9.3 Enhanced Plan

9.3.2 Loss Avoidance Study: Oregon, Property Acquisition and Structure Elevation

Loss Avoidance Study

Oregon, Property Acquisition and Structure Elevation

September 2009

FEMA

Federal Emergency Management Agency
U.S. Department of Homeland Security
500 C Street, Southwest
Washington, DC 20472

Loss Avoidance Study

Oregon, Property Acquisition and Structure Elevation

September 2009

FEMA

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Executive Summary:

Every year, Federal, State, and local agencies, as well as private entities, contribute funding to mitigation projects that will reduce or eliminate the long-term risks posed to people, the built environment, and the economy by natural hazards. The U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) awards mitigation grants on the basis of whether the proposed mitigation projects are cost-effective.

Tools that have been used by FEMA in the past for determining the effectiveness of a project are based on the analysis of a probabilistic hazard event, completed prior to project funding and prior to project construction. With such significant investment in mitigation being made, policy makers have taken great interest in the effectiveness of mitigation during actual hazard events. In response, FEMA developed a methodology using a quantitative approach to assess the performance of mitigation projects based on actual post-construction hazard events.

Low-lying areas between the Coast Range and the Pacific Ocean in southwestern Oregon are particularly vulnerable to severe flooding. The City of Tillamook, which is located in this region, has repeatedly experienced severe floods, most recently on January 8, 2009. In response, the City and County of Tillamook implemented a number of flood mitigation projects to reduce the damage from future floods. The projects consisted of the acquisition, elevation, and relocation of floodprone buildings. The local governments completed the projects with assistance from FEMA, the State of Oregon, other public agencies, and private entities.

Multiple flood events have occurred since the completion of the mitigation projects; the floods could have damaged the buildings if the projects had not been completed. To evaluate losses avoided by the projects, FEMA partnered with the State of Oregon to conduct a study to evaluate losses avoided by nine of the projects, the elevation of three commercial buildings and the acquisition/demolition of six commercial buildings along U.S. Highway 101 in the City of Tillamook.

FEMA calculated the value of the losses avoided and compared the value to the cost of mitigation. The aggregate losses avoided were valued at $3.1 million, and the aggregate project cost was valued at approximately $4.7 million (both values in 2009 dollars), resulting in a return on investment of 66%. FEMA estimates that elevation projects are estimated to have an average useful life of 30 years, and that acquisition projects have a useful life of 100 years. The

majority of the projects were implemented after 2003, which is only 6 years into the useful life. It is anticipated that the value of the losses avoided, and therefore the Return on Investment, will increase in the future as other flood events occur.

This report includes detailed information about the methodology that was used for the Oregon loss avoidance study. Recommended practices are also included that were identified through the completion of the study and that can be used as guidance for future loss avoidance studies for acquisition and elevation projects.

Section One:

Introduction

Tillamook, Oregon, is in a region of the state that is prone to repetitive and often severe flood events, several of which have been declared Major Disasters by the President. Because of repeated damage from flooding and the continuing high risk of flooding, the City and County of Tillamook implemented a number of mitigation projects to reduce the potential for damage during future floods. The projects consisted of the acquisition, elevation, and relocation of floodprone buildings. The local governments completed the projects with assistance from the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA), the State of Oregon, other public agencies, and private entities.

Following a major flood in Tillamook on January 8, 2009, FEMA partnered with the State of Oregon to conduct a loss avoidance study (LAS or study) to assess the cost-effectiveness of nine of the flood mitigation projects—three elevation and six acquisition/demolition projects. All nine projects involved commercial buildings along U.S. Highway 101 in the City. The study, referred to in this report as the Oregon study, was conducted to determine the Return on Investment (ROI) for these mitigation projects by comparing losses avoided in all floods since the project implementation to the cost of the mitigation projects. This report contains the results of the Oregon study.

1.1 Background

FEMA defines mitigation as any sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Every year, FEMA provides States and communities with substantial financial assistance for projects that will reduce or eliminate risks from natural hazards through Hazard Mitigation Assistance grants, which include post-disaster grants under the Hazard Mitigation Grant Program and pre-disaster grants under the Pre Disaster Mitigation Program, the Flood Mitigation Assistance Program, the Repetitive Flood Claims Program, and the Severe Repetitive Loss Program.

Mitigation refers to any sustained action taken to reduce or eliminate long-term risk from hazards and their effects.

With significant investment being made in mitigation, demonstrating cost-effectiveness is crucial for continued support. In order to evaluate the cost-effectiveness of mitigation projects, FEMA has developed a methodology for loss avoidance studies. The methodology is based on the analysis of actual natural hazard events that have occurred

in the project study area since the completion of the mitigation project. The methodology provides a way to assess the benefits of a mitigation project in terms of its actual performance. Losses avoided are determined by comparing damage that would likely have been caused by the same storms without the project (Mitigation Project Absent [MP_A]) with damage that actually occurred with the project in place (Mitigation Project Complete [MP_C]).

The LAS methodology used for this study is consistent with the methodology described in *Loss Avoidance: Riverine Flood Methodology Report* (FEMA, in press[b]).

1.2 Purpose

The purposes of the study are to verify the effectiveness of the elevation and acquisition/demolition projects that were analyzed and to document their economic performance. The study endeavors to answer the question, "How much damage could have been caused by a storm event if the elevations or acquisitions had not been completed?" Further, the study provides comprehensive documentation of the losses avoided (damages avoided or project benefits) determined using quantitative methods.

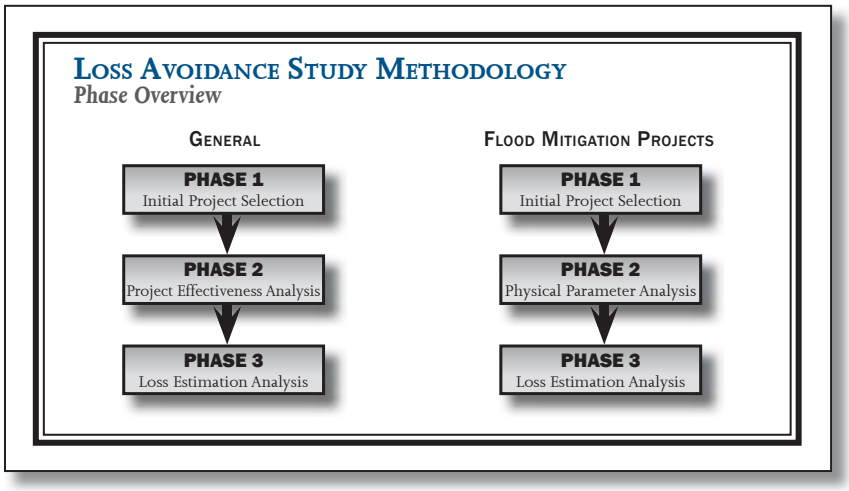
1.3 Methodology Overview

Loss avoidance methodology can be applied to the mitigation of any type of natural hazard (e.g., flood, wildfire, seismic, wind). Flood hazard mitigation projects can be classified as either building modification or flood reduction projects. Building modification projects mitigate damages by modifying a building to reduce its risk of flooding through acquisition/demolition, acquisition/relocation, elevation, and floodproofing. Acquisition/demolition projects are referred to as "acquisition projects," and acquisition/relocation projects are referred to as "relocation projects." Flood reduction projects mitigate damages by reducing the hazard itself and include stormwater drainage system improvements, channel modifications, flood walls/barriers, and other projects that reduce the severity of flooding. This study is focused on the performance of elevation and acquisition/demolition projects.

An LAS consists of three phases (see Figure 1.1). Although Phases 1 and 3 are similar regardless of the type of mitigation project, Phase 2 varies depending on the type of hazard and mitigation project. In flood-related studies, Phase 2 is called "Physical Parameter Analysis."

Phase 1 consists of the development of the initial project list. Projects are selected based on criteria determined by the sponsoring agency.

Figure 1.1



Source: FEMA (2007)

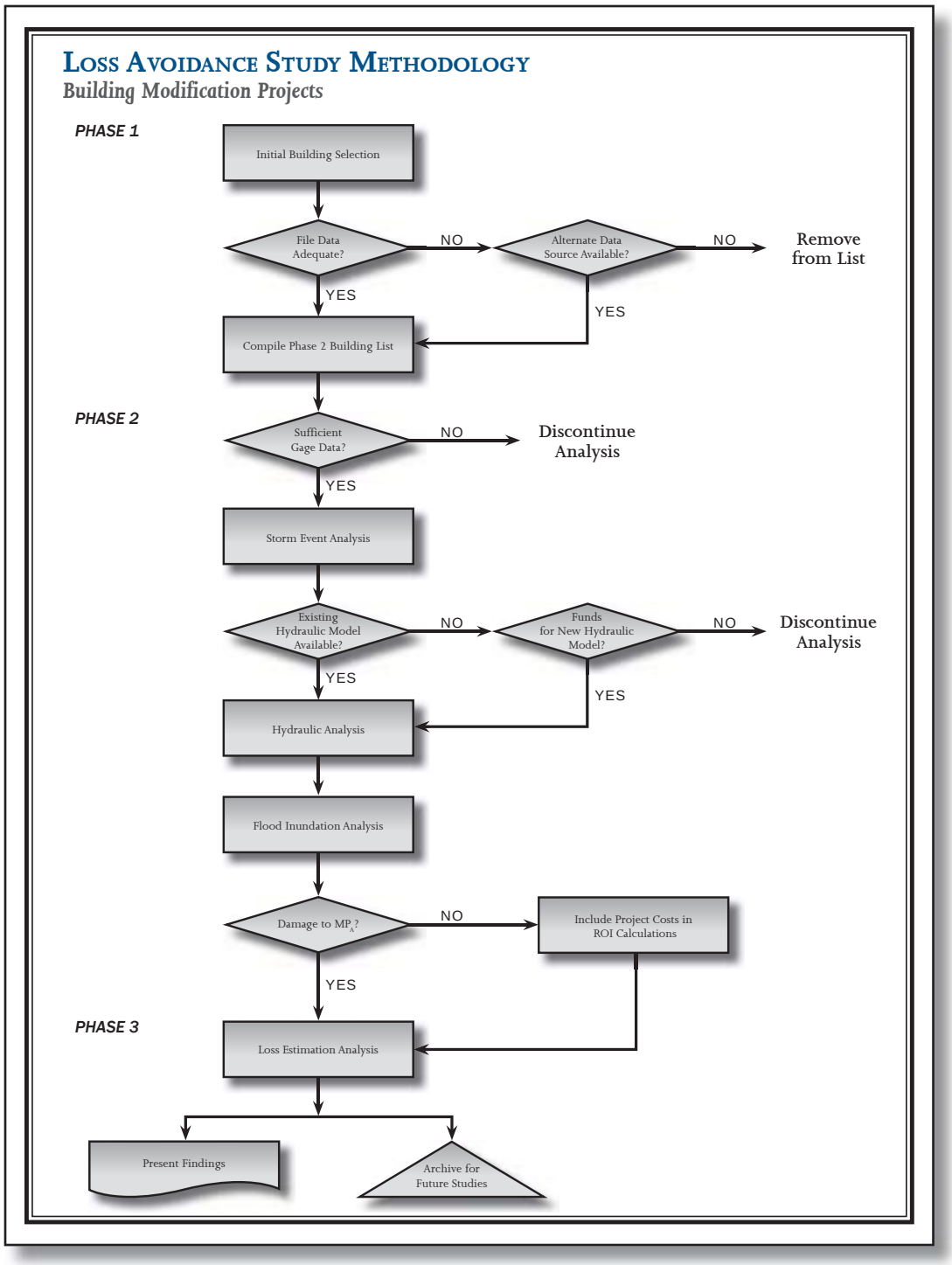
For building modification projects, the initial list of buildings in each project is screened based on the availability of data required for completion of all phases of the study. Buildings with adequate data advance to Phase 2 of the study.

Phase 2 is composed of three distinct analyses—Storm Event Analysis, Hydraulic Analysis, and Flood Inundation Analysis. A Storm Event Analysis is performed to determine if any storm event occurred since the mitigation project was implemented that would have caused damages in the MP_A scenario. A Hydraulic Analysis is performed to determine the extent and depth of flooding in those events. A Flood Inundation Analysis uses the results of the Hydraulic Analysis and is conducted to determine the depth of flooding inside buildings within the project. If the depth or limit of inundation determined for the MP_A scenario indicates damage would have occurred if the project had not been implemented, the building advances to Phase 3 for a Loss Estimation Analysis.

In Phase 3 for building modification projects, damages are calculated for the MP_A and MP_C conditions. Because no damages would have occurred for the MP_C condition for acquisition projects, the MP_A damages are equivalent to the losses avoided. The ROI is calculated by comparing the losses avoided to the project investment. The definition of ROI used in this study is not the same as a financial ROI, which is a measure of net profit, expressed relative to the dollars invested. For the LAS, an ROI of greater than 100 percent indicates that project benefits have exceeded project costs and the project is therefore considered cost-effective.

The LAS methodology for building modification projects is shown in Figure 1.2.

Figure 1.2


LOSS AVOIDANCE STUDY METHODOLOGY
Building Modification Projects
PHASE 1
Initial Building Selection
File Data Adequate?
NO
Alternate Data Source Available?
NO
Remove from List
YES
YES
Compile Phase 2 Building List
PHASE 2
Sufficient Gage Data?
NO
Discontinue Analysis
YES
Storm Event Analysis
Existing Hydraulic Model Available?
NO
Funds for New Hydraulic Model?
NO
Discontinue Analysis
YES
YES
Hydraulic Analysis
Flood Inundation Analysis
Damage to MP$_A$?
NO
Include Project Costs in ROI Calculations
YES
PHASE 3
Loss Estimation Analysis
Present Findings
Archive for Future Studies

Section Two:

Mitigation Project Information

This LAS focuses on commercial building acquisitions and elevations in the City of Tillamook, Oregon, that took place between 1997 and 2007. Each of the nine buildings included in the study experienced repeated flooding from the Wilson River and associated sloughs. At least three of the buildings were considered repetitive loss properties, including one property that incurred at least eleven National Flood Insurance Program (NFIP) losses over 20 years. As a result, three commercial buildings were elevated above the base (100-year) flood elevations (BFEs) for the area and six commercial buildings were acquired and demolished.

2.1 History

In Oregon, flooding causes residents, businesses, and taxpayers millions of dollars in damage every year even though not every flood is severe enough to be declared a Major Disaster by the President. Low-lying areas between the Coast Range and the Pacific Ocean are particularly vulnerable to severe flooding caused by any combination of heavy rains, melting snow, high tides, and strong winds. Between 1996 and 2009, the President declared 12 Major Disasters due to severe storms and flooding (FEMA, 2009). Between 1996 and 2000 alone, flooding in Tillamook County resulted in losses in excess of $60 million. The losses included damages to homes, businesses, and infrastructure (Tillamook County, 2009). Following the floods of 1996 and 1998, FEMA reanalyzed and remapped the flood hazards in the City of Tillamook and prepared a revised Flood Insurance Rate Map (FIRM) showing new BFEs.

Table 2-1 is a list of the ten highest flood crests for the Wilson River as recorded by the U.S. Geological Survey (USGS) gage ID# 14301500, which is approximately 6 miles east (upstream) of Tillamook. Major Disaster declarations are indicated.

Two additional floods that resulted in losses occurred on November 12, 2008, and January 8, 2009. The flood events had the same crest (15.92 feet), which is the 15th largest event on flood record for the Wilson River gage. According to the National Oceanic and Atmospheric Administration (NOAA) Advanced Hydrologic Prediction Service (NOAA, 2009), when flood stages on the Wilson River exceed 14 feet, sloughs north of the city (primarily Dougherty Slough) begin to overflow. This stage causes minor flooding in the business district north of Tillamook and along U.S. Highway 101,

Table 2.1

Flood Crests on the Wilson River

Crest Height (ft)[1]	Peak Discharge (cfs)	Event Date	Declared Disaster
22.89	38,600	November 6, 2006	DR-1672
20.37	33,100	December 3, 2007	DR-1733
20.26	32,100	December 22, 1964	DR-184
19.59	35,300	December 27, 1998	—
19.51	35,000	February 8, 1996	DR-1099
19.08	26,600	February 6, 1996	DR-1099
17.06	25,400	November 25, 1999	—
16.91	36,000	January 20, 1972	DR-319
16.83	32,000	December 13, 1977	—
16.67	31,000	December 4, 1989	—

[1]Gage datum 42.12 feet above sea level National Geodetic Vertical Datum of 1929 (NGVD29)
— = Not a declared disaster event
cfs = cubic foot (feet) per second
ft = foot (feet)

particularly during high tide. Any flooding with a crest above 19 feet causes widespread flooding in the City of Tillamook and surrounding areas. U.S. Highway 101 through the northern portion of Tillamook has historically been closed at this and higher stages.

