feet per second, is capable of crushing buildings, and can strike with very little warning. As with soil slips, the development of debris flows is strongly tied to exceptional storms with periods of prolonged rainfall. Failure typically occurs during an intense rainfall event, following saturation of the soil by previous rains.

A debris flow most commonly originates as a soil slip in the rounded, soil-filled "hollow" at the head of a drainage swale or ravine. The rigid soil mass is deformed into a viscous fluid that moves down the drainage, incorporating into the flow additional soil and vegetation scoured from the channel. Debris flows also occur on canyon walls, often in soil-filled swales that do not have topographic expression. The velocity of the flow depends on the viscosity, slope gradient, height of the slope, roughness and gradient of the channel, and the baffling effects of vegetation. Even relatively small amounts of debris can cause damage from inundation and/or as a result of crashing into a structure (Ellen and Fleming, 1987; Reneau and Dietrich, 1987). Recognition of this hazard led FEMA to modify its National Flood Insurance Program to include inundation by "mudslides."

Watersheds that have been recently burned typically yield greater amounts of soil and debris than those that have not burned. Erosion rates during the first year after a fire are estimated to be 15 to 35 times greater than normal and peak discharge rates range from two to 35 times higher. These rates drop abruptly in the second year, and return to normal after about five years (Tan, 1998). In addition, debris flows in burned areas can develop in response to small storms and do not require a long period of antecedent rainfall. These kinds of flows are common in small gullies and ravines during the first rains after a burn, and can become catastrophic when a severe burn is followed by an intense storm season (Wells, 1987). An example is the debris flows that impacted several communities at the base of the portion of the Los Angeles National Forest that burned during the Station Fire of August and September 2009. The debris flows, which occurred in February 2010, following several intense rainstorms, severely damaged more than 40 homes and many cars were swept by the mud- and debris-laden water.

Within the Coachella General Plan area, locations that are most susceptible to debris flows are those properties at the base of moderate to steep slopes, or at the mouths of small to large natural drainage channels.

2.3.1.2 *Mitigation of Slope Instability in Future Development*

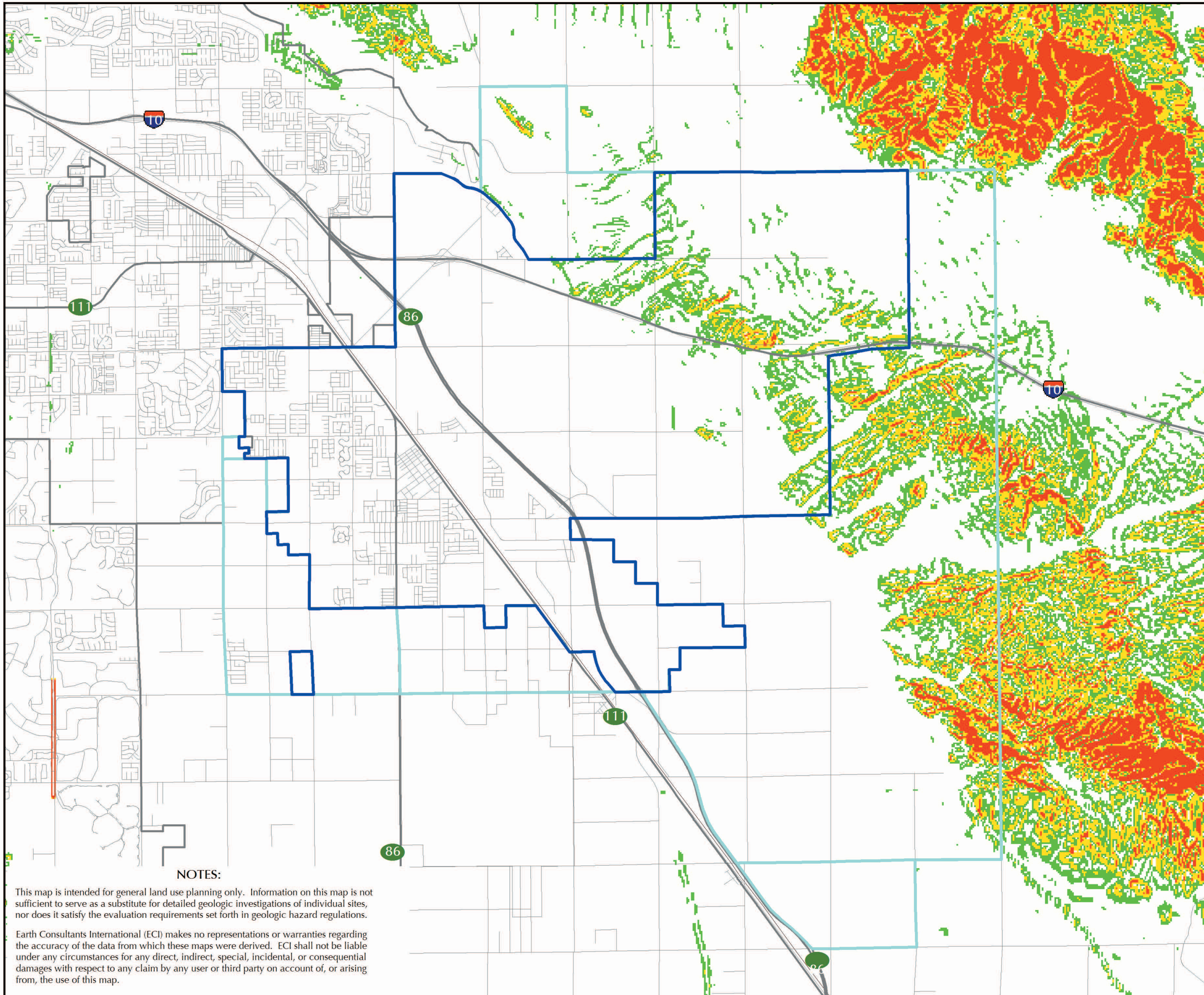
Careful land management in hillside areas can reduce the risk of economic and social losses from slope failures. This generally includes land use zoning to restrict development in unstable areas, grading codes for earthwork construction, geologic and soil engineering investigation and review, construction of drainage structures, and if warranted, placement of warning systems. Other important factors are risk assessments (including susceptibility maps), a concerned local government, and an educated public.

The City of Coachella has developed a comprehensive Hillside Conservation & Development Ordinance, which is currently in the draft stage. The ordinance would establish an overlay district with the intent to: 1) protect the health and safety of the public; 2) protect and preserve existing landforms, drainage patterns, natural ridgelines and rock outcrops, scenic vistas, native vegetation, and wildlife habitat; 3) discourage mass grading and terracing; 4) encourage design that blends with the natural terrain; and 5) mitigate seismic hazards, slope instability, erosion, and sedimentation by requiring geotechnical reports, and where necessary, engineered drainage and flood control facilities. The draft ordinance also considers other issues related to hillside development, such as open space, archeological resources, and fire protection.

Within the city of Coachella, the hillsides are zoned largely as low density residential, with smaller areas dedicated to open space (generally watercourses, either natural or manmade) and commercial development. The draft ordinance would generally restrict development, allowing only trails and access roads, on slopes steeper than a 20-percent gradient (a 20-percent slope is slightly steeper than 11 degrees). For alluvial fans flatter than 20 percent, permitted uses include golf courses, parks, and certain other recreational facilities; water wells, pump stations, and water tanks; substations, transmission lines, antennas, and trails. Alluvial fans may be developed for other uses if flood protection is provided. Single-family residential and commercial developments, along with associated facilities, are permitted on hillside slopes flatter than 20 percent. All hillside development is subject to various regulations and guidelines, as well as planning and engineering reviews by the City.

Slope Distribution Map

Coachella, California



NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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Explanation

Slope (in Percent Grade)

- 0 to 10
- 10 to 20
- 20 to 36
- 37 and greater

- Coachella City Boundary
- Coachella Planning Area Boundary

N
W E
S

Scale: 1:72,000

6000 0 6000
Feet

2000 0 2000
Meters

Base Map: From the City of Coachella.
Source: Derived from USGS 30m Digital Elevation Model.

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Project Number: 3106/3218
Date: 2014

Plate 2-2

For the unincorporated portions of the General Plan area, Riverside County Ordinances provide similar standards and guidelines for growth and development, in addition to providing a basis for county-wide planning and construction of public facilities such as drainage control. The ordinances address zoning, permitting, grading, and investigation requirements for areas subject to potential geologic problems, including slope instability.

Soils and geology reports for hillside areas, which are required by both the City and the County, should include a geotechnical evaluation of any slope that may impact the future use of the property, as well as any impact to adjacent properties. This includes existing slopes that are to remain natural, and any proposed graded slopes. This type of investigation typically includes borings and/or test pits to collect geologic data and soil samples, laboratory testing of soil samples to determine soil strength parameters, and engineering calculations. Numerous soil-engineering methods are available for stabilizing slopes that pose a threat to development. These methods include designed buttresses (replacing the weak portion of the slope with engineered fill); reducing the height of the slope; designing the slope at a flatter gradient; and adding reinforcements to fill slopes such as soil cement or layers of geogrid (a tough polymeric net-like material that is placed between the horizontal layers of fill). Most slope stabilization methods include a subdrain system to prevent excessive ground water (typically landscape water) from building up within the slope area. If it is not feasible to mitigate the slope stability hazard, building setbacks are typically imposed.

For debris flows, assessment of this hazard for individual sites should focus on structures located or planned in vulnerable positions. This generally includes canyon areas; at the toes of steep, natural slopes; and at the mouth of small to large drainage channels. Mitigation of soil slips and debris flows is usually directed at containment (debris basins), or diversion (impact walls, deflection walls, diversion channels, and debris fences). A system of baffles may be added upstream to slow the velocity of a potential debris flow. Other methods may include avoidance by restricting habitable structures to areas outside of the potential debris flow path.

Temporary slope stability is also a concern, especially where earthwork construction is taking place next to existing improvements. Temporary slopes are those made for slope stabilization backcuts, fill keys, alluvial removals, retaining walls, and underground utility lines. The risk of slope failure is higher in temporary slopes because they are generally cut at a much steeper gradient. In general, temporary slopes should not be cut steeper than 1:1 (horizontal:vertical, equal to 45 degrees), and depending on actual field conditions, flatter gradients or shoring may be necessary. The potential for slope failure can also be reduced by cutting and filling large excavations in segments, and by not leaving temporary excavations open for long periods of time. The stability of large temporary slopes should be geotechnically analyzed prior to construction, and mitigation measures provided as needed.

The City can further reduce slope instability losses in developed hillsides by:

- Encouraging homeowners to install landscaping consisting primarily of drought-resistant, preferably native vegetation that helps stabilize the hillsides;
- Providing public education on slope stability, including the importance of rodent control, maintaining drainage devices, and avoiding heavy irrigation.

2.3.2 Compressible Soils

Compressible soils are typically geologically young, unconsolidated sediments of low density that may compress under the weight of proposed fill embankments and structures. The settlement potential and the rate of settlement in these sediments can vary greatly, depending on the soil characteristics (texture and grain size), natural moisture and density, thickness of the compressible layer(s), the weight of the proposed load, the rate at which the load is applied, and drainage.

In the Coachella General Plan area, compressible soils are most likely to occur in the valley and within drainage channels in the hills, where unconsolidated sediments are present (see Plate 2-1). This generally includes the modern floodplain and prehistoric lake deposits and the surface of young alluvial fan sediments. Compressible soils are also present in hillside areas, within canyon bottoms, swales, and at the base of natural slopes. Although the older sedimentary deposits forming the hills are relatively dense, the upper few feet, which are commonly weathered and/or disturbed, are typically compressible.

2.3.2.1 *Mitigation of Compressible Soils*

When development is planned within areas that contain potentially compressible soils, a geotechnical analysis is required to confirm whether or not this hazard is present. The analysis should consider the characteristics of the soil column in that specific area, and also the load of any proposed fills and structures that are planned, the type of structure (i.e. a road, pipeline, or building), and the local groundwater conditions. At a minimum, the removal and recompaction of the near-surface soils is required. Deeper removals may be needed for heavier loads, or for structures that are sensitive to minor settlement. Based on location-specific data and analyses, partial removal and recompaction of the compressible soils is sometimes performed, followed by settlement monitoring for a number of months after additional fill has been placed, but before buildings or infrastructure are constructed. Similar methods are used for deep fills. In cases where it is not feasible to remove the compressible soils, buildings can be supported on especially engineered foundations that may include deep caissons or piles.

2.3.3 Collapsible Soils

Hydroconsolidation or soil collapse typically occurs in recently deposited sediments that accumulated in an arid or semi-arid environment. Sediments prone to collapse are commonly associated with alluvial fan and debris flow sediments deposited during flash floods. These deposits are typically dry and contain minute pores and voids. The soil particles may be partially supported by clay, silt or carbonate bonds. When saturated, collapsible soils undergo a rearrangement of their grains and a loss of cementation, resulting in substantial and rapid settlement under relatively light loads. An increase in surface water infiltration, such as from irrigation, or a rise in the groundwater table, combined with the weight of a building or structure, can initiate rapid settlement and cause foundations and walls to crack. Typically, differential settlement of structures occurs when landscaping is heavily irrigated in close proximity to the structures' foundations.

Granular alluvial sediments in the Coachella General Plan area that are very dry may be susceptible to this hazard due to their rapid deposition in the desert environment. Collapsible soils do not appear to be widespread in the planning area, but most likely do occur in localized areas. Consequently, geotechnical studies for future projects in areas underlain at shallow depth by susceptible geologic units should include testing for this potential hazard.

2.3.3.1 *Mitigation of Collapsible Soils*

The potential for soils to collapse should be evaluated on a routine, site-specific basis as part of the geotechnical studies for development. If the soils are determined to be collapsible, the hazard can be mitigated by several different measures or combination of measures, including excavation and recompaction, or in-place pre-saturation and pre-loading of the susceptible soils to induce collapse prior to construction. After construction, infiltration of water into the subsurface soils should be minimized by proper surface drainage design, which directs excess runoff to catch basins and storm drains.

2.3.4 Expansive Soils

Fine-grained soils, such as silts and clays, may contain variable amounts of expansive clay minerals. These minerals can undergo significant volumetric changes as a result of changes in moisture content. The upward pressures induced by the swelling of expansive soils can have significant harmful effects upon structures and other surface improvements.

The valley portion of the Coachella General Plan area is underlain by sediments that are composed of fine-grained sand interlayered with very fine-grained lakebed deposits (silts and clays). Consequently, after site grading, the expansion characteristics of the soils at finish grade can be highly variable. In the hillsides, expansion potential within the Palm Spring Formation could range from very low (sandstone layers) to moderate or high (siltstone and clay layers). If pedogenic soil profiles have developed on older alluvial fan deposits (Ocotillo Conglomerate) as a result of weathering, these may be clay-rich and would probably fall in the moderately expansive range.

The rock that forms the hills and mountains generally has low expansion characteristics, however sheared zones within the rock may contain clays with expansive minerals.

In some cases, engineered fills may be expansive and cause damage to improvements if such soils are incorporated into the fill near the finished surface.

2.3.4.1 *Mitigation of Expansive Soils*

The best defense against this hazard in new developments is to avoid placing expansive soils near the surface. If this is unavoidable, building areas with expansive soils are typically "presaturated" to a moisture content and depth specified by the soil engineer, thereby "pre-swelling" the soil prior to constructing the structural foundation or hardscape. This method is often used in conjunction with stronger foundations that can resist small ground movements without cracking. Good surface drainage control is essential for all types of improvements, both new and old. Property owners should be educated about the importance of maintaining relatively constant moisture levels in their landscaping. Excessive watering, or alternating wetting and drying, can result in distress to improvements and structures.

2.3.5 Corrosive Soils

Corrosive soils can, over time, cause extensive damage to buried metallic objects, commonly impacting such things as buried pipelines (such as water mains), and even affecting steel elements within foundations. The electrochemical and bacteriological processes that take place between the soil and the buried structure are complex and depend on a number of factors involving the structure type and certain soil characteristics. For instance, the type, grade, length, and size of the piping, as well as the materials used in the pipe connections, may control the electrochemical reactions that will take place between the pipes and the surrounding soil, and different soils may react differently. For soils, the most common factor used in identifying the potential for corrosion is electrical resistivity. Soils with low resistivity are especially susceptible to corrosion reactions. Other soil characteristics that increase the risk of corrosion to metals are low pH (acidic soils), wet soils, high chloride levels, low oxygen levels, and the presence of certain bacteria.

Soils with high concentrations of soluble sulfates are not directly corrosive to metals, however the presence of sulfate-reducing bacteria in the soil may cause sulfates to convert to sulfides, which are compounds that do increase the risk for corrosion. If the concentration of soluble sulfates is high enough, the soil will be corrosive to concrete.

Several consulting reports for projects in the valley area have indicated, based on laboratory testing, that the near-surface soils are moderately corrosive to metals, but not to concrete. Nevertheless, soils with high sulfate concentration are known to exist in the area. Consequently laboratory testing should be done where structures that will be in contact with the soil are planned. The City's Standard Specifications and Procedures require corrosion testing for all ductile iron and steel pipelines.

2.3.5.1 *Mitigation of Corrosive Soils*

Corrosion testing is an important part of geotechnical investigations. Onsite soils, as well as any imported soils, are typically tested in the laboratory for resistivity, pH, chloride, and sulfates. For treatment of high sulfate content, special cement mixes and specified water contents are typically used for concrete that will be in contact with the soil. For corrosion of metals, there are a number of procedures that can be used to protect the structure, including cathodic protection, coatings such as paint or tar, or wrapping with protective materials. As mentioned above, the corrosion processes are complex; consequently, the site-specific recommendations must be provided by an engineer who is a corrosion specialist.

2.3.6 Ground Subsidence

Ground subsidence is the gradual settling or sinking of the ground surface with little or no horizontal movement. Most ground subsidence is man-induced. In the areas of California where ground subsidence has been reported (such as the San Joaquin Valley, Coachella Valley, and the Long Beach-Wilmington area), this phenomenon is most commonly associated with the extraction of fluids (water and/or petroleum) from sediments below the surface. Less commonly, ground subsidence can also occur as a response to natural forces such as earthquake movements. Earthquakes have caused abrupt regional elevation changes in excess of one foot across faults. For instance, the Imperial Valley earthquake of 1979 resulted in ground subsidence of approximately 15 inches on the east side of the Imperial fault (Sharp and Lienkaemper, 1982).

Ground-surface effects related to regional subsidence can include earth fissures, sinkholes or depressions, and disruption of surface drainage. Damage is generally restricted to structures sensitive to slight changes in elevations, such as canals, levees, underground pipelines, and drainage courses; however, significant subsidence can result in damage to wells, buildings, roads, railroads, and other improvements. Subsidence due to the overdraft of groundwater supplies can also result in the permanent loss of aquifer storage capacity. Subsidence has largely been brought under control in affected areas by careful management of local water supplies, including reducing pumping of local wells, importing water, and providing artificial recharge (Johnson, 1998; Stewart et al., 1998).

The Coachella Valley is filled with as much as 14,000 feet of sediments, with the upper 2,000 feet defined as water-bearing deposits. As discussed before, this area is tectonically active, and regional subsidence over the last several millions of years is responsible for the great thickness of alluvial deposits forming the valley floor. Nevertheless, the rate of subsidence in some areas appears to have accelerated recently, at rates too great to be accounted for solely by tectonics. Increased groundwater pumping coincident with these rapid rates of subsidence suggests that groundwater extraction is causing the subsidence that has been reported locally in the Coachella Valley. Recognizing that significant subsidence in the area could pose a major environmental constraint, several agencies (including the U.S. Geological Survey and the Coachella Valley Water District) are currently devoting resources to the study and mitigation of this potential hazard.

Regional subsidence related to groundwater withdrawal was first suspected in the Coachella Valley when ground fissuring developed suddenly in the city of La Quinta in 1948. The fissures occurred after nearly 30 years of intense groundwater pumping for agricultural, municipal and domestic purposes. Water levels declined as much as 50 feet between the early 1920s and the late 1940s, before imported water from the Colorado River became the area's main water source. Once surface water from the Coachella Canal was introduced in 1949, pumping of ground water decreased, and between 1950 and the 1970s, groundwater levels actually recovered throughout most of the valley. Some of the basin recharge was also attributed to leakage from unlined water canals. Since the late 1970s, however, the demand for water has exceeded the deliveries of imported surface water, and groundwater levels have again declined as a result of increased pumping. By 1996, water levels in some wells had dropped 50 to 100 feet, to all-time historical lows.

Recognizing that these observed declines in water level had the potential to induce new or renewed land subsidence in the area, the U.S. Geological Survey established in 1996 a precise geodetic network to monitor land subsidence in the lower Coachella Valley. This network of monuments extended from the Salton Sea on the south to just northwest of Indio (Ikehara et al., 1997). The study compared elevation measurements made in 1996 using Geographic Positioning System (GPS) technology with elevation survey data collected by several agencies over several years, dating back to 1936. Because the methods and geographic scales used varied from agency to agency, there are substantial error bars on the results, but the data indicate that between 1936 and 1996, the lower Coachella Valley subsided by as much as 0.5±0.3 feet (Ikehara et al., 1997; Sneed et al., 2001).

Where data were available, historical subsidence was plotted over time and compared to water level changes in nearby wells. In general, subsidence occurred during periods of water level decline, and rebound occurred during intervening periods of water level recovery. Since the timing of the subsidence measurements corresponds with water level declines, land subsidence appears to be occurring in response to groundwater pumping. Water levels began declining below their previously recorded low levels in the early 1990s. Researchers believe that most of the subsidence measured in 1996 had probably just occurred in the last few years prior to the survey. Rapid rates of subsidence over a relatively short period of time are suggested by a study conducted in 1998, when 14 of the 17 original monuments were re-surveyed. The measurements indicate that between 1996 and 1998, vertical changes (subsidence) in the land surface elevation of between 0.04 and 0.22 feet (±0.13 feet) occurred locally.

Since a large portion of the Coachella Valley was not covered in the first study, new technology referred to as Interferometric Synthetic Aperture Radar (InSAR) was used to extend the study area northwesterly, to the Palm Springs/Palm Desert area. InSAR uses differences in reflected radar signals acquired at different times to measure ground-surface deformations. [This method has been used successfully in the last few years to study changes in the land and built environment resulting from earthquakes, volcanic activity, and even warfare]. The InSAR-generated maps reviewed by Sneed et al. (2001) show three areas that appear to have subsided between May 7, 1996 and September 30, 1998: in the Rancho Mirage/Palm Desert area, in the Indian Wells area, and southeast of the modern Lake Cahuilla. The Rancho Mirage/Palm Desert area that appears to have subsided extends from about Country Club Drive on the north, to Fred Waring Drive on the south, and between Highway 111 and the San Jacinto Mountains on the west, to Portola Avenue on the east. Subsidence of as much as 0.23 feet was measured in the southwestern portion of this area. The subsidence area in Rancho Mirage/Palm Desert coincides with an area of substantial groundwater development, where more than 70 production wells produced about 170,000 acre-feet of water during the 1996-98 period (Sneed et al., 2001).

The results of a third study were released in 2002, covering the period between 1998 and 2000. During this time, four additional GPS stations were placed in the valley (including one in the Rancho Mirage/Palm Desert area). Four InSAR images (two pairs) were combined to evaluate ground elevation changes between two time periods as follows: 1) June 1998 to June 1999, and 2) November 1999 to October 2000. The InSAR data indicate that subsidence was still occurring in the three areas previously identified, plus in a new area near La Quinta. The Rancho Mirage/Palm Desert subsidence area (with a 0.2-foot drop in the surface elevation during this time period) coincides with or is near areas where groundwater levels have again declined, in some cases to new lows from their recorded histories (Sneed et al., 2002). The U.S. Geological Survey team recommended that monitoring for subsidence be continued in the area. However, given that the rates of subsidence appear to be small compared to the GPS measurement error, the team indicated that GPS surveys need not be conducted on an annual basis.

The most current study released by the U.S. Geological Survey reports that subsidence rates have increased two to four times since the year 2000 in Palm Desert, Indian Wells, and La Quinta. Water levels in wells within or near the subsiding areas fluctuated seasonally but declined overall between 1996 and 2005. In fact, some of the 2005 water levels measurements were the lowest in the wells' recorded histories. The report concluded that due to the localized character of the subsidence, as well as the coincident areas of declining water levels and subsidence, some aquifer compaction may be taking place. Although the relationship between subsidence and groundwater pumping is complex and more data are needed, the researchers suggest that pumping is the most likely cause (Sneed and Brandt, 2007). The report also suggests improvements for future monitoring that could be used to develop groundwater models that would assist the Coachella Valley Water District in balancing groundwater withdrawal with land subsidence.

Permanent (irreversible) subsidence can occur if ground water is removed from clay and silt layers in the underlying aquifers. This phenomenon has heavily impacted the Antelope Valley, where surface fissures or cracks in the land surface have been reported. The cracks, which have measured as much as 1,300 feet long, 6 feet wide, and 13 feet deep, have caused substantial damage to runways, roads, wells, pipelines, and other structures. With the exception of the cracks observed in the La Quinta area in 1948, no cracks or fissures have been reported in the Coachella Valley. There is however, the potential for fissuring to develop if subsidence as a result of groundwater pumping continues or increases in the area. It is not clear why ground fissures developed in the La Quinta area, but the area where they developed, near the intersection of Avenue 52 and Adams Street, is near the margin of the Coachella Valley, at the base of the Santa Rosa Mountains. While subsidence typically occurs throughout an overdrafted valley, differential displacement and fissures are generally manifested at or near the valley margin. Therefore, if subsidence continues in the lower Coachella Valley, damage to structures as a result of regional subsidence would be expected to be greatest along the edges of the valley, next to the mountains.

There are at least four geodetic monuments (flat metal disks that are anchored to the ground or to a structure) in the Coachella General Plan area that are part of the GPS station network used in the U.S. Geological Survey studies. These four monuments have recorded subsidence ranging from about 0.3 feet to 1 foot between 1996 and 2005. InSAR data for the Indio-Coachella area indicated the land surface elevation changes were rising or stable. However, because InSAR measurements are relative, Sneed and Brandt (2007) suggest this could indicate the Indio-Coachella area is not rising, but is subsiding at a slower rate than nearby areas, such as La Quinta.

2.3.6.1 *Mitigation of Ground Subsidence*

Prevention of subsidence requires a regional approach to groundwater conservation and recharge. Conservation efforts will be more than offset by the rapid growth of the region and the heavy water requirements of golf courses (±8 acre-feet per acre per year) unless water consumption is diligently managed. Some measures that are typically implemented to manage subsidence include:

- Increased use of reclaimed water, storm water, or imported water;
- Implementation of artificial recharge programs (this is already being done, with percolation ponds near Palm Springs, recharge ponds near Desert Hot Springs, and the Levy Groundwater Replenishment Facility in La Quinta);
- Determination of the safe yields of the local groundwater basins, so that available supplies can be balanced with extraction;
- Continued cooperative efforts with the U.S. Geological Survey to monitor groundwater levels and subsidence;
- Protection of groundwater quality;
- Reduction of long-term water demand with specific programs of water conservation;
- Acquisition of additional imported water supplies; and
- Increased public education to encourage (or if necessary, enforce) water conservation.

The Coachella Valley Water District (CVWD) has already implemented most of the actions mentioned above and continues to expand those activities related to water supply, including the goals of developing a shared water resources database with other water agencies, cities, and tribes; developing or updating groundwater and water quality models; and monitoring water demands and the effectiveness of conservation programs (MWH, 2010 and 2011). Current CVWD programs also include the artificial recharge with water from the Colorado River Aqueduct, utilization of canal and recycled water for the irrigation of agricultural fields and golf courses, the requirement that water-efficient plumbing be used in new construction, and the use of more efficient irrigation practices, especially for high quantity users such as farmers, golf courses, and large developments. The goal is to reduce water consumption in the valley even with the expected population increase. In 2003, the Coachella Valley Water District adopted a landscape model ordinance that calls for the use of water-efficient vegetation in new and remodeled landscaping.

The City of Coachella provides potable water to the City, all of which is provided by City-owned wells, reservoirs, and distribution system. Unincorporated areas are serviced by the Coachella Valley Water District (CVWD). The underlying aquifer, known as the lower Whitewater River Sub-basin, is shared with the CVWD, the City of Indio, local tribes, and numerous private well owners. In order to meet future demands without increasing depletion of the aquifer, the City is researching additional water sources, including a water treatment plant for Coachella Canal water, exchange programs with other agencies in the valley, and the feasibility of developing the infrastructure for recycled water use. The City has also adopted conservation programs and incentives including a requirement for the use of drought-resistant landscaping and highly efficient irrigation systems, offering water audits, encouraging plumbing retrofits, and providing public education (TKE Engineering & Planning, 2011). In addition, the City has prohibitions against wasting water, and can apply specific limitations on water usage during a water shortage emergency (Coachella Municipal Code, Chapter 13.04).

2.3.7 Erosion

Erosion, runoff, and sedimentation are influenced by several factors, including climate, topography, soil and rock types, and vegetation. The topographic relief between the valley and the adjacent mountains makes erosion and sedimentation an important issue for Coachella. The fractured condition of the bedrock forming the mountains, combined with rapid geologic uplift and infrequent but powerful storms, leads to high erosion rates. Further, erosion can increase significantly when mountain slopes are denuded by wildfires. Winter storms that follow a season of mountain wildfires can transport great volumes of sediment onto the low-lying areas below.

Natural erosion processes, even on more consolidated sediments, are often accelerated through man's activities – whether they be agricultural or land development. Grading increases the potential for erosion and sedimentation by removing protective vegetation, altering natural drainage patterns, compacting the soil, and constructing cut and fill slopes that may be more susceptible to erosion than natural slopes. Developments also reduce the surface area available for infiltration, leading to increased flooding and sedimentation downstream of the project.

In the Coachella General Plan area, the unconsolidated sediments in the canyon bottoms and valley floor, as well as the granular semi-consolidated sediments forming the hills, are generally the most susceptible to erosion.

2.3.7.1 *Mitigation of Erosion*

Erosion will have an impact on those portions of Coachella located above and below natural and man-made slopes. Hilltop homes or structures above natural slopes should not be permitted at the head of steep drainage channels or gullies without protective measures against headward erosion of the gully. Structures placed near the base of slopes or near the mouths of small canyons, swales, washes, and gullies will need protection from sedimentation. Developments in the valley that are adjacent to natural drainage channels should be adequately set back from eroding channel banks. Alternatively, modification of the channel to reduce erosion should be included in the project design. Although development is generally not present and not permitted within canyons and major drainage channels, roadways and utility lines, out of necessity, must sometimes cross these areas and will need protection from erosion and sedimentation.

Mitigation of erosion and sedimentation typically includes structures to slow down stream velocity, such as check dams and drop structures, devices to collect and channel the flow, catchment basins, and elevating structures above the toes of the slopes. Diversion dikes, interceptor ditches, swales, and slope down-drains are commonly lined with asphalt or concrete, however ditches can also be lined with gravel, rock, decorative stone, or grass.

There are many options for protecting manufactured slopes from erosion, such as terracing slopes to minimize the velocity attained by runoff, the addition of berms and v-ditches, and installing adequate storm drain systems. Other measures include establishing protective vegetation, and placing mulches, rock facings (either cemented on non-cemented), gabions (rock-filled galvanized wire cages), or building blocks with open spaces for plantings on the slope face. All slopes within developed areas should be protected from concentrated water flow over the tops of the slopes by the use of berms or walls. All ridge-top building pads should be engineered to direct drainage away from slopes.

Temporary erosion control measures must be provided during the construction phase of a development, as required by local building codes and ordinances, as well as State and Federal stormwater pollution regulations. In addition, permanent erosion control and clean water runoff measures are required for new developments. These measures might include desilting basins, percolation areas to cleanse runoff from the development, proper care of drainage control devices, appropriate irrigation practices, and rodent control. Erosion control devices should be field-checked following periods of heavy rainfall to assure they are performing as designed and have not become blocked by debris.

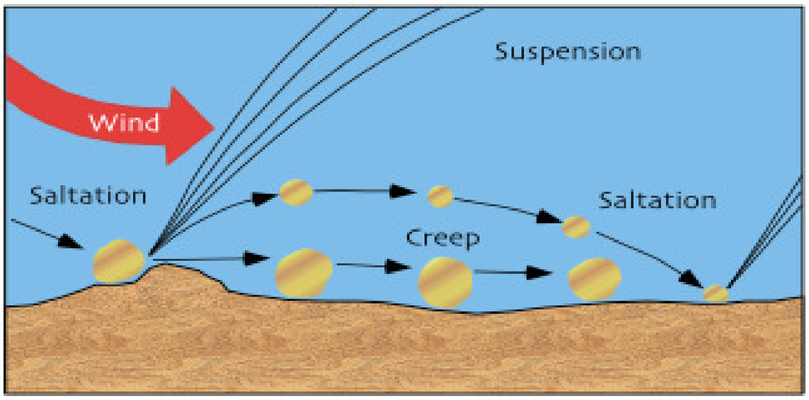
Both the City of Coachella and the County of Riverside require plans be developed for both temporary and permanent erosion control in new projects. Construction must comply with the project's Storm Water Pollution Prevention Plan and Best Management Practices, which are part of the site's grading plans (see Chapter 5, Section 5.2.1). The goal is to minimize or restrict the release of runoff and sediment from the site, as well as debris or potential pollutants.

2.3.8 Wind-Blown Sand

Wind erosion is a serious environmental problem attracting the attention of many across the globe. It is a common phenomenon occurring mostly in flat, bare areas; dry, sandy soils; or anywhere the soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing soil from one place and depositing it in another. It causes soil loss, dryness and deterioration of soil structure, nutrient and productivity losses, air pollution, and sediment transport and deposition.

Soil movement is initiated as a result of wind forces exerted against the surface of the ground. For each specific soil type and surface condition, there is a minimum velocity required to move soil particles. This is called the threshold velocity. Once this velocity is reached, the quantity of soil moved is dependent upon the particle size, the cloddiness of the particles, and the wind velocity itself. Suspension, saltation, and surface creep are the three types of soil movement that occur during wind erosion (Figure 2-2). While soil can be blown away at virtually any height, the majority (over 93 percent) of soil movement takes place at or within one meter (3 feet) of the ground surface.

Figure 2-2: Wind-Induced Soil Movement



Wind-induced soil movement is initiated as a result of wind forces exerted against the surface of the ground, and includes suspension, saltation, and surface creep.
Soil can be blown high into the atmosphere; however, most soil movement takes place at or within one meter of the ground surface.

According to El-Aghel (1984), five physical factors determine the distribution and intensity of the wind-blown sand hazard in the Coachella Valley:

- **Orientation of hill and mountain masses**: The major mountain masses bordering the valley have their long axes aligned in a northwest-southeast direction. As a result, these mountains offer little resistance to the free flow of air down the long axis of the Coachella Valley. The narrow San Gorgonio Pass accelerates the wind and improves its ability to pick-up and transport sand.

- **Nature of the bedrock**: The granitic rock that comprises the local mountains readily weathers to grain size categories that are easily transported by wind.

- **Location of the Whitewater River floodplain**: The Whitewater River is the main stream feeding the upper Coachella Valley, and the floodplain is located at the eastern end of San Gorgonio Pass, precisely where wind velocities are the greatest. The river drains much of the adjacent parts of the San Bernardino Mountains, and is the primary source of sand and gravel in the area. During flood events, large quantities of sand and gravel are deposited on the Whitewater floodplain. Studies have shown that increases in the amount of wind-blown sand are related to episodic flooding of the Whitewater River (Sharp, 1964, 1980). For example, a 15-fold increase in wind erosion rates has been noted following heavy flood events (Sharp, 1980). Flood events generally change the character of the Whitewater River drainage from a stony to a sandy appearance. Yet, within a few months of the flooding event, the drainage bottom typically returns to a predominantly stony appearance, as the finer-grained sand is removed from the streambed by the wind, depositing it elsewhere on the valley floor where it becomes a nuisance. Plate 2-3 shows those areas underlain by sediments susceptible to erosion as a result of the strong winds that physically assault the valley portion of the Coachella General Plan area.

- **Slope of the valley floor**: From the summit of the San Gorgonio Pass, at an elevation of about 1,300 feet, to the Salton Sea, with elevations below sea level, the valley floor slopes without interruption, thereby allowing air to move unhindered down the long axis of the Coachella Valley. The region of greatest blow-sand activity is located down the central axis of the valley, in a region that stretches from eastern Palm Springs to La Quinta and Coachella.

- **Climate:** The Coachella Valley is a hot dry desert with sparse, widely spaced vegetation. As a result, surficial materials are exposed to wind activity. The precipitation in the adjacent mountains is often short and intense, leading to torrential run-off and considerable detritus deposition on the valley floor.

Wind and wind-blown sand pose an environmental, often destructive, hazard throughout the Coachella Valley, including the city of Coachella. To measure the effects of the high winds that blow through the valley, in the late 1970s, Caltech investigators conducted several tests near Garnet Hill. The researchers stocked sample plots with 2- to 3-inch-thick lucite rods, common bricks, hard crystalline rock, and gypsum-cement cubes. Then they measured, over several years, the effects of the wind on these artifacts. As a result of wind erosion, one lucite rod was severed, and many samples were eroded up to several centimeters per year. It is no wonder, therefore, that buildings, fences, roads, crops, trees and shrubs can all be damaged by abrasive blowing soil. In some areas, wind-blown sand has actually forced the abandonment of dwellings and subdivided tracts in the central Coachella Valley (Sharp, 1980). Utility poles in the area are frequently armored with sheet metal around the base to help reduce wind erosion. Wind-blown sand has repeatedly caused the closure of roads, costing cities thousands of dollars in cleanup.

The presence of dust particles in the air is also the source of several major health problems. Atmospheric dust causes respiratory discomfort, and may carry pathogens that cause eye infections and skin disorders. Dust storms reduce highway- and air-traffic visibility. Since high winds blow down the axis of the Coachella Valley, the recreational and resort communities that first developed in the Coachella Valley were generally located in areas sheltered from these winds, tucked in coves at the base of the mountains. However, as the area has grown, development has spread into the central axis of the valley and into the high-wind areas. Rapid development of the Coachella Valley is in part responsible for changes in land use, such as removing native vegetation and building roads and other types of infrastructure, that have led to increases in wind-blown sand across the valley floor (grading a site for development results in loose soil that can be readily picked up and transported down-wind). Recreational land-uses, especially use of off-road vehicles, can also accelerate erosion in the area.

Most of the Coachella General Plan area is within the active wind erosion zone. The area is also underlain by highly erodible sediments (see Plates 2-1 and 2-3).

2.3.8.1 *Mitigation of Wind-Blown Sand*

Mitigation measures that have been used and are used in the area include hedges and other barriers to wind. Increased development in the valley has had the positive side-effect of reducing the local sand available to be picked up and transported by the wind. This is due to the increasing amount of hardscape (homes, asphalt, and concrete) and vegetation (such as golf courses and ornamental plants) covering the soil and isolating it from the wind.

During grading and construction, however there is the potential for increased amounts of soils available for transport. Therefore, water is typically sprayed at construction sites to reduce dust in the air. On very windy days earthwork construction may be curtailed altogether.

2.4 Summary

The Coachella General Plan area is highly diverse geologically. This diversity is strongly related to the youthful (in geologic terms) seismic setting of the surrounding region, which includes tectonic subsidence of the Coachella Valley and the ongoing uplift of the surrounding mountains. This, along with the effects of climate, has resulted in a landscape that is complex in geologic processes and hazards. As Coachella's population grows in the next decades, new development will be needed to meet the demand for homes. When meeting this demand, it is imperative to manage land uses in a responsible way, as development disrupts natural processes, often leading to negative impacts on the environment as well as on the development and adjacent projects. The impacts of land development can be minimized, however, if both site-specific and regional planning elements are recognized and considered, the projects incorporate knowledge gained from scientific research in developing and implementing a design appropriate to the area, and protective measures are constructed and maintained for the lifetime of the projects.

The surrounding mountains not only form a dramatic backdrop to the city, but also greatly influence the area's climate, geology, and hydrology. These elements combine in various ways to create geologic hazards, as well as benefits to the community. Hazards that have the greatest impact on the General Plan area are summarized below.

Slope instability will be a potential hazard when development encroaches into the hills in the northeastern part of the General Plan area. The geologic unit forming most of the hills is generally resistant to large-scale landsliding, so future slope failures are more likely to consist of surficial failures and erosion of sandy geologic materials. Such failures typically occur during exceptional and/or prolonged rainfall, and may manifest as mud or debris flows. Larger slope failures could occur in the small portion of the hills underlain by the Palm Spring Formation due to the presence of clay beds and deformation by the San Andreas fault. Cut slopes in this area will most likely need remedial grading to meet minimum engineering requirements.

Potentially compressible and/or collapsible soils underlie a significant part of the valley and canyons, typically where geologically young sediments have been deposited, such as young alluvial fans, washes, and canyon bottoms. These are generally sediments of low density with variable amounts of organic materials. Under the added weight of fill embankments or buildings, these sediments can settle, causing distress to improvements. Construction in these areas will require some removal and recompaction of the near surface soils, based on soil engineering testing.

Some of the geologic units, primarily in that portion of the valley that was once occupied by ancient Lake Cahuilla, have fine-grained components that are likely to be moderately to highly expansive. These materials may be present at the surface or may be exposed by grading activities. Man-made fills can also be expansive, depending on the soils used to construct them.

Sediments in the valley areas may be corrosive to metallic objects, such as pipelines, that are in contact with the soil. All soils should be tested for corrosion potential, with mitigation measures developed by a corrosion engineer where needed.

Regional ground subsidence from groundwater withdrawal is a hazard that can be reduced or prevented by aggressive water management, the use of recycled water, the continued development of new water sources, continuing public education, the widespread use of drought-tolerant plants in landscaping, and the implementation and enforcement of stringent water conservation measures, especially during droughts. Coachella should also require new subdivisions or commercial developments to install infrastructure for water recycling, so that these sites can be connected to recycled water mains as they become available. With the expected increase in population, water shortage is one of the most serious challenges ahead. Overdraft of the aquifer underlying Coachella could result in permanent ground subsidence, with resultant negative impact on the area's environmental quality.

Because of the topographic relief in and around Coachella, erosion and sedimentation are inherently significant elements of the natural setting. Land development can have adverse impacts on these elements by altering the natural processes, topography, and protective vegetation, in addition to reducing the area of natural infiltration. This in turn can lead to damage from increased flooding, erosion, and sedimentation in other areas, typically downstream. Erosion and sedimentation are also important considerations on a site-specific basis, with respect to developments adjacent to slopes and drainage channels. These issues are not only critical during the design of a project, but also during construction and during the long-term maintenance of the developed site.

Like most of the valley, damage from strong winds and blowing sand is a hazard to Coachella. Increased development and irrigation in the Coachella Valley has alleviated the hazard of blowing sand somewhat, however many sand sources are still available, including sediments in the Whitewater River channel.

Losses resulting from geologic hazards are generally not covered by insurance policies, causing additional hardship on property owners. The potential for damage can be greatly reduced by:

- Strict adherence to grading ordinances – many of which have been developed as a result of past disasters;
- Sound land planning and project design that avoids severely hazardous areas;
- Detailed, site-specific geotechnical investigations, followed by geotechnical oversight during grading and during construction of foundations and underground infrastructure;
- Effective geotechnical and design review of projects performed by qualified, California-registered engineering geologists, soil (geotechnical) engineers, and design engineers; and
- Public education that focuses on reducing losses from geologic hazards, including the importance of proper irrigation and landscaping practices, in addition to the care and maintenance of slopes and drainage devices.

CHAPTER 3: FLOOD HAZARDS

Floods are natural and recurring events that only become hazardous when man encroaches onto floodplains, modifying the landscape and building structures in the areas meant to convey excess water during floods. Unfortunately, floodplains have been alluring to populations for millennia, since they provide level ground and fertile soils suitable for agriculture, as well as access to water supplies and transportation routes. Notwithstanding, these benefits come with a price – flooding is one of the most destructive natural hazards in the world, responsible for more deaths per year than any other geologic hazard. Furthermore, average annual flood losses (in dollars) have increased steadily over the last decades as development in floodplains has expanded.

The city of Coachella and surrounding areas are, like most of southern California, subject to unpredictable seasonal rainfall. Most years, the winter rains are barely sufficient to turn the hills and mountains green for a few weeks, but every few years the region is subjected to periods of intense and sustained precipitation that results in flooding. Historic flood events that occurred in southern California have resulted in an increased awareness of the potential for public and private losses as a result of this hazard, particularly in the highly urbanized parts of floodplains and alluvial fans. As the population grows, there is an increased pressure to build on flood-prone areas, and in areas upstream of previously developed land. With increased development also comes an increase in impervious surfaces, such as asphalt. Water that used to be absorbed into the ground becomes runoff to downstream areas. If drainage channels that convey storm waters are not designed or improved to carry these increased flows, areas that have not flooded in the past may be subject to flooding in the future. This is especially true for developments on alluvial fans and downstream from natural drainages that have the potential to convey mudflows.

3.1 Storm Flooding

3.1.1 Hydrologic Setting

The Coachella General Plan area straddles the eastern margin of the Salton Trough (also known as the Salton Sink and Coachella Valley), an arid, low-lying valley with hot summers, cool winters, and infrequent, but potentially violent rainstorms. The valley is a broad, gently sloping basin shaped by a combination of sediments deposited by flash flooding on alluvial fans emerging from canyons in nearby mountains; by past flooding of the valley's main watercourse, the Whitewater River; and by sediments deposited in prehistoric lakes that once occupied the area. The portion of the valley encompassed by the city of Coachella is still largely agricultural. Except for widely scattered farm structures, most of the existing development is within the central and western parts of the city. The northeastern part of Coachella occupies low hills that are still undeveloped, except for localized farming, aggregate mining operations, and a landfill. Several large projects, along with associated infrastructure, have been proposed for both the valley and hillside areas.

There are two distinct flood sources in the Coachella Valley: 1) the Whitewater River and its tributaries upstream from the valley, and 2) the streams entering the valley from mountain ranges flanking the northeast and southwest sides of the valley. The Whitewater River, with a watershed of more than 1,000 square miles, is the most significant drainage course in the area. Collecting runoff from the precipitous slopes and steep canyons of the San Bernardino and San Jacinto Mountains, the river emerges from the mountains near the southern entrance to the San Gorgonio Pass, where it joins and captures the San Gorgonio River, and near Palm Springs, Taquitz Creek. In recent historical times, during flood stage, the river flowed on the southwestern side of the valley above Point Happy (near the intersection of Highway 111 and Washington Street in La Quinta). At this point the main channel crossed to the other (easterly) side of the valley, where it was less well-defined, and bifurcated, with one channel carrying floodwaters down the center of the valley, and a more pronounced channel that followed, somewhat, its current route to the Salton Sea (Coachella Valley County Water District[1], 1967). Today the river follows its historical path through the northern part of the valley where it is surrounded by dense development, including some areas where the riverbed itself is developed as golf courses. The southern part of the river, below Point Happy, is now confined to the man-made Coachella Valley Stormwater Channel and is largely surrounded by undeveloped land or agricultural fields.

The Coachella Valley is flanked by mountains and hills drained by steep canyons and washes, including the San Jacinto and Santa Rosa Mountains to the west, and the Little San Bernardino Mountains, as well as the Indio and Mecca Hills, to the north and east. When a storm arrives, normally dry, rocky canyons and arroyos can quickly become dangerous torrents of water, sand, mud, and rocks, capable of transporting boulders, trees, and even cars. Drainage channels in the mountains are deeply incised; however, when they reach the valley floor they loose their definition and sediment-laden water spills out onto braided ephemeral stream channels and as sheet flow. Light or moderate rainfall is usually absorbed on the alluvial fans and the valley floor, but strong storms, especially if combined with snowmelt, can produce flows that eventually reach the Whitewater River and the Salton Sea. Numerous large drainages from the nearby Little San Bernardino Mountains flow toward Coachella; the most significant of these in terms of flood hazard are Fargo Canyon and Thermal Canyon. The region currently has facilities in place that have greatly reduced the potential for flooding from these sources in the valley portion of Coachella.

3.1.2 Weather and Climate

Southern California owes its agreeable climate of generally mild winters and warm, dry summers to a semi-permanent high-pressure area located over the eastern Pacific Ocean, which deflects storms to the north. During the winter months, this high pressure area breaks down, allowing the jet stream to move storms along a more southerly track.

In spite of southern California's reputation for a mild Mediterranean climate, there are varied and distinct climatic zones in close proximity that are controlled by terrain and altitude. The local mountain ranges, including the San Bernardino, San Jacinto, and Santa Rosa Mountains, have a powerful effect on the climatic conditions in this region. Capturing precipitation from strong Pacific storms that pass through, the mountains separate the semi-arid environment to the west from the dry, desert regions to the east. Most precipitation occurs in the winter months, between November and April. However, high-intensity, short-duration tropical thunderstorms emanating from the south are common during the summer and fall, typically occurring July through September. Often accompanied by strong winds, these powerful storms frequently result in localized damage to roadways, power poles, trees, and structures. These storms are highly localized, drenching one area with several inches of rain in a short period of time, while leaving nearby areas completely dry.

The mountains receive significantly more precipitation than the adjacent lowlands. Consequently, mountain thunderstorms can inundate the adjacent valleys with floodwaters, mud, and debris, even if no rain actually falls on the valley. The average yearly precipitation in the Coachella area is a little more than 3 inches (see Table 3-1), whereas more than 25 inches (average) of precipitation fall annually in the San Jacinto Mountains (Table 3-2).

[1] The Coachella Valley County Water District was established in 1918. In 1979, the word "County" was dropped from its name.

Table 3-1: Average Annual Rainfall* by Month for the Coachella Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	0.6	0.5	0.3	0.1	0.1	0.0	0.1	0.3	0.3	0.2	0.3	0.5	**3.3**

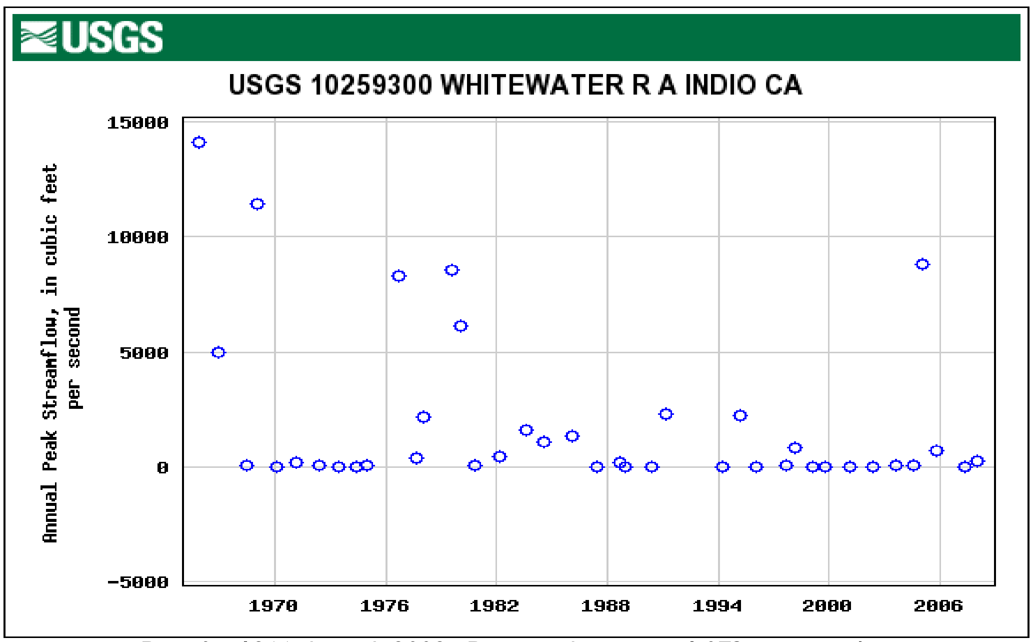
Source: Global Historical Climatology Network; http://www.worldclimate.com/
Data based on 1314 months between 1877 and 1989
Weather Station location: Indio, California, about 33.70° N and 116.30° W
Weather Station elevation: About 9 feet above mean sea level
*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

Table 3-2: Average Annual Rainfall* by Month for the San Jacinto Mountains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	6.0	4.7	3.9	1.5	0.3	0.0	0.5	1.2	0.8	0.6	3.3	2.7	**25.3**

Source: NCDC Cooperative Stations; http://www.worldclimate.com/
Data based on 8 complete years between 1965 and 1978
Weather Station location: Mount San Jacinto, California, about 33.80°N and 116.63°W
Weather Station elevation: About 8,425 feet above mean sea level
*Average rainfall = Mean monthly precipitation, including rain, snow, hail, etc.

Figure 3-1: Peak Annual Streamflow Values for Gage Station USGS 10259300 Located on the Whitewater River in Indio, Near Coachella



Data for 1966 through 2008. Drainage basin size: 1,073 square miles.

Not only does rainfall in southern California vary from one location to the next, often within short distances, it is also extremely variable from year to year, with periods of drought alternating with periods of flooding. For instance, annual rainfall totals are illustrated in the peak streamflow graph for a gage on the Whitewater River (see Figure 3-1). This gage, located at the Southern Pacific Railroad Crossing in Indio, has recorded the extreme fluctuations in stream discharge that occurred in the area over a 42-year period (1966-2008) that, given its location, best represents the conditions that have occurred and can occur in Coachella. With peaks typically at or near zero cubic feet per second (cfs) for most years, peak flows reached more than 10,000 cfs on November 22, 1965 and on January 25, 1969. Floodwaters at these rates move at high velocities, with the potential to do considerable damage. Other relatively high peak flows were reported in 1976, 1980, and 2005.

Both winter storms and late summer monsoons can impact the Coachella area, as described further below, in the following paragraphs.

Winter Storms. Winter storms are characterized by heavy and sometimes prolonged precipitation over a large area. These storms usually occur between November and April, and are responsible for most of the precipitation recorded in southern California. This is illustrated by the data presented above in Tables 3-1 and 3-2. The storms originate over the Pacific Ocean and move eastward. Mountain ranges, such as the San Bernardino and San Jacinto Mountains, form a rain shadow, slowing down or stopping the eastward movement of this moisture. A significant portion of the moisture is dropped on the mountains as snow. If large storms are coupled with snowmelt from the local mountains, large peak discharges can be expected in the main watersheds at the base of the mountains.

Some of the severe winter storm seasons that have historically impacted the southern California area have been related to El Niño events. El Niño is the name given to a phenomenon that originates every few years, typically in December or early January, in the southern Pacific, off the western coast of South America, but whose impacts are felt worldwide. Briefly, warmer than usual waters in the southern Pacific are statistically linked with increased rainfall in both the southeastern and southwestern United States, droughts in Australia, western Africa and Indonesia, reduced number of hurricanes in the Atlantic Ocean, and increased number of hurricanes in the Eastern Pacific. Two of the largest and most intense El Niño events on record occurred during the 1982-83 and 1997-98 water years. [A water year is the 12-month period from October 1 through September 30 of the second year. Often a water year is identified only by the calendar year in which it ends, rather than by giving the two years, as above.] These are also two of the worst storm seasons reported in southern California in recent decades.

More recently, the severe storms of December 2004 and January 2005 have been blamed on a different climatic condition, one where the sub-tropical jet stream carries moisture-laden air directly from the tropics to the west coast of California. Because it passes over the Hawaiian Islands, it is commonly referred to as the “Pineapple Express.” In December 2004, as this condition was developing, the northern jet stream shifted towards the California coast allowing storms from the north to tap into the deep tropical moisture, dramatically increasing the rainfall in southern California (NOAA, 2005a). Powerful winter storms during February 2005, however, have been attributed to a weak but persistent El Niño condition, combined with an atmospheric condition that blocked or slowed the normal eastward movement of the storms (NOAA, 2005b). These events combined to give the region record-breaking rainfall in the 2005 water year, in addition to spawning numerous waterspouts and small tornadoes.

Monsoon Storms. Typically developing in late summer to fall, these storms are usually most prevalent in the higher mountains and the deserts, but can also move into nearby valleys. They develop when moist, unstable air moves into our area from Mexico through Arizona (Mexican monsoons), from the Sea of Cortez (Gulf Surge), or at times from tropical storms or hurricanes that reach Baja California. Once the monsoonal moisture enters California and flows up steep mountain slopes, explosive thunderstorms can develop. Although these high-intensity, short-duration storms typically impact relatively small areas, they often release torrential rainfall that causes flash flooding and mudslides. Frequently packing lightning, hail, very strong wind gusts, and even small tornadoes, thunderstorms cause power outages and damage to people and property. Such storms have impacted Coachella and the surrounding area in the past.

The ARkStorm. Much research in the last decade has focused on the study of a meteorological phenomenon called the Atmospheric River (AR). ARs are narrow streams of water vapor transported in the lower atmosphere that are probably responsible for most of the large storms on the west coast of the U.S. Typically packing high wind speeds, ARs are no more than 400 to 500 kilometers wide, but are thousands of kilometers long, sometimes extending across whole ocean basins. When ARs traveling across the Pacific Ocean collide with the mountain ranges in the west coast, the vapor is forced upwards, where it condenses and rains out, leading to significant flooding (Ralph and Dettinger, 2011).

The U.S. Geological Survey's Multi Hazards Demonstration Project (MHDP) has been combining various science disciplines to test and improve the resiliency of communities to natural disasters. By developing a disaster scenario (such as the 2008 ShakeOut Earthquake Scenario discussed in Chapter 1) scientists, engineers, and other experts are engaging emergency planners, first responders, businesses, universities, insurance companies, government agencies and the public in preparing for a major natural disaster. The second major project of the MHDP is a catastrophic winter storm scenario consisting of a hypothetical (but not unrealistic) Pacific storm striking the west coast of California, similar in intensity to the 1861-1862 series of storms that resulted in state-wide flooding that left the central coast impassible, the capital underwater for three months, and the State bankrupt. Named the ARkStorm (for Atmospheric River 1,000), the impacts of such a storm today are expected to overwhelm the State's flood protection system, which is normally designed to control the 100- to 200-year storm runoff. Property damages and business disruptions from the ARkStorm are estimated to be on the order of $725 billion, nearly three times the loss expected for the hypothetical southern California earthquake (Porter et al., 2011). The USGS report indicates an ARkStorm is not only plausible, but probable, and may not be a worst case. The geological record suggests that six megastorms may have occurred in California in the past 1800 years – all more severe than the 1862 event. The products of the ARkStorm Scenario are intended to be used by emergency planners, policymakers and other to review disaster preparedness, conduct risk assessments and disaster drills, explore ways to adequately fund response and recovery, plan future hazards mapping, and educate the public.

Although ARkStorm flooding in the Coachella Valley is predicted to be less severe than in southern California coastal areas, Coachella would be impacted by both deep-seated and shallow, surficial landsliding in the local hills and mountains. Much of the damage in Coachella would likely be from alluvial fan flooding and debris flows. Additional information on this megastorm scenario can be obtained from http://pubs.usgs.gov/of/2010/1312/.

