DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-CP

22 June 2009

MEMORANDUM FOR PLANNING COMMUNITY OF PRACTICE

SUBJECT: Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles

1. Purpose. The purpose of this memorandum is to release and provide guidance for the use of generic vehicle depth-damage curves for U.S. Army Corps of Engineers flood risk management studies.

2. Background. The Flood Damage Data Collection Program provides information from flood events to estimate reliable economic relationships for flood damage reduction studies. As part of residential post-flood damage surveys, data were collected for vehicles kept at residences in ten communities that experienced major flooding. Depth-damage functions were determined using flood victims' self-reported assessments of vehicle values and damage and the depth of flooding above the wheel base for each vehicle.

3. Results. Damage functions were computed for five types of vehicles based on a sample of 640 vehicles. Regression analysis was used to compute the damage functions. The regression equations for all types of vehicles were highly significant. The damage functions are included in the appendix to this memorandum along with a brief summary of the data and analysis used to derive these functions.

4. Application for Vehicles Parked at Residential Locations. These damage functions can be used to estimate vehicle damage when applied to expected water surface elevations for flood events.

a. Depth-damage functions should be applied to vehicles at ground elevations of affected properties. Damage to vehicles at residences is dependent on the average number of vehicles per household; the approximate percentage breakdown by type of vehicle, the average vehicle value based on the make, model, and age; and the percentage of vehicles that are likely to be at the residence at the time the flood waters reach the property and the availability of safe evacuation routes.

b. The number of vehicles per household can be estimated using the American FactFinder section of the U.S. Census website by entering the zip code and looking under household characteristics: http://factfinder.census.gov

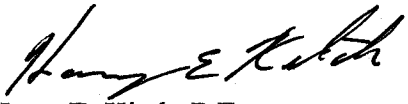
c. Information for determining the approximate distribution by type of vehicle and value can be found by conducting random samples of the study area, when a representative number of vehicles can be expected to be present, or by contacting the state department of motor vehicles to obtain information on motor vehicle registrations. Vehicle information can also be obtained by contacting R.L. Polk Company at http://usa.polk.com/ The Polk National Vehicle Profile, which has vehicle registration by zip code, is described at: http://usa.polk.com/Products/1_nvpp.htm.

d. Average vehicle values for new and used cars can be obtained from the Kelly's Blue Book at www.kbb.com and Edmunds at www.edmunds.com.

e. The length of potential warning time and the access to a safe evacuation route to a flood-free location must be considered in estimating the percentage of vehicles that would likely remain in the flood prone location. The results section of the attached appendix gives the percentages from a post-flood data collection of residential respondents that moved vehicles to higher ground by the length of the respondents' warning time.

5. Application for Vehicles Parked at Nonresidential Locations. The depth-damage relationships found in this EGM are applicable for vehicles parked at all floodplain locations. The above procedures (paragraph 4) used to estimate the number of vehicles that might be flooded are not generally applicable to non-residential locations such as car sales lots, rental car lots, other commercial facilities and industrial facilities. Additional project specific data and analysis are required to document the assumptions related to potential vehicle damage estimates in nonresidential locations.

6. Points of Contact. The HQUSACE program monitor for the Flood Damage Data Collection Program is Mr. Kenneth Claseman, CECW-PC, at kenneth.g.claseman@usace.army.mil or (202) 761-5451, who can address any questions concerning the program. Questions related to this memorandum should be addressed to Mr. Bruce Carlson, CECW-PC, at bruce.d.carlson@usace.army.mil or by telephone at (202) 761-4703.



Harry E. Kitch, P.E.
Deputy Chief, Planning and Policy
Directorate of Civil Works

Enclosure

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Appendix A
Computation of Depth-Damage Relationships for Vehicles

Background

This memorandum presents the results of analysis of vehicle damage data collected from the Flood Damage Data Collection Program post-flood damage surveys. Victims of residential flooding in ten communities were interviewed to determine the extent of flooding costs to their households. The survey instrument included questions about motor vehicles to help determine the damage to vehicles that might be expected from future flooding. These surveys were part of a larger survey effort to establish damage functions for buildings, contents, cleanup costs and time, and emergency costs. Table One gives the number of vehicles for each case study in this data collection:

