FLOOD CONTROL STUDY

FOR THE

CITY AND COUNTY OF NACOGDOCHES, TEXAS

MAY 1, 1996

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CITY OF NACOGDOCHES

FLOOD CONTROL STUDY

EXECUTIVE SUMMARY

The City of Nacogdoches and surrounding area is drained by Banita Creek and LaNana Creek. Both of these streams run through much of the City of Nacogdoches. Flooding of these streams has caused great damage to public and private property, and has endangered the public. Development is occurring in these two watersheds at a steady pace. As development occurs in these watersheds the potential for and severity of flooding in developed areas increases dramatically.

This study has investigated the drainage system facilities within the watershed and evaluated the following identified alternatives:

1. Purchase of improvements subject to potential flood damage.

2. Construct stream crossing and channel improvements of sufficient size and capacity to transport peak design flows and remove the flood damage potential to the same improvements identified in #1 above.

3. Construct regional detention reservoir(s) to dampen peak flows combined with stream crossing and channel improvements of sufficient size and capacity to transport the dampened flows and remove the flood damage potential to the same improvements identified in #1 above.

These alternatives were evaluated on the basis of economics and the protection of public health and public safety. Alternatives #2 & #3 would provide much improved and comparable results with respect to protecting the public whereas Alternate #1 would provide no improvements to this consideration. A design storm event under Alternate #1 would result in numerous stream crossings' rendered impassable, the forcing of rodents, snakes, etc. from flooded habitats into populated areas, and other similar health and safety hazards.

The total purchase value of improvements subject to flood damage is estimated to be $37,277,100. The total cost of improvements proposed under Alternate #2 is $31.24 million and under Alternate #3 is $23.7 million.

Alternate #3 was selected as the most advantageous option both economically and with respect to protection of the public. A cost summary of proposed improvements for the selected alternate is as follows:

COST SUMMARY OF PROPOSED IMPROVEMENTS

Regional Detention Reservoirs	$ 6,400,00.00
Major Channel Crossings	$ 10,567,500.00
Channel Improvements	$ 4,330,400.00
Other Channel Crossings	$ 386,400.00
Internal Storm Sewer	$ 2,000,000.00
Total Estimated Construction Cost	$ 23,684,300.00

The improvements are proposed to be funded through bond sales and revenue generated for bond payments through a Municipal Drainage Utility System (MDUS). The rates established under the MDUS would be based on the contribution each parcel of land made to the total stormwarter run-off. Annual revenue would be $1.5 million with approximately two-thirds for bonded indebtedness and one-third for facilities operation and maintenance. Phased improvements would follow the following priority;

1. Reservoirs and the up/downstream crossing and channel improvements that would impact the reservoirs storage capacity. $10.0 Million
2. Other major crossing improvements $ 7.0 Million
3. Channel improvements $ 4.3 Million
4. Other identified deficient crossings $ 0.4 Million
5. Internal storm sewer $ 2.0 Million

The following table is an itemized listing of all project components, a description of each component with capacities, and individual cost estimates for each component. These proposed improvements are shown on the attached exhibit.

CITY OF NACOGDOCHES
FLOOD CONTROL STUDY
ESTIMATED CONSTRUCTION COST OF PROPOSED IMPROVEMENTS

I. PROPOSED RESERVOIR IMPROVEMENTS

			Estimated Construction Cost
A.	LaNana Reservoir #1	=	$1,600,000.00
B.	LaNana Reservoir #2	=	$1,630,000.00
C.	Banita Reservoir #3	=	$1,300,000.00
D.	Banita Reservoir #4	=	$1,870,000.00
	RESERVOIR SUB-TOTAL	=	$6,400,000.00

II. PROPOSED CHANNEL CROSSING IMPROVEMENTS

A. LaNana Creek

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Loop 224 (South) 22,570 CFS	Bridge	Deepen Channel 3'± 60' Bottom @ 5:1(H:V) sideslopes Concrete Lining 350' Downstream 175' Upstream Through crossing	$ 503,300.00
2.	Butt St. 14,080 CFS	Bridge	Extend Bridge 20' Deepen Channel 3'± 40' Bottom @ 3:1 sideslopes Concrete Lining 340' Downstream 170' Upstream Through Crossing	$ 364,600.00
3.	Main St. 13,300 CFS	Bridge	Deepen Channel 2' ± 45' Bottom @ 3.25:1 sideslopes Concrete Lining 370' Downstream 185' Upstream Through Crossing	$ 321,400.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
4.	Park St. 13,000 CFS	Bridge	Deepen Channel 1' ± 40' Bottom @ 3:1 sideslopes Concrete Lining 340' Downstream 170' Upstream Through Crossing	$ 229,700.00
5.	Martinsville Road 12,900 CFS	Bridge	Deepen Channel 0.5' ± 35' Bottom @ 3:1 sideslopes Concrete Lining 380' Downstream 190' Upstream Through Crossing	$ 249,900.00
6.	Starr St. 12,800 CFS	Bridge	Deepen Channel 3' ± 50' Bottom @ 3:1 sideslopes 45' Bottom @ 3:1 sideslopes at limits of concrete lining Concrete Lining 500' Downstream 250' Upstream Through Crossing	$ 426,400.00
7.	College St. 12,700 CFS	Bridge	25' Bottom @ 3:1 sideslopes 40' Bottom 3:1 sideslopes at limits of concrete lining Concrete Lining 350' Downstream 175' Upstream Through Crossing	$ 246,400.00
8.	Austin St. 12,210 CFS	Bridge	Deepen Channel 3' ± 40' Bottom @ 3:1 sideslopes Concrete Lining 360' Downstream 90' Upstream Through Crossing	$ 424,100.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
9.	Loop 224 (North) 13,100 CFS	Bridge	Extend Bridge 80' Deepen Channel 4' ± 80' Bottom @ 4:1 sideslopes Concrete Lining 360' Downstream 180' Upstream Through Crossing	$ 750,500.00
	LaNana Creek SUB-TOTAL		=	**$ 2,042,500.00**

B. BANITA

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
1.	Butt St. 7,490 CFS	Bridge	Deepen Channel 1' ± 60' Bottom @ 2.4:1 sideslopes Concrete Lining 280' Downstream 250' Upstream Through Crossing	$ 215,900.00
2.	SPRR 7,490 CFS	Trestle	40' Bottom @ 2:1 sideslopes within limits of crossing	$ 16,800.00
3.	Church St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 270' Downstream 135' Upstream Through Crossing	$ 182,300.00
4.	Fredonia St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 230' Downstream 85' Upstream Through Crossing	$ 134,800.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
5.	Pecan St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 155' Downstream 100' Upstream Through Crossing	$ 140,400.00
6.	North St. 7,490 CFS	Bridge	Deepen Channel 2.0' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 235' Downstream 130' Upstream Through Crossing	$ 169,100.00
7.	Pilar St. 7,490 CFS	Bridge	Extend Bridge 20' Deepen Channel 3' ± 50' Bottom @ 2:1 sideslopes at crossing 45' Bottom @2:1 sideslopes at down /upstream limits of concrete lining Concrete Lining 40' Downstream 160' Upstream Through Crossing	$ 194,500.00
8.	Main St. 7,290 CFS	Bridge	Extend Bridge 10' Deepen Channel 4' ± 50' Bottom @ 2:1 sideslopes at crossing 40' Bottom @ 2:1 sideslopes at down/upstream limits of concrete lining Concrete Lining 60' Downstream 220' Upstream Through Crossing	$ 212,000.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
9.	Powers St. 6,990 CFS	Bridge	Deepen Channel 3' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 260' Downstream 140' Upstream Through Crossing	$ 190,100.00
10.	SPRR 5,990 CFS	Trestle	Deepen Channel 4' ± 30' Bottom @ 2.25:1 sideslopes Extend Channel section 240' downstream & 60' upstream	$ 19,600.00
11.	Loop 224 (North) 5,700 CFS	Bridge	Widen Channel to 30' Bottom @ 2:1 sideslopes Extend Channel section 200' downstream & 200' upstream	$ 49,000.00
	BANITA CREEK SUB-TOTAL		**=**	**$ 1,524,500.00**

C. EGGNOG BRANCH

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	FM #1275 3,720 CFS	2-7 ' x 6' Box Culverts	Replace Box culverts with 80'x40' bridge Deepen Channel 3' ± 30' Bottom @ 3:1 sideslopes Concrete Lining 30' Downstream 15' Upstream Through Crossing	$ 377,700.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
2.	Loop 224 (South) 2,730 CFS	2-6 ' x 10' Box Culverts	Add 2-6'x10' Box culverts Widen to 40' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 100' Upstream	$ 434,000.00
3.	FM #2259 2,070 CFS	1-8 ' x 8' Box Culvert	Replace Box culvert with 60' x 40' bridge Depen Channel 2′ ± Widen channel to 16' Bottom @ 2:1 sideslopes Concrete Lining 30' Downstream 15' Upstream Through Crossing	$ 274,400.00
4.	Eastwood Terrace 2,070 CFS	54" Dia. RCP	Replace culvert with 50' x 40' bridge Deepen Channel 3' ± 16' Bottom @ 2:1 sideslopes Concrete Lining 30' Downstream 100' Upstream Through Crossing	$ 240,800.00
5.	Hwy. 21 880 CFS	1-5' x 11' Box Culvert	Add 1-5' x 11' Box Culvert Widen channel to 22' Bottom & 1:1 sideslopes Concrete Lining 40' Downstream 100' Upstream	$ 179,200.00

EGGNOG BRANCH SUB-TOTAL = $ 1,506,100.00

D. TRIBUTARY A

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	SPRR 3,240 CFS	Trestle	Extend Trestle 35' Deepen Channel 5' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 80' Upstream Through Crossing	$ 133,600.00
2.	Press Rd. 3,240 CFS	Bridge	New 60' x 32' Bridge Deepen Channel 5' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 70' Downstream 35' Upstream Through Crossing	$ 251,300.00
3.	Park Entrance 2,660 CFS	Bridge	New 62' x 25' Bridge Deepen Channel 3' ± 20' Bottom @ 1.5:1 sideslopes Extend channel section 70' Downstream & 35' upstream	$ 174,300.00
4.	South St. 2,390 CFS	2-7' x 7' & 2-9' x 9' Box Culverts	Replace 2-7' x 7' Box culverts with 3-9' x 9' Box culverts Add 1-9' x 9' box culvert Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes Extend channel section 80' downstream & 130' Upstream	$ 627,600.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
5.	S. Fredonia St. 1,750 CFS	2-5' x 6' Box Culverts	Replace 2-5' x 6' Box culverts with 3-9' x 9' Box culverts Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes at crossing 10' Bottom @ 1:1 sideslopes at limits of channel of extension Extend channel section 50' downstream & 100' upstream	$ 440,300.00

TRIBUTARY A SUB-TOTAL = $ 1,627,100.00

E. TRIBUTARY B

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Parking Lot Drive 2,070 CFS	Bridge	New 66' x 24' Bridge Deepen Channel 5' ± 15' Bottom @ 2:1 sideslopes at crossing Extend channel section 930' upstream to 10' Bottom @ 2:1 sideslopes Concrete lining through crossing	$ 296,400.00
2.	S. Fredonia St. 1,980 CFS	Bridge	New 62' x 56' Bridge Deepen Channel 5' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 50' Downstream 40' Upstream Through Crossing	$ 405,200.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
3.	South St. 1,880 CFS	Bridge	New 50' x 42' Bridge Deepen Channel 1' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 90' Downstream 45' Upstream Through Crossing	$ 248,400.00
4.	Virginia Ave. 1,880 CFS	1-5' x 11' Box culvert	New 45' x 42' Bridge Deepen Channel 2' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 140' Downstream 45' Upstream Through Crossing	$ 261,200.00
5.	Sunset Ave. 1,570 CFS	Bridge	New 50' x 32' Bridge Deepen Channel 1' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 90' Downstream 45' Upstream Through Crossing	$ 209,200.00
6.	Burk St. 1,570 CFS	Bridge	New 37' x 36' Bridge Deepen Channel 1' ± 15' Bottom @ 1.5:1 sideslopes at crossing 15' Bottom @ 2:1 sideslopes at limits of concrete lining Concrete Lining 70' Downstream 35' Upstream Through Crossing	$ 154,000.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
7.	Durst St. 1,020 CFS	1-4' x 12' Box culvert	Replace 1-4' x 12' Box Culvert with 22' x 34' Bridge Deepen Channel 3' ± 12' Bottom @ 1:1 sideslopes	$ 84,300.00
8.	Perry Dr. 710 CFS	1-3' x 12' Box culvert	Replace 1-3' x 12' Box Culvert with 1-6' x 12' Box culvert Deepen Channel 3' ± 12' Bottom @ 1:1 sideslopes Concrete Lining 50' Downstream 25' Upstream	$ 97,700.00

TRIBUTARY B SUB-TOTAL = $ 1,756,400.00

F. TRIBUTARY C (Mill Pond)

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	SPRR 2,410 CFS	Trestle	Extend Trestle 30' Deepen Channel 1' ± 25' Bottom @ 3:1 sideslopes Extend channel section 100' downstream & 50' upstream	$ 70,000.00
2.	Old Tyler* Road 2,340 CFS	2-60" Dia. R.C.P.	Replace 2-60" RCP with new 70' x 40' Bridge Deepen Channel 3' ± 25' Bottom @ 3:1 sideslopes Concrete Lining 100' Downstream 200' Upstream Through Crossing	$ 435,300.00

TRIBUTARY C SUB-TOTAL = $ 505,300.00

*(See Note, Pg. 21a)

G. **TRIBUTARY D, D-1, & D-2**

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	University Dr. (D) 4,400 CFS	2- Box Culvert	New 45' x 50' Bridge Deepen Channel 2' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 150' Upstream Through Crossing	$ 312,100.00
2.	FM #1411 (D) 4,200 CFS	2-9' x 11' Box culvert	Replace 2-9' x 11' Box Culverts with new 60' x 40' Bridge Widen channel to 25' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 110' Upstream Through Crossing	$ 297,800.00
3.	FM #1878 (D) 3,940 CFS	1-7' x 16' Box culvert	Replace 1-7' x 16' Box Culvert with new 80' x 40' Bridge Deepen Channel 3' ± 30' Bottom @ 2.5:1 sideslopes Concrete Lining 60' Downstream 330' Upstream Through Crossing	$ 439,500.00
4.	Loop 224 (D-1) 260 CFS	1-36" Dia. R.C.P.	Replace 1-36" R.C.P. with 2-60" DIA. R.C.P. Deepen Channel 2' ± 10' Bottom @ 0.5:1 sideslopes Concrete Lining 50' Downstream 50' Upstream	$ 64,100.00

H. TRIBUTARY G

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Stallings Dr. 1,810 CFS	Bridge	Extend Bridge 10' Widen channel to 16' Bottom @ 1.5:1 sideslopes at crossing 10' Bottom @ 1.5:1 sideslopoes at limits of concret lining Concrete Lining 140' Downstream 50' Upstream Through Crossing	$ 83,600.00

TRIBUTARY G SUB-TOTAL = $ 83,600.00

CHANNEL CROSSINGS IMPROVEMENTS SUB-TOTAL $ 10,567,500.00

III. PROPOSED CHANNEL IMPROVEMENTS

	Location & Flow Rate	Proposed	Estimated Construction Cost
A.	**LANANA**		
1.	Loop 224 (South) to Butt St. 14,080 - 22,570 CFS	Deepen channel 3' ± 60' Bottom @ 5:1 sideslopes Upstream of Loop 224 Transition to 50' Bottom @ 5:1 Sideslopes 1400' Upstream Transition to 40' Bottom @ 4:1 Sideslopes 1600' Downstream of Butt St. 40' Bottom @ 3:1 sideslopes Downstream of Butt St.	$ 753,200.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
2.	Butt St. to Main St. 13,300 - 14,080 CFS	Deepen channel 2'-3' ± 40' Bottom @ 3:1 sideslopes at Butt St. to Natural Channel 200' Upstream 45' Bottom @ 3.25:1 sideslopes from Natural Channel 1000' Downstream to Main St.	$ 122,500.00
3.	Main St. to Park St. 13,000 - 13,300 CFS	Deepen channel 1'-2' ± 45' Bottom @ 3.25:1 sideslopes Upstream of Main St. 40' Bottom @ 3:1 sideslopes Downstream of Park St.	$ 207,400.00
4.	Park St. to Martinsville Rd. 12,900 - 13,000 CFS	Deepen channel 0.5'-1' ± 40' Bottom @ 3:1 sideslopes Upstream of Park St. 35' Bottom @ 3:1 sideslopes Downstream of Martinsville Rd.	$ 50,800.00
5.	Martinsville Rd. to Starr St. 12,800 - 12,900 CFS	Deepen channel 0.5'-3' ± 35' Bottom @ 3:1 sideslopes Upstream of Martinsville Rd. 45' Bottom @ 3:1 sideslopes Downstream of Starr	$ 200,400.00
6.	Starr to College St. 12,700 - 12,800 CFS	Deepen channel 0-3' ± 45' Bottom @ 3:1 sideslopes Upstream of Starr 40' Bottom @ 3:1 sideslopes Downstream of College	$ 154,000.00
7.	College St. to Austin St. 12,210 - 12,700 CFS	Deepen channel 0-3' ± 40' Bottom @ 3:1 sideslopes at Austin from Natural Channel 2900' Upstream of College	$ 168,000.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
5.	South St. to Pillar St. 7,490 CFS	Deepen channel 3' ± 40' Bottom @ 2:1 sideslopes Upstream of North 50' Bottom @ 2:1 sideslopes Downstream of Pillar	$ 75,600.00
6.	Main St. to Powers St. 6,990 - 7,290 CFS	Deepen channel 3' ± 45' Bottom @ 2:1 sideslopes	$ 114,800.00
7.	Powers St. to SPRR 5,990 - 6,990 CFS	Deepen channel 3' ± 40' Bottom @ 2:1 sideslopes Upstream of Powers 30' Bottom @ 2.25:1 sideslopes Downstream of SPRR	$ 965,300.00

BANITA CREEK SUB-TOTAL = $ 1,292,900.00

C. EGGNOG BRANCH

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	LaNana Creek to FM #1275 3,720 - 4,020 CFS	Deepen channel 0'-2' ± 30' Bottom @ 3:1 sideslopes from FM #1275 to Natural Channel 1300' Downstream	$ 113,400.00
2.	FM #1275 to Loop 224 2,730 - 3,720 CFS	40' Bottom @ 2:1 sideslopes from Loop 224 to Natural Channel 200' Downstream	$ 16,800.00
3.	Loop 224 to FM #2259 2,070 - 2,730 CFS	Deepen Channel 0-2' ± 20' Bottom @2:1 sideslopes	$ 93,800.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
4.	FM #2259 to Eastwood Terrace 2,070 CFS	Deepen Channel 2' ± 16' Bottom @ 2:1 sideslopes	$ 18,200.00
5.	Eastwood Terrace to Hwy. #21 880 - 2,070 CFS	16' Bottom @ 1:1 sideslopes from Eastwood Terrace to Natural Channel 1600' Upstream 22' Bottom @ 1:1 sideslopes from Hwy #21 to Natural Channel 1600' Downstream	$ 58,800.00
6.	Upstream of Hwy. #21 880 CFS	22' Bottom @ 1:1 sideslopes from Hwy. #21 to Natural Channel 800' Upstream	$ 16,800.00

