APPENDIX F
Economic Considerations

US Army Corps of Engineers
Corte Madera Creek Flood Risk Management Project
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F-01 Areas of Consideration:

The study area comprises a stretch of Corte Madera Creek in Marin County, California. The floodplain extends from the town of Ross south past the Town of Kentfield to the Greenbrae community, on the banks of the San Francisco Bay. The study area is entirely contained within Marin County, California. The floodplain is active, and has experienced flooding fourteen times within the last 73 years. Figure 1, below, presents the study area and the 0.2% AEP floodplain.

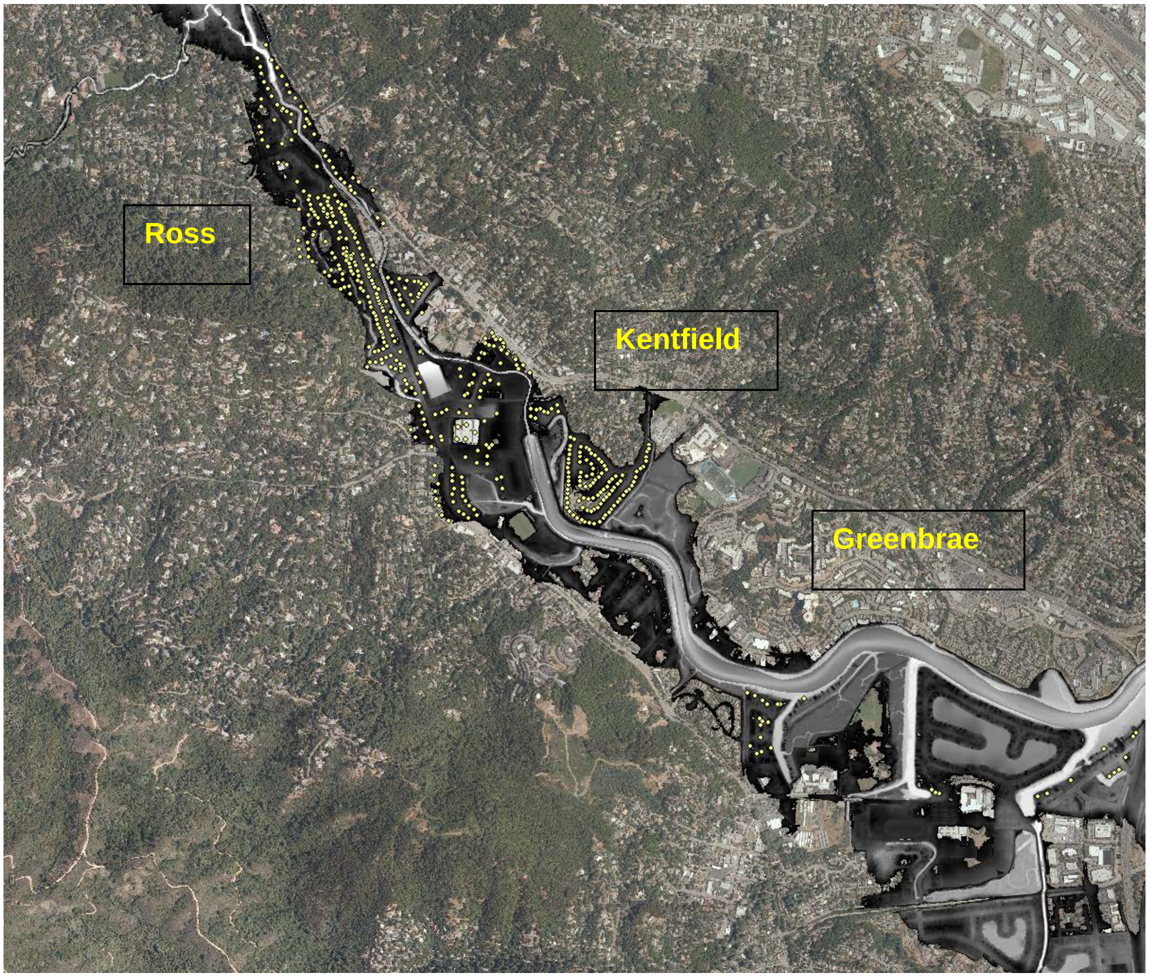


Figure 1 – Study area and 0.2% AEP floodplain (future, without-project condition)

This Corte Madera FRM project is situated in a narrow valley within small communities. There is a high risk of economic flood damage to urban infrastructure in the community of Kentfield and the Town of Ross. There is also risk to human life and safety in these communities and commercial areas. The Corte Madera project is being formulated to reduce the risk of flooding to commercial, residential and public infrastructure along the creek, consistent with protecting the nation's environment, pursuant to national environmental statutes, with applicable executive orders and with other federal planning requirements.

F-02 General Computational Procedures:

The principal guidance referenced for this analysis comes from the U. S. Army Corps of Engineers (USACE) "*Planning Guidance Notebook*", ER 1105-2-100, with specific guidance from Appendix D – Economic and Social Considerations. Additional guidance on risk-based analysis has been obtained from USACE ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, dated July 17, 2017. Benefits and costs are expressed in average annual terms at FY 2017 (Oct 2016) price levels using the mandated federal discount rate of 2.875%. The period of analysis is 50 years. The study/project Base Year, defined as the year when the project is expected to be operational and benefits begin to be realized, is 2025. Within the floodplain there is little or no vacant, developable land, and for this reason the analysis assumes that the future without-project floodplain inventory of structures and land use is equivalent to the current without-project condition.

The assumptions and procedures used to analyze and quantify the economic variables are presented in this section. The hydro-economic model used to develop expected annual damages is based on discharge-frequency, stage-frequency, and depth-percent damage curves used to develop a damage-frequency curve. Depth-percent damage curves express dollar damages resulting from varying depths of water based on a percentage of the value of structure and contents.

By policy, USACE Flood Risk Management feasibility reports must evaluate the flooding problem (and potential measures to reduce the risk of flooding) against four "accounts." These are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). While all four accounts will ultimately be considered in the evaluation of potential federal investments, this flood damage analysis focuses on the NED account. The USACE Planning Guidance Notebook (PGN) describes the NED account as such:

> *Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.*

The NED account is exclusively concerned with national net economic benefits, and thus does not include local or regional economic transfers. For example, according to the PGN, the prevention of income loss results in a contribution to national economic development only to the extent that such loss cannot be compensated for by postponement of an activity or transfer of the activity to other establishments.

The primary NED damage categories evaluated for this study phase is as follows:

- Structure and Content Damages to residences, business & industry, and public buildings
- Automobile Damages
- Emergency and Cleanup Costs

Each surveyed property is assigned to a category (e.g., commercial, residential, public, apartment, transportation facilities, utilities, and vehicles) with as many subcategories (e.g., contents) as necessary, and details of ground and first floor elevations are noted. Each category has an associated depth-damage relationship expressed as a cumulative percentage of value for each foot of inundation. The depth-damage relationships were derived from historical data obtained from insurance companies, a recent commercial content survey conducted by the Albuquerque District, the Flood Insurance Administration, and prior Corps of Engineers experience. Note that the 2003 residential curves developed by the Institute of Water Resources (IWR) were used; thus, the residential content damages are a function of structure value. Table 1 depicts the depth-damage relationships used in this study.

Table 1 – Depth-percent damage relationships used in this study

Occ_Name	Occ_Description	Cat_Name	Parameter			Depth (feet)													
AUTO	Automobiles_Composite EGM-09-04_CA	Autos	Depth				0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)				0	3.4	24.0	33.7	43.4	60.2	74.6	86.4	94.1	97.4	99.4	100.0	100.0
			Standard Deviation structure damage (percent)				0	9.6	8.0	7.1	6.3	4.6	3.3	4.3	7.0	7.2	7.5	7.7	7.7
			Mean content damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Standard Deviation content damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				0	Error in CON/STR VAL				0
COMM-1	Commercial GEC97	Commercial	Depth				0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)				1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)				0	12.8	16.2	28.9	34	64.8	80.2	81.9	89.5	91.8	91.8	91.8	91.8
			Standard Deviation content damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.33		Err STR VAL (%)			15	CON/STR Val ratio (%)				171	Error in CON/STR VAL				145
COMM-2	2SNB structure, two story M, O, C content	Commercial	Depth				0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)				0	9.9	16	22	28	37	43	47	49	50	51	55	58
			Standard Deviation structure damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)				0	13	26	33	39	48	55	61	67	73	73	73	73
			Standard Deviation content damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.4		Err STR VAL (%)			15	CON/STR Val ratio (%)				50	Error in CON/STR VAL				35
GROC-GAS	Commercial Grocery and Gas GEC97	Commercial	Depth				0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)				1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)				0	9	26.9	68.6	79.3	86.6	89.8	95.7	95.9	95.9	95.9	95.9	95.9
			Standard Deviation content damage (percent)				0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				140	Error in CON/STR VAL				65
IND	Industrial Generic GEC97	Industrial	Depth			-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)			0	1.6	12	12	17.2	17.4	22.4	26.3	29.5	29.5	29.5	31.9	42.3	48.4
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	8.1	12	16	20.1	26.6	30.9	39	46.2	53.4	60.6	67.9	72.5
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				68	Error in CON/STR VAL				98
IND-RD	Industrial RD GEC97	Industrial	Depth			-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)			0	1.6	12	12	17.2	17.4	22.4	26.3	29.5	29.5	29.5	31.9	42.3	48.4
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	8.1	12	16	20.1	26.6	30.9	39	46.2	53.4	60.6	67.9	72.5
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				68	Error in CON/STR VAL				98
IND-W	Industrial Warehouse GEC97	Industrial	Depth		-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)		0	0	1.6	12	12	17.2	17.4	22.4	26.3	29.5	29.5	29.5	31.9	42.3	48.4
			Standard Deviation structure damage (percent)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)		0	0	0	8.1	12	16	20.1	26.6	30.9	39	46.2	53.4	60.6	67.9	72.5
			Standard Deviation content damage (percent)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				68	Error in CON/STR VAL				98
MFR1	Multi-Family Residential 1-story egm04-01	Residential	Depth	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)	0	2.5	7.95	13.4	18.35	23.3	27.7	32.1	40.1	47.1	53.2	58.6	63.2	67.2	70.5	73.2
			Standard Deviation structure damage (percent)	0	2.7	2.35	2	1.8	1.6	1.6	1.6	1.8	1.9	2	2.1	2.2	2.3	2.4	2.7
			Mean content damage (percent)	0	2.4	5.25	8.1	10.7	13.3	15.6	17.9	22	25.7	28.8	31.5	33.8	35.7	37.2	38.4
			Standard Deviation content damage (percent)	0	2.1	1.8	1.5	1.35	1.2	1.2	1.2	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.1
			Elev. Error (Feet)	0.5		Err STR VAL (%)			17	CON/STR Val ratio (%)				100	Error in CON/STR VAL				12
MFR2	Multi-Family Residential 2-story egm04-01	Residential	Depth	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)	0	3	6.15	9.3	12.25	15.2	18.05	20.9	26.3	31.4	36.2	40.7	44.9	48.8	52.4	55.7
			Standard Deviation structure damage (percent)	0	4.1	3.75	3.4	3.2	3	2.9	2.8	2.9	3.2	3.4	3.7	3.9	4	4.1	4.2
			Mean content damage (percent)	0	1	3	5	6.85	8.7	10.45	12.2	15.5	18.5	21.3	23.9	26.3	28.4	30.3	32
			Standard Deviation content damage (percent)	0	3.5	3.2	2.9	2.75	2.6	2.55	2.5	2.5	2.7	3	3.2	3.3	3.4	3.5	3.5
			Elev. Error (Feet)	0.5		Err STR VAL (%)			17	CON/STR Val ratio (%)				100	Error in CON/STR VAL				12
MH	Mobile Homes source unknown	Residential	Depth	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)	0	0	0	8	29	50	60	71	82	87	89	91	91	91	100	100
			Standard Deviation structure damage (percent)	0	0	0	2	1.8	1.6	1.6	1.6	1.8	1.9	2	2.1	2.2	2.3	2.4	2.7
			Mean content damage (percent)	0	0	0	0	20	35	43	56	72	79	84	87	88	90	100	100
			Standard Deviation content damage (percent)	0	2.1	1.8	1.5	1.35	1.2	1.2	1.2	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.1
			Elev. Error (Feet)	0.5		Err STR VAL (%)			19	CON/STR Val ratio (%)				50	Error in CON/STR VAL				25
OFFICE-C	Commercial Office Class C GEC97	Commercial	Depth			-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
			Mean structure damage (percent)			0	1.6	12	12	17.2	17.4	22.4	26.3	29.5	29.5	29.5	31.9	42.3	48.4
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	12.8	16.2	28.9	34	64.8	80.2	81.9	89.5	91.8	91.8	91.8	91.8
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				90	Error in CON/STR VAL				90

OFFICE-D	Commercial Office Class D GEC97	Commercial	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	12.8	16.2	28.9	34	64.8	80.2	81.9	89.5	91.8	91.8	91.8	91.8
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				90	Error in CON/STR VAL				90
OFFICE-1	1SNB structure, one story M, O, C conten	Commercial	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	0	10.7	14	17.5	21	26	29	30	41	43	44	45	46
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	18	35	42.5	50	60	68	74	78	81	83	85	87
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.4		Err STR VAL (%)			15	CON/STR Val ratio (%)				50	Error in CON/STR VAL				35
OFFICE-2	2SNB structure, two story M, O, C content	Commercial	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	0	9.9	16	22	28	37	43	47	49	50	51	55	58
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	13	26	33	39	48	55	61	67	73	73	73	73
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.4		Err STR VAL (%)			15	CON/STR Val ratio (%)				50	Error in CON/STR VAL				35
PUBLIC-C	Public Class C GEC97	Public	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	1.6	12	12	17.2	17.4	22.4	26.3	29.5	29.5	29.5	31.9	42.3	48.4
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	0	36.1	65	65	65	90	100	100	100	100	100	100
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				37	Error in CON/STR VAL				48
PUBLIC-D	Public Class D GEC97	Public	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	0	36.1	65	65	65	90	100	100	100	100	100	100
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				37	Error in CON/STR VAL				48
PUBLIC-1	1SNB structure, one story M, O, C conten	Public	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	0	10.7	14	17.5	21	26	29	30	41	43	44	45	46
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	18	35	42.5	50	60	68	74	78	81	83	85	87
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.4		Err STR VAL (%)			15	CON/STR Val ratio (%)				50	Error in CON/STR VAL				35
PUBLIC-10	2SNB structure, two story M, O, C content	Public	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	0	9.9	16	22	28	37	43	47	49	50	51	55	58
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	13	26	33	39	48	55	61	67	73	73	73	73
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.4		Err STR VAL (%)			15	CON/STR Val ratio (%)				50	Error in CON/STR VAL				35
REST	Commercial Restaurant GEC97	Commercial	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	17.8	23.9	44.6	47.8	76.5	91.3	93.5	94.4	96.7	96.7	96.7	96.7
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.5		Err STR VAL (%)			15	CON/STR Val ratio (%)				40	Error in CON/STR VAL				65
RETAIL	Commercial Retail GEC97	Commercial	Depth			**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)			0	1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mean content damage (percent)			0	0	10.9	23	33.3	55	68.5	77.4	85.9	94.4	94.4	94.4	94.4	97
			Standard Deviation content damage (percent)			0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Elev. Error (Feet)	0.33		Err STR VAL (%)			15	CON/STR Val ratio (%)				171	Error in CON/STR VAL				145
SFR1	Single Family Residential 1-story egm04-0	Residential	Depth	**-2**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)	0	0	0	1.1	18.3	18.3	24.4	27.2	30.9	37	44.5	44.5	46.2	47.6	52.1	52.1
			Standard Deviation structure damage (percent)	0	2.7	2.4	2	1.8	1.6	1.6	1.6	1.8	1.9	2	2.1	2.2	2.3	2.4	2.7
			Mean content damage (percent)	0	2.4	5.3	8.1	10.7	13.3	15.6	17.9	22	25.7	28.8	31.5	33.8	35.7	37.2	38.4
			Standard Deviation content damage (percent)	0	2.1	1.8	1.5	1.4	1.2	1.2	1.2	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.1
			Elev. Error (Feet)	0.5		Err STR VAL (%)			17	CON/STR Val ratio (%)				100	Error in CON/STR VAL				12
SFR2	Single Family Residential 2-story egm04-0	Residential	Depth	**-2**	**-1**	**-0.5**	**0**	**0.5**	**1**	**1.5**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
			Mean structure damage (percent)	0	3	6.2	9.3	12.3	15.2	18.1	20.9	26.3	31.4	36.2	40.7	44.9	48.8	52.4	55.7
			Standard Deviation structure damage (percent)	0	4.1	3.75	3.4	3.2	3	2.9	2.8	2.9	3.2	3.4	3.7	3.9	4	4.1	4.2
			Mean content damage (percent)	0	1	3	5	6.9	8.7	10.5	12.2	15.5	18.5	21.3	23.9	26.3	28.4	30.3	32
			Standard Deviation content damage (percent)	0	3.5	3.2	2.9	2.75	2.6	2.55	2.5	2.5	2.7	3	3.2	3.3	3.4	3.5	3.5
			Elev. Error (Feet)	0.5		Err STR VAL (%)			17	CON/STR Val ratio (%)				100	Error in CON/STR VAL				12

The elevation of each property (determined from GIS-based topographic maps and field investigations) is identified by location and structure type to compute the vertical distribution of damageable property at each structure. Each property category is then tabulated in terms of the number of units, average value per unit and aggregate value, for several specific Annual Exceedance Probability (AEP) events. That inventory is set into the Hydrologic Engineering Center's Flood Damage Analysis (FDA) ver. 1.4.2 to compute expected annual and Equivalent Annual Damages.

For the without-project, present condition, each structure was assigned a water surface elevation profiles which were actually floodplain depths generated by HEC-RAS and overlaid onto GIS maps of the study area. All of the floodplains were then attached to an H&H Index point at the upper end of the creek. This adjustment was necessary due to the relatively "flat" probability-stage relationship within the overbank floodplains. Since HEC-FDA is largely dependent upon change-in-depth flooding (as opposed to sheet-flow flooding where subsequent larger events tend to have similar depths but larger geographical extents), the HEC-RAS floodplains depths were attached to an in-channel HEC-RAS probability-stage curve. This methodology has been used in other San Francisco and Sacramento District studies as an appropriate way to accurately model damages while using the USACE-approved HEC-FDA model. Flood maps are displayed showing the depths of flooding for the 8 modeled events previously noted. The actual depths in and around the structures generally averages no more than a few feet, due to the sheet-flow nature of the overbank flooding.

