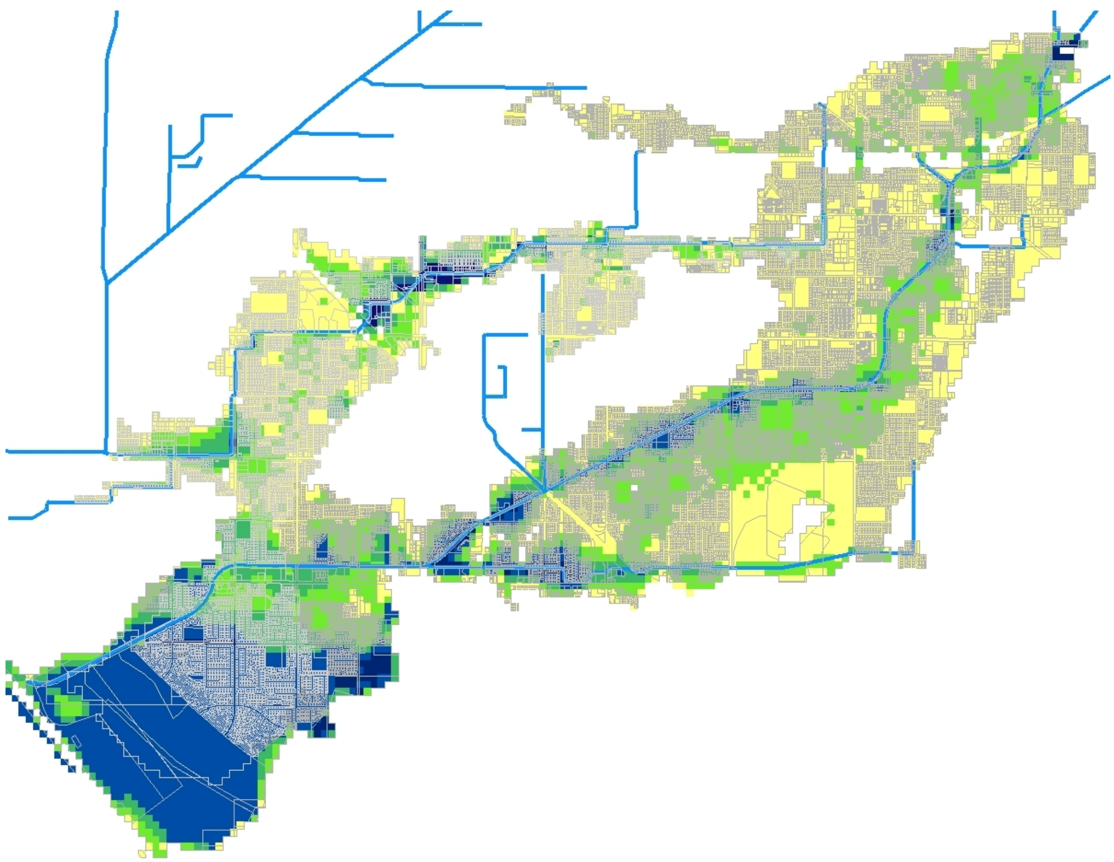
US Army Corps
of Engineers®

Westminster Watershed Feasibility Study

Without-Project Economics
January, 2007



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Introduction

Purpose

The purpose of this appendix is to document the methodology and results of the economic analysis used to assess the without-project conditions as it relates to potential flood damages from several channels that are located within the Westminster Watershed. The analysis focuses on existing and future without-project conditions related to flood damages to structures, contents, and vehicles, and to costs incurred as a result of flood fighting, evacuation, and cleanup. The primary focus of this analysis is to estimate the economic damages associated with future flood events in the study area. Also, because any potential future project may have a recreation component, this report includes a description of the recreation resources in the market area. At subsequent study phases, the magnitude of the without-project damages will be compared to the damages estimated with various alternative projects in place in order to determine the extent to which these projects would provide economic benefits to the nation.

This Economic Analysis includes the floodplains of channels CO4 (Westminster), CO5 (East Garden Grove Wintersburg), and CO6 (Ocean View). For future study phases, some analysis of the CO2 floodplain may also be conducted, although the ultimate analysis of this floodplain will likely be less detailed and smaller in scope than the analysis of the floodplains evaluated here.

Methodology & Overview

The principal controlling guidance of the analysis comes from the U. S. Army Corps of Engineer's (USACE) "*Planning Guidance Notebook*", ER 1105-2-100, with specific guidance from Appendix D – Economic and Social Considerations. Benefits and costs are expressed in average annual terms at 2006 price levels using the fiscal year 2007 federal discount rate of 4.875%. The period of analysis is 50 years. Within the floodplains there is little or no vacant, developable land, and for this reason the analysis assumes that the future without-project economic condition is equivalent to the current without-project condition. That is, the flood damage estimate does not include any structures that are not currently in the floodplains. Additional guidance on the risk-based analyses has been obtained from USACE ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, dated January 3, 2006.

From a broad perspective, the analysis focuses on estimating damages to private and public property, as well as emergency response and recovery costs, which includes emergency assistance to flood victims. Each of these categories has several components. The specific methodology employed in evaluating each category, as well as a description of key assumptions, is explained in the text provided for each particular category.

In general though, structure and content data were first processed through an @RISK Excel spreadsheet to generate the appropriate stage-damage references with uncertainty for entry into the HEC-FDA model. The effects of this construction are that individual risk-based damage assessments are performed for each damage category external to the HEC-FDA model in a process that mimics the HEC-FDA methodology – the foundation of which is Monte Carlo simulation. With respect to damages, the results of the @RISK calculations are entered directly into the HEC-FDA model as cumulative damage functions for each damage category and for each study reach (termed Impact Areas in this report). More details on the cumulative damage function methodology are included in the Property Damages section.

Study Area

Location

The Westminster watershed is located in the southwestern corner of Orange County, CA. The watershed encompasses an area of approximately 74 square miles (around eight percent of the total area of Orange County). The watershed consists of all or portions of the cities of Anaheim, Cypress, Fountain Valley, Garden Grove, Huntington Beach, Los Alamitos, Santa Ana, Seal Beach, Stanton, and Westminster. The combined floodplains span large portions of the land between the cities of Huntington Beach (to the south), Fountain Valley (to the east), and Westminster (to the north), an area which is over twenty square miles. The aerial image below shows the major cities in the area surrounding the study area, and an overlain picture in the center of the image shows the 500-year combined floodplains for CO4, CO5, and CO6. The northeastern edge of the floodplain is just less than eleven miles from the coast.

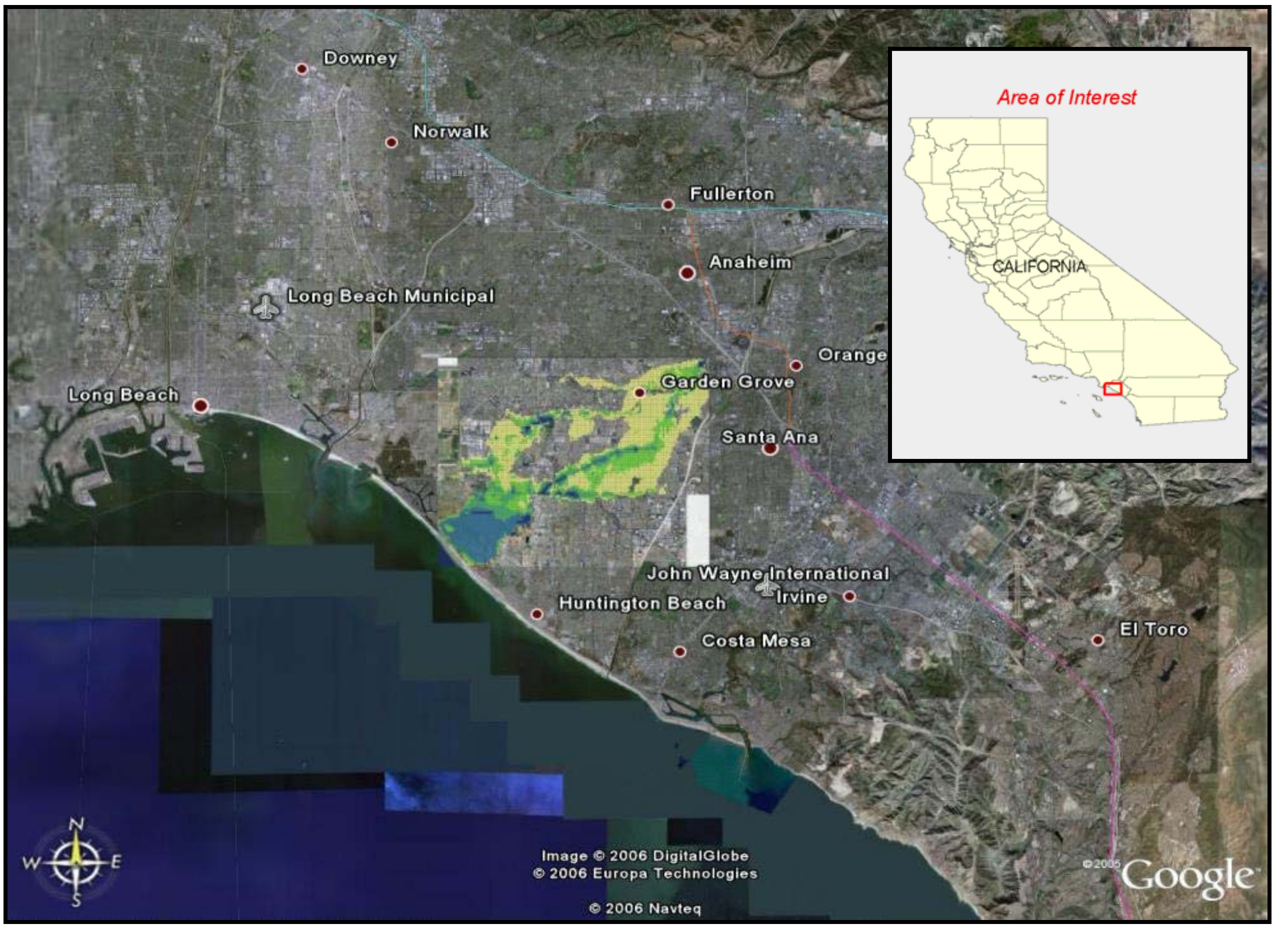

Figure 1: Regional View of the Study Area

Floodplain Characteristics

The analysis includes the floodplains of channels CO4, CO5, and CO6. Flood modeling performed by USACE engineers was conducted for CO4 in isolation, but CO5 and CO6 were modeled in combination – one floodplain was created representing overflows from both channels.

CO4

The CO4 floodplain is contained within the cities of Huntington Beach and Westminster, with a very small portion (furthest point East) in the city of Garden Grove. The 500-year floodplain is approximately 6.4 square miles large.

The figure below shows the 500-year floodplain with the peak depths across the flooded area. The figure shows the delineation of the five impact areas. Although difficult to decipher from the figure below, Impact Areas 1 and 2 are separated by the channel.

The overflows from CO4 occur across approximately eight miles of the channel, flooding roughly five miles of land in the affected area. At its widest, downstream stretch, the floodplain spans approximately 1.3 miles. The models show that the CO4 floodplain overlaps the CO5 & CO6 floodplain during events of or greater than 100-year. The primary area of overlap is the western-most portion of the CO5 floodplain. In this area, flood depths as a result of overflows from CO4 are relatively shallow compared to overflows from CO5 and CO6.

According to the floodplain mapping data, the average flood depths within the 50, 100, and 500-year floodplains are 1.2, .95, and .76 feet, respectively. The average depth decreases as the storm event grows because the overall flooding is spread over a greater area, decreasing the mean depth associated with the flood event. It is estimated that the approximately 45,000 people reside within the 500-year floodplain. Approximately 3,000 of these residents would be subject to flooding of greater than one foot within their homes during a 500-year flood event, and around 600 would have over three feet of water in their homes.

Table 1: Mean Flood Depth per Impact Area – CO4

Impact Area	50-yr	100-yr	500-yr
1	0.36	1.24	3.15
2	0.96	2.06	4.19
3	1.35	1.19	3.66
4	0.50	0.46	0.49
5	0.81	0.34	0.52

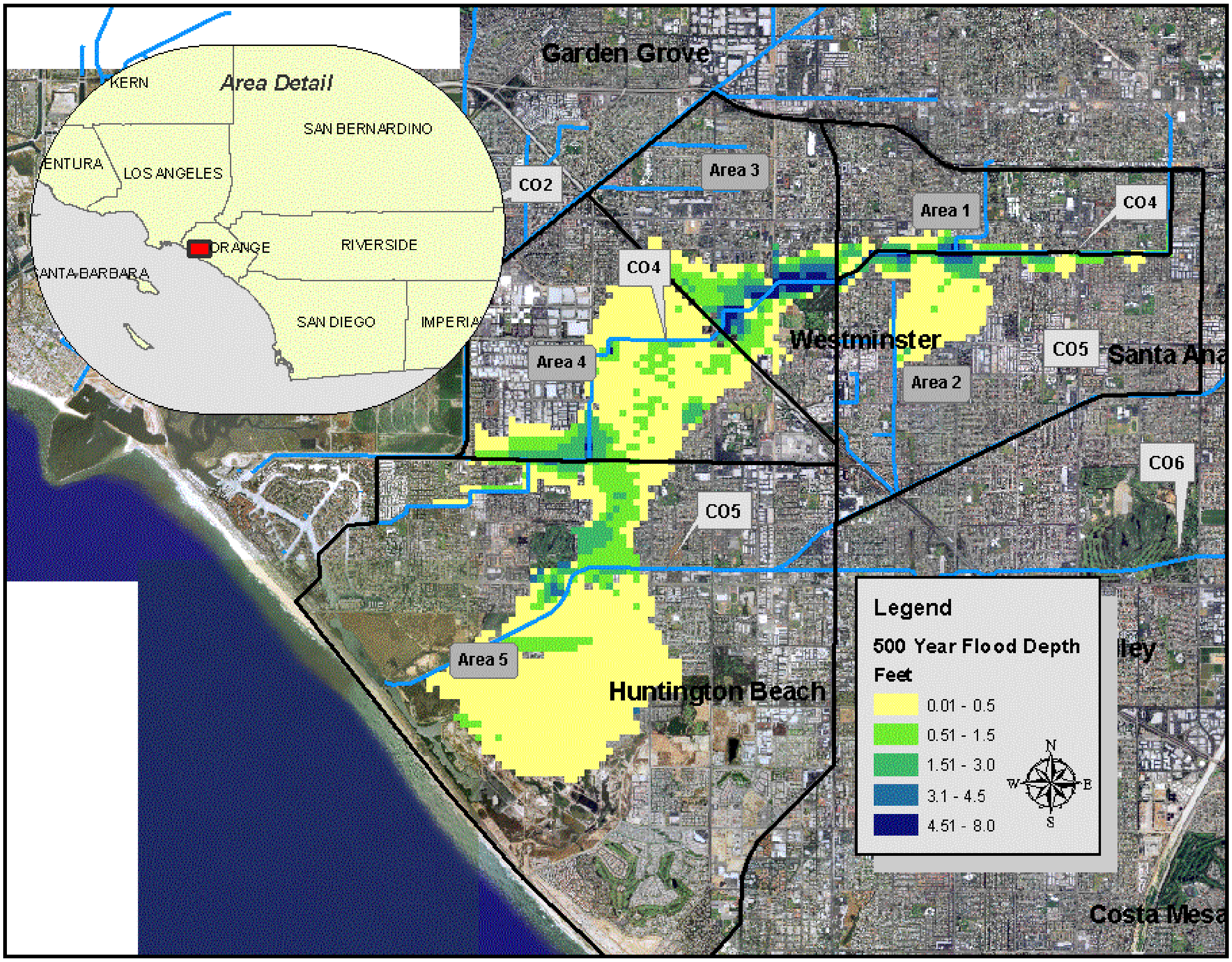

Figure 2: 500-Year Floodplain Aerial with Depth – CO4

As will be discussed in more detail in a subsequent section, real estate data show that there are approximately 11,500 parcels in CO4's 500-year floodplain. Approximately 93% of these parcels have a land use classified as Single Family Residence (SFR).

The non-damaging event varies between Impact Areas. Within Impact Area 3, it is less than the 2-year flood, although, according to the USACE floodplain modeling, the amount of overflow for the 2, 5, and 10-year events in this area is very small. In fact, for the 2-year event, breakout occurs at just one location, inundating to an average depth of around half a foot a small area in Westminster approximately 2,700 square feet in size.

CO5 & CO6

According to the latest 100 and 500-year floodplain delineations developed by USACE Engineers, the CO5 and CO6 floodplain spans areas within the cities of Huntington Beach, Fountain Valley, Westminster, Santa Ana, and Garden Grove (see picture below). The floodplain extends approximately 10 miles inland from the coast of Huntington Beach, with the easternmost point located within the city of Garden Grove, just shy of the city of Orange. The widest section of either floodplain is approximately two miles across. Utilizing the ArcMap program, it is estimated that the 500 and 100-year floodplains encompass around 17 and 11 square miles, respectively. As the map below of the 500-year floodplain shows, the floodplain narrows at the confluence of the CO5 with the CO6 channel, but then widens, and for the next three miles along the CO5 channel the floodplain mostly comprises the land south of CO5 and north of CO6. At that point, the floodplain breaks out on both sides of CO5 for approximately four miles upstream. According to hydrologic and hydraulic (H&H) data, the average flood depths within the 50, 100, and 500-year floodplains are 1.72, 1.80, and 2.02 feet, respectively.

The floodplain was divided into eight impact areas. Seven impact areas are shown in the figure below, while, for the analysis, Impact Area 3 was divided into two impact areas. The impact areas were delineated based on channel and overflow characteristics. This is done primarily because the HEC-FDA program requires the assignment of damages to a particular point within a channel reach. As the table here shows, Impact Area 7 has the greatest average depth of flooding – greater than five feet for the 500-year event.

Table 2: Mean Flood Depth per Impact Area – CO5 & CO6

Impact Area	50-yr	100-yr	500-yr
1	0.15	0.32	0.82
2	0.12	0.2	0.67
3	0.49	0.74	1.6
4	0.62	0.99	2.14
5	0.98	1.25	2.05
6	1.71	2.17	4.09
7	2.77	3.51	5.39

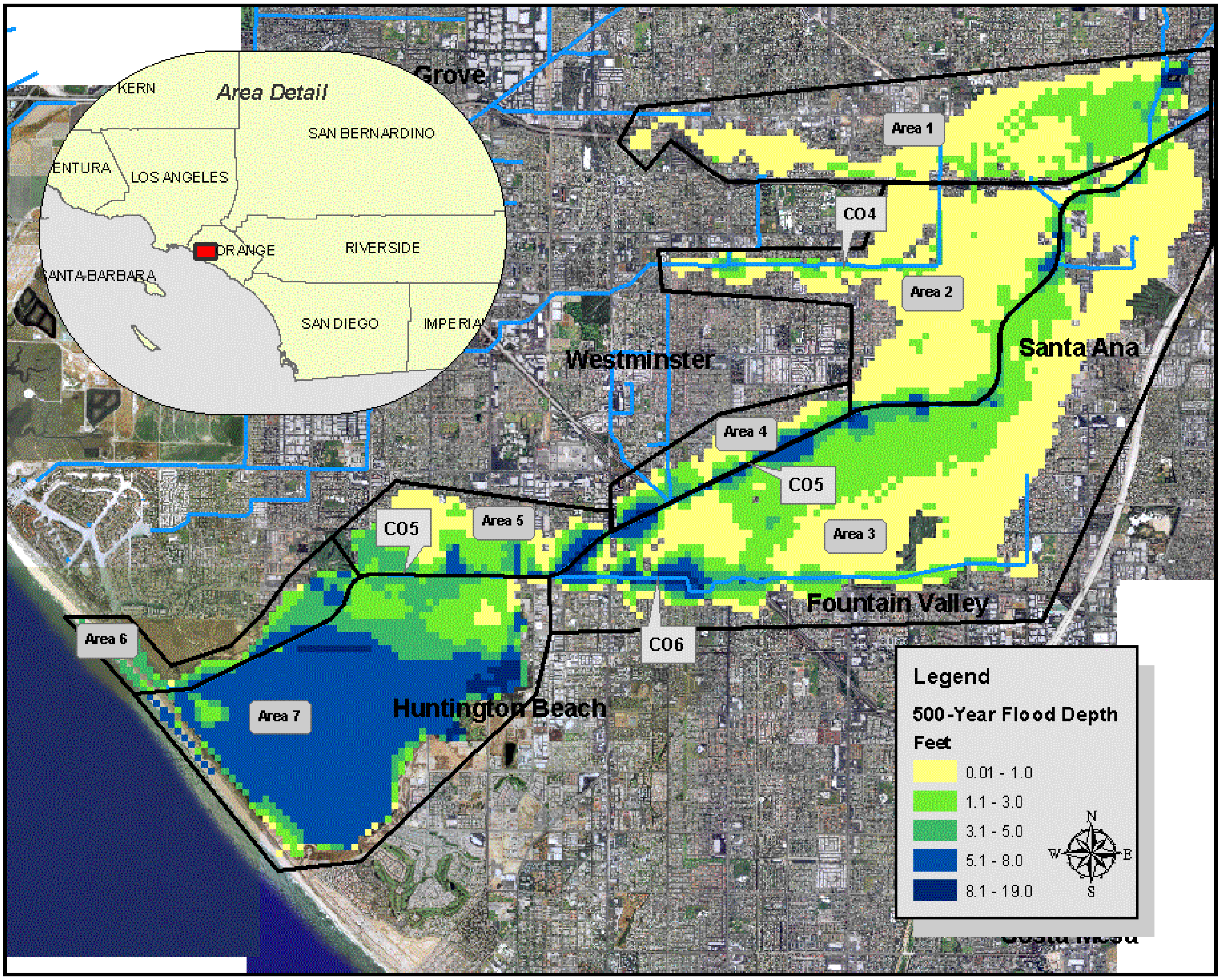

Figure 3: 500-Year Floodplain Aerial with Depth– CO5 & CO6

The figure above shows the extent and depths associated with the 500-year floodplain of both CO5 and CO6, separated by impact area. As can be seen, Impact Area 7 – the furthest area downstream – has the greatest flood depths.

The ten-year storm event is designated by study engineers as the non-damaging event for the entire length of the CO5 and CO6 channels based on channel conveyance capacities. As will be discussed in more detail in the Land Use section, the floodplains of these channels consist of high-density urban development – primarily residential with a small amount of industrial and commercial activities (10% or less of the acreage within the floodplain footprint). With a per square mile population of approximately 7,000, approximately 140,000 people are estimated to live within the 20-square mile 500-year floodplain. It is estimated that for the 500-year flood, approximately 20,000 residents would be subject to flooding of greater than two feet within their homes, while around 12,000 residents would be subject to greater than four feet of flooding.

Historical Flooding

FEMA claims records associated with overflows from CO5 and CO6 show that between the years 1992 and 1998, for four storm events, claims totaled approximately $533,000 and $495,000, respectively. No information has yet been gathered on the historic damages from overflows from CO4.

Previous storm events in the local area and region demonstrate the area's significant susceptibility to flood damages from large storm events. While there are no records directly attributing significant flood damages to CO4, CO5, and CO6, overflows from these channels have almost certainly contributed to damages have been attributed to other nearby flood conveyance systems such as the nearby Santa Ana River; but no accounting of this has been completed for these events. With recent improvements to the Santa Ana River and other flood damage reduction features in the region, most of the remaining flooding threat to Orange County is attributable to CO4, CO5, and CO6. The table below describes some of the more notable flood events in Orange County since the early 19th century.

Table 3: Significant Flood Events in Orange County

Year	Description of Event
1825	Flood on the Santa Ana River said to have created Balboa Island in Newport Beach.
1862	Considered the area's worst-recorded flood; most of County covered by at least three feet of water.
1914	Santa Ana River overflow submerges nearly all of Newport Beach; row boats used to get around.
1916	Four die in massive flooding that washes out most roads and rail lines, leaving Orange, Fullerton and Tustin marooned.
1938	Fifty-eight people killed, portions of downtown Garden Grove, Santa Ana and Anaheim under water, all bridges washed out.
1969	Five people die in Silverado Canyon when they are buried by mudslide; $12 million in damage countywide.
1983	Intense rain overwhelms channels, damaging nearly 1,000 homes and causing $48.5 million in damage.
1995	Channels again overflow, flooding dozens of homes from Seal Beach to Garden Grove.
Source: Los Angeles Times, October 3, 1999 'Disaster Prompted $1.3 Billion Effort to Tame Santa Ana River, Protect Basin'	

Population

Based upon information obtained from the State of California Department of Finance, Orange County had just over three million residents in 2006. This figure represents an increase of .8% over the previous year. Between 2000 and 2006 the rate of growth in the County's population was slightly lower than the overall rate of population growth in California.

With respect to population, Orange County is the fifth largest county in the nation, and the second largest in California. The annual rate of growth of the County population was as high as 22% per year during the 1950s, but as the absolute number of residents increased, and as open land became increasingly scarce, the annual rate of growth decreased significantly over each subsequent decade – to the current rate of less than 2%. While the *rate* of population growth has slowed, the County is still adding a large number of new residents each year; over 30,000 each year, which ranks it eighth among U.S. counties.

The State of California Department of Finance projects that Orange County's population will approximate 3.5 million by 2020, and that it will exceed 3.7 million by the year 2050 as shown in the table below. Such growth rates imply average annual compound increases of one percent between 2006 and 2020, and an annual increase of just .2 percent between 2020 and 2050. According to the projections, the County population will stabilize at or around the year 2040. It is expected that over the next several decades the population growth will increasingly be from a natural increase, and net migration (in-migration minus out-migration) is expected to turn negative by 2010.

Table 4: Population Projections for Selected Southern California Counties

County	2006	2010	2020	2030	2040	2050	Percent Growth 2006-2050
Orange	3.07	3.26	3.53	3.67	3.70	3.70	20.5
Los Angeles	10.25	10.46	10.86	11.24	11.38	11.43	11.5
Riverside	1.95	2.17	2.68	3.18	3.72	4.31	120.8
San Bernardino	1.99	2.13	2.46	2.76	3.03	3.29	65.3
San Diego	3.07	3.26	3.63	4.01	4.29	4.51	46.8
CALIFORNIA	37.17	39.24	43.85	48.11	51.54	54.78	47.4

Source: 2003 California Statistical Abstract; California Department of Finance, Demographic Research Unit. All population numbers in millions.

For the cities located entirely or partially within the Study Area watershed, the 2006 population was about 1.34 million, or roughly 45% of the County total. Between 2005 and 2006, all of the cities had a population growth rate that was less than the growth rate for the County overall.

Table 5: Westminster Watershed City Populations

City	Population (2006)	Population Growth % (05-06)
Anaheim	342,410	0.20
Cypress	48,854	0.30
Fountain Valley	57,405	0.40
Garden Grove	171,765	0.20
Huntington Beach	201,000	0.50
Los Alamitos	12,004	0.40
Santa Ana	351,322	0.20
Seal Beach	25,298	0.20
Stanton	38,761	0.20
Westminster	92,408	0.50
Total	1,341,227	0.45

Source: California Dept. of Finance

As shown in the table at left, the most populous city within the watershed is Santa Ana, followed by Anaheim, Huntington Beach, and Garden Grove.

Population projections for the cities within the watershed were not available, but assuming that the future growth rate until build out is equivalent to the current rate, and assuming build out occurs at 2040 (as is expected for the County), the cities would combine to have 1.49 and 1.59 million residents by 2020 and 2050, respectively. This represents a net increase of around 24,000 residents by the year 2050. Currently, the majority of new residents each year in the County are the result of natural increase (births minus deaths).

Income & Employment

Orange County has a diversified economy, with a labor force of just over 1.5 million and a November 2006 unemployment rate of 3.8%, according to the California Economic Development Department. The average annual unemployment rate in the County over the last decade has been persistently lower than both the national and California rates. The most significant labor markets in the County are trade (around 19% of employment), business and professional services (18%), and manufacturing (13%). Orange County's Gross Metropolitan Product (the value of goods and services produced in the County) is comparable in value to the Gross Domestic Product of Finland or Venezuela.

The table below compares several local economic indicators to the state and national economies. This and the other tables in this section are meant to be generally illustrative of the relative population and economic characteristics of the cities and regions, and do not necessarily represent the latest available data for a particular city or region. In compiling and presenting the data, priority was given to using a single, reliable source for each indicator over simply finding the most recent figures available from a variety of sources.

According to the figures, the median household income in Orange County is thirty and fifteen percent higher than the national and state income figures, respectively. Median home prices (single-family owner-occupied) in Orange County are more than three times the national median price, and more than twenty-five percent higher than home prices in broader California. Incredibly, according to the California Association of Realtors, the median home price in Orange County rose 30% between July 2003 and July 2004, and 13.6% between 2004 and 2005, to $617,000. It should be noted that in the table below the combined city data is only approximated for the year indicated because of a lack of data. The actual unemployment rate for the cities is expected to be marginally lower than what is shown in the table, while the median household income and median home price are expected to be slightly higher.

Table 6: Comparative Economic Indicators

	Population (million)**	Gross Metropolitan Product ($B)^	Unemployment Rate**	Median Household Income ($)^	Median Home Price ($)*
US	296	10,980	4.5%	43,318	188,900
California	37.1	1,446	4.6%	48,440	474,500
Orange County	3.07	154	3.4%	55,861	627,000
Westminster Watershed Cities	1.34	N/A	5.0% (approx.)	48,327 (approx.)	299,073 (approx.)
Sources: US Census Bureau; California Economic Development Department; National Associations of Realtors; California Association of Realtors; *2004; **2006; ^2003					

An overall comparison of the cities within the Westminster Watershed can be seen in the table below. Three of the cities have median household incomes that are greater than the County median; these are Cypress, Fountain Valley, and Huntington Beach. Overall, the cities have a lower average median household income and a higher unemployment rate than the County.

Table 7: Westminster Watershed City Comparison

City	Population (2005)	Unemployment Rate (Feb 2005, %)	Median Household Income ($)^	Housing Units (2003)	Median Home Price ($)^*
Anaheim	345,317	5.0	45,707	100,277	346,074
Cypress	48,863	4.1	64,377	16,145	252,800
Fountain Valley	57,353	3.3	69,734	18,479	289,500
Garden Grove	172,042	5.5	47,754	46,958	199,700
Huntington Beach	200,763	3.1	64,824	76,818	311,800
Los Alamitos	12,003	2.0	55,286	4,337	307,100
Santa Ana	351,697	6.5	36,968	74,912	330,761
Seal Beach	25,334	2.8	42,079	14,370	363,500
Stanton	38,600	6.4	39,127	11,054	164,000
Westminster	92,270	4.4	49,450	27,057	227,300
Total or Weighted Average	1,344,242	5.0	48,327	390,407	299,073

Sources: California Dept. of Finance; U.S. Census Bureau. ^2003 data for Anaheim and Santa Ana. All others 2000. *Single family owner-occupied home.

Land Use & Housing

According to Orange County's Watershed & Coastal Resources Division, the watershed covers an area of approximately 57,500 acres. Residential development covers around 21,000 acres, or roughly 35% of the watershed. Commercial and industrial activities occur on approximately 6,900 and 4,300 acres within the watershed, respectively, while 255 acres are devoted to recreational use. Vacant land comprises nearly 8,000 acres.

Table 8: Land Use – Westminster Watershed

Land Use Type	Acres
Residential	20,910
Vacant Land	7,986
Commercial	6,897
Industrial	4,334
Transportation, Communication & Utility	417
Education and Religion	398
Recreational	255
Agriculture Use	162
No Data Available	4,921

*Source: Orange County Watershed & Coastal Resources Division, April 2005

Orange County is one of the nation's most densely populated counties, and it ranks second in California behind San Francisco. The County has a population density that is approximately fifty percent higher than Los Angeles County, and ten times that of Maricopa County, Arizona. The table below shows the population and housing densities of the cities within the Westminster watershed as of the 2000 U.S. Census. Given the population growth since 2000, and the lack of open, developable space, the current densities are undoubtedly higher.

Table 9: Comparative Population and Housing Density

	Area, Square Miles			Density, Per Square Mile	
	Total Area	Water Area	Land Area	Population	Housing Units
California	163,696	7,736	155,959	217	78
Orange County	948	159	789	3,605	1,228
Anaheim	50.5	1.5	48.9	6,702	2,038
Cypress	6.6	0.0	6.6	6,991	2,424
Fountain Valley	8.9	0.0	8.9	6,168	2,072
Garden Grove	18.0	0.0	18.0	9,165	2,591
Huntington Beach	31.6	5.2	26.4	7,184	2,867
Los Alamitos	4.1	0.1	4.0	2,876	1,079
Santa Ana	27.4	0.3	27.1	12,452	2,748
Seal Beach	13.2	1.7	11.5	2,100	1,240
Stanton	3.1	0.0	3.1	11,971	3,524
Westminster	10.1	0.0	10.1	8,724	2,665
Los Angeles County				2,344	806
Maricopa County, AZ				339	136
Source: US Census Bureau, 2000 Census					

Importantly, housing demand within the cities that comprise Orange County continues to outpace housing unit construction. According to the 2005 Community Indicators report, one indication of the degree of demand for housing relative to supply in an area is the ratio of new jobs to new housing permits issued. The higher the ratio the greater the excess demand for housing is presumed to be, which is said to cause housing prices and rents to increase. According to the report, as of 2003 Orange County's ratio of 2.36 was nearly four times as high as that for San Diego, over six times as high as Phoenix, and fifty-nine times higher than Minneapolis. In 2003 the County added 21,800 new jobs while issuing just 9,248 housing permits. Assuming three persons per housing unit, the population projections cited previously for the watershed cities would indicate that there will be around 10,000 additional housing units needed by the year 2050.

To meet this demand, the County is making an effort to make future development more efficient by increasing the density of residential housing projects. According to the County, higher net housing density (measured as units per acre on land devoted purely to housing – not counting land dedicated to roads, parks, commercial space, etc.) will, among other things, reduce infrastructure costs, make public transit more effective, and increase the amount of land available for other uses such as recreation. The net density of existing residential development is 7.8 units per acre, and the County is proposing that new residential projects have a net density of approximately 20 units per acre. The construction of housing developments with a higher net density will ostensibly allow the population to grow at a higher rate than it would have grown otherwise.