EGGNOG BRANCH SUB-TOTAL = $ 317,800.00

D. TRIBUTARY A

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	LaNana Creek to SPRR 3,240 - 3,370 CFS	Deepen Channel 0-5' ± 20' Bottom @ 2:1 sideslopes from SPRR to Natural Channel 750' Downstream	$ 18,200.00
2.	Press Rd. to Park Entrance 2,660 - 3,240 CFS	Deepen Channel 2'-5' ± 20' Bottom @ 2:1 sideslopes Upstream of Press Rd. 20' Bottom @ 1.5:1 sideslopes Downstream of Park Entrance	$ 228,900.00
3.	Park Entrance to South St. 2,390 - 2,660 CFS	Deepen Channel 2'-3' ± 20' Bottom @ 1.5:1 sideslopes Upstream of Park Entrance 30' Bottom @ 1:1 sideslopes Downstream of North St.	$ 95,900.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
4.	South St. to Fredonia St. 1,750 - 2,390 CFS	Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes	$ 134,000.00
	TRIBUTARY A SUB-TOTAL	**=**	**$ 477,100.00**

E. TRIBUTARY B

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	Fredonia St. to South St. 1,880 - 1,980 CFS	Deepen Channel 1'-5' ± 15' Bottom @ 2:1 sideslopes	$ 14,000.00
2.	Virginia Ave. to Sunset Ave. 1,570 - 1,880 CFS	Deepen Channel 1'-2' ± 15' Bottom @ 2:1 sideslopes	$ 49,600.00
3.	Sunset Ave. to Burk St. 1,570 CFS	Deepen Channel 1' ± 15' Bottom @ 1.5:1 sideslopes	$ 15,400.00
4.	Burk St. to Durst St. 1,020 - 1,570 CFS	Deepen Channel 1'-3' ± 15' Bottom @ 2:1 sideslopes from Burk to Natural Channel 1600' Upstream 12' Bottom @ 1:1 sideslopes from Durst to Natural Channel 200' Downstream	$ 26,600.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
5.	Durst St. to Perry Dr. 710 - 1,020 CFS	Deepen Channel 0-3' ± 10' Bottom @ 1:1 sideslopes from Durst to Natural Channel 250' Upstream 10' Bottom @ 1:1 sideslopes from Perry to Natural Channel 900' Downstream	$ 14,000.00
	TRIBUTARY B SUB-TOTAL	**=**	**$ 119,600.00**

F. TRIBUTARY C

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	Banita Creek to SPRR 2,410 CFS	Deepen Channel 0-1' ± 25' Bottom @ 3:1 sideslopes From SPRR to 20' Bottom @ 3:1 sideslope 300' Downstream	$ 4,000.00
2.	SPRR to Old Tyler Rd. 2,340 - 2,410 CFS	Deepen Channel 1'-3' ± 25' Bottom @ 3:1 sideslopes	$ 35,700.00
3.	Upstream of Old Tyler Rd. 2,340 CFS	Deepen Channel 0-3' ± 15' Bottom @ 3:1 sideslopes Extend Channel Section 200' Upstream	$ 14,000.00
	TRIBUTARY C SUB-TOTAL	**=**	**$ 53,700.00**

G. TRIBUTARY D, D-1, & D-2

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	University Dr. to FM #1411 (D) 4,200 - 4,400 CFS	Deepen Channel 0-2' ± 20' Bottom @ 2:1 sideslopes from University Dr. to Natural Channel 700' Upstream 25' Bottom @ 2:1 sideslopes from FM #1411 to Natural Channel 300' Downstream	$ 19,600.00
2.	FM #1411 to FM #1878 (D) 3,940 - 4,200 CFS	Deepen Channel 0-3' ± 25' Bottom @ 2.5:1 sideslopes from FM #1411 to Natural Channel 900' Upstream 25' Bottom @ 2.5:1 sideslopes from FM #1878 to Natural Channel 900' Downstream	$ 117,600.00
3.	FM #1878 to Briargrove Dr. (D-1) 880 CFS	Deepen Channel 4' ± 10' Bottom @ 1:1 sideslopes	$ 4,200.00
4.	Briargrove Dr. to Tudor Dr. (D-2) 550 - 880 CFS	Deepen Channel 0'-6' ± 10' Bottom @ 1:1 sideslopes from Briargrove to 5' Bottom @ 1:1 sideslopes 800' Upstream	$ 13,300.00

TRIBUTARY D SUB-TOTAL = $ 154,700.00

CHANNEL IMPROVEMENTS SUB-TOTAL = $ 4,330,400.00

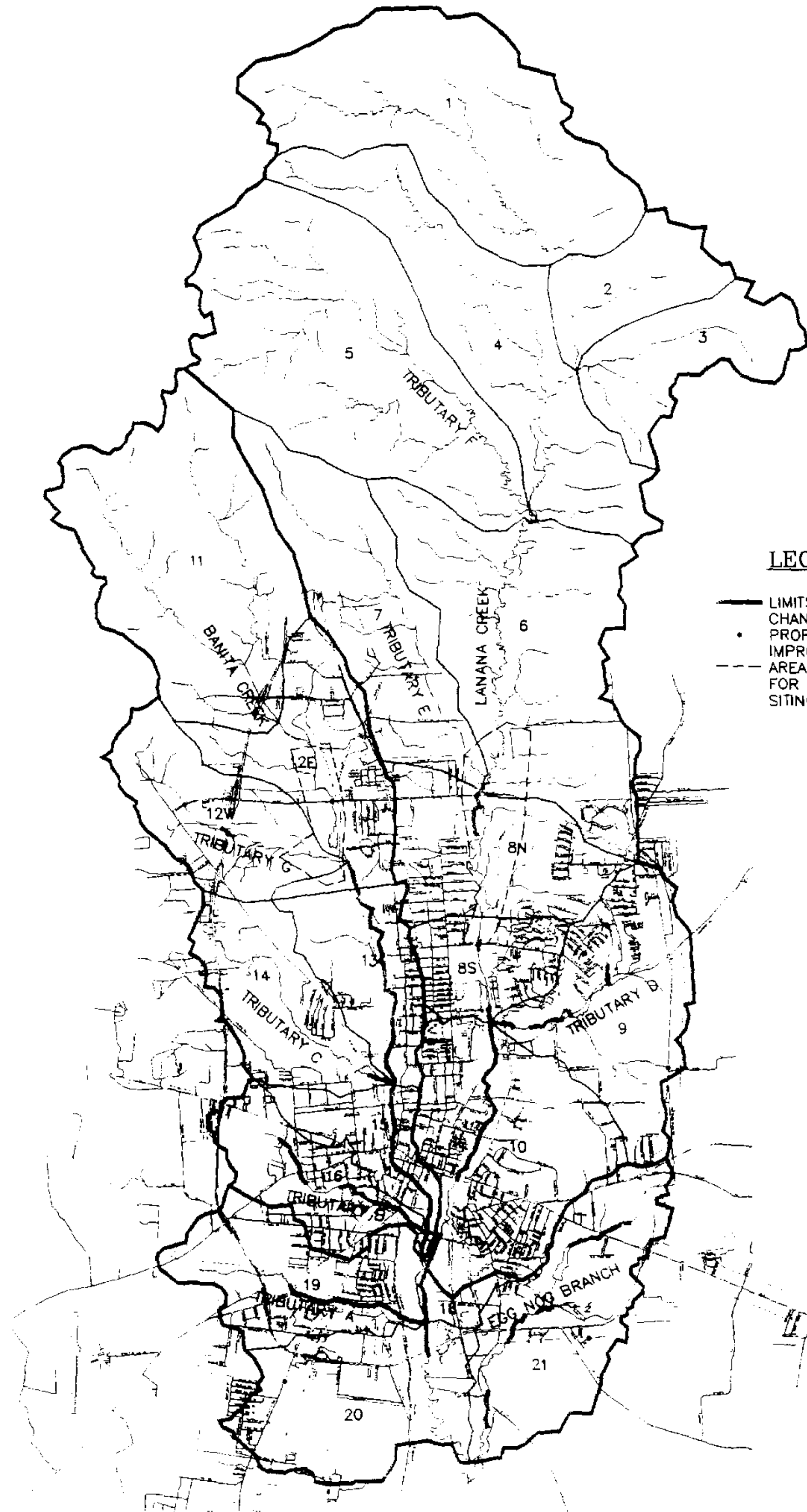
IV. OTHER CROSSING IMPROVEMENTS

	Location	Existing	Proposed	Estimated Construction Cost
1.	Baywood Dr. @ LaNana Trib.	2-36" DIA. R.C.P.	3-42" DIA, R.C.P.	$ 83,100.00
2.	Chevy Chase LaNana Trib.	2-36" DIA. R.C.P.	3-42" DIA. R.C.P.	$ 83,100.00
3.	Old Lufkin Rd. @ LaNana Trib.	3-30" DIA. R.C.P.	3-42" DIA. R.C.P.	$ 49,000.00
4.	Chalon @ LaNana Trib.	1-36" DIA. R.C.P.	3-48" DIA. R.C.P.	$ 148,800.00
5.	Ila @ LaNana Trib.	1-18" DIA. R.C.P.	1-36" DIA. R.C.P.	$ 22,400.00
	OTHER CROSSING IMPROVEMENT SUB-TOTALS			**$ 386,400.00**

NOTE: At least one listed project, (Item F.2, Pg 10a, Old Tyler Road @ Tributary C) and possibly others, are being considered for imporvements by either the state highway department or County. Coordination of these efforts during future planning or design should result in cost savings for all entities involved.

TABLE V - CONSTRUCTION COST SUMMARY OF PROPOSED IMPROVEMENTS

		Estimated Cost
I.	RESERVOIRS	$ 6,400,000.00
II.	MAJOR CHANNEL CROSSINGS	$ 10,567,500.00
III.	CHANNEL IMPROVEMENTS	$ 4,330,400.00
IV.	OTHER CHANNEL CROSSINGS	$ 386,400.00
V.	INTERNAL STORM SEWER	$ 2,000,000.00
	TOTAL ESTIMATED CONSTRUCTION COST =	**$23,684,300.00**



LEGEND

- LIMITS OF PROPOSED CHANNEL IMPROVEMENTS
- • PROPOSED CROSSING IMPROVEMENTS
- --- AREAS TO BE CONSIDERED FOR STORAGE RESEVOIR SITING

EXHIBIT O
PROPOSED IMPROVEMENTS
FLOOD CONTROL STUDY AREA
CITY OF NACOGDOCHES, TEXAS
REGIONAL FLOOD CONTROL STUDY
LANANA AND BANITA CREEK
WATERSHEDS

PREPARED BY:
SCHAUMBURG & POLK, INC.
CONSULTING ENGINEERS

INTRODUCTION

Drainage for the City of Nacogdoches, surrounding areas, and significant areas north of the City is provided by Banita Creek and LaNana Creek (Exhibit A - See Appendix D). A major portion of each stream passes through the most densely developed sections of the City with their confluence occurring within the southerly segment of development. Previous flooding of these streams has caused significant damage to both public and private property, and, more importantly, has endangered the public. With development occurring within these two watersheds at a steady pace, the potential for severity of flooding in developed areas increases dramatically. The last catastrophic flood event occurred in 1975 with property damages estimated as high as $20,000,000. The frequency for this storm approximated the 30-year storm event which would result in significantly less flooding than the 100-year frequency storm used in this study.

In recognizing these potential dangers and losses, the City of Nacogdoches has previously instituted drainage policies for new development within their boundaries and allotted additional budgetary funds to address some of the identified problems. Although these steps are greatly beneficial, the policies can only impact a small portion of the overall problems and the cost of needed improvements to alleviate flooding are far in excess of what annual general budgetary funding can realistically support. In addition, approximately one-half of the two watersheds is outside the jurisdictional boundaries of the City and is not impacted by either measure.

This Flood Control Study was initiated to evaluate the flooding potential of the entire watershed (Banita and LaNana) and determine regional solutions to the flooding problems that are reasonable and cost effective. This evaluation considers a combination of regional detention basins to dampen peak downstream flows, channel improvements, crossing improvements, and water shed management policies. To assist in funding the Flood Control Study, the City of Nacogdoches applied for and received a Flood Protection Planning Grant from the Texas Water Development Board. The total grant amount of $100,000 is being matched by local funds from the City of Nacogdoches.

PRELIMINARY ANALYSIS

A preliminary analysis of needed improvements was performed and cost estimates developed to allow the City to initiate the financial planning study for the project. These cost estimates also compared two of the alternative solutions or methods available to the City to assure that the most cost effective approach was taken. These alternatives are (1) Improvements to the channels, crossings, and storm sewers to accommodate peak flows and (2) peak flow dampening through regional detention reservoirs combined with lesser improvements to channels, crossings and storm sewers. As shown in Table I, (See Section 8) the reservoir option results in a lesser total cost and therefore the more cost effective of the two alternatives .

It should be noted that the tributaries' crossings cost was not impacted by the reservoirs inclusion. The reservoirs would dampen peak flows on LaNana Creek & Banita Creek but not the peak flows of the tributaries. The lower peak flows on the main channels would result in lower water surface elevations at the mouth of a tributary but none were lowered enough to reduce any of the needed improvements along the tributaries.

The total of the final cost estimate is approximately 15% higher than the preliminary numbers but comparable increases were reflected in individual crossing improvements for either alternative. In addition, the total reservoir cost decreased approximately 10% resulting in the detention reservoir option being more cost effective than the preliminary estimates indicated.

A third alternative, purchase of improvements subject to flood damage combined with no or minimum facilities improvements, could not be adequately evaluated on a preliminary basis, but is addressed later in the report.

PHYSICAL CONDITIONS AND TOPOGRAPHY

The City of Nacogdoches is located in Nacogdoches County in central East Texas with a current estimated population of 31,500. The study area encompasses both the Banita Creek and LaNana Creek watersheds (36,250 acres). These watersheds include all of the City of Nacogdoches, part of the City of Appleby and a very large unincorporated area north of the City. Most of the unincorporated area is undeveloped and heavily wooded.

The area is very hilly outside the floodplain and ranges in elevation from in excess of 610 feet in the northerly limits to approximately 220 feet southerly. Drainage is provided mainly by natural streams and creeks tributary to either Banita Creek or LaNana Creek. This study evaluated twelve individual streams or creeks (inclusive of Banita and LaNana) comprising the larger streams in the total 52 miles of channels in the watershed. Internal drainage improvements to serve improved areas consist of curb and gutter streets with underground storm sewers or roadways with roadside ditch drainage. Drainage from improved areas is typically directed to one of the main tributaries through either underground trunk sewers, smaller natural channels or man-made ditches.

DESIGN CRITERIA AND METHODOLOGY

This study and evaluation was performed using widely accepted practices for hydrology and stream hydraulics utilizing the best available data acquired from several sources.

The design storm hydrographs were developed using the basic equation of

$$i = b/(t+d)^e$$

where:

i =	Rainfall intensity; in./hr.
b =	Coefficient
t =	Time of concentration; minutes
d =	Coefficient
e =	Coefficient

The variables b, d, and e were obtained from the Texas Department of Transportation's publication "Hydraulic Manual", December, 1985. The values for the Nacogdoches area and a 100-year frequency storm are:

b =	92
d =	8.3
e =	0.725

These values were developed from actual historical storm event data for the Nacogdoches area. Using these values in the above equation reflects an approximation of a storm event that is representative of past storms for the specific area.

Initially the worse case storm event was assumed to be of a 100-year frequency, 24-hour duration. However, depending upon location, topography and other variables the worse case in terms of stream storage, ponding and flooding, could be of a duration approximately equal to the travel time through the watershed. For this study area the travel time was found to be about 8 hours, thus both the 100-year, 24-hour duration storm and the 100-year, 8-hour duration storm were considered.

In 1992 the City of Nacogdoches had detailed section sheets of the City prepared from aerial photographs by William-Stackhouse, Inc. These maps were developed with precise vertical and horizontal control and prepared through computer digitizing technology. Horizontal control is based on the Texas State Plane Coordinate System, Central Zone, 1983 Adjustment, and vertical control is based on the National Geodetic Vertical Datum, 1929 Adjustment. The computer files generated through this process were used in this study by the Watershed/Surface Modeling companion program prepared by Eagle Point, Inc., for use within the computer aided design (CAD) program Auto Cad, by Auto Desk, Inc.

The end product of using aerial photography generated computer files as the raw data input to the watershed modeling software was precise definition of the total watershed and individual watersheds within the total watershed, accurate channel lengths, and a three-dimensional computer model of the existing ground surface of the watershed(s).

A graphic representation of a portion of the water shed is provided in Exhibit Q - Appendix D. The area shown in this exhibit is at and around the confluence of LaNana and Banita Creeks. The vertical scale (elevation) has been enhanced to provide a more defined three-dimensional view.

Through the input of design storm data as described above, the watershed modeling module generates the flood hydrographs for each individual drainage area. The flood hydrographs are then routed and combined through the appropriate streams and/or reservoirs to develop the flood hydrographs throughout the watershed. Flood and routed hydrographs were developed for the following conditions:

- 100-year frequency, 24-hour duration storm under present development conditions
- 100-year frequency, 8-hour duration storm under present development conditions
- 100-year frequency, 24-hour duration storm under future development conditions
- 100-year frequency, 24-hour duration storm under future development conditions routed through regional detention reservoirs.

Coefficients for run-off, stream/channel roughness, sheet flow, etc. were determined for each area, sub-area, channel segment, etc. through the reference tables provided with the watershed modeling software and included in this report as Appendix A.

Land use sub-areas for current and future development were derived from the City of Nacogdoches Comprehensive Plan prepared in 1994 through a joint effort of J. Dennis Wilson, & Associates, Dallas; Barton-Aschman Associates, Inc., Dallas; and Schaumburg & Polk, Inc., Beaumont. The future development projections utilized by this study are representative of those foreseen by the year 2020. (Exhibits B-1 & B-2 - Appendix D).

Storm analyses were performed with the computer model HEC-2 as developed by the Corps of Engineers' Hydrologic Engineering Center. Stream evaluation requires peak flow data, channel cross-sections, physical features of stream crossings and flow coefficients, and lengths for channels, overbanks and crossings. Stream cross-sections and crossings' data were obtained primarily from actual field surveys. Supplemental data was obtained from the aerial photography computer files or from USGS maps for locations outside the limits of the computer file data. Flow coefficients were obtained from Appendix A as each location's physical conditions warranted. The flow data was derived from the Watershed Modeling procedure described previously.

