FLOODPLAIN MANAGEMENT SERVICES

SPECIAL STUDY

MINNIE CREEK

VICINITY OF CHENEY, WASHINGTON

CITY OF CHENEY, WA
SPOKANE COUNTY, WA

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY SECTION

FEBRUARY 2007

Floodplain Management Services Special Study
Minnie Creek
Vicinity of Cheney, Washington

Description   Page

PHOTOGRAPHS

FIGURES

TABLES

PLATES

MAPS

FLOODPLAIN MANAGEMENT SERVICES SPECIAL STUDY
MINNIE CREEK
IN THE VICINITY OF CHENEY, WASHINGTON

1. PURPOSE AND SCOPE

Washington State Department of Ecology requested the U.S. Army Corps of Engineers to perform a limited detail study of Minnie Creek in the vicinity of Cheney, Washington. This limited detail study includes determining the 1 percent chance flood discharge and developing the floodplain and floodway for a portion of Minnie Creek in the vicinity of Cheney, Washington. The study area is 5 miles in length beginning at the Union Pacific Rail Road Bridge and ends at Meadow Lake. The information was requested for use in planning future developments, and is supported by the City of Cheney and Spokane County. In response to this request, the Walla Walla District, U.S. Army Corps of Engineers performed this hydrologic and hydraulic analysis, the results of which are covered in this report.

2. PREVIOUS STUDIES

No previous detailed flood insurance studies have been performed on Minnie Creek in the vicinity of Cheney, Washington. A portion of the area was studied by approximate methods and included in the September 30, 1992 Spokane County Flood Insurance Study (FIS). The area is presently listed as C and unnumbered A zones on the City of Cheney, Washington and Spokane County, Washington Flood Insurance Rate Maps (Panel Numbers 530175 0001 A, 530174 0375 B)

3. HYDROLOGIC ANALYSIS

This section presents the hydrology of the Minnie Creek basin, upstream of the Union Pacific Rail Road Bridge, the downstream limit of the detailed study.

3.1 STREAMS AND DRAINAGE AREAS

Minnie Creek is a tributary of Hangman Creek, a tributary of the Spokane River on the eastern edge of Washington State.

The basin has an irregular shape, draining the hillsides to the northeast and southwest of Minnie Creek.

The drainage basin is 12.4 square miles with a length of approximately 6.8 miles along its axis, and a width of about 2.9 miles at its widest point. Minnie Creek flows from northwest to southeast through a relatively flat valley bottom that contains a significant amount of wetlands. The average slope of Minnie Creek is 18.3 feet per mile. However, the majority of the elevation change is downstream of Betz Road. The basin is sparsely vegetated with increasing vegetation in the valley. The basin is shown on Map 1. The Minnie Creek basin ranges in elevation from about 2,880 feet National Geodetic Vertical Datum (NGVD) 1929 (see Map 1) to approximately 2,280 feet NGVD 1929 near the downstream limits of the study area.

3.2 CLIMATE

The climate of the Minnie Creek area is cold harsh winters with generally mild summers. At nearby climatological stations the mean annual temperature of the basin is approximately 49 degrees Fahrenheit, and the mean annual precipitation for the basin is approximately 17 inches. Precipitation is lowest in July and August, gradually reaches a maximum in mid-winter, decreases in the spring, and increases slightly in May and June. Most winter precipitation is in the form of snow. Warm winds and rain often melt the snow rapidly. If the soil underneath is frozen much of the moisture is lost by runoff. Near the basin there are two climatological recording stations, both just northeast of the basin. Table 1 lists the meteorological data gathered from the Western Regional Climate Center.

Table 1
Temperature and Precipitation Summary
For period of record

STATION	AVERAGE MAXIMUM ANNUAL TEMP. (F)	AVERAGE ANNUAL TEMP. (F)	AVERAGE MINIMUM ANNUAL TEMP. (F)	ONE DAY MAXIMUM PRECIP. (in.)	AVERAGE TOTAL ANNUAL PRECIP. (in.)	AVERAGE TOTAL ANNUAL SNOWFALL (in.)
Spokane WSO Airport #457938 (1889-2006)	58	48	38	2.19	16.04	41.1
Spokane #457933 (1953-1983)	59.8	49.5	39.3	1.81	17.62	10.7
Spokane WSO Airport #457938 (NCDC 1971-2000 Annual Normal)	58	47	37	n/a	16.7	n/a

In addition to the climatological stations listed in Table 1, mapping exists of eastern Washington precipitation in the Climatological Handbook Columbia Basin States Precipitation, September 1969 (Reference 1). This mapping indicated average annual precipitation for the Minnie Creek basin of 18.8 inches for the period of 1930-1957. The NCDC 1961- 1990 precipitation normal for the Minnie Creek basin is 17.2 inches.

3.3 STREAMFLOW CHARACTERISTICS

No stream gaging stations exist on Minnie Creek. The extreme peak discharges of record from 8 United States Geological Survey (USGS) stream gages in the region were collected and the unit discharge per square mile calculated for each gage. The drainage areas for the gages ranged from 2.02 square miles to 31.9 square miles. The period of record ranged from 13 to 20 years. Individual gages are listed in Table 2.

Table 2
Unit Discharges for Selected Stations

Station Number	Station Name	Drainage Area (square miles)	NCDC 1961-1990 Normal Average Precip. (inch)	Peak Unit Discharge for period of record (cfs/square mile)	Period of Record (years)	Years of Record (years)
12429200	Bear Creek near Milan, WA	10.5	22	9.3	1963-1975	13
12429600	Deer Creek Near Chattaroy, WA	31.9	27.6	12.3	1962-1975	14
12430370	Bigelow Gulch near Spokane	2.07	19.14	107.2	1962-1975	14
12431100	Little Creek at Dartford	11.9	20	27.3	1963-1977	15
12423900	Stevens Creek Tributary near Moran	2.02	19	61.9	1954-1973	20
14017070	East Fork McKay Creek	4.92	18	149.0	1963-1977	15
13343520	Clayton Gulch Near Alpowa, WA	5.6	15	53.2	1961-1976	16
14016600	Hatley Creek Near Dayton, WA	4.92	23	61.4	1955-1974	19

3.4 FLOOD CHARACTERISTICS

Winter floods are the most common in Eastern Washington. In these floods, rainfall, snowmelt, and occasionally frozen soil conditions combine to produce short-duration, intense runoff. The stations shown in Table 2 indicate the major event in the region was the 3-4 February 1963 flood.

3.5 FLOOD FREQUENCIES

Three methods were evaluated to determine the flood frequencies of Minnie Creek; Regional Frequency (Reference 2), Magnitude and Frequency of Floods in Washington Water-Resources Investigations Report 97-4277 (Reference 3), and A Method of Estimating Flood-Frequency Parameters for Streams in Idaho USGS Open-File Report 81-909 (Reference 4).

A regional analysis was performed for the Minnie Creek drainage basin. Five streams in the region having stream gage data, obtained from the United States Geological Survey, were chosen for having basins of similar size and vicinity of Minnie Creek. The stations used are included in Table 2, and depicted in Table 3.

The U.S Army Corps Program titled Regional Frequency Computation, dated 1989 (Reference 2), was used to compute statistics of annual maximum events of each of the five stations. These statistics, namely log mean, standard deviation, and skew, are necessary to a regional frequency study. The program computes missing events so that complete sets of events are obtained for all years at all stations while preserving all intercorrelations. Computed values for these statistics are shown in Table 3.

Table 3
Statistics of Annual Maximum Events and Regression Results

Station/R^2	Drainage Area	Mean Annual Precipitation[1]	Log Mean	Standard Deviation	Skew
12429200	10.5	22	1.704	0.13	-0.156
12431100	11.9	20	1.577	0.483	0.216
14017070	4.9	18	1.764	0.502	0.324
13343520	5.6	15	1.905	0.555	-2.989
14016600	4.9	23	1.834	0.45	-0.647
R^2			0.75	0.39	0.24

[1]Mean annual precipitation for all stations used was derived from mean annual precipitation data, NCDC normals for 1961-1990, which was the time period of gage data for most of the gaging stations.

Regression analysis was performed with each of the stations statistical results plotted against the product of the drainage area (DA) times the mean annual precipitation (MAP). The product of DA and MAP results in a volume of water and allows basins differing in DA and MAP to be associated. Regression equations were derived to plot a linear regression line through the statistical data. The residuals squared, R^2, was used as an indicator of goodness of fit.

Using the product of the drainage area (DA) times the mean annual precipitation (MAP) for Minnie Creek, parameters for log mean, standard deviation, and skew were obtained from regression equations, see Table 4.

Table 4
Minnie Creek Frequency Parameters

Location	Minnie Creek at Cheney
Drainage Area (DA) square miles	12.37
Contributing NCDC 1961-1990 Mean Annual Precipitation (MAP) inches[1]	17.2
DA x MAP	212.764
Regression Equation	Y = a + m * DA * MAP
Y = Log Mean	
a	1.956937
m	-0.001359
Log Mean at Specified Location	1.667783
Y = Standard Deviation	
a	0.617825
m	-0.001316
Standard Deviation at Location	0.33779
Y = Skew	
a	-1.868919
m	0.008274
Skew at Specified Location	-0.108428

[1]For consistency with the source of mean annual precipitation and the period of record for the stream gaging stations mean annual precipitation values for the Minnie Creek basin were taken from the NCDC 1961-1990 normals.

