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Prepared in cooperation with the Village of Homer, Nebraska,
and the Papio-Missouri River Natural Resources District

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Scientific Investigations Report 2008–5107

U.S. Department of the Interior
U.S. Geological Survey

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U.S. Geological Survey

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Conversion Factors, Abbreviations, and Datum

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch (in)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot per second (ft/s)	0.3048	meter per second (m/s)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Estimated Flood Discharges and Map of Flood-Inundated Areas for Omaha Creek Near Homer, Nebraska, 2005

By Benjamin J. Dietsch, Richard C. Wilson, and Kellan R. Strauch

Abstract

Repeated flooding of Omaha Creek has caused damage in the Village of Homer. Long-term degradation and bridge scouring have changed substantially the channel characteristics of Omaha Creek. Flood-plain managers, planners, homeowners, and others rely on maps to identify areas at risk of being inundated.

To identify areas at risk for inundation by a flood having a 1-percent annual probability, maps were created using topographic data and water-surface elevations resulting from hydrologic and hydraulic analyses. The hydrologic analysis for the Omaha Creek study area was performed using historical peak flows obtained from the U.S. Geological Survey streamflow gage (station number 06601000). Flood frequency and magnitude were estimated using the PEAKFQ Log-Pearson Type III analysis software. The U.S. Army Corps of Engineers' Hydrologic Engineering Center River Analysis System, version 3.1.3, software was used to simulate the water-surface elevation for flood events. The calibrated model was used to compute streamflow-gage stages and inundation elevations for the discharges corresponding to floods of selected probabilities. Results of the hydrologic and hydraulic analyses indicated that flood inundation elevations are substantially lower than from a previous study.

Introduction

Flooding of Omaha Creek has caused damage in the Village of Homer, Nebraska, since the 1920's. To mitigate flood damages financially and to manage development within the regulatory floodplain, the village entered into the National Flood Insurance Program administrated by the Federal Emergency Management Agency (Federal Emergency Management Agency, 1983). This program provides maps for identifying areas at risk for flooding and helps flood-plain managers, planners, homeowners, stakeholders, and others make decisions about areas that are at risk for flooding. The Flood Insurance Study for the Village of Homer in Dakota County, Nebraska, was issued by Federal Emergency Management Agency (FEMA) in 1983 (Federal Emergency Management Agency, 1983) and was revised in 1996 (Federal Emergency Management Agency,1996). Since the 1996 revision, additional streamflow data have been collected to aid in estimating the frequency of large floods. In addition, the Omaha Creek channel has undergone long-term general degradation and localized scour near bridges that may have affected the hydraulic properties of the channel near Homer since it was last surveyed in 1993. As channel characteristics of Omaha Creek continue to change, the Village of Homer and the Papio-Missouri River Natural Resources District entered into a cooperative agreement with the U.S. Geological Survey (USGS) to study the effects of these changes on the areas at risk for flooding around Homer, Nebraska.

Purpose and Scope

The purpose of this report is to estimate flood discharges to update the 1996 FEMA Flood Insurance Study for the Village of Homer, Nebraska, (FEMA, 1996) and the map of the area inundated by the flood having a 1-percent annual probability using additional streamflow data and recent (2005) topographic data (Nebraska Department of Natural Resources, written commun., 2005).

Topics addressed for this report included peak-flow analyses of records from the USGS streamflow-gaging station on Omaha Creek at Homer, Nebraska, (station number 06601000; fig. 2); collection of topographic and channel-geometry data; hydraulic analysis of Omaha Creek using the U.S. Army Corps of Engineers' (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) computer software (U.S. Army Corps of Engineers, 2001); and mapping flood-inundation areas that correspond to the flood having a 1-percent annual probability by comparing hydraulic results with topographic data.

The geographical scope of this report was limited to areas near Homer, Nebraska, where cross sections from previous studies were available. This includes the reach of Omaha Creek from Elma Road, located about 1 mile (mi) east of Homer, to Grant Road, located approximately 1.5 mi south of Homer.

Description of the Study Area

Omaha Creek is a northeasterly flowing tributary of the Missouri River and is located in Dakota and Thurston Counties in northeastern Nebraska (fig. 1). The total drainage area is 175 square miles (mi^2) at the gaging station at Homer. Soils in the basin are derived primarily from glacial tills capped with loess (Elder, 1969). The climate of Dakota and Thurston Counties is classified as continental, consisting of a subhumid moisture regime and moderate temperatures. The normal annual rainfall is approximately 26 inches at Sioux City, Iowa (National Weather Service, 2005).

The study area (fig. 2) surrounds the Village of Homer and its extent corresponds to the available hydraulic cross section data; the downstream limit is located about 2 mi upstream (north) from the mouth of Omaha Creek. It is a deeply incised channel that is widening in some parts of the study area and exhibits steep banks, bank failures, and streambed degradation (Rus and others, 2003). The stream channel slope is about 8.5 feet per mile (ft/mi) through the 4-mi study reach. Bed materials at the site are composed of silty clays. Vegetation along the downstream part of the reach generally is sparse because of steep bank angles and recent bank failures; however, grass, shrubs, and small trees line the upstream areas of the reach.

