The WLB Group Inc.

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

ADDENDUM
TO
WITTMANN ADMS

Effects of Floodplain Encroachment and Channelization on Stormwater Runoff

Engineering • Planning • Surveying • Urban Design • Landscape Architecture
Offices located in Tucson, Phoenix, Las Vegas, and Rancho Cucamonga, California
333 East Osborn Suite 380 • Phoenix, Arizona 85012 • (602) 279-1016

The WLB Group Inc.

TABLE OF CONTENTS

	Page No.
Introduction	1
Method of Analysis	1
Floodplain Encroachment	2
Channelization	3
Summary of Results	3
Appendix A - Routing Parameter Modification as a Result of Floodplain Encroachment	
Appendix B - Routing Parameter Modification as a Result of Channelization	

Introduction

This study has been prepared for the Flood Control District of Maricopa County as an addendum to the Wittmann Area Drainage Master Study (ADMS). The purpose of the study is to analyze the effects that future floodplain encroachment and channelization will have on stormwater runoff.

Concern for the safety of McMicken Dam and the outlet channel was the impetus for this analysis. Moreover, there is a concern that floodplain encroachment and channelization will tend to increase the peak discharges in the study area which, in turn, will create a future flood hazard for the adjacent properties along the encroached floodplains and channels.

Method of Analysis

To analyze the effects of floodplain encroachment and channelization, an adjustment was made to the Muskingum K coefficient in the HEC-1 hydrologic model developed as part of the Wittmann ADMS. This parameter was modified to reflect the increase in velocity caused by floodplain encroachment or channelization. The Muskingum X value, which accounts for channel storage, was not modified because there was no way of quantifying the change in X due to the absence of observed data in this area.

However, a sensitivity analysis was performed on the variable X. The value was changed from .2 to .3 in the HEC-1 model for the channelized condition, thereby assuming less attenuation of the flood hydrograph. The results indicated that this particular model was relatively insensitive to changes in X. For example, in the case of the 100-year flood, the peak inflow at McMicken Dam increased only 4.6% with no change in peak stage and the PMF peak increased 1.3% with a 0.06 foot increase in peak stage.

Two separate models were developed to model the change in the K coefficient. One was prepared to model the effect of floodplain encroachment and the other was to model the effect of channelization. The following paragraphs describe the procedure used to adjust this routing parameter for each model.

To determine the impact on McMicken Dam and the outlet channel, both the Standard Project Flood (SPF) and Probable Maximum Flood (PMF) were modeled. In addition, the 100-year flood was modeled to determine the increase in peak flow along the washes in the study area and hence, the potential for a future increase in water surface elevation.

Floodplain Encroachment

In the model to determine the effect of floodplain encroachment, it was assumed that all of the routing reaches associated with the 322 square mile drainage area were in an encroached condition. That is, the routing parameters for every reach were adjusted to reflect the increase in velocity expected from floodplain encroachment.

The increase in velocity for each routing reach was obtained by one of three methods.

1. For the washes that were studied in detail with floodplains and floodways, the computed increase in average velocity was used to modify the routing parameters. In other words, the computed floodway velocity was divided by the average floodplain velocity to calculate the percent increase. This percentage was applied to the existing condition (unencroached) velocity used in the original Wittmann ADMS HEC-1 model which resulted in an increase in velocity and decrease in travel time.

2. For many of the smaller washes, particularly the ones east of Grand Avenue, where only the floodplain was delineated (no floodway), the increase in velocity was calculated by taking the computed average channel velocity and dividing it by the average floodplain velocity to compute the percentage increase.

3. For the remainder of the routing reaches which were not studied in detail, the percent increase in velocity was taken from similar washes that were studied in detail.

Channelization

In the hydrologic model to determine the impact of channelization in the watershed, conceptual channel sections were developed to estimate flow velocities and travel times for each reach. The channel sections were assumed to be trapezoidal in shape with 2:1 side slopes. The channel bed slope was set equal to the existing ground slope and a Mannings n value of 0.025 was used to reflect an improved earthen channel condition with riprap or grouted riprap bank protection.

The peak discharges previously computed as part of the Wittmann ADMS were used to calculate velocities. The channel data and computed velocities are summarized for each reach in Appendix B.

Summary of Results

The results of both the floodplain encroachment run and channelization run were compared against the original hydrologic model to ascertain whether these modifications to the routing parameters would adversely effect major structures and peak discharges in the watershed.

The following table shows the resulting increases in peak discharge at selected locations. The results are shown for both the effects of floodplain encroachment and channelization.

TABLE SHOWING

PERCENT INCREASE IN PEAK DISCHARGE

(As a Result of Floodplain Encroachment and Channelization)

Location	100-Year Flood		SPF		PMF	
	E	C	E	C	E	C
Inflow to McMicken Dam	2.5%	25.0%	2.6%	15.6%	2.2%	10.5%
Trilby Wash at the CAP Canal	4.0%	58.1%	0.5%	12.2%	0.6%	4.1%
Trilby Wash at Beardsley Road	4.8%	58.3%	3.6%	17.9%	2.3%	10.2%
Trilby Wash at Grand Avenue	3.8%	25.3%	0.8%	3.6%	0.0%	0.2%
CAP1WEST at the CAP Canal	1.9%	25.3%	0.9%	3.0%	0.3%	0.6%
Padelford Wash at the Beardsley Canal	1.7%	19.0%	0.9%	5.2%	0.9%	7.3%
CAP4EAST at Grand Avenue	0.0%	15.4%	0.0%	7.3%	0.0%	0.6%

E = Encroachment

C = Channelization

From inspection of the preceding table, it is clear that the effects of channelization are considerably more significant than the effects of floodplain encroachment. It is also clear that both floodplain encroachment and channelization affects the 100-year flood greater than the SPF and the PMF.

The fact that channelization results in a greater increase in peak discharge than floodplain encroachment is understandable. Channelization tends to increase flow velocities more than floodplain encroachment and it decreases channel storage more than floodplain encroachment. Both of these factors will result in higher peak discharges.

As noted above, the effect on peak discharge of both floodplain encroachment and channelization diminishes with flood frequency. For example, the 100-year flood on Trilby Wash at the CAP Canal increases 58.1% as a result of channelization. Whereas, the increase in the PMF is only 4.1%. The reason for this diminishing effect is that both the floodways and channels are designed to convey the 100-year flood. Floods of lesser frequency will exceed the conveyance capacity and flow in the overbanks. Consequently, the increase in flow velocity and decrease in channel storage for the SPF and PMF is not nearly as great as for the 100-year flood. Therefore, the increase in peak discharge as a result of channelization and floodplain encroachment is not as great.