This report contains descriptive tables (number of structures subject to flooding by event, value of damageable property by property type and event, and single occurrence damages associated with specific frequency events) that were generated as a reality check of the FDA analysis. The study area's floodplain is fairly wide and flat, such that structure first floor height has a tremendous bearing on start of damages and damages attributable to specific events. To compute the number of structures in a given floodplain, the FDA_StrucDetail.out file was consulted, which computes number of structures, value of damageable property, and single occurrence damages. This computation occurs "without-risk" but serves as a consistency check on EAD and equivalent annual benefit calculations.

Table 2 displays the number of damageable property units by floodplain, in the present hydraulic conditions. Table 3 presents the same information for the future hydraulic condition. TablTable 4 – Value of damageable property, present conditione 3 presents the depreciated replacement values of those properties, by floodplain and hydraulic condition. As a quality check, these tables also display average value per structure, which is computed by dividing the number of structures in Table 3 by the corresponding values in Table 2. The 2011-2015 American Community Survey (Bureau of the Census) indicates the average household size in Marin County is 2.41 persons. Multiplying this figure by the number residential and apartment units in the 1% chance and 0.2% chance floodplains suggest that the study area has a Population at Risk (PAR) of 871 persons from the 1% chance flood and 924 persons from the 0.2% chance flood. Further investigations into the alternatives will provide a bit more accuracy as the floodplain is disaggregated to determine which alternatives provide benefits to which flood-prone structures.

NUMBER OF STRUCTURES WITHOUT PROJECT CONDITIONS (PRESENT) CORTE MADERA CREEK FLOODPLAIN								
	EVENT							
	50%	20%	10%	4%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Residential	0	6	41	66	79	88	98	107
Commercial	0	0	15	19	22	23	26	30
Public	0	0	12	17	17	22	24	27
Apartment	1	1	5	9	9	9	11	11
Outbuildings	0	2	42	53	59	61	63	63
Vehicles	0	12	117	172	190	201	217	222
TOTAL STR.	**1**	**9**	**115**	**164**	**186**	**203**	**222**	**238**

Table 2 – Number of structures

NUMBER OF STRUCTURES WITHOUT PROJECT CONDITIONS (FUTURE) CORTE MADERA CREEK FLOODPLAIN								
	EVENT							
	50%	20%	10%	5%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Residential	0	10	42	62	78	88	101	108
Commercial	0	2	17	21	23	25	27	28
Public	0	1	13	17	17	22	27	27
Apartment	1	2	5	8	8	9	11	12
Outbuildings	0	23	43	52	58	60	64	65
Vehicles	0	26	122	164	184	200	220	229
TOTAL STR.	**1**	**38**	**120**	**160**	**184**	**204**	**230**	**240**

Table 3 – Number of structures, future conditions

VALUE OF DAMAGEABLE PROPERTY WITHOUT PROJECT CONDITIONS (PRESENT) CORTE MADERA CREEK FLOODPLAIN (x $1,000 August, 2017 price level)								
	EVENT							
	50%	20%	10%	4%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
$/str	#DIV/0!	134	157	155	159	163	164	165
Residential	0	803	6,430	10,256	12,572	14,326	16,052	17,662
Res. Content	0	803	6,376	10,201	12,517	14,271	15,943	17,552
$/str	#DIV/0!	#DIV/0!	430	402	433	424	398	394
Commercial	0	0	6,448	7,644	9,520	9,751	10,337	11,823
Comm. Content	0	0	14,051	16,225	17,350	17,406	18,606	20,325
$/str	#DIV/0!	#DIV/0!	2,743	2,158	2,158	1,679	1,649	1,479
Public	0	0	32,917	36,687	36,687	36,946	39,575	39,932
Pub. Content	0	0	17,447	19,209	19,209	19,426	22,137	22,324
$/str	132	132	210	175	175	175	154	154
Apartment	132	132	1,050	1,577	1,577	1,577	1,691	1,691
Apt. Contents	66	66	525	789	789	789	846	846
$/str	#DIV/0!	21	11	12	14	14	15	15
Outbuilding	0	41	443	617	842	880	924	924
Out.. Contents	0	25	436	595	741	767	811	811
$/veh	#DIV/0!	11	11	11	11	11	11	11
Vehicles	0	133	1,299	1,909	2,109	2,231	2,409	2,464
Total	**198**	**2,005**	**87,423**	**105,709**	**113,912**	**118,370**	**129,330**	**136,354**

Table 4 – Value of damageable property, present condition

VALUE OF DAMAGEABLE PROPERTY WITHOUT PROJECT CONDITIONS (FUTURE) CORTE MADERA CREEK FLOODPLAIN (x $1,000 August, 2017 price level)								
	EVENT							
	50%	20%	10%	5%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
$/str	#DIV/0!	143	155	156	157	160	163	163
Residential	0	1,432	6,503	9,692	12,243	14,094	16,479	17,586
Res. Content	0	1,432	6,448	9,637	12,188	14,039	16,369	17,476
$/str	#DIV/0!	332	421	371	356	410	400	407
Commercial	0	665	7,152	7,796	8,187	10,257	10,799	11,400
Comm. Content	0	1,810	14,636	16,264	17,065	18,234	18,990	19,472
$/str	#DIV/0!	86	2,733	2,158	2,158	1,679	1,479	1,479
Public	0	86	35,533	36,687	36,687	36,946	39,932	39,932
Pub. Content	0	91	18,820	19,209	19,209	19,426	22,324	22,324
$/str	132	265	210	176	176	175	154	157
Apartment	132	530	1,050	1,410	1,410	1,577	1,691	1,883
Apt. Contents	66	265	525	705	705	789	846	941
$/str	#DIV/0!	10	11	14	14	14	14	14
Outbuilding	0	222	471	754	839	865	926	937
Out.. Contents	0	218	464	653	726	752	813	824
$/veh	#DIV/0!	11	11	11	11	11	11	11
Vehicles	0	289	1,354	1,820	2,042	2,220	2,442	2,542
Total	**198**	**7,037**	**92,958**	**104,627**	**111,300**	**119,200**	**131,610**	**135,317**

Table 5 – Value of damageable property, future condition

Section 308 of the Water Resources Development Act of 1990 states "The Secretary shall not include in the benefit base for justifying Federal flood damage reduction projects...any new or substantially improved structure...built in the 100-year flood plain with a first floor elevation less than the 100-year flood elevation after July 1,1991." To comply with that requirement, the latest and historic aerial photos of the study area were consulted in Google Earth to get a sense of where any development may have occurred in the time since July 1, 1991. The study area is highly developed and, existing within the Bay Area, was not expected to be experiencing new development. Historic FIRM mapping indicates the study area did not have Base Flood Elevations (BFE) identified until the mapping effective March 17, 2014. Therefore, as there is no elevation that new or modified structures have to be elevated clear until that time, no structures built or modified since enactment of the law and March 17, 2014 are subject to the Section 308 exclusion.

Section 308 exclusions are limited to structures built or substantially improved since March, 2014. Aerial photography of the study in May, 2014 can be compared to the most recent mapping (June, 2017) to identify differences. However, no significant differences can be identified from the two images.

Figure 2 – Study area as of July, 1993

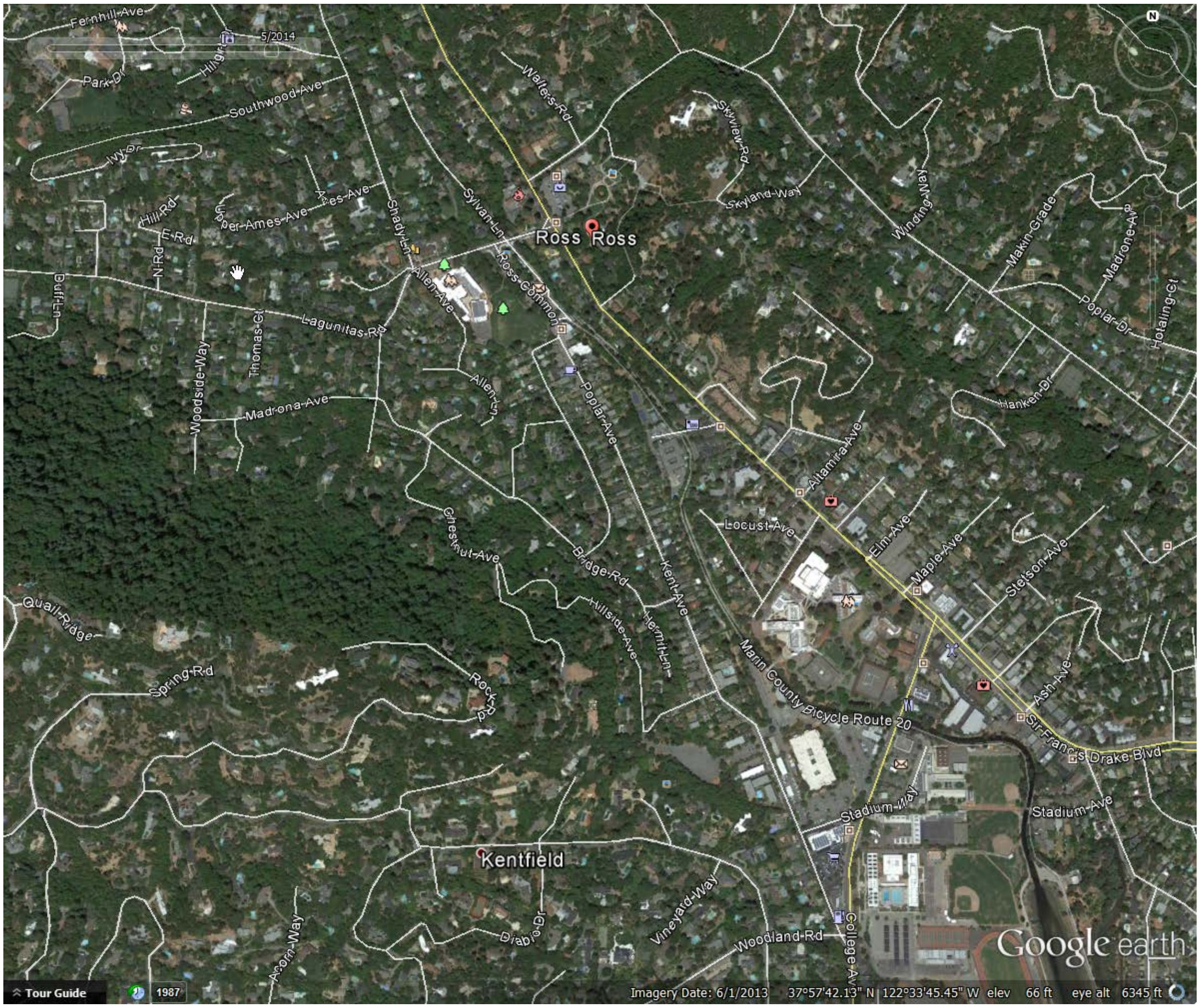


Figure 3 – Study area as of May, 2014

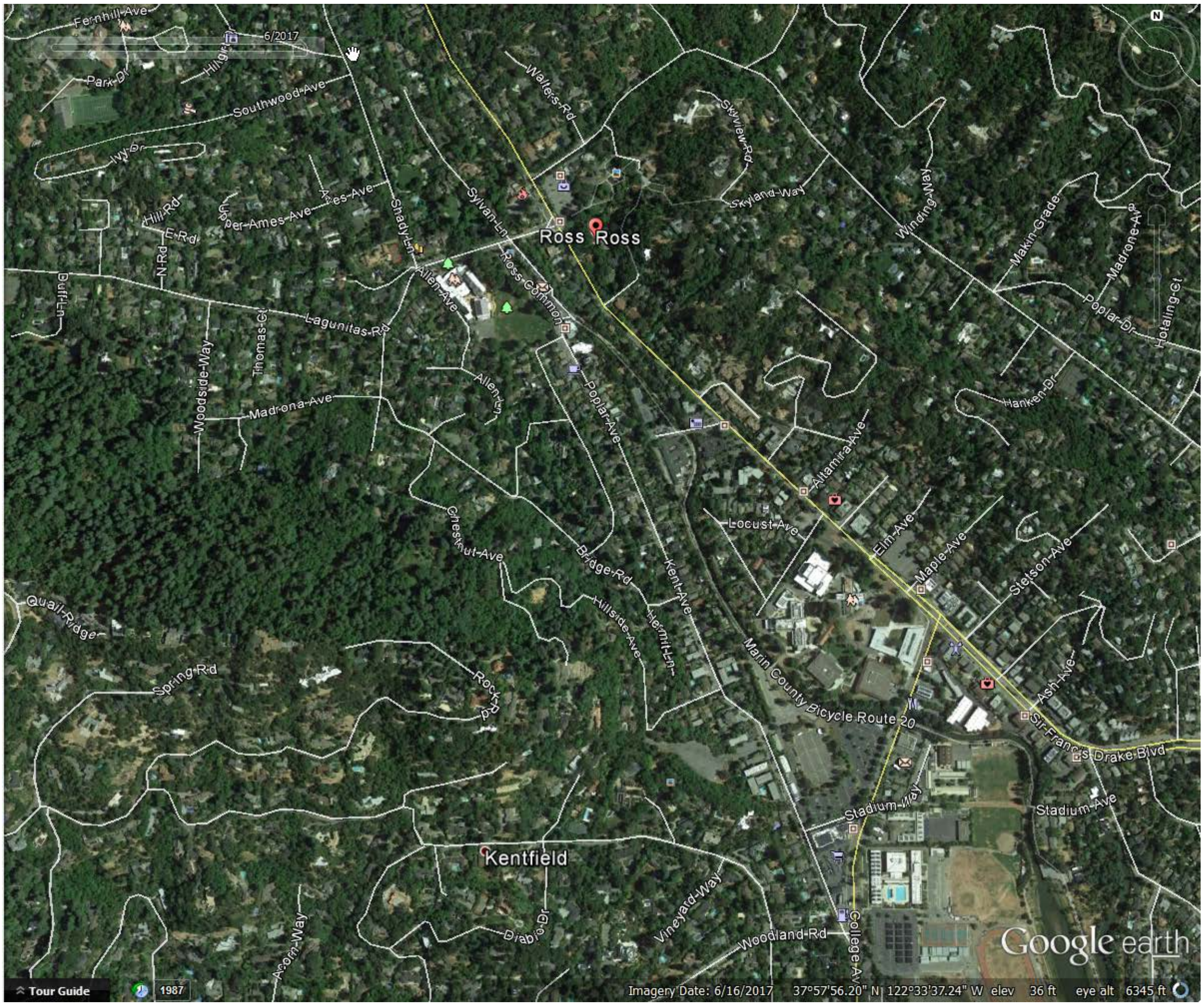


Figure 4 – Study area as of June, 2017

For each category, the aggregate value of property at each flood depth is combined with the depth-damage relationship to compute total, single event damages for each level of flooding. Table 4 displays the single occurrence damages by category for the floodplain evaluated. Again, the "FDA_StrucDetail.out" file is consulted to produce these tables describing the impacts of specific frequency events such as number of structures, value of damageable property, and single occurrence damages. The value of damageable property in the HEC-FDA model is computed "with risk," and is essentially combined with the discharge-frequencies of the reference floods to produce damage-frequency relationships. Damage-frequency relationships provide probable average annual damages for each category under the conditions of each reference flood, and can then be compared to the hydrologic, hydraulic, and economic data analyzed within HEC-FDA. Table 10 and Table 11 present the average annual damages computation from the HEC-FDA analysis.