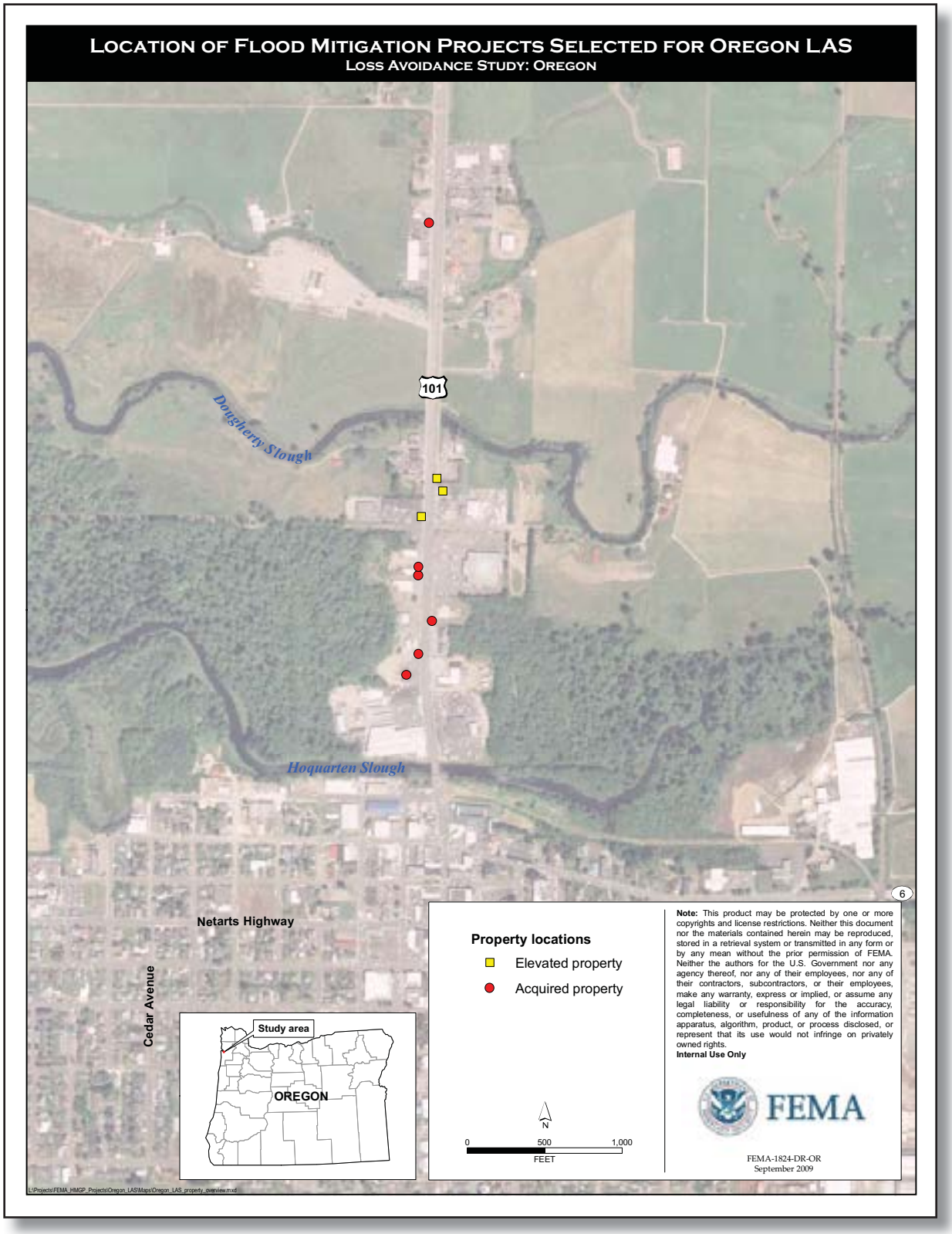
2.2 Funding and Timeline

The first project to be completed was the elevation of the Veterinary Hospital in 1997. The most recent projects were completed in 2007. FEMA funded 75% of the approximately $4.7 million cost of the nine projects (FEMA, n.d.[d]).

2.3 Location

The City of Tillamook is located on the southeastern end of Tillamook Bay on the Pacific Ocean. The locations of the nine properties assessed in this study are shown in Figure 2.1. All of the properties are along a 1-mile stretch of U.S. Highway 101, known as Main Street within the City limits.

Figure 2.1


Location of Flood Mitigation Projects Selected for Oregon LAS
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Property locations
Elevated property
Acquired property
N
0
500
1,000
FEET
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2.4 Typical Elevation and Acquisition Projects

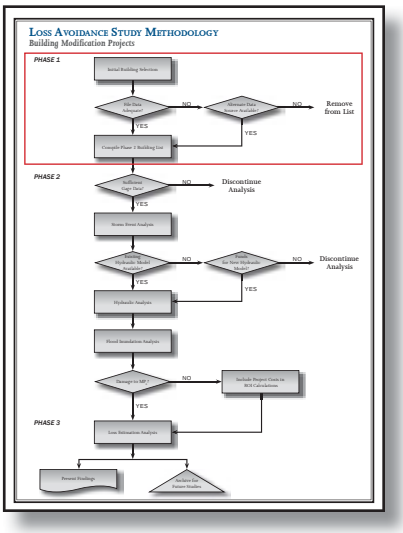
The study includes both elevation and acquisition projects. Figure 2.2 shows a typical elevation, the elevation of the Western Royal Inn. Figure 2.3 shows a typical acquisition, the acquisition/demolition of the Dean Property.

Figure 2.2 Elevation of Western Royal Inn

Figure 2.3 Acquisition of Dean Property

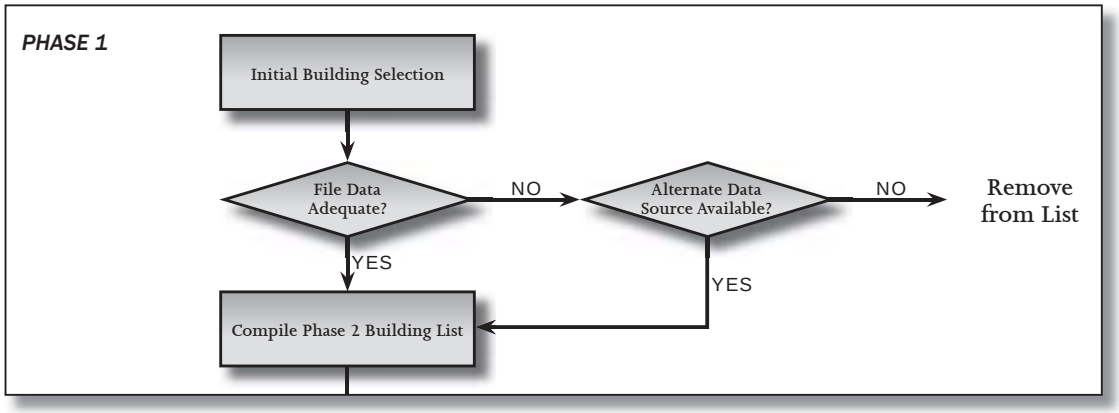
Section Three:

Phase 1 – Initial Project Selection and Screening



This section contains a discussion of Phase 1, Initial Project Selection, for building modification projects (see Figure 3.1). In Phase 1, an initial list of candidate projects is selected, and data are collected for analysis of the projects. For a building modification project, buildings are analyzed and screened individually based on the availability of the data that are required for Phase 1, and a list of buildings advancing to Phase 2 is compiled.

Figure 3.1



3.1 Initial Data Collection and Screening

The selection of the initial projects for an LAS is based on criteria defined for that LAS. The criteria may include but are not limited to:

- **Area of Interest**: The area of interest is the geographic boundary of a study. The boundary can be a reach of a river or channel, a single community or watershed, a region, a jurisdictional boundary (e.g., city, county, State, special district), or any other area. The boundary must be defined by the agency sponsoring the study. A building modification project can consist of a single building but more often includes multiple buildings. Regardless of the number of buildings in a project, every building is evaluated individually using the information that is available for that building.
- **Hazard Type**: Projects in an LAS are selected based on the type of hazard they are mitigating. Examples of hazard types are riverine flood and coastal flood.
- **Project Type**: Many project types can be analyzed in an LAS. Flood-related projects include building modification

projects, which consist of elevation, acquisition, relocation, and floodproofing projects; and flood reduction projects, such as stormwater drainage system improvements, channel modifications, flood walls/barriers, and other projects that would reduce the severity of flooding.

- **Study Baseline**: The study baseline for an LAS is the date the mitigation activity was completed. Only the storm events that occurred after the study baseline should be evaluated for an LAS. For a building modification project, the study baseline is the date of elevation or demolition of each building. Consequently, it is more likely that losses avoided can be assessed for buildings with older study baseline dates. A building modification project, which may include the elevation or acquisition of multiple buildings, is not closed until after the mitigation of each building included in the project is complete. Therefore, it is recommended that the individual elevation or acquisition date be used as the study baseline instead of the project closeout date.

For building modification projects, once an initial list of projects has been selected, buildings in each project must be analyzed individually. Buildings should be removed from the analysis during Phase 1 if specific, necessary building data are not available or cannot be easily estimated. Buildings may also be eliminated based on the quality of the available data.

The data that are required to complete an LAS for building modification projects are:

- Total, actual costs for the implementation of the mitigation activity. Elevation costs may include the construction costs to elevate the building and costs for management of the project, while acquisition costs may include the fair market value of the building paid to the homeowner, demolition costs, legal fees, and assessor's costs.
- The construction completion date for each building elevation, and the demolition date for each building acquired.
- First floor elevations (FFEs) for the MP_A, and also MP_C scenario for the elevation projects, preferably in the form of FEMA elevation certificates. FFEs can be estimated using highly accurate topographic mapping and standard values from FEMA's Hazards U.S.–Multihazard (HAZUS-MH) loss estimation system (FEMA, 2006) in the absence of surveyed FFEs. Building location information in the form of latitude/longitude data, address, and/or assessor parcel number.
- Building location information in the form of latitude/longitude data, address, and/or assessor parcel number.

Data required for a building modification project:

- Project cost
- Project completion date
- First floor elevation
- Building location information
- Building characteristics and replacement value

- Building information, including building type (i.e., residential, commercial, industrial, or municipal), construction type (e.g., wood frame, manufactured), basement information (i.e., finished versus unfinished and square footage), number of floors, square footage of living space, foundation type, number of stories, garage type and square footage, and building replacement value (BRV).

FFEs are important because they provide the basis for the damage calculations. Damages are calculated in Phase 3 based on the depth of flooding inside the building. Because of the sensitivity of the damage calculations, even an error of 0.5 feet in the FFE can affect the damage calculations significantly. Surveyed FFEs are therefore preferred.

3.2 Oregon Study: Phase 1 Summary

FEMA and the State of Oregon worked together to develop a project list for the study based on the following criteria:

- **Area of Interest**: Projects located in the City of Tillamook, particularly those along U.S. Highway 101
- **Hazard Type**: Riverine flooding
- **Project Type**: Elevation and acquisition of commercial buildings
- **Study Baseline**: Elevations and acquisitions were completed between October 1997 and October 2007. The Dairy Queen provided an unusual case in that the building was abandoned after the November 2006 flood event but was not demolished until 2009. However, since repairs would have been made to the building if an acquisition were not planned for the site, the losses avoided for the 2006 event and all subsequent events were included in the study.

Elevations and acquisitions were completed between October 1997 and October 2007

A field visit was completed on August 25 and 26, 2009. The field visit, which included representatives of FEMA, the State, and local agencies, served as the kick-off meeting for the study. Potential data sources and action items were identified. A walk-through of each project site was completed, and photographs were taken. Remaining foundations of acquired buildings were measured by hand, nearby high water marks were recorded, and local business owners were interviewed about previous flooding.

Subsequent data collection efforts for the Oregon study are described below.

- **Project Cost Data**. Total project cost data were provided by the State for each building, which were then inflated to 2009 values.
- **Building Location Data**: Building location data can be difficult to obtain for acquisition projects because the buildings no longer exist. In this study, although some of the buildings had been demolished up to nine years earlier, building address, latitude, and longitude data were available and provided by the County for all buildings. Building locations were plotted using latitude and longitude in a Geographic Information System (GIS).
- **Building Information**: Building information consisting of construction type, number of floors, square footage, and BRV was obtained from appraisal data provided by the City. FFEs were obtained from FEMA elevation certificates provided for the buildings that were elevated. For the properties that were acquired, a City surveying team measured the elevations of the remaining concrete slabs. FFEs were then estimated using pictures of the buildings from project files provided by the State. Project completion dates were determined using construction dates obtained from the State project files.
- **Building Screening**: No buildings were removed from the analysis during Phase 1. All buildings had sufficient data to proceed to Phase 2.

FFEs determined for the buildings included in the Oregon study are shown in Table 3.1.

Table 3.1

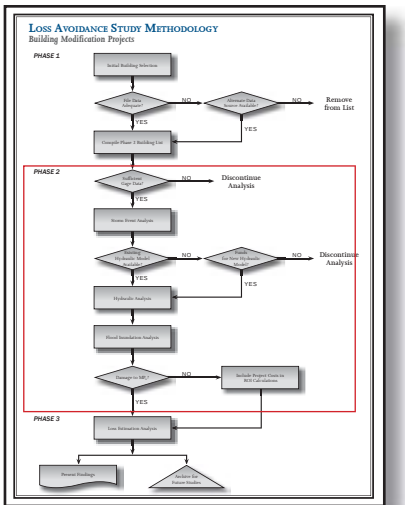
FFEs for Buildings in the Oregon Study

Property Name	Pre-Project FFE	Post-Project FFE
Veterinary Hospital	*12.00 feet*	*15.00 feet*
Tillamook Inn	*8.97 feet*	*Acquired*
Coast Tire	*8.57 feet*	*Acquired*
Western Royal Inn	*12.00 feet*	*14.50 feet*
Dairy Queen	*9.50 feet*	*Acquired*
Dean Property	*8.49 feet*	*Acquired*
Rental Center Bldg. #1 Tool & Equipment Repair	*8.49 feet*	*Acquired*
Rental Center Bldg. #2	*8.49 feet*	*Acquired*
Northport Plaza	*12.00 feet*	*14.60 feet*

Source: Tillamook (2009)
Note: All FFEs are referenced to NGVD29
FFE = first floor elevation

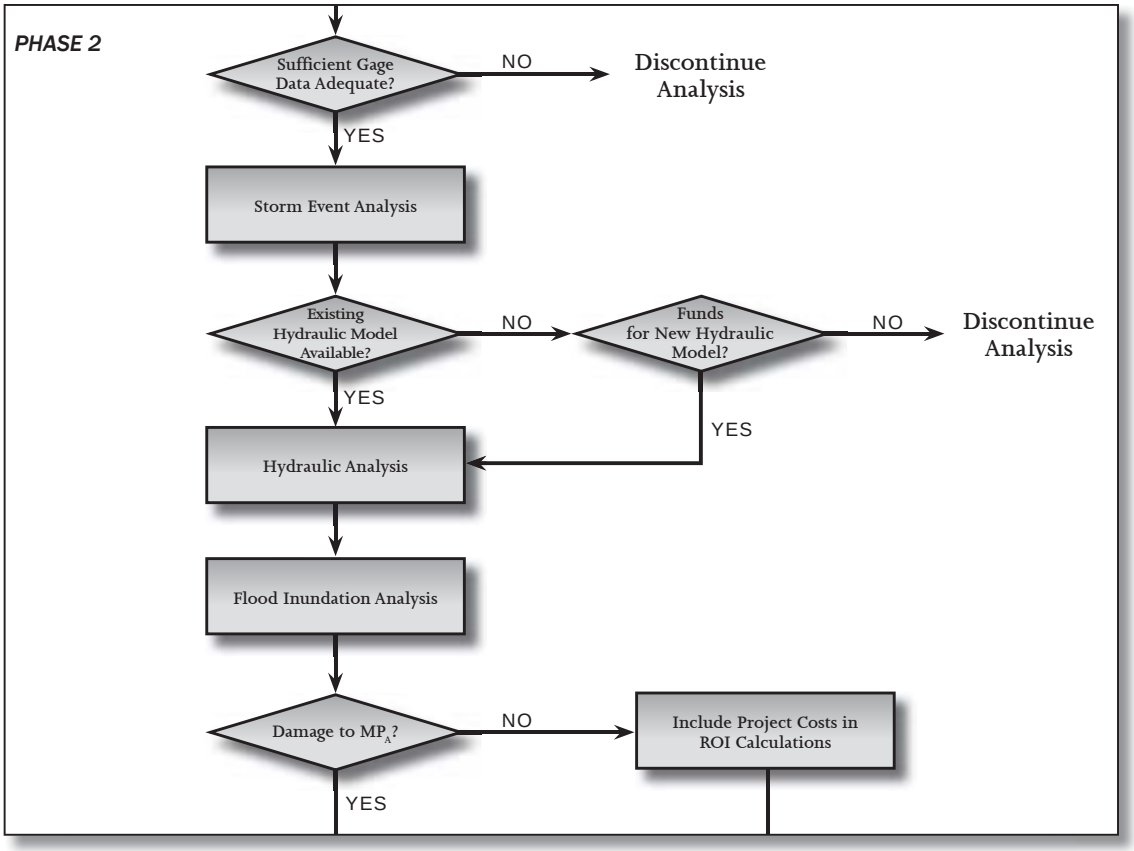
Section Four:

Phase 2 – Physical Parameter Analysis



This section contains a discussion of Phase 2, Physical Parameter Analysis, for building modification projects (see Figure 4.1). Phase 2 consists of a Storm Event Analysis, a Hydraulic Analysis, and a Flood Inundation Analysis.