In addition to peak discharges, the peak stages for existing flood control structures were also compared. As can be seen in the following Comparison Table of Peak Discharges and Peak Elevations, the water surface elevation at McMicken Dam for the 100-year flood increases only 0.02' as a result of floodplain encroachment and 0.07' as a result of channelization. Similarly, the increase at the dam for the SPF is 0.01' and 0.06', respectively and 0.07' and 0.45' for the PMF. The relatively small rises in water surface elevation would be expected considering the large volume stored by the dam. However, the increase due to channelization causes a rise in water surface elevation, for the PMF, of almost 0.5 feet behind McMicken Dam which would result in the Dam being overtopped.

COMPARISON TABLE
OF
PEAK DISCHARGES AND PEAK ELEVATIONS

100-Year Flood

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP Overchutes									
CAP1WEST (C65)	6553	6459	1551.94'	6680	6590	1551.97'	7017	6933	1552.06'
CAP2WEST (C64)	3172	2268	1548.43'	3475	2310	1548.51'	4352	2583	1549.00'
TRILBY WASH (CAP3WEST) (C63)	3851	3845	1548.87'	4005	3997	1548.97'	6090	6051	1550.31'

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
IONA WASH (CAP4WEST) (C62)	5309	5001	1552.35'	5640	5263	1552.39'	8920	7793	1552.76'
CAP5WEST (C60)	4953	3724	1541.91'	5005	3749	1541.94'	6514	4324	1542.60'
CAP1EAST - CAP9EAST (C50)	11128	3043	1549.88'	11137	3044	1549.88'	12212	3062	1549.93'
CAP10EST - CAP14EST (C53)	5389	2200	1545.90'	5465	2204	1545.91'	5774	2224	1545.96'
BEARDSLEY CANAL OVERCHUTES									
CAP5EAST (C120)	2227	2227	1337.36'	2291	2289	1337.38'	3085	3081	1338.16'
PADELFORD WASH (C123)	2718	2718	1342.13'	2763	2763	1342.13'	3234	3178	1342.18'
CAP16EST (C125)	4535	4197	1340.26'	4829	4425	1340.54'	5244	4722	1340.91'

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
MCMICKEN DAM									
OUTLET WORKS (C97)	20430	2998	1349.92'	20918	3004	1349.94'	25541	3028	1349.99'
SPILLWAY (DIV97)	20430	---	1349.92'	20918	---	1349.94'	25541	---	1349.99'
CAP1WEST									
HAPPY VALLEY RD. (C102A)	6230	6230	---	6641	6641	---	7161	7161	---
DEER VALLEY RD. (C102)	6222	6222	---	6756	6756	---	7292	7292	---
CAP2WEST									
PINNACLE PEAK RD. (C95)	2340	2340	---	2465	2465	---	2851	2851	---
BEARDSLEY RD. (C93)	2377	2377	---	2511	2511	---	3058	3058	---

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
TRILBY WASH, IONA WASH AND CAP5WEST									
BEARDSLEY RD. (C78T)	11499	11499	---	12051	12051	---	18202	18202	---
CAP1EAST									
GRAND AVE. (C106)	330	330	1522.80'	330	330	1522.80'	332	332	1522.82'
CAP4EAST									
GRAND AVE. (C110)	786	785	1420.08'	787	787	1420.08'	907	906	1420.28'
MCMICKEN DAM OUTLET CHANNEL									
OUTLET INTO WASH (C123)	5087	5087	---	5253	5253	---	6258	6258	---
WITTMANN WASH									
GRAND AVE. (C38)	2202	2202	1676.33'	2208	2208	1676.33'	2223	2223	1676.34'
TRILBY WASH									
GRAND AVE. (C26)	2970	2970	1856.34'	3083	3083	1856.40'	3722	3722	1856.72'

Standard Project Flood

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP CANAL OVERCHUTES									
CAP1WEST (C65)	7483	7471	1552.38'	7552	7539	1552.40'	7710	7695	1552.44'
CAP2WEST (C64)	3693	3189	1550.06'	3711	3228	1550.11'	3922	3379	1550.28'
TRILBY WASH (CAP3WEST) (C63)	5033	5031	1550.04'	5060	5059	1550.06'	5645	5639	1550.50'
IONA WASH (CAP4WEST) (C62)	6988	6964	1552.80'	7104	7083	1552.82'	8100	8019	1552.99'
CAP5WEST (C60)	4648	4191	1543.09'	4667	4199	1543.10'	5060	4304	1543.24'
CAP1EAST - CAP9EAST (C50)	10807	6266	1553.26'	10811	6268	1553.26'	11415	6389	1553.32'
CAP10EST - CAP14EST (C53)	5574	3480	1551.10'	5573	3480	1551.10'	5693	3513	1551.24'

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
BEARDSLEY CANAL OVERCHUTES									
CAP5EAST (C120)	3788	3787	1338.56'	3852	3852	1338.62'	4631	4628	1339.30'
PADELFORD WASH (C123)	4909	4906	1342.48'	4953	4950	1342.49'	5165	5161	1342.51'
CAP16EST (C125)	3511	3505	1339.88'	3550	3541	1339.94'	3601	3583	1340.01'
MCMICKEN DAM									
OUTLET WASH (C97)	37503	4541	1354.98'	38538	4543	1354.99'	43368	4551	1355.04'
SPILLWAY (DIV97)	37503	10977	1354.98'	38538	11062	1354.99'	43368	11477	1344.04'
CAP1WEST									
HAPPY VALLEY RD. (C102A)	8723	8723	---	8871	8871	---	9057	9057	---
DEER VALLEY RD. (C102)	9218	9218	---	9503	9503	---	9726	9726	---

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP2WEST									
PINNACLE PEAK RD. (C95)	3536	3536	---	3761	3761	---	4144	4144	---
BEARDSLEY RD. (C93)	3716	3716	---	3963	3963	---	4624	4624	---
TRILBY WASH, IONA WASH, AND CAP5WEST									
BEARDSLEY RD. (C78T)	20544	20544	---	21292	21292	---	24220	24220	---
CAP1EAST									
GRAND AVE. (C106)	399	399	---	399	399	---	402	402	---
CAP4EAST									
GRAND AVE. (C110)	1157	1157	---	1159	1159	---	1242	1242	---
MCMICKEN DAM OUTLET CHANNEL									
OUTLET INTO (C122)	18747	18747	---	19043	19043	---	20436	20436	---

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
WITTMANN WASH									
GRAND AVE.	2306	2306	---	2306	2306	---	2306	2306	---
TRILBY WASH									
GRAND AVE. (C26)	2867	2867	---	2890	2890	---	2972	2972	---
Probable Maximum Flood									
CAP CANAL OVERCHUTES									
CAP1WEST (C65)	20727	20727	1552.89'	20780	20780	1552.89'	20859	20859	1552.89'
CAP2WEST (C64)	9858	8700	1556.39'	9916	8796	1556.50'	10065	9129	1556.88'
TRILBY WASH (CAP3WEST) (C63)	12811	12804	1554.16'	12889	12885	1554.18'	13334	13330	1554.29'
IONA WASH (CAP4WEST) (C62)	18877	18875	1552.81'	19155	19152	1552.82'	20176	20176	1552.87'
CAP5WEST	11448	11447	1546.14'	11460	11458	1546.14'	11572	11572	1546.15'