A log-pearson type III frequency curve was fit to the parameters, log mean, standard deviation and skew. Peak discharge-drainage area relationships for Minnie Creek are shown in Table 5.

Table 5
Summary of Regional Frequency Discharges

Flooding Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Percent Chance	2-Percent Chance	1-Percent Chance	0.2-Percent Chance
Minnie Creek	12.4	125	220	270	395

Hydrologic analyses were carried out using methodologies in Magnitude and Frequency of Floods in Washington Water-Resources Investigations Report 97-4277. Equations chosen were for Region 9. Specific flood frequencies are shown in Table 6.

Table 6
Specific Frequency Flood Discharges Report 97-4277

Location	Drainage Area (Square Miles)	Specific Frequency Discharge (Cubic Feet per Second) 10 Percent Chance Flood (10-Year)	2 Percent Chance Flood (50-Year)	1 Percent Chance Flood (100-Year)
Minnie Creek	12.4	470	1,010	1,320

Hydrologic analyses were carried out to determine peak discharge frequencies for selected recurrence intervals on Minnie Creek using USGS Open-File Report 81-909, "A Method of Estimating Flood-Frequency Parameters for Streams in Idaho". Minnie Creek, Washington is on the periphery of this report.

The drainage area, 12.4 square miles, mean basin elevation 2,463 feet, and average slope 57.6 feet/mile were determined from 1:250,000 scale USGS quadrangles Cheney, and Four Lakes, Washington. A regional skew value of -0.3 was used.

Equations used from USGS open file report 81-909 were chosen for Region 3. Specific flood frequencies are shown in Table 7.

Table 7

Specific Frequency Flood Discharges USGS 81-909

Location	Drainage Area (Square Miles)	Specific Frequency Discharge (Cubic Feet per Second) 10 Percent Chance Flood (10-Year)	2 Percent Chance Flood (50-Year)	1 Percent Chance Flood (100-Year)	0.2 Percent Chance Flood (500-Year)
Minnie Creek	12.4	310	450	510	640

Peak unit discharges ranged from 21.8 cfs/sq mi to 106.7 cfs/sq mi (1 percent chance flood) for the three methods used to determine flood frequencies.

The recommendation is to adopt the results of the regional frequency analysis. The resulting frequency curve is shown on Plate 1. The Open File Report 81-909 did not use streamflow gaging stations in the vicinity of Minnie Creek with similar basin characteristics and the results from the Water-Resources Investigations Report 97-4277 indicate a unit discharge in excess of the peak of the gaging stations in the region. The regional frequency approach did not have a good fit to the skew, or a station with a long period of record, but provided what is the best available data for the determination of flood frequencies.

4. DEVELOPMENT OF THE BASE MAP

The base map for the study was developed from georeferenced USGS 7.5-minute quadrangles (quad sheets) for Cheney, Idaho, aerial photographs, a 2006 Digital Ortho Photo and field surveying data. Cross sections surveyed in July/August 2006 were provided horizontally referenced to the Idaho West North

American Datum (NAD 27), North American Vertical Datum (NAVD 29). The surveys were overlaid on the quad sheets "Cheney, Wa. 1980" and "Four Lakes, Wa. 1973" and verified by matching identifiable features such as edge of pavement, and old buildings. Aerial photographs were overlaid and centerline stationing was made following the channel indicated on the aerial photographs, between cross section locations. A 2006 Digital Ortho Photo was obtained for the Cheney area and utilized for placing newer roads and housing developments that were not on the older quadrangles. Contour data was generated from the quadrangles and is expressed at 20 foot intervals.

5. HYDRAULIC ANALYSIS

This hydraulic analysis was performed using the Hydrologic Engineering Center's computer program "River Analysis System", version 3.1.3, May 2005 commonly known as HEC-RAS. Cross section surveys were performed in August 2006 to provide channel and overbank geometry for the hydraulic model. The cross section locations for the study are indicated on Maps 2-5. The model began at cross section A, 2,500 feet downstream of Marshall Road at the Burlington Northern Santa Fe (BNSF) Railroad Crossing, and ended 700 feet downstream of Meadow Road.

There are 12 bridges in the study area. Downstream to upstream they include: BNSF Railroad Bridge, private bridge, Marshall Road, Palouse and Coulee City (PCC) Railroad Maintenance Road, PCC Railroad, PCC Railroad, Betz Road, private road, private road, Washington State Highway 904, PCC Railroad Bridge, Jensen Road. Cross sections for the bridges were developed from surveyed bridge data and road profile surveys immediately surrounding the bridge.

The culvert roadway cross section for Jensen Road, near cross section P, and adjacent cross sections were corrected for their skew from perpendicular to the flood flow path (shortening the cross section to account for reduced flow path through the cross section). The culvert opening was not skewed due to its perpendicular orientation with the flood flow path. As a result, the model output will not directly agree with the mapping. The other bridges required no correction since openings were perpendicular to the flood flow paths.

Buildings were added to the cross sections in the model by blocking out portions of the floodplain to more accurately account for loss of overbank conveyance. Considering the vegetation growth in the floodplain, Manning's n values for the channel ranged from 0.03 to 0.045 throughout the study reach.

The PCC Railroad crossing near cross section F constricted flow such that 45 cfs split from the main channel and flowed along the Northeast ditch of the railroad rejoining the main channel downstream the PCC Railroad near cross section D.

A significant backwater occurred upstream the Washington State Highway 904 crossing and the adjacent Palouse and Coulee City Railroad crossing (see Maps 3-5, vicinity of M through U). This is due to undersized culverts at these adjacent crossings, a highly elevated Roadway and Railroad causing dam like conditions, and relatively flat channel slope upstream. Steady flow modeling produced a greater volume of water that ponded upstream this area then was available in the basin. As a result, an unsteady flow model was developed for the 1-percent chance flood and floodway using Snyder's method to derive the hydrograph. The peak of the hydrograph was 270 cfs. The resulting hydrograph is shown on Plate 2.

The unsteady flow model resulted in a maximum water surface that was lower than the steady flow model and more reflective of the maximum elevation obtained by the volume of water that the basin would produce.

Although water presently backs up due the undersized PCC Railroad crossing, the undersized culvert at the State Highway 904 crossing would be little better if the flow area under the PCC railroad were increased. These culverts cause high backwater and pond like conditions from this point upstream to Meadow Road. If these culverts were replaced with larger capacity culverts such as the grouping at Jensen Road, and the sediment buildup downstream the Highway 904 culvert and between the Highway and Railroad culverts were removed, the upstream floodplain could be reduced.

Unsteady flow modeling was only performed from the Washington State Highway 904 crossing upstream to Meadow Road. Downstream this location steady flow modeling was used. The rational for this decision is as follows. The unsteady flow modeling was chosen due to the lack of basin runoff volume during a 1-percent chance flood to fill the backwatered area upstream the Highway 904 crossing using steady flow analysis. The unsteady flow modeling was not continued downstream as neither the PCC Railroad culvert and embankment or the Washington State Highway 904 culvert and embankment are approved flood control structures, and there is no indication that the downstream flood control benefit will continue. In addition, the Washington State Department of Transportation is preparing to Widen Highway 904 to 4 lanes and at that time will be replacing the culverts. As a result, steady flow modeling was used downstream this location.

In modeling floodplains, effective flow areas are limited by the waters ability to contract or expand within the floodplain. The ineffective flow areas are most commonly found upstream and downstream bridges but can be anywhere there is a contraction or expansion limit. Ineffective flow areas are blocked out in this HEC-RAS model. Although there is no flow exchange in these areas, water is still present.

The boundaries of the floodway were defined using equal conveyance reduction with a maximum 1.0-foot surcharge criteria (see Figure 1).

5.1 MAINTENANCE CONCERNS

Multiple bridges or culverts were blocked with debris, sediment or crossed by fencing. The mapping and modeling for this study considered these culverts and bridge openings clear of debris, sediment or fencing blocking an opening. The following locations need debris, sediment, or fencing removed from the culvert to function as indicated on Maps 2-5.

Photograph 1. Marshall Road culvert downstream face has a fence across the opening

Photograph 2. Betz Road culvert upstream face has a fence across the opening

Photograph 3. Highway 904 culvert has sediment and debris. Deposited material is both upstream and downstream this opening hindering effective flow area.

Photograph 4. Palouse and Coulee City Railroad culvert has accumulated sediment and debris at the culvert.

6. RESULTS

Appendix A contains the cross section cross reference table. Appendix B contains the HEC-RAS computer program input and output.

The 10-, 2-, and 1-percent chance flood flows, as determined in the hydrologic analysis are 125 cfs, 220 cfs, and 270 cfs, respectively. No 0.2-percent chance floodplain was determined due to the hydraulic complexities requiring additional survey data beyond that obtained for this study.

Base flood elevations were computed using the backwater computation model HEC-RAS version 3.1.3. The Base Flood Elevations, and 1-percent chance floodplain boundaries are indicated on Maps 2-5. The water surface profiles for the 1-, 2-, and 10-percent chance flood flows are shown on Plate 3. This model also defines the boundaries of a floodway that would meet the maximum 1.0-foot surcharge. The floodway is defined by encroaching the 1 percent chance floodplain so as not to exceed the 1.0-foot rise criteria or to encroach within the stream channel or its meanders. The floodway data are shown on Table 8, and floodway boundaries on Maps 2-5. The cross section locations are indicated on Maps 2-5.