Structure Inventory & Valuation

In order to estimate the value of damages to property as a result of flood events within the study's floodplains, it is first necessary to inventory the structures and other assets within the floodplain. This section describes how the inventory and valuation of structures were accomplished. The next section will utilize this data to develop an estimate of the damages likely to occur from flooding.

Structure and Content Inventory

The combined floodplains for CO5 and CO6 contain nearly 30,000 parcels, and CO2 and CO4 contain over 11,000 parcels (the number for CO2 is not currently known). More than 92% of these structures are classified as SFRs. Given such a large number of structures in the floodplain, a complete field inventory was not feasible. Instead, field inventorying of the SFR structures was completed by multi-stage cluster sampling, while for all other structure types the attempt was made to attain a complete inventory. The sampling method for SFRs is explained in the Methodology section below.

Table 10: Structure Categories

Category	Description
SFR	Single-family residences
MFR	Multi-family residences
MH	Manufactured housing units
Commercial	Retail stores, offices, hotels, etc.
Industrial	Manufacturing and similar facilities
Public	Municipal buildings, schools, etc.

For the structure valuation, the Depreciated Replacement Cost was estimated using Marshall & Swift construction unit cost estimates, and adjusting for the existing condition and variance of local costs from the national average.

Because the value of contents within commercial and industrial structures can vary significantly between regions, cities, and even floodplains, it is often the case that for the Economic Analysis a detailed content survey of these types of structures within the floodplain is undertaken. The end result of the survey process is a ratio of content value to structure value (CSVR) that can be applied to the relevant structure types in the study's structure inventory. This study, however, because of limited resources available for the study, and because of the high proportion of SFRs relative to other structure categories (over 90%), utilizes CSVRs that were developed either for other studies or by an expert panel for application in USACE flood damage studies. There does not appear to be any reason to believe that these ratios would not be broadly applicable within the study area, and their use has saved a considerable amount of study resources.

The table below shows the ratios assumed for the content-to-structure values of the different classifications of residential and non-residential buildings in the floodplain. The content ratios represent an estimate of the depreciated replacement value of the goods inside each structure. For residential structures, ER 1005-2-100 restricts Corps studies from using baseline estimates of content to structure value ratios greater than 50% unless an empirical survey was undertaken in the study area.

Table 11: Content-to-Structure Value Ratios (CSVR) Used

Structure Type		CSVR	Source
Residential	SFR	0.5	1
	MFR	0.22	2
	MH	0.5	1
Commercial	Eating and Recreation	0.4	2
	Groceries & Gas Stations	1.42	2
	Professional Businesses	0.91	2
	Repairs and Home Use	0.62	2
	Retail and Personal Services	1.71	2
	Warehouse & Contractor Services	0.68	2
Other	Industrial	1.7	3
	Public	0.37	2

Sources: 1 - ER 1105-2-100; 2 - Expert Panel Meeting, Houma, Louisiana, February 13, 1997; 3 - Previous Los Angeles District Surveys, including Murrieta Creek and Lower Mission Creek.

Methodology

An initial inventory of the parcels in the 500-year floodplain was compiled in ArcGIS (ArcMap) software by linking a shapefile of the floodplain with a shapefile containing the parcel information, and then exporting to a spreadsheet those parcels in the floodplain. For each parcel, the data was linked to the geographic center of mass of the particular parcel by creating a data centroid within the ArcMap program. Because only those parcels whose centroid overlaps the floodplain are considered as impacted, only those parcels that are at least bisected by the floodplain are included in the inventory. This is done in an attempt to improve the accuracy of the structure inventory – eliminating the inclusion (and ultimate valuation) of those parcels that are least likely to have structures that are actually impacted by the flooding, even while a portion of the parcels receive some non-zero level of flooding. The centroid creation is also used to automate the determination of flooding at the structure; this will be discussed in greater detail in a subsequent section.

The parcels identified as within the 500-year floodplain via the procedure described above were then matched to data downloaded from the First American Real Estate Solutions® database. The real estate database includes parcel-specific information on structure type, square footage, construction date, information on improvements, etc. The vast majority of the residential structures inventoried fit into the Class D category. Class D buildings are characterized by combustible construction. The exterior walls may be made up of closely spaced wood or steel studs, as in the case of a typical frame house, with an exterior covering of wood siding, shingles, stucco, brick, or stone veneer, or other materials. They may also consist of an open-skeleton wood frame on which some form of a curtain wall is applied including the pre-engineered pole or post-frame buildings.

The calculation of structure value in a floodplain can be done several different ways, each having their advantages and disadvantages. One method, estimating the Depreciated Replacement Cost of the structures in the floodplain, involves integrating the following: size of the structure, the unit cost of construction as measured in cost per square foot, and an allowance for deterioration as measured as a percent of total value. An alternative way of calculating the total structure value in the floodplain would be to use tax assessment records on each parcel's improvement value. While this assessment information is readily available, California's Proposition 13, which limits increased assessments until a home is sold, results in unequal valuations of one home relative to another. It is primarily for this reason that this study will use the Depreciated Replacement Cost method. More information on the different structure valuation methods can be found in IWR Report 95-R-9, *Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*. The Depreciated Replacement Cost method requires visits to the structures themselves in order to attain the necessary information, which includes foundation height, structure type, and structure condition. This process is explained below.

Given the massive floodplain, sampling was done to collect information on a representative sample of the residential structures in the floodplain. For the other structure categories (commercial, industrial, etc.), of which there are much fewer, a more complete inventory was collected.

There are numerous possible sampling methods for the residential structure inventory. According to IWR Report 91-R-10, multi-stage sampling is most useful for sampling large populations across a large geographic area. The sampling is done in two or more stages, either simple random or systematic random sampling, and each stage should be less broad (less macro) than the previous. Importantly, the sampling percentage or proportion at each stage should be the same.

For the first step in the structure sampling, each parcel in the floodplain is associated with a particular Thomas Guide© map reference number (for example: page 857, grid A3), which was downloaded along with the real estate data. There are a total of 94 unique map reference numbers that are wholly or partially in the 500-year floodplain. The first stage of sampling was done at this level, with one-third of the map numbers being selected at random within Microsoft Excel by assigning each map reference number a unique, random number using the "=rand()" function, then sorting the columns in ascending order according to the value of the random number, and selecting the top one-third for sampling. The same procedure was followed for the selection of streets within the map reference numbers – again selecting a number equivalent to one-third of the eligible streets. Those structures along these sampled streets comprised the final structure inventory sample. For example, following this methodology, approximately ten percent (2,400) of the SFRs within the CO5 and CO6 floodplains should be inventoried. In reality, this sampling methodology resulted in a sampling of approximately 15% (3,500) of the SFR structures in this area. The same sampling method was followed for the residential structures in the CO4 floodplain.

While the number of structures sampled is large in absolute terms, the percentage of structures in the floodplain that were sampled is smaller than for the typical feasibility study. While the proportion of structures inventoried would ideally be greater, it is believed that, done properly, sampling can result in a reasonably accurate description of the assets in the floodplain.

Done properly, a sample provides an estimate that closely approximates what one would find if every structure within the floodplains were inventoried. In order for the sample to be representative of the greater population, the sample must be of a sufficient size. The size of the sample that is required depends, among other things, on the variance of the population and the amount of sampling error that one is willing to tolerate. The relevant variables for the determination of the sample size include the following:

a) An estimate of the mean of the critical variable;
b) An estimate of the variance of the critical variable;
c) The level of precision desired; and
d) The "t" value corresponding to the particular level of precision desired.

The required sample size (n) is calculated by the following equation:

$$n = t^2 * \frac{s^2}{(\hat{Y} * r)^2}$$

Where,

s^2	=	The variance of the critical variable.
$\hat{Y}$	=	An estimate of the mean of the critical variable.
r	=	The level of precision desired – in this case .05, or 5% of the true mean for the sample.
t	=	The t table value corresponding to the probability that the resulting sample estimate of the variable mean will be within the specified range of precision.

The critical variable in this case is the depreciated replacement cost per square foot.

For SFRs, prior to beginning the field inventory work, the mean critical variable (the DRC per square foot) was estimated to be 75, and the range was expected to be between 40 and 110. These values are arrived at by combining Marshall & Swift square foot construction cost estimates with adjustments for construction quality and a depreciation factor that is based on structure condition. For SFRs, it is assumed that the mean home is of average construction quality and in good condition. The lower end represents homes of fair construction quality in fair condition, and the high end represents those structures of very good construction quality in new condition. When the variance is unknown, IWR 91-R-10 states that one method of estimating it is to divide the range of values (the difference between the high and low) by four and square the result. This results in a standard deviation of 17.5 and a variance of 306. The range of values was assumed to be particularly high in order to ensure that the calculation of the required sample size did not underestimate the number of samples needed. Inserting these values into the equation, as shown below, results in a sample size of 84. The criterion employed here, as shown in the equation below, is that the estimate of the mean be within 5% of the actual population mean 95% of the time.

$$n = 1.96^2 * \frac{306}{(75 * .05)^2};$$

$$n = 84$$

The sample size calculated above serves as a minimum requirement for statistically significant results under random sampling[1]. Importantly, the methodology employed for this study was multi-stage cluster sampling - not pure random sampling – and thus a greater sample size would be needed to compensate for the fact that the final sample includes small groups of structures that are located near each other (and are thus, on average, more similar to each other than would be expected under random sampling). For a given sample size, the results of multi-stage cluster sampling would be less accurately representative of the actual population of structures than under pure random sampling. Thus, for cluster sampling a larger sample is required to achieve the desired level

[1] According to the inventory sample results, the variance of per square foot cost may be less than originally assumed, and would indicate the need for a slightly smaller sample size (70 instead of 84).

of precision. For this reason, for CO5 and CO6, the study sampled 212 clusters with an average of 16 SFRs per cluster.

The valuation of the structures in the floodplain requires information on construction quality, current condition, number of stories, and first floor elevation. Once collected, this information was utilized to calculate the structure depreciated replacement values. Base per square foot construction cost estimates for each structure type were determined by utilizing the Marshall and Swift Real Estate Valuation Service method according to the following procedure:

- Construction quality and current condition of the structures were noted from field surveys.
- For a given structure type, the per square foot construction cost (replacement cost) was determined using the most current Marshall & Swift Valuation Service data. This per square foot cost estimate reflects the construction quality of the structure.
- The per square foot costs, which are based on a national average, were modified to reflect local cost conditions using Marshall & Swift local cost multipliers.
- This current, locally adjusted cost per square foot was then adjusted additionally for the condition of the structure, which determines the appropriate depreciation factor to apply. In order to correlate the current condition of the structure to a percent depreciation, the study utilized Tables 7 through 9 of IWR Report 95-R-9, '*Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*'.
- The depreciated replacement cost per square foot values were multiplied by square footage to arrive at the total depreciated replacement value for the different types of structures.
- If the square footage was not available within the real estate records for a particular property, square footage estimates were made from either aerial photography measurements using the ArcMap program or by applying the mean square footage of other structures of the same classification for which square footage is known.

Inventory Results

CO4

The table below shows an inventory of the approximate number of the various types of structures in the CO4 floodplain according to the real estate records. The numbers are only approximate because the numbers reflect an assumption of one structure per parcel. In the case of public structures, the numbers shown below are greater than what actually exists because many public parcels – parks, etc. – do not have structures on them. Alternatively, for commercial structures the table underestimates the number of structures because often more than one structure exists on a given commercially-zoned parcel. Importantly, in this analysis as the term structure is defined, a single structure can comprise more than one business – as is the case for many community centers (otherwise known as strip malls). While the table below is not an accurate accounting of the *number of businesses* on a particular parcel or within a particular structure, because there is not typically more than one structure one a particular parcel the figure for commercial structures in the table is likely only a slight underestimation of the actual number of commercial structures in the floodplain. This also applies to the inventory numbers shown further below for CO5 and CO6. As can be seen from the table, Single Family Residences (SFRs) comprise the vast majority of the structures in the floodplain – just greater than 93%. For the SFRs, approximately 90% were built between 1956 and 1978, and just 2% were constructed after 1979.

Table 12: Floodplain Structures – CO4

Type	500-Year	100-Year	50-Year	Mean Build Year - All
SFR	10,740	1,817	439	1965
MFR	238	70	38	1966
MH	8	1	1	na
Pub	106	31	14	na
Com	183	50	21	1967
Ind	189	57	27	1976
Ag	0	0	0	na
Total	11,464	2,026	540	na

CO5 & CO6

The table below shows an inventory of the numbers of the various types of structures in the CO5 and CO6 floodplains according to the real estate records. As can be seen from the table, Single Family Residences (SFRs) comprise most of the structures in the floodplain.

The real estate data shows that the vast majority of the housing stock in the floodplain was constructed between 1950 and 1979. The mean and median construction date for both SFRs and MFRs is 1964. Approximately half of the structures were constructed between 1960 and 1969, and 95% of the structures built between 1946 and 1983. There has been very little new construction since 1980, and these relatively newer homes account for only around 2% of the housing stock.

Table 13: Floodplain Structures – CO5 & CO6

Type	500-Year	100-Year	50-Year	Mean Build Year - All
SFR	24,900	15,403	11,935	1964
MFR	1,019	513	400	1964
MH	54	23	10	na
Pub	221	169	131	1948
Com	664	352	265	1965
Ind	197	69	37	1972
Ag	2	0	0	na
Total	27,057	16,529	12,778	na

Structure and Content Valuation

This section describes the estimates of structure and content value in the two floodplain areas. It is important to note that the tables contain estimates of depreciated replacement value, and do not represent expected damages. Instead, the estimates can be seen as the value of the assets that are exposed to flood damages.

CO4

Using the Marshall and Swift construction cost data, and applying the field data, the depreciated replacement cost of the structures and contents in the floodplain was estimated. The table below shows the estimated total values for the 500-year floodplain. Employing the methodologies described above, the structure and content values for each structure were estimated. The table includes the mean structure value for each category. The mean value for commercial structures is particularly high because a significant percentage of the structures are represented by larger, multi-unit community shopping centers (and not a single store). According to the inventory, the total depreciated replacement cost of the structures and contents in the 500-year floodplain is approximately $2.6 billion.

Table 14: Value of Structures and Contents in 500-Year Floodplain – CO4

Type	Total Structure Value ($M)	Mean Structure Value ($)	Content Value ($M)	Mean $/SF	Mean FFE
SFR	$1,066	$97,084	$533	61	0.6
MFR	$97	$486,400	$22	49	0.8
MH	tbd	tbd	tbd	tbd	tbd
Pub	$83	$3,316,000	$32	81	0.5
Com	$233	$808,619	$221	72	0.5
Ind	$116	$678,900	$199	38	0.5
Subtotals	$1,600		$1,007		
Total Structure & Content ($M)	$2,607				
^SF is square foot and FFE is first floor elevation in feet - both are means. $/SF					

CO5 & CO6

The table below shows the estimated value of structures and contents in the CO5 and CO6 floodplain. The estimated total value is around $6.3 billion. The table also shows the estimated mean depreciated replacement cost per square foot and the mean first floor elevation.

Table 15: Value of Structures and Contents in 500-Year Floodplain - CO5 & CO6

Type	Structure Value ($M)	Mean Structure Value ($)	Content Value ($M)	Mean $/SF	Mean FFE
SFR	$2,548	$95,000	$1,275	61	1.04
MFR	$460	$429,000	$101	45	0.89
MH	$20	$46,000	$10	37	2
Pub	$173	$216,000	$60	83	0.5
Com	$537	$813,000	$614	78	0.62
Ind	$190	$824,000	$315	52	0.34
Subtotal	$3,928		$2,375		
Total Structure & Content ($M)	$6,303				
^SF is square foot and FFE is first floor elevation in feet.					

The next section will discuss the estimation of damages to these structures across various flood events, as well as assess the economic damages related to other impacts.

Property Damages

Flooding can cause myriad significant damages to structures of all types. According to Martin L. King of the Association of Specialists in Restoration and Cleaning, in an article for Slate.com[2], water can cause a structure's structural components to shift or warp – including the studs and foundation. Water can also damage the wiring, gas lines, and septic system. For high water, ceilings may sag under the weight of trapped water or soggy drywall, wet floorboards can bend and buckle, and the roof may leak or break altogether. Flooding in a basement can be especially dangerous; if the water is removed too quickly, pressure from the soaked earth outside can push inward and crack the foundation walls. Most of the structures in the floodplains that are studied in this analysis are wood frame, and this type of structure will suffer greater exterior damages than those made of brick or masonry. In all types of residential housing, though, flooding will most likely destroy the interior walls. Soaked wallboard becomes so weak that it must be replaced, as do most kinds of wall insulation, and any plywood in the walls is likely to swell and peel apart. Water can also dissolve the mortar in a chimney, which creates leaks and thus a risk of carbon monoxide poisoning once the heat comes back on.

Also, floods often deposit dirt and microorganisms throughout the house. Silt and sediment can create short circuits in the electrical system as gunk collects in walls and in the spaces behind each switch box and outlet. Appliances, furnaces, and lighting fixtures also fill with mud, making them dangerous to use. Anything that gets soaked through with water may contain sewage contaminants or provide a substrate for mold. Most upholstered items must be thrown away, as well as carpets and bedding.

This section includes a description of flood damages expected to accrue to structures, contents, and vehicles in each floodplain. The other damage categories included in the analysis – clean-up, emergency, administration, etc. – will be discussed in subsequent sections.

Methodology Overview

For the typical flood damage analysis, the HEC-FDA program is used to combine H&H and economic data (structure inventory, etc.) in order to derive a stage-damage function for each reach or impact area. Among other inputs to this procedure are water surface profiles for the various channel or river reaches, which are an output of the HEC-RAS model utilized by engineers. For this study though, a different flood modeling program was used (FLO2D) that doesn't create water surface profiles, but instead provides as an output surface flood depths across the floodplain. For this reason, it was necessary to calculate the stage-damage function outside of the HEC-FDA program, which would then be an input into the HEC-FDA program, further incorporating risk and uncertainty into the analysis and resulting in an estimate of the Expected Annual Damages from flooding.

Using numerous shapefiles within the ArcMap computer program, each structure in the floodplain was associated flood depths for the 50, 100, and 500-year flood events. The flood depth shapefiles are an output of the FLO2D program model, and were provided by USACE Engineers. A shapefile delineating parcels in the floodplain was provided by Orange County officials for use in this analysis. The figure below is an example of the overlay of the two shapefiles (shown at close range).

[2] "What Happens to Flooded Houses?" by Daniel Engber; August 31, 2005. Can be found at http://slate.msn.com/id/2125351/

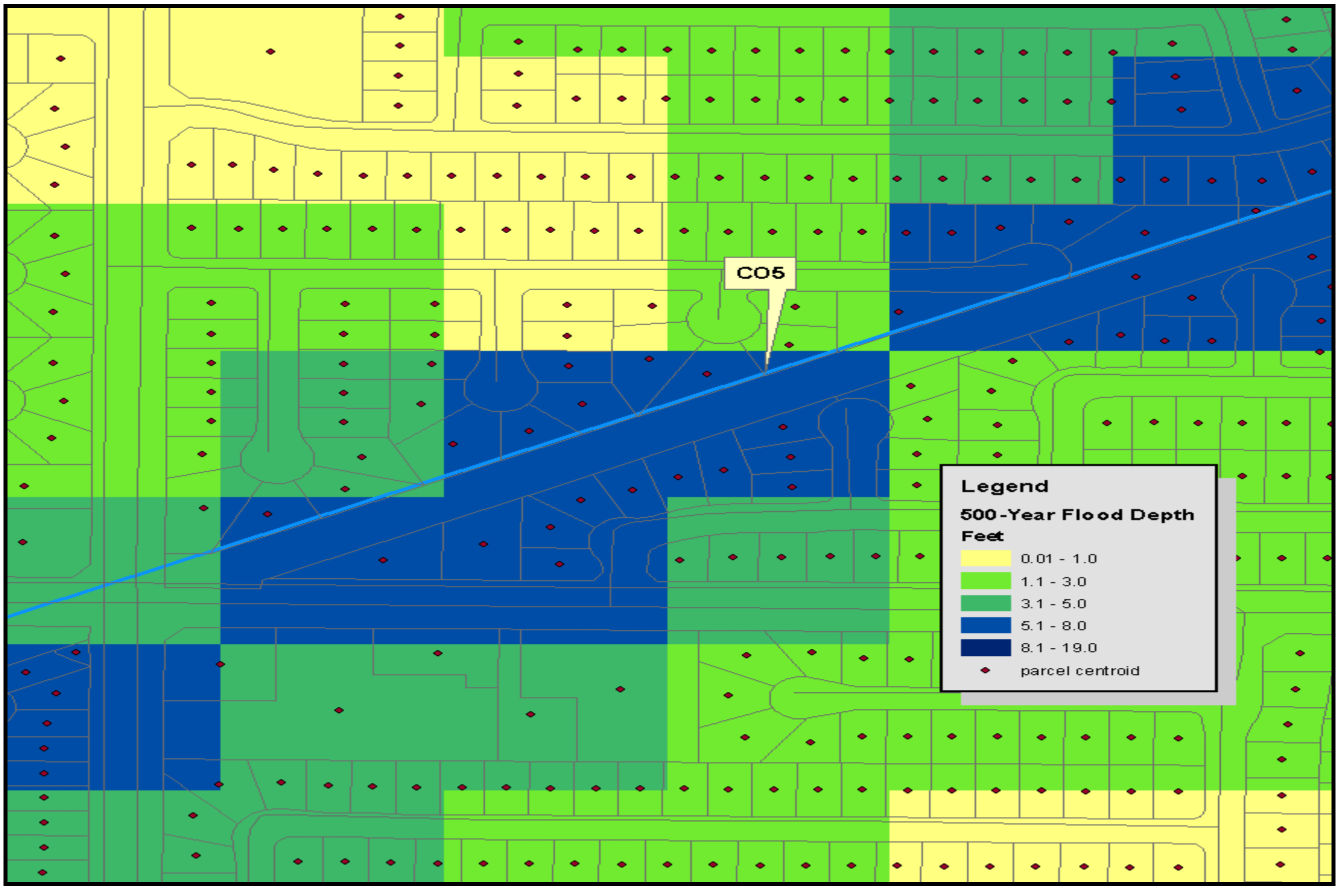

Figure 4: Flood Depth at Structure Example

Using the shapefiles produced as FLO2D outputs, the parcel centroids were spatially joined to their respective flood depths for the three different flood frequency events (50, 100, and 500). The ArcMap program was then prompted to produce an output table giving the depth of flooding at each structure for each of the three flood events.

The estimation of damages was conducted in part by using the @RISK program, which is essentially an add-on tool used within the Microsoft EXCEL program. The U.S. Army Corps of Engineers developed a template to estimate damages from various single storm events, which provides as an output a mean damage estimate and a corresponding standard deviation. Damages were estimated for three flood events: the 50, 100, and 500-year events. These results serve as inputs to the HEC-FDA program. The @RISK program template allows for direct entry of water depths at each parcel, combining this information with data on the foundation height and structure characteristics at each parcel in the particular floodplain. Like the HEC-FDA program, the @RISK program uses Monte Carlo simulation in the calculations. Unlike HEC-FDA though, the @RISK template calculates the damages by referencing the depth of water at each individual structure, as opposed to referencing the structure to a water surface profile that corresponds to a channel or river cross section. The @RISK outputs are a frequency-damage function that is then matched transitively with the appropriate frequency-stage functions to arrive at a stage-damage function for entry into HEC-FDA.

The @RISK program was used to calculate and aggregate damages associated with most of the damage categories included in the analysis. These include damages associated with all structures and contents, vehicles, private cleanup costs, and displacement costs (temporary relocation).

The HEC-FDA program was utilized to calculate expected annual damages. Among the data requirements for the program to calculate EAD are three functions:

1) Exceedance Probability/Discharge Function – A relationship that defines for many points within each channel, and across a large range of values, the probability in a given year that a specific discharge will be exceeded.
2) Stage/Discharge Function – A relationship between the depth or elevation of water and the amount of discharge (cfs) in the channel.
3) Stage/Damage Function – A relationship between the depth or elevation of water in the interior of the floodplain and the amount of economic damage expected as a result.

Each of these functions must be defined for each reach/impact area, based upon a representative cross section, or index location, within the impact area. The first two functions were derived by Engineering Division staff based upon output from the HEC-RAS model. The third function is typically derived within the HEC-FDA program. Structure inventory data, including values, elevations, depth/damage functions, and locations, are entered into the Economics Module of the program. The program calculates aggregated stage/damage functions by cross referencing water surface profile data imported from HEC-RAS with the structure data based upon the cross section, or river mile location, assigned to each structure.

As noted, for this study, because of the nature of flooding in the study area, a determination was made that the FLO2D model provided better estimates of overbank flooding than would be capable with the HEC-RAS model. Because of this, frequency/damage functions were derived outside the HEC-FDA program within the @Risk framework as discussed previously. The output of the @Risk model is frequency/damage functions for each impact area. Since the HEC-FDA model requires a stage/damage function for each impact area, the frequency/damage functions were transitively associated with stages instead of frequencies based upon the Exceedance Probability/Discharge and corresponding Stage/Discharge functions derived from HEC-RAS modeling. For example, if the @Risk model results yielded SFR structure damages of $10 million for the 50 year event for Impact Area X, first the discharge for the 50-year event for Impact Area X is determined from the Exceedance Probability/Discharge function, and then for this discharge, the corresponding stage is determined from the Stage/Discharge function. This stage is then associated with damages to derive stage/damage functions for each impact area.

In some areas, adjustments were needed to the stages used for the Stage/Discharge and Stage/Damage functions, again, because of the nature of flooding in the study area. The topography in many locations is such that elevations are the same or even lower as one moves further from the channel. The result is a large floodplain with generally shallow flooding. The HEC-RAS model output shows water surface elevations for discharges exceeding channel capacity that essentially do not change for less frequent events. Although the water surface elevation at the location of the channel may not increase, the actual flood depths in the overbank area do increase with less frequent flood events. Accordingly, stages for discharges exceeding channel capacity were adjusted to reflect the average increase in overbank flood depth based upon the FLO2D results. This has the benefit of both reflecting the nature of flooding in the floodplain and enabling the HEC-FDA program to function properly, as the program requires increases in each of the major parameters for less frequent flood events (discharges, stages, and damages) to yield logical results.

The following outlines and summarizes the major steps taken to estimate the damages to property in the various floodplains.

- Structure value and FFE are estimated for each parcel in the floodplain (see Structure Inventory and Valuation section) – structure inventory database created within MS Excel;
- Structures are separated into various impact areas;

- Within the ArcMap program, a parcel shapefile with centroids is overlain with flood shapefiles of the 50, 100, and 500-year events – results exported to a database file;
- For each parcel, the structure inventory database is updated to include flood depth for each of the three flood frequencies analyzed;
- Utilizing the @RISK program, Monte Carlo simulations are performed (1000 iterations per simulation) to estimate the mean and standard deviation of damages associated with each of the flood frequencies – incorporating Risk and Uncertainty in the calculations;
- H&H data are entered into the HEC-FDA program in order to further incorporate Risk and Uncertainty – frequency-discharge and stage-discharge data;
- Outputs of the @RISK simulations entered into HEC-FDA as stage-damage functions for each damage category for each impact area – frequency-damage data from @RISK transitively converted to stage-damage data by utilizing frequency-stage data;
- The HEC-FDA model is run, producing an estimate of the Expected Annual Damages for each category for each impact area for each channel.

Use of Depth-Damage Functions in @RISK

Depth-damage functions were utilized for the estimate of damages to structures, contents, and vehicles. For a given depth of flooding, the amount of damage depends on the type of structure. The methodology here utilizes depth-damage curves derived by FEMA data, previous feasibility study data, and USACE guidance documents.

The structure depth-damage curves estimate the flood damage as a percentage of structure value. Thus, to calculate the damages for an individual structure, the appropriate depth-damage curve is applied to the structure via a spreadsheet lookup function, which combines the appropriate damage percentage with the structure value to give an estimate of structure damage. The depth-damage curves for the major structure categories are shown in the graphs below.

In the depth-damage graphs below, each line shows the structure damage as a percentage of total depreciated replacement value for each particular property category. In the legend, the numbers following the structure type (for example, SFR-1) designate the number of stories.

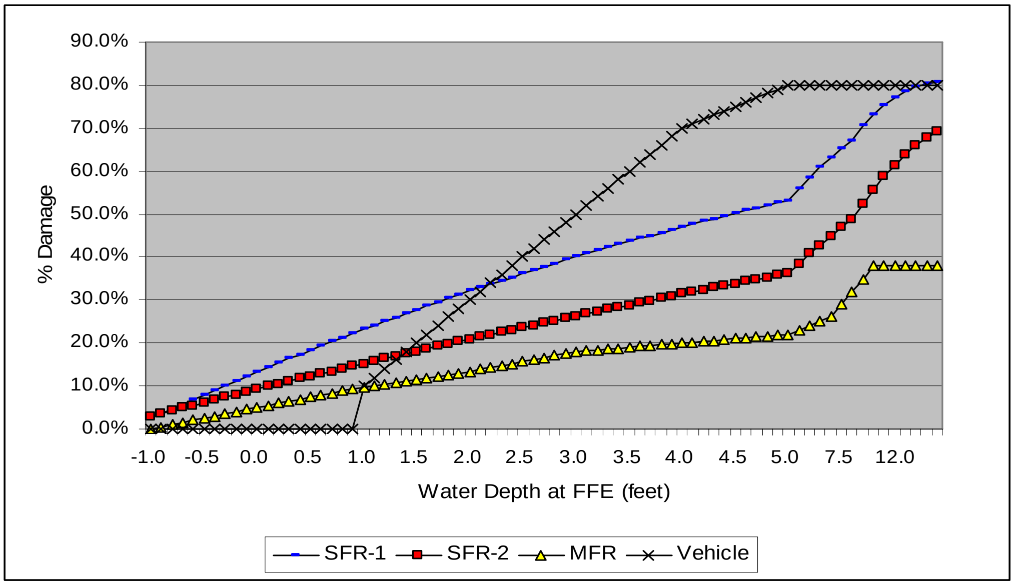

Figure 5: Structure Depth-Damage Curves (1)

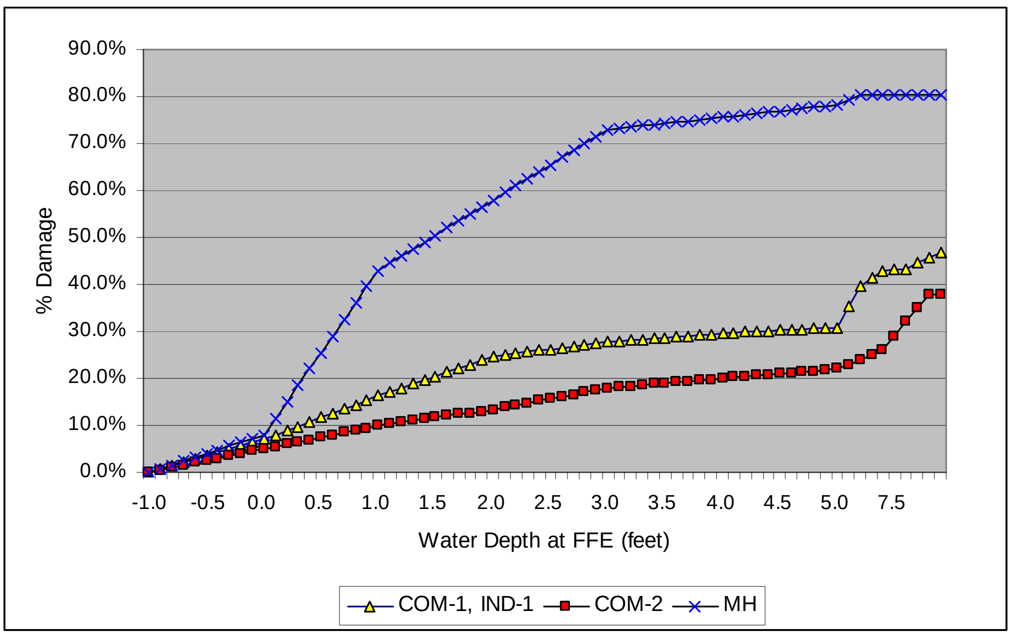

Figure 6: Structure Depth-Damage Curves (2)

The approach taken here to quantify damage to *contents* relies on three pieces of information: 1) structure value; 2) content-to-structure value ratio; and 3) the content depth-damage relationship. The content-to-structure value ratio and content depth-damage relationship are unique to the structure occupancy type to which a structure is assigned. To estimate content damage for an individual structure, the structure value is first multiplied by the content-to-structure value ratio to provide an estimate of the total content value. This content value is then multiplied by the value of percent damage specified by that type of structure's particular content depth-damage function.

For vehicles, on average, very little damage is expected at low flood levels (around one foot or less). At depths greater than one foot, however, damages increase dramatically as water reaches electrical components and floods key engine parts. No single, definitive depth-damage curve was found for use in this study, but other Corps studies have conducted useful surveys of both vehicle owners and car dealers. While the curves vary somewhat between studies, they show important similarities. All three curves show no damage between zero and one foot of flooding, and all show eighty percent damage at five feet of flooding and above. The curve chosen for use in this study is the only one of the three to be developed as part of a post-flood damage survey[3].

Like the estimation of the frequency damage relationship for structures and contents, the damage to vehicles was calculated within the @RISK program for the 50, 100, and 500 year events. Within the program, residential structures were assigned a vehicle that was assumed to be parked at the first floor elevation. Given the depth-damage curve employed for the vehicles, non-zero damages were calculated only for those vehicles assigned to structures at which there was at least one foot of flooding above the first floor elevation. Given that in many cases vehicles are likely to be parked at street level (typically below the first floor elevation of the structure), the inclusion of this assumption likely means that the estimate is conservatively low. Upon further consideration, it is believed that this assumption is erroneous, and a more realistic assumption would be to assign the vehicles to an elevation at least slightly below the FFE – an elevation between the ground and the structure's basic foundation. Given the time required to re-run the aggregate damages model, it was decided that this adjustment to the analysis would be made for the next study phase. Such an adjustment should at least moderately increase the estimate of expected damage to vehicles, and preliminary tests indicate that it could as much as double the total vehicle damage.