SINGLE OCCURRENCE DAMAGES WITHOUT PROJECT CONDITIONS (PRESENT) CORTE MADERA CREEK FLOODPLAIN (x $1,000 August, 2017 price level)								
	EVENT							
	50%	20%	10%	4%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Residential	0	142	1,282	2,157	2,734	3,151	3,653	4,102
Res. Content	0	81	729	1,218	1,547	1,784	2,066	2,323
Commercial	0	0	953	1,305	1,535	1,763	2,064	2,312
Comm. Content	0	0	9,198	10,207	11,105	11,751	12,733	13,251
Public	0	0	3,257	4,531	5,213	5,737	6,881	7,581
Pub. Content	0	0	2,360	5,110	6,494	7,348	8,608	9,560
Apartment	12	12	218	321	360	383	482	507
Apt. Contents	3	3	63	92	104	111	140	147
Outbuildings	0	7	97	155	222	248	282	301
Out. Contents	0	3	68	101	130	142	159	171
Subtotal - Structures	**12**	**161**	**5,807**	**8,469**	**10,064**	**11,283**	**13,361**	**14,802**
Subtotal - Contents	**3**	**87**	**12,417**	**16,729**	**19,380**	**21,135**	**23,705**	**25,452**
Subtotal - Structures and Contents	**16**	**248**	**18,225**	**25,197**	**29,444**	**32,418**	**37,066**	**40,254**
Vehicles	0	19	316	595	768	885	1,039	1,154
Clean-Up	0	24	1,159	1,984	2,480	2,791	3,213	3,549
Displacement	1	19	148	244	301	340	400	443
Total	**17**	**310**	**19,848**	**28,020**	**32,994**	**36,435**	**41,719**	**45,399**

Table 6 – Single occurrence damages, present conditions

SINGLE OCCURRENCE DAMAGES WITHOUT PROJECT CONDITIONS (FUTURE) CORTE MADERA CREEK FLOODPLAIN (x $1,000 August, 2017 price level)								
	EVENT							
	50%	20%	10%	5%	2%	1%	0.4%	0.2%
Land Use Category	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Residential	0	131	1,272	2,026	2,458	2,991	3,608	4,074
Res. Content	0	74	723	1,145	1,389	1,693	2,041	2,308
Commercial	0	5	940	1,248	1,406	1,693	2,023	2,295
Comm. Content	0	2	9,162	10,020	10,694	11,537	12,626	13,228
Public	0	0	3,255	4,422	4,962	5,622	6,793	7,593
Pub. Content	0	0	2,359	4,800	6,054	7,182	8,513	9,576
Apartment	12	12	218	297	343	374	478	504
Apt. Contents	3	3	63	86	99	108	139	146
Outbuildings	0	13	99	153	212	244	281	302
Out. Contents	0	6	71	101	125	141	161	173
Subtotal - Structures	**12**	**161**	**5,784**	**8,146**	**9,381**	**10,925**	**13,184**	**14,768**
Subtotal - Contents	**3**	**86**	**12,378**	**16,153**	**18,361**	**20,661**	**23,479**	**25,432**
Subtotal - Structures	**16**	**247**	**18,162**	**24,299**	**27,742**	**31,586**	**36,663**	**40,200**
Vehicles	0	22	318	555	701	848	1,023	1,148
Clean-Up	0	28	1,165	1,884	2,306	2,705	3,178	3,541
Displacement	1	17	147	229	276	328	396	442
Total	**17**	**314**	**19,793**	**26,966**	**31,025**	**35,467**	**41,259**	**45,331**

Table 7 – Single occurrence damages, future condition

Residual, average annual damages for each alternative, including the without project alternative, are obtained through consecutive iterations of the above computations for each alternative. The difference between damages in the without-project alternative and the residual damages for each alternative is the value of the benefits (inundation reduction) for each alternative. The following figure demonstrates the integration of hydrology, hydraulic data, and the economic information developed in this appendix is integrated to generate the Equivalent Annual Damages (EAD) computation:

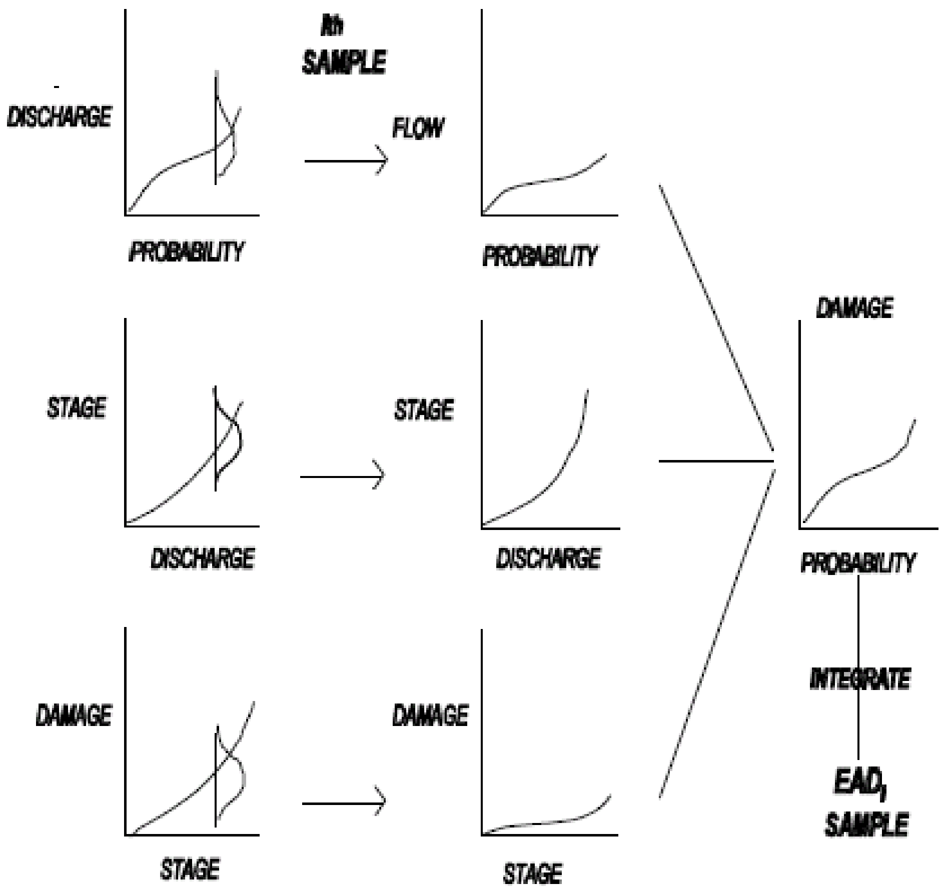


Figure 5 - EAD Development Methodology

F-03 Value of Property:

A survey of structures within the floodplain was initially conducted in May 2017, to evaluate the flood threat to the area. The property examined was categorized into residential, commercial, and public buildings, as well as, vehicles, streets and utilities, and outbuildings (sheds and detached garages). The field survey gathered primary data such as structure description (quality of construction, construction materials, number of floors, and presence of basements), an estimate of effective age for depreciation purposes, occupancy type, elevation above grade, an estimate of structure size in square feet, and the number of nearby structures that share these attributes. Table 2 shows number of property units affected by the 4-percent, 2-percent, 1-percent, 0.4-percent and 0.2 percent chance flood events, respectively. Table 3 shows the value of those property units in each floodplain. These tables were generated using HEC-FDA's FDA_StrucDetail.out file for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA.

Depreciated, replacement residential structure values were computed using the factors and methods described in the Marshall Valuation Service, published by the Marshall and Swift Company. Corps regulations require cost-benefit evaluations use depreciated replacement costs. Replacement cost is the cost of physically replacing (reconstructing) the structure. Depreciation accounts for deterioration occurring prior to flooding, and variation in remaining useful life of structures. Depreciated replacement cost computations include factors such as construction type (wood, masonry) and quality, effective age (for depreciation purposes), and local market prices that bring the value of the structure to what we'd expect to spend on a "replacement in kind" structure in the study area. That computation was then verified in the field through interviews with local Realtors, and insurance agents to verify structure ages and replacement costs of structures in the floodplain. A windshield survey of all structures was also conducted to establish average first floor elevation above grade of structures in each damage reach. That "elevation above grade" was added to the ground surface elevation DTM data used in the hydraulic model to tie the economic inventory to the floodplain model. Commercial, public and apartment structures were inventoried in the field survey using the Marshall and Swift Valuation Service.

Content values were estimated from several sources. Residential content values were held at 50% of the structure value. Insurers contacted estimated content values are greater than 55% of structure value. (Where the IWR 2001 and 2003 structure and content depth-percent damage relationships were used, content damages are expressed as a percentage of structure value.) Commercial and public content values were computed using the previously published values by San Francisco, Galvestion, Walla Walla, Albuquerque districts, as well as IWR Report 96-R-12, Analysis of Nonresident Content Value and Depth-Damage Data for Flood Damage Reduction Studies, which estimated content and inventory values based upon factors like SIC code for the property, size of the property in square feet.

Vehicle estimates were determined using IWR-published data and published surveys. Total vehicles in the floodplain depicted are for residential structures and apartments. The typical household in San Rafael, California has 1.7 vehicles. It is assumed that one of these vehicles is driven out of the floodplain before any flood event. The remaining vehicles were distributed to the residential and apartment structures located within the 0.2 percent chance exceedance flood plain. It was assumed that all business-related vehicles were already evacuated from the floodplain.

Flood waters leave debris, sediment, salts and the dangers of diseases throughout flooded structures, making the cleaning of these structures a necessary post-flood activity. Clean-up costs for the extraction of flood waters, dry-out, and decontamination vary significantly based upon various factors, including depth of flooding. Studies conducted by both Sacramento and New Orleans Districts indicate a maximum value of ten dollars per square foot ($10/ft2) for such clean-up costs. This maximum per square foot cost covers clean-up costs associated with mold and mildew abatement, which entails having professional firms apply fans, chemicals, and other techniques to eliminate and prevent mold/mildew in inundated areas. The maximum clean-up cost of $10/ft2 was used for this assessment and was applied to flood depths equal to and exceeding five feet, with damage percentages scaled down for depths between zero and five feet. Figure 6 below displays dollar-per-square foot clean-up costs as a function of flood depths; Figure 7 displays the depth-percent damage curve used in the HEC-FDA analysis.

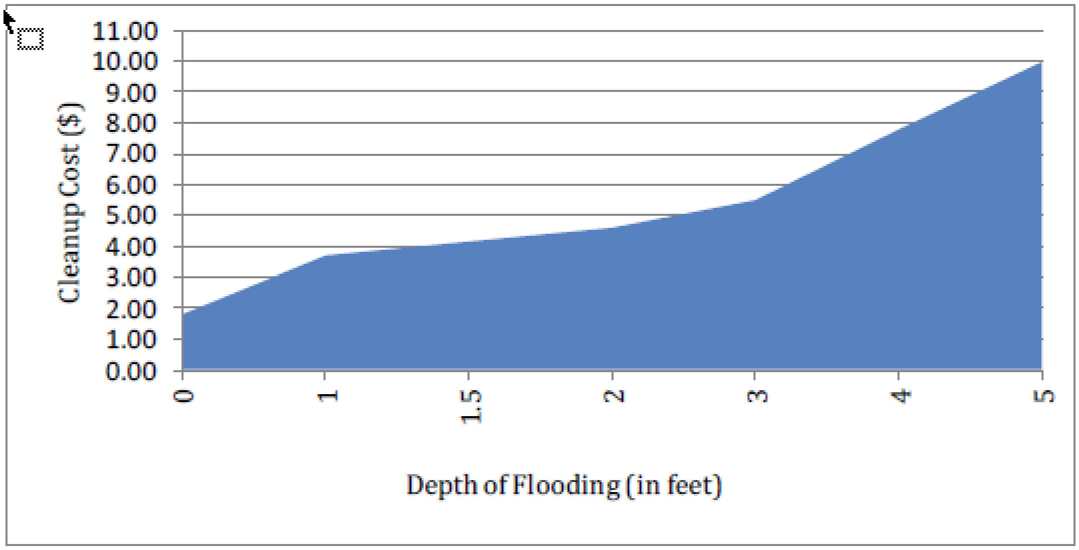


Figure 6 - Dollar-Per-Square Foot Clean-Up Costs as a Function of Depth of Flooding

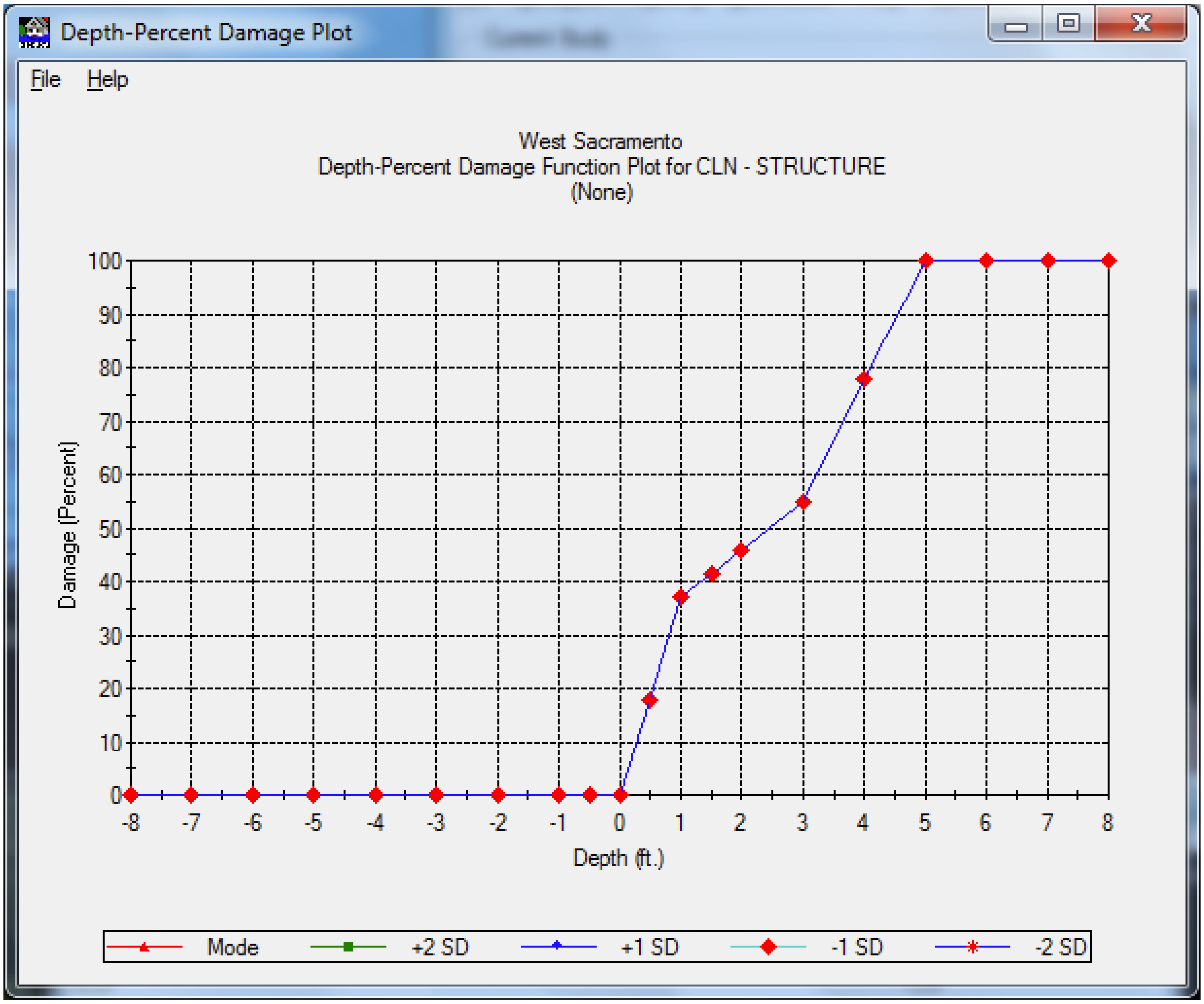


Figure 7 - Depth-Percent Damage Curve for Clean-Up Costs Used in HEC-FDA Analysis

Displacement costs:

ER 1105-2-100 states, "Flood damages are classified as physical damages or losses, income losses, and emergency costs." The guidance then defines emergency costs as "those expenses resulting from a flood what would not otherwise be incurred." It further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates.

The Federal Emergency Management Agency (FEMA) provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster, since it is an expenditure that is only undertaken when a disaster occurs. Therefore, it falls under the emergency cost guidance of ER 1105-2-100, and the funds expended by

FEMA for temporary evacuation, relocation, and housing assistance (TERHA) in the event of a flood are a legitimate flood damage category under the NED account.

Cost estimates for the relocation and emergency services provided to flood plain residents displaced during peak flood events and post-flood structural renovations were based on FEMA's methodology for evaluating TERHA costs. This methodology relates TERHA costs to relocation costs, structure damage percentages and the number of days residents spend displaced from their structures. The maximum TERHA costs of $9,912 correspond with one year of FEMA evacuation, relocation and/or housing assistance costs. These costs are based on the median rent of a two bedroom apartment, and were derived for this assessment using rent prices in Marin County as posted on the website www.zillow.com. The maximum cost of $15,000 was applied to structures sustaining at least 50 percent damage, with scaled down costs being computed for less damaging flood events. Figure 8 below shows percent of maximum TERHA damages as a function of the depth of flooding. The depth-percent damage relationship for a one-story single family residential (SFR) structure is also shown as a point of reference; however, unique depth-percent damage relationships for one-story residential, two-story residential, and mobile homes were applied in HEC-FDA to derive damages and benefits for TERHA.

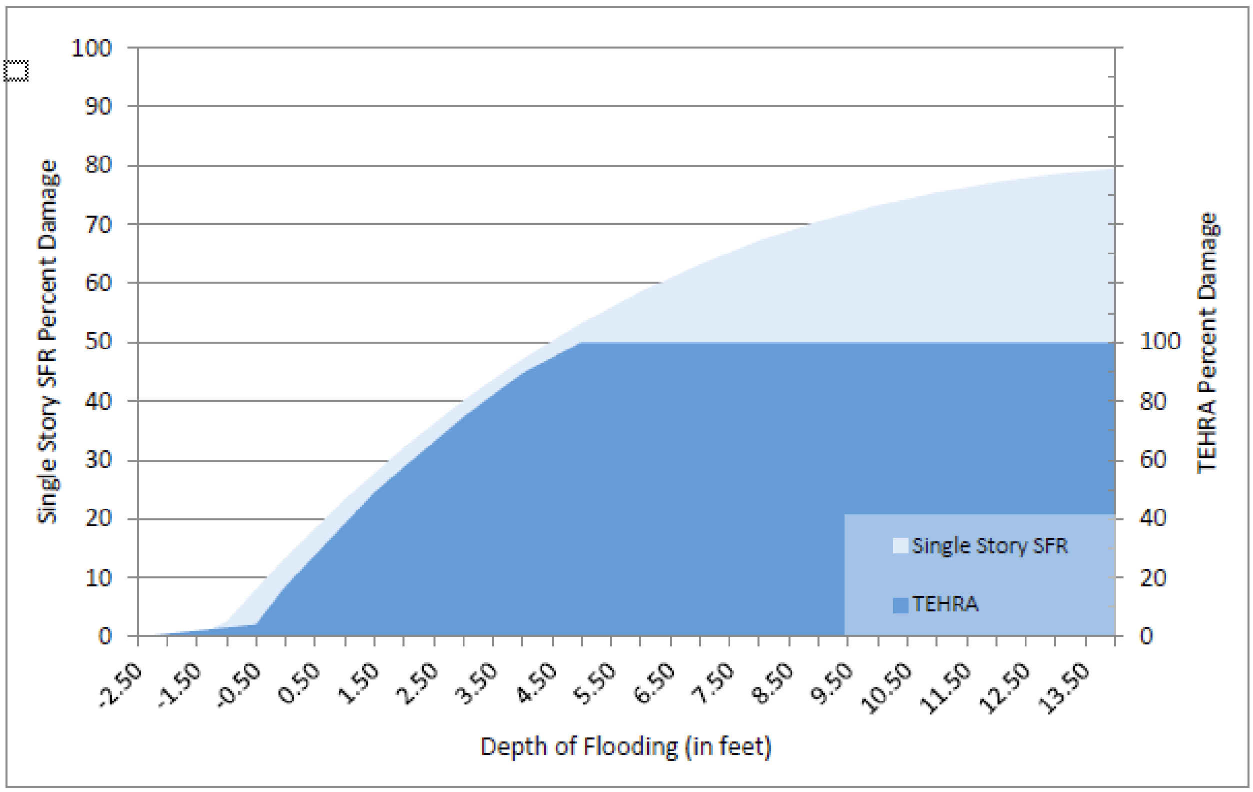


Figure 8 - Depth-Percent Damage Curve for Displacement Costs Used in HEC-FDA Analysis

F-04 Sources of Uncertainty:

The major sources of economic uncertainty include many of the same variables identified above in the damage estimate analysis and others noted as follows:

1. Value of property;
2. Value of property contents;
3. Flood stage at which damage begins;
4. First floor elevations of structures;
5. Responses to flood forecasts and warnings;
6. Flood fighting efforts;
7. Cleanup costs;
8. Business losses;
9. Depth-percent damage curves;
10. Estimate of the stage associated with a given discharge;
11. Estimate of damage for a given flood stage; and
12. Estimate of future land use

Principal sources of error affecting the stage-damage relationship were examined in a risk and uncertainty framework. Those sources of error are 1) errors associated with the damageable property elevation, 2) errors associated with the values of structures in the floodplain inventory, 3) errors associated with values of structure contents in the floodplain inventory, 4) errors associated with the damage functions used against the floodplain inventory. Table 1 shows the error distributions used by occupancy type in the study area.