Figure 4.1



- **Storm Event Analysis**: A Storm Event Analysis is conducted to identify potentially damaging events that occurred since the study baseline and to assess data availability. Data include high water marks (HWMs) or stream/precipitation gage readings.
- **Hydraulic Analysis**: A Hydraulic Analysis is used to determine how flows move through the project area and the water surface elevations (WSEs) for known storm events. For building modification projects, if a water surface profile from an existing model is available, or enough HWMs to create a digital water surface were collected during the Storm

Event Analysis, it may not be necessary to prepare additional hydraulic modeling.

- **Flood Inundation Analysis**: The Flood Inundation Analysis is conducted to determine the depth of flooding that would have occurred during storm events since the study baseline at each building location in the MP_A scenario.

For a more information on Phase 2, see *Loss Avoidance: Riverine Flood Methodology Report* (FEMA, in press[b]).

4.1 Storm Event Analysis

An LAS for any flood-related project is dependent on the occurrence of a storm event after the study baseline that is severe enough to have caused damage in the MP_A scenario. For some projects, more than one storm event may have occurred since project completion that could have caused damages.

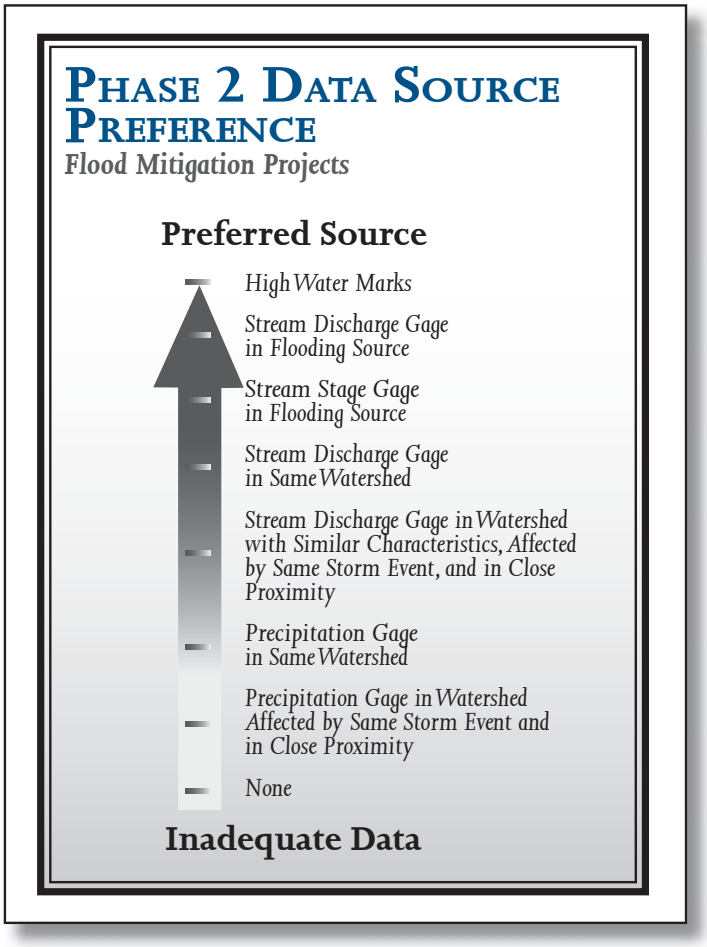
The purpose of the Storm Event Analysis is to determine which storm event data are available. Data for the Storm Event Analysis may be collected in the form of HWMs from floods, stream gage discharge data, stream gage stage data, or precipitation gage data according to the order of preference for storm event data (see Figure 4.2). If no HWMs were recorded, the availability of sufficient stream gage data should be determined because stream gage data are the next best source of data for the analysis. The stream gage should be in or near the study area and have a period of record covering the event(s) of interest. Stream gage data may include measurements of stage (WSE), discharge (flow rate), or both.

When no stream gages are available, precipitation gages must be located. If precipitation gages are used, a hydrologic analysis must be completed to convert rainfall data to flow at the project site. If no storm event data are available, the buildings along that flooding source must be eliminated from evaluation. A list of peak events since the first mitigation activity was completed can be compiled from the gage data during this phase if the scope of the study calls for the analysis of more than one event.

4.1.1 Oregon Study: Storm Event Analysis

The earliest study baseline date for the buildings in the City of Tillamook corresponds to the elevation of the Veterinary Hospital in October 2007. An analysis of flow data for the USGS gage (ID# 14301500) for the Wilson River near Tillamook was performed to determine the dates of damaging storms that could have occurred within the study area after October 1997. The gage is

Figure 4.2



approximately 6 miles east (upstream) of the City limits (see Figure 4.3).

The data available from the USGS gage include instantaneous discharge (generally available every 15 minutes), daily mean flow, annual peak stream flow, and all corresponding gage heights. Annual peak stream flows from October 1997 through December 2007 were collected for the analysis (see Table 4.1).

For the published annual peak flows listed in Table 4.1, a corresponding daily mean flow was determined and a mean daily flow to peak annual flow ratio was calculated, as shown in Table 4.2. The average mean-to-peak ratio between October 1997 and December 2007 was 1.40.

Annual peak data after December 2007 are considered provisional (data have not received final approval from USGS). Therefore, it was necessary to determine statistically the peak annual discharges for calendar years 2008 and 2009 (up to the date of this report). The average mean-to-peak ratio was applied to the maximum 2008 and 2009 mean daily flows to calculate the statistical peak flow, as shown in Table 4.3.

Figure 4.3

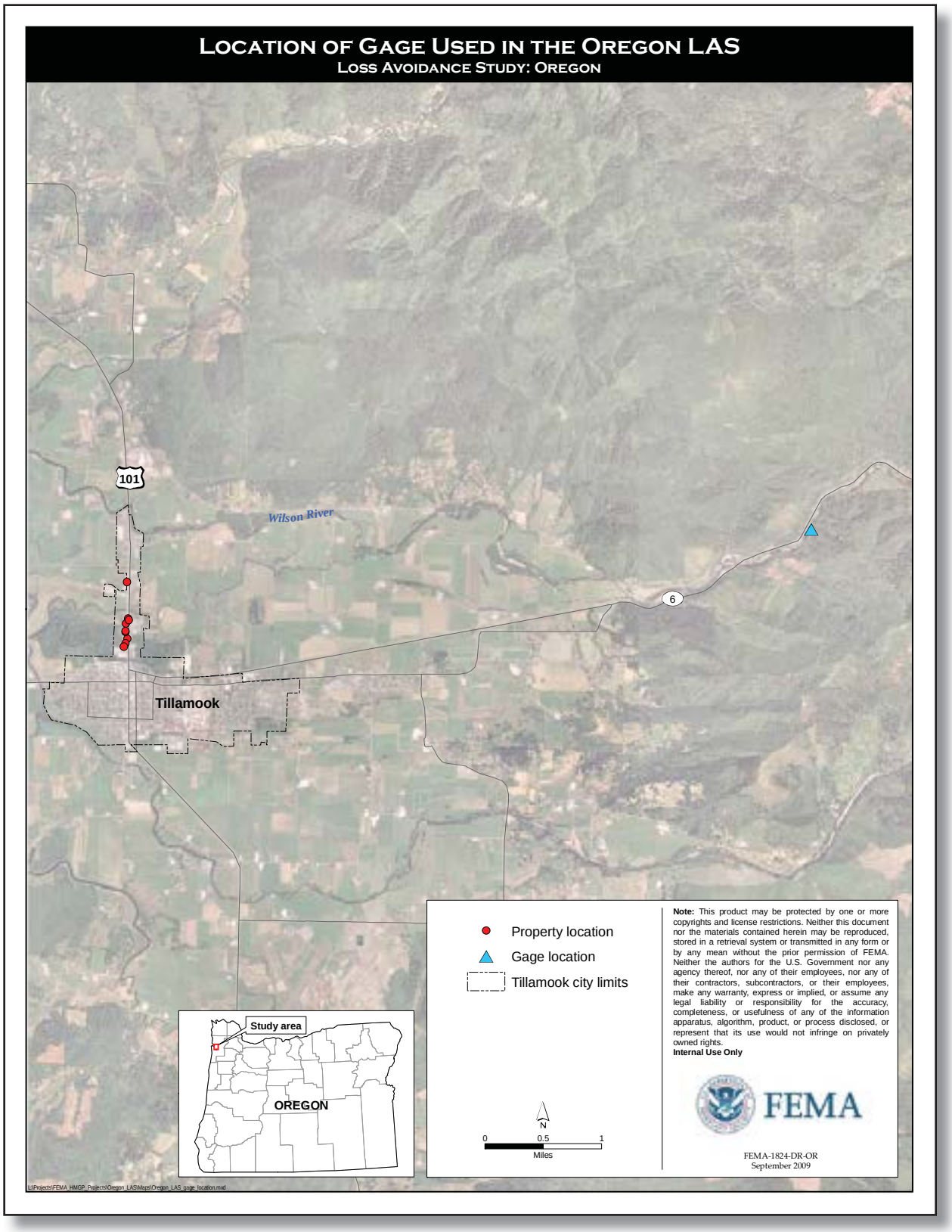

Location of Gage Used in the Oregon LAS
Loss Avoidance Study: Oregon
101
Wilson River
6
Tillamook
Study area
OREGON
Property location
Gage location
Tillamook city limits
N
0
0.5
1
Miles
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Table 4.1

Annual Peak Stream Flow at USGS Gage #14301500

Date of Event	Annual Peak Flow (cfs)
October 30, 1997	21,900
December 27, 1998	35,300
November 25, 1999	25,400
December 23, 2000	3,750
December 16, 2001	16,400
January 31, 2003	17,800
January 29, 2004	12,600
January 18, 2005	15,500
January 10, 2006	22,600
November 6, 2006	38,600
December 3, 2007	33,100

Source: USGS (2009) cfs = cubic foot (feet) per second

Table 4.2

Ratio of Mean Daily Discharges to Peak Annual Discharges for Events in the Study Period

Date of Event	Peak Annual Flow (cfs)	Mean Daily Flow (cfs)	Mean-to-Peak Ratio
October 30, 1997	21,900	12,100	1.81
December 27, 1998	35,300	17,300	2.04
November 25, 1999	25,400	19,400	1.31
December 23, 2000	3,750	3,420	1.10
December 16, 2001	16,400	10,800	1.52
January 31, 2003	17,800	13,900	1.28
January 29, 2004	12,600	11,600	1.09
January 18, 2005	15,500	12,200	1.27
January 10, 2006	22,600	18,100	1.25
November 6, 2006	38,600	26,100	1.48
December 3, 2007	33,100	26,800	1.24
		Average	1.40

Source: USGS (2009) cfs = cubic foot (feet) per second

Table 4.3

Statistically Calculated Peak Flows for 2008 and 2009

Date of Largest Event	Mean Daily Flow (cfs)	Calculated Peak Flow (cfs)
November 13, 2008	11,600	16,213
January 8, 2009	18,500	25,857

Source: USGS (2009) cfs = cubic foot (feet) per second

Table 4.4

Statistically Calculated Peak flows for Other Storms Likely to Have Caused Damage

Date of Event	Mean Daily Flow (cfs)	Calculated Peak Flow (cfs)
November 28, 1998	13,400	16,731
December 15, 1999	13,200	16,482
January 25, 2002	12,400	17,331

Source: USGS (2009) cfs = cubic foot (feet) per second

The mean daily gage data were examined to determine whether any similar events occurred during the study period that could have potentially caused damage but were not large enough to register as the peak flow for that year. Three events fit this description (see Table 4.4 above). The mean-to-peak ratio was applied to these events to determine their statistical peak flow.

Because loss avoidance calculations are based on the assumption that sufficient time elapses between storm events to allow for repairs to be completed, it was necessary to limit the storm event analysis to a single storm within a selected time interval. Following methodology developed for the Wisconsin LAS (FEMA, in press [c]), an interval of at least 180 days (six months) between storms was chosen to allow for the hypothetical repairs to be completed. The storm during this period that would have resulted in the most damage was selected. Therefore, the events occurring on November 1998, December 1999, January 2002, and November 2008 were eliminated from further analysis.

Next, historical loss data from flood insurance claims made under the NFIP were reviewed. No claim was made for any of the buildings in the study for an event with a discharge of less than 19,500 cfs.

This corresponds to anecdotal evidence from NOAA that minimal flooding starts along U.S. Highway 101 when flood stage at the Wilson River gage reaches approximately 14 feet (see Section 2.1). According to the USGS data for the gage, historical crests ranging from 14.22 feet (December 16, 2001) to 14.36 feet (January 24, 1982) had corresponding discharges ranging from 16,400 cfs to 19,200 cfs, respectively. Therefore, all events with flow rates less than 19,500 cfs were removed from the study.

The final list of storm of events used for the study are shown in Table 4.5.

Table 4.5

Final List of Storm Events Used in the Study

Date of Event	Peak Discharge (cfs)
October 30, 1997	21,900
December 27, 1998	35,300
November 25, 1999	25,400
January 10, 2006	22,600
November 6, 2006	38,600
December 3, 2007	33,100
January 8, 2009	25,857

cfs = cubic foot (feet) per second

4.2 Hydraulic Analysis

Hydraulic modeling is usually required to determine the WSE and depth of flooding at locations of interest. Peak flows determined in the Storm Event Analysis (see Section 4.1.1) are used for the discharges in the hydraulic model. Detailed topographic data are used to prepare a series of cross sections for the project area. The hydraulic model is then used to estimate WSEs at a series of cross sections for the event(s) of interest. It may not be necessary to use a hydraulic model for each event if results of HWM studies or WSE profiles developed from existing hydraulic models are sufficient to determine the WSE and flood depths for the desired storm events.

A hydraulic model may exist for the study area. If FEMA has published a FIRM and Flood Insurance Study (FIS) for the community, and the flooding source in question was studied in detail for the FIS, it may be possible to obtain a copy of the FIS modeling. Results from the FIS model may be used to interpolate actual storm events, or it may be possible to modify the model simply by replacing the original

discharges with discharges for the event of interest. However, only portions of the original model may be applicable for use, especially if the channel has migrated since the model was completed.

When an existing hydraulic model is not available, it may be necessary to create a model for the project area. A list of FEMA-acceptable hydraulic models is available at www.fema.gov. The parameters required to set up a new model include cross section elevation data, roughness coefficients, boundary conditions, discharges (from the Storm Event Analysis), and data for any hydraulic structures in the model area. Detailed topographic data for the project area are necessary for the creation of channel cross sections. Outlier buildings or buildings located where adequate topographic data are not available should be removed from the building list.

Buildings located on flooding sources with existing hydraulic modeling available or on flooding sources that can be modeled with appropriate methods will proceed to the Flood Inundation Analysis.

4.2.1 Oregon Study: Hydraulic Modeling

In 1977, FEMA studied the Wilson River and its associated sloughs in detail for preparation of the Tillamook County FIS and FIRM and in 2002, restudied the Wilson River and its sloughs and published revisions to the Tillamook County FIS and FIRM. The revised FIS contains flood profiles and discharge summaries for the 10-, 50-, 100-, and 500-year storm events. The hydraulic model for the restudy was prepared using a U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) electronic model. Subsequently, Northwest Hydraulic Consultants (NHC) prepared HEC-RAS modeling for Project Exodus, a proposal to create a flood corridor between Hoquarten and Dougherty sloughs (NHC, 2009). Both models were used to analyze the events from the Storm Event Analysis.

Hydraulic conditions in the project area are affected by the Trask/Wilson Spillway. The spillway is on the right bank of the Tillamook River, approximately 2 miles downstream of U.S. Highway 101. It discharges into the overflow channel between the Tillamook and Wilson rivers. The spillway was completed in September 2008, so it was not included in any of the modeled events that occurred prior to September 2008. Although the spillway may have affected flood levels in the January 8, 2009, event, the results of the modeling were not used to estimate losses for that event. Rather, the losses were calculated using historical data from similar events (see Section 4.3.1). Therefore, the spillway was not included in the analysis for this LAS.

4.2.1.1 FEMA FIS Model

Prior to 1919, Dougherty Slough, which runs through the northern part of Tillamook, was known as Dougherty River. During a large storm in 1919, a log jam plugged the Dougherty River and part of the Lower Wilson River, creating a tidally influenced slough. The area was studied for a FEMA FIS in 1977. During the December 1998 event, the log jam washed away and, as a result, Dougherty Slough began to behave like a river again (CRC, n.d.). In 2002, FEMA restudied the Wilson River from approximately the location of USGS Gage #14301500 to where the river discharges into Tillamook Bay, using the November 1998 event for calibration. The electronic model used in the restudy was obtained from the FEMA Engineering Library. Within the model, two junctions are used to model the split of the Dougherty Slough from the Wilson River and the Hoquarten Slough split from the Dougherty Slough. Both sloughs were modeled as rivers in order to capture existing flooding conditions (see Figure 4.4).