Economic Uncertainty Parameters

Many of the factors that influence the estimate of flood damages can and should be represented by a range of values instead of a single number. The estimate of the value of and damage to economic assets in the floodplain is based on numerous inputs, none of which are understood or known with 100% certainty. Errors in measurement, variation in classification and judgment, and a general lack of information all contribute to the inability to accurately describe these values with a single, discrete number. For the economic elements of this study, in accordance with EM 1110-2-1619, uncertainties in the following parameters were considered in the damage estimation:

- Structure Value
- Content Percentage
- First Floor Elevation
- Depth-Damage Percentage (structures, contents, vehicles)
- Vehicle Value
- Displacement Cost
- Cleanup Cost

For each individual structure, these values are assigned a particular distribution and analyzed by utilizing the technique of Monte Carlo sampling with one-thousand iterations. Monte Carlo sampling is a technique for using random or pseudo-random numbers to sample from a probability distribution. With Monte Carlo sampling (as opposed to, for example, Latin Hypercube sampling), it is especially important that a large number of iterations be run in order to ensure that the lower probability events in the distribution are adequately sampled and accounted for in the results.[4] Of course, there is also uncertainty in the hydrologic and hydraulic relationships (discharge-stage and frequency-discharge), and this is accounted for in the HEC-FDA model.

[3] Post Flood Damage Survey, Las Vegas Flood of 1999, USACE Los Angeles District
[4] More on the principles of Monte Carlo sampling can be found at: www.epa.gov/ncea/raf/montecar.pdf.

Residential Structure Damage

For each of the channels, this section shows a) the total structure and content damages associated with the SFR structure category, and b) the Expected Annual Damage (EAD) for each structure category. Only total damage to SFRs is shown both in the interest of brevity and because this category constitutes the vast majority of structure and content damages for most impact areas. In the following tables, the Total Damages numbers are an output of the @RISK model, and these are displayed for the three events being analyzed. Alternatively, the EAD results are the output of the HEC-FDA program, and these numbers incorporate a probabilistic factor. As a result of the lack of real estate data for manufactured housing units (MH), estimates of damage to these units have not yet been fully completed; these damages will be fully accounted for the next phase of the study process.

For CO4, the output of the @RISK damages model indicates that for the nearly 11,000 SFR structures in this floodplain, there would be more than $140 million in structure and content damages from a 500-year event. Such an event would cause an average of $13,200 in structure and content damage to SFRs in this floodplain. The 100 and 50-year events would cause over $23 million and $7 million in damages, respectively. For MFRs in the floodplain, structure and content damage for the 500-year event are estimated to total $5.4 million.

Table 16: Total Damages, SFR Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	4,200	1,846	546	228	179	52
	2	17,546	5,707	3,226	1,344	1,423	643
	3	7,387	3,732	3,279	1,319	1,773	674
	4	29,682	6,510	3,628	962	1,377	415
	5	52,736	12,014	8,163	941	397	185
	Total	111,551	29,809	18,842	4,794	5,149	1,969
		141,360		23,636		7,118	

The following table shows the structure and content damages in terms of EAD for all structure categories in the CO4 floodplain. As shown, total EAD for structures and contents is just over $2.7 million, and damage to SFR and MFR structures and contents accounts for 60% of the total structure and content damages in the CO4 floodplain.

Table 17: EAD, All Structures & Contents, CO4 ($'000s)

Channel	Impact Area	Occupancy Type						Total
		SFR	MFR	Com	Ind	Pub	MH	
CO4	1	60	0	243	0	17	tbd	320
	2	303	5	33	3	11	tbd	355
	3	191	63	21	469	52	tbd	796
	4	400	3	68	80	10	tbd	561
	5	600	23	65	0	16	tbd	704
	Total	1,554	94	430	552	106	tbd	2,736

For the nearly 25,000 SFRs in the combined CO5 and CO6 floodplain (valued at around $3.8 billion including contents), the economic damages model predicts structure and content damages from the 500-year event to total just less than $780 million, while the damage from a 100-year and 50-year event total $427 million and $321 million, respectively. According to these numbers, the average per-structure damage to SFRs in this floodplain from a 500-year event would be just over $31,000.

Table 18: Total Damages, SFR Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	29,561	10,765	12,630	2,557	6,513	949
	2	40,515	12,083	11,710	4,389	6,859	3,102
	3	77,559	32,914	35,911	17,440	25,306	10,770
	4	24,377	12,293	12,162	6,107	7,767	3,912
	5	41,184	19,959	26,960	12,729	21,166	10,552
	6	16,729	9,341	9,856	5,042	7,985	3,924
	7	196,769	143,358	143,358	79,417	118,797	62,695
	Subtotal	426,694	240,713	252,587	127,681	194,393	95,904
CO6	1	76,783	35,206	35,102	11,516	23,193	7,395
	Total	503,477	275,919	287,689	139,197	217,586	103,299
		779,396		426,886		320,885	

In terms of EAD, the SFRs and MFRs combine to account for approximately three-quarters of the total for the combined CO5 and CO6 floodplain. As shown below, the total EAD for structures and contents is just less than $30 million, while SFRs and MFRs account for 76% of the total, or around $22.7 million. Around sixty percent of the residential damages, and fifty percent of the total structure and content damages, occur in Impact Area 7 of CO5.

Table 19: EAD, All Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	Occupancy Type						Total
		SFR	MFR	Com	Ind	Pub	MH	
CO5	1	948	98	1,322	22	252	0	2,642
	2	970	26	246	183	228	6	1,659
	3	2,830	230	867	635	668	91	5,321
	4	732	31	476	0	0	0	1,239
	5	2,108	151	87	402	37	0	2,785
	6	726	1	0	0	0	0	727
	7	10,481	523	620	0	107	12	11,743
	Subtotal	18,795	1,060	3,618	1,242	1,292	109	26,116
CO6	1	2,252	621	672	0	0	0	3,545
	Total	21,047	1,681	4,290	1,242	1,292	109	29,661

Commercial & Industrial Structure Damage

For CO4, according to the models, just over 350 commercial structures would be damaged as a result of a 500-year flood event, and these structures would, on average, suffer just over $100,000 of damage each (including both structures and contents). On average, industrial properties would suffer $171,000 in damages. Table 17 shows that the EAD for commercial and industrial structures and contents totals $430,000 and $552,000, respectively. The majority of damages to commercial structures occur in Impact Area 1, while most of the damage to industrial structures occurs in Impact Area 3.

For CO5 and CO6, the 500-year event would cause damages to commercial structures totaling approximately $157 million, and damage to industrial structures totaling $51 million. Thus, the commercial and industrial structures and contents, on average, would suffer $279,000 and $231,000, respectively. Table 19 shows that the commercial structure and content EAD totals nearly $4.3 million, and EAD for industrial structures and contents totals over $1.2 million. Nearly one-third of the commercial damages occur in Impact Area 1 of CO5, while 80% of the industrial damages are split between Impact Areas 3 and 5.

Public Structure Damage

For the CO4 floodplain, the 500-year flood event is estimated to cause $8.6 million in damages to public structures and their contents. For this size event, the average damage to the structures and contents of those public facilities that are shown to have non-zero damages totals over $346,000. This per structure damage estimate is much higher than the average damage estimate for, for example, SFRs both because public structures (like schools) tend to be much larger than other types of buildings, and the construction cost per square foot for schools is often much higher than the cost for other structure categories. The overall EAD for public structures and contents in this floodplain is $106,000.

For the CO5 and CO6 floodplain, total structure and content damage from a 500-year event is estimated to be $38.5 million. For the sixty-nine public structures that are damaged to some extent, the average damage incurred as a result of a 500-year event is $558,000. The overall EAD for public structures in this combined floodplain is $1.3 million.

Private Vehicle Damage

The damage to vehicles in a floodplain is typically not a significant damage category for the study in either absolute or relative terms. That is, compared to the value associated with other damage categories such as structure damage and emergency costs, damage to vehicles is typically not significant, and thus, in most cases, is not estimated as part of the feasibility study. In this case however, the floodplain comprises such a massive geographic area (approximately 20 square miles) that the number of vehicles affected will likely be in the tens of thousands. While, compared to structure damage, damage to vehicles will be relatively small, the absolute value of these damages is likely to be significant. Importantly, the analysis includes only damages to private vehicles, and does not include damages that would be incurred by, for example, public vehicle fleets such as school buses.

According to IWR Report 88-R-2 “Motor vehicles can suffer extensive damage from floods that barely reach the first floor level of nearby buildings… Expected vehicle damage potential should be given a lot of attention where the flood warning lead time is six hours or less.” According to USACE Engineers, for each of the three frequency events, bank overtopping begins approximately five hours after the beginning of the storm event. Of course, the timing of the storm impacts the number of households that receive the flood warning – for example, fewer people would receive the warning during sleeping hours. In general, though, given that at least some degree of flooding occurs a relatively short time after the storm, and given that any flood warning would be made even less time before flooding begins, this analysis assumes that vehicle flooding will constitute a significant source of damages, and as such should be investigated in reasonable detail.

The number of vehicles in the floodplain will be estimated as a function of the number of households in the floodplain. The *number* of vehicles damaged in a flood event is estimated as a function of the following:

- The duration of the warning lead time prior to the local flood event;
- The number of vehicles remaining at the residences during the typical working hours;
- The timing of the flood event – both time of day and day of the week; and
- The location of the parked vehicles within the flooded area – at street level or within a garage.

The *value* of the damages to vehicles from a flood event is estimated as a function of:

- All of the above;
- The depreciated value of the vehicles affected; and
- The depth-damage relationship for the vehicles.

Since the prevailing land use in the floodplain is residential, the number of vehicles damaged would, ostensibly, be highest were the flood event to occur during the off-peak work hours, and highest during non-waking hours. The number of damaged vehicles would be lowest during the typical working hours of a weekday.

According to the US Census Bureau's 2003 American Community Survey, approximately 80% of commuters in Orange County drove alone to work, while approximately 10% carpooled – almost all of these in 2-person carpools. Thus, during the primary working hours, the percentage of primary vehicles parked at residences is estimated at around 15% (20% minus half the carpool percentage of 5%) for the working, commuting population. According to the survey, in 2003 there were approximately 1.36 million employed persons over the age of sixteen in Orange County. Of course, many families have more than one vehicle, which may remain at the residence with a stay-at-home spouse or simply as a second vehicle. According to 2000 US Census, the average number of vehicles per household in Orange County is 1.87[5].

During a flood event, some percentage of the residential vehicles will be away from the floodplain as a result of chance (vehicle driven to work or elsewhere) or as a result of the owner intentionally moving the vehicle out of the floodplain. The proportion of vehicles subject to flood damages is thus a function of the amount of flood warning time and the timing of the flood event (time of day as well as day of the week).

For this analysis it is assumed that two-thirds of the vehicles will be out of the floodplain during a flood event. This assumption is based on the idea that, with adequate warning time, around half of the vehicles that are in the floodplain just prior to an event will be intentionally moved out of the floodplain, while an additional proportion of the vehicles will by chance not be located in the floodplain.

In order to value the flood damages to vehicles in the floodplain, an estimate of the average vehicle value is made. In 2000-2001, the average vehicle license fee (VLF) paid in the State of California was $60. According to the State, this amounts to approximately .65% of the average vehicle value during that year.[6] Thus, given these two numbers, it can be shown that the State of California estimated the average vehicle value in the state during that fiscal year to be $9,230. Inflating this amount by the consumer price index for the Los Angeles and Orange County Metropolitan areas general price index[7] (13.6% inflation over the period) results in a June 2006 average value of approximately $10,500. This value approximates an inflation-adjusted estimate included in a RAND Corporation study[8].

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[5] Source: U.S. Census Bureau. *Census of Population and Housing, 1990 and 2000* long-form (sample) data.
[6] The previous VLF of 2% of vehicle value was reduced 67.5%, resulting in a VLF that is represents .65% of the vehicle value. Source: California Legislative Analysts: *The 2002-2003 Budget Bill: Perspectives and Issues*. Found at www.lao.ca.gov/analysis_2002/2002_pandi/pi_part_5d_vlf_anl02.html
[7] Source: US Bureau of Labor Statistics, June 2005.
[8] *Fighting Air Pollution in Southern California by Scrapping Old Vehicles.* RAND Corp., 2001.

For CO4, the output of the @RISK program shows that total damages to private automobiles for the 500-year event totals just over $2 million. Impact Area 3 accounts for the majority of total CO4 auto damages for each frequency analyzed. The EAD for automobiles within the CO4 floodplain is estimated to be $36,000.

For CO5 and CO6, the majority of auto damages occur in Impact Area 7 of the CO5 floodplain. This is, of course, because of the combination in this area of large numbers of residential structures and high flood depths. For the entire combined floodplain, the 500-year event is expected to cause damages to automobiles totaling $66 million. As shown in the table below, the total EAD to private automobiles is just over $1.2 million.

Table 20: EAD, Auto Damages, All Channels ($'000s)

Channel	Impact Area	Auto Damages
CO4	1	2
	2	2
	3	29
	4	3
	5	0
	CO4 Total	36
CO5	1	14
	2	49
	3	158
	4	50
	5	144
	6	72
	7	528
	CO5 Total	1,015
CO6	1	234
	CO5 & CO6 Total	1,249

Emergency Costs & Other Damage Categories

Beyond damages to the actual structures themselves, both the possibility of flood events and, of course, the floods themselves impose additional costs that should be accounted for. These costs include: cleanup costs; emergency costs expended by the federal government (FEMA) during and in the aftermath of a flood event for such things as temporary rental assistance and emergency home repairs; the costs to homeowners associated with flood policy administration; damage to roads and critical infrastructure; temporary relocation expenses financed by individuals and households; the costs associated with road closures, which include time value, as well as the additional fuel and vehicle wear; and income lost by businesses.

ER 1105-2-100 states, "Flood damages are classified as physical damages or losses, income losses, and emergency costs." The ER then defines emergency costs as "those expenses resulting from a flood what would not otherwise be incurred…" The ER further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates. As with all flood damage estimates and especially in the case of emergency costs, the potential to double count damages are a distinct possibility and must be guarded against.

Structure Cleanup Costs and Temporary Relocation Assistance (TRA)

Flooding not only causes damage to structures and contents but floodwaters present a significant cost in their aftermath clean up. Floodwaters leave debris, sediment and the dangers of diseases and mycotoxins throughout flooded structures. The cleaning of most structures that have received some level of inundation is a necessary post-flood activity. These costs are not reflected in either the structure or content depth-damage curves employed in this analysis. Thus, the cleanup costs are a separate, legitimate NED damage category.

Based on prior studies[9] and price quotes from a local provider of emergency cleanup services, the cleanup cost per square foot for the extraction of floodwaters, dry-out, and decontamination of residential and commercial structures has a mean of $2.52 and a standard deviation of $0.50[10]. This price assumes no sewage contamination within the structures. For the analysis, all residential and commercial structures that receive water above the first floor elevation are assumed to incur this cleanup cost for the entire square footage of first floor of the structure. The total damages per event were calculated using the @RISK program assuming a normal distribution, and the EAD was calculated within the FDA program. The results of the model runs within the HEC-FDA program can be found in the table below, which also includes the results for Temporary Relocation Assistance (TRA).

For CO4, total cleanup damages for the 100-year event are estimated to be $3.4 million. SFRs and commercial structures account for over 80% of the total cleanup costs for this event. This category's EAD is $182,000.

For CO5 and CO6, total cleanup damages for the 100-year event are estimated to approximate $39 million. SFRs account for 70% of the damages, while the remainder is roughly evenly split between MFRs, Commercial, and Public structures. Total EAD for this category within this floodplain is $1.8 million.

[9] *Centralia Flood Damage Reduction Project, General Reevaluation Report, Economic Appendix*, July 2002
[10] The standard deviation was calculated as one-fourth the likely range of per square foot costs.

The estimate of TRA costs (also known as displacement costs) was based on actual historic disaster housing grants paid by FEMA to flood victims of sixty-eight prior floods across the nation. The mean housing assistance grant for these events was $1,583 with a standard deviation of $657. FEMA funds are typically only available within federally-declared disaster areas, and the scale of flooding here would likely entail qualification for a federal disaster declaration. These damages are applied to all residences that receive flooding above the first floor elevation. It should be noted that this damage estimate does not include the cost associated with the displacement of commercial structures, offices, or industrial operations – which would be incurred when office equipment, employees, and job functions have to be temporary relocated during cleanup and repair to flood damaged structures. Given informational constraints, no method or model for determining which of the thousands of commercial and industrial structures would be displaced was developed.

For CO4, the total TRA for the 100-year event is estimated to be approximately $730,000. As shown in Table 21, the total EAD is estimated to be $53,000.

For CO5 and CO6, the 100-year event is estimated to cause approximately $7.2 million in costs associated with temporary relocation of residents. The total EAD is estimated to be $773,000.

Table 21: EAD, Cleanup & TRA, All Channels ($'000s)

Channel	Impact Area	Damage Category		Total
		Cleanup	TRA	
CO4	1	33	3	36
	2	27	12	39
	3	47	11	58
	4	31	11	42
	5	44	16	60
	CO4 Total	182	53	235
CO5	1	204	25	229
	2	167	39	206
	3	357	122	479
	4	93	32	125
	5	195	103	298
	6	75	36	111
	7	527	294	821
	CO5 Total	1,618	651	2,269
CO6	1	216	122	338
	CO5 &CO6 Total	1,834	773	2,607

Emergency Costs

These costs include those emergency response costs that would not have been incurred in the absence of flooding from the channels. These costs include those associated with evacuation of the floodplain, flood fighting, disaster relief, and overtime pay for first responders and governmental employees. The ultimate cost of emergency services for a flood event depends on many factors, including the reach, depth and duration of flooding, the flood warning time, and the population and housing density within the flooded area. Complete records of emergency costs expended during previous flood events in Orange County were not available. In the absence of this data, one approach to estimating the emergency costs of a future flood event is to use as a baseline a cost per acre estimate from a flood event in a region for which thorough records are available. The City of Santa Barbara reports that it spent $1,632 (in 2006 dollars) per acre on emergency services for a 1995 flood estimated to be a 50-year event. While there is a great deal of uncertainty regarding the importance of the various factors that determine the magnitude of emergency costs, this per acre cost estimate can be considered conservatively low given that two of the most likely drivers – the population and housing density – is approximately fifty and twenty-five percent higher, respectively, in the Westminster study area as compared to Santa Barbara. However, in the absence of more information on the relationship between emergency costs and floodplain characteristics – such as flood depth, population density, warning time, etc. – the reported cost per acre will simply be applied.

The floodplain sizes were calculated by summing the FLO2D grid cells, which each represent an area 300 square feet in size. The total acreage and estimated emergency costs for each of the floodplains is shown in the table below. It is important to note that because there is some amount of overlapping between the two floodplains, the combined total shown below includes some amount of double-counting. Under this methodology, the estimated combined total emergency cost will be slightly les than is shown in the table below.

For CO4, the nearly 6.5 square mile 500-year floodplain is estimated to be associated with nearly $6.7 million in emergency costs, while the 1.5 square mile 100-year floodplain is associated with $1.4 million in costs. The total EAD is estimated to be $76,000.

For CO5 and CO6, the nearly 17 square mile 500-year floodplain is estimated to be associated with just less than $17.5 million in emergency costs, while the 11 square mile floodplain is associated with $11.5 million in costs. The total EAD is estimated to be $583,000.

Table 22: Emergency Costs, All Floodplains

Channel	Total Emergency Costs ($'000s)			EAD
	500-yr	100-yr	50-yr	
CO4	$6,669	$1,389	$566	$76
Acres	4,083	851	347	
CO5 & CO6	$17,483	$11,542	$9,091	$583
Acres	10,713	7,072	5,570	
Total	$24,152	$12,931	$9,657	$659

Insurance Policy Administration

IWR Report 88-R-2 states that the administrative cost of flood insurance is considered a valid non-physical damage category, and thus a decrease in the number of flood insurance policies as a result of the removal of structures from the 100-year floodplain represents a legitimate NED benefit category.

Table 23: Insurance Policy Administration

Channel	Number of Policies	Total Cost
C04	1,157	$222,144
CO5	15,747	$3,023,424
CO6	666	$127,872
Total	17,570	$3,373,440

According to USACE Economic Guidance Memorandum 06-04, National Flood Insurance Program Operating Cost Fiscal Year 2006, the annual cost per policy is $192. According Orange County officials, there are currently just fewer than 16,500 total policies associated with CO5 and CO6, and just over 1,150 policies associated with CO4. The total annual administrative cost for the three channels is just less than $3.4 million.

Traffic Delay and Detour Costs

For significant flood events, roads may be simply impassable both during the event and during any necessary cleanup operations following the event. An estimate of the cost of traffic delay and detour as a result of street flooding from the various channels in this study can be calculated as the sum of the time value associated with the additional commuting time and the cost related to the additional mileage driven as part of an alternative, longer route between locations. The critical variables to estimate include the number of vehicles detoured or slowed, the additional travel time and distance involved, and the duration that the delays and detours are in effect.

The estimation of traffic delay costs for the floodplains that are a part of this study is especially difficult because the flooding occurs across such a massive number of streets, making the determination of the most likely combination of alternative routes very complicated and highly uncertain. Additional uncertainties abound, including the proportion of drivers that will decide to forego some or all of their usual trips during the storm event, and c) what the impact of detoured vehicles will have on travel times for those vehicles traveling on roads outside of and adjacent to the flooded area.

Given these uncertainties, and in absence of a sophisticated traffic model for the flood events (the cost of developing such a model was considered but found to be prohibitively expensive), several simplifying assumptions are necessary; these are listed further below. The analysis of the traffic impacts is simplified in a way that, given the USACE value of time estimate methodology, will ensure a conservatively low total damage estimate. For example, no attempt is made to estimate the value of delay for those indirectly impacted by the flooding, which are vehicles that are delayed as a result of increased traffic volumes outside of the flooded areas as a result of drivers detouring around the flooded areas.

First, the analysis will focus on the traffic impacts from flooding from the CO5 and CO6 channels. These channels account for the vast majority of the likely impacts given its size, flood depths, and location. Also, because the floodplains are located near each other, estimating the vehicles affected for each separately would result in massive double-counting. Also, for these affected vehicles, the incremental delay and detour impacts associated with non-CO5 and CO6 floodplains are likely small.

Figure 7 below shows the 50-year floodplains for CO5-CO6, and CO4. This CO5-CO6 floodplain is smaller but similar in shape and scale to the 100-year floodplain. As the figure shows, at this frequency the flooding occurs in three major areas – these are labeled Areas 1, 2, and 3 in the figure. Baseline daily average traffic counts for all roads were obtained from CALTRANS. In order to minimize double-counting of vehicles, the vehicle counts were restricted to north and southbound travel, and for each area the counts were taken at points between the same two adjacent and parallel east/west-bound streets. While double-counting is minimized using this approach, not counting the east and west-bound traffic will result in an underestimate of the ultimate vehicle count. Traffic counts for residential, low traffic streets were not available and not included.

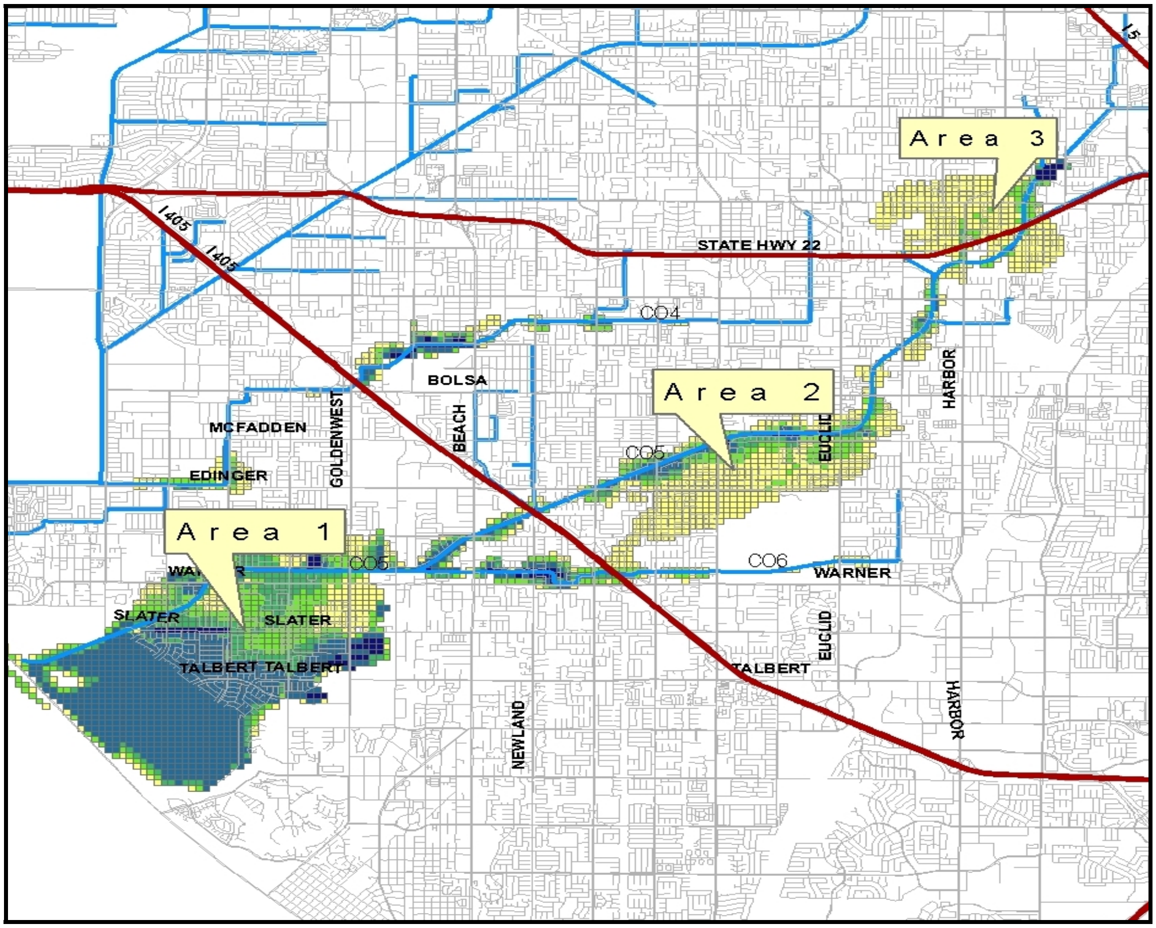


Figure 7: Traffic Delay Areas

Once the relevant traffic counts are determined, it is necessary to estimate the additional travel distance and time associated with the detour. For the 50-year flood, vehicles are assumed to choose the shortest alternate route along major roads that allows them to circumvent the primary flooded areas.

As stated previously, the analysis makes several simplifying assumptions. These include the following:

- The duration of significant traffic impacts is equal to the expected duration of flooding (45 hours);
- The average per mile vehicle operating cost is $.15 per mile, which is according to AAA and does not include fixed or variable depreciation;
- There are on average 1.6 persons per vehicle;
- For the 50 and 100-year events, the average delay is between 15 and 30 minutes per affected vehicle;
- For the 500-year event, the average delay is between 30 and 60 minutes per affected vehicle.

The estimate of operating cost per mile does not include depreciation because AAA's depreciation estimate does not distinguish between depreciation due to use and depreciation due to age alone. In order to prevent overestimation of operating cost, this component is simply eliminated.

According to USACE guidance (IWR Report 91-R-12 "*Value of Time Saved for Use in Corps Planning Studies*"), opportunity cost of time estimates are based upon the duration of the delay and the estimated annual wage of the motorist (the methodology recommends using family income). According to the U.S. Census Bureau, the average of median family annual incomes in Orange County and Los Angeles County is $64,000. The median family hourly wage is approximately $32. The guidance indicates that the hourly opportunity cost for automobile trips depends on the trip purpose and should be valued at various percentages of the motorist's hourly wage. The trip purposes are a) work, b) social/recreational, c) other trips including personal business, and d) vacation. For example, for those delayed less than five minutes, the appropriate *hourly* value should be calculated as 6.4, 1.3, .1, or 75.1% of the motorist's hourly wage, respectively. For delays greater than five minutes but less than 15 minutes, the opportunity cost per hour is valued at 32.2, 23.1, 14.5, and 75.1% of the motorist's hourly wage. For all delays over 15 minutes, the percentages increase to 53.8, 60, 64.5, and 75.1%. As is indicated above, the applicable hourly proportion for vacationers is the same across all delay durations. It is important to clarify that the value is calculated by multiplying the hourly fraction of the actual delay by the percentages listed above (for example, a 30 minute delay of a work commuter would mean .5 x .538 x the median hourly income x the number of passengers). Also, only for those cars commuting to work is the average passengers per vehicle relevant – as the calculation of average value for that purpose involves a summation of the median family incomes of all work commuters in a particular vehicle.

Because the trip purpose percentages on weekdays will vary considerably from the percentages on the weekends, this factor must be included in the valuation. The final valuation of the flood impacts to traffic is thus weighted for the probability of the timing of the flood event. While the traffic counts for the freeway is assumed to be equivalent for both weekday and weekend days, the proportions of trips by purpose will clearly change between weekdays and weekend days. Whereas during the week the trips by purpose are assumed half for work, it is assumed that on the weekend the proportion of work trips is one-quarter, while the remaining three-quarters are divided equally between the other non-work purposes. For simplicity, the 45-hour flood event is assumed to occur across only two days: two weekdays, one weekday and one weekend day, or two weekend days. The calculations account for the likelihood of the events occurring on different combination of days (two weekdays, one weekday and one weekend day, etc.), weighting them appropriately.

Traffic counts by the Orange County Transportation Administration (OCTA) for the year 2000 were utilized. The 2000 data gives the data for the major roads and freeways in the floodplain. Drawing a straight line across the floodplain in a way that touches each of the major east-west oriented roads just once and avoids crossing any north-south oriented roads, it is possible to get a rough, albeit ostensibly highly conservative, estimate of the daily trips through the floodplain; this method will presumably minimize double-counting of trips. The traffic counts indicate that there is at a minimum 400,000 trips per day through what would be the flooded portion of the study area for the 500-year event.

The analysis utilizes the @RISK software to help the analysis incorporate into the results the uncertain nature of the factors that will determine the magnitude of the final estimate of economic impact estimate. The variables and the parameters assigned to each are listed below. For the type of distribution, the numbers represent the minimum and maximum values of the triangular distribution.

Table 24: Risk and Uncertainty Parameters – Traffic Impact

Variable	Frequency	Type of Distribution
Number of Vehicles (1,000s)	50 to 100-Year	Triangular (150, 200)
Number of Vehicles (1,000s)	500-Year	Triangular (300, 400)
Avg. Vehicle Delay (minutes)	50 to 100-Year	Triangular (15,30)
Avg. Vehicle Delay (minutes)	500-Year	Triangular (15,90)
Avg. Detour Length (miles)	50 to 100-Year	Triangular (4,6)
Avg. Detour Length (miles)	500-Year	Triangular (4,15)
Duration of Flooding Impacts (hours)	All	Triangular (24,48)

The table below shows the EAD of the traffic impacts from flooding. It is important to reiterate that the analysis has been completed using generally conservative estimates. While there is a high degree of uncertainty associated with the results, the estimate most likely occupies the lower end of the likely range.

Table 25: Traffic Delay and Detour Cost

Category	Total Cost ($'000s)			EAD
	500-yr	100-yr	50-yr	
Delay	$17,979	$4,270	$4,270	$296
Operating	$675	$160	$160	$12
Total	$18,654	$4,430	$4,430	$308

Income Loss to Businesses

According to IWR Report 88-R-2, "Income losses are reductions in the national income when flooding or the threat of flooding halts production or delivery of goods and services. National losses occur 1) when the production or delivery of these goods and services are not recuperated by postponing the activity or transferring it to another location, or, 2) when there are additional costs caused by delay or transfer of the activity." These losses can occur before, during, and after the flood event. The key to the definition of NED income losses is that the loss is not recuperated, in other words non-recoverable. Businesses where losses would be expected to be non-recoverable include: public utilities, those where delays in delivery or processing causes spoilage of perishable items, businesses that produce unique products or whose competitors are at full production, and media outlets such as newspapers and radio stations that provide the only sources of local or national information.

When calculating these losses that are part of this NED category, it is important to include only factors that provide real increases in the value of the output, and, in order to avoid double-counting, exclude costs to the business not already included in the property and content estimates. Institute for Water Resources Report 88-R-2 provides guidance on how to compute income-loss for a given business. According to the report, the equation is as follows:

$$L = N * V * D / H$$

Where L = the income loss for an individual business;
N = the number of employees;
V = the annual value-added by the business per employee;
D = the duration in operating hours that a business is closed; and

H = the number of hours the business operates in one calendar year.

One of the redeeming qualities of this equation is that the broad estimates of all of the variables are readily available via sources like the U.S. Bureau of Economic Analysis. Given that the floodplain is so large though, there is great difficulty in determining just how many businesses would incur losses that classify as "non-recoverable". Given the complexity and uncertainty associated with estimating income loss (as narrowly defined within the NED framework) in this floodplain, and given that the magnitude of income loss is not likely to be significant relative to the sum of other damage categories such as structure and content damage, the analysis does not attempt to quantify income loss as a result of flood events.

Damage to Roads

The Corps has recently begun attempts to develop a methodology to help estimate the damage to roads caused by flooding. A recent study addressing this issue was completed by BMA Engineering for the USACE Institute for Water Resources (IWR) entitled "*Methodology for Developing Predictive Models for Flood Damage to Roads*". It had previously been determined that "quality data of actual flood damage to roadways was not in a user-friendly environment, and parametric modeling was a desirable and realistic approach for an effective software tool to develop cost estimates of flood damage of roadways." This latest study is meant to be used by USACE Economists to help estimate the monetary damages of floods and, thus, the benefits of flood protection as it relates to roads.