There are numerous factors which affect the frequency distributions as well as the rating curves for the study area's hydraulic reaches. Those factors are discussed in detail in Appendix E.

Elevation of damageable property:

A standard deviation was established during the field surveys to account for the uncertainty associated with the elevation of damageable property. In the study area, the flooding depths are relatively shallow and the flood plains are large and flat; therefore, an elevation difference of one foot could potentially double the damages associated with a given stage. The 0.4 feet standard deviation was used for three reasons. First, since the economic inventory was conducted by a visual windshield inspection, the first floor elevations of structures were estimated rather than measured. Second, the digital terrain model (DTM) used to develop specific frequency event floodplains introduces a source of uncertainty relative to elevation. Sensitivity analyses also indicated that the overbank flooding areas was overstating the impact of relatively frequent flooding, so a more conservative start of damages condition was established in HEC-FDA to minimize this impact.

Structure value:

It was assumed that the estimated structure value, which was derived from sales information and a field inventory, has a standard deviation which varies by occupancy type. That standard deviation comes from prior Albuquerque and San Francisco District studies, and prior experience of the Ft. Worth District, which developed that estimate from interviews with various County Assessor's offices.

The structure inventory values and associated error distribution were then evaluated to compute floodplain inventory that incorporates errors concerning structure value. It was assumed that the estimated structure value (derived from field inventory and consultations with Realtors, insurance agents) could be off by 15% of the structure value. The floodplain inventory was then assessed using these assumptions, dropping all values more than three standard deviations from the reported (mean) value. The resulting distribution of structure values with error would contain 99% of possible values given the assumptions above.

Content value:

The error distribution associated with content value varied by structure type. In terms of average annual damages for residential contents the damage curves relate to the structure value rather than the content value.

The content value error distribution varied by structure type. Corps guidance stipulates residential content values should be held to no more than 50% of structure values, though local insurers note that contents are valued at 55-60% of structure value, or more. Residential and apartment content value distributions with error were fixed to the error distributions associated with residential and apartment structures. New depth-percent damage relationships published by IWR in 2001 and 2003 compute content damages as a percentage of structure value. Content valuation in this appendix is for illustrative purposes only, and content damages for residences use the IWR methods. Commercial and public contents used standard deviations that vary by occupancy type to develop the content value with error. All content relationships were truncated to eliminate the possibility of negative values.

Structure Type		CSVR	Standard Deviation
Residential	SFR	1.0	0.12
	MFR	1.0	0.12
	MH	1.0	0.12
Commercial	Eating and Recreation	0.4	0.7
	Groceries & Gas Stations	1.4	0.7
	Professional Businesses	0.9	0.9
	Retail and Personal Services	1.7	1.45
Other	Industrial	0.7	1.0
	Public	0.4	0.5

Table 8– Content to Structure Value Relationships (CSVR) and standard deviations used in this study

Depth-percent damage relationship:

Flooding can cause significant damage to structures of all types. Water can cause a structure's structural components to shift or warp – including the studs and foundation. Water can also damage the wiring, gas lines, and septic system. For high water, ceilings may sag under the weight of trapped water or soggy drywall, wet floorboards can bend and buckle, and the roof may leak or break altogether. Flooding in a basement can be especially dangerous; if the water is removed too quickly, pressure from the soaked earth outside can push inward and crack the foundation walls. In all types of residential housing flooding will most likely destroy the interior walls. Soaked wallboard becomes so weak that it must be replaced, as do most kinds of wall insulation, and any plywood in the walls is likely to swell and peel apart. Water can also dissolve the mortar in a chimney, which creates leaks and thus a risk of carbon monoxide poisoning once the heat comes back on.

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

Damages to structures, contents, and vehicles were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth damage curves were used. These curves assign loss as a percentage of value for each parcel or structure. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on structure type.

The depth-damage relationships for the primary structure types, contents, and vehicles are shown in the following figures below. SFR1 and SFR2 stand for Single Family Residential 1-Story and 2-Story, respectively. The curves for these are taken from USACE Economic Guidance Memorandum (EGM) 04-01, and are shown for comparison's sake. Although the current analysis pertains only to freshwater fluvial flooding, the tables also show the saltwater curves that will likely be used once the coastal flooding models for the San Francisquito study are completed