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP1EAST - CAP9EAST (C50)	27169	26806	1556.25'	27171	26809	1556.25'	27263	26984	1556.27'
CAP10EST - CAP14EST (C53)	26244	26220	1555.82	26251	26228	1555.82'	26382	26362	1555.83'
BEARDSLEY CANAL OVERCHUTES									
CAP5EAST (C120)	13058	13056	1340.83'	13228	13223	1340.85'	14659	14659	1341.01'
PADELFORD WASH (C123)	29640	29625	1345.86'	29912	29898	1345.89'	31796	31796	1346.15'
CAP16EST (C125)	8328	8326	1342.63'	8339	8336	1342.63'	8349	8347	1342.63'
MCMICKEN DAM									
OUTLET WASH (C97)	110374	5272	1360.46'	112725	5280	1360.53'	121955	5349	1360.91'
SPILLWAY (DIV97)	110374	89770	1360.46'	112725	90966	1360.53'	121955	101432	1360.91'

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP1WEST									
HAPPY VALLEY RD. (C102A)	25474	25474	---	25703	25703	---	26122	26122	---
DEER VALLEY RD. (C102)	27030	27030	---	27500	27500	---	28065	28065	---
CAP2WEST									
PINNACLE PEAK RD. (C95)	10213	10213	---	10698	10698	---	11490	11490	---
BEARDSLEY RD. (C93)	11045	11045	---	11572	11572	---	13049	13049	---
TRILBY WASH, IONA WASH, AND CAP5WEST									
BEARDSLEY RD. (C78T)	58642	58642	---	59963	59963	---	64629	64629	---
CAP1EAST									
GRAND AVE. (C106)	525	525	---	525	525	---	526	526	---

Location	No Encroachment			Encroachment			Channelization		
	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)	Inflow (CFS)	Outflow (CFS)	Elev. (FT)
CAP4EAST									
GRAND AVE. (C110)	2360	2360	---	2361	2361	---	2374	2374	---
MCMICKEN DAM OUTLET CHANNEL									
OUTLET INTO WASH (C122)	87711	87711	---	90193	90193	---	108621	108621	---
WITTMANN WASH									
GRAND AVE. (C38)	5991	5991	---	5991	5991	---	5991	5991	---
TRILBY WASH									
GRAND AVE. (C26)	6328	6328	---	6332	6332	---	6343	6343	---

REFERENCES

"Atchison, Topeka and Santa Fe Railroad Plan and Profile", As-Built 1941.

Adam, Hamlyn, Anderson, "McMicken Dam Restoration Construction Plans", March 1983.

Arizona Department of Transportation, "Hydrologic Design for Highway Drainage in Arizona", Revised April 1975.

Arizona Department of Transportation, "Morristown, New River Highway Plans", As-Built 1966 & 1971.

Arizona Department of Transportation, "Phoenix, Wickenburg Plans (State Highway 60 and 89)", As-Built 1943 and 1966.

Arizona State Land Department, State Trust Lands and Bureau of Land Management Map, Yavapai County, April 1984.

Arizona State Land Department, State Trust Lands and Bureau of Land Management Map, Maricopa County, September 1986.

Brater, Ernest F. and King, Horace Williams, "Handbook of Hydraulics for the Solution of Hydraulic Engineering Problems", Sixth Edition, 1982.

Chow, Ven Te, "Handbook of Applied Hydrology", 1964.

Chow, Ven Te, "Open-Channel Hydraulics", 1959.

Collar, Williams & White Engineering, "Drainage Report Sun Valley Parkway Phase I", March 1987.

Collar, Williams & White Engineering, "Sun Valley Parkway Grading, Drainage and Paving Plans, Phase I-A and Phase I-B", April 1987.

Collar, Williams & White Engineering, "Hydrologic/Hydraulic Design Analysis", Bell Road Crossing of McMicken Dam and Reservoir, October 1986.

Cooper Aerial Survey Company, Aerial Photographs, June 1986.

Dames and Moore, "Surface Water Design Considerations for the Maricopa County Northwest Regional Landfill", Technical Memorandum, November 21, 1986.

Dames & Moore, "Northwest Regional Landfill Plans", April 1987.

Dibble & Associates, "Hydrologic Study", 163rd Avenue from Grand Avenue to Jomax Road Maricopa County, Arizona, August 1985.

Dibble & Associates, "Plans for the Construction of 163rd Avenue, Grand Avenue to Jomax Road", As-Built June 27, 1986.

Federal Emergency Management Agency, Federal Insurance Administration, "Flood Insurance Study Guidelines and Specifications for Study Contractors", September 1985.

Flood Control District of Maricopa County, "Uniform Drainage Policys and Standards for Maricopa County, Arizona", February 25, 1987.

Flood Control District of Maricopa County, "Floodplain Regulation for Maricopa County", Amended March 23, 1987.

HDR, Inc., "Paving and Grading Plans, Sun City West Unit 12", 1979.

HDR, Inc., "El Mirage Channel HEC-2 Computer Runs", March 1979.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Routing of Floods Through River Channels", EM 1110-2-1408, March 1960.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "HEC-1 Flood Hydrograph Package", Users Manual, Revised January 1985.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "HEC-2 Water Surface Profiles", Users Manual", September 1982.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Application of the HEC-2 Split Flow Option", Training Document No. 18, Smith, April 1982.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Storm Drainage and Urban Region Flood Control Planning", Technical Paper No. 40, by Darryl Davis, October 1974.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Hydrologic Engineering in Planning", Training Document No. 14, April 1981.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Introduction and Application of Kinematic Wave Routing Techniques Used in HEC-1", Training Document No. 10, May 1979.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "The New HEC-1 Flood Hydrograph Package", Technical Paper No. 82, by David Goldman, May 1981.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Testing of Several Runoff Models on an Urban Watershed", Technical Paper No. 59, by Jess Abbot, October 1978.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Comparative Analysis of Flood Routing Methods", Research Document No. 24, September 1980.

Hydrologic Engineering Center, U.S. Army Corps of Engineers, "Hydrologic Analysis of Ungaged Watersheds Using HEC-1", Training Document No. 15, April 1982.

Johannessen & Girand, "Drainage Report for Chrysler Arizona Proving Grounds", September 1979.

Johannessen & Girand, "Drainage Report for Northerly Extension of 203rd Avenue", October 1978.

Johannessen & Girand, "Plan and Profile for Chrysler Proving Grounds and 203rd Avenue Access Road", 1979.

Maricopa County, Arizona "Zoning Maps", 1985.

Maricopa County Highway Department, "Patton Road and 203rd Avenue Plan and Profile", As-Built January 1986.

Maricopa County Highway Department, "Plan and Profile for Proposed Deer Valley Road", 1987.

National Oceanic and Atmospheric Administration, "NOAA Atlas 2", Precipitation Frequency Atlas of the Western Unied States, Volume VIII - Arizona, 1973.