The report describes a multivariate, linear regression model with four explanatory factors that include: flood flow direction relative to roadway centerline, floodwater velocity, roadway slope type, and roadway sub-base type. The final equation takes the following form:

$$DamageRatio(Y) = -1.135 + 0.279X_1 + 0.169X_2 + 0.077X_3 + .064X_4,$$

Where X_1 is the flow velocity, X_2 is the direction of flood flow relative to roadway centerline, X_3 considers the road slope type (grass, rock, etc.), and X_4 factors in the sub-base type of the road. Each variable is assigned an ordinal value based on a scale defined as part of the study. According to the equation, the primary determinants of the degree of road damage are the velocity and direction of the flood flows. Because the FLO2D program creates as an output the velocity and direction of flows for each of the flood events, identifying where flood damage is most likely to occur is relatively straightforward. Unfortunately though, as it exists now, the regression model developed is not perfectly applicable to the type of roads that exist in this study's floodplains and across the broader watershed. The model appears to have been developed with the types of roads found in more rural settings – not those with adjacent concrete sidewalks and asphalt parking lots. Researchers at IWR have indicated that they believe the model can be adjusted to account for the more urban setting. It is hoped that these adjustments can be made in the near future so that the with-project analysis can include this damage category. The following text and figures provide a brief introduction to how the road damages will be evaluated in the future.

The figure below shows the flow velocity and direction for the 500-year flood event near the intersection of the CO5 and CO6 channels. As the figure shows, nearly all of the flows are less than 1.5 ft/sec. Where the flow is between .51 and 1.5 ft/sec., according to the IWR road damage model, damage would only be incurred when the flood flow is perpendicular to the roadway.

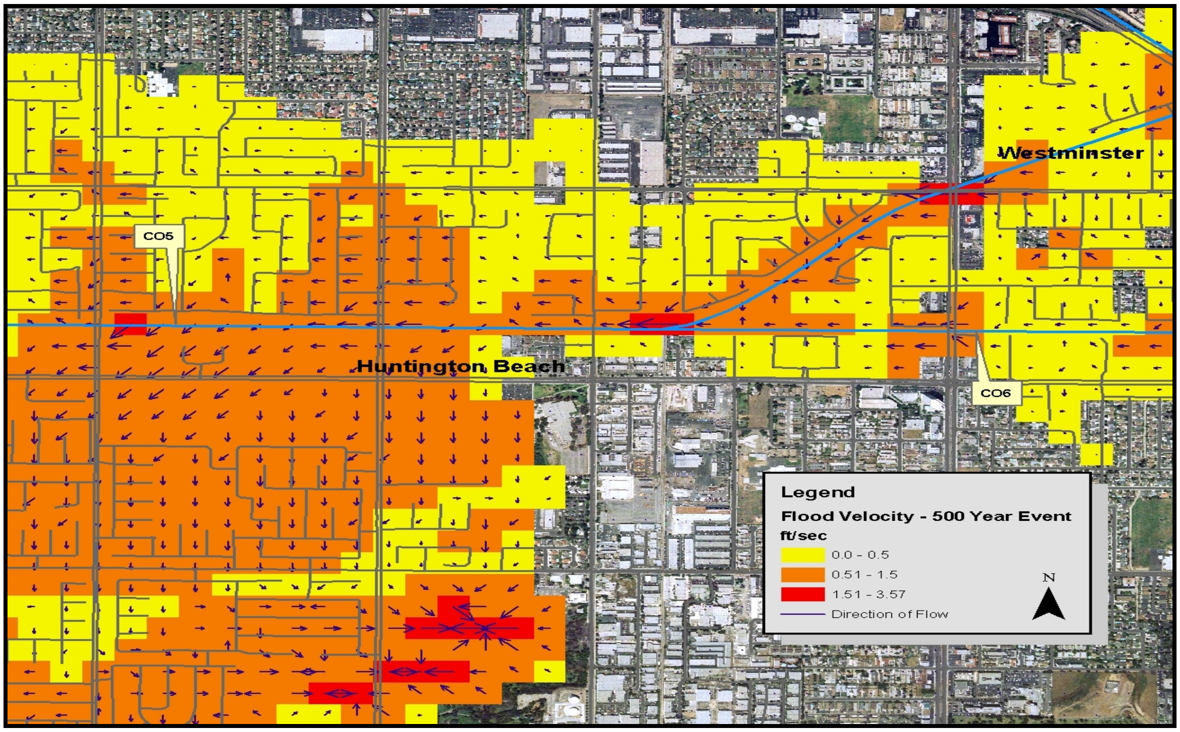


Figure 8: 500-Year Flood Velocity, CO5 & CO6

Of course, given that there are hundreds of miles of roads in the floodplains, developing a comprehensive estimate of total road damages from flooding is beyond the scope of this analysis. The analysis should instead focus on estimating the likely damage in areas where there is a relatively long, continuous stretch of impacted roadway. The figure below identifies those stretches of roadway that the analysis is most likely to include in the damage estimate.

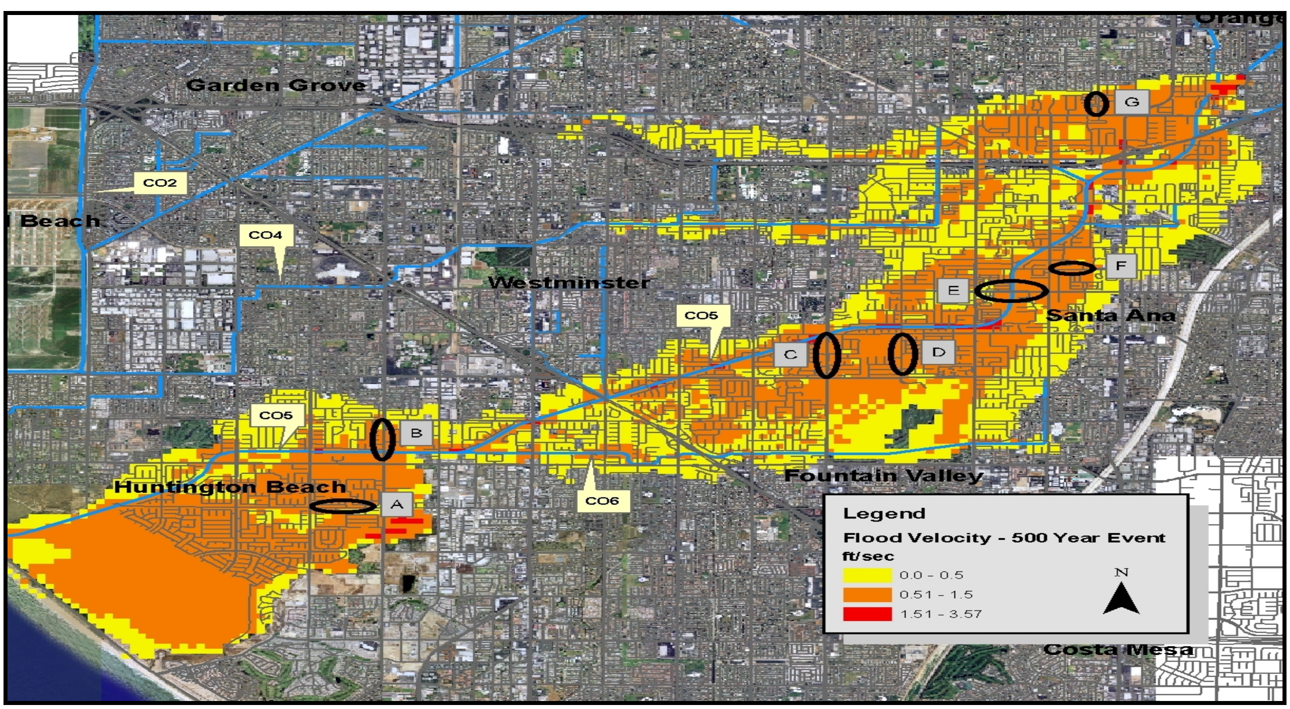


Figure 9: Major Roads Likely Impacted in a 500-Year Event, CO5&CO6

Summary of Without-Project Flood Damages

The Economic Analysis of without-project flood damages from the CO4, CO5, and CO6 channels considered eight separate damage categories. A ninth damage category – Income Loss – was discussed, but because of the lack of information no damage estimate was made. Estimates of Road Damages have not yet been completed, but it is anticipated that, given the development of refinements to the road damage model, this category will be evaluated for the next study phase. Given the magnitude of the total damages though, and given preliminary indications of the likely magnitude of the road damages, the addition of this damage estimate will not make a material difference in the overall damage estimate.

The results of the analysis are shown in the tables at right. The total Expected Annual Damages for each channel is displayed. The annual damages associated with CO4, CO5, and CO6 are $3.4 million, $33.3 million, and $4.2 million, respectively. Except where noted, the tables should be considered in isolation. This is because there is some overlap of the CO4 and CO5 floodplains, which means that summing the damages from the floodplains would result in some amount of double-counting. It should be noted, however, that the overlapping only really begins at the CO4 200-year frequency event, and within the overlapping area the average flood depth contributed by CO4 is just half a foot or less. There is some overlap between CO4 and CO5 for all categories except for Insurance Policy Administration and Road Damage. At this point it is not known how combining the floodplains would affect the floodplain characteristics (extent and depth). More on this issue will be included in the next (with-project) study phase.

Risk and Uncertainty was incorporated in the analysis for four of the seven categories where a damage estimate was made. Importantly, these four categories comprise around 90% of the total damages estimated for each of the channels. Thus, the vast majority of the damages estimated include the consideration of Risk and Uncertainty.

A more detailed breakdown of many of the damage categories can be found in the tables within the Appendix.

Table 26: Total EAD

	Category	EAD ($'000s)
CO4	Structures & Contents	$2,736
	Vehicle Damage	$36
	Structure Cleanup	$182
	Emergency	$76
	Residential Displacement	$53
	Insurance Policy Admin.	$222
	Traffic Delay & Detour	$75
	Road Damage	tbd
	Total	**$3,380**

	Category	EAD ($'000s)
CO5	Structures & Contents	$26,116
	Vehicle Damage	$1,015
	Structure Cleanup	$1,618
	Emergency	$583
	Residential Displacement	$651
	Insurance Policy Admin.	$3,023
	Traffic Delay & Detour	$308
	Road Damage	tbd
	Total	**$33,314**

	Category	EAD ($'000s)
CO6	Structures & Contents	$3,545
	Vehicle Damage	$234
	Structure Cleanup	$216
	Emergency	see CO5
	Residential Displacement	$122
	Insurance Policy Admin.	$128
	Traffic Delay & Detour	see CO5
	Road Damage	tbd
	Total	**$4,245**

Regional Economic Development and Other Social Effects

Per USACE EC 1105-2-409, any alternative plan that has net beneficial effects across the four USACE Planning & Guidance (P&G) accounts may be the recommended plan. Furthermore, "highest budgetary priority will be given to collaborative planning activities that embrace the full range of the national Federal interest. At this point, recommendations within USACE guidance documents for the actual implementation of RED in the feasibility study process are not complete. The description of any estimated RED impacts within the study area as a result of a federal project will be included in subsequent report phases as warranted as further guidance and instruction becomes available. The following two sections will briefly describe each of the accounts.

Regional Economic Development (RED)

According to EC 1105-2-409, "the regional economic development account registers changes in the distribution of regional economic activity that result from each alternative plan". According to the EC, measurement of RED effects is generally to be quantitative within available and selected methods. USACE is currently developing a handbook of contemporary techniques for RED.

This type of impact analysis requires relatively sophisticated input/output modeling, which would require a significant amount of additional funds and time to incorporate in this study. While a quantitative analysis is not included here, it is useful to describe in generalities some of the more easily identifiable indirect impacts of a major flood event in this area. Possible impacts include changes in gross regional product, employment, sales and property tax revenues, and development patterns.

The Orange County Metropolitan Area has a Gross Metropolitan Product (GMP) of approximately $154 billion annually according to U.S. Census Bureau. A reduction in GMP would result if those residents and businesses that were subject to flooding relocated out of the region permanently and were not replaced by new residents. Given the overall demand for housing and real estate in the area though, very little loss of residents or businesses as a result of flooding is expected.

In the aftermath of a significant flood event, sales and business activity in some sectors will be hurt, while others will receive a boost. For example, while it could be expected that some sectors would be adversely impacted in the short-term, other sectors such as construction and some retail businesses would likely benefit as homeowners rebuild and repair their homes and replace damaged goods. Thus, in the absence of a more detailed analysis, the net effect on sales tax revenues is uncertain.

For property tax revenues, assuming that nearly all damaged or destroyed homes would be repaired or replaced, a decrease in property taxes as a result of a flood event is not expected. It is possible to imagine both positive and negative affects on property taxes in the region. Decreased property value of land in the floodplain would decrease tax revenues, while, as a result of California's Proposition 13, an increase in property taxes would be associated with parcels where substantial improvements were made to the structure or with those parcels where ownership changed in the aftermath of the flooding.

At the next study phase (the with-project analysis), the expected RED impacts of the various alternatives will be discussed, and these impacts will be quantified to the extent possible given informational, time, and budgetary constraints.

Other Social Effects (OSE)

OSE is defined by EC 1105-2-409, “The other social effects account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts”. Measurement of OSE effects is generally qualitative; however quantitative data is encouraged within available and accepted methods.

Flooding on such a massive scale as what would occur under the storm events analyzed in this study would clearly cause large-scale disruptions in the availability of important health, safety, and social services. These impacts are difficult to quantify, but are nonetheless important to capture in the analysis, even if only qualitatively.

For example, under the 500-year flood scenario for CO5 and CO6, at least 25 public elementary schools, 14 public high schools, and 6 private schools would be inundated to various degrees. Given that a large storm event is most likely to occur in the non-summer months, flooding of these facilities represents a significant inconvenience and cost to the affected communities. In the aftermath of the flooding, many of these schools would require extensive cleanup and repair before reopening to students and teachers. Many parents would be forced to miss some amount of work in order to care for young children that would normally be attending the affected schools. There is at least one major hospital located in the city of Garden Grove that would be inundated to approximately three feet, significantly compromising its ability to provide health care both during the flood and during repair and cleanup after the flooding subsides. Additionally, there are at least eight fire stations and numerous police stations in the floodplain.

Finally, it is important to note that in portions of the study area, the flood depths for various flood events (50, 100, and 500) are so deep as to represent a very real risk to cause injuries and loss of life. In particular, Impact Area 7 of CO5 shows very deep flood water across a large number of residences. While it is not possible to make an accurate estimate of the extent to which injuries and death would occur, given the depth of the water it is reasonable to assume that injuries and deaths would, in fact, occur as a result of significant flood events in the study area.

Recreation Analysis

According to the Westminster Watershed Project Management Plan, there are many opportunities to improve the quality and quantity of recreation in the study area as part of one or more multi-purpose projects. In order to describe and estimate the value of potential future project-related recreational resources, the without-project Economic Analysis typically defines the market area and describes the existing and expected future without-project recreational resources. At the next, with-project, study phase, understanding the level of unmet demand for recreation in the study area will help the study team understand and estimate the value of potential future recreation management measures. The descriptions and visitation estimates below are in large part taken from other USACE studies recently conducted within the study area. Some, but not all, data and descriptions have been updated with more recent information. It is expected that this information will be more thoroughly updated, as warranted, for the next study phase.

Recreation Market Area

The recreation market area is assumed to be Orange County, California. This assumption is based upon discussions with local experts from the Orange County Department of Harbors, Beaches, and Parks. The Westminster Watershed offers unique recreation experiences that are enjoyed by residents throughout the County. Although watershed recreation opportunities do attract some visitors from outside Orange County, for example from Riverside and San Bernardino Counties, their numbers are small enough relative to Orange County visitors to make their effect on these recreation analyses insignificant.

Recreation Supply

Orange County Regional Parks

Orange County's recreational resources consist of coastal facilities, wilderness parks, regional parks, and historic parks. A large portion of these resources is under the management of the County's Harbors, Beaches, & Parks Department. The County's coastal facilities include: the beaches of Aliso, Sunset, Salk Creek, and Capistrano; Dana Point Youth and Group Facility; and the harbors of Dana Point, Newport, and Sunset-Huntington. The wilderness parks operated and maintained by the County include: Aliso and Wood Canyons; Caspers; Laguna Coast; Thomas F. Riley; Whiting Ranch; and Talbert Nature Preserve. The County lists fifteen parks as being under its management. These include the following: Carbon Canyon; Clark; Craig; Featherly; Irvine; Laguna; Mason; Mile; Oneil; Peters Canyon; Santiago Oaks; Harriett M. Wieder; Yorba; and the Orange County Zoo. Finally, the County lists six facilities as historic parks under its management.

The Orange County Department of Harbors, Beaches, and Parks oversees regional & local parks as described in the Orange County General Plan. Regional parks offer recreational or scenic attractions that are of countywide significance and not generally available in local and municipal parks. They provide a spaciousness which the typical neighborhood or municipal park does not provide. Orange County's regional recreation facilities include: recreation harbors, beaches, parks, and historical sites. They comprise approximately 27,000 existing acres with an estimated 24,000 additional acres proposed. Much of this proposed acreage consists of additions to existing facilities. In all there are 25 existing regional parks spread over the entire County, 19 existing beaches, three County harbors, and six regional historic sites or parks. Additionally, as described below, seven regional parks and two historic sites exist in the nearby San Diego Creek Watershed.

In addition to the County parkland, there are 42 miles of beach, 55,000 acres of open space in the County's portion of Cleveland National Forest, and many acres of federal, state, local, and city parks. The total acreage of County parkland per resident has increased slightly each year between 2001 and 2004. The majority of this additional acreage is within the Limestone-Whiting and Laguna Coast Wilderness Preserves. According to a report by the County, *2005 Community Indicators*, Orange County has just less than 39,000 acres of regional (County-owned) parkland. In 2004 this equated to 12.8 acres per 1,000 residents. This includes wilderness and nature preserves and properties that have been irrevocably offered. This ratio of park acres to residents is above what the National Parks and Recreation Association recommends (between 6 and 10 acres). However, according to the County of Orange's Watershed and Coastal Resources Division, within the Westminster Watershed there is just 255 acres of land devoted to recreation, which equates to less than 1 acre per 1,000 residents. As of 2004 the County's system of off-road paved bikeway and unpaved trails totaled around 382 miles. The County plans to add another combined 142 miles of bikeway and trails by 2010, and another 130 miles after 2010.

Thus, while regional parkland and regional recreational resources are relatively abundant in the area, local recreational resources in this large geographic area are quite scarce.

The table at right shows the annual attendance at six out of the seven Regional Parks and one out of two historic sites from years 1996 through 2000. Attendance figures for the seventh regional park and the second historic site were unavailable. For these parks, visitation is estimated by park rangers, whom have no set rules on how to count the number of people visiting the park. When parks have one or a few principle vehicular entrances, estimates are made based on the number of cars in the parking lots and the average number of people per car. Estimates also include people who access the park by bike or by foot. Individuals are also accounted for during special events. Overall, rangers try to make estimates of park attendance monthly.

Average Annual visitation for the six regional parks and one historic site are listed below. Visits for William Mason Regional Park are the highest at 221,037 while Limestone-Whiting Wilderness Park and Santiago Oaks Regional Park are next at 63,644 and 45,323, respectively.

Table 27: Regional Park Attendance ('000s)

Regional Parks[1]	1996	1997	1998	1999	2000
Laguna Coast Wilderness Park	6	5	3	4	6
Peter's Canyon Regional Park	27	21	32	50	48
Upper Newport Bay Regional Park and Ecological Reserve[2]		36	33	31	28
William R. Mason Regional Park	241	219	197	242	207
Limestone-Whiting Ranch Wilderness Park	62	70	50	60	75
Santiago Oaks Regional Park	48	47	43	45	43
Heritage Hill Historic Park				19	19

[1]Visitation numbers were not available for Irvine Ranch Headquarters Historic Park and San Joaquin Freshwater Marsh Reserve.

Some cells are blank because figures are not available for those years.

Orange County Local Parks

Local parks are generally improved with sports fields, open play areas, play equipment, landscaped areas, and trails. They fulfill the specialized role of meeting neighborhood and community recreation needs.

Many local parks exist throughout the Orange County and the San Diego Creek Watershed. The parks that fall under city jurisdiction are classified as mini parks, view/lookout parks, neighborhood parks and community parks. (This does not include private parks, golf courses and country clubs.) Descriptions of these types of parks are given as follows. A mini park is small and local and about 2,500 square feet to one acre in size. While some mini parks are planned as structured urban open spaces in new developments, others are developed on vacant lots in older neighborhoods. Mini parks are essentially substitutes for backyards and are normally provided in high-density areas. View/lookout parks are generally small (under two acres) and have been built to take advantage of unique views. Neighborhood Parks are developed to serve the active recreational needs of a particular neighborhood within a community. The size of the park depends on population but usually ranges from two to 20 acres. Typically, neighborhood parks have a maximum service radius of one half mile. Community parks are about 20 to 50 acres in size and are generally designed to meet the needs of several neighborhoods. These parks are intended to serve a radius of up to three miles.

Unincorporated Orange County has 63 developed local parks and 20 additional parks that have been offered to and accepted by the County but are not yet developed. In addition, there are a number of local parks sites that have been offered to the County, but are not yet accepted at this time. To evaluate the extent to which local park numbers are being achieved, net park acreage offered to and accepted by the County is compared with the unincorporated area population. More specifically, the County's goal is to strive to provide 2.5 acres of local parkland for every 1,000 County residents. (This policy is implemented through the Local Parks Code.)

Valuation Methodology

The valuation of recreational resources is *not* an assessment of the economic value of the facilities in terms of employment, income, or tourism. It is simply an estimate, based on well-established national parameters developed by federal water resource agencies, of users' willingness to pay for recreational experiences at the site. The aggregate willingness of individuals to pay for the recreational resources is considered part of the National Economic Development (NED) account, which helps determine federal interest in a project.

National Economic Development benefits arising from recreation opportunities created by a project are measured in terms of aggregate willingness to pay. USACE Principles and Guidelines document describes three techniques which have been developed to estimate recreation demand and value. The three methods are: 1) Travel Cost; 2) Contingent Valuation; and 3) Unit Day. Because of its simplicity and general acceptability, the Unit Day method (Unit Day Value, or UDV) was selected for use in this analysis.

Unlike the Travel Cost method, the UDV method does not attempt to account for the impact of price on visitations to a recreation site. Instead, an assigned user day value is applied to the total number of estimated visitors. User day values are simulated market values derived from a range of values agreed to by Federal water resource agencies. It is intended to represent a typical user's average willingness to pay for a full day of recreation activity at the site. When a properly formulated unit day value is applied to estimated use, an approximation of the area under the site demand curve is obtained, which is used in estimating recreation value at a site as well as the net recreation benefits of a proposed project.

A national schedule is available showing a range of values for both specialized and general recreation opportunities. A point rating system can be used to select a specific value from the published schedule of value ranges. Unit Day Values will be calculated by assigning points to each activity (based upon Federal guidelines) and then converting total points to dollar recreation values. As described in the table below, point values are derived by ranking the recreation resource according to five different criteria.

Table 28: Unit Day Value Schedule

Criteria	Key Variables	Range of Point Values
Recreation Experience	Number & Type of Facilities	0-30
Availability of Opportunity	Number of Similar Opportunities Nearby	0-18
Carrying Capacity	Adequacy of Facilities for Activities	0-14
Accessibility	Ease of Access to and Within Site	0-18
Environmental	Esthetic Quality of Site	0-20
Total		0-100
Source: USACE ER 1105-2-100		

Based upon the total number of points assigned and the type of activity, UDV's can range from $3.19 to $37.88 per recreation day. This dollar figure is meant to represent each participant's willingness to pay for a day's participation in the particular recreational activity. The recreational opportunities most likely to be offered by any project are considered general recreation for purposes of the UDV calculation. The specialized activities are those that typically require special equipment or involve unique experiences for which people are believed to be willing to pay a premium to participate.

Appendix of Tables & Figures

Table 29: Depth-Damage Curves, Structures (condensed)

Flood Depth at FFE (ft)	COM-1 *FEMA 1998*	IND-1 *FEMA 1998*	MH *1998 FEAS*	PUB-1 *FEMA 1998*	SF-1 *EGM 01-03*	SF-2 *EGM 01-03*	APT-2 *FEMA 1998*
-2.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
-1.0	0.0%	0.0%	0.0%	0.0%	2.5%	3.0%	0.0%
-0.5	3.5%	3.5%	4.0%	3.5%	8.0%	6.2%	2.5%
0.0	7.0%	7.0%	8.0%	7.0%	13.4%	9.3%	5.0%
0.5	11.7%	11.7%	25.5%	11.7%	18.4%	12.3%	7.4%
1.0	16.3%	16.3%	43.0%	16.3%	23.3%	15.2%	9.9%
1.5	20.5%	20.5%	50.5%	20.5%	27.7%	18.1%	11.6%
2.0	24.7%	24.7%	58.0%	24.7%	32.1%	20.9%	13.4%
2.5	26.2%	26.2%	65.5%	26.2%	36.1%	23.6%	15.7%
3.0	27.7%	27.7%	73.0%	27.7%	40.1%	26.3%	18.0%
3.5	28.7%	28.7%	74.3%	28.7%	43.6%	28.9%	19.0%
4.0	29.6%	29.6%	75.6%	29.6%	47.1%	31.4%	20.0%
4.5	30.3%	30.3%	76.9%	30.3%	50.2%	33.8%	21.0%
5.0	30.9%	30.9%	78.2%	30.9%	53.2%	36.2%	22.0%
5.5	35.3%	35.3%	79.3%	35.3%	55.9%	38.5%	23.0%
6.0	39.8%	39.8%	80.3%	39.8%	58.6%	40.7%	24.1%
6.5	41.3%	41.3%	80.3%	41.3%	60.9%	42.8%	25.1%

Table 30: Depth-Damage Curves, Contents (condensed)

Flood Depth at FFE (ft)	COM-1 *FEMA 1998*	IND-1 *FEMA 1998*	MH *1998 FEAS*	PUB-1 *FEMA 1998*	SF-1 *EGM 01-03*	SF-2 *EGM 01-03*	APT-2 *FEMA 1998*
-100.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
-2.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
-1.0	0.0%	0.0%	0.0%	0.0%	4.8%	2.0%	0.0%
-0.5	5.2%	0.0%	0.0%	5.2%	10.5%	6.0%	3.6%
0.0	10.5%	0.0%	0.0%	10.5%	16.2%	10.0%	7.2%
0.5	14.0%	10.0%	13.3%	14.0%	21.4%	13.7%	8.5%
1.0	17.6%	20.0%	26.6%	17.6%	26.6%	17.4%	9.8%
1.5	20.7%	26.5%	36.0%	20.7%	31.2%	20.9%	13.8%
2.0	23.7%	33.0%	45.4%	23.7%	35.8%	24.4%	17.7%
2.5	26.6%	39.0%	54.8%	26.6%	39.9%	27.7%	20.2%
3.0	29.5%	45.0%	64.1%	29.5%	44.0%	31.0%	22.6%
3.5	32.4%	51.5%	66.6%	32.4%	47.7%	34.0%	25.5%
4.0	35.3%	58.0%	69.1%	35.3%	51.4%	37.0%	28.3%
4.5	37.7%	63.5%	71.6%	37.7%	54.5%	39.8%	30.7%
5.0	40.0%	69.0%	74.1%	40.0%	57.6%	42.6%	33.1%
5.5	42.5%	76.5%	75.7%	42.5%	60.3%	45.2%	36.2%
6.0	45.0%	84.0%	77.3%	45.0%	63.0%	47.8%	39.2%
6.5	47.5%	90.5%	77.3%	47.5%	65.3%	50.2%	41.6%

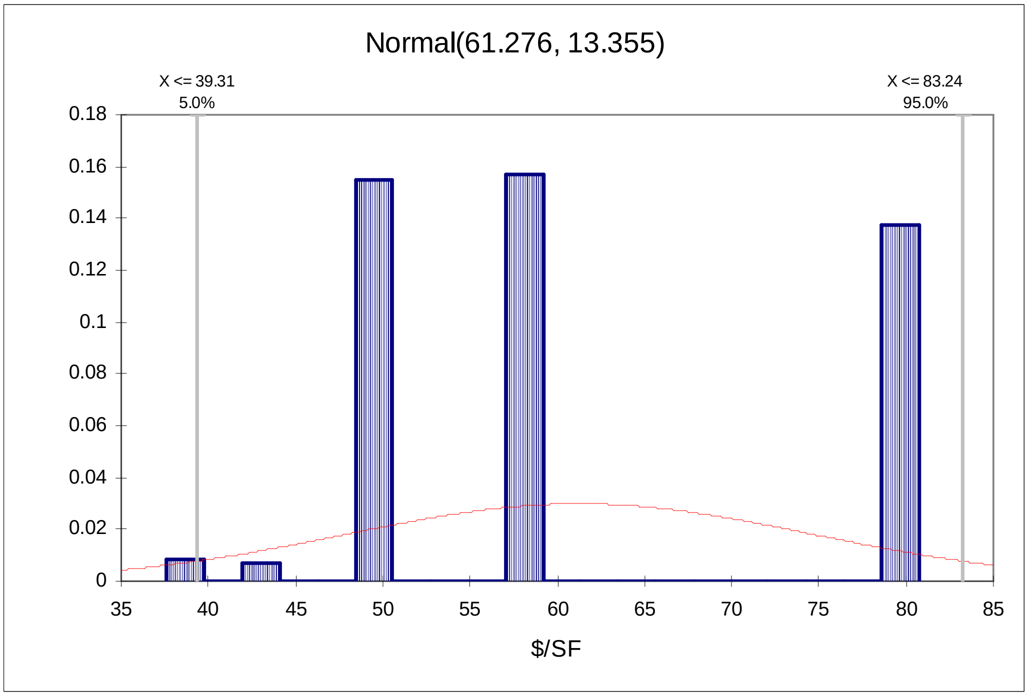


Figure 10: Probability Distribution of $/SF from SFR Sampling - CO5 & CO6

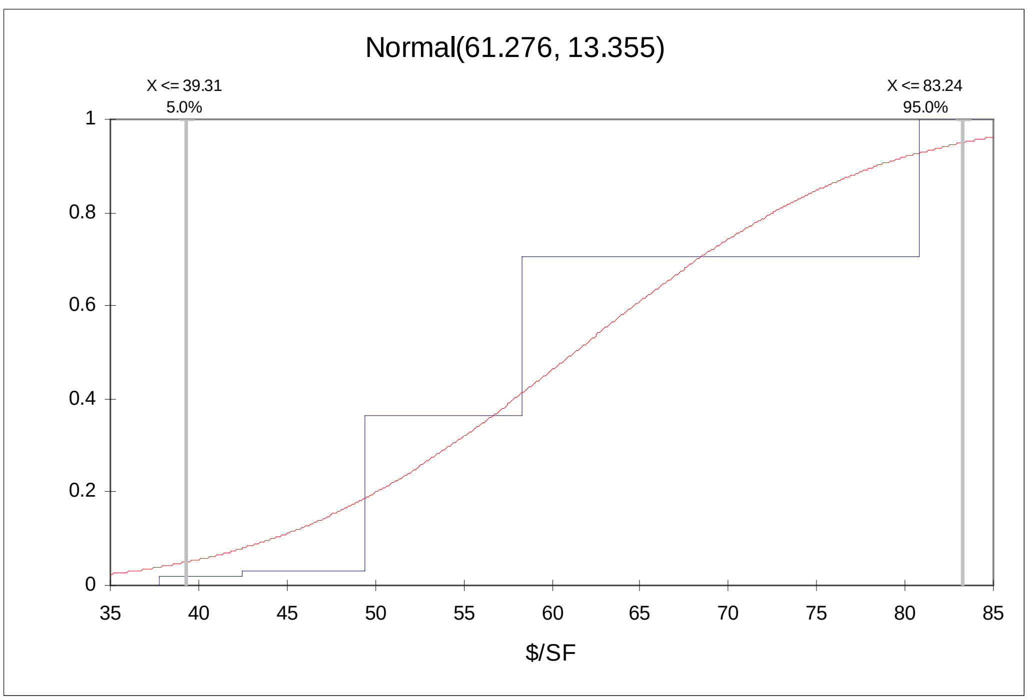


Figure 11: Cumulative Distribution of $/SF from SFR Sampling - CO5 & CO6

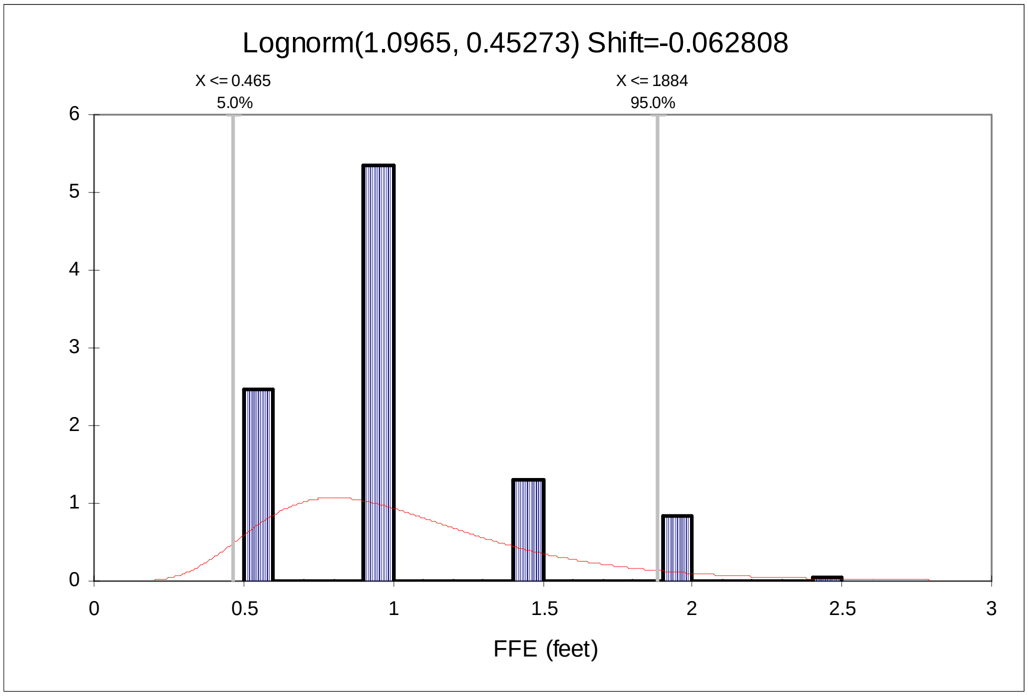


Figure 12: Probability Distribution of FEE from SFR Sampling - CO5 & CO6

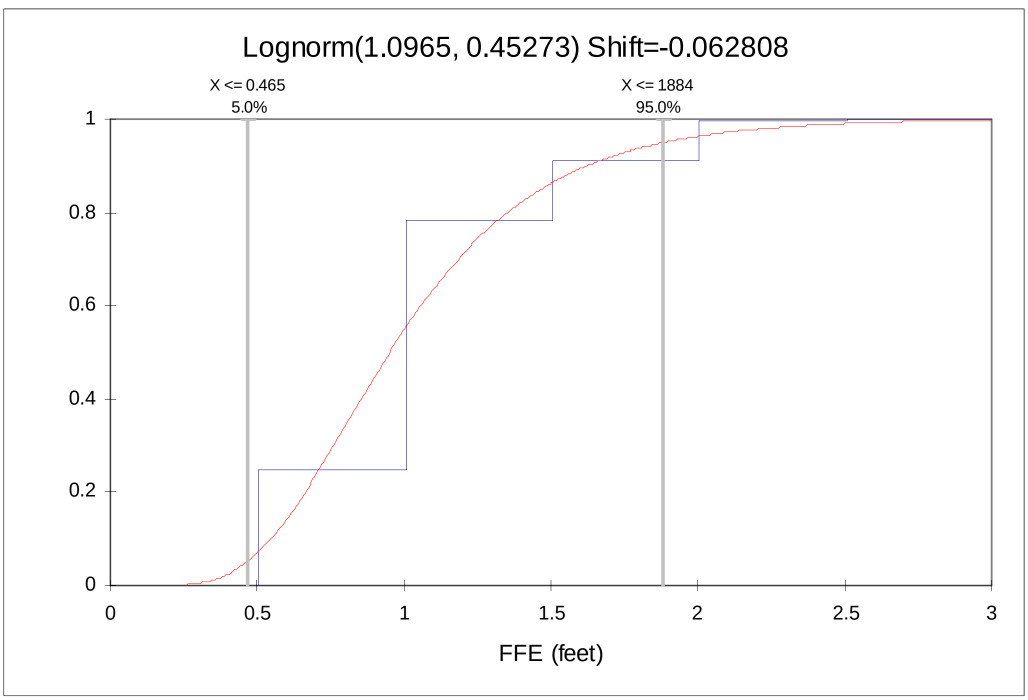


Figure 13: Cumulative Distribution of FFE from SFR Sampling - CO5 & CO6

Damage Tables for CO4

Table 31: Vehicle Damages ($'000s), CO4

Impact Area	500-Year	100-Year	50-Year
1	$213	$11	$0
2	$234	$54	$0
3	$1,347	$649	$413
4	$271	$67	$31
5	$10	$0	$0
Total	$2,076	$782	$444