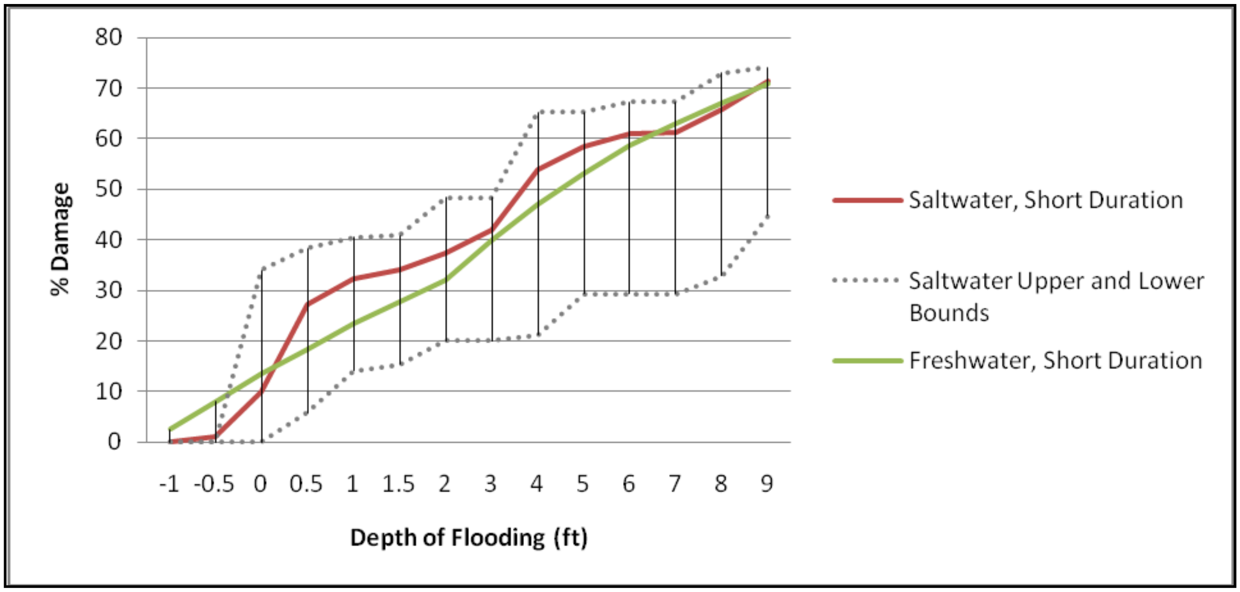


Figure 9 – SFR1 Structure Depth-Damage Curve

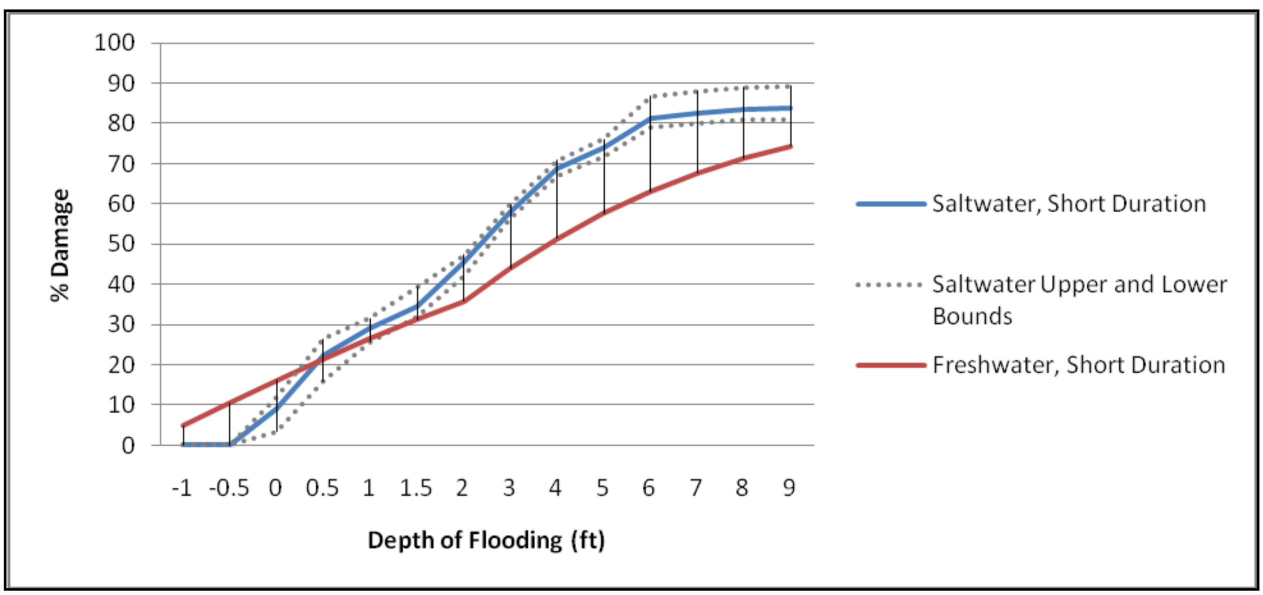


Figure 10 – SFR1 Content Depth-Damage Curve

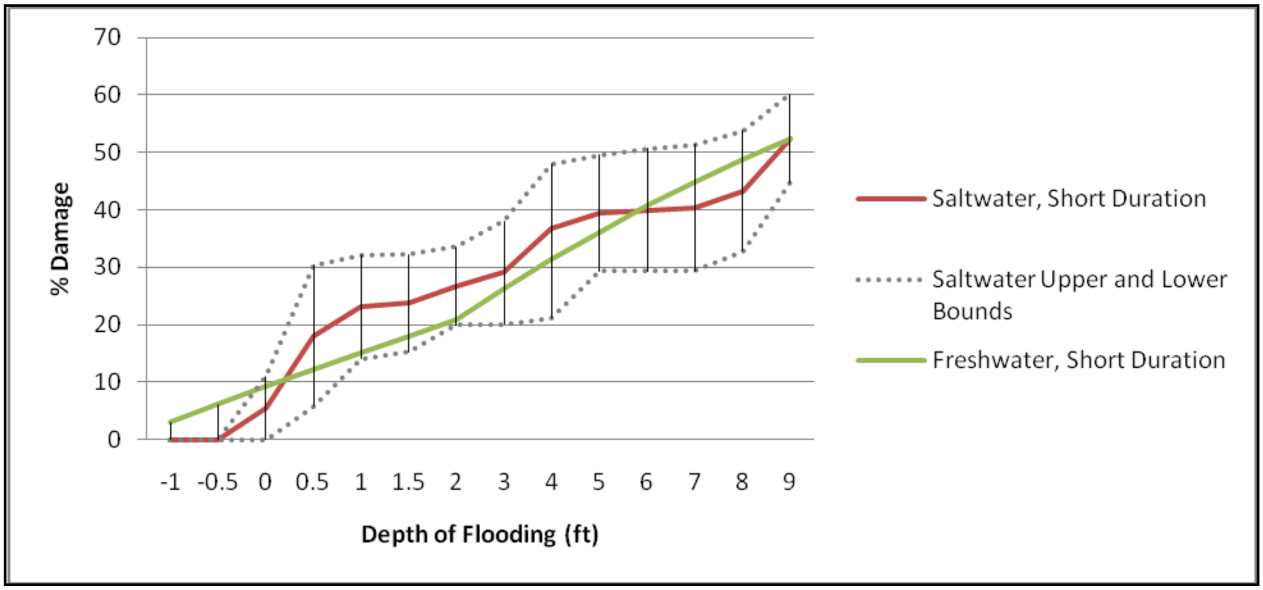


Figure 11 – SFR2 Structure Depth-Damage Curve

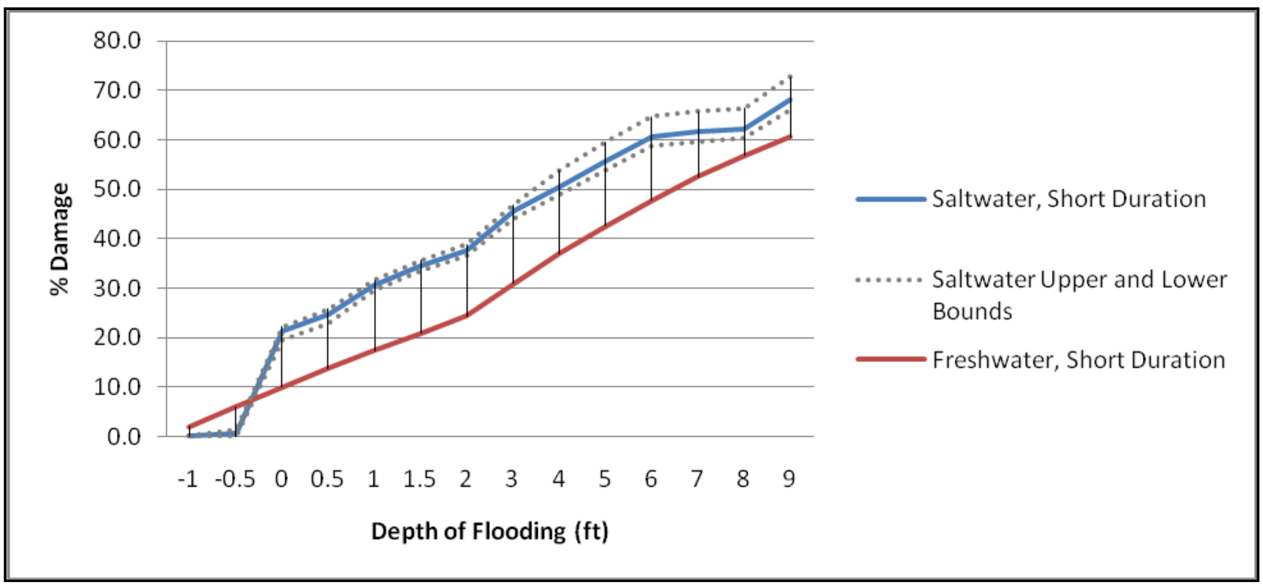


Figure 12 – SFR2 Content Depth-Damage Curve

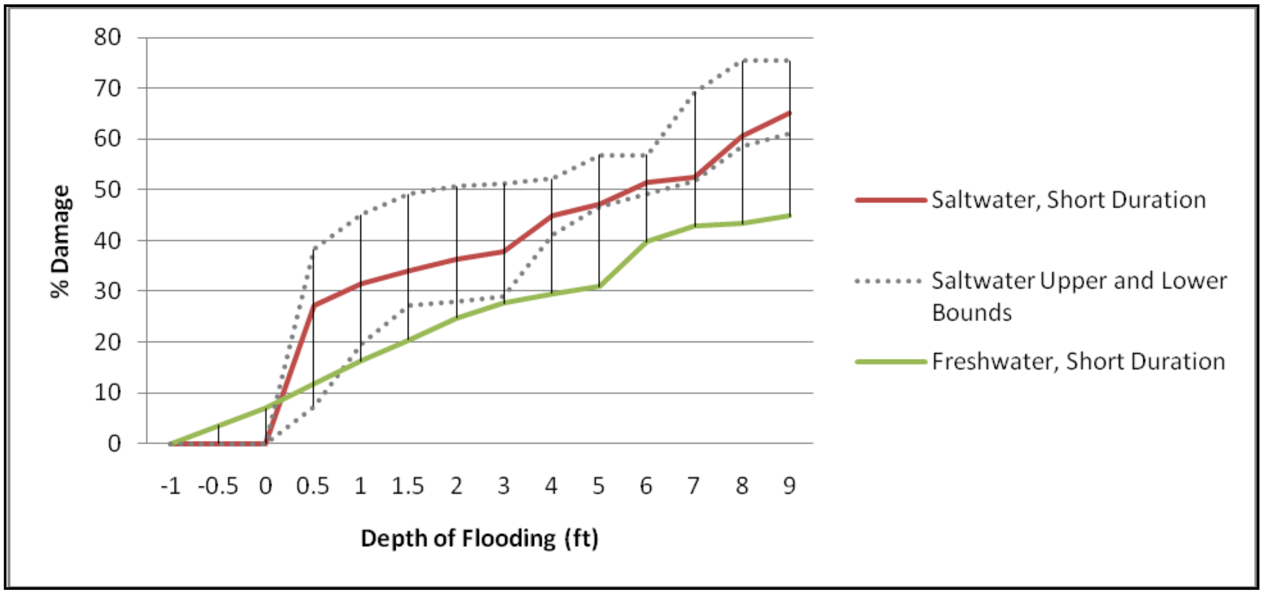


Figure 13 – Commercial Structure Depth-Damage Curve

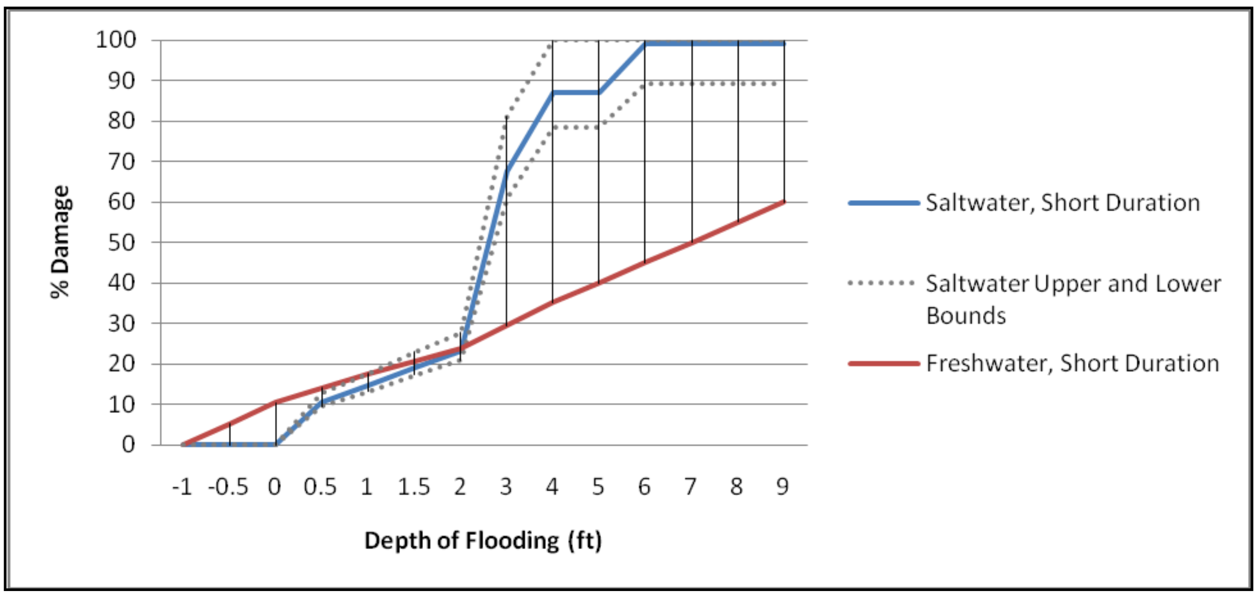


Figure 14 – Commercial Content Depth-Damage Curve

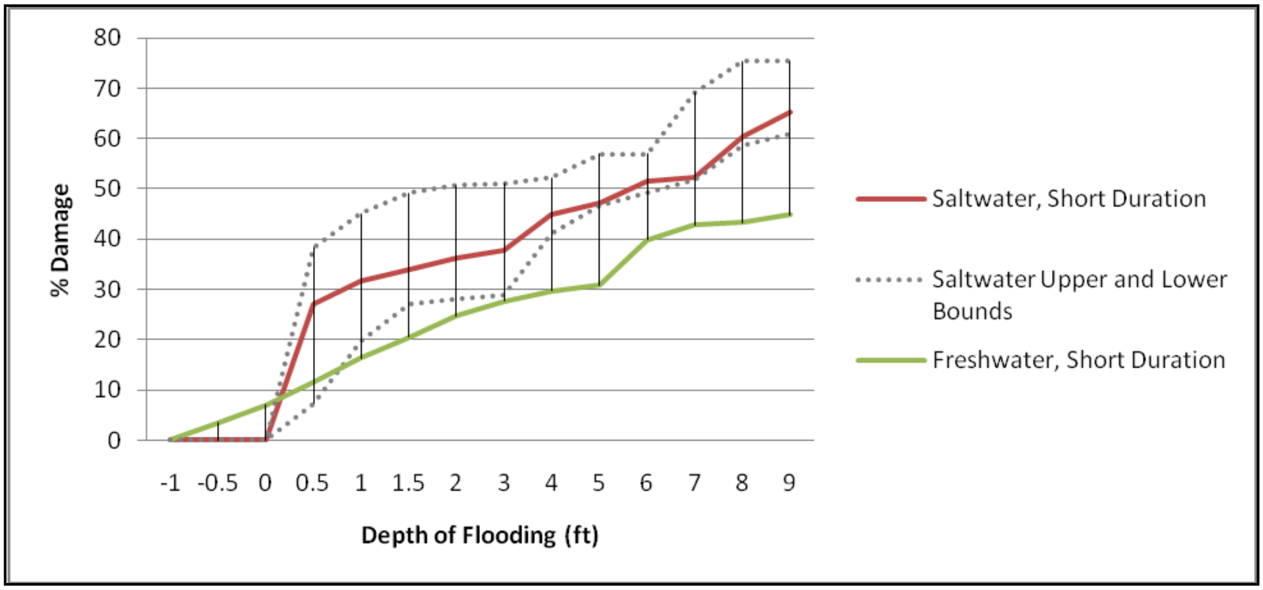


Figure 15 – Industrial Structure Depth-Damage Curve

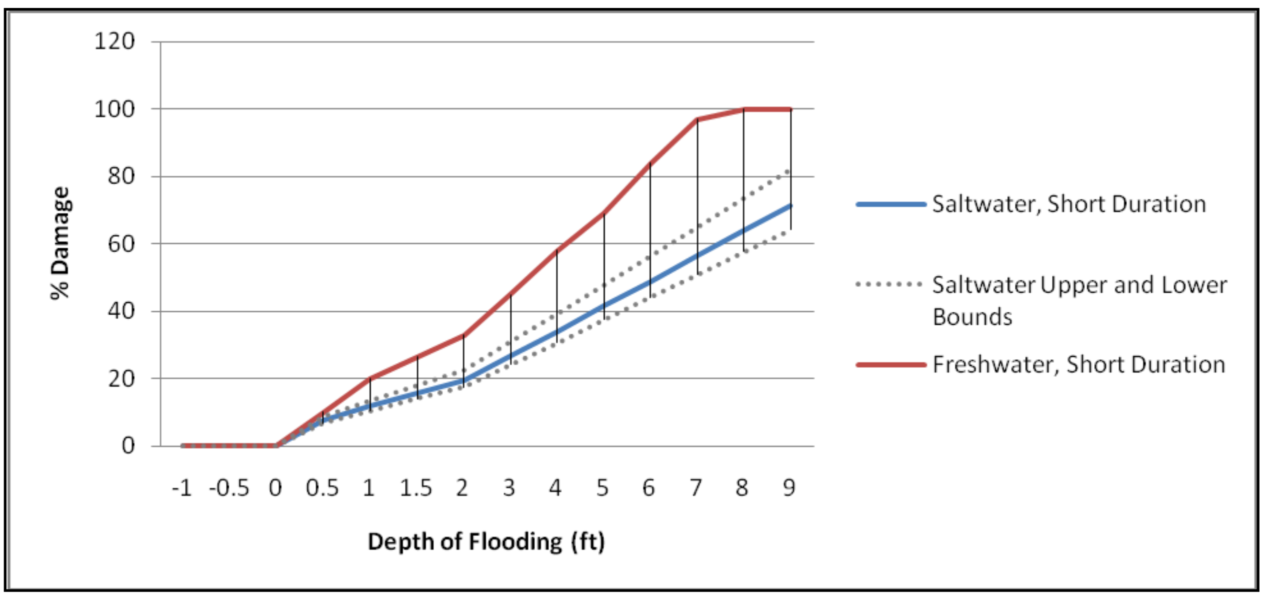


Figure 16 – Industrial Contents Depth-Damage Curve

The errors associated with the stage-%damage relationship were evaluated for structures and contents of commercial and public occupancy types. Table 1 displays the errors associated with each of the depth-%damage relationships used in this study. The standard deviations came from prior San Francisco and Albuquerque District studies, stage-%damage relationships developed by Galveston and Albuquerque Districts through post-flood surveys of property owners, and interviews with local business owners. Residential and apartment structures and contents use the IWR stage-percent damage relationships, which include errors for each stage presented. Errors associated with the depth-percent damage functions used were applied after the uncertain structure and content values were determined.

Damage to automobiles was estimated as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. Depth-damage relationships for autos come from USACE Economic Guidance Memorandum (EGM) 09-04 and modified based on weighted average of distributions of car types (SUV, truck, sedan, sports car, etc) in California. Damages for autos begin once flood depth has reached 0.5 feet, and this damage curve can be seen in the figure below. Since these curves were developed for freshwater flooding, they can be expected to slightly understate the damages from flooding, but they are assumed to be reasonable for use in this study.

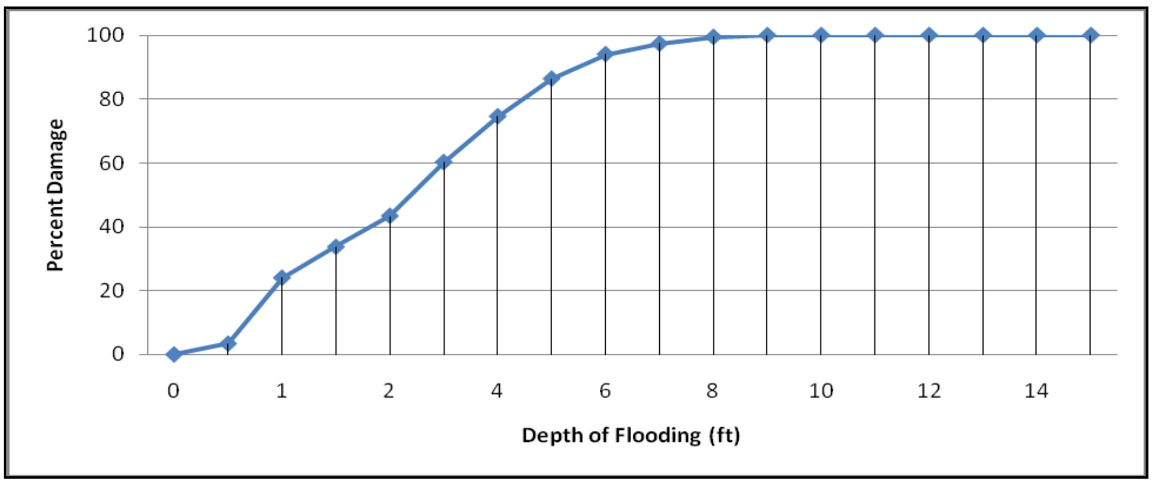


Figure 17 – Vehicle Depth-Damage Curve

Source: USACE Economic Guidance Memorandum (EGM) 09-04

According to the U.S. Census, the average number of vehicles at households in the study area is just less than two. Specifically, it's 1.94 per household in San Mateo County and 1.99 vehicles per household in Santa Clara County (U.S. Census Bureau, 2011-2015 American Community Survey 5-Year Estimates). In general there should be significant warning time before a potential flood event, since regional gauges and storm tracking should effectively inform the communities of an approaching risk. The survey described in EGM 09-04 indicates that when there is greater than twelve hours warning time, almost 90% of residents are expected to move at least one vehicle to higher ground. The EGM does not indicate the percentage that moved both vehicles to higher ground. For this analysis, it will be assumed that all households remove at least once vehicle out of the floodplain. Vehicles that were exposed to flood risk are assumed to be at the ground elevation.

F-05 HEC-FDA Use

Consistent with the requirements set forth in EC 1105-2-412, "Assuring Quality of Planning Models" HEC-FDA version 1.4.2 was used to compute average annual and equivalent annual damages (EAD). Corps guidance stipulates that the plan which reasonably maximizes net national economic development benefits, consistent with the Federal objective, be identified. Project benefits for flood risk management measures are identified through successive iterations of existing and future without-project scenarios, changing key hydrologic and/or hydraulic variables as the measures warrant. HEC-FDA is the only model certified for formulation and evaluation of flood risk management plans using risk analysis methods, and was used in this study. Damages are computed in August, 2017 price levels using the fiscal year 2018 Federal discount rate of 2.75%. The period of analysis is 50 years.

There were special conditions in the Corte Madera Creek study area that required changes to how HEC-FDA performs its analysis. First, HEC-FDA is set up expecting an incised channel with overbank flooding areas higher than the channel.

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in the magnitude of the damage. The GIS database contained spatially-referenced polygons for each parcel in the study area, as well as locations of structures and other improvements (e.g. swimming pools). Each parcel was then assigned one or more structures in order to quality check the field inventory at the parcel. Figure 1 shows an example of the location of the structures in a residential area of the floodplain. Using GIS, the economist developed data tables containing depths at each structure for each probability event modeled.

The elevation of each structure in the study area - along with an adjustment for the first floor elevation (FFE) - were combined with economic data (structure and content value, uncertainty of value expressed as a standard deviation percentage, etc.) and imported into the HEC-FDA model. For all structures, the first floor elevation (FFE) was observed in the field and applied with uncertainty to the population of structures in the study area.

F-06 Potential Flood Damages:

It is currently estimated that the mean 1-percent chance exceedance flood would cause damages of about $36.4 million in the study area. Table 4 presents the single occurrence damages associated with the 50%, 20%, 10%, 4%, 2%, 1%, 0.4% and 0.2% chance flows in the assorted floodplains. These tables were generated using HEC-FDA results for descriptive purposes only, to better understand the nature of the damages reported by HEC-FDA. HEC-FDA does not generate point estimates of flows, stages, or damages for a specific event. The software, essentially, performs a statistical analysis of hydrology, hydraulic, and economic information using concepts of risk and uncertainty, meaning that a specific event frequency can have a range of flows, stages, and damages as a result of all the variables entered into the study. HEC-FDA was used to compute average and equivalent annual damages for structures and their contents only. Other damage categories were evaluated by identifying damages associated with the same event frequencies, as described below. This study's hydrology and hydraulic evaluations assume that flood events of a magnitude greater than the 10% chance event damage structures, contents, and vehicles in the flooding areas analyzed. It should be noted that many intangible damages (such as loss of life, disruption to community services, and increased health risks) that could occur because of flooding are not represented in these damage values.

Future flood damages resulting from basin development or growth in the floodplain have not been included, but are not expected to be significant for several reasons. 1) The study area is largely developed, with all developable space taken. 2) Local Realtors contacted noted that growth in the study area has been flat and may remain stagnant in the future. Much of the development that does occur is characterized by retrofitting and refurbishing activity.

Future flood damages to existing properties are expected to remain consistent. Several tables in this appendix show existing conditions information, information for conditions 50 years hence. Figure 18 presents Expected Annual Equivalent damages and benefits, discounting future values to present value for purposes of selecting the NED plan.

F-07 Average Annual Damages:

Risk and uncertainty analysis was used to derive average annual damages. Hydrologic and hydraulic uncertainty was combined through Monte Carlo simulations within HEC-FDA. When flooding from all sources is considered, the study area presently faces the risk of approximately $3.7 million in average annual damages to structures and contents. Figure 18 presents the average annual damages that could occur from flooding in the study area without any flood protection, by land use category and floodplain.

Equivalent Annual Damage Analysis

File Help

study
Equivalent Annual Damage by Damage Categories and Plans
(Damage in $1,000)

Discount Rate: 2.750
Analysis Period: 50 Years
Version 1.4.2, July 2017; Less Simple Method (0.010)

Plan Name	Plan Description	Equivalent Annual Damage for Damage Categories									Total Damage
		Apartment	Clean-Up	Commercial	Displacement	Outbuildings	Public	Residential	Something Else	Vehicles	
Without	Without project condition	52.81	253.39	1574.78	32.34	34.26	1239.64	452.53	0.00	77.65	3717.41

Figure 18 – Expected Annual Damages computation

This estimate was evaluated against HEC-FDA's FDA_StrucDetail.out file, which contains a "non-risk" evaluation of the impacts of the 8 modeled events (0.2%, 0.4%, 1%, 2%, 4%, 10%, 20%, 50%) on the floodplain inventory. Table 6, above, contains the damages by event and property type, which is generated from this file. Plotting those damages in a probability-damage space and computing the area under that curve gives the user a "non-risk" estimate of Average Annual Damages faced by the study area. Tables xx and xx show that calculation. There wasn't much change between the figures between the present and future condition so no EAD calculation was performed in this quality check of the HEC-FDA output.

EAD Verification	From FDA_StrucDetail.out			**Present Condition**	
				Total (x$1,000)	
00			45,398.97		
		0.002		45,398.97	90.80
500 yr	0.002		45,398.97		
		0.002		43,558.79	87.12
250 yr	0.004		41,718.60		
		0.006		39,076.65	234.46
100 yr	0.01		36,434.69		
		0.01		34,714.28	347.14
50 yr	0.02		32,993.86		
		0.02		30,506.99	610.14
25 yr	0.04		28,020.13		
		0.06		23,933.96	1,436.04
10 yr	0.1		19,847.80		
		0.1		10,079.03	1,007.90
5 yr	0.2		310.26		
		0.3		163.63	49.09
2 yr	0.5		17.00		
		0.01		8.50	0.08
SOD	0.51		0.00		
					3,862.69

Table 9 – Average Annual Damage calculation "without risk", present condition

EAD Verification	From FDA_StrucDetail.out			**Future Condition**	
				Total (x$1,000)	
00			45,331		
		0.002		45,330.75	90.66
500 yr	0.002		45,331		
		0.002		43,295.09	86.59
250 yr	0.004		41,259		
		0.006		38,363.32	230.18
100 yr	0.01		35,467		
		0.01		33,246.31	332.46
50 yr	0.02		31,025		
		0.02		28,995.94	579.92
25 yr	0.04		26,966		
		0.06		23,379.51	1,402.77
10 yr	0.1		19,793		
		0.1		10,053.05	1,005.30
5 yr	0.2		314		
		0.3		165.26	49.58
2 yr	0.5		17		
		0.01		8.50	0.08
SOD	0.51		0		
					3,777.47

Table 10 – Average Annual Damage calculation "without risk", future condition

F-08 Alternatives Considered:

Several alternatives of varying sizes were developed to address the flooding problems in the study area. Briefly, they are described in Table XX, below. The effects of those alternatives were evaluated in a framework incorporating elements of risk and uncertainty in hydrology, hydraulics and economics. Any analysis of alternatives must include the no action alternative. If no action is taken, the floodplains defined by the study will continue to suffer damages described in Tables F-6A to F-6C.

The table which follows describes how the alternatives were selected to contain specific flood events. Given the Risk and Uncertainty framework used in plan selection, it is inappropriate to describe an alternative in terms of "level of protection." However, each of these alternatives were designed to contain flows associated with the mean 4% AEP event in order to get a reasonable start to the comparison of alternatives. Smaller project sizes were deemed ineffective and larger project sizes were unlikely to be implemented in the available space. The PDT knew that large projects involving real estate acquisitions would be very expensive in Marin County.

Project performance measurements (formerly known as Reliability) are discussed in paragraph F-16.