The FEMA FIS model performs steady-state flow calculations using the most upstream cross section of the Wilson River as the entry point for the governing flows and a total of 31 flow change locations along the riverine system.

The summary of discharges table from the City of Tillamook FIS (FEMA, 2002) is provided in Table 4.6.

The FEMA FIS model did not use flows from the USGS gage and instead used the flows just downstream of the gage at the confluence with Little North Fork Creek as the governing flow. However, the drainage area at the gage is only 1.1 square miles smaller and flows are 100 to 200 cfs smaller, which equates to less than 1 percent of the 10-year flow. Given these negligible differences, the flows at the USGS gage were used in the analysis of events occurring during the study period.

For the 10-, 50-, 100-, and 500-year storms, flows ratios were calculated comparing flows at each of the 31 flow change locations to the corresponding governing flow. Next, the relative size of each storm from the Storm Event Analysis was determined (see Table 4.7).

Flows at flow change locations for each event identified in the Storm Event Analysis were determined by multiplying the flow at the gage by the appropriate flow-change-location-to-governing-flow ratios calculated in the previous step. For example, since the December 2007 event was approximately a 50-year event, flow-change-location-to-governing-flow ratios for the 50-year event were used.

Figure 4.4

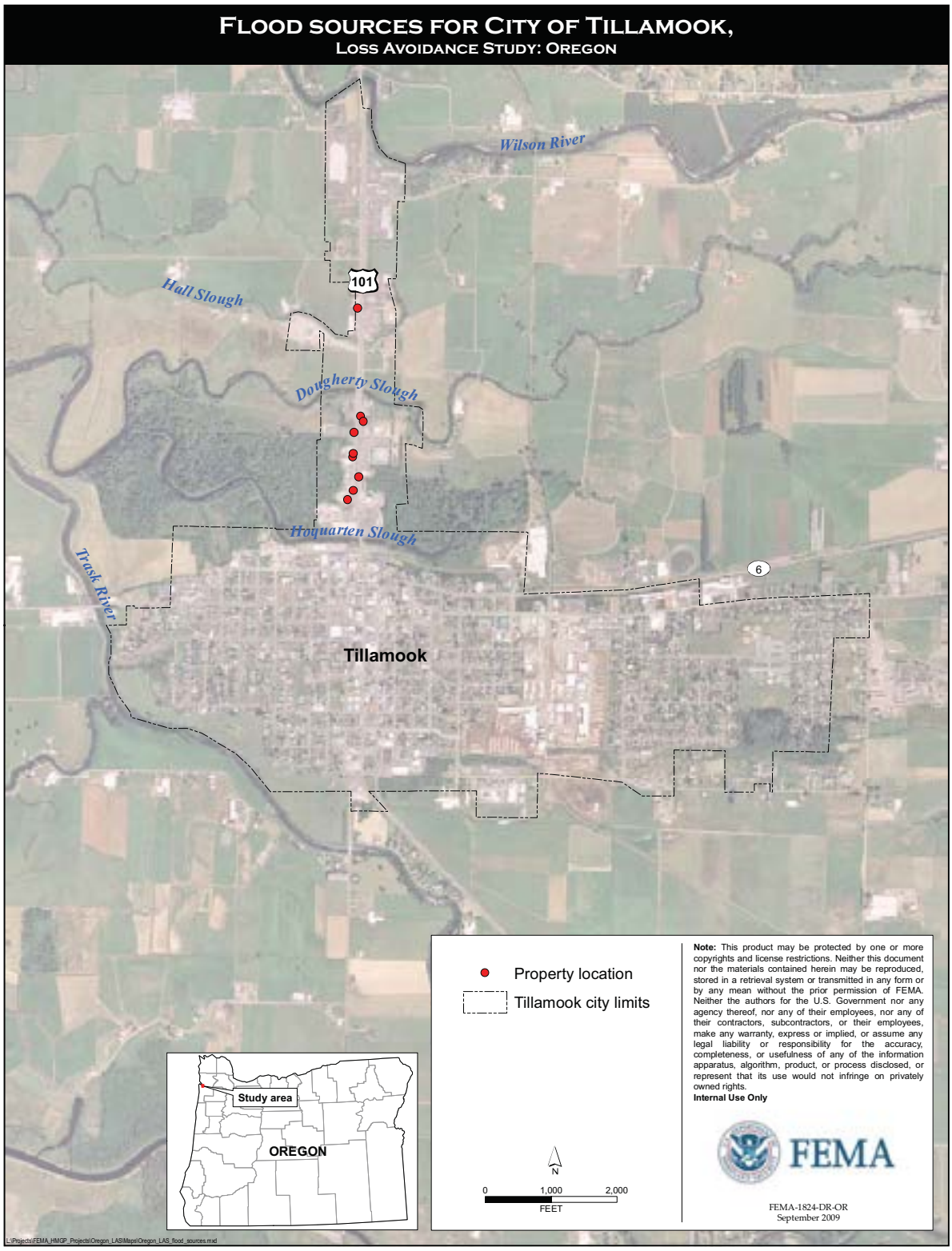
Flood sources for City of Tillamook,
Loss Avoidance Study: Oregon
Wilson River
Hall Slough
101
Dougherty Slough
Hoquarten Slough
Trask River
6
Tillamook
Study area
OREGON
Property location
Tillamook city limits
N
0
1,000
2,000
FEET
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Table 4.6

Summary of Discharges on the Wilson River

Location	Drainage Area (sq mi)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
Mouth	192.20	28,600	37,700	41,500	49,700
Beaver Creek	187.30	28,000	37,000	40,700	48,800
Little North Fork	162.10	25,100	33,200	36,500	43,700
Gage #14301500	161.00	25,000	33,000	36,300	43,500
Cross Section A	147.20	23,800	30,800	34,000	40,500
Fall Creek	145.40	23,600	30,600	33,700	40,300

Source: FEMA (2002) cfs = cubic foot (feet) per second sq mi = square mile(s)

Table 4.7

Approximate Return Interval of Events Used in Analysis

Date of Event	Peak Flow (cfs)	Size of Event
October 30, 1997	21,900	<10-year
December 27, 1998	35,300	Between 50- and 100-year
November 25, 1999	25,400	10-year
January 10, 2006	22,600	<10-year
November 6, 2006	38,600	Between 100- and 500-year
December 3, 2007	33,100	50-year
January 8, 2009	23,622	<10-year

cfs = cubic (foot) feet per second

To complete the Hydraulic Analysis, the seven events identified in the Storm Event Analysis were routed through the FEMA FIS model using a steady-flow simulation.

4.2.1.2 Northwest Hydraulic Consultants Model

The HEC-RAS model obtained from NHC was set up as an unsteady flow model. The model extends from the downstream tidal boundary at Tillamook Bay to the upstream reaches of the Wilson, Trask, and Tillamook rivers. Multiple reaches were included between the three rivers to account for the flows in the sloughs and overbank flows through the floodplain. Several storage areas were also included to account for floodplain storage from overflowing channels. In the vicinity of the study area along U.S. Highway 101, the following reaches were included, from north to south:

- Wilson River
- An overflow channel between the Wilson River and Hall Slough
- Hall Slough
- An overflow channel between Hall Slough and Dougherty Slough
- Dougherty Slough
- An overflow channel between Dougherty Slough and Hoquarten Slough
- Hoquarten Slough

The inflows to the areas in the floodplain were modeled with lateral weirs along the main channels. The model included a tidal stage hydrograph as the downstream boundary at Tillamook Bay with other boundary conditions including lateral inflows and upstream direct inflow hydrographs.

The peak WSE results at U.S. Highway 101 were obtained from the model for peak discharges of 15,500 cfs, 25,400 cfs. 33,100 cfs, and 38,600 cfs at the Wilson River gage.

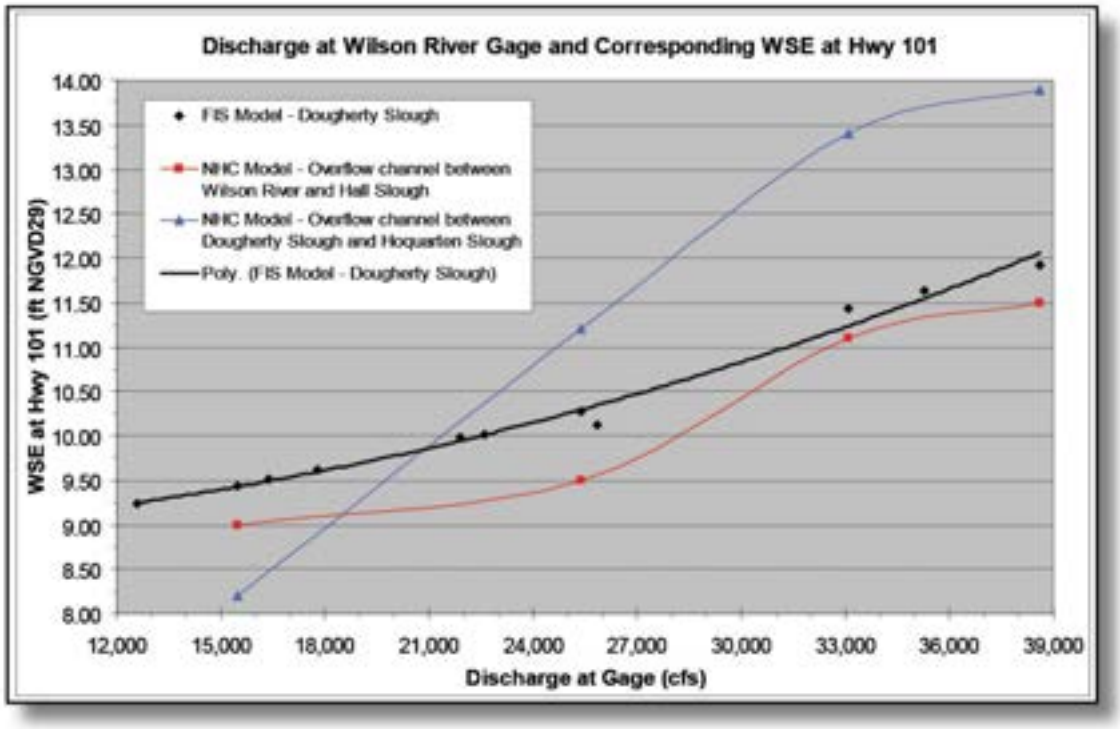
4.2.1.3 Comparison of Existing Hydraulic Models

During the field visit, it was determined that the main source of flooding for most of the buildings within the project area is Dougherty Slough. Tillamook Inn is north of the other buildings in the study and thus is affected primarily by overflow of Hall Slough. U.S. Highway 101 runs north and south through the project area and crosses both sloughs. Flows that enter the sloughs from the Wilson River during large storm events often exceed the hydraulic capacity of the channel at the U.S. Highway 101 bridge crossing, resulting in a backup effect that forces water into the overbanks. This was confirmed by the FEMA FIS model, which shows a backup effect on the output profiles upstream of the bridge for all modeled flooding sources. Therefore, WSEs at cross sections just upstream of the U.S. Highway 101 bridge for both FEMA FIS and the NHC models were analyzed for the Flood Inundation Analysis because all buildings were located along U.S. Highway 101 and subject to flooding from the constraining effects of the bridge crossings at each slough.

Figure 4.5 shows the WSEs corresponding to each modeled discharge at the cross section directly upstream of U.S. Highway 101 for:

- Dougherty Slough from the FEMA FIS model
- Overflow channel between Dougherty and Hoquarten sloughs from the NHC model

Figure 4.5



- Overflow channel between Wilson River and Hall Slough from the NHC model

A polyline fitted to the FIS model to more clearly show the hydrologic trend of Dougherty Slough is shown in the figure.

4.3 Flood Inundation Analysis

For building modification projects, the Flood Inundation Analysis is the final step of Phase 2. WSEs are compared to the MP_A and MP_C FFEs to determine whether the buildings would have been affected by the peak storm event(s). Mapping the flood boundary is not necessary for building modification projects because the flood depths are only required at the individual buildings.

Most Flood Inundation Analyses are conducted using GIS software. The cross sections from the hydraulic model are digitized and attributed with peak WSEs for the events of interest. Flood elevations are then interpolated and converted to a water surface layer to account for flood elevations in all areas between the cross sections. From this surface, a peak WSE at each building is exported in table format.

When MP_A FFE data are available for building modification projects, extracting the WSE at the building from the flood elevation surface

greatly reduces analysis time by eliminating the need to compare the ground elevation and flood elevation surfaces. To determine the depth of flooding in the building for the MP_A scenario, the FFE is subtracted from the WSE at each building.

When the FFE is unknown, detailed topographic information is needed to calculate the flood depth between the ground and the WSE. The flood depth at each building is then calculated by subtracting an assumed height above grade using data from FEMA's HAZUS-MH loss estimation system (FEMA, 2006), based on the building's foundation type or building photography, from the overall flood depth.

4.3.1 Oregon Study: Flood Inundation Analysis

The Veterinary Hospital was elevated in 1997, but the next mitigation project was not completed until August 2000 when the Tillamook Inn was acquired and demolished. Therefore, the three storm events from October 30, 1997, to November 25, 1999, relate only to the Veterinary Hospital. No FFE data were available for the Veterinary Hospital, but the building is immediately adjacent to the Western Royal Inn, as shown in Figure 4.6. Therefore, the Veterinary Hospital was assumed to have the same FFE as the Western Royal Inn (12 feet, NGVD29).

According to the results of the FEMA FIS model (see Figure 4.5), the October 1997, December 1998, and November 1999 events would not have flooded the Veterinary Hospital. The NHC model shows flooding of 1.7 feet above the FEE for the December 1998

Figure 4.6 Veterinary Hospital Post-Elevation

event. These results were checked against NFIP flood claims data for the Western Royal Inn because no claims data were available for the Veterinary Hospital. The NFIP flood claims data showed that no claim was made for the Western Royal Inn for the October 1997 event with a discharge of 21,900 cfs but that the flood in November 1999, with a discharge of 25,400 cfs, and the flood in December 1998, with a discharge of 35,300, caused significant flooding. The damage to the Western Royal Inn from the two events was compared to its BRV, and a percent damage was calculated and compared to the standard building damage curve for a hotel from FEMA's Benefit-Cost Analysis (BCA) software Version 4 (FEMA, 2008). According to the curve, the November 1999 event would have caused approximately 1 foot of flooding and the December 1998 event would have caused approximately 2.8 feet of flooding. These flood depths were not used in the loss calculations for the Western Royal Inn because it was not elevated until 2004 but were used to approximate flooding depths inside the Veterinary Hospital.

Based on the FIS and NHC model results and the analysis of the historical data for the Western Royal Inn, it was assumed that the Veterinary Hospital did not flood in the October 1997 event. Because both hydraulic models showed that the hospital would not have flooded in the November 1999 event, but the historical evidence showed that it would have, it was assumed that the building would have experienced 1 foot of flooding in the November 1999 event, similar to the Western Royal Inn. Although the historical evidence for the Western Royal Inn indicates it would have flooded to approximately 2.8 feet, the WSE for the December 1998 event was based on the NHC model that provided a depth of 1.7 feet above the FFE. For purposes of loss avoidance, this is a conservative assumption.

Mitigation projects were completed for four buildings prior to the flood on January 10, 2006: the Veterinary Hospital, Western Royal Inn, Coast Tire, and the Tillamook Inn. This flood had a discharge of 22,600 cfs. According to the FEMA FIS model, this discharge would cause a WSE of 10.0 feet, and according to the NHC model, the flood would have reached a WSE of approximately 10.3 feet. As stated above, the Veterinary Hospital and Western Royal Inn have a FFE of 12 feet NGVD29 and therefore would not have flooded. The event would have caused minimal damage to Coast Tire and the Tillamook Inn with FFEs of 8.97 and 8.57 feet NGVD29, respectively. This is consistent with the NFIP flood claims data that show both buildings experienced flooding in the October 1997 event, which had a similar discharge of 21,900 cfs. Although both the FEMA FIS and the NHC hydraulic models show that the buildings would flood, based on an analysis of the historical losses compared to the

BRV and the FEMA standard damage curves, the FEMA FIS model provided more accurate data for the flood event. Therefore, the FEMA FIS model WSE of 10.0 feet was used for all buildings for the January 2006 event.

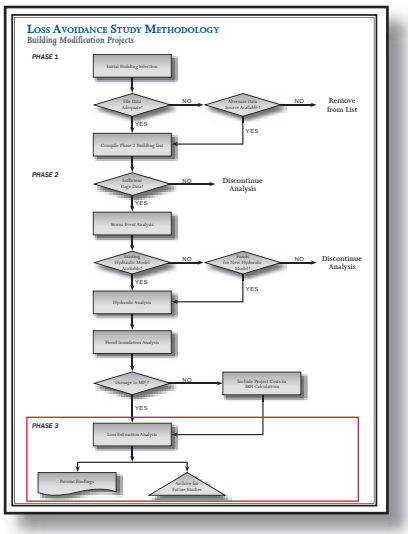
The January 8, 2009, event had a discharge of 25,857 cfs. Modeling results and NFIP flood claims data for similar events were analyzed, including the April 5, 1991, event with a discharge of 25,800 cfs and the November 25, 1999, event with a discharge of 25,400 cfs. This analysis showed that the results for both the FEMA FIS and NHC hydraulic models may not be accurate for this flow rate range. Therefore, for all buildings, data from historical flood claims for these events were inflated to 2009 values and used to estimate the losses, rather than model results. The one exception was the Veterinary Hospital, for which NFIP flood claims data were not available. It was assumed that the building would have experienced approximately 1 foot of flooding, similar to the November 25, 1999 event.