Extensive straightening and channel modification of streams in the Omaha Creek Basin have occurred since the early 20th century (Nebraska Department of Roads and Irrigation, 1954). These changes in channel alignment may have triggered a degradation response in the lower part of the Omaha Creek Basin, including most of the study area. From 1952 to 1996, the streambed degraded approximately 2.6 ft at Omaha Creek at Homer, but the migration of this bed elevation change may have been limited by the construction of a rock riffle near the gage in the 1950's (Rus and others, 2003). Field inspections indicate that severe scour has occurred around bridge piers along the study reach.

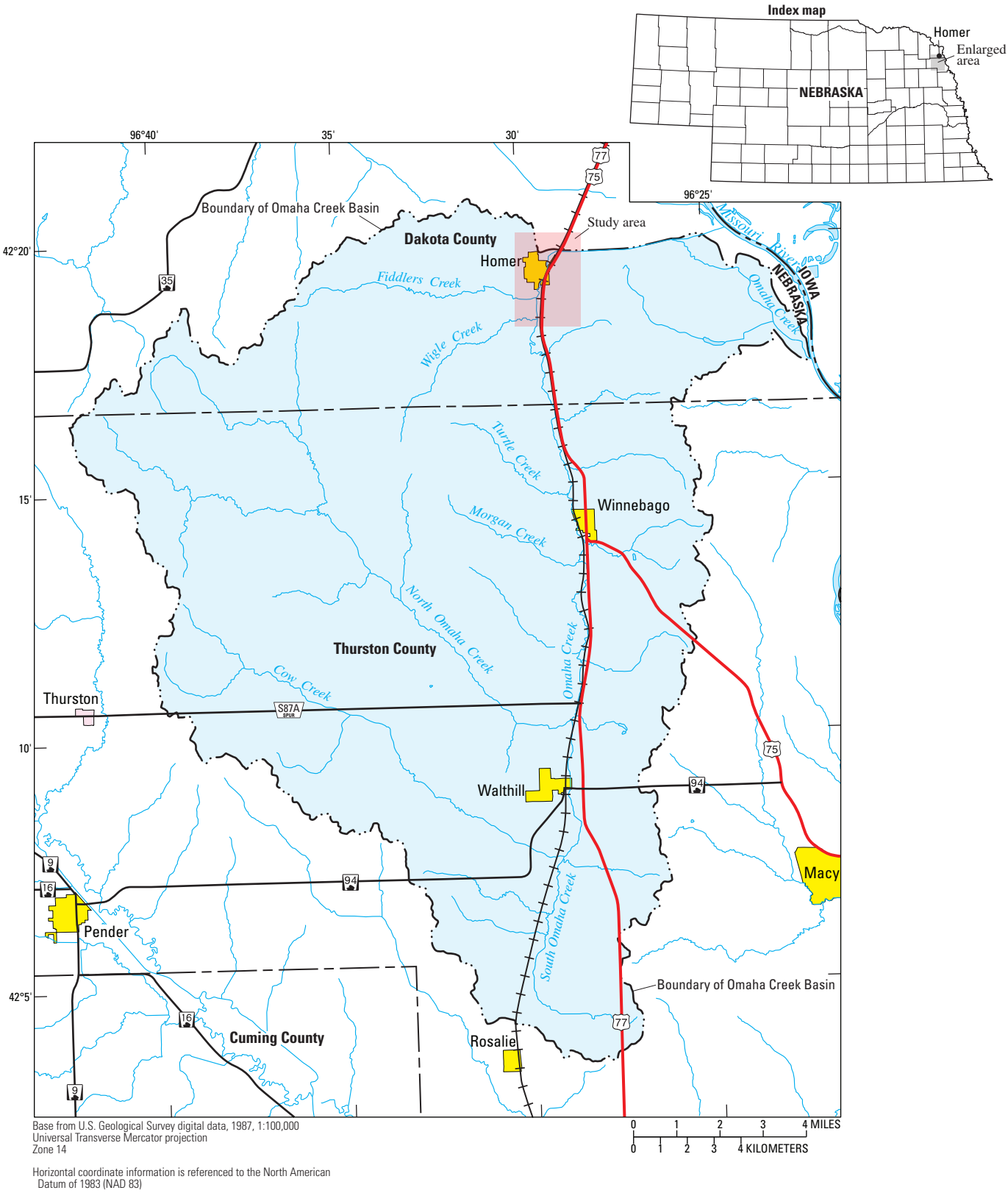
Flooding has occurred in the Village of Homer since it was incorporated in 1871 (Federal Emergency Management Agency, 1996). Significant flooding occurred in June, 1875; June, 1900; September, 1903; March, 1909; May, 1920; June, 1940; February, 1971; and July, 1996. The most severe documented floods occurred in 1920 and 1940. On May 31, 1920, excessive rainfall occurred, which caused widespread flooding. Newspaper and historical accounts of the 1940 flood describe severe damage to many homes and businesses with water elevations higher than any flood since 1920. The USGS began operating a streamflow-gaging station located on Omaha Creek near Homer (station 06601000) in 1940. The maximum peak flow for the period of record occurred June 4, 1940, at a gage height of 34.50 ft (2005 gage datum) with a discharge of 51,000 cubic feet per second (ft^3/s) estimated from indirect measurements. Other significant floods occurred in 1971 (18,100 ft^3/s) and 1996 (21,500 ft^3/s).