DRAINAGE FACILITIES' EVALUATION

The total watershed was initially divided into 21 separate drainage areas for the purpose of isolating the individual tributaries to Banita Creek and LaNana Creek. Subsequently, two of these drainage areas were sub-divided to further assist analysis.

Through the Watershed Modeling software, a three-dimensional surface model of the entire watershed was developed. The limits of each drainage area was then defined by outlining the high-point ridge line between tributaries to the intersections with other tributaries or major stream. The area enclosed within each outline defines the surface from which the tributary would receive run-off during a rain event. These individual drainage areas are listed below and shown on Exhibit A - Appendix D:

Watershed		Drainage Area		Acres
LaNana		1		3086
LaNana		2		805
LaNana		3		1059
LaNana		4		2437
LaNana		5 - Tributary F		3619
LaNana		6		3011
LaNana		7 - Tributary E		1914
LaNana		8 - N		1448
LaNana		8 - S		718
LaNana		9 - Tributary D, D-1, & D-2		1698
LaNana		10		2124
LaNana		17		23
LaNana		18		166
LaNana		19 - Tributary A		1376
LaNana		20		1633
LaNana		21 - Eggnog Branch		1758
	TOTAL =			26,875
Banita		11		3023
Banita		12 - E		1414
Banita		12 - W - Tributary G		1270
Banita		13		950
Banita		14 - Tributary C		1183
Banita		15		634
Banita		16 - Tributary B		905
	TOTAL		=	9379
	TOTAL WATERSHED		=	36,254

The 1978 Flood Study published by the Federal Emergency Management Agency (FEMA) performed a detailed analysis of all of the streams and tributaries listed above except Tributaries E, F, & G. Comparison of FEMA data and this study found the area of comparable drainage areas to be approximately the same with a few minor variations.

Each drainage area was evaluated and values assigned for run-off, sheet flow, shallow flow and channel flow coefficients and factors. This input data combined with the rainfall intensity coefficients and storm duration definition, as previously described, provided flood hydrographs for each drainage area. These flood hydrographs were there routed and combined along the entire channel route(s) to develop peak flows that could be expected to occur at various points along the stream(s).

As previously discussed, the 100-year, 8-hour duration storm was evaluated in addition to the 100-year, 24-hour duration storm. The 8-hour duration is significant because that is the approximate time for run-off generated at the uppermost reaches of the watershed to pass through the entire watershed. This condition can result in the worse case storm event in terms of instantaneous peak flows to be transported and therefore merits analysis. However, this study found the 24-hour storm to result in the greater flows and thus used as the design storm.

Flood hydrographs for the design storm under present development, and the design storm under future development both with and without the regional detention reservoirs are provided in Appendix B - Appendix D. The peak flows from these hydrographs are reflected in Tables II and III - Section 8 and are the flow rates used in the HEC-2 stream modeling in this study.

Field surveys were performed to collect data for the HEC-2 stream modeling and included the following:

- Channel cross-sections
- Bridge Data
  - Width
  - Length
  - Depth of Deck structure
  - Piling
- Culvert data
  - Size: Diameter, width, depth
  - Inlet/outlet conditions
- Photographs
- Elevations
  - Bench mark loops between crossings to collect all elevations on same datum

For bridge analysis, four separate cross-sections of the channel were taken; one at each face of the structure plus one each up/downstream of the structure at a point approximating where the flow transition does not affect the effective flow area. Cross sections were also taken at the up/downstream faces of other crossings and at various intermittent points between crossings.

To check accuracy and validity, several cross-sections were generated from the aerial photography computer files and compared to actual field survey cross-sections of the same location. These comparisons were very favorable and additional cross-sections at selected points along the channels were developed from these computer files to supplement the field surveys. Other cross-sections were obtained from USGS quadrangles where neither field surveys nor computer file data was available. These cross-sections were used infrequently and mainly on the outer limits of drainage areas to terminate a stream model. Although not as accurate as either field surveys or computer files data, the USGS cross-sections were sufficiently accurate for their intended purpose.

The three-dimensional surface model developed from the aerial photography computer files resulted in a very accurate, to-scale channel route that included all bends and meanders. These routes were utilized to obtain channel lengths between the cross-sections.

With the channel cross-sections, bridge and culvert data, channel lengths, roughness coefficients and flow rates, a basic HEC-2 model was constructed for the following channels:

1. LaNana Creek
2. Banita Creek
3. Eggnog Branch
4. Tributary A
5. Tributary B
6. Tributary C
7. Tributary D
8. Tributary D-1
9. Tributary D-2
10. Tributary E
11. Tributary F
12. Tributary G

Other than the flow roughness coefficient, the raw input data for the HEC-2 model is fairly precise and definitive. The Manning coefficients however, were determined through visual observation of the channel or structure and comparing the observed conditions to the channel conditions described in Appendix A and other similar reference materials. Although this has proven to provide satisfactory results, the previous FEMA study provides an excellent basis for comparison to test the HEC-2 models' accuracy.

From the data supplied in the FEMA Flood Study, flow rates were extracted at channel locations common to the HEC-2 models developed in this study. A direct comparison of these flows are favorable for LaNana Creek, Eggnog Branch, Tributary A and Tributary D. (Table II - Section 8). Comparisons of Tributaries B and C were not favorable while only the flows at the upper end of Banita Creek were found favorable. Tributaries E, F and G were not analyzed in detail as part of the FEMA study.

Review of input and methods used in developing the flow rates where favorable comparisons were not found did not reveal any errors or inconsistencies thus the flow rates developed in this study are believed to be accurate and representative of the design storm event.

The HEC-2 analyses were then performed using the FEMA-based flows. Through minimal adjustment to Manning's coefficients within the base models, a generally favorable comparison of water surface elevations was found between the study model and FEMA values. (Table III - Section 8). Some locations did reveal significant differences in water surface elevations, but review of the model data did not reveal any errors and the study model is considered representative of the channels and crossings as they currently exist.

Stream analyses were then performed for the following storm events:

- 100-year intensity, 8-hour duration, present
- 100-year intensity, 24-hour duration, present
- 100-year intensity, 24-hour duration, future

Peak flows and water surface elevations for each scenario are provided in Tables II and III - Section 8, respectively. Water surface elevations (WSEL) profiles of each stream model are provided in Exhibits C through N - Appendix D.

EVALUATION OF IMPROVEMENTS

The improvements required to transport the design flows are determined by modifying and editing the HEC-2 stream models. Changes to bottom width, sideslopes, depth and/or roughness coefficients are made to the stream model input to reflect the proposed improvements.

As can be seen from the WSEL profiles, (Exhibits C through N - Appendix D) the major flow obstructions occur at road or railroad crossings. Other obstructions occur mainly from overbank conditions for the magnitude of flows being evaluated. A major portion of the flow is within the overbanks rather than the channel. The roughness coefficients of overbanks are higher than that of the channel, so under peak flow conditions, significantly greater than normal energy losses are experienced along the stream segments. For these reasons, proposed improvements were concentrated on enlarging crossings and widening stream cross-sections to contain the majority of the flow primarily in the channel.

Stream improvements were determined by beginning with the most downstream crossing of a stream segment and modifying the crossings size to allow the peak flow to pass without the water surface elevation exceeding the top of the crossing. Additional improvements up and downstream of the crossing are included as part of the crossing to provide for transition to the crossing. The next upstream segment was adjusted in a similar manner as was the channel segment between the two crossings. This method was repeated on each upstream crossing and channel segment through the entire length of the stream model. As each crossing/channel segment was completed, the previous downstream segment was re-evaluated to determine if the new upstream improvements would impact the previous segment. If so, the downstream improvements were modified accordingly. In most cases this would allow reducing the needed improvements with a corresponding reduction in cost. For the terrain of the study area, typically, the impact of improvements at one crossing would not extend further than one crossing upstream or downstream.

For channel segments between crossings that passed through developed areas, the improvements where to a degree that would provide mostly channel flow thus eliminating overbank flowing and flooding. For segments in mostly undeveloped areas, the channel improvements were extended sufficiently up and downstream of crossings to lower the WSEL to channel flow conditions near the crossings to provide flood protection to development along the crossings route.

Much of the channel and crossing improvements include concrete lining of the channel bottom and sideslopes through the crossing as well as up & downstream of the crossing. However, unless flow conditions warranted, the improved channel sections were proposed as earthen sections only.

Pipe and box culvert crossings were initially improved by adding additional conduits of the same size of the existing. If this were found unsatisfactory, larger culverts were considered. If insufficient capacity could still not be obtained, a bridge crossing was proposed to replace the culvert(s).

In addition to crossing and channel improvements, regional detention reservoirs are proposed on the mid-to upper reaches of LaNana Creek and Banita Creek.

These basins can be described as small flood control reservoirs, except that the areas outside the stream channels will remain dry during dry weather and minor rains. Basins will be designed for the 100 year, 24 hour storm event with a corresponding maximum downstream flood level designed to protect existing commercial and residential areas.

A simplified description of basin operation is as follows:

- Low flows compatible with downstream flood protection will flow through the basin unimpeded.

- During storm events which would (if uncontrolled) cause downstream flood damage, water will be discharged from the basins at the maximum allowable design rate, with flows in excess of that amount impounded within the basins. Water would rise in the basins until it reaches equilibrium, or until a preset maximum level near the top of the levees is reached.

- For a storm event in excess of the design storm, as the water in the basins approaches the design high level, all excess flows would automatically be discharged regardless of downstream flooding. Otherwise, the basins would cause unacceptable upstream flooding outside the basin limits, and/or the levees could fail and cause even more damage downstream. By definition, this problem should occur less than once every 100 years.

  Physically this will be accomplished by constructing the spillway to have weirs or a channel section designed to limit the basin outflow to the design value at any reservoir depth up to but less than the maximum reservoir water surface elevation. Adjacent to the weir or channel section, the levee will be constructed with a crest near but less than maximum reservoir level. The crest length along the levee will be long enough to accommodate flows far in excess of the design outflow at only several inches of water depth flowing over the crest. Should a storm event occur producing flows in excess of the design storm, the reservoir spillway would limit the flows out of the reservoir to the design value up until the reservoir level approaches its design maximum. Prior to reaching the maximum design level, all excess flows would pass over the wide shallow crest.

- Each basin will gradually drain after the storm flows have subsided.

In essence, by allowing the runoff from upstream to reach the flood-prone neighborhoods at a lower controlled rate rather than all at once, the basins will prevent the flood waters from rising high enough to cause flood damage within the neighborhoods.

Proposed Improvements are shown on Exhibit O - Appendix D. A brief description of the improvements for each proposed crossing and channel segment is provided in Table IV - Section 8 along with construction cost estimates. Cost estimates for regional detention reservoirs, internal storm sewers, and other identified crossing improvements not located along the stream models as also included in Table IV - Section 8. Table V - Section 8 provides a total cost summary of all proposed improvements.

The cost estimates include approximately 20% for engineering design and inspection fees and another 20% for environmental factors and contingencies. The channel improvements between crossings will primarily be confined within a stream's existing top-of-bank limits. Being natural streams, no easements nor rights-of-way exist and, by staying within the stream limits, none are proposed. These conditions prevail for the major stream sections at the mid to lower segments of streams. The upper sections of the streams narrow considerably, especially at culvert crossings, and additional permanent easement or right-of-way may be required in these areas adjacent to crossing rights-of-way. These easements may be needed to accommodate the transition from the channel to an improved and widened crossing but should be relatively small. Detail design will identify any such easements or rights-of-way where necessary.

Most of the crossing improvements will be confined within existing rights-of-way and, other than the temporary easements, no additional land acquisition, right-of-way, nor permanent easements are foreseen. Temporary construction easements for ingress and egress will be required during the actual construction of either channel or crossing improvements.

Land acquisition costs for the regional detention reservoirs are included in the cost estimates for the reservoirs. To determine the total costs for reservoirs, preliminary sitings and design were performed. Four possible locations were selected; two on LaNana Creek and two on Banita Creek The reservoirs are proposed in undeveloped areas in the northerly sections of the City. The drainage areas upstream of the reservoirs are fairly large resulting in a significant run-off into the basins. The final sitings of the reservoirs should be such to (1) receive a large portion of the watershed(s)' runoff, (2) located to make the most efficient use of the terrain to minimize construction costs, and (3) selected to keep land acquisition costs as low as possible.

The effectiveness and impact of the proposed improvements on the outward reach of flood waters are shown on Exhibit P - Appendix D. These flood limits are plotted for the following conditions:

1. FEMA regulatory 100 year flood levels

2. 100-Year, 24-Hour duration storm under future development and no improvements

3. 100-Year, 24-Hour duration storm under future development with proposed reservoirs and improvements

The third alternative the City has is to purchase all improvements that are within the area subject to design storm flooding without any improvements but outside the flood limits of the design storm with improvements and reservoirs. This would be the area on Exhibit P - Appendix D between the limits of numbers 2 & 3 above. If the cost of purchasing the improvements within these limits is greater than the cost of the improvements, then the most cost effective alternative is the proposed improvements as outlined herein. Otherwise, the most cost effective method is to purchase the existing improvements with no or a minimum of improvements.

The limits of the FEMA 100-year floodplain levels are shown on Exhibit P - Appendix D for reference purposes, but is also significant to the third alternative. As can be seen, the future 100-year flood levels exceed the FEMA levels and therefore the limits of the flood reach will encompass more development than the current regulatory levels. Conversely, the majority of the future 100-year flood levels with the proposed improvements are less than their FEMA counterparts and will encompass less development than the regulatory levels. As a result, the proposed improvements would not only significantly reduce the magnitude of the potential for flood damage, but should allow the lowering of the regulatory levels accordingly. It should be noted that the flood limits and FEMA limits were developed from hard cont scans and imported into the computer drawing file. As a result some minor distortion and inadequacies may occur in places, but the overall exhibit is representative of the anticipated condition. Information relative to structure count and other factors effecting costs were derived from the original hard copies rather than the scanned data.

Previous analysis of development within the current regulatory flood plain showed that a total of 147 structures exist with a total 1995 value of $18,830,700. The total number of structures between the flood limits with and without improvements is 291 at a total estimated value of $37,277,100.00 assuming a uniform value of structures. Based on cost alone, at $23.7 million, the proposed improvements and reservoir alternative is the most advantageous. This alternative also has the major advantage of providing the largest degree of public safety, which cannot be equated to dollars, but is obviously a more important consideration than cost.

Actual implementation of these proposed improvements will have to consider a major factor that can not be completely addressed in this report. Nacogdoches is an attractive, historical city and the natural wooded terrain and meandering streams further enhance the City's appeal. The proposed improvements were designed with the concept of minimizing disruption of natural features not only from the preservation standpoint, but also because this results in the most economical design. However, the magnitude of the peak flows associated with the design storm resulted in the proposal of concrete lining at many of the major stream crossings including upstream and downstream segments. This obviously destroys any natural beauty of a stream at the points it will be most visible.

For most of the major stream crossings at or near the confluence of LaNana and Banita Creeks, alternate solutions that will resolve the flood condition simply are not available. However, further upstream and along the other tributaries, where proposed improvements are less intense, alternate and more expensive solutions may be available that would achieve the same basic result but in a manner that would preserve more of a stream segments natural beauty or possibly leave a particular segment untouched.

The cost versus benefits associated with this set of factors is more difficult than an engineering design. These are more of the many tough decisions the City's elected officials must make after weighing the input from all sources; citizens, staff, conservation agencies and groups, engineers, attorneys, etc. The information provided in this study could be used as a baseline to target for alternate solutions in order to minimize upstream or downstream effects.

WATERSHED MANAGEMENT PLAN

The existing drainage facilities are inadequate to transport the present day stormwater run-off generated by the 100-year, 24-hour duration storm event. Major flooding, property damage and endangerment to public safety and public health will result from such a storm occurrence. Two significant flood events in 1975 caused an estimated $20,000,000 in damage. The worst of the two storms has been estimated to be a 30-year frequency storm and therefore less severe than the design storm of this study.

In addition, the City must consider and plan for future growth and development. Improvements to previously unimproved land results in a higher percentage of total rainfall becoming run-off. As a result, the inadequacies of existing drainage facilities will become even more severe as development occurs.

In the past, Nacogdoches, like most other cities, has found that their drainage needs received much less attention than the high profile areas of water, wastewater and solid waste. However, during the last four to five years the City has implemented the following steps to address some of the identified problems:

1. All drainage complaints received are added to a comprehensive list in order of priority. This list currently consists of more than 90 items.

2. A complaint's order or priority is established as follows:

    - Flooding of a habitable structure
    - Flooding of a non-habitable structure
    - Flood damage of other property
    - Other flooding

3. The City commission has approved approximately $250,000 per year over the past several years for drainage improvements. This funding allowed completion of numerous of the higher priority complaints.

4. Establishment of a 5 - member committee to develop a drainage policy.

    - Policy basically requires localized detention of peak run-off if a development creates 14,000 square feet or more impervious area.

    - Adherence to policy is required but no penalties can be assessed for failing to comply.

    - Detention design must comply with method adopted by Soil Conservation Service.

5. Established a rigorous and thorough plan check procedure to identify potential drainage problems. This applies to plans and individual structures, commercial/industrial development or residential subdivisions.

The City is also a participant in the FEMA Program and has passed the necessary ordinances that obligates the City to enforce the requirements of the program.

The City is currently investigating the possible establishment of a Municipal Drainage Utility System. Under this arrangement, needed drainage improvements would be constructed and the funding for the work would be generated by the drainage customers. The impact a particular parcel of land and its improvements, if any, has on the drainage facilities would be the basis of billing determination. This provides an equitable manner of distributing the cost to those who benefit. A feasibility report on a Drainage Utility System for Nacogdoches is included as Appendix C.

It is recommended that the City of Nacogdoches implement the alternative of constructing reservoirs and improvements to crossings and channel as proposed in this study. The evaluation of available alternatives show this choice to be the most advantageous in both cost and public safety.

Implementation of the plan should include the following steps or procedures:

1. Public meetings - The City should hold one or more public meetings to allow citizen involvement and input to the plan. These meetings should provide an overview of the proposed project in sufficient detail and with adequate exhibits and fact sheets to allow the general public a clear understanding of the need, purpose and intent of the proposed improvements. Citizen input should be promoted and any comments or recommendations given due consideration.