Modeling results for the December 3, 2007, event with a discharge of 33,100 cfs, and the November 6, 2006, event with a discharge of 38,600 cfs were compared to the NFIP flood claims data. For this flow range, the NHC model provided more accurate results than the FIS model. Because the NHC model provided a detailed analysis of multiple channels, this model was used to determine the WSE in the overflow channel between the Wilson River and Hall Slough. This WSE was used to estimate damages to the Tillamook Inn. At the Tillamook Inn, a WSE of 11.1 feet was obtained from the model for the December 2007 event, and a WSE of 11.5 feet was obtained from the model for the November 2006 event.

The WSE obtained from the NHC model for the overflow channel between Dougherty Slough and Hoquarten Slough was used to estimate the damages for all other buildings. WSEs of 13.4 feet for the December 2007 event and 13.9 feet for the November 2006 event were obtained from the model for the overflow channel between Dougherty Slough and Hoquarten Slough. These WSEs were verified using HWMs that were measured in adjacent buildings during the site visit. At the Texaco station directly north of the Dairy Queen, an HWM from the November 2006 event was measured at 4 feet 11 inches above the FFE. Comparing the FFE of the Dairy Queen (9.5 feet NGVD29) to the modeled WSE (13.9 feet NGVD29) yields a flood depth of 4.4 feet. Therefore, the WSEs for the December 2007 and November 2006 events were assumed to be properly represented by the NHC model and were compared directly to the FFEs to estimate flood depths inside the buildings.

Section Five:

Phase 3 – Loss Estimation Analysis

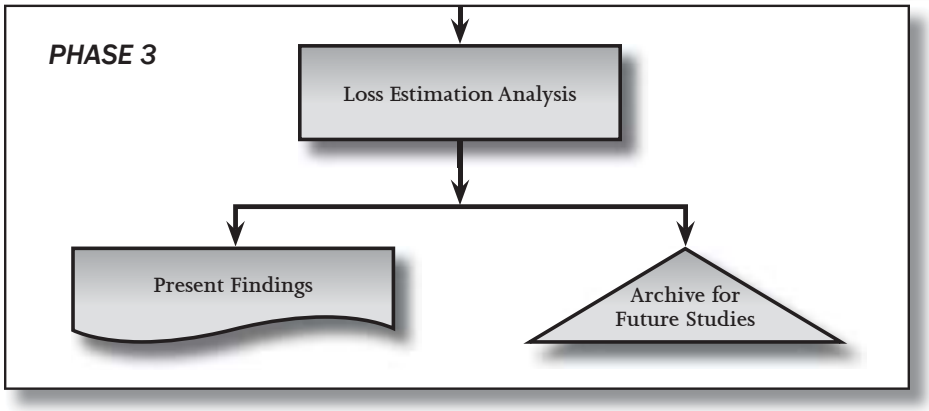


The final phase of an LAS consists of estimating the losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. This section provides a synopsis of Phase 3, the Loss Estimation Analysis, for a building modification project. The methodology is illustrated in Figure 5.1.

The two major tasks in Phase 3 are:

- Calculating losses avoided
- Calculating the ROI

Figure 5.1



The approach used to estimate flood damages is based on the FEMA BCA Version 4 software (FEMA, 2008) and technical guidance unless stated otherwise in the text. *What Is a Benefit?* (FEMA, 2001) also provides a basis for calculating losses. The values in the 2001 publication have been updated since the document was published, but the methodology is still current.

For a more information on Phase 3, see *Loss Avoidance: Riverine Flood Methodology Report* (FEMA, in press[b]) and *Loss Avoidance: Nontraditional Benefits Methodology Report* (FEMA, in press[a]).

5.1 Calculating Losses Avoided

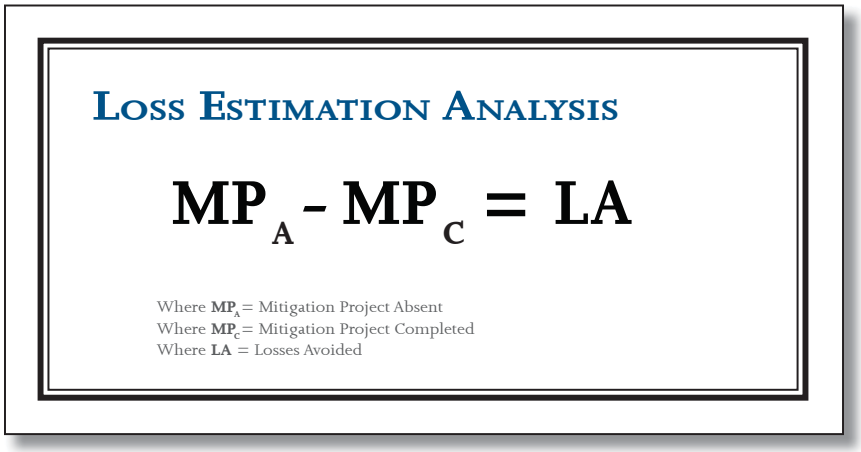
In Phases 1 and 2 of a building modification study, the following information is determined:

- The storm events that have occurred since the study baseline that would have caused damages in the MP_A scenario or may have caused damages in the MP_C scenario

- The number and type of buildings affected by the storm events being analyzed in the MP_A scenario
- The flood depth at each building in the MP_A scenario, estimated from the Flood Inundation Analysis

For Phase 3, the dollar value estimate of the losses (damages) is calculated for the MP_A and MP_C scenarios using the flood depth at each building for events occurring after the study baseline. The general method of calculating losses avoided (in dollars) is to subtract MP_C damages from MP_A damages (see Figure 5.2).

Figure 5.2



For acquisition projects, there are no MP_C damages because the building no longer exists. Therefore, losses avoided are equal to MP_A damages.

When losses are calculated, all of the losses should be presented as present-day[1] values. Therefore, if historical losses from similar events are used as estimates, they should be adjusted to present-day values.

5.1.1 Loss Categories

When the Flood Inundation Analysis is complete and the potentially affected buildings have been identified, flood damages must be evaluated. Potential damages are divided into loss categories (see Table 5.1). Loss categories generally include physical damage, loss of function, and emergency management costs, all of which contain multiple loss types. The calculation of the losses avoided for building modification projects differs from flood reduction projects in that only the loss types that apply to buildings can be used in calculating losses.

[1] Present-day value is the current value of past, present, or future payments that are adjusted to a base period by a discount or inflation rate.

Table 5.1

Loss Estimation Categories and Types

Loss Category	Loss Type
Physical Damage	Buildings*
	Contents*
	Roads and Bridges
	Infrastructure
	Landscaping
	Environmental Impacts
	Vehicles/Equipment
Loss of Function	Displacement Expense*
	Loss of Rental Income*
	Loss of Business Income*
	Lost Wages*
	Disruption Time for Residents*
	Loss of Public Services*
	Economic Impact of Utility Loss
	Economic Impact of Road/ Bridge Closure
Emergency Management	Debris Cleanup
	Governmental Expense

Source: FEMA (2007)
** Applies to building modification projects*

5.1.1.1 Physical Damage

For a building modification study, physical damage is limited to the direct damage to the building and its contents. Physical damages can be estimated using either:

- FEMA BCA Version 4 software depth-damage functions
- Historical damages from events of similar size

When available, actual repair costs (or replacement costs if the building was substantially damaged) should be used to estimate losses if similar flood events have occurred in the past. However, it must first be verified that the hydraulic conditions of the river and the physical condition of the project site were substantially the same during the two events. For example, if the building has been altered since the historical event, or if sandbagging was used during the event, repair costs related to flood damage should not be used for the LAS.

Historical damage data may be obtained from various sources such as homeowner insurance claims, flood insurance claims, the NFIP BureauNet database, Small Business Administration loan application

databases, local contractors, and homeowner interviews. The BCA that was performed for the funding application of the mitigation project may also contain historical damage data. Additionally, for events in which there was a disaster declaration, FEMA may have provided grant funds under the Public Assistance (PA) Program for repairs to buildings owned by public entities and certain private, non-profit organizations. Damage and repair information may be obtained from Damage Survey Reports (DSRs) or Project Worksheets (PWs) that FEMA prepared to document eligible costs under the PA Program. If this information is not available, the losses must be estimated. To estimate damages, standardized damage curves relating depth of flooding to building and contents damage (calculated as a percentage of the BRV) are available from FEMA and the USACE.

5.1.1.2 Loss of Function

For a building modification LAS, loss-of-function damages are the economic impacts to an individual or the community that occur because of the physical damage to the building. Loss-of-function damages can vary extensively depending on the type of building. For example, loss-of-function costs associated with damage to a residence could be costs associated with moving to and renting another residence while flooding subsides and repairs occur. Loss-of-function costs associated with damages to a business could be lost business, temporary relocation to another building, or lost wages for employees. Loss-of-function costs resulting from damages to public buildings could be the loss of critical public services, such as police and fire departments.

For a building modification LAS, loss of function includes displacement expense, loss of rental income, loss of business income, lost wages, disruption time for residents, and loss of public service.

Loss-of-function costs are based on the amount of time a building is not functional after a flood because of the amount of destruction to the building and the value of the particular function. The amount of time a building cannot be used in its normal capacity increases with the severity of damage to the building.

As with physical depth-damage relationships, published relationships between flood depth and loss-of-function time can be used to calculate these costs. For example, the FEMA BCA Version 4 software contains methodologies and values that can be used to calculate loss of function. The *HAZUS-MH Technical Manual* (FEMA, 2006) contains

methods similar to the FEMA BCA Version 4 software with regional adjustments to various loss-of-function methods.

Communities may also provide costs from past events that demonstrate the impact of the events. In these cases, local values provide a more accurate representation of a project area than the national or regional values from tools such as the FEMA BCA Version 4 software or HAZUS-MH. Additionally, USACE publications on post-disaster impacts from flooding and FEMA DSRs or PWs contain information about loss-of-function from specific locations.

5.1.1.3 Emergency Management Costs

Emergency management costs are costs related to response and recovery activities conducted by local, State, and Federal government agencies as a result of a hazard event. For example, the community experiences costs for ensuring public safety. It is important to note that emergency management costs should be considered only for a building modification LAS when a large group of adjacent buildings is acquired. The costs are obtained primarily from historical damage records, such as DSRs or PWs prepared by FEMA during declared disaster events under the PA Program. If actual costs from previous events are known, they should be used. If costs are to be estimated, the following steps can be used to calculate the impacts of emergency response measures:

- Local representatives can be interviewed to identify the types of services required and the level of effort required in delivering those services.
- The duration of the flood and the appropriate salary categories can be used to estimate the costs for first responders.
- The estimated flood recovery time and the appropriate salary categories can be used to estimate the impact to other municipal employees. The impact may include cleanup and costs associated with implementing repairs.

5.1.2 Oregon Study: Calculating Losses Avoided

The methodology described above was used to calculate MP_A and MP_C damages for the nine buildings in this study. Physical damages were limited to buildings and contents damage. Because all buildings were commercial, loss-of-function costs were limited to loss of business income.

For all of the buildings except for the Veterinary Hospital and the Tillamook Inn, the BRVs were estimated from Replacement Cost Value (RCV) data provided in the NFIP loss claim information,

inflated to 2009 values. The BRVs for the Veterinary Hospital and Tillamook Inn were obtained from appraisal data obtained from the City and inflated to 2009 values because RCV data from NFIP insurance documents were not available. For each building, the value of the contents was estimated using the BRV and an appropriate building-to-content ratio provided by the FEMA BCA Version 4 software. As described in Section 4.3.1, some losses were based on depths of flooding from hydraulic modeling results. In these cases, the damages to the buildings and contents were calculated using the appropriate depth-damage functions based on building type, provided by the FEMA BCA Version 4 software. All depth-damage functions used in this study can be found in Appendix A. For loss calculations based on actual losses from similar events, the building and contents damages claimed under the NFIP were inflated to 2009 values and used to estimate losses for the events analyzed in this study.

As explained previously, no MP_C damages exist for acquired buildings because all of the buildings were demolished. However, according to the NFIP flood claims data, the Western Royal Inn experienced some damage in the December 3, 2007, event, even though it was elevated in December 2004. These damages were included in the loss calculations for the December 3, 2007, event, which are provided in Appendix G.

Because no information was available from building owners, the net incomes for the businesses were obtained from information in the detailed property appraisals provided by the City for the Dairy Queen, Dean Property, and Northport Plaza. For the remaining buildings, the Tillamook County commercial appraiser provided estimates (K. Fleisher, commercial appraiser, Tillamook County, oral communication, September 14, 2009). Gross income is estimated by assigning a value per square foot based on the business operating from the premises. However, the net income, rather than the gross income, should be considered for calculating losses. Therefore, the operating expenses (OEX) and vacancy and credit loss (VCL) were discounted from the gross income to determine the net income (see Section 6.1). The net annual income was then divided by 365 to determine the daily income. Similar to the calculations for physical damages, the depth of flooding for each building was used in conjunction with the damage functions from the FEMA BCA Version 4 software to determine the number of days the building would have lost function for each event. Because damages for the January 8, 2009, event were based on historical loss rather than modeled depths of flooding, the damage from the event was compared to the BRV for the buildings, and a percent damage was calculated and compared to the FEMA standard building damage

functions to estimate a depth of flooding. This was then used to calculate the loss-of-function days for that event.

Emergency management costs are not expected to change and therefore are generally not included in LASs for elevation or small acquisition projects. Acquisition of a single residential building, small groups of buildings, or groups in scattered locations is unlikely to reduce a community's emergency management costs because the area affected by a disaster is not decreased and the total population affected by disaster is not substantially decreased (FEMA, 2001). Therefore, emergency management costs should be considered only when a large group of adjacent buildings is acquired. Consequently, emergency management costs were not estimated for this study.

Table 5.2 shows the losses avoided for each event.

5.2 Calculating Return on Investment

Calculating the ROI is the final task in determining losses avoided. The results vary depending on the number of events evaluated for each building and the resulting level of damage. The formula used in calculating ROI is shown in Figure 5.3.

Figure 5.3

Return on Mitigation Investment

$$\frac{\$\ LA}{\$\ PI} \times 100 = \%ROI$$

Where **LA** = Losses Avoided
Where **PI** = Project Investment
Where **ROI** = Return on Investment

The denominator, Project Investment (PI), is the total project investment for the project being evaluated. Project investment does not represent the Federal investment alone. Rather, it is the total investment for the project made by all parties involved. The investment total must be representative of the total mitigation costs. Also, all of the losses avoided are calculated in present-day values; therefore, the actual costs to acquire or elevate each building should also be adjusted to present-day values.

The numerator, Losses Avoided (LA), represents the total losses avoided for the mitigation project being evaluated. The ROI may be

Table 5.2

Loss Estimation Analysis Results for Buildings in Tillamook

Analysis Information			Results by Loss Categories						Total Losses Avoided
			MP_A Scenario Damages			MP_C Scenario Damages			
			Physical Damage		Loss of Function	Physical Damage		Loss of Function	
Event Date	Buildings Included in Analysis[1]	Buildings for which Losses Were Avoided	Damage to Building Subtotal	Damage to Contents Subtotal	Loss of Business Income Subtotal	Damage to Building Subtotal	Damage to Contents Subtotal	Loss of Business Income Subtotal	
October 1997	1	0	$0	$0	$0	$0	$0	$0	$0
December 1998	1	1	$17,372	$3,116	$1,645	$0	$0	$0	$22,133
November 1999	1	1	$12,141	$1,889	$968	$0	$0	$0	$14,998
January 2006	4	2	$62,898	$32,182	$6,381	$0	$0	$0	$101,462
November 2006	6	6	$476,925	$188,435	$129,491	$0	$0	$0	$794,852
December 2007	9	9	$721,055	$363,699	$135,417	$47,769	$0	$0	$1,172,402
January 2009	9	9	$681,261	$238,320	$94,445	$0	$0	$0	$1,014,026
		Total	$1,971,653	$827,641	$368,347	$47,769	$0	$0	$3,119,872

[1]Only buildings that were acquired/elevated prior to the event were included in the analysis

calculated for one or many flood events occurring after the study baseline. If a storm event did not occur that was large enough to have caused damage in the MPA scenario, the losses avoided are zero. If multiple events are being evaluated for each mitigation project, the LA would represent the total losses avoided for all the flood events. Therefore, the ROI would represent the cumulative ROI.

An ROI can be calculated for each individual building, for a mitigation project (which could include multiple buildings), by storm event, or for the whole study area (which could include multiple projects). If an ROI is calculated for multiple buildings, taking an average of the ROI for each building is not appropriate. The total losses avoided for all of the buildings should be added and divided by the total construction costs. This is referred to as aggregation.