Table 32: Cleanup Costs ($'000s), CO4

Impact Area	500-Year	100-Year	50-Year
1	$2,816	$825	$142
2	$1,823	$394	$233
3	$2,181	$1,006	$691
4	$2,860	$511	$191
5	$4,717	$701	$62
Total	$14,398	$3,437	$1,319

Table 33: TRA ($'000s), CO4

Impact Area	500-Year	100-Year	50-Year
1	$296	$43	$14
2	$719	$179	$116
3	$592	$228	$136
4	$1,015	$143	$57
5	$1,824	$136	$27
Total	$4,447	$729	$350

Damage Tables for CO5 & CO6

Table 34: Vehicle Damages ($'000s), CO5

Impact Area	500-Year	100-Year	50-Year
1	$575	$234	$112
2	$1,831	$808	$618
3	$6,919	$2,787	$1,842
4	$4,102	$1,030	$511
5	$5,229	$2,801	$2,011
6	$2,291	$784	$586
7	$33,540	$22,232	$12,658
Total	$54,486	$30,676	$18,338

Table 35: Cleanup Costs ($'000s), CO5

Impact Area	500-Year	100-Year	50-Year
1	$8,070	$3,210	$1,775
2	$5,182	$1,782	$1,184
3	$11,124	$6,995	$4,689
4	$3,873	$2,934	$1,433
5	$5,430	$3,699	$3,098
6	$1,531	$1,139	$976
7	$17,110	$15,196	$14,449
Total	$52,320	$34,956	$27,604

Table 36: TRA ($'000s), CO5

Impact Area	500-Year	100-Year	50-Year
1	$2,085	$427	$141
2	$1,612	$464	$310
3	$4,197	$2,493	$1,505
4	$2,330	$579	$423
5	$2,940	$2,019	$1,602
6	$734	$537	$462
7	$9,051	$8,363	$8,110
Total	$22,948	$14,882	$12,554

Table 37: Three Damage Categories ($'000s), CO6

Category	500-Year	100-Year	50-Year
Vehicle Damages	$11,446	$3,625	$1,450
Cleanup Costs	$11,546	$4,028	$2,961
TRA	$5,629	$2,661	$1,692

Westminster Watershed Feasibility Study
Orange County, California

ECONOMICS
APPENDIX

U.S. Army Corps of Engineers
Los Angeles District

APRIL 2010

TABLE OF CONTENTS

1. Introduction

Purpose

The purpose of this appendix is to document the methodology and results of the economic analysis used to assess potential flood damages from several channels that are located within the Westminster Watershed. The analysis focuses on existing and future conditions related to flood damages to structures, contents, and vehicles, and to costs incurred as a result of flood fighting, evacuation, and cleanup. The primary focus of this analysis is to estimate the economic damages associated with flood events in the study area and to estimate the residual damages associated with various alternative projects in place in order to determine the extent to which these projects would provide economic benefits to the nation. This Economic Analysis includes the floodplains of channels CO4 (Westminster), CO5 (East Garden Grove Wintersburg), and CO6 (Ocean View).

Methodology & Overview

The principal controlling guidance of the analysis comes from the U. S. Army Corps of Engineer's (USACE) "Planning Guidance Notebook", ER 1105-2-100, with specific guidance from Appendix D – Economic and Social Considerations. Benefits and costs are expressed in average annual terms at 2010 price levels using the fiscal year 2010 federal discount rate of 4.375%. The period of analysis is 50 years. Within the floodplains there is little or no vacant, developable land, and for this reason the analysis assumes that the future without-project economic condition is equivalent to the current without-project condition. That is, the flood damage estimate does not include any structures that are not currently in the floodplains. Additional guidance on the risk-based analyses has been obtained from USACE ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies, dated January 3, 2006.

From a broad perspective, the analysis focuses on estimating damages to private and public property, as well as emergency response and recovery costs, which includes emergency assistance to flood victims. Each of these categories has several components. The specific methodology employed in evaluating each category, as well as a description of key assumptions, is explained in the text provided for each particular category.

Very broadly, structure and content data were first processed through an @RISK Excel spreadsheet to generate the appropriate stage-damage references with uncertainty for entry into the HEC-FDA model. The effects of this construction are that individual risk-based damage assessments are performed for each damage category external to the HEC-FDA model in a process that mimics the HEC-FDA methodology. With respect to damages, the results of the @RISK calculations are entered directly into the HEC-FDA model as cumulative damage functions for each damage category and for each study reach (termed Impact Areas in this report). More details on the cumulative damage function methodology are included in the Property Damages section.

2. Study Area

Location

The Westminster watershed is located in the southwestern corner of Orange County, CA. The watershed encompasses an area of approximately 74 square miles (around eight percent of the total area of Orange County). The watershed consists of all or portions of the cities of Anaheim, Cypress, Fountain Valley, Garden Grove, Huntington Beach, Los Alamitos, Santa Ana, Seal Beach, Stanton, and Westminster. The combined floodplains span large portions of the land between the cities of Huntington Beach (to the south), Fountain Valley (to the east), and Westminster (to the north), an area which is over twenty square miles. The aerial image below shows the major cities in the area surrounding the study area, and an overlain picture in the center of the image shows the 500-year combined floodplains for CO4, CO5, and CO6. The northeastern edge of the floodplain is just less than eleven miles from the coast.

Figure 1 - Regional View of Floodplains and Study Area

Floodplain Characteristics

The analysis includes the floodplains of channels CO4, CO5, and CO6. Flood modeling performed by USACE engineers was conducted for CO4 in isolation, but CO5 and CO6 were modeled in combination – one floodplain was created representing overflows from both channels.

CO4

The CO4 floodplain is contained within the cities of Huntington Beach and Westminster, with a very small portion (furthest point East) in the city of Garden Grove. The 500-year floodplain is approximately 6.4 square miles large.

The figure below shows the 500-year floodplain with the peak depths across the flooded area. The figure shows the delineation of the five impact areas. Although difficult to decipher from the figure below, Impact Areas 1 and 2 are separated by the channel.

The overflows from CO4 occur across approximately eight miles of the channel, flooding roughly five square miles of land in the affected area. At its widest, downstream stretch, the floodplain spans approximately 1.3 miles. The models show that the CO4 floodplain overlaps the CO5 & CO6 floodplain during events of or greater than 100-year. The primary area of overlap is the western-most portion of the CO5 floodplain. In this area, flood depths as a result of overflows from CO4 are relatively shallow compared to overflows from CO5 and CO6.

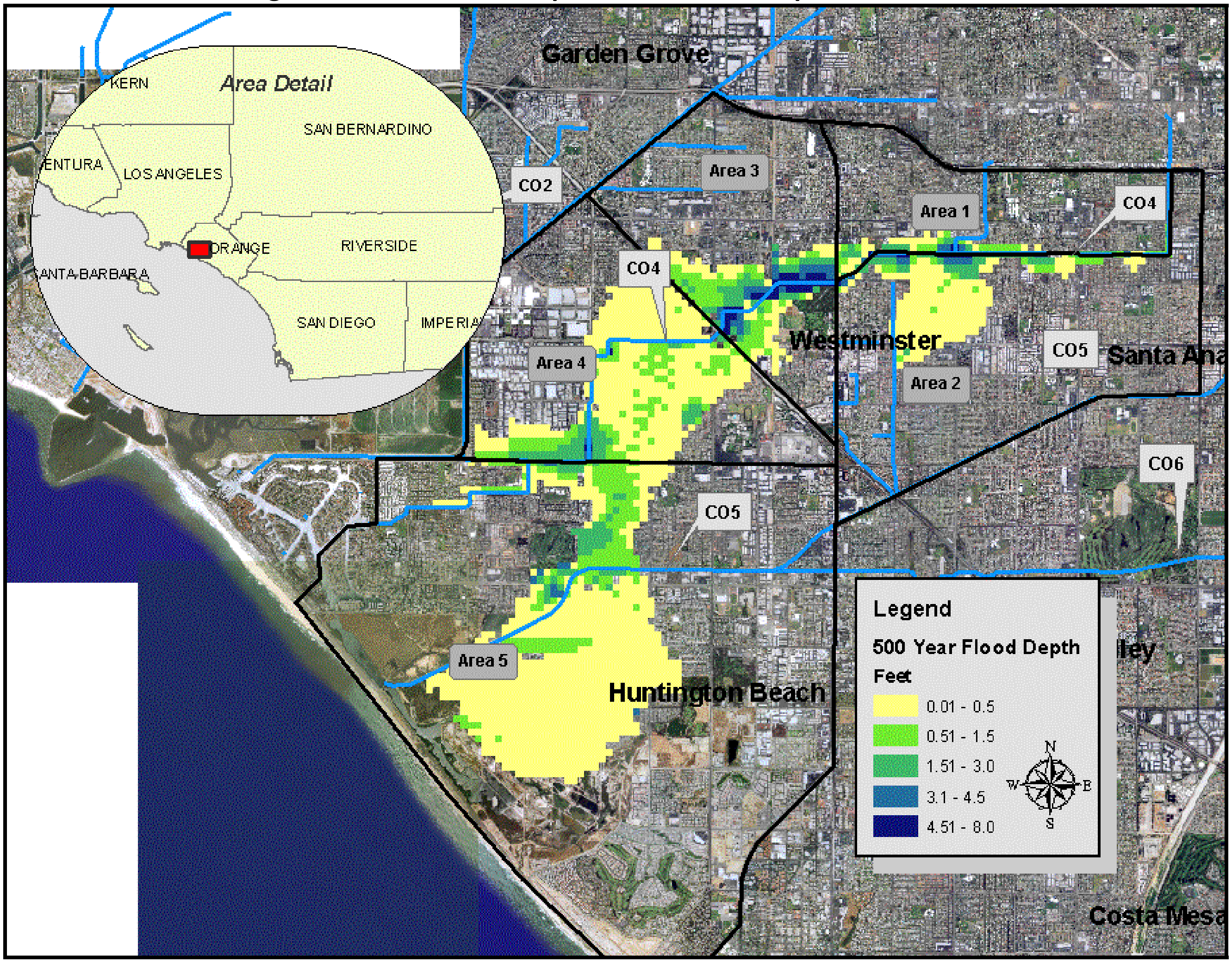
The table below shows the average peak depth for Single Family Residential (SFR) properties during three storm events for each of the five impact areas. These depths were calculated as the mean depth across flooded grid cells in each particular impact area, as provided by the FLO2D model. It is important to reiterate that this is simply an average, and as such does not provide a complete depiction of flooding within each impact area. In general, the CO4 floodplain is relatively flat, increased flooding results more spreading than deepening. It is estimated that the approximately 45,000 people reside within the 500-year floodplain. Approximately 2,000 of the single family residences would be subject to flooding of greater than one foot during a 500-year flood event, and around 250 would have over three feet of water on their property.

As will be discussed in more detail in a subsequent section, real estate data show that there are approximately 11,500 parcels in CO4's 500-year floodplain. Approximately 93% of these parcels have a land use classified as SFRs.

Table 1: Mean Flood Depth per Impact Area – CO4

CO 4 Area 1 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	27	48	355
Average Depth on Properties	0.36	0.94	0.99
Properties With Flooding > 1'	0	18	132
Properties With Flooding > 3'	0	0	18
Maximum Flood Depth	0.86	1.87	4.18
CO 4 Area 2 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	115	228	1913
Average Depth on Properties	0.99	1.19	0.73
Properties With Flooding > 1'	31	110	401
Properties With Flooding > 3'	0	17	119
Maximum Flood Depth	2.68	3.63	5.92
CO 4 Area 3 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	132	270	419
Average Depth on Properties	1.10	0.98	1.71
Properties With Flooding > 1'	43	103	286
Properties With Flooding > 3'	10	32	55
Maximum Flood Depth	3.58	4.43	6.06
CO 4 Area 4 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	136	392	3030
Average Depth on Properties	0.52	0.47	0.49
Properties With Flooding > 1'	25	44	343
Properties With Flooding > 3'	8	8	8
Maximum Flood Depth	3.06	4.14	5.78
CO 4 Area 5 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	29	879	5023
Average Depth on Properties	0.96	0.34	0.51
Properties With Flooding > 1'	17	70	803
Properties With Flooding > 3'	0	0	54
Maximum Flood Depth	1.97	2.65	3.95
CO 4 Entire Area Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	439	1817	10740
Average Depth on Properties	0.84	0.58	0.61
Properties With Flooding > 1'	116	345	1965
Properties With Flooding > 3'	18	57	254
Maximum Flood Depth	3.58	4.43	6.06

Figure 2: 500-Year Floodplain Aerial with Depth – CO4



CO5 & CO6

According to the latest 100 and 500-year floodplain delineations developed by USACE Engineers, the CO5/CO6 floodplain spans areas within the cities of Huntington Beach, Fountain Valley, Westminster, Santa Ana, Anaheim, Orange, and Garden Grove (see picture below). The floodplain extends approximately 11 miles inland from the coast of Huntington Beach, with the easternmost point located within the city of Orange. The widest section of either floodplain is approximately two miles across. Utilizing the ArcMap program, it is estimated that the 500 and 100-year floodplains encompass around 18 and 11 square miles, respectively. As the map below of the 500-year floodplain shows, the floodplain narrows at the confluence of the CO5 with the CO6 channel, but then widens, and for the next three miles along the CO5 channel the floodplain mostly comprises the land south of CO5 and north of CO6. At that point, the floodplain breaks out on both sides of CO5 for approximately four miles upstream.

The CO5 floodplain was divided into eight impact areas with one impact area for CO6. Eight impact areas are shown in Figure 3 below, while, for the analysis, Impact Area 3 was divided into two impact areas - one for CO5 the other for CO6. The impact areas were delineated based on channel and overflow characteristics. This is done primarily because the HEC-FDA program requires the assignment of damages to a particular point within a channel reach. As Table 2 shows, Impact Area 7 has the greatest average depth of flooding – greater than five feet for the 500-year event.

Figure 3 shows the extent and depths associated with the 500-year floodplain of CO5 and CO6, separated by impact area. As can be seen, Impact Area 7 – the furthest area downstream – has the greatest flood depths.

The ten-year storm event is designated by study engineers as the non-damaging event for the entire length of the CO5 and CO6 channels based on channel conveyance capacities. As will be discussed in more detail in the Land Use section, the floodplains of these channels consist of high-density urban development – primarily residential with a small amount of industrial and commercial activities (10% or less of the acreage within the floodplain footprint). With a per square mile population of approximately 7,000, approximately 140,000 people are estimated to live within the 20-square mile 500-year floodplain. It is estimated that for the 500-year flood, approximately 14,000 single family properties would be subject to flooding of greater than one foot, while over 6,000 properties residents would be subject to greater than three feet of flooding.

For the CO6 flood impact area depths are similar to area 3 of CO5. Average flood depth increase form slightly below 1 foot in the 50-yr event to nearly 1.5 feet in the 500-yr event. Although there is a modest increase in average depth between the 50- and 500-yr event, the number of SFRs impacted doubles from 2,367 to 5,083 and maximum depth increase over 3 feet from 6.69' to 9.86'.

Figure 3: 500-Year Floodplain Aerial with Depth– CO5 & CO6

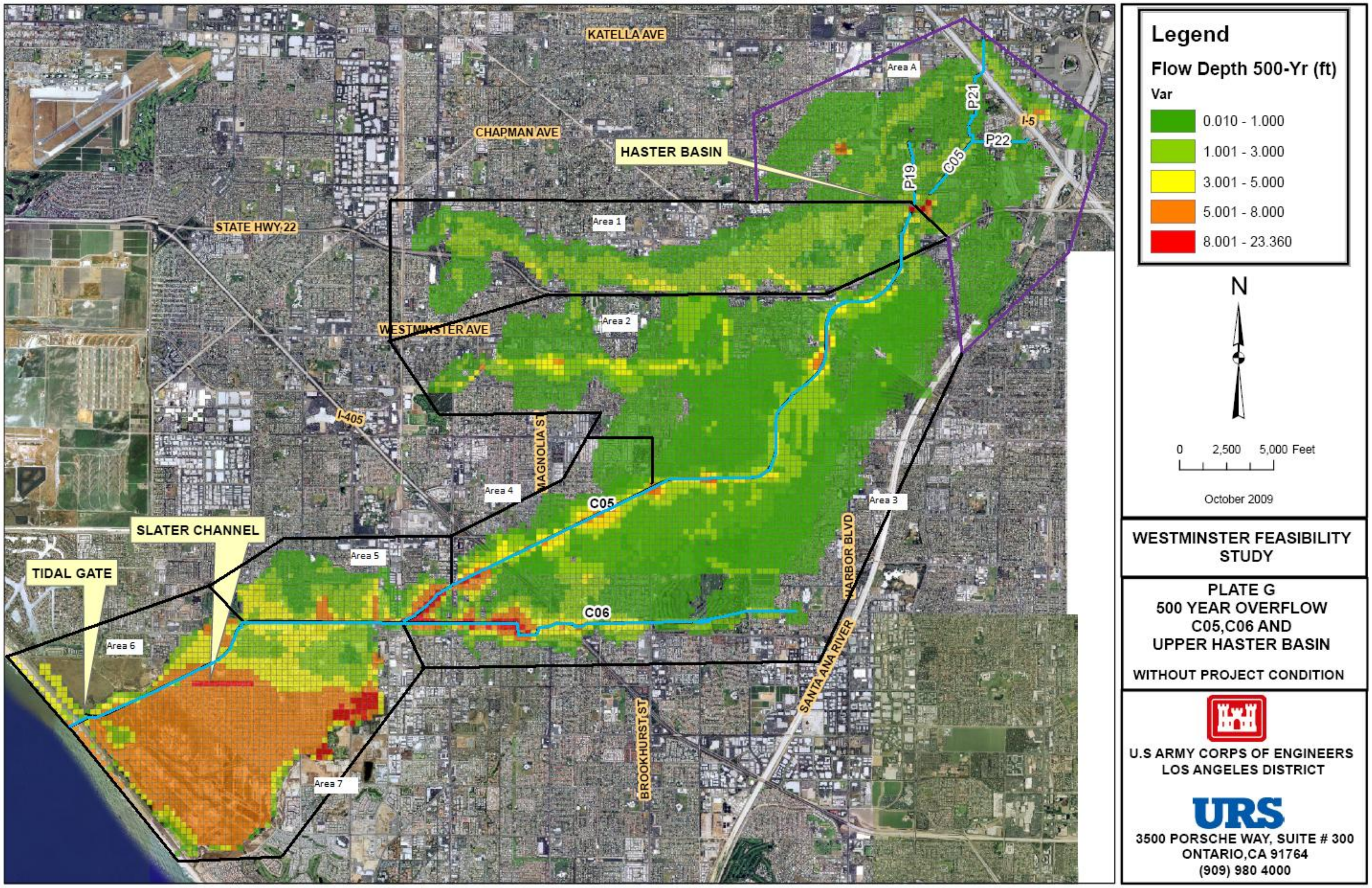


Table 2: Mean Flood Depth per Impact Area – CO5 & CO6

CO 5 Area A Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	2182	2515	4835
Average Depth on Properties	0.30	0.33	0.51
Properties With Flooding > 1'	50	92	753
Properties With Flooding > 3'	17	17	17
Maximum Flood Depth	3.39	3.49	4.76

CO 5 Area 1 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	2878	3091	3288
Average Depth on Properties	0.85	0.94	1.57
Properties With Flooding > 1'	917	1226	2544
Properties With Flooding > 3'	14	31	149
Maximum Flood Depth	3.63	3.77	4.37

CO 5 Area 2 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	3069	3540	4779
Average Depth on Properties	0.51	0.51	0.85
Properties With Flooding > 1'	272	304	1372
Properties With Flooding > 3'	104	104	314
Maximum Flood Depth	5.57	5.65	6.06

CO 5 Area 3 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	5117	6204	8342
Average Depth on Properties	0.90	0.93	1.24
Properties With Flooding > 1'	1230	1499	2814
Properties With Flooding > 3'	415	492	942
Maximum Flood Depth	6.69	7.60	9.86

CO 5 Area 4 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	396	543	887
Average Depth on Properties	1.67	1.54	1.62
Properties With Flooding > 1'	265	302	462
Properties With Flooding > 3'	76	77	204
Maximum Flood Depth	5.01	5.38	6.82

CO 5 Area 5 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	1093	1472	1986
Average Depth on Properties	1.88	1.77	2.12
Properties With Flooding > 1'	746	844	1200
Properties With Flooding > 3'	180	252	561
Maximum Flood Depth	6.30	6.79	9.55

CO 5 Area 6 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	386	408	435
Average Depth on Properties	1.95	2.34	4.12
Properties With Flooding > 1'	283	336	429
Properties With Flooding > 3'	76	77	336
Maximum Flood Depth	4.89	5.13	7.05

CO 5 Area 7 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	4194	4247	4247
Average Depth on Properties	2.84	3.56	5.48
Properties With Flooding > 1'	3681	3809	4197
Properties With Flooding > 3'	2085	2729	3647
Maximum Flood Depth	6.72	7.70	9.88

CO 5 Entire Area Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	19315	22020	28799
Average Depth on Properties	1.27	1.40	1.83
Properties With Flooding > 1'	7444	8412	13771
Properties With Flooding > 3'	2967	3779	6170
Maximum Flood Depth	6.72	7.70	9.88

CO 6 Area 3 Single Family Flood Depths			
Flood Event	50-yr	100-yr	500-yr
Properties With Flood Waters	2367	3056	5083
Average Depth on Properties	0.80	0.99	1.44
Properties With Flooding > 1'	460	749	2565
Properties With Flooding > 3'	204	272	531
Maximum Flood Depth	6.69	7.6	9.86

Historical Flooding

While FEMA claims from homeowners that suffered flooding damage from the three channels included in this study here have not yet been acquired, claims by the County of Orange for damage to their facilities have been gathered. These records show that between the years 1992 and 1998, for four storm events, claims associated with the CO5 and CO6 channels totaled approximately $533,000 and $495,000, respectively. No information has yet been gathered on the historic damages from overflows from CO4.

Previous storm events in the local area and region demonstrate the area's significant susceptibility to flood damages from large storm events. While there are no records directly attributing significant flood damages to CO4, CO5, and CO6, overflows from these channels have almost certainly contributed to damages have been attributed to other nearby flood conveyance systems such as the nearby Santa Ana River; but no accounting of this has been completed for these events. With recent improvements to the Santa Ana River and other flood damage reduction features in the region, most of the remaining flooding threat to Orange County is attributable to CO4, CO5, and CO6. The table below describes some of the more notable flood events in Orange County since the early 19th century.

Table 3: Significant Flood Events in Orange County

Year	Description of Event
1825	Flood on the Santa Ana River said to have created Balboa Island in Newport Beach.
1862	Considered the area's worst-recorded flood; most of County covered by at least three feet of water.
1914	Santa Ana River overflow submerges nearly all of Newport Beach; row boats used to get around.
1916	Four die in massive flooding that washes out most roads and rail lines, leaving Orange, Fullerton and Tustin marooned.
1938	Fifty-eight people killed, portions of downtown Garden Grove, Santa Ana and Anaheim under water, all bridges washed out.
1969	Five people die in Silverado Canyon when they are buried by mudslide; $12 million in damage countywide.
1983	Intense rain overwhelms channels, damaging nearly 1,000 homes and causing $48.5 million in damage.
1995	Channels again overflow, flooding dozens of homes from Seal Beach to Garden Grove.
Source: Los Angeles Times, October 3, 1999 'Disaster Prompted $1.3 Billion Effort to Tame Santa Ana River, Protect Basin'	

Population

Based upon information obtained from the State of California Department of Finance, Orange County had about 3.2 million residents in 2009. This figure represents an increase of 1.0% over the previous year. Between 2000 and 2009 the rate of growth in the County's population was slightly lower than the overall rate of population growth in California.

With respect to population, Orange County is the fifth largest county in the nation, and the third largest in California. The annual rate of growth of the County population was as high as 22% per year during the 1950s, but as the absolute number of residents increased, and as open land became increasingly scarce, the annual rate of growth decreased significantly over each subsequent decade – to the current rate of 1%. While the rate of population growth has slowed, the County is still adding a large number of new residents each year; over 30,000 each year, which ranks it eighth among U.S. counties.

The State of California Department of Finance projects that Orange County's population will approximate 3.5 million by 2020, and that it will near 4.0 million by the year 2050 as shown in the table below. Such growth rates imply average annual compound increases of one percent between 2009 and 2020, and an annual increase of just .4 percent between 2020 and 2050. It is expected that over the next several decades the population growth will increasingly be from a natural increase, and net migration (in-migration minus out-migration) is expected to turn negative by 2010

Table 4: Population Projections for Selected Southern California Counties

County	2009	2010	2020	2030	2040	2050	Percent Growth 2009-2050
Orange	3.12	3.23	3.52	3.71	3.85	3.99	27.9
Los Angeles	10.41	10.51	11.21	11.92	12.49	13.06	25.5
Riverside	2.13	2.24	2.90	3.51	4.10	4.73	122.1
San Bernardino	2.06	2.18	2.58	2.96	3.31	3.66	77.7
San Diego	3.21	3.20	3.55	3.95	4.24	4.51	40.5
CALIFORNIA	38.49	38.14	44.14	49.24	54.27	59.51	54.6

Source: State of California, Department of Finance, *Population Projections for California and its Counties 2000-2050, by Age, Gender and Race/Ethnicity*, Sacramento, California, July 2007. All population numbers in millions.

For the cities located entirely or partially within the Study Area watershed, the 2009 population was about 1.50 million, or roughly 48% of the County total. Between 2008 and 2009, the area had a population growth rate consistent with the County's overall growth rate.

Table 5: Westminster Watershed City Populations

City	Total Population		Percent
	1/1/2008	1/1/2009	Change
Anaheim	345,349	348,467	0.9
Cypress	49,330	49,647	0.6
Fountain Valley	57,675	58,309	1.1
Garden Grove	172,335	174,715	1.4
Huntington Beach	201,127	202,480	0.7
Los Alamitos	12,141	12,217	0.6
Orange	140,270	141,634	1.0
Santa Ana	351,521	355,662	1.2
Seal Beach	25,877	25,913	0.1
Stanton	39,108	39,480	1.0
Westminster	92,627	93,284	0.7
Total	1,487,360	1,501,808	1.0

Income & Employment

Orange County has a diversified economy, with a labor force of just over 1.6 million and a December 2009 unemployment rate of 9.1%, according to the California Economic Development Department. The average annual unemployment rate in the County over the last decade has been persistently lower than both the national and California rates. The most significant labor markets in the County are trade (around 19% of employment), business and professional services (18%), and manufacturing (13%). If Orange County were a country, its Gross Metro Product (GMP) in 2007 would rank 39th in the world – ahead of such nations as Israel, Singapore, and the Czech Republic. Within the United States, Orange County is the 15th top producing economy in the nation.

The table below compares several local economic indicators to the state and national economies. This and the other tables in this section are meant to be generally illustrative of the relative population and economic characteristics of the cities and regions, and do not necessarily represent the latest available data for a particular city or region. In compiling and presenting the data, priority was given to using a single, reliable source for each indicator over simply finding the most recent figures available from a variety of sources.

Table 6: Study Area Employment & Unemployment

Monthly Labor Force Data for Cities and Census Designated Places (CDP)
December 2009 - Preliminary
Data Not Seasonally Adjusted

			Unemployment	
Area Name	**Labor Force**	**Employment**	**Number**	**Rate**
Anaheim city	176,900	156,300	20,700	11.7%
Cypress city	27,400	24,700	2,600	9.6%
Fountain Valley city	32,800	30,300	2,500	7.6%
Garden Grove city	85,700	76,000	9,800	11.4%
Huntington Beach city	122,100	112,900	9,100	7.5%
Los Alamitos city	6,600	6,200	300	4.7%
Orange city	73,200	67,000	6,200	8.4%
Santa Ana city	163,000	139,600	23,400	14.4%
Seal Beach city	11,300	10,500	800	6.7%
Stanton city	18,800	16,100	2,800	14.6%
Westminster city	46,400	41,700	4,700	10.2%

Source: State of California, Employment Development Department

According to the figures, the per capita income in Orange County is over thirty and twenty percent higher than the national and state income figures, respectively. When compared to peer and neighboring markets, Orange County has the fourth highest per capita income, trailing only San Jose, Boston and Seattle. For 2007, the Bureau of Economic Analysis reports per capita income for Orange County at $50,463 with median household income at $73,107.