2. Develop and implement policies, standards and/or regulations on new and current development to promote the reduction of peak run-off rates from sites. Citizen input should be invited on these issues also. Such policies should include but not be limited to the following:

   - Promote the increase of green areas within new developments as well as existing developed tracts
   - Promote localized detention where feasible
   - Establish or modify design criteria for drainage systems to reduce peak velocities thus lengthening run-off times and dampening peak flows
   - Establish limits for total run-off to major facilities and regulate development to maintain such limits
   - Establish a public awareness and education program to emphasize the significance of improvements on peak flow rates and provide guidance to the general public on how to assist in the effort
   - Involve and gather input from local developers, architects, engineers, landscapers,

etc. on methods to reduce peak run-off rates

- Involve local clubs or groups, such as garden clubs, that have interest and goals that could compliment the reduction of peak flow rates
- Provide incentives to promote peak flow reduction
- Provide penalties to inhibit peak flow increase and misuse of drainage facilities that would be contrary to this overall effort
- Pursue non-structural means to promote reducing flood damage and protection of the general public such as:

    - Buy-out specific sites or structures that may not fit within the overall cost effective analysis
    - Flood warning systems
    - Flood proofing specific sites or structures

3. Advise and coordinate planned improvements with other private or governmental agencies or bodies having jurisdiction within the watershed and develop Joint-Venture arrangements to implement the improvements.

    - Nacogdoches County
    - City of Appleby
    - Texas Department of Transportation
    - Southern Pacific Railroad

4. Establish a means and method of funding the proposed improvements. The attached report, "Evaluation of the Feasibility to Establish a Municipal Drainage Utility System for Nacogdoches, Texas", by David M. Griffith & Associates, was prepared for the City to address these issues and is attached hereto as part of this study as Appendix C. This report provides a detailed analysis of the financial considerations for the improvements and proposes a phasing plan and rate structure that will support the proposed improvements.

5. Establish a phased improvement plan that will provide for constructing the highest benefit - to - cost ratio facilities initially. A priority list of required improvements is as follows:

    1. Reservoirs and the up/downstream crossing and channel improvements that would impact the reservoirs storage capacity.
    2. Other major crossing improvements
    3. Channel improvements
    4. Other identified deficient crossings
    5. Internal storm sewer
    6. City's list of isolated and localized problems from citizen complaints

    This plan will require revision and updating occasionally as improved information allows and funding permits. Preliminary scheduling of improvements and corresponding plans for funding are included in Appendix C.

SECTION 7-ENVIRONMENTAL ASSESSMENT

Task II. Develop Environmental Assessment for the Planning Area

A. DESCRIPTION OF STUDY AREA

The planning area for the regional flood protection study consists of a portion of Nacogdoches County along the LaNana Creek watershed, including most of the City of Nacogdoches. The study area extends north to the headwaters of LaNana Creek and its main tributary, Banita Creek. The area extends south for a short distance outside Nacogdoches.

Nacogdoches has a 1995 population estimated at 31,500. Other communities located within the study area include most of the city of Appleby (pop. 449, 1990) and the unincorporated communities of Central Heights and Mahl.

B. CURRENTLY EXISTING ENVIRONMENT WITHOUT THE PROPOSED PROJECT

(See Appendix E for details.)

1. Geological Elements

a. Topography. The study area lies within the Piney Woods region of East Texas, which is characterized by hills forested with pine and hardwood forest. The elevation of the study area varies from 220 to 610 feet. The ground surface varies from level to 25% or more on hillsides. The entire county, including the study area, lies inside the drainage basin of the Neches River.

b. Soil Types. The study area includes four mapping units as defined by a 1980 USDA soil survey: Nacogdoches-Trawick, Lilbert-Darco, and Cuthbert-Tenaha, all of which are upland soils; and Tuscosso-Hannahatchee, a bottomland soil.

The upland soils are predominantly sandy or loamy at the surface, with gravel occurring in some areas. Bottomland surface soils, as well as subsoils throughout the area, are mainly clay and loam. Almost all surface soils and subsoils have varying degrees of acidity. The soils are noted by the USDA as well drained or moderately well drained during their formation. The soils have moderate or moderately slow permeability.

The USDA lists a number of detailed soil mapping units as being prime farmland *(provided they are not located in urbanized or otherwise developed areas)*. The soils qualifying for prime farmland are scattered extensively throughout the portion of the planning area north of Nacogdoches. Within the City, they occur only in limited areas, and some of these areas may be excluded because of urbanization. South of the City, some prime farmland can be found, mainly on the fringes of the LaNana Creek floodplain.

The prime farmland soils occur in topography ranging from floodplains to broad interstream divides, but do not generally fall immediately adjacent to major streams such as LaNana Creek.

Some prime farmland falls within the general areas of the detention basins, but only small areas are subject to impact from the basins. Along the streams proposed for channel or stream crossing improvements, most prime farmland does not extend close enough to the streams to be included in the work areas.

The Nacogdoches-Trawick and Cuthbert-Tenaha general mapping units are noted by the USDA as eroding easily. Also, the Nacogdoches and Trawick soils, as well as the Hannahatchee bottomland soils, have been noted as being unstable in pits and road banks because of low shear strength.

All project elements along LaNana and Banita Creeks fall into the Tuscosso-Hannahatchee unit. In addition, the basins will extend away from the creeks into the Nacogdoches-Trawick unit and possibly into the Lilbert-Darco unit. Most elements along tributary streams will be in the Lilbert-Darco, with some possibly in the other two units. No work falls into the Cuthbert-Tenaha unit.

c. Geologic Structures. The principal subsurface rocks in the study area are classified as Cenozoic, within the Cenozoic subclass. Predominant surface rocks in the area are of the Claiborne Group, including in descending order the Stone City Formation,. the Sparta Sand, the Therill Formation, and the Weches Formation.

East Texas lies within a structural province known as the Gulf of Mexico Basin. The geological structures in East Texas are represented by two major elements, the East Texas Embayment and the Sabine Uplift. Nacogdoches lies within the East Texas Embayment, which covers approximately 90% of East Texas with a north-south axis running through Cherokee County *(west of Nacogdoches)*.

A major fault system in the Nacogdoches vicinity is the Elkhart-Jarvis-Mount Enterprise fault which runs east and west approximately twenty miles north of Nacogdoches. More localized fault lines occur in the northeastern portion of the study area and just east of the area.

2. Hydrological Elements

a. Streams. The two major streams within the study area are LaNana Creek and its main tributary, Banita Creek. Both of these streams head in northern Nacogdoches County at the beginning of the study area and flow south. Banita Creek flows into LaNana Creek in Nacogdoches. LaNana Creek continues southward to the Angelina River. Several miles of the LaNana Creek channel within Nacogdoches were straightened during the 1970's.

Stream flow in LaNana Creek at the Nacogdoches wastewater treatment plant *(south of the City)* averages 56.8 cfs, with monthly averages as low as 1.5 cfs during dry years. Instantaneous flows up to 25, 650 cfs have occurred.

Other named streams within the study area are Toliver Branch, Mill Branch, and Egg Nog Branch.

The streams within the study area are not affected by any significant wastewater discharges until they reach the Nacogdoches wastewater treatment plant. That plant receives flows from the entire City including local industries. The area north of Nacogdoches is affected to some extent by natural erosion and some agricultural runoff, and possibly by timber clear cutting operations. The streams within and downstream from Nacogdoches are also affected by urban runoff.

b. Lakes. There are several small lakes on minor tributary streams in the study area, none of which covers over 15 acres. The existing lakes cover only a negligible portion of the study area and have little effect on flood control.

c. Aquifers. The Carrizo Sand supplies all of the ground water used by the City of Nacogdoches. This aquifer outcrops in a band across the northern and northeastern parts of Nacogdoches County. The top of the formation in the immediate Nacogdoches area varies from 400 to 500 feet below ground, and the aquifer is generally 60 to 90 feet thick in this area.

The Carrizo sand contains water of a generally good quality. The water is generally soft from Nacogdoches southward, including the City's south well field. The portion of the aquifer north of Nacogdoches (including the city's north well field) contains significant amounts of iron, which can be removed for domestic use of the water.

It was noted several years ago that Nacogdoches pumped an average of 4.5 mgd of ground water, representing approximately 55% of the City's water usage. The remainder comes from Lake Nacogdoches ten miles west of town (outside the study area). Ground water pumpage is expected to diminish in the future, with an increase in surface water use.

In addition to the Carrizo Sand, aquifers favorable for producing water for small users within the study area include the Wilcox Group and the Sparta Sand. Other aquifers in the area include the Reklaw Formation, the Queen City Sand, the Weches Formation, and the Alluvium along LaNana Creek. The aquifers other than the Carrizo contain a number of small shallow wells, but are not used for major water supplies.

d. Springs. At least two springs are known to exist in the immediate Nacogdoches area, near the fringes of the study area.

3. Floodplains and Wetlands. Floodplains occur as relatively narrow strips along streams in the study area. Within the City of Nacogdoches, where a detailed floodplain study has been performed, the 100 year floodplain along LaNana Creek generally varies between 1000 and 2000 feet wide. The Banita Creek floodplain generally varies between 700 and 1000 feet wide within the City.

Within the City, 100 year flood elevations along LaNana Creek vary from 255 to 316 feet. Banita Creek, which has a steeper gradient, has flood elevations up to 354 feet. Future conditions are predicted in this study as ranging up to seven feet higher without a project or up to five feet lower with the proposed project.

The study area does not contain significant amounts of wetlands outside the immediate vicinity of streams.

4. Climatic Elements

a. General. The study area is located in the humid sub-tropical region of Central East Texas. The average rainfall as shown in the Texas Almanac is 47.5 inches. Average maximum temperature in July is 94° F, with an average minimum temperature of 39° F in January. Record high and low temperatures are 100° F and – 4° F.

The study area has a growing season of approximately 243 days which, coupled with the generous amounts of rainfall, makes the area highly suitable for agriculture.

The region experiences quite rapid fluctuations in both temperature and wind direction during the fall, winter, and summer months because of the interaction of the continental weather systems with warm, moist air from the Gulf. The prevailing wind direction for the area during the summer months is influenced mainly by the warm Gulf air currents from the south and southeast. The winter months are mainly characterized by winds from the northerly direction resulting from the influence of Arctic or Pacific cool fronts.

b. Air Quality. The nearest air monitoring stations to the study area are at Tyler and Longview, Texas and Shreveport, Louisiana. The Tyler and Shreveport areas, similar to the study area, are in attainment for ozone concentration. The Longview area is out of attainment, however, possibly because certain industries in that immediate area *(refineries, at least one petrochemical industry, and a brewery)* which either generate ozone or create conditions conducive to its formation. Because of the lesser amount of industrialization *(lack of those types of industries)* and the large rural areas in the Nacogdoches area, it is not expected that there are any major air pollution violations except from clear cutting of timber.

6. Cultural Resources. Several agencies were contacted in October of 1995 regarding cultural or historic resources. The responses, if any, from these agencies will be included in attached correspondence. It should be noted that the Nacogdoches area is noted for historic sites, since Nacogdoches is one of the oldest towns in the state. Previous correspondence from the Texas Antiquities Committee for a wastewater project also indicated a high potential for archeological sites within the Nacogdoches area.

7. Economic Conditions. Nacogdoches, one of the oldest towns in Texas, is both a university town and a diversified industrial center. Stephen F. Austin State University *(fall 1995 enrollment of 11, 770)* is by far the largest employer in the community. Its almost 3700 students living on campus make up over 11% of the City's population.

   Local industries include manufacturers of valves, outdoor furniture, feed and fertilizer, processed poultry, transformers, business forms, motor homes, industrial sealing products, poultry coops, cooling coils, oriented strand board, millwork and commercial fixtures, soft drinks, candy, flanges, and various wood products. Other significant employers include the U. S. Postal Service; city and county governments; the school district; two hospitals; large retailers; and a construction company. Unemployment is relatively low in comparison with the East Texas area 4.6%, December 1995).

   Nacogdoches County has considerable timber resources, with ⅔ of the county covered by commercial timber. Many county residents are employed in timber production, livestock production, oil and gas production, and tourism.

   For Nacogdoches County, the per capita income for 1989 was $13,208. Average weekly wage rate was $300.74 in 1990, with retail sales over $300 million and tax value over $1.6 billion.

   Nacogdoches has many opportunities for cultural and recreational activities, including theater groups, art galleries, museums, libraries, parks, swimming pools, golf courses, and tennis courts. Several lakes in the region offer fishing and water sports, including Lake Nacogdoches, Sam Rayburn Reservoir, and Lake Stryker. The surrounding timber land offers considerable hunting opportunities.

   Nacogdoches residents tend to have a higher level of education than the nation as a whole. The 1980 census showed that over 48% of all residents 18 years and older had completed at least one year of college. For residents 25 years and older, the percentage was over 41%.

   Nacogdoches has an estimated present (1995) population of 31,522, with a projected population of 40,053 in the design year 2020.

   Education through high school is provided by the Nacogdoches Independent School District and by the Central Heights ISD. Medical facilities include two general hospitals.

8. Land Use. Nacogdoches has had zoning within the City since 1970. Zoning designations include several categories of residential, business, and industrial use, as well as medical, agricultural, planned development, and floodplain zones. Applicable City ordinances, including the Floodplain Ordinance, place significant restrictions on further development within floodplains,

   In the event of annexation of some land within the study area, zoning for the annexed area is expected to be similar to existing zoning patterns.

   Land in the study area outside Nacogdoches is primarily covered with timber, with some agricultural use including crops, pasture, and chicken houses. A small portion of the study area includes portions of the city of Appleby as well as residential communities and commercial development. At least one industry is located in the study area outside Nacogdoches, a creosote plant at Mahl.

   Population within floodplains within the study area is reported at 284 within Nacogdoches, with an estimated 120 additional residents outside the City.

9. Other Programs. The general effect of various public and private programs in Nacogdoches is to promote continued growth in the area. The most significant programs are those which encourage industrial and business growth. These programs include industrial revenue bonds issued by several nonprofit organizations managed by the Nacogdoches County Chamber of Commerce.

   Small businesses may obtain financial assistance through the Small Business Administration and the Deep East Texas Regional Certified Development Corporation. Technical assistance is available through the Small Business Institute at SFA University.

   The Nacogdoches Area Industrial Park, a nonprofit organization, has purchased property at the north end of the city to facilitate industrial development.

   The City of Nacogdoches had a study of its water system performed in 1985, with a further analysis reflected in a comprehensive plan prepared for the City in 1994. The study outlined a twenty year program for upgrading water storage and distribution facilities. The City also plans to expand the capacity of its surface water intake and distribution facilities on Lake Nacogdoches.

   The City has also been implementing a major improvement program for its wastewater collection and treatment facilities. Portions of the program are covered by SRF funding, with some portions funded by TDHCA grants.

(3) Road or Railroad Crossing Improvements. Alterations to landforms would include channel widening and/or deepening at crossings, removal of existing road fill for a distance on each side of the stream, and/or possible increases in the width or height of the fill. Such alterations would be permanent. However, in the case of removal of road fill and replacement with increased bridge length, the project would to a slight extent restore the area to its natural condition prior to the original road crossing construction.

Drainage patterns would not be altered for road crossing improvements, unless the improvements include additional culverts or bridges serving as relief structures to supplement existing structures.

(4) Storm Sewers. Any linework *(except boring or tunnelling)* will temporarily alter the ground surface. Local drainage patterns will often be disturbed, including temporary impediments to small ditches and streams. However, contractors will normally be required to restore existing conditions, with little permanent impact.

b. Siltation and Sedimentation. Siltation and sedimentation are expected to occur temporarily in all construction areas. For basin construction, some fill material can be expected to erode during construction (prior to revegetation) and wash into the stream on both the upstream and downstream sides of the levee. For channel improvements, considerable siltation would occur from channel excavation. For road crossing improvements, siltation would occur from any channel widening, from any culvert or bridge construction, and possibly from removing or adding road fill. For storm sewer work, siltation would occur in ditches and streams for a distance downstream from any given work area.

As discussed above, some siltation may occur periodically after project completion in stream channels within the basin impoundment areas. However, any riprap constructed within channels would reduce the amount of siltation in the affected streams by eliminating a source of erosion.

Control measures will be covered to a large extent by a Pollution Prevention Plan *(if required for the project)* and may include silt curtains, hay bales, salvaging/replacing topsoil, reseeding, and scheduling operations for favorable weather. For any bridge supports or culverts located within channels, possible control measures include scheduling the work for times of low stream flow and/or temporarily sandbagging the stream flow. Construction equipment should be located outside the stream if possible, with the next best course of action being the use of mats for the equipment to rest on.

Measures for the storm sewer work will be similar. Additionally, ditch crossings will be sodded and/or covered with riprap as necessary. Headwalls will be placed around outfall lines if necessary.

c. Injury to Cover Vegetation. Vegetation must be removed from construction areas, but the areas will be restored where not covered by permanent improvements such as basin levees, roadways, etc. For storm sewer work, care will be taken to minimize destruction to adjacent tree roots.

Any rare or endangered species found in a construction area will be considered for preservation by transplanting or design modifications.

d. Herbicides, Defoliants, Cutting, Burning. Clearing will not involve herbicides or defoliants. Significant amounts of cutting are expected within the basin levee areas to the extent that the levees fall in wooded areas. Cutting may also be required for the borrow sources and some channel improvements, and to a lesser extent for storm sewers. However, the areas which will be impounded will not generally require cutting.

Burning, if applicable, will be conducted according to TNRCC regulations for areas within and outside cities.

e. Disposal of Soil and Vegetative Spoil. Any channel excavation or removed road fill must normally be removed from the site, although in some cases it may be used to refill abandoned channels. Likewise, any excess linework excavation which cannot be spread along the route must be removed. Some of this material may possibly be placed on nearby vacant land or construction sites.

Vegetative spoil, if not placed within channels to be refilled, can be disposed of in the City landfill.

f. Land Acquisition.

(1) Amount to be Acquired.

The recommended project is not expected to involve relocation of people, since the areas for the basin sites appear to be vacant. *(One alternative, not recommended, involves a buyout of all floodplain residents in the City in lieu of drainage improvements. That alternative does not appear to be cost effective.)*

The project will require title or other rights to an estimated 410 acres of land for the four basin sites, including actual construction areas and impoundment areas. The City will need to purchase virtually all construction areas, but it may prove more feasible to purchase flood control easements for the untouched impoundment areas, similar to the Corps of Engineers easements around the boundaries of Sam Rayburn Reservoir. *(Such easements would prohibit most types of structures within the impoundment areas.)* Additionally, the City may need to compensate some land owners for impaired access to land adjacent to basin sites, or for reducing their tracts of land to unusable sizes.

Only minimal easement requirements are expected for channel improvements. Channel easements may already exist along some portions of LaNana Creek which were improved in the 1970's.

Road crossing improvements *(exclusive of associated upstream and downstream channel improvements)* can be constructed within existing highway and road right-of-way. Likewise, the two extensions of railroad trestles can be constructed within existing railroad ROW, although temporary working easements may be required.

Storm sewers can probably be located within existing street and highway ROW in most cases, but may require easements in a few areas.

(2) Method of Acquisition. The construction sites and/or easements will be acquired according to the Uniform Relocation and Assistance Act of 1970. Eminent domain will be exercised only if necessary. Some existing improvements may remain undisturbed, such as fences or roads within the impoundment areas. However, any existing buildings within impoundment areas are expected to be (a) purchased and removed or demolished or (b) relocated on the owner's property outside the impoundment area.