ALTERNATIVES EVALUATED

Alternative Description

No Action	No structural feature is designed or modeled. This alternative describs the without-project and future, without-project condition. Other alternatives are compared to this one to evaluate impacts of those alternatives.
Alternative A	Alternative A would construct top-of-bank floodwalls along the length of Unit 4. Top-of-bank floodwalls would be constructed along Units 2 and 3 with setback floodwalls (floodwalls located away from channel) at the downstream end of Unit 2 near Kent Middle School.
Alternative B	Alternative B would utilize a combination of top-of-bank and setback floodwalls. For College of Marin widening, the concrete channel would be removed in portions of Unit 3 (around the College of Marin) and Unit 2 (around Kent Middle School) and replaced with features that replicate a natural tidal creek.
Alternative F	Alternative F would utilize a combination of top-of-bank and setback floodwalls, an underground bypass, Allen Park Riparian Corridor, and College of Marin widening. Alternative F would include an underground bypass culvert along Sir Francis Drake Boulevard to convey flow from the upstream portion of Unit 4 downstream to the Allen Park Riparian Corridor downstream from the Denil fish ladder. The underground bypass would alleviate the need to construct any floodwalls in Unit 4. Downstream of the Allen Park Riparian Corridor, the channel would be identical to Alternative B, including removal of 2,740 feet of concrete channel to restore natural features between Stations 345 +50 and 318+10, construction of floodwalls, and construction of box culverts at College Avenue Bridge.
Alternative G	Alternative G would utilize a combination of floodwalls, Allen Park Riparian Corridor, and College of Marin widening. This alternative is identical to Alternative F downstream of the fish ladder, but would construct floodwalls instead of bypass culverts for Unit 4. Top-of-bank floodwalls would be constructed in Unit 4 similar to Alternative A. In Units 2 and 3, construction would be identical to Alternative F.

Figures 19 to 22 depict a layout and key features of the alternatives evaluated:

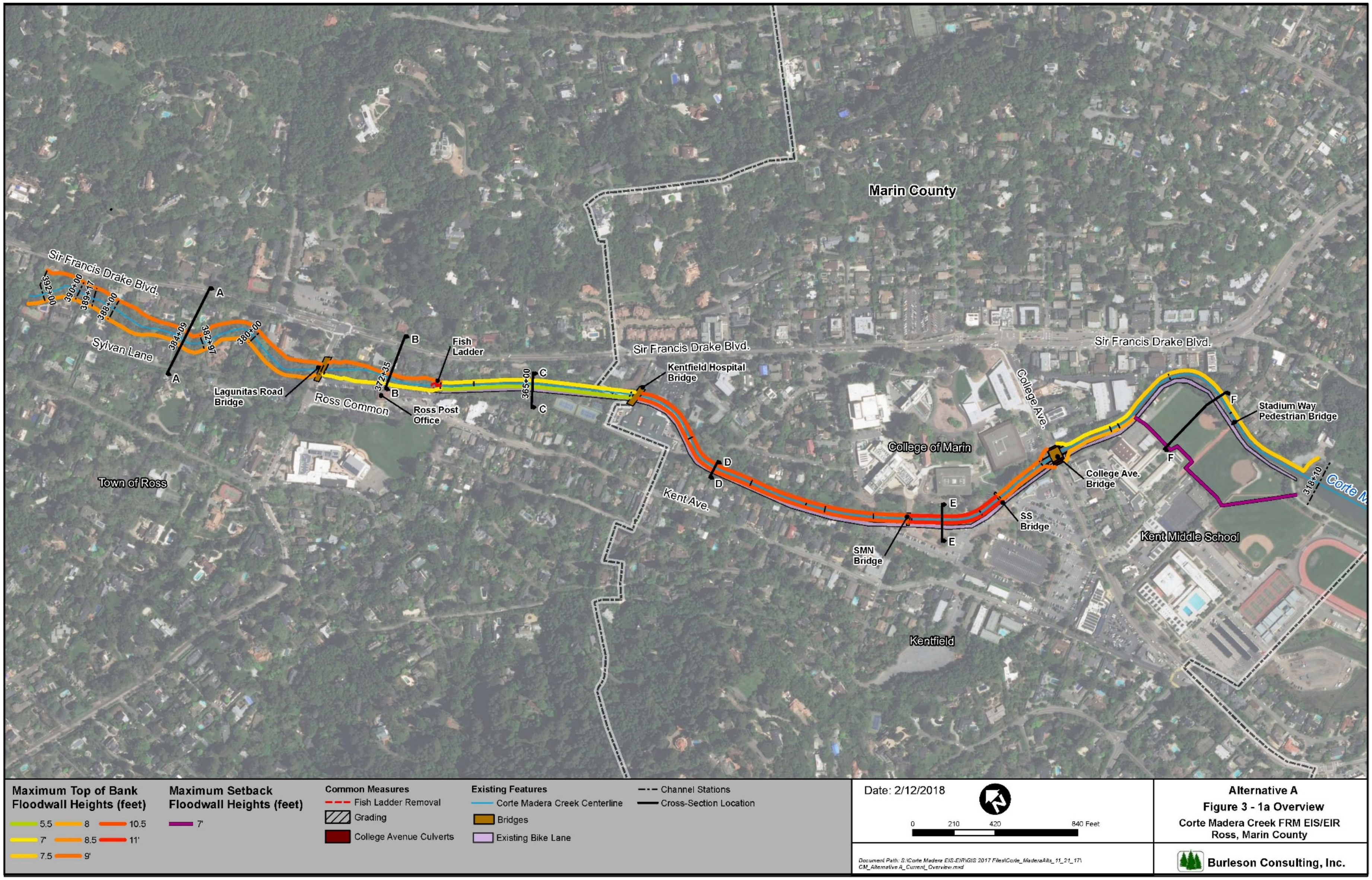


Figure 19 – Alternative A

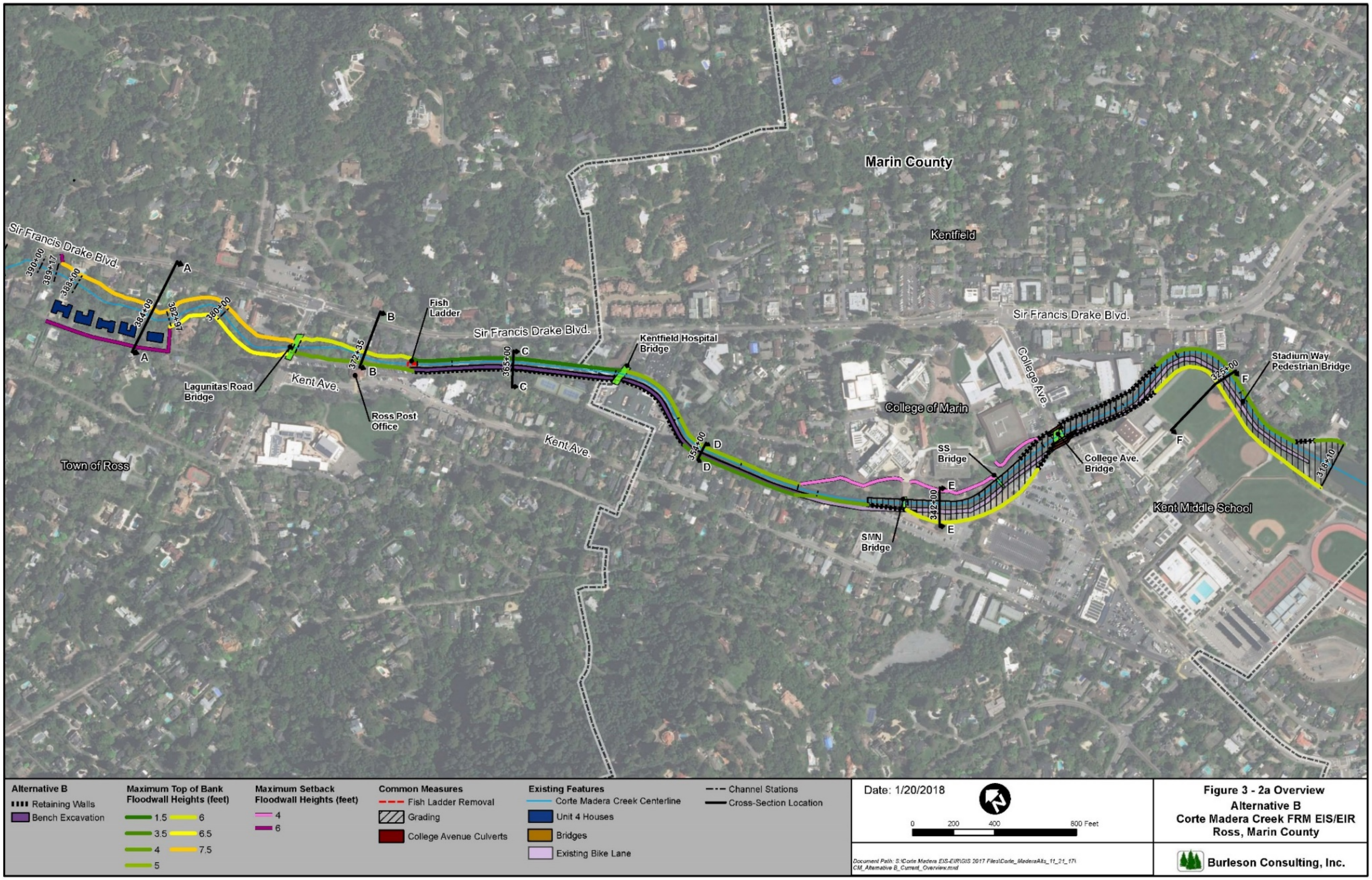


Figure 20 – Alternative B

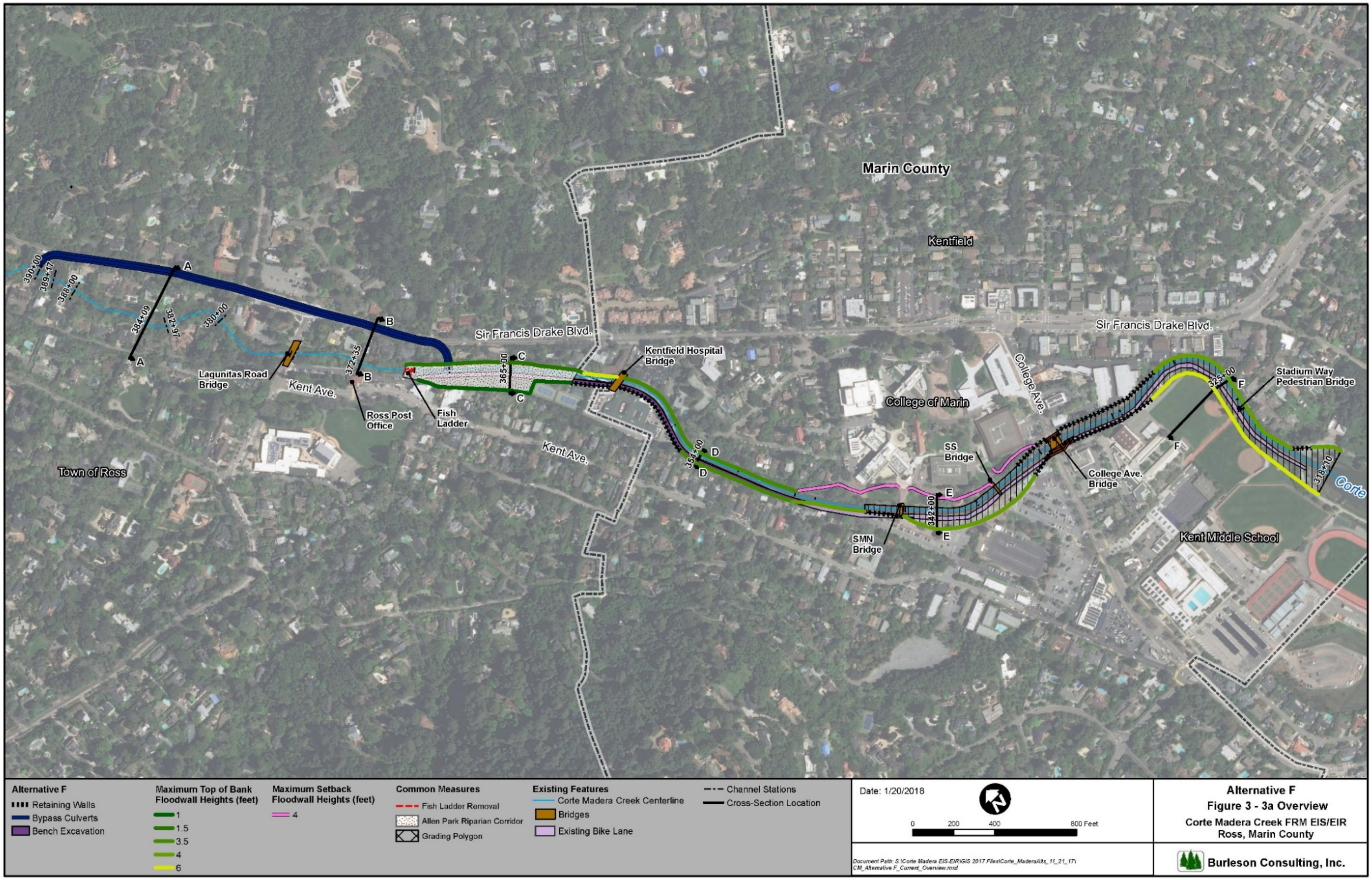


Figure 21 – Alternative F

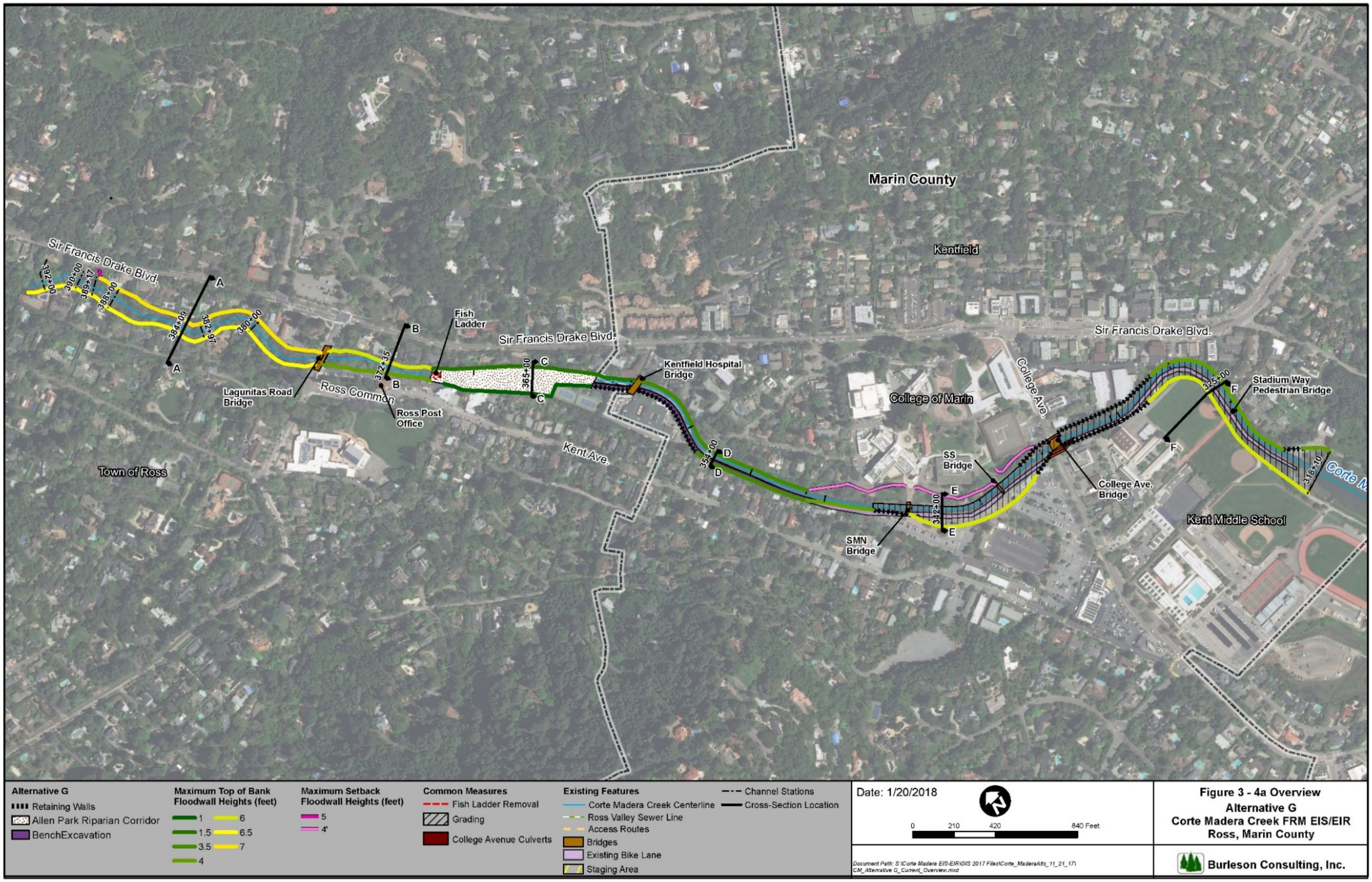


Figure 22 – Alternative G

To capture the benefits of the proposed projects, the study team evaluated the post-project depths of specific events, as a direct comparison to corresponding depths in the without-project condition, using the procedures described in Paragraph F-05 above.

F-09 Average Annual Cost:

Table F-18 shows, for each alternative and the aggraded channel future situation considered, construction cost, interest during construction, total investment cost, interest and amortization costs, and total average annual costs. The period of construction is indicated in the table with equal mid-monthly payments and no project benefits until the project is complete. The fiscal year 2018 Federal interest rate of 2.75% was used in the calculations to further refine the cost of the tentatively selected plan.