Figure 4: Orange County Per Capita Income

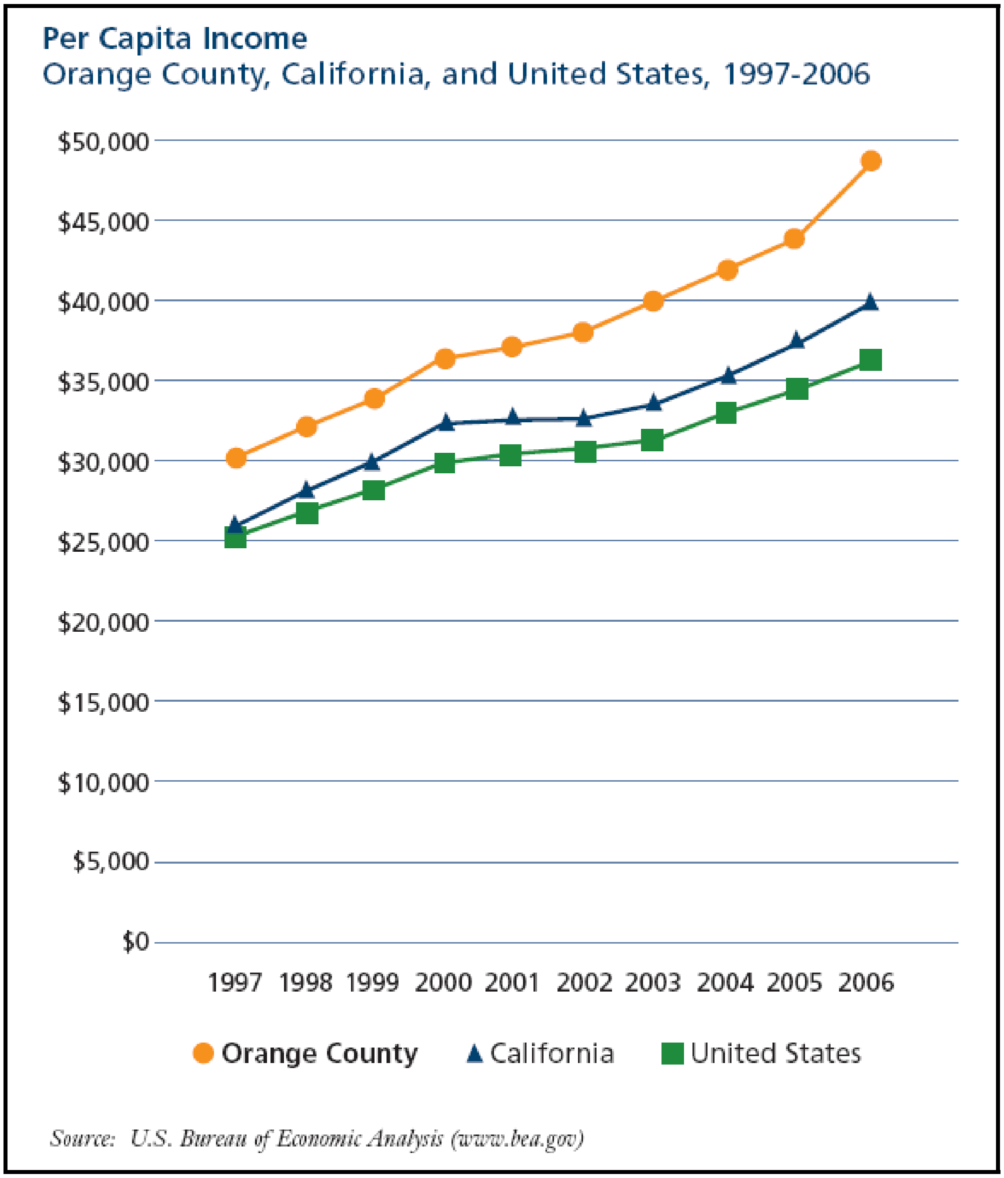
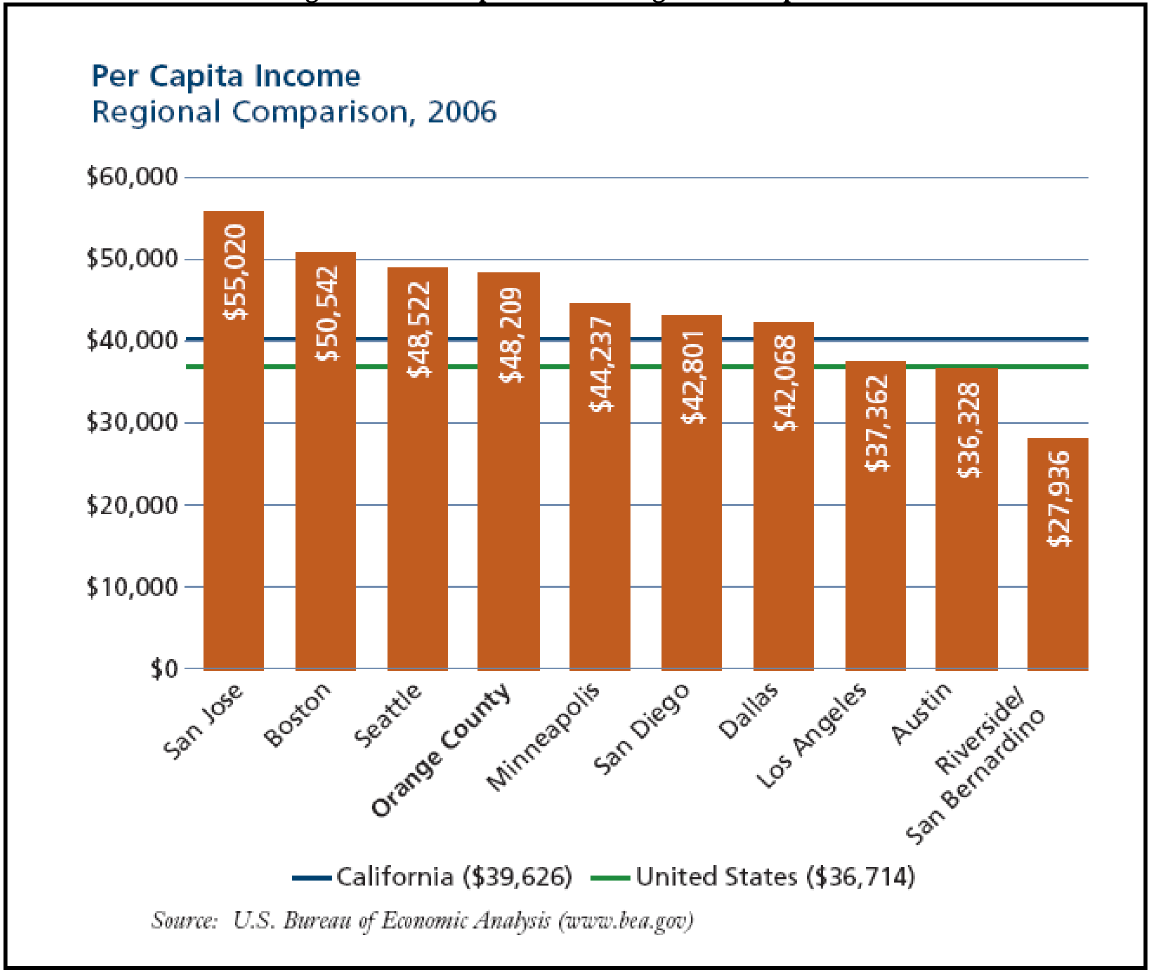


Figure 5: Per Capita Income Regional Comparison

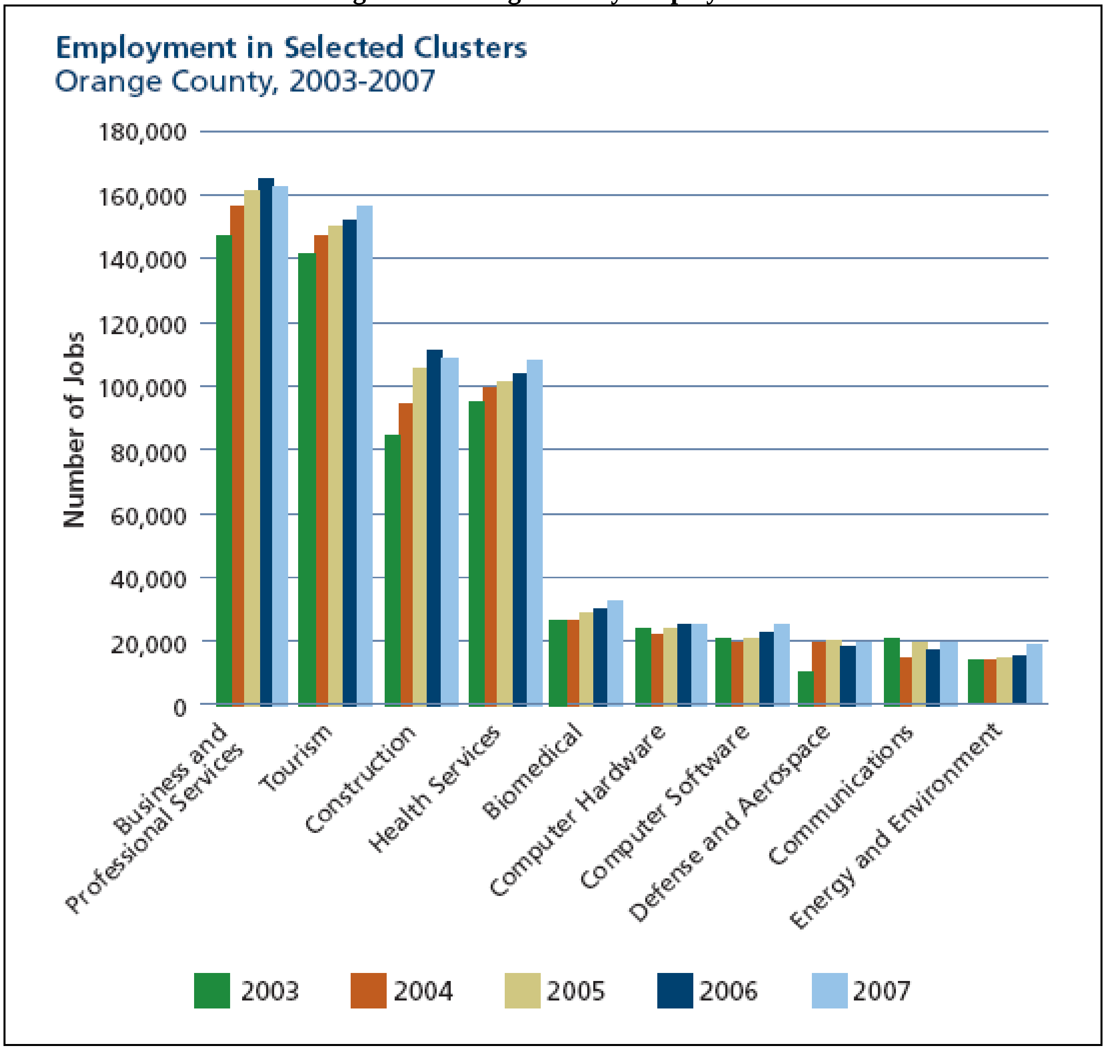


In December 2009, the median sale price of an existing single-family detached home in Orange County was $431,750, down $106,000 or 20% since July 2008. This price is still nearly $130,000 more than the state median price for a comparable home in December 2009, according to the Employment Development Department of the State of California.

Between 2006 and 2007, employment grew in seven of the 10 major industry clusters:

- Two of the largest clusters –Tourism and Health Services – were part of this growth.
- The other two largest clusters – Business and Professional Services, and Construction – experienced employment declines.
- Computer Hardware also experienced a decline.
- The largest employment gains occurred in Communications (19.2%), Energy and Environment (11.5%), and Computer Software (6.4%).

Figure 6: Orange County Employment



Land Use & Housing

According to Orange County's Watershed & Coastal Resources Division, the watershed covers an area of approximately 57,500 acres. Residential development covers around 21,000 acres, or roughly 35% of the watershed. Commercial and industrial activities occur on approximately 6,900 and 4,300 acres within the watershed, respectively, while 255 acres are devoted to recreational use. Vacant land comprises nearly 8,000 acres.

Table 7: Land Use – Westminster Watershed

Land Use Type	Acres
Residential	20,910
Vacant Land	7,986
Commercial	6,897
Industrial	4,334
Transportation, Communication & Utility	417
Education and Religion	398
Recreational	255
Agriculture Use	162
No Data Available	4,921
*Source: Orange County Watershed & Coastal Resources Division, April 2005	

Orange County is one of the nation's most densely populated counties, and it ranks second in California behind San Francisco. The County has a population density that is approximately fifty percent higher than Los Angeles County, and ten times that of Maricopa County, Arizona. The table below shows the population and housing densities of the cities within the Westminster watershed as of the 2000 U.S. Census. Given the population growth since 2000, and the lack of open, developable space, the current densities are undoubtedly higher.

Table 8: Comparative Population and Housing Density

	Area, Square Miles			Density, Per Square Mile	
	Total Area	Water Area	Land Area	Population	Housing Units
California	163,696	7,736	155,959	217	78
Orange County	948	159	789	3,605	1,228
Anaheim	50.5	1.5	48.9	6,702	2,038
Cypress	6.6	0.0	6.6	6,991	2,424
Fountain Valley	8.9	0.0	8.9	6,168	2,072
Garden Grove	18.0	0.0	18.0	9,165	2,591
Huntington Beach	31.6	5.2	26.4	7,184	2,867
Los Alamitos	4.1	0.1	4.0	2,876	1,079
Santa Ana	27.4	0.3	27.1	12,452	2,748
Seal Beach	13.2	1.7	11.5	2,100	1,240
Stanton	3.1	0.0	3.1	11,971	3,524
Westminster	10.1	0.0	10.1	8,724	2,665
Los Angeles County				2,344	806
Maricopa County, AZ				339	136

Source: US Census Bureau, 2000 Census

Importantly, housing demand within the cities that comprise Orange County continues to grow. To meet this demand, the County is making an effort to make future development more efficient by increasing the density of residential housing projects. According to the County, higher net housing density (measured as units per acre on land devoted purely to housing – not counting land dedicated to roads, parks, commercial space, etc.) will, among other things, reduce infrastructure costs, make public transit more effective, and increase the amount of land available for other uses such as recreation. The net density of existing residential development is 7.8 units per acre, and the County is proposing that new residential projects have a net density of approximately 20 units per acre. The construction of housing developments with a higher net density will ostensibly allow the population to grow at a higher rate than it would have grown otherwise.

3. Structure Inventory & Valuation

In order to estimate the value of damages to property as a result of flood events within the study's floodplains, it is first necessary to inventory the structures and other assets within the floodplain. This section describes how the inventory and valuation of structures were accomplished. The next section will utilize this data to develop an estimate of the damages likely to occur from flooding.

Structure and Content Inventory

The combined 500-year floodplains for CO5 and CO6 contain over 38,000 parcels, and CO4 contains over 11,000 parcels. More than 90% of these structures are classified as SFRs. Given such a large number of structures in the floodplain, a complete field inventory was not feasible. Instead, field inventorying of the SFR structures was completed by multi-stage cluster sampling, while for all other structure types the attempt was made to attain a complete inventory. For those structures for which data on construction quality and condition were not available, inventory population averages were applied in combination with square footage data from the real estate records to calculate depreciated structure value. The sampling method for SFRs is explained in the Methodology section below.

Table 9: Structure Categories

Category	Description
SFR	Single-family residences
MFR	Multi-family residences
MH	Manufactured housing units
Commercial	Retail stores, offices, hotels, etc.
Industrial	Manufacturing and similar facilities
Public	Municipal buildings, schools, etc.

For the structure valuation, the Depreciated Replacement Cost was estimated using Marshall & Swift construction unit cost estimates, and adjusting for the existing condition and variance of local costs from the national average.

Because the value of contents within commercial and industrial structures can vary significantly between regions, cities, and even floodplains, it is often the case that for the Economic Analysis a detailed content survey of these types of structures within the floodplain is undertaken. The end result of the survey process is a ratio of content value to structure value (CSVR) that can be applied to the relevant structure types in the study's structure inventory. This study, however, because of limited resources available for the study, and because of the high proportion of SFRs relative to other structure categories (over 90%), utilizes CSVRs that were developed either for other studies or by an expert panel for application in USACE flood damage studies. There does not appear to be any reason to believe that these ratios would not be broadly applicable within the study area, and their use has saved a considerable amount of study resources.

The table below shows the ratios assumed for the content-to-structure values of the different classifications of residential and non-residential buildings in the floodplain. The content ratios represent an estimate of the depreciated replacement value of the goods inside each structure.

Table 10: Content-to-Structure Value Ratios (CSVR)

Structure Type		CSVR	Source
Residential	SFR[1]	.5	1
	MFR	0.22	2
	MH	0.5	1
Commercial	Eating and Recreation	0.4	2
	Groceries & Gas Stations	1.42	2
	Professional Businesses	0.91	2
	Repairs and Home Use	0.62	2
	Retail and Personal Services	1.71	2
	Warehouse & Contractor Services	0.68	2
Other	Industrial	1.7	3
	Public	0.37	2

Sources: 1 - ER 1105-2-100; 2 - Expert Panel Meeting, Houma, Louisiana, February 13, 1997; 3 - Previous Los Angeles District Surveys, including Murrieta Creek and Lower Mission Creek.

Methodology

An initial inventory of the parcels in the 500-year floodplain was compiled in ArcGIS (ArcMap) software by linking a shapefile of the floodplain with a shapefile containing the parcel information, and then exporting to a spreadsheet those parcels in the floodplain. For each parcel, the data was linked to the geographic center of mass of the particular parcel by creating a data centroid within the ArcMap program. Because only those parcels whose centroid overlaps the floodplain are considered as impacted, only those parcels that are at least bisected by the floodplain are included in the inventory. This is done in an attempt to improve the accuracy of the structure inventory – eliminating the inclusion (and ultimate valuation) of those parcels that are least likely to have structures that are actually impacted by the flooding, even while a portion of the parcels receive some non-zero level of flooding.

[1] The SFR *content* depth-damage curves used in this study were designed by IWR to be applied to the full depreciated replacement value of the *structure* – thus making, for the purposes of a flood damage estimate to contents, a direct estimate of content value of SFRs unnecessary. For purposes of the report, however, content value of SFRs has been estimated and reported using the ratio .5, which is a generally-accepted CSVR for SFRs, and has been successfully used in numerous previous studies.

The centroid creation is also used to automate the determination of flooding at the structure; this will be discussed in greater detail in a subsequent section.

The parcels identified as within the 500-year floodplain via the procedure described above were then matched to data downloaded from the First American Real Estate Solutions® database. The real estate database includes parcel-specific information on structure type, square footage, construction date, information on improvements, etc. The vast majority of the residential structures inventoried fit into the Class D category. Class D buildings are characterized by combustible construction. The exterior walls may be made up of closely spaced wood or steel studs, as in the case of a typical frame house, with an exterior covering of wood siding, shingles, stucco, brick, or stone veneer, or other materials. They may also consist of an open-skeleton wood frame on which some form of a curtain wall is applied including the pre-engineered pole or post-frame buildings.

The calculation of structure value in a floodplain can be done several different ways, each having their advantages and disadvantages. One method, estimating the Depreciated Replacement Cost of the structures in the floodplain, involves integrating the following: size of the structure, the unit cost of construction as measured in cost per square foot, and an allowance for deterioration as measured as a percent of total value. An alternative way of calculating the total structure value in the floodplain would be to use tax assessment records on each parcel's improvement value. While this assessment information is readily available, California's Proposition 13, which limits increased assessments until a home is sold, results in unequal valuations of one home relative to another. It is primarily for this reason that this study will use the Depreciated Replacement Cost method. More information on the different structure valuation methods can be found in IWR Report 95-R-9, Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations. The Depreciated Replacement Cost method requires visits to the structures themselves in order to attain the necessary information, which includes foundation height, structure type, and structure condition. This process is explained below.

Given the massive floodplain, sampling was done to collect information on a representative sample of the residential structures in the floodplain. For the other structure categories (commercial, industrial, etc.), of which there are much fewer, a more complete inventory was collected.

There are numerous possible sampling methods for the residential structure inventory. According to IWR Report 91-R-10, multi-stage sampling is most useful for sampling large populations across a large geographic area. The sampling is done in two or more stages, either simple random or systematic random sampling, and each stage should be less broad (less macro) than the previous. Importantly, the sampling percentage or proportion at each stage should be the same.

For the first step in the structure sampling, each parcel in the floodplain is associated with a particular Thomas Guide© map reference number (for example: page 857, grid A3), which was downloaded along with the real estate data. There are a total of 94 unique map reference numbers that are wholly or partially in the 500-year floodplain. The first stage of sampling was done at this level, with one-third of the map numbers being selected at random within Microsoft Excel by assigning each map reference number a unique, random number using the "=rand()" function, then sorting the columns in ascending order according to the value of the random number, and selecting the top one-third for sampling. The same procedure was followed for the selection of streets within the map reference numbers – again selecting a number equivalent to one-third of the eligible streets. Those structures along these sampled streets comprised the final structure inventory sample. For example, following this methodology, approximately ten percent (2,400) of the SFRs within the CO5/CO6 floodplain should be inventoried. In reality, this sampling methodology resulted in a sampling of approximately 15% (3,500) of the SFR structures in this area. The same sampling method was followed for the residential structures in the CO4 floodplain.

While the number of structures sampled is large in absolute terms, the percentage of structures in the floodplain that were sampled is smaller than for the typical feasibility study. While the proportion of structures inventoried would ideally be greater, it is believed that, done properly, sampling can result in a reasonably accurate description of the assets in the floodplain.

Done properly, a sample provides an estimate that closely approximates what one would find if every structure within the floodplains were inventoried. In order for the sample to be representative of the greater population, the sample must be of a sufficient size. The size of the sample that is required depends, among other things, on the variance of the population and the amount of sampling error that one is willing to tolerate. The relevant variables for the determination of the sample size include the following:

- a) An estimate of the mean of the critical variable;
- b) An estimate of the variance of the critical variable;
- c) The level of precision desired; and
- d) The "t" value corresponding to the particular level of precision desired.

The required sample size (n) is calculated by the following equation:

Where,

s^2	=	The variance of the critical variable.
$\hat{Y}$	=	An estimate of the mean of the critical variable.
r	=	The level of precision desired – in this case .05, or 5% of the true mean for the sample.
t	=	The t table value corresponding to the probability that the resulting sample estimate of the variable mean will be within the specified range of precision.

The critical variable in this case is the depreciated replacement cost per square foot.

For SFRs, prior to beginning the field inventory work, the mean critical variable (the DRC per square foot) was estimated to be 75, and the range was expected to be between 40 and 110. These values are arrived at by combining Marshall & Swift square foot construction cost estimates with adjustments for construction quality and a depreciation factor that is based on structure condition. For SFRs, it is assumed that the mean home is of average construction quality and in good condition. The lower end represents homes of fair construction quality in fair condition, and the high end represents those structures of very good construction quality in new condition. When the variance is unknown, IWR 91-R-10 states that one method of estimating it is to divide the range of values (the difference between the high and low) by four and square the result. This results in a standard deviation of 17.5 and a variance of 306. The range of values was assumed to be particularly high in order to ensure that the calculation of the required sample size did not underestimate the number of samples needed. Inserting these values into the equation, as shown below, results in a sample size of 84. The criterion employed here, as shown in the equation below, is that the estimate of the mean be within 5% of the actual population mean 95% of the time.

$$n = 1.96^2 * \frac{306}{(75*.05)^2};$$

$$n = 84$$

The sample size calculated above serves as a minimum requirement for statistically significant results under random sampling[2]. Importantly, the methodology employed for this study was multi-stage cluster sampling - not pure random sampling – and thus a greater sample size would be needed to compensate for the fact that the final sample includes small groups of structures that are located near each other (and are thus, on average, more similar to each other than would be expected under random sampling). For a given sample size, the results of multi-stage cluster sampling would be less accurately representative of the actual population of structures than under pure random sampling. Thus, for cluster sampling a larger sample is required to achieve the desired level of precision. For this reason, for CO5/CO6, the study sampled 212 clusters with an average of 16 SFRs per cluster.

The valuation of the structures in the floodplain requires information on structure type, construction quality, current condition, and number of stories[3]. Once collected, this information was utilized to calculate the structure depreciated replacement values. Base per square foot construction cost estimates for each structure type were determined by utilizing the Marshall and Swift Real Estate Valuation Service method according to the following procedure:

- Construction quality and current condition of the structures were noted from field surveys.

[2] According to the inventory sample results, the variance of per square foot cost may be less than originally assumed, and would indicate the need for a slightly smaller sample size (70 instead of 84).
[3] Structure first floor elevation (estimated via hand level) was also recorded for each structure visited as part of the field inventory work. While this data is not relevant for the structure valuation, it is a critical variable in the estimate of flooding damage.

- For a given structure type, the per square foot construction cost (replacement cost) was determined using the most current Marshall & Swift Valuation Service data. This per square foot cost estimate reflects the construction quality of the structure. The per square foot costs, which are based on a national average, were modified to reflect local cost conditions using Marshall & Swift local cost multipliers.
- This current, locally adjusted cost per square foot was then adjusted additionally for the condition of the structure, which determines the appropriate depreciation factor to apply. In order to correlate the current condition of the structure to a percent depreciation, the study utilized Tables 7 through 9 of IWR Report 95-R-9, '*Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*'.
- The depreciated replacement cost per square foot values were multiplied by square footage to arrive at the total depreciated replacement value for the different types of structures.
- If the square footage was not available within the real estate records for a particular property, square footage estimates were made from either aerial photography measurements using the ArcMap program or by applying the mean square footage of other structures of the same classification for which square footage is known.

As described above, under this study's methodology, the value of the contents within each structure is assumed to be a function of the value of the structure. The value of the contents of each structure was estimated by multiplying the CSVR for the particular structure type by the estimated structure value (as calculated per the method described above).

Inventory Results

CO4

The table below shows an inventory of the approximate number of the various types of structure parcels in the CO4 floodplain according to the real estate records. The numbers are only approximate because the numbers reflect an assumption of one structure per parcel. In the case of public structures, multi-family and mobile homes, the numbers shown below are less than what actually exists because many of these parcels may have more than one structure on the parcel. Similarly, for commercial structures the table underestimates the number of structures because often more than one structure may exists on a given commercially-zoned parcel. Importantly, in this analysis as the term structure is defined, a single structure can comprise more than one business – as is the case for many community centers (otherwise known as strip malls). While the table below is not an accurate accounting of the number of businesses on a particular parcel or within a particular structure, because there is not typically more than one structure one a particular parcel the figure for commercial structures in the table is likely only a slight underestimation of the actual number of commercial structures in the floodplain. This also applies to the inventory numbers shown further below for CO5/CO6. As can be seen from the table, Single Family Residences (SFRs) comprise the vast majority of the structures in the CO4 floodplain – over 94%. For the SFRs, approximately 90% were built between 1956 and 1978, and just 2% were constructed after 1979.

Table 11: Floodplain Structure Parcels – CO4

Type	500 Year	100 Year	50 Year	Mean Build Year - All
SFR	10,740	1,817	439	1965
MFR	238	70	38	1966
MH	8	1	1	na
Pub	25	6	4	na
Com	182	50	21	1967
Ind	188	56	26	1976
Ag	0	0	0	na
Total	11,353	2,000	529	na

CO5 & CO6

The table below shows an inventory of the numbers of the various types of structures in the CO5/CO6 floodplain according to the real estate records. As can be seen from the table, Single Family Residences (SFRs) comprise most of the structures in the floodplain.

The real estate data shows that the vast majority of the housing stock in the floodplain was constructed between 1950 and 1979. The mean and median construction date for both SFRs and MFRs is 1964. Approximately half of the structures were constructed between 1960 and 1969, and 95% of the structures built between 1946 and 1983. There has been very little new construction since 1980, and these relatively newer homes account for only around 2% of the housing stock.

Table 12: Floodplain Structure Parcels – CO5 & CO6

Type	500 Year	100 Year	50 Year	Mean Build Year - All
SFR	33,882	25,076	21,682	1964
MFR	1,568	1,238	1,169	1964
MH	1,502	1,227	1,077	na
Pub	137	111	96	1948
Com	940	707	659	1965
Ind	230	165	130	1972
Ag	2	0	0	na
Total	38,261	28,524	24,813	na

It should be noted for the above tables that the figures for MFR and MH represent parcels and not the number of residential units involved since multiple housing units can exist on a parcel. The number of housing units for MFR and MH by floodplain and flood event are shown below.

Table 13: MFR & MH Floodplain Housing Units

Type	Area	500 Year	100 Year	50 Year
MFR	CO4	2,425	743	256
	CO5/CO6	12,763	9,270	8,989
	Total	15,188	10,013	9,245
MH	CO4	125	25	25
	CO5/CO6	1,665	1,341	1,241
	Total	1,790	1,366	1,266

Structure and Content Valuation

This section describes the estimates of structure and content value in the two floodplain areas. It is important to note that the tables contain estimates of depreciated replacement value, and do not represent expected damages. Instead, the estimates can be seen as the value of the assets that are exposed to flood damages.

CO4

Using the Marshall and Swift construction cost data, and applying the field data, the depreciated replacement cost of the structures and contents in the floodplain was estimated. The table below shows the estimated total values for the 500-year floodplain. Employing the methodologies described above, the structure and content values for each structure were estimated. The table includes the mean structure value for each category. The mean value for commercial structures is particularly high because a significant percentage of the structures are represented by larger, multi-unit community shopping centers (and not a single store). According to the inventory, the total depreciated replacement cost of the structures and contents in the 500-year floodplain is approximately $2.8 billion.

Table 14: Value of Structures and Contents in 500-Year Floodplain – CO4

Type	Total Structure Value ($M)	Content Value ($M)	Mean $/SF	Mean FFE
SFR	1,239	620	73	0.7
MFR	170	37	76	0.8
MH	6	3	45	2
Pub	95	35	99	0.5
Com	134	129	84	0.5
Ind	129	221	44	0.5
Subtotals	1,773	1,045		
Total Structure & Content ($M)	2,818			
^SF is square foot and FFE is first floor elevation in feet - both are means.				

CO5 & CO6

The table below shows the estimated value of structures and contents in the CO5/CO6 floodplain. The estimated total value is around $11.2 billion. The table also shows the estimated mean depreciated replacement cost per square foot and the mean first floor elevation.

Table 15: Value of Structures and Contents in 500-Year Floodplain - CO5 & CO6

Type	Structure Value ($M)	Content Value ($M)	Mean $/SF	Mean FFE
SFR	4,005	2,002	73	1.04
MFR	1,223	269	76	0.89
MH	88	44	45	2
Pub	263	114	113	0.5
Com	1,225	1,300	119	0.62
Ind	240	398	59	0.34
Subtotal	7,044	4,127		
Total Structure & Content ($M)	11,171			
^SF is square foot and FFE is first floor elevation in feet.				

The next section will discuss the estimation of damages to these structures across various flood events, as well as assess the economic damages related to other impacts.

4. Property Damages

Flooding can cause myriad significant damages to structures of all types. According to Martin L. King of the Association of Specialists in Restoration and Cleaning, in an article for Slate.com[4], water can cause a structure's structural components to shift or warp – including the studs and foundation. Water can also damage the wiring, gas lines, and septic system. For high water, ceilings may sag under the weight of trapped water or soggy drywall, wet floorboards can bend and buckle, and the roof may leak or break altogether. Flooding in a basement can be especially dangerous; if the water is removed too quickly, pressure from the soaked earth outside can push inward and crack the foundation walls. Most of the structures in the floodplains that are studied in this analysis are wood frame, and this type of structure will suffer greater exterior damages than those made of brick or masonry. In all types of residential housing, though, flooding will most likely destroy the interior walls. Soaked wallboard becomes so weak that it must be replaced, as do most kinds of wall insulation, and any plywood in the walls is likely to swell and peel apart. Water can also dissolve the mortar in a chimney, which creates leaks and thus a risk of carbon monoxide poisoning once the heat comes back on.

Also, floods often deposit dirt and microorganisms throughout the house. Silt and sediment can create short circuits in the electrical system as gunk collects in walls and in the spaces behind each switch box and outlet. Appliances, furnaces, and lighting fixtures also fill with mud, making them dangerous to use. Anything that gets soaked through with water may contain sewage contaminants or provide a substrate for mold. Most upholstered items must be thrown away, as well as carpets and bedding.

This section includes a description of flood damages expected to accrue to structures, contents, and vehicles in each floodplain. The other damage categories included in the analysis – clean-up, emergency, administration, etc. – will be discussed in subsequent sections.

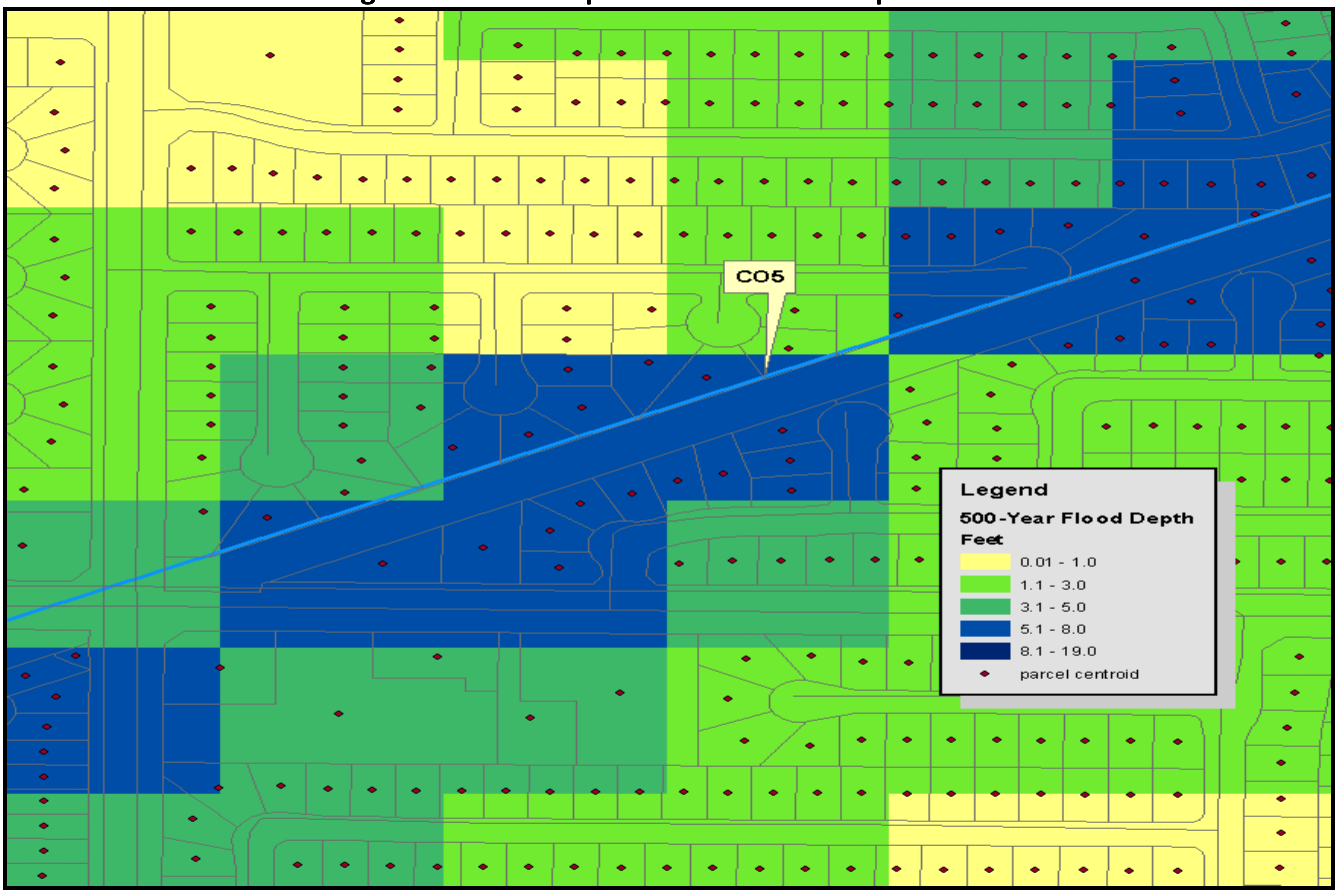
Methodology Overview

For the typical flood damage analysis, the HEC-FDA program is used to combine H&H and economic data (structure inventory, etc.) in order to derive a stage-damage function for each reach or impact area. Among other inputs to this procedure are water surface profiles for the various channel or river reaches, which are an output of the HEC-RAS model utilized by engineers. For this study though, a different flood modeling program was used (FLO2D) that doesn't create water surface profiles, but instead provides as an output surface flood depths across the floodplain. For this reason, it was necessary to calculate the stage-damage function outside of the HEC-FDA program, which would then be an input into the HEC-FDA program, further incorporating risk and uncertainty into the analysis and resulting in an estimate of the Expected Annual Damages from flooding.