All bridges except the most downstream BN Railroad Bridge, Highway 904 Bridge, and adjacent PCC Railroad Bridge were perched or overtopped for the 1-percent chance flood flows.

Some bridges were perched for the 2- and 10-percent chance flood flows. Table 9 indicates at what flow values and where perching or overtopping occurred.

Table 9
Where Bridges are Perched or Overtopped

Bridge		10 Percent Chance Flood (10-Year)	2 Percent Chance Flood (50-Year)	1 Percent Chance Flood (100-Year)
BN Railroad	Left			
	Right			
Private Road	Left			
	Right	X	X	X
Marshall Road	Left		X	X
	Right			
PCC Maintenance	Left	X	X	X
Road	Right	X	X	X
PCC Railroad	Left			
	Right		X	X
PCC Railroad	Left		X	X
	Right			
Betz Road	Left			
	Right		X	X
Private Road	Left	X	X	X
	Right	X	X	X
Private Road	Left	X	X	X
	Right		X	X
State Highway 904	Left	N/A	N/A	
	Right			
PCC Railroad	Left	N/A	N/A	
	Right			
Jensen Road[1]	Left	N/A	N/A	X
	Right			X

[1]The State Highway 904 Bridge and adjacent PCC Railroad Bridge had significantly undersized culverts which inundated significant areas upstream for the 10-, 2-, and 1-percent floods. This included inundating Jensen Road.

7. SUMMARY

The base flood elevation and floodway presented are necessary technical information for successful floodplain management. We recommend that this information be submitted to the Federal Emergency Management Agency (FEMA) for the purpose of floodplain management. For ease in floodplain administration digital ortho photographs are included as a backdrop on the floodplain Maps 6-9. Technical information displayed on these maps match Maps 2-5.

8. BIBLIOGRAPHY AND REFERENCES

1. Pacific Northwest River Basins Commission, Meteorology Committee, Climatological Handbook Columbia Basin States Precipitation, Volume 2, September 1969.

2. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, Computer Program Regional Frequency Computation, Davis, California, 1989.

3. U.S. Department of the Interior, Geological Survey, Water-Resources Investigations Report 97-4277, Magnitude and Frequency of Floods in Washington, S.S. Sumioka, D.L. Kresch, and K.D. Kasnick, 1997.

4. U.S. Department of the Interior, Geological Survey, Open-File Report 81-909, A Method of Estimating Flood-Frequency Parameters for Streams in Idaho, L.C. Kjelstrom, and R.L. Moffatt, 1981.

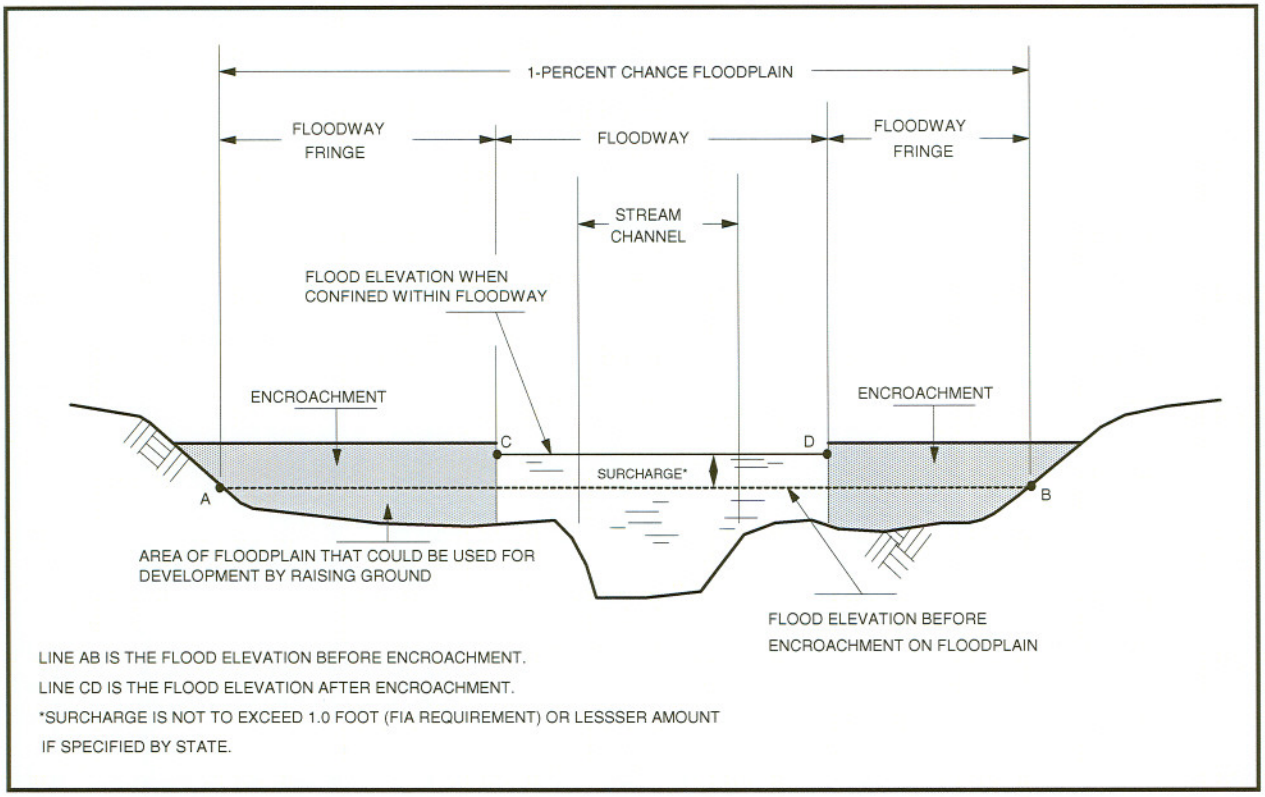


Figure 1. Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET)	WITHOUT FLOODWAY (FEET)	FLOODWAY (FEET)	INCREASE (FEET)
A	179	16	34	8.93	2,289.3 [1]	2,289.3 [1]	2,290.2	0.9
B	1,571	76	140	2.52	2,327.9	2,327.9	2,328.8	0.9
C	2,551	10	28	9.52	2,340.8	2,340.8	2,340.9	0.1
D	3,072	36	202	1.87	2,352.7	2,352.7	2,353.6	0.9
E	4,526	79	76	3.55	2,356.7	2,356.7	2,356.8	0.1
F	5,365	28	92	4.16	2,362.9	2,362.9	2,363.3	0.4
G	6,220	41	64	4.22	2,367.1	2,367.1	2,367.1	0.0
H	7,262	107	283	0.95	2,371.2	2,371.2	2,371.6	0.4
I	8,110	33	160	1.69	2,371.2	2,371.2	2,371.7	0.5
J	9,070	37	184	1.52	2,371.2	2,371.2	2,372.2	1.0
K	10,173	134	766	0.35	2,371.3	2,371.3	2,372.3	1.0
L	11,006	253	1,752	0.15	2,371.3	2,371.3	2,372.3	1.0
M [2]	12,724	415	2,835	0.03	2,374.1	2,374.1	2,375.1	1.0
N	14,141	840	4,327	0.02	2,374.1	2,374.1	2,375.1	1.0
O	15,338	1,010	6,179	0.01	2,374.1	2,374.1	2,375.1	1.0
P	16,700	660	2,836	0.03	2,374.1	2,374.1	2,375.1	1.0
Q	17,633	680	1,931	0.04	2,374.1	2,374.1	2,375.1	1.0
R	18,535	636	2,099	0.05	2,374.1	2,374.1	2,375.1	1.0
S	20,373	968	4,888	0.02	2,374.1	2,374.1	2,375.1	1.0
T	22,519	877	4,470	0.03	2,374.1	2,374.1	2,375.1	1.0
U	23,495	448	880	0.07	2,374.1	2,374.1	2,375.1	1.0