National Oceanic and Atmospheric Administration and U.S. Department of the Army Corps of Engineers, "Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages", Hydrometeorological Report No. 49, September 1977.

Sergent, Hauskins and Beckwith, "Surface Water Hydrology Report", McMicken Dam Restoration Study Maricopa County, Arizona, February 1983.

Soil Conservation Service, "Soil Survey, Aguila - Carefree Area", Parts of Maricopa and Pinal Counties, Arizona, Advance Copy, 1985.

Soil Conservation Service, "Urban Hydrology for Small Watersheds", Technical Release No. 55, June 1986.

Soil Conservation Service, "Design of Open Channels", Technical Release No. 25, October 1977.

Soil Conservation Service, "National Engineering Handbook" Section 5, Hydraulics, August 1956.

Soil Conservation Service, "National Engineering Handbook" Section 4, Hydrology", March 1985.

Soil Conservation Service, "General Soil Map Maricopa County Arizona", March 1973.

Soil Conservation Service and Forest Service, "Soil Survey of Yavapai County, Arizona, Western Part", March 1976.

Soil Conservation Service, "Soil Survey of Maricopa County, Arizona - Central Part", September 1977.

U.S. Army Corps of Engineers, "Design Memorandum No. 1", Hydrology and Hydraulic Design for Trilby Wash Detention Basin and Outlet Channel, November 1953.

U.S. Army Corps of Engineers, "Design Memorandum No. 2 - Hydrology - Part 2," Gila River Basin, New River and Phoenix City Streams, Arizona, 1982.

U.S. Army Corps of Engineers, "Trilby Wash Detention Basin Dam and Appurtenances", Land to be Acquired Plans, April 1955.

U.S. Bureau of Reclamation, "Central Arizona Project, Plan and Profile Reach 8 and Reach 9 Granite Reef Aqueduct", As-built June 16, 1982 and As-built June 17, 1980.

U.S. Bureau of Reclamation, "Specifications Design Data for Reach 8 and Reach 9, Granite Reef Aqueduct, Central Arizona Project, Arizona", Memorandum, June 9, 1978.

U.S. Department of Commerce, Bureau of Public Roads, "Hydraulic Charts for the Selection of Highway Culverts", Hydraulic Engineering Circular No. 5, September 1961.

U.S. Department of Housing and Urban Development, Federal Insurance Administration, "Approximate Studies - Unincorporated Areas of Maricopa County, Arizona", Flood Insurance Study, January 1979.

U.S. Department of Housing and Urban Development, Federal Insurance Administration, "Unincorporated Areas of Maricopa County", Flood Insurance Study, January 1979.

U.S. Bureau of Reclamation, "Patton Road Bridge Approaches Plan and Profile", Granite Reef Aqueduct, Reach 8, Central Arizona Project, As-built 1982.

U.S. Bureau of Reclamation, "Central Arizona Project, R-O-W Boundary Map - Granite Reef Aqueduct Reach 9", December 1978.

U.S. Geological Survey, "Roughness Coefficients for Stream Channels in Arizona", (Unofficial), 1973.

U.S. Geological Survey, Roughness Characteristics of Natural Channels, Geological Survey Water - Supply Paper 1849, 1977.

U.S. Geological Survey Quadrangle Maps - Wickenburg (1964) Red Picacho (1964) Garfias MTN (1964) Governor's Peak (1964) Wickenburg SW (1965) Wittmann (1965) Hieroglyphic MTNS SW (1965) Baldy MTN (1964) White Tank MTNS (1957) White Tank MTNS NE (1971) White Tank MTNS SE (1971) McMicken Dam (1974) Waddell (1975) Calderwood Butte (1974) El Mirage (1974).

Appendix

The WLB Group Inc. WLB

APPENDIX A

ROUTING PARAMETER MODIFICATION AS A RESULT OF FLOODPLAIN ENCROACHMENT

APPENDIX A

ROUTING PARAMETER MODIFICATION AS A RESULT OF FLOODPLAIN ENCROACHMENT

ROUTING FROM	REACH TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C1	C62L	4750	.45	2.45	1.02	.53	2.50
C62L	C62I	7500	.69	3.03	1.02	.67	3.09
C62I	C62H	7000	.56	3.50	1.02	.54	3.57
C2	C62M	4500	.33	3.75	1.02	.33	3.83
C62M	C62K	13125	1.01	3.61	1.02	.99	3.68
C62H	C62K	2000	.13	4.23	1.02	.13	4.31
C62K	C62G	6750	.45	4.19	1.08	.41	4.53
C3	C62K	17125	1.50	3.18	1.02	1.47	3.24
C4	C62K	17125	2.06	2.31	1.02	2.02	2.36
C5	C62K	14875	1.45	2.85	1.02	1.42	2.91
C6	C62K	14875	2.29	1.80	1.02	2.25	1.84
C7	C62K	14000	1.72	2.26	1.02	1.69	2.31
C8	C62G	18250	3.78	1.34	1.02	3.71	1.37
C9	C62G	18000	3.11	1.61	1.02	3.04	1.64
C62G	C62E	5125	.33	4.33	1.08	.30	4.68
IONA WASH							
C10	C62E	21000	1.28	4.55	1.02	1.26	4.64
C11	C62E	20750	2.88	2.00	1.02	2.83	2.04
C12	C62E	20750	2.88	2.00	1.02	2.83	2.04
C13	C62E	20250	2.70	2.08	1.02	2.65	2.12
C14	C62E	20250	3.93	1.43	1.02	3.86	1.46
C15	C62E	18750	2.00	2.61	1.01	1.98	2.64

ROUTING REACH FROM	TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C16	C62E	18250	2.29	2.21	1.01	2.27	2.23
C17	C62E	18000	2.34	2.14	1.02	2.29	2.18
C18	C62E	17750	2.71	1.82	1.02	2.66	1.86
C19	C62E	17625	2.31	2.12	1.02	2.26	2.16
C20	C62E	17625	1.81	2.70	1.02	1.78	2.75
C21	C62E	18000	3.36	1.49	1.02	3.29	1.52
C62E	C62D	2250	.12	5.39	1.19	.10	6.40
C62D	C62B	5875	.29	5.55	1.15	.26	6.38
C62B	C62	20125	1.30	4.31	1.15	1.13	4.96
C62A	C62	19750	2.15	2.55	1.15	1.87	2.93
C60D	C60B	15400	1.37	3.12	1.02	1.34	3.18
C60B	C60A	8000	.59	3.78	1.02	.58	3.86
C60C	C60A	21200	1.88	3.13	1.05	1.79	3.29
C60A	C60	6800	.54	3.49	1.05	.52	3.66
C59	C60	7600	.94	2.25	1.00	.94	2.25
C61	C60	3200	.60	1.47	1.00	.60	1.47
TRILBY WASH							
C26B	C26A	17000	.46	10.32	1.00	.46	10.32
C26A	C26	19100	.67	7.92	1.15	.58	9.11
C26	C63B	11800	.53	6.19	1.00	.53	6.19
C22	C63B	13800	1.64	2.34	1.02	1.61	2.39
C23	C63B	13800	1.21	3.18	1.02	1.18	3.24