Hydrologic Analysis

The hydrologic analysis for the Omaha Creek study area used historical data for peak flows obtained at the stream gage. Historical data for peak flows were available from the instantaneous-discharge records for the USGS streamflow-gaging station at Homer (station 06601000) which includes the period of streamflow gage operation from 1946 through 2004, and the estimate of peak discharge in 1940, which was the greatest peak discharge since 1920. Flood frequency and magnitude were estimated using the USGS PEAKFQ log-Pearson Type III analysis software (Flynn and others, 2006). The PEAKFQ software (version 5.0.0) was used for standard log-Pearson Type III analysis as outlined in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982). The systematic-record analysis computed by PEAKFQ utilizes the mean, standard deviation, and skew coefficient of the log-transformed annual peak flow series, or systematic record, to fit a log-Pearson distribution function to the data. The frequency curve derived from the systematic-record analysis is an initial estimate of the Bulletin 17B frequency curve. Additional analyses are used to adjust the frequency curve for historic data, regional (generalized) skew information, and high and low outliers; historic data, or flood information outside that contained in the systematic records, can be used to extend the period of analysis. The analytical techniques to adjust for historic data are described in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) and implemented in PEAKFQ. PEAKFQ provides a routine for weighting the computed skew coefficient with a regionalized skew coefficient. Because the skew coefficient computed from historical streamflow data for a station can be sensitive to extreme events, guidance in Bulletin 17B recommends weighting skew coefficients computed for stations with natural streamflow regimes with a generalized skew coefficient computed for an entire region or similar set of sites. For the PEAKFQ analysis for the USGS streamflow-gaging station at Homer (station 06601000), the generalized skew coefficient of -0.539 was used (Soenksen and others, 1999). PEAKFQ also computes outliers, or extremely high and extremely low peak flows in a record, that can disproportionately affect the results of flood frequency analysis. Thresholds for determining outliers are computed based on the sample size (Flynn and others, 2006). Peak streamflows were estimated for floods of the 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual probabilities.

Hydraulic Analyses

The U.S. Army Corps of Engineers HEC-RAS, version 3.1.3, software was used to simulate the water-surface elevation for floods (U.S. Army Corps of Engineers, 2001). Simulated water-surface elevations of Omaha Creek within the study reach were calculated by the HEC-RAS hydraulic flow model that requires topographic data, channel and bridge geometry and characteristics, and steady, gradually varied



Base from U.S. Geological Survey digital data, 1987, 1:100,000
Universal Transverse Mercator projection
Zone 14

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Figure 1. Location of Omaha Creek Basin and the study area in Dakota and Thurston Counties, northeastern Nebraska.