(3) Effects on Adjacent Land Values. The value of any unpurchased land within impoundment areas would diminish because of periodic flooding in excess of that which would occur naturally. Also, almost all types of structures within such areas would be necessarily prohibited. However, the easement payments would be sufficient to compensate the owner for the reduction in value.

The value of land outside but adjacent to the impoundment areas should not be affected except for possible impaired access or in cases where the remaining portion of the tract is too small or narrow to be usable.

Land values in areas now subject to periodic severe flooding could be improved significantly.

Land values adjacent to channel or stream crossing improvements should not be affected other than by lowered flood levels. Land adjacent to storm sewer routes should not be affected in value except for possible improvement if an existing local drainage problem is relieved.

g. Abandonment of Facilities. Abandonment of existing facilities will primarily be limited to road crossing structures to be removed to allow construction of improved structures. Some existing channels may be abandoned in favor of relocated channels, while some storm sewer line may be removed for replacement with a larger size.

Some elements of the City water or sewer systems, or various privately owned underground utilities may have to be abandoned as a result of construction at the site where they are located.

h. Bypassing of Sewage. In the event that channel improvements or other work require temporary or permanent relocation of sanitary sewer lines, the plans and specifications will include measures to prevent any bypassing or temporary spills. Possible measures include temporary pumping until a relocated line can be constructed. Stream crossings of sewer lines will be reconstructed if necessary in a manner which will prevent any future spills.

i. Construction in Waterways. The Corps of Engineers has been contacted regarding the possible need for Section 10 and Section 404 permits *(for construction in waterways or wetlands)*. Some or all of the construction may be covered under a nationwide permit rather than requiring an individual permit.

j. Dust Control. Dust problems may occur as a result of earth moving for basin construction and for road reconstruction associated with stream crossing improvements. Some dust problems may occur from storm sewer construction. If necessary, construction areas can be watered in dry weather.

k. Noise. Normal construction noise will be a short term nuisance in the immediate vicinity. Noise will occur in residential and commercial areas, along streets and highways, and also in remote areas. OSHA requirements, including mufflers, should protect residents and wildlife.

l. Blasting. No blasting should be required. There is a slight chance that rock excavation could be required for some storm sewer work, but it is anticipated that a rock bucket or similar equipment would be used.

m. Safety Provisions. Construction within basin sites and at most channel improvement sites will not interfere with vehicular or pedestrian traffic. If heavy construction traffic causes problems on roads leading to the sites, or in cases of linework or reconstruction of road crossings, standard safety precautions will be taken such as barricades, warning signs, etc. Parking of construction vehicles will be kept away from heavy traffic or sensitive areas as much as possible.

   Some road crossings may require temporary closure during reconstruction. Likewise, storm sewer work may result in temporary street closures where the work crosses a street.

   Any open trenches will be closed as soon as possible or barricaded to prevent accidental entry. If necessary, pedestrian walkways will be provided.

   Safety measures for extension of railroad trestles will be in accordance with accepted railroad safety standards.

   The relatively inaccessible locations of some construction sites will tend to keep the public away. Other measures such as warning signs, fences, and locked gates will be used as needed.

n. Night Work. Night work is not anticipated except in unusual situations. One possibility may be the need to restore railway traffic when a railroad trestle is being extended in length. Effects of the resulting noise will be minimized by noise control measures or remote locations as appropriate.

o. Effects on Existing Utilities. Owners of all utilities affected by construction will be notified well in advance of construction. Pipeline owners will be contacted to determine pipeline depths, avert damage, and arrange for any necessary adjustments. Consideration will be given to relocating some or all utilities within impoundment areas, according to the expected effects on each facility.

p. Effects on Railroad Traffic. No determination has been made as to how long rail traffic would be curtailed at the two trestles to be lengthened. No local detour routes are available. However, every effort would be made to consult *(during project design)* with the railroad's engineering department as to construction methods which would minimize interference with rail traffic.

Most railroad crossing improvements involve only channel improvements under existing trestles. In the event that the existing substructure requires some type of upgrading as a result of the improvements, every effort will be made to avoid prolonged closure of the trestles.

2. Long Term Impacts

a. Land Affected, Beneficial Uses. Amounts of land and/or easements required for various construction elements are discussed in subsection C. 1. f (1) above.

Away from construction sites, land uses may be affected by slight improvement in developability as a result of reduction of the flooding level. This future development is not expected to affect wetlands or prime agricultural land, and should not affect floodplains other than through infilling. Some existing residential land may increase in value from lowered flood hazard.

Existing usage of the basin areas appears to be primarily for pasture, along with some timber production. The areas covered by the levees and related structures will be necessarily taken out of these uses permanently. However, if the City and the property owners should negotiate agreements for flood control easements, the impounded areas could continue to enjoy their present uses, subject to interruption during impoundment episodes.

b. Scenic Views. No scenic views should be affected. No landscaping, other than fine grading of embankments and restoring existing surface conditions where applicable, is needed .

c. Wind Patterns. Prevailing winds are from the south and southeast in the summer and from a northerly direction in the winter.

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c. Wind Patterns. Prevailing winds are from the south and southeast in the summer and from a northerly direction in the winter.

j. Access Control. No special measures are proposed for any of the channel, road crossing, and storm sewer improvements, since the nature of these areas will be unchanged from their present state. If necessary, the levee sites can be surrounded by fences with lockable gates. The impoundment areas can likewise be enclosed, or (if a flood control easement is used) they can remain under their existing fences. In either event, special warning signs should be installed around the perimeter of each impoundment area to warn the public of sudden rises in the water level.

k. Insect Nuisance. Because of the nature of the project,. no insect nuisance will be created or aggravated.

l. Floodplains. The project will be of benefit to all existing floodplain areas within the portion of Nacogdoches inside the study area, as well as portions of the area immediately to the south, with the exception of the areas covered by detention basins. Those areas will be impacted permanently on the levee sites, and the impoundment areas will suffer increased flooding effects on a periodic basis. However, the impacts on those areas will be far outweighed by the benefits to other floodplain areas.

m. Air Quality. The project should have no effect on air quality.

n. Energy and Chemical Consumption. Because of the nature of the project, no energy or chemicals will be involved in operation.

o. Effects on Wildlife. Long-term effects on wildlife should be minimized by leaving the impoundment areas in their natural state. Channel, road crossing, and storm sewer improvements should have no effect on wildlife.

p Effects on Utilities. Detention basins will be designed to minimize any problems for existing pipelines and power lines crossing the sites. All existing rights of protection contained in easement agreements will be honored, or alternate arrangements will be made. Channel, road crossing, and storm sewer improvements will be designed to minimize effects on any utilities crossing or paralleling the channels or storm sewers. Coordination would be made with utility owners during construction.

D. SECONDARY IMPACTS OF VARIOUS ALTERNATIVES

1. Land Uses. The project may facilitate residential growth in a few marginal areas on the edge of the floodplain by lowering the flood level and thus removing these areas from the floodplain. Similarly, the project may encourage some existing residents to remain in their homes rather than vacating them because of flood problems. Otherwise, no impact on land use is expected.

2. Air Quality. No secondary effects on air quality through increased automobile usage are expected, since total population growth should not be affected.

Because of the nature of the project, no odors will be produced.

d. Effects on Aquatic Life. The only effect of the project on aquatic life would be a possible improvement in stream quality from construction of riprap within channels and thus reducing erosion and siltation.

e. Effects on Water Uses. By reducing the amount of siltation where riprap is constructed in channels, the project may be of slight benefit to any immediate downstream recreational usage of the waters.

f. Diversion of Flows. No diversion of flows between river basins or local watersheds is included in the project.

g. Historical, Cultural, and Archeological Resources. Although no special investigation of any of the potential work areas has been made, the City and the Engineer are not immediately aware of any historical or archeological resources within the work sites. However, the City and the Engineer recognize that such resources have been found in some areas of the town and that Nacogdoches has a high potential for such resources, having been a Caddo Indian settlement several hundred years ago.

The appropriate state historical agencies were notified of the proposed improvements. The TWDB archeological staff may wish to conduct on-site surveys in connection with any state loan funding.

If any archeological resources are discovered during construction, work at the immediate site will be suspended pending archeological investigation.

h. Recreational Areas and Preserves. No known recreational areas or preserves will be adversely affected by the project except for minor effects of channel widening and road crossing improvements in city parks located along streams, such as Pioneer Park *(or nature conservancies)*. Any parks within floodplains could benefit slightly by reducing the depth and frequency of flooding.

Appropriate agencies are being notified of the proposed work elements within and adjacent to five City parks. Their comments, if any, will be included in the final draft of this report.

i. Noise Levels. Because of the nature of the project, no permanent noise sources will be created.

j. Access Control. No special measures are proposed for any of the channel, road crossing, and storm sewer improvements, since the nature of these areas will be unchanged from their present state. If necessary, the levee sites can be surrounded by fences with lockable gates. The impoundment areas can likewise be enclosed, or (if a flood control easement is used) they can remain under their existing fences. In either event, special warning signs should be installed around the perimeter of each impoundment area to warn the public of sudden rises in the water level.

k. Insect Nuisance. Because of the nature of the project,. no insect nuisance will be created or aggravated.

l. Floodplains. The project will be of benefit to all existing floodplain areas within the portion of Nacogdoches inside the study area, as well as portions of the area immediately to the south, with the exception of the areas covered by detention basins. Those areas will be impacted permanently on the levee sites, and the impoundment areas will suffer increased flooding effects on a periodic basis. However, the impacts on those areas will be far outweighed by the benefits to other floodplain areas.

m. Air Quality. The project should have no effect on air quality.

n. Energy and Chemical Consumption. Because of the nature of the project, no energy or chemicals will be involved in operation.

o. Effects on Wildlife. Long-term effects on wildlife should be minimized by leaving the impoundment areas in their natural state. Channel, road crossing, and storm sewer improvements should have no effect on wildlife.

p Effects on Utilities. Detention basins will be designed to minimize any problems for existing pipelines and power lines crossing the sites. All existing rights of protection contained in easement agreements will be honored, or alternate arrangements will be made. Channel, road crossing, and storm sewer improvements will be designed to minimize effects on any utilities crossing or paralleling the channels or storm sewers. Coordination would be made with utility owners during construction.

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1. Land Uses. The project may facilitate residential growth in a few marginal areas on the edge of the floodplain by lowering the flood level and thus removing these areas from the floodplain. Similarly, the project may encourage some existing residents to remain in their homes rather than vacating them because of flood problems. Otherwise, no impact on land use is expected.

2. Air Quality. No secondary effects on air quality through increased automobile usage are expected, since total population growth should not be affected.

3. Water Quality. Population growth and thus water usage will not be affected. Consequently, the project should not have indirect impacts on water quality in the Carrizo aquifer or Lake Nacogdoches as from excess withdrawal rates..

4. Effect on Public Services. Since population growth will not be affected, the project should not affect the total demand for public services such as water, gas, and electric power supply; wastewater collection/treatment; solid waste collection/disposal; fire and police protection; and education.

5. Economic Impacts. Scheduling and financing of the project will require serious consideration by the City for at least two reasons. First, the magnitude of the project *(approximately $23.6 million in construction)* is very substantial in comparison with other ongoing capital improvements programs such as water and sewer projects. This represents a capital cost of approximately $750 per capita for City residents. Second, the project is of a nature which does not normally generate revenue as do water and sewer service.

   It is anticipated that the City will follow the recommendations of a report prepared by others to address the issue of financing major drainage improvements. This report, which is attached as an appendix, discusses a means of collecting fees from owners of improved property which contributes runoff to the drainage facilities involved in the project. Such fees, which could be added as a separate line item to monthly water/sewer bills, would be based on the amount of excess peak runoff generated from a piece of property. *(The peak runoff is a function of various factors such as lot size, vegetation, amount of impervious area such as buildings and pavement, and any detention volume which may be provided on site. Only the additional runoff resulting from improvements would be subject to the fees)*

   Other potential alternatives to drainage fees include property and sales taxes.

   Initial financing for the project, or for one or more phases, could come from a bond issue on the open market or from a loan from the Texas Water Development Board. Debt service could come from various sources discussed above.

   Estimated financial requirements at project completion are $1,000,000 per year for debt service and $500,000 per year for operation and maintenance. This averages roughly $50 per year per capita, considering that small portions of the City populaton fall outside the LaNana Creek basin and thus outside the project area.

6. Land Use Changes Versus Land Use Plans. As discussed above, the project may remove some marginal areas from the floodplain and thus facilitate development. It is anticipated that the City would amend its zoning to reflect any such changes in floodplain extent and thus allow development, provided such areas are not otherwise sensitive for reasons such as wetland characteristics or archeological resources.

7. Impacts of Growth on Sensitive Areas. No substantial growth in floodplains other than infilling is anticipated because of the City's floodplain ordinance. Also, no development of

land with significant wetland characteristics is expected, since each plat can be scrutinized (by applicable local governments) for any local problems prohibitive to development.

Growth may occur in areas which are removed from the floodplain by means of the project. However, such growth would not be allowed in sensitive areas.

There are no known developable areas within the planning area comprising critical habitats, or environmentally sensitive, other than floodplains and wetlands.

TABLES

TABLE I - PRELIMINARY COST COMPARISON

		DESCRIPTION	ESTIMATED CONSTRUCTION COST	
			Without Reservoirs	With Reservoirs
I.	RESERVOIRS			
	1.	LaNana Reservoir #1	__	$ 2,082,000
	2.	LaNana Reservoir #2	__	$ 2,463,000
	3.	Banita Reservoir	__	$ 2,544,000
		RESERVOIRS' TOTAL ESTIMATED COST		$ 7,089,000
II.	SELECTED CROSSINGS			
	1.	Eggnog Branch @ Hwy # 1275	$201,000	$201,000
	2.	Eggnog Branch @ Loop # 224	$177,000	$177,000
	3.	Eggnog Branch @ Hwy # 2259	$118,400	$118,400
	4.	Eggnog Branch @ Railroad St.	$197,600	$197,600
	5.	Tributary D-2 @ Tudor Dr.	$108,000	$108,000
	6.	Tributary D @ Hwy # 1878	$ 96,800	$ 96,800
	7.	Tributary A @ Press Rd.	$179,500	$179,500
	8.	Tributary A @ Park Entrance	$104,000	$104,000
	9.	Tributary A @ South St.	$173,600	$173,600
	10.	Tributary A @ Fredonia	$360,000	$360,000
	11.	LaNana Tributary @ Hwy. # 225	$ 94,200	$ 94,200
	12.	Tributary C Old Tyler Road	$ 418,400	$ 418,400

13.	Banita @ Powers St.	$ 536,800	$ 474,500
14.	Banita @ Main	$ 419,100	$ 67,200
15.	Banita @ Pilar	$ 216,800	$ 85,600
16.	Banita @ Fredonia	$ 473,600	$ 59,800
17.	Banita @ Butt St.	$ 373,600	$ 96,800
18.	LaNana @ Butt St.	$ 681,000	$ 220,800
19.	LaNana @ Main	$ 831,800	$ 531,000
20.	LaNana @ Park St.	$ 629,400	$ 136,000
21.	LaNana @ Martinsville Rd.	$ 496,300	$ 104,000
22.	LaNana @ Starr Ave.	$ 477,000	$ 193,000
23.	LaNana Tributary @ Baywood	$ 83,100	$ 83,100
24.	LaNana Tributary @ Chevy Chase	$ 83,100	$ 83,100
25.	LaNana Tributary @ Old Lufkin Rd.	$ 49,000	$ 49,000
26.	LaNana Tributary @ Tudor	$ 29,600	$ 29,600
27.	Tributary D-2 @ Briar Grove	$ 66,400	$ 66,400
28.	LaNana Tributary @ Chalon	$ 148,800	$ 148,800
29.	LaNana Tributary @ Ila	$ 22,400	$ 22,400
SELECTED CROSSINGS TOTAL ESTIMATED COST		$7,846,300	$4,679,000

III.	OTHER CHANNEL CROSSINGS	$7,500,000	$4,000,000
IV.	INTERNAL STORM SEWER	$2,000,000	$2,000,000
V.	CHANNEL IMPROVEMENTS	$7,500,000	$3,000,000
	TOTAL ESTIMATED COST	$24,846,300	$20,768,000

NOTE:

Table I was used as the cost basis for the Municipal Drainage Utility System included as Appendix C. Table I has been included to facilitate updating the preliminary costs reflected in Appendix C to the comparative costs provided in the final cost estimate.

TABLE II - PEAK FLOW RATES

LaNana Creek - (Exhibit C - Appendix D)

Location	Cross-Section	* A	B	C	D	E	F
Eggnog	20.0	21830	21830	20620	24280	25350	24770
Loop 224(S)	20.2	19500	19500	18420	22960	23900	22570
Trib A	20.3	18480	18480	18380	22630	23560	21430
Banita	10.0	16800	16800	13800	17500	17500	14500
Butt	10.1	16300	16300	13400	16990	17010	14080
SPRR	10.2	15800	15800	13350	16800	16800	13600
Main	10.3	15300	15300	13300	16600	16600	13300
Park	10.5	14940	14940	13290	16540	16600	13000
Martinsville	10.7	14920	14920	13290	16510	16550	12900
Starr	10.8	14900	14900	13290	16480	16510	12800
College	8.0	14840	14840	13250	16400	16500	12700
Austin	8.2	14200	14200	12950	15840	15850	12210
--	8.3	14130	14130	12900	15750	15700	13910
Loop 224(N)	6.0	12430	12430	12650	15430	15430	13100

*Category Description

A. Valves obtained from FEMA Report
B. Current HEC-2 model values using FEMA based flow rates
C. Current HEC-2 model values using present 100 yr - 8 hr. storm
D. Current HEC-2 model values using present 100 yr, - 24 hr. storm
E. Current HEC-2 model values using future 100 yr. - 24 hr. storm
F. Current HEC-2 model values using future 100 yr. - 24 hr. storm with reservoirs and improvements

TABLE II - PEAK FLOW RATES (Cont.)

Banita Creek -(Exhibit D - Appendix D)

Location	Cross-Section	A	B	C	D	E	F
LaNana	17.0	7880	7880	6400	8330	8700	7600
Butt	17.1	7780	7780	6300	8230	8600	7490
SPRR	15.1	7340	7340	6300	8230	8600	7490
Church	15.2	9300	9300	6300	8230	8600	7490
Fredonia	15.3	9290	9290	6300	8230	8600	7490
Pecan	15.4	9280	9280	6300	8230	8600	7490
North	15.5	8800	8800	6300	8230	8600	7490
Pilar	15.6	8800	8800	6300	8200	8600	7490
Main	15.7	8800	8800	6300	8100	8500	7290
Powers	15.9	8300	8300	6300	8000	8400	6990
Trib C	13.0	7900	7900	6270	7910	8280	6690
--	13.1	7170	7170	6250	7700	8000	6700
--	12.0	6500	6500	6200	7500	7800	6300
Trib. G	12.1	6400	6400	6110	7380	7710	5990
Loop 224	12.2	5880	5880	5600	6900	7200	5700

TABLE II - PEAK FLOW RATES (Cont.)