5.2.1 Oregon Study: Calculating Return on Investment

The actual cost of construction for each building was available from the State project files. Each value had to be adjusted to present-day values because all of the losses were calculated in 2009 values. The project investment was then compared to the losses avoided to calculate the ROI.

The ROI is influenced by data quality, storm severity, and the relative cost of the mitigation project. In general, buildings affected by a greater number of events yielded higher ROIs. The ROI was calculated in 4 ways:

- An ROI was calculated for each individual building for each event analyzed (see Appendices B through H).
- An ROI was calculated for each building, including all of the events that would have impacted that building after the mitigation was complete. For the individual buildings in the study, the ROI ranged from 25% to 240%. These values are shown in Table 5.3.
- A total ROI was calculated for each event analyzed. This calculation was based on the cumulative avoided losses for all buildings within the study for which the mitigation was complete and the total cost to elevate or acquire them. These values are shown in Table 5.3.
- A total ROI was calculated for the study as a whole. This calculation was based on the cumulative avoided losses for all buildings and all storm events and the total cost to elevate or acquire all buildings. This value is shown in Table 5.4.

Table 5.4 shows that the aggregate ROI for all projects in the Oregon study was 66%. This calculation is based on combined losses avoided

Table 5.3

Summary of Losses Avoided and ROI Calculations for All Events

Property Name	Address	Acquisition/ Elevation Completion Date	2009 Value of Total Acquisition/ Elevation Cost (including Demo Cost)	Oct 1997 Losses Avoided	Dec 1998 Losses Avoided	Nov 1999 Losses Avoided	Jan 2006 Losses Avoided	Nov 2006 Losses Avoided	Dec 2007 Losses Avoided	Jan 2009 Losses Avoided	Total Losses Avoided	ROI (%)
Veterinary Hospital	*1095 Hwy 101 N*	October 1997	$20,964	$0	$22,133	$14,998	$0	$24,172	$19,075	$14,998	$93,375	61%
Tillamook Inn	*1810 Hwy 101 N*	Augugust 2000	$696,297	$0	$0	$0	$32,675	$56,226	$50,796	$35,781	$175,478	25%
Coast Tire	*635 Hwy 101 N*	September 2003	$328,090	$0	$0	$0	$68,787	$176,597	$163,844	$26,138	$435,365	133%
Western Royal Inn	*1125 Hwy 101 N*	December 2004	$271,424	$0	$0	$0	$0	$222,985	$131,926	$297,192	$652,104	240%
Dairy Queen	*440 Hwy 101 N*	November 2006	$645,361	$0	$0	$0	$0	$213,143	$196,229	$77,290	$486,662	75%
Dean Property	*542 Hwy 101 N*	July 2006	$871,550	$0	$0	$0	$0	$101,729	$95,232	$149,278	$346,238	40%
Rental Center Bldg. #1 Tool & Repair Equipment	*800 Hwy 101 N*	October 2007	$133,464	$0	$0	$0	$0	$0	$87,299	$79,368	$166,667	125%
Rental Center Bldg. #2	*840 Hwy 101 N*	October 2007	$130,419	$0	$0	$0	$0	$0	$127,788	$9,180	$136,969	105%
Northport Plaza	*1000 Hwy 101 N*	October 2007	$1,596,572	$0	$0	$0	$0	$0	$300,213	$324,801	$625,014	39%
											Total	
			Total Acquisition Costs	$20,964	$20,964	$20,964	$1,316,775	$2,833,685	$4,694,140	$4,694,140	$4,694,140	
			Total Losses Avoided	$0	$22,133	$14,998	$101,462	$794,852	$1,172,402	$1,014,026	$3,119,872	
			ROI	0%	106%	72%	8%	28%	25%	22%	66%	

Not included in the calculations because the acquisition/elevation was not completed before the event

Table 5.4

Return on Mitigation Investment for Buildings in Tillamook County

Analysis Information			Results by Loss Category/Losses Avoided					
			Physical Damage		Loss of Function			
Event Date	Buildings Included in Analysis[1]	Buildings for which Losses Were Avoided	Damage to Building Subtotal	Damage to Contents Subtotal	Loss of Business Income Subtotal	Total Loses Avoided	Project Investment[2] Adjusted for 2009 Dollars	Current ROI
October 1997	1	0	$0	$0	$0	$0	$20,964	0%
December 1998	1	1	$17,372	$3,116	$1,645	$22,133	$20,964	106%
November 1999	1	1	$12,141	$1,889	$968	$14,998	$20,964	72%
January 2006	4	2	$62,898	$32,182	$6,381	$101,462	$1,316,775	8%
November 2006	6	6	$476,925	$188,435	$129,491	$794,852	$2,833,685	28%
December 2007	9	9	$673,286	$363,699	$135,417	$1,172,402	$4,694,140	25%
January 2009	9	9	$681,261	$238,320	$94,445	$1,014,026	$4,694,140	22%
		Total	$1,923,883	$827,641	$368,347	$3,119,872	$4,694,140	66%

[1]Only buildings that were acquired/elevated prior to the event were included in the analysis

[2]Project investment costs for each event include only the project costs for the buildings that were included in the analysis for that event

of $3,119,872 and a combined project investment of $4,694,140. The ROI reflects all the losses avoided for events occurring after each building's elevation or demolition completion date, and it will increase as additional storm events occur.

Section Six:

Considerations and Recommended Practices

The Oregon study yielded findings of potential value to future loss avoidance studies. This section is a summary of the special considerations and recommended practices that have resulted from this study.

6.1 Data Collection and Availability

The Oregon study included physical damage to commercial buildings and an associated loss in net business income. Businesses are often unwilling to share financial information. Data from the Tillamook County commercial appraiser were therefore used to estimate the value of the loss in net income (see Section 5.1.2).

One of three methods is used to determine property taxes:

- Market: The market data (sales comparison) approach
- Cost: The reproduction or replacement cost new, less accrued depreciation approach
- Income: The income or capitalization of economic rents approach.

When actual income and expense data are available for an area, income is considered the most reliable method of appraising the value of property.

Business income, vacancy levels, and operating expenses used in the income approach are determined for different areas by reconciling various data including completed surveys, interviews with tenants, owners and brokers, and market research.

For the commercial buildings that were inundated, the net income was estimated by taking the income per square foot, multiplying this by the building area to calculate the gross income, and then discounting this by multiplying by a percentage for operating expenses (OEX) and a percentage for vacancy and credit loss (VCL), as shown below.

$$Net\ Income = \frac{Income\ Value\ (\$)}{square\ feet}(Total\ square\ feet)(100 - VCL)(100 - OEX)$$

Where:

VCL = vacancy and credit loss (%)
OEX = operating expenses (%)

6.2 Analysis Methodology

The Oregon study provided an unusual situation in which two existing hydraulic models of the flooding source were available for the analysis and that provided different results. The steady-state flow HEC-RAS model that FEMA used to prepare the City of Tillamook FIS was compared to the unsteady-state flow HEC-RAS model prepared by NHC for Project Exodus. Because the two models provided widely varying results (see Figure 4.5), NFIP flood claims data were reviewed to verify results. Based on that review, it became apparent that for flows in the vicinity of 25,000 cfs, neither model accurately reflected the flood depths for the actual events. However, generally speaking, for events below that threshold, the FIS model results appeared to be more accurate, and for events above that threshold, the NHC model results appeared to be more accurate. Therefore, in the study, data from the FIS model were used for events below approximately 25,000 cfs. NFIP flood claims data were used for events at approximately 25,000 cfs, and NHC model data were used for events exceeding 25,000 cfs (see Section 4.3.1).

It is important to note that the modeled results were used whenever possible because of the uncertainty in the NFIP flood claims data. For example, the building owner could have used sandbags in the event, which would have reduced the potential for a flood insurance claim even though a model of the event would otherwise indicate that the building would be flooded. Therefore, for consistency, without a detailed narrative of the historical event, model data were used when appropriate.

Appendix A:

Loss Avoidance Study: Oregon, Property Acquisition and Structure Elevation Depth-Damage Calculation Table

List of Tables

Table A.1 FEMA BCA Version 4 Depth-Damage Functions.....A-3

Table A.1

FEMA BCA Version 4 Depth-Damage Functions

	Data Type	Building Type	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Buildings	Percent Damaged (% BRV)	Medical Office	0.0	0.0	0.0	0.6	11.7	18.9	24.4	32.7	37.2	46.3	50.7	55.8	58.9	61.2	61.2	61.2	61.2	61.2	61.2	61.2
	Percent Damaged (% BRV)	Hotel	0.0	0.0	0.0	0.1	10.2	15.3	19.2	23.6	27.8	29.8	32.5	35.6	37.7	39.8	39.8	39.8	39.8	39.8	39.8	39.8
	Percent Damaged (% BRV)	Retail Furniture	0.0	0.0	0.0	0.0	10.3	15.7	20.3	26.0	30.4	33.1	36.2	40.7	43.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2
	Percent Damaged (% BRV)	Fast Food	0.0	0.0	0.0	0.0	14.4	25.6	32.8	41.6	47.1	52.0	56.9	60.5	63.4	65.1	65.1	65.1	65.1	65.1	65.1	65.1
	Percent Damaged (% BRV)	Light Industrial	0.0	0.0	0.0	0.0	10.4	16.8	20.9	25.9	30.1	33.8	37.0	41.5	44.6	46.7	46.7	46.7	46.7	46.7	46.7	46.7
	Percent Damaged (% BRV)	Warehouse, Non-Refrigerated	0.0	0.0	0.0	0.0	10.2	16.7	20.4	25.5	29.7	32.8	35.5	39.6	42.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5
Contents	Percent Damaged (% Content Value)[1]	Medical Office	0.0	0.0	0.0	0.0	14.0	27.0	40.0	57.0	67.0	75.0	82.0	91.0	96.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
	Percent Damaged (% Content Value)[1]	Hotel	0.0	0.0	0.0	0.0	16.0	26.0	34.0	40.0	49.0	52.0	58.0	61.0	63.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
	Percent Damaged (% Content Value)[1]	Retail Furniture	0.0	0.0	0.0	0.0	47.0	62.0	68.0	79.0	86.0	91.0	97.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
	Percent Damaged (% Content Value)[1]	Fast Food	0.0	0.0	0.0	0.0	21.0	39.0	53.0	63.0	73.0	79.0	88.0	95.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
	Percent Damaged (% Content Value)[1]	Light Industrial	0.0	0.0	0.0	0.0	19.0	31.0	42.0	52.0	61.0	72.0	82.0	91.0	94.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
	Percent Damaged (% Content Value)[1]	Warehouse, Non-Refrigerated	0.0	0.0	0.0	0.0	21.0	34.0	47.0	57.0	66.0	74.0	81.0	88.0	92.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0
Loss of Function	Loss of Function Time (days)	Commercial	0.0	0.0	0.0	0.0	45.0	90.0	135.0	180.0	225.0	270.0	315.0	360.0	405.0	450.0	450.0	450.0	450.0	450.0	450.0	450.0

Note:
Only the first floor area is considered for estimating building and content damage

[1]FEMA standard value for contents is a percentage of the Building Replacement Value.
1. For Medical Office, the content-to-BRV ratio is 13%.
2. For Hotel, the content-to-BRV ratio is 15%.
3. For Retail Furniture, the content-to-BRV ratio is 14%.

Appendix B:

Summary of Losses Avoided and ROI Calculations for October 1997 Event

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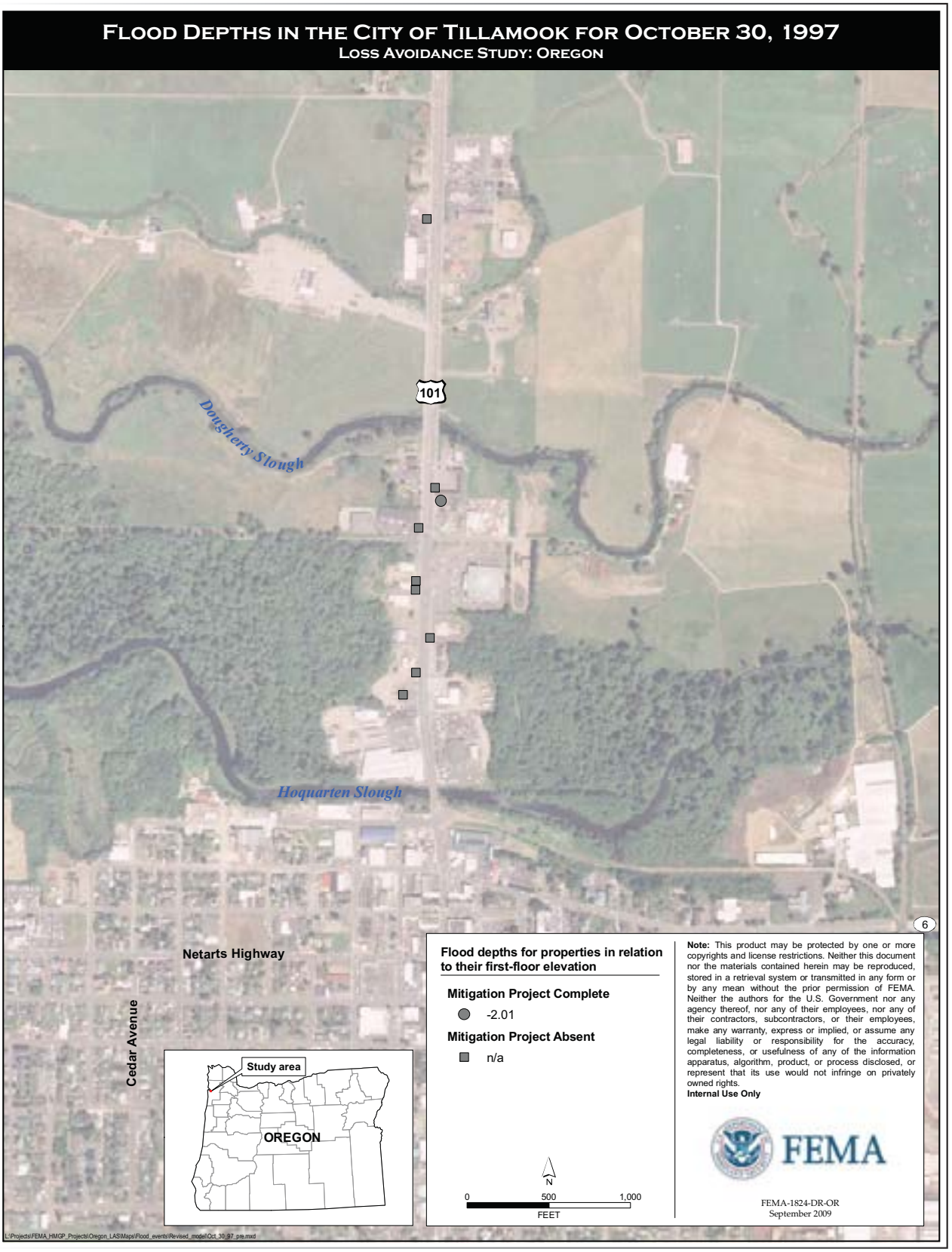
Figure B.1 Flood Depths in the City of Tillamook for October 30, 1997 .....B-3

List of Tables

Table B.1 Summary of Losses Avoided and ROI Calculations for October 30, 1997, Event.....B-4

Figure B.1


Flood Depths in the City of Tillamook for October 30, 1997
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
-2.01
Mitigation Project Absent
n/a
N
0
500
1,000
FEET
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FEMA
FEMA-1824-DR-OR
September 2009
L:\Projects\FEMA_HMGP_Projects\Oregon_LAS\Maps\Flood_events\Revised_model\Oct_30_97_pre.mxd

Table B.1

Summary of Losses Avoided and ROI Calculations for October 30, 1997 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	9.99	-2.01	$ -	$ -	$ -	$ -	$ 20,964	0%
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	9.99	1.02	$ -	$ -	$ -	$ -	$ 696,297	0%
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	9.99	1.42	$ -	$ -	$ -	$ -	$ 328,090	0%
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	9.99	-2.01	$ -	$ -	$ -	$ -	$ 271,424	0%
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	9.99	0.49	$ -	$ -	$ -	$ -	$ 645,361	0%
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	9.99	1.50	$ -	$ -	$ -	$ -	$ 871,550	0%
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	9.99	1.50	$ -	$ -	$ -	$ -	$ 133,464	0%
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	9.99	1.50	$ -	$ -	$ -	$ -	$ 130,419	0%
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	9.99	-2.01	$ -	$ -	$ -	$ -	$ 1,596,572	0%
									TOTAL	**$ -**	**$ -**	**$ -**	**$ -**	**$ 20,964**	**0%**

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Not included in the calculations - the mitigation project was not completed before the event.