3.1.3 Past Flooding

Because of the arid climate and the generally dry local washes, Coachella residents might be surprised to learn that desert alluvial fans and valleys are the sites of infrequent but catastrophic flooding. Flood hazards in the Coachella area can be classified into two general categories: 1) flash flooding down natural or man-made channels, and 2) sheet flooding across the valley floor.

Flash floods are short in duration, but have high peak volumes and high velocities. This type of flooding occurs in response to the local geology and geography, and the built environment (man-made structures). The local mountains are steep and consist of rock types that are fairly impervious to water. Consequently, little precipitation infiltrates the ground. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the mountains into natural or modified channels within the foothill and valley areas. Because of the steep terrain and the constant shedding of debris from the mountain slopes (primarily as dry ravel and rock falls), flood flows often carry large amounts of mud, sand, and rock fragments. Sheet flow occurs when the capacities of the existing channels (either natural or man-made) are exceeded or when channels become blocked by debris or structures, causing water to flow into adjacent areas.

Using historical records dating back to 1769, the U.S. Army Corp of Engineers determined that there were relatively large flood events in the Whitewater River basin in 1825, 1833, 1840, 1850, 1859, 1862, 1867, 1876, 1884, 1886, and 1891. Damaging floods also occurred in January 1916, December 1921, April 1926, February 1927, February 1937, March 1938, and December 1940. More recently, substantial floods occurred in November 1965, December 1966, January 1969, February 1969, and September 1976. The maximum flood of record in the lower Coachella Valley occurred in 1965. FEMA (2008a) reports that the most extensive flood damage occurs on alluvial fans between the base of the mountains and the Whitewater River – the portion of Coachella that is still mainly agricultural, but where several large residential developments have been proposed.

3.1.4 National Flood Insurance Program (NFIP)

Because floods are the leading cause of natural disaster losses in the United States, the nation invests significant resources to reduce the risk of flooding. Floods can be widespread and cause catastrophic losses, therefore insurance companies generally consider flood hazards too costly to insure (National Research Council, 2009). In order to manage the increasing flood losses, the Federal Emergency Management Agency (FEMA) was mandated by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 to evaluate flood hazards and provide affordable flood insurance to residents in communities that regulate future floodplain development. To that end, FEMA created **Flood Insurance Rate Maps (FIRMS)** for the purpose of setting flood insurance premiums and for regulating the elevations and flood proofing of structures in mapped flood zones.

The NFIP is required to offer federally subsidized flood insurance to property owners in those communities that adopt and enforce floodplain management ordinances that meet minimum criteria established by FEMA. Floodplain management may include such measures as requirements for zoning, subdivisions, and building construction, as well as special-purpose floodplain ordinances. The National Flood Insurance Reform Act of 1994 further strengthened the NFIP by providing a grant program for State and community flood mitigation projects. The act also established the **Community Rating System (CRS)**, a system for crediting communities that implement measures to protect the natural and beneficial functions of their floodplains, and managing their erosion hazard.

The City of Coachella has participated as a regular member in the NFIP since 1980 (Community ID No. 060249#), and the required floodplain regulations are set forth in Chapter 15.56 of the Coachella Municipal Code. Coachella's most current effective FIRM maps are dated August 2008 (four community panels), however maps and flood elevations are amended periodically to reflect future changes. For unincorporated areas, the County of Riverside has participated as a regular member in the NFIP since 1980 (Community ID No. 060245#).

Because Coachella and Riverside County are participating members of the NFIP, flood insurance is available to any property owner in the General Plan area. In fact, to secure financing to buy, build, or improve structures in a Special Flood Hazard Zone (SFHZ – see definition below), property owners are required to purchase flood insurance. Lending institutions that are federally regulated or federally insured must determine if the structure is located in a SFHZ and must provide written notice requiring flood insurance.

FEMA recommends that most property owners, whether residential or commercial, purchase and keep flood insurance, even if they are not located in a mapped flood hazard zone. Keep in mind that approximately 20 to 25 percent of all flood claims occur outside of mapped high flood risk areas, and typical homeowner or business insurance policies do not cover flooding. Residents or business owners that rent property can also purchase coverage for the contents of their homes or business inventories. In low to moderate risk areas, property owners should ask their insurance agents if they are eligible for the FEMA Preferred Risk Policy, which provides inexpensive flood insurance protection. Insured property owners can be reimbursed for all covered losses, even if the flood-impacted zone is not officially declared a Federal disaster area. Residents should also be aware that localized flooding could be caused by a temporary situation, such as a storm drain inlet or culvert that becomes blocked by debris during a storm. Hillside areas are generally outside of the FEMA-mapped flood zones, however these areas can be vulnerable to mudslides, which are also covered under flood insurance.

FEMA also recommends that residents do not forgo purchasing insurance, assuming instead Federal disaster assistance will pay for flood damage. In order to receive assistance, a community must first be declared a Federal disaster area, and these declarations are issued in less than 50 percent of flood events. Remember also that Federal assistance is usually in the form of a loan, which must be repaid with interest. Furthermore, if uninsured property owners do receive Federal assistance, they must purchase flood insurance to remain eligible for future disaster relief.

3.1.5 FEMA Flood Zone Mapping

Flood risk information presented on FIRMs is based on historic, meteorological, hydrologic, and hydraulic data, as well as topographic surveys, open-space conditions, flood-control works, and existing development. Rainfall-runoff and hydraulic models are utilized by the FIRM program to analyze flood potential, adequacy of flood protective measures, surface-water and groundwater interchange characteristics, and the variable efficiency of mobile (sand bed) flood channels. For riverine flooding, the extent of potential flooding is predicted from statistical analyses and hydrologic models that rely heavily on data from U.S. Geological Survey stream gages and land surface topography.

Some FEMA flood map features that are relevant to the residents of Coachella are:

Flood Insurance Study (FIS). To prepare FIRMs that illustrate the extent of flood hazards in a flood-prone community, FEMA conducts engineering studies referred to as Flood Insurance Studies. The General Plan area is included in the FIS for Riverside County; the most recent version is dated August 2008. This document includes community descriptions, flooding sources (including the Whitewater River), information on historical flooding, existing flood protection measures, hydrologic and hydraulic analyses, and definition of potential flood areas.

Special Flood Hazard Area (SFHA). Using information gathered in FIS studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas on FIRMs. SFHAs are those areas subject to a high risk of inundation by a "base flood" which FEMA sets as a 100-year flood. As mentioned above, SFHAs are regulated zones, requiring the mandatory purchase of flood insurance. They are also subject to special standards and regulations that apply to new construction, and in some cases, existing buildings. Floodplain regulations required by the NFIP apply only to properties located in a SHFA. However, these are minimum requirements, and local jurisdictions may regulate areas outside of the SHFAs, based on knowledge specific to their area.

Base Flood. The base flood, also called the **100-year flood,** is defined by looking at the long-term average period between floods of a certain size, and identifying the size of a flood that has a 1 percent chance of occurring during any given year. This base flood has a 26 percent chance of occurring during a 30-year period, the length of most home mortgages. However, a recurrence interval such as "100 years" represents only the long-term average period between floods of a specific magnitude; rare floods can in fact occur at much shorter intervals or even within the same year.

The base flood is a regulatory standard used by the National Flood Insurance Program (NFIP) as the basis for insurance requirements nationwide. The Flood Disaster Protection Act requires owners of all structures in identified SFHAs to purchase and maintain flood insurance as a condition of receiving Federal or federally related financial assistance, such as mortgage loans from federally insured lending institutions.

The base flood is also used by Federal agencies, as well as most County and State agencies, to administer floodplain management programs. The goals of floodplain management are to reduce losses caused by floods, while preserving and restoring the natural and beneficial value of the floodplain.

Base Flood Elevation (BFE). This is the calculated elevation of the water surface during a base flood event. The BFE is important because it is the regulatory standard used for the elevation or flood-proofing of structures. Further, the height of the first floor elevation above the BFE determines the amount of the flood insurance premium. BFEs are shown on FIRMs for those flooding sources that have been analyzed using detailed methods. BFEs on FIRM maps have been rounded to whole-foot elevations and are intended for use in flood insurance rating purposes only. Data in the FIS should be utilized for construction and floodplain management as well.

Floodway. The basis of floodplain management is the concept of the "floodway." FEMA defines this as the channel of a river or other watercourse, and the adjacent land areas that must be kept free of encroachment in order to discharge the base flood without cumulatively increasing the water surface elevation more than a certain height. The intention is not to preclude development, but to assist communities in managing sound development in areas of potential flooding. The community is responsible for prohibiting encroachments into the floodway unless it is demonstrated by detailed hydrologic and hydraulic analyses that the proposed development will not increase the flood levels downstream.

Mapped flood areas outside of the 100-year flood zone. FIRMs in the Coachella area also show the estimated limits of areas with moderate to low risk of flooding. The flood having a 0.2 percent annual chance of occurring (also called the 500-year flood) is usually the basis for these categories, with moderate risk defined as the zone between the limits of the 100-year and 500-year floods, and low risk defined as the area outside of the 500-year flood limits. These zones may also include areas where the base flood is less than one foot deep, or where the drainage basin is small (less than one square mile), or areas that are protected from the base flood by levees. Flood insurance is available for properties in these zones, but is not mandated by the NFIP.

Letter of Map Revision (LOMR). A Letter of Map Revision is a modification to the FIRM or floodway boundaries, generally based on physical changes that affect the hydraulic or hydrologic characteristics of the flood source (usually as a result of development or new flood control facilities). The letter is typically accompanied by an annotated copy of the portion of the map that has been revised. Modifications to the FIRM maps are usually made in response to an agency supplying new hydraulic data that show that the flooding hazard in a specific area has changed or has been abated.

In addition to their original purpose of setting insurance rates and regulating flood hazards, FIRMs are now widely used by local and regional planners for other purposes, including land-use planning, emergency preparedness and response, natural resource management, and risk assessment. However, it should be noted there are many uncertainties inherent in the establishment of FEMA flood zones (Larson, 2009). Given the importance of these maps, some of the limitations that communities should be aware of are discussed below:

- It is important to realize that FIRMs only identify potential flood areas based on the conditions at the time of the study, and do not consider the impacts of future changes in the area. Conditions that affect the maps and decisions made on their basis may include changes in corporate boundaries, changes in population, man-made and natural changes to the landscape, removal of vegetation, changes to hydrologic systems, construction of flood control facilities, and potential climate changes. These changes in the environment may increase or reduce the area susceptible to flooding.
- The level of detail studied and presented on the maps, as well as the boundaries of the area studied, depend on the type of flood hazard, the funding available, and the risk of flood damage at the time of the analysis. For instance, areas studied by approximate methods do not provide BFEs on the map, and some study areas are limited in extent.
- The maps do not necessarily identify all areas of flooding. For instance, drainages of small size, areas of localized ponding during storms, or areas where drainages are restricted by temporary or permanent structures may not be shown.
- The analytical process relies on many assumptions and incomplete data. Data used to construct the maps may be too old, incomplete, interpolated, and/or inaccurate. For instance, in relatively flat floodplains, such as Coachella, small elevation errors in the topography can result in large errors in flood zone boundaries.
- One major drawback is the very short time period for which we have meteorological records. Research on some parts of southern California has shown slight climate fluctuations between wet and dry cycles have occurred since the late 1800s (Hereford and Longpre, 2009). Future global climate change is still intensely debated, but many scientists now believe even slight global warming could bring an increase in precipitation overall, although the specific effects on the Coachella region are not known.

- Long-term changes in the watershed or floodplain, primarily from man's encroachment, are even harder to predict. Even flood-control structures, such as berms and levees, can increase the flood risk to other areas. The design of high-density developments often requires taking drainages that used to be spread over a wide area and constricting them into narrow channels, thereby increasing the velocity and erosive power of the flow, and perhaps leading to overtopping. Consequently, there are clearly limitations in using hydrologic calculations based on past, imperfect records to predict the future.
- Larson (2009) also argues that the process of placing a line on a map (flood zone boundaries) conveys a sense of certainty about the risk to the public and policy makers that does not exist.

Flood Map Modernization Program. Because many flood maps and related products were outdated, FEMA started its Map Modernization Program in 2003 to reduce reliance on paper maps and transition to digital processes for distributing and reading flood maps. The program also includes collecting new flood data for unmapped areas. Based on funding limitations and feedback from stakeholders, FEMA changed its goals midway through the program. Rather than try to create digitized flood maps for the entire nation, it was decided to improve the accuracy of the newly updated maps by establishing two criteria: 1) a floodway boundary standard that would insure flood maps match the topographic data used (although use of the standard itself does not validate the accuracy of the topographic data); and 2) guidelines for determining whether an existing flood study is adequate for current use or if an updated study is needed. The adjusted goal was to have 65 percent of the continental U.S. land area and 92 percent of the population covered by digital maps by 2008 (National Research Council, 2009).

Risk MAP Program. With the Risk MAP Program approved in March 2009, FEMA is moving from simply portraying flood hazard zones on maps to more accurately communicating and assessing risk to the local community. Building on the digitized maps, FEMA developed a five-year plan to fill in data gaps, increase public awareness, increase their outreach on flood risks, support state and local agencies in risk-based mitigation planning, and provide an enhanced digital platform that improves communication and sharing of risk data. In 2011, FEMA started a multi-year project to improve their guidelines and standards for flood risk analysis and mapping, the goal being to bring better overall consistency, clarity, and efficiency to the mapping process. The result of this work was publication of a compendium document covering all standards applicable to the Risk MAP program (FEMA, 2013a). FEMA plans to issue updates to their mapping policies on a semi-annual basis (FEMA, 2014).

New Levee Analysis. FEMA considers accredited levees (levees that meet the requirements of Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations) to be those that protect the surrounding area from the 100-year flood. FEMA recently joined with the U.S. Army Corps of Engineers and engineering experts to review different technical approaches for analysis and modeling of flood hazards in the vicinity of levees, in order to more precisely identify SFHAs. Consequently, approval of non-accredited or provisionally accredited levees was put on hold, including those within Coachella, while the new methods of analysis were developed. In 2013, FEMA published a document outlining the new procedures for analyzing and mapping flood hazards on the landward side of non-accredited levees. The new methodology provides a more refined approach to mapping, based on recent advances in data collection, as well as hydrologic and hydraulic modeling (FEMA, 2013b).

3.1.6 Flood Zone Mapping in Coachella

As part of the National Flood Insurance Program, the potential for flooding in portions of the Coachella General Plan area has been analyzed through the Flood Insurance Study for Riverside County (FEMA, 2008a). The potential flood zones mapped by FEMA are published in Flood Insurance Rate Maps that were updated in 2008. The current FEMA flood zones for the General Plan area are illustrated on Plate 3-1. According to the FIRMs, the Coachellla Valley Stormwater Channel (Whitewater River) is the only part of the General Plan area that is classified as a 100-year flood zone.

Nevertheless, FEMA studies indicate a large part of the valley area still has a low to moderate risk of flooding. This could occur during an event stronger than the 100-year storm, may include areas that could be flooded with average depths of less than one foot during the 100-year storm, or problem areas too small to map. Other parts of Coachella are shown as outside of the 500-year flood zone. It should be noted that the eastern half of the General Plan area has not been studied by FEMA, and the flood hazard there, for insurance purposes, is undetermined.

In order to identify flood hazard areas in California that have not been mapped under the NFIP, the California Department of Water Resources (DWR) has initiated a program to provide communities and residents with information on potential flood hazard areas that are not currently regulated floodplains. The maps identify 100-year flood hazard areas by approximate means, without specific depths or other flood hazard data. The DWR mapping indicates portions of the area between the base of the mountains and the Coachella Canal are subject to flooding (shown on Plate 3-1). A berm (Eastside Dike) protecting the canal from hillside runoff also provides protection to valley properties west of the canal. The DWR mapping is broad-based and very general, consequently it should be used as a starting point by local agencies for mandating more detailed studies when and where developments are proposed.

3.1.7 Existing Flood Protection Measures

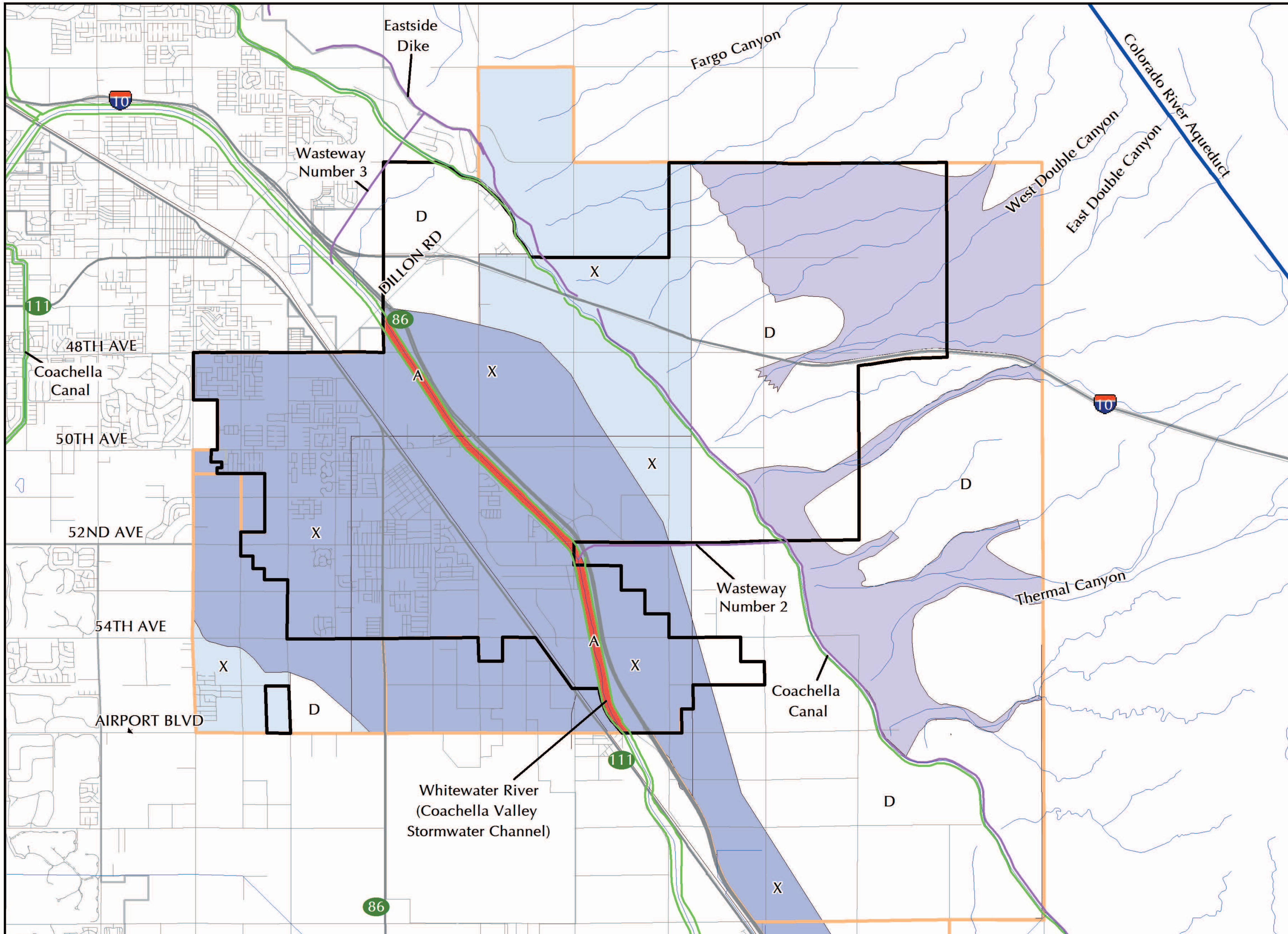
Coachella flood control facilities fall into two categories:

1. Regional facilities that convey runoff from the mountains to the Whitewater River. The river (also known as the Coachella Valley Stormwater Channel) and its major tributary facilities are maintained by the Coachella Valley Water District (CVWD). However, bridges, culverts, and low-flow crossings across the Coachella Valley Stormwater Channel are maintained by the cities and Riverside County.
2. Local facilities that collect runoff from streets and properties, and direct it to the regional channels and basins. These are usually maintained by the City within the incorporated area, or Riverside County in unincorporated areas.

Flood control facilities in the Coachella area are briefly described below and major regional structures are identified on Plate 3-1.

Coachella Valley Stormwater Channel: The Whitewater River is the principal drainage course through Coachella Valley, collecting runoff from the surrounding mountain ranges. It is typically dry, but flows southeasterly through the valley when carrying water. Approximately 25 miles of the Whitewater River, from Point Happy in La Quinta to the Salton Sea, is a man-made channel that roughly follows the recent historical path of the natural drainage. The channel is known throughout the valley as the Coachella Valley Stormwater Channel (in some publications it is referred to as the Whitewater River Storm Channel).

Flood Hazard Map
Coachella, California



NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.

Explanation

FEMA Flood Insurance Rate Zones

High Risk Areas

A — Zone that corresponds to the 100-year flood areas, as determined by approximate methods. Because detailed hydraulic analyses were not performed, no base flood elevations or depths are shown. Flood insurance is mandatory.

Moderate and Low Risk Areas

X — Zone that corresponds to areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood. No base flood elevations or depths are shown. Flood insurance is available but not required.

X — Zone that corresponds to areas outside of the 500-year flood. No base flood elevations or depths are shown. Flood insurance is available but not required.

Undetermined Risk Areas

D — Zone that corresponds to unstudied areas where flood hazards are undetermined, but flooding is possible. Flood insurance is available but not required.

DWR Awareness Floodplain Mapping

Area that corresponds to the 100-year flood hazard, as determined using approximate assessment procedures. These floodplains are shown simply as flood-prone areas without specific depths.

- Levee or Dike
- East Side Dike and Wasteways
- Drainage Course
- Coachella City Boundary
- Coachella Planning Area Boundary

* For elevations or depths see original FEMA Flood Insurance Rate Maps available at the City, County, or www.fema.gov.

N
W E
S

Scale: 1:72,000

6000 0 6000
Feet
2000 0 2000
Meters

Base Map: City of Coachella
Sources: California Department of Water Resources (2006) and Federal Emergency Management Agency, Riverside County, Flood Insurance Rate Maps (Panel Numbers: 06065C2254G, 06065C2260G, 06065C2262G, 06065C2270G).

Earth Consultants International

Project Number: 3106/3218
Date: 2014

Plate 3-1

In addition to its main purpose of collecting stormwater, the Coachella Valley Stormwater Channel also receives treated wastewater and agricultural runoff. The channel is mostly unlined with an average cross-section width of about 260 feet, however within the General Plan area, the southwestern slope of the channel is lined with reinforced concrete from the City of La Quinta south to Avenue 54. The concrete slope protection is designed to contain the 100-year storm with three feet of freeboard (FEMA standard) and the Standard Project Flood (CVWD standard) with one foot of freeboard. The northeastern bank of the channel, from the Monroe Street crossing to the Salton Sea is not lined.

FEMA (2008a) indicates there is a potential for a major breakout of the Whitewater River during a 100-year storm at the bend in the river between Jefferson Street and Miles Avenue (within the city of Indio), where the man-made channel deviates from the natural watercourse. FEMA attributes this to the lack of sufficient channel capacity at that point and the erodibility of the levee at the bend. A breakout would result in a 50 percent loss of channel capacity and send floodwaters throughout the cities of Indio and Coachella.

Figure 3-2: Coachella Valley Stormwater Channel.
The Whitewater River's course through Coachella is confined to this broad, soft-bottom channel. The western bank of the channel is reinforced with concrete north of Avenue 54. This view, looking north from Avenue 50, shows the sand levees along the channel and concrete facing on the western bank.

Levees constructed of large sandpiles with no reinforcement occur along both sides of the channel (see Plate 3-1). The levees are easily eroded and require periodic maintenance. According to the most recent (August 2008b) FIRMs, and the CVWD, the levees along the Whitewater River that protect Coachella from the 100-year flood are currently not accredited. Detailed hydraulic analyses, based on the new FEMA procedures, were performed by the CVWD for the reach extending from the Monroe Street bridge (in the city of Indio) to the Salton Sea. The result of these analyses indicated areas adjacent to channel, from just north of Airport Boulevard (Avenue 56) to the south, are susceptible to inundation from a levee breach or overtopping during a 100-year flood event. The CVWD is currently working with FEMA and the local impacted communities, forming a Local Levee Partnership Team. These efforts should allow channel improvements to move forward, ultimately resulting in the revision of FEMA maps (T. Demissie, Associate Engineer with the CVWD, personal communication via email, 2014).

FEMA points out that because these structures are potentially at risk of overtopping or failure, citizens, community officials, builders, insurance agents, lenders, and others need to understand the risk to life and property posed to land near to, but behind these levees. This is a risk that even the best flood control system cannot completely eliminate. Communities traversed by these flood-protection facilities are well-served by having evacuation plans in place, and property owners adjacent to these structures are encouraged to purchase flood insurance.

Eastside Dike: The Bureau of Reclamation constructed the Eastside Dike in the 1940s to protect the Coachella Canal by detaining runoff from the Mecca Hills, Indio Hills, and Little San Bernardino Mountains, and diverting it to the Coachella Valley Stormwater Channel (thereby protecting the valley area as well). North of Interstate 10, the earthen dike is located northeast of the canal, where it forms a detention basin with a capacity of 21,000 acre-feet. South of Interstate 10, the dike lies adjacent to the east side of the canal, forming a detention basin with a capacity of 18,000 acre-feet (Coachella Valley County Water District, 1967). In the city of Coachella area, two inlet structures allow water detained behind the dike to reach the Stormwater Channel via open, concrete-lined diversion channels. One of the channels is located at the northern edge of the General Plan area (Wasteway No. 3, see Plate 3-1), and one is present in the central part of the area, running parallel to Avenue 52 (Wasteway No. 2). The Eastside Dike and its diversion channels are maintained by the Coachella Valley Water District. The District is currently implementing plans to repair the wasteway channels in order to facilitate the flow of stormwater impounded behind the dike during floods, and to provide a way to drain the Coachella Canal during an emergency.

Agricultural Tile Drain System: Tile drain installations in the Coachella Valley were started in 1949 in order to lower the high water table created by the heavy application of irrigation water, and to drain the agricultural fields of excess water with high salt concentrations. The drain lines commonly consist of clay or concrete pipes surrounded by gravelly sand or pea gravel, and are laid out in a grid pattern, with spacing dependent on soil type, orientation of row crops, and locations of collector lines (Halsey and Marsh, 1967). The effectiveness of some drains has declined with age, resulting in crop damage. Today there are miles of tile drains on valley farms which are connected to an extensive collection system installed and maintained by the Coachella Valley Water District. Water from the drains is released into the Coachella Valley Stormwater Channel. Although their primary purpose is to lower the artificially high water table and remove salts in the water, the drains also capture some surface runoff. When future developments are planned in these agricultural areas, the drains need to be removed from the project area, while maintaining the integrity of the outfall system for the remaining farms. New drainage systems may need to be added. The CVWD will consider use of the existing drains for urban drainage if:

- The surface and subsurface drainage facilities can physically handle the new urban runoff;
- The area is incorporated into the National Pollutant Discharge Elimination System permit and Waste Discharge Requirements for the discharge of stormwater in the Whitewater River Watershed (known as the MS4 Permit);
- The project is annexed into a future district(s) for recovery of capital and operation/maintenance costs associated with the new urban drainage system.

Figure 3-3: Coachella Canal and Eastside Dike.
The Eastside Dike, the earthen berm shown in the upper left corner of the photo, protects the Coachella Canal from stormwater flowing out of the nearby hills and mountains.

Local Structures: Although the Coachella Valley Water District has as a goal to safely convey floodwaters from the mountains across the valley to the Salton Sea, rain that falls directly on incorporated or unincorporated areas is the responsibility of the local cities or the county. Currently, there is not a permanent, interconnected flood control system in the area, nor does the City or County have a comprehensive master drainage plan. Most stormwater passes through Coachella as surface flow, as there are very few underground structures (such as storm drains) and existing local structures are not tied to the Coachella Valley Stormwater Channel. As a consequence, the city experiences localized, periodic flooding of downtown streets. Furthermore, streets in the older parts of the city have very slow drainage, which occasionally results in runoff water ponding at some locations for days after a storm.

3.1.8 Future Flood Protection

Improvement and additions to regional structures are the responsibility of the CVWD. In addition to improvements to the Coachella Valley Stormwater Channel and levees, the CVWD is currently preparing a Stormwater Master Plan for the Eastern Coachella Valley, a document that will address regional flooding and valley floor drainage. This study should help identify areas subject to flooding, both within and upstream of the city of Coachella that are not currently shown on the FEMA maps.

The City of Coachella is also currently working on a Storm Drain Master Plan that will identify areas of poor drainage. The Plan will guide the future development of structures that will help mitigate local flooding problems.

Developers of new construction projects are responsible for the planning, design, and construction of local flood control facilities, as determined by development agreements. Flood control guidelines and requirements for new construction in the City of Coachella are spelled out in the City's Municipal Code, Title 15, Chapter 15.56, and in the City's Standard Specifications and Standard Drawings. Design of flood control structures is based on the Riverside County Flood Control Manual and hydrology reports must be prepared in accordance with requirements of the Riverside County Flood Control District.

As new developments are considered, it is important that hydrologic studies be conducted to assess the impact that increased development may have on the existing development down gradient. These studies should quantify the effects of increased runoff and alterations to natural stream courses. Such constraints should be identified and analyzed during the earliest stages of planning. If any deficiencies are identified, the project proponent needs to prove that these can be mitigated to a satisfactory level prior to proceeding forward with the project, in accordance with California Environmental Quality Act (CEQA) guidelines. Mitigation measures typically include flood-control devices such as catch basins, storm drain pipelines, culverts, detention basins, dry wells, desilting basins, and velocity reducers, in addition to debris basins for protection from mud and debris flows below hillside areas.

In general, existing tributary drainages must be able to flow around or through a newly developed site without adversely impacting adjacent or downstream properties. Further, all runoff within a developed site must be contained within the property. This usually requires the construction of shallow retention basins and dry wells. Drainage on the project site should be designed to flow toward low-lying permeable areas for infiltration. New developments must also consider and make provisions for any disruptions to the extensive network of agricultural tile drains.

Hydrology studies and proposed flood control measures are reviewed by the City, the CVWD, and the Riverside County Flood Control District. In order to achieve effective flood control for the City and its neighbors, all agencies must be involved in the planning and approval of mitigation measures, to assure compatibility.

Across the United States, substantial changes in the philosophy, methodology and mitigation of flood hazards are currently in the works. For example:

- Some researchers have questioned whether or not the current methodology for evaluating average flood recurrence intervals is still valid, since we are presently experiencing a different, warmer and wetter climate. Even small changes in climate can cause large changes in flood magnitude (Gosnold et al., 2000).
- Flood control in undeveloped areas should not occur at the expense of environmental degradation. Certain aspects of flooding are beneficial and are an important component of the natural processes that affect regions far from the particular area of interest. For instance, lining major channels with concrete reduces the area of recharge to the underlying groundwater table. Thus there is a move to leave nature in charge of flood control. The advantages include lower cost, preservation of wildlife habitats and improved recreation potential.
- Floodway management design in land development projects can also include areas where stream courses are left natural or as developed open space, such as parks or golf courses. Where flood control structures are unavoidable, they are often designed with a softer appearance that blends in with the surrounding environment.
- Environmental legislation is increasingly coming in conflict with flood control programs. Under the authority of the Federal Clean Water Act and the Federal Endangered

Species Act, development and maintenance of flood control facilities has been complicated by the regulatory activities of several Federal agencies including the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service. For instance, FEMA requires that the County and incorporated cities therein maintain the carrying capacity of all flood control facilities and floodways. However, this requirement can conflict with mandates from the U.S. Fish and Wildlife Service regarding maintaining the habitat of endangered or threatened species. Furthermore, the permitting process required by the Federal agencies is lengthy, and can last several months to years. Yet, if the floodways are not cleared of vegetation and other obstructing debris in a timely manner, future flooding of adjacent areas could develop.

As the population of Coachella grows, the consequences of flooding are likely to increase. In light of the uncertainties with respect to estimating floods, land use planning in the City and the General Plan area in general could benefit from additional mapping in undeveloped areas, a conservative approach to permitting, and a strong adherence to an area-wide, long-term vision for flood safety as individual projects are considered.

3.1.9 Flood Protection Measures for Property Owners

As discussed above, flooding remains a risk locally, especially in areas of future development where adequate mapping of the flood hazard is incomplete. Mitigation measures that can reduce the flood hazard are discussed below.

At the Community Level:

- Continue the enforcement of the County's provisions for flood hazard reduction, tract drainage, and storm water management (Ordinance Nos. 458, 460, and 754) and the City's flood hazard and floodplain regulations (Municipal Code Chapter 15.56). These regulations include construction standards that address the major causes of flood damage – i.e., structures that are not adequately elevated, flood-proofed, or otherwise protected from flooding. The regulations apply to new construction or substantial improvements, and include provisions for anchoring, placement of utilities, elevating the lowest floors, flood-resistant materials, and other methods to minimize damage.
- Map flood problem areas too small or currently outside of FEMA mapped areas.
- Because most of the General Plan area is still undeveloped or used as farmland, there is an opportunity to develop a comprehensive outline for drainage that would then be used as a guideline as the City is built out in the future.
- FEMA recommends that communities be proactive in protecting lives and preventing property damage in areas with provisional structures (such as levees and dikes), due to the risk of overtopping or failure of these structures. This might include having evacuation plans in place and encouraging residents and businesses to buy flood insurance.
- Encourage residents to purchase flood insurance for areas outside of the 100-year flood zone.
- Develop methods to conduct real-time storm warnings and evacuations if necessary.
- Continue to educate the public on the risks of flooding, including the uncertainties inherent in flood hazard zoning.
- Establish easements for entrenched flow paths.
- Create flood overlays for zoning and land use maps.

- Create an atmosphere of working with nature and the natural processes inherent to the semi-arid environment characteristic of this area.

For Property Owners:

- Elevate new homes on pads, foundations, or piers in flood-prone areas.
- Orient new homes and pads to provide minimum obstruction to the direction of flow, and do not force flows onto adjacent properties.
- Try to accommodate natural flows rather than restricting them.
- Any grading to direct flow around a home or structure should include directing it back to its natural path downstream.
- Protect foundations or piers from erosion and scour.
- Numerous methods are available for flood protection – which methods are most appropriate for an individual lot should be based on the local conditions surrounding and upstream from the lot.
- Some lots may require special engineering studies to determine the extent of the hazard and to design appropriate mitigation.

FEMA has identified several flood protection measures that can be implemented by property owners to reduce flood damage. These include: installing waterproof veneers on the exterior walls of buildings; putting seals on all openings, including doors, to prevent the entry of water; raising electrical components above the anticipated water level; and installing backflow valves that prevent sewage from backing up into the house through the drainpipes. Obviously, these changes vary in complexity and cost, and some need to be carried out only by a professional licensed contractor. For additional information and ideas, refer to the FEMA web page at www.fema.gov (and links therein such as http://www.fema.gov/small-business-toolkit/protect-your-property-or-business-disaster). Structural modifications require a permit from the City or County Building Departments. Refer to them for advice regarding whether or not flood protection measures would be appropriate for your property.

3.1.10 Bridge Scour and Flood Channel Crossings

Nationwide, several catastrophic collapses of highway and railroad bridges due to scouring and a subsequent loss of support of foundations have occurred. This has led to a nationwide inventory and evaluation of bridges (Richardson and others, 1993). Scour at highway bridges involves sediment-transport and erosion processes that cause streambed material to be removed from the bridge vicinity. Scour is generally separated into components of pier scour, abutment scour, and contraction scour. Pier scour occurs when flow impinges against the upstream side of the pier, forcing the flow in a downward direction and causing scour of the streambed adjacent to the pier. Abutment scour happens when flow impinges against the abutment, causing the flow to change direction and mix with adjacent main-channel flow, resulting in scouring forces near the abutment toe. Contraction scour occurs when flood flow is forced back through a narrower opening at the bridge, where an increase in velocity can produce scour. Total scour for a particular site is the combined effects of each component. While different materials scour at different rates, the ultimate scour attained for different materials is similar and depends mainly on the duration of peak streamflow acting on the material (Lagasse and others, 1991). Scour can occur within the main channel, on the floodplain, or both. California's seismic retrofit program of bridges includes underpinning of foundations that is expected to help reduce the vulnerability to undermining of the foundations by scour..

Figure 3-4: Bridge Crossing the Coachella Valley Stormwater Channel (Whitewater River) at Dillon Road

Dillon Road, Avenue 50, Avenue 52, and Airport Boulevard (Avenue 56) are Coachella's only crossings of the Coachella Valley Stormwater Channel. Except for Avenue 50, these crossings consist of bridges over the channel. The roadway for Avenue 50 dips into the channel and is impassable when the channel is flooded. Highway 111 (Grapefruit Boulevard) and the Southern Pacific Railroad tracks cross the channel just south of Coachella. In December 1966, one of the most damaging storms on record hit the valley. Although water remained within the channel banks, the channel bed from Airport Road south to Avenue 60 was scoured so deeply it caused damage to the Airport Road bridge, threatened the stability of Highway 111, and exposed about three feet of the pile footing under the railroad bridge piers (Coachella Valley County Water District, 1967). Again, in January-February of 1969, a series of strong storms damaged roads, storm channel crossings and railroad bridges. The rail bridge and Highway 111 bridge south of Thermal were washed out, as was the Airport Road bridge just east of Thermal. In fact, between Palm Springs and the Salton Sea, the only usable crossings remaining were the Highway 86 (Indio Boulevard) bridge and the rail crossing west of Indio. It is thus very important that these crossings continue to be inspected by the City's Public Works Department, during and after flooding, for obstructions and potential scour damage.

The city's current Capital Improvement Program includes a new bridge which will replace the dry weather crossing at Avenue 50. This will allow another safe crossing of the channel during storms.

Figure 3-5: Proposed Location of New Bridge.
The city of Coachella is currently planning a bridge for the Avenue 50 dry-weather crossing.

3.2 Seismically Induced Inundation

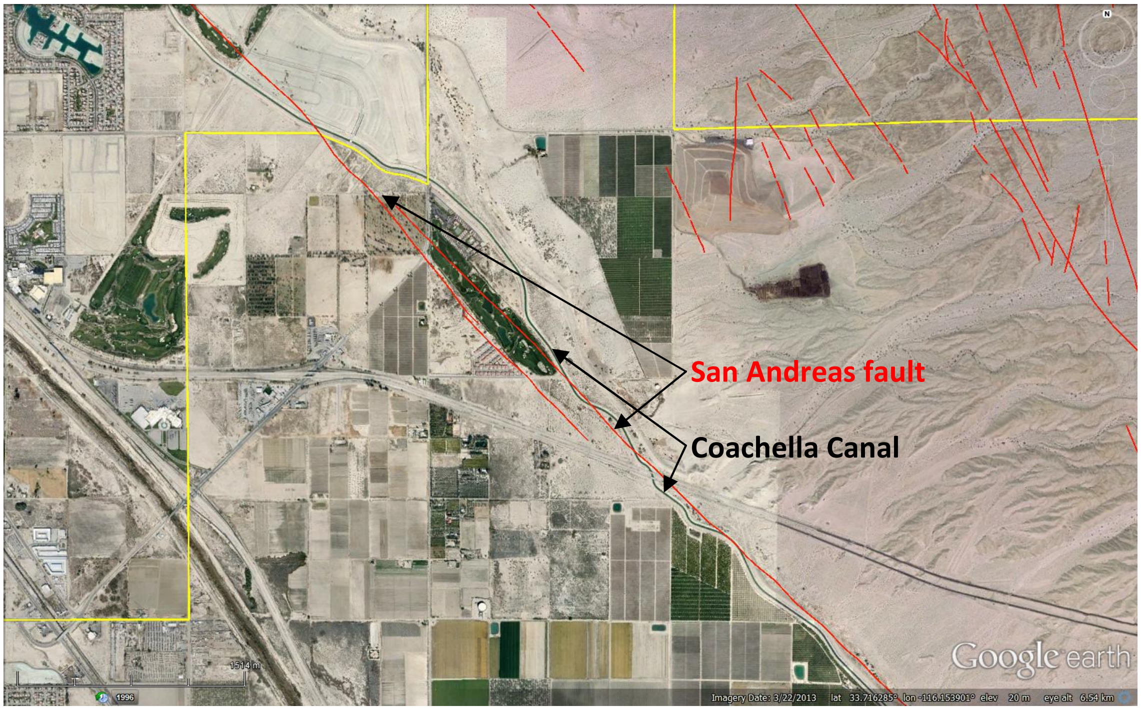
3.2 1 Dam or Levee Failure

Seismically induced inundation refers to flooding that results when water retention structures, such as dams, fail due to an earthquake. Statutes governing dam safety are defined in Division 3 of the California State Water Code (California Department of Water Resources, 1986). These statutes empower the California Division of Safety of Dams to monitor the structural safety of dams that are greater than 25 feet in height or have more than 50 acre-feet of storage capacity. A review of records maintained by the California Office of Emergency Services indicates that there are no existing dams with the potential to inundate Coachella.

Nevertheless, there are water-retaining structures in Coachella not under the jurisdiction of the California Division of Safety of Dams. Local flooding associated with failure of the Coachella Canal, the Eastside Dike, or the Coachella Valley Stormwater Channel levees, remains a risk for the people of Coachella. The channel's levee system and/or the canal could be impacted by a severe earthquake, with the potential for the foundation soils to fail as a result of lateral spreading (see Chapter 1, Section 1.6). Liquefaction and lateral spreading damaged Imperial Valley canals during earthquakes in 1979 and 1987, and more recently, as a result of the Easter Sunday (Sierra El Mayor-Cucapah) earthquake of 2010. Field reconnaissance of the Imperial Valley canal following the 2010 earthquake showed that there was significant slumping and lateral spreading along the canals, although none of them failed, and there were no reports of flooding as a result of slumping of the canal levees. However, these damages were the result of an earthquake many miles to the south, with the damage the result of shaking-induced lateral spreading, and not the result of surface fault rupture.

Within the City, the Coachella Canal is especially vulnerable to primary fault rupture, as its alignment nearly coincides with the trace of the San Andreas fault – a condition considerably more severe than a high-angle fault crossing (see Figure 3-6 and Chapter 1, Section 1.5). The 2008 USGS ShakeOut Scenario estimates that rupture by offset of the canal would likely occur in at least three places, resulting in flooding of valley areas to the southwest. Immediate offset could be on the order of 7.2 to 15.7 feet (2.2 to 4.8 meters), with an additional afterslip of 5.9 to 10.8 feet (1.8 to 3.2 meters), which is likely to hamper repairs of the damaged canal (Jones et al., 2008).

Figure 3-6: Crossings of the Coachella Canal by the San Andreas Fault.
Faults in red. Compare this Figure with Plate 1-2.



In anticipation of a major earthquake, the Coachella Valley Water District has a comprehensive Emergency Response Plan in place that includes the canal system. They have also participated in Shakeout drills that include simulated earthquake damage and practiced response to a break in the canal. The only structures within the canal system that are seismically designed are the siphon under-crossings. Additional information regarding the potential impacts to the potable water system as a result of an earthquake on the San Andreas fault is provided in Chapter 1, Section 1.9.6.

Other regional aqueducts that deliver imported water to many parts of southern California, including the Colorado River Aqueduct, are likely to suffer extensive damage if a major earthquake occurs on either the San Andreas fault or other nearby active faults. Repairs to these aqueducts could take weeks to months (Toppozada et al., 1993; Jones et al., 2008).

The canal and Eastside Dike diversion channels in the city are also subject to seiches (sloshing of water back and forth) during an earthquake, which in itself can damage containment structures such as levees and berms.

3.2.2 Inundation From Above-Ground Storage Tanks

Seismically induced inundation can also occur if strong ground shaking causes structural damage to above-ground water tanks. If a tank is not adequately braced and baffled, sloshing water can lift a water tank off its foundation, splitting the shell, damaging the roof, and bulging the bottom of the tank (causing what is referred to as "elephant's foot") (EERI, 1992). Movement can also shear off the pipes leading to the tank, releasing water through the broken connections. These types of damage were reported as a result of the 1992 Landers, 1992 Big Bear, 1994 Northridge, and 2010 Sierra El Mayor-Cucapah (Baja California) earthquakes. The Northridge earthquake alone rendered about 40 steel tanks non-functional (EERI, 1995), including a tank in the Santa Clarita area that failed and inundated several houses below. As a result of lessons learned from the 1992 and 1994 earthquakes, revised standards for design of steel water tanks were adopted in 1994 (Lund, 1994). The revised tank design includes flexible joints at the inlet/outlet connections to accommodate movement in any direction.

The City of Coachella has three above-ground water reservoirs in the General Plan area. The newest tank, located at Well 18, is the only one constructed to current seismic standards. All tanks have isolation valves. The only above-ground reservoir in the Coachella General Plan area owned by the Coachella Valley Water District is located in their Coachella yard. It is an older tank that has not been retrofitted. The District is currently evaluating whether to upgrade or demolish the facility.

Figure 3-7: View of One of the Above-ground Water Tanks in the Coachella General Plan Area

Table 3-3: Above-ground Water Tanks Owned by the City of Coachella Water Department

Reservoir	Type	Year Built	Capacity (millions of gallons)	Seismic Upgrades	Containment/ Diversion Structures
Dillon	Steel	1971	1.5	No	No
Mecca	Steel	1987	3.0	No	No
Well 18	Steel	2007	5.0	Yes	No

Water lost from tanks during an earthquake can affect not only structures down slope from the tanks, but can significantly reduce the water resources available to suppress earthquake-induced fires. Damaged tanks and water mains can also limit the amount of water available to residents. Similar damage can be expected to the groundwater wells in the region, further limiting the water available to the community after an earthquake. Therefore, it is of paramount importance that the water storage tanks in the area retain their structural integrity during an earthquake, so water demands after an earthquake can be met. In addition to evaluating and retrofitting water reservoirs to meet current standards, this also requires that the tanks be kept at or near full capacity at all times.

3.3 Loss Estimation Analyses Using HazUS

HazUS is a regional multi-hazard loss estimation model developed by FEMA and the National Institute of Building Sciences. The primary purpose of HazUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. Local, state and regional officials can use these loss estimates to evaluate the area's vulnerability to multi-hazards and prepare for emergency response and recovery. Additional information regarding HazUS, including its uses and limitations, is provided in Chapter 1, Section 1.9. Unlike the earthquake analyses, where HazUS uses census tracts as the smallest areal unit of study, for flood analyses, HazUS uses census blocks. The geographical size of the region analyzed is nearly 62.5 square miles (see Figure 1-6); this region contains 521 census blocks (in 7 census tracts).

The flood analysis was conducted using a digital version of the 500-year flood zone shown on the Flood Insurance Rate Map presented on Plate 3-1 as a "user-supplied hazard" that was converted to a HazUS compatible format. We used HazUS to generate building stock and essential facility loss estimates for a 0.2 percent annual chance flood event (500-year flood) on the Whitewater River, with average water depths of 1 foot. The 500-year flood was chosen because the 100-year flood event would be mostly confined to the channel of the Whitewater River, whereas the 500-year flood event, while a lot less likely, would impact a significant part of the community. The results of the analysis are presented in the sections below.

The HazUS analysis conducted for Coachella uses the enhanced building stock data and essential facilities compiled for Riverside County by MMI Engineering and ABSG Consulting Inc. for the Riverside County Essential Facilities Risk Assessment (RCEFRA) Project (MAP IX – Mainland, 2009). The enhanced data used include parcel data for single-family homes, apartment and condominiums, hotels/motels and agricultural properties that replace the basic, "out-of-the-box" default inventory provided with HazUS. Parcel data for mobile homes obtained for the RCEFRA project was used to supplement the HazUS default inventory. Essential facility data were provided by the facilities themselves. Use of these data is expected to yield more accurate results than the default data, however, the numbers generated should still be considered generalized and used with caution. The results do provide an estimate of the risk, and this information can be used to develop realistic disaster mitigation plans, hazard mitigation grant applications, and to design emergency response exercises (MAP IX – Mainland, 2009).

3.3.1 Building-Related Losses

There are an estimated 9,000 households in this region, and 16,000 buildings with a total replacement value, excluding contents, of $3,743 million (in 2006 dollars). More than 90 percent of the buildings, and 85.6 percent of the building value, is associated with residential housing. The building exposure by occupancy type for the scenario considered is summarized in Table 3-4, and the expected building damage, by both occupancy and building type, is presented in Tables 3-5 and 3-6, respectively. The damage is measured as a percent of the replacement cost. Specifically, if the damage amounts to between 1 and 10 percent of the replacement cost, the damage is considered slight, whereas 11 to 50 percent damage is considered moderate. If a building suffers damage exceeding 50 percent of its replacement cost, it is considered substantially damaged. These buildings would be considered unsafe for continued occupancy and would be "red-tagged."

Table 3-4: Building Exposure by Occupancy Type for the Flood Scenario

Scenario	Whitewater River (500-Year Flood)	
Occupancy	**Exposure ($1,000)**	**Percent of Total**
Residential	1,142,490	78.0
Commercial	130,798	8.9
Industrial	21,961	1.5
Agricultural	71,367	4.9
Religion	9,254	0.6
Government	2,463	0.2
Education	86,275	5.9
Total	**1,464,608**	**100**

Tables 3-5 and 3-6 show that a 500-year flood in the Whitewater River is not anticipated to completely destroy any buildings in Coachella. However, the 500-year flood is anticipated to cause minor to moderate damage to nearly 2,360 residential structures in the region, with nearly 1,500 of these experiencing about 20 to 30 percent damage, and 283 structures experiencing more than 40 percent damage. The 2,348 damaged structures amount to more than 37 percent of the total number of buildings considered in the scenario. A comparison of Tables 3-5 and 3-6 shows that the residential structures anticipated to experience the most damage are all manufactured housing (i.e., mobile homes).

Table 3-5: Expected Building Damage by Occupancy Type

Flood Scenario	Occupancy	1-10 Count	11-20 Count	21-30 Count	31-40 Count	41-50 Count	Substantially Count
500-Year Flood Whitewater River	Agriculture	211	0	0	0	0	0
	Commercial	120	57	0	0	0	0
	Education	145	0	0	0	0	0
	Government	5	0	0	0	0	0
	Industrial	6	3	27	0	0	0
	Religion	11	0	0	0	0	0
	Residential	98	529	1,449	0	283	0
	Total	**596**	**589**	**1,476**	**0**	**283**	**0**

Table 3-6: Expected Building Damage by Building Type

Scenario	Building Type	1-10 Count	11-20 Count	21-30 Count	31-40 Count	41-50 Count	Substantially Count
500-Year Flood Whitewater River	Concrete	113	5	0	0	0	0
	Manufactured Housing	0	0	0	0	283	0
	Masonry	104	8	8	0	0	0
	Steel	108	0	0	0	0	0
	Wood	222	537	1,422	0	0	0

Building-related losses are broken into two categories: direct building losses and business interruption losses. Direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. Business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the flood. This includes loss of income for business owners, and loss of wages for employees of facilities impacted by the flood. Business interruption losses also include temporary living expenses and relocation expenses for those people displaced from their homes because of the flood.

Table 3-7: Building-Related Losses (in Millions of Dollars) as a Result of the Flood Scenario

Flood Scenario	Category	Area	Residential	Commercial	Industrial	Others	Total
500-Year Flood Whitewater River	Building Loss	Building	73.0	10.52	2.87	6.10	92.49
		Content	41.81	27.23	4.59	16.24	89.87
		Inventory	0.00	0.63	1.14	1.53	3.30
		Subtotal	114.81	38.37	8.60	23.88	185.66
	Business Interruption	Income	0.01	0.26	0.00	0.14	0.40
		Relocation	0.57	0.07	0.00	0.05	0.69
		Rental Income	0.16	0.04	0.00	0.00	0.20
		Wage	0.03	0.23	0.00	0.39	0.65
		Subtotal	0.76	38.97	0.00	0.57	1.93
	Totals		**115.57**	**38.97**	**8.60**	**24.45**	**187.59**

The HazUS analysis estimates that the 500-year flood event in the Whitewater River will generate $187.59 million in building-related losses in the Coachella General Plan area, with approximately 1 percent of this figure related to business interruption. The total economic loss represents 12.8 percent of the total replacement value of the buildings considered in the analysis. Residential occupancies make up 61.6 percent of the total loss. Table 3-7 shows the estimated building-related losses by categories that this flood event is estimated to generate in the study area.

3.3.2 Debris Generation

HazUS estimates the amount of debris that will be generated by a given flood. The model breaks debris into three general categories:

1. finishes (dry wall, insulation, etc.),
2. structural (wood, brick, etc.), and
3. foundation (concrete slab, concrete block, rebar, etc.). These distinctions are made because of the different types of equipment required to handle the debris. The HazUS estimates of debris that will be generated by the flood scenario considered for this study are presented in Table 3-8.

The model estimates that a 500-year flood event in the Whitewater River will generate 18,266 tons of debris with 100 percent of that consisting of finishes (dry wall, insulation, and like materials). This amounts to approximately 731 truckloads (at 25 tons per truckload) needed to remove this debris from the study area.

Table 3-8: Debris Generated by Flood Scenarios (in Tons)

Flood Scenario	Category of Debris Generated			Truckloads Required to Clean Debris
	Finishes	Structural	Foundation	
500-Year Whitewater River	18,266	0	0	731

3.3.3 Shelter Needs

HazUS estimates the number of households expected to be displaced from their homes due to the flood and the associated potential evacuation. HazUS also estimates those displaced people that will require accommodations in temporary public shelters. The results of the HazUS analysis for the 500-year flood event modeled for this study are presented in Table 3-9.

Table 3-9: Shelter Requirements Due to Flooding Scenarios

Flood Scenario	# Households Displaced	# of People that will Look for Shelter in Public Shelters
500-Year Whitewater River	10,558	30,348

3.3.4 Expected Damage to Essential Facilities

Essential facilities in these scenarios include hospitals, fire stations, police stations, emergency operation centers, hospitals, and schools. The essential facilities in the study area considered in the analysis include zero (0) hospitals, three fire stations, 366 school buildings, two police stations and one emergency operation center. The Coachella Emergency Operations Center is located at 53-462 Enterprise Way, in a dedicated room on the second floor of the City's Corporate Yard facility.

The results presented in Table 3-10 show the number of essential facilities that will experience at least moderate damage as a result of the flooding scenario considered. The model suggests that one of the fire stations and the 2 police stations in the study area will experience at least moderate damage. Approximately 145 school buildings are also estimated to experience at least moderate damage. However, none of these damaged facilities are expected to experience loss of use.

Table 3-10: Estimated Damage to Essential Facilities as a Result of the 500-Year Flood Scenario

Flood Scenario	Classification	Total	No. of Facilities		
			At Least Moderate Damage	At Least Substantial Damage	Loss of Use
500-Year Whitewater River	Fire Stations	3	1	0	0
	Police Stations	2	2	0	0
	School Buildings	366	145	0	0
	Emergency Operations Center	1	0	0	0

3.4 Summary

The Coachella Valley Water District, the agency in charge of regional flood control, has been proactive is protecting the valley areas from the significant flooding that occurred in the last century. Further, based on new FEMA guidelines, the Coachella Valley Water District, impacted communities, and FEMA have formed a partnership with the goal of improving the regional flood hazard from the Coachella Valley Stormwater Channel and obtaining accreditation for the levees. In addition, the District is currently preparing a Stormwater Master Plan for the eastern Coachella Valley, and the City of Coachella is developing a Storm Drain Master Plan to identify local problem areas and plan future flood control projects.

Currently, except for the Coachella Valley Stormwater Channel, no parts of the General Plan area identified as within a FEMA Special Flood Hazard Zone, thereby mandating property owners to purchase flood insurance. Nevertheless, a number of flood risks remain:

- Large portions of the General Plan area have not been mapped by FEMA, consequently the flood hazard in these areas has not been identified and evaluated.
- A significant portion of Coachella is zoned by FEMA as having a moderate flood hazard, meaning this area may be flooded during a storm stronger than the 100-year event, or subject to shallow flooding during a 100-year storm.
- A low-probability but possible 500-year flood event is estimated to cause significant losses in the city, with approximately 37 percent of the buildings in the area at least moderately damaged. Given the large area within the 500-year flood, nearly 70 percent of the city's population may be temporarily displaced.
- Levees forming the Coachella Valley Stormwater Channel are not accredited by FEMA, indicating the impacts of levee failure or overtopping have not been mitigated.
- Areas within the city are subject to localized flooding, due most commonly to the lack of adequate storm drains or the lack of temporary retention facilities.
- Unpredictable local flooding can also occur during storms if catch basins or inlets are clogged with debris.
- The areas near the Coachella Valley Stormwater Channel and the Wasteway Channels could be inundated if the channels were breached (while containing water) during a severe earthquake.
- The Eastside Dike that protects the Coachella Canal also provides significant flood protection to Coachella's valley area. However, the hillside areas northeast of the dike are subject to flooding and debris flows.

- The valley area southwest of the Coachella Canal is at risk of inundation if the canal is offset by a major ground-rupturing earthquake on this section of the San Andreas fault. Areas around and downgradient of the older water tanks may also be at risk if the tanks or associated piping rupture during a strong earthquake.

For the reasons discussed above, FEMA encourages property owners outside of the Special Flood Hazard Areas to purchase flood insurance. Further, the City should have evacuation plans in place in the event of a levee or dike failure. This is especially important for critical facilities such as schools. This also true for facilities using, storing, or otherwise dealing with substantial quantities of onsite hazardous materials, unless all requirements for elevation, anchoring, and flood proofing have been met. Hazardous materials should always be stored in watertight containers that are not capable of floating.

Given the anticipated extensive damage to the regional potable water system (including aqueducts, water mains, and distribution lines) resulting from a large-magnitude earthquake on the San Andreas fault, it is very important that the water storage tanks in the area remain structurally sound, and that they be maintained as full of water as possible. Thus, even if the water distribution pipelines are damaged, the City would have access to stored water that can be distributed to the community using water trucks or other similar methods, at least until water can be imported while the pipelines are repaired.

The City should continue to require that future planning for new developments consider the impact on flooding potential, as well as the impact of flood control structures on the environment, both locally and regionally. Flood control should not be introduced in the undeveloped areas at the expense of environmental degradation. Land development planning should continue to consider leaving watercourses natural wherever possible, or continuing to develop them as parks, nature trails, golf courses or other types of recreation areas that can withstand inundation.

CHAPTER 4: FIRE HAZARDS

4.1 Vegetation Fires

Wildfires are a significant hazard throughout the United States, and especially in the West, where they occur often. Large areas of southern California are particularly susceptible to wildfire due to the region's weather, topography and native vegetation. The typically mild, wet winters characteristic of our Mediterranean climate result in an annual growth of grasses and plants that dry out during the hot summer months. This dry vegetation provides fuel for wildfires in the autumn. Although wildfires are often considered highly disruptive and even dangerous, the fact is that wildland fires are a necessary part of the natural ecosystem of many parts of southern California, and have been part of the natural environment for millennia. Many of the native plants require periodic burning to germinate and recycle nutrients that enrich the soils. Native Americans took advantage of this, and used fire extensively to control their environment by enhancing feed for wildlife, decreasing insects and pests that impact wild foods, increasing the abundance and density of edible tubers, greens and other useful plants, and clearing underbrush to ease travel and provide increased visibility (Anderson, 2006).