[4] "What Happens to Flooded Houses?" by Daniel Engber; August 31, 2005. Can be found at http://slate.msn.com/id/2125351/

Using numerous shapefiles within the ArcMap computer program, each structure in the floodplain was associated flood depths for the 50, 100, and 500-year flood events. The flood depth shapefiles are an output of the FLO2D program model, and were provided by USACE Engineers. A shapefile delineating parcels in the floodplain was provided by Orange County officials for use in this analysis. The figure below is an example of the overlay of the two shapefiles (shown at close range).

Figure 7: Flood Depth at Structure Example



Using the shapefiles produced as FLO2D outputs, the parcel centroids were spatially joined to their respective flood depths for the three different flood frequency events (50, 100, and 500). The ArcMap program was then prompted to produce an output table giving the depth of flooding at each structure for each of the three flood events.

The estimation of damages was conducted in part by using the @RISK program, which is essentially an add-on tool used within the Microsoft EXCEL program. The U.S. Army Corps of Engineers developed a template to estimate damages from various single storm events, which provides as an output a mean damage estimate and a corresponding standard deviation. Damages were estimated for three flood events: the 50-, 100-, and 500-year events. These results serve as inputs to the HEC-FDA program. The @RISK program template allows for direct entry of water depths at each parcel, combining this information with data on the foundation height and structure characteristics at each parcel in the particular floodplain. Like the HEC-FDA program, the @RISK program uses Monte Carlo (or Latin

Hypercube) simulation in the calculations. Unlike HEC-FDA though, the @RISK template calculates the damages by referencing the depth of water at each individual structure, as opposed to referencing the structure to a water surface profile that corresponds to a channel or river cross section. The @RISK outputs are a frequency-damage function that is then matched transitively with the appropriate frequency-stage functions to arrive at a stage-damage function for entry into HEC-FDA.

The @RISK program was used to calculate and aggregate damages associated with most of the damage categories included in the analysis. These include damages associated with all structures and contents, vehicles, private cleanup costs, and displacement costs (temporary relocation).

The HEC-FDA v. 1.2.4 program was utilized to calculate expected annual damages. Among the data requirements for the program to calculate EAD are three functions:

1. Exceedance Probability/Discharge Function – A relationship that defines for many points within each channel, and across a large range of values, the probability in a given year that a specific discharge will be exceeded.
2. Stage/Discharge Function – A relationship between the depth or elevation of water and the amount of discharge (cfs) in the channel.
3. Stage/Damage Function – A relationship between the depth or elevation of water in the interior of the floodplain and the amount of economic damage expected as a result.

Each of these functions must be defined for each reach/impact area based upon a representative cross section or index location within the impact area. The first two functions were derived by Engineering Division staff based upon output from the HEC-RAS model. The third function is typically derived within the HEC-FDA program. Structure inventory data, including values, elevations, depth/damage functions, and locations, are entered into the Economics Module of the program. The program calculates aggregated stage/damage functions by cross referencing water surface profile data imported from HEC-RAS with the structure data based upon the cross section, or river mile location, assigned to each structure.

As noted, for this study, because of the nature of flooding in the study area, a determination was made that the FLO2D model provided better estimates of overbank flooding than would be capable with the HEC-RAS model. Because of this, frequency/damage functions were derived outside the HEC-FDA program within the @Risk framework as discussed previously. The output of the @Risk model is frequency/damage functions for each impact area. Since the HEC-FDA model requires a stage/damage function for each impact area, the frequency/damage functions were transitively associated with stages instead of frequencies based upon the Exceedance Probability/Discharge and corresponding Stage/Discharge functions derived from HEC-RAS modeling. For example, if the @Risk model results yielded SFR structure damages of $10 million for the 50 year event for Impact Area X, first the discharge for the 50-year event for Impact Area X is determined from the Exceedance Probability/Discharge function, and then for this discharge, the corresponding stage is determined from the Stage/Discharge function. This stage is then associated with damages to derive stage/damage functions for each impact area.

In some areas, because of the nature of flooding, it was necessary to make adjustments to the Stage/Discharge and Stage/Damage functions. The topography in many locations is such that elevations are the same or even lower as one moves further from the channel. The result is a large floodplain with generally shallow flooding. The HEC-RAS model output shows water surface elevations for discharges exceeding channel capacity that essentially do not change for less frequent events. Although the water surface elevation at the location of the channel may not increase, the actual flood depths in the overbank area do increase with less frequent flood events. Accordingly, stages for discharges exceeding channel capacity were adjusted to reflect the average increase in overbank flood depth based upon the FLO2D results. This has the benefit of both reflecting the nature of flooding in the floodplain and enabling the HEC-FDA program to function properly, as the program requires increases in each of the major parameters for less frequent flood events (discharges, stages, and damages) to yield logical results.

The following outlines and summarizes the major steps taken to estimate the damages to property in the various floodplains.

- Structure value and first floor elevation are estimated for each parcel in the floodplain (see the Structure Inventory and Valuation section) – structure inventory database created within MS Excel;
- Structures are separated into various impact areas, as shown in the maps contained previously;
- Within the ArcMap program, a parcel shapefile with centroids is overlain with flood shapefiles of the 50, 100, and 500-year events. The results are exported to a database file;
- For each parcel, the structure inventory database is updated to include flood depth for each of the three flood frequencies analyzed;
- Utilizing the @RISK program, Latin Hypercube simulations are performed to estimate the mean and standard deviation of damages associated with each of the flood frequencies. These simulations include the use of distributions to help account for the risk and uncertainty associated with several of the relevant variables;
- H&H data (frequency-discharge and stage-discharge data) are entered into the HEC-FDA program in order to further account for Risk and Uncertainty;
- Outputs of the @RISK simulations are entered into HEC-FDA as stage-damage functions for each damage category for each impact area – frequency-damage data from @RISK transitively converted to stage-damage data by utilizing frequency-stage data;
- The HEC-FDA model is run, producing an estimate of the Expected Annual Damages for each category for each impact area for each floodplain.

Use of Depth-Damage Functions in @RISK

Property damage from flooding is of course to a large extent a function of the depth of the floodwater. The study uses depth-damage functions that were created in order to relate the depth of flooding to the amount of property damage to structures, their contents, and vehicles. The methodology here utilizes such depth-damage curves that have been derived by the Corps (EGM04-01 & EGM09-04), FEMA, and previous feasibility studies.

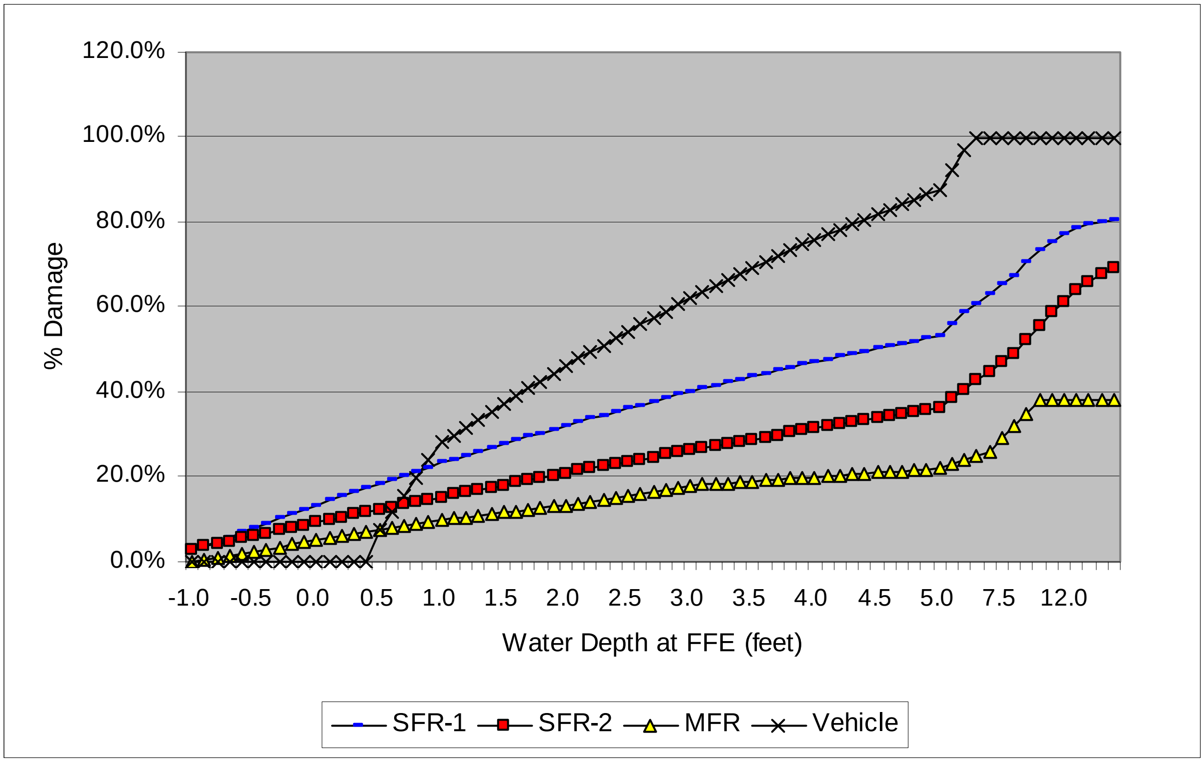
The structure depth-damage curves estimate the flood damage as a percentage of structure value. Thus, to calculate the damages for an individual structure, the appropriate depth-damage curve is applied to the structure via a spreadsheet lookup function, which combines the appropriate damage percentage with the structure value to give an estimate of structure damage. The depth-damage curves for the major structure categories are shown in the graphs below.

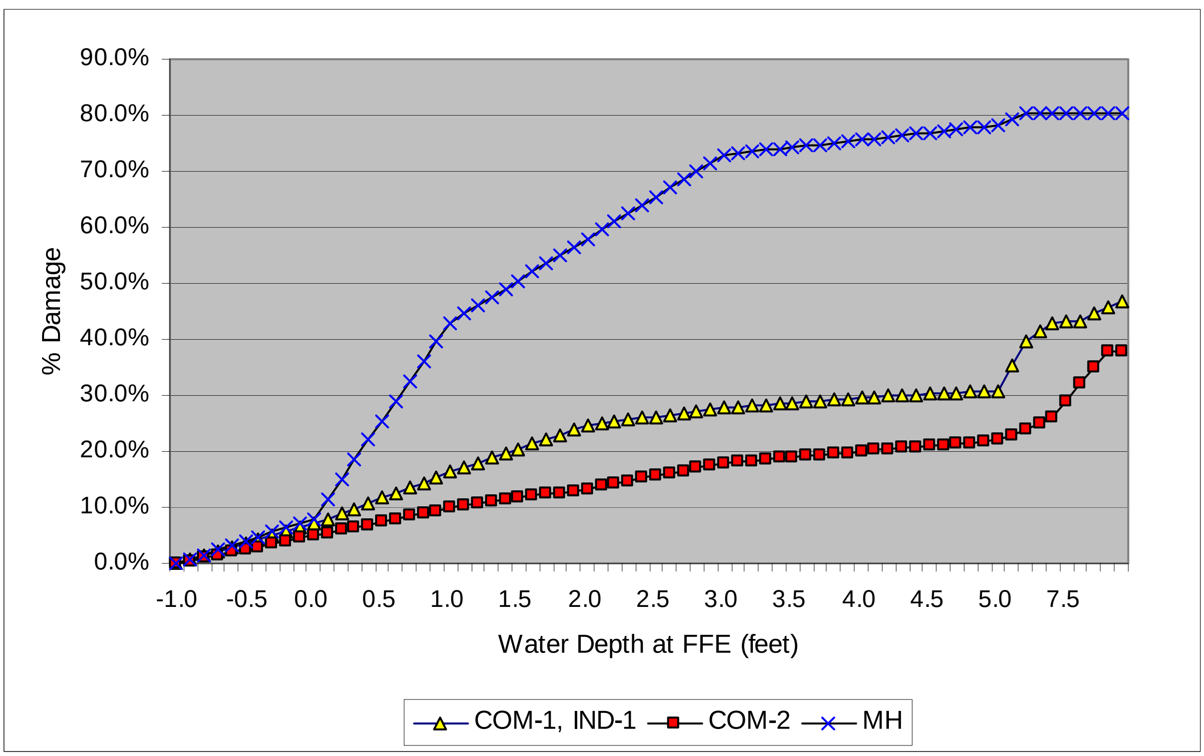
In the depth-damage graphs below, each line shows the structure damage as a percentage of total depreciated replacement value for each particular property category. In the legend, the numbers following the structure type (for example, SFR-1) designate the number of stories.

The approach taken to quantify damage to contents relies on three pieces of information: 1) structure value; 2) content-to-structure value ratio; and 3) the content depth-damage relationship. The content-to-structure value ratio and content depth-damage relationship are unique to the structure occupancy type to which a structure is assigned. To estimate content damage for an individual structure, the structure value is first multiplied by the content-to-structure value ratio to provide an estimate of the total content value. This content value is then multiplied by the value of percent damage specified by that structure type's particular content depth-damage function. The content depth-damage functions can be found in the Appendix. All of the functions shown in the content depth-damage table are expressed as a percentage of the content value, which, as discussed previously, is calculated as a particular percentage of the structure value – the percentage used being endogenous to the study. Importantly though, the content damage curves used for one- and two-story SFRs were created by IWR as a function of depreciated structure value, and as such the calculation of content value of these structures is irrelevant for the damage calculation. The content depth-damage curves are contained in a table in the Appendix.

For vehicles, on average, very little damage is expected at low flood levels (around one foot or less). At depths greater than one foot, however, damages increase dramatically as water reaches electrical components and floods key engine parts. For the study, vehicle damage has been calculated employing the recently issued guidance of EGM09-04. Like the estimation of the frequency damage relationship for structures and contents, the damage to vehicles was calculated within the @RISK program for the 50, 100, and 500 year events, and the vehicles were assumed to be parked at the ground level of the parcel.

Figure 8: Property Depth Damage Curves





Economic Uncertainty Parameters

Many of the factors that influence the estimate of flood damages can and should be represented by a range of values instead of a single number. The estimate of the value of and damage to economic assets in the floodplain is based on numerous inputs, none of which are understood or known with 100% certainty. Errors in measurement, variation in classification and judgment, and a general lack of information all contribute to the inability to accurately describe these values with a single, discrete number. For the economic elements of this study, in accordance with EM 1110-2-1619, an attempt was made to account for the uncertainties associated with several variables. The table below shows, for each variable, the error value used in the model of damages associated with SFRs (structures, contents, private vehicles, displacement, and cleanup). Similar errors were also accounted for in the damage estimates of the other structure categories, as appropriate.

For the variables listed in the table below, several sources were relied upon for guidance on the appropriate standard deviation to use. These include specific guidance documents, previous empirical studies, and, where necessary, professional opinion. The error in first floor elevation was taken from EM 1110-2-1619 (section 6-5), structure and content depth-damage function errors were derived from EGM 04-01 (an IWR guidance document), displacement claim was taken from an analysis of historical payouts from flood disasters, and the remainder were based on professional judgment and supported by some amount of research (internet or otherwise).

Table 16: Errors and Distributions Used - SFR Damages

Variable	Standard Deviation/Coefficient of Variation	Distribution Shape
Structure Value	10%	Normal
Content Value	10%	Normal
First Floor Elevation	0.2 Feet	Normal
Structure DD Curve - 1 Story	2%	Normal
Structure DD Curve - 2 Stories	3%	Normal
Content DD Curve - 1 Story	2%	Normal
Content DD Curve - 2 Stories	4%	Normal
Vehicle DD Curve	2%	Normal
Cleanup Cost Per SF	.9375	Truncated Normal(3.65,.9375,0,10)
Avg. Displacement Claim	$717	Truncated Normal (1550,717,0,10000)
Vehicle Value	NA	Discrete({4300,7300,12200,19900},{.383,.223,.258,.136})

For each individual structure, these values are assigned a particular distribution and analyzed by utilizing the technique of Latin Hypercube sampling, which is a stratified sampling method that generally requires fewer iterations than Monte Carlo sampling in order to arrive at an accurate re-creation of the probability distributions used under simulation. Of course, there is also uncertainty in the hydrologic and hydraulic relationships (discharge-stage and frequency-discharge), and this is accounted for in the HEC-FDA model.

Residential Structure Damage

For each of the channels, this section shows: a) the total structure and content damages associated with the SFR structure category, and b) the Expected Annual Damage (EAD) for each structure category. In the following tables, the Total Damages numbers are an output of the @RISK model, and these are displayed for the three events being analyzed. Alternatively, the EAD results are the output of the HEC-FDA program, and these numbers incorporate a probabilistic factor.

For CO4, the output of the @RISK damages model indicates that for the nearly 11,000 SFR structures in this floodplain, there would be more than $180 million in structure and content damages from a 500-year event. Such an event would cause an average of over $16,000 in structure and content damage to SFRs in this floodplain. The 100- and 50-year events would cause approximately $30 million and $9 million in damages, respectively. Table 18 and Table 19 below show the structure and content damages to MFR and MH properties.

Table 17: Total Damages, SFR Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	4,778	2,815	607	359	213	132
	2	22,335	13,360	3,696	2,144	1,630	956
	3	8,438	4,809	3,788	2,231	2,018	1,187
	4	33,895	20,612	4,071	2,514	1,529	940
	5	44,034	25,261	6,523	3,699	355	213
	Total	113,480	66,857	18,685	10,947	5,745	3,428
		180,337		29,632		9,173	

Table 18: Total Damages, MFR Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	535	130	173	55	86	28
	2	667	190	90	25	12	4
	3	3,132	939	1,700	477	1,239	344
	4	372	106	61	19	0	0
	5	2,861	813	683	215	56	18
	Total	7,567	2,178	2,707	791	1,393	394
		9,745		3,498		1,787	

Table 19: Total Damages, MH Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	913	359	139	17	1	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	Total	913	359	139	17	1	0
		1,272		156		1	

For the nearly 34,000 SFRs in the combined CO5/CO6 floodplain (valued at around $6 billion including contents), the economic damages model predicts structure and content damages from the 500-year event to total almost $1.1 billion, while the damage from a 100-year and 50-year event total $675 million and $546 million, respectively. Tables 21 and 22 below show the event-based damages expected to occur to MFR and MH structures in this floodplain.

Table 20: Total Damages, SFR Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	57,959	33,588	36,514	21,863	31,640	19,102
	2	51,687	30,997	28,376	17,618	24,786	15,361
	3	132,019	75,861	80,610	46,843	64,997	37,967
	4	18,879	10,899	11,476	6,612	8,839	5,037
	5	49,575	27,833	32,271	18,332	25,391	14,484
	6	19,720	11,051	11,484	6,463	9,162	5,149
	7	232,274	131,069	168,255	95,702	138,845	79,221
	A	38,821	24,639	15,714	10,422	12,945	8,666
	Subtotal	600,934	345,937	384,700	223,855	316,605	184,987
CO6		92,543	52,555	42,766	23,896	28,798	16,094
	Total	693,477	398,492	427,466	247,751	345,403	201,081
		1,091,969		675,217		546,484	

Table 21: Total Damages, MFR Structures and Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	9,540	2,544	4,157	1,199	3,371	976
	2	4,613	1,308	2,692	829	1,812	561
	3	19,224	6,062	12,472	3,578	9,698	2,661
	4	2,015	553	0	0	0	0
	5	6,246	1,686	3,787	1,046	2,782	770
	6	96	22	0	0	0	0
	7	16,395	4,575	12,766	3,458	11,618	3,027
	A	16,704	4,729	6,407	1,874	5,435	1,587
	Subtotal	74,833	21,479	42,281	11,984	34,716	9,582
CO6		13,423	4,390	8,400	2,409	5,957	1,587
	Total	88,256	25,869	50,681	14,393	40,673	11,169
		114,125		65,074		51,842	

Table 22: Total Damages, MH Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	1,607	569	619	188	534	155
	2	1,469	467	155	2	110	1
	3	1,312	514	370	60	107	1
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
	7	5,826	2,131	4,437	1,383	3,448	975
	A	586	23	53	0	16	0
	Subtotal	10,800	3,704	5,634	1,633	4,215	1,132
CO6		0	0	0	0	0	0
	Total	10,800	3,704	5,634	1,633	4,215	1,132
		14,504		7,267		5,347	

Commercial & Industrial Structure Damage

For the approximately 200 commercial structures in the CO4 floodplain, a total of around $26 million in damages would result from the 500-year event. Industrial properties would suffer around $36 million from the 500-year event. The commercial damages occur throughout CO4, while most of the damage to industrial structures occurs in Impact Areas 3and 4.

Table 23: Total Damages, COM Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	1,880	2,189	583	662	295	383
	2	2,094	2,602	209	237	74	110
	3	601	872	258	377	161	219
	4	3,228	4,297	929	1,372	212	434
	5	4,616	3,497	1,608	1,042	71	101
	Total	12,419	13,457	3,587	3,690	813	1,247
		25,876		7,277		2,060	

Table 24: Total Damages, IND Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	0	0	0	0	0	0
	2	73	124	0	0	0	0
	3	7,221	19,732	4,084	9,200	2,397	4,928
	4	5,263	3,705	614	203	187	16
	5	0	0	0	0	0	0
	Total	12,557	23,561	4,698	9,403	2,584	4,944
		36,118		14,101		7,528	

For the CO5/CO6 floodplain, the 500-year event would cause damages to commercial structures totaling approximately $253 million, and damage to industrial structures totaling $63 million. The tables below show the total structure and content damages to commercial and industrial structures in the CO5/CO6 floodplain for the three storm events that were modeled.

Table 25: Total Damages, COM Structures & Contents, C05 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	19,470	23,931	13,413	17,078	12,616	16,099
	2	6,450	9,388	4,081	6,201	3,407	5,104
	3	12,812	16,454	10,171	12,982	9,328	11,865
	4	6,397	11,568	4,733	8,090	2,972	5,086
	5	698	936	456	560	400	486
	6	0	0	0	0	0	0
	7	9,166	10,924	6,579	8,197	5,620	7,297
	A	36,651	50,676	21,119	30,355	15,834	23,283
	Subtotal	91,644	123,877	60,552	83,463	50,177	69,220
CO6		14,494	22,897	7,206	10,960	5,454	8,692
	Total	106,138	146,774	67,758	94,423	55,631	77,912
		252,912		162,181		133,543	

Table 26: Total Damages, IND Structures & Contents, C05 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	1,219	671	211	131	202	94
	2	5,775	5,655	2,993	3,783	1,969	3,525
	3	6,712	15,246	5,582	10,752	4,981	9,041
	4	0	0	0	0	0	0
	5	6,101	13,459	3,223	5,587	2,212	2,986
	6	0	0	0	0	0	0
	7	0	0	0	0	0	0
	A	2,999	4,714	2,616	3,822	1,716	2,187
	Subtotal	22,806	39,745	14,625	24,075	11,080	17,833
CO6		0	0	0	0	0	0
	Total	22,806	39,745	14,625	24,075	11,080	17,833
		62,551		38,700		28,913	

Public Structure Damage

For the CO4 floodplain, the 500-year flood event is estimated to cause approximately $11 million in damages to public structures and their contents.

Table 27: Total Damages, PUB Structures & Contents, CO4 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO4	1	1,190	471	258	142	103	57
	2	1,010	415	155	86	0	0
	3	2,243	1,098	727	277	613	225
	4	1,082	591	0	0	0	0
	5	1,761	932	0	0	0	0
	Total	7,286	3,507	1,140	505	716	282
		10,793		1,645		2,060	

For the CO5/CO6 floodplain, total structure and content damage from a 500-year event is estimated to be approximately $51 million.

Table 28: Total Damages, PUB Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	500-year		100-year		50-year	
		Structure	Contents	Structure	Contents	Structure	Contents
CO5	1	4,889	2,098	3,751	1,583	3,185	1,372
	2	6,089	2,625	4,842	2,025	4,412	1,788
	3	12,422	5,430	9,620	4,014	7,720	3,027
	4	1,695	2,303	0	0	0	0
	5	1,279	569	1,078	505	999	472
	6	807	811	398	463	329	409
	7	2,601	1,297	1,651	838	1,547	795
	A	3,841	1,975	2,200	1,200	1,767	964
	Subtotal	33,623	17,108	23,540	10,628	19,959	8,827
CO6		0	0	0	0	0	0
	Total	33,623	17,108	23,540	10,628	19,959	8,827
		50,731		34,168		28,786	

Expected Annual Damages to Structures & Contents

The following table shows the structure and content damages in terms of EAD for all structure categories in the CO4 floodplain.

Table 29: Expected Annual Damage, All Structures & Contents, CO4 ($'000s)

Channel	Impact Area	Damage Categories						Total
		SFR	MFR	Com	Ind	Pub	MH	
CO4	1	66.10	9.35	55.05	0.00	18.57	9.71	158.78
	2	331.38	7.12	38.16	1.30	12.07	0.00	390.03
	3	220.44	84.43	24.66	487.45	50.65	0.00	867.63
	4	477.31	4.11	86.60	72.35	11.16	0.00	651.53
	5	569.67	35.27	85.54	0.00	17.16	0.00	707.64
	Total	1,664.91	140.28	290.01	551.10	109.60	9.71	2,765.61

For the CO4 floodplain, the residential structures combine to account for approximately 66% of the total EAD, while Industrial and Commercial structures comprise just over 30% of the total EAD for structures and contents.

Table 30: Expected Annual Damage, All Structures & Contents, CO5 & CO6 ($'000s)

Channel	Impact Area	Damage Categories						Total
		SFR	MFR	Com	Ind	Pub	MH	
CO5	1	1,857.68	191.49	967.59	54.74	159.49	31.66	3,262.65
	2	2,035.81	136.06	425.64	284.55	283.95	17.70	3,183.71
	3	5,522.60	673.14	1,013.65	698.81	554.32	19.68	8,482.20
	4	765.92	17.13	474.04	0.00	26.67	0.00	1,283.76
	5	1,448.76	139.31	30.45	274.28	43.83	0.00	1,936.63
	6	657.51	0.75	0.00	0.00	33.40	0.00	691.66
	7	9,232.21	581.82	528.39	0.00	95.36	196.07	10,633.85
	A	2,078.13	683.98	3,430.72	343.76	233.38	9.68	6,779.65
	Subtotal	23,598.63	2,423.67	6,870.48	1,621.38	1,430.40	274.79	36,219.35
CO6		3,021.56	457.59	864.18	0.00	0.00	0.00	4,343.33
	Total	26,620.19	2,881.26	7,734.66	1,621.38	1,430.40	274.79	40,562.68

As shown in the table above, the total EAD for structures and contents in the combined CO5/C06 floodplain is just over $40.5 million, with residential structures accounting for approximately 73% of the total, or $29.8 million.

Private Vehicle Damage

The damage to vehicles in a floodplain is typically not a significant damage category for the study in either absolute or relative terms. That is, compared to the value associated with other damage categories such as structure damage and emergency costs, damage to vehicles is typically not significant, and thus, in most cases, is not estimated as part of the feasibility study. In this case however, the floodplain comprises such a massive geographic area (approximately 20 square miles) that the number of vehicles affected will likely be in the tens of thousands. While compared to structure damage the damage to vehicles will be relatively small, the absolute value of these damages is likely to be significant. Importantly, the analysis includes only damages to private vehicles, and does not include damages that would be incurred by, for example, public vehicle fleets such as school buses.

According to IWR Report 88-R-2 “Motor vehicles can suffer extensive damage from floods that barely reach the first floor level of nearby buildings…Expected vehicle damage potential should be given a lot of attention where the flood warning lead time is six hours or less.” According to USACE Engineers, for each of the three frequency events, bank overtopping begins approximately five hours after the beginning of the storm event. Of course, the timing of the storm impacts the number of households that receive the flood warning – for example, fewer people would receive the warning during sleeping hours. In general, though, given that at least some degree of flooding occurs a relatively short time after the storm, and given that any flood warning would be made even less time before flooding begins, this analysis assumes that vehicle flooding will constitute a significant source of damages, and as such should be investigated in reasonable detail.

The number of vehicles in the floodplain will be estimated as a function of the number of households in the floodplain. The number of vehicles damaged in a flood event is estimated as a function of the following:

- The duration of the warning lead time prior to the local flood event;
- The number of vehicles remaining at the residences during the typical working hours;
- The timing of the flood event – both time of day and day of the week; and
- The location of the parked vehicles within the flooded area – at street level or within a garage.

The value of the damages to vehicles from a flood event is estimated as a function of:

- All of the above;
- The depreciated value of the vehicles affected; and
- The depth-damage relationship for the vehicles.

Since the prevailing land use in the floodplain is residential, the number of vehicles damaged would, ostensibly, be highest were the flood event to occur during the off-peak work hours, and highest during non-waking hours. The number of damaged vehicles would be lowest during the typical working hours of a weekday.

According to the US Census Bureau's 2003 American Community Survey, approximately 80% of commuters in Orange County drove alone to work, while approximately 10% carpooled – almost all of these in 2-person carpools. Thus, during the primary working hours, the percentage of primary vehicles parked at residences is estimated at around 15% (20% minus half the carpool percentage of 5%) for the working, commuting population. According to the survey, in 2003 there were approximately 1.36 million employed persons over the age of sixteen in Orange County. Of course, many families have more than one vehicle, which may remain at the residence with a stay-at-home spouse or simply as a second vehicle. According to 2000 US Census, the average number of vehicles per household in Orange County is 1.87[5].

During a flood event, some percentage of the residential vehicles will be away from the floodplain as a result of chance (vehicle driven to work or elsewhere) or as a result of the owner intentionally moving the vehicle out of the floodplain. The proportion of vehicles subject to flood damages is thus a function of the amount of flood warning time and the timing of the flood event (time of day as well as day of the week). For this analysis it is assumed that 50 percent of the vehicles will be out of the floodplain during a flood event.

Losses to automobiles were determined as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. The depth-damage relationship for autos was taken from EGM 09-04. Without a specific automotive mix identified for the study area the depth-damage function for sedans is used as a proxy for all automobiles. Damages for autos begin once flood depth has reached 0.5 feet. Vehicle counts were estimated using an assumption of 2 vehicles per residential structure. Evacuation (autos moved out of the flooded area) was assumed to be 50%, as used on American River and other Corps studies. Depreciated replacement value of autos was based on average used car prices (taken from National Auto Dealer Association Data (NADA), Kelly's Blue Book and Edmunds.com databases). Uncertainty was incorporated into the analysis using a discrete distribution with an expected value of $7,300 per vehicle and the following distribution proportions.

Table 31: Automotive Fleet Value Distribution

Value	% of Automotive Fleet
$4,300	38.3
$7,300	22.3
$12,200	25.8
$19,900	13.6

For CO4, the output of the @RISK program shows that total damages to private automobiles for the 500-year event totals just under $13 million. Table 34 shows that the EAD for automobiles within the CO4 floodplain is estimated to be $133,080.

[5] Source: U.S. Census Bureau. Census of Population and Housing, 1990 and 2000 long-form (sample) data.

As seen in Table 33, for CO5/CO6, the majority of auto damages occur in Impact Area 7 of the CO5 floodplain. This is, of course, because of the combination in this area of large numbers of residential structures and high flood depths. For the entire CO5/CO6 combined floodplain, the 500-year event is expected to cause damages to automobiles totaling over $136 million. Total EAD to private automobiles is just under $3.2 million in the CO5/CO6 floodplain, as shown in Table 34 below.

Table 32: Total Damages, Autos, C04 ($'000s)

Impact Area	500-Year	100-Year	50-Year
1	1,165	239	52
2	2,230	509	211
3	2,363	1,105	738
4	1,965	274	119
5	5,200	276	419
Total	12,923	2,403	1,539

Table 33: Total Damages, Autos, C05 & CO6 ($'000s)

Channel	Impact Area	500-Year	100-Year	50-Year
CO5	1	11,630	6,092	4,866
	2	7,397	2,586	2,099
	3	25,920	15,185	11,889
	4	3,474	1,503	1,241
	5	9,965	6,427	4,963
	6	2,993	1,798	1,421
	7	43,319	34,005	29,042
	A	11,499	2,673	2,006
	Subtotal	116,197	70,269	57,527
CO6		20,275	9,676	6,431
	Total	136,472	79,945	63,958

Table 34: EAD, Auto Damages, All Channels ($'000s)

Channel	Impact Area	Auto Damages
CO4	1	11.17
	2	22.88
	3	43.31
	4	18.09
	5	37.63
	CO4 Total	133.08
CO5	1	202.60
	2	129.54
	3	655.46
	4	72.86
	5	183.86
	6	65.06
	7	1,184.76
		273.09
	CO5 Total	2,767.07
CO6		430.58
	CO5/CO6 Total	3,197.65

5. Emergency Costs & Other Damage Categories

Beyond damages to the actual structures themselves, both the possibility of flood events and, of course, the floods themselves impose additional costs that should be accounted for. These costs include: cleanup costs; emergency costs expended by the federal government (FEMA) during and in the aftermath of a flood event for such things as temporary rental assistance and emergency home repairs; the costs to homeowners associated with flood policy administration; damage to roads and critical infrastructure; temporary relocation expenses financed by individuals and households; the costs associated with road closures, which include time value, as well as the additional fuel and vehicle wear; and income lost by businesses.

ER 1105-2-100 states, “Flood damages are classified as physical damages or losses, income losses, and emergency costs.” The ER then defines emergency costs as “those expenses resulting from a flood what would not otherwise be incurred…” The ER further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates. As with all flood damage estimates and especially in the case of emergency costs, the potential to double count damages are a distinct possibility and must be guarded against.

Emergency Costs

A basic methodology for the calculation of emergency costs was presented in the Centralia Flood Damage Reduction Project - Chehalis River, Washington, General Reevaluation Study. The Chief’s Report for the Centralia Flood Damage Reduction Project - Chehalis River, Washington, General Reevaluation Study includes two NED benefit categories (Temporary Rental Assistance and Public Assistance) which are commonly evaluated. For the Chehalis River study, these benefit categories are based on FEMA disaster report data between 1997 and 1999. Since 1999, several flooding events have occurred and FEMA damage reports (DR) on these disasters are available.