1 Model started at critical depth

2 Unsteady flow modeling cross sections M through U

TABLE 8

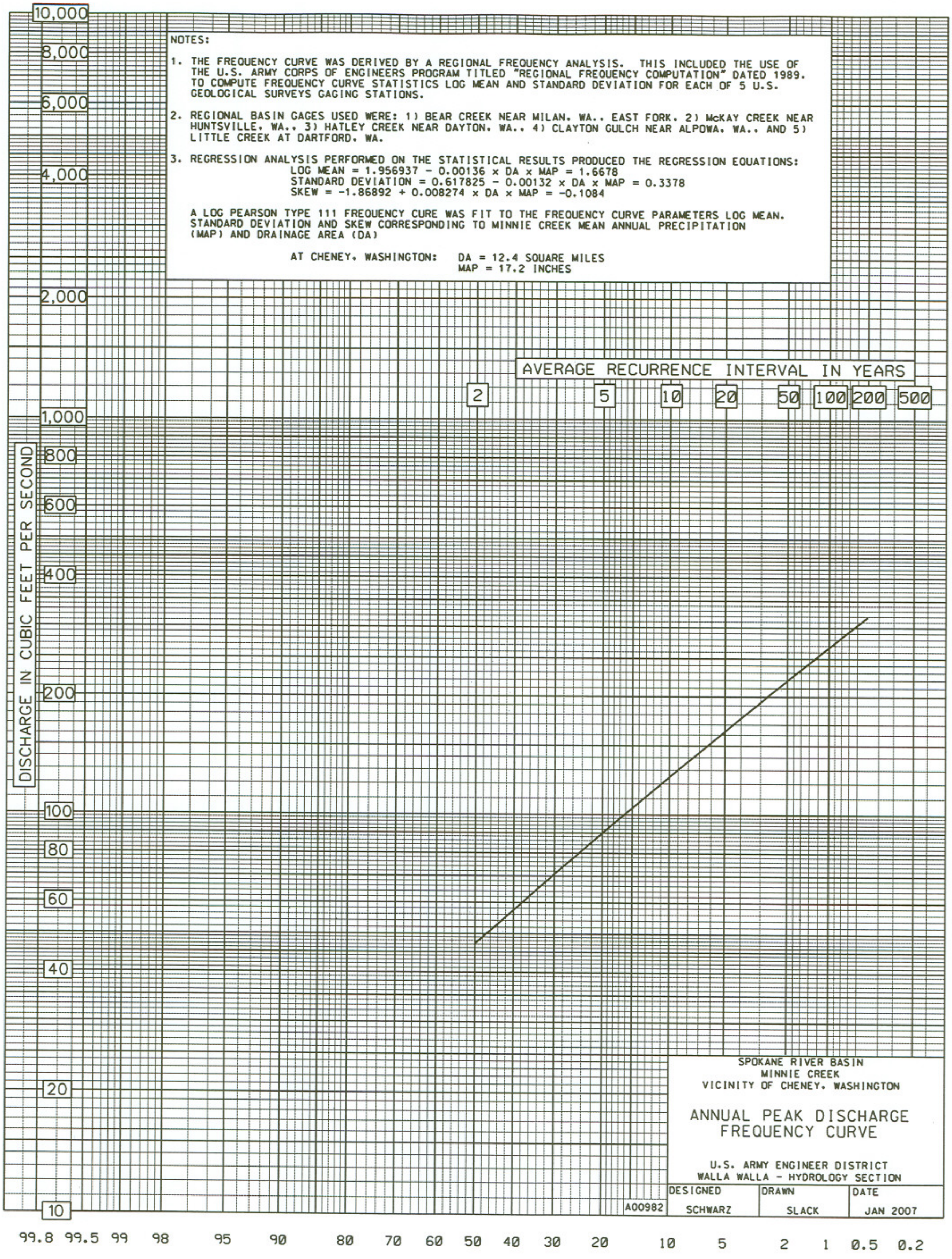
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY SECTION

CITY OF CHENEY/SPOKANE COUNTY, WA

(UNINCORPORATED AREAS)

FLOODWAY DATA

MINNIE CREEK



NOTES:

1. THE FREQUENCY CURVE WAS DERIVED BY A REGIONAL FREQUENCY ANALYSIS. THIS INCLUDED THE USE OF THE U.S. ARMY CORPS OF ENGINEERS PROGRAM TITLED "REGIONAL FREQUENCY COMPUTATION" DATED 1989. TO COMPUTE FREQUENCY CURVE STATISTICS LOG MEAN AND STANDARD DEVIATION FOR EACH OF 5 U.S. GEOLOGICAL SURVEYS GAGING STATIONS.

2. REGIONAL BASIN GAGES USED WERE: 1) BEAR CREEK NEAR MILAN, WA., EAST FORK, 2) McKAY CREEK NEAR HUNTSVILLE, WA., 3) HATLEY CREEK NEAR DAYTON, WA., 4) CLAYTON GULCH NEAR ALPOWA, WA., AND 5) LITTLE CREEK AT DARTFORD, WA.

3. REGRESSION ANALYSIS PERFORMED ON THE STATISTICAL RESULTS PRODUCED THE REGRESSION EQUATIONS:

LOG MEAN = 1.956937 - 0.00136 x DA x MAP = 1.6678
STANDARD DEVIATION = 0.617825 - 0.00132 x DA x MAP = 0.3378
SKEW = -1.86892 + 0.008274 x DA x MAP = -0.1084

A LOG PEARSON TYPE 111 FREQUENCY CURE WAS FIT TO THE FREQUENCY CURVE PARAMETERS LOG MEAN, STANDARD DEVIATION AND SKEW CORRESPONDING TO MINNIE CREEK MEAN ANNUAL PRECIPITATION (MAP) AND DRAINAGE AREA (DA)

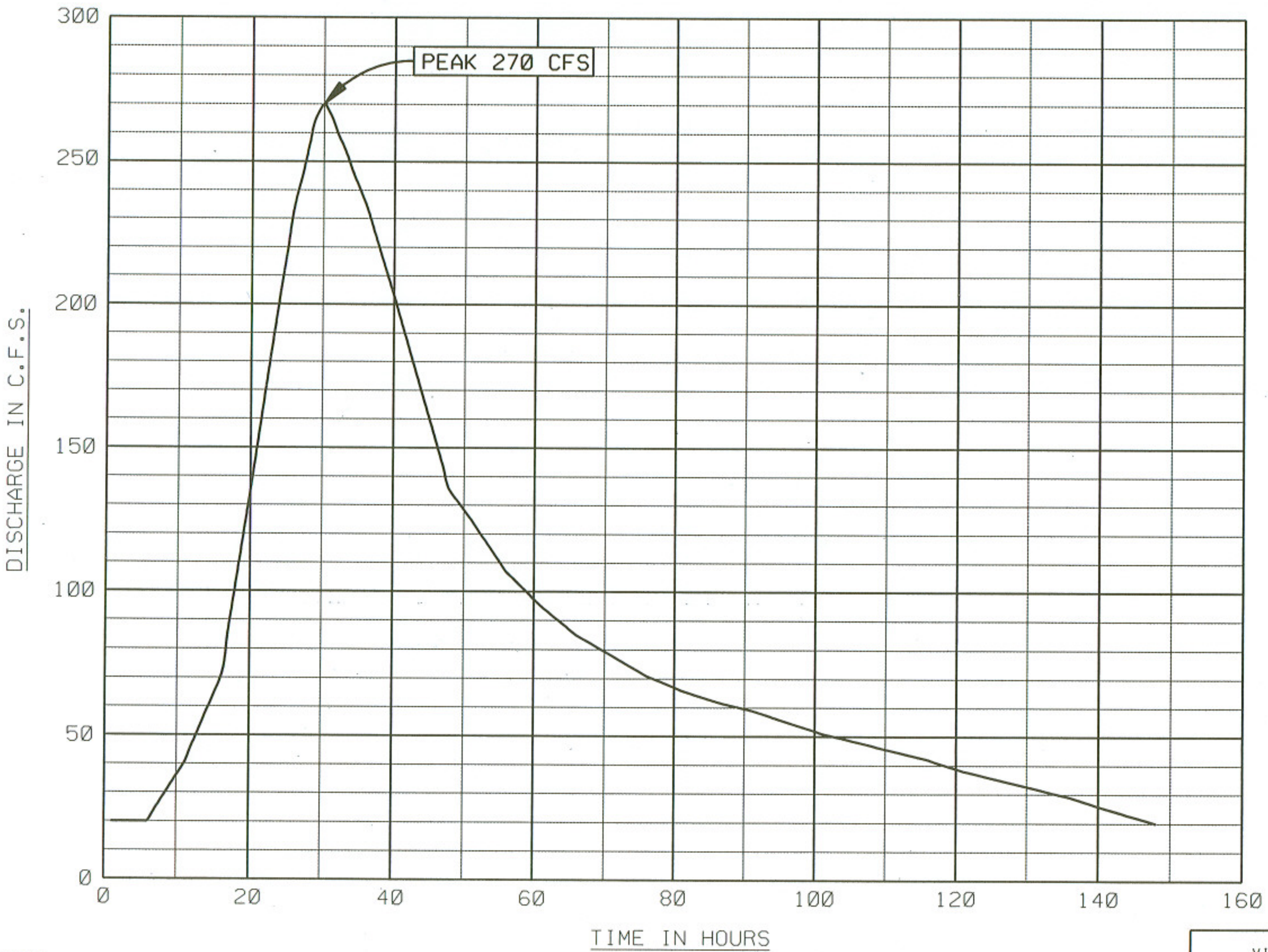
AT CHENEY, WASHINGTON: DA = 12.4 SQUARE MILES
MAP = 17.2 INCHES

SPOKANE RIVER BASIN
MINNIE CREEK
VICINITY OF CHENEY, WASHINGTON

ANNUAL PEAK DISCHARGE FREQUENCY CURVE

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY SECTION

DESIGNED	DRAWN	DATE
SCHWARZ	SLACK	JAN 2007



NOTE:

BASED ON SNYDERS UNIT HYDROGRPAH.

DRAINAGE AREA (DA) = 12.4 SQUARE MILES.
PEAK FLOW (QP) = 270 C.F.S.