Wildfires become a hazard when they extend out of control into developed areas, with a resultant loss of property, and sometimes, unfortunately, loss of life. The wildfire risk in the United States has increased in the last few decades with the increasing encroachment of residences and other structures into the wildland environment, and the increasing number of people living and playing in wildland areas. The National Interagency Fire Center estimates that approximately 15 percent of all wildland fires in the United States are started by lightning strikes, with humans causing the rest. The most common human causes of wildfires are arson, sparks from brush-clearing equipment and vehicles, improperly maintained campfires, improperly disposed cigarettes, and children playing with matches.

As the 2003, 2006, 2007, 2009, and May 2014 fires in southern California have shown, the containment of wildfires that consume thousands to hundreds of thousands of acres of vegetated property require the participation of a multi-jurisdictional emergency response effort, with hundreds to thousands of people at or near the fire lines combating the flames, clearing brush ahead of the fire to establish defensible zones, and assisting evacuees (Figures 4-1 and 4-2). Under the right wind conditions, multiple ignitions can develop as a result of the wind transport of burning cinders (called **firebrands**) over distances of a mile or more. Wildfires in those areas where the wildland approaches or interfaces with the urban environment (referred to as the **wildland-urban interface** area or **WUI** area) can be particularly dangerous and complex, posing a severe threat to public and firefighter safety, and potentially causing devastating losses of life and property. This is because when a wildland fire encroaches onto the built environment, ignited structures can then sustain and transmit the fire from one building to the next. It has become increasingly clear that continuous planning, preparedness, and education are required to reduce the fire hazard and limit the destruction caused by fires. These mitigation measures are discussed in this document.

Wildland fires usually last a few hours to days, but their effects can last much longer, especially in the case of intense fires that develop in areas where large amounts of dry, combustible vegetation have been allowed to accumulate. If wildland fires are followed by a period of intense rainfall, debris flows emanating from the recently burned hillsides can develop. Studies (Cannon, 2001) suggest that in addition to rainfall and slope steepness, other factors that contribute to the formation of post-fire debris flows include the underlying rock or sediment type, the shape of the drainage basin, and the presence or absence of water-repellant soils (during a fire, the organic material in the soil may be burned off or decompose into water-repellent substances that prevents water from percolating into the soil.) Flood control facilities may be severely taxed by the increased flow from the denuded hillsides and the resulting debris that washes down. If this debris overwhelms the flood control structures, widespread damage can ensue in areas down gradient from the failed structures. As an example, in San Bernardino County 16 people died as a result of debris flows during the 2004 storms that followed the 2003 fire season. During the storms of 2010, the Los Angeles County Public Works Department and several cities had crews around the clock cleaning out the debris basins between the mountains and the communities at the foot of the 250-square-mile area that burned during the Station Fire. These efforts helped significantly in reducing the hazard of mudflows, although unfortunately nearly 50 homes were still seriously damaged in the communities of La Crescenta, La Canada Flintridge, and Acton.

Other effects of wildfires are economical and social. Homeowners who lose their house to a wildfire may take years to recover financially and emotionally. Recreational areas that have been affected may be forced to close or operate at a reduced scale. In addition, buildings destroyed by fire are usually eligible for re-assessment, which reduces income to local governments from property taxes. The impact of wildland fire on plant communities is generally beneficial, although it often takes time for plant communities to re-establish themselves. If a grassland area has been burned, it will re-sprout the following spring. Chaparral plant communities will take three to five years. Oak woodland, if it has had most of the seedlings and saplings destroyed by fire, will require at least five to ten years for a new crop to start. Desert plants, like cacti, typically take more than a decade to recover after a fire.

Figure 4-1: View of the Cedar Fire of October 2003 Moving Down Oak Canyon, Toward the 52 Freeway, in San Diego County.
This fire burned more than 273,000 acres, destroyed 2,820 structures, damaged 63 others, and caused 15 fatalities. The fire was cased by a signal flare set off by a lost hunter. This is the largest fire by acreage burned in California since at least 1932, when reliable records were first kept.

Figure 4-2: View of a Backfire to the Station Fire Behind Homes in La Crescenta.
The Station Fire burned 160,557 acres, 209 structures and caused 2 deaths. It is considered the 10th largest California fire by acreage burned (http://cdfdata.fire.ca.gov/incidents/incidents_statsevents). (Photograph by Jae C. Hong/AP Photo, taken on September 1, 2009).

4.1.1 Local Characteristics and History on Local Fires

The fire hazard of an area is typically based on the combined input of several parameters. These conditions include: 1) fuel loads – that is, the type of fuel or vegetation, and its density and continuity, 2) topography – elevation and slope, 3) weather, 4) wildfire history, 5) dwelling density, and 6) existing local mitigation measures that help reduce the area's fire hazard – such as fuel modification zones, fire-rated construction, fire hydrants, etc. The fuel loads, weather and wildfire history of the Coachella General Plan area are discussed further immediately below. Other aspects of the fire hazard equation, with emphasis on the fire risk areas mapped in the study region, and the fire suppression services available are discussed further in Sections 4.1.2 and 4.3, respectively.

4.1.1.1 Fuel Loads and Topography

Coachella is for the most part located in the Colorado Desert section of the Southeastern Deserts Bioregion (Brooks and Minnich, 2006). The Southeastern Deserts bioregion comprises about 27 percent of the land mass in California, and the Colorado Desert section comprises about 10 percent of that. The Deserts Bioregion is characterized by isolated mountain ranges separated by broad basins blanketed with alluvial fan, dune and playa deposits. This wide range in elevations and soil types results in a wide range of vegetation and fuel types. In its native state, the Colorado Desert section is characterized by low- to mid-size riparian vegetation, with desert scrub (including creosote bush scrub and desert saltbush scrub) being the predominant vegetation type (estimated at 57 percent by Brooks and Minnich, 2006). Barren areas, devoid of vegetation, are estimated to account for anywhere between about 40 percent and 90 percent of the acreage in this region (Brooks and Minnich, 2006; Crosswhite and Crosswhite, 1982). Unlike the primary vegetation types common in other bioregions of southern California, desert plants do not need fire to reproduce, and many of the native plants common to this area are highly susceptible to fire. Furthermore, native desert plant communities may take decades to re-establish after a fire, whereas non-native grasses are quick to invade burned areas, generally at the expense of the native plants.

In Coachella, however, most of the acreage within the Colorado Desert section is no longer in a natural state, as the native cover has been replaced by crops and urban development, or has been altered to varying degrees by road construction, introduction of invasive plant species, and other stressors. Pockets of native desert saltbush scrub, often intergrading with Sonoran creosote bush scrub have been reported along and to the west of the Coachella Canal. The saltbush scrub occurs in areas of moist, sandy loam soil with relatively high salinity, whereas the creosote bush scrub occurs on alluvial fans and low-gradient desert slopes, on coarse-grained, well-drained soils with lower salinity. Woody wetlands with denser stands of vegetation still occur primarily in the southern part of Coachella, just north of the Thermal airport (Bureau of Reclamation, 2006).

Figures 4-3a and 4-3b: Examples of Vegetation Cover in the Coachella Area.
Photo at left shows typical desert vegetation in the foreground, cultivated vegetation in the background. Photo at right shows dense stands of vegetation near the Whitewater River channel.

The hilly, far eastern section of the planning area, in the southeastern foothills of the San Bernardino Mountains, is placed by Keeley (2006) in a small outlier of the South Coast Bioregion. The South Coast Bioregion includes the highest peaks outside of the Sierra Nevada (the San Bernardino Mountains reach an elevation of more than 11,500 feet), although more than 50 percent of the area is at elevations below 1,600 feet. As with the deserts region, this range of elevations translates into a high diversity of vegetation types and fire regimes. In the Coachella area, vegetation series that have been reported along the Coachella Canal and in the hillsides to the east include tamarisk, catclaw acacia shrub, mesquite hummocks, and along the canyon bottoms and washes, Fremont cottonwood.

Mesquite hummocks, which are relatively large clumps of honey mesquite shrubs forming hummocks (hills) over sand fields and sand dunes, occur locally in the planning area, typically along or near the San Andreas fault (where not disturbed by the Coachella Canal) (Bureau of Reclamation, 2006). Furthermore, the San Andreas fault brings groundwater up to near the ground surface, forming isolated springs and seeps. These springs support stands of denser vegetation consisting of cottonwood and willows.

In southern California, the predominant vegetation types generally germinate after the first rains of spring, and dry up in the fall, when the weather is dry and hot. This dried-up vegetation provides fuel for wildfires (Photo 4-4). In the desert bioregion, the primary factor controlling fire occurrence and spread is fuel condition, especially fuel type and continuity. Since fuel continuity is generally low in the region, fires typically do not spread beyond their ignition points. In the currently developed portions of the City, vegetation fires are not considered a hazard given the low topographic relief and low fuel loads. In the areas developed as agricultural fields, the carefully maintained and regularly watered vegetation combine to mitigate the potential for wildfires. Vegetation fires in these areas are possible, typically the result of intentionally set brush and grass fires, but these tend to be small in area (typically less than one acre in size), and less intense in heat than dense brush and forest fires.

Figure 4-4: **Photo of a Wildfire in Thousand Palms**,
With Barren Areas Limiting the Fire Spread

Source: Photo of the Palm Fire of November 26, 2010, taken by Thousand Palms resident Mike Smith, from http://thousandpalms.kpsplocal2.com/content/palm-fire-90-contained-coachella-valley-preserve, article by Anne Hsu, Local 2 Mobile Journalist, dated Friday, November 26th, 2010, 10:33PM.

4.1.1.2 Weather

The Coachella General Plan area is arid. Annual temperatures in the Coachella Valley fluctuate significantly given the region's inland location, away from the stabilizing influence of the Pacific Ocean. Average minimum temperatures in the Indio-Coachella region, based on data collected at the Indio Fire Station for the 30 years between 1961 and 1990, range from 39.9 degrees Fahrenheit in January to 77.7 degrees in July; average maximum temperatures range from 71.8 degrees in January to 107.2 degrees in July (http://www.worldclimate.com/). Average annual precipitation in Coachella is a little over 3 inches (see Chapter 3, Section 3.1.2 for more details), with approximately 60 percent of the precipitation occurring in the winter months between November and February, and approximately 20 percent occurring in the late summer and early fall, between July and September. These summer storms typically approach from the south (from Mexico through Arizona, or from the Sea of Cortez or Baja California).

Both winter and summer thunderstorms that pass through southern California often include lightning. The deserts have the highest frequency of lighting than any other California bioregion. In the Colorado Desert, lightning averages 12 strikes per 100 square kilometers per year (based on Bureau of Land Management detection data by van Wagtendonk and Cayan, 2008, as reported in Brooks and Minnich, 2006). Most lightning in the desert occurs between July and September, and most occurs during daylight hours (Brooks and Minich, 2006). As discussed in the introduction, lightning is responsible for a significant percentage of the acreage burned by wildfires in the United States, although human-caused fires are far more common.

4.1.1.3 Wildfire History

According to data by the California Department of Forestry and Fire Protection (Cal Fire; http://frap.cdf.ca.gov/data/frapgismaps/download.asp), there have not been any large fires in the Coachella General Plan study area between 1900 and 2008. Three fires were mapped by Cal Fire to the south of Coachella, including a fire in 1981 that occurred approximately one mile south of the City limits, off Highway 86 (Harrison Street). The other two fires reported by Cal Fire south of the study area occurred in 1975 and 2008. This database, however, is incomplete, as the Cal Fire data typically do not include fires less than 10 acres in size. The National Oceanic and Aeronautic Agency (NOAA) maintains a database of wildland fires that, in the case of Riverside County, extends back to 1996 (in other areas, and for other hazards, the records may extend back to 1950). Several fires in the NOAA list are not in the Cal Fire database and vice-versa. Table 4-1 summarizes wildland fires reported in the Coachella Valley, including the city of Coachella, for the period between 1996 and January 2014, with data obtained both from the NOAA database and newspaper accounts.

Table 4-1: Wildland Fires Reported in the Coachella Valley and In and Near the City of Coachella, 1996 to January 2014

Date	Fire Description
January 21, 1999	Strong winds caused palm fronds to touch electrical power lines and ignite about 8 miles east-southeast of Mecca, near the intersection of Palm Island Drive and Highway 111. Wind gusts to 80 mph then fanned the flames into a 30-acre wildfire that affected the community of North Shore, destroying one house, a garage, small office building, one storage shed, two travel trailers, and eight vehicles. Several residents were evacuated and one family was left homeless. Property damage was estimated at $400k.
August 9, 1999	A wildfire was quickly spread by shifting winds, burning 10 acres about 2 miles north of the Thermal Airport (in **Coachella**). Flames approached within 2 feet of six homes but did not burn any structures.
September 8, 2000	A wildfire triggered by lightning started in the Santa Rosa Mountains, about 9 miles southwest of the Thermal Airport, and spread about 35 acres before it was fully contained. No property damage was reported.
June 17-18, 2001	A brush fire occurred along the Palm Springs Tramway Road that eventually burned 300 acres and forced temporary closure of the Aerial Tramway. Winds in the canyon of between 25 and 30 mpg during the night impeded the Fire Department's efforts to stop the blaze.
May 9, 2002	A brush fire consumed 35 acres about 2 miles north of **Coachella** before being contained. No structures were damaged, and no injuries were reported.

Date	Fire Description
June 1, 2002	Flames from a house fire about 2 miles northwest of the Palm Springs Airport were spread by wind to the surrounding brush, consuming a telephone pole. Property damage was estimated at $95K.
June 17, 2002	Gusty winds and 120 degree temperatures helped fuel a brush fire about 2 miles southwest of Desert Hot Springs that eventually consumed one house, several vehicles and numerous trees. Four firefighters were treated for heat exhaustion, and another suffered a minor injury. Property damage was estimated at $300K.
June 25, 2002	A wildfire was reported in White Water, in the center divide of the I-10 freeway, with dense smoke affecting traffic. No property damage or injuries reported.
June 30, 2002	A vehicle fire was spread by winds, burning 10 acres of brush about 3 miles north of Palm Springs. Property damage was estimated at $20K.
June 26, 2003	A brush fire burned 324 acres, threatened 120 structures, and forced the evacuation of 300 residents from the Torres Martinez Indian Reservation in Mecca. Two firefighters were treated for smoke inhalation.
August 26-31, 2005	The Blaisdell (Canyon) Fire, as it was named, started as an out-of-control campfire in Blaisdell Canyon, on the north face of the San Jacinto Mountain. The fire raced up canyon, shutting down temporarily the Palm Springs Aerial Tramway. The fire burned 5,493 acres before it was extinguished. No property damage was reported.
April 3-5, 2009	A blaze started in the afternoon, south of Tramway Road, Palm Springs, and quickly spread due to the strong winds, burning 50 acres. The fire damaged two homes and forced mandatory evacuations for residents in the Racquet Club Road area west of Hwy. 111. At least two people suffered smoke inhalation. The Palm Springs Aerial Tramway was closed for the duration of the fire due to wind gusts up to 70 mph. $250k in property damage reported.
November 26-27, 2010	The Palm Fire occurred in the Coachella Valley Preserve near Thousand Palms. No structures were threatened and no injuries were reported. Most of the damage was confined to the Willis Grove, with the palm fronds and skirts of most trees impacted by the blaze. By the spring of 2011, most trees tops were showing new green growth.
September 24-26, 2011	The Windy Point Fire occurred in steep, rocky terrain west of the Palm Springs Tramway. State Highway 111 was closed in both directions while the blaze was fought. The fire burned 541 acres before being fully contained on the 26th. No structures were damaged or threatened, and there were no injuries reported.

Sources: NOAA, at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms;
Los Angeles Times, and The Californian

The list presented above is undoubtedly incomplete, as it does not include small, vegetation/refuse fires. Data compiled by the National Fire Protection Agency (NFPA) show that many local fire department responses are for brush, grass and other miscellaneous fires. In fact, statistics from the NFPA for the years between 2004 and 2008 show that nationwide, brush, grass and forest fires account for about 23 percent of all fires reported to local fire departments. Nearly three-fourths of these fires burn less than one acre, and only 4 percent burn more than ten acres (Ahrens, 2010). About 20 percent of the vegetation fires reported are intentionally set, and another 15 percent start as refuse or debris disposal fires (both permitted and not permitted). Other leading causes of vegetation fires include hot embers or ashes (17 percent), high winds (13 percent), smoking materials (12 percent), playing with heat or fire sources such as matches (6 percent), fireworks (5 percent), electrical power or utility lines (4 percent), and lightning (4 percent) (Ahrens, 2010). For statistics regarding the types of incidents that the Riverside County Fire Department responded to between 2010 and 2013 in Coachella, refer to Table 4.2. Note that fires comprise less than 5 percent of the total yearly incident calls, with vegetation fires (presumably categorized under "Other Fires") comprising an even smaller percentage.

Table 4-2: Statistics on Incident Types Responded to by the Fire Department in the City of Coachella for the Years 2010-2013

Incident Type / Year	2010	2011	2012	2013
Structure Fires	28	20	24	14
Other Fires	65	49	71	90
Ringing Alarms	118	133	147	160
Medical Incidents	1,523	1,485	1,608	1,682
Other Incidents	342	341	387	325
Total (within City Limits)	**2,076**	**2,028**	**2,237**	**2,271**

Source: Data provided by Battalion Chief De La Cruz, written communication on May 12, 2014.

4.1.2 Regulatory Context and Fire Risk Areas

Since the early 1970s, several fire hazard assessment and classification systems have been developed for the purpose of quantifying the severity of the fire hazard in a given area. Many of these are regulatory in that they were implemented as a result of legislation enacted either at the State or Federal level. Early systems characterized the fire hazard of an area based on a weighted factor that typically considered fuel, weather and topography. More recent systems rely on the use of Geographic Information System (GIS) technology to integrate the factors listed above to map the hazards, and to predict fire behavior and the impact on watersheds.

4.1.2.1 HUD Study System

In April 1973, the California Department of Forestry (CDF – now the California Department of Forestry and Fire Protection, also known as Cal Fire) published a study funded by the Department of Housing and Urban Development (HUD) under an agreement with the Governor's Office of Planning and Research (Helm et al., 1973). As is the case with several other more recent programs, the study was conducted in response to a disaster: during September and October 1970, 773 wildfires burned more than 580,000 acres of California land. The HUD mapping process relied on information obtained from U.S. Geological Survey (USGS) 15- and 7.5-minute quadrangle maps on fuel loading (vegetation type and density) and slope, and combined it with fire weather information (now available in real-time at http://gacc.nifc.gov/oscc/predictive/fuels_fire-danger/index.htm) to determine the **Fire Hazard Severity** of an area. This system was the basis for several subsequent studies and programs that have been conducted as a result of more recent legislation, as described further below.

4.1.2.2 California Department of Forestry and Fire Protection – State Responsibility Areas System

Legislative mandates passed in 1981 (Senate Bill 81, Ayala, 1981) and 1982 (Senate Bill 1916, Ayala, 1982) that became effective on July 1, 1986, required the CDF to develop and implement a system to rank fire hazards in California. Areas were rated as moderate, high or very high based primarily on fuel types. Thirteen different fuel types were considered using the 7.5-minute quadrangle maps by the USGS as base maps (Phillips, 1983). Areas identified as having a fire hazard were referred to as **State Responsibility Areas** (SRAs) (Public Resources Code Section 4125). These are non-federal and non-incorporated lands covered wholly or in part by timber, brush, undergrowth or grass, for which the State has the primary financial responsibility of preventing and suppressing fires. SRAs also do not exceed a housing density of 3 units per acre, and the land has watershed and/or range/forage value, effectively eliminating most desert lands from the SRA definition.

*There are no State Responsibility Areas in the Coachella General Plan area. However, there are several areas in the Coachella General Plan study region that are classified as **Federal Responsibility Areas (FRAs)** with a **moderate fire hazard** (CDF, 2007). A small section in the far northeastern corner of the planning area is considered to have a **high fire hazard** (see orange areas on Plate 4-1). Most of the eastern and northeastern portions of Coachella are mapped as Local Responsibility Areas (LRAs*), as described further below.

4.1.2.3 Bates Bill Process

The Bates Bill (Assembly Bill 337, September 29, 1992) was a direct result of the great loss of lives and homes in the Oakland Hills Tunnel Fire of 1991. Prior to the adoption of this bill, the authority to apply wildland fire safety regulations in areas outside State control varied from one jurisdiction to the next, depending on the regulations adopted by individual legislative bodies. The original intent of the bill was to create a single fire district to provide coordinated response to any future fires in the area; the final document developed fire safety regulations to be applied consistently throughout the State (Collins, 2000). As part of this effort, the California Department of Forestry and Fire Protection (CDF), in cooperation with local fire authorities, was tasked to evaluate the fire hazard **of Local Responsibility Areas** (**LRA**s) and identify **Very High Fire Hazard Severity Zones** (VHFHSZs) therein. To accomplish this, the CDF formed a working group comprised of state and local representatives that devised a point system that considers fuel (vegetation), slope, weather, and dwelling density. To qualify as a VHFHSZ, an area has to score ten or more points in the grading scale. Once the boundaries of a VHFHSZ have been delineated, the CDF notifies the local fire authorities that are responsible for fire prevention and suppression within that area. Since the State is not financially responsible for Local Responsibility Areas, local jurisdictions have final say regarding whether or not an area should be included in a VHFHSZ (Government Code Section 51178). Declaring an area a VHFHSZA means that the local fire department has to enforce the provisions of Section 4291 of the Public Resources Code. Local jurisdictions that do not follow the Bates system are required to follow at a minimum the model ordinance developed by the State Fire Marshal for mitigation purposes. The risk of fire in VHFHSZs needs to be addressed in the Safety Element of the General Plan (see section below entitled Senate Bill 1241, Kehoe Statutes of 2012).

*The CDF (2008) recommended that the hillside areas in the eastern and northeastern portions of Coachella, which are **Local Responsibility Areas**, be classified as having a **moderate fire hazard** (see pink areas on Plate 4-1). There are no very high fire hazard severity zones in the Coachella General Plan area. The developed areas in the valley floor are mapped as Non-WIdland or Urban Unzoned, and are considered to not have a wildland fire hazard.*

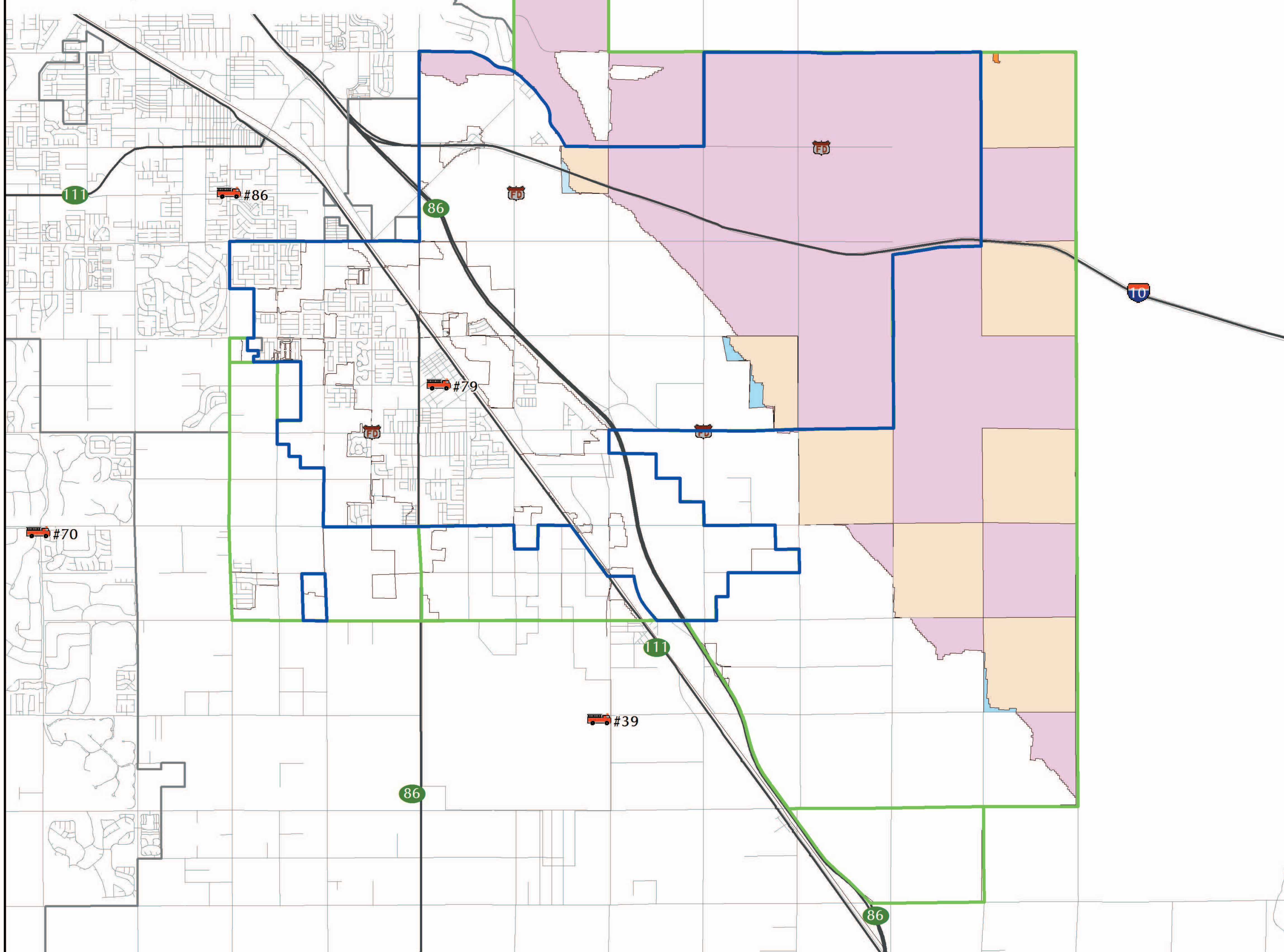
4.1.2.4 California Fire Plan

The 1996 California Fire Plan is a cooperative effort between the State Board of Forestry and Fire Protection and the CDF (California Board of Forestry, 1996). This system ranks the fire hazard of the wildland areas of the State using four main criteria: fuels, weather, assets at risk, and level of service (which is a measure of the fire department's success in initial-attack fire suppression). The California Fire Plan uses GIS-based data layers to conduct the initial evaluations, and local CDF Ranger Units are then tasked with field validation of the initial assessment. The final maps use a Fire Plan grid cell with an area of approximately 450 acres, which represents 1/81 of the area of a 7.5-minute quadrangle map (called Quad 81). The fire hazard of an individual cell is ranked as **moderate**, **high** or **very high**. The main objective of the California Fire Plan is to reduce total costs and losses from wildland fire in the State by protecting assets at risk before a fire occurs. To do so, the plan identifies prefire management

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.



High Fire Hazard Areas

Coachella, California

Explanation

Local Responsibility Area

- Moderate Fire Hazard Severity Zone
- Non-Wildland/Non-Urban or Urban Unzoned

Federal Responsibility Area

- High Fire Hazard Severity Zone
- Moderate Fire Hazard Severity Zone
- Non-Wildland/Non-Urban or Urban Unzoned

- Fire Station
- Approximate location of proposed or recommended new fire stations (City of Coachella Fire and Emergency Master Plan, 2007).
- Coachella City Boundary
- Coachella Planning Area Boundary

Possible future fire station in the McNaughton area not shown.

N
W E
S

Scale: 1:72,000

6000 0 6000
Feet

2000 0 2000
Meters

Base Map: City of Coachella.
Sources: Fire and Resource Assesment Program, California Department of Forestry and Fire Protection (2007&2013); Riverside County Fire Department (www.rvcfire.org/opencms/facilities/).

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Date: 2014

City of Coachella, California

Plate 4-1

prescriptions that can be implemented to reduce the risk, and analyzes policy issues and develops recommendations for changes in public policy. The most current California Fire Plan, as of the writing of this document, dates from 2010. For more information, including a digital copy of the entire 2010 Plan, go to http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan.

*Under the California Plan, most of the Coachella General Plan area east of the Coachella Canal, given the area's vegetation types and slope characteristics, is mapped as having a **moderate fuel rank** and **potential fire behavior**, with isolated pockets of high fuel rank potential fire behavior (http://frap.cdf.ca.gov/data/frapgismaps/download.asp). The western and southwestern portions of the General Plan area are mapped as having non-wildland fuel.*

4.1.2.5 National Fire Plan

During the 2000 fire season, wildfires burned millions of acres of land throughout the United States, prompting politicians, fire managers and government agencies to re-think their approach to fire management. Under Presidential Executive Order, the Secretaries of Agriculture and the Interior were tasked with preparing a report that outlined recommendations to minimize both the long- and short-term impacts of wildfires with a broader effort and closer cooperation between agencies and fire programs. The resultant report, entitled the "National Fire Plan," has as its main purposes to protect communities and restore ecological health on Federal lands (http://www.forestsandrangelands.gov/NFP/index.shtml). The Plan outlines five key points: 1) firefighting, 2) rehabilitation and restoration, 3) hazardous fuel reduction, 4) community assistance, and 5) accountability. The Plan, which was first funded in 2001, commits to funding for a continued level of "Hazardous Fuel Reduction" and new funding for a "Community Assistance/Community Protection Initiative." The intent of the Community Assistance initiative is to provide communities that interface with federal lands an opportunity to get technical assistance and funding to reduce their threat of wildfires.

As part of the Community Assistance/Community Protection Initiative, the National Fire Plan funded a study to identify areas that are at high risk of damage from wildfire. Under this program, Federal fire managers authorized State foresters to determine which communities are at significant risk from wildland fire on Federal lands. In California, this task was undertaken by the California Fire Alliance (CFA), a cooperative group of State, Federal and local agencies, who in 2001 generated a list of communities at risk. Given California's extensive Wildland-Urban Interface (WUI), the list of communities extends beyond just those on Federal lands. In fact, as of 2014, the CFA has identified 1,289 fire-threatened communities in California, and *the City of Coachella* was, in 2001, placed on the list of Federally regulated ***Communities at Risk****, as the city is located adjacent to Federal lands with a fire threat that are Federally protected* (http://www.cafirealliance.org/communities_at_risk/). Communities can change their status on the Communities at Risk list, or they can request to be added to the list. Information on this program, including the Communities at Risk Application Form, is available from the worldwide web at http://www.cafirealliance.org/communities_at_risk/communities_at_risk_changestatus.

Under the auspices of the National Fire Plan, the CDF also produced a **Wildland Fire Threat Map**, released on October 20, 2005, that takes into account the combined effects of potential fire behavior (fuel rank) and expected fire frequency (fire rotation) from the past 50 years to create four threat classes for risk assessment. These threat classes are extreme, very high, high and moderate. Areas that do not support wildland fuels (such as open water, and agricultural lands) were not considered in the analysis. Most large urbanized areas receive a moderate fire threat classification to account for fires carried by ornamental vegetation and flammable structures. *The Fire Threat Map (available at http://www.frap.fire.ca.gov/data/frapgismaps/*

download.asp) shows that the developed areas of Coachella west of the Canal are included in the non-fuel fire threat classification, whereas the eastern and northeastern sections to the east of the Coachella Canal predominantly have a ***moderate fire threat****.* ***High fire threat areas*** *are shown locally in the northern and southeastern sections of the General Plan area.*

4.1.2.6 California Fire Alliance (CFA)

In addition to generating and updating the Communities at Risk list described above, the CFA funds a variety of projects designed to reduce the threat of wildfire before it happens. As part of this effort, the CFA encourages the development of Community Wildfire Protection Plans (CWPP), as defined by the Healthy Forest Restoration Act (HFRA) of 2003. CWPPs enable a community to plan how it will reduce its risk of wildfire by identifying strategic sites and methods for fuel reduction projects across the landscape and jurisdictional boundaries. Benefits of having a CWPP include National Fire Plan funding priority for projects identified in a CWPP. The USDA Forest Service and Bureau of Land Management can expedite the implementation of fuel treatments, identified in a CWPP, through alternative environmental compliance options offered under the HFRA. The CWPP must be agreed to by three entities: the local government, the local Fire Department, and the CDF. Communities developing CWPPs are encouraged to integrate their CWPP planning process into other planning processes, including the Safety Element of the General Plan (i.e., this document), Local Hazard Mitigation Plans, Flood Mitigation Plans, and other local hazard, evacuation and emergency plans. As of May 2014, *neither the City of Coachella, nor Riverside County, had a Community Wildfire Protection Plan on file with the California Department of Forestry and Fire Protection.*

4.1.2.7 Real-Estate Disclosure Requirements

California state law [Assembly Bill 6; Civil Code Section 1103(c)(6)] requires that fire hazard areas be disclosed in real estate transactions; that is, real-estate sellers are required to inform prospective buyers whether or not a property is located within a wildland area that could contain substantial fire risks and hazards, such as a State Responsibility Area.

Real-estate disclosure requirements are important because in California the average period of ownership for residences is only five years (Coleman, 1994). This turnover creates an information gap between the several generations of homeowners in fire hazard areas. Un-informed homeowners may attempt landscaping or modifications that could be a detriment to the fire-resistant qualities of their structure, with potentially negative consequences.

Although Federal, State and to some degree, local agencies have inventoried and classified the fire hazard of a given area, some users are in need of additional detail, or need to evaluate the fire conditions of an area at a specific time of the year, or under specific fuel loading and weather conditions. The tools below are not regulatory, but given that they are used by specific industry groups, or have applications that can be useful to an agency such as the local or County Department or the National Forest Service, they are described further.

4.1.2.8 FireLine System

The Insurance Services Office (ISO) developed a program used by the insurance industry to identify those areas where the potential loss due to wildfire is greatest (ISO, 1997). ISO retained Pacific Meridian Resources of Emeryville, California to develop the FireLine software, which uses satellite-imagery interpretation to evaluate the factors of fuel types, slope and roads (access) to develop the risk rating. Most insurance companies that provide insurance services to homeowners in California now use this system. This software is only available through ISO.

Updated versions of this system are being developed that include the factors of elevation, aspect, and relative slope position.

4.1.2.9 BEHAVE, FARSITE, FlamMap and Other Models

These are computer programs, typically PC-based, that can be used by fire managers to calculate potential fire behavior in a given area using GIS data inputs for terrain and fuels. The purpose of these models is to predict fire behavior. Data inputs that can be used in the analyses include elevation, slope, aspect, surface fuel, canopy cover, stand height, crown base height and crown bulk density.

The oldest of these models is the **BEHAVE** Fire Behavior Prediction and Fuel Modeling System (Burgan and Rothermel, 1984; Burgan, 1987; Andrews, 1986; Andrews and Chase, 1989; Andrews and Bradshaw, 1990) that has been used since 1984. A newer version of it is referred to as the BehavePlus Fire Modeling System (Andrews and Bevins, 1999). **BehavePlus** is a suite of fire behavior systems that includes FlamMap, FARSITE, and FSPro. Input to the BehavePlus model is supplied interactively by the user; typically users run several calculations to evaluate and compare the effects that a range of values will have on the results. Each run consists of a set of uniform conditions.

FARSITE (Finney, 1995, 1998) is a deterministic modeling system that calculates the growth and behavior of a wildfire as it spreads through variable fuel and terrain under changing weather conditions (http://www.firemodels.org/index.php/farsite-introduction). This software can be used to project the growth of ongoing wildfires and prescribed fires, and can be used as a planning tool for fire suppression and prevention, and fuel assessment.

FlamMap (Finney, 2006; Stratton, 2006) is a mapping and analysis system that can be used to model fire behavior across the landscape under constant weather and fuel moisture conditions. The system provides the spatial component to the software suite. Because the environmental conditions remain constant, the software cannot be used to simulate temporal variations in fire behavior. Given that fuel is a variable in the input data, this software is well-suited to run landscape-level comparisons to evaluate the effectiveness of different fuel treatments under varying topographic conditions.

FSPro is used to calculate the probability that fire will spread from a known perimeter or point, but it does not provide fire perimeters, nor does it provide a projection of fire size. This piece of software requires more computing power than that typically provided by a personal computer (http://www.firemodels.org/index.php/behaveplus-introduction/behaveplus-overview).

4.1.2.10 Disaster Mitigation Act of 2000

This Act requires local governments to prepare and adopt a Local Hazard Mitigation Plan that has been reviewed and approved by the State's Mitigation Officer (in California this agency is the California Emergency Management Agency – Cal-EMA) and the Federal Emergency Management Agency (FEMA), as a condition of receiving mitigation project assistance. These documents are to focus on pre-disaster planning and activities as a way to reduce response and post-disaster costs. Local Hazard Mitigation Plans should be consistent with the policies contained in the General Plan, especially the Safety Element. Wildfire mitigation programs discussed in these two documents should be consistent and integrated to ensure that the hazard of wildfire is addressed in an effective manner. *The City of Coachella is a participant member of the Riverside County Operational Area Multi-Jurisdictional Hazard Mitigation Plan (HMP) approved by FEMA in March 2005 and ongoing updates to that document.*

4.1.2.11 Senate Bill 1241 (2012 Kehoe Statutes)

To address the increasing issues at the wildland-urban interface, Senate Bill 1241 (Kehoe, Statutes of 2012) revised the Safety Element requirements for state responsibility areas and very high fire hazard severity zones (Government Code Sections 65302 and 65302.5). Specifically, SB 1241 requires cities revising their Housing Element of the General Plan on or after January 1, 2014, to also review and update their Safety Element to address the risk of fire in state responsibility areas and very high fire hazard severity zones. SB 1241 requires the Safety Element include the following:

1. Fire hazard severity zone maps available from the Department of Forestry and Fire Protection.
   a. Historical data on wildfires available from local agencies;
   b. Information about wildfire hazard areas that may be available from the United States Geological Survey;
   c. General location and distribution of existing and planned uses of land in very high hazard severity zones and in state responsibility areas, including structures, roads, utilities, and essential public facilities;
   d. Local, state and federal agencies with responsibility for fire protection, including special districts and local offices of emergency services.

2. A set of goals, policies, and objectives based on the information identified in subparagraph (1) regarding fire hazards for the protection of the community from the unreasonable risk of wildfire.

3. A set of feasible implementation measures designed to carry out the goals, policies, and objectives based on the information identified in subparagraph (2) including, but not limited to:
   a. Avoiding or minimizing the wildfire hazards associated with new uses of land;
   b. Locating, whenever feasible, new essential public facilities outside of high fire risk areas, including, but not limited to, hospitals and health care facilities, emergency shelters, emergency command centers, and emergency communication facilities, or identifying construction methods or other methods to minimize damage if these facilities are located in a state responsibility area or very high fire hazard severity zone;
   c. Designing adequate infrastructure if a new development is located in a state responsibility area or in a very high fire hazard severity zone, including safe access for emergency response vehicles, visible street signs, and water supplies for structural fire suppression;
   d. Working cooperatively with public agencies with responsibility for fire protection.

4. If a city or county has adopted a fire safety plan or document separate from the General Plan, an attachment of, or reference to a city or county's adopted fire safety plan or document that fulfills commensurate goals and objectives and contains information required pursuant to this paragraph.

SB 1241 also requires that the draft Element of or draft amendment to the Safety Element of a county or a city's General Plan be submitted to the State Board of Forestry and Fire Protection and to every local agency that provides fire protection to territory in the city or county at least 90 days prior to either: 1) the adoption or amendment to the Safety Element of its General Plan for each county that contains state responsibility areas; or 2) the adoption or amendment to the

Safety Element of its General Plan for each city or county that contains a very high fire hazard severity zone as defined pursuant to subdivision (b) of Section 51177.

There are no State Responsibility Areas and no very high fire hazard severity zones in the Coachella General Plan area. Thus, the provisions of SB 1241 do not apply to Coachella. However, this does not prevent the City from submitting a copy of this report to the Riverside County Fire Department and other agencies for informational purposes.

4.1.3 Fire Prevention and Suppression Programs and Regulations

There are several fire prevention and suppression programs that communities can implement to reduce their wildland fire hazard. Some of these programs aim to control the type, density and continuity of fuel (vegetation) available for a fire to burn; others are directed at the strengthening of structures to be more fire resistant. Given that the increase in catastrophic, human-caused wildland fires is associated with an increased number of people living and playing in wildland areas, limiting human-wildland interaction during periods of heightened fire risk can also help reduce the likelihood of human-caused fires in an area. Finally, the effective containment of a wildland fire before it impacts vulnerable structures is in great part the result of the suppression resources available to the agencies fighting the fire, and the fire department's accessibility to the impacted area. Some of these programs are described in more detail below.

4.1.3.1 Vegetation Management

Experience and research have shown that vegetation management is an effective means of reducing the wildland fire hazard. Therefore, in those areas identified as susceptible to wildland fire, land development is governed by special State, county and local codes, and property owners are required to follow maintenance guidelines aimed at reducing the amount and continuity of the fuel (vegetation) available.

Requirements for vegetation management at the wildland-urban interface (WUI) in California were revisited following the 1993 wildland fires that impacted large areas of Orange, Los Angeles and Ventura counties. The International Fire Code Institute formed a committee to develop a Wildland-Urban Interface Code under the direction of the California State Fire Marshal. The first draft of this code was published in October 1995. Then, in 2003, the International Fire Code Institute consolidated into the International Code Council. The International Code Council updates these documents every three years; the most recent Wildland-Urban Interface Code is the 2012 edition. The code contains provisions addressing fire spread, accessibility, defensible space, and water supply for buildings constructed near wildland areas. California incorporated the Wildland-Urban Interface Code into the California Building Standards Code, which incorporates the fire safety provisions of the California Fire Code and the California Building Code. The California Fire Code contains standards for building design, water supply and brush clearance.

Per the City of Coachella Municipal Code, Sections 3.08.070 and 3.08.080 - Uniform Fire Code and California Fire Code Violations, the Fire Chief shall have exclusive enforcement authority regarding any violation of the Uniform Fire Code and California Fire Code, respectively, unless otherwise provided in writing by the Fire Chief pursuant to the Uniform Fire Code and California Fire Code or any other applicable statutes, codes, rules and/or regulations.

Hazard reduction and **fuel modification** are the two methods that communities most often employ to reduce the risk of fire at the WUI. Both methodologies use the principle of reducing the amount of combustible fuel available, which reduces the amount of heat, associated flame lengths, and the intensity of the fire that would threaten adjacent structures. The purpose of these methods is to reduce the hazard of wildfire by establishing a **defensible space** around buildings or structures in the area. Defensible space is defined as an area, either natural or man-made, where plant materials and natural fuels have been treated, cleared, or modified to slow the rate and intensity of an advancing wildfire, and to create an area for firefighters to suppress the fire and save the structure. These standards require property owners in the WUI to conduct maintenance, modifying or removing non-fire-resistive vegetation around their structures to reduce the fire danger. This affects any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining the WUI.

Since January 1, 2005, properties in California within a wildland fire hazard area are required to maintain a defensible space clearance around buildings and structures of 100 feet (Public Resources Code 4291), or to their property line, whichever is less. This requirement applies to any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining a mountainous area, forest-covered land, brush-covered land, grass-covered land, or any land that is covered with flammable material, and located within a State Responsibility Area. While individual property owners are not required to clear beyond the 100-foot distance, or beyond their property line, groups of property owners are encouraged to extend clearances beyond the 100-foot requirement to create community-wide defensible spaces (State Board of Forestry and Fire Protection, 2006).

Fuel or vegetation treatments often used include mechanical, chemical, biological and other forms of biomass removal (Greenlee and Sapsis, 1996) within a given distance from habitable structures. The intent of this hazard-reduction technique is to create a defensible space that slows the rate and intensity of the advancing fire, and provides an area at the wildland-urban interface where firefighters can set up to suppress the fire and save the threatened structures. **Hazard reduction** includes requirements for the maintenance of existing trees, shrubs, and ground cover within a setback zone, to reduce the amount of fuel on those sides of any structure that face the WUI. These requirements include: clearing all dead or dying foliage; planting fire-resistive vegetation; keeping clearances between tree stands, bushes and shrubs, and between trees and structures; irrigating ground covers, storing firewood and combustible materials away from habitable structures; using fire-resistant roofing and construction materials; cleaning vegetation debris from roofs and rain gutters; and using spark arresters on chimneys.

In some communities or developments adjacent to a wildland area, residents are required to comply with **fuel modification** requirements. A **fuel modification zone** is a ribbon of land surrounding a development within a fire hazardous area that is designed to diminish the intensity of a wildfire as it approaches the structures. Fuel modification includes both the thinning (reducing the amount) of combustible vegetation, and the removal and replacement of native vegetation with fire-resistive plant species. These modification zones may be owned by individual property owners or by homeowners' associations. Emphasis is placed on the space near structures that provides natural landscape compatibility with wildlife, water conservation and ecosystem health. Immediate benefits of this approach include improved aesthetics, increased health of large remaining trees and other valued plants, and enhanced wildlife habitat.

4.1.3.2 Notification and Abatement

City and county codes typically specify that property owners are required to mitigate the fire hazard in their properties by implementing vegetation management practices. *Coachella's Municipal Code, Title 3, has several provisions that address the maintenance and abatement of nuisances, including weeds, trees and shrubs with dead or fallen limbs or branches that pose a safety* *hazard, and the accumulation of dry or dead plant matter, combustible refuse or waste that comprise a fire hazard (see Chapter 3.10 of the Municipal Code).* If dry weeds, grass, brush, plant material, dead trees, or other hazardous vegetation are present in an improved or unimproved real property in the city, the Fire Chief has the authority to give the person or persons responsible for the violation(s) a Notice of Violation (Section 3.24.010 of the Coachella Municipal Code). Failure to comply with the notice of violation typically results in the issuance of a field citation, a notice of public nuisance or other such action. If the person responsible for the public nuisance conditions does not abate the hazard during the time period specified in the notice, the City may elect to perform the abatement work. In that case, the owner of record of the property is liable for all abatement costs incurred by the City, including administrative costs (Section 3.36.010). Weed abatement issues are handled by the Fire Department in conjunction with the City of Coachella Code Enforcement Office. Fire Department personnel provide fire safety presentations and prepare and distribute flyers providing information about fire safety, including weed abatement, at many school and city events.

The County of Riverside has similar provisions regarding the issue of weeds and other vegetation as a potential fire hazard that apply to the unincorporated regions of the Coachella General Plan area. In the County, the Fire Chief or his designated representative has the authority to give the property owner of record a Notice of Violation and Order to Abate the hazard. If the owner does not abate the fire hazard during the time period specified in the notice, typically 30 days, the County may take further action to reduce the hazard. The costs of notification and abatement are then charged to the property owner of record, and if not paid within 15 calendar days, the County has the option of making the outstanding costs a Special Assessment against the property, or authorizing the recordation of a Nuisance Abatement Lien against the subject property. Furthermore, a citation may be issued for non-compliance. For additional information refer to Riverside County Ordinance 695.4.

4.1.3.3 Building to Reduce the Fire Hazard

Building construction standards for such items as roof coverings, fire doors, and fire resistant materials help protect structures from external fires and contain internal fires for longer periods. The portion of a structure most susceptible to ignition from a wildland fire is its roof, which is exposed to burning cinders (or brands) generally carried by winds far in advance of the actual fire. Roofs can also be ignited by direct contact with burning trees and large shrubs (Fisher, 1995). The danger of combustible wood roofs, such as wooden shingles and shakes, has been known to fire fighting professionals since at least 1923, when California's first major urban fire disaster occurred in Berkeley. It was not until 1988, however, that California was able to pass legislation calling for, at a minimum, Class C roofing in fire hazard areas (Class C roof coverings are effective against light fire exposures; under such exposures roof coverings of this class are not readily flammable, afford a measurable degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands). Then, in the early 1990s, there were several other major fires, including the Paint fire of 1990 in Santa Barbara, the 1991 Tunnel fire in Oakland/Berkeley, and the 1993 Laguna Beach fire, whose severe losses were attributed in great measure to the large percentage of combustible roofs in the affected areas. In 1994-1996, new roofing materials standards were approved by California for Very High Fire Hazard Severity Zones.

To help consumers determine the fire resistance of the roofing materials they may be considering, roofing materials are rated as to their fire resistance into three categories that are based on the results of test fire conditions that these materials are subjected to under rigorous laboratory conditions, in accordance with test method ASTM-E-108 developed by the American

Society of Testing Materials. The rating classification provides information regarding the capacity of the roofing material to resist a fire that develops outside the building on which the roofing material is installed (Institute for Local Self Government, 1992). The ratings are as follows:

- **Class A**: Roof coverings that are effective against **severe** fire exposures. Under such exposures, roof coverings of this class are not readily flammable, afford a high degree of fire protection to the roof deck, do not slip from position; and do not produce flying brands.

- **Class B**: Roof coverings that are effective against moderate fire exposures. Under such exposures, roof coverings of this class are not readily flammable, afford a moderate degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands.

- **Class C**: Roof coverings that are effective against light fire exposures. Under such exposures, roof coverings of this class: are not readily flammable, afford a measurable degree of fire protection to the roof deck, do not slip from position, and do not produce flying brands.

Roofing materials can also be:

- **Non-Combustible**: Roof made of non-combustible materials like metal. Although metal roofs don't burn, they are excellent heat conducts, and during an intense fire, heat can be conducted through the metal to the underlying, combustible materials.

- **Non-Rated**: Roof coverings have not been tested for protection against fire exposure. Under such exposures, non-rated roof coverings may be readily flammable; may offer little or no protection to the roof deck, allowing fire to penetrate into attic space and the entire building; and may pose a serious fire brand hazard, producing brands that could ignite other structures a considerable distance away.

The City of Coachella does not require a minimum fire-rated roof type, but it has adopted the 2013 California Building and Fire Codes, with some exceptions. The City implements Section 1505 (Table 1505.1) of the California Building Code, which provides minimum roof covering classifications for different types of construction. Furthermore, all new single family residential construction projects since 2005 have been and continue to be required to use concrete or clay tile roofing, in accordance with the City's Single Family Residential Design Guidelines (Luis Lopez, Development Services Director, City of Coachella, written communication, April 28, 2014). Concrete and clay tile roofing qualify as Class A roofing material under the Building Code, as defined above.

Attic ventilation openings are also a concern regarding the fire survivability of a structure. Attics require significant amounts of cross-ventilation to prevent the degradation of wood rafters and ceiling joists. This ventilation is typically provided by openings to the outside of the structure, but these opening can provide pathways for burning brands and flames to be deposited within the attic. To prevent this, it is important that all ventilation openings be properly screened.

Additional prevention measures that can be taken to reduce the potential for ignition of attic spaces is to "use non-combustible exterior siding materials and to site trees and shrubs far enough away from the walls of the house to prevent flame travel into the attic even if a tree or shrub does torch" (Fisher, 1995).

The type of exterior wall construction used can also help a structure survive a fire. Ideally, exterior walls should be made of non-combustible materials such as stucco or masonry. During a wildfire, the dangerous active burning at a given location typically lasts about 5 to 10 minutes (Fisher, 1995), so if the exterior walls are made of non-combustible or fire-resistant materials, the structure has a better chance of surviving. For the same reason, the type of windows used in a structure can also help reduce the potential for fire to impact a structure. Single-pane, annealed glass windows are known for not performing well during fires; thermal radiation and direct contact with flames cause these windows to break because the glass under the window frame is protected and remains cooler than the glass in the center of the window. This differential thermal expansion of the glass causes the window to break. Larger windows are more susceptible to fracturing when exposed to high heat than smaller windows. Multiple-pane windows, and tempered glass windows perform much better than single-pane windows, although they do cost more. Fisher (1995) indicates that in Australia, researchers have noticed that the use of metal screens helps protect windows from thermal radiation.

The latest version of the California Building Code (2013) has specific construction requirements for new buildings located in any State Responsibility Areas, in Very High Fire Hazard Severity Zone in Local Responsibility Areas, and in any Wildland-Urban Interface Fire Area (Chapters 7A and 15 of Title 24, California Code of Regulations). The 2013 California Building Code also has specific fire-resistance-rated construction requirements for all types of construction, based on occupancy type and construction type. Although these conditions do not apply to the City of Coachella because there are no State Responsibility Areas, Very High Fire Hazard Severity Zones or Wildland-Urban Interface areas in Coachella, *the City has adopted and enforces the use of the 2013 California Building Code for all new construction.*

4.1.3.4 Restricted Public Access

In addition to the fire-susceptibility conditions described before, the wildfire susceptibility of an area changes throughout the year, and from year to year in response to local variations in precipitation, temperature, vegetation growth, and other conditions. To map these changes, the EROS Data Center (EDC) in Sioux Falls, South Dakota, has produced since the early 1990s weekly and biweekly maps for the 48 contiguous states and Alaska (available at http://edc.usgs.gov/). These maps, prepared under the Greenness Mapping Project, display plant growth and vigor, vegetation cover, and biomass production, using multi-spectral data from satellites of the National Oceanic and Atmospheric Administration (NOAA). The EDC also produces maps that relate vegetation conditions for the current two weeks to the average (normal) two-week conditions during the past seven years. EDC maps provide comprehensive growing season profiles for woodlands, rangelands, grasslands, and agricultural areas. With these maps, fire departments and land managers can assess the condition of all vegetation throughout the growing season, which improves planning for fire suppression, scheduling of prescribed burns, and study of long-term vegetation changes resulting from human or natural factors.

Another valuable fire management tool developed jointly by the U.S. Geological Survey and the U.S. Forest Service is the Fire Potential Index (FPI). The FPI characterizes relative fire potential for woodlands, rangelands, and grasslands, both at the regional and local scale. The index combines multi-spectral satellite data from NOAA with geographic information system (GIS) technology to generate 1-km resolution fire potential maps. Input data include the total amount of burnable plant material (fuel load) derived from vegetation maps, the water content of the dead vegetation, and the fraction of the total fuel load that is live vegetation. The proportion of living plants is derived from the greenness maps described above. Water content of dead vegetation is calculated from temperature, relative humidity, cloud cover, and precipitation. The FPI is updated daily to reflect changing weather conditions.

Local fire authorities can obtain data from either of the two sources above to better prepare for the fire season. When the fire danger is deemed to be of special concern, local authorities can rely on increased media coverage and public announcements to educate the local population about being fire safe. For example, to reduce the potential for wildfires during fire season, hazardous fire areas can be closed to public access during at least part of the year. Typically, the fire season in southern California begins in May and lasts until the first rains in November, but different counties or jurisdictions can opt to start the fire season earlier and end it later. With more site-specific data obtained from the FPI or Greenness Mapping Project, however, the fire hazard of an area can be assessed on a weekly or bi-weekly basis (for more information see http://edc.usgs.gov/greenness/index.html). These data can also be used to establish regional prevention priorities that can help reduce the risk of wildland fire ignition and spread, and help improve the allocation of suppression forces and resources, which can lead to faster control of fires in areas of high concern.

4.1.3.5 Fire Safety Education

Individuals can make an enormous contribution to fire hazard reduction if provided with the information and tools to do so. In addition to the specific code requirements and guidelines mentioned in the sections above regarding defensible space and appropriate landscaping and construction materials, homeowners can implement several measures to reduce their fire risk. Some of these measures are listed below:

- Do not mow or use gas-powered landscaping tools during the hottest time of the day.
- Use care when refueling garden equipment and maintain it regularly.
- Dispose of cuttings and debris promptly, according to local regulations.
- Store firewood away from structures.
- If an irrigation system is used, keep it well maintained.
- Store and use flammable liquids properly.
- Dispose of smoking materials carefully, such as in metal containers.
- Only use State Fire Marshal-approved "Safe and Sane" fireworks during the authorized July 4^{th} period, and with responsible adult supervision.
- Become familiar with local regulations regarding vegetation clearings, disposal of debris, and fire safety requirements for equipment.
- Follow manufacturers' instructions when using fertilizers and pesticides.
- When building, selecting or maintaining a home, consider the slope of the terrain. Be sure to build on the most level portion of the lot since fire spreads rapidly on slopes, even minor ones.
- Watch out for construction on ridges, cliffs, or drainage embankments. Keep a single-story structure at least 30 feet away from the edge of a cliff or ridge; increase this distance if the structure exceeds one story.
- Use construction materials that are fire-resistant or non-combustible whenever possible.
- Install an approved automatic fire sprinkler system. The California Building Code has fire sprinkler requirements for new buildings according to occupancy and construction type, but

all types of structures can benefit from having a fire sprinkler system installed. This is particularly true of older construction.

- Driveways should provide easy access for fire engines. Driveways and access roads should be well maintained, clearly marked, and include ample turnaround space near houses.
- So that everyone has a way out, provide at least two ground level doors for safety exits and at least two means of escape (doors or windows) in each room.
- Keep gutters, eaves, and roofs clear of leaves and other debris.
- Occasionally inspect your home, looking for deterioration, such as breaks and spaces between roof tiles, warping wood, or cracks and crevices in the structure.
- If an all-wood fence is attached to your home, a masonry or metal protective barrier between the fence and house is recommended.
- Use non-flammable metal when constructing a trellis and cover it with high-moisture, non-flammable vegetation.
- Prevent combustible materials and debris from accumulating beneath patio decks or elevated porches. Screen, or box in, areas that lie below ground level with wire mesh.
- Make sure an elevated wooden deck is not located at the top of a hill where it will be in the direct line of a fire moving up slope.
- Install automatic seismic shut-off valves for the main gas line to your house. Information for approved devices, as well as installation procedures, is available from the Southern California Gas Company.

4.2 Structure Fires

Based on census data, in 2010 the city of Coachella has a population of about 40,700 (http://census.gov/). A large percentage of the housing stock in the city of Coachella area consists of single-family, detached structures, but approximately 25.75 percent of the housing stock in the city consists of apartments, condominiums, and other multi-occupancy structures. Multiple-family and multiple-occupancy units have special fire protection needs, including the requirement to have fire and life-safety systems in place, such as automatic fire sprinklers and smoke detectors, in conformance with the latest California Building and Fire Codes. Given that only since January 2011 has the State required one- and two-family dwellings and townhouses to be fitted with fire sprinklers, most of Coachella's residential stock is likely to be un-sprinklered.

In the United States, deaths from fires and burns are the third leading cause of fatal injury, and four out of five fire deaths in 2008 occurred in homes (Karter, 2009, as reported by the Center for Disease Control and Prevention at http://www.cdc.gov/HomeandRecreationalSafety/FirePrevention/fires-factsheet.html). Smoking is the leading cause of fire-related deaths, and cooking is the primary cause of residential fires (Ahrens, 2009a, as reported by the Center for Disease Control and Prevention). Although the number of fatalities and injuries caused by residential fires has declined in the last decades, residential fire-related deaths and injuries still pose a significant public health issue. The good news is that residential fire-related deaths and injuries can be prevented.