The first benefit and cost evaluation occurred in January, 2018, with results as follows:

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED PROJECT (X$1,000, January, 2018 price level)				
	1/25/2018	1/25/2018	1/25/2018	1/25/2018
	Alt. A	Alt. B	Alt. F	Alt. G
Construction Cost	57,000.00	59,600.00	72,800.00	60,800.00
Real Estate	92,393.25	75,793.62	22,317.64	75,238.27
Mitigation	1,789.30	0.00	0.00	0.00
Construction Mgt.	Included in Construction Cost			
PED	Included in Construction Cost			
Total First Cost	151,182.55	135,393.62	95,117.64	136,038.27
Construction Period (months)	25.00	26.00	28.00	28.00
IDC (XX months construction, 2.75%)*	4,353.98	4,058.32	3,075.07	4,397.99
Total Investment	155,536.52	139,451.94	98,192.70	140,436.27
Avg. Ann. Cost (2.75%, 50 yr. project life)	5,761.22	5,165.43	3,637.15	5,201.89
OMRR&R	150.00	150.00	150.00	150.00
Total Avg. Ann. Cost	5,911.22	5,315.43	3,787.15	5,351.89
Equivalent Avg. Ann. Benefits	3,546.86	3,333.77	2,938.99	3,228.61
Benefit/Cost Ratio	0.60	0.63	0.78	0.60
Net Benefits	-2,364.36	-1,981.66	-848.16	-2,123.28

Table 11 – Benefits and Costs of Alternatives, January, 2018 prices and assumptions

Following internal reviews, and after extensive consultation with reviewers and the Sponsor, the plan which was closest to meeting a BCR > 1.0 was reevaluated in hopes of finding an alternative which could meet the flood risk management needs of the study at a lower cost. Subsequent iterations of alternative development focused on variants of Alternative F and were analyzed to identify the NED plan. Post project depths at individual structures were identified, and water surface profiles were created in HEC-FDA to model the effect of alternatives. A total of six iterations of alternative screening was conducted with the goal of identifying the NED plan.

COMPARISON OF COSTS AND EQUIVALENT ANNUAL BENEFITS FOR THE PROPOSED PROJECT (X$1,000, Month, Year price level)									
Date of analysis	1/19/2018	1/19/2018	1/19/2018	3/14/2018	8/1/2018	8/1/2018	8/1/2018	3/21/2018	1/19/2018
Alternative	Alt. A	Alt. B	Alt. F	Alt. F "Scaled" - Full	Alt. F "Scaled" - 10 yr LOP	Alt. F "Scaled" - Skinny	Alt. F "Scaled" - 50 yr LOP	Alt. F "Scaled" - Skinny w/ RE	Alt. G
Construction Cost	57,000.00	59,600.00	72,800.00	27,900.00	11,485.37	16,154.99	21,919.62	22,430.00	60,800.00
Real Estate	140,446.87	112,922.07	36,256.69	13,463.84	18,159.76	19,232.26	20,304.76	21,816.24	112,695.58
Mitigation	1,789.30	0.00	0.00	0.00	0.00	0.00	0.00	1,825.82	0.00
Construction Mgt.	0.00	0.00	0.00	0.00	1,148.54	1,615.50	2,191.96	0.00	0.00
PED	0.00	0.00	0.00	0.00	2,297.07	3,231.00	4,383.92	0.00	0.00
Contingency (28%)	0.00	0.00	0.00	0.00	4,180.67	5,880.42	7,978.74	0.00	0.00
Total First Cost	199,236.17	172,522.07	109,056.69	41,363.84	37,271.41	46,114.17	56,779.00	46,072.06	173,495.58
Construction Period (months)	25.00	26.00	28.00	28.00	28.00	28.00	32.00	28.00	28.00
IDC (XX months construction, 2.75%)*	5,737.89	5,171.21	3,525.70	1,337.25	1,204.95	1,490.83	2,072.05	1,422.43	0.00
Total Investment	204,974.06	177,693.29	112,582.39	42,701.10	38,476.36	47,605.00	58,851.06	47,494.49	173,495.58
Avg. Ann. Cost (2.75%, 50 yr. project life)	7,592.43	6,581.92	4,170.16	1,581.69	1,425.20	1,763.33	2,179.90	1,759.24	6,426.44
OMRR&R	1,140.00	1,192.00	1,456.00	558.00	250.00	265.00	400.00	448.60	1,216.00
Total Avg. Ann. Cost	8,732.43	7,773.92	5,626.16	2,139.69	1,675.20	2,028.33	2,579.90	2,207.84	7,642.44
Equivalent Avg. Ann. Benefits	3,546.86	3,333.77	2,938.99	2,497.60	1,867.43	2,558.60	3,044.68	2,558.60	2,467.70
Benefit/Cost Ratio	0.41	0.43	0.52	1.17	1.11	1.26	1.18	1.16	0.32
Net Benefits	-5,185.57	-4,440.15	-2,687.17	357.91	192.23	530.27	464.78	350.76	-5,174.73

Table 12 – Benefits and Costs of Alternatives various months, 2018 prices and assumptions

Table 13 demonstrates the product of that iterative analysis, where the plan which maximizes net NED benefits is a modification to Alternative F, which is depicted in Figure 23 , below.

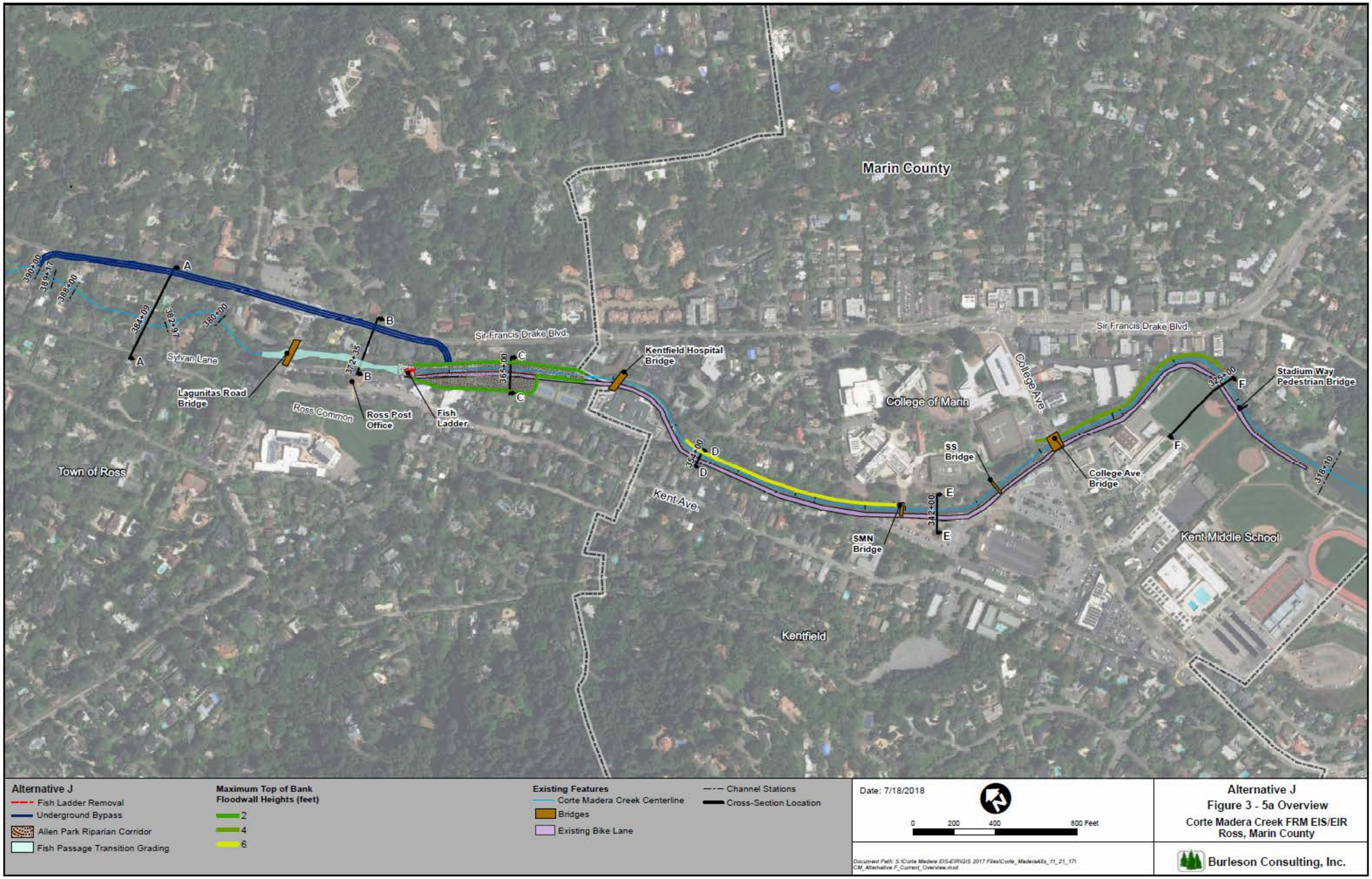
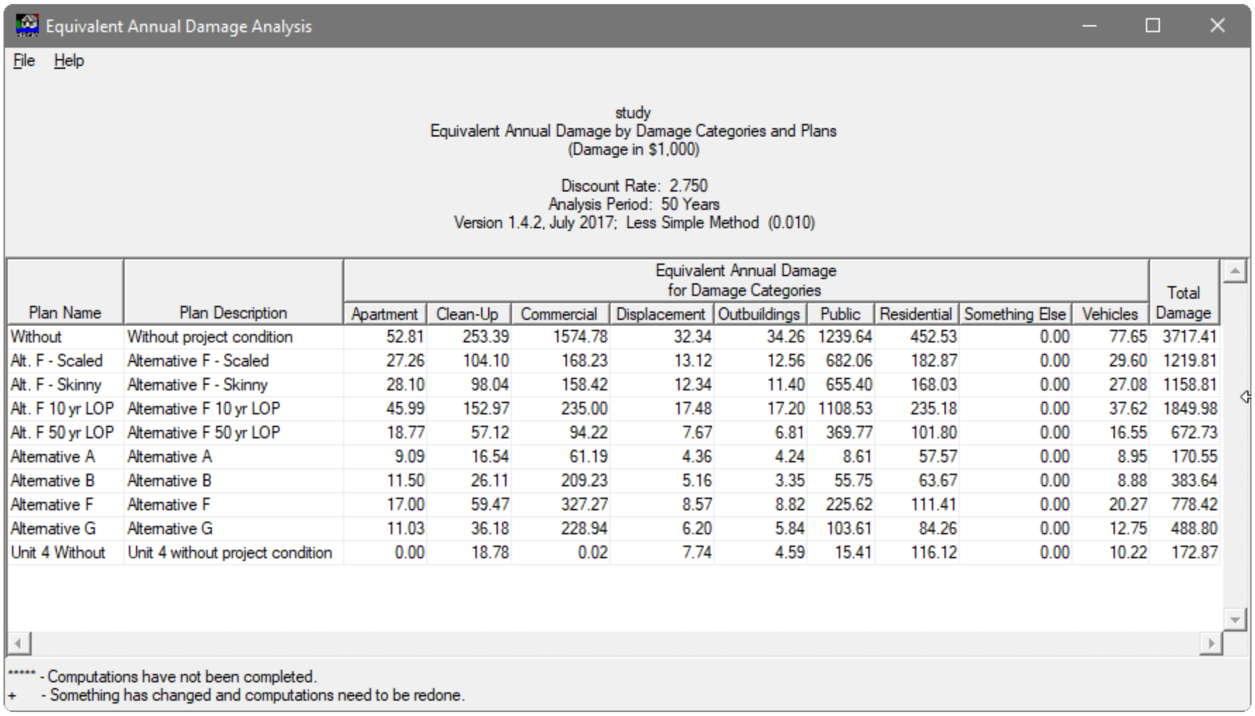


Figure 23 – Modified Alternative F

F-10 Average Annual Benefits:

Figure 24 shows Equivalent Annual Damages (EAD), for the without project and the analyzed alternatives. The difference between the EAD and the residual damages for each of the alternatives analyzed represents the benefits of the proposed alternatives. Those benefits are depicted in Table XX.



Equivalent Annual Damage Analysis

File Help

study
Equivalent Annual Damage by Damage Categories and Plans
(Damage in $1,000)

Discount Rate: 2.750
Analysis Period: 50 Years
Version 1.4.2, July 2017; Less Simple Method (0.010)

Plan Name	Plan Description	Equivalent Annual Damage for Damage Categories									Total
		Apartment	Clean-Up	Commercial	Displacement	Outbuildings	Public	Residential	Something Else	Vehicles	Damage
Without	Without project condition	52.81	253.39	1574.78	32.34	34.26	1239.64	452.53	0.00	77.65	3717.41
Alt. F - Scaled	Alternative F - Scaled	27.26	104.10	168.23	13.12	12.56	682.06	182.87	0.00	29.60	1219.81
Alt. F - Skinny	Alternative F - Skinny	28.10	98.04	158.42	12.34	11.40	655.40	168.03	0.00	27.08	1158.81
Alt. F 10 yr LOP	Alternative F 10 yr LOP	45.99	152.97	235.00	17.48	17.20	1108.53	235.18	0.00	37.62	1849.98
Alt. F 50 yr LOP	Alternative F 50 yr LOP	18.77	57.12	94.22	7.67	6.81	369.77	101.80	0.00	16.55	672.73
Alternative A	Alternative A	9.09	16.54	61.19	4.36	4.24	8.61	57.57	0.00	8.95	170.55
Alternative B	Alternative B	11.50	26.11	209.23	5.16	3.35	55.75	63.67	0.00	8.88	383.64
Alternative F	Alternative F	17.00	59.47	327.27	8.57	8.82	225.62	111.41	0.00	20.27	778.42
Alternative G	Alternative G	11.03	36.18	228.94	6.20	5.84	103.61	84.26	0.00	12.75	488.80
Unit 4 Without	Unit 4 without project condition	0.00	18.78	0.02	7.74	4.59	15.41	116.12	0.00	10.22	172.87

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Figure 24 – EAD and residual damages for the analyzed alternatives

Plan	EAD (2.75%)	Benefits (x$1,000)
Without	$3,717.41	
Alt. F - Scaled	$1,219.81	$2,497.60
Alt. F - Skinny	$1,158.81	$2,558.60
Alt. F 10 yr LOP	$1,849.98	$1,867.43
Alt. F 50 yr LOP	$672.73	$3,044.68
Alternative A	$170.55	$3,546.86
Alternative B	$383.64	$3,333.77
Alternative F	$778.42	$2,938.99
Alternative G	$488.80	$3,228.61

Table 13 – Benefits of Alternatives, 2018 prices , 2.75% discount rate

F-11 Sensitivity Analyses:

Figure 1, above, shows the location of the floodplain inventory used in this analysis. As stated previously, the floodplain inventory was spatially positioned in GIS and then depths were selected by event for each and every structure subject to flooding. This data selection provides 8 event information for 480 locations within the floodplain. HEC-FDA requires some sort of grouping of this information into what it terms "damage reaches" which are specific geographical areas within a floodplain. Those damage reaches "are used to define consistent data for plan evaluations and to aggregate structure and other potential flood inundation damage information by stage of flooding." (HEC-FDA User's Manual, page 3-6). The User's Manual elaborates to say that damage reach delineation is important for the HEC-FDA computational engine, as results are aggregated to the defined index points for the damage reach.

Index point identification has become a rather significant issue in HEC-FDA study development. Experience on this and other FRM projects has indicated that care must be taken to look over how index points were selected and observe those impacts on damage and benefit calculations. For this study, index point and damage reach identification can alter Federal interest determination. This section explores some sensitivity runs that were conducted to evaluate this issue as it pertains to the Corte Madera study area.

Figure 18, above, shows EAD for the study area. That figure is reasonably close to the "non-risk" computations of average annual damages in the present condition (Table xx) and the future condition (Table xx). This particular data run uses an index point in the channel just upstream of the Lagunitas Road crossing, which was used on the advice of the PDT's hydraulic engineer. Other data runs were computed, changing the index point based upon specific assumptions. The "additive" and "subtractive" WSP runs built index points based upon the arithmetic mean of nonzero depths for all 480 water surface profile locations. HEC-FDA doesn't function if depths don't increase with increasing event severity, so occasionally, users must manually add 0.01' to, for instance, the 4% event depth at the index point to ensure it's greater than the 10% depth at the index point. This addition is the key assumption behind the "additive" WSP run. The "subtractive" WSP run subtracts 0.01' from an event to ensure the less severe event produces less depth at the index point if needed. A third sensitivity run was computed using the arithmetic mean of all depths (including zeroes) and adding 0.01' to previous events to ensure the index point's rating curve wasn't flat. Table xx shows the results of these sensitivity runs, and demonstrates that the assumptions governing index point rating curve development have significant impacts on EAD calculation.

Assumption	EAD
Adopted (Lagunitas index point)	$3,717.41
Additive WSP	$10,639.82
Subtractive WSP	$2,046.44
Arithmetic mean (incl. zeroes)	$3,022.75
Random index points	$13,520.30
Random index points ver. 2	$3,022.95

Table 14 – Index point sensitivity runs, 2018 prices , 2.75% discount rate, x$1,000

Two other sensitivity runs were developed, disaggregating the floodplain inventory into damage reaches that were consistent with prior iterations of this study and then selecting two random structures to represent each damage reach. Those two HEC-FDA runs indicated that index points that weren't in common event floodplains could skew the EAD calculations much higher. The second pass of "Random index points" picked random locations that were within the 10% AEP floodplain.

Ultimately, index point selection has proven to be a significant determinant of damages and benefits of proposed work. HEC-FDA requires an index point, but that point can significantly impact Federal interest determination. The fix MIGHT be to sample an index point from the grid cells or structures that are sampled to make water surface profiles, but it's unclear what constitutes a representative data point. Appendix E of the HEC-FDA User's Manual indicates the index points are used to simplify the process to calculate stage-aggregated damage "with risk." HEC-FDA puts a lot of weight on the index point in a time when hydraulics essentially can build a rating curve for individual structures in a floodplain.

A sample that reduces sampling error would have, at a minimum, too many data points to manage (https://www.research-advisors.com/tools/SampleSize.htm). That's unwieldy for the HEC-FDA user, as those index points need event-depth relationships built. That's done manually in the software, and it's unreasonable to do that for present conditions, future conditions in the without AND each alternative that's developed.

The FDA_StrucDetail.out file presents an event-damage relationship "without risk" to see if the FDA output is close, which indicates the index point near Lagunitas road is a reasonable approximation of the flood risk in the study area.