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON

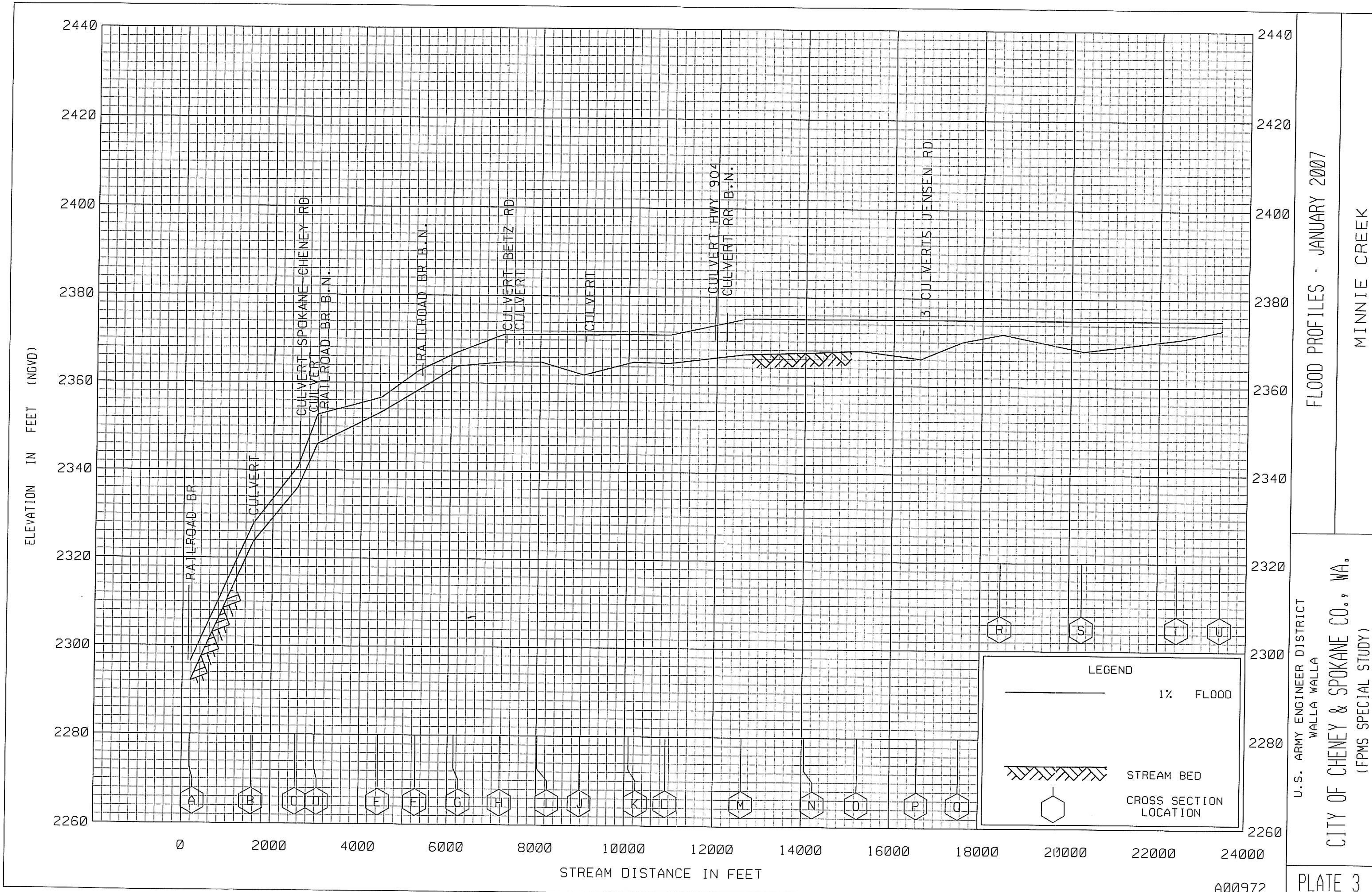
MINNEY CREEK
UNIT HYDROGRAPH
1% CHANCE EXCEEDENCE FLOOD

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY SECTION

DESIGNED	DRAWN	DATE
SCHWARZ	SLACK	24 JAN 2007

A00971

PLATE 2

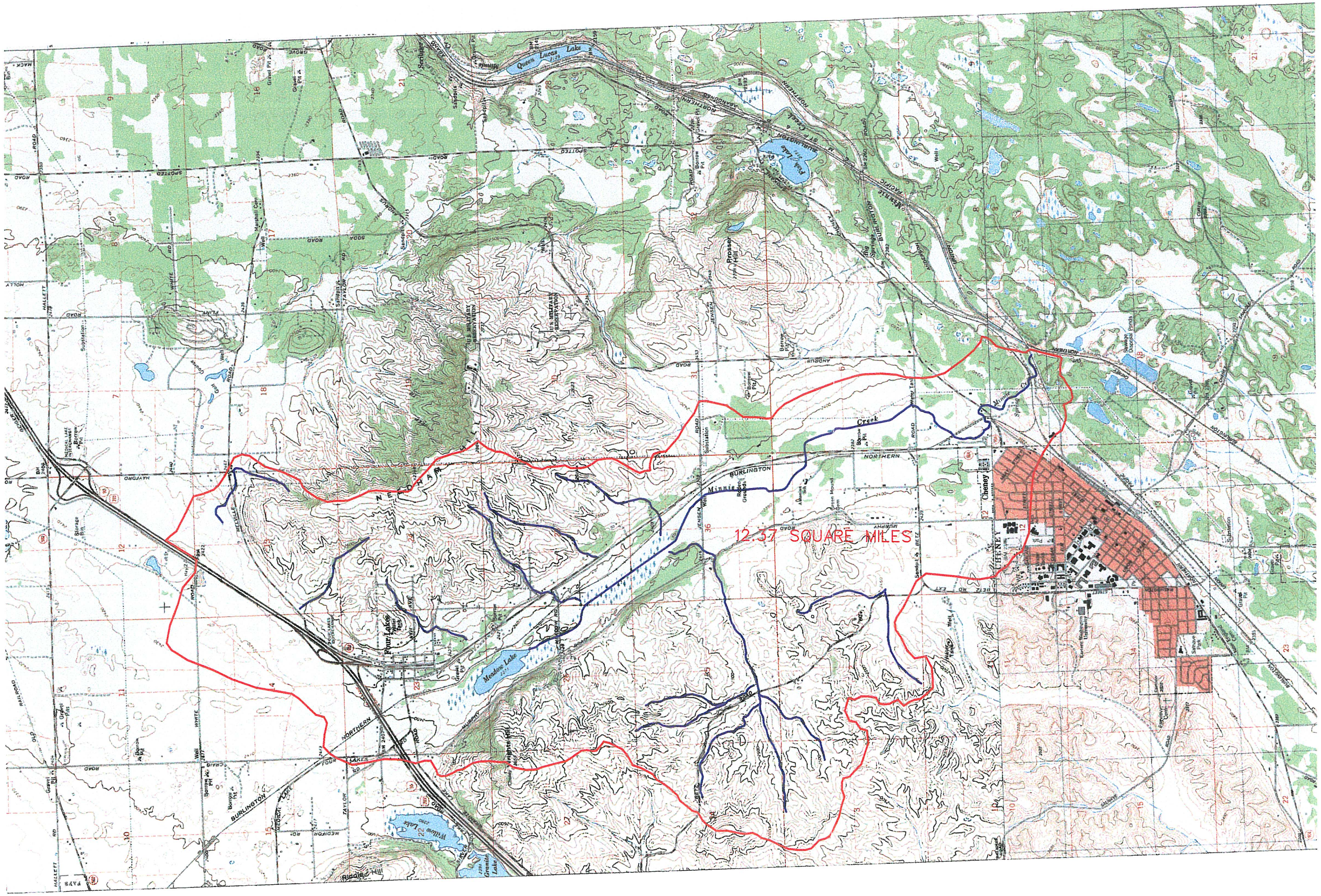


U.S. ARMY ENGINEER DISTRICT
WALLA WALLA

CITY OF CHENEY & SPOKANE CO., WA.
(FPMS SPECIAL STUDY)

PLATE 3

A00972



LEGEND

BASIN BOUNDARY

CREEK AND TRIBUTARIES

4000 0 4000

SCALE IN FEET

NOTES:

1. THE BASE MAP WAS DIGITIZED FROM THE U.S.G.S. 7.5 MINUTE QUADRANGLES "FOUR LAKES, WA., 1973" AND "CHENEY, WA., 1980".

2. THE HORIZONTAL DATUM IS NAD 83, WASHINGTON NORTH STATE PLANE ZONE. THE VERTICAL DATUM IS NGVD 29, TAKEN FROM THE QUADRANGLES. THE FOUR LAKES QUAD IS 20 FOOT CONTOUR INTERVAL WHILE THE CHENEY QUAD IS 10 FOOT CONTOUR INTERVAL.

A00981

SPOKANE RIVER BASIN
MINNEY CREEK, VICINITY OF CHENEY, WA.