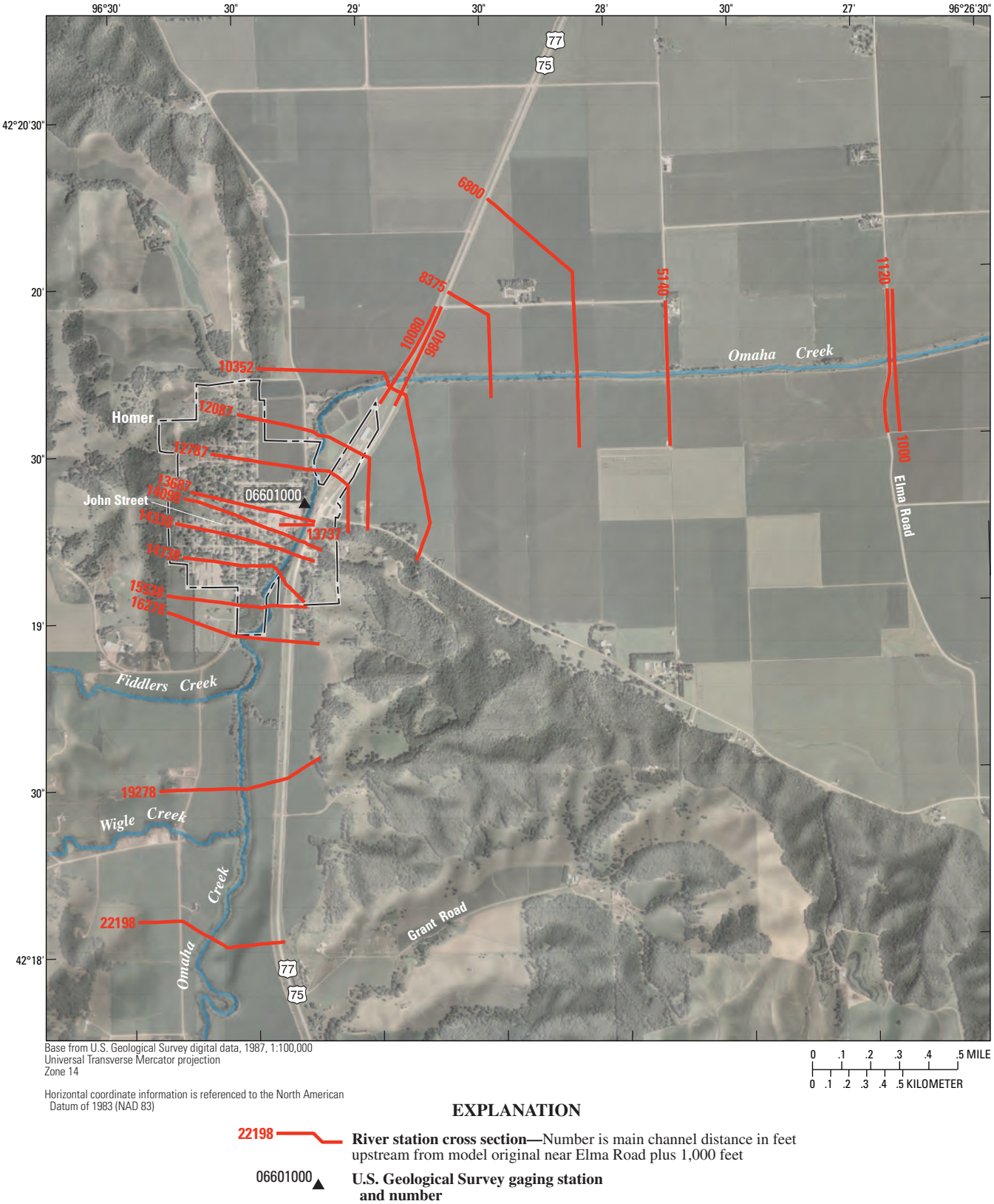


Figure 2. Location of U.S. Geological Survey streamflow-gaging station, survey cross sections, and study area.

streamflow as inputs. Energy losses were computed using friction and contraction/expansion calculations.

Topographic data were field surveyed in 1993 and 2005 by the Nebraska Department of Natural Resources (Nebraska Department of Natural Resources, written commun., 2005). Twenty-two river station cross sections were surveyed in the Omaha Creek channel in the study reach. Land-surface elevations of the areas within and adjacent to the channel were surveyed in 1993. In 2005, field surveys were limited to parts of the cross section including and between the tops of stream banks. The cross sections used in the HEC-RAS model were a composite of the topographic points surveyed in 1993 (overbank areas) and in 2005 (channel areas between tops of banks).

Comparison of 1993 and 2005 survey data indicated channel widening throughout the study reach and extensive scouring had occurred near bridges (fig. 3).

Geometric data included hydraulic characteristics of the stream, such as friction coefficients, expansion and contraction ratios, reach distances, and hydraulic properties of structures, such as bridge dimensions. Manning's roughness coefficients were estimated from field observations, aerial photographs, and previous studies (Federal Emergency Management Agency, 1996) using methods described in Barnes (1967) and Arcement and Schneider (1989). Manning's roughness coefficients ranged from 0.036 to 0.050 in the channel, and from 0.065 to 0.175 in areas adjacent to the channel. Bridge geometry was obtained from aerial photographs and previous studies (Federal Emergency Management Agency, 1996).

Steady-flow input data included results of the hydrologic analysis and downstream boundary conditions. Peak discharges estimated from the hydrologic analysis were used as steady-flow input values of streamflow for simulations of the floods. Two downstream boundary-condition scenarios were simulated for the peak discharge with 1-percent annual probability: normal depth was assumed at the downstream boundary; and alternatively the water-surface elevation at the downstream boundary was assumed to be equal to the water-surface elevation of the Missouri River corresponding to its peak discharge with 1-percent annual probability. Energy slope for the normal-depth boundary-condition simulation was assumed to be 0.0006 ft/ft, based on the previous study (Federal Emergency Management Agency, 1996). The results of the simulation using this boundary condition and slope were compared