ROUTING REACH FROM	TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C24	C63B	13400	1.65	2.25	1.02	1.62	2.30
C25	C63B	12400	1.97	1.75	1.02	1.93	1.78
C27	C63B	10500	1.70	1.72	1.02	1.66	1.75
C63B	C63C	6300	.32	5.43	1.08	.30	5.86
C28	C63C	14400	4.04	.99	1.02	3.96	1.01
C29	C63C	13500	4.69	.80	1.02	4.60	.82
C30	C63C	13000	3.88	.93	1.02	3.81	.95
C31	C63C	12800	2.74	1.30	1.02	2.68	1.33
C32	C63C	11500	3.76	.85	1.00	3.76	.85
C33	C63C	11000	4.85	.63	1.00	4.85	.63
C63C	C63	18800	1.16	4.51	1.05	1.10	4.74
C63A	C63	14000	1.06	3.66	1.02	1.04	3.73
C34	C64A	19000	2.81	1.88	1.03	2.72	1.94
C35	C64A	17600	2.13	2.29	1.02	2.09	2.33
C64A	C64	9200	.96	2.67	1.20	.58	4.41
C36	C64B	15550	1.02	4.24	1.02	1.00	4.32
C37	C64B	14000	1.09	3.56	1.05	1.04	3.74
C64B	C64	8600	.72	3.32	1.20	.60	3.98
C38B	C38	5000	.32	4.34	1.10	.29	4.77
C38	C65B	10000	.69	4.03	1.24	.56	5.00
C39	C65B	7000	.97	2.00	1.10	.88	2.20
C65B	C65A	5500	.41	3.72	1.10	.37	4.09
C65A	C65	3800	.26	4.06	1.00	.26	1.00
C40	C41	4700	.20	6.69	1.05	.19	7.02
C41	C65	1200	.05	6.97	1.00	.05	6.97

ROUTING REACH FROM	TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
CHRYSLER PROVING GROUND							
C40A	C40	11600	.49	6.58	1.04	.47	6.84
C40E	C40C	3700	.34	3.02	1.00	.34	3.02
C40F	C40C	3700	.16	6.63	1.00	.16	6.63
C40C	C40B	4600	.18	7.04	1.00	.18	7.04
C40H	C40G	13250	.50	7.43	1.00	.50	7.43
C40I	C40G	13250	.66	5.55	1.00	.66	5.55
C40G	C40D	3250	.12	7.47	1.00	.12	7.47
C40D	C40B	5000	.23	6.12	1.00	.23	6.12
C40B	C40	10700	.48	6.20	1.04	.46	6.45
C66	C67	900	.28	.89	1.00	.28	.89
C67	C68	800	.16	1.43	1.00	.16	1.43
C68	C69	2700	.54	1.40	1.00	.54	1.40
C68	C70	1200	.25	1.32	1.00	.25	1.32
C70A	C70	15000	.60	6.95	1.00	.60	6.95
C70	C71	5500	.98	1.56	1.00	.98	1.56
C71	C72	1400	.25	1.55	1.00	.25	1.55
C72	C73	8000	1.48	1.50	1.00	1.48	1.50
C73	C74	5800	1.13	1.43	1.00	1.13	1.43
C75	C74	8500	.79	3.00	1.05	.75	3.15
C74	C76T	1600	.31	1.44	1.00	.31	1.44
C90T	C89T	10700	.88	3.37	1.00	.88	3.37

ROUTING FROM	REACH TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C89AT	C89T	16100	1.24	3.60	1.05	1.18	3.78
C60	C89T	6300	.39	4.49	1.18	.33	5.32
C89T	C87T	9300	.58	4.46	1.44	.40	6.42
C86AT	C87T	24050	1.39	4.80	1.08	1.29	5.18
C87T	C81T	7100	.29	6.70	1.07	.28	7.17
C62	C83T	21000	1.25	4.67	1.08	1.16	5.04
C63	C83T	21800	1.69	3.58	1.18	1.43	4.22
C83T	C78T	5200	.26	5.49	1.08	.24	5.93
C81T	C78T	4200	.23	5.07	1.08	.21	5.48
C78T	C76T	14700	.69	5.91	1.38	.50	8.18
C79T	C76T	12800	1.30	2.74	1.38	.94	3.78
C77T	C76T	12300	1.08	3.15	1.08	1.00	3.40
C64	C96	16900	1.13	4.17	1.37	.82	5.71
C96	C95	5700	.47	3.40	1.03	.45	3.50
C95	C93	14200	1.10	3.57	1.00	1.10	3.57
C93	C91	7700	.58	3.67	1.13	.52	4.14
C76T	C91	2000	.25	5.68	1.00	.25	5.68
C65	C102A	16700	.82	5.68	1.54	.53	8.75
C104	C102A	15200	2.79	1.51	1.05	2.66	1.59
C105	C102A	14800	3.77	1.09	1.05	3.59	1.14
C42	C106	2500	.24	2.86	1.00	.24	2.86

ROUTING FROM	REACH TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
CHRYSLER PROVING GROUND							
C42D	C42A	5300	.63	2.35	1.00	.63	2.35
C42A	C42	16000	1.60	2.77	1.00	1.60	2.77
C42E1	C42E	3400	.27	3.44	1.00	.27	3.44
C42E	C42B	5400	.45	3.35	1.00	.45	3.35
C42B	C42	15400	1.53	2.79	1.00	1.53	2.79
C42F1	C42F	3200	.33	2.71	1.00	.33	2.71
C42F	C42C	4600	.45	2.85	1.00	.45	2.85
C42C	C42	15800	1.37	3.20	1.05	1.31	3.36
C106	C102A	14000	1.47	2.65	1.05	1.40	2.78
CHRYSLER PROVING GROUNDS							
C43B	C43A	11750	.53	6.14	1.00	.53	6.14
C43A	C43	22500	.98	6.35	1.02	.96	6.48
C43C	C43	22600	1.86	3.38	1.00	1.86	3.38
C43D	C43	22600	1.81	3.47	1.00	1.81	3.47
C43E	C43	22500	1.80	3.47	1.00	1.80	3.47
C43	C107	6200	.60	2.88	1.01	.59	2.91
C107	C102A	8800	.89	2.74	1.05	.85	2.88
C108	C102A	6800	.71	2.66	1.00	.71	2.66
C109	C102A	6100	.92	1.84	1.00	.92	1.84
C102A	C102	10400	.51	5.67	1.42	.34	8.05
C98A	C102	13100	1.44	2.53	1.08	1.33	2.73
C102	C97	9000	.58	4.33	1.66	.35	7.19