Several changes have occurred since the compilation of data for the Chehalis River study. First, FEMA has been incorporated into the Department of Homeland Security and secondly, the benefit category of Temporary Rental Assistance (TRA) has undergone a program change. Previously, TRA was a separate program line item, however to streamline the assistance process, FEMA has created a new lead program called “Housing Assistance” (HA) to which TRA has been rolled into under the name of “Disaster Housing Grants”.

Temporary Disaster Housing Grants go directly to those affected by the disaster. The aid may include rental reimbursement for people who cannot return to their homes because of the disaster and need to rent temporary substitute housing. It may also include small grants of money to make temporary repairs after a disaster.

The Other Needs Assistance (ONA) program is a second component to the Housing Assistance program. The ONA program gives assistance to applicants who have disaster-related necessary expenses and serious needs not covered by insurance. These may include medical, dental and funeral expenses, as well as transportation and other emergency expenses. This aid is funded 75 percent by FEMA, 25 percent by the state.

The Public Assistance Program provides supplemental Federal disaster grant assistance for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. The Federal share of assistance is not less than 75% of the eligible cost for emergency measures and permanent restoration. The State determines how the non-Federal share (up to 25%) is split with the applicants.

To be eligible, the work must be required as the result of the disaster, be located within the designated disaster area, and be the legal responsibility of an eligible applicant. Work that is eligible for supplemental Federal disaster grant assistance is classified as either emergency work or permanent work.

> *Emergency Work:*
> Debris removal from public roads and rights-of-way as well as from private property when determined to be in the public interest and emergency protective measures performed to eliminate or reduce immediate threats to the public, including search and rescue, warning of hazards, and demolition of unsafe structures.
>
> *Permanent Work:*
> Work to restore an eligible damaged facility to its pre-disaster design. Work range from minor repairs to replacement.

Categories of permanent work include:

- Roads, bridges and associated features, such as shoulders, ditches, culverts, lighting and signs.
- Water Control Facilities including drainage channels, pumping facilities, and the emergency repair of levees. Permanent repair of Flood Control Works is the responsibility of the U.S. Army Corps of Engineers and the Natural Resources Conservation Service.
- Buildings including their contents and systems.
- Utility Distribution Systems, such as water treatment and delivery systems; power generation facilities and distribution lines; and sewage collection and treatment facilities.
- Public Parks, Recreational Facilities and Other Facilities, including playgrounds, swimming pools and cemeteries.

Disaster Housing Grants and Public Assistance

The evaluation of disaster housing grants (HA) and public assistance (PA) is based on the disaster reports contained in the archive at FEMA’s web site. Unfortunately for this evaluation, FEMA does not have available either a final summary of expenditures by disaster or an annual expenditure report by disaster for analysis. Instead, interim reports by disaster are the only available data sources. To minimize the influences of factors other than flooding, the current analysis excludes from its database hurricanes, tropical storms, flooding events associated with tornadoes and other non-flood events.

The cost per TRA claim ($1,537) in the Chehalis River study was based on a disaster size of 13. The updated database for disaster housing grants is 132, as shown in Attachment A. The average dollar amount per application for HA is $1,550 based on individual events. The median per claim amount is $1,479 and the standard deviation of the sample is $717. ONA expenditures average $825 per HA claim over the entire data set with a standard deviation of $651 and a minimum per HA of $0 and a maximum of $3,702.

Public assistance benefits in the Chehalis study is based on the ratio of public assistance expenditures to disaster housing grants (TRA expenditures). In the Chehalis study this ratio was based on total expenditures for both and not on individual events. This methodology may have been selected because of the limited number (6) of disasters with data for both expenditures. The current database contains 60 events having data for both HA and PA. With this sample size, a change in methodology of determining the PA/HA ratio to individual events is made. Based on the data, the mean ratio of PA to HA is 3.08 with a standard deviation of 3.61.

Table 35: Total Damages, ONA, C04 ($'000s)

Impact Area	500-Year	100-Year	50-Year
1	274	52	7
2	546	125	67
3	464	213	150
4	854	99	37
5	1,287	103	13
Total	3,425	592	274

Table 36: Total Damages, TRA, CO4 ($'000s)

Impact Area	500-Year	100-Year	50-Year
1	454	88	12
2	903	207	110
3	766	352	249
4	1,411	164	61
5	2,125	169	22
Total	5,659	980	454

Table 37: Total Damages, PA, CO4 ($'000s)

Impact Area	500-Year	100-Year	50-Year
1	1,647	481	154
2	3,915	876	480
3	3,316	1,438	1,085
4	6,122	703	267
5	9,221	590	97
Total	24,221	4,088	2,083

Expected annual damages in CO4 for the ONA, TRA, & PA accounts are shown in Table 41, below.

Table 38: Total Damages, ONA, C05 & CO6 ($'000s)

Channel	Impact Area	500-Year	100-Year	50-Year
CO5	1	2,496	1,334	1,079
	2	1,442	491	407
	3	4,311	2,768	2,324
	4	684	292	238
	5	1,757	1,223	948
	6	418	325	264
	7	5,629	5,242	5,015
	A	2,648	592	439
	Subtotal	19,385	12,267	10,714
CO6		3,318	1,680	1,238
	Total	22,703	13,947	11,952

Table 39: Total Damages, TRA, C05 & CO6 ($'000s)

Channel	Impact Area	500-Year	100-Year	50-Year
CO5	1	4,126	2,205	1,784
	2	2,384	812	673
	3	7,129	4,576	3,840
	4	1,131	482	394
	5	2,904	2,022	1,567
	6	691	537	436
	7	9,305	8,664	8,289
	A	4,404	977	723
	Subtotal	32,074	20,275	17,706
CO6		5,487	2,775	2,046
	Total	37,561	23,050	19,752

Table 40: Total Damages, PA, C05 & CO6 ($'000s)

Channel	Impact Area	500-Year	100-Year	50-Year
CO5	1	17,915	9,582	7,745
	2	10,331	3,514	2,924
	3	30,884	19,827	16,591
	4	4,920	2,090	1,706
	5	12,608	8,784	6,797
	6	2,996	2,332	1,889
	7	40,350	37,506	36,036
	A	19,088	4,235	3,134
	Subtotal	139,092	87,870	76,822
CO6		23,842	11,118	8,896
	Total	162,934	98,988	85,718

Table 41: EAD, ONA, TRA, & PA, CO4 ($'000s)

Impact Area	ONA	TRA	PA
1	2.46	4.11	19.28
2	5.79	9.57	41.27
3	8.57	14.19	60.63
4	7.40	12.24	53.03
5	9.67	15.97	67.74
Total	33.89	56.08	241.95

Table 42: EAD, ONA, TRA, & PA, CO5/CO6 ($'000s)

Channel	Impact Area	ONA	TRA	PA
CO5	1	44.19	73.05	317.24
	2	25.06	41.44	179.70
	3	120.95	199.91	864.87
	4	14.10	23.31	101.13
	5	34.12	56.41	244.89
	6	11.11	18.35	79.60
	7	185.94	307.34	1,333.74
	A	61.66	102.16	442.82
	Subtotal	497.13	821.97	3,563.99
CO6		76.89	127.08	542.58
	Total	574.02	949.05	4,106.57

Residential Clean-up Costs

Coastal storm flooding not only causes damage to structures and contents but floodwaters present a significant cost in their aftermath clean up. Floodwaters leave debris, sediment, salts and the dangers of diseases and mycotoxins throughout flooded structures. The cleaning of these structures is a necessary post-flood activity. Clean-up costs for the extraction of floodwaters, dry-out, and decontamination range from $1 to $4.75 per square foot, with a mean cost of $3.65 and standard deviation of $0.94 based on prior studies.[6]

Table 43: Total Damages, Cleanup Costs, C04 ($'000s)

Impact Area	500-Year	100-Year	50-Year
1	1,804	341	53
2	3,233	645	319
3	4,972	2,600	1,794
4	6,964	1,034	342
5	6,405	1,046	76
Total	23,378	5,666	2,584

[6] The Chief's Reports for the Centralia Flood Damage Reduction Project - Chehalis River, Washington, General Reevaluation Study and Nogales Wash & Tributaries, Nogales, Arizona - Limited Reevaluation Report and Environmental Evaluation amongst others have employed the methodologies for clean-up and emergency costs. Cleanup costs were also compared to the Bluebook Cost Guide for Cleaning, Restoration and Repair.

Table 44: Total Damages, Cleanup Costs, C05 & CO6 ($'000s)

Channel	Impact Area	500-Year	100-Year	50-Year
CO5	1	18,974	10,670	9,083
	2	12,090	5,437	4,313
	3	22,959	15,239	13,034
	4	3,964	2,453	1,919
	5	8,922	6,357	5,160
	6	2,222	1,735	1,412
	7	25,404	22,662	21,486
	A	14,064	4,193	2,831
	Subtotal	108,599	68,746	59,238
CO6		17,768	8,721	6,702
	Total	126,367	77,467	65,940

Expected annual cleanup costs for the study area are shown in the table, below.

Table 45: EAD, Cleanup Costs, All Channels ($'000s)

Channel	Impact Area	Cleanup Costs
CO4	1	16.34
	2	32.31
	3	99.41
	4	63.61
	5	54.37
	CO4 Total	266.04
CO5	1	352.30
	2	246.10
	3	667.16
	4	104.38
	5	178.30
	6	59.30
	7	807.06
		360.50
	CO5 Total	2,775.09
CO6		410.99
	CO5/CO6 Total	3,186.08

6. Summary of Without-Project Flood Damages

The floodplains evaluated in this analysis span a very large, densely populated area of Orange County, CA – an area that is over twenty square miles large and populated by over 100,000 residents. The size and population density of these floodplains adds to the challenge and complexity of estimating damages from flood events. In order to help the analysis manage this complexity – and the corresponding uncertainty – principles of Risk & Uncertainty (R&U) Analysis were applied. The analysis incorporated these principles in the estimate of the damage categories evaluated.

Given that there is little or no vacant or developable land in the floodplains, the analysis assumed that the future without-project economic condition is equivalent to the current without-project condition - the flood damage estimate did not include any structures that are not currently found in the floodplains. The analysis focused on estimating damages to private and public property, as well as on emergency response and recovery costs, which includes emergency assistance to flood victims.

An initial inventory of the parcels in the 500-year floodplain was compiled in ArcGIS (ArcMap) software by linking a shapefile of the floodplain with a shapefile containing the parcel information. The parcels identified as within the 500-year floodplain were then matched to data downloaded from the First American Real Estate Solutions® database. Given the massive floodplain, sampling was done to collect information on a representative sample of the residential structures in the floodplain, while for the other structure categories (commercial, industrial, etc.), of which there are much fewer, a more complete inventory was collected. The valuation of the structures in the floodplain synthesized information that had been collected on structure type, construction quality, current condition, and number of stories. Once collected, this information was utilized to calculate the structure depreciated replacement values. Base per square foot construction cost estimates for each structure type were determined by utilizing the Marshall and Swift Real Estate Valuation Service

In order to begin to estimate damages, structure and content data were first processed through an @RISK Excel spreadsheet to generate the appropriate stage-damage references with uncertainty for entry into the HEC-FDA model. Each structure in the floodplain was associated with flood depths for the 50-, 100-, and 500-year flood events based on digital overflow maps created as an output of the FLO2D flood model. The results of the @RISK calculations were entered directly into the HEC-FDA model as cumulative damage functions for each damage category for each impact area.

The without-project flood damages from each of the floodplains considered flooding damages associated with eleven different categories.

The event-based (50-, 100-, 500-year, etc.) analysis shows very large damages occurring across the floodplains, and in particular within the CO5/CO6 floodplain. The results of the analysis show that the 500-year event is expected to cause in excess of $1.7 billion in property damages across the CO5/CO6 floodplain, and in excess of $277 million across the CO4 floodplain. The EAD, which is the probability-weighted value of damages expected per year when considering a very long time horizon, of the without-project analysis is shown in the table below. The total EAD for each channel and for each damage category are displayed. As shown, the annual damages associated with CO4, CO5, and CO6 are $3.4 million, $46.6 million, and $5.9 million, respectively.

Category	EAD ($'000s)		
	CO4	CO5	CO6
Industrial	551.10	1,621.38	0.00
Commercial	290.01	6,870.48	864.18
Single-Family	1,664.91	23,598.63	3,021.56
Multi-Family	140.28	2,423.67	457.59
Manufactured Housing	9.71	274.79	0.00
Public	10.60	1,430.40	0.00
ONA	33.89	497.13	76.89
TRA	56.08	821.97	127.08
PA	241.95	3,563.99	542.58
Vehicle	133.08	2,767.07	430.58
Cleanup	266.04	2,775.09	410.99
Total	3,397.65	46,644.60	5,931.45

Project Performance- Without Project Conditions

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and conditional non-exceedance probability by events.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.
- Conditional non-exceedance probability indicates the chance of not having a damaging flood given a specific magnitude event.

Existing condition project performance statistics for each impact area is displayed in Figure 9, below.

Figure 9: Without Project Performance

Westminster Project Performance
by Plans and Damage Reaches by Analysis Year 2010
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	CO4	Area 5		levee	0.0603	0.0642	0.4850	0.8097	0.9638	0.8653	0.2447	0.0471	0.0090	0.0011	0.0003
		Area 4		levee	0.0406	0.0452	0.3704	0.6855	0.9011	0.9582	0.5001	0.1650	0.0479	0.0073	0.0018
		Area 3		levee	0.0580	0.0632	0.4792	0.8042	0.9617	0.8710	0.2622	0.0542	0.0121	0.0017	0.0005
		Area 2		levee	0.0333	0.0373	0.3161	0.6132	0.8504	0.9896	0.6141	0.2361	0.0810	0.0169	0.0051
		Area 1		levee	0.0564	0.0633	0.4801	0.8051	0.9620	0.8617	0.2733	0.0653	0.0159	0.0022	0.0008
	CO6	CO6		levee	0.0862	0.0903	0.6118	0.9061	0.9912	0.6230	0.0926	0.0172	0.0048	0.0011	0.0003
	CO5	Area 7		levee	0.0496	0.0551	0.4327	0.7576	0.9413	0.9190	0.3521	0.0895	0.0224	0.0034	0.0011
		Area 6		levee	0.0496	0.0551	0.4327	0.7576	0.9413	0.9190	0.3521	0.0895	0.0224	0.0034	0.0011
		Area 5		levee	0.0292	0.0329	0.2844	0.5668	0.8123	0.9940	0.6983	0.2880	0.1003	0.0184	0.0052
		Area 4		levee	0.0709	0.0755	0.5437	0.8594	0.9802	0.7689	0.1671	0.0364	0.0101	0.0023	0.0011
		Area 3		levee	0.0709	0.0755	0.5437	0.8594	0.9802	0.7689	0.1671	0.0364	0.0101	0.0023	0.0011
		Area 2		levee	0.0490	0.0531	0.4203	0.7441	0.9345	0.9335	0.3666	0.1069	0.0338	0.0076	0.0030
		Area 1		levee	0.0346	0.0386	0.3251	0.6258	0.8600	0.9848	0.5913	0.2168	0.0800	0.0187	0.0072
		Area A		levee	0.1091	0.1036	0.6651	0.9351	0.9958	0.4054	0.1141	0.0635	0.0338	0.0214	0.0164

Attachment A

Westminster
Expected Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) Plan and Analysis Year 2010
(Damage in $1,000's)
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Damage Categories																	Total
				CLEANUP	COMC	COMS	INDC	INDS	MFRC	MFRS	MHC	MHS	ONA	PA	PUBC	PUBS	SFRC	SFRS	TRA	VEHICLE	
CO4		Area 5		54.37	36.42	49.12	0.00	0.00	8.03	27.24	0.00	0.00	9.67	67.74	5.94	11.22	207.51	362.16	15.97	37.63	893.02
		Area 4		63.61	51.12	35.48	27.30	45.05	0.93	3.18	0.00	0.00	7.40	53.03	3.94	7.22	180.87	296.44	12.24	18.09	805.89
		Area 3		99.41	14.48	10.18	334.29	143.16	18.74	65.69	0.00	0.00	8.57	60.63	14.96	35.69	81.04	139.40	14.19	43.31	1083.74
		Area 2		32.31	21.13	17.03	0.82	0.48	1.58	5.54	0.00	0.00	5.79	41.27	3.69	8.38	123.43	207.95	9.57	22.88	501.87
		Area 1		16.34	29.94	25.11	0.00	0.00	2.08	7.27	2.42	7.29	2.46	19.28	5.86	12.71	24.61	41.49	4.11	11.17	212.13
	Total for stream: CO4			266.04	153.09	136.92	362.41	188.69	31.35	108.93	2.42	7.29	33.90	241.95	34.39	75.21	617.46	1047.45	56.07	133.08	3496.65
CO6		CO6		410.99	528.35	335.83	0.00	0.00	102.17	355.42	0.00	0.00	76.89	542.58	0.00	0.00	1086.98	1934.58	127.08	430.58	5931.45
	Total for stream: CO6			410.99	528.35	335.83	0.00	0.00	102.17	355.42	0.00	0.00	76.89	542.58	0.00	0.00	1086.98	1934.58	127.08	430.58	5931.45
CO5		Area 7		807.06	294.15	234.24	0.00	0.00	122.93	458.89	46.71	149.36	185.94	1333.74	32.13	63.23	3345.97	5886.24	307.34	1184.76	14452.69
		Area 6		59.30	0.00	0.00	0.00	0.00	0.14	0.61	0.00	0.00	11.11	79.60	17.81	15.59	236.50	421.01	18.35	65.06	925.08
		Area 5		178.30	16.99	13.46	177.68	96.60	29.96	109.35	0.00	0.00	34.12	244.89	13.88	29.95	523.87	924.89	56.41	183.86	2634.21
		Area 4		104.38	300.69	173.35	0.00	0.00	3.69	13.44	0.00	0.00	14.10	101.13	15.36	11.31	279.12	486.80	23.31	72.68	1599.36
		Area 3		667.16	568.17	445.48	460.18	238.63	150.36	522.78	4.10	15.58	120.95	864.87	160.67	393.65	2029.47	3493.13	199.91	655.46	10990.54
		Area 2		246.10	254.87	170.77	164.96	119.59	31.50	104.56	3.26	14.44	25.06	179.70	83.14	200.81	774.75	1261.06	41.44	129.54	3805.56
		Area 1		352.30	539.59	428.00	7.06	12.92	41.82	149.67	7.73	23.93	44.19	317.24	47.74	111.75	692.23	1165.45	73.05	202.60	4217.28
		Area A		360.50	2020.75	1409.97	200.54	143.22	153.03	530.95	0.32	9.36	61.66	442.82	81.30	152.08	821.50	1256.63	102.16	273.09	8019.89
	Total for stream: CO5			2775.09	3995.22	2875.26	1010.42	610.96	533.42	1890.25	62.11	212.68	497.13	3563.99	452.02	978.38	8703.42	14895.21	821.97	2767.07	46644.62

FEMA Disaster Expenditures

DR #	State	HA	HA$	ONA$	PA$	$HA/HA	$ONA/HA
1729	Illinois	1,361	$3,200,000			$2,351	$0
1722	Illinois	1,014	$1,390,000			$1,371	$0
1719	Wisconsin	4,608	$6,823,360	$380,000	$365,000	$1,481	$82
1717	Minnesota	5,115	$16,790,683	$1,427,148	$7,419,349	$3,283	$279
1711	Kansas	4,113	$14,253,213	$3,615,790	$532,963	$3,465	$879
1708	Missouri	547	$2,200,000		$1,770,000	$4,022	$0
1700	Connecticut	2,493	$2,302,434	$106,707	$1,977,374	$924	$43
1695	New Hampshire	2,005	$3,315,216	$255,780	$19,000,000	$1,653	$128
1694	New Jersey	14,827	$15,900,000			$1,072	$0
1693	Maine	2,746	$1,898,380		$16,000,000	$691	$0
1692	New York	4,941	$10,600,000	$1,100,000	$15,600,000	$2,145	$223
1671	Washington	2,388	$4,528,389			$1,896	$0
1670	New York	899	$2,680,000	$232,495	$14,200,000	$2,981	$259
1668	Louisiana	3,801	$2,300,000			$605	$0
1662	Indiana	3,241	$9,056,440	$768,387		$2,794	$237
1659	New Mexico	1,525	$1,600,000		$8,900,000	$1,049	$0
1656	Ohio	5,802	$8,100,000			$1,396	$0
1650	New York	15,530	$24,570,000	$6,690,000	$84,500,000	$1,582	$431
1649	Pennsylvania	7,430	$16,900,000	$2,600,000	$23,400,000	$2,275	$350
1644	Maine	531	$870,666	$60,400	$1,357,136	$1,640	$114
1643	New Hampshire	4,218	$8,199,875	$665,513	$3,266,514	$1,944	$158
1642	Massachusetts	11,000	$16,500,000	$1,800,000	$12,400,000	$1,500	$164
1640	Hawaii	463	$447,898			$967	$0
1631	Missouri	3,746	$1,898,934	$1,436,512	$2,483,988	$507	$383
1628	California	1,671	$4,500,000	$1,300,000	$6,700,000	$2,693	$778
1614	Massachusetts	1,187	$2,700,000	$296,311		$2,275	$250
1610	New Hampshire	347	$767,000	$170,000	$1,800,000	$2,210	$490
1589	New York	3,421	$5,058,081	$2,916,987	$17,625,078	$1,479	$853
1588	New Jersey	1,795	$1,612,515	$503,052		$898	$280
1587	Pennsylvania	2,381	$2,948,662	$461,222		$1,238	$194
1580	Ohio	4,653	$6,585,028			$1,415	$0
1573	Indiana	8,828	$11,200,000			$1,269	$0
1570	Virginia	964	$1,048,412	$528,190		$1,088	$548
1569	Minnesota	970	$2,535,399	$796,777		$2,614	$821
1565	New York	1,240	$970,000	$293,000		$782	$236
1564	New York	6,680	$1,200,000	$604,000	$15,000,000	$180	$90
1558	West Virginia	4,118	$10,400,000	$5,500,000	$88,000,000	$2,525	$1,336
1556	Ohio	5,115	$12,016,614	$8,446,895		$2,349	$1,651
1555	Pennsylvania	16,311	$41,200,000	$18,300,000		$2,526	$1,122
1544	Virginia	5,426	$5,698,538	$2,355,101	$10,181,940	$1,050	$434
1536	West Virginia	519	$883,853	$49,346		$1,703	$95
1530	New Jersey	2,283	$4,045,624	$744,615		$1,772	$326
1527	Michigan	30,722	$33,899,137	$13,266,133		$1,103	$432
1526	Wisconsin	5,858	$3,653,733	$828,325	$494,299	$624	$141
1525	Virginia	573	$1,019,386	$122,421		$1,779	$214
1523	Kentucky	9,521	$12,904,182	$6,767,195	$1,500,000	$1,355	$711
1522	West Virginia	8,919	$14,000,000	$3,400,000	$8,700,000	$1,570	$381
1521	Louisiana	7,662	$6,400,000			$835	$0
1520	Indiana	5,214	$4,688,687			$899	$0
1519	Ohio	9,802	$12,318,977	$4,637,366	$12,122,200	$1,257	$473
1518	Iowa	4,813	$4,800,000	$1,000,000	$17,000,000	$997	$208
1517	Nebraska	828	$301,179	$230,268	$1,450,335	$364	$278

DR #	State	HA	HA$	ONA$	PA$	$HA/HA	$ONA/HA
1512	Massachusetts	1,611	$2,000,000	$156,000		$1,241	$97
1507	Ohio	400	$896,313	$226,325		$2,241	$566
1500	West Virginia	7,052	$11,900,000	$3,400,000	$2,400,000	$1,687	$482
1499	Washington	1,389	$2,273,604			$1,637	$0
1487	Indiana	2,251	$6,022,987			$2,676	$0
1486	New York	2,162	$1,477,083	$180,213	$1,877,825	$683	$83
1485	Pennsylvania	769	$1,779,838	$302,708	$5,100,320	$2,314	$394
1484	Ohio	14,999	$13,733,069	$4,688,215		$916	$313
1478	Ohio	378	$828,184	$281,189		$2,191	$744
1476	Indiana	4,011	$8,772,065	$3,098,965		$2,187	$773
1475	Kentucky	3,237	$3,762,560	$1,623,799		$1,162	$502
1474	West Virginia	5,068	$7,642,690	$2,424,181	$6,194,467	$1,508	$478
1471	Kentucky	2,097	$2,707,156	$1,246,067		$1,291	$594
1469	Illinois	509	$491,375	$590,591		$965	$1,160
1466	Alabama	12,976	$9,365,997	$8,171,447		$722	$630
1464	Tennessee	13,573	$8,700,000	$12,700,000	$35,000,000	$641	$936
1463	Missouri	6,714	$3,804,022	$3,861,525		$567	$575
1462	Kansas	1,314	$1,800,000			$1,370	$0
1459	Mississippi	12,380	$28,000,000			$2,262	$0
1458	Virginia	683	$1,280,000	$276,315		$1,874	$405
1439	Texas	17,500	$14,000,000	$13,000,000		$800	$743
1432	Wisconsin	81	$110,072	$92,857		$1,359	$1,146
1428	Vermont	262	$559,156			$2,134	$0
1425	Texas	5,181	$9,474,357			$1,829	$0
1423	Alaska	125	$300,000	$150,000	$2,500,000	$2,400	$1,200
1420	Iowa	791	$1,400,000	$175,000		$1,770	$221
1419	Minnesota	4,090	$4,825,801	$840,737		$1,180	$206
1418	Indiana	199	$375,389			$1,886	$0
1416	Illinois	2,070	$2,866,441	$901,988		$1,385	$436
1414	Kentucky	6,269	$7,093,104	$4,913,869	$11,314,567	$1,131	$784
1410	West Virginia	6,140	$10,080,000	$3,800,000	$10,440,000	$1,642	$619
1406	Virginia	1,198	$1,800,000	$646,000	$1,500,000	$1,503	$539
1389	DC	2,501	$2,015,380			$806	$0
1388	Kentucky	758	$1,611,559	$755,527	$10,426,863	$2,126	$997
1387	Tennessee	817	$1,105,024	$567,823	$2,586,448	$1,353	$695
1386	Virginia	1,078	$2,096,850	$765,954		$1,945	$711
1379	Texas	90,000	$179,900,000	$239,600,000	$150,700,000	$1,999	$2,662
1378	West Virginia	13,576	$58,800,000	$17,300,000	$31,900,000	$4,331	$1,274
1370	Minnesota	1,003	$1,570,100	$177,401	$1,522,653	$1,565	$177
1369	Wisconsin	1,500	$1,500,000	$290,000	$16,000,000	$1,000	$193
1368	Illinois	468	$506,948	$12,068		$1,083	$26
1367	Iowa	1,120	$1,430,177			$1,277	$0
1364	Massachusetts	2,569	$4,232,363			$1,647	$0
1349	Oklahoma	53	$132,050	$88,994		$2,492	$1,679
1348	Hawaii	1,100	$2,400,000	$1,100,000		$2,182	$1,000
1347	Arizona	280	$556,000	$743,000	$4,400,000	$1,986	$2,654
1346	Michigan	3,779	$9,371,957	$886,644		$2,480	$235
1345	Flordia	19,743	$28,500,000	$31,300,000	$92,600,000	$1,444	$1,585
1339	Ohio	1,750	$3,038,646	$200,000		$1,736	$114
1333	Minnesota	2,226	$3,307,744	$413,588		$1,486	$186
1322	Alabama	503	$996,442	$989,775		$1,981	$1,968
1321	Ohio	671	$1,115,130	$352,194		$1,662	$525
1320	Kentucky	277	$766,358	$413,859	$311,691	$2,767	$1,494
1310	Kentucky	176	$150,086		$923,482	$853	$0

DR #	State	HA	HA$	ONA$	PA$	$HA/HA	$ONA/HA
1298	Pennsylvania	11,266	$9,634,491	$595,013		$855	$53
1289	Pennsylvania	11,266	$9,634,491	$595,013		$855	$53
1286	Nebraska	1,282	$1,280,000	$141,532	$976,000	$998	$110
1283	Minnesota	590	$768,847	$155,038	$14,000,000	$1,303	$263
1282	Iowa	744	$1,181,245			$1,588	$0
1281	Nevada	271	$372,175			$1,373	$0
1280	South Dakota	1,171	$486,784	$329,000	$648,208	$416	$281
1279	North Dakota	12,321	$20,600,000	$12,000,000	$45,700,000	$1,672	$974
1277	Iowa	2,617	$2,202,706	$938,701	$144,007	$842	$359
1276	Colorado	2,664	$1,642,371	$810,006	$7,200,000	$617	$304
1272	Oklahoma	1,612	$1,729,062	$4,189,443		$1,073	$2,599
1270	Missouri	409	$418,263	$519,048		$1,023	$1,269
1266	Arkansas	726	$836,572	$1,457,956		$1,152	$2,008
1258	Kansas	2,388	$3,380,199	$2,459,248	$1,196,242	$1,415	$1,030
1239	Texas - SW	1,445	$2,156,601	$5,349,805	$4,874,795	$1,492	$3,702
1245	Texas - SE	2,159	$4,190,165	$2,209,979	$5,267,342	$1,941	$1,024
1257	Texas - S,C,SE	13,786	$28,047,095	$34,842,781	$11,406,977	$2,034	$2,527
1256	Missouri	2,231	$1,300,000	$440,491		$583	$197
1254	Kansas	3,212	$2,700,000	$748,077	$86,130	$841	$233
1253	Kansas	3,762	$3,335,504	$1,140,378		$887	$303
1238	Wisconsin	5,221	$7,000,173	$693,299		$1,341	$133
1224	Massachusetts	3,527	$5,400,000			$1,531	$0
1221	Oregon	132	$215,294			$1,631	$0
1211	North Carolina	703	$1,213,285	$306,987	$7,187,159	$1,726	$437
1203	California	15,000	$22,000,000			$1,467	$0
1209	Georgia	2,455	$3,100,000	$1,800,000	$29,300,000	$1,263	$733
TOTAL		642,552	$995,729,895	$530,082,549	$909,431,352		

FEMA Public Assistance Expenditures

DR #	State	HA$	PA$	PA/HA
1719	Wisconsin	$6,823,360	$365,000	0.05
1717	Minnesota	$16,790,683	$7,419,349	0.44
1711	Kansas	$14,253,213	$532,963	0.04
1708	Missouri	$2,200,000	$1,770,000	0.80
1700	Connecticut	$2,302,434	$1,977,374	0.86
1695	New Hampshire	$3,315,216	$19,000,000	5.73
1693	Maine	$1,898,380	$16,000,000	8.43
1692	New York	$10,600,000	$15,600,000	1.47
1670	New York	$2,680,000	$14,200,000	5.30
1659	New Mexico	$1,600,000	$8,900,000	5.56
1650	New York	$24,570,000	$84,500,000	3.44
1649	Pennsylvania	$16,900,000	$23,400,000	1.38
1644	Maine	$870,666	$1,357,136	1.56
1643	New Hampshire	$8,199,875	$3,266,514	0.40
1642	Massachusetts	$16,500,000	$12,400,000	0.75
1631	Missouri	$1,898,934	$2,483,988	1.31
1628	California	$4,500,000	$6,700,000	1.49
1610	New Hampshire	$767,000	$1,800,000	2.35
1589	New York	$5,058,081	$17,625,078	3.48
1564	New York	$1,200,000	$15,000,000	12.50
1558	West Virginia	$10,400,000	$88,000,000	8.46
1544	Virginia	$5,698,538	$10,181,940	1.79
1526	Wisconsin	$3,653,733	$494,299	0.14
1523	Kentucky	$12,904,182	$1,500,000	0.12
1522	West Virginia	$14,000,000	$8,700,000	0.62
1519	Ohio	$12,318,977	$12,122,200	0.98
1518	Iowa	$4,800,000	$17,000,000	3.54
1517	Nebraska	$301,179	$1,450,335	4.82
1500	West Virginia	$11,900,000	$2,400,000	0.20
1486	New York	$1,477,083	$1,877,825	1.27
1485	Pennsylvania	$1,779,838	$5,100,320	2.87
1474	West Virginia	$7,642,690	$6,194,467	0.81
1464	Tennessee	$8,700,000	$35,000,000	4.02
1423	Alaska	$300,000	$2,500,000	8.33
1414	Kentucky	$7,093,104	$11,314,567	1.60
1410	West Virginia	$10,080,000	$10,440,000	1.04
1406	Virginia	$1,800,000	$1,500,000	0.83
1388	Kentucky	$1,611,559	$10,426,863	6.47
1387	Tennessee	$1,105,024	$2,586,448	2.34
1379	Texas	$179,900,000	$150,700,000	0.84
1378	West Virginia	$58,800,000	$31,900,000	0.54
1370	Minnesota	$1,570,100	$1,522,653	0.97
1369	Wisconsin	$1,500,000	$16,000,000	10.67
1347	Arizona	$556,000	$4,400,000	7.91
1345	Flordia	$28,500,000	$92,600,000	3.25
1320	Kentucky	$766,358	$311,691	0.41
1310	Kentucky	$150,086	$923,482	6.15
1286	Nebraska	$1,280,000	$976,000	0.76
1283	Minnesota	$768,847	$14,000,000	18.21
1280	South Dakota	$486,784	$648,208	1.33
1279	North Dakota	$20,600,000	$45,700,000	2.22
1277	Iowa	$2,202,706	$144,007	0.07
1276	Colorado	$1,642,371	$7,200,000	4.38
1258	Kansas	$3,380,199	$1,196,242	0.35
1239	Texas - SW	$2,156,601	$4,874,795	2.26
1245	Texas - SE	$4,190,165	$5,267,342	1.26
1257	Texas - S,C,SE	$28,047,095	$11,406,977	0.41
1254	Kansas	$2,700,000	$86,130	0.03

DR #	State	HA$	PA$	PA/HA
1211	North Carolina	$1,213,285	$7,187,159	5.92
1209	Georgia	$3,100,000	$29,300,000	9.45

avg	3.08
min	0.03
max	18.21
median	1.48
stdev	3.61