When a fire develops in a newer, single-family residential structure constructed of fire-resistant materials and with internal fire sprinklers, the fire can generally be contained to the room of origin, unless the building contents are highly flammable. In older residential areas where the building materials may not be fire-rated, and the structures are not fitted with fire sprinklers, there is a higher probability of a structural fire impacting adjacent rooms, and even adjacent structures, unless there is ample distance between structures, there are no strong winds, and the local fire department is able to respond quickly. Fire losses, as a percentage of the total area of the building, are thus potentially higher in older buildings not built with fire-resistant materials (such as gypsum wallboard) that help slow down the spread of fire from the ignition source to other rooms in the structure. Older structures are also less likely to have the redundant exits and window-height requirements that allow occupants to more easily evacuate the building if needed.

In high-density residential areas, especially in older neighborhoods, fire can easily spread from one structure or unit to the next, and the narrow spaces between structures and property lines provide limited room for emergency access, hindering fire suppression and evacuation efforts. Emergency access and exits may also be compromised if obstructions, such as bay windows and roof awnings, project into the setback between structures, or if non-structural items, such as garbage cans or sheds are stored in those areas. Newer multiple-family units typically meet special fire protection requirements, including automatic fire sprinklers and smoke detectors, and fire-resistant construction materials, in conformance with the more recent California Building and Fire Codes. These improvements help retard the spread of fire between dwelling units.

Post-fire forensic data show that fire safety in structures is controlled to a great degree by the contents in the structure: upholstered furniture, bedding, curtains, mattresses and floor coverings (such as carpets and rugs) allow for quick fire spread and fire growth, and ignition of these materials is responsible for more deaths and injuries than the collapse of structures due to fire (Canadian Wood Council, 2000). Most injuries or deaths due to fire are in fact the result of smoke or toxic fumes inhalation, and not burns (Hall, 2001), so smoke detectors and/or fire alarm systems, combined with window and door openings that allow the occupants to evacuate safely, are very important in managing the impact of a structure fire. Approximately 40% of the home fire deaths occur in homes without smoke alarms (Ahrens, 2009b as reported by the Center for Disease Control and Prevention).

Data provided by the Riverside County Fire Department (see Table 4-2 in Page 4-8) shows that between 2010 and 2013, only about 1 percent of the incident calls received by the Fire Department in the city of Coachella were for structure fires. Losses due to fires, as the data in Table 4-2 show, vary from year to year. The reality is that one fire incident in a high consequence structure (see below) could alter the yearly statistics significantly. Although mostly residential, some of the businesses and land-uses in and around Coachella could result in chemical fires. Issues associated with the storage, use and disposal of hazardous materials are discussed in more detail in Chapter 5, whereas a discussion of chemical fires is provided in Section 4.4 below. Finally, fires after earthquakes are a real concern in southern California, given the region's seismic potential. This is discussed further in Section 4.5.

4.2.1 Target Fire Hazards and Standards of Coverage

In order to quantify the structural fire risk in a community, it is necessary for the local fire departments to evaluate occupancies based upon their type, size, construction type, built-in protection (such as internal fire sprinkler systems) and risk (high-occupancy versus low-occupancy) to assess whether or not they are capable of controlling a fire in the occupancy types identified. Simply developing an inventory of the number of structures present within a fire station's response area is not sufficient, as those numbers do not convey all the information necessary to address the community's fire survivability. As mentioned above, in newer residential areas where construction includes fire-resistant materials and internal fire sprinklers, most structure fires can be confined to the building or property of origin. In older residential areas where the building materials may not be fire-rated, and the structures are not fitted with fire sprinklers, there is a higher probability of a structure fire impacting adjacent structures, unless there is ample distance between buildings, there are no strong winds, and the Fire

Department is able to respond in a timely manner.

Fire departments quantify and classify structural fire risks to determine where a fire resulting in large losses of life or property is more likely to occur. The structures at risk are catalogued utilizing the following criteria:

- Their size, height, location and type of occupancy;
- The risk presented by the occupancy (probability of a fire and the consequence if one occurs);
- The unique hazards presented by the occupancy (such as the occupant load, the types of combustibles therein and any hazardous materials);
- Potential for loss of life;
- The presence of fire sprinklers and fire-resistant construction materials;
- Proximity to exposures;
- The estimated dollar value of the occupancy;
- The needed fire flow versus available fire flow; and
- The ability of the on-duty forces to control a fire therein.

These occupancies are called "Target Hazards." Target Hazards encompass all significant community structural fire risk inventories. Typically, fire departments identify the major target hazards and then perform intensive pre-fire planning, inspections and training to address the specific fire problems in that particular type of occupancy (for example, training to respond to fires in facilities that handle hazardous materials is significantly different than training to respond to a fire in a high-occupancy facility such as a mall, auditorium or night club). Typically, the most common target hazard due to its life-loss potential, 24-hour occupancy, risk, and frequency of events, is the residential occupancy. However, the consequences of residential fires can be high or low, depending on the age of the structure, location, size, and occupancy load, among other factors. Four classifications of risk are considered, as follows:

- **High Probability/High Consequences:** such as multi-family dwellings and residential buildings like apartments and condominiums, single-family residential homes in the older sections of the Town, hazardous materials occupancies, and large shopping stores and high-occupancy facilities like movie theaters, convention centers, and meeting halls.
- **Low Probability/High Consequences:** such as the medical offices, mid-size shopping centers, industrial occupancies, and large office complexes.
- **High Probability/Low Consequences:** such as older, detached single-family dwellings.
- **Low Probability/Low Consequences:** such as newer, detached single-family dwellings, and small office buildings.

The Fire Department (Battalion Chief De La Cruz, written communication, May 12, 2014) has indicated that the largest target hazards in Coachella include the local schools, large shopping centers, the Armtec Defense Products facility, bulk petroleum plants and a biodiesel manufacturing plant.

4.2.2 Regulatory Context

Effective fire protection cannot be accomplished solely through the acquisition of equipment, personnel and training. The area's infrastructure also must be considered, including adequacy of nearby water supplies, transport routes and access for fire equipment, addresses, and street signs, as well as maintenance.

The City of Coachella has adopted the 2013 California Fire Code as amended by the County (Riverside County Ordinance No. 787.7), a modification of the International Fire Code. These provisions include sprinkler and fire hydrant requirements in new structures and remodels, road widths and configurations designed to accommodate the passage of fire trucks and engines, and requirements for minimum fire flow rates for water mains. The Riverside County Fire Department Chief is authorized and directed to enforce the provisions of the California Fire Code throughout the City. Coachella has also adopted the most recent (currently 2013) version of the California Building Code that includes sections on fire-resistant construction material requirements based on building use and occupancy. The construction requirements are a function of building size, purpose, type, materials, location, proximity to other structures, and the type of fire suppression systems installed.

Some of the more significant Fire Code items that help reduce the hazard of structural fire include requirements regarding fire-extinguishing systems such as automatic fire sprinklers. Fire sprinklers can help contain a fire that starts inside a structure from spreading to other nearby structures, and also help prevent total destruction of a building. The most recent version of the California Fire Code requires fire sprinklers in all new one- and two-family residential structures built after January 1, 2011.

Fire apparatus access to a burning structure is critical to the rapid containment of a fire. Given the size and weight configurations of fire engines, access roads need to comply with minimum width, maximum grade and surface requirements. Approved fire apparatus access roads need to be provided for every facility or building in the city. Fire apparatus roads need to extend to within 150 feet of all of the facility and all portions of the exterior walls of the first story of the building. In some areas, more than one road may be required if and when it is determined that access by a single road may be impaired by vehicle congestion, difficult terrain, weather conditions which could result in dangerous situations or other factors that could limit access. Furthermore, appropriate signage is important to identify the emergency access roads, and to identify the street number of a property, and the buildings therein.

Fire flow is the flow rate of water supply (measured in gallons per minute – gpm) available for fire fighting, measured at 20 pounds per square inch (psi; equal to 138 kPa) residual pressure. Available fire flow is the total water flow available at the fire hydrants, also measured in gallons per minute. The California Fire Code lists the minimum required fire-flow and flow duration for buildings of different floor areas and construction types; a reduction in required fire flow is allowed when the building is provided with an approved automatic sprinkler system. Fire flow requirements within commercial projects are based on square footage and type of construction of the structures. Minimum fire flow for any commercial structure is 1,500 gallons per minute (gpm) at a residual pressure of 20 psi, and can rise to 8,000 gpm, per Table A-III of the California Fire Code. For additional information regarding the required fire-flow for your building, contact the City's Building Department and the Riverside County Fire Department. The Fire Department, in conjunction with the City Water Department, conducts inspections of all public fire hydrants in Coachella to make sure that they are working properly at the appropriate flows for the area.

Emergency water storage is critical, especially when battling large structural fires or fires after earthquakes. During the 1993 Laguna Beach fire, water streams sprayed on burning houses sometimes fell to a trickle (Platte and Brazil, Los Angeles Times, 1993), primarily because of dwindling water pressure, inadequate pipeline connections and insufficient pumping capacity: most water reservoirs in Laguna Beach were located at lower elevations than the fire, and the water district could not supply water to the higher elevations as fast as the fire engines were using it.

Some, but not all of the above-ground storage tanks in the Coachella General Plan area are located at higher surface elevations than the neighborhoods that they serve. This allows for a gravity-fed mechanism for water distribution. However, regional gravity-fed water distribution systems can still be compromised, especially as a result of an earthquake. While the majority of pipeline failures during earthquakes occur due to fault rupture and lateral spreading, about 40 percent of the failures are due to wave propagation effects, such as amplification in sedimentary basins (O'Rourke and Liu, 1999). Studies conducted by Eguchi (1991) [as referenced in O'Rourke and Liu (1999)] indicate that damage to X-grade welded steel pipes as a result of wave propagation is typically an order of magnitude less than that for ductile iron pipes, and nearly two orders of magnitude less than that for welded steel gas-welded joint, concrete or asbestos cement pipes. Thus, municipalities that have an older utilities system that includes some of these more vulnerable pipe types should consider upgrading their systems to prevent significant pipeline failures during an earthquake.

Furthermore, as the City grows to the east, and onto higher elevations, the existing water storage tanks will not be able to provide water to all the new proposed structures, unless the water is pumped. During and after an earthquake, if there is loss of electric power with a resultant failure of the water pumps, and there are substantial breaks in the water mains due to surface fault rupture, other types of surface failure, and ground shaking, large portions of Coachella will be left without water for days or weeks. In fact, the HazUS analyses conducted for this study indicate that a M7.8 earthquake on the San Andreas fault is expected to have a significant negative impact on both the potable water and electric power services – essentially all households in the Coachella study area are expected to have no potable water for at least 90 days (3 months) following the earthquake, and possibly even longer. The number of pipe breaks is expected to be such that the entire water system is going to have to be recreated. Given that the M7.8 ShakeOut scenario is going to impact a very large area, "there will not be enough pipe and connectors or trained manpower to repair all the breaks quickly. The worst hit areas may not have water in the taps for 6 months" (Jones et al., 2008). The smaller M7.1 earthquake scenario on the San Andreas fault is anticipated to leave more than 6,100 households without water for 24 hours, and nearly 1,700 households would have no water after three days. However, all households are anticipated to have water a week after the earthquake.

Also important to consider is the fact that two of the three existing water reservoirs in Coachella do not have the seismic valves, flexible joints and other seismic upgrades that are now required in newer tanks (see Chapter 3, Section 3.2.2), based on lessons learned from the 1992 Landers and 1994 Northridge earthquakes. Damage to these tanks during an earthquake, in addition to leaking irrigation lines and open valves in damaged homes can reduce the amount of water available to fire fighters. A minimum seven-day emergency storage supply is recommended, especially in areas likely to be impacted by fires after earthquakes, due to the anticipated damage to the main water distribution system as a result of ground failure and/or weaknesses in the pipes due to corrosion or age.

4.3 Fire Suppression Services

Between 1946, when the City of Coachella was incorporated and 1990, the City was served by its own fire department. On October 1, 1990, the City of Coachella entered into a cooperative fire services agreement with the Riverside County Fire Department (RCFD). Since then, fire suppression, emergency medical, and "all-risk" emergency services in the city of Coachella and in the Coachella General Plan area have been provided by the RCFD. The Riverside County Fire Department, in turn, is administered and operated by the California Department of Forestry and Fire Prevention (Cal Fire) under an agreement with the County of Riverside. The RCFD is a "full service" agency, providing all fire services including suppression, inspection and prevention, fire safety, hazardous materials response, urban search and rescue, and emergency medical (paramedic) response to citizens within its jurisdiction. The RCFD also monitors the fire hazard in the area, and has ongoing programs for public education, and the investigation and mitigation of hazardous situations.

Fire-fighting resources in Coachella and the immediate surrounding area include the fire stations listed in Table 4-3 and shown on Plate 4-1. The general telephone number for the Riverside County Fire Department, Battalion 6 Headquarters (Station 79 in Coachella) is **760-398-8895. For emergencies, dial 9-1-1.**

Table 4-3: Fire Stations In and Near Coachella

Station No.	Address
Station 79 - Coachella Battalion Headquarters.	1377 Sixth Street, Coachella, 92236
Station 86 – Indio	46-990 Jackson Street, Indio 92201
Station 87 - Indio	42-900 Golf Center, Indio 92201
Station 39 - Thermal	86-911 Avenue 58, Thermal 92274
Station 70 – La Quinta	54-001 Madison Street, La Quinta 92253

Fire Station 79 is currently the only fire station physically located in the city of Coachella. The station has been in operation at its current location since 1978, and is staffed by 13 full-time Cal Fire firefighters via a cooperative agreement with Riverside County Fire Department. An Office Assistant is also included with this agreement, and a regional Cal Fire Battalion Chief serves as the Fire Chief for the city of Coachella. A minimum of five firefighters on-duty at all times (Battalion Chief De La Cruz, written communication, May 12, 2014) operate one of the City's two Type-1 fire engines (the 1997 frontline or 1994 back-up unit) plus a Paramedic Rescue Squad. The fire engine is staffed with a Fire Captain, a Fire Apparatus Engineer, and a Firefighter II. This unit is also a paramedic assessment unit, meaning that at least one of the above personnel is a certified paramedic. The Paramedic Rescue Squad is staffed with a Fire Apparatus Engineer and a Firefighter II, of which one or both members are certified paramedics. For units and personnel available on a daily basis by Fire Station serving the Coachella region, refer to Table 4-4 below.

Table 4-4: Units and Personnel Available on a Daily Basis by Fire Station

Fire Station #, City	Units Available (Daily)				# of Personnel Available (Daily)
	Engines	Truck Company	Reserve Apparatus	Paramedic Ambulance	
#79, Coachella	1	No	1	1 Squad (non-transport)	5
#86, Indio	1	1	No	Yes	9
#87, Indio	1	No	Yes	No	3
#39, Thermal	1	No	No	No	3
#70, La Quinta	1	No	Yes	No	3

Source: Battalion Chief De La Cruz, written communication dated May 12, 2014.

Being a cooperative partner with the RCFD, the Coachella fire station receives supplemental assistance as needed for fire department resources from other RCFD stations in the region, with the responses handled as part of the regional and integrated fire protection system. The neighboring cities of La Quinta and Indio are also part of the RCFD, and as such, stations from these cities provide emergency response as needed in Coachella and surrounding unincorporated areas. The fire stations in these cities include Fire Stations #86 and #87 in Indio, and Fire Station #70 in La Quinta (see Tables 4-3 and 4-4). The fire units from these cities, as well as the surrounding unincorporated communities, are not bound by city limits, boundaries or jurisdictions. As a result, the closest available fire unit(s) will respond to an emergency in any of these jurisdictions with no regard for city boundaries. Formal automatic and/or mutual aid agreements do not apply.

The Riverside County Fire Department (RCFD) has been in business for nearly 70 years (the first county-owned fire stations and engines were established in 1946), and includes city, county, state, and volunteer fire stations in its regional, integrated fire protection organization. The RCFD serves 21 of the 28 cities in the County of Riverside, in addition to one Community Services District. Funding for the RCFD is obtained from various sources, including the County's general fund, city general and benefit assessment funds, redevelopment money and other sources. RCFD's combined State, County, and contract cities budget is over $80 million. Volunteer firefighters, trained and available for emergencies, are paid for actual fire fighting services.

In addition, following the tragic Esperanza Fire that started on October 26, 2006 near Cabazon, the Riverside County Board of Supervisors created a Fire Hazard Reduction Task Force. This Task Force is tasked with reviewing and providing recommendations to reduce the fire hazards and clarify evacuation measures throughout the County.

4.3.1 Response Objectives and Statistics

The National Fire Protection Association (NFPA Standard 1710, 2010) recommends the following objectives for fire departments:

- An alarm answering time of not more than 15 seconds for at least 95 percent of the alarms received, and not more than 40 seconds for at least 99 percent of the alarms received;
- When the alarm is received at a public safety answering point (PSAP) and transferred to a secondary answering point (or communication center), the agency responsible for the PSAP should have an alarm transfer time of not more than 30 seconds for at least 95 percent of all alarms processed;
- The responding fire department should have an alarm processing time (the time interval from when the alarm is acknowledged at the communication center until response information begins to be transmitted via voice or electronic means to emergency response facilities and emergency response units) of not more than 60 seconds for at least 90 percent of the alarms, and not more than 90 seconds for at least 99 percent of the alarms;
- Turnout time for fire and special operations of 80 seconds, and turnout time for EMS response of 60 seconds;
- Travel time of 240 seconds or less for the arrival of the first arriving engine company at a fire suppression incident and 480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident;
- Travel time of 240 seconds or less for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher level capability at an emergency medical incident;

- Travel time of 480 seconds or less for the arrival of an advanced life support unit at an emergency medical incident, where this service is provided by the fire department, provided that a first responder with AED or basic life support unit arrived in 240 seconds or less travel time.

These time recommendations for fire suppression incidents are based on the demands created by a structure fire: It is critical to attempt to arrive and intervene at a fire scene prior to the fire spreading beyond the room of origin, and this typically occurs within 8 to 10 minutes after ignition. In reality however, response times are going to vary depending on the distance between the responding fire stations and the incident location, the setting (urban, rural or outlying), traffic density and patterns, and conditions specific to the area that may hamper fire response times.

The Coachella Fire Department reports that their response time to emergency calls within the city in 2013 averaged 3.6 minutes, and that in 83 percent of the time, on scene response took 5 minutes or less (De La Cruz, personal communication 2014). For statistics regarding fire department response times in the city of Coachella, refer to Table 4-5 below.

4.5: Fire Department Response Times Within Coachella City Limits

Year	2010	2011	2012	2013
Average Response Time (in Minutes)	3.6	3.6	3.7	3.6
% of Calls on Scene in Five Minutes or Less	84	84	82	83

Rapid growth and development can create traffic challenges that can have an impact on emergency response, including extended response times and service delays. Some of the highest daily traffic volumes in the Coachella Valley occur in the city of Coachella. In 2007, the section of Grapefruit Boulevard near Avenue 48 and Dillon Road serviced nearly 52,000 vehicles daily; similarly, the section of Grapefruit Boulevard north of Harrison Street serviced more than 43,000 vehicles daily. Heavy traffic congestion on these roads during peak commuting hours can impact the fire department's response time to an emergency in these areas.

The Union Pacific railroad and canal crossings are also limiting factors, obstructing traffic from the fire stations on the western portion of the Coachella Valley to the eastern sections of the city. The Riverside County Fire Department also reports that emergency response times in Coachella can be impacted by flooding as a result of heavy rains, and due to downed electrical lines and/or debris buildup along roadways during periods of high to strong winds. Other issues that can hamper response times include restricted access at gated communities (such as the Prado Tract at Avenue 50, between Van Buren and Frederick streets, and the Villas at Vineyards, at Dillon Road and Avenue 44), and medians on roads (such as Harrison Street).

Another potential reality that can impact emergency responses is multiple and/or simultaneous alarms. When these occur, the fire department's 9-1-1 Emergency Command Center (ECC) will dispatch the next closest and most appropriate unit to the new incident. Multiple alarms and/or large resource requests are also managed by the ECC where the closest fire department resources are dispatched to mitigate emergencies, where the response can consist of as few as two units, or as many as twenty or more.

A component to total response time is known as "setup" time. This is the time which begins once a fire engine arrives on scene of a fire and ends after firefighters establish a water supply, set up firefighting equipment, and prepare to extinguish the fire. This may range from 2 minutes at a small house fire to 15 minutes or more at a large or multi-story occupancy, such as a large apartment complex, or a large school, such as Coachella Valley High School. Structure fire response requires numerous critical tasks to be performed simultaneously, and the number of firefighters required to perform the tasks varies based upon the risk.

Obviously, the number of firefighters needed at a maximum high-risk occupancy, such as a shopping mall or large industrial occupancy would be significantly higher than for a fire in a lower-risk occupancy. Given the large number of firefighters that are required to respond to a high-risk, high-consequence fire, Fire Departments routinely rely on stations from adjacent jurisdictions to address the fires suppression needs of their community. As mentioned before, given that Coachella is a cooperative partner with the Riverside County Fire Department, supplemental needs for emergency response resources are handled through the regional and integrated fire protection system, which does not rely on automatic and/or mutual aid agreements. If additional resources are needed due to the intensity or size of the fire, additional fire units from other jurisdictions and agencies may be requested to provide assistance.

The Riverside County Fire Department has established specific objectives (or goals) for Land Use/Fire Suppression in their area of coverage that specify the Department's response times, fire ground operations and fire station locations. These objectives are summarized in Table 4-6.

Table 4-6: Riverside County Fire Department
Land Use / Fire Suppression Objectives

Objectives	Heavy Urban	Urban	Rural	Outlying
Extinguishing agent applied to fires within listed minutes from dispatch	5 Response +3 Setup 8 Minutes	7 Response +3 Setup 10 Minutes	11 Response +3 Setup 14 Minutes	17 Response +3 Setup 20 Minutes
Full assignment in operation within listed minutes from dispatch	6 Response +4 Setup 10 Minutes	11 Response +4 Setup 15 Minutes	16 Response +4 Setup 20 Minutes	26 Response +4 Setup 30 Minutes
Suppression initiated within listed minutes of dispatch for 90 percent of all fires	Prior to flashover	8 Minutes	10 Minutes	15 Minutes
Fire station located within listed miles	1-1/2 miles	3 miles	5 miles	8 miles

The Insurance Services Office (ISO) provides rating and statistical information for the insurance industry in the United States. To do so, ISO evaluates a community's fire protection needs and services, and assigns each community evaluated a Public Protection Classification (PPC) rating. The rating is developed as a cumulative point system, based on the community's fire-suppression delivery system, including fire dispatch (operators, alarm dispatch circuits, telephone lines available), fire department (equipment available, personnel, training, distribution of companies, etc.), and water supply (adequacy, condition, number and installation of fire hydrants). Insurance rates are based upon this rating. The worst rating is a Class 10. The best is a Class 1.

The City of Coachella currently has a Class 4 ISO rating. As urban sprawl continues to increase in the Coachella Valley, this land development may have a cumulative adverse impact on the Fire

Department's ability to provide an acceptable level of service, unless additional fire stations are built to provide the needed coverage. The increase in population and development is also anticipated to result in an increased number of emergency and public service calls. As development extends onto the east side of the Coachella Canal, both to the south and north of Interstate 10, at least one new fire station will be required in this area. It is also important to note that when the San Andreas fault breaks in the next earthquake, the surface fault displacements anticipated in the Coachella area will be large enough that vehicular traffic across the fault will be impossible immediately following the earthquake. Given that all of the fire stations are currently on the west side of the fault, emergency personnel from Coachella will not be able to access the eastern half of the Coachella General Plan until the roads crossing the San Andreas fault have been repaired.

The NFPA Fire Protection Handbook (Volume II, 20th Edition) provides guiding principles for the location of additional fire stations, including:

- Consideration of criteria established by the ISO regarding the distributions of fire companies within the community;
- Consideration of NFPA Standard 1710 guidelines with regards to response times, including that an engine company should respond within 240 seconds of travel time to fire incidents and emergency medical services, and within 640 seconds for a full first-alarm group in a minimum of 90 percent of annual incidents;
- Consideration of the proximity of travel time to other station protection zones for timely inclusion in the full first-alarm response group;
- Consideration of rapid and safe access to multi-directional major response routes;
- Consideration of appropriate locations given the land use issues in the surrounding environment;
- Consideration of utility availability, plot size, and surrounding traffic control issues; and
- Consideration of historical and projected call volume (response workload) in the area of concern using risk versus cost analysis.

Battalion Chief De La Cruz (written communication, May 12, 2014) further indicates that City's Planning Department staff should work in concert with the Strategic Planning Bureau of the Riverside County Fire Department to ensure that any proposed fire station locations meet the overall response time criteria and meet the goal of regional fire protection. A typical six-step process that can be used as a decision guide for placement of future fire stations includes:

1. Identify the geographic area of concern on a regional map;
2. Use response mapping computer software to locate a hypothetical station at or near the center of the geographic area or near a major response route;
3. Use a realistic safe response speed or appropriately varied response speeds to plot color-coded timed distances on all streets and roads emanating from the hypothetical station extending out to the response area boundary
4. Determine the number of responders and types of apparatus that would respond from that station for various types of calls and compare with the department standards of cover for that type of area and its hazards;
5. Evaluate the response time and resources that would be dispatched to fire and emergency medical service calls from other stations to make up the first alarm assignment "standards of cover" set by policy for that area; and

6. Adjust the hypothetical station location, if necessary while maintain the station location as close to the center of that geographic area as possible to maintain equity of response time.

4.3.2 Automatic and Mutual Aid Agreements

Fire-fighting agencies team up and work together during emergencies. These teaming arrangements are typically handled through automatic and mutual aid agreements, which obligate fire departments to help each other under pre-defined circumstances. **Automatic aid** agreements obligate the nearest fire company to respond to a fire regardless of the jurisdiction. **Mutual aid** agreements obligate fire department resources to respond outside of their district upon request for assistance.

The California Disaster and Civil Defense Master Mutual Aid Agreement (California Government Code Section 8555-8561) states: "Each party that is signatory to the agreement shall prepare operational plans to use within their jurisdiction, and outside their area." These plans include fire and non-fire emergencies related to natural, technological, and war contingencies. The State of California, all State agencies, all political subdivisions, and all fire districts signed this agreement in 1950.

Riverside County was one of the first counties in the State to endorse and support cooperative and integrated fire protection in support of greatest efficiency and economy. As early as 1906, the County authorized funds to augment the State's fire protection efforts. Since 1921 the County has appointed the California Department of Forestry Unit Chief as the County Fire Chief. It also has appropriated County funds to augment and improve the level of protection in 3,570,000 acres of local responsibility area, and to protect lives and structural property in the unincorporated areas of the County. The County also enhances the existing California Department of Forestry system that protects 1,070,000 acres of state responsibility area for year-round protection.

The County of Riverside contracts with the State of California for fire and "al-risk" emergency services. Public Resources Code 4142 affords legal authority for the California Department of Forestry and Fire Protection (CDF or Cal Fire) to enter into agreements with local government entities to provide fire protection services with the approval of the Department of General Services. By virtue of this authority, Cal Fire administers the Riverside County Fire Department. Cal Fire is primarily a wildland fire protection agency with the legal responsibility for protection of approximately 33 million acres of private and state lands in California. The Riverside Unit of Ca lFire provides direct protection for 1,070,000 acres of vegetation-covered wildlands designated by the State Board of Forestry as state responsibility areas (SRAs).

Numerous other agencies are available to assist the Riverside County Fire Department if needed. These include the Police Department and the California Highway Patrol, who, depending on the location of the incident, would provide support during evacuations and to discourage people from traveling to the incident area to observe Fire Department operations, as this can hinder fire suppression and emergency response efforts. Several State and Federal agencies have roles in fire hazard mitigation, response and recovery, depending on the type of incident and its location.

Other agencies that could provide assistance to the Riverside County Fire Department in the event of a significant fire include the Office of Emergency Services, Office of Aviation Services, National Weather Service, the Department of the Interior, and, in extreme cases, the

Department of Defense. In forest and open areas, agencies that often assist with fire suppression include the National Park Service, U.S. Forest Service, National Association of State Foresters, Fish and Wildlife Service, and the Department of Agriculture. Private companies and individuals may also be asked to provide assistance in some cases.

4.3.3 Standardized Emergency Management System (SEMS) and National Incident Management System (NIMS)

The SEMS law refers to the Standardized Emergency Management System described by the Petris Bill (Senate Bill 1841; California Government Code Section 8607, made effective January 1, 1993) that was introduced by Senator Petris following the 1991 Oakland fires. The intent of the SEMS law is to improve the coordination of State and local emergency response in California. It requires all jurisdictions within the State of California to participate in the establishment of a standardized statewide emergency management system.

When a major incident occurs, the first few moments are absolutely critical in terms of reducing loss of life and property. First responders must be sufficiently trained to understand the nature and the gravity of the event to minimize the confusion that inevitably follows catastrophic situations. The first responder must then put into motion relevant mitigation plans to further reduce the potential for loss of lives and property damage, and to communicate with the public. According to the State's Standardized Emergency Management System, local agencies have primary authority regarding rescue and treatment of casualties, and making decisions regarding protective actions for the community. This on-scene authority rests with the local emergency services organization and the incident commander.

Depending on the type of incident, several different agencies and disciplines may be called in to assist with emergency response. Agencies and disciplines that can be expected to be part of an emergency response team include medical, health, fire and rescue, police, public works, and coroner. The challenge is to accomplish the work at hand in the most effective manner, maintaining open lines of communication between the different responding agencies to share and disseminate information, and to coordinate efforts.

Emergency response in every jurisdiction in the State of California is handled in accordance with SEMS, with individual City agencies and personnel taking on their responsibilities as defined by the City's Emergency Plan. This document describes the different levels of emergencies, the local emergency management organization, and the specific responsibilities of each participating agency, government office, and City staff.

The framework of the SEMS system is the following:

- Incident Command System – a standard response system for all hazards that is based on a concept originally developed in the 1970s for response to wildland fires;
- Multi-Agency Coordination System – coordinated effort between various agencies and disciplines, allowing for effective decision-making, sharing of resources, and prioritizing of incidents;
- Master Mutual Aid Agreement and related systems – agreement between cities, counties and the State to provide services, personnel and facilities when local resources are inadequate to handle and emergency;
- Operational Area Concept – coordination of resources and information at the county level, including political subdivisions within the county; and

- Operational Area Satellite Information System – a satellite-based communications system with a high-frequency radio backup that permits the transfer of information between agencies using the system.

The SEMS law requires the following:

- Jurisdictions must attend training sessions for the emergency management system;
- All agencies must use the system to be eligible for funding for response costs under disaster assistance programs; and
- All agencies must complete after-action reports within 120 days of each declared disaster.

The September 11, 2001 terrorist attacks, and later, the 2004 and 2005 hurricane seasons demonstrated the need for improve the country's emergency management, incident response capabilities and coordination processes. On February 28, 2003, the President issued Homeland Security Presidential Directive 5 (HSPD-5), and in response, on March 1, 2004, the Department of Homeland Security unveiled the basic framework guiding the development and administration of the **National Incident Management System** (**NIMS**). NIMS provides a nationwide template that is meant to enable Federal, State, tribal, and local governments, in addition to non-governmental organizations and the private sector, to work together to "prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity." NIMS is a core set of doctrines, concepts, principles, terminology and organizational processes that enable effective, efficient and collaborative incident management. NIMS works hand in hand with the National Response Framework (NRF), which provides the structure and mechanisms for national-level policy for incident management.

NIMS is the following:

- A comprehensive, nationwide systematic approach to incident management, including the Incident Command System, Multiagency Coordination Systems, and Public Information;
- A set of preparedness concepts and principles for all hazards;
- Essential principles for a common operating picture and interoperability of communications and information management;
- Standardized resource management procedures that enable coordination among different jurisdictions and organizations;
- Scalable, so that it may be used for all incidents (from day-to-day to large-scale); and
- A dynamic system that promotes ongoing management and maintenance.

NIMS components include:

- Preparedness;
- Communications and Information Management;
- Resource Management;
- Command and Management; and
- Ongoing Management and Maintenance.

HSPD-5 requires all Federal departments and agencies to adopt NIMS and use it in all their individual incident management and activities. *Furthermore, the directive requires Federal departments and agencies to make adoption of NIMS by State, tribal and local (i.e., cities) organizations a condition for receiving Federal preparedness assistance.* Given that the basic framework for NIMS was put together in short order, it was understood that it would be a work in progress. In the years since 2004, the NIMS process has been reviewed continuously to incorporate best practices and lessons learned from recent incidents. In 2005, all state, local and tribal jurisdictions were to adopt NIMS for all Departments/Agencies, and were to revise and update their emergency operations plans, standard operating procedures, and standard operating guidelines to incorporate NIMS and National Response Framework components, principles and policies. In 2008, local jurisdictions were to use existing resources, such as programs, personnel and training facilities to coordinate and deliver NIMS training requirements. These training requirements are based on a group of training courses at different levels have been developed and that all appropriate emergency response personnel at all levels of government are required to take to satisfy the NIMS objectives. For the most recently published NIMS compliance metrics refer to the FEMA website at http://www.fema.gov/.

The Riverside County Fire Department has been NIMS-SIMS-ICS compliant since 2007, formalized by a Board of Supervisors Action.

Consistent with both SIMS and NIMS requirements, all firefighting personnel of the Riverside County Fire Department are required to train daily. Each employee trains either individually and/or in groups (such as engine company drills and multi-engine company drills), and participates in a formalized program of instruction (with a lesson plan, instructor, or instructional device) to acquire the skills and knowledge necessary to improve the employee's performance in his or her current position. The drills are held at the local fire station, local buildings or complexes, or at the Riverside County Fire Department's Roy Wilson Fire Training Center. In addition, the RCFD maintains an in-service training program that consists of monthly company drills, quarterly re-certification training, monthly emergency medical service skills labs, on-duty EMS skills proficiency verification, structured multi-company drills, on-line training delivery, spot drills, interagency drills, twelve hours of station-level training per month, quarterly truck/rescue drills, annual wildland preparedness drills, and company manipulative drills at both the Ben Clark (3423 Davis Avenue, Riverside) and Roy Wilson Desert (31920 Robert Road, Thousand Palms) Training Centers.

4.4 Chemical Fires

Chemical substances are often unstable under high temperatures. Other chemicals are reactive to water or oxygen, and can self-ignite if exposed to water or air. For example, sulfuric acid, one of the most abundant and widely distributed chemicals produced in the U.S., is highly reactive when exposed in its concentrated form to water. Other substances if mixed together can also generate a fire. Therefore, when dealing with chemical fires it is important to know what type of chemicals are present in the area and where they are being stored or used. It is also important to note that when dealing with chemical fires, time is critical: the longer chemicals are exposed to extreme heat, the more likely that they will react violently, increasing the severity of the fire. Fire fighters can better respond to a situation with the appropriate equipment if they have the information needed to make these decisions immediately available to them. This is what the business plans and the Material Safety Data Sheets (MSDS) discussed in Chapter 5 – Hazardous Materials Management – are intended to provide.

Firefighters recognize five different types of fires:

- **Class A** fires involve ordinary combustibles, such as paper, wood, cardboard, rubber and plastics.
- **Class B** fires involve flammable and combustible liquids and gases, such as gasoline, kerosene, propane, oils and paints. Do not use water because it may spread the fire!
- **Class C** fires involve "energized" electrical equipment, such as appliances, power tools, electrical circuit boxes, and televisions. Do not use water because of the risk of electrical shock!
- **Class D** fires involve combustible metals, such as magnesium, titanium, potassium and sodium. Do not use water as these materials burn at high temperature and will react violently with water application!
- **Class K** fires involve cooking oils, fats and greases. These typically have a higher auto-ignition temperature and are found in commercial cooking kitchens. Do not use water as this will likely spread the fire!

It is not uncommon for fires to be a combination of the types discussed above. Therefore, it is typically recommended that fire extinguishers obtained for household and office use have an ABC rating, which means that they have the capacity to fight Class A, B and C fires.

Common types of extinguishers include:

- **Water extinguishers**, which are suitable for class A (paper, etc.) fires, but not for class B, C and D fires, because the water can make the flames spread.
- **Dry chemical extinguishers**, which are useful for class ABC fires and are the best all-around choice. They have an advantage over CO_2 extinguishers because they leave a blanket of non-flammable material on the extinguished material that reduces the likelihood of re-ignition. There are two kinds of dry chemical extinguishers:
  - Type BC fire extinguishers contain sodium or potassium bicarbonate, and
  - Type ABC fire extinguishers that contain ammonium phosphate.
- **CO_2 (carbon dioxide) extinguishers** are for class B and C fires. They do not work very well on class A fires because the material usually re-ignites. CO_2 extinguishers have an advantage over dry chemical extinguishers in that they leave behind no harmful residue – a good choice for an electrical fire on a computer or other delicate instrument. Note that CO_2 is a bad choice for flammable metal fires such as Grignard reagents, alkyllithiums and sodium metal because CO_2 reacts with these materials. CO_2 extinguishers are not approved for class D fires.
- **Metal/Sand Extinguishers** are for flammable metals (class D fires) and work by simply smothering the fire.
- **Wet Chemical or Class K Extinguishers** work on the principle of saponification, where an alkaline mixture (such as potassium acetate) combines with the burning cooking media, resulting in a soapy foam layer. This reaction cools and smothers the fire.

Not only is it imperative to control chemical fires as soon as possible, but two main "by-products" of these types of fires require special attention, including special handling and evacuation procedures. These by-products include the "smoke plume" and water run-off from the fire-extinguishing process. The smoke plume has the potential to pose a severe hazard to those exposed to it: chemicals in the vapor phase can be mildly to extremely toxic if inhaled, depending on the chemicals involved. Smoke inhalation is a hazard in itself, but when chemicals are part of the smoke, it can have severe negative impacts on the health of those nearby, including fire-fighting personnel and individuals not evacuated in time to prevent them from inhaling the smoke. Soot from some types of fires can also cause chemical burns on skin. Therefore, depending on the types of chemicals involved in the fire, an evacuation of the immediate area and especially of those areas down-wind should be conducted.

If water is used to fight a fire, the runoff could include chemicals or substances that pose a hazard to the environment. Therefore, the runoff should be contained to prevent it from flowing into storm drains or leach fields. Containing the water runoff from a fire is difficult but possible, especially if the special equipment to do so is available.

4.5 Fires Following Earthquakes

Wildland fires are not a concern in the Coachella area, and thus are not the worst-case scenario for the community. History shows, however, that earthquake-induced fires have the potential to be the worst-case fire-suppression scenarios for a community because an earthquake typically causes multiple ignitions distributed over a broad geographic area, with the potential to severely tax the local fire suppression agencies. Furthermore, if fire fighters are involved with search and rescue operations, they are less available to fight fires. Fire suppression efforts can also be limited by a water distribution system that has been impaired by the earthquake. Thus, many factors affect the severity of fires following an earthquake, including ignition sources, types and density of fuel, weather conditions, functionality of the water systems, and the ability of firefighters to suppress the fires. The principal causes of earthquake-related fires are open flames, electrical malfunctions, gas leaks, and chemical spills. Downed power lines may ignite fires if the lines do not automatically de-energize. Unanchored gas heaters and water heaters are common problems, as these readily tip over during strong ground shaking (State law requires new and replaced gas-fired water heaters to be attached to a wall or other support).

The major urban conflagrations of yesteryear in major cities were often the result of closely built, congested areas of attached buildings with no fire sprinklers, no adequate fire separations, no Fire Code enforcement, and narrow streets. In the past, fire apparatus and water supplies were also inadequate in many large cities, and many fire departments were comprised of volunteers. Many of these conditions no longer apply to the cities of today. Nevertheless, major earthquakes can result in fires and the loss of water supply, as it occurred in San Francisco in 1906, and in Kobe, Japan in 1995. A large portion of the structural damage caused by the great San Francisco earthquake of 1906 was the result of fires rather than ground shaking.

The 1992 Landers earthquake caused two residential fires in Landers, most likely the result of propane gas leaks from overturned appliances; both structures burned down completely. In Yucca Valley, two mobile homes fell off their supports and ignited, also most likely as a result of severed propane gas lines or overturned gas appliances. One of these mobile homes was completely destroyed. Despite multiple breaks in the water distribution system, the San Bernardino County Fire Department reported sufficient water supply to fight these fires (EERI, 1992).

The moderately sized, M6.7 Northridge earthquake of 1994 caused 15,021 natural gas leaks that resulted in three street fires, 51 structure fires (23 of these caused total ruin) and the destruction, by fire, of 172 mobile homes. In one incident, the earthquake severed a 22-inch gas transmission line and a motorist ignited the gas while attempting to restart his stalled vehicle. Response to this fire was impeded by the earthquake's rupture of a water main; as a result, five nearby homes were destroyed. Elsewhere, one mobile home fire started when a ruptured transmission line was ignited by a downed power line. In many of the destroyed mobile homes, fires erupted when inadequate bracing allowed the houses to slip off their foundations, severing gas lines and igniting fires.

As the examples above indicate, fires following earthquakes can cause severe losses. In some instances, these losses can outweigh the losses from direct damage, such as the collapse of buildings and disruption of lifelines. This potential hazard is particularly applicable to the southern California area given its high seismic potential, and to the city of Coachella, given its location relative to the San Andreas fault, the most significant seismic source in southern California, with a high probability of rupturing in the near-future. A strong earthquake on this fault could trigger multiple fires and disrupt lifelines services (such as the water supply in the region (discussed in more detail in Section 4.2.2 above, and in Chapters 1 and 3).

Given that thousands of leaks and breaks in the natural gas system are expected in Coachella following an earthquake on the San Andreas fault (refer to Table 1-15 in Chapter 1), several fires following the earthquake can be expected. In support of this argument consider the following example from the Los Angeles area: In 1988 the California Division of Mines and Geology (now the California Geological Survey; Toppozada and others, 1988) published a study that identified projected damages in the Los Angeles area as a result of an earthquake on the Newport-Inglewood fault. The Newport-Inglewood earthquake scenario estimated that thousands of gas leaks would result from damage to pipelines, valves and service connections. This study prompted the Southern California Gas Company to start replacing their distribution pipelines with flexible plastic polyethylene pipe, and to develop ways to isolate and shut off sections of supply lines when breaks are severe. Nevertheless, as a result of the 1994 Northridge earthquake, which occurred on a buried thrust fault that did not cause surface fault rupture, the Southern California Gas Company reported 35 breaks in its natural gas transmission lines and 717 breaks in its distribution lines. About 74 percent of the leaks were corrosion related. There were 51 structure fires, and approximately 172 mobile homes were destroyed by fire. The structure fires were caused by overturned water heaters (20), other overturned or damaged gas appliances (8), broken interior gas lines (8), broken gas meter set assemblies (2), street fires due to breaks in gas mains (7), and other unknown causes (8). The mobile home fires were primarily the result of failure of the supports leading to breakage of the gas risers, and breakage of the interior gas lines due to overturned water heaters and other appliances (Savage, 1995).

A regional earthquake scenario that involves rupture of the entire southern section of the San Andreas fault was conducted in 2008 for the ShakeOut Scenario (Jones and others, 2008; Scawthorn, 2008). The scenario estimates that as a result of a magnitude 7.8 earthquake on the southern San Andreas, a total of 239 ignitions would occur in Riverside County. This estimate does not include ignitions that are suppressed by responding citizens. Of the estimated 239 ignitions that will require fire department response, 157 would develop into large fires, each requiring the response of more than one fire engine company. The estimated ultimate burnt area in the County would be equivalent to about 1,000 single-family dwellings (Scawthorn, 2008). Using the 1994 Northridge earthquake as proxy, about half of the ignitions are expected to be electric related, about a quarter would be gas related, and the rest would be the result of a variety of causes, including chemical reactions. Also based on the Northridge earthquake, about 70 percent of all ignitions will occur in residential structures. Although city-specific estimates were not computed as part of the ShakeOut scenario, the data clearly highlight the hazard associated with earthquake-induced fires. Response to these fires will be hindered by a damaged water distribution system, overwhelmed local fire department resources, overwhelmed 9-1-1 centers, and extremely delayed response from strike teams coming in from outlying areas due to damage to the transportation system and traffic disruption (Scawthorn, 2008).

The Riverside County Fire Department has policies specific to earthquake planning. Specifically, in the event of an earthquake, the Fire Captain and/or Fire Apparatus Engineer first ensures that their personnel are accounted for and are safe, then fire department personnel conduct a facility damage assessment inspection, move the fire apparatus outside the fire station, and start a local area damage reconnaissance. The assessment considers a review and identification of target hazards, potential rescue hazards, road closures, utility failures, hazardous materials releases, and other life-safety concerns. If an earthquake is more severe, the local stations call for more resources as needed, including the activation of emergency operations centers, and the County's Office of Emergency Services. All fire engines in the County have the ability to draft water from alternate sources (such as swimming pools and ponds) to use for fire suppression, a capability of great value, especially if the water distribution system has been damaged and the Fire Department has to resort to alternative water sources to fight fires.

4.6 Summary and Recommended Programs

The Riverside County Department manages the fire hazard in the city of Coachella by providing fire prevention, suppression and public education programs. The City and the County have also invested and continue to invest on infrastructure and equipment that help the Fire Department be as responsive as possible. However, the coverage area is large, and land development and traffic congestion at times hinder the Fire Department's response time to emergency calls. Coachella's ISO rating of 4 could drop if the fire department does not keep pace with the level of development expected in the area.

Although very few historical wildland fires have been reported in the Coachella General Plan area, a few small vegetation fires do occur annually. The eastern and northeastern portions of the General Plan area are currently mapped as either Local Responsibility or Federal Responsibility areas, typically with a moderate fire hazard. A small area in the far northeastern portion of the General Plan area is mapped as having a high fire hazard. The boundaries of these regions are shown on Plate 4-1. Residents of and near these fire hazard areas should be encouraged to practice fire-safe procedures, including maintaining a fire-safe landscape, and keeping combustibles (such as fire wood) a safe distance away from all structures. Similarly, the County and City should continue to enforce the weed abatement and notification program, to reduce the potential for vegetation fires to occur in vacant or poorly maintained lots.

Fires in the Coachella General Plan area represent a very small percentage of the annual emergency calls that the Fire Department receives and responds to. However, fires can represent a large percent of the total annual losses. Therefore, programs that can be continued or implemented to reduce these losses should be encouraged.

Specifically the City and County:

- Should continue to regularly reevaluate specific fire hazard areas and adopt reasonable safety standards, covering such elements as adequacy of nearby water supplies, routes or throughways for fire equipment, clarity of addresses and street signs, and maintenance.
- Should encourage owners of non-sprinklered properties, especially high-occupancy structures, to retrofit their buildings and include internal fire sprinklers. The City may consider some form of financial assistance (such as low-interest or no-interest loans) to encourage property owners to do this as soon as possible.
- Should continue to conduct emergency response exercises, including mock earthquake-induced fire-scenario exercises to prepare for the multiple ignitions that an earthquake is expected to generate. Civilians should be encouraged to participate in these exercises as much as possible also, to empower neighborhoods to be self-reliant in the face of a natural or man-made disaster. These training sessions should use the adopted emergency management systems (SEMS and NIMS).
- Should continue to conduct regular assessments of the Fire Department's response objectives, to identify those areas that, because of increasing population, will require an increase in fire

department presence. Specifically, as the city's population increases, additional fire stations will be required, their locations to be selected based on population demands. The City should continue to require that funding for the construction of these new fire stations be supported, at least in part, by the developers of the proposed large-scale master-planned communities. Fees that cover the purchasing of fire equipment and manning of these new fire stations should also be considered.

- Should consider siting and building additional above-ground storage tanks on the west side of the San Andreas fault, where most of the City's residents currently live. Furthermore, strengthening of the City's water distribution system should be considered a top priority to reduce the estimated damage caused by an earthquake on the San Andreas fault.

CHAPTER 5: HAZARDOUS MATERIALS MANAGEMENT

5.1 Setting and Definitions

A high standard of living has driven our increasing dependence on chemicals. Chemicals like hydrocarbon fuels, chlorine, pesticides and herbicides are used on a daily basis and in large quantities. In areas with an agricultural tradition, such as the Coachella Valley and the city of Coachella, pesticides, herbicides and fertilizers have been used and are being used extensively. Because of the high demand for these types of chemicals, their storage and transportation is necessary. Some industrial, commercial and manufacturing facilities also use hazardous materials, and releases of these compounds onto the environment, either intentionally or accidentally, even if it was years or decades ago, can still pose a threat to public health. Compounds that were used extensively decades ago, when regulations regarding the manufacture, use and storage of these substances were lax, have been found to be hazardous to human health and to the environment. In response to these concerns, which began in the late 1960s, dozens of Federal, State, and local regulations have been implemented to dictate the use, storage, transportation, handling and clean-up of hazardous materials and wastes. It is the aim of these regulations to minimize the risk of exposure to hazardous materials by the general public.

The United States Environmental Protection Agency (herein referred to as the EPA) has defined hazardous waste as substances that 1) may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; 2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed; and 3) whose characteristics can be measured by a standardized test or reasonably detected by generators of solid waste through their knowledge of their waste. Hazardous waste is also ignitable, corrosive, or reactive (explosive) (EPA 40 CFR 260.10). A material may also be classified as hazardous if it contains defined amounts of toxic chemicals. The EPA has developed a list of specific hazardous wastes that are in the forms of solids, semi-solids, liquids, and gases. Producers of such wastes include private businesses, and Federal, State, and local agencies.

The State of California further defines hazardous materials as substances that are toxic, ignitable or flammable, reactive, and/or corrosive. The State also defines an extremely hazardous material as a substance that shows high acute or chronic toxicity, carcinogenity, bioaccumulative properties, is persistent in the environment, or is water reactive (California Code of Regulations, Title 22).

5.2 Regulatory Context and Lists of Sites

Various Federal and State programs regulate the use, storage, and transportation of hazardous materials. These will be discussed in this section as they pertain to the Coachella area and the City's management of hazardous materials. The goal of the discussions presented herein is to provide information that can be used to reduce or mitigate the danger that hazardous substances may pose to Coachella's residents and visitors, both in normal, day-to-day conditions, and as a result of a regional disaster, such as an earthquake.

Several of the Federal and State programs are summarized in the subsections below.

5.2.1 Federal Clean Water Act (33 U.S.C. §1251 et seq., 1972) and California Water Code

"Out of sight, out of mind" has been the traditional approach to dealing with trash, sediment, fertilizer-laden irrigation water, used motor oil, unused paint and thinner, and other hazardous substances that people dump onto the ground, or into the sewer and storm drains. What we often forget is that substances dumped into the storm drain system can make their way into drainages, lakes, rivers, and eventually the ocean. Contaminants in these waterways can endanger aquatic organisms and wildlife dependent on these water sources, and can impact human health and the environment. Some substances dumped onto the ground can eventually make their way into the groundwater, with the potential for contamination of our drinking water resources.

In part to deal with these issues, the Federal government enacted the Clean Water Act in 1972. This Act establishes the framework by which discharges of pollutants into the waters of the United States are regulated, including the establishment of quality standards for surface waters. One of the earliest programs established under the Act was the National Pollutant Discharge Elimination System (NPDES) to control wastewater discharges from various industries and wastewater treatment plants known as a "point sources." A point source is defined by the EPA as a discrete, easily discernible source of pollution, such as a smokestack or sewer. Then, in 1987, the Water Quality Act amended the NPDES permit system to include "non-point source" (NPS) pollution. NPS pollution refers to the introduction of bacteria, sediment, oil and grease, heavy metals, pesticides, fertilizers and other chemicals from less well-defined sources into our rivers, lakes, bays and oceans. These pollutants are not released at one specific, identifiable point, but rather, from a number of points that are spread out and are thus difficult to identify and control. The pollutants are washed away from roadways, parking lots, yards, farms and other areas by rain and dry-weather urban runoff into the storm drain system, from where they are ultimately conveyed to the area's water bodies and the ocean. NPS pollution is now thought to account for most water quality problems in the United States. Therefore, strict enforcement of this program at the local level, with everybody doing his or her part to reduce NPS pollution, can make a significant difference.

The NPDES program is handled at the State-level by the California Water Resources Control Board (CWRCB, SWRCB or "the Board"), with regional offices of the Board overseeing implementation and enforcement of the program at the local level. NPDES permits are required by all municipalities that own or operate a <u>m</u>unicipal <u>s</u>eparate <u>s</u>torm <u>s</u>ewer <u>s</u>ystem (MS4) that: a) serves a population greater than 100,000 (medium) or 250,000 (large); b) contributes to a violation of a Water Quality Standard, c) is a significant contributor of pollutants to waters of the U.S., or d) is owned and/or operated by a small municipality that is interrelated to a medium or large municipality.

Urban runoff from Coachella discharges into the Whitewater River watershed within the Colorado River Regional Board (Region 7) jurisdiction. The main office of Region 7 of the Water Quality Control Board is located at 73-720 Fred Waring Drive, Suite 100, Palm Desert, California 92260. Their general telephone number is (760) 346-7491. In accordance with the Clean Water Act, and the Porter-Cologne Water Quality Control Act (contained in Division 7 of the California Water Code), the CWRCB is responsible for the formulation and adoption of State policy for water quality control. This includes the development of water quality principles and guidelines for ground waters, surface waters and the use of reclaimed water; the formulation, adoption and periodic review and revision of water quality control plans; and the formulation and enforcement of <u>w</u>aste <u>d</u>ischarge <u>r</u>equirements (WDRs).

In 2013, the Colorado River Regional Water Quality Control Board (Regional Board) re-issued a municipal storm water NPDES permit to the County of Riverside and the Riverside County Flood Control and Water Conservation District (RCFCWCD) as Principal Permittees, and to the Coachella Valley Water District (CVWD) and incorporated cities of Riverside County within the Whitewater River Watershed as Co-Permitees. The incorporated cities that collectively are referred to as co-permitees include Banning, Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage. On November 21, 2012, the joint group of permittees submitted NPDES Application No. CAS617002, a Report of Waste Discharge (RoWD) and a revised Whitewater River Region Storm Water Management Plan (SWMP) to renew their MS4 permit for the urbanized area of the Whitewater River Region (the Permit Area) within Riverside County. The updated Order (Urban Runoff Management Program Order No. R7-2008-0001, NPDES Permit No. CAS617002) was adopted on June 20, 2013, and will expire on June 19, 2018. A completed application for re-issuance of the order needs to be submitted no later than December 23, 2017.

Co-permittees, such as the City of Coachella, have certain responsibilities defined by the NPDES permit order and the region's Storm Water Management Plan (SWMP). Some of these responsibilities are summarized below (for the complete texts refer to the NPDES permit order and extensive resources provided by the Colorado River Basin RWCB for construction, industrial and municipal storm water programs available from http://www.waterboards.ca.gov/coloradoriver/water_issues/programs/stormwater/). Specifically, a permittee is required to:

1. Comply with the requirements of the MS4 permit within its jurisdictional boundaries.
2. Provide certification for all reports and other information requested by the Board as specified in Section 1.9 of the MS4 permit;
3. Annually review the Whitewater River region map to ensure that it encompasses urbanized areas within the permittee's jurisdiction. Any changes or errors in the map need to be submitted to the principal permittees as an amendment to the map.
4. Prepare in a timely manner and provide to the principal permittees all documents required by the MS4 permit.
5. Implement the Whitewater River Region Storm Water Management Plan (SWMP) to: a) reduce potential pollutants in urban runoff from commercial, industrial and residential areas, b) reduce potential pollutants in the urban runoff from land development and construction sites through the use of structural and non-structural best management practices, c) reduce potential pollutants in urban runoff from permittee's maintenance activities to the maximum extent practicable, d) eliminate illegal connections and illegal discharges to the maximum extent practicable, e) encourage spill prevention and containment, as well as provide appropriate spill response plan for permittees' maintenance facilities to the maximum extent practicable; f) increase public awareness to the maximum extent practicable, g) continue to provide MS4 permit compliance-related training for permittee's staff to the maximum extent practicable, and g) control increases in urban runoff flows within the permittee's jurisdictional boundaries to the maximum extent practicable so as not to cause erosion and sedimentation problems downstream.
6. Designate at least one representative to the Desert Task Force, who shall attend Desert Task Force meetings. The Principal Permittees shall be notified immediately of changes to the designated representative.
7. Establish and maintain adequate legal authority which authorizes or enables the permittee to implement and enforce, at a minimum, the following requirements: a) control through ordinance, permit, contract, order or similar means, the contribution of

pollutants to the MS4 by urban runoff associated with industrial activity and the quality of urban runoff discharged from sites of industrial activity, b) prohibit through ordinance, order or similar means, illegal discharges to the MS4 including, but not limited to discharges of wash water resulting from:

i) the hosing or cleaning of gas stations, auto repair garages or other types of automotive services facilities,

ii) the cleaning, repair, or maintenance of any types of equipment or machinery including motor vehicles, cement-related equipment, and port-a-potty servicing,

iii) mobile operations such as oily or greasy discharges from mobile automobile washing, and/or discharges from steam cleaning, power washing, carpet cleaning, etc.,

iv) runoff from material storage areas containing chemicals, fuels, grease, oil, or other hazardous materials, and

v) food-related wastes (such as grease, fish processing, and restaurant kitchen mat and trash bin wash water, etc.).

8. Control, through ordinance, order or similar means, the discharge to the MS4 of spills, dumping or disposal of materials other than urban runoff.
9. Control through interagency agreements among permittees the contribution of pollutants from one portion of the MS4 to another portion of the MS4.
10. Require compliance with conditions in its ordinances, permits, contracts or orders consistent with the enforcement and compliance strategy (Section 1.7) of the storm water management plan.
11. Carry out all inspection, surveillance, and monitoring of procedures necessary to determine compliance with MS4 permit conditions, including the prohibition on illegal discharges to the MS4.
12. Maintain in good working condition at all times the facilities that collect, transport and store urban runoff.

In addition to regulatory activities, and in compliance with the Whitewater River Region Storm Water Management Plan and the MS4 permit, permittees are required to implement public education and outreach programs to increase public awareness about controlling pollution associated with urban runoff. The Desert Task Force provides oversight and guidance for the implementation of the public education program in the Whitewater River Region, whereas the Riverside County Flood Control and Water Conservation District (District), as a Principal Permittee, is the administrator of the program, and is responsible for developing a consistent message about stormwater/urban runoff pollution prevention throughout the County. The cost-sharing program pools staff and resources to: 1) prepare informational materials that can be distributed to the public in general, at schools and businesses; 2) conduct workshops and community events where information on the NPDES program is provided to attendees; and 3) sponsor presentations to civic/rotary/group organizations to discuss the prevention of stormwater pollution. For additional information regarding this program, including scheduling of events, and downloadable materials, refer to http://www.floodcontrol.co.riverside.ca.us/ stormwater/. Pamphlets with information regarding stormwater pollution, with emphasis on how to prevent it, and how to report an unauthorized release, are also available at Coachella's City Hall, at the front counter.