Eggnog Branch - (Exhibit E - Appendix D)

Location	Cross - Section	A	B	C	D	E	F
LaNana	21.0	3500	3500	3340	3890	4020	4020
Hwy 1275	21.1	3240	3240	3090	3600	3720	3720
Loop 224	21.2	2380	2380	2270	2650	2730	2730
Hwy 2259	21.3	1800	1800	1720	2000	2070	2070
Eastwood Terrace	21.4	1800	1800	1720	2000	2070	2070
Hwy 21	21.5	770	770	730	850	880	880
Stallings	21.6	190	190	180	200	210	210

Tributary A - (Exhibit F - Appendix D)

Location	Cross - Section	A	B	C	D	E	F
LaNana	19.0	3060	3060	2710	3130	3370	3370
SPRR	19.1	3025	3025	2600	3000	3240	3240
Press Rd.	19.2	3015	3015	2600	3000	3240	3240
Park Ent.	19.5	2690	2690	2140	2470	2660	2660
North St.	19.6	2510	2510	1920	2220	2390	2390
Fredonia	19.8	2220	2220	1410	1630	1850	1750

TABLE II - PEAK FLOW RATES (Cont.)

Tributary B - (Exhibit G - Appendix D)

Location	Cross - Section	A	B	C	D	E
Banita	16.0	2800	2800	1590	1870	2070
Pk. Lot	16.1	2800	2800	1590	1870	2070
Fredonia	16.2	2800	2800	1520	1790	1980
SPRR	16.3	2800	2800	1520	1790	1980
North	16.4	2800	2800	1450	1700	1880
Virginia	16.41	2800	2800	1450	1700	1880
Sunset	16.5	2780	2780	1210	1420	1570
Burk	16.6	2500	2500	1210	1420	1570
Durst	16.7	1800	1800	790	930	1020
Perry	16.8	1200	1200	550	650	710

Tributary C - (Exhibit H - Appendix D)

Location	Cross - Section	A	B	C	D	E
Banita	14.0	3200	3200	1680	2070	2410
SPRR	14.1	3200	3200	1680	2070	2410
Old Tyl. Road	14.2	3020	3020	1630	2010	2340
--	14.23	2790	2790	1500	1840	2150
Dam	14.26	2590	2590	1380	1700	1980
--	14.3	2360	2360	1180	1450	1690
--	14.33	2000	2000	970	1200	1400
--	14.4	600	600	390	480	550

TABLE II - PEAK FLOW RATES (Cont.)

Tributary D - (Exhibit I - Appendix D)

Location	Cross - Section	A	B	C	D	E
Univ. Dr.	9.0	3930	3930	3800	4400	4400
FM 1411	9.1	2990	2990	3630	4200	4200
FM 1878	9.2	2880	2880	3400	3940	3940
--	9.21	2420	2420	2340	2710	2710
--	9.22	1000	1000	970	1120	1120
Loop 224	9.5	600	600	290	340	340

Tributary D-1 - (Exhibit J - Appendix D)

FM 1878	9.2	--	--	1620	1870	1870
Loop 224	9.7	--	--	220	260	260

Tributary D-2 - (Exhibit K - Appendix D)

FM 1878	9.3	--	--	760	880	880
Briar Grove	9.4	--	--	880	880	880
Tudor	9.8	--	--	250	550	550

TABLE II - PEAK FLOW RATES (Cont.)

Tributary E - (Exhibit L - Appendix D)

Location	Cross-Section	A	B	C	D	E
LaNana	7.0	--	--	2470	3100	3100
Loveless Rd.	7.1	--	--	1880	2360	2360
	7.4	--	--	690	870	870

Tributary F - (Exhibit M - Appendix D)

LaNana	6.9	--	--	4380	5550	5550
--	5.1	--	--	4380	5550	5550
--	5.2	--	--	3850	4970	4970
--	5.5	--	--	1900	2500	2500

Tributary G - (Exhibit N - Appendix D)

Banita	12.1	--	--	1870	2350	3010
Stallings	12.3	--	--	1120	1410	1810

CITY OF NACOGDOCHES
FLOOD CONTROL STUDY

TABLE III - WATER SURFACE ELEVATIONS

LaNana Creek - (Exhibit C - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
Loop 224 (S)	20.2	262.7	256.4	258.9 259.4	259.0 259.5	259.7 261.0	259.9 261.4	256.4 256.5
Trib A	20.3	--	262.2	265.3	265.1	266.4	266.7	260.9
Banita	10.0	--	265.7	267.8	267.5	268.7	268.9	263.3
Butt	10.1	266.4	266.5	269.8 271.2	269.1 270.1	270.2 271.6	270.3 271.7	264.2 265.5
SPRR	10.2	279.5	271.7	272.1 272.2	271.1 271.1	272.5 272.6	272.6 272.6	268.8 268.9
Main	10.3	272.4	274.5	275.2 276.3	274.5 275.5	275.5 276.7	275.5 276.7	270.4 272.4
Park	10.5	278.1	279.6	280.0 281.9	279.4 281.1	280.3 282.6	280.3 282.6	274.8 276.9
Martinsville	10.7	283.0	284.7	284.5 286.5	283.9 285.7	285.1 287.3	285.1 287.3	278.6 278.9
Starr	10.8	282.3	286.2	288.4 288.9	287.6 288.1	289.0 289.6	289.0 289.6	281.0 282.5
College	8.0	293.0	288.9	292.6 294.2	291.8 293.1	293.3 295.2	293.4 295.2	285.1 288.3
Austin	8.2	300.1	295.0	297.8 298.9	298.0 298.5	298.3 300.2	298.4 300.2	291.7 299.0
--	8.3	--	299.5	299.9	299.0	300.7	300.7	300.2
Loop 224 (N)	6.0	315.4	314.5	311.2 315.9	311.4 316.0	312.0 316.6	312.1 316.6	309.2 315.0

*Where two (2) elevations are given for a cross-section, the top value is for the downstream face of the crossing and the bottom value is for the upstream face.

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Banita Creek - (Exhibit D - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
LaNana	17.0	--	266.0	267.1	266.3	268.1	268.2	263.9
Butt	17.1	266.8	267.0	269.5 270.3	269.1 269.7	269.6 270.5	269.7 270.6	266.2 267.1
SPRR	15.1	275.9	271.7	271.4	270.7	271.7	271.8	269.3
Church	15.2	273.2	273.1	273.5 275.4	272.6 273.5	273.5 275.0	273.6 275.9	269.3 270.3
Fredonia	15.3	274.7	275.9	276.2 277.8	274.4 275.8	275.7 277.2	275.9 277.4	270.8 272.5
Pecan	15.4	276.4	276.5	277.9 279.3	276.0 277.3	277.4 278.6	277.6 278.9	273.2 275.6
South	15.5	277.4	277.3	279.5 280.3	277.5 278.3	278.8 279.8	279.1 280.0	275.6 277.1
Pilar	15.6	279.0	280.1	281.3 282.8	279.9 281.0	281.0 282.3	281.2 282.6	278.0 278.8
Main	15.7	280.4	281.0	282.9 284.0	281.2 282.1	282.4 283.5	282.7 283.8	278.8 279.7
Powers	15.9	285.6	289.8	288.2 289.7	287.5 288.6	288.2 289.5	288.3 289.7	283.0 285.4
Trib. C	13.0	--	296.5	293.4	292.7	293.3	293.5	291.8
--	13.1	--	315.9	316.8	316.4	317.0	317.1	315.5
--	12.0	--	333.2	333.3	333.2	333.7	333.8	331.7
Trib. G	12.1	--	340.9	339.1	339.0	339.3	339.4	336.6 345.0
Loop 224(N)	12.2	394.7	353.5	353.7 353.7	353.6 353.6	354.3 354.3	354.4 354.4	352.8 360.0

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

- Eggnog Branch - (Exhibit E - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
LaNana	21.0	--	--	247.0	247.0	247.0	247.0	247.0
Hwy 1275	21.1	265.8	--	269.4 268.5	269.2 268.5	269.5 268.5	269.5 268.8	265.6 266.7
Loop 224	21.2	302.3	295.8	294.6 302.9	294.4 302.5	294.9 303.3	296.2 303.7	292.8 295.8
Hwy 2259	21.3	310.4	307.3	312.3 311.8	312.2 311.4	312.5 312.1	312.5 312.2	306.2 307.5
Eastwood Terrace	21.4	313.6	--	313.4 316.2	313.2 316.1	313.9 316.4	314.0 316.4	309.9 313.4
Main/Hwy.21	21.5	347.1	--	347.7 348.6	347.6 348.5	347.8 348.9	347.8 349.0	347.4 347.8
Stallings	21.6	393.9	--	379.2 380.2	379.1 380.1	378.5 380.6	378.6 381.1	379.7 381.1

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary A - (Exhibit F - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
LaNana	19.0	--	--	260.9	260.0	261.6	261.4	260.0
SPRR	19.1	261.0	260.0	262.7 268.1	262.7 267.1	262.7 268.0	262.8 268.6	260.6 260.7
Press Rd.	19.2	260.7	260.9	268.1 271.4	267.1 269.8	268.0 271.0	268.6 271.7	260.9 261.2
Park Ent.	19.5	275.7	268.1	274.5 277.4	274.7 276.6	274.5 277.0	274.5 277.3	270.8 271.9
South St.	19.6	289.0	283.3	282.1 287.6	282.2 285.4	282.9 287.2	281.8 286.8	279.2 282.1
South St.	19.61	289.0	283.3	287.7 293.1	285.4 291.3	287.2 292.3	286.9 292.6	282.1 284.3
Fredonia	19.8	307.4	304.2	309.3 317.6	306.5 312.9	306.3 314.0	306.7 314.6	301.6 302.8

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary B - (Exhibit G - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
Banita	16.0	--	--	269.0	268.4	269.0	269.4	265.7
Pk. Lot	16.1	266.4	--	269.1 271.5	268.5 269.4	269.1 270.1	269.5 270.7	267.4 269.1
Fredonia	16.2	271.9	276.4	274.9 280.6	273.5 276.9	273.9 277.7	274.1 278.3	269.4 269.4
SPRR	16.3	276.4	--	280.7 281.2	277.0 277.4	277.8 278.3	278.4 278.9	274.0 274.3
South	16.4	281.7	285.3	283.5 285.7	279.8 281.1	280.7 282.3	281.6 283.3	278.6 279.0
Virginia	16.41	281.7	285.3	285.9 290.7	283.7 286.7	284.1 287.5	284.3 287.9	279.2 280.4
Sunset	16.5	295.1	295.1	298.6 300.8	296.8 297.3	297.1 297.8	297.8 298.6	293.0 293.0
Burk	16.6	298.8	--	301.8 306.4	300.6 302.2	301.0 303.0	301.2 303.5	297.0 298.0
Durst	16.7	332.6	--	335.1 340.4	332.9 335.7	333.3 336.4	333.6 336.9	330.4 332.3
Perry	16.8	349.0	--	351.9 355.5	349.3 351.3	349.9 352.1	350.0 352.5	347.3 349.3

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary C - (Exhibit H - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
Banita	14.0	--	--	292.3	291.6	292.0	292.4	289.6
SPRR	14.1	293.7	295.3	295.0 299.2	295.9 296.1	294.5 297.1	294.7 297.8	292.9 294.0
Old Tyler Hwy.	14.2	296.7	299.0	300.2 305.9	298.2 302.0	298.9 303.1	299.4 304.1	294.5 295.3
--	14.23	--	306.3	306.6	304.1	304.4	304.9	305.9
Dam	14.26	--	327.7	330.1	328.8	329.2	329.5	329.5
--	14.3	--	337.7	339.8	339.1	339.3	339.5	339.5
--	14.33	--	351.5	350.8	349.8	350.1	350.3	350.3
--	14.4	--	--	384.6	384.3	384.5	384.6	384.6

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary D - (Exhibit I - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
Univ. Dr.	9.0	288.3	288.9	287.2 293.2	286.1 292.6	287.7 294.1	287.7 294.1	283.6 283.7
FM 1411	9.1	298.5	295.9	296.2 300.2	296.8 300.7	296.1 301.6	296.1 301.6	292.8 295.1
FM 1878	9.2	305.8	304.6	308.2 312.1	308.7 313.5	309.2 314.8	309.2 314.8	303.6 304.2
--	9.21	--	326.1	315.5	315.4	316.1	316.1	316.2
--	9.22	--	335	333.8	333.9	333.4	333.4	333.4
Loop 224	9.5	392.8	--	391.2 393.6	388.3 389.3	389.0 389.6	389.0 389.6	389.0 389.6

Tributary D-1 - (Exhibit J - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
FM 1878	9.2	305.8	304.6	312.1	313.5	314.8	314.8	304.2
Loop 224	9.7	390.1	--	386.7 390.3	386.7 394.7	386.6 395.6	386.6 395.6	384.8 388.4

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary D-2 - (Ehxibit K - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
FM 1878	9.3	330.3	326.1	330.4 335.8	330.4 335.8	330.7 336.5	330.7 336.5	328.9 330.1
Briar Grove	9.4	333.0	--	335.7 339.2	335.7 339.2	336.4 339.9	336.4 339.9	330.4 332.4
Tudor	9.8	391.0	--	383.3 393.6	383.3 393.6	385.2 396.4	385.2 396.4	381.8 389.6

Tributary E - (Exhibit L - Appendix D)

Location	Cross - Section	A	B	C	D	E	F
LaNana	7.0	--	--	312.5	313.2	313.2	313.5
Loveless Rd.	7.1	--	--	352.7	352.6	352.6	351.1
--	7.4	--	--	437.2	437.4	437.4	437.4

Tributary F - (Exhibit M - Appendix D)

Location	Cross - Section	A	B	C	D	E	F
LaNana	6.9	--	--	346.8	347.6	347.6	347.4
--	5.1	--	--	348.0	348.3	348.3	348.3
--	5.2	--	--	370.7	371.2	371.2	371.2
--	5.5	--	_	398.0	398.4	398.4	398.4

TABLE III - WATER SURFACE ELEVATIONS (Cont.)

Tributary G - (Exhibit N - Appendix D)

Location	Cross - Section	Top of Crossing	A	B	C	D	E	F
Banita	12.1	--	--	--	338.5	338.9	339.2	337.2
Stallings	12.3	380.3	--	--	378.5 377.0	375.2 378.9	376.2 380.9	371.2 377.9

CITY OF NACOGDOCHES
FLOOD CONTROL STUDY
TABLE IV - ESTIMATED CONSTRUCTION COST OF PROPOSED IMPROVEMENTS

I. PROPOSED RESERVOIR IMPROVEMENTS

			Estimated Construction Cost
A.	LaNana Reservoir #1	=	$1,600,000.00
B.	LaNana Reservoir #2	=	$1,630,000.00
C.	Banita Reservoir #3	=	$1,300,000.00
D.	Banita Reservoir #4	=	$1,870,000.00
	RESERVOIR SUB-TOTAL	=	$6,400,000.00

II. PROPOSED CHANNEL CROSSING IMPROVEMENTS

A. LaNana Creek

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Loop 224 (South) 22,570 CFS	Bridge	Deepen Channel 3'± 60' Bottom @ 5:1(H:V) sideslopes Concrete Lining 350' Downstream 175' Upstream Through crossing	$ 503,300.00
2.	Butt St. 14,080 CFS	Bridge	Extend Bridge 20' Deepen Channel 3'± 40' Bottom @ 3:1 sideslopes Concrete Lining 340' Downstream 170' Upstream Through Crossing	$ 364,600.00
3.	Main St. 13,300 CFS	Bridge	Deepen Channel 2' ± 45' Bottom @ 3.25:1 sideslopes Concrete Lining 370' Downstream 185' Upstream Through Crossing	$ 321,400.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
4.	Park St. 13,000 CFS	Bridge	Deepen Channel 1' ± 40' Bottom @ 3:1 sideslopes Concrete Lining 340' Downstream 170' Upstream Through Crossing	$ 229,700.00
5.	Martinsville Road 12,900 CFS	Bridge	Deepen Channel 0.5' ± 35' Bottom @ 3:1 sideslopes Concrete Lining 380' Downstream 190' Upstream Through Crossing	$ 249,900.00
6.	Starr St. 12,800 CFS	Bridge	Deepen Channel 3' ± 50' Bottom @ 3:1 sideslopes 45' Bottom @ 3:1 sideslopes at limits of concrete lining Concrete Lining 500' Downstream 250' Upstream Through Crossing	$ 426,400.00
7.	College St. 12,700 CFS	Bridge	25' Bottom @ 3:1 sideslopes 40' Bottom 3:1 sideslopes at limits of concrete lining Concrete Lining 350' Downstream 175' Upstream Through Crossing	$ 246,400.00
8.	Austin St. 12,210 CFS	Bridge	Deepen Channel 3' ± 40' Bottom @ 3:1 sideslopes Concrete Lining 360' Downstream 90' Upstream Through Crossing	$ 424,100.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
9.	Loop 224 (North) 13,100 CFS	Bridge	Extend Bridge 80' Deepen Channel 4' ± 80' Bottom @ 4:1 sideslopes Concrete Lining 360' Downstream 180' Upstream Through Crossing	$ 750,500.00

LaNana Creek SUB-TOTAL = $ 2,042,500.00

B. BANITA

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
1.	Butt St. 7,490 CFS	Bridge	Deepen Channel 1' ± 60' Bottom @ 2.4:1 sideslopes Concrete Lining 280' Downstream 250' Upstream Through Crossing	$ 215,900.00
2.	SPRR 7,490 CFS	Trestle	40' Bottom @ 2:1 sideslopes within limits of crossing	$ 16,800.00
3.	Church St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 270' Downstream 135' Upstream Through Crossing	$ 182,300.00
4.	Fredonia St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 230' Downstream 85' Upstream Through Crossing	$ 134,800.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
5.	Pecan St. 7,490 CFS	Bridge	Deepen Channel 1.5' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 155' Downstream 100' Upstream Through Crossing	$ 140,400.00
6.	North St. 7,490 CFS	Bridge	Deepen Channel 2.0' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 235' Downstream 130' Upstream Through Crossing	$ 169,100.00
7.	Pilar St. 7,490 CFS	Bridge	Extend Bridge 20' Deepen Channel 3' ± 50' Bottom @ 2:1 sideslopes at crossing 45' Bottom @2:1 sideslopes at down /upstream limits of concrete lining Concrete Lining 40' Downstream 160' Upstream Through Crossing	$ 194,500.00
8.	Main St. 7,290 CFS	Bridge	Extend Bridge 10' Deepen Channel 4' ± 50' Bottom @ 2:1 sideslopes at crossing 40' Bottom @ 2:1 sideslopes at down/upstream limits of concrete lining Concrete Lining 60' Downstream 220' Upstream Through Crossing	$ 212,000.00
9.	Powers St. 6,990 CFS	Bridge	Deepen Channel 3' ± 40' Bottom @ 2:1 sideslopes Concrete Lining 260' Downstream 140' Upstream Through Crossing	$ 190,100.00