ROUTING REACH FROM	TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C91	C97	10300	1.58	1.81	1.00	1.58	1.81
C97A	C97	14600	2.28	1.78	1.05	2.17	1.87
C100	C97	2800	.36	2.16	1.00	.36	2.16
C44	C110	14800	1.40	2.93	1.02	1.38	2.99
C45	C110	14800	1.39	2.95	1.02	1.37	3.01
C110	C101	9900	.88	3.13	1.14	.77	3.57
C111	C101	8100	1.81	1.24	1.05	1.73	1.30
C112	C101	4100	.39	2.89	1.02	.39	2.95
C113	C101	2700	.36	2.09	1.00	.36	2.09
C114	C101	1600	.37	1.20	1.00	.37	1.20
C101	C97	4800	.46	2.92	1.00	.46	2.92
C46	C117A	24000	2.25	2.96	1.05	2.15	3.11
C47	C117D	14000	1.31	2.97	1.02	1.28	3.03
C117D	C117B	8500	.79	3.00	1.08	.73	3.24
C48	C117F	7200	.67	2.97	1.02	.66	3.03
C49	C117G	8000	.74	3.00	1.02	.73	3.06
C117F	C117E	6000	.56	3.00	1.02	.54	3.06
C117E	C117B	7100	.66	3.00	1.08	.61	3.24
C50A	C117C	18900	1.88	2.80	1.02	1.84	2.86
C117A	C117	4200	.40	2.90	1.15	.35	3.34
C117	C120	3800	.17	6.10	1.10	.16	6.71
C51	C117	21000	2.16	2.96	1.10	1.98	3.26

ROUTING FROM	REACH TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C120	C119	2800	.17	4.58	1.10	.15	5.04
C97	C119	18500	2.82	1.82	1.05	2.69	1.91
C103	C119	16500	4.41	1.04	1.05	4.20	1.09
C52B	C52C	1500	.07	5.66	1.00	.07	5.66
C52A	C52	43000	1.65	7.23	1.05	1.57	7.59
C52C	C52	20900	.73	7.99	1.05	.69	8.39
C52P1	C124A	10400	.60	4.84	1.05	.57	5.08
C52P2	C124B	12400	1.07	3.22	1.02	1.05	3.28
C124A	C124	4000	.26	4.34	1.05	.24	4.56
C124B	C124	1300	.11	3.18	1.00	.11	3.18
C53	C123B	5500	.33	4.69	1.00	.33	4.69
C123B	C123A	8350	.71	3.28	1.02	.69	3.35
C54	C123C	5000	.43	3.21	1.00	.43	3.21
C123A	C123	9800	.61	4.46	1.10	.55	4.91
C55	C127A	8800	.43	5.65	1.02	.42	5.76
C127A	C127	9800	.48	5.71	1.38	.34	7.88
C56	C127B	5600	.38	4.14	1.02	.37	4.22
C124	C123	9500	.59	4.51	1.10	.53	4.96
C123	C121	4000	.21	5.34	1.15	.18	6.14
C119	C121	4900	.47	2.90	1.10	.43	3.19
C121	C123	7700	.69	3.12	1.28	.54	3.99

ROUTING REACH FROM	TO	LENGTH (FT)	TRAVEL TIME BEFORE ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)	PERCENT INCREASE	TRAVEL TIME AFTER ENCROACHMENT (HRS.)	AVG. VEL. (FT/SEC)
C127	C125	2500	.10	6.81	1.30	.08	8.85
C125	C132	14500	.81	4.98	1.20	.67	5.98
C122	C132	9000	.44	5.68	1.19	.37	6.79
C131	C132	5100	.54	2.61	1.00	.54	2.61
C128	C129	7700	.82	2.60	1.00	.82	2.60
C129	C130	9500	.62	4.28	1.00	.62	4.28
C130	C134	8800	.46	5.29	1.00	.46	5.29
C132	C134	10500	.33	8.97	1.00	.33	8.97
C115	C103	3700	.97	1.06	1.02	.95	1.08
C116	C119	13000	2.72	1.33	1.05	2.59	1.40
C118	C119	13000	2.74	1.32	1.05	2.60	1.39

APPENDIX B

ROUTING PARAMETER MODIFICATION AS A RESULT OF CHANNELIZATION

APPENDIX B

ROUTING PARAMATER MODIFICATION AS A RESULT OF CHANNELIZATION

MANNINGS N = .025

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C1	C62L	4750	83	.0122	8	2:1	1.24	6.38	.21	.45
C62L	C62I	7500	372	.0076	10	2:1	2.88	8.18	.25	.69
C62I	C62H	7000	591	.0080	20	2:1	2.66	8.76	.22	.56
C62H	C62K	2000	1122	.0090	30	2:1	3.01	10.36	.05	.13
C2	C62M	4500	325	.0102	10	2:1	2.48	8.75	.14	.33
C62M	C62K	13125	353	.0101	10	2:1	2.60	8.93	.41	1.01
C3	C62K	17125	301	.0103	10	2:1	2.38	8.59	.55	1.50
C4	C62K	17125	91	.0103	10	2:1	1.22	5.97	.80	2.06
C5	C62K	14875	195	.0104	10	2:1	1.87	7.58	.55	1.45
C6	C62K	14875	31	.0108	10	2:1	.65	4.24	.97	2.29
C7	C62K	14000	77	.0109	10	2:1	1.10	5.77	.67	1.72
C62K	C62G	6750	2064	.0064	50	2:1	3.58	10.10	.19	.45
C8	C62G	18250	12	.0109	8	2:1	.42	3.24	1.56	3.78
C9	C62G	18000	25	.0107	8	2:1	.65	4.15	1.20	3.11
C62G	C62E	5125	2470	.0067	70	2:1	3.24	9.97	.14	.33
C10A	C10	22125	1788	.0120	40	2:1	3.10	12.49	.49	1.36
C10	C62E	21000	2372	.0098	80	2:1	2.62	10.64	.55	1.28
C11&C12	C62E	20750	79	.0098	8	2:1	1.28	5.83	.99	2.88