BASIN BOUNDARY MAP

WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

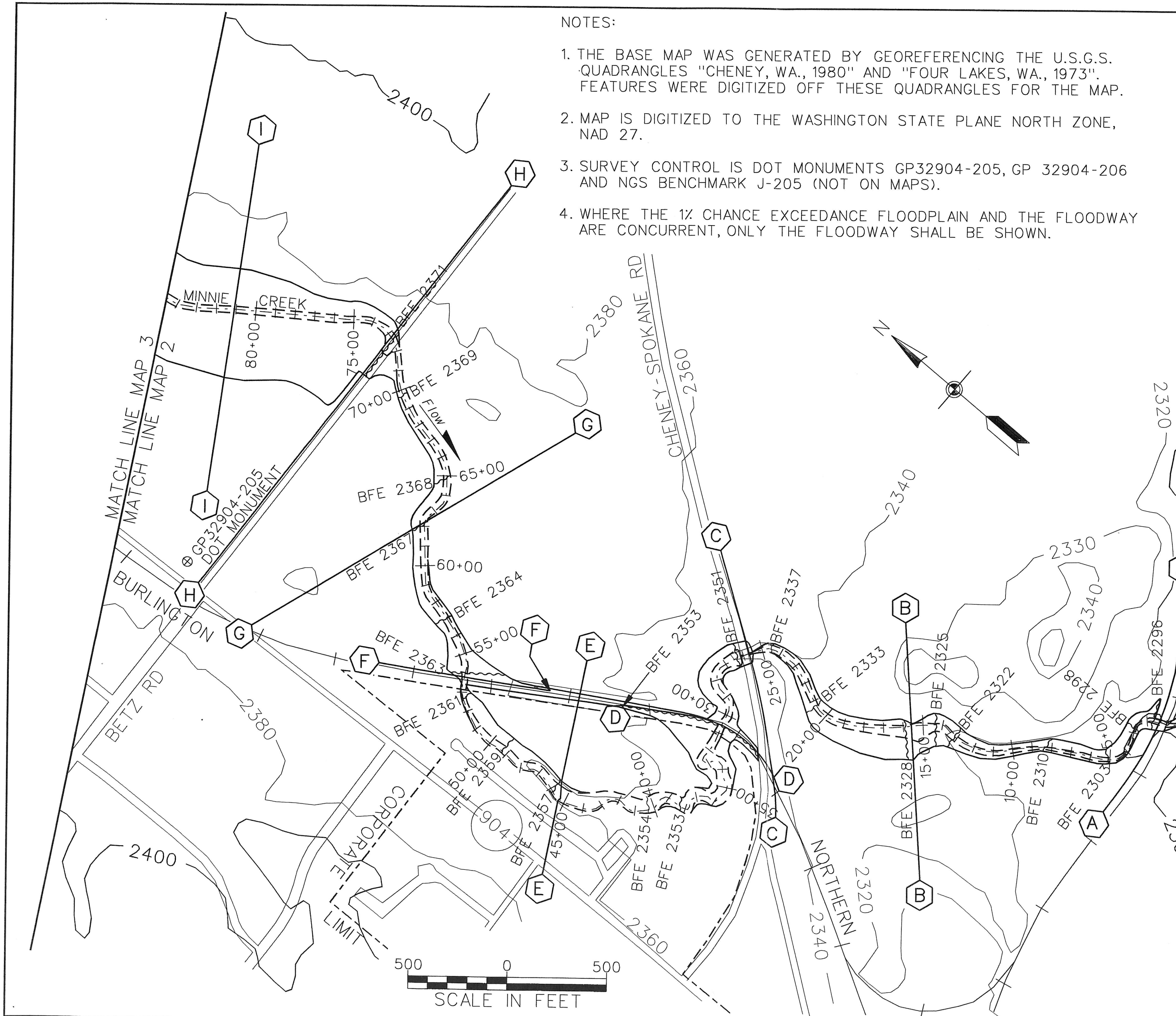
DESIGNED BY: SCHWARZ
DWN BY: SLACK
CHKD BY:
SUBMITTED BY: N
DATE: APRIL 2005
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: FN

SPOKANE RIVER BASIN
MINNEY CREEK, VICINITY OF CHENEY, WA.
BASIN BOUNDARY MAP
WALLA WALLA DISTRICT – HYDROLOGY SECTION

MAP 1

BORDER SIZE IS ANSI D

DATE AND TIME PLOTTED: 30-JAN-2007 11:19



NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. SURVEY CONTROL IS DOT MONUMENTS GP32904-205, GP 32904-206 AND NGS BENCHMARK J-205 (NOT ON MAPS).
4. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.

LEGEND

- 80+00 MINNIE CREEK
- MINOR CONTOUR
- 2300 MAJOR CONTOUR
- FLOODWAY
- 1% CHANCE EXCEEDANCE FLOODPLAIN
- RAILROAD
- (A)—(A) SURVEY CROSS SECTION
- BASE FLOOD ELEVATIONS

A00973

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
SUBMITTED BY: N
DATE: 18 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: FN

Sheet number: MAP 2

BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED:30-JAN-2007 08:34 DESIGN FILE:C:\JOBFILES\MINNEY_CREEK\MAP1-500.DGN SCALE$SCALE$ USERNAME$USER$

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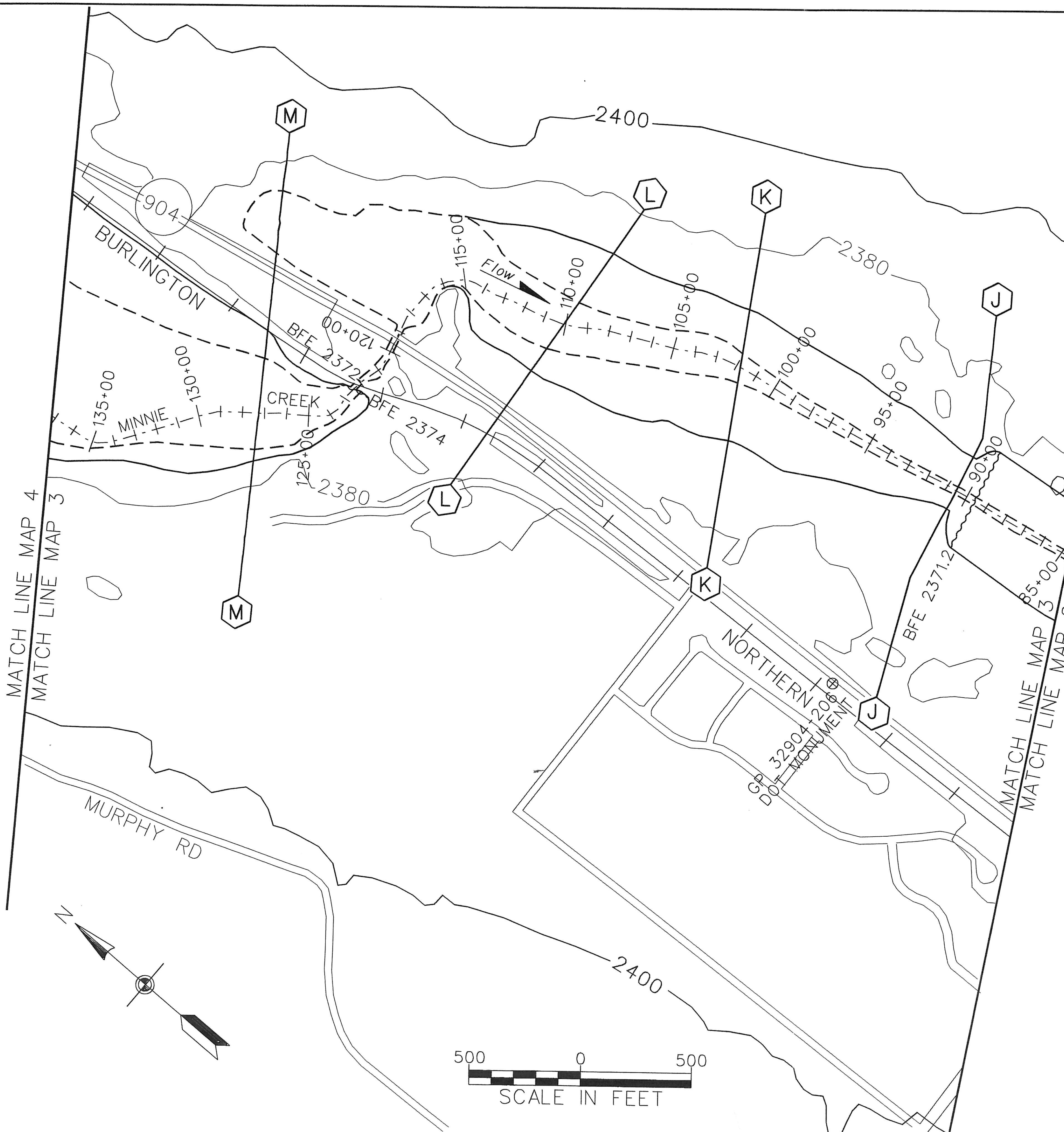

LEGEND

- 80+00 MINNIE CREEK
- MINOR CONTOUR
- 2300 MAJOR CONTOUR
- FLOODWAY
- 1% CHANCE EXCEEDANCE FLOODPLAIN
- RAILROAD
- (A)—(A) SURVEY CROSS SECTION
- BASE FLOOD ELEVATIONS

NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. SURVEY CONTROL IS DOT MONUMENTS GP32904-205, GP 32904-206 AND NGS BENCHMARK J-205 (NOT ON MAPS).
4. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.