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
10.	SPRR 5,990 CFS	Trestel	Deepen Channel 4' ± 30' Bottom @ 2.25:1 sideslopes Extend Channel section 240' downstream & 60' upstream	$ 19,600.00
11.	Loop 224 (North) 5,700 CFS	Bridge	Widen Channel to 30' Bottom @ 2:1 sideslopes Extend Channel section 200' downstream & 200' upstream	$ 49,000.00

BANITA CREEK SUB-TOTAL = $ 1,524,500.00

C. EGGNOG BRANCH

Location & Flow Rate		Existing	Proposed	Estimated Construction Cost
1.	FM #1275 3,720 CFS	2-7 ' x 6' Box Culverts	Replace Box culverts with 80'x40' bridge Deepen Channel 3' ± 30' Bottom @ 3:1 sideslopes Concrete Lining 30' Downstream 15' Upstream Through Crossing	$ 377,700.00
2.	Loop 224 (South) 2,730 CFS	2-6 ' x 10' Box Culverts	Add 2-6'x10' Box culverts Widen to 40' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 100' Upstream	$ 434,000.00
3.	FM #2259 2,070 CFS	1-8 ' x 8' Box Culvert	Replace Box culvert with 60' x 40' bridge Depen Channel 2' ± Widen channel to 16' Bottom @ 2:1 sideslopes Concrete Lining 30' Downstream 15' Upstream Through Crossing	$ 274,400.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
4.	Eastwood Terrace 2,070 CFS	54" Dia. RCP	Replace culvert with 50' x 40' bridge Deepen Channel 3' ± 16' Bottom @ 2:1 sideslopes Concrete Lining 30' Downstream 100' Upstream Through Crossing	$ 240,800.00
5.	Hwy. 21 880 CFS	1-5' x 11' Box Culvert	Add 1-5' x 11' Box Culvert Widen channel to 22' Bottom & 1:1 sideslopes Concrete Lining 40' Downstream 100' Upstream	$ 179,200.00

EGGNOG BRANCH SUB-TOTAL = $ 1,506,100.00

D. TRIBUTARY A

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	SPRR 3,240 CFS	Trestle	Extend Trestle 35' Deepen Channel 5' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 80' Upstream Through Crossing	$ 133,600.00
2.	Press Rd. 3,240 CFS	Bridge	New 60' x 32' Bridge Deepen Channel 5' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 70' Downstream 35' Upstream Through Crossing	$ 251,300.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
3.	Park Entrance 2,660 CFS	Bridge	New 62' x 25' Bridge Deepen Channel 3' ± 20' Bottom @ 1.5:1 sideslopes Extend channel section 70' Downstream & 35' upstream	$ 174,300.00
4.	South St. 2,390 CFS	2-7' x 7' & 2-9' x 9' Box culverts	Replace 2-7' x 7' Box culverts with 3-9' x 9' Box culverts Add 1-9' x 9' box culvert Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes Extend channel section 80' downstream & 130' Upstream	$ 627,600.00
5.	S. Fredonia St. 1,750 CFS	2-5' x 6' Box Culverts	Replace 2-5' x 6' Box culverts with 3-9' x 9' Box culverts Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes at crossing 10' Bottom @ 1:1 sideslopes at limits of channel of extension Extend channel section 50' downstream & 100' upstream	$ 440,300.00

TRIBUTARY A SUB-TOTAL = $ 1,627,100.00

E. TRIBUTARY B

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Parking Lot Drive 2,070 CFS	Bridge	New 66' x 24' Bridge Deepen Channel 5' ± 15' Bottom @ 2:1 sideslopes at crossing Extend channel section 930' upstream to 10' Bottom @ 2:1 sideslopes Concrete lining through crossing	$ 296,400.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
2.	S. Fredonia St. 1,980 CFS	Bridge	New 62' x 56' Bridge Deepen Channel 5' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 50' Downstream 40' Upstream Through Crossing	$ 405,200.00
3.	South St. 1,880 CFS	Bridge	New 50' x 42' Bridge Deepen Channel 1' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 90' Downstream 45' Upstream Through Crossing	$ 248,400.00
4.	Virginia Ave. 1,880 CFS	1-5' x 11' Box culvert	New 45' x 42' Bridge Deepen Channel 2' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 140' Downstream 45' Upstream Through Crossing	$ 261,200.00
5.	Sunset Ave. 1,570 CFS	Bridge	New 50' x 32' Bridge Deepen Channel 1' ± 15' Bottom @ 2:1 sideslopes Concrete Lining 90' Downstream 45' Upstream Through Crossing	$ 209,200.00
6.	Burk St. 1,570 CFS	Bridge	New 37' x 36' Bridge Deepen Channel 1' ± 15' Bottom @ 1.5:1 sideslopes at crossing 15' Bottom @ 2:1 sideslopes at limits of concrete lining Concrete Lining 70' Downstream 35' Upstream Through Crossing	$ 154,000.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
7.	Durst St. 1,020 CFS	1-4' x 12' Box culvert	Replace 1-4' x 12' Box Culvert with 22' x 34' Bridge Deepen Channel 3' ± 12' Bottom @ 1:1 sideslopes	$ 84,300.00
8.	Perry Dr. 710 CFS	1-3' x 12' Box culvert	Replace 1-3' x 12' Box Culvert with 1-6' x 12' Box culvert Deepen Channel 3' ± 12' Bottom @ 1:1 sideslopes Concrete Lining 50' Downstream 25' Upstream	$ 97,700.00

TRIBUTARY B SUB-TOTAL = $ 1,756,400.00

F. TRIBUTARY C (Mill Pond)

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	SPRR 2,410 CFS	Trestle	Extend Trestle 30' Deepen Channel 1' ± 25' Bottom @ 3:1 sideslopes Extend channel section 100' downstream & 50' upstream	$ 70,000.00
2.	Old Tyler* Road 2,340 CFS	2-60" Dia. R.C.P.	Replace 2-60" RCP with new 70' x 40' Bridge Deepen Channel 3' ± 25' Bottom @ 3:1 sideslopes Concrete Lining 100' Downstream 200' Upstream Through Crossing	$ 435,300.00

TRIBUTARY C SUB-TOTAL = $ 505,300.00

*(See Note - Pg. 55)

G. TRIBUTARY D, D-1, & D-2

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	University Dr. (D) 4,400 CFS	2-Box Culverts	New 45' x 50' Bridge Deepen Channel 2' ± 20' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 150' Upstream Through Crossing	$ 312,100.00
2.	FM #1411 (D) 4,200 CFS	2-9' x 11' Box culvert	Replace 2-9' x 11' Box culverts with new 60' x 40' Bridge Widen channel to 25' Bottom @ 2:1 sideslopes Concrete Lining 80' Downstream 110' Upstream Through Crossing	$ 297,800.00
3.	FM #1878 (D) 3,940 CFS	1-7' x 16' Box culvert	Replace 1-7' x 16' Box Culvert with new 80' x 40' Bridge Deepen Channel 3' ± 30' Bottom @ 2.5:1 sideslopes Concrete Lining 60' Downstream 330' Upstream Through Crossing	$ 439,500.00
4.	Loop 224 (D-1) 260 CFS	1-36" Dia. R.C.P.	Replace 1-36" R.C.P. with 2-60" DIA. R.C.P. Deepen Channel 2' ± 10' Bottom @ 0.5:1 sideslopes Concrete Lining 50' Downstream 50' Upstream	$ 64,100.00

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
5.	FM #1878 (D-2) 880 CFS	2-36" Dia. R.C.P.	Replace 2-36" R.C.P. with 2-7' x 7' Box Culverts Deepen Channel 4' ± 14' Bottom @ 1:1 sideslopes at crossing 10' Bottom @ 1:1 sideslopes at limits of concrete lining Concrete Lining 200' Downstream 65' Upstream	$ 165,300.00
6.	Briargrove Dr. (D-2) 880 CFS	1-36" Dia. R.C.P.	Replace 1-36" R.C.P. with 2-6' x 7' Box culverts Deepen Channel 5' ± 14' Bottom @ 1:1 sideslopes at crossing 10' Bottom @ 1:1 sideslopes at limits of channel extension Extend channel section 100' Downstream & 200' Upstream	$ 119,700.00
7.	Tudor Dr. (D-2) 550 CFS	1-36" Dia. R.C.P.	Replace 1-36" R.C.P. with 2-6' x 6' Box culverts Deepen Channel 1' ± 12' Bottom @ 1:1 sideslopes at crossing 10' Bottom @ 1:1 sideslopes at limits of concrete lining Concrete Lining 100' Downstream 100' Upstream	$ 123,500.00
	TRIBUTARY D SUB-TOTAL		**=**	**$ 1,522,000.00**

H. TRIBUTARY G

	Location & Flow Rate	Existing	Proposed	Estimated Construction Cost
1.	Stallings Dr. 1,810 CFS	Bridge	Extend Bridge 10' Widen channel to 16' Bottom @ 1.5:1 sideslopes at crossing 10' Bottom @ 1.5:1 sideslopoes at limits of concret lining Concrete Lining 140' Downstream 50' Upstream Through Crossing	$ 83,600.00
	TRIBUTARY G SUB-TOTAL		=	**$ 83,600.00**

CHANNEL CROSSINGS IMPROVEMENTS SUB-TOTAL $ 10,567,500.00

III. PROPOSED CHANNEL IMPROVEMENTS

	Location & Flow Rate	Proposed	Estimated Construction Cost
A.	LANANA		
1.	Loop 224 (South) to Butt St. 14,080 - 22,570 CFS	Deepen channel 3' ± 60' Bottom @ 5:1 sideslopes Upstream of Loop 224 40' Bottom @ 3:1 sideslopes Downstream of Butt St.	$ 753,200.00
2.	Butt St. to Main St. 13,300 - 14,080 CFS	Deepen channel 2'-3' ± 40' Bottom @ 3:1 sideslopes at Butt St. to Natural Channel 200' Upstream 45' Bottom @ 3.25:1 sideslopes from Natural Channel 1000' Downstream to Main St.	$ 122,500.00
3.	Main St. to Park St. 13,000 - 13,300 CFS	Deepen channel 1'-2' ± 45' Bottom @ 3.25:1 sideslopes Upstream of Main St. 40' Bottom @ 3:1 sideslopes Downstream of Park St.	$ 207,400.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
4.	Park St. to Martinsville Rd. 12,900 - 13,000 CFS	Deepen channel 0.5'-1' ± c 4E40' @ottom 3:1 sideslopes Upstream of Park St. 35' @ottom 3:1 sideslopes Downstream of Martinsville Rd.	$ 50,800.00
5.	Martinsville Rd. to Starr St. 12,800 - 12,900 CFS	Deepen channel 0.5'-3' ± 35' @ottom 3:1 sideslopes Upstream of Martinsville Rd. 45' @ottom 3:1 sideslopes Downstream of Starr	$ 200,400.00
6.	Starr to College St. 12,700 - 12,800 CFS	Deepen channel 0-3' ± 45' @ottom 3:1 sideslopes 500' Upstream of Starr 40' @ottom 3:1 sideslopes 1000' Downstream of College	$ 154,000.00
7.	College St. to Austin St. 12,210 - 12,700 CFS	Deepen channel 0-3' ± 40' @ottom 3:1 sideslopes at Austin from Natural Channel 2900' Upstream of College	$ 168,000.00
8.	Austin St. to Loop 224 (North) 13,100 - 12,210 CFS	40' @ottom 3:1 sideslopes & Deepen 3' ± at Austin to Natural Channel 90' Upstream 80' @ottom 4:1 sideslopes & Deepen 3' ± at Loop 224 to Natural Channel 2300' Downstream	$ 216,300.00
9.	Upstream of Loop 224 (North) 13,100 CFS	80' @ottom 4:1 sideslopes & Deepen 4' ± at Loop 224 to Natural Channel 290' Upstream	$ 42,000.00
	LaNana Creek SUB-TOTAL	=	**$ 1,914,600.00**

B. BANITA CREEK

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	LaNana Creek to Butt St. 7,490 - 7,600 CFS	60' Bottom @ 2.4:1 sideslopes & Deepen Channel 1' ± from Butt St. to Natural Channel 1550' Downstream	$ 72,800.00
2.	Butt St. to SPRR 7,490 CFS	60' Bottom @ 2.4:1 sideslopes & Deepen channel 1' ± Upstream of Butt St. 40' Bottom @ 2:1 sideslopes Downstream of SPRR	$ 21,000.00
3.	SPRR to Church St. 7,490 CFS	Deepen channel 0-1.5' ± 40' Bottom @ 2:1 sideslopes	$ 30,800.00
4.	Church St. to Fredonia St. 7,490 CFS	Deepen channel 1.5' ± 40' Bottom @ 2:1 sideslopes	$ 12,600.00
5.	South St. to Pilar St. 7,490 CFS	Deepen channel 3' ± 40' Bottom @ 2:1 sideslopes Upstream of North 50' Bottom @ 2:1 sideslopes Downstream of Pilar	$ 75,600.00
6.	Main St. to Powers St. 6,990 - 7,290 CFS	Deepen channel 3' ± 45' Bottom @ 2:1 sideslopes	$ 114,800.00
7.	Powers St. to SPRR 5,990 - 6,990 CFS	Deepen channel 3' ± 40' Bottom @ 2:1 sideslopes Upstream of Powers 30' Bottom @ 2.25:1 sideslopes Downstream of SPRR	$ 965,300.00
	BANITA CREEK SUB-TOTAL	**=**	**$ 1,292,900.00**

C. EGGNOG BRANCH

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	LaNana Creek to FM #1275 3,720 - 4,020 CFS	Deepen channel 0'-2' ± 30' Bottom @ 3:1 sideslopes from FM #1275 to Natural Channel 1300' Downstream	$ 113,400.00
2.	FM #1275 to Loop 224 2,730 - 3,720 CFS	40' Bottom @ 2:1 sideslopes from Loop 224 to Natural Channel 200' Downstream	$ 16,800.00
3.	Loop 224 to FM #2259 2,070 - 2,730 CFS	Deepen Channel 0-2' ± 20' Bottom @2:1 sideslopes	$ 93,800.00
4.	FM #2259 to Eastwood Terrace 2,070 CFS	Deepen Channel 2' ± 16' Bottom @ 2:1 sideslopes	$ 18,200.00
5.	Eastwood Terrace to Hwy. #21 880 - 2,070 CFS	16' Bottom @ 1:1 sideslopes from Eastwood Terrace to Natural Channel 1600' Upstream 22' Bottom @ 1:1 sideslopes from Hwy #21 to Natural Channel 1600' Downstream	$ 58,800.00
6.	Upstream of Hwy. #21 880 CFS	22' Bottom @ 1:1 sideslopes from Hwy. #21 to Natural Channel 800' Upstream	$ 16,800.00
	EGGNOG BRANCH SUB-TOTAL	**=**	**$ 317,800.00**

D. TRIBUTARY A

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	LaNana Creek to SPRR 3,240 - 3,370 CFS	Deepen Channel 0-5' ± 20' Bottom @ 2:1 sideslopes from SPRR to Natural Channel 750' Downstream	$ 18,200.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
2.	Press Rd. to Park Entrance 2,660 - 3,240 CFS	Deepen Channel 2'-5' ± 20' Bottom @ 2:1 sideslopes Upstream of Press Rd. 20' Bottom @ 1.5:1 sideslopes Downstream of Park Entrance	$ 228,900.00
3.	Park Entrance to South St. 2,390 - 2,660 CFS	Deepen Channel 2'-3' ± 20' Bottom @ 1.5:1 sideslopes Upstream of Park Entrance 30' Bottom @ 1:1 sideslopes Downstream of North St.	$ 95,900.00
4.	South St. to Fredonia St. 1,750 - 2,390 CFS	Deepen Channel 2' ± 30' Bottom @ 1:1 sideslopes	$ 134,000.00
	TRIBUTARY A SUB-TOTAL	**=**	**$ 477,100.00**

E. TRIBUTARY B

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	Fredonia St. to South St. 1,880 - 1,980 CFS	Deepen Channel 1'-5' ± 15' Bottom @ 2:1 sideslopes	$ 14,000.00
2.	Virginia Ave. to Sunset Ave. 1,570 - 1,880 CFS	Deepen Channel 1'-2' ± 15' Bottom @ 2:1 sideslopes	$ 49,600.00
3.	Sunset Ave. to Burk St. 1,570 CFS	Deepen Channel 1' ± 15' Bottom @ 1.5:1 sideslopes	$ 15,400.00
4.	Burk St. to Durst St. 1,020 - 1,570 CFS	Deepen Channel 1'-3' ± 15' Bottom @ 2:1 sideslopes from Burk to Natural Channel 1600' Upstream 12' Bottom @ 1:1 sideslopes from Durst to Natural Channel 200' Downstream	$ 26,600.00

	Location & Flow Rate	Proposed	Estimated Construction Cost
5.	Durst St. to Perry Dr. 710 - 1,020 CFS	Deepen Channel 0-3' ± 10' Bottom @ 1:1 sideslopes from Durst to Natural Channel 250' Upstream 10' Bottom @ 1:1 sideslopes from Perry to Natural Channel 900' Downstream	$ 14,000.00
	TRIBUTARY B SUB-TOTAL	**=**	**$ 119,600.00**

F. TRIBUTARY C

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	Banita Creek to SPRR 2,410 CFS	Deepen Channel 0-1' ± 25' Bottom @ 3:1 sideslopes From SPRR to 20' Bottom @ 3:1 sideslope 300' Downstream	$ 4,000.00
2.	SPRR to Old Tyler Rd. 2,340 - 2,410 CFS	Deepen Channel 1'-3' ± 25' Bottom @ 3:1 sideslopes	$ 35,700.00
3.	Upstream of Old Tyler Rd. 2,340 CFS	Deepen Channel 0-3' ± 15' Bottom @ 3:1 sideslopes Extend Channel Section 200' Upstream	$ 14,000.00
	TRIBUTARY C SUB-TOTAL	**=**	**$ 53,700.00**

G. **TRIBUTARY D, D-1, & D-2**

	Location & Flow Rate	Proposed	Estimated Construction Cost
1.	University Dr. to FM #1411 (D) 4,200 - 4,400 CFS	Deepen Channel 0-2' ± 20' Bottom @ 2:1 sideslopes from University Dr. to Natural Channel 700' Upstream 25' Bottom @ 2:1 sideslopes from FM #1411 to Natural Channel 300' Downstream	$ 19,600.00
2.	FM #1411 to FM #1878 (D) 3,940 - 4,200 CFS	Deepen Channel 0-3' ± 25' Bottom @ 2.5:1 sideslopes from FM #1411 to Natural Channel 900' Upstream 25' Bottom @ 2.5:1 sideslopes from FM #1878 to Natural Channel 900' Downstream	$ 117,600.00
3.	FM #1878 to Briargrove Dr. (D-1) 880 CFS	Deepen Channel 4' ± 10' Bottom @ 1:1 sideslopes	$ 4,200.00
4.	Briargrove Dr. to Tudor Dr. (D-2) 550 - 880 CFS	Deepen Channel 0'-6' ± 10' Bottom @ 1:1 sideslopes from Briargrove to 5' Bottom @ 1:1 sideslopes 800' Upstream	$ 13,300.00
	TRIBUTARY D SUB-TOTAL	**=**	**$ 154,700.00**
	CHANNEL IMPROVEMENTS SUB-TOTAL	**=**	**$ 4,330,400.00**

IV. OTHER CROSSING IMPROVEMENTS

	Location	Existing	Proposed	Estimated Construction Cost
1.	Baywood Dr. @ LaNana Trib.	2-36" DIA. R.C.P.	3-42" DIA, R.C.P.	$ 83,100.00
2.	Chevy Chase LaNana Trib.	2-36" DIA. R.C.P.	3-42" DIA. R.C.P.	$ 83,100.00
3.	Old Lufkin Rd. @ LaNana Trib.	3-30" DIA. R.C.P.	3-42" DIA. R.C.P.	$ 49,000.00
4.	Chalon @ LaNana Trib.	1-36" DIA. R.C.P.	3-48" DIA. R.C.P.	$ 148,800.00
5.	Ila @ LaNana Trib.	1-18" DIA. R.C.P.	1-36" DIA. R.C.P.	$ 22,400.00
	OTHER CROSSING IMPROVEMENT SUB-TOTALS			**$ 386,400.00**

NOTE: At least one listed project, (Item F.2, Pg. 45, Old Tyler Road @ Tributary C) and possibly others, are being considered for improvements by either the state highway department or County. Coordination of these efforts during future planning or design should result in cost savings for all entities involved.