TABLE ONE
VEHICLES BY CASE STUDY

Case Study	Frequency	Percent of Total
Wenden, Arizona	7	1%
Elba, Alabama	19	3%
Falmouth, Kentucky	140	22%
Feather River, California	158	25%
Louisville, Kentucky	109	17%
Bound Brook, New Jersey	74	12%
New Orleans, Louisiana	28	4%
Puerto Rico	79	12%
Rocky Mount, North Carolina	2	<1%
Salem, Oregon	24	4%
Total	640	100%

The Survey

The respondents were asked to enumerate the number of motor vehicles that were at their homes at the time of flooding, whether vehicles were moved off the property, the make and model of vehicles, the dollar value of vehicles, the depth of water above ground where vehicles were parked, and the dollar damage to vehicles. The data included here are for vehicles that either remained at the flood victims' homes or were moved, but may have still experienced flood damage from the same flood event. Figure One presents the questions that were asked in each of the surveys to obtain the information for this analysis.

FIGURE ONE: SURVEY QUESTIONS

For each motor vehicle, including cars, trucks, recreational vehicles, boats, and motorcycles, located at this residence during the flood, please indicate the dollar value, whether or not it was moved, the amount of damage to the vehicle, if any, and the level, in feet and inches, that the flood water reached above the bottom of the vehicle's wheels.

Vehicle Category and Year (Categories include: sedan, van, sports utility, sports cars, pickup trucks, and motorcycles)	*Dollar Value*	*Was it Moved? (Yes or no)*	*Dollar Damage*	*Depth Above Ground At Vehicle*
Vehicle 1:				
Vehicle 2:				
Vehicle 3:				
Vehicle 4:				
Vehicle 5:				
Vehicle 6:				

The make and model of vehicle were used to classify each vehicle by category, including sedan, sports utility vehicle, mini van, sports car, pickup truck, motorcycle, or boat. Respondents valued vehicles at the current market value, reflecting depreciation by the age of the vehicle. Information on the make, model, and age of the vehicle served as a check on the respondents' estimate of value. The amount of damage represented the repair cost or the total value of the vehicle, if there was damage beyond repair. The depth of water above ground was the key variable in determining the percent of flood damage to each vehicle. Percent damage to vehicle was computed by dividing estimated vehicle damage by vehicle value. The number of each type of vehicle in the database is reported below in Table Two. The same surveys also included a question regarding the length of warning time, asking the length of time between becoming aware of potential flooding till the water reached the respondents' property.

TABLE TWO VEHICLES BY CATEGORY		
Vehicle Category	**Frequency**	**Percent of Total**
Boat	14	2%
Motor Home	7	1%
Motorcycle	23	4%
Pickup Truck	125	20%
Sedan	369	57%
Sports Car	37	6%
Sports Utility Vehicle	31	5%
Mini Van	34	5%
Total	640	100%

Survey Results

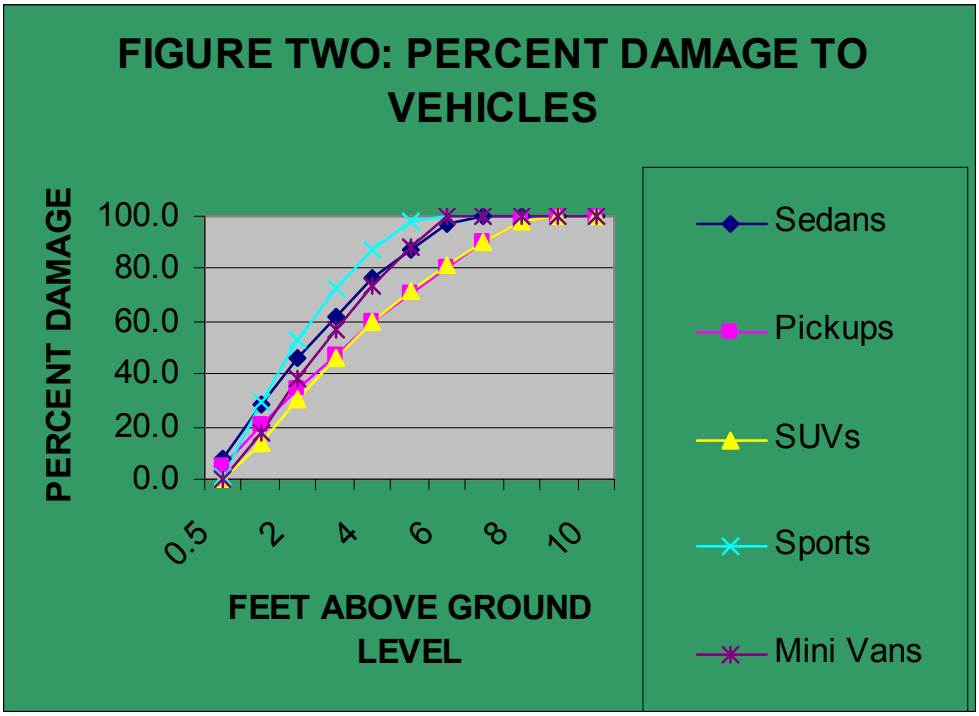
Regression analysis was used to separately compute a damage function for each type of vehicle. Quadratic equations with depth and depth squared serving as the independent variables were the most successful regression models for explaining variations in the percent damage to vehicle. The squared term indicates that in each case there was a point where there was a significant change in the slope of the damage function.