Appendix C:

Summary of Losses Avoided and ROI Calculations for December 1998 Event

List of Figures

Figure C.1 Flood Depths in the City of Tillamook for December 27, 1998 .....C-4

List of Tables

Table C.1 Summary of Losses Avoided and ROI Calculations for December 27, 1998, Event C-5

Figure C.1

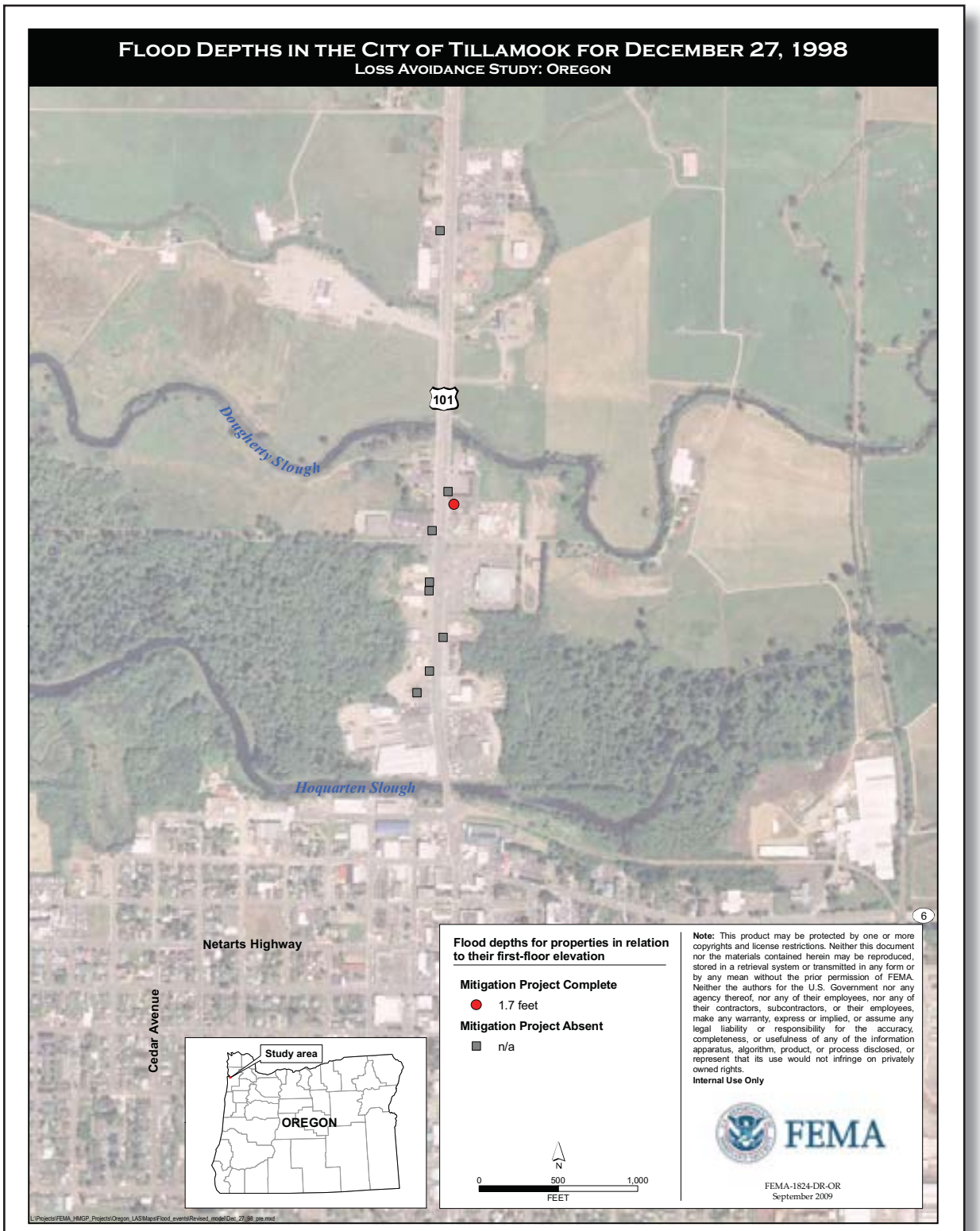
Flood Depths in the City of Tillamook for December 27, 1998
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
1.7 feet
Mitigation Project Absent
n/a
N
0
500
1,000
FEET
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Table C.1

Summary of Losses Avoided and ROI Calculations for December 27, 1998 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	13.7	1.7	$ 17,372	$ 3,116	$ 1,645	$ 22,133	$ 20,964	**105.6%**
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	13.7	4.73	$ -	$ -	$ -	$ -	$ 696,297	**0%**
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	13.7	5.13	$ -	$ -	$ -	$ -	$ 328,090	**0%**
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	13.7	1.70	$ -	$ -	$ -	$ -	$ 271,424	**0%**
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	13.7	4.20	$ -	$ -	$ -	$ -	$ 645,361	**0%**
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	13.7	5.21	$ -	$ -	$ -	$ -	$ 871,550	**0%**
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	13.7	5.21	$ -	$ -	$ -	$ -	$ 133,464	**0%**
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	13.7	5.21	$ -	$ -	$ -	$ -	$ 130,419	**0%**
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	13.7	1.70	$ -	$ -	$ -	$ -	$ 1,596,572	**0%**
									TOTAL	**$ 17,372**	**$ 3,116**	**$ 1,645**	**$ 22,133**	**$ 20,964**	**106%**

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Not included in the calculations - the mitigation project was not completed before the event.

Appendix D:

Summary of Losses Avoided and ROI Calculations for November 1999 Event

List of Figures

Figure D.1 Flood Depths in the City of Tillamook for November 25, 1999..... D-3

List of Tables

Table D.1 Summary of Losses Avoided and ROI Calculations for November 25, 1999, Event D-4

Figure D.1

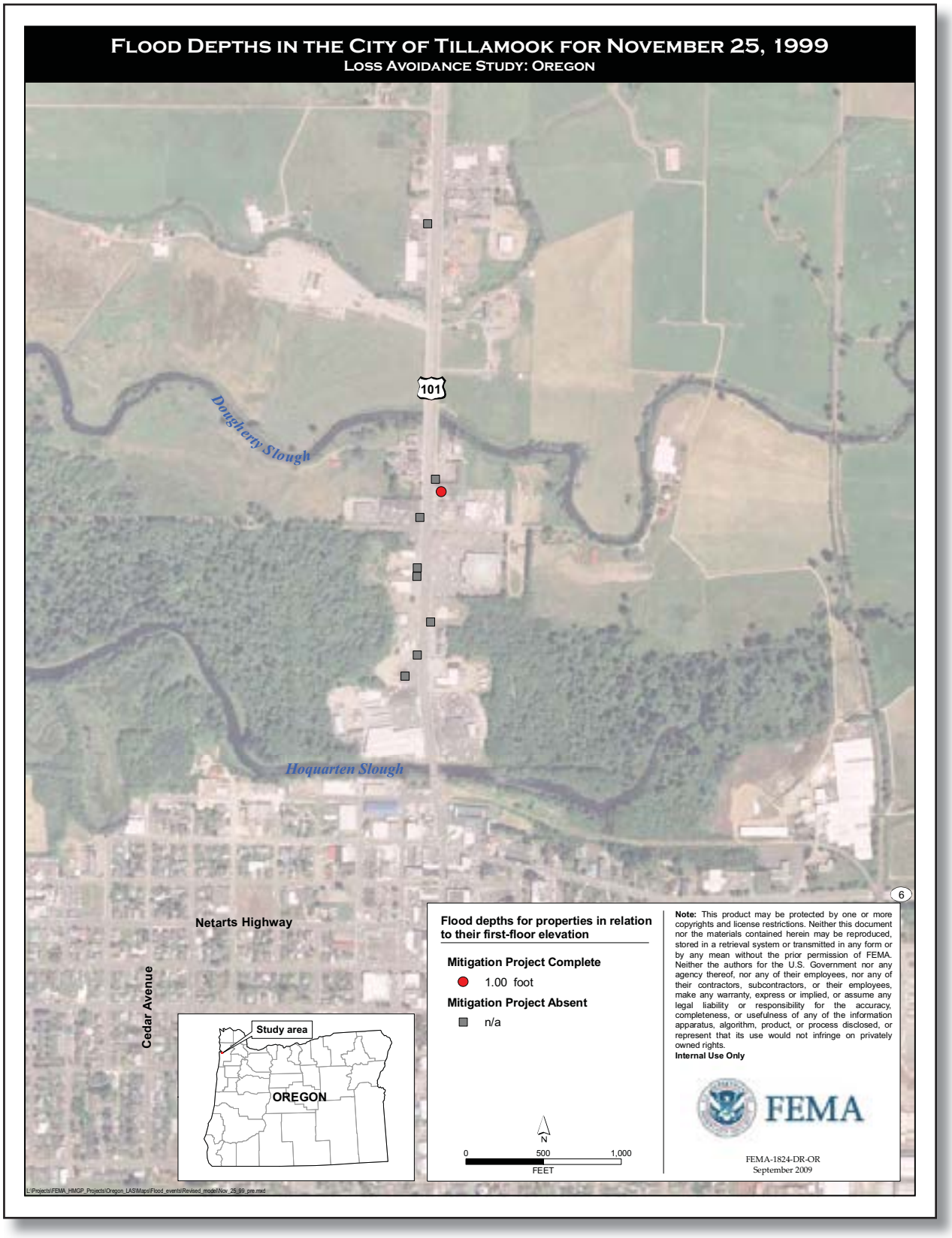
Flood Depths in the City of Tillamook for November 25, 1999
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
1.00 foot
Mitigation Project Absent
n/a
N
0
500
1,000
FEET
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Table D.1

Summary of Losses Avoided and ROI Calculations for November 25, 1999 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	13.0	1	$ 12,141	$ 1,889	$ 968	$ 14,998	$ 20,964	71.5%
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	13.0	4.03	$ -	$ -	$ -	$ -	$ 696,297	0%
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	13.0	4.43	$ -	$ -	$ -	$ -	$ 328,090	0%
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	13.0	1.00	$ -	$ -	$ -	$ -	$ 271,424	0%
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	13.0	3.50	$ -	$ -	$ -	$ -	$ 645,361	0%
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	13.0	4.51	$ -	$ -	$ -	$ -	$ 871,550	0%
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	13.0	4.51	$ -	$ -	$ -	$ -	$ 133,464	0%
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	13.0	4.51	$ -	$ -	$ -	$ -	$ 130,419	0%
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	13.0	1.00	$ -	$ -	$ -	$ -	$ 1,596,572	0%
									TOTAL	$ 12,141	$ 1,889	$ 968	$ 14,998	$ 20,964	72%

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Not included in the calculations - the mitigation project was not completed before the event.

Value based on historical NFIP claim data from similar event.

Appendix E:

Summary of Losses Avoided and ROI Calculations for January 2006 Event

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Figure E.1 Flood Depths in the City of Tillamook for January 10, 2006 ..... E-3

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Table E.1 Summary of Losses Avoided and ROI Calculations for January 10, 2006, Event..... E-4

Figure E.1

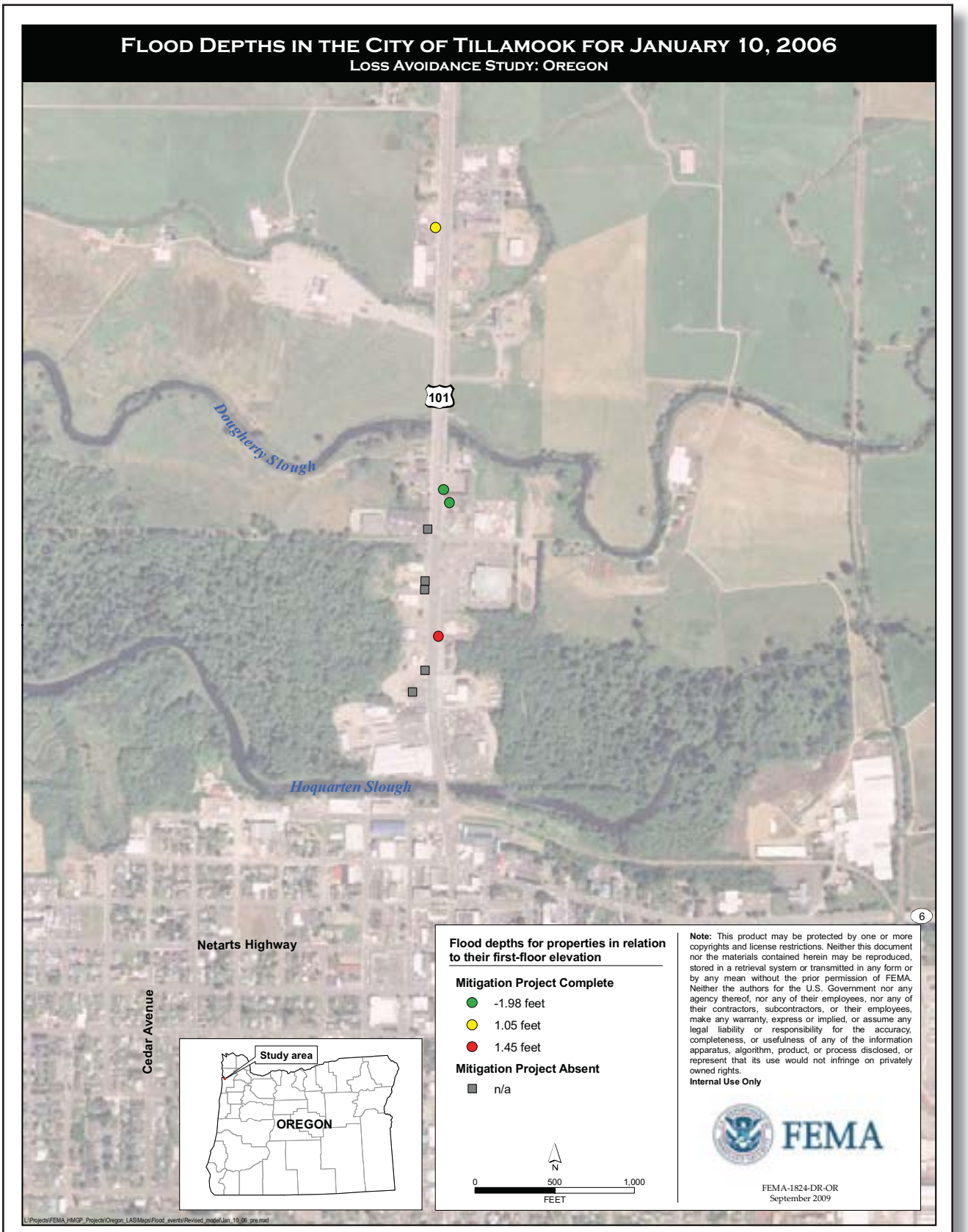
Flood Depths in the City of Tillamook for January 10, 2006
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
-1.98 feet
1.05 feet
1.45 feet
Mitigation Project Absent
n/a
N
0
500
1,000
FEET
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Table E.1

Summary of Losses Avoided and ROI Calculations for January 10, 2006 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	10.02	-1.98	$ -	$ -	$ -	$ -	$ 20,964	0%
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	10.02	1.05	$ 25,419	$ 6,015	$ 1,241	$ 32,675	$ 696,297	4.7%
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	10.02	1.45	$ 37,479	$ 26,168	$ 5,140	$ 68,787	$ 328,090	21.0%
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	10.02	-1.98	$ -	$ -	$ -	$ -	$ 271,424	0%
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	10.02	0.52	$ -	$ -	$ -	$ -	$ 645,361	0%
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	10.02	1.53	$ -	$ -	$ -	$ -	$ 871,550	0%
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	10.02	1.53	$ -	$ -	$ -	$ -	$ 133,464	0%
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	10.02	1.53	$ -	$ -	$ -	$ -	$ 130,419	0%
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	10.02	-1.98	$ -	$ -	$ -	$ -	$ 1,596,572	0%
									TOTAL	$ 62,898	$ 32,182	$ 6,381	$ 101,462	$ 1,316,775	8%

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Not included in the calculations - the mitigation project was not completed before the event.