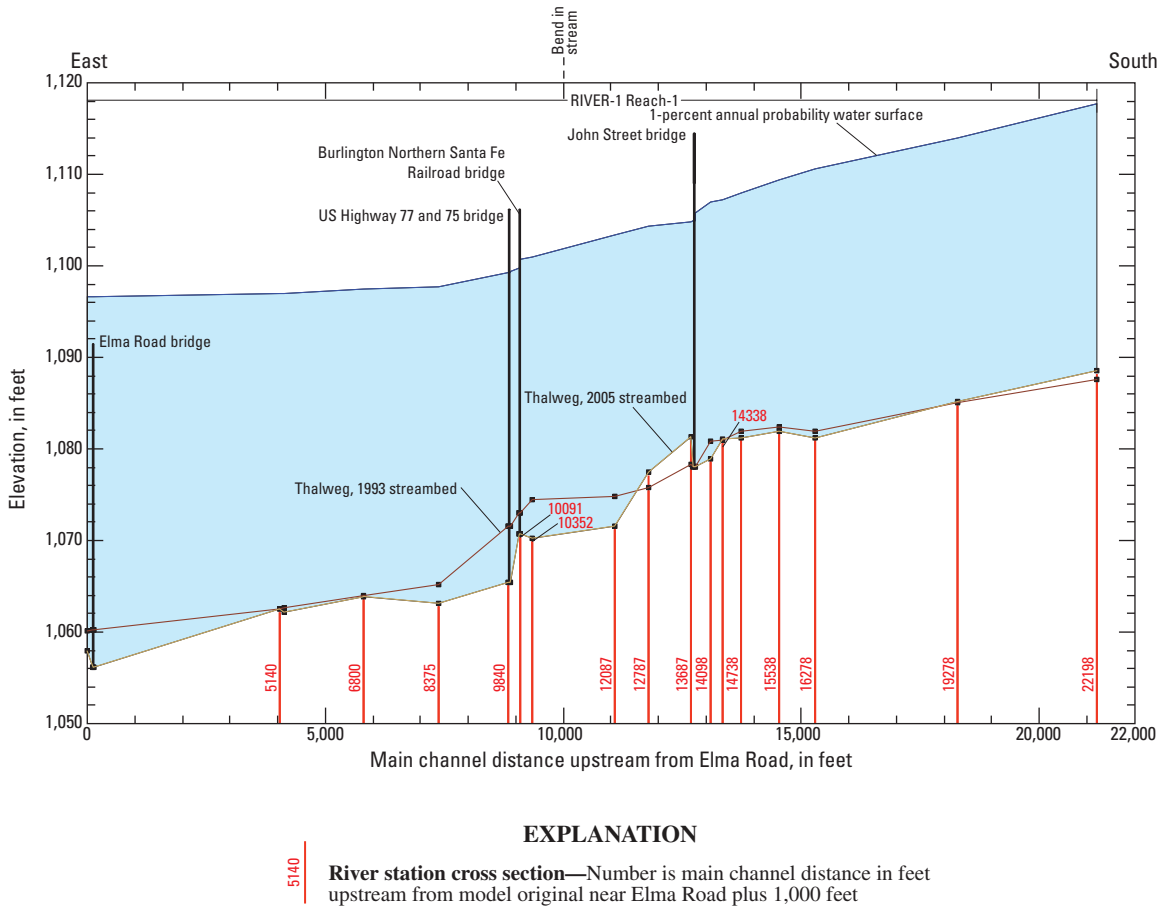


Figure 3. Comparison of streambed elevations at locations surveyed in 1993 and 2005 along Omaha Creek at Homer, Nebraska.

to simulation using the channel slope surveyed in 2005 and the normal depth boundary conditions and were determined to be similar. The downstream water-surface elevation corresponding to the peak discharge of the Missouri River with 1-percent annual chance flood was 1096.6 ft above the National Geodetic Vertical Datum of 1929 (NGVD 29) (Federal Emergency Management Agency, 1996).

The hydraulic model for Omaha Creek was calibrated to the stage and discharge that was measured on August 30, 1993, at the USGS streamflow-gaging station at Homer (station 06601000). The measurement was selected because it was the most recent direct measurement of a discharge near or exceeding the peak flow with 50-percent annual probability. The measured discharge on that date was 3,530 ft^3/s at a stage of 9.06 ft (1,089.51 ft NGVD 29). The hydraulic model was calibrated by iteratively making small adjustments to Manning's roughness coefficients until the water-surface elevation computed by the model closely agreed with the measured flood discharge and stage values at hydraulic cross section 12787 (fig. 2).

The calibrated model was used to simulate stages and inundation elevations for the discharges with 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual probabilities, which is the annual probability multiplied by 100 (0.5, 0.2, 0.1, 0.04, 0.02, 0.01, 0.002).

Delineation of Areas Inundated by a Flood with 1-Percent Annual Probability

The areas at risk for inundation by a flood with1-percent annual probability were mapped using topographic data and water-surface elevations from the hydraulic analyses. A triangulated irregular network (TIN) representation of the three-dimensional land surface was constructed from surveyed cross sections and longitudinal lines (Nebraska Department of Natural Resources, written commun., 2005), and 10-ft interval elevation contours (U.S. Geological Survey, 1976). A water-surface elevation model (as a TIN) was constructed from the results of the hydraulic analyses for a flood with 1-percent annual probability under the condition in which the water-surface elevation at the downstream boundary was assumed to be equal to the water-surface elevation of the Missouri River corresponding to its peak discharge with 1-percent annual probability. The water-surface elevation TIN represents the flood profile for a flood with 1-percent annual probability interpolated linearly between the cross sections used in the hydraulic model. The water-surface elevation TIN was overlaid digitally onto the land-surface TIN, and areas where the estimated water-surface elevation was greater than the land-surface elevation were considered to be at risk for inundation by a flood with a 1-percent annual probability. The outlines of the inundated areas were smoothed to remove unnatural corners and edges. The outline of the areas at risk for inundation was overlaid on high-resolution aerial photography of the study area.