A00974

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
SUBMITTED BY: N
CHIEF ______ DES. SEC.
DATE: 19 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.: ----------
FILE NO.: FN

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

Sheet number: MAP 3

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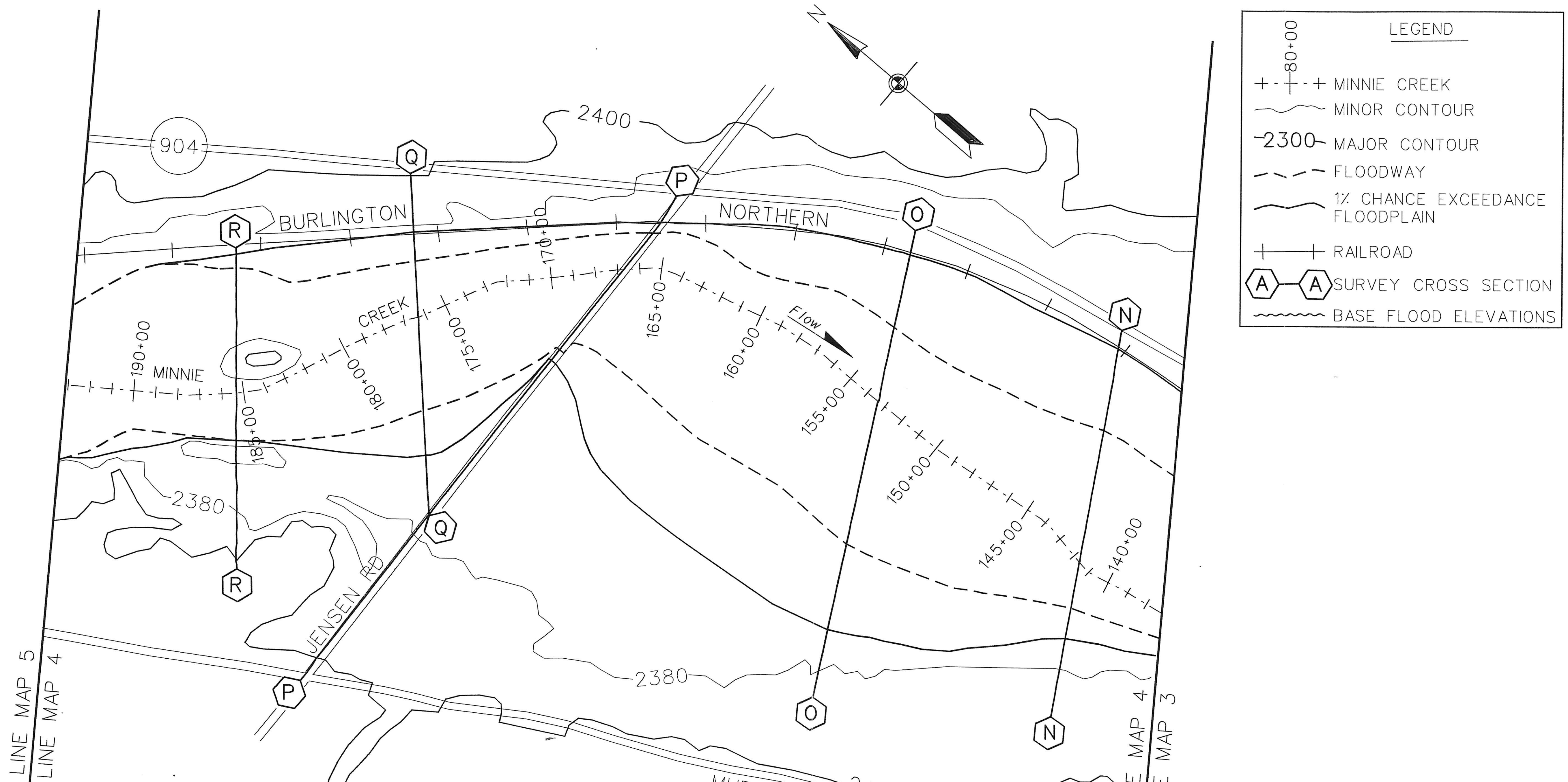
BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED: 30-JAN-2007 11:07 DESIGN FILE: C:\JOBFILES\MINNEY_CREEK\A00974.DGN SCALE$SCALE$ USERNAME$USER$



NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. SURVEY CONTROL IS DOT MONUMENTS GP32904-205, GP 32904-206 AND NGS BENCHMARK J-205 (NOT ON MAPS).
4. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.

500 0 500
SCALE IN FEET

A00975

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CKD BY: N
SUBMITTED BY: N
DATE: 22 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: FN

Sheet number: MAP 4

BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED:30-JAN-2007 09:00 DESIGN FILE:C:\JOBFILES\MINNEY_CREEK\MAP3-500.DGN SCALE$SCALE$ USERNAME$USER$

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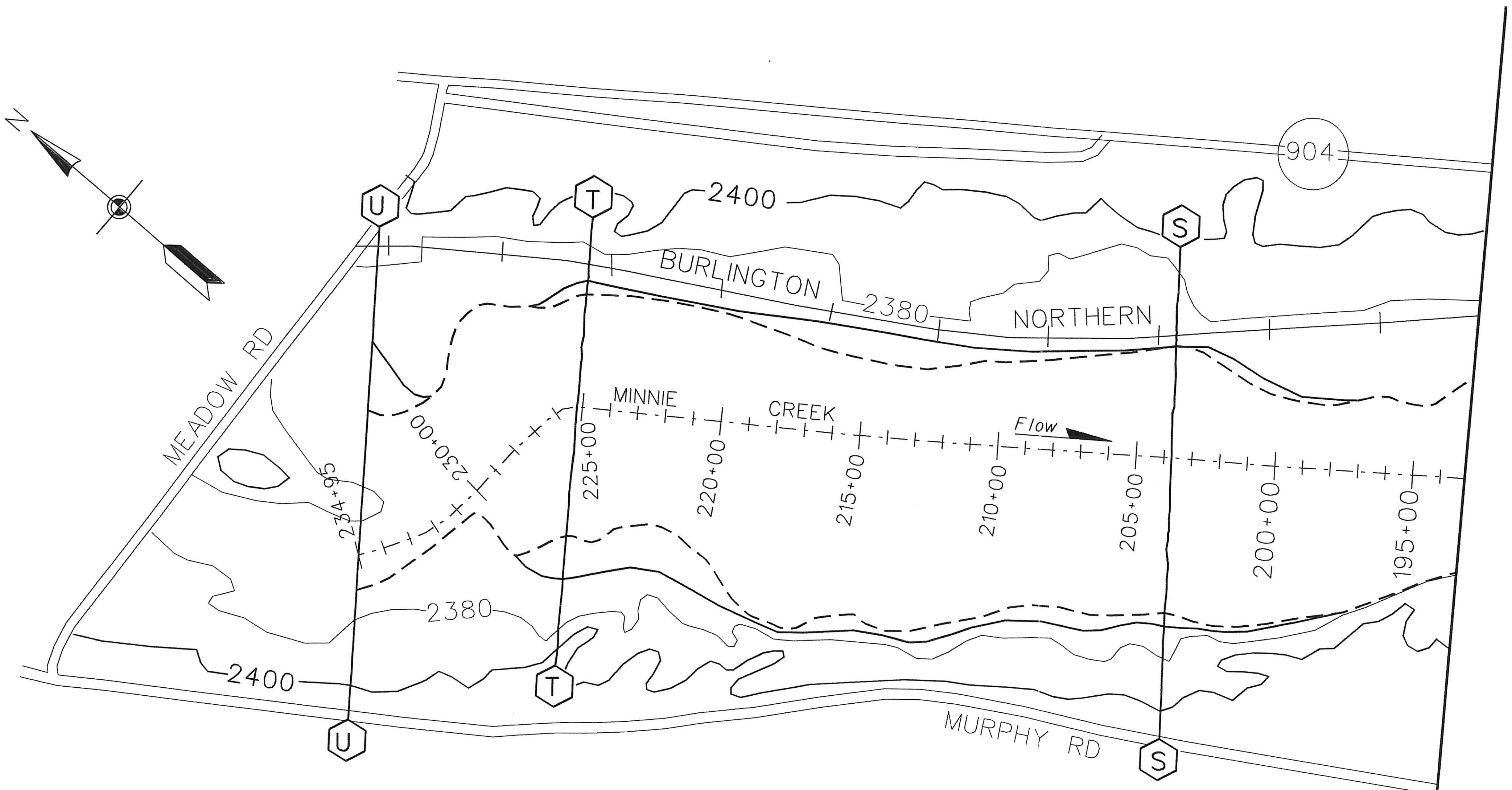

NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.

2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.

3. SURVEY CONTROL IS DOT MONUMENTS GP32904-205, GP 32904-206 AND NGS BENCHMARK J-205 (NOT ON MAPS).

4. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.