F-12 Benefit-Cost Comparisons and Plan Selection:

Table xx, above, displays annualized equivalent annual benefit and cost information, discounting future benefits of flood control (which increases due to sediment aggradation along most reaches) and amortizing those benefits over the project life. Figure 25 displays the optimization curve for the recommended Alternative and all sizes considered. Alternatives that were deemed to have costs in excess of benefits were not added to the optimization.

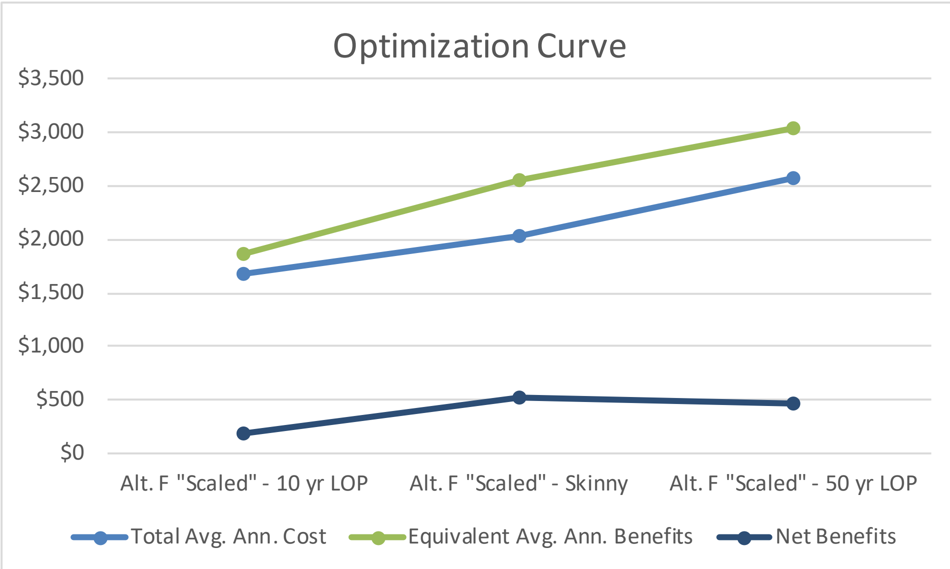


Figure 25 - Optimization Curve

F-13 Impact of Addressing Flood Risk in Four Accounts (NED, NER, OSE, RED):

The Principles and Guidelines establish four accounts to facilitate the evaluation and display of effects of alternative plans. They are described in ER 1105-2-100, para. 2-3. Engineering Circular EC 1105-2-409 further dictates that any alternative plan that has net beneficial effects across the four USACE Planning & Guidance (P&G) accounts may be the recommended plan. Furthermore, "highest budgetary priority will be given to collaborative planning activities that embrace the full range of the national Federal interest." The evaluation of the tentatively selected plan against those accounts follows:

- The National Economic Development (NED) Account displays changes in the economic value of the national output of goods and services. The damages and benefits described in this appendix describe NED impacts of flooding in the study area and the effects of alternatives designed to address the flood threat.

- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans. The array of plans described in this appendix have flood risk management as their stated goals.

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

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

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

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

The Regional Economic Development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment). This account can also capture the regional impacts of a large capital infusion of project implementation dollars on income and employment throughout the study area through the use of income and employment multipliers. The important point to be made here is that a large infrastructure project in the study area will have a positive impact on local income and employment.

- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. OSE is defined by EC 1105-2-409, "The other social effects account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts". Measurement of OSE effects is generally qualitative; however quantitative data is encouraged within available and accepted methods.

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

  There are three schools in the floodplain, and, given that a large storm event is most likely to occur in the non-summer months, flooding of these facilities represents a significant inconvenience and cost to the affected communities. In the aftermath of the flooding, many of these schools would require extensive cleanup and repair before reopening to students and teachers. Many parents would be forced to miss some amount of work in order to care for young children that would normally be attending the affected schools.

In most cases, impacts of proposed projects not covered in other accounts are described and evaluated here. Generally, the plans described here meet USACE criteria for project adequacy (completeness, effectiveness, efficiency, and acceptability). Residual risk of implementing channels and flow conveyances of various sizes is described in Para. F-12 of this appendix. In the unfortunate circumstance that the proposed channels were exceeded, the resultant flood magnitude, timing, and duration is not expected to become even more severe than the without-project and without-project, future condition. In fact, the proposed project features could attenuate events that exceed the project's containment capacity.

The floodplain is roughly 0.5 miles wide, and sits around and right up against Corte Madera Creek. In the event of a flood, warning times may prevent evacuation, but flood velocities are not expected to be sufficient to dislodge vehicles using local roads, however, the field inventory did not identify any high water marks as the floodplain is generally flat, and does not include low water crossings, although there may be unexpected areas with more flood depth due to local topography. Most flood fatalities occur in vehicles moving through the floodplain (http://www.nws.noaa.gov/oh/hic/flood_stats/recent_individual_deaths.shtml, accessed 9/5/18).

F-14 Project Performance:

Besides a strict benefit/cost comparison, another measure of the effectiveness of flood protection is its ability to contain damaging floods where there was limited protection before. Limitations of the analysis package preclude a rigorous analysis of project performance, but inspection of the available data could provide decision makers a glimpse of the nature of the flood problem and how the project will act to contain it. Table xx presents the likelihood of flood stages being exceeded by specific flood events at each cross section used within the study in the without and with-project, future conditions. One scenario was developed to describe the effectiveness of the various alternatives considered.

Vulnerable location identified –

The index point in channel just upstream of Lagunitas Road was selected in the without project scenario where the flood flow would best represent the flood risk to the study area. Project performance was evaluated at that reference point for all project sizes that effect that location. For each alternative and project size, that reference point was selected for the events analyzed would exceed the start of damages most often. For purposes of this analysis, this reference point is important in that start of damages flows occur most frequently, thus the term "vulnerable location" is applied. The vulnerable location does not move to other reference points as various project sizes and configurations are applied to the floodplain. With that in mind, project performance tables indicate only project performance at the index point, as there are several other reference points where project protection is much improved. Project benefits of the various alternatives could be a combination of complete removal of a structure from a specific frequency floodplain or lower damages for a specific frequency event as the project alternatives attenuate floodplain depths.

Table 15 presents the probability that the recommended alternative, and various sizes of that alternative, would contain the specified events, for the present and future conditions. This table also presents the probability that each evaluated alternative would be exceeded on an annual basis by damaging flood events and the long term risk of exceedance (likelihood that project will be exceeded over an extended time frame) for indicated time frames.

Corte Madera Creek
Project Reliability Estimates

Without Porject Base Year Performance Target Criteria
Event Exceedance Probability 0.01
Residual Damage 5% Present Condition

		Target Stage Annual Exceedance Probability		Long Term Risk Years			Conditional Non-Exceedance Probability by Events					
Plan	Target Stage	Median	Expected	10	30	50	10.0%	4.0%	2.0%	1.0%	0.4%	0.2%
Without	13.07	0.1647	0.1714	0.8474	0.9964	0.9999	0.06	0	0	0	0	0
Alt. F - Scaled	13.07	0.0359	0.0408	0.3409	0.7136	0.8756	0.9997	0.5282	0.2043	0.047	0.0117	0.0052
Alt. F - Skinny	13.07	0.0317	0.0389	0.3276	0.696	0.8625	0.9998	0.5581	0.2655	0.0779	0.0224	0.0101
Alt. F 10 yr LOP	13.07	0.0356	0.0474	0.3844	0.7667	0.9116	0.9046	0.5537	0.2089	0.0485	0.0118	0.0068
Alt. F 50 yr LOP	13.07	0.0206	0.0227	0.205	0.4975	0.6824	0.9997	0.8939	0.4725	0.0204	0.002	0
Alt. A	13.07	0.0441	0.0495	0.3981	0.7819	0.921	0.9992	0.3649	0.0038	0.0016	0	0
Alt. B	13.07	0.0449	0.0505	0.4045	0.7889	0.9251	0.9988	0.346	0	0	0	0
Alt. F	13.07	0.0286	0.0377	0.3187	0.6837	0.8532	0.9998	0.5438	0.3023	0.086	0.0293	0.0145
Alt. G	13.07	0.0437	0.0488	0.3939	0.7773	0.9182	0.9993	0.3783	0.0088	0.0029	0	0

Without Porject Base Year Performance Target Criteria
Event Exceedance Probability 0.01
Residual Damage 5% Future Condition

		Target Stage Annual Exceedance Probability		Long Term Risk Years			Conditional Non-Exceedance Probability by Events					
Plan	Target Stage	Median	Expected	10	30	50	10.0%	4.0%	2.0%	1.0%	0.4%	0.2%
Without	13.06	0.159	0.1661	0.8375	0.9957	0.9999	0.0536	0	0	0	0	0
Alt. F - Scaled	13.06	0.0295	0.0383	0.3233	0.6901	0.8581	0.9998	0.5336	0.2864	0.0842	0.0298	0.0151
Alt. F - Skinny	13.06	0.0262	0.0365	0.3102	0.6718	0.8438	0.9998	0.5492	0.3517	0.1311	0.0586	0.0326
Alt. F 10 yr LOP	13.06	0.0293	0.0353	0.3017	0.6595	0.8339	0.9688	0.6644	0.2937	0.0918	0.0333	0.0191
Alt. F 50 yr LOP	13.06	0.0205	0.0219	0.1987	0.4856	0.6697	0.9997	0.8969	0.4837	0.0905	0.0319	0.0136
Alt. A	13.06	0.0434	0.0484	0.3911	0.7743	0.9163	0.9993	0.3913	0.0118	0	0	0
Alt. B	13.06	0.0437	0.0489	0.3942	0.7777	0.9184	0.9992	0.3788	0.01	0.001	0	0
Alt. F	13.06	0.0267	0.0366	0.3112	0.6732	0.845	0.9998	0.5593	0.334	0.0962	0.0435	0.0206
Alt. G	13.06	0.0431	0.0477	0.3869	0.7695	0.9133	0.9993	0.3968	0.0273	0.0144	0.0064	0.0051

Table 15 – Project performance indicators, present and future conditions

The table indicates that the proposed plan achieves its design intent. The proposed channel and conveyance modifications are designed to capture the 4% AEP event, and the performance indicators suggest it contains a bit more than half of the possible flows that would result from such an occurrence.

F-15 Evaluation of Non-Structural Alternatives:

A variety of non-structural flood damage reduction measures were identified, which could be used to meet the planning objectives. The initial evaluation of these measures is discussed below.

Floodplain Management Regulations

Marin County does participate in the National Flood Insurance Program (NFIP), which is administered through the Federal Emergency Management Agency (FEMA). FEMA has published Flood Insurance Rate Maps (FIRMs) for both jurisdictions that identify Special Flood Hazard Areas for Corte Madera Creek and tributaries. For local jurisdictions to maintain eligibility in the NFIP, minimum levels of floodplain management regulations must be adopted and enforced. Floodplain management regulations and enforcement would have the effect of mitigating flood damages in tne future due to new development, but does nothing for the exiting flood problem, nor the future flooding condition. Floodplain management is considered a reasonable and prudent measure with or without a constructed flood risk management feature, but this measure was not carried forward for alternative evaluation in this appendix. The future conditions in this economic evaluation does not include any future development in the floodplain for reasons described in Para. F-06.

Flood Warning Systems

A flood warning and preparedness system is often the most cost effective flood mitigation measure comprised of computer hardware, software, technical activities and/or organizational arrangements aimed at decreasing flood hazards. Advanced warning is not generally effective in reducing structural damages (outside of sandbagging efforts given early warning); the primary benefits of such a system are credited for providing early evacuation of residents and reduction in damages to vehicles and structure contents.

The evaluation presented in the Economics Appendix assumes that 1.0 of the 1.7 vehicles per capita in Marin County residences have been evacuated, and that all operable commercial and public vehicles have already been evacuated prior to any flooding. A flood warning system would present benefits by reducing the amount of residential contents subject to flooding. Assuming that residential contents were half the Residential EAD presented in Table F-6C, that would indicate an effective and understood flood warning system would decrease EAD by at most 7.8%. The high residual damages, and the flood threat to public properties (schools, fire, police stations) as well as the other infrastructure (roads, agriculture, utilities, public and commercial properties) suggests that a flood warning system is ineffective and incomplete on its own. Further, relative to the structural alternative presented (Alternative F, with a levee height corresponding to Base levee +4' elevation and net benefits of over $530 thouseand), it's impossible for a flood warning system to provide greater net benefits.

Flood Proofing

Flood proofing offers the opportunity to provide flood protection on an individual structure-by-structure basis or a group of structures. Flood proofing techniques typically include buyouts, relocation, elevation, floodwalls or levees, and dry flood proofing. Elevation, buyout, and relocation are the most dependable of these flood proofing methods. Flood proofing costs can vary substantially depending on the type of flood proofing method being considered and the type, size, age, and location of the structure(s). Flood proofing techniques considered for alternative development are:

1) Relocation of Existing Structures: Relocation is perhaps the most dependable flood proofing technique since it totally eliminates flood damages, minimizes the need for flood insurance and allows for the restoration/reclamation of the floodplain. This technique requires the physical relocation of flood prone structures outside of the identified flood hazard area. This also requires purchase of the flood prone property; selecting and purchasing a new site; and lifting/moving the structure to the new site.

   Corps experience has indicated that relocations and buyouts only work when the land left behind is repurposed to some other public good, such as a public park or reuniting the acquired land with the floodway. The Federal Emergency Management Agency estimates relocation costs at between $99 and $116 per square foot (1999 dollars), which exceeds the depreciated replacement costs of just about every structure in the floodplain. (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-28, Table 3-9). The study area floodplain extends for several river miles, and represents a narrow area next to Corte Madera Creek. Relocations do nothing for the flood risk to public properties and is therefore an incomplete solution to the flood problem.

2) Buyout or Acquisition: This technique requires the purchase of the flood prone property and structure; demolition of the structure; relocation assistance; and applicable compensation required under Federal and State law. This alternative typically requires voluntary relocation by the property owners and/or eminent domain rights exercised by the non-federal sponsor.

   As stated previously with relocations, acquiring properties in Marin County has limited utility. The acquired land has remarkably high acquisition costs. Repurposing land for a public good like a park would be infeasible, as it would represent an incomplete solution to the flood problem.

3) Retrofitting or Dry Flood Proofing: Dry flood proofing of existing structures is a common flood proofing technique applicable for flood depths of three (3) feet or less on buildings that are structurally sound. Installation of temporary closures or flood shields is a commonly used flood proofing technique. A flood shield is a watertight barrier designed to prevent the passage of floodwater though doors, windows, ventilating shafts, and other openings of the structure exposed to flooding. Such shields are typically made of steel or aluminum and are installed on structures only prior to expected flooding. However, flood shields can only be used on structures with walls that are strong enough to resist the flood-induced forces and loadings. Exterior walls must be made watertight in addition to the use of flood shields. This technique is not applicable areas subject to flash flooding (less than one hour) or where flow velocities are greater than three (3) feet per second. It would also not be applicable to mobile homes, due to the type of construction and typical lack of anchoring to a foundation.

   Aside from the cost, dry flood proofed homes and businesses can still suffer flood damages due to the potentially incomplete nature of the solution. Enclosures for windows and doors require human intervention in order to fully implement the solution and, this action would have to occur in a relatively short time frame. Tables F-2A and F-2B in the economics appendix display the water surface elevations associated with various events. In many locations, flood stages are expected to exceed 3', rendering the flood proofing measures ineffective. Due to the incomplete nature and limited applicability of this flood proofing method, it was not carried forward for alternative evaluation.

4) Localized Levees or Floodwalls: Ring levees or floodwalls can be built around individual structures to protect single or small groups of structures. Ring levees are earthen embankments with stable or protected side slopes and a wide top. Floodwalls are generally constructed of masonry or concrete and are designed to withstand varying heights of floodwaters and hydrostatic pressure. Closures (e.g., for driveway access) are typically manually operated based on flood forecasting and prediction that would alert the operator. Disadvantages of levees or berms are: 1) can impede or divert flow of water in a floodplain; 2) can block natural drainage; 3) susceptible to scour and erosion; 4) give a false sense of security; and 5) take up valuable

property space. Disadvantages of floodwalls are: 1) high cost; 2) closures for openings required, and 3) give a false sense of security.

In this evaluation, the Towns of Ross and Kentfield represent relatively concentrated locations receiving flood damages. However, one characteristic of these concentrated locations is the lack of space between them for more individualized structures to mitigate the flood threat. The alternatives analyzed in this appendix include some floodwalls, because there is no space for levees of any height, and represent the limits of tailoring local floodwalls to serve the communities protected.

5) Elevation of Structures: Existing structures can be elevated or raised above the potential flood elevation. Structures can be raided on concrete columns, metal posts, piles, compacted earth fill, or extended foundation walls. Elevated structures must be designed and constructed to withstand anticipated hydrostatic and hydrodynamic forces and debris impact resulting from flooding. The access and utility systems of the structures to be raised would need to be modified to ensure they are safe from flooding.

   FEMA has estimated that elevation in place for slab-on-grade homes (the most common foundation type in the study area) can cost $80-88 per square foot (2009 dollars) for a frame home, and $88-96 per square foot for a masonry home (FEMA, Homeowner's Guide to Retrofitting, December 2009, page 3-20, Table 3-3). That value exceeds the per square foot depreciated replacement cost of most of the improvements in the floodplain, which makes this alternative infeasible.

F-16 Plan for Updating Project Benefits in the Future:

At the time that a project update is required, the significant assumptions regarding hydrology and hydraulics will be reviewed. All pertinent economic assumptions shall be reviewed. After determining whether there have been changes in the basic assumptions, the following shall be analyzed:

Residential neighborhoods shall be sampled to determine current values. Real estate agents, appraisers and the Marshall and Swift Valuation Service will be used in updating residential values.

Discussions with local realtors and businessmen combined with field sampling will be made to determine if major changes have occurred to businesses existing at the time of the initial inventory. Important changes affecting structure or content values will be included in the update. As is the case of residential values, the Marshall and Swift Valuation Service and local appraisers and realtors will be contacted regarding commercial values.

After consultation with city planners and examining city building permits; residential, public and commercial growth since the inventory was taken shall be sampled as needed within the flood plain. The growth shall be included, as appropriate, in the updated benefit computations.

The results of the reanalysis shall be documented in a "Special Evaluation Report" (SER).