Estimated Flood Discharges and Map of Flood-Inundated Areas

Peak streamflows were estimated for floods of 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual probabilities (table 1). The results of the PEAKFQ analysis are shown in table 1 and figure 4. One low outlier and one high outlier were removed from the analysis. The high outlier is the discharge estimated for the flood of 1940. An annual peak of 230 ft^3/s in 1970 was treated as a low outlier.

The calibrated hydraulic model was used to simulate stages and inundation elevations for the discharges with 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual probabilities. Near the stream gage at Homer, the simulated stage for the discharge with 1-percent annual probability was 24.4 ft (1104.8 ft, NGVD 29), which was derived by interpolation between hydraulic cross sections 12787 and 13687. The results of these analyses are shown in table 2 and figure 4.

Results of the hydraulic analysis indicated that flood inundation elevations are substantially lower than elevations published in the previous study (Federal Emergency Management Agency, 1996). The most important reason for these differences is the set of lower flood discharges resulting from the hydrologic analysis completed for this study. In addition, channel cross-section area has increased because of degradation and channel widening. At river station cross section 10352 (fig. 2) located upstream from the highway bridge, the flood inundation elevation was 3.7 ft lower than that in the previous study. At river station cross section 13768 located upstream from the bridge on the road entering the Homer from the east,

Table 1. Summary of flood frequency for Omaha Creek at Homer, Nebraska, determined by log-Pearson Type III analysis of the systematic record (1946–2004) and historical data.

[—, no published value available]

Recurrence interval, in years	Annual chance	Estimated peak flow, in cubic feet per second	Estimated peak flow for 1993 flood insurance study[1], in cubic feet per second
2	0.5	3,630	—
5	.2	7,050	—
10	.1	9,710	10,800
25	.04	13,400	—
50	.02	16,330	21,600
100	.01	19,370	27,600
500	.002	26,840	45,700

[1] Determined using the systematic record from 1946 to 1981 and historical data as published in Federal Emergency Management Agency (1996).

Table 2. Water-surface elevation for estimated discharges and flood-recurrence intervals at U.S. Geological Survey streamflow-gaging station on Omaha Creek near Homer, Nebraska (station 06601000).

[ft³/s, cubic feet per second, NGVD 29, National Geodetic Vertical Datum of 1929]

	Estimated 2-year flood recurrence interval	Estimated 10-year flood recurrence interval	Estimated 50-year flood recurrence interval	Estimated 100-year flood recurrence interval	Estimated 500-year flood recurrence interval
	Annual probability				
	0.500	0.100	0.020	0.010	0.002
River station 12787 is located near the streamflow gage	Percent annual probability (%)				
	50	10	2	1	0.2
	Estimated discharge for indicated flood, in ft³/s				
	3,630	9,710	16,330	19,370	26,840
River station cross section number	**Simulated water-surface elevation, in feet above NGVD29**				
1000	1,078.76	1,085.44	1,087.29	1,087.98	1,089.49
1120	1,078.87	1,085.44	1,087.16	1,087.82	1,089.29
1138	1,078.89	1,085.49	1,087.53	1,088.37	1,090.08
5040	1,080.92	1,088.40	1,091.52	1,092.37	1,093.97
5140	1,081.00	1,088.46	1,091.54	1,092.35	1,093.98
6800	1,082.39	1,090.36	1,094.40	1,095.27	1,096.68
8375	1,083.27	1,091.64	1,095.62	1,096.38	1,097.60
9840	1,083.89	1,092.56	1,097.06	1,098.20	1,100.71
9887	1,083.93	1,092.64	1,097.21	1,098.40	1,101.06
10080	1,084.03	1,092.80	1,097.45	1,098.71	1,102.00
10102	1,086.04	1,093.83	1,098.58	1,100.04	1,103.34
10352	1,086.45	1,094.10	1,098.85	1,100.32	1,103.55
12087	1,087.74	1,095.85	1,101.11	1,102.89	1,107.80
12787	1,088.27	1,096.39	1,101.96	1,103.90	1,108.45
13687	1,090.28	1,097.28	1,102.62	1,104.45	1,108.58
13737	1,090.42	1,097.39	1,102.73	1,104.56	1,108.65
13768	1,090.84	1,098.17	1,103.62	1,105.53	1,110.90
14098	1,091.77	1,099.30	1,104.82	1,106.79	1,112.65
14338	1,092.15	1,099.59	1,105.03	1,107.00	1,112.84
14738	1,093.19	1,100.49	1,105.87	1,107.82	1,113.41
15538	1,094.68	1,101.79	1,107.19	1,109.22	1,113.94
16278	1,095.87	1,103.05	1,108.46	1,110.53	1,114.65
19278	1,099.89	1,106.80	1,111.91	1,113.94	1,117.10
22198	1,103.76	1,110.83	1,115.77	1,117.74	1,121.13