Appendix F:

Summary of Losses Avoided and ROI Calculations for November 2006 Event

List of Figures

Figure F.1 Flood Depths in the City of Tillamook for November 6, 2006 ..... F-3

List of Tables

Table F.1 Summary of Losses Avoided and ROI Calculations for November 6, 2006, Event..... F-4

Figure F.1

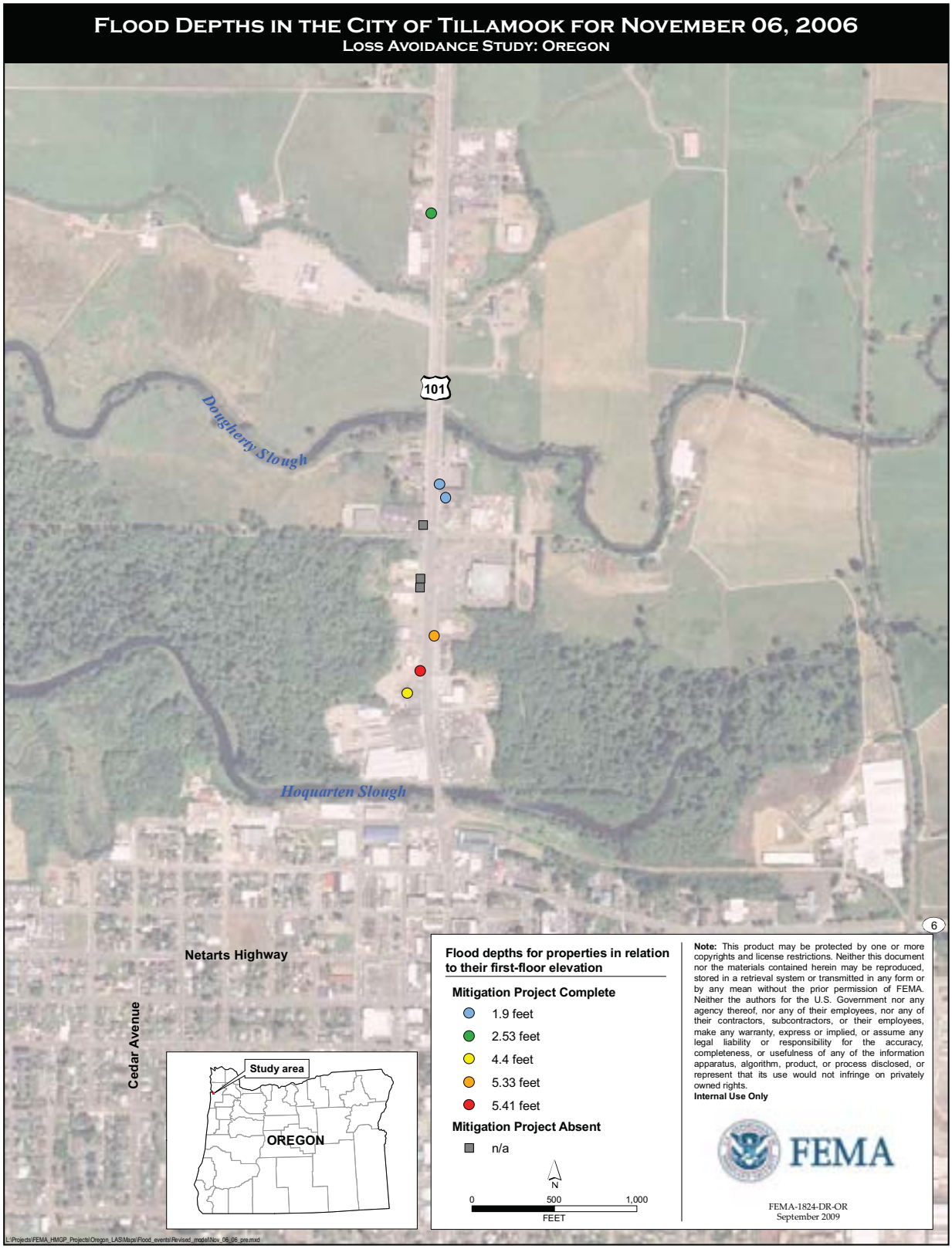
Flood Depths in the City of Tillamook for November 06, 2006
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
Study area
OREGON
6
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
1.9 feet
2.53 feet
4.4 feet
5.33 feet
5.41 feet
Mitigation Project Absent
n/a
N
0
500
1,000
FEET
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Table F.1

Summary of Losses Avoided and ROI Calculations for November 6, 2006 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	13.9	1.90	$ 18,866	$ 3,467	$ 1,839	$ 24,172	$ 20,964	**115.3%**
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	11.5	2.53	$ 42,212	$ 11,023	$ 2,991	$ 56,226	$ 696,297	**8.1%**
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	13.9	5.33	$ 88,392	$ 69,312	$ 18,893	$ 176,597	$ 328,090	**53.8%**
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	13.9	1.90	$ 144,162	$ 36,552	$ 42,271	$ 222,985	$ 271,424	**82.2%**
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	13.9	4.40	$ 139,794	$ 32,076	$ 41,273	$ 213,143	$ 645,361	**33.0%**
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	13.9	5.41	$ 43,500	$ 36,005	$ 22,224	$ 101,729	$ 871,550	**11.7%**
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	13.9	5.41	$ -	$ -	$ -	$ -	$ 133,464	**0%**
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	13.9	5.41	$ -	$ -	$ -	$ -	$ 130,419	**0%**
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	13.9	1.90	$ -	$ -	$ -	$ -	$ 1,596,572	**0%**
									TOTAL	**$ 476,925**	**$ 188,435**	**$ 129,491**	**$ 794,852**	**$ 2,833,685**	**28%**

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Not included in the calculations - the mitigation project was not completed before the event.

Appendix G:

Summary of Losses Avoided and ROI Calculations for December 2007 Event

List of Figures

Figure G.1 Flood Depths in the City of Tillamook for December 3, 2007 .....G-3

List of Tables

Table G.1 Summary of Losses Avoided and ROI Calculations for December 3, 2007 Event.....G-4

Figure G.1

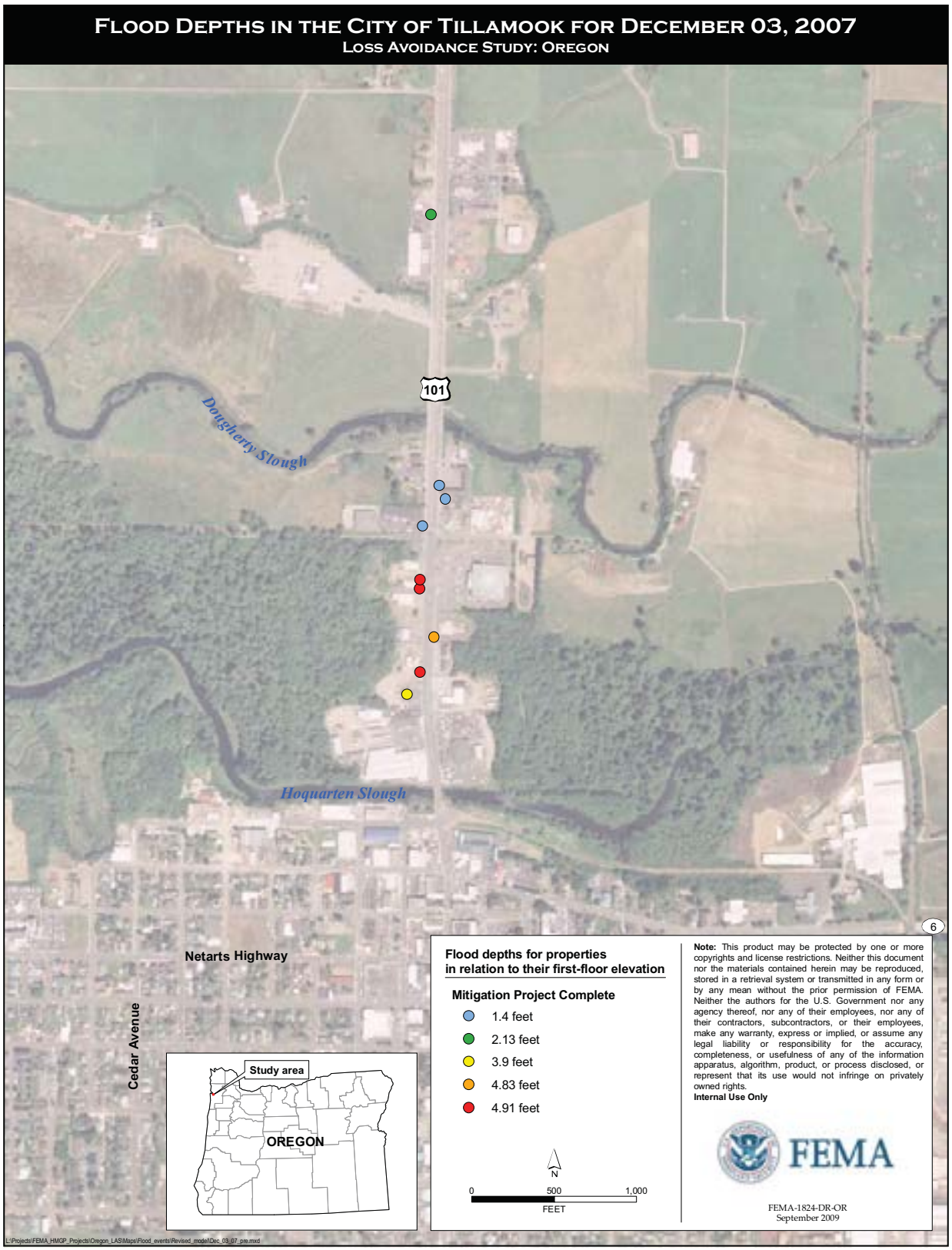
Flood Depths in the City of Tillamook for December 03, 2007
Loss Avoidance Study: Oregon
101
Dougherty Slough
Hoquarten Slough
Netarts Highway
Cedar Avenue
6
Study area
OREGON
Flood depths for properties in relation to their first-floor elevation
Mitigation Project Complete
1.4 feet
2.13 feet
3.9 feet
4.83 feet
4.91 feet
N
0
500
1,000
FEET
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Table G.1

Summary of Losses Avoided and ROI Calculations for December 3, 2007 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	MP_A Damages ($)	MPC Damages ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	13.4	1.40	$ 15,130	$ 2,590	$ 1,355	$ 19,075		$ 19,075	$ 20,964	**91.0%**
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	11.1	2.13	$ 38,421	$ 9,857	$ 2,518	$ 50,796		$ 50,796	$ 696,297	**7.3%**
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	13.4	4.83	$ 82,945	$ 63,778	$ 17,121	$ 163,844		$ 163,844	$ 328,090	**49.9%**
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	13.4	1.40	$ 119,306	$ 29,242	$ 31,147	$ 179,695	$ 47,769	$ 131,926	$ 271,424	**48.6%**
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	13.4	3.90	$ 129,963	$ 29,682	$ 36,583	$ 196,229		$ 196,229	$ 645,361	**30.4%**
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	13.4	4.91	$ 41,183	$ 33,879	$ 20,170	$ 95,232		$ 95,232	$ 871,550	**10.9%**
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	13.4	4.91	$ 44,834	$ 34,504	$ 7,960	$ 87,299		$ 87,299	$ 133,464	**65.4%**
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	13.4	4.91	$ 67,347	$ 51,829	$ 8,612	$ 127,788		$ 127,788	$ 130,419	**98.0%**
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	13.4	1.40	$ 181,925	$ 108,338	$ 9,950	$ 300,213		$ 300,213	$ 1,596,572	**18.8%**
									TOTAL	**$ 721,055**	**$ 363,699**	**$ 135,417**	**$ 1,220,171**	**$ 47,769**	**$ 1,172,402**	**$ 4,694,140**	25%

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Value based on NFIP claim data.

Appendix H:

Summary of Losses Avoided and ROI Calculations for January 2009 Event

List of Tables

Table H.1 Summary of Losses Avoided and ROI Calculations for January 8, 2009, Event.....H-3

No map exists because National Flood Insurance Program claims data from similar historical events were used to estimate losses rather than modeled depths of flooding and depth-damage functions.

Table H.1

Summary of Losses Avoided and ROI Calculations for January 8, 2009 Event

Number	Property Name	Address	Damage Curve	First Floor Elevation (Pre-project)	First Floor Elevation (Post-project)	Mitigation Completion Date	2009 BRV (Based on RCV[1])	WSE (Feet)	Final Flood Depth	Building Damage ($)	Contents Damage ($)	Loss of Function ($)	Total Losses Avoided ($)	Total Project Investment[2]	ROI
9	Veterinary Hospital	1095 Hwy. 101 N.	Medical Office	12.00	15.00	Oct 1997	$103,773	13.0	1	$ 12,141	$ 1,889	$ 968	$ 14,998	$ 20,964	**71.5%**
1	Tillamook Inn	1810 Hwy. 101 N.	Hotel	8.97	8.97	Aug 2000	$486,028	12.55	3.58	$ 28,748	$ 2,800	$ 4,233	$ 35,781	$ 696,297	**5.1%**
2	Coast Tire	635 Hwy. 101 N.	Light Industrial	8.57	8.57	Sep 2003	$282,222	12.55	3.98	$ 7,272	$ 4,758	$ 14,108	$ 26,138	$ 328,090	**8.0%**
6	Western Royal Inn	1125 Hwy. 101 N.	Hotel	12.00	14.50	Dec 2004	$1,949,450	12.55	0.55	$ 204,322	$ 80,634	$ 12,236	$ 297,192	$ 271,424	**109.5%**
8	Dairy Queen	440 Hwy. 101 N.	Fast Food	9.50	9.50	2006	$319,164	12.55	3.05	$ 32,594	$ 16,086	$ 28,610	$ 77,290	$ 645,361	**12.0%**
3	Dean Property	542 Hwy. 101 N.	Warehouse, Non-Refrigerated	8.49	8.49	Jul 2006	$140,459	12.55	4.06	$ 81,339	$ 51,261	$ 16,678	$ 149,278	$ 871,550	**17.1%**
4	Rental Center Bldg. #1 Tool & Equipment Repair	800 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$150,856	12.55	4.06	$ 9,085	$ 63,701	$ 6,582	$ 79,368	$ 133,464	**59.5%**
5	Rental Center Bldg. #2	840 Hwy. 101 N.	Light Industrial	8.49	8.49	Oct 2007	$226,604	12.55	4.06	$ -	$ 2,059	$ 7,121	$ 9,180	$ 130,419	**7.0%**
7	Northport Plaza	1000 Hwy. 101 N.	Retail Furniture	12.00	14.60	Oct 2007	$1,460,074	12.55	0.55	$ 305,760	$ 15,132	$ 3,909	$ 324,801	$ 1,596,572	**20.3%**
									TOTAL	**$ 681,261**	**$ 238,320**	**$ 94,445**	**$ 1,014,026**	**$ 4,694,140**	**22%**

[1] Replacement Cost Value (RCV) obtained from NFIP claim data. BRVs for the Tillamook Inn and the Veterinary Hospital obtained from appraiser data, since no RCV data was available. All values are inflated to present-day (2009) dollars.

[2] Project investment costs for each event only include the project costs for the buildings that were included in the analysis for that event.

Value based on historical NFIP claim data from similar event. Loss of function damages based on estimated depth of flooding that would have caused similar damage.

Acronyms:

BCA
Benefit-Cost Analysis

BFE
Base (100-year) Flood Elevation

BRV
building replacement value

cfs
cubic foot (feet) per second

CHC
Chehalis River Council

DSR
Damage Survey Report

FEMA
Federal Emergency Management Agency

FFE
first floor elevation

FIRM
Flood Insurance Rate Map

FIS
Flood Insurance Study

GIS
Geographic Information System

HAZUS-MH
Hazards U.S. – Multihazard

HEC
Hydrologic Engineering Center

HEC-RAS
Hydrologic Engineering Center River Analysis System

HMGP
Hazard Mitigation Grant Program

HWM
high water mark

LA
Losses Avoided

LAS
loss avoidance study

MP_A
Mitigation Project Absent

MP_C
Mitigation Project Complete

NFIP
National Flood Insurance Program

NGVD29
National Geodetic Vertical Datum of 1929

NHC
Northwest Hydraulic Consultants

NOAA
National Oceanic and Atmospheric Administation

NWS
National Weather Service

OEX
Operating Expenses

PA Program
Public Assistance Program

PI
Project Investment

PW
Project Worksheet

RCV
Replacement Cost Value

ROI
Return on Investment

USACE
U.S. Army Corps of Engineers

USGS
U.S. Geological Survey

VCL
Vacancy and Credit Loss

WSE
water surface elevation

References and Resources:

R.1 Printed/Published Documents

CRC (Chehalis River Council). n.d. "Other Flooding Solutions." Available at http://www.crcwater.org/issues6/19990210otherflood.html. Accessed on September 14, 2009.

FEMA (Federal Emergency Management Agency). 2001. *What Is a Benefit? Guidance on Benefit-Cost Analysis of Hazard Mitigation Projects.* Draft. Revision 2.

——. 2002. *City of Tillamook, Oregon Flood Insurance Study.*

——. 2006. *HAZUS-MH MR3 Technical Manual.*

——. 2008. Benefit-Cost Analysis software, Version 4.

——. 2009. "Oregon Disaster History." Available at http://www.fema.gov/news/disasters_state.fema?id=41. Accessed on September 10, 2009.

——. In press (a). *Loss Avoidance: Nontraditional Benefits Methodology Report.*

——. In press (b). *Loss Avoidance: Riverine Flood Methodology Report.*

——. In press (c). *Loss Avoidance Study: Wisconsin Property Acquisition and Structure Demolition.*

NHC (Northwest Hydraulic Consultants). 2009. *Report on First Flood Control Project, Project Exodus.*

USGS (U.S. Geological Survey). 2009. Surface-Water Data for Oregon. Available at http://waterdata.usgs.gov/or/nwis/sw/. Accessed on September 1, 2009.

R.2 Personal Communication

Fleisher, Kari. Commercial appraiser, Tillamook County. Personal interview. September 14, 2009.

R.3 General Resources

FEMA Flood Insurance Studies. Available at http://msc.fema.gov.

Google Maps. Available at http://maps.google.com.

NOAA (National Oceanic and Atmospheric Administration). 2009. Advanced Hydrologic Prediction Service - Wilson River. Available at http://ahps2.wrh.noaa.gov/ahps2/hydrograph.php?wfo=pqr&gage=tlmo3.

Tillamook County General Flood Information. 2009. Available at http://www.co.tillamook.or.us.