Specific programs that Co-permittees typically conduct in support of the NPDES program include:

- Regular maintenance of public rights of way, including street sweeping, litter collection, and storm drain facility maintenance to reduce the discharge of pollutants, including trash and debris, to their respective MS4 facilities;
- Documentation of the observations of field personnel of unauthorized dumping or spills to help locate the source of pollutants, using standardized reporting forms to document, track and report illicit connections / illegal discharge incidents,
- Maintenance of a database of investigations of illegal connections/illegal discharges;
- Provision, collection, and maintenance of litter receptacles in strategic public areas and during public events;
- Assessment and modification, if necessary, of existing field programs to detect and prevent dumping, or routine discharge of pollutants into MS4 facilities;
- Implementation and enforcement of leash laws and other pet laws (i.e., pet waste cleanup, no pets in public areas) in selected public-use areas;
- Adoption and enforcement of ordinances prohibiting the discharge of pollutants into the storm drain system;
- Plan review procedures to ensure that unauthorized connections to the storm sewer system are not made; and
- Public education efforts to inform residents about storm water quality. These efforts typically include publishing the City's annual water quality report describing the NPDES program and stormwater pollution prevention measures; stenciling of storm drains with warnings about the illegal dumping/discharge of substances; and organizing educational presentations at fairs and other public events, and for school programs.

The California Water Code states that anyone who is discharging or proposing to discharge wastewater onto land shall file a report with the Regional Board. After review, and following any necessary hearings, the Board may impose waste discharge requirements on that individual or facility. All dischargers, except from small, residential, on-site systems, are required to complete and submit to the Regional Board a Report of Waste Discharge. The appropriate forms, including descriptions and instructions for each, can be obtained online at http://www.waterboards.ca.gov/santaana/publications_forms/docs/form200.pdf.

The Regional Board also monitors development projects during the construction stage. Specifically, all dischargers whose projects will disturb one or more acres of soil, or whose projects are less than one acre in size but that are part of a larger development that in total will disturb one or more acres of land are required to obtain a General Permit for Discharges of Storm Water Associated with Construction Activity, under Construction General Permit Order 2009-0009-DWQ adopted on September 2, 2009, and amendments issued in Orders 2010-0014-DWQ and 2012-0006-DWQ. Construction activity includes clearing, grading and disturbances such as stockpiling or excavation. The Construction General Permit requires the development of a Storm Water Pollution Prevention Plan (SWPPP). For additional information regarding this program, copies of the appropriate forms, and specifics regarding the contents of a SWPPP, refer to http://www.waterboards.ca.gov/water_issues/programs/stormwater/constpermits.shtml.

5.2.2 Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) is a regulatory or statute law developed to protect the water, air, and land resources from the risks created by past chemical disposal practices. This act is also referred to as the Superfund Act and contains the National Priority List (NPL) of sites, which are referred to as Superfund sites. Superfund is the name of the environmental program and fund established by CERCLA to address abandoned hazardous waste sites. The fund allows the EPA to clean up these sites and compel responsible parties to do the cleanup or to reimburse the government for the EPA-led cleanup. There are two main types of response actions authorized under CERCLA: 1) removal actions, and 2) remedial actions. Removal actions are short-term responses, often to address emergency situations that require a prompt response, such as the finding of abandoned drums containing hazardous materials or soils contaminated with a substance that poses an acute risk to human health or the environment. Remedial actions are typically long-term responses at sites in the National Priorities List (NPL) with the objective of permanently and significantly reducing the risk associated with the past release of hazardous substances at these sites.

According to the EPA (http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm), there are no Superfund sites in the City of Coachella General Plan Area.

5.2.3 Emergency Planning and Community Right-To-Know Act

The primary purpose of the Federal Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 is to inform communities and citizens of chemical hazards in their area. Sections 311 and 312 of EPCRA require businesses to report the locations and quantities of chemicals stored on-site to state and local agencies. These reports help communities prepare to respond to chemical spills and similar emergencies.

The EPA maintains and publishes a database that contains information on toxic chemical releases and other waste management activities that are reported annually by certain industry groups and federal facilities. The database is referred to as the Toxics Release Inventory (TRI), and it was first established under the EPCRA and expanded by the Pollution Prevention Act of 1990. EPCRA's power has allowed for the mandate that Toxic Release Inventory (TRI) reports be made public. TRI reports provide information about potentially hazardous chemicals and their uses in an attempt to give the community more power to hold companies accountable and to make informed decisions about how such chemicals should be managed.

Section 3131 of EPCRA requires manufacturers to report releases to the environment of more than 600 designated toxic chemicals. These reports are submitted to the EPA and State agencies. The EPA compiles these data into an on-line, publicly available national digital TRI. These data are readily available on the EPA website at http://www.epa.gov/tri/. The facilities are required to report on releases of toxic chemicals to the air, soil, and water. They are also required to report on off-site transfers of waste for treatment or disposal at separate facilities. Pollution prevention measures and activities and chemical recycling must also be reported. All reports must be submitted on or before July 1 of every year and must cover all activities that occurred at the facility during the previous year. Reporting by facilities is based on the following factors:

- If the facility has ten or more full-time employees;
- If the facility manufactures or processes over 25,000 pounds of approximately 600 designated chemicals, or 28 chemical categories specified in the regulations, or uses more than 10,000 pounds of any designated chemical or category; and
- If the facility engages in certain manufacturing operations in the industry groups specified in the U.S. Government Standard Industrial Classification Codes (SIC) 20 through 39; or
- If the facility is a Federal facility.

There is one facility in Coachella listed in the most recent TRI database released to the public based on data extracted on April 1, 2014. *This TRI facility is the ARMTEC Defense Products Company (TRI Facility No. 92236RMTCD85901), an ordnance and accessories manufacturer located at 85-901 Avenue 53, in Coachella 92236.* In 2012, the facility reported the total on-site release of 4,288 pounds of chemicals, including 930 pounds of ethylbenzene, 110 pounds of n-hexane, and 3,248 pounds of xylene (mixed isomers). This site is also listed in the GeoTracker database maintained by the California Water Regional Control Board (http://geotracker.swrcb.ca.gov/), where it is listed as a land disposal site (see Table 5-5).

The EPA web site (http://www.epa.gov/tri/) should be reviewed periodically for updates to this information, including the potential future presence of other TRI sites in the Coachella area.

5.2.4 Resources Conservation and Recovery Act

The Resources Conservation and Recovery Act (RCRA) is the principal Federal law that regulates the generation, management and transportation of waste materials. Hazardous waste management includes the treatment, storage, or disposal of hazardous waste. Treatment is defined as any process that changes the physical, chemical, or biological character of the waste to make it less of an environmental threat. Treatment can include neutralizing the waste, recovering energy or material resources from the waste, rendering the waste less hazardous, or making the waste safer to transport, dispose of, or store. Storage is the holding of waste for a temporary period of time. The waste is treated, disposed of, or stored at a different facility at the end of the storage period. Disposal is the permanent placement of the waste into or on the land. Disposal facilities are usually designed to contain the waste permanently and to prevent the release of harmful pollutants to the environment.

Many different types of businesses can be producers of hazardous waste. Small businesses like dry cleaners, auto repair shops, medical facilities or hospitals, photo processing centers, and metal plating shops are usually generators of small quantities of hazardous waste. The EPA (Title 40 of the Code of Federal Regulations) defines a small quantity generator as a facility that produces between 100 and 1,000 kilograms (Kg) of hazardous waste per month (approximately equivalent to between 220 and 2,200 pounds, or between 27 and 275 gallons). A "conditionally exempt" small quantity generator is a business that generates 220 pounds (27 gallons) or less of hazardous waste per month.

Since these facilities are often small, start-up businesses that come and go, the list of small-quantity generators in a particular area typically changes over time. Sometimes, a facility remains, but the name of the business changes with new ownership. As of May 2011, there were 21 locations in the City of Coachella study area reported as small-quantity generators. These facilities are included in Table 5-1, below, and their locations are depicted on Plate 5-1. Two of these are listed as "conditionally exempt," meaning that they generate 100 kilograms or less per month of hazardous waste, or 1 kilogram or less per month of acutely hazardous waste. In addition, two Circle K store locations are listed on the RCRA database as "unspecified inactive." A more recent (2014) list of these facilities is not available from the Environmental Protection Agency, and thus, the data on Table 5-1 was not updated for this 2014 version of the report.

Larger businesses are sometimes generators of large quantities of hazardous waste. These generally include some gas stations, chemical manufacturers, large electroplating facilities, petroleum refineries, and military installations. The EPA defines a large-quantity generator as a facility that produces over 1,000 Kg (2,200 pounds or about 275 gallons) of hazardous waste per month. Large-quantity generators are fully regulated under RCRA. The EPA identified three large-quantity generators in the Coachella area as of May 2011 (see bottom of Table 5-1 and Plate 5-1).

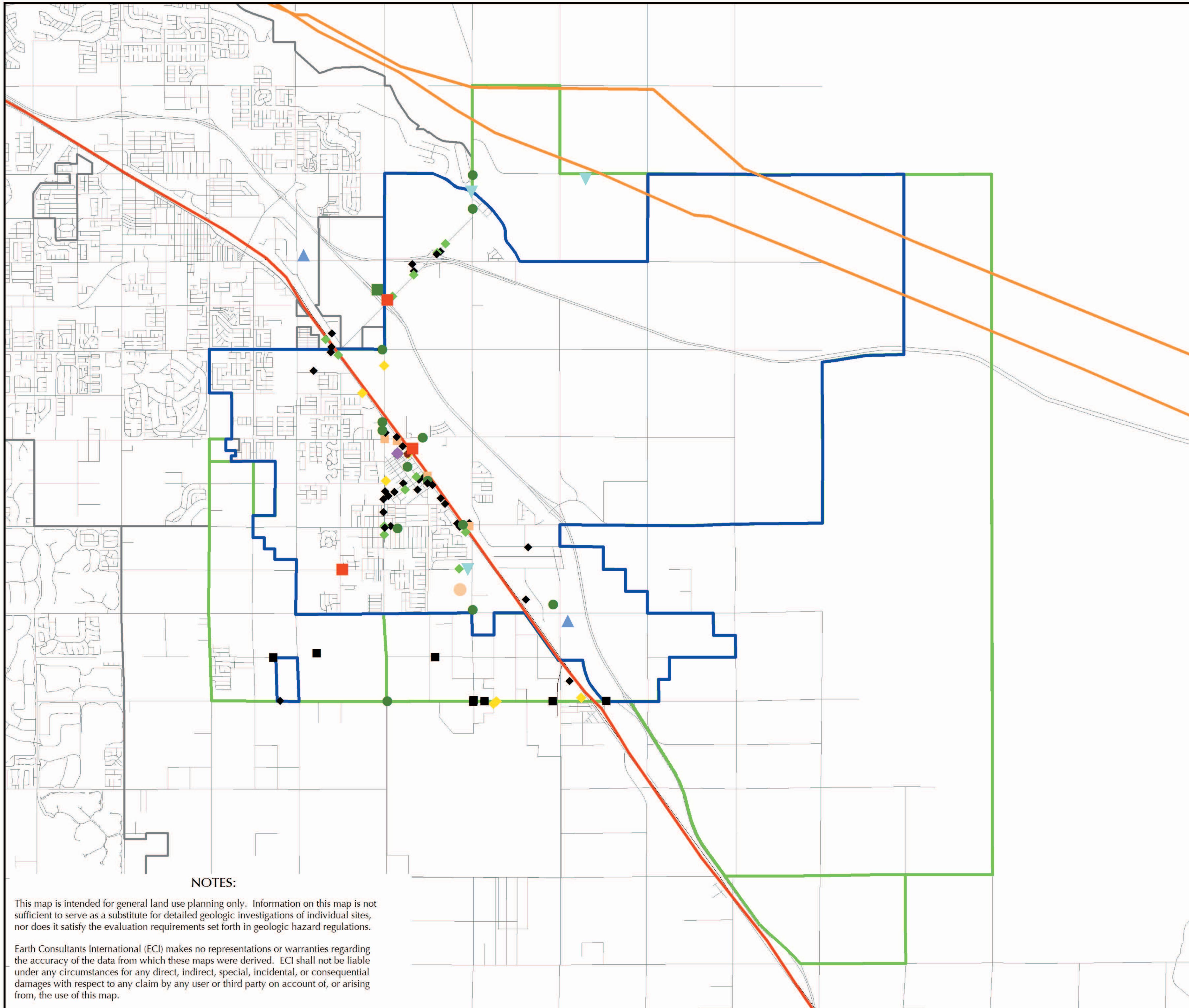
Table 5-1: EPA-Registered Small- and Large-Quantity Generators of Hazardous Materials in the Coachella General Plan Area (2011)

Facility Name, Address	EPA ID	Type Facility
Amigo Mini Mart (Fuel Station) 85-509 Highway 111, Coachella 92236	CAD982411449	Small-Quantity Generator
Arco Facility No. 05826 48-055 Grapefruit Blvd., Coachella 92236	CAR000102608	Small-Quantity Generator
Bulk Plant No. 0104 50-021 Highway 86, Coachella 92236	CAR000051730	Small-Quantity Generator
Cakota Dunes (general rental center) 85-200 Avenue 50, Coachella 92236	CAC002611320	Small-Quantity Generator
Circle K Store No. 330 85-101 Avenue 52, Coachella 92236	CAD981680283	Small-Quantity Generator
Coachella Valley USD Transportation Department 83-800 Airport Blvd., Coachella 92236	CA0000133421	Small-Quantity Generator
Coachella Valley Water District Avenue 52 and Highway 111, Coachella 92236	CAD982446056	Small-Quantity Generator
Desert Cottonseed Products Co. Inc. 86-600 Avenue 54, Coachella 92236	CAD126792191	Small-Quantity Generator
Ernie Ball Inc. 53973 Polk Street, Coachella 92236	CAR000171678	Small-Quantity Generator
Foster Manufacturing Inc. 1577 First Street, Coachella 92236	CAD063129456	Small-Quantity Generator
Garner Implement Company 49-980 Highway 86, Coachella 92236	CAR000069625	Small-Quantity Generator
General Telephone of California 723 Vine Street, Coachella 92236	CAD980889786	Small-Quantity Generator
Lee Escher Oil Company, Inc. 85-119 Avenue 50, Coachella 92236	CAD982374514	Small-Quantity Generator
McCalla Division of Layne Western 381 Highway 111, Coachella 92236	CAD982002842	Small-Quantity Generator
R and S Auto Wrecking 84-811 Avenue 48, Coachella 92236	CAD983600651	Small-Quantity Generator
Santa Fe Pacific Pipeline Coachella Site 85-985 Avenue 52, Coachella 92236	CAR000032789	Small-Quantity Generator
Shell Service Station 45800 Dillon Road, Coachella 92236	CAR000110528	Small-Quantity Generator
Sun World 87-951 Avenue 73, Coachella 92236	CAR000071498	Small-Quantity Generator

Facility Name, Address	EPA ID	Type Facility
Travel Centers of America 46-145 Dillon Road, Coachella 92236	CAR000069369	Small-Quantity Generator
Rite Aid 5678 51-101 Harrison Street, Coachella 92236	CAR000209676	Conditionally Exempt Small Generator
Spotlight 29 Casino 46-200 Harrison Place, Coachella 92236	CAR000168658	Conditionally Exempt Small Generator
Circle K Store No. 1303 4-9989 Grapefruit Street, Coachella 92236	CAD981681208	Unspecified - Inactive
Circle K Store No. 529 50-898 Grapefruit Street, Coachella 92236	CAD981680333	Unspecified - Inactive
Amazing Coachella Inc. DBA Peter Rabbit Farms 85-810 Peter Rabbit Lane, Coachella 92236-1897	CAL000028217	Large-Quantity Generator
Armtec Defense Products Company 85-901 Avenue 53, Coachella 92236	CAD008252157	Large-Quantity Generator
Chevron 355918 46-651 Dillon Road, Coachella 92236	CAR000201608	Large-Quantity Generator

Source: http://iaspub.epa.gov/enviro/, based on data extracted May 10, 2011, and searches performed on June 9 and June 15, 2011.

The Department of Toxic Substances Control (DTSC) has an official database of hazardous waste transporters in the state of California. All transporters of hazardous waste have to be registered with the DTSC in order to operate in the state. As of 2014, there are no transporters of hazardous waste based in Coachella that are registered in the DTSC database of hazardous waste transporters (http://www.dtsc.ca.gov/database/Transporters/trans_city.cfm). Although there are no transporters of hazardous waste registered in Coachella, hazardous waste is being transported through the area by transporters registered or based elsewhere (there is, for example, one registered transporter in Indio and one in La Quinta). This is discussed further in Section 5.6.



NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

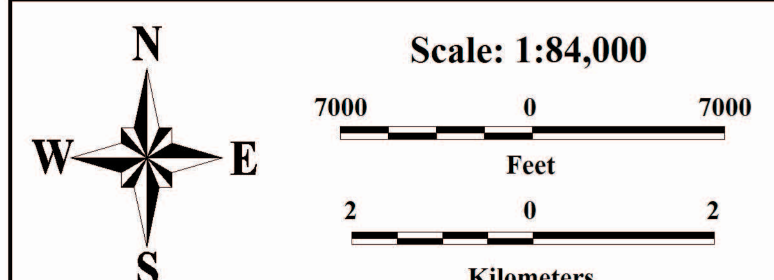
Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.

Hazardous Materials Site Map

Coachella, California

Explanation

- Toxic Release Inventory Facility
- Cortese Site
- EPA-Registered Large Quantity Hazardous Waste Generator Facility
- EPA-Registered Small Quantity Hazardous Waste Generator Facility
- Leaking Underground Storage Tank Site (closed case shown in black)
- Other Cleanup Site (closed case shown in black)
- EPA-Registered Conditionally Exempt Small Quantity Generator
- Disposal Site
- Waste Water Treatment Plant
- Permitted Underground Storage Tank Site
- EPA-Registered Facility Unspecified - Inactive
- Gas Transmission Pipeline
- Hazardous Liquid Pipeline
- Coachella City Boundary
- Coachella Planning Area Boundary



Base Map: City of Coachella
Sources: http://iaspub.epa.gov/enviro/, http://www.dtsc.ca.gov/database/Transporters/trans_cnty.cfm;http://iaspub.epa.gov/enviro/, http://oaspub.epa.gov/enviro/, http://www.burrtec.com/coachella, http://www.rivcowm.org, http://geotracker.swrcb.ca.gov/, http://www.epa.gov/tri/, and http://www.calepa.ca.gov/sitecleanup/corteselist/Background.htm

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Project Number: 3106/3218
Date: 2014

Plate 5-1

5.2.5 Cortese List

This California legislation (Government Code § 65962.5) was originally enacted in 1985, and became effective on January 1, 1992. The code required several different State agencies to compile and update annually a list of hazardous materials sites as indicated below, and submit these lists to the Secretary for Environmental Protection. The Secretary was to consolidate all the information received and then forward the complete list of sites to each city and county with sites on the composite list.

1. The California Department of Toxic Substances Control (DTSC) [Subsection 65962.5. (a)] was to compile information on:
   - All hazardous waste facilities subject to corrective action pursuant to Section 25187.5 of the Health and Safety Code;
   - All land designated as hazardous waste property or border zone property pursuant to Article 11 (commencing with Section 25220) of Chapter 6.5 of Division 20 of the Health and Safety Code;
   - All information received by the Department of Toxic Substances Control pursuant to Section 25242 of the Health and Safety Code on hazardous waste disposals on public land;
   - All sites listed pursuant to Section 25356 of the Health and Safety Code; and
   - All sites included in the Abandoned Site Assessment Program.

2. The State Department of Health Services [Subsection 65962.5. (b)] was to compile data on:
   - All public drinking water wells that contain detectable levels of organic contaminants and that are subject to water analysis pursuant to Section 116395 of the Health and Safety Code.

3. The State Water Resources Control Board [Subsection 65962.5. (c)] was to compile:
   - All underground storage tanks for which an unauthorized release report is filed pursuant to Section 25295 of the Health and Safety Code (this list is now available from GeoTracker, see Section 5.3);
   - All solid waste disposal facilities from which there is a migration of hazardous waste and for which a California regional water quality control board has notified the Department of Toxic Substances Control pursuant to subdivision (e) of Section 13273 of the Water Code; and
   - All cease and desist orders issued after January 1, 1986, pursuant to Section 13301 of the Water Code, and all cleanup or abatement orders issued after January 1, 1986, pursuant to Section 13304 of the Water Code, that concern the discharge of wastes that are hazardous materials.

4. The local enforcement agency, as designated pursuant to Section 18051 of Title 14 of the California Code of Regulations, shall submit to the California Integrated Waste Management Board [Subsection 65962.5. (d]:

- All solid waste disposal facilities from which there is a known migration of hazardous waste.

Most of this information is now available directly from the various individual state agencies that make the data available on their respective websites. Furthermore, some of the activities required under this code are no longer being implemented, and in some cases, the information to be contained in the Cortese list does not exist (http://www.calepa.ca.gov/sitecleanup/corteselist/Background.htm).

There is, however, one facility in Coachella listed in the Cortese List that is not included with the same level of detail in other, more current databases. The *Foster-Gardner site located at 1577 1st Street*, is a 2.79-acre site that has been on the active state list since 8/30/1992. The company purchased the pesticide and fertilizer business from Shell in 1958, and between 1959 and the early 1970s, formulated base fertilizer and mixed and re-packaged pesticides and fertilizers. The company ceased mixing pesticides in the 1970s, however, between the 1960s and early 1990s, they formulated aqueous ammonia by mixing anhydrous ammonia and water. The company still stores and sells herbicides, soil and grain fumigants, insecticides, nematocides, fungicides, and fertilizers (http://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=33280137).

Contaminants of concern as a result of past uses of the site include pesticide wastes resulting from production, organochlorine pesticides, volatile organics, and ammonia. These compounds have been detected in the water samples collected from the shallow groundwater (not suitable for drinking purposes) underlying the site. Groundwater quality under the site has been monitored since August 1991, when the first monitoring wells onsite and immediately offsite were installed (Hargis + Associates, Inc., 2010). The concentration of the contaminants in the groundwater is being monitored to determine whether or not natural attenuation (a remediation method that relies on in-situ, naturally occurring physical, chemical and biological processes to reduce the mass or concentration of contaminants) is working at this site. There are several land use restrictions imposed on this property: the site cannot be used to raise food, nor can it be used as a day care center, elder care center, hospital, residential area, or as either a public or private school for persons under 21 years of age. For more information regarding this property, including future groundwater monitoring reports and review documents from the Department of Toxic Substances Control, refer to http://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=33280137.

5.2.6 Hazardous Materials Disclosure Program

Both the Federal government (Code of Federal Regulations, EPA, SARA and Title III) and the State of California (California State Health and Safety Code, Division 20, Chapter 6.95, Sections 25500–25520; California Code of Regulations, Title 19, Chapter 2, Sub-Chapter 3, Article 4, Sections 2729-2734) require all businesses that handle more than a specified amount of hazardous materials or extremely hazardous materials, termed a reporting quantity, to submit a Hazardous Materials Business Plan to its local Certified Unified Program Agency (CUPA). The CUPA with responsibility for the City of Coachella is the Riverside County Department of Environmental Health, Hazardous Materials Division (RCDEH-HMD). The Business Plan includes the Business Owner/Operator Identification page, Hazardous Materials Inventory – Chemical Description page, and an Emergency Response Plan and Training Plan.

According to the RCDEH-HMD guidelines, the preparation, submittal and implementation of a Business Activity Form is required by all businesses that handle a hazardous material or a mixture containing a hazardous material in quantities equal to, or greater than, those outlined below:

- All hazardous waste generators, regardless of quantity generated.
- Any business that uses, generates, processes, produces, treats, stores, emits, or discharges a hazardous material in quantities at or exceeding:
  - 55 gallons or more of a liquid;
  - 500 pounds or more of a solid; or
  - 200 cubic feet (compressed) of gas at any one time in the course of a year.
- Any business that recycles more than 100 kg per month of excluded or exempted recyclable materials per Health and Safety Code (HSC) §25143.2.
- Any business that handles, stores, or uses Category (I) or (II) pesticides, as defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), regardless of amount.
- Any business that handles Department of Transportation (DOT) Hazard Class 1 (explosives, found in Title 49 of the Code of Federal Regulations).
- Any business that handles extremely hazardous substances in quantities exceeding the threshold planning quantity, as listed in Title 40 of the Federal Code of Regulations, Part 355, Appendix A or B.
- Any business subject to the EPCRA (also known as SARA Title III; see Section 5.2.2 above). EPCRA generally includes facilities that handle hazardous substances above threshold planning quantities.
- Any business that owns or operates an underground storage tank that contains hazardous substances as defined in the Health and Safety Code (HSC) §25316.
- Any business that handles radioactive materials in quantities for which an emergency plan is required pursuant to Parts 30, 40 or 70 of Chapter 10, Title 10, Code of Federal Regulations (CFR), or equal to or greater than the amounts specified above, whichever amount is less.

Within 30 days of any one of the following events, businesses are required to submit an amendment to their business plan to the CUPA:

- A 100-percent or more increase in the quantity of a previously disclosed hazardous material;
- Any handling of a previously undisclosed hazardous material subject to the inventory requirements of this chapter;
- Change of mailing address, phone number or location; change of emergency contact person;
- Change of ownership; or
- Change of business name.

Business plans must include an inventory of the hazardous materials at the facility. If no changes have been made to the facility's inventory, a written certification suffices for the update; however, if changes have been made, those changes must be submitted to the Riverside County

Department of Environmental Health – Hazardous Materials Division (RCDEH-HMD). Businesses are required to update their business plan at least once every three years and the chemical inventory portion of their plan every year. They must certify in writing to the RCDEH-HMD that a review was conducted and all necessary changes were made. A copy of all changes must be submitted as part of the certification. Also, business plans are required to include emergency response plans and procedures to be used in the event of a significant or threatened significant release of a hazardous material. These plans need to identify the procedures to follow for immediate notification to all appropriate agencies and personnel of a release, identification of local emergency medical assistance appropriate for potential accident scenarios, contact information for all emergency coordinators of the business, a listing and location of emergency equipment at the business, an evacuation plan, and a training program for business personnel. Additional information regarding business plans and the CUPA forms required in the County of Riverside, including the City of Coachella, is available at http://www.rivcoeh.org/opencms/rivcoeh/Forms_Guidelines/#CUPA. They can also be contacted by phone at (888) 722-4234 (888-RC-CHA-EH).

Business plans are designed to be used by responding agencies, such as the Riverside County Fire Department, during a release or spill to allow for a quick and accurate evaluation of each situation for appropriate response. Businesses that handle hazardous materials are required by law to provide an immediate verbal report of any release or threatened release of hazardous materials if there is a reasonable belief that the release or threatened release poses a significant present or potential hazard to human health and safety, or to property or the environment. Fines of up to $25,000 per day and one year in prison may be awarded to an individual or business if a release or threatened release is not reported. If a release involves a hazardous substance listed in Title 40 of the Code of Federal Regulations in an amount equal to or exceeding the reportable quantity for that material, a notice must be filed with the California Office of Emergency Services within 15 days of the incident.

The Riverside County Department of Environmental Health, Hazardous Materials Division is charged with the responsibility of conducting compliance inspections of regulated facilities in Riverside County. Specialists are assigned countywide to address the wide variety of complex issues associated with hazardous substances. For example, all new installations of underground storage tanks require an inspection, along with the removal, under strict chain-of-custody protocol, of the old tanks (see Section 5.3 below).

5.2.7 Hazardous Materials Incident Response

There are thousands of different chemicals available today, each with unique physical characteristics; what might be an acceptable mitigation practice for one chemical could be totally inadequate for another. Therefore it is essential that agencies responding to a hazardous material release have as much available information as possible regarding the type of chemical released, the amount released, and its physical properties to effectively and quickly evaluate and contain the release. The EPA-required business plans are an excellent resource for this type of information. Other sources of information are knowledgeable facility agents or employees present onsite.

In 1986, Congress passed the Superfund Amendments and Reauthorization Act (SARA). Title III of this legislation requires that each community establish a Local Emergency Planning Committee (LEPC) that is responsible for developing an emergency plan to prepare for and respond to chemical emergencies in their community.

This emergency plan must include the following:

- An identification of local facilities and transportation routes where hazardous materials are present;
- The procedures for immediate response in case of an accident (this must include a community-wide evacuation plan);
- A plan for notifying the community that an incident has occurred;
- The names of response coordinators at local facilities; and
- A plan for conducting exercises to test the plan.

The plan is reviewed by the State Emergency Response Commission (SERC) and publicized throughout the community. The LEPC is required to review, test, and update the plan each year.

The Riverside County Office of Emergency Services (OES), the Riverside County Department of Environmental Health – Hazardous Materials Division, the Riverside County Fire Department, and the City of Coachella's Emergency Services Coordinator are responsible for coordinating hazardous material and disaster preparedness planning and appropriate response efforts with City departments, as well as local and State agencies. The goal is to improve public and private sector readiness, and to mitigate local impacts resulting from natural or man-made emergencies. The OES is a branch of the Riverside County Fire Department that deals with the planning for and response to the natural and technological disasters in the County, whereas the Riverside County Department of Environmental Health – Hazardous Materials Division deals with the coordination and inspection of hazardous materials facilities in the County and in the City of Coachella. The Riverside County Fire Department has developed and teaches a Community Emergency Response Team (CERT) training program to help county residents prepare for potential disasters. The CERT course, which is taught as a series of modules that combined add to about 20 hours of instruction over three consecutive days, is certified by the Federal Emergency Management Agency (FEMA) and the State OES. For more information on the CERT program, contact the County's CERT Program at (951) 955-4700 or visit http://rivcocert.webs.com/. Information on CERT training held locally in Coachella is also available at Coachella's City Hall (Photo 5-1).

The Riverside County Fire Department has two Type-2 Hazardous Materials Response Teams as designated and approved by the California Emergency Management Agency, now known as Cal OES. One team (Hazmat 34 and Hazmat Support 34) is housed at 32-655 Haddock Street, Winchester, CA, while the other team (Hazmat 81 and Hazmat Support 81) is located at 37-955 Washington Street, Palm Desert, CA, thus allowing efficient responses to hazardous materials incidents anywhere within the county. The Hazardous Materials Response Team (HMRT) closest to the city of Coachella responds from North Bermuda Dunes Fire Station #81 Palm Desert). They are also equipped with a mass decontamination trailer and a 4-wheel drive response vehicle.

According to the Riverside County Fire Department, all hazardous materials team members receive extensive training, including Hazardous Materials Incident Commander, Railcar Specialist, Cargo Tank Specialist, Weapons of Mass Destruction, Assistant Safety Officer, Clandestine Drug Lab, Clandestine Drug Lab Cylinder Safety, Clandestine Drug Lab Waste, HazMat 2 Unknown

Chemical Identification, Reference Material Identification, and Confined Space Rescue. All team members also participate in continuous specialty monthly training exercises.

Figure 5-1: Community Emergency Response Team (CERT) Classes Are Held Regularly at Coachella's City Hall

The Hazardous Materials Team Members have a cooperative working relationship with the Riverside County Health Agency, Department of Environmental Health. An Emergency Response Hazardous Materials Management Specialist from the Riverside County Health Agency responds with Hazardous Materials team members to all hazardous materials incidents. The Health Agency member arranges for clean up of the chemical emergency incident and assist with proper notifications. Health Agency Hazardous Materials personnel also enhance the Hazardous Materials Teams with expanded knowledge regarding technical referencing.

Riverside County Fire Department Hazardous Materials Team members are capable of monitoring unknown atmospheres, identifying unknown chemicals, plugging, patching and intervening in large chemical leaks, conducting mass decontamination, and handling confined space entry rescue operations. The Hazardous Materials Team members often also assist the local fire stations with medical emergencies, structural fires and mass casualty incidents (http://www.rvcfire.org/opencms/functions/hazmat/index.html).

5.2.8 Hazardous Material Spill/Release Notification Guidance

All significant spills, releases, or threatened releases of hazardous materials must be immediately reported. **To report all significant releases or threatened releases of hazardous materials, immediately call 9-1-1**, and then call Cal OES HazMat Spills Notifications at 1-800-852-7550.

This guidance summarizes pertinent emergency notification requirements and applies to all significant releases of hazardous materials. Requirements for immediate notification of all significant spills or threatened releases cover: Owners, Operators, Persons in Charge, and Employers. Notification is required regarding significant releases from facilities, vehicles, vessels, pipelines and railroads.

State notification requirements for a spill or threatened release include (at a minimum):

- Identity of caller,
- Location, date and time of spill, release, or threatened release,
- Substance and quantity involved,
- Chemical name (if known; also report whether or not chemical is extremely hazardous), and
- Description of what happened.

Federal notification requires additional information for spills (CERCLA chemicals) that exceed Federal-reporting requirements. This information includes:

- Medium or media impacted by the release,
- Time and duration of the release,
- Proper precautions to take,
- Known or anticipated health risks, and
- Name and phone number for more information.

Many State statutes require emergency notification of a hazardous chemical release. These statutes include:

- Health and Safety Codes §25270.7, 25270.8, and 25507,
- Vehicle Code §23112.5,
- Public Utilities Code §7673, (PUC General Orders #22-B, 161),
- Government Code §51018, 8670.25.5 (a),
- Water Codes §13271, 13272, and
- California Labor Code §6409.1 (b)10.

In addition, all releases that result in injuries, or workers harmfully exposed, must be immediately reported to Cal/OSHA (CA Labor Code §6409.1 (b)). For additional reporting requirements, also refer to the Safe Drinking Water and Toxic Enforcement Act of 1986, better known as Proposition 65, and §9030 of the California Labor Code.

The California Accidental Release Prevention Program (CalARP) became effective on January 1, 1997 in response to Senate Bill 1889. The CalARP replaced the California Risk Management and Prevention Program (RMPP). Under the CalARP, the Governor's Office of Emergency Services must adopt implementing regulations and seek delegation of the program from the EPA. The

CalARP aims to be proactive and therefore requires businesses to prepare Risk Management Plans (RMPs), which are detailed engineering analyses of:

- The potential accident factors present at a business, and
- The mitigation measures that can be implemented to reduce this accident potential.

In most cases, local governments have the lead role in working directly with businesses in this program. The County of Riverside Department of Environmental Health – Hazardous Materials Division is designated as the Administering Agency for hazardous materials in the City of Coachella.

5.3 Leaking Underground Storage Tanks

Leaking underground storage tanks (LUSTs) have been recognized since the early 1980s as the primary cause of groundwater contamination by gasoline compounds and solvents. In California, regulations aimed at protecting against underground storage tank (UST) leaks have been in place since 1983, one year before the Federal Resource Conservation and Recovery Act (RCRA) was amended to add Subtitle I requiring UST systems to be installed in accordance with standards that address the prevention of future leaks. These Federal laws are found in the Code of Federal Regulations (CFR), parts 280-281. The State law and regulations are found in the California Health and Safety Code, Division 20, Chapter 6.7, and in the California Code of Regulations Title 23, Division 3, Chapter 16, commonly referred to as the "Underground Tank Regulations." Federal and State programs include leak reporting and investigation regulations, and standards for clean up and remediation. UST cleanup programs are available to fund the remediation of contaminated soil and ground water caused by leaking tanks. California's program is more stringent than the Federal program, requiring that all tanks be double walled, and prohibiting gasoline delivery to non-compliant tanks. The State Water Resources Control Board (SWRCB) is the lead regulatory agency in the development of UST regulations and policy.

Most older tanks were typically single-walled steel tanks. Many of these leaked as a result of corrosion and detached fittings. As a result, the state of California required the replacement of older tanks with new double-walled, fiberglass tanks with flexible connections and monitoring systems. UST owners were given a ten-year period to comply with the new requirements, and the deadline came due on December 22, 1998. However, many UST owners did not act by the deadline, so the State granted an extension for the Replacement of Underground Storage Tanks (RUST) program to January 1, 2002. Nevertheless, in that RUST loan funds are still available in 2014 indicates that there are still UST owners, typically small, independent operators that have yet to comply with the RUST requirements. RUST loans, ranging from $10,000 to $750,000 (maximum per person or entity), can be used to finance up to 100 percent of the costs to upgrade USTs by installing containment sumps, double-walled piping, dispensers, under-dispenser containment boxes or pans, electronic monitoring systems, and enhanced vapor recovery systems. The funds can also be used to conduct enhanced leak detection tests. For additional information on this program, refer to http://www.swrcb.ca.gov/water_issues/programs/ustcf/rust.shtml. The RUST program is scheduled to sunset on January 1, 2016.

The California legislature established the Barry Keene Underground Storage Tank Cleanup Fund Act of 1989 to provide a means for petroleum UST owners and operators to meet the Federal and state requirements, and to assist small businesses and individuals by providing reimbursement for unexpected and catastrophic expenses associated with the cleanup of leaking petroleum USTs. The fund also provides money to the Regional Water Quality Control Boards to cleanup abandoned sites or abate emergency situations that pose a threat to human health, safety and the environment as a result of a petroleum release from an UST (http://www.swrcb.ca.gov/water_issues/programs/ustcf/). Revenues for the Fund are generated by a storage fee for every gallon of petroleum product placed into a UST. The State Board of Equalization collects these fees on a quarterly basis from owners of active USTs. In the last few years, the fund has experienced a cash shortage. As a result, in May 2009, the State Water Resources Control Board passed Resolution No. 2009-0042 that defines specific actions that the Regional Boards are to take to improve administration of the UST Cleanup Fund and the UST Cleanup Program. The most significant decision in this resolution is that the Regional Boards are to review the open UST cleanup cases and identify those where continued investigation, remediation or monitoring poses little to no environmental benefit. Those sites open for more than five years that are found to not pose a threat to water quality or sensitive receptors, are recommended for closure.

In 2009 the State Water Resources Control Board received a federal grant from the U.S. Environmental Protection Agency using American Recovery and Reinvestment Act funds to cleanup leaks from underground storage tanks. The funds are available to eligible applicants under a new program called the Orphan Site Cleanup Fund (OSCF) or Orphan Site Fund. Orphan sites are sites contaminated by leaking petroleum underground storage tanks where there is no financially responsible party. Additional information on this program, including eligibility requirements and copies of the application for funding can be obtained at http://www.waterboards.ca.gov/water_issues/programs/ustcf/oscf.shtml.

The California Regional Water Quality Control Board (CRWQCB), in cooperation with the Office of Emergency Services, maintains an inventory of leaking underground storage tanks (LUSTs) in a Statewide database called GeoTracker, which is available at http://geotracker.waterboards.ca.gov/. The database lists 37 reported LUST cases in the Coachella area. Of these, according to the LUST database, 33 sites have been remediated and closed, leaving four (4) cases still open (the **open** cases are listed first, in **bold**). All 37 cases are listed in Table 5-2, below, and their approximate location is shown on Plate 5-1. Please note, however, that the ongoing assessment and remediation of the current open cases will eventually get these sites signed off by the reviewing agencies. Furthermore, given that there are at least 16 permitted underground storage tank (UST) locations in the General Plan area (see Plate 5-1), new leaks from these USTs could be reported in the future. Therefore, the GeoTracker list should be reviewed periodically to determine the status of the currently open sites, and for information regarding any new leaks.

Because of the relatively shallow ground water table in several parts of the Coachella area, sixteen of the leaks listed in Table 5-2 reportedly impacted groundwater in an aquifer used for drinking water purposes, and eleven impacted other groundwater not used for drinking purposes. Two of these leaks impacted both types of aquifers, meaning that the petroleum hydrocarbon (gasoline in both cases) migrated down through the layer that separates the shallow, non-potable aquifer to the deeper aquifer. Groundwater monitoring wells were and/or are being used at most of these sites to study the areal distribution and concentration of the contaminants as part of the site assessment and remediation phases. At ten (possibly eleven) sites, soil was reportedly impacted by the leaked contaminant. In these cases, the stained soils are typically excavated and replaced with clean soil; the contaminated soil is then shipped to a facility that accepts hazardous materials. Specific information about each of these sites, including reports submitted to the Regional Board by the consultants conducting the studies and remediation, is available from the GeoTracker site at http://geotracker.swrcb.ca.gov/.

Table 5-2: Leaking Underground Fuel Tanks Reported in the Coachella Area

Site Name	Address	State Case No.	Case Type	Status, Contaminant (Date Case Closed)	Date Leak Discovered
Amigo Minimart	**85509 Highway 111**	**T0606500931**	**G**	**Open Inactive, G**	**5/20/1986**
Quail Oil	**48487 Highway 86**	**T0606500954**	**U, S**	**2, D,G**	**4/26/1993**
Soco Apple Market #4	**50980 Highway 86**	**T0606500945**	**O, G**	**3, G**	**6/5/1990**
Sossa's Market #7	**48975 Grapefruit Blvd.**	**T0606500937**	**O**	**6** (2/21/2014), **G**	**1/5/2000**
Arco #9924	48055 Grapefruit Blvd.	T0606500950	G	5, G (4/21/2011)	10/18/1990
Autos del Valle	51890 Highway 86	T0606500951	G	5, G (10/28/1998)	1/2/1979
Burns Brothers Travel Stop	46155 Dillon Road	T0606500958	O, S	5, G (1/7/2005)	8/7/1998
Chevron Coachella	49975 Harrison Street	T0606500941	G	5, G (7/9/1998)	2/7/1989
Chevron Dillon Road	45760 Dillon Road	T0606570130	O	5, G (7/17/2008)	1/22/2003
Circle K#330	85-101 Avenue 52	T0606500934	O, G	5, G (1/8/2014)	7/2/1992
Circle K #1303	49989 Grapefruit Blvd.	T0606500949	G	5, G (11/13/2000)	3/27/1991
Circle K (Former)	51989 Grapefruit Blvd.	T0606500955	O	5, G (12/12/2002)	6/22/1993
Coachella City Fire Station	1377 Sixth Street	T0606500940	G	5, O (1/17/2003)	10/3/1986
Coachella City Yard	1670 Second Street	T0606500932	S	5, D (12/8/1999)	10/1/1986
Coachella Sanitary District	Avenue 56 and Van Buren	T0606500959	S	5, D (1/28/2000)	4/26/1999
Coachella Travel Center	46155 Dillon Road	T0606557357	O	5, D (7/28/2010)	5/4/2006
Coachella Valley USD Transportation	83800 Airport Blvd.	T0606500957	G	5, G (5/4/1999)	10/24/1996
Coachella Valley Water District	85820 Coachella Heights	T060657197	S	5, G (4/29/2005)	12/04/2001
Coachella Valley Water District	85820 Coachella Heights	T0606500943	G	5, G (8/26/1996)	4/13/1989
Coachella Valley Water District	85995 Avenue 52	T10000002057	S	5, O (1/13/2011)	4/15/2010
Coachella Valley School District – Coachella Valley High School	83800 Airport Blvd.	T0606501077	O	5, D, G (8/17/1994)	12/1/1987
Coachella Valley School District – Palm View Maintenance	1101 Orchard Street	T0606500935	G	5, G (1/13/1997)	12/1/1987
Cox Oil Company	1121 Highway 111	T0606500936	S	5, D (7/24/1992)	4/9/1987

Site Name	Address	State Case No.	Case Type	Status, Contaminant (Date Case Closed)	Date Leak Discovered
DeLeon's Service	51298 Harrison Street	T0606500953	O	5, G (2/11/2014)	10/8/1990
El Super Toro Loco #3	52051 Grapefruit Ave.	T0606555198	O	5, G (7/7/2006)	2/25/2004
Frank (Abandoned)	51655 Highway 86	T0606500938	S	5, G (8/2/1992)	2/17/1987
Koolco	52112 Industrial Way	T0606500956	G	5, G (12/21/1994)	4/26/1994
Lee Escher Oil	85119 Avenue 50	T0606500939	G	5, G (1/27/1997)	7/10/1988
Lucky's Auto Service	51229 Harrison Street	T0606500948	S	5, O (8/21/1995)	12/22/1989
Old Builders Supply	85220 Avenue 50	T0606500944	S?	5, G (4/1/1992)	11/17/1989
Rancho Coachella (Lusardi)	54000 Highway 111	T0606500942	G	5, G (5/15/1998)	3/13/1989
Red Dragon Restaurant	85981 Grapefruit Blvd.	T0606500933	S	5, G (11/7/1986)	9/1/1986
Sanchez MiniMart	1003 Grapefruit Ave.	T0606599289	S	5, G (8/22/2007)	6/6/2001
Valley Gas	45800 Dillon Road	T0606536453	S	5, G (5/23/2008)	6/10/2005
W C Hancock	85289 Highway 111	T0606500947	G	5, G (1/30/1997)	5/13/1987
Walter Oversen	84540 Mitchell	T0606500946	G	5, G (4/23/1993)	12/9/1989
White's Black Gold #133	52138 Harrison Street	T0606500952	O	5, G (5/2/2008)	5/14/1990

Source: GeoTracker (http://geotracker.swrcb.ca.gov/) checked on May 22, 2014.

Abbreviations Used for Case Type: **S** = Soil contaminated, groundwater not impacted; **G** = Aquifer used for drinking water supply impacted; **O** = Other groundwater (uses other than drinking water); **U** = Under investigation.
Abbreviations Used for Status: **1** = Case Opened; **2** = Site Assessment; **3** = Remediation; **4** = Assessment and Interim Remedial Action; **5** = Case Closed; 6 = Eligible for Closure as of date in parenthesis..
Abbreviations Used for Contaminant: **D** = Diesel; **G** = Gasoline; **S** = Other Solvent or Non-Petroleum Hydrocarbon; **O** = Waste Oil / Motor / Hydraulic / Lubricating; **P** = Petroleum / Fuels / Oils, Volatile Organic Compounds.

5.4 Drinking Water Quality

Most people in the United States take for granted that the water that comes out of their kitchen taps is safe to drink. In most areas, this is true, thanks to the efforts of hundreds of behind-the-scene individuals that continually monitor the water supplies for contaminants, in accordance with the drinking water standards set by the EPA. Primary authority for EPA water programs was established by the 1986 amendments to the Safe Drinking Water Act (SDWA) and the 1987 amendments to the Clean Water Act (CWA).

The National Primary Drinking Water Standard protects drinking water quality by limiting the levels of specific contaminants that are known to occur or have the potential to occur in water and can adversely affect public health. All public water systems that provide service to 25 or more individuals are required to satisfy these legally enforceable standards. Water purveyors must monitor for these contaminants on fixed schedules and report to the EPA when a Maximum Contaminant Level (MCL) has been exceeded. MCL is the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. Drinking water supplies are tested for a variety of contaminants, including organic and inorganic chemicals (minerals), substances that are known to cause cancer (carcinogens), radionuclides (such as uranium and radon), and microbial contaminants. The contaminants for which the EPA has established MCLs are listed at http://water.epa.gov/drink/contaminants/index.cfm. Changes to the MCL list are typically made every three years, as the EPA adds new contaminants or, based on new research or new case studies, revised MCLs for some contaminants are issued.

5.4.1 Contaminants of Concern

5.4.1.1 Coliform

One of the contaminants checked for on a regular basis is the coliform count. Coliform is a group of bacteria primarily found in human and animal intestines and wastes. These bacteria are widely used as indicator organisms to show the presence of such wastes in water and the possible presence of pathogenic (disease-producing) bacteria. Pathogens in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with compromised immune systems. One of the fecal coliform bacteria that water samples are routinely tested for is Escherichia coli (E. coli). To fail the monthly Total Coliform Report (TCR), the following must occur:

- For systems testing more than 40 samples, more than 5 percent tested positive for Total Coliform, or
- For those systems testing less than 40 samples, more than one sample tested positive for Total Coliform.

The City of Coachella Water Department (also referred to as the Coachella Municipal Water Department) provides drinking water to most residents of the City. Unincorporated areas in the General Plan study region are serviced by the Coachella Valley Water District. The City of Coachella serves a population of approximately 42,591, whereas the Coachella Valley Water District (under three separate water system names including Cove Community, I.D. No. 10, and I.D. No. 8) serves a population estimated at nearly 211,000 (http://oaspub.epa.gov/enviro/ based on data extracted on February 10, 2014). Several smaller water systems that serve less than 100 people, such as the Coachella Valley Public Cemetery and the Coachella Valley Facility, and private wells, may occur in unincorporated parts of the study area. Groundwater is the primary water source type for all of these water systems. The City of Coachella owns and operates four wells, with a water production capacity from all wells of 5,000 gallons per minute (gpm). The wells tap groundwater from deep aquifers at depths of between 400 and 1,000 feet (ESA, 2009).

According to the EPA Safe Drinking Water Information System, available at www.epa.gov/enviro /html/sdwis/sdwis_ov.html, the City of Coachella has had five monitoring and reporting violations in the last 14 years, since 2000. These violations are listed in Table 5-3 below. Although having any violations is a concern, this is in fact a good record, as the EPA indicates that in 2005, the last fiscal year for which the EPA has complete data, 24 percent of all water purveyors had a reporting/monitoring violation, 6.1 percent reported a MCL violation, and 1.5

percent reported a treatment technique violation. During the same time period, the Coachella Valley Water District has had no health violations, or monitoring and reporting violations.

Table 5-3: Violations Reported by the City of Coachella Water Department for 2000-2011

Type of Violation	Sampling Period	Contaminant	Comments
Monitoring and Reporting	April 1 – June 30, 2009	Chlorine	Issued a formal Notice of Violation on August 20, 2009
Monitoring and Reporting	Jan 1 – March 31, 2009	Chlorine	Issued a formal Notice of Violation on August 20, 2009
Monitoring Repeat Major	May 1 – May 31, 2004	Coliform	Issued an Action Order without penalty on July 2, 2004 Achieved compliance on July 2, 2004
Monitoring and Reporting	Jan 1 – March 31, 2004	Chlorine	Issued a formal Notice of Violation on August 20, 2009
Initial Tap Sampling for Lead and Copper	June 30, 1993 to March 1, 2000	Lead and Copper Rule	Achieved Federal Compliance on March 1, 2000

Source: Environmental Protection Agency website webpage, at http://oaspub.epa.gov/enviro/, data search made on May 24, 2014, with results based on data extracted on February 10, 2014.

5.4.1.2 Perchlorate

A contaminant that California water agencies are increasingly testing for is perchlorate. Perchlorates are negatively charged molecules that are highly persistent in the environment, lasting decades under typical groundwater and surface conditions. Perchlorate salts are used extensively in several industries. For example, ammonium perchlorate is used as a booster or oxidant for solid fuel powering rockets and missiles, in explosives, and for chemical processes and pyrotechnics. Ammonium perchlorate typically constitutes 60 to 75 percent of missile propellant and about 70 percent of space shuttle rocket motors. Potassium perchlorate is also used as a solid rocket fuel oxidizer, and in flares and pyrotechnics. Sodium perchlorate is used as a precursor to potassium and ammonium perchlorate, and in explosives. Magnesium perchlorate is used in military batteries (Rogers, 1998). Perchlorate salts are used in automobile air bags, as a component of air bag inflators, and in nuclear reactors and electronic tubes. Other commercial and industrial uses of perchlorate salts include: as additives in lubricating oils; as fixatives (mordants) for fabrics and dyes, in the production of paints and enamels, tanning and finishing of leathers; electroplating; aluminum refining; and the manufacture of rubber (Siddiqui et al., 1998).

Humans exposed to perchlorate are likely to absorb this compound primarily through ingestion, either by drinking water with perchlorate, or possibly by ingesting produce (such as lettuce or other vegetables that store water) that has been irrigated with water containing perchlorate. Although studies indicate that most ingested perchlorate is eliminated rapidly in the urine without being metabolized (Eichler and Hackenthal, 1962; Anbar et al., 1959), small amounts of perchlorate can displace iodide in the thyroid gland. In adults, this can lead to hypothyroidism and goiter (enlarged thyroid). Symptoms and effects of hypothyroidism include depression and slow metabolism. In children, the thyroid plays a major role in proper development. Impairment of thyroid function in expectant mothers and newborns can result in delayed development and decreased learning capability. Even temporary disruptions in thyroid function can cause permanent physical and mental impairment, including mental retardation, speech impairments, deafness and/or mutism, impaired fine motor skills, delayed reflexes and gait disturbances.

In 2004, the California's Office of Environmental Health Hazard Assessment (OEHHA) established a public health goal (PHG) of 6.0 micrograms per liter (µg/L) for perchlorate (www.dhs.ca.gov/ps/ddwem/chemicals/perchl/perchlorateMCL.htm). Effective October 2007, perchlorate became a regulated drinking water contaminant in California, with a maximum contaminant level (MCL) of 6 µg/L. In January 2011, and following the review of new data on environmental exposures to and possible effects of perchlorate primarily on infants, the OEHHA submitted a proposal to reduce perchlorate's Public Health Goal (PHG) from 6 µg/L to 1 µg/L. In December 2012, the OEHHA released a revised draft of the 2011 document, again supporting the reduction of perchlorate's PHG to 1 µg/L.

Perchlorate in relatively small amounts was detected in the early 2000s in water samples from a few wells in the Coachella Valley, including one well in La Quinta, one well in Palm Springs, and at least three wells in the Torres Martinez Indian Reservation (The Desert Sun, January 10, 2003; B. Spillman, The Desert Sun, January 11, 2005). Then, in February and March 2007, the U.S. Geological Survey, in cooperation with the State Water Resources Control Board, sampled 35 wells in the Coachella Valley Study Unit as part of the Groundwater Ambient Monitoring and Assessment (GAMA) Program. Of the 35 wells sampled, 19 were spatially distributed, selected based on a randomized grid-based method to provide a statistical representation of the study region. The other 16 wells were selected to evaluate changes in water chemistry along a specific groundwater flow path, to evaluate land-use impacts on water quality, or to collect groundwater data where little data was previously available. Of the 35 wells sampled, twelve (34%) were found to contain perchlorate, although in most wells, the concentration of perchlorate was less than 1 µg/L. Only two of the water wells sampled had concentrations above the PHG of 6.0 µg/L; one well in La Quinta (9.0 µg/L), and one well southwest of Mecca (6.1 µg/L) (Goldrath et al., 2009).

Perchlorate contamination of some of the Coachella Valley groundwater is thought to be the result of irrigation with Colorado River water. In 1997, Colorado River water was found to be impacted with perchlorate that had been released from the Kerr-McGee Chemical LLC (now Tronox LLC) manufacturing facility and from the former Pacific Electrochemical Production Company, both in Nevada. Groundwater and surface water contaminated with perchlorate released from these facilities entered the Las Vegas Wash upstream of Lake Mead, which feeds the Colorado River. Mitigation measures implemented since 1999 have reportedly significantly reduced the concentration of perchlorate entering the Las Vegas Wash. As a result, reportedly the concentration of perchlorate in Lower Colorado River water has also steadily decreased (Coachella Valley District 2010 Urban Water Management Plan, May 2011 Draft). Still, water samples collected from several wells in and around Coachella have reportedly tested positive for perchlorate, with concentrations less than 4 µg/L (RMC, 2013).

5.4.1.3 Hexavalent Chromium

Hexavalent chromium has been detected in hundreds of wells in the Coachella Valley at levels below the 50 µg/L for total chromium established by California in 1977. In December 2010, the California Office of Environmental Health Hazard Assessment proposed a Public Health Goal for hexavalent chromium (chromium-6) of 0.02 µg/L. In January 2011, the U.S. Environmental Protection Agency recommended that public water systems conduct enhanced testing and monitoring for hexavalent chromium, in addition to total chromium, to better inform their users (the consumers) about the presence of chromium-6 in their drinking water, "evaluate the degree to which other forms of chromium are transformed into chromium-6 in their drinking water and assess the degree to which existing treatment is affecting the levels of chromium-6" (http://water.epa.gov/drink/info/chromium/guidance.cfm). Since then, the California Department of Public Health submitted a regulation package establishing a Maximum Contaminant Level for hexavalent chromium in drinking water of 10 µg/L.

There are several wells in the Coachella Valley region with hexavalent chromium groundwater concentrations exceeding a concentration of 10 µg/L, including wells in and around La Quinta, Indio, Coachella, Indian Wells and north Palm Springs (RMC, 2013).

5.4.1.4 Nitrate and Nitrite

Nitrate and nitrite are nitrogen-oxygen combinations that occur in several organic and inorganic compounds. Nitrates are used extensively in fertilizers and are thus found in agricultural areas and landscaped areas where fertilizers are used extensively. Other sources of nitrates include leaks from septic tanks and leaching fields, and erosion of natural deposits. Nitrate does not bind well with soil and typically makes its way into the groundwater where it can impact the drinking aquifers. Drinking water with high concentrations of nitrates can have a serious health hazard, especially to infants. The Maximum Contaminant Level for nitrate is 10 parts per million (ppm or mg/L) as nitrogen, and 45 ppm as nitrate (http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm; Coachella Valley Water District 2010 Urban Water Management Plan, May 2011 Draft). Nitrate at concentrations above the MCL has been detected in some wells in the Cove Communities area (Coachella Valley Water District 2010 Urban Water Management Plan, May 2011 Draft, Goldrath et al., 2009). Several mitigation measures have been proposed to reduce the risk of nitrate migration into the deep, drinking-water bearing aquifers.

Other quality issues of concern, or constituents of special interest in the Coachella Valley that are being monitored, and where necessary, remediated for, include salinity (in the form of high Total Dissolved Solids), arsenic, and solvents with carcinogenic properties. Concentrations of naturally occurring **arsenic** have been detected in several wells in the Coachella Valley at levels above the State-adopted Maximum Contaminant Level of 10 µg/L. As a result, the Coachella Valley Water District has built and is operating facilities that reduce, via an ion-exchange process, the amount of arsenic present in those municipal water wells that exceed the MCL. Arsenic at relatively high concentrations has reportedly also been detected in water wells in Coachella, Mecca, Oasis and Thermal (Coachella Valley Water District 2010 Urban Water Management Plan, May 2011 Draft).

5.5 Household Hazardous Waste and Recycling

According to The American Red Cross (1994), most victims of chemical accidents are injured at home. These accidents usually result from ignorance or carelessness in using flammable, combustible or corrosive materials. This is not surprising considering that households do use environmentally significant quantities of hazardous materials. For example, FEMA has estimated that in an average city of 100,000 residents, 23.5 tons of toilet bowl cleaner, 13.5 tons of liquid household cleaners, and 3.5 tons of motor oil are discharged into the sewer and storm drain systems each month (http://www.fema.gov/hazard/hazmat/backgrounder.shtm). However, with the development of new, "greener" products, and recognizing that sensitive individuals can react to many of the chemicals used in these products, many people find themselves with unused household hazardous waste that they need to dispose off properly. Good, usable leftovers of these products can be donated to willing recipients, such as family members, neighbors and community organizations like churches. But others will want to deliver these substances to an appropriate collection center.

The Riverside County Waste Management Department has adopted a Household Hazardous Waste and Oil-Recycling program free to residents, in accordance with the California Integrated Solid Waste Management Act of 1989 (AB 939). The County has established several permanent and temporary regional household hazardous waste collection centers, in addition to Regional Antifreeze, Batteries, Oil (and Filters), and Paint (Latex only) (ABOP) Only Collection Centers. Those permanent and temporary facilities within approximately 25 miles of the City of Coachella are listed in Table 5-4 below. Personnel who have been trained in hazardous waste handling and emergency response procedures operate these facilities.