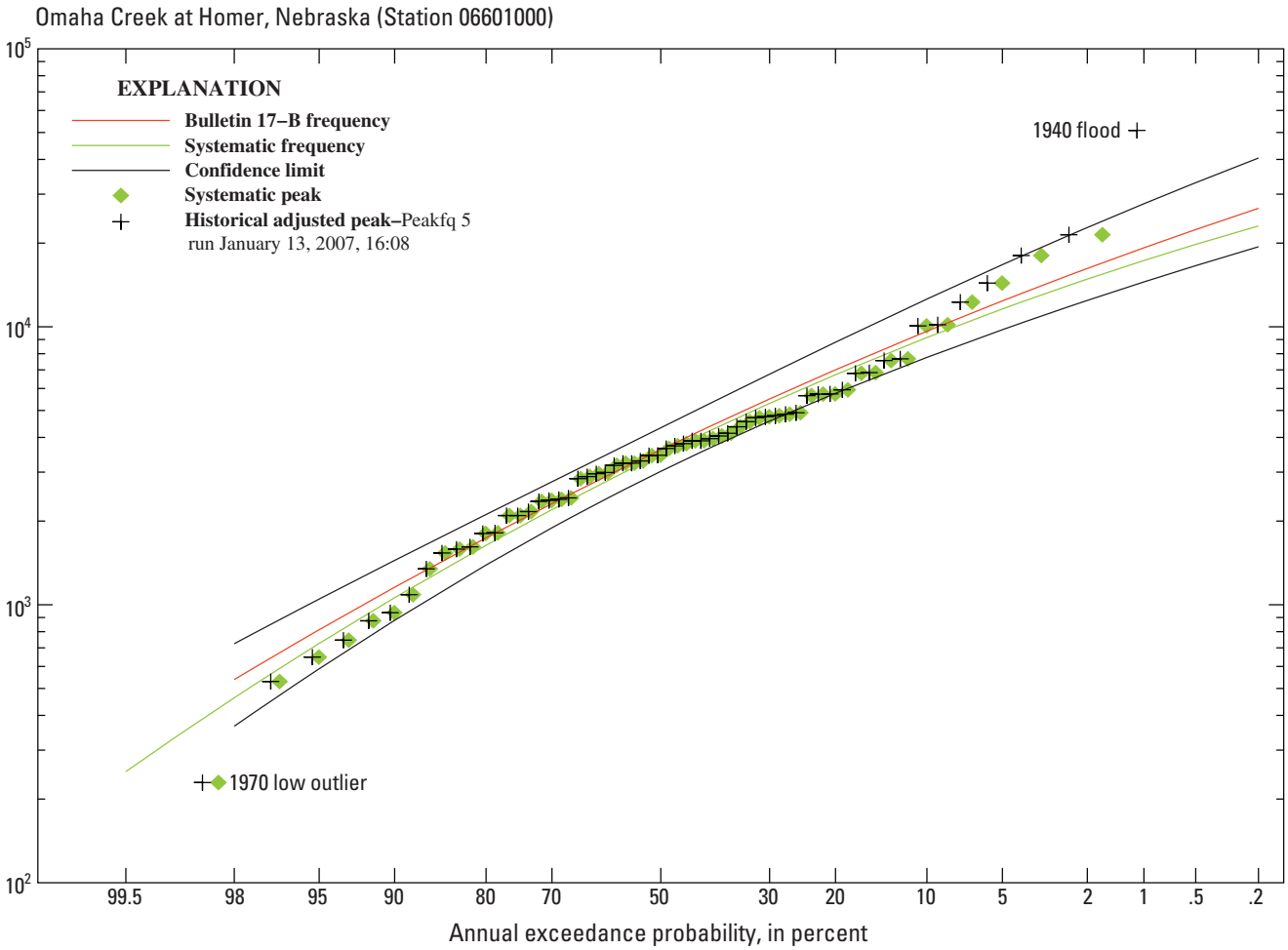


Figure 4. Frequency of selected flooding events for Omaha Creek near Homer, Nebraska, determined by log-Pearson Type III analysis for the systematic record (1946–2004) and historic data.

the flood inundation elevation was 8.2 ft lower than that in the previous study.

The final-flood inundation map for the 1-percent annual probability flood is shown in figure 5.