500 0 500
SCALE IN FEET

LEGEND

80+00 MINNIE CREEK
MINOR CONTOUR
2300 MAJOR CONTOUR
FLOODWAY
1% CHANCE EXCEEDANCE FLOODPLAIN
RAILROAD
(A)—(A) SURVEY CROSS SECTION
BASE FLOOD ELEVATIONS

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
SUBMITTED BY: N
CHIEF, DES. SEC.
FILE NO.: FN
DATE: 22 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY
BOUNDARY LOCATIONS
WALLA WALLA DISTRICT - HYDROLOGY SECTION

A00976

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON

MINNIE CREEK

FLOODPLAIN AND FLOODWAY
BOUNDARY LOCATIONS

WALLA WALLA DISTRICT – HYDROLOGY SECTION

Sheet number:
MAP 5

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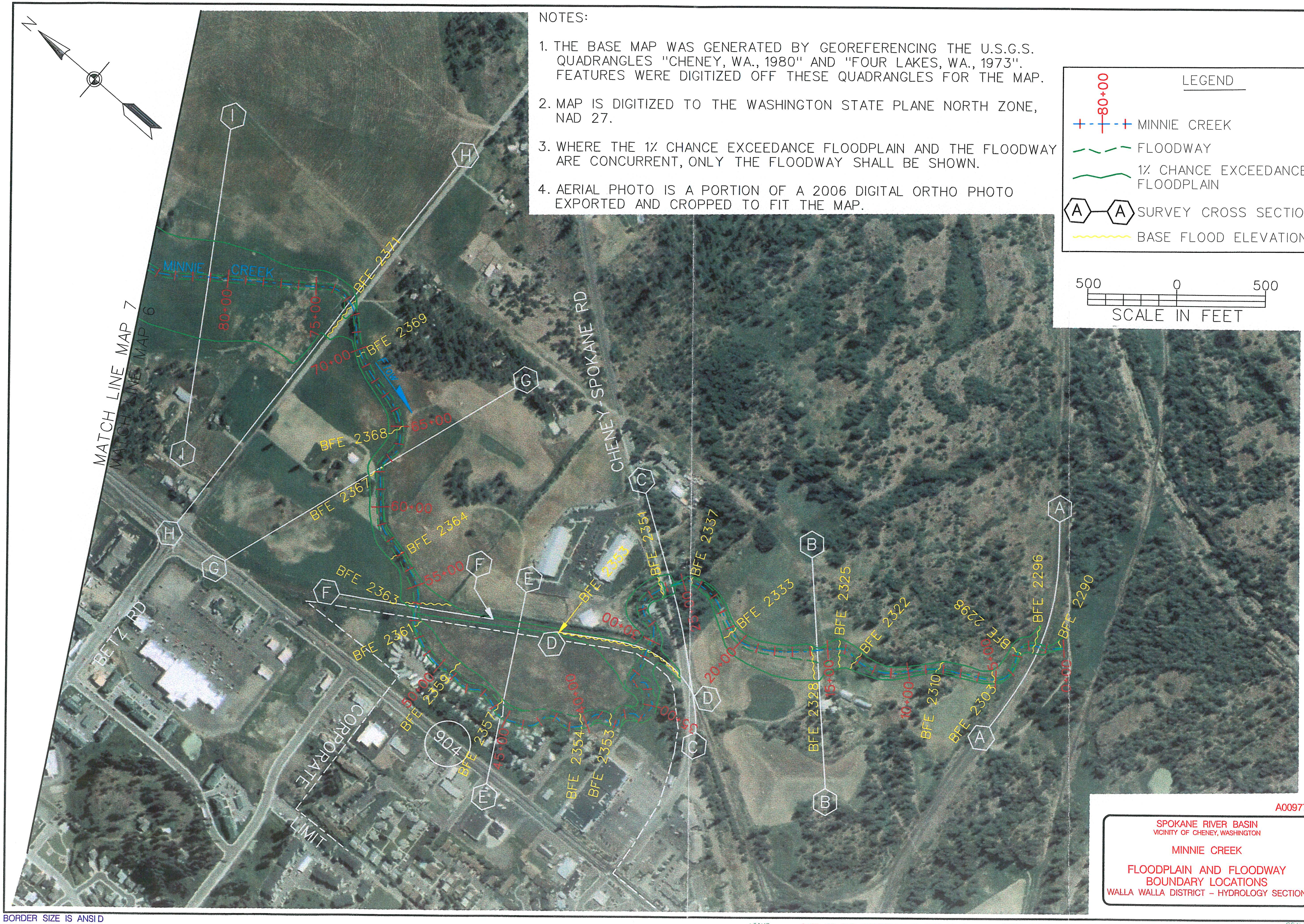
BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED:30-JAN-2007 09:06 DESIGN FILE:C:\JOBFILES\MINNEY_CREEK\MAP4-500.DGN SCALE$SCALE$ USERNAME$USER$

NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.
4. AERIAL PHOTO IS A PORTION OF A 2006 DIGITAL ORTHO PHOTO EXPORTED AND CROPPED TO FIT THE MAP.



LEGEND

80+00

MINNIE CREEK

FLOODWAY

1% CHANCE EXCEEDANCE FLOODPLAIN

(A)—(A) SURVEY CROSS SECTION

BASE FLOOD ELEVATIONS

500 0 500

SCALE IN FEET

A00977

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON

MINNIE CREEK

FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS

WALLA WALLA DISTRICT - HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
SUBMITTED BY: N
DATE: 18 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: FN

Sheet number
MAP 6

BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED: 30-JAN-2007 10:15 DESIGN FILE: C:\JOBFILES\MINNEY_CREEK\A00977.DGN SCALE$SCALE$ USERNAME$USER$

LEGEND

- MINNIE CREEK (80+00)
- FLOODWAY
- 1% CHANCE EXCEEDANCE FLOODPLAIN
- SURVEY CROSS SECTION (A—A)
- BASE FLOOD ELEVATIONS

N

500 0 500

SCALE IN FEET

NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.
4. AERIAL PHOTO IS A PORTION OF A 2006 DIGITAL ORTHO PHOTO EXPORTED AND CROPPED TO FIT THE MAP.

A00978

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
DATE: 19 JAN 2007
SOLICITATION NO. XX-B-XXXX
FILE NO.: FN

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

MAP 7

C:\JOBFILES\MINNEY_CREEK\A00978.DGN

BORDER SIZE IS ANSI D

DATE AND TIME PLOTTED: 32 JAN 2007 12:20
DESIGN FILE: C:\JOBFILES\MINNEY_CREEK\A00978.DGN

NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
2. MAP IS DIGITIZED TO THE WASHINGTON STATE PLANE NORTH ZONE, NAD 27.
3. WHERE THE 1% CHANCE EXCEEDANCE FLOODPLAIN AND THE FLOODWAY ARE CONCURRENT, ONLY THE FLOODWAY SHALL BE SHOWN.
4. AERIAL PHOTO IS A PORTION OF A 2006 DIGITAL ORTHO PHOTO EXPORTED AND CROPPED TO FIT THE MAP.

A00979

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKED BY: N
SUBMITTED BY: N
CHIEF ______ DES. SEC.
FILE NO.: FN
DATE: 22 JAN 2007
SOLICITATION NO. XX-B-XXXX
CONTRACT NO. ________

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

Sheet number:
MAP 8

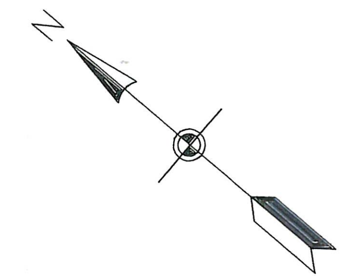
C:\JOBFILES\MINNEY_CREEK\A00979.DGN

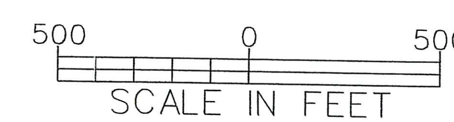
BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED: 30-JAN-2007 12:57 DESIGN FILE: C:\JOBFILES\MINNEY_CREEK\A00979.DGN SCALE$SCALE$ USERNAME$USER$

LEGEND

- 80+00 MINNIE CREEK
- FLOODWAY
- 1% CHANCE EXCEEDANCE FLOODPLAIN
- (A)—(A) SURVEY CROSS SECTION
- BASE FLOOD ELEVATIONS





NOTES:

1. THE BASE MAP WAS GENERATED BY GEOREFERENCING THE U.S.G.S. QUADRANGLES "CHENEY, WA., 1980" AND "FOUR LAKES, WA., 1973". FEATURES WERE DIGITIZED OFF THESE QUADRANGLES FOR THE MAP.
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4. AERIAL PHOTO IS A PORTION OF A 2006 DIGITAL ORTHO PHOTO EXPORTED AND CROPPED TO FIT THE MAP.

A00980

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: SLACK/SCHWARZ
DWN BY: SLACK
CHKD BY: N
DATE: 22 JAN 2007
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
SUBMITTED BY: N
FILE NO.: FN

SPOKANE RIVER BASIN
VICINITY OF CHENEY, WASHINGTON
MINNIE CREEK
FLOODPLAIN AND FLOODWAY BOUNDARY LOCATIONS
WALLA WALLA DISTRICT – HYDROLOGY SECTION

Sheet number:
MAP 9

BORDER SIZE IS ANSI D

$TIME DATE AND TIME PLOTTED: 30-JAN-2007 10:52 DESIGN FILE: C:\JOBFILES\MINNEY_CREEK\A00980.DGN SCALE=$SCALE$ USERNAME=$USER$