At the permanent waste collection centers, a variety of household toxics are accepted, including: chlorine bleach, disinfectants, hair dyes, mercury devices, fiberglass and epoxy resins, paint stripper, paint thinner and turpentine, chemicals used in photo processing, insecticides, pesticides and herbicides, motor oils, rodent poisons, pool/spa chemicals, camp propane tanks, etc. The waste needs to be in its original container or labeled properly. Containers also need to be in good condition, sealed, and not leaking, and the total amount of waste cannot exceed 5 gallons or 50 pounds per trip. Proof of residency in Riverside County is generally required. **For a complete list of acceptable and non-acceptable materials and tips on how to transport these materials, refer to http://www.rivcowm.org/, or call the Household Hazardous Waste Information Hotline at (800) 304-2226**. At the ABOP Only centers, they accept only Antifreeze, Batteries (various kinds, including vehicle batteries), Oil (used motor oil and oil filters), and Paint (latex only).

Several other businesses in and around the City of Coachella, such as The Home Depot, UPS Mailing Centers, Office Depot and similar stores may receive and recycle certain kinds of materials such as used batteries, spent light bulbs, and old electronics. To obtain additional information regarding these facilities, their hours of operation, and the types of waste that they receive, call them directly.

Table 5-4: Regional Household Hazardous Waste Collection Centers

Type	Name	Address	Other Information
Permanent Site	Palm Springs	1100 Vella Road, Palm Springs, CA 92264	City Parking Lot Non-holiday Saturdays only: October – May: 9:00 AM to 2:00 PM June – September: 7:00 AM to Noon
Temporary Site	Coachella	84625 Bagdad Avenue, Coachella, CA 92236	Bagdouma Park Parking Lot Check for event dates and times at http://www.rivcowm.org/HHW_Schedule.htm
Temporary Site	Indio	46-350 Arabia Street, Indio, CA 92201	Date Festival Grounds, Gate 6 Check for event dates and times http://www.rivcowm.org/HHW_Schedule.htm
Temporary Site	La Quinta	78495 Calle Tampico, La Quinta, CA 92253	South City Hall Parking Lot Check for event dates and times http://www.rivcowm.org/HHW_Schedule.htm
Temporary Site	Rancho Mirage	69-825 Highway 111, Rancho Mirage, CA 92270	City Hall Parking Lot Check for event dates and times http://www.rivcowm.org/HHW_Schedule.htm
Temporary Site	Oasis	84-505 84th Avenue, Oasis, CA 92274	Oasis Landfill Check for event dates and times http://www.rivcowm.org/HHW_Schedule.htm
Regional ABOP Collection Center	East Coachella Coachella Valley Transfer Station	87-011A Landfill Road, Coachella, CA 92236	Monday – Friday: 8:00 AM to 5:00 PM Saturdays: 8:00 AM to Noon (760) 863-4094

Type	Name	Address	Other Information
Regional ABOP Collection Center	North-West Coachella Valley Area	Edom Hill Transfer Station 70-100 Edom Hill Road Cathedral City, CA 92235	Non-holiday Saturdays only: 8:00 AM to 4:30 PM (760) 340-2113

Waste collection, in the form of curbside pick-up and recycling services, in the City of Coachella is provided by **Burrtec**. Their phone number is **(760) 393-0635**, and their website is http://www.burrtec.com/coachella. Burrtec has a series of programs designed to reduce the amount of waste that is taken to the landfill. Their waste reduction and recycling programs include separate containers for grass and composting materials, recyclable materials (paper, glass, aluminum, cardboard, etc.), and non-recyclable trash. Additional residential services provided by Burrtec include pick-up of bulky items, Christmas tree recycling, pick-up of electronic waste, and used motor oil collection. Information on which items are recyclable and which are non-recyclable, motor oil recycling and the recycling of electronic waste is provided on Burrtec's website.

Burrtec operates the two transfer stations closest to Coachella, including the Coachella Valley Transfer Station and the Edom Hill Transfer Station (see Table 5-5). Transfer stations are facilities that serve as local collection points prior to the final disposal site, where waste is separated into types, and sent to the appropriate final destinations. Burrtec operates several landfills in the southern California area. Those closest to Coachella include the Salton City Landfill (Highway 86, Salton City) and the Landers Landfill (59200 Winters Road, Landers). Riverside County has several other active landfills in the region. Those closest to Coachella include Mecca II, Oasis, and Lamb Canyon Road (see Table 5-5).

There are three land disposal sites in the Coachella General Plan area listed in GeoTracker. These are also summarized in Table 5-5 below.

Table 5-5: Transfer Stations, Active Landfills and Land Disposal Sites In and Near the Coachella General Plan Area

Name	Address	Status with Geotracker	GeoTracker ID No.	Comments
Coachella Valley Transfer Station	87-011 Landfill Road, Coachella, CA 92236	Not in GeoTracker		Operated by Burrtec. Accepts solid waste, household refuse, yard trimmings, furniture, appliances, televisions and computers, and electronic waste.
Edom Hill Transfer Station	70-100 Edom Hill Road Cathedral City, CA 92235	Not in GeoTracker		Operated by Burrtec. Accepts solid waste, household refuse, yard trimmings, furniture, appliances, televisions and computers, and electronic waste.
Mecca II Sanitary Landfill	95250 66th Avenue, Mecca, CA 92254	Not in GeoTracker		Owned and operated by the Riverside County Waste Management Department. Accepts solid

Name	Address	Status with Geotracker	GeoTracker ID No.	Comments
				waste, household refuse, yard trimmings, furniture, tires, appliances, televisions and computers, and electronic waste.
Oasis Landfill	84-505 84th Avenue, Oasis, CA 92274	Not in GeoTracker.		Owned and operated by the Riverside County Waste Management Department. Accepts solid waste, household refuse, yard trimmings, furniture, tires, appliances, televisions and computers, and electronic waste.
Lamb Canyon Sanitary Landfill	16411 Lamb Canyon Road, Beaumont, CA 92223	Not in GeoTracker		Owned and operated by the Riverside County Waste Management Department. Accepts solid waste, household refuse, yard trimmings, furniture, tires, appliances, televisions and computers, and electronic waste.
Coachella Class III WMF 01-098 (non-hazardous residential, agricultural, construction, industrial, mixed municipal and dead animals).	87011 44th Avenue, Coachella, CA 92236	Open Case. Contamination associated with a diesel fuel area was reported in 2000. Groundwater samples from monitoring wells have tested positive for nitrate, tetrachloroethene, and trichloroethene. Site is equipped with a landfill gas collection system, and semi-annual groundwater sampling and monitoring reports are submitted to the RWQCB.	L10003659217	The facility, which is owned and maintained by the Riverside County Waste Management Department, is closed and no longer receives refuse. The site opened in 1972; approximately 67 acres of the 640-acre site was filled with refuse. Last load of trash received in May 1997. Closure construction was completed in August 1999.
Armtec Defense Products 02-106	85901 Avenue 53, Coachella	Open Case.	L10007426352	Classified as a Land Disposal Site; open case as of 1/1/1965, although no site history is available in GeoTracker.
California Biomass 02-118	83109 Avenue 62, Thermal, CA 92274	Open Case.	L10005617105	Classified as a Land Disposal Site; open case as of 1/1/1965, although no site history is available in GeoTracker.

Sources: http://www.burrtec.com/coachella; http://www.rivcowm.org; http://geotracker.swrcb.ca.gov/

5.6 Releases due to Transportation Accidents and Pipeline Failures

Interstate 10 traverses the northern half of the city and planning area in an approximately east-west direction. According to the National Hazardous Materials Route Registry maintained by the Federal Motor Carrier Safety Administration, a division of the U.S. Department of Transportation, the only major route in the Coachella area prescribed or permitted to carry hazardous materials is Interstate 10. All types of hazardous materials are permitted on this road, and it is recommended for the transport of Class 1 Explosives, Class 7 highway road-controlled quantity (HRCQ) radioactive, and toxic inhalation hazard (TIH) materials. The sections of State Routes 86 and 111 that extend through Coachella are not on the registry.

As a result, Interstate 10 poses a potential for spills or leaks from non-stationary sources to occur within the area. Vehicles carrying hazardous materials are required to have placards that indicate at a glance the chemicals being carried, and whether or not they are corrosive, flammable or explosive. The conductors are required to carry detailed “material data sheets” for each of the substances on board. These documents are designed to help emergency response personnel assess the situation immediately upon arrival at the scene of an accident, and take the appropriate precautionary and mitigation measures. The California Highway Patrol is in charge of spills that occur in or along freeways, with Caltrans, and local sheriffs and local fire departments responsible for providing additional enforcement and routing assistance.

Railroad tracks of the Union Pacific extend across the Coachella planning area on their way from San Bernardino to Yuma, Arizona. These tracks serve two Amtrak trains in addition to Union Pacific’s traffic to and from Arizona, Texas and the southeastern U.S. The Union Pacific freight trains carry a variety of cargo, including hazardous materials that may consist of flammable liquids and gases, toxic substances that may react if exposed to air or water, and explosives (Byers, 2008). A train accident, for example, as a result of a collision between a locomotive and a vehicle attempting to cross the tracks at the same time, could result in the derailment of the train, and the release of hazardous substances. Given that the railroad tracks extend across the business section of Coachella, a hazardous release from an overturned or derailed train could result in a serious public threat. As with trucks on the interstate, cargo trains transporting hazardous materials are required to carry detailed paperwork indicating the substances on board, in addition to placards on the cars carrying the hazardous materials. Agencies responding to such an incident would include the Riverside County Fire Department’s Hazmat Team, the Riverside County Department of Environmental Health – Hazardous Materials Division, the California Highway Patrol and local police department to control traffic around the accident location and conduct and enforce evacuations if necessary, and Union Pacific contractors to right the derailed or overturned train and fix the track. It is important to note that less than 2 percent of train accidents or incidents result in a hazardous material release. For example, according to statistics compiled by the Federal Railroad Administration, only 21 of the 1,868 (1.2%) train accidents reported in the United States in 2010 resulted in a release of hazardous materials. Forty railroad cars were implicated in the releases, and 1,682 people were evacuated as a result of these incidents. Between January and April 2011, only seven of the 635 (1.07%) train accidents resulted in a release of hazardous materials, resulting in the evacuation of 145 people. Similarly, in calendar year 2013, 1,781 train accidents occurred in the United States. Of those, 18 (1%) resulted in the release of hazardous materials (http://safetydata.fra.dot.gov/OfficeofSafety/).

In the Coachella planning area the railroad tracks run sub-parallel to, and approximately 2 to 2.5 miles east of the San Andreas fault zone, and as a result, should the San Andreas fault rupture, this section of railroad track will not be impacted by surface ground rupture, although ground deformation as a result of liquefaction may occur along some sections traversed by the railroad (see Chapter 1). Sections of the railroad track extend immediately along or cross the San Andreas fault to the south, in the Desert Beach and Bombay Beach areas respectively, and to the north of Palm Springs, where the Garnet Hill fault is mapped. Trains can derail if they attempt to run over tracks that have been damaged by surface fault rupture or some other kind of earthquake-induced ground failure. This is what happened to Amtrak's Southwest Chief passenger train on October 16, 1999, immediately following the Hector Mine earthquake in the Mojave Desert. The westbound passenger train, en route from Chicago to Los Angeles, derailed near Ludlow, California about 24 minutes after the earthquake occurred, when it reached a section of track that had been damaged by ground deformation. The train was running at reduced speed, in accordance with the American Railway Engineering and Maintenance-of-Way Association (AREMA, 2009 as reported in Byers, 2011) guidelines that require trains within 100 miles of a location reporting earthquake shaking to operate at restricted speed, and as a result, only four out of the 155 passengers on board suffered minor injuries.

Trains running at the time of the earthquake near the epicenter could also derail as a result of strong ground shaking, although this does not occur always. For example, trains running in areas shaken intensely during the 1999 Izmit, Turkey and 2001 Bhuj, India, earthquakes, did not derail (Byers, 2008). The mechanisms required for trains to derail or overturn as a result of ground shaking are not well understood, but the direction of shaking, the magnitude of the earthquake, and the duration of the acceleration are all thought to be part of the equation. The probability of an earthquake-induced derailment of a train carrying hazardous materials through the City of Coachella is considered low. The same agencies identified above would be responsible for responding if such an incident occurred, but their response times would be greatly impacted by the damage to the roads, freeways and railroad tracks, in addition to competing requests for assistance from many other incidents throughout the region. For additional information regarding the potential impacts as a result of a local earthquake on the San Andreas fault, refer to Chapter 1, Section 1.9.

Two Southern California Gas transmission pipelines and one hazardous liquid (Kinder-Morgan's 20-inch diesel) pipeline extend across and near the city of Coachella (https://www.npms.phmsa.dot.gov /searchp/Application.asp; Ballantyne, 2008) (see Plate 5-1). Other smaller product and gas pipelines extend through the area. Rupture of any portion of these pipelines could adversely impact the surrounding area. Leaks from pipelines extending across the region have been reported in the past (see Table 5-6).

Pipeline operators are responsible for the continuous maintenance and monitoring of their pipelines to evaluate and repair, when necessary, corroded sections of pipe that no longer meet pipeline-strength criteria. All excavations or drilling operations near pipelines, or anywhere else, for that matter, should be conducted only after proper clearance by the appropriate utility agencies or companies. California law requires that all excavations be cleared in advance. This is done locally by the **Underground Service Alert of Southern California,** or **DigAlert** (http://www.digalert.com or www.call811.com). Their telephone number is **8-1-1.** Calls need to be made at least two (2) working days before digging, and the proposed excavation area needs to be delineated or marked.

Table 5-6: Pipeline and Equipment Releases
That Have Been Reported in the Coachella Area

Site Name	Address	State Case No.	Case Type	Status, Contaminant	Date Leak Discovered
Escher Oil Company	85-119 Avenue 50	SL0606529297	O	2, D, G	10/1/1986

Site Name	Address	State Case No.	Case Type	Status, Contaminant	Date Leak Discovered
Former Unocal/Tosco Bulk Plant	50-021 Harrison Street	SL0606515826	O	4, D, G (closed 12/17/13)	3/15/1991
Kinder Morgan Energy Partners	85989 Avenue 52	SL0606535159	O	3, O	6/14/1990
Santa Fe Pacific Pipeline Partners	Avenue 52 and Highway 111	SL20703104	O	3, P	4/1/1994

Source: GeoTracker (http://geotracker.swrcb.ca.gov/)

Abbreviations Used for Case Type: O = Other groundwater (uses other than drinking water).
Abbreviations Used for Status: 1 = Case Opened; **2** = Site Assessment; **3** = Remediation; 4 = Case Closed.
Abbreviations Used for Contaminant: D = Diesel; **G** = Gasoline; **O** = Waste Oil / Motor / Hydraulic / Lubricating; **P** = Petroleum / Fuels / Oils, Volatile Organic Compounds.

Pipeline and power line failures during an earthquake are more often the result of permanent ground deformations, including fault rupture, liquefaction, landslides, and consolidation of loose granular soils. Tectonic uplift or subsidence can also impact a pipeline. Seismic shaking typically has less of an impact on buried utilities than it does on aboveground structures. The city of Coachella is bisected by the San Andreas fault, so the hazard of surface fault rupture and its potential impact on the city's utilities distribution system is high (see Chapter 1, Section 1.9.6). In addition, Coachella is located near several other major seismic sources, such as the Anza segment of the San Jacinto fault to the west, the Pisgah-Bullion Mountain-Mesquite Lake fault to the north-northeast, and the Pinto Mountain fault, also to the north, any of which could generate significant ground shaking in the area. Liquefaction and earthquake-induced settlement as a result of an earthquake on any of these seismic sources have the potential to locally impact pipelines, power lines, communication towers, and other lifelines that service Coachella.

The gas transmission pipelines mentioned above and shown on Plate 5-1 extend along and across the San Andreas fault zone to the north and northwest of the General Plan study area. Given the large displacements expected along the San Andreas fault when this section of the fault ruptures next, the pipelines are expected to rupture where they cross or overlie the fault. Gas would be spewed into the air, and if there are ignition sources nearby, a fire can ensue. Although the hazardous fluid pipeline that extends across Coachella does not cross the San Andreas fault in the planning area, strong ground shaking is expected to cause several breaks of the pipeline, in addition to a significant break of the line in the Palm Springs area, where it crosses the San Andreas fault (Ballantyne, 2008). Cleanup of the spilled petroleum product will be required at all breaks along the pipeline.

5.7 Earthquake-Induced Releases of Hazardous Materials

Isolated unauthorized releases of hazardous materials can occur at any time, but natural disasters, such as an earthquake or flood, have the potential to cause several incidents at the same time. Strong seismic shaking can lead to the release of hazardous materials by damaging storage facilities and transport infrastructure. During an earthquake, chemical storage tanks could buckle or, if improperly secured and fastened, could easily be punctured and/or tipped over. Improperly segregated chemicals could react forming a toxic gas cloud. Even small amounts of chemicals, if kept in breakable containers and stored together (like in the same chemical closet at a high school chemistry lab or the same aisle at the grocery store), could result in a potentially hazardous situation if the containers break and the chemicals react with each other. As discussed in the section above, pipelines are especially vulnerable to damage as they can be pulled apart or ruptured by strong ground motion and surface ground deformation. Natural gas lines pose a significant hazard due to the high number of pipelines in urban environments and because gas leaks from ruptured lines can lead to secondary fires. Train derailment during an earthquake can also lead to significant hazardous materials release.

As a result of the Northridge earthquake, 134 locations reported hazardous materials issues, 60 of which required emergency responses. The majority of these events occurred where structural damage was minimal or absent (Perry and Lindell, 1995). The earthquake caused 1,377 breaks in the natural gas pipeline system and half a dozen leaks in a 10-inch crude oil pipeline (Hall, 1994). A train derailment following the Northridge earthquake included a train with 29 cars and one locomotive. One of the cars spilled an estimated 2,000 gallons of sulfuric acid, and 1,000 gallons of diesel fuel spilled from the locomotive.

The M5.9 Whittier Narrows earthquake in 1987 was nearly 100 times smaller than the ShakeOut earthquake scenario on the San Andreas fault discussed at length in Chapter 1 (see Section 1.9), and yet, 22 hazardous materials release incidents were reported as a result of the shaking. The most significant of these incidents was the release, from a collapsed tank in a chlorine re-packaging facility, of nearly one ton of chlorine gas (FEMA, 19987; Eguchi and Ghosh, 2008). This leak caused the evacuation of a neighborhood in Santa Fe Springs. The Whittier Narrows earthquake also caused over 1,400 natural gas leaks, three of which caused subsequent fires. At least 5,000 pounds of anhydrous ammonia were released in 1989, during the Loma Prieta earthquake, at a food processing plant in Watsonville (ABAG, 1990; Seligson et al., 1992).

The facilities listed in previous sections of this report that manufacture, use or store hazardous materials are for the most part using chemical substances that occur in a liquid or solid state at normal temperatures and pressures. A leak of any of these substances (such as ethylbenzene, n-hexane and xylene reportedly used by ARMTEC Defense Products) would impact the underlying soils and have the potential to impact the groundwater under the site. While such a release and subsequent contamination would be unfortunate and would require extensive resources to cleanup, it would not pose an immediate danger to the surrounding population. Past studies of hazardous materials release scenarios as a result of an earthquake have concentrated on the two substances that are thought to pose the biggest threat to a community during an earthquake: Chlorine and anhydrous ammonia. These substances, under normal temperature and pressures, occur in a gas state, and thus if released to the atmosphere, form clouds that can spread to adjacent areas, posing a threat to the surrounding community.

Chlorine is one of the products most often used as a disinfectant by swimming pool, drinking water and wastewater facilities, making chlorine one of the most prevalent extremely hazardous substances. Chlorine is typically found in the form of a colorless to amber-colored liquid, or as a greenish-yellow gas with a characteristic odor. The liquid solutions are generally very unstable, reacting with acids to release chlorine gas (such as bleach mixed with vinegar or toilet bowl cleaner containing hydrochloric acid). Mixing bleach with other products is the largest single source of inhalation exposure reported to poison control centers (http://www.emedicine.com/EMERG/topic851.htm). Chlorine gas is heavier than air and therefore stays close to the ground, where it can impact individuals. Exposure to chlorine gas generally impacts the respiratory system, with cough, shortness of breath, chest pain, and burning sensation in the throat reported as the most common symptoms. Respiratory distress can occur at even low concentrations of less than 20 parts per million (ppm). At high concentrations (> 800 parts per million – ppm) chlorine gas is lethal.

Ammonia is a compound of hydrogen and nitrogen that is used extensively, either directly or indirectly, in several different types of applications, including the manufacture of pharmaceuticals, fertilizers, and commercial cleaning products. The colorless gas has a strong pungent odor, an unlike chlorine gas, is lighter than air. Exposure to high concentrations of ammonia can lead to lung damage and death. Solutions of ammonia can be irritating to the eyes and mucous membranes, and to a lesser extent, the skin. Mixture of an ammonia solution with a chlorine-containing compound, such as bleach, can result in the formation of a highly poisonous gas.

Chlorine pellets, chlorine solutions and ammonia solutions can be found at supermarkets, hardware stores and other locations that sell pool supplies and cleaning products. Bleach and ammonia solutions can be found in almost every household and in commercial and industrial facilities, including hotels, hospitals, medical and veterinary facilities, etc. Proper storage and usage practices are required at all of these locations to reduce or eliminate the potential for a toxic release of chlorine, ammonia, or even worse, a mixture of the two. Chlorine and ammonia are used in or near the Coachella planning area, at the two wastewater treatments plants (the Coachella Sanitary District Wastewater Treatment Plant in Coachella, and the Valley Sanitary District Wastewater Treatment Plant in Indio, less than a mile to the northwest of Coachella) (http://www.epa.gov/enviro/index.html; search for chlorine and ammonia users in the Coachella area). Chlorine is also likely to be used by the City at its water storage facilities to treat the municipal supply of drinking water. Proper operations and maintenance procedures are required to prevent equipment and process failures that could lead to the unauthorized release of these substances at concentrations that could impact the surrounding areas. These facilities are required to maintain a comprehensive program of personnel training, security enforcement and equipment monitoring to reduce the risk of an accidental or intentional (terrorist) release.

A key point to remember regarding the management of hazardous materials spills in the aftermath of an earthquake is that it is substantially more difficult to do so than under non-earthquake conditions. Hazardous material response teams responding to a release as a result of an earthquake have to deal with potential structural and non-structural problems of the buildings housing the hazardous materials, potential leaks of natural gas from ruptured pipes, and/or downed electrical lines or equipment that could create sparks and cause a fire. When two hazards with potentially high negative consequences happen coincidently, the challenges of managing each are greatly increased. During an earthquake response, hazardous material emergencies become an additional threat that must be integrated into the response management system.

5.8 Other Potential Hazardous Materials Release Incidents

Petroleum contains several components that are considered hazardous by the state of California, such as benzene, a known carcinogen. Oil field activities often include the use of hazardous materials like fuels and solvents. Day-to-day practices in some of the earlier oil fields were not environmentally sensitive, and oil-stained soils and other contaminants can often be found in and around oil fields. This typically becomes an issue when the oil field is no longer economically productive, and the property is developed, usually for residential purposes. Assessing the feasibility of developing an oil field property requires comprehensive site investigations in order to accurately identify and characterize any soil and groundwater contamination that may have resulted from the oil field operations. These site investigations are required by local and/or regional environmental laws and regulations, and vary in scope according to applicable government regulations, generally accepted standards of practice, and site-specific conditions (Fakhoury and Patton, 1992).

According to records from the California Division of Oil, Gas and Geothermal Resources (CDOGGR; http://www.conservation.ca.gov/dog/maps/Pages/index_map.aspx), no oil or geothermal wells have been drilled in the Coachella area. Thus issues associated with oil and gas production are not anticipated to be significant in the region.

5.9 Hazard Analysis

The primary concern associated with a hazardous materials release is the short- and/or long-term effect to the public from exposure to the hazardous substance, especially if a toxic gas is involved. The best way to reduce the risk posed by a hazardous material release is enforcement of stringent regulations governing the storage, use, manufacturing, and handling of hazardous materials.

The City of Coachella observes the most current version of the California Fire Code (currently the 2013 edition that was adopted in January 2014) for usage, storage, handling and transportation requirements for hazardous materials. Risk minimization criteria include secondary containment, segregation of chemicals to reduce reactivity during a release, sprinkler and alarm systems, monitoring, venting and auto shutoff equipment, and treatment requirements for toxic gas releases.

There are four reported Significant Hazardous Materials Sites in the Coachella General Plan area. A Significant Hazardous Materials Site, as used herein, includes facilities identified in Federal and/or State databases as Superfund-Active or Archived Sites (CERCLIS), Cortese List, RCRA/RCRIS-EPA registered Large-Quantity Hazardous Waste Generators, and Toxic Release Inventory Sites (TRIs). As of 2011, there were also 21 reported Small-Quantity Generators of hazardous materials in the Coachella General Plan area. Compared to other cities in southern California, Coachella at this time has a relatively small number of facilities that use or store hazardous materials. Nevertheless, several of the existing significant hazardous sites are located within about 1 mile of schools in the community (see Plate 5-1). Furthermore, this is a snapshot in time, and as the city continues to grow, more, especially small-quantity generators of hazardous materials are expected to be located in the area. City planners are advised to encourage the establishment of future significant hazardous materials sites in the city in areas far away from critical facilities with evacuation constraints, such as schools and nursing homes. Facilities that use, store, generate or transport hazardous materials are also expected to come and go; so these lists, or comparable lists, should be updated at least once a year. Residents and property and business owners that are interested in obtaining current data for a particular area or site should request it from the Riverside County Department of Environmental Health, Hazardous Materials Division, or by visiting the appropriate websites referenced herein.

The Coachella area is bisected by the San Andreas fault, and is located about 20 miles of the Anza segment of the San Jacinto fault. The San Andreas and San Jacinto faults are both thought to have a relatively high probability of generating an earthquake in the next 30 years (see Chapter 1). Therefore, all hazardous materials sites in Coachella could be subject to moderate to severe seismic shaking. Their business plans should address, provide and implement mitigation measures designed to reduce the potential for releases of hazardous materials during an earthquake. It has been shown in previous urban earthquakes that hazardous materials spills can occur even when the building does not suffer significant damage. Hazardous material containers not properly secured and fastened could easily be punctured and/or tipped over, pipes may rupture, and storage tanks may fail. Containers may also explode if subject to high temperatures, such as those generated by a fire. Improperly segregated chemicals could react forming a toxic gas cloud. In a worst-case scenario, several hazardous materials releases could occur simultaneously. Comparison of Plate 5-1 with Plates 1-1 and 1-2 shows that two small-quantity generators of hazardous waste and a disposal facility are located very close to the mapped traces of the

San Andreas fault. Surface fault rupture at these facilities could result in structural damage and release of the chemical substances stored therein.
Most of the hazardous materials facilities shown on Plate 5-1 are located within the 500-year floodplain (see Plate 3-1), but none are located within the 100-year flood zones defined by either FEMA or the California Department of Water Resources. Avoidance of the 100-year flood zones by facilities using or storing hazardous materials should be continued in the future. Exceptions may be possible in the 100-year zones defined by the Department of Water Resources if all standards of elevation, anchoring, and flood proofing have been satisfied, and hazardous materials are stored in watertight containers designed to not float.

5.10 Summary of Findings

The primary concern associated with a hazardous materials release is the short- and/or long-term effect to the public from exposure to the hazardous materials released. The best way to reduce the possibility for a hazardous material release is by implementing and enforcing stringent regulations governing the storage, use, manufacturing and handling of hazardous materials. Given that the San Andreas fault extends across the Coachella General Plan area, the hazards of surface fault rupture, ground deformation and strong ground shaking, and the impact that these geologic conditions may have on the structural integrity of the storage containers and pipelines carrying hazardous materials need to be considered and planned for.

The entire area will be subjected to intense ground shaking as a result of an earthquake on the southern segment of the San Andreas fault that extends across the planning area (for more information refer to Chapter 1). It has been observed in previous urban earthquakes that hazardous materials spills can occur even when the building housing the materials does not suffer significant damage. Hazardous material containers not properly secured and fastened can easily be punctured and/or tipped over. Improperly segregated chemicals could react, forming a toxic gas cloud. In a worst-case scenario, several hazardous materials releases could occur simultaneously. Therefore, hazardous material sites in Coachella should be designed with secondary containment systems, tank bracing systems, and other engineering solutions to reduce the potential for tanks and containers to tip over during an earthquake. All business plans for sites within the city should address the hazard of intense ground shaking and identify specific measures to be taken to reduce this hazard to an acceptable level.

Most of the significant hazardous materials sites identified in Coachella are located within the 500-year flood zone. None of the sites are located within the 100-year flood zones defined by either FEMA or the California Department of Water Resources. It is recommended that future hazardous materials sites established in Coachella not be located in the 100-year floodplain, unless very specific containment measures are implemented to reduce the potential for hazardous materials to leak during a flood. Furthermore, street flooding as a result of intense storms and inadequate storm drain capacity could result in the flooding of some of the hazardous materials facilities, and rupture of the Coachella Canal due to surface fault rupture or strong ground shaking could also result in the flooding of hazardous materials facilities located in the inundated zones. Therefore, the business plans for all hazardous materials businesses should address the hazards of flooding and of strong ground shaking during an earthquake, and provide for mitigation measures to be implemented to reduce the potential for hazardous materials to leak during a natural disaster.

Several of the existing significant hazardous materials sites are also located within 1 mile of schools and other facilities with populations with special evacuation needs (such as nursing homes). It is advisable to encourage the establishment of any future significant hazardous materials sites in areas far away from critical facilities with evacuation concerns. Furthermore, these critical facilities should have plans that include protocol to be followed in the event of a leak of hazardous materials that would require them to evacuate.

5.10.1 National Pollutant Discharge Elimination System (NPDES)

Urban runoff from the urbanized sections of Coachella discharge into the Whitewater River watershed that is under the Colorado River Regional Board (Region 7) jurisdiction. The city, together with all other incorporated cities in the Coachella Valley, is regulated by a municipal separate storm sewer system (MS4) permit issued by the Regional Board. Under this permit, the County of Riverside and the Riverside County Flood Control and Water Control District are the Principal Permittees, and the Coachella Valley Water District, together with the incorporated cities of Banning, Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, are Co-Permittees. The City of Coachella, as Co-Permittee, has several responsibilities defined by the NPDES permit orders.

5.10.2 Superfund, Hazardous Waste, and Toxic Release Inventory Sites

According to EPA data, there are no Superfund (CERCLIS) sites in the Coachella General Plan area. In 2011, the EPA reported three permitted Large Quantity Generators of hazardous materials in Coachella. One of these sites (ARMTEC Defense Products) is also listed as the only Toxic Release Inventory (TRI) site in the Coachella General Plan area. One site (the Foster-Gardner site) is included in the CORTESE list, in addition to being identified, under a different name, as a Small-Quantity Generator. As of May 10, 2011, there were 21 permitted Small-Quantity Generators of hazardous materials located throughout the city. This figure is expected to increase as the city grows. As of 2014, there are no businesses in Coachella listed in the Department of Toxic Control Substances official database of registered transporters of hazardous waste in California.

5.10.3 Hazardous Materials Disclosure Program

Both the Federal government and the State of California require businesses that handle more than a specified amount of hazardous materials or extremely hazardous materials, termed a reporting quantity, to submit a business plan to the local Certified Unified Program Agency (CUPA). In Coachella, the local CUPA is the Riverside County Department of Environmental Health, Hazardous Materials Division, (RCDEH-HMD); they are responsible for reviewing the annually submitted business plans. For more information refer to their website (http://www.rivcoeh.org/), or contact them by phone at (888) 722-4234 (888-RC-CHA-EH).

5.10.4 Leaking Underground Fuel Tanks

According to data from the State Water Quality Control Board, 37 leaking underground storage tank (LUST) sites were reported in Coachella between 1979 and 2013. Thirty-three of these LUST sites have been remediated and/or considered to not pose a risk to human health and the environment; their cases have been closed by the appropriate regulatory agency. The remaining four are in various states of assessment and/or remediation. Fifteen of these sites reportedly impacted the groundwater in an aquifer used for drinking water purposes, and eleven impacted groundwater in an aquifer not used for drinking purposes. Ten to eleven leaks reportedly impacted the surrounding soil (see the Statewide database, GeoTracker, which is available at http://geotracker.swrcb.ca.gov/). The California Regional Water Quality Control Board (CRWQCB), in cooperation with the County of Riverside Department of Environmental Health – Hazardous Materials Division provides oversight and conducts inspections of all underground tank removals and installation of new ones (http://www.rivcoeh.org/opencms/rivcoeh/

ProgServices/EPO_Division/EPO_Home.html). Given that there are at least 16 permitted underground storage tanks in the city, future leaks could be reported. The GeoTracker database should be reviewed periodically for updates.

5.10.5 Water Quality

The City of Coachella Water Department (also known as the Coachella Municipal Water Department) provides drinking water to the residents of the City of Coachella. Residents of the unincorporated areas within the General Plan study area are serviced by the Coachella Valley Water District (with the exception of those residents that have their own water wells). According to the EPA Safe Drinking Water Violation Report, the Coachella Valley Water District has not had any violations reported in the last ten years, whereas the City of Coachella Water Department has had five monitoring and reporting violations in the last fourteen years. These violations have been for the monitoring and reporting of chlorine (two sampling periods in 2009, one in 2004), a monitoring violation of coliform (in 2004), and sampling of lead and copper (in 2000; the water department achieved compliance in March 2000). Compared to State statistics for drinking water violations, the City of Coachella Water Department's record is good.

Perchlorate at relatively low concentrations of less than 4 μg/L (equivalent to parts per billion) has been detected in some wells in the Coachella Valley, including some in and around the city of Coachella (RCM, 2013). Only two of the wells (one in La Quinta and one in southwest of Mecca) tested with concentrations of perchlorate that exceed the current Maximum Contaminant Level established by California of 6 μg/L.

Other substances that have the potential to impact the drinking water aquifers that provide water to the residents of the City of Coachella include naturally occurring arsenic, salinity (in the form of Total Dissolved Solids), hexavalent chromium, nitrates and nitrites, and other man-made contaminants such as solvents and pharmaceuticals. All of these compounds and conditions are being monitored by both the City of Coachella Water Department and the Coachella Valley Water District.

5.10.6 Household Hazardous Waste

Riverside County has adopted a Household Hazardous Waste and Oil-Recycling program that is free to county residents, in accordance with the California Integrated Solid Waste Management Act of 1989. There are a few permanent and temporary facilities in the region where residents from Coachella can drop off their unwanted household hazardous waste. For a list of collection sites, schedules, and types of materials accepted, refer to the Riverside County Waste Management Department at http://www.rivcowm.org/ or call the Household Hazardous Waste Information Hotline at (800) 304-2226. The City of Coachella, together with Burrtec, their trash hauler, have programs designed to reduce the amount of waste taken to the landill. Waste reduction and recycling programs include: curb-side collection service with separate containers for grass clippings and composting materials, recyclables, and non-recyclable trash. For additional information regarding the services provided by Burrtec refer to their website at http://www.burrtec.com/coachella, or call (760) 393-0635.

There is one transfer station in Coachella (Coachella Valley Transfer Station) operated by Burrtec. There is also a now closed landfill in the Coachella General Plan area, the Coachella Class III Waste Management Facility landfill. This facility operated as a municipal solid waste landfill between 1972 and 1997. Several groundwater wells onsite and offsite, near the landfill, are monitored semi-annually for the presence of nitrate, tetrachloroethane and trichloroethene, inorganic compounds that may be leaking out of the landfill and impacting the local water resources. The California Regional Water Control Board has an open file on this site that can be accessed on the GeoTracker website. Two other land disposal sites in the General Plan area are identified by the Regional Water Board, but there is little information regarding these sites with the exception of their name and address.

5.10.7 Releases due to Transportation Accidents and Pipeline Failures

Interstate 10 is the only major route through Coachella that is permitted to transport hazardous materials, including Class I explosives, radioactive and toxic-inhalation hazard materials. Other internal roads may also be used to transport hazardous materials. Hazardous materials are also transported by rail, on the Union Pacific tracks that extend across the business section of Coachella. Both the Interstate 10 and the railroad tracks pose a potential for spills or leaks from a non-stationary source in the event of an accident involving a vehicle carrying hazardous substances. All transportation of hazardous materials needs to be conducted under strict protocol. Material data sheets for each substance being transported need to be carried by the conductor. These data sheets are designed to help emergency response personnel identify the most appropriate action to contain the specific substances involved in the spill. The California Highway Patrol is in charge of spills that occur in or along freeways, with Caltrans, the local sheriffs and fire departments providing additional resources as needed. The Riverside County Department of Environmental Health – Hazardous Materials Division would also provide assistance.

Two gas transmission lines and one hazardous liquid line extend across and near the Coachella General Plan area. Rupture of any portion of these pipes could adversely impact the surrounding area. Rupture of sections of these pipelines could occur if there is significant ground failure, in the form of liquefaction or slope failure, as a result of a large regional earthquake. Pipeline operators are responsible for the continuous maintenance and monitoring of their pipelines, including the repair, when necessary, of corroded sections of pipe. All excavations or drilling operations near pipelines should be conducted only after proper clearance by the appropriate utility agencies or companies. California law requires that all excavations be cleared – this is done by the Underground Service Alert of California or DigAlert (http://www.digalert.com or www.call811.com). Their telephone number is **8-1-1.** Calls need to be made at least two (2) working days before digging, and the proposed excavation area needs to be delineated or marked.

5.10.8 Oil Fields

There are no oil or gas fields in or near Coachella. Environmental issues associated with oil and gas fields are not anticipated in the study area.

CHAPTER 6: SEVERE WEATHER HAZARDS

Severe weather, including high winds, hail, excessive precipitation, wildfires, blizzards, snowstorms and ice storms, dust storms, heat spells and drought, have the potential to cause significant damage to property and infrastructure, cause serious social disruption, and result in injuries and/or loss of life. Many of these hazards can create conditions that disrupt essential systems such as public utilities, telecommunications, and transportation routes. Flooding associated with excessive precipitation and wildfires are discussed in other chapters, although wildfires fanned by winds are also included herein. This chapter discusses primarily high winds, dust storms, hail, temperature extremes, and drought. Historical occurrences of these conditions in the Coachella Valley are summarized as background information, and definitions and terminology associated with each condition are also provided. Climate variability and its effects on regional weather patterns and increased potential for severe weather hazards is also discussed.

6.1 High Winds

This section discusses the specific hazards associated with unusual and potentially damaging wind activity based on scientific data and historical records. In southern California, strong winds may be associated with Santa Ana conditions, thunderstorm-related strong winds and tornadoes, and macrobursts and microbursts. Each of these strong wind conditions is discussed further in the subsections below. In addition, strong wind activity combined with loose soil in an arid or semi-arid environment such as southern California's can result in dust storms. These are also discussed below.

6.1.1 Definitions and Setting

Wind is air that is in motion relative to the earth. It generally has both horizontal and vertical components, but the horizontal component normally dominates (National Research Council, Committee on Natural Disasters, NRC-CND, 1993). Due to friction, wind speed drops off at the ground surface, with approximately 50 percent of the transition in wind speed due to the frictional forces exerted by the ground surface occurring in the first six feet above the ground. As a result, "near-surface wind is the most variable of all meteorological events" (NRC-CND, 1993), and it commonly consists of a combination of high-frequency oscillations in both speed and direction superimposed on a more consistent flow with a prevailing speed and direction. With an increase in wind speed, the high-frequency oscillations can become more abrupt and of greater amplitude – these are referred to as wind gusts. Because wind speeds vary as a function of height, time and the terrain upwind, it is difficult to obtain a value that is representative of the wind speeds over a large region. The recommended convention for measuring wind speed is at a height of 33 feet (10 m), in flat, open terrain, such as that provided by an airport field. Temporal variations are taken into account by averaging speed and direction over a given time, typically 1-minute averages for sustained wind, and 2- to 5-second averages for peak or extreme winds. The mean annual wind speed for the contiguous 48 states is 8 to 12 miles per hour (mph), with most areas of the country frequently experiencing 50-mph winds (NRC-CND, 1993).

To better appreciate the impact that wind has on the sea and land, and the wind speeds required to move different objects, refer to the Beaufort Scale in Table 6-1, below. This scale was developed by Sir Francis Beaufort in 1805 to illustrate and measure the effect that varying wind speed can have on sea swells and structures. Note that the highest wind speeds in the Beaufort Scale approach the lowest wind speed on the Fujita Scale presented in Table 6-2.

Table 6-1: The Beaufort Scale

Beaufort Force	Wind Speed (mph/ knots)	*Wind Description* – State of Sea – Effects on Land
0	< 1 / <1	*Calm* – Mirror-like – Smoke rises vertically.
1	1 - 3 / 1 - 3	*Light* – Scaly ripples; no foam crests – Smoke drifts show direction of wind, but wind vanes do not.
2	4 - 7 / 4 - 6	*Light Breeze* – Small but pronounced wavelets; crests do not break – Wind vanes move; leaves rustle; you can feel wind on face.
3	8 - 12 / 7 - 10	*Gentle Breeze* – Large wavelets; crests break; glassy foam; a few whitecaps – Leaves and small twigs move constantly; small, light flags are extended.
4	13 - 18 / 11 - 16	*Moderate Breeze* – Small (1-4 ft) waves; numerous whitecaps – Wind lifts dust and loose paper; small tree branches move.
5	19 - 24 / 17 - 21	*Fresh breeze* – Moderate (4-8 ft) waves taking longer to form; many whitecaps; some spray – Small trees with leaves begin to move.
6	25 - 31 / 22 - 27	*Strong Breeze* – Some large (8-13 ft) waves; crests of white foam; spray – Large branches move; wires whistle.
7	32 - 38 / 28 - 33	*Near Gale* – Sea heaps up; waves 13-20 ft; white foam from breaking waves blows in streaks with the wind – Whole trees move; resistance felt walking into the wind.
8	39 - 46 / 34 - 40	*Gale* – Moderately high (13-20 ft) waves of greater length; crests break into spin drift, blowing foam in well-marked streaks; Twigs and small branches break off trees; difficult to walk.
9	47 - 54 / 41- 47	*Strong Gale* – High waves (20 ft) with wave crests that tumble; dense streaks of foam in wind; poor visibility from spray – Slight structural damage; shingles blow off roofs.
10	55 - 63 / 48 - 55	*Storm* – Very high (20-30 ft) waves with long, curling crests; sea surface appears white from blowing foam; heavy tumbling of sea; poor visibility – Trees broken or uprooted; considerable structural damage.
11	64 – 73 / 56 - 63	*Violent Storm* – Waves high enough (30-45 ft) to hide small and medium-sized ships; sea covered with patches of white foam; edges of wave crests blown into froth; poor visibility – Seldom experienced inland; considerable structural damage.
12	> 74 / > 64	*Hurricane* – Sea white with spray; foam and spray render visibility almost non-existent; waves over 45 ft high – Widespread damage; very rarely experienced on land.

Sources: www.spc.noaa.gov/faq/tornado/beaufort.html; http://www.stormfax.com/beaufort.htm

6.1.2 Types of High Winds in Southern California

6.1.2.1 Santa Ana Winds

Most incidents of high wind in southern California are the result of **Santa Ana wind** conditions. Santa Ana winds are generally dry, often dust-bearing winds that blow from the east or northeast toward the coast, and offshore (Figure 6-1). These winds commonly develop when a region of high atmospheric pressure builds over the Great Basin – the arid high plateau that covers most of Nevada and parts of Utah, between the Sierra Mountains on the west and the Rocky Mountains to the east. Clockwise circulation around the center of this high-pressure area forces air downslope from the plateau. As the air descends toward the California coast, it warms at a rate of about 5 degrees Fahrenheit per 1,000 feet elevation. Since the air originates in the high deserts of Utah and Nevada, it starts out already very low in moisture; as it is heated, it dries out even further. The wind picks up speed as it is squeezed through the canyons and passes in the coastal ranges of southern California, blowing with exceptional speed through the Santa Ana Canyon (from where these strong winds derive their name). Forecasters at the National Weather Service usually reserve the use of "Santa Ana" winds for those with sustained speeds over 25 knots (1 knot = 1.15 mph); as they move through canyons and passes, these winds may reach speeds of 35 knots, with gusts of up to 50 to 60 knots (see Table 6-1).

Santa Ana winds commonly occur in the southern California area, with Santa Ana conditions expected yearly in the region, typically in the fall through early spring. For the most part these winds are a nuisance, bringing dust indoors, breaking tree branches, and causing minor damage. For people with respiratory ailments, however, Santa Ana winds often result in headaches, sinus pain, difficulty breathing, and even asthma attacks. Strong Santa Ana winds can cause extensive damage to trees, utility poles, vehicles and structures, and can even be deadly. In 2003, for example, two deaths were blamed on these strong winds: a downed tree struck and killed a woman in San Diego, and a passenger in a vehicle was struck by a flying pickup truck cover (http://cbsnews.com/ January 8, 2003 article). Wildfires in the region often occur during Santa Ana wind conditions, when the air humidity is low to very low. Because the winds fan and help spread these fires, Santa Ana wind conditions always are serious concerns to fire fighters.

6.1.2.2 Thunderstorm-Related Tornadoes

A variety of mechanisms give rise to **thunderstorms**, but most often these develop when warm, moist air meets a cold front, producing strong winds, and sometimes tornadoes, and hail. More than 100,000 thunderstorms occur every year in the United States, and more than 10,000 of these are considered severe, resulting in annual property losses in excess of $1 billion (NRC-CND, 1993). Most of these occur in the central Great Plains and the southeastern coastal states, but thunderstorms do occur in every state. A thunderstorm is officially labeled as severe if: 1) it produces a tornado, 2) has winds in excess of 58 mph, or 3) produces surface hail greater than 0.75 inch in diameter. An exceptionally severe thunderstorm can generate several tornadoes and downbursts.

Tornadoes are "violently rotating columns of air extending from a thunderstorm to the ground" (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html; see Figure 6-2). Although tornadoes occur in many parts of the world, they are most common during the spring and summer months in the Central Plains of the United States, east of the Rocky Mountains. In the spring, tornadoes often form where warm, moist air from the east meets hot, dry air from the west (this boundary is called a "dryline"). In the winter and early spring, tornadoes can form when strong frontal weather systems originating in the Central states move eastward. Thunderstorms, and associated tornadoes, can also form at the range front, where near-ground air is forced to move "upslope" along the ascending mountain slopes. In California, tornadoes are occasionally generated by strong storms. Although the number of tornadoes reported in California is only a fraction of those reported in the central states, California does get its share of these. In the 30 years between 1959 and 1988, 133 tornadoes were reported in California, for an average of 4 tornadoes a year (NRC-CND, 1993).

Tornadoes can also accompany tropical storms and hurricanes as they move on land, where they usually occur ahead of the path of the storm center as it comes onshore (http://www.nssl.noaa.gov/edu/safety/tornadoguide.html). Weak tornadoes that form over warm water are called **waterspouts**. Occasionally, waterspouts can move on land and become tornadoes. **Funnel clouds** are cone-shaped or needle-like clouds that extend downward from the main cloud base but do not extend to the ground surface. If a funnel cloud touches the ground, it becomes a tornado; if it touches or moves across water, it is a waterspout. Waterspouts that have moved onto land are more often reported in southern California in the fall and winter, but some have also been reported in the spring. For example, on April 6, 1926, a waterspout that came on land at National City, near San Diego, unroofed several homes and injured eight people; one on February 12, 1936 unroofed two homes, blew down five oil derricks and injured six people.

Figure 6-1:
View From Space of Smoke from the October 2003 Fires in Southern California, Carried Offshore by Strong Santa Ana Winds

Source: Image by Jacques Descloitres, MODIS Rapid Response Team at NASA/GSFC, obtained from the archives at http://visibleearth.nasa.gov/

Figure 6-2:
View of a Tornado

Source:
http://www.photolib.noaa.gov/700s/nssl0123.jpg

To measure the intensity, area and strength of a tornado, in 1973 Dr. Ted Fujita (then with the University of Chicago) and Allen Pearson (at the time director of the National Severe Storm Forecast Center) introduced the Fujita-Pearson Tornado Intensity Scale (see Table 6-2). An improvement over the scale first published by Dr. Fujita in 1971, this scale compared the estimated wind velocity with the corresponding amount of damage to human-built structures and vegetation (a component first introduced by Fujita) and the width and length of the tornado path (the component added by Pearson). The scale classified tornadoes into six levels (from F0 to F5) with larger numbers indicating more damaging and larger tornadoes (the Fujita scale smoothly divided wind speed between the highest Beaufort level and Mach 1.0 (the speed of sound) into 12 levels – F0 through F12, but recognized that an F6 tornado would be inconceivable, and indeed no tornado above F5 has ever been measured. The Fujita-Pearson scale was used to classify all tornadoes reported after its introduction, in addition to retroactively classify all tornadoes reported since 1950 that were listed in the National Oceanic and Atmospheric Administration's (NOAA) national tornado database.

Table 6-2: The Fujita-Pearson Tornado Damage Scale

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
F0	40 – 72	30 - 150	**Light** damage (gale tornado). Some damage to chimneys and television antennas; twigs and branches break off trees; winds push over shallow-rooted trees; sign boards are damaged.
F1	73 – 112	100 - 500	**Moderate** damage (weak tornado). Winds peel off roofs; windows break; light trailer homes are pushed off their foundations or overturned; some trees are uprooted or snap; moving autos are pushed off the road; attached garages may be destroyed. Hurricane speed starts at 74 mph.
F2	113 – 157	360 - 820	**Considerable** damage (strong tornado). Roofs are torn off frame houses, leaving strong walls upright; weak rural buildings are demolished; trailer homes are destroyed; large trees snap or are uprooted; railroad boxcars are pushed over; light objects become airborne missiles; cars are blown off highways.
F3	158 – 206	650 – 1,650	**Severe** damage (severe tornado). Roofs and some walls are torn off well-constructed frame structures; some rural buildings are completely demolished; trains are overturned; steel-framed hangars and warehouse-type structures are torn; cars are lifted off the ground; most trees are uprooted, snapped or leveled.
F4	207 – 260	1,300 – 3,000	**Devastating** damage (devastating tornado). Well-constructed frame houses are leveled, leaving piles of debris; steel structures are badly damaged; trees are de-barked by small flying objects; cars and trains are thrown some distances or roll considerable distances; large objects become missiles.
F5	261 – 318	~ 3,600	**Incredible** damage (incredible tornado). Strong, whole-frame houses are lifted off their foundations and carried considerable distances; steel-reinforced concrete structures are badly damaged; automobile-sized missiles are generated and carried through the air >100 meters; trees are debarked.
F6	319 –379		**Inconceivable** damage: These winds are unlikely. Should a tornado with maximum speed in excess of F5 occur, the extent and type of damage may not be conceived. A number of airborne missiles, such as refrigerators, water heaters, storage tanks, automobiles, etc. create serious secondary damage on structures.

Fujita's wind estimates have since been found to be inaccurate, with the original wind speed estimates higher than the wind speeds actually required to incur the damage described in each category, especially for tornadoes classified as F3 or larger. In response to these criticisms, a new **Enhanced Fujita** (EF) **Scale** for tornado damage was developed between 2004 and 2006. The EF scale, which was officially implemented in the United States on February 1, 2007, is considered an improvement over the old scale: engineers and meteorologists estimated the wind speeds in the new scale (although actual speed winds have not been empirically measured), and records of past tornadoes were reviewed to better equate the wind speeds with the storm damage reported. The new scale also includes more types of structures and vegetation in the damage assessment, and better accounts for differences in construction quality. Similar to the original Fujita scale, the EF Scale has six levels of tornado damage, EF-0 to EF-5 (see Table 6-3). A researcher assigning a level of damage to a tornado using the EF scale needs to refer to a list of 28 different damage indicators (DI) or types of structures and vegetation, and then the degree of damage (DoD) for each. Damage indicators include barns or farm outbuildings, residences, manufactured homes (with distinctions made for single-wide and double-wide), apartments, masonry buildings, strip malls, automobile lots, elementary schools, low-, middle- or high-rise buildings (each a different category of indicator), electrical transmission lines, free-standing towers, and softwoods or hardwood trees. The new scale is likely to be modified or updated as new tornado data become available.

Table 6-3: Enhanced Fujita Scale

Scale	Wind Speed Estimate		Relative Frequency (%)
	mph	Km/h	
EF-0	65 - 85	105 - 137	53.5
EF-1	86 - 110	138 - 178	31.6
EF-2	111- 135	179 – 218	10.7
EF-3	136 – 165	219 – 266	3.4
EF-4	166 – 200	267 – 322	0.7
EF-5	> 200	> 322	< 0.1

6.1.2.3 Macrobursts and Microbursts

Storm researcher Dr. Ted Fujita first coined the term "**downburst**" to describe a strong, straight-direction surface wind in excess of 39 miles per hour (mph) caused by a small-scale, strong downdraft from the base of a thundershower and thunderstorm cell. Unlike tornadoes, the origin of a downburst is downward-moving air from a thunderstorm's core (as opposed to the upward movement of air associated with tornadoes). Downbursts are further classified into macrobursts and microbursts.

Macrobursts are downbursts with winds up to 117 mph that spread across a path greater than 2.5 miles wide at the surface, and which last from five to 30 minutes. **Microbursts** are confined to smaller areas, less than 2.5 miles in diameter from the initial point of downdraft impact. An intense microburst can result in winds near 170 mph but often lasts less than five minutes. Like tornadoes, microbursts can do significant damage: When a microburst hits a tree, the winds strip the limbs and branches off it; a microburst that hits a house has the potential to flatten the structure. After striking the ground, a powerful outward-running gust can generate significant damage along its path. Damage associated with a microburst appears to have been caused by a tornado, except that the damage pattern away from the impact area is characteristic of straight-line winds, rather than the twisted pattern typical of tornado damage.

Microbursts are particularly dangerous to aircraft landing or taking off, and have caused several planes to crash, with resultant loss of life. Microbursts have also been responsible for capsizing and sinking ships, causing structural damage in many communities, lifting roofs off structures, downing electrical lines, and generally causing millions of dollars in damage.

Most of the microbursts reported have occurred in the northeastern and central parts of the United States, including New York, New Jersey, Massachusetts, Ohio, and Kansas, but microbursts have also been reported in Arizona and Utah (http://en.wikipedia.org/wiki/ Microburst#Danger_to_aircraft), and in southern California. On March 29, 1998, in a Lake Elsinore neighborhood, an apparent microburst uprooted a tree and ripped two 20-foot sections of roofing tiles from a home. A funnel cloud was also spotted that afternoon near Dulzura, to the east-southeast of San Diego. On August 12, 2012 a microburst damaged the roofs of homes near Lake Elsinore, as well as downed nearby power lines and tree limbs (http://latimesblogs.latimes.com/lanow/2012/08/microburst-blamed-tornado-type-activity-riversidecounty.html; http://www.pe.com/localnews/riversidecounty/riverside/riverside-headlines-index/20120812-lake-elsinore-tornado-touches-down-more-expected.ece?ssimg=677704#ssStory677446).

6.1.2.4 Dust Storms

Dust storms are high wind events common in arid and semi-arid regions. Strong winds pick up sand and other particulates and transport them by saltation and suspension to another location, where they are deposited. Dust storms are significant erosive agents, with both short- and long-term impacts on people, structures and other property, and on the environment. In the short-term, a dust storm causes reduced visibility, which can affect motorists and aircraft. Fine particulates in the air will enter the respiratory pathways and can cause serious health conditions, including nose, ear and eye infections, sinus infections, asthma, dry eyes (a condition that if left untreated can led to blindness), silicosis, and even premature death. Dust storms can also spread virus spores and contaminants that can result in skin rashes and other infections. Long-term impacts of dust storms include loss of productivity from agricultural fields that have had their organic-rich, topsoil removed, whereas the deposition of sand and dirt elsewhere can bury and destroy crops and landscaping. Sandblasting of buildings, signs, fences, and vehicles can have both an aesthetic and structural impacts; in the long term the damage due to continuous pitting may require the replacement of a structure. For additional information regarding blowing sand refer to Chapter 2.

6.1.3 Historic Southern California Windstorms

As mentioned above, Santa Ana winds are common in the southern California region, typically in the fall through spring. Some of the strong winds in the winter are associated with storms emanating from Alaska and Canada. The desert areas are also subject to high winds associated with short-duration tropical thunderstorms emanating from the south. These storms typically occur in the summer months, between July and September.

As of the writing of this document, the National Climatic Data Center (NCDC) listed 49 thunderstorm-generated wind events in Riverside County between January 1, 2000 and January 31, 2014, with 17 of those events in the Coachella Valley. In addition, for the same time period, the NCDC database included 58 high wind and 6 strong wind events in the Coachella Valley (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms). Table 6-4 below includes these wind events specific to the Coachella Valley area, in addition to other exceptional historical storms that impacted the southern California area, causing extensive damage either directly, or indirectly. Please note that this list is not likely to include all damaging windstorms that have impacted the city of Coachella, as some events may have been so localized as to have not made it into the National Climatic Data Center database.