TABLE THREE PERCENT DAMAGE TO VEHICLES										
	Sedans		Pickups		SUVs		Sports		Mini Vans	
Depth Above Ground	Percent Damage	Standard Deviation	Percent Damage	Standard Deviation	Percent Damage	Standard Deviation	Percent Damage	Standard Deviation	Percent Damage	Standard Deviation
.5	7.60%	2.42%	5.20%	3.02%	0.00%	11.28%	1.40%	19.22%	0.00%	9.11%
1	28.00%	1.84%	20.30%	2.53%	13.80%	8.76%	29.20%	16.81%	17.80%	6.82%
2	46.20%	1.51%	34.40%	2.33%	30.60%	6.67%	52.80%	13.17%	38.30%	5.33%
3	62.20%	1.45%	47.50%	2.38%	45.80%	5.24%	72.20%	8.47%	56.80%	4.88%
4	76.00%	1.57%	59.60%	2.57%	59.40%	4.78%	87.40%	3.61%	73.30%	5.34%
5	87.60%	1.74%	70.70%	2.81%	71.40%	5.36%	98.40%	6.12%	87.80%	6.23%
6	97.00%	1.92%	80.80%	3.04%	81.80%	6.61%	100.00%	13.80%	100.00%	7.20%
7	100.00%	2.06%	89.90%	3.21%	90.60%	8.17%	100.00%	13.80%	100.00%	7.20%
8	100.00%	2.06%	98.00%	3.32%	97.80%	9.88%	100.00%	13.80%	100.00%	7.20%
9	100.00%	2.06%	100.00%	3.36%	100.00%	11.70%	100.00%	13.80%	100.00%	7.20%
10	100.00%	2.06%	100.00%	3.36%	100.00%	11.70%	100.00%	13.80%	100.00%	7.20%

Despite the limited sample, the regression equations did have a high explanatory power for cross sectional data. The adjusted R^2, the coefficient of determination for each regression equation, is given below in the Table 4.

TABLE FOUR COEFFICIENT OF DETERMINATION FOR REGRESSION EQUATIONS	
Type of Vehicle	Adjusted R^2
Pickup Truck	.707
Sedan	.674
Sports Car	.695
Sports Utility Vehicle	.795
Mini Van	.712

Results of the regression analysis are also presented in graphic format, below in Figure Two.



Results of the survey also indicated the percentage of households that moved at least one vehicle to higher ground. These percentages are given by the amount of warning time in Table Five.

TABLE FIVE PERCENTAGE OF RESPONDENTS MOVING AT LEAST ONE VEHICLE TO HIGHER GROUND					
Warning of 6 Hours or Less		Warning of Greater than 6 and Up to 12 Hours		Warning Greater than 12 Hours	
Respondents Moving Vehicles to Higher Ground	Respondents Who Did Not Move Vehicles	Respondents Moving Vehicles to Higher Ground	Respondents Who Did Not Move Vehicles	Respondents Moving Vehicles to Higher Ground	Respondents Who Did Not Move Vehicles
50.5%	49.5%	80.6%	19.4%	88.1%	11.9%