Summary and Conclusions

A map of the areas at risk for inundation by a flood with 1-percent annual probability was produced for the study area by the U.S. Geological Survey in cooperation with the Papio-Missouri Natural Resources District and the Village of Homer, Nebraska. The map allows resources at risk of being inundated along Omaha Creek at Homer, Nebraska, to be identified.

The hydrologic analysis for the Omaha Creek study area was performed using historical data for peak flows recorded at the USGS streamflow-gaging station at Homer (station 06601000). Flood discharges were estimated for events with annual probabilities ranging from 0.5 to 0.002. The U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 3.1.3 software was used to simulate the water-surface elevation for selected flood discharges. The calibrated model was used to compute stages and flood-inundation elevations for the selected discharges. The areas at risk for inundation by a flood with 1-percent annual probability were mapped using topographic data and water-surface elevations resulting from the hydraulic analyses.

Results of the hydraulic analysis indicated that flood inundation elevations are substantially lower than elevations published in a previous study. The most important reason for these differences is the set of lower flood discharges resulting from the hydrologic analysis completed for this study.

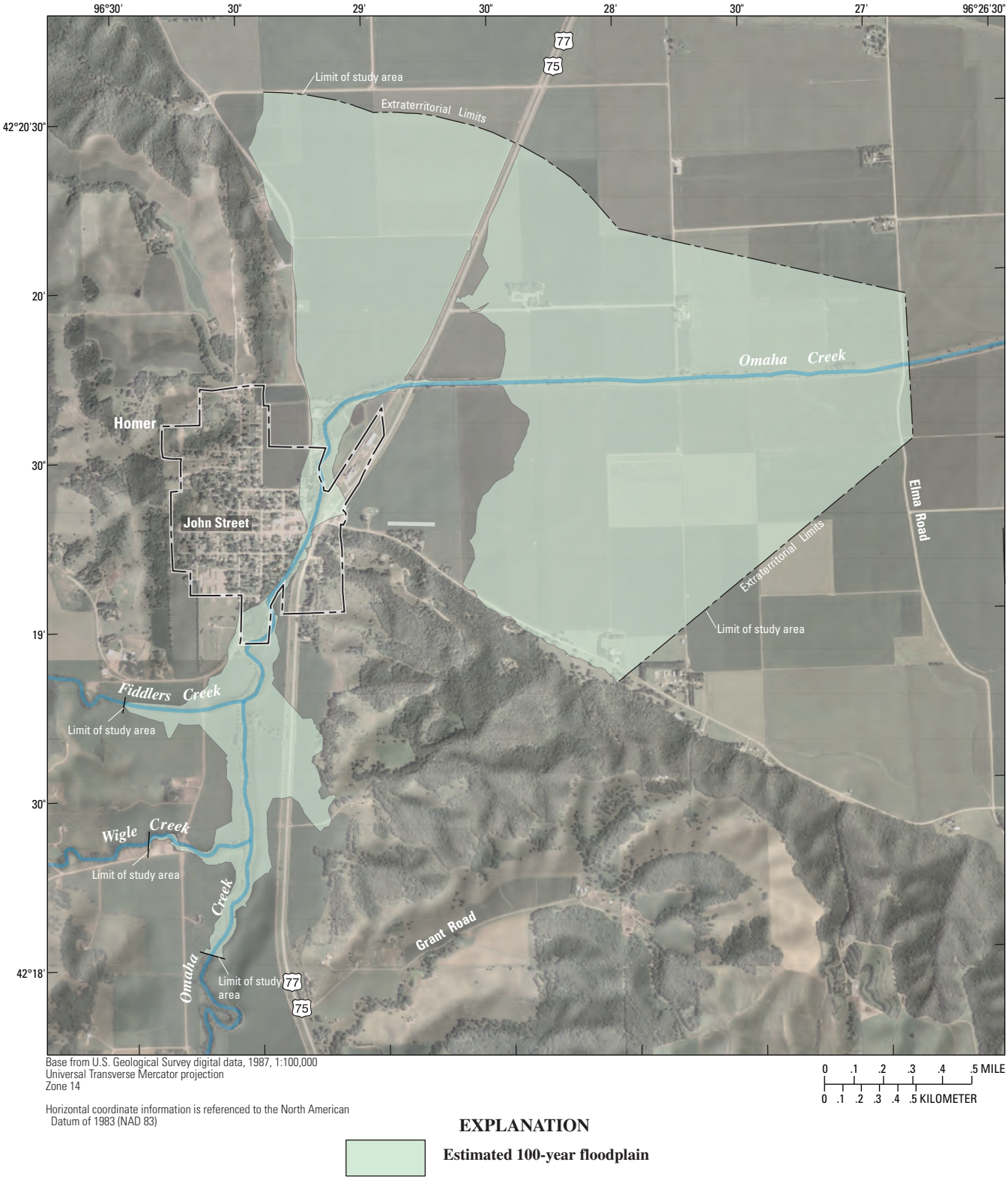


Figure 5. Areas at risk for inundation by the 1-percent annual probability flood (100-year flood) on Omaha Creek, at Homer, Nebraska.

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