Table 6-4: Major Southern California Windstorms (1858 - 2012) and Strong Winds Reported in the Coachella Valley Area (January 2000 – January 2014)

Date	Description, Including Location and Damage Reported
October 2, 1858	Category I hurricane hits San Diego. Sustained winds to 75 mph are estimated based on the extensive damage to property reported.
May 23, 1932	Strong winds and low humidity; 12 serious brush fires, blackening nearly 2,000 acres in San Diego County were reported. The biggest fire was in Spring Valley.
September 24-25, 1939	Tropical storm that lost hurricane status shortly before moving onshore at San Pedro had sustained winds of 50 mph. At least 48 people died from sinking boats.
November 19-29, 1956	Strong and prolonged Santa Ana winds fanned a fire north of Descanso that burned 44,000 acres and killed 11. Two wooden bridges and a power plant were destroyed. A 100 mph

Date	Description, Including Location and Damage Reported
	gust was recorded on November 20 at a forest lookout near Saugus.
November 21-22, 1957	Extremely destructive Santa Ana winds fan a 28,000-acre brush fire west of Crystal Lake. Flying debris forced people indoors in some areas. Extreme turbulence due to a downdraft injured 12 out of 33 people on an airplane near Ontario.
November 5-6, 1961	Strong Santa Ana winds fan fires in Topanga Canyon, Bel Air and Brentwood; 103 firemen are injured; $100 million in economic losses, including 484 buildings (mostly residential) and 6,090 acres scorched.
January 18-28, 1969	Strong storm winds cause power outages and falling trees in southern California; 4 killed by downed trees.
September 26-29, 1970	Gusts to 60 mph in Cuyamaca Rancho State Park. Fires from Cuyamaca to Alpine, including the Laguna Fire, resulted in 400 homes destroyed, 185,000 acres burned, and 8 killed.
September 10, 1976	Hurricane Kathleen brought to the Southwest US the highest sustained winds associated with an eastern Pacific tropical cyclone; sustained winds of 57 mph at Yuma, Arizona.
November 30 – December 1, 1982	Widespread strong winds associated with a big storm result in 1.6 million homes without power.
January 20, 1987	Wind gusts to 80 mph below Cajon Pass, 70 mph in San Bernardino, 60 mph in Mt. Laguna, and 40 mph at El Toro. Winds cause thick dust clouds; trucks blown over; trees toppled. 100 power poles downed in the Inland Empire. Numerous power outages force school closures. Brush fires started.
March 15, 1987	Widespread strong storm winds; winds of 25-35 mph sustained all day, gusts to 40 mph in San Diego. Result in power outages all over the San Diego metropolitan area; motor homes toppled in the desert; light standard fell over onto cars in Coronado; boats flipped over in harbors; a 22-foot boat turned over at Mission Beach jetty; Catalina cruise ships delayed, stranding 1,200 tourists there.
December 12-13, 1987	Strong Santa Ana winds in San Bernardino with 60-80 mph gusts. 38-mph winds recorded in San Diego. 80 power poles blown down within a ½-mile stretch in Fontana and Rancho Cucamonga; downed tree limbs damaged cars, homes and gardens; 1 injured when tree fell on truck; power poles and freeway signs damaged; parked helicopter blown down a hillside in Altadena; trees downed and power outages in San Diego County. In Spring Valley, 1 dead when eucalyptus tree fell on truck.
January 21-22, 1988	Strong offshore winds following major Pacific storm with gusts to 80 mph at the Grapevine, 60 mph in Ontario, and 80 mph in San Diego County. Power poles, road signs and big rigs knocked down in the Inland Empire. In San Diego County, 6 injured; roofs blown off houses, trees toppled, and crops destroyed. Barn demolished and garage crushed by tree in Pine Valley; 20 buildings damaged or destroyed at Viejas; avocado and flower crops destroyed at Fallbrook and Encinitas, respectively, with 5 greenhouses damaged in Encinitas.
February 16-19, 1988	Very strong Santa Ana winds with gusts to 90 mph in Newport Beach, 70+ mph in the San Gabriel Mountain foothills; gusts to 76 mph at Monument Peak – Mt. Laguna; 63 mph at Ontario, and 50 mph at Rancho Cucamonga. Numerous trees and power lines downed resulting in power outages along the foothills of the San Gabriel and San Bernardino mountains. Mobile home overturned and shingles torn off roofs in Pauma Valley; Fontana schools closed due to wind damage; 3 killed when truck overturned and burned; 1 killed when stepped on downed power line. Power outages impacted 200,000 customers in Los Angeles and Orange counties. Grass fires. Roof damage widespread in communities around Glendale and Burbank, and at John Wayne Airport. Boats torn from moorings at Newport Harbor.
December 8, 1988	Strong Santa Ana winds across southern California, with gusts to 92 mph at Laguna Peak. Winds fanned several major fires; buildings were unroofed; trees and power lines downed. $20 million in estimated damages.
December 11, 1989	Strong Santa Ana winds with gusts to 100 mph near the Grapevine. Winds reduced visibility to near zero in the **desert areas** and closed major interstate highways east of

Date	Description, Including Location and Damage Reported
	Ontario.
October 26-27, 1993	Strong Santa Ana winds with gusts to 62 mph at Ontario. Twenty fires in the southern California area, including the Laguna Hills Fire. 4 dead, 162 injured, $1 billion in property losses alone; 194,000 acres destroyed.
December 14, 1996	Strong Santa Ana winds with gusts to 111 mph at Fremont Canyon and 92 mph in Rialto, toppled trees and electric poles, smashed windows, knocked out power to tens of thousands across southern California. Two deaths in Fontana; one man killed by a live power line that was blown on him; the second died when a tree branch fell onto his van. Minor injuries (3 total) in Orange and San Diego counties. In Crestline, a radio tower was blown down and the roof blown off the transmitter building. I-15 near Devore closed for 15 hours where two trailers flipped.
December 17, 1996	Santa Ana winds with gusts to 66 knots downed trees and power poles. In Rancho Cucamonga, winds toppled a 500,000 kilovolt electric power, sparking a fire that burning 250 acres and forced evacuation of 80 homes.
January 6, 1997	High winds to 86 knots throughout southern California injured four: Three students at the CSU campus at San Bernardino, and a man that suffered cuts when his trailer overturned. Fourteen tractor trailer rigs tipped over in the I-15 between Devore and Corona forcing closure of the freeway; over 900,000 customers lost power; vehicle pile-ups in the **Coachella Valley**.
February 13, 1997	Strong Santa Ana winds uprooted trees, downed power lines and toppled rigs. One firefighter suffered minor injuries when the winds blew boards off a truck and onto him while he was trying to extinguish a fire. The Interstate 10/15 transition roads were closed for hours. Sporadic power outages were reported due to downed power lines.
February 24-25, 1997	Gusty Santa Ana winds occurred below selected passes and canyons, with gusts to 80 mph measured in Fremont Canyon. The winds knocked down power lines, fanned several small fires, and forced closure of the I-215 in San Bernardino County for one hour. One of the fires destroyed an abandoned house in San Bernardino.
October 13-14, 1997	Santa Ana winds of 30-40 mph with frequent gusts over 60 mph developed below Cajon Pass, in Orange County, and valley areas of San Bernardino County. Fire in Orange County burned almost 6,000 acres and destroyed two buildings. Trees and power lines blown down in Rialto and Fontana; a shed was destroyed at the Banning/Beaumont border.
December 10-12, 1997	Santa Ana winds with gusts to 96 mph at Pine Valley; 87 mph in Upland. Flying debris killed 2 construction workers, one in Riverside, another in Irvine. Fish farm in Sun City reported more than $1 million in structural damages; extensive damage to the avocado crop; boats damaged and sunk at Coronado and Avalon.
December 18-22, 1997	Gusts to 60 mph in Rialto; 67 mph at Idyllwild and below Cajon Pass. Driver near Pedley killed when he lost control of his van because of strong wind gust; his passenger was injured. Fires; downed trees; and widespread wind damage. More than 9,500 homes and businesses without power in Ontario, Rancho Cucamonga, Fontana, and Chino. On the 22nd, strong winds toppled at least 6 trucks on the I-15 and 60 freeways. In the **Coachella Valley**, winds uprooted many trees in Palm Desert and overturned several big-rig trucks near Indio. Several trees and signs downed in Desert Hot Springs.
December 28, 1997	Santa Ana winds with gusts to 80 mph snapped a dozen power poles near Corona, cutting power to dozens of rural customers. A downed tree crushed a car in Riverside. In Mira Loma, a dozen power poles were downed, leaving hundreds without power and closing Hamner Avenue for two days. Heavy blowing dust and restricted visibility created hazardous driving conditions on the Interstate 15.
February 3-4, 1998	Strong storm winds with gusts to 60 mph and heavy downpours. The strongest winds were clocked in Orange County and the mountains of San Bernardino County in advance of the storm. Wind gusts to 60 mph downed trees and caused scattered power outages. Moderate to heavy rain flooded intersections in coastal areas; snow fell as low as 4,500 feet. Two young illegal immigrants near Campo died, and 12 others suffered from exposure to strong winds, cold temperatures and rain.

Date	Description, Including Location and Damage Reported
December 9-10, 1998	Santa Ana winds with 101-mph gusts at Modjeska Canyon, 93-mph gusts at Fremont Canyon, 52-mph gusts in Santa Ana, and 83-mph gusts at Ontario disrupted transportation, power and daily activities. Winds toppled trees and power lines, overturned vehicles, and caused property damage. 180,000 customers without electric power; 17 trucks were blown over along I-15 and Highway 60. 7 students at CSU in San Bernardino were knocked down and injured. Trees fell on passing motorists in Fontana. A total of 24 injuries reported, with property damage amounting to $1.1 million.
January 20-21, 1999	80-mph gust in the Salton Sea area; 70-mph gust in the **Coachella Valley**; 47-mph gust in Palm Springs; and 36-mph gust in Thermal.
February 10-12, 1999	Santa Ana winds with gusts to 85 mph at Rialto; gusts to 80 mph on the I-8, forcing the closure of several major roads and interstates. Extensive property damage throughout and west of San Gorgonio Pass. Freshly plowed field west of San Gorgonio Pass was stripped of its topsoil; 30 Beaumont residents treated for breathing problems and skin rashes associated with the dust storm. Trees and signs were blown down; large commercial building in Lake Elsinore was blown down; 150-foot tall tree was blown over and crushed a trailer home. $950K in property damages reported.
April 8, 1999	Strong winds to 54 knots reported in Apple and Yucca valleys, the **Coachella Valley**, San Bernardino County mountains, San Diego County mountains, and Santa Ana mountains and foothills. $10K in property damage reported.
October 17, 1999	Santa Ana winds caused wind damage in the mountains and valleys of Orange, Riverside, and San Bernardino counties. In San Bernardino, 40 mph wind gusts caused a fire that damaged 11 houses and a 12-plex apartment building; other fires in the Inland Empire fanned by the gust winds. $30K in property damage reported.
November 21-22, 1999	Santa Ana winds with gusts to 54 knots caused power outages throughout the Inland Empire and the Santa Ana mountains and foothills. A semi-tractor trailer was toppled over at the I-15 and Highway 60 intersection. Farther south on I-15, tumbleweeds caused traffic hazards. $190K in property damage and 1 injury reported.
December 3-4, 1999	Strong Santa Ana winds with gusts to 90 mph at San Bernardino and 68 mph in Fontana. Ten power poles knocked down just below Cajon Pass, and in Muscoy, Rialto, Fontana, Murrieta and Lake Elsinore. Most major highways in the Inland Empire and through the Santa Ana Mountains were closed due to semi-tractor trailers overturned, blowing dust reduced visibility and road signs and debris blown around. Two barns were destroyed when their roofs were lifted off; six horses received minor injuries. $210K in property damages reported.
December 10-11, 1999	Strong winds in the **Coachella Valley**, valleys in Riverside and San Bernardino counties, and Santa Ana mountains and foothills. Winds downed power lines and traffic signs. Gust to 60 mph clocked in Palm Springs. Blowing sand and dust caused poor visibility and forced road closures and cancellation of outdoor events. Several trees were knocked over. $50K in property damage, $10K in crop damages, and one injury reported.
December 21-22, 1999	Strong Santa Ana winds; 68-mph gust at Campo, 53-mph gust at Huntington Beach; 44-mph gust in Orange. Widespread power and phone outages due to fallen trees knocking down lines and snapped poles. Large dust cloud over the San Jacinto Valley that reached height of 500 feet closed highways and sandblasted cars. Gusty winds spread a fire in Glendale to an adjacent house, causing two injuries and $50K in damages. Three wildfires in San Diego County. $227K in property damage reported throughout the region.
January 5-6, 2000	Santa Ana winds with 93-mph gust at Fremont Canyon; 60-mph gust at Ontario; 58-mph gust at Devore. Winds blew over four semi-tractor trailer rigs on I-10, I-15, I-215 and Highway 60 causing 10-hour delay between Apple Valley and the Inland Empire. Elsewhere in the Inland Empire, blowing sand and dust reduced visibilities to near zero. Roof damage in Rialto. Power outages to 10,000 customers due to downed power lines and poles. Two injuries and $400K in property damage reported.
March 5, 2000	Sustained 40-knot winds associated with a winter storm caused damage to trees and power lines. Participants in outdoor athletic events developed hypothermia. Later outdoor events were cancelled. As reinforcing cold air arrived at night, the snow level lowered dramatically,

Date	Description, Including Location and Damage Reported
	trapping at least 30 people in the wilderness areas of the San Diego Mountains, closing highways and freeways with seven inches of snow in the passes. Three people died and another thirteen were hospitalized for hypothermia. Blizzard conditions were reported throughout the southwestern California mountains. $20K in damage in the **Coachella Valley**.
March 20-21, 2000	Santa Ana winds in the **Coachella Valley**, valleys in Riverside and San Bernardino counties, San Diego County and Santa Ana Mountains and foothills. Winds downed power poles, felled trees on cars and houses, knocked fruit off trees, and blew sand and dust, lowering visibility to near zero. Semi-tractor trailer was blown over near Pedley. $100K in property damage and $30K in crop damage reported in the Coachella Valley.
March 31- April 1, 2000	Strong Santa Ana winds caused $375K in property damage in the Inland Empire area. Twenty-five power poles were toppled in the Sun City area; several others fell in Yucaipa. A large tree was blown down in Beaumont. Blowing dust reduced visibility along most highways.
August 29, 2000	Thunderstorms that formed over the Santa Rosa Mountains moved slowly toward the northeast across the lower end of the **Coachella Valley**. Large boulders washed down onto Highway 74, and flooding was reported along the Whitewater Wash at several locations in Palm Desert, Indian Wells and Indio. A downdraft to 50 knots toppled a large tree near the College of the Desert. $5K in property damage due to winds.
November 7, 2000	Santa Ana winds with 82-mph gust at Fremont Canyon caused damage in Orange, San Bernardino and Riverside counties. In San Bernardino County, strong winds knocked power lines together causing them to spark; the sparks ignited wildfires. In Colton, blowing sand covered the I-215. Two semi-tractor trailers overturned at the intersection of the I-15 and Highway 60. $167K in property damages reported.
December 25-26, 2000	Santa Ana winds; 87-mph gust at Fremont Canyon. Damage and injuries reported in Mira Loma, and in Orange and Riverside counties. 50-mph winds in northern Orange County toppled utility poles leaving about 25,000 customers in Tustin, Garden Grove, Orange, Santa Ana and Westminster without power for a few hours. Across the Inland Empire, winds knocked down power poles, trees, signs and fences at 23 separate locations. Many trees were uprooted. Power disrupted to 9,000 homes and businesses. Four injuries and $665K in property damage reported.
February 7, 2001	High winds across the San Jacinto Mountains generated lee mountain waves that touched in the **Coachella Valley** between Palm Springs and Thermal. Power lines were knocked down in Rancho Mirage. In La Quinta, trees were uprooted and tents, fences, and banners set up for a golf tournament were blown down and damaged. Blowing sand reduced visibility to 15 feet in several areas. $250K in property damage and $30K in crop damage reported.
September 30, 2001	An outflow boundary from thunderstorms associated with tropical depression Juliette over the northern Gulf of California moved northwest across Riverside County. Wind gusts to 39 mph were measured at the Palm Springs International Airport. Trees and power lines were knocked down across the Coachella Valley. Blowing dust reduced visibility to zero. $50k in property damage was reported.
December 7-8, 2001	Santa Ana winds with gust to 87-mph at Fremont Canyon affected most of southern California. Trees, power lines and signs were toppled. Two construction workers were injured when a 20-foot-high brick wall they were working next to collapsed. Several major freeways were closed to high profile vehicles. Power outages affected about 40,000 customers. Three injuries and $250K in property damage. Winds fanned the Potrero Fire.
January 23-24, 2002	Santa Ana winds throughout the mountains and valleys of Riverside, San Bernardino, San Diego and Orange counties. Semi-tractor trailer rig blown over in Fontana. Strong winds fanned several wildfires. In San Bernardino, one house was damaged and a few outlying structures were destroyed by the wind-fanned flames. $190K in property damage.
February 8-13, 2002	Santa Ana winds with 80-mph gust at Descanso, 78-mph gust at Fremont Canyon, and 76-mph gust at San Bernardino. Blown-over semi-tractor trailer rigs forced closure of I-15, I-215 and I-8 for a day. Twelve million pounds of avocados blown off of trees. Winds fanned

Date	Description, Including Location and Damage Reported
	several fires caused by downed power lines. In Orange County, fire that started in Corona burned 2,400 acres. In Tijuana, fire destroyed 50 buildings, and killed one woman. Gavilan fire spread from Fallbrook to Camp Pendleton, torching 5,783 acres, destroying 44 houses and damaging 14 others, destroying 40 vehicles and injuring 19. $2 million in property damage and $7.8 million in crop damage.
March 13, 2002	High winds whipped up dust across the deserts, reducing visibility to zero along all major highways. The winds also flipped over a semi-tractor trailer in the Coachella Valley and tore a roof off a Community College building. $150K in property damage.
March 18, 2002	Thunderstorm-related winds to 56 knots in San Bernardino County valleys; whiteout conditions in the High Desert areas with snow down to the 2,500 foot level; hail in Apple Valley; lightning in San Diego struck an aircraft on final approach to the San Diego International Airport.
August 18, 2002	Gusts associated with a thunderstorm knocked down several power lines in Indio. Dust raised by the wind reduced visibility to less than a mile in the Coachella Valley.
November 8, 2002	Strong winds associated with the first winter storm of the season reported in Apple and Yucca valleys, Coachella Valley, and San Bernardino mountains and valleys. Winds downed power lines and caused damage to roofs and signs. $550K in property damage; $100K of that in the Coachella Valley.
December 16, 2002	Strong winds in San Bernardino County mountains, and San Diego coastline. Car windows blown out at Cajon Pass; power lines and trees blown down at Arrowhead and Big Bear City; motor home blown over in Hesperia. Tractor-trailer blown over west of Phelan. Visibility reduced to zero due to blowing dust in local highways. Two injuries and $750K in property damage reported.
January 5-7, 2003	Strong, widespread Santa Ana winds throughout southern California blew down numerous trees and power poles. At least 60 communities affected. Interstate 8, 10, and 15 were blocked for several hours by large trucks blown over. Winds toppled power poles in Orange; blew over a mobile derrick in Placentia, crushing two vehicles; and delayed Metrolink rail service. Dust storms forced closure of I-215. One commercial plane sustained damage at Ontario Airport; others had to be diverted. Two dead, 11 injured. Widespread property damage, road closures, wildfires, 20 million pounds of avocado lost. $3.3 million in property damage and $28 million in crop damage. $30K in damages in the Coachella Valley.
February 2, 2003	High winds blew down trees in Redlands, Jurupa and Riverside. Blowing sand and dust disrupted traffic in the Coachella Valley.
March 26, 28-29, 2003	Area of low pressure off the California coast brought strong winds to portions of the Mojave Desert. Winds with gusts to nearly 50 mph blew shingles off several roofs in Twentynine Palms, causing $5K in property damage. Elsewhere, wind blew trees over, falling on cars and power lines. A semi-tractor trailer was blown over in I-8 in the San Diego County mountains. A total of $140K in property damages reported.
October 25-27, 2003	Strong Santa Ana winds; 45-mph at Ontario, 43-mph at Fremont Canyon. Extensive wildfires consumed hundreds of thousands of acres; killed more than 20 people, and caused more than $1 billion in damage.
November 22-23, 2003	High winds knocked down trees, power lines and signs, causing about $175K in damages, $35K in the Coachella Valley.
February 26, 2004	Winter storm moving southeasterly from the Gulf of Alaska picked up moisture before moving onshore. Strong winds occurred in the mountains, and heavy rains reported throughout southern California. Most roads along the foothills of the San Bernardino Mountains, both on the north and south sides were closed due to flooding and mudslides.
September 11, 2004	Thunderstorm winds toppled at least 138 trees at "The Palms" golf course in La Quinta. One tree fell onto a maintenance building causing structural damage. Other golf courses in the area reported downed trees. A building at Avenue 58 and Madison Street had its roof tiles blown off, causing minor water damage to the interior. Nine utility poles were blown over, and four transformers were lost due to the winds. Gust of 46 mph was reported at

Date	Description, Including Location and Damage Reported
	Thermal Airport, but winds gusts to 70 mph were probably occurring in the La Quinta area at that time. $100K in property damage was reported.
December 16, 2004	Santa Ana winds with sustained speeds of 51 mph and 78-mph gusts at Fremont Canyon; gusts to 69-mph northwest of San Bernardino and 66 mph near Pine Valley. At least five big rigs were blown over in Inland Empire roads; the I-15 was closed temporarily. Trees were blown over and power lines were downed. $150K in property damage reported.
January 7, 2005	Strong winds and thunderstorms throughout the southern California area. Very saturated soils and wind gusts in excess of 50 mph knocked down hundreds of trees. The felled trees knocked out power, blocked roads, and damaged many cars and property. One woman injured when tree fell onto her car. $600K in property damage reported throughout the region.
February 3, 2005	Strong storm-related winds to 70-mph impacted the region. At least 15 homes in Idyllwild were damaged by felled trees; downed power lines in the Inland Empire; big rig was overturned on the I-8. $1 million in property damage.
August 4, 2005	Gusty winds produced by a severe thunderstorm uprooted trees and damaged property in the Coachella Valley. The highest wind gust measured at the Palm Springs Airport was 54 mph, but gusts in some areas were estimated at greater than 60 mph. $25K in property damage.
August 6, 2005	Thunderstorm-related winds caused $15K in damage to mobile homes in Sky Valley, near Desert Hot Springs.
August 9, 2005	This was the 21st consecutive day with thunderstorms in the region. A storm moved out of Nevada during the morning hours and swept across the San Bernardino, Riverside and San Diego deserts in the afternoon, bringing flash flooding to Yucca Valley. The thunderstorm complex continued southward into the Coachella Valley area where blowing dust reduced visibility to near zero and the strong winds blew down trees. Heavy rains caused sporadic flooding problems and lightning sparked several palm tree fires. A 63 mph gust was reported at Desert Hot Springs. $5K in property damage reported.
January 2, 2006	Post-frontal 50+-mph winds widespread throughout the region. Winds downed trees, power lines, and power poles onto houses and cars. In Crestline, 20 houses were so damaged as to be uninhabitable. In San Diego Bay, boats broke loose from their moorings. In Apple Valley, winds toppled power poles, downed trees and caused damage to numerous homes. A trailer home was knocked off its supports in Hesperia. $210K in property damage reported.
January 22-24, 2006	Santa Ana winds; peak winds of 71 mph at Fremont Canyon on the 24^{th}; gusts exceeded 60 mph on 19 hourly observations. Seven big rigs overturned in Fontana; downed power lines and trees caused power outages and property damage. Dust storm closed the Ramona Expressway. One fatality when spooked horse threw off its rider. $80K in property damage.
September 2, 2006	A severe thunderstorm north of the Santa Rosa Mountains produced heavy rain, localized flash flooding and damaging wind gusts in western **Coachella Valley**. Downed power lines affected 3,000 Southern California Edison customers from Palm Springs to Cathedral City. $20K in property damage reported.
October 26, 2006	Offshore winds blew to 40-mph in the Banning Pass. An arsonist started the Esperanza Fire; it burned 40,200 acres from Cabazon to San Jacinto, destroying 43 homes and killing 5 firefighters.
November 29, 2006	Offshore winds with sustained speeds of 54 mph and 73-mph gust at Fremont Canyon; 58-mph gust at Ontario, caused widespread property damage and power outages as a result of downed power lines, poles and trees. Caltrans reported more than 100 calls in 4 hours reporting downed street signs, trees and power lines. About 15,000 people lost power in Orange County. $30K in property damage.

Date	Description, Including Location and Damage Reported
January 5 & 7, 2007	Strong winds across southern California. Damaged or downed power poles; damage to trees or tree limbs; blowing dust reduced visibility to near zero along I-215 and the Ramona Expressway; small, wind-driven wildfires along I-15. In the mountains, high winds forced vehicles to slide across icy stretches of road near Rim Forest. Large trees fell on homes and cars in the Lake Arrowhead area. $700K in property damage.
February 27, 2007	Widespread wind activity on the desert slopes of the San Bernardino Mountains and eastward; strong winds caused property damage to three homes in Palm Springs. One house had its roof ripped off; the others reported broken fences, damaged solar panels and downed trees. Poor visibility due to blowing dust forced closure of several roads in the Coachella Valley. Gust to 52 mph recorded at Thermal Airport; gust to 57 mph recorded at a golf course in La Quinta. $75K in property damage.
March 20, 2007	Strong winds caused extensive damage in **North Palm Springs,** where 14 power poles were knocked down; several snapped in half. This affected nearly 500 Southern California Edison customers. Isolated gust at 81 mpg was measured at the Burns Canyon Remote Automated Weather Station (RAWS) located a few miles to the northwest of Yucca Valley while a peak wind gust of 38 mph was observed at the Palm Springs airport. $150K in property damage.
March 27, 2007	Strong down-slope winds and mountain wave activity caused a palm tree to fall on a home in Indian Wells and leaving 79,000 customers in the Coachella Valley without power. Peak wind of 53 mph was measured in Thermal, and gust to 48 mph was measured in Palm Springs. It is likely that high wind occurred in some of the more unpopulated areas of the **Coachella Valley**, especially considering how widespread the reports were of wind gusts in excess of 40 mph; a 60 mph wind gust was measured to the north at Burns Canyon. $40K in property damage.
October 21-22, 2007	Strong Santa Ana winds caused widespread damage across the Inland Empire, with gusts in excess of 70 mph snapping power poles, toppling trees, overturning big rigs and damaging roofs. Sustained winds over 50 mph were recorded at several locations for several hours. Winds fanned the flames of several large wildfires. $35 million in property damage reported.
January 17, 2008	Strong Santa Ana winds caused widespread tree and property damage in the Inland Empire area. Numerous tractor-trailers were blown over, one hangar at Corona airport sustained major damage; power was knocked out, $250K in property damages reported.
February 3, 2008	Strong wind gusts associated with a winter storm downed power lines, toppled trees, and caused areas of thick blowing dust. Fallen trees damaged homes and vehicles, and one small airplane at **Palm Springs International Airport** was blown over. A 61-mph wind gust was measured at Whitewater, and a 55-mph wind gust was measured by the Palm Springs ASOS (Automatic Surface Observation System). A weather spotter in the **Coachella Valley** estimated a wind gust in excess of 70 mph. $375K in property damage.
June 4, 2008	Strong onshore pressure gradients caused a period of gusty winds in the mountains and deserts. The high winds downed power poles causing outages, broke tree limbs, and blew dust in the **Coachella Valley**. A 59-mph wind gust was measured in Thousand Palms. $25K in property damage.
August 8, 2008	An active day of monsoon thunderstorms over the mountains and deserts resulted in large hail, gusty winds, and flash flooding. Wind gusts to 63 mph were measured in the south La Quinta Cove area.
September 11, 2008	A low-pressure system moved down the California coast, causing severe thunderstorms to develop across the region's mountains and deserts. A trained spotter measured a 67 mph wind gust in **La Quinta**, the result of outflow from a thunderstorm nearly 30 miles to the southeast.
December 25, 2008	Strong onshore flow brought gusty Northwest winds to the **Coachella Valley**. These winds ripped off part of the roof and a balcony at the Cambridge Inn in Palm Springs. Twenty-six out of 66 rooms in the hotel were closed due to damage. Several cars in a nearby parking lot suffered minor damage due to flying debris. $500K in property damage.
March 22, 2009	High winds reported in the **Coachella Valley**; a peak wind gust of 62 mph was measured

Date	Description, Including Location and Damage Reported
	in Whitewater. The high winds resulted in an overturned car along Interstate 10 in Indio, as well as numerous downed trees and power lines. Approximately 13,400 customers were without power. High winds were also observed at Thermal Regional Airport. About a dozen flights into Palm Springs International Airport were diverted due to the winds. $50K in property damage.
April 3, 2009	A large upper level low moving over northern California, combined with a strong onshore surface pressure gradient led to strong and high winds in the mountains and deserts of southern California. Numerous reports of damage throughout the **Coachella Valley**. Several power lines and traffic signals were downed in the high winds, causing power outages to approximately 1,900 customers. Many trees suffered broken limbs; about 40 trees were uprooted. Two tractor-trailers overturned on Interstate 10. A small fire fueled by strong winds burned at least two homes in Palm Springs. Damage to structures included roofs being torn off buildings and damaged bleachers at the Palm Springs Stadium. $100K in property damage.
April 14, 2009	An upper-level trough of low pressure and a surface cold front with a strong northwest flow brought high winds to the Coachella Valley. Wind gusts in excess of 58 mph, with a peak gust of 72 mph, were measured by the Whitewater RAWS. The winds downed power lines and overturned a tractor-trailer in the **Coachella Valley**. $5K in property damage.
July 19, 2009	Isolated thunderstorms developed in the afternoon over the San Bernardino and Riverside County deserts. A storm in **La Quinta** produced winds to 61 mph near the southern part of the cove. The storm also produced frequent lightning and brief heavy rain.
October 27, 2009	Strong onshore flow behind a cold front brought gusty winds to the mountains and deserts of southern California. The wind blew down several eucalyptus trees and caused a few power outages in the region. In the **Coachella Valley**, the wind gusts were clocked at 59 knots. No property or crop damage reported in Coachella.
December 7, 2009	A strong onshore flow behind a cold front brought high winds to the mountains and deserts. Peak wind gust of 68 mph measured at the Whitewater RAWS. The winds blew down several eucalyptus trees and caused power outages.
December 22, 2009	A strong onshore flow associated with a winter storm produced strong to high winds in the mountains and deserts. Multiple wind gusts of 66 mph were measured by the Whitewater RAWS; a peak wind gust of 63 mph was measured at **Palm Springs Airport**. Blowing dust and downed palm fronds were reported.
January 19-21, 2010	A strong southerly jet stream ahead of a cold front contributed to moderate low-level wind shear with high winds and a peak wind gust of 73 mph measured at Burns Canyon RAWS. The thunderstorms brought in waterspouts, at least one tornado, and hurricane-force winds in Orange County. In San Diego County, the winds contributed to structural damage and one fatality.
April 5, 2010	An upper level trough of low pressure brought light to moderate showers and gusty winds, especially in the mountains and deserts. Wind gusts in excess of 58 mph, with a peak gust of 64 mph, were measured by the Whitewater RAWS.
April 27-29, 2010	Multiple upper-level low-pressure areas brought winter-like weather to southern California during the last part of April. Rain and mountain snow were common, with strong gusty winds. Wind gusts between 58 and 71 mph were measured at the Whitewater RAWS between the 28th and the 29th. A trained spotter reported blowing dust with visibility down to 1/8 mile and some large tree branches down in **Thousand Palms** where gusts were as high as 55 mph.
October 24-25, 2010	Strong onshore flow brought gusty winds to the mountains and deserts. High winds began in Whitewater between 2050 and 2150 PST, with a peak gust of 58 mph measured by the Whitewater RAWS. Winds caused area of blowing dust and local power outages.
November 20, 2010	A cold trough digging down the California coast brought precipitation and gusty winds to the mountain and desert areas. High winds began in the **Coachella Valley** between 0050 and 0150 PST and continued through 0350 PST. Peak wind gusts of 60 and 61 mph were measured by the Whitewater RAWS.

Date	Description, Including Location and Damage Reported
November 28, 2010	Fast-moving storm produced gust west winds in the mountains and deserts. High winds began in the **Coachella Valley** between 0250 and 0350 PST and continued until approximately 0400 PST. A peak wind gust of 58 mph was measured by the Whitewater RAWS.
January 14, 2011	Moderately high Santa Ana winds estimated at between 40 and 50 mph downed three power lines and a transformer in San Bernardino. Three residents that stepped outside to try to extinguish spot fires caused by sparks were electrocuted and died. A water line also ruptured in one of the houses and 2,700 customers lost power because of the downed lines. Gusty winds were also reported in the mountains.
February 2-4, 2011	A strong cold upper level, low-pressure system moved southward from the Four Corners region into northern Mexico. A strong surface high pressure settled over the region and brought strong offshore winds. The winds knocked over a 70- to 75-foot tall tree with a 30-inch diameter trunk over three units in an apartment development in Glen Avon. No injuries were reported, but the units were declared uninhabitable and the residents were relocated. Strong winds were also helpful in knocking over five big rigs near the Interstate 10-15 interchange and contributed to a crash on Highway 60 near the Interstate 15. No injuries were reported. Other downed trees and power lines were reported. About $60K in property damage reported.
March 7, 2011	A strong westerly jet brought strong winds to the mountains and deserts and light rain to the coastal areas. High winds in the **Coachella Valley**, with a peak gust of 72 mph measured by the Whitewater RAWS, downed a power pole that forced closure of a portion of **Indian Canyon Drive**. A tractor-trailer overturned near the intersection of Interstate 10 and Highway 111, but no injuries were reported. $7.5K in property damage.
April 7, 2011	A very cold late-season winter storm brought rain and mountain snow, as well as strong winds. Gusty winds were responsible for moderate damage in the **Coachella Valley**. A power line fell in an alley in the city of **Coachella**, causing six homes to be evacuated as a precaution while power was restored. Two trees fell in the Indian Springs area, one landing on the hood of an SUV, the other blocking traffic in Palm Desert. No injuries or fires were reported with any of the incidents. The Palm Springs Tramway closed its mountain station early due to high winds. $1K in property damage.
April 21, 2011	A series of storm systems moving through the Pacific Northwest brought windy conditions to the southern California area. The **Palm Springs Airport** measured a peak wind gust of 45 mph. Wind gusts were responsible for blowing over a single-engine Cessna 172 aircraft after it landed. The pilot, the only passenger, was not injured. **Indian Canyon Drive** was closed due to large amounts of blowing sand near the Whitewater Wash; it had recently been reopened after a couple of days of closure due to blowing sand. $8K in property damage.
May 8-9, 2011	Deepening low pressure and strong onshore flow brought gusty winds to the mountains and deserts. Strong winds toppled 35-40 mature, 15- to 20-foot tall trees at the **Rancho Mirage** Public library. The winds toppled at least one power pole that caused a small brush fire in Palm Springs, near Via Monte Vista and Stevens Road. Power was out for around 400 customers in the area for about a day. No one was injured. $30K in property damage.
June 15-17, 2011	A strong thermal gradient (105 degrees at Thermal, 60s near the coast), combined with an upper low over Utah allowed for significant pressure falls, producing strong westerly winds. These strong winds were responsible for two overturned big rigs along **Highway 111** just south of Overture Drive. No one was injured, but officers asked high profile vehicles to avoid the wind-prone area of Hwy 111 and even began turning them away from the area. Hwy 111 was eventually shut down for a time from Interstate 10 past Overture Drive for about four hours. On the 16th, strong winds in **Coachella** kicked up a cloud of dust that was blamed for a pile-up involving 5 vehicles and 3 semi-trucks. Visibility was reported to be near zero at the time of the crash. Several people were taken to the hospital for non-serious injuries. Highway 86 was shutdown between Avenues 50 and 52 for several hours. On the 17th, gusty winds caused a small experimental plane to flip onto its nose just after landing, while turning to taxi off the runway at the Palm Springs Airport. The pilot, the only

Date	Description, Including Location and Damage Reported
	passenger, was not injured. $155K in property damage.
November 19, 2011	A closed upper level low-pressure system brought two days of heavy rainfall, mountain snow and gusty winds. High winds occurred in the **Coachella Valley** for about three hours during the morning. During that time, two gusts of 58 mph were measured at the Whitewater RAWS.
January 21, 2012	A powerful jet stream brought two storm systems to southern California, with very strong west-northwest winds in all mountain and desert areas. High winds were reported in the **Coachella Valley** all afternoon, with gusts over 60 mph, and sustained winds of 30 to 45 mph. Three major roadways through Palm Springs were closed due to zero visibility caused by blowing dust and sand: Indian Avenue, Gene Autry Trail and Vista Chino. Bridges and wash crossings were closed at Washington and Adams Streets due to reduced visibility from blowing dust and sand. Reduced visibility from blowing sand is believed to have caused a crash between a bus, a truck and a sedan on I-10 westbound near the Gene Autry Trail exit. Four people were taken to the hospital for injuries from the crash. Power poles were knocked down on Gene Autry Trail as well as Palm Canyon Drive at Linden Way (also closed). Carports were knocked over by winds and crushed cars at an apartment complex at Highway 111 and Escoba. Numerous power lines and approximately 400 trees were also damaged or knocked down in the Palm Springs area. The Humana Challenge Golf Tournament at the La Quinta Country Club was stopped due to the high winds. The main tent in the Bob Hope Square fan area collapsed. There was also damage to the vendor and event tents. No injuries were reported. Several trees were knocked over or uprooted on the **La Quinta** course, while a few other courses had only cosmetic damage and blowing debris. $600K in property damage.
February 11, 2012	An amplified ridge over the eastern Pacific allowed a few upper-level short wave troughs to move over the region, bringing strong gusty winds, widespread rain and mountain snow. Sustained winds to 30 mph, with gusts to 47 mph, were reported in **La Quinta**. Blowing dust reduced visibility to only about 1/10 of a mile, or less.
March 1-3, 2012	High pressure system off the west coast led to strong and gusty N to NE winds in the mountains and deserts. In the **Coachella Valley**, winds to 63 knots reported.
March 6, 2012	A closer upper-level system brought a strong cold front to southern California that caused very strong winds in the mountains and deserts. Strong winds in the **Coachella Valley** caused several instances of blowing dust as well as some traffic sign damage and trees down. A street sign was partially knocked down from its supporting pole on Sunrise Way, near Gene Autry Trail. Palm Springs police also closed Gene Autry Trail between Via Escuela and Interstate 10 for much of the day. $2K in property damage.
March 17, 2012	A strong, cold upper-level low developed over the north Pacific, with a deep trough and strong, embedded jet extending into southern California. Moderate to heavy precipitation occurred over and west of the mountains. The Coachella Valley received 1/10 to ¼-inch of rain. Strong, gusty winds accompanied the system, with winds to 62 knots reported in the area. This resulted in power outages, blowing dust and traffic signs blown down.
April 10-11, 2012	An upper-level trough swung through southern California bringing moderate to heavy precipitation to the coastal and mountain front areas, and strong thunderstorm-related winds inland. High winds were measured at the **Whitewater** RAWS between the evening of the 10^{th} and early morning on the 11^{th}. During that time, sustained winds of 35-40 mph occurred, with a peak gust of 64 mph.
April 23-26, 2012	Gusty southwesterly winds occurred in the mountains and desert slopes in southern California and northern Baja. High winds were measured at the **Whitewater** RAWS with a peak gust of 60 mph occurring on the 23^{rd}, and another gust to 59 mph on the 25^{th}. No damage was reported, however.
May 2-4, 2012	An upper-level trough over southern California caused gusty surface winds in the mountains and deserts. High winds occurred at the **Whitewater** RAWS on the 2nd with a peak gust of 65 mph. Sustained winds 35-40 mph with gusts in the 50s continued through the early afternoon on the 3rd. No damage was reported.
May 17-18, 2012	An upper-level, low-pressure system caused strong, gusty westerly to northwesterly winds

Date	Description, Including Location and Damage Reported
	in the mountains, passes and canyons. Winds first gusted over 45 mph at the Whitewater RAWS and Edom Hill station on the 17th and continued through at least the early morning on the 18th. A peak gust of 63 mph was measured at Whitewater around 10 o'clock at night on the 17th.
May 22-24, 2012	An area of low pressure began building south along the coast, resulting in a deep marine layer, scattered showers along and west of the mountains, below-normal temperatures and strong, gusty winds in the mountains, deserts, passes and canyons. Wind gusts over 45 mph, with a few to 60 mph, were measured at the Whitewater RAWS.
June 4, 2012	An upper-level, low-pressure system brought gusty west to southwest winds to the mountains and deserts. Peak wind gusts of 57 and 59 mph were measured at the **Edom Hill** station and the Whitewater RAWS, respectively, during this period. No damage was reported.
June 8-9, 2012	Another upper-level, low-pressure system caused gusty westerly winds in the mountains and deserts. The **Edom Hill** station recorded a peak gust of 58 mph on the 9th.
June 19-20, 2012	Upper-level, low-pressure system moved eastward through the area bringing strong onshore flow and gusty west to northwest winds to the mountains and deserts during the night and early morning. A peak wind gust of 59 mph was recorded at the Edom Hill station.
September 9, 2012	Monsoonal moisture in an easterly flow aloft brought showers and thunderstorms to the mountains and deserts. Outflow boundaries from the storms created winds that picked up dust and lowered visibility in the **Coachella Valley** and near Borrego Springs. Visibility lowered to near zero at times in these areas. Wind gusts over 45 mph were measured at the Thermal ASOS, with a peak gust of 61 mph. Visibility was between ¾ of a mile and 3 miles.
November 8-9, 2012	A cold low-pressure system from Alaska moved through California bringing light to moderate precipitation with strong, gusty west to northwest winds. Sustained winds of between 35 and 48 mph, with gusts over 59-80 mph were measured at the Whitewater RAWS. On the 9th, the station measured sustained winds of 31-41 mph, with a peak gust of 61 mph. No damage was reported.
December 23-26, 2012	A weak trough moved through southern California late on the 23rd, bringing light to moderate precipitation, and strong winds in the mountains and desert slopes. High winds were measured at the Whitewater RAWS in the very early morning of the 24th, with a peak gust of 60 mph. Winds over 50 mph were also reported on the 26th, with peak gusts of 59 and 64 mph in the late evening of the 26th.
January 10, 2013	A cold trough of low pressure dropped down the West Coast and into southern California, bringing light to moderate showers to most areas except the Coachella Valley, snow in the mountains, and gusty west winds. Blowing dust reported in the **Coachella Valley** where measured gusts to 66 knots were reported.
January 14, 2013	The trough slowly moved eastward, bringing dry and warmer offshore flow to develop, bringing gusty, northerly winds through the passes and canyons. Local damage in the form of downed power lines and road signs reported. In the **Coachella Valley**, gusts to 56 knots were reported.
February 7-10, 2013	A very cold trough of low pressure moved through southern California, bringing significant cooling. Low snow levels, gusty west winds, and light to moderate precipitation along and west of the mountains. Winds up to 62 knots were measured in the **Coachella Valley** on the afternoon of the 8th.
February 19, 2013	Strong, cold low pressure system from the Gulf of Alaska came down the West Coast and over southern California. Storm was accompanied by thunderstorms with localized hail, moderate rain showers, snow above 2,300 feet elevation, and very strong wind gusts along and below the ridges and desert slopes. A big (but empty) rig overturned on Highway 111 at Overture Drive, near Windy Point. A fuel spill cleanup forced the closure of the northbound lanes for more than 2 hours. Property damage in the **Coachella Valley** reported at $5K.

Date	Description, Including Location and Damage Reported
February 24, 2013	A surface high pressure over the Great Basin brought strong gusty northeast winds to southern California. A power line was downed at the intersection of Twentynine-Palms Highway and North Indian Canyon Drive, just south of Morongo Valley. $7K in property damage reported in the **Coachella Valley**.
March 3, 2013	An upper level low-pressure trough brought gusty winds to the area, with gusts to 58 knots measured in the **Coachella Valley** area. No damage was reported.
April 8, 2013	A deep trough of low pressure from the Northwest moved through southern California, bringing minor cooling, light to moderate precipitation west of the mountains, and damaging west winds to the mountains and deserts. Damage to trees and structures, as well as blowing dust and sand, was reported in the Borrego Springs and **Palm Springs** areas. A big rig was blown over along I-10 in Palm Springs, near Date Pam Drive. A power pole was downed near Whitewater Wash and Vista Chino in Palm Springs, along with several downed palm trees across the valley. Vista Chino Road was closed while crews fixed the pole, and two of the eastbound lanes on the I-10 were also closed for 2 hours while the overturned rig was removed and the investigation was concluded. Winds to 70 knots were measured in the area, and $30K in property damage was reported.
April 14-16, 2013	Large upper-level low over the Pacific Northwest swung through the Great Basin, driving strong, gusty westerly winds across the mountains and deserts. Winds resulted in widespread blowing dust in the Coachella Valley, limiting visibility to less than 1/8 of a mile, accumulating sand and closing main roadways. The winds impacted the Coachella Music Festival. Gene Autry Trail, between I-10 and Via Escuela, and Indian Canyon Road, from Palm Springs Train Road to Tramway Road were closed until the 16th due to blowing sand and reduced visibility, and downed trees. . Gust to 68 knots were measured in the area, and $10K in property damage was reported.
September 1-7, 2013	Isolated to scattered thunderstorms over the mountains, deserts and portions of the Inland Empire caused flash flooding in some areas. On the 3rd, the hot spots included the **Coachella Valley**. Palm Springs experienced flooding due to runoff from storms in the adjacent mountains, closing Araby Drive. Flash flooding and debris flows were also reported in Tahquitz Creek and through the Tahquitz Creek golf resort, closing Cathedral Canyon Drive at the Whitewater Wash. Additional flash floods and a debris flow 2 feet deep and 20 feet wide across Golf Club Drive in Cathedral City reported on the 4th and 5th. The same road was closed on the 7th due to additional flooding from Whitewater Wash. $100K in property damage reported in Cathedral City.
September 9, 2013	A monsoon thunderstorm with gusty downdraft winds downed nine power lines and poles in the Coachella Valley, in the **Bermuda Dunes** area. Wind gusts were estimated at 50-55 mph. $100K in property damage reported.
September 21-22, 2013	Broad trough of low pressure moved through the desert bringing strong, gusty winds to the mountains and deserts, especially the **Coachella Valley**. Winds gusts to 56 knots were measured.
October 4, 2013	Large area of surface high pressure built over the Great Basin, bringing strong gusty winds over the mountain ridges and canyons. In the **Coachella Valley**, the winds were clocked at 52 knots.
October 8, 2013	Strong, upper-level low pressure system moved through southern California, bringing gusty westerly winds to the mountain ridges and desert slopes. Visibility was reduced in the Coachella Valley due to blowing sand and dust. No damage reported, however. Rain was responsible for 318 accidents in southern California, exceeding by far the 75 that occur on average every day.
October 27, 2013	Strong, upper-level low moved down the West Coast bringing strong to severe pre-frontal SW to W winds to the northern desert slopes. A 130-knot jet moved around the backside of the low, increasing westerly winds in the mountains and lower deserts. Wind gusts to 74 knots were reported in the Coachella Valley.
December 4, 2013	Cold, upper-level trough of low pressure brought gusty west winds and scattered rain. Snow dropped to about 3000 feet elevation, with a trace to 2 inches of snow measured from I-8 to Big Bear. High winds to 64 knots reported in the Coachella Valley.

Date	Description, Including Location and Damage Reported
December 7, 2013	A deep trough of low pressure that dug through the Great Basin brought gusty winds, rain and mountain snow to the southern California area. Winds of up to 63 knots were reported in the Coachella Valley.
December 14, 2013	A surface high pressure over western Utah resulted in moderate to strong Santa Ana winds in southern California. In the **Coachella Valley**, gusts to 63 knots were reported.
December 19, 2013	Strong, upper level trough brought cold weather, along with rain, mountain snow and SW to W winds to the area. The strongest winds were reported in the **Coachella Valley** in the early morning of the 19th.
January 14, 2014	Strong surface high pressure over the Great Basin resulted in high winds in southern California. In the **Coachella Valley**, winds with gusts to 50 knots were reported.

Sources: NCDC database (http://www.ncdc.noaa.gov/stormevents/), a compilation by the National Weather Service in San Diego (http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf).

As discussed above, although most tornado activity in the United States occurs in the Midwest states, **tornadoes** can and do occur in California. The Tornado Project, an organization that researches, compiles and makes tornado information available on the web at www.tornadoproject.com, indicates that in Riverside County, there were nine tornadoes between 1955 and 1998; NOAA includes an additional nine tornadoes and eleven funnel clouds between 2000 and January 2014, with the majority of these near Hemet and Perris. A list compiled by the San Diego office of the National Weather Service includes several additional tornadoes in and near Riverside County, including several in the Hemet area. Table 6-5 lists the tornadoes reported in Riverside County, and a couple in northern San Diego and Imperial counties. The data available indicate that in the last about 60 years, tornadoes have caused at least two injuries and about $4 million in property damage in Riverside County, with most, but not all, of these between Elsinore and Moreno Valley. The Coachella Valley can be impacted by tornadoes and funnel clouds, but the historical record suggests that these meteorological events do not occur often in the area.

Table 6-5: Tornadoes and Funnel Clouds Reported In and Near Riverside County Between 1955 and January 2014

Date and Location	Time	Dead	Injured	Fujita Scale	Damage Description
April 6, 1955, near Moreno Valley	13:30	0	0	F1	The tornado in the hills near Moreno Valley was reportedly 1 mile long and about 50 yards wide. No damage was reported.
August 16, 1973, just west of Blythe	19:00	0	0	F2 or F3	$25K in property damage
July 20, 1974, in Hemet	13:49	0	1	F1	The tornado was reportedly 1 mile long and about 20 yards wide. $25K in property damage
January 20, 1982, in Riverside	02:05	0	0	F0	Of unknown length, its width was estimated at 60 yards. No damage or injuries reported.
September 18, 1985, along the NE shore of the **Salton Sea**	09:55	0	0	F0	10 yards wide, of unknown length. No damage or injuries reported.
March 20, 1991, in Riverside	11:30	0	0	F0	10 yards wide, of unknown length. No damage or injuries reported.
January 18, 1993 in Hemet	NA	0	0	F0	Funnel cloud reported.

Date and Location	Time	Dead	Injured	Fujita Scale	Damage Description
March 26-28, 1993, various	NA	0	0	F0	Funnel clouds near Temecula and a funnel cloud in Moreno Valley.
August 12, 1994, in Valley Vista, just east of Hemet	13:00	0	0	F0	The tornado touched down causing a tree to smash onto the living room of a residence. Several other funnel clouds reported in the area at the time, which uprooted trees and blew over utility poles. A trailer was also destroyed.
March 13, 1996, various	NA	0	0	F0	Two funnel clouds were observed southwest of Moreno Valley, one northwest of Hemet, and one in Irvine.
December 22, 1996 in Cabazon	09:00	0	0	F1	Tornado moved northeastward for about 700 feet before dissipating. Lifted a 5-ton mobile home and deposited it 30 feet from its foundation, its roof and contents removed. Six other mobile homes suffered minor damage.
May 20, 1997 near Borrego Springs	NA	0	0	NA	Tornado 7 miles east of Borrego Springs.
May 13, 1998 in Homeland	14:45	0	0	F0	Tornado touched down in the Highland Palms mobile home park, ripping awnings from several trailers. Funnel clouds in Homeland and Moreno Valley.
February 13, 2001 In **Palm Desert**	NA	0	0	NA	Funnel clouds reported.
August 15, 2001 in Menifee	NA	0	0	F0-F1	Dust devil that damaged a shed.
October 26, 2002 near Borrego Springs	NA	0	0	F0	Funnel cloud 5 miles northeast of Borrego Springs.
November 12, 2003 in Temecula	15:00	0	0	NA	Funnel cloud reported.
January 9, 2005 near Hemet	17:11	0	0	F0	Tornado touched down in the Diamond Valley area, where it picked up a metal storage shed and tossed it onto a power pole. $5K in property damage
January 9, 2005 near Mira Loma	15:18	0	0	F0	Funnel cloud observed near Mira Loma.
February 19, 2005 in Temecula	09:35	0	0	F1	The most devastating of two tornadoes that occurred in southern California that day, this tornado touched down in the Temecula Creek Golf Course Inn and Rainbow Canyon Villages. At least 100 trees, many more than 100 years old, were blown over. In the residential area of Rainbow Canyon Villages most fences and trees were blown over, and several homes lost roof shingles. $100K in property damage.
February 20, 2005 near **Palm Springs**	16:00	0	0	F0	A funnel cloud was spotted in Palm Springs around Indian Avenue and Gene Autry Trail. The funnel cloud was also seen from Interstate 10. Motorists stopped to take pictures. No injuries or damages reported.
February 22, 2005 near Mira Loma	15:18	0	0	F0	Funnel cloud reported near Mira Loma.

Date and Location	Time	Dead	Injured	Fujita Scale	Damage Description
February 26, 2005 in Lake Elsinore	15:00	0	0	F0	Tornado witnessed over Nichols Road in Lake Elsinore. It lasted about 5 minutes and developed under a cumulus cloud cover in the Elsinore Convergence Zone. It caused no damages or injuries.
April 28, 2005 in Hemet and Carlsbad	12:18	0	0	F0	Several funnel clouds were reported in these areas.
July 23, 2005 in Hemet	13:06	0	0	F0	The tornado was first spotted near the intersection of Highways 74 and 79; it then traveled westward toward the Hemet-Ryan airport, causing mostly broken tree limbs. Caused about $1.5K in property damage.
April 5, 2006 near Riverside	11:20	0	0	F0	A funnel cloud was spotted in Riverside near Highway 60 and I-215.
July 23, 2006 in Menifee	15:15	0	0	F0	A thunderstorm produced a tornado that blew over a dozen pine trees and a few palm trees at the Menifee Lakes Country Club. A few homes were damaged by the fallen trees. $25K in property damage
May 22, 2008 near March Air Force Base	15:30	0	0	EF0	Observations indicate tornado touched down approximately four miles southeast of the ARB and was on the ground for six minutes. No reports of damage were received. Its exact path is unknown.
May 22, 2008 near March Air Force Base	15:42	0	1	EF2	This tornado traveled approximately three miles in a west-southwest direction for 21 minutes, and had a max width of 75 yards. As the tornado crossed Interstate 215, a semi-truck was lifted 30 to 40 feet into the air and nine empty BNSF railroad cars were derailed. The driver of the semi had to be extricated and was hospitalized for over a month due to moderate head injuries. The tornado also damaged the roofs of several homes and a trailer. Another tornado developed nearby while this tornado was in progress. Damage to the rail cars was consistent with wind gusts up to 120 mph, or an EF-2 tornado (first EF-2 tornado in California since the new scale was implemented in February 2007, and the first F2 tornado in California since the 1998 Sunnyvale tornado). $350k in property damage.
May 22, 2008 near March Air Force Base and Val Verde	15:50	0	0	EF-0	Photos and video of the tornado described above show a separate tornado occurring in its vicinity at the same time. Based on photographic evidence and eyewitness accounts, this separate tornado would be the third tornado produced by the storm. Its exact path is not known, however several videos indicate that this tornado was just west of Interstate 215 in close proximity to the Riverside National Cemetery. No reports of damage were received.
May 22, 2008 in Lake Elsinore area	16:40	0	0	EF0	A trained weather spotter captured video of this tornado in an unpopulated area near the Gavilan Hills between Woodcrest and Lake Elsinore, however the exact path is unknown. This was the fourth and final tornado produced by the storm. No reports of damage were received.
January 21, 2010 in and	15:10	0	0	EF0	Motorists reported a tornado crossing Interstate 10 near Intake Blvd, where two semi trucks were blown over.

Date and Location	Time	Dead	Injured	Fujita Scale	Damage Description
around Blythe					Numerous power poles were downed, and considerable damage to homes and other structures. Roofs were blown off some homes. The rain-wrapped tornado had peak wind gusts estimated at 80 mph as it moved toward the northeast. Nearby Blythe airport recorded a peak gust of 55 mph, with thunderstorms in the area. Record low pressure of 29.02 inches was observed at Blythe. $3M in property damage.
October 2, 2010 in Calimesa	16:10	0	0	F0	Funnel cloud observed. No damage reported.
September 13, 2011 near Perris	14:15	0	0	F0	Funnel cloud observed. No damage reported.
August 12, 2012 near Nuevo and Perris	14:30	0	0	EF0	A tornado and funnel cloud associated with and southwest of the parent thunderstorm occurred over Nuevo, on the east side of Perris. Separate wind damage from the parent thunderstorm was observed to the northeast over Nuevo on Menifee Road. There was no damage reported from the tornado.
September 9, 2012 in Perris	13:30	0	0	EF0	A land spout was observed along Interstate 215 and Hwy. 74 near Perris. No funnel was observed at the cloud base. The land spout remained nearly stationary.
September 7, 2013 in Perris	13:00	0	0	EF0	Radio operator reported two funnel clouds over Perris.
Totals 37		0	2		About $4 million in damages

Sources: NCDC database (http://www.ncdc.noaa.gov/stormevents/), The Tornado Project (http://www.tornadoproject.com/), compilation by the National Weather Service office in San Diego (http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf).

The NCDC database lists nine **dust storm** events in the Coachella Valley area between 2000 and January 2014 that combined caused at least $90 thousand in property damage. At least 38 more events were culled from the windstorm descriptions provided in Table 6-4. Given the many instances of strong winds reported in the region, this list is very likely under-representing the hazard of dust storms in the Coachella Valley.