TABLE V - CONSTRUCTION COST SUMMARY OF PROPOSED IMPROVEMENTS

				Estimated Cost
I.	RESERVOIRS		$	6,400,000.00
II.	MAJOR CHANNEL CROSSINGS		$	10,567,500.00
III.	CHANNEL IMPROVEMENTS		$	4,330,400.00
IV.	OTHER CHANNEL CROSSINGS		$	386,400.00
V.	INTERNAL STORM SEWER		$	2,000,000.00
	TOTAL ESTIMATED CONSTRUCTION COST	=	**$**	**23,684,300.00**

APPENDIX A

RUN-OFF & FLOW COEFFICIENTS

Runoff Coefficients

Description of Area		Coefficient
Business	Central Business	0.70 - 0.95
	District and Local	0.50 - 0.70
Residential	Single Family	0.35 - 0.45
	Multi-units	0.40 - 0.75
	½ acre lots or larger	0.25 - 0.40
Industrial:	Light	0.50 - 0.80
	Heavy	0.60 - 0.90
	Parks, cemeteries	0.10 - 0.25
	Playgrounds	0.20 - 0.35
	Railroad yards	0.20 - 0.40
	Unimproved	0.10 - 0.30

For Impervious Surfaces

Description of Surface	Coefficient
Asphalt	0.70 - 0.95
Concrete	0.80 - 0.95
Roofs	0.75 - 0.95

For Pervious Surfaces

Slope	SCS Soils			
	A	B	C	D
Flat (0-2%)	0.04	0.07	0.11	0.15
Average (2-6%)	0.09	0.12	0.16	0.20
Steep (Over 6%)	0.13	0.18	0.23	0.28

Manning's Roughness Coefficients for Sheet Flow

Surface	Manning's N Value
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Brick with cement mortar	0.014
Cast iron	0.015
Corrugated metal pipes	0.023
Cement rubble surface	0.024
Short grass	0.015
Dense grass	0.024
Bermuda grass	0.041
Light underbrush woods	0.40
Dense underbrush woods	0.80
Rangeland	0.13

SOURCE: *Hydraulic Analysis and Design,* Richard H. McCuen, 1989.

Manning's Coefficient for Channel Flow, continued

Description of Area			Manning's n Range
Roadside channels and swales with maintained vegetation (Values shown are for velocities of 2 and 6 ft/sec)			
Depth of flow up to 0.7 ft	Bermuda grass, Kentucky bludgrass, buffalo grass	Mowed to 2 in.	0.045 - 0.070
		Length 4 to 6 in.	0.050 - 0.090
	Good stand, any grass	Length about 12 in.	0.090 - 0.180
		Length about 24 in.	0.150 - 0.300
	Fair stand, any grass	Length about 12 in.	0.080 - 0.140
		Length about 24 in.	0.130 - 0.250
Depth of flow 0.7 - 1.5 ft	Bermuda grass, Kentucky bluegrass, buffalo grass	Mowed to 2 in.	0.035 - 0.050
		Length 4 to 6 in.	0.040 - 0.060
	Good stand, any grass	Length about 12 in.	0.070 - 0.120
		Length about 24 in.	0.100 - 0.200
	Fair stand, any grass	Length about 12 in.	0.060 -,0.100
		Length about 24 in.	0.090 - 0.170

Manning's Coefficient for Channel Flow, continued

Description of Area			Manning's n Range
Natural Stream Channels			
Minor Streams (surface width at flood stage less than 100 ft)	Fairly regular section	Some grass and weeds, little or no brush	0.030 - 0.035
		Dense growth of weeds, depth of flow materially greater than weed height	0.035 - 0.050
		Some weeds, light brush on banks	0.040 - 0.050
		Some weeds, heavy brush on banks	0.050 - 0.070
		some weeds, dense willows on banks	0.060 - 0.080
	For trees within channel, with branches submerged at high stage, increase all above values by:		0.010 - 0.020
	Irregular section, with pools, slight meander, increase value for fairly regular sections by about:		0.010 - 0.020
	Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage	Bottom of gravel, cobbles and few boulders	0.040 - 0.050
		Bottom of cobbles, with large boulders	0.05 - 0.07

SOURCE: *Hydraulic Analysis and Design,* Richard H. McCuen, 1989

K Coefficient for Shallow Flow

Land Use	K
Forest with heavy ground litter, hay meadow	0.25
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland	0.50
Short grass pasture (outland flow)	0.70
Cultivated straight row (outland flow)	0.90
Nearly bare and untilled (overland flow)	1.00
Grassed waterway	1.50
Unpaved Area	1.60
Paved area (sheet flow); small upland gullies	2.00

SOURCE: *Hydraulic Analysis and Design,* Richard H. McCuen, 1989

Constants for Inlet Control Design Equations

Chart Number	Shape and Material	Nomograph Scale	Inlet Edge Description	Equation Form
1	Circular	1	Square edge w/headwall	1
	Concrete	2	Groove end w/headwall	
		3	Groove end projecting	
2	Circular	1	Headwall	1
	CMP	2	Mitered to slope	
		3	Projecting	

3	Circular	A	Beveled ring, 45° bevels	1
		B	Beveled ring, 33.7° bevels	
8	Rectangular	1	30° to 75° wingwall flares	
	Box	2	90° and 15° wingwall flares	1
		3	0° wingwall flares	
9	Rectangular	1	90° headwall w/¾" camfers	2
	Box	2	18° to 33.7° wingwall flare, d = .083D	
10	Rectangular	1	90° headwall w/¾" camfers	2
	Box	2	90° headwall w/45° bevels	
		3	90° headwall w/33.7° bevels	

Constants for Inlet Control Design, continued

Chart Number	Unsubmerged		Submerged	
	K	M	c	Y
11	.522	0.667	.0402	0.73
	.533	0.667	.0425	0.705
	.545	0.667	.04505	[0.68]
	.498	0.667	.0327	0.75
12	.497	0.667	.0339	0.803
	0.493	0.667	0.0361	0.806
	0.495	0.667	0.0386	0.71
13	0.497	0.667	0.0302	0835
	0.495	0.667	0.0252	0.881
	0.493	0.667	0.0227	0.887
16-19	0.0083	2.0	0.0379	0.69
	0.0145	1.75	0.0419	0.64
	0.0340	1.5	0.0496	0.57

SOURCE: *Hydraulic Design of Highway Culverts, Hydraulic Design Series, No. 5.* U.S. Department of Transpiration, 1985.

NOTE: The chart and equation form or scale, refer to a series of nomographs developed by The Federal Highway Administration and included in the above publication. The software utilized on this project has the equations included in the program such that the only input required is the chart and equation form numbers that best describe the inlet condition.

Roughness Coefficients (Manning's n Values) for Selected Conduits

Surface	Manning's n Value
Reinforced concrete pipe	0.013
Reinforced concrete box	0.013
Vitrified clay pipe	0.013
Coated cast iron pipe	0.011
Uncoated cast iron pipe	0.012
Commercial wrought-iron, black pipe	0.013
Commercial wrought-iron, galvanized pipe	0.014
Smooth lockbar and welded "OD" pipe	0.011
Riveted and spiral steel	0.015
Corrugated metal pipe	0.0225
Corrugated aluminum pipe	0.0225
Corrugated metal pipe (paved invert)	0.020
Corrugated metal multi-plate pipe	0.035
Polyvinyl chloride (PVC) pipe	0.010

Entrance Loss Coefficients k_e

Box Culverts

Type of Structure and Design of Entrance	Coefficient
Headwall Parallel to Embankment (no wingwalls):	--
Square-edged on three edges	0.50
Three edges rounded to radius of ½ barrel dimension	0.20
Wingwalls at 15 to 45 degrees to Barrel:	—
Square-edged top corner	0.40
Top corner rounded to radius of ½ barrel dimension	0.20

Pipe Culverts

Type of Structure and Design of Entrance	Coefficient
Concrete Pipe Projecting from Fill (no headwall):	—
Socket end of pipe	0.20
Square cut end of pipe	0.50
Concrete Pipe with Headwall of Headwall and Wingwalls:	—
Socket end of pipe	0.20
Square cut end of pipe	0.50
Rounded entrance, with rounding radius = ½ of diameter	0.20
Corrugated Metal Pipe:	—
Projecting from fill (no headwall)	0.90
With headwall or headwall and wingwalls, square edge	0.50

SOURCE: *Hydraulic Design of Highway Culverts, Hydraulic Design Series, No. 5.* U.S. Department of Transportation, 1985.

Runoff Curve Numbers (Ave. Watershed Condition)
$I_a = 0.2S$

SCS developed a soil classification system consisting of four groups, identified by the letters A, B, C and D. Soil characteristics associated with each group are:

- **Group A: deep sand, deep loess, aggregated silts**
- **Group B: shallow loess; sandy loam**
- **Group C: clay loams; shallow sandy loams; soils low in organic content; soils**
- **Group D: soils that swell significantly when wet; heavy plactic clays; certain saline soils**

Land Use Description	Average (%) impervious[b]	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Fully developed urban areas[a] (vegetation established) Lawns, open spaces, parks, gold courses, cemeteries, etc. Good condition; grass cover on 75% or more of the area Fair condition; grass cover on 50% to 75% of the area Poor condition; grass cover on 50% or less of the area	—	39 49 68	61 69 71	74 79 86	80 84 89
Paved parking lots, roof, driveways, etc.	—	98	98	98	98
Streets and Roads Paved with curbs and storm sewers Gravel Dirt Paved with open ditches	—	 98 76 72 83	 98 85 82 89	 98 89 87 92	 98 91 89 93
Commercial and business areas	85	89	92	94	95
Industrial districts	72	81	88	91	93

Cover			Curve Numbers for Hydrologic Soil Group			
Land Use	**Treatment of Practice**	**Hydrologic Conditions[d]**	**A**	**B**	**C**	**D**
Residential: average lot size						
¼ acre	38	61	75	83	87	
⅓ acre	30	57	72	81	86	
½ acre	25	54	70	80	85	
1 acre	20	51	68	79	84	
2 acre	12	46	65	77	82	
Developing urban areas[c] (no vegetation established Newly graded area	—	77	86	91	94	
Cultivated agricultural land						
Fallow	Straight row		77	86	91	94
	Conservation tillage	Poor	76	85	90	93
	Conservation tillage	Good	74	83	88	90
Row Crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Conservation tillage	Poor	70	80	87	90
	Conservation tillage	Good	64	75	82	85
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and	Poor	69	78	83	87
	conservation tillage	Good	64	74	81	85
	Contoured and terraces	Poor	66	74	80	82
	Contoured and terraces	Good	62	71	78	81
	Contoured and terraces	Poor	65	737	79	81
	and conservation tillage	Good	61	70	77	80

Cover			Curve Numbers for Hydrologic Soil Group			
Lane Use	**Treatment of Practice**	**Hydrologic Conditions**	**A**	**B**	**C**	**D**
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Conservation tillage	Poor	64	75	83	86
	Conservation tillage	Good	60	72	80	84
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	3	81	84
	Contoured and	Poor	62	73	81	84
	Conservation tillage	Good	60	2	80	83
	Contoured and terraces	Poor	61	72	79	82
	Contoured and terraces	Good	59	70	78	81
	Contoured and terraces	Poor	60	71	78	81
	and conservation tillage	Good	58	69	77	80
Close-seeded legumes or rotation meadow[e]	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraces	Poor	63	73	80	83
	Contoured and terraces	Good	51	67	76	80
noncultivated agricultural land						
Pasture or range	No mechanical treatment	Poor	68	79	86	89
	No mechanical treatment	Fair	49	69	79	84
	No mechanical treatment	Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow	—	—	30	58	71	78
Forestland - grass or orchards-evergreen or deciduous	—	Poor	55	73	82	86
		Fair	44	65	76	82
		Good	32	8	72	79
Brush	—	Poor	48	67	77	83
		Good	20	48	65	73

Cover			Curve Numbers for Hydrologic Soil Group			
Land Use	**Treatment of Practice**	**Hydrologic Conditions**	**A**	**B**	**C**	**D**
Woods	—	Poor Fair Good	45 36 25	66 60 55	77 73 70	83 79 77
Farmsteads	—	—	59	74	82	86
Forest-range Herbaceous	—	Poor Fair Good	—	79 71 61	86 80 74	—
Oak - aspen	—	Poor Fair Good	—	72 58 41	83 73 61	—
Sage - grass	—	Poor Fair Good	—	67 50 35	80 63 46	—

[a]For land uses with impervious areas, curve numbers are computed assuming that 100% of runoff from impervious areas are directly connected to the drainage system. Pervious areas (lawn) are considered to be equivalent to lawns in good condition and the impervious areas have a CN of 98.

[b]Includes paved streets.

[c]Use for the design of temporary measures during grading and construction. Impervious area percent for urban areas under development vary considerably.

[d]For conservation tillage poor hydrologic condition, 5 to 20% of the surface is cov-ered with residue (less than 750-lb/acre row crops or 300-lb/acre small grain).

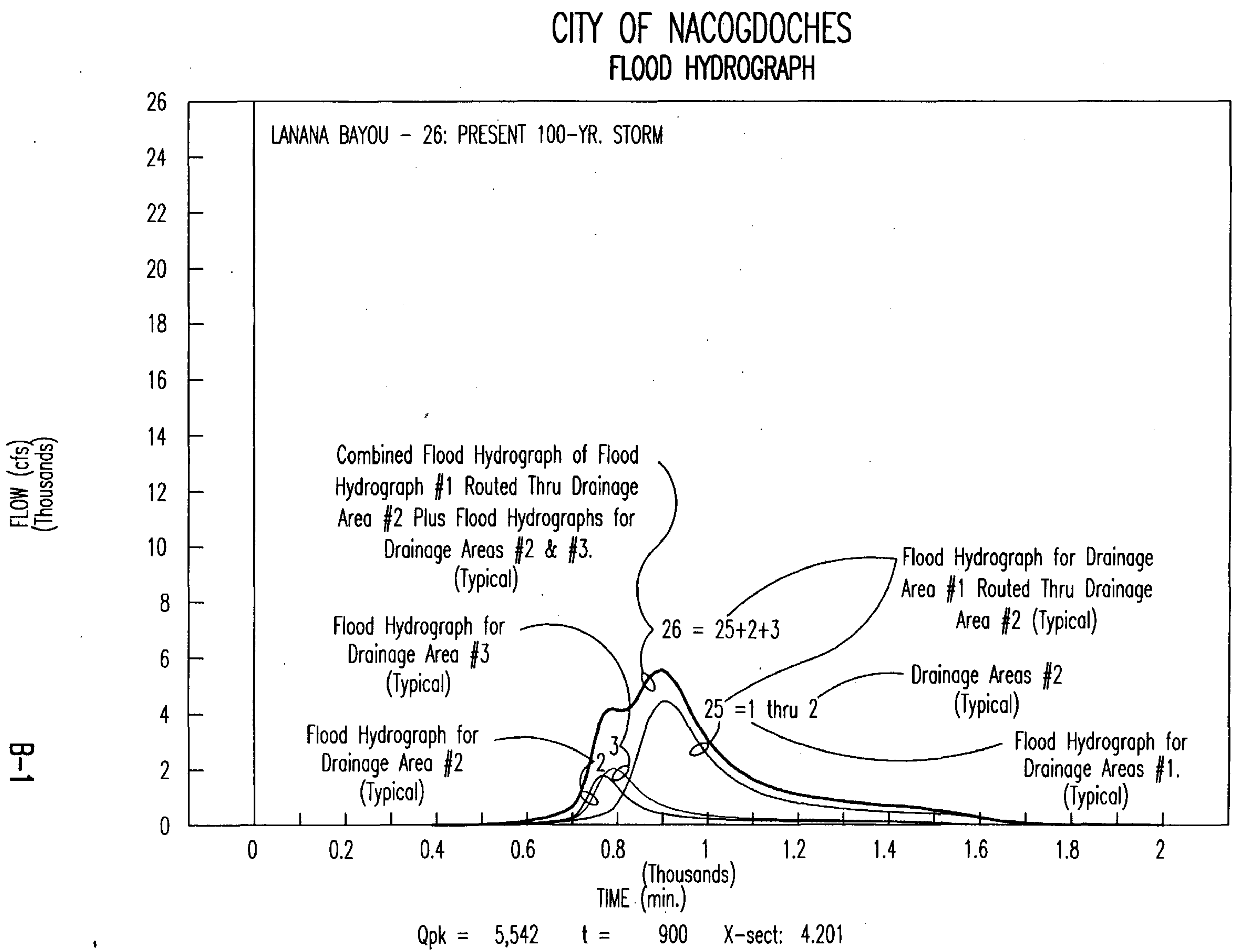
[e]Close-drilled or broadcast.
For noncultivated agricultural land:
Poor hydrologic condition has less than 25% ground cover density.
Fair hydrologic condition has between 25 and 50% ground cover density.

APPENDIX B
FLOOD HYDROGRAPHS
FOR LaNANA CREEK
AND BANITA CREEK