ROUTING REACH FROM	TO	LENGTH (FT)	DISCHARGE (CFS)	CHANNEL DIMENSIONS SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	TRAVEL TIME AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C13	C62E	20250	87	.0097	8	2:1	1.35	6.00	.94	2.70
C14	C62E	20250	20	.0101	8	2:1	.58	3.77	1.49	3.93
C15	C62E	18750	215	.0100	8	2:1	2.20	7.89	.66	2.00
C16	C62E	18250	114	.0099	8	2:1	1.59	6.53	.78	2.29
C17	C62E	18000	101	.0100	8	2:1	1.46	6.32	.79	2.34
C18	C62E	17750	47	.0100	8	2:1	.95	4.99	.99	2.71
C19	C62E	17625	78	.0099	8	2:1	1.27	5.83	.84	2.31
C20	C62E	17625	205	.0098	8	2:1	2.16	7.72	.63	1.81
C21	C62E	18000	19	.0099	4	2:1	.81	4.18	1.20	3.36
C62E	C62D	2250	4915	.0089	100	2:1	3.64	12.58	.05	.12
C62D	C62B	5875	5360	.0046	100	2:1	4.66	10.52	.16	.29
C62B	C62	20125	5350	.0065	100	2:1	4.20	11.74	.48	1.30
C62A	C62	19750	744	.0064	50	2:1	1.96	7.03	.78	2.15
C62	C83T	21000	5001	.0053	100	2:1	4.29	10.74	.54	1.25
C22	C63B	13800	80	.0105	8	2:1	1.27	5.99	.64	1.64
C23	C63B	13800	198	.0105	8	2:1	2.08	7.84	.49	1.21
C24	C63B	13400	3	.0108	---	2:1	---	---	---	---
C25	C63B	12400	32	.0111	8	2:1	.74	4.56	.76	1.97
C26B	C26A	17000	4685	.0188	75	2:1	3.35	17.11	.28	.46
C26A	C26	19100	3550	.0135	75	2:1	3.14	13.93	.38	.58
C26	C63B	11800	2970	.0107	75	2:1	3.02	12.12	.27	.53
C27	C63B	10500	28	.0107	8	2:1	.69	4.31	.68	1.70

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C63B	C63C	6300	3035	.0076	75	2:1	3.39	10.95	.16	.32
C28	C63C	14400	70	.0100	8	2:1	1.19	5.66	.71	4.04
C29	C63C	13500	31	.0100	8	2:1	.75	4.36	.86	4.69
C30	C63C	13000	50	.0100	8	2:1	.99	5.09	.71	3.88
C31	C63C	12800	224	.0098	20	2:1	1.44	6.81	.52	2.74
C32	C63C	11500	42	.0107	8	2:1	.87	4.92	.65	3.76
C33	C63C	11000	14	.0102	4	2:1	.68	3.86	.79	4.85
C63C	C63	18800	3322	.0070	100	2:1	3.10	10.09	.52	1.16
C63A	C63	14000	1088	.0068	50	2:1	2.41	8.23	.47	1.06
C63	C83T	21800	3845	.0037	60	2:1	5.44	9.96	.61	1.69
C83T	C78T	5200	6965	.0063	150	2:1	3.92	11.27	.13	.26
C60D	C60B	15400	1292	.0064	50	2:1	2.72	8.58	.50	1.37
C60B	C60A	8000	2183	.0068	100	2:1	2.44	8.55	.26	.59
C60C	C60A	21200	786	.0068	50	2:1	1.99	7.31	.81	1.88
C60A	C60	6800	3063	.0041	100	2:1	3.46	8.27	.23	.54
C59	C60	7600	811	.0039	50	2:1	2.39	6.20	.34	.94
C61	C60	3200	757	.0013	50	2:1	3.17	4.24	.21	.60
C60	C89T	6300	3724	.0048	100	2:1	3.71	9.34	.18	.39
C90T	C89T	10700	824	.0075	50	2:1	1.99	7.68	.39	.88
C89AT	C89T	16100	1006	.0075	80	2:1	1.70	7.09	.63	1.24

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C89T	C87T	9300	4554	.0049	250	2:1	2.42	7.38	.35	.58
C86AT	C87	24050	1543	.0120	100	2:1	1.67	8.93	.75	1.39
C87T	C81T	7100	5548	.0121	250	2:1	2.08	10.50	.19	.29
C81T	C78T	4200	6036	.0063	500	2:1	1.76	6.83	.17	.23
C78T	C76T	14700	11499	.0062	500	2:1	2.60	8.77	.47	.69
C79T	C76T	12800	663	.0062	50	2:1	1.85	6.68	.53	1.30
C77T	C76T	12300	1054	.0062	50	2:1	2.43	7.90	.43	1.08
C66	C67	900	345	.0004	---	---	---	---	---	---
C67	C68	800	2594	.0004	---	---	---	---	---	---
C68	C69	2700	2977	.0004	---	---	---	---	---	---
C69	C70	1200	2528	.0004	---	---	---	---	---	---
C70A	C70	15000	2720	.0162	---	---	---	---	---	---
C70	C71	5500	4286	.0004	---	---	---	---	---	---
C71	C72	1400	3428	.0004	---	---	---	---	---	---
C72	C73	8000	3459	.0004	---	---	---	---	---	---
C73	C74	5800	2830	.0004	---	---	---	---	---	---
C75	C74	8500	798	.0073	50	2:1	1.97	7.52	.31	.79
C74	C76T	1600	2669	.0004	---	---	---	---	---	---
C76T	C91	2000	14002	.0006	---	---	---	---	---	---
C34	C64A	19000	89	.0093	8	2:1	1.39	5.94	.89	2.81
C35	C64A	17600	112	.0091	8	2:1	1.59	6.31	.77	2.13
C64A	C64	9200	926	.0060	50	2:1	2.28	7.46	.34	.96

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C36	C64B	15550	1115	.0091	80	2:1	1.71	7.83	.55	1.02
C37	C64B	14000	810	.0089	50	2:1	1.87	8.06	.48	1.09
C64B	C64	8600	1897	.0059	100	2:1	2.34	7.76	.31	.72
C64	C95	16900	3172	.0062	100	2:1	3.13	9.55	.49	1.13
96	C95	5700	755	.0082	80	2:1	1.39	6.54	.24	.47
C95	C93	14200	2340	.0048	100	2:1	2.82	7.87	.50	1.10
C93	C91	7700	2377	.0055	100	2:1	2.73	8.26	.26	.58
C91	C97	10300	15990	.0003	---	---	---	---	---	---
38B	C38	5000	1195	.0078	100	2:1	1.63	7.09	.20	.32
C38	C65B	10000	2202	.0078	150	2:1	1.85	7.75	.36	.69
C39	C65B	6500	270	.0076	20	2:1	1.73	6.67	.27	.97
C65B	C65A	5500	2275	.0076	150	2:1	1.90	7.79	.20	.41
C65A	C65	4000	2291	.0008	100	2:1	4.73	4.43	.25	.26
C40A	C40	11600	1824	.0092	150	2:1	1.57	7.58	.43	.49
C40B	C40	10700	2883	.0092	150	2:1	2.07	9.05	.33	.48
C40J	C40H	10250	1658	.0167	100	2:1	1.58	10.17	.28	.37
C40H	C40G	13250	1764	.0152	100	2:1	1.69	10.11	.36	.50
C40I	C40G	13250	686	.0152	50	2:1	1.45	8.95	.41	.66
C40	C41	4700	4439	.0083	175	2:1	2.52	9.80	.13	.20
C41	C65	1200	4475	.0092	175	2:1	2.45	10.14	.03	.05
C65	C102A	16700	6455	.0073	200	2:1	3.02	10.37	.45	.82
C104	C102A	15200	38	.0073	8	2:1	.92	4.17	1.01	2.79
C105	C102A	14800	15	.0073	4	2:1	.77	3.51	1.17	3.77