Table 6-6: Dust Storms Reported in the Coachella Valley Between 1987 and January 2014

Date	Description, Including Location and Damage Reported
January 20, 1987	Wind gusts to 80 mph below Cajon Pass, 70 mph in San Bernardino, 60 mph in Mt. Laguna, and 40 mph at El Toro. Winds cause thick dust clouds..
December 28, 1997	Santa Ana winds with gusts to 80 mph cause heavy blowing dust and restricted visibility, creating hazardous driving conditions on the Interstate 15.
February 11, 1999	Santa Ana winds with gusts to 85 mph forced the closure of several major roads and interstates. Winds stripped the topsoil off a freshly plowed field west of San Gorgonio Pass and tracked it downstream for 15 miles; 30 Beaumont residents were treated for breathing problems and skin rashes associated with the dust storm.
December 3-4, 1999	Strong Santa Ana winds with gusts to 90 mph; blowing dust reduced visibility.
December 10-11, 1999	Strong winds with gusts to 60 mph resulted in blowing sand and dust. Forced the closure of roads and cancellation of outdoor events in the **Coachella Valley** and

Date	Description, Including Location and Damage Reported
	other areas.
December 21-22, 1999	Strong Santa Ana winds caused a large dust cloud that closed the San Jacinto Valley highways, sand-blasted cars, and reached a height of 500 feet. Winds carrying sand and dirt, and cross winds forced the cancellation of three flights and re-routing of two commercial airplanes from Ontario International Airport.
January 5-6, 2000	Santa Ana winds blew sand and dust, reducing visibilities to near zero in the Inland Empire.
March 20-21, 2000	Santa Ana winds in the **Coachella Valley**, valleys in Riverside and San Bernardino counties, San Diego County and Santa Ana Mountains and foothills. Winds downed power poles, felled trees on cars and houses, knocked fruit off trees, and blew sand and dust, lowering visibility to near zero.
March 31- April 1, 2000	Strong Santa Ana winds blew dust, reducing visibility along most highways in southern California.
August 11, 2000	A thunderstorm gust front caused a dust storm that lowered visibilities in the **Palm Springs International Airport** area. During a period of more than one hour, several flights had to be delayed or diverted to Ontario, until visibility improved. Peak wind gust at the airport was 28 mph.
February 7, 2001	High winds across the San Jacinto Mountains generated lee mountain waves that touched in the Coachella Valley between Palm Springs and Thermal. Blowing sand reduced visibility to 15 feet in several areas.
August 17, 2001	Thunderstorms moved northwest across the Imperial Valley and Salton Sea. The 30-mph sustained winds caused a dust storm that reduced visibility to less than 1 mile over eastern San Diego County, the **Coachella Valley** and the Banning Pass.
September 30, 2001	An outflow boundary from thunderstorms associated with tropical depression Juliette over the northern Gulf of California moved northwest across Riverside County. Trees and power lines were knocked down across the Coachella Valley. Blowing dust reduced visibility to zero.
February 10, 2002	Santa Ana winds blew dust and sand, disrupting traffic by reducing visibility to near zero and sandblasting windshields. Signs, trees, power poles and fences were blown down in several communities in the Inland Empire.
March 13, 2002	High winds in the **Coachella Valley** stirred up dust across the desert, reducing visibility to near zero along all major highways. Dust storms caused an estimated $40k in property damage, whereas the high winds caused about $150K in property damage.
March 16, 2002	High winds caused a dust storm in the **Coachella Valley** and fanned a brush fire the next day in the Corona area. More than 100 acres burned before the fire was controlled.
August 18, 2002	Gusts associated with a thunderstorm knocked down several power lines in **Indio**. Dust raised by the wind reduced visibility to less than a mile in the **Coachella Valley**.
November 22, 2002	High winds throughout the region. In the **Coachella Valley**, the winds picked up sand causing a dust storm. About $35K in property damage reported.
November 25, 2002	Blowing dust caused visibility to be near zero from Perris to Moreno Valley; small rocks were blown across Highway 74 in the San Jacinto Valley. Strong winds reported throughout the southern California area.
December 16, 2002	Strong winds in Apple and Yucca valleys, San Bernardino Mountains and San Diego coastline. Visibility reduced to zero in local highways due to blowing dust.
January 5-7, 2003	Strong, widespread Santa Ana winds throughout southern California blew down numerous trees and power poles, impacting at least 60 communities. Dust storms forced closure of I-215. One commercial plane sustained damage at Ontario Airport; others had to be diverted.
February 2, 2003	High winds caused blowing sand in the **Coachella Valley**. The dust storm disrupted traffic and outdoor activities. About $15K in property damage reported.
August 24, 2003	Thunderstorm downdraft winds caused a dust storm in eastern Moreno Valley, north

Date	Description, Including Location and Damage Reported
	of Highway 60, with sustained winds to 40 mph.
August 12, 2004	Dust storm reduced visibility to near zero on the Interstate 10 between Blythe and Desert Center.
August 9, 2005	A thunderstorm brought blowing dust to the Coachella Valley. Reduced visibility to near zero and several downed trees were reported.
January 22-24, 2006	Santa Ana winds downed power lines and trees, caused power outages and property damage. Dust storm closed the Ramona Expressway.
January 5 & 7, 2007	Strong winds across southern California. Damaged or downed power poles; damage to trees or tree limbs; blowing dust reduced visibility to near zero along I-215 and the Ramona Expressway; small, wind-driven wildfires along I-15.
February 27, 2007	Widespread wind activity on the desert slopes of the San Bernardino Mountains. Poor visibility due to blowing dust forced closure of several roads in the **Coachella Valley**.
February 3, 2008	Winds associated with a winter storm caused areas of thick blowing dust in the Coachella Valley region.
June 4, 2008	Strong onshore pressure gradients caused a period of gusty winds in the mountains and deserts. The high winds downed power poles causing outages, broke tree limbs, and blew dust in the **Coachella Valley**. $25K in property damage.
March 22, 2009	Visibility of 0.25 miles due to blowing dust was observed at **Thermal Regional Airport** from 0823 to 0852 PST. No property damage reported.
December 22, 2009	A strong onshore flow associated with a winter storm produced strong to high winds in the mountains and deserts. Blowing dust and downed palm fronds were reported in the **Palm Springs** area.
April 27-29, 2010	Multiple upper-level low-pressure areas brought winter-like weather to southern California in late April. A trained spotter reported blowing dust with visibility down to 1/8 mile and some large tree branches down in **Thousand Palms** where gusts were as high as 55 mph.
October 24-25, 2010	Strong onshore flow brought gusty winds to the mountains and deserts. Winds caused area of blowing dust and local power outages.
April 21, 2011	A series of storm systems moving through the Pacific Northwest brought windy conditions to the southern California area. **Indian Canyon Drive** was closed due to large amounts of blowing sand near the Whitewater Wash; it had recently been reopened after a couple of days of closure due to blowing sand.
June 16, 2011	Strong winds in **Coachella** kicked up a cloud of dust in the evening of the 16th. The winds, coupled with the dust, were blamed for a pile-up involving 5 vehicles and 3 semi-trucks. Visibility was reported to be near zero at the time of the crash around 1610 PST. Several people were taken to the hospital for non-serious injuries. Highway 86 was shutdown between Avenues 50 and 52 for several hours, reopening around 2000 PST that night.
January 21, 2012	A powerful jet stream brought two storm systems to southern California, with very strong west-northwest winds in all mountain and desert areas. Three major roadways through **Palm Springs** were closed due to zero visibility caused by blowing dust and sand: Indian Avenue, Gene Autry Trail and Vista Chino. Bridges and wash crossings were closed at Washington and Adams Streets due to reduced visibility from blowing dust and sand. Reduced visibility from blowing sand is believed to have caused a crash between a bus, a truck and a sedan on I-10 westbound near the Gene Autry Trail exit. Four people were taken to the hospital for injuries from the crash.
February 11, 2012	An amplified ridge over the eastern Pacific allowed a few upper-level short wave troughs to move over the region, bringing strong gusty winds, widespread rain and mountain snow. Blowing dust reduced visibility to only about 1/10 of a mile, or less.
February 13, 2012	A spotter in **La Quinta**, near Thermal, reported blowing dust, reducing visibility to one tenth of a mile or less. Winds at the time were sustained 30 mph and gusting to 47 mph. No property damage reported as a result of the dust storm.

Date	Description, Including Location and Damage Reported
March 6, 2012	Strong winds in the **Coachella Valley** caused several instances of blowing dust as well as some traffic sign damage and trees down. A street sign was partially knocked down from its supporting pole on Sunrise Way, near Gene Autry Trail. Palm Springs police also closed Gene Autry Trail between Via Escuela and Interstate 10 for much of the day.
March 17, 2012	A strong, cold upper-level low pressure system brought precipitation and strong gusty winds to the southern California area. In the Coachella Valley, the winds caused power outages, blowing dust, and downed traffic signs.
September 9, 2012	Monsoonal moisture in an easterly flow aloft brought showers and thunderstorms to the mountains and deserts. Outflow boundaries from the storms created winds that picked up dust and lowered visibility in the **Coachella Valley** and near Borrego Springs. Visibility lowered to near zero at times in these areas.
January 10, 2013	Blowing dust was reported in the Coachella Valley area as a result of a trough of low pressure that extended into southern California, bringing showers and snow to other areas.
April 8, 2013	Blowing dust and sand was reported in the Borrego Springs and Palm Springs areas. A dust devil, combined with strong and gusty winds, produced damage at the Salton City RV Resort in **Salton City**. The winds downed several awnings, ripped off some siding, and broke a water pipe, for a total of about $9K in property damage. No injuries were reported.
April 14, 2013	Large upper-level low over the Pacific Northwest swung through the Great Basin bringing gusty westerly winds to the mountains and deserts. Widespread blowing dust reported in the Coachella Valley, with visibilities down to 1/8- mile or less at times, sand accumulating and closing main roadways. Large quantities of sand reported near Vamer Road and Monterey Avenue. Police closed sections of Gene Autry Trail and Indian Canyon Road due to blowing sand and poor visibility.
October 8, 2013	Gusty westerly winds picked up sand and dust, reducing visibility in the Coachella Valley.

Sources: NCDC database (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms), compilation by the National Weather Service office in San Diego (http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf), and data presented in Table 6-4 above.

6.2 Other Extreme Weather Events

6.2.1 Hail

Hail is solid precipitation consisting of fragments of water ice called hailstones. These can be irregular in shape, oval or rounded, and can vary in size from 0.2 inch (5 mm) in diameter, to nearly 8 inches (20 cm), although hail more than 4 inches in diameter is unusual. The stones can range from soft to very hard. Hail is produced in thunderstorms with strong upward motion of the air, similar to a tornado, and freezing levels at relatively low elevations. A hailstone forms as a result of super-cooled water that freezes around an ice-condensing particle, such as a grain of sand, a bit of compacted snow, or even a particle of pollen or other debris carried up into the atmosphere by the thunderstorm updrafts. The resulting hailstone may be carried upward into colder sections of the atmosphere, all the while collecting additional super-cooled water droplets. Once it gets too heavy for the wind to keep it aloft, it falls to the ground as hail. Hailstones have rings like an onion, with translucent ice layers alternating with white, opaque layers. It is believed that the translucent layers are formed in those sections of clouds where water occurs as droplets, whereas the opaque, white sections form in areas where water vapor predominates. Hailstones also form by accretion, with smaller stones sticking together to form larger, irregular stones. These are often lumpy or even spiky on the outside.

With current weather detection methods, such as weather satellites and radar, it is possible to detect thunderstorms that will produce hail. Severe weather warnings are generally issued in the United States for hail that is more than about 1 inch (2.5 cm) in diameter.

The NCDC website lists nine hail events in Riverside County between 2000 and January 2014; these are listed in Table 6-7 below. The list compiled by the San Diego office of the National Weather Service, although not considered comprehensive, includes several hailstone events in San Bernardino and San Diego counties, but none in Riverside County. Of the events in Table 6-7, only one occurred in the Coachella Valley, impacting the nearby community of La Quinta. Thus, the data available suggest that hailstorms are rare in the region, and have a low probability of impacting the city of Coachella.

Table 6-7: Hail Events In Riverside County Between 2000 and January 2014

Date	Description, Including Location and Damage Reported
July 24, 2004	A thunderstorm dropped nickel-sized (0.88 inch diameter) in the Anza area near the intersection of Highways 371 and 74. No injuries or damages were reported.
September 9, 2004	A heavy monsoonal thunderstorm dropped ¾-inch in diameter hail in the Idyllwild - Pine Cove area. No injuries or damages reported.
July 23, 2005	A severe thunderstorm developed along the Elsinore Convergence Zone northeast of Hemet. The storm produced a tornado, damaging straight-line winds to 70 mph, dime- to nickel-sized (1/4 to ¾-inch in diameter) hail, and flash flooding. Hail was reported in Hemet at 13:21 and 14:05 PST in Hemet, and at 13:25 in San Jacinto. The storm traveled southwestward and dissipated near Interstate 15 in Murrieta. No damage was reported due to the hail, but the heavy winds, tornado and flash flooding combined caused about $67.5K in property damage.
April 5, 2006	Hail to ¾-inch in diameter was reported in the Corona area of Riverside County at 11:18 PST.
May 22, 2008	A severe thunderstorm produced ¾-inch in diameter hail in Murrieta. No reports of damage were received.
May 22, 2008	A thunderstorm left a swath of hail up to several inches deep from north of Moreno Valley to Perris. Snowplows were called out to clear the hail from Interstate 10. While most of the hailstones were pea-size, several reports of marble- to nickel-sized hail were received from Moreno Valley just prior to the tornadoes. The larger hailstones left holes in awnings and stripped leaves from trees. $5K in property damage.
August 4, 2008	The public reported dime- to nickel-sized hail from a thunderstorm that started in Indio and moved into the south **La Quinta Cove** area during an active day of monsoon thunderstorms. In addition to hail, the storms brought gusty winds and flash flooding.
August 30, 2008	A severe thunderstorm developed over the Fern Valley (Idyllwild) area and significantly interfered with an ongoing search and rescue operation involving two injured climbers at Suicide Rock. Several eyewitness accounts from climbers on Suicide and Tahquitz Rocks, as well as from people involved in the ongoing search and rescue mission, describe hailstones ranging in size from marbles to walnuts. A helicopter was forced to abort a rescue attempt of the climbers and make an emergency landing after the thunderstorm moved into the area. One of the injured climbers suffered additional contusions from the hail while another person received cuts. Please note that the severe thunderstorm did not move into the area until nearly two hours after the initial (non-weather related) rock climbing accident.
August 24, 2013	Significant amounts of tropical moisture streamed northward into southeastern California ahead of dissipating tropical storm Ivo. The atmosphere in the area became very moist and unstable; scattered thunderstorms developed that generated copious amounts of rain, with rain rates exceeding 3 inches per hour in some areas. Large hail up to 1-inch in diameter fell in Eagle Mountain for about 30 minutes. No damage was reported.

Date	Description, Including Location and Damage Reported
September 3, 2013	Isolated to scattered thunderstorms occurred throughout the mountains, deserts and portions of the Inland Empire September 1-7. Hail up to ½-inch fell in the Idyllwild/ Pine Cove area on the 3rd. Other areas in Riverside County reported small hail. Pea to dime-sized hail accompanied storms on the 6th that caused flooding near the Highway S2 and SR79 intersection.

Source: NOAA database (http://www.ncdc.noaa.gov/stormevents).

6.2.2 Heavy Snow and Ice

Snow and ice normally do not come to mind at the mention of southern California, but some of the mountain communities do receive substantial precipitation in the form of snow and ice during the winter months. Sudden drops in temperature, combined with reduced visibility due to the snow, have stranded hikers in the mountains of San Diego, Riverside and San Bernardino counties. The low elevations in the Coachella Valley, combined with its location in the rainshadow provided by the San Jacinto Mountains, limits the historical occurrences of snow and ice in the area. However, several instances of snow have been reported at the northern end of the valley, in Palm Springs, which is approximately 450 feet higher in elevation than downtown Coachella, but at about the same elevation as the easternmost portions of the General Plan area. The snow falls historically reported in Palm Springs and other low-lying areas in the southern California region are summarized in Table 6-8 below.

Table 6-8: Historical Snowfalls Reported in the Low-Lying Areas of Southern California

Date	Event Description, including Location
December 1847	Light snow reported in the hills above Old Town San Diego. Greater amounts of snow reported to the east.
1848	Several feet of snow covered the San Bernardino Valley, staying on the ground for a long time. Several thousand head of cattle died.
April 21-22, 1908	0.6 inch of snow fell in Santa Ana.
January 11, 1930	2 inches of snow fell at **Palm Springs**.
January 15, 1932	Up to 2 inches of snow fell all over the Los Angeles Basin, including 1 inch at the Los Angeles Civic Center; the beaches at Santa Monica whitened.
January 21, 1937	Snow flurries reported in San Diego, with trace amounts of sticking snow in the northern and eastern parts of the city.
February 11, 1946	Snow flurries reported in many parts of San Diego.
January 9-11, 1949	Snow reported in many lowlands, including 1 inch in Laguna Beach and Long Beach. A trace in San Diego, with light covering in La Jolla, Point Loma, Escondido, and even El Centro.
December 13-19, 1967	Light snow covering reported in low-lying areas, including many San Diego mesas, Carlsbad, and even 4.5 inches at Anza Borrego State Park.
January 4, 1974	Snow flurries reported in **Palm Springs.**
January 31, 1979	Snow fell in many parts of southern California, including at least 2 inches at **Palm Springs**. The snow shut down Interstate 10 on both sides of Palm Springs, isolating the city. Schools were closed down and hundreds of cars were abandoned in the roadways.
February 2, 1985	2 inches of snow reported at **Palm Springs**.
March 2, 1985	Snow fell briefly in Escondido, with ice pellets reported in Coronado, La Mesa and Escondido, and hail reported in Linda Vista and downtown San Diego.

Date	Event Description, including Location
February 22-25, 1987	2-3 inches of snow pellets reported in Huntington Beach. Sleet and hail reported at the San Diego Bay front. 2.25 inches of snow recorded in Tarzana, Northridge, Torrance, Fontana and Redlands.
December 16, 1987	Snow fell for two minutes at Malibu Beach.
December 24, 1987	Snow flurries recorded throughout the San Diego metro area, but not in the downtown area proper.
February 7-9, 1989	Snow fell at the beaches in Los Angeles and in the desert, in **Palm Springs**. Numerous accidents and road closures reported throughout the region.
January 16-17, 1990	Snow flurries reported in the San Diego city limits.
February 14, 1990	Snowflakes reported all over the San Diego metro area.
March 28-29, 1998	The coldest storm of the year brought ice pellets and hail 1-inch deep to some coastal and foothill areas. Serious traffic accidents and considerable damage to crops reported.
January 12-13, 2007	Trace amounts of snow reported in areas as low as 500 feet in elevation in the Inland Empire. On the 13th, a trace of snow was reported in coastal San Diego County.

Sources: NCDC database (http://www.ncdc.noaa.gov/stormevents/), and compilation by the National Weather Service office in San Diego (http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf).

6.2.3 Temperature Extremes

Temperature extremes are responsible for more deaths in the United States on a yearly basis than all other extreme weather events combined, including flooding. Based on data collected by the Centers for Disease Control and Prevention (CDC, as reported in Goklany, 2007), between 1979 and 2002, an average of 358 people were killed annually by excessive heat. Extreme cold is even more deadly; an average of 680 people died in the United States each year due to cold weather between 1979 and 2002 (Goklany, 2007). In addition to the significant loss of life and injuries, temperature extremes also cause significant economic losses in agricultural production, and in transportation, energy and infrastructure costs.

Heat waves, which are periods of excessive heat, typically exceeding 95 degrees Fahrenheit, often with high levels of humidity, and lasting more than three days, can be deadly by pushing the human body beyond its limits. The heat itself is not deadly, but dehydration and loss of salts through sweating can lead to blood clots that can result in heart attacks or strokes; people with weak hearts may not be able to deal with the increased blood flow necessary to keep the body cool. Sensitive populations include older adults, children, and those that are sick or overweight. Those at greatest risk of dying during a heat wave are city-dwelling seniors that do not have access to an air-conditioned environment for at least part of the day. [Urban areas, due to the heat-absorbing properties of asphalt and concrete, are generally hotter than rural areas.] Athletes that do not take extra precautions or do not decrease their usual exercise routine in response to the high heat can also be impacted by a life-threatening, heat-induced illness such as heat exhaustion or heat stroke. These heat-induced illnesses can also impact outdoor workers, such as those in the agricultural or construction fields, that are not acclimatized, and do not have access to water and shade, or do not slow down and take cool-down breaks in the shade. Poor air quality often occurs during heat waves if a stagnant atmospheric condition develops, trapping dust and air contaminants near the ground surface. The resulting brown haze can cause serious respiratory problems in the elderly, infants, asthmatics, and others with compromised immune systems.

In addition to the potential injuries and loss of life brought on by heat waves, excessive heat can impact agricultural production, both of livestock and crops. Poultry, in particular, do poorly during heat waves. Millions of birds died during a severe heat wave that impacted the Midwestern states in 1980. Crops can also be adversely impacted by excessive heat and/or drought. Increased irrigation, with concurrent increased production costs, is generally necessary to prevent permanent damage to certain crops, such as vegetables and leafy greens.

High heat and **excessive heat** events that have occurred historically in the southern California area and that are known or inferred to have impacted the Coachella Valley are listed in Table 6-9. High heat events are periods of high heat that either did not last for at least three days, or where the heat and/or humidity levels were not sufficiently high to be defined as an excessive heat event. The data provided in Table 6-9 is most likely not comprehensive, but it does show that periods of temperature extremes have occurred historically in the region, and thus, that periods of excessive heat can be anticipated in the future.

The definition and effects of **extreme cold** vary across different areas of the country. In southern California, where we are not generally accustomed to cold weather, temperatures near freezing are considered “extreme cold.” A cold wave, where temperatures drop rapidly within a 24-hour period, can be devastating to susceptible and unprotected populations, crops, livestock and wildlife. Frost, that is, the deposition of ice crystals directly on the surface of an exposed object, can occur even when air temperatures are several degrees above freezing.

Exposure to extreme cold can lead to several life-threatening health conditions, including frostbite and hypothermia. **Frostbite** is an injury to the body, typically to the extremities such as fingers, toes, ear lobes or nose, caused by freezing body tissue. The main symptoms include a loss of feeling in the affected area, often combined with a pale, gray, white or yellow, and possibly waxy, appearance. Immediate medical attention is generally required, and the affected area should be slowly re-warmed to avoid further tissue damage. **Hypothermia** is an abnormally low body temperature (typically below 95 degrees Fahrenheit). Warning signs include uncontrollable shivering, disorientation, memory loss, slurred speech, drowsiness, and apparent exhaustion. Medical attention should be provided immediately if at all possible, and the body should be warmed to normal temperature levels in a slow and controlled manner to prevent further tissue damage.

Populations vulnerable to cold weather include (but are not limited to) the homeless, older adults, persons with medical conditions, including heart disease, diabetes, high blood pressure, mental illness, and cognitive disorders, infants and small children under the age of five, pregnant women, persons of limited economic resources that cannot afford to keep their homes warm, people who are socially isolated, and people who are caught outside in the storm, unprepared. The use of space heaters, barbeques, and fireplaces to keep structures warm increase the potential for structural fires and the risk of carbon monoxide poisoning.

Crop damage and livestock kills due to cold weather have historically cost the southern California area billions of dollars. For example, the December 1990 winter storms cost the state of California $3.4 billion in direct and indirect losses, whereas the 2002 winter caused more than $2 million in crop and property damage to the southern California area alone. Extreme cold events that are known or inferred to have impacted the Coachella Valley area are listed in Table 6-9.

Table 6-9: Historical High Heat, Excessive Heat, Extreme Cold Events and Frost Warnings Reported in Southern California that Impacted or Are Inferred to Have Impacted the Coachella Valley Area

Date	Description, Including Location and Damage Reported
June 11, 1877	**High heat:** A high of 112 degrees was observed in Los Angeles. It would be considered the all-time record, but official records did not begin until 20 years later.
March 28-29, 1879	**Excessive heat:** 95 degrees reported on the 28th, and 99 degrees on the 29th in San Diego. 99 degrees in Los Angeles on the 29th.
January 9, 1888	**Extreme cold:** Cold wave with freezing temperatures impacted the citrus-growing areas with substantial loss of the citrus crop.
July 25, 1891	**High heat:** 109 degrees in Los Angeles.
December 23-30, 1891	**Extreme cold:** Cold wave impacted the southern California area; 1-inch thick ice on oranges on trees in Mission Valley, 1/2-inch thick ice in San Diego pools.
May 27, 1896	**High heat:** 124 degrees at **Salton City**, the national maximum temperature for May.
April 25, 1898	**High heat:** 118 degrees at **Volcano Springs**, on the east side of where the Salton Sea later formed, the national maximum temperature for June. 127 degrees measured at Salton City.
June 23, 1902	**High heat:** 129 degrees at **Volcano Springs**, 127 at **Salton City**. The reading at Volcano Springs was the national maximum temperature for June.
November 12, 1906	**High heat:** 105 degrees at Craftonville, now Crafton Hills near Redlands. This was the national maximum temperature for November.
April 23, 1910	**High heat:** 100 degrees in Los Angeles, a record for April.
January 6-7, 1913	**Extreme cold:** 25 degrees at San Diego on the 7th, the lowest temperature on record. Killing freeze that caused extreme damage to the citrus crop all over California. Many other crops lost. Water pipes frozen, trolley lines disrupted. The damage directly led to the establishment of the U.S. Weather Bureau's Fruit Frost forecast program.
July 10, 1913	**High heat:** 134 degrees at Death Valley, the hottest reading on record for the Western Hemisphere, and the nation's highest temperature on record for July. The heat was accompanied by sandstorm conditions.
September 17, 1913	**High heat:** 110 degrees at San Diego, the highest temperature on record until September 26, 1963. An unofficial report of 127 degrees at San Bernardino. One man died, a carpenter working outside. Few small fires reported in San Diego, including one downtown that destroyed a house.
June 16, 1917	**Excessive heat:** A destructive heat wave in California history climaxes at **Mecca** with a temperature of 124 degrees.
July 6-August 17, 1917	**Excessive heat:** A prolonged hot spell hit Death Valley with 43 consecutive days of temperatures of 120 degrees or higher.
January 22, 1937	**Extreme cold:** 19 degrees at **Palm Springs**.
September 18-22, 1939	**Excessive heat:** Heat wave with 95-degree plus readings in San Diego, 106 degrees on the 21st. Los Angeles experienced 100-degree weather for seven consecutive days, with a peak of 107 degrees on the 20th. Eight heat-related deaths.
September 2, 1950	**High heat:** 126 degrees at Mecca, the national maximum temperature for September.
August 31 to September 7, 1955	**Excessive heat:** On September 1st, it was 110 degrees in Los Angeles, and all-time record, and 104 degrees in San Diego.
July 17, 1960	**High heat:** 101 degrees in Idyllwild.
October 14, 1961	**High heat:** Hot Santa Ana winds drove the temperature to 110 degrees in Long Beach, the hottest in the nation, 107 degrees in San Diego, 105 degrees in Los Angeles, and over 100 degrees in many coastal and inland areas.
September 26, 1963	**High heat:** Hot weather throughout the southern California region, including the coastline, with 112 degrees at El Cajon, 109 degrees at Imperial Beach, 113 degrees at El Toro (the hot spot in the nation for that date), 108 degrees in Carlsbad. Crop damage and animal deaths reported. Schools dismissed; workers sent home early.

Date	Description, Including Location and Damage Reported
October 20-29, 1965	**Excessive heat:** Very long heat wave, with a peak of 104 degrees in San Diego on the 22nd. Los Angeles had ten consecutive days with afternoon highs reaching 100 degrees.
November 1, 1966	**High heat:** 101 degrees at the Los Angeles airport, 100 in Los Angeles, and 97 degrees in San Diego. Santa Ana winds fanned several fires, including one that killed 16 firefighters.
August 22, 1969	**High heat:** 110 degrees at Cuyamaca.
September 25-30, 1970	**Excessive heat:** Drought in southern California came to a climax, with hot Santa Ana winds that sent the temperature soaring to 105 degrees in Los Angeles, and 97 degrees in San Diego on the 25th. The Laguna Fire consumed entire communities in eastern San Diego County. Half a million acres burned, with $50 million in property damage.
January 29, 1979	**Extreme cold: -**25 degrees in Big Bear Lake, the lowest temperature ever recorded in southern California.
July 10, 1979	**High heat:** 123 degrees at **Palm Springs**.
September 4-19, 1984	**High heat:** Tropical air from weakening hurricane Marie brought hot temperatures and high humidity to the region. 100 degrees in San Diego on the 8th and 9th. Numerous health problems reported due to the poor air quality and high humidity.
January 16-18, 1987	**Extreme cold:** Very cold air mass remained over the region, 22 degrees at Valley Center, 24 degrees in Poway, 26 degrees in El Cajon, 36 degrees in San Diego. Substantial avocado crop loss in the millions of dollars. Two homeless men died of hypothermia on the 17th.
October 3-4, 1987	**High heat:** Dry, hot weather, with 108 degrees both days in Los Angeles (a record for October), 109 degrees in El Cajon, 106 degrees in Chula Vista, Fallbrook and Santee, 104 degrees in San Diego on the 3rd. The dry weather and winds fueled the Palomar Mountain fire.
December 25-26, 1987	**Extreme cold:** Low temperatures caused extensive damage to the avocado and citrus crop. 9 degrees at Mt. Laguna and 22 degrees in Valley Center on the 25th; 15 degrees in Julian and Mt. Laguna, 16 degrees in Campo, 26 degrees in El Cajon, 30 degrees in Del Mar and 37 degrees in San Diego on the 26th.
March 25-26, 1988	**High heat:** Santa Ana conditions brought temperatures into the 90s all over the region, with record heat, and fanning of several brush fires. 102 degrees reported in Santee on the 25th, 97 degrees throughout the San Diego valleys, 95 degrees in Los Angeles and Santa Maria, 90 degrees in San Diego.
December 24-30, 1988	**Extreme cold:** A week of sub-freezing temperatures in southern California; 5 people died directly from the cold weather.
April 6-7, 1989	**Excessive heat:** Record high heat reported at all recording stations in southern California, including 112 degrees in **Palm Springs,** 106 degrees in Los Angeles, 104 degrees in Riverside, 103 degrees in Escondido, 101 degrees in Tustin, 95 degrees in Victorville, and 76 degrees in Big Bear Lake. Part of a major heat wave that lasted from late March into early April.
December 21-23, 1990	**Extreme cold:** An artic air mass produced record cold temperatures in the region, such as a low of 29 degrees at Redondo Beach on the 22nd. Throughout the state, December 1990 brought record-low temperatures to many areas, causing $3.4 billion in damages to public buildings, utilities, residential burst pipes, and especially, crop and fruit tree damage. Thirty-three counties were included in a disaster declaration, and as a result, the State established the State Agency Freeze Disaster Task Force, and the development of the State Agency Freeze Disaster Action Plan of 1991.
July 28, 1991	**High heat:** 120 degrees at Borrego Springs, 100 degrees in Campo.
August 17, 1992	**High heat:** Tropical air brought high temperatures and heat index values to Los Angeles and vicinity the entire week. On the 17th, it was 99 degrees, with a heat index of 110 degrees.
August 1, 1993	**High heat:** 123 degrees in **Palm Springs**.
July 27-29, 1995	**Excessive heat:** Heat wave in the region; 123 degrees at Palm Springs on the 28th and 29th, 120 degrees in **Coachella**, 113 degrees in San Jacinto, 112 degrees in Riverside, 111 degrees in Banning, Moreno Valley and Sun City; 110 degrees in Yucaipa on the 27th.
August 2-7, 1997	**Excessive heat**: Dangerously hot weather across all of southern California except in the

Date	Description, Including Location and Damage Reported
	coastal areas. Riverside and Ontario both peaked at 110 degrees Fahrenheit. Intense heat also felt at higher elevations. Beaumont hit 113 degrees, Julian hit 101 degrees, 121 degrees at **Thermal**. Five deaths were directly attributed to hyperthermia. One woman died near Dulzura on the 5th; an elderly female collapsed in her yard in Cabazon on the 6th. On the 7th, a man collapsed in a parking lot in Riverside, and another died at a residence in Flowing Wells. A woman from Campo was hospitalized on the 8th and died several days later. The heat made brush fires difficult to control.
December 26, 1997	**Extreme cold:** 0 degrees reported at Big Bear Lake, 4 degrees at Big Bear Airport.
July 16, 1998	**High heat:** 120 degrees at **Palm Springs**, 118 degrees at Borrego Springs, 127 degrees at Death Valley.
July 27, 1998	**High heat:** 123 degrees at **Thermal**, 118 degrees at Borrego Springs, 118 degrees at **Palm Springs**.
August 29-31, 1998	**Excessive heat:** Record heat in the region, with 112 degrees in Yorba Linda and the Wild Animal Park, 110 degrees at El Cajon, Hemet and Riverside; 108 degrees at Ramona, 106 degrees in Vista and Escondido, over 100 degrees in most of Orange County, 114 degrees in Dulzura on the 29th. Blazes at Camp Pendleton and Lake Jennings.
June 3, 1999	**Extreme cold:** Unseasonably cold air mass brings record low temperatures this late in the season to the southern California area. The high temperature of 38 degrees at Mt. Wilson became the lowest high temperature on record for June.
May 7-9, 2001	**Excessive heat:** Heat wave with 109 degrees at **Palm Springs**, **Therma**l and Borrego Springs, 103 degrees at Hemet, 102 degrees in San Bernardino. On the 11th, emergency crews rescued 19 people on a freight train near the city of Cabazon. They were suffering from heat exhaustion and dehydration. The train was en route to Los Angeles from Palm Springs, and it is unclear when the people had boarded the train. On the 13th, a man's body was discovered in Palm Canyon, near the Dos Cabezas mine in extreme eastern San Diego County.
July 01, 2001	**Heat:** A female hiker and a male softball umpire suffered heat exhaustion as the temperature rose to 115 degrees over the Coachella Valley.
January 28-February 3, 2002	**Extreme cold**: Very cold weather reported throughout the southern California area caused water pipes to freeze and burst, damaged vegetable and flower crops, and caused homeless shelters to fill to capacity. $230K in property damage and $1.8M in crop damage reported. One death directly attributed to cold spell. Most freezing damage occurred in January, but the hard freezes continued in the valleys and deserts into early February. Overnight lows in the single digits were common at mountain resort locations.
July 8-11, 2002	**Excessive heat**: Temperatures over 100 degrees Fahrenheit reported in the San Bernardino Mountains for three days. On the third day nine people were admitted to local hospitals for heat exhaustion. A smog alert was also issued due to the hot stagnant air over the area.
September 1, 2002	**High heat:** Tropical heat wave; 118 degrees in Dulzura, 113 degrees in Temecula, 112 degrees in Riverside and Menifee. Sharp temperature gradients, with areas adjacent to the coastline 10 to 30 degrees cooler than areas slightly farther inland (77 degrees at Newport Beach vs. 107 degrees in Santa Ana, 10 miles away; 72 degrees at Oceanside Harbor vs. 87 degrees at Oceanside Airport, 2 miles away).
July 20, 2003	**High heat**: A truck a man and a woman were riding in became stuck near the Twentynine Palms Air-Ground Combat Center. They tried to walk for help, but were overcome by the heat and died.
April 26-27, 2004	**High heat:** Record highs for April set, with 103 degrees at the Wild Animal Park, 100 degrees at Yorba Linda on the 26th, 85 degrees at Idyllwild on the 27th.
December 1-3, 2004	**Extreme cold:** 30s in the coast, 20s in the inland valleys and deserts, teens and single digits in the mountains, 8 degrees on all three mornings at Big Bear. Wrightwood reported a low of 9 degrees. Crop damage.
July 10-20, 2005	**Excessive heat**: Record heat reported throughout the area due to a strong high pressure,

Date	Description, Including Location and Damage Reported
	with temperatures soaring to 121 degrees at **Indio** and **Thermal**, 120 degrees at **Palm Springs**, and 116 degrees at Hesperia. No relief was to be found in the mountains either, where even at elevations above 7,000 feet temperatures reached into the mid and upper 90s. Big Bear Lake tied an all-high record high of 94 degrees on the 18th, while Idyllwild hit a high of 98 degrees. Daytime temperatures in the inland valleys hit 100 degrees or higher on most days, with a slew of record high minimums reported. One teen died of heat exposure when he and his father went looking for help after their dune-buggy broke down in Anza-Borrego Desert State Park. Near record high power consumption. Desert locations reported the all-time warmest month on record.
July 21-27, 2006	**Excessive heat**: A strong high pressure centered over the southwest US and monsoon moisture during the second half of July led to numerous daily high minimums and high maximum temperature records. Desert locations reported the all-time warmest month on record. Heat wave reached its peak on the 22nd; several highs were tied or broken that day. Temperature rose to 105 degrees in Julian, 114 degrees at Ontario, 120 degrees at Indio and Thermal, and 121 degrees at Palm Springs. Palm Springs experienced 10 consecutive days with a minimum temperature of 85 degrees or greater, breaking the previous record of 5 days in 1917. There were at least 16 deaths and 27 injuries reported as a result of the heat wave, but these numbers, especially the injuries, are thought to be underestimated. Some power outages occurred.
January 12-18, 2007	**Extreme cold:** A cold snap peaked on the 15th with -7 degrees at Fawnskin, -2 degrees at Big Bear Lake and Wrightwood, 5 degrees at Hesperia, 6 degrees at Mt. Laguna, 18 degrees at **Thermal**, 19 degrees in Hemet, and 20 degrees at Camp Pendleton. San Diego, Riverside and San Bernardino counties declared disaster areas. Except for right along the immediate coastline, the freeze lasted for a week or longer. $68.85 million in crop damage in the **Coachella Valley**, $86 million in Riverside County, and $11.1 million in San Bernardino County. $600K in damage from frozen pipes in San Bernardino County's mountains and deserts, $100K in property damage in the **Coachella Valley**. Golf courses in Palm Springs were affected by the freeze.
July 3-6, 2007	**Excessive heat**: A significant heat wave occurred in the mountains and the **Coachella Valley**, with high temperatures generally around 115 degrees reported in the lower deserts, 105 degrees in the mountains between 3,000 and 5,000 feet, 100 degrees between 5,000 and 6,000 feet, and 95 degrees between 6,000 and 7,000 feet. 119 degrees at Ocotillo Wells, 116 degrees in **Palm Springs** and **Indio**. Most valleys and coastal cities west of the mountains were not affected because of a persistent marine layer, and as a result, there was little media coverage regarding the heat wave. The heat wave likely made many people ill, but the number is unknown.
September 1-4, 2007	**Excessive heat**: A strong high pressure and easterly flow brought hot, humid weather to much of southern California. Temperatures exceeded 110 degrees in the Inland Empire and high deserts, and 115 degrees in the **lower deserts**. Humidity levels were quite high for the region. At least 6 people died of heat-related causes; the actual number is probably higher.
June 20, 2008	**High heat**: High temperatures were recorded in the Inland Empire area, including 105-111 degrees in the valleys and 115-118 degrees in the **lower deserts**. High temperatures reached 115 degrees at **Indio**, 117 at **Palm Springs**, and 118 at **Thermal**. The relatively short duration of the heat spell and the lack of humidity kept this episode from meeting the excessive heat criteria. News reports indicated that several people were treated for heat-related illnesses, but no specifics were provided.
May 17-19, 2011	**Cold/Wind Chill:** On both the 17th and 18th, numerous low temperatures (both maximum and minimum) were recorded in the **Coachella Valley**. Palm Springs and Thermal both broke records with high temperatures of 76 and 77 degrees respectively. These temperatures are about 25-20 degrees below normal for that time of year.
May 12, 2012	**Heat:** A low of high pressure over the area created a warming trend with inland temperatures 5 to 15 degrees above normal. Temperatures in the **lower deserts** ranged from 97 to 105 degrees. An 86-year old male was hospitalized for heat-related illness near

Date	Description, Including Location and Damage Reported
	Mecca. On the 18th, the Health Department confirmed his death as heat-related.
June 28-29, 2013	**Excessive Heat:** A record setting ridge of high pressure brought extreme high temperatures to the Coachella Valley area. Palm Springs reported a high of 118 degrees, tying the previous record set on 6/28/1979. Indio also tied its previous high record of 118 set in 2003.
July 1-3, 2013	**Excessive Heat:** A record setting ridge of high pressure brought several record high temperatures, with highs well over 100 degrees. In Cathedral Canyon a high of 115 degrees was recorded; in Indian Wells, 122 degrees.

Sources: NOAA database (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms), and compilation by the National Weather Service office in San Diego (http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf), for events through January 31, 2014.

6.2.4 Drought

Drought is defined as an extended period of below-average precipitation relative to levels normal for that region. Given this definition, drought can occur almost anywhere in the world, and has impacted human populations throughout history. Extended drought periods, posing a severe impact on ecosystems and agriculture, have been responsible for damaged local economies, political unrest, many mass migrations, and even the collapse of civilizations. Because drought occurs over a lengthy period of time, measured in months to years (and even decades), rather than in seconds to days (such as earthquakes, tornadoes, hurricanes and floods), its impacts are generally difficult to recognize until severe damage has occurred. It is also difficult to predict when a drought will pass. As a result of climate change and global warming, some regions of the world are expected to experience drought more often, or possibly even change permanently to a more arid condition, impacting local populations severely (additional information on climate change is presented in the Sustainability and the Natural Environment Element.)

In the southwestern United States, variations in precipitation levels are often tied to oceanic and atmospheric weather cycles such as the El Niño – Southern Oscillation (ENSO) and La Niña events. These are natural climate phenomena related to annual differences in the sea-surface temperature (SST) and air pressure in the equatorial Pacific Ocean that affect climate the world over. The El Niño conditions occur when warming of the Pacific Ocean SST occurs in concert with an oscillation in air pressure, referred to as the Southern Oscillation, between the eastern and western Pacific Ocean. La Niña conditions are associated with a cooling of the Pacific Ocean SST in the same area off the western coast of South America. These warming (El Niño) or cooling (La Niña) episodes affect the climate in North America during the winter and early spring months (typically between December and February, but can last through multiple seasons). These conditions are often modulated by other climate cycles, such as the Pacific Decadal Oscillation, the North Atlantic Oscillation, and the Atlantic Multidecadal Oscillation. The Pacific Decadal Oscillation, in particular, impacts the southwestern United States in a cycle that lasts 20 to 30 years characterized by warming or cooling of the surface water in the Pacific Ocean facing the western coast of North America. The interaction of all of these climate cycles makes it difficult to forecast the strength and length of El Niño and La Niña events.

During El Niño events, a widened Pacific jet stream draws tropical moisture over southern California, causing an increase in precipitation and storms. El Niño episodes thus increase the likelihood of extreme winter storms, storm-related high winds and flash flooding in the region, including the Coachella Valley. During La Niña events, the jet stream stays up in the Pacific Northwest, causing increased precipitation in Washington and Oregon, and less precipitation in the southwestern and southeastern states. Thus, La Niña episodes increase the likelihood of drought and Santa Ana wind conditions in southern California, including in the Coachella Valley. Most severe weather episodes reported historically in southern California can be associated with El Niño and La Niña events.

In the period between the years 2000 and January 2014, the Coachella Valley area was impacted by drought conditions during three consecutive years, between 2007 and 2009. By the end of the 2006-2007 rainfall season, most of southern California had received 30 percent or less of normal precipitation, with most major reservoirs reporting water storage at about 80 percent of their 30-year average. By July 2007, extreme drought conditions, with more than $4 million in crop damage, prompted the Governor to declare a state of emergency for Riverside County. Many wells in the county began to dry up, forcing rural communities to truck in extra water or get hooked up to city water systems. A fairly inactive monsoon season provided no drought relief to the area. By August and September 2007, local agencies were using radio and television announcements to encourage water conservation, especially after a court-ordered reduction in water supplies from the Sacramento River Delta raised concerns about a possible water crisis in the region. Rainstorms at the end of November, in December, and January 2008 helped downgrade the situation from severe drought to abnormally dry levels.

The dry spring that followed resulted in a moderate drought classification for the southern California area. In June 2008 the Governor issued a state-wide drought declaration due in great part because of the dry conditions reported in the northern part of the state. Voluntary water conservation was encouraged through public broadcasts and in printed media. Mandatory conservation measures were put in place for farmers in San Diego County. Moderate drought conditions continued in the month of July, despite thundershowers and monsoonal flow in the lower deserts. The northwestern portion of the upper deserts was declared a severe drought area. Although rain fell in November, it was not enough to make a difference. That month, the U.S. Department of Agriculture (USDA) granted a Secretarial Disaster Designation for San Diego, Orange and Riverside counties due to the drought-induced losses in the agricultural sector. Losses to range lands were classified at greater than 40 percent.

December 2008 was wet, but January 2009 was dry. As a result, the state-wide drought declaration remained in effect. Municipalities and water districts in the region, including the entire Coachella Valley, instituted water conservation measures. Although several storms brought rain to the area in February 2009, at the end of the month the Governor issued a State of Emergency for all of California, calling for all residents to decrease their water use. Very small amounts of precipitation were measured between March and June, 2009. By the end of June, the desert areas had received 70 percent to 100 percent of their average annual precipitation. The State of Emergency for continued drought remained in effect, with water cuts required for certain agricultural activities, mainly the avocado and citrus farmers in San Diego and southern Riverside counties. The deserts were considered to be in a moderate drought condition, whereas the rest of the southern California area was classified as in a severe drought condition. Summer thunderstorms added little to the overall rainfall numbers, and on September 17, 2009, the USDA granted a Secretarial Disaster designation for several parts of California, including Orange, San Bernardino, San Diego and Riverside counties, primarily for agricultural losses due to the drought. Several storms brought rain to the region in October and November, and by December 2009, most of the region had received between 150 percent and 250 percent of normal precipitation levels, except for the high deserts, which had received only 50 percent of their normal level.

During 2010 and the first half of 2011, the Coachella Valley area was not impacted by drought. In June 2011, the area began to experience some dryness, and for the rest of the year, the valley was abnormally dry. The year 2012 began abnormally dry, and by February, the Coachella Valley area was deemed to be experiencing moderate drought conditions. Reduced precipitation levels characteristic of a moderate drought remained in effect for the remainder of 2012, and during the first four months of 2013. Severe drought conditions prevailed from May through October 1, 2013, when the intensity was down-sized to moderate drought. Moderate drought conditions were reported in the Coachella Valley area through the end of 2013 and into the first week of February 2014. Since then, and through the first weeks of May 2014, when this report was finalized, the Coachella Valley region have been mapped as within a severe drought condition (http://droughtmonitor.unl.edu/archive.html).

6.3 Summary: Coachella's Vulnerability to Severe Weather Damage

6.3.1 Hazards Assessment

The previous sections describe the various extreme weather conditions that have impacted and are likely to impact again the Coachella Valley area. By reviewing the historical record we can better understand the geographic extent of the hazard, the intensity of the events likely to impact the study area, and their probability of occurrence. Each of the hazards covered above is discussed further in the paragraphs below, addressing these issues, with an emphasis on how they pertain specifically to the Coachella Valley area, including the city of Coachella.

6.3.1.1 Windstorms

Windstorms are significant chronic events that cumulatively cause extensive damage, with property losses in the millions of dollars, in addition to injuries and loss of life. A windstorm event in the region can range from a short-term microburst or high wind lasting a few hours, to either Santa Ana or thunderstorm-related wind conditions that can last for several days.

The data in Table 6-4 show that high winds can occur in Coachella Valley almost any time during the year, but primarily in the months of January, February, March, April, November and December. More specifically, **Santa Ana wind** conditions occur most often in the winter months, occurring as early as October, and as late as April, but mostly between December and January. These winds tend to impact a large geographic area. Similarly, high winds accompanying **winter storms** approaching from the north or northeast also occur most often between November and April, with most winter storms occurring in November, February and April. **Tropical storms** that make landfall in Baja California and move north into Arizona and California generally occur between July and September, with most of these taking place in August and September.

The data presented in Table 6-4 may give the impression that windstorm events have increased in frequency over time. However, this is most likely the result of an incomplete historical record rather than a change in wind frequency. The records are likely missing data because: 1) there were less people in the area that would be impacted by these natural hazards, and 2) only unusually damaging storms would be recorded in newspapers, journals and other sources. Using the record from between 2000 and 2012 only, the study area appears to be impacted by windstorms approximately six times per year, on average, but there is significant variability from year to year. For example, in the years 2001 and 2004, only three high wind events were reported in the area, whereas in 2012, there were 14 wind events, in 2011, eight, and in 2000 and 2002, seven events.

The records (see Table 6-5) indicate that **tornadoes** can occur in Riverside County at almost any time of the year, but that they do occur more often in January, February, and August. The only month with no tornado activity reported in Table 6-5 is June. The tornado numbers also vary significantly from year to year. Using only the records between 2000 and 2012, which are deemed to be more complete than those for previous decades, we find that in some years there is substantial tornado activity, while in others, there is none. For example, several tornadoes were reported in the region in 2005, but no tornadoes were reported in 2000, 2007 and 2009. Tornadoes and microbursts usually impact a relatively small geographic area. Tornadoes in the southern California area have for the most part been size F0 or F1, but even these tornadoes are capable of causing property damage, injuries and potentially, loss of life. Table 6-5 also shows that most tornado activity in Riverside County occurs in the Moreno Valley – Hemet area, with only a few funnel cloud incidents historically reported within about 50 miles of Coachella. These events have occurred predominantly in the Palm Springs area.

Based on the data presented in Table 6-6, winds in Riverside County producing **dust storms** are often caused by Santa Ana conditions and winter storms, occurring primarily between December and March. Summer thunderstorms can also cause dust storms in the region, with several of these events occurring in August. For dust storms to occur, there has to be a source of sand, dirt, or ash present, generally the result of vegetation stripping either as a result of man-made activities (such as farming, grading during construction), an antecedent natural disaster (drought, forest fire, a flood event depositing loose sand and silt), or a natural condition (desert). Depending on the availability of sand and other debris, and the regional extent of the wind event responsible for picking up and transporting the dust, a dust storm will be either local or regional in extent. Santa Ana wind conditions, given their regional extent and their wind strength, have the capacity to move large amounts of dust, if there is a source available, great distances (see the Photo on Figure 6-1 showing ash and smoke from wildfires being transported hundreds of miles out to sea). Based on the data in Table 6-6, dust storms are significant events in the Coachella Valley area, typically impacting vehicular and air traffic, and causing significant property and crop damage.

Unlike flooding hazards, which are generally confined to a discrete area that can be mapped, windstorms may travel in any direction, and are only partly affected by topography (with stronger winds usually observed in canyons and passes, where the winds are funneled by the surrounding topographic highs). Given that we cannot predict when or where a windstorm will occur, nor its intensity, the conservative approach is to assume that a windstorm event can take place anywhere in the Coachella Valley area anytime during the year, but preferentially in the late summer, fall and winter (August through April).

6.3.1.2 Hail

The data presented in Table 6-7 suggest that hail events occur very infrequently in the Coachella Valley. The only reported hail event, in the south La Quinta Cove area on August 4, 2008, was the result of a summer thunderstorm. Most hail events that have been reported in the county occur in the region referred to as the Elsinore Convergence Zone, an area that extends eastward between Elsinore Lake and the San Jacinto Valley. In this region, air moving inland from the Pacific Coast that is funneled through a low spot in the Santa Ana Mountains meets (converges) with air coming from the northwest, funneled through the Santa Ana River Canyon. The convergence of these airstreams results in some unusual weather in the area around Temecula, Menifee, Perris, and Hemet, where a large percentage of the tornadoes and hail events in Riverside County occur.

Based on the damage descriptions, these hailstorm events are typically localized, impacting a relatively small area, and the hailstones produced by these storms are relatively small in diameter, generally less than 1 inch. Most events have not caused any injuries and only minor property damage. The only exception is the two injuries caused by the hail storm reported in the Idyllwild area on August 30, 2008. It is noteworthy to mention a thunderstorm reported in 1960 that impacted a large regional area, with hail reported in San Diego, Riverside, and San Bernardino. The large hailstones produced by this storm (2.75 inches in diameter and over 1 pound in weight) caused significant property damage, although a dollar amount was not assigned. This particular event indicates that the southern California area can be affected by severe but very unusual (low probability) thunderstorms if the atmospheric conditions are just right to produce large hailstones.

6.3.1.3 Heavy Snow and Ice

Winter storms that bring snow and ice to the San Bernardino and San Jacinto Mountains occur on a yearly basis, with most storms occurring between December and April. The storms that impact the mountains and high deserts tend to be regional in scale, generally affecting a large portion of southern California. These events have the potential to impact city of Coachella residents indirectly, if they travel or commute out of and into the valley when a winter storm has hit the area, as traffic accidents caused by unsafe road conditions and road closures due to slope failures and snowdrifts can be expected. Most property losses reported to date for an individual storm event vary between a few thousands dollars to hundreds of thousands of dollars. When these storms impact agricultural areas, the losses to crops and livestock can amount to millions of dollars.

6.3.1.4 Temperature Extremes

Table 6-9 includes fifteen **extreme cold** and **cold/wind chill** events that have impacted or are inferred to have impacted the Coachella Valley area between 1888 and 2012. Since 1987, at least eight deaths have been directly attributed to cold weather in the southern California area. Most of these events, as expected, occurred in December, January and February, during the winter months. Property and crop damages are often not fully accounted for, but it can be in the millions of dollars; the January 2007 freeze alone caused $100 thousand in property damage and $68.85 million in crop damage in the Coachella Valley. One extreme cold event reported occurred in early June (1999), when a winter storm brought unseasonably low temperatures to the southern California area, with up to 3 inches of snow reported in the mountains above the 5,500-foot elevation in San Bernardino, Los Angeles, Riverside and San Diego counties.

Table 6-9 also includes 17 **extreme heat** and 29 **high heat** events between 1877 and 2012. At least 32 people reportedly died from high heat between 1997 and 2012, although this number is likely to be underestimated; dozens more were hospitalized for heat-related illnesses. Most extreme and high heat events occurred between July and September, but at least one extreme heat and one high heat events were reported in March, three high heat and one extreme heat events have occurred in April, and two high heat events have been reported as late in the year as November. Property and crop losses associated with these events amount to billions of dollars, especially if the damage as a result of the fires associated with these heat waves is included in the loss count.

Temperature extreme events tend to be regional in scale, although to some extent they are controlled by elevation, with high and extreme heat impacting low-lying inland areas preferentially, and extreme cold more likely to impact the higher elevation areas. The city of Coachella has significant relief, with the valley areas located at or below sea level, and the highlands along its eastern border reaching heights of more than 1,000 feet above sea level. The more extensively developed valley portion of the city is impacted by extreme heat and high heat events preferentially, with mild winters being the norm. However, the eastern part of the General Plan area that is being proposed for development may experience both extreme heat and extreme cold events.

6.3.1.5 Drought

Drought is one of the most devastating natural hazards; history abounds with examples of civilizations that have been wiped out or have been forced to migrate and be assimilated by other groups as a result of drought. Reduced precipitation can cause the collapse of the agricultural tradition in an area, setting the stage for famine, and bringing social, economic, political and cultural unrest. Drought occurs over a long period of time, and is thus not readily apparent at first. This makes planning for and mitigating for drought more difficult, but not impossible. Nowadays, the impacts of drought need not be catastrophic, especially in developed countries. Constant, weekly monitoring and recording of potential drought conditions throughout the United States is conducted by a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. This monitoring allows for early detection of patterns that can suggest a long-term drought period to come. With this information, government officials, policy makers, farmers, and the public in general can be provided with the necessary information to enforce water conservation measures and implement other mitigation as needed to reduce the impact of drought. Increased communication and transportation links between regions allow for the transport of water and food resources into drought-affected areas. Several large water storage reservoirs and associated aqueducts have been constructed or expanded in the southern California area in the past two decades. The Eastside Valley reservoir near Hemet alone stores sufficient water to serve the entire southern California region for at least six months. Of course, in arid and semi-arid areas like the Coachella Valley and southern California in general, water conservation should be a priority always, not only during drought periods.

6.3.2 Damage Assessment

As past events show, storms and other severe weather hazards in the Coachella Valley area and elsewhere have the potential to impact life, property, utilities, infrastructure and transportation systems, causing damage to trees, power lines, utility poles, road signs, cars, trucks, and building roofs and windows. Structures and facilities can be impacted directly by high winds and/or can be struck by air-borne debris or downed trees and power poles. Windstorms can disrupt power to facilities and disrupt land-based communications as well. In fact, historically, trees downed during a windstorm have been the major cause of power outages in the southern California area. Uprooted trees and downed utility poles can also fall across public right-of-ways disrupting transportation.

High winds, especially those associated with Santa Ana conditions and dust storms, pose a significant impact to delicate crops, such as leafy greens and vegetables, as the winds draw moisture from the plants. High heat, extreme heat, extreme cold, and drought can also harm or destroy most crops. High winds, extreme temperatures and drought can have a severe impact on livestock. Given that agriculture is an important component of the region's economy, damage to crops and livestock can have a severe negative effect.

Extreme cold is typically only one of the hazards associated with winter storms. Thus, in addition to cold temperatures, residents and visitors to the area impacted by a storm have to deal with other potential hazards including icy roadways, strong winds, and power outages. Vehicular accidents and falls on icy sidewalks are two leading causes of injuries during winter storms.

Hail can and will cause significant damage to structures, vehicles, aircraft, and livestock (not to mention people that don't find cover). Hail can also cause significant damage to crops. The structural components most often damaged by hail include roofs (including glass roofs and roof-mounted solar panels), skylights, window awnings, and windows. Vehicular accidents as a result of reduced visibility, and hail stones on the pavement acting as ball bearings, can be expected during these kinds of storms.

These events can be major hindrances to emergency response and disaster recovery. For example, if transportation routes are compromised by fallen debris, and loss of power occurs in the area, emergency response facilities like hospitals, fire stations, and police stations may find it difficult to function effectively. Falling or flying debris, downed trees and power lines can also injure or kill motorists and pedestrians. As discussed previously, windstorms, are often also associated with wildfires, which, if they occur in or near a populated area, can result in enormous losses to property, in addition to injuries and loss of life. Such an event may require the involvement of city and county maintenance personnel responding to cleanup and repairs during and following the windstorm. Similarly, maintenance crews may be required to secure certain facilities ahead of a potential storm, provided sufficient advanced notice is available and if municipal crews are available to respond on short notice.

6.3.2.1 Structural Damage

Depending on its age, condition, and structural design, any structure may be susceptible to windstorm damage. However, buildings with weak reinforcements are most susceptible. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift suction forces that pull building components and surfaces outward and/or upward. Under extreme wind forces, the roof or entire building can fail or sustain considerable damage. Mobile homes are particularly susceptible to windstorm damage. Debris carried by the wind may also contribute to loss of life and, indirectly, to the failure of building envelopes, sidings or walls.

A windstorm also has the potential to displace residents, which may require the city of Coachella to provide short-term and/or long-term shelters to accommodate these individuals, in addition to providing for other emergency response activities such as cleanup and repair. This has the potential to impact the city economically, as Coachella's general funds would have to be tapped into to respond adequately to the needs of the impacted members of the community.

6.3.2.2 Lifelines and Critical Facilities

Historically, downed trees have been a major cause of power outages in the region during windstorms and winter storms. Some tree limbs can break in winds of about 45 mph, and the broken limbs can be carried by the wind more than 75 feet from their source. Thus, overhead power lines can be damaged even in relatively minor windstorm events. Downed trees can also bring electric power lines down to the pavement or ground, where they become serious, life-threatening, sources of electric shock. Similar damage can be caused by winds associated with winter storms, with broken tree branches and fallen trees that in turn down power and telephone lines.

Lifelines and critical facilities should remain accessible, if at all possible, during a natural hazard event. The impact of closed transportation arteries is particularly severe if a blocked road or bridge is critical to access a hospital or other emergency facilities. Population growth and new infrastructure in the region could result in a higher probability for damage to occur from windstorms and winter storms as more lives and property are exposed to these hazards.

Cold waves can cause poorly insulated water pipes to freeze, which in turn can result in substantial property damage. Fires can become more hazardous in extreme cold conditions, especially if the water supply has become unreliable due to water main breaks that hinder firefighting efforts.

6.3.2.3 Infrastructure

As mentioned above, windstorms may damage buildings, power lines, and other property and infrastructure due to falling trees and branches. Windstorms can also result in damaged or collapsed buildings, blocked roads and bridges, damaged traffic signals and streetlights, and damaged park facilities. Roads blocked by fallen trees during a windstorm may severely impact people attempting to access emergency services. Emergency response operations can be compromised when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric services and from extended road closures. They can also sustain direct losses to buildings, personnel and other vital equipment.

In addition to the problems caused by downed trees and electrical wires blocking streets and highways, storms can also force the temporary closure of roads to vehicular traffic. This is especially true during extremely strong Santa Ana winds and winter storms, and as a result of microbursts or tornadoes associated with summer thunderstorms.

The high demand for air-conditioning during a heat wave has a significant impact on the electric transmission system. The heat itself can cause overhead electric lines to sag and short-out. As a result of demand exceeding supply, in addition to the physical damage to the electric transmission lines, it is not uncommon for electric companies to institute or be forced to establish rolling black-outs during periods of excessive heat. Excessive heat can buckle roads, stress engines, and distort rail lines. Hot weather can also impact the goods being transported, especially produce and livestock. All of these conditions add up, increasing the costs of transporting goods. Heat waves also have an impact on the water resources and water infrastructure, with increased demand for water. If wildfires occur during a heat wave, there will be increased use of water for fire-fighting purposes, which can tax the available resources, reducing water supply and water pressure.

Widespread weather observation stations and networks, in addition to great advancements in computer modeling and a better, if not yet comprehensive understanding of atmospheric processes, have greatly facilitated the forecasting of meteorological events such as winter storms, windstorms, and extreme temperature events. Weather forecasts, combined with an increased use of the internet and media resources, permit the wide dissemination of weather warnings in real time, with the potential to greatly reduce the effect of extreme weather events on people and property. Utility companies, relief organizations, and government officials can and should use weather warnings to anticipate an increase in demand for electricity, heating oil or gas, shelters for the homeless, and maintenance and emergency response personnel.