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C42A	C42	16000	86	.0098	8	2:1	1.34	5.98	.74	1.60
C42B	C42	15400	108	.0098	8	2:1	1.53	6.41	.67	1.53
C42C	C42	15800	137	.0098	8	2:1	1.74	6.87	.64	1.37
C43B	C43A	11750	692	.0149	50	2:1	1.46	8.94	.27	.53
C47C	C47B	28750	5428	.0179	100	2:1	3.14	16.27	.49	.95
C47B	C47A	14700	3939	.0133	100	2:1	2.83	13.15	.31	.43
C47A	C47	5500	4122	.0105	100	2:1	3.12	12.42	.12	.18
C42	C106	2500	311	.0088	30	2:1	1.43	6.61	.11	.24
C106	C102A	14000	330	.0073	30	2:1	1.57	6.36	.61	1.47
C43	C107	6200	323	.0082	30	2:1	1.49	6.55	.26	.60
C107	C102A	8800	354	.0073	30	2:1	1.63	6.52	.37	.89
C108	C102A	6800	319	.0073	30	2:1	1.54	6.28	.30	.71
C109	C102A	6100	79	.0073	8	2:1	1.39	5.26	.32	.92
C102A	C102	10400	6228	.0059	200	2:1	3.15	9.58	.30	.51
C98A	C102	13100	426	.0056	40	2:1	1.67	5.89	.62	1.44
C102	C97	9000	6219	.0045	200	2:1	3.42	8.80	.28	.58
C97A	C97	14600	223	.0045	20	2:1	1.80	5.25	.77	2.28
C100	C97	2800	449	.0045	40	2:1	1.84	5.60	.14	.36
C44	C110	14800	330	.0080	30	2:1	1.52	6.55	.63	1.40
C45	C116	14800	340	.0080	30	2:1	1.55	6.62	.62	1.39
C110	C101	9900	785	.0068	50	2:1	1.99	7.31	.38	.88

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C111	C101	8100	23	.0068	4	2:1	.99	3.88	.58	1.81
C112	C101	4100	613	.0068	30	2:1	2.30	7.71	.15	.39
C113	C101	2700	162	.0068	10	2:1	1.90	6.18	.12	.36
C114	C101	1600	20	.0068	4	2:1	.92	3.73	.12	.37
C101	C97	4800	1773	.0046	100	2:1	2.42	7.00	.19	.46
C97	C119	18500	2998	.0009	90	LSS=65:1 RSS=5:1	3.99	3.27	1.57	2.82
C115	C103	3700	17	.0082	4	2:1	.80	3.79	.27	.97
C103	C119	16500	276	.0009	90	2:1	1.38	2.16	2.12	4.41
C116	C119	13000	697	.0009	30	2:1	4.41	4.07	.89	2.72
C118	C119	13000	683	.0009	30	2:1	4.36	4.04	.89	2.74
C46	C117A	24000	346	.0069	20	2:1	2.05	7.01	.95	2.25
C47	C117D	14000	350	.0086	20	2:1	1.94	7.58	.51	1.31
C117D	C117A	8500	382	.0053	20	2:1	2.34	6.62	.36	.79
C48	C117F	7200	350	.0097	20	2:1	1.87	7.89	.25	.67
C49	C117G	8000	357	.0087	20	2:1	1.95	7.66	.29	.74
C117F	C117E	6000	762	.0098	60	2:1	1.58	7.66	.22	.56
C117E	C117B	7100	779	.0053	60	2:1	1.92	6.36	.31	.66
C50A	C117C	18900	337	.0090	20	2:1	1.87	7.60	.69	1.88
C117A	C117	4200	2006	.0095	150	2:1	1.65	7.94	.15	.40
C117	C120	3800	2044	.0089	150	2:1	1.70	7.84	.13	.17

ROUTING REACH FROM	TO	LENGTH (FT)	DISCHARGE (CFS)	CHANNEL DIMENSIONS SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	TRAVEL TIME AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C52A	C52	43000	1982	.0146	100	2:1	1.83	10.44	1.14	1.65
C52B	C52C	1500	2308	.0067	100	2:1	2.53	8.69	.05	.07
C52C	C52	20900	4281	.0121	200	2:1	2.03	10.32	.56	.73
C51	C120	21000	191	.0084	20	2:1	1.37	6.13	.95	2.16
C120	C119	2800	2227	.0082	150	2:1	1.83	7.90	.10	.17
C119	C121	4900	3823	.0008	80	LSS=65:1 RSS=8:1	4.64	3.31	.41	.47
C52P1	C124A	10400	988	.0103	80	2:1	1.53	7.77	.37	.60
C124A	C124	4000	1094	.0067	80	2:1	1.87	7.07	.16	.26
C52P2	C124B	12400	252	.0105	20	2:1	1.57	7.25	.48	1.07
C124B	C124	1300	397	.0077	20	2:1	2.15	7.61	.05	.11
C124	C123	9500	1409	.0080	100	2:1	1.79	7.61	.35	.59
C53	C123B	5500	768	.0136	80	2:1	1.21	7.69	.20	.33
C54	C123C	5000	372	.0110	30	2:1	1.49	7.57	.18	.43
C123B	C123A	8350	1079	.0105	80	2:1	1.60	8.09	.29	.71
C123A	C123	9800	1122	.0080	80	2:1	1.78	7.54	.36	.61
C123	C121	4000	2718	.0070	200	2:1	1.82	7.31	.15	.21
C121	C122	7700	5064	.0008	80	LSS=65:1 RSS=8:1	5.25	3.55	.60	.69
C122	C132	9000	5087	.0061	50	2:1	4.56	9.41	.27	.44
C55	C127A	8800	1652	.0097	150	2:1	1.46	7.41	.33	.43

ROUTING REACH		LENGTH	DISCHARGE	CHANNEL DIMENSIONS					TRAVEL TIME	
FROM	TO	(FT)	(CFS)	SLOPE (FT/FT)	BOTTOM WIDTH (FT)	SIDE SLOPE	NORMAL DEPTH (FT)	VELOCITY (FT/SEC)	AFTER CHANNEL-IZATION (HRS.)	BEFORE CHANNEL IZATION (HRS.)
C56	C127B	5600	375	.0161	30	2:1	1.34	8.58	.18	.38
C127A	C127	9800	2078	.0087	50	2:1	3.28	11.20	.24	.48
C127	C125	2500	3898	.0081	100	2:1	3.26	11.21	.06	.10
C125	C132	14500	4197	.0061	100	2:1	3.71	10.53	.38	.81
C131	C132	5100	294	.0061	20	2:1	1.93	6.38	.22	.54
C132	C134	10500	6023	.0054	200	2:1	3.17	9.20	.32	.33
C128	C129	7700	662	.0027	50	2:1	2.36	5.12	.42	.82
C129	C130	9500	1233	.0030	75	2:1	2.62	5.87	.45	.62
C130	C134	8800	1495	.0054	75	2:1	2.93	6.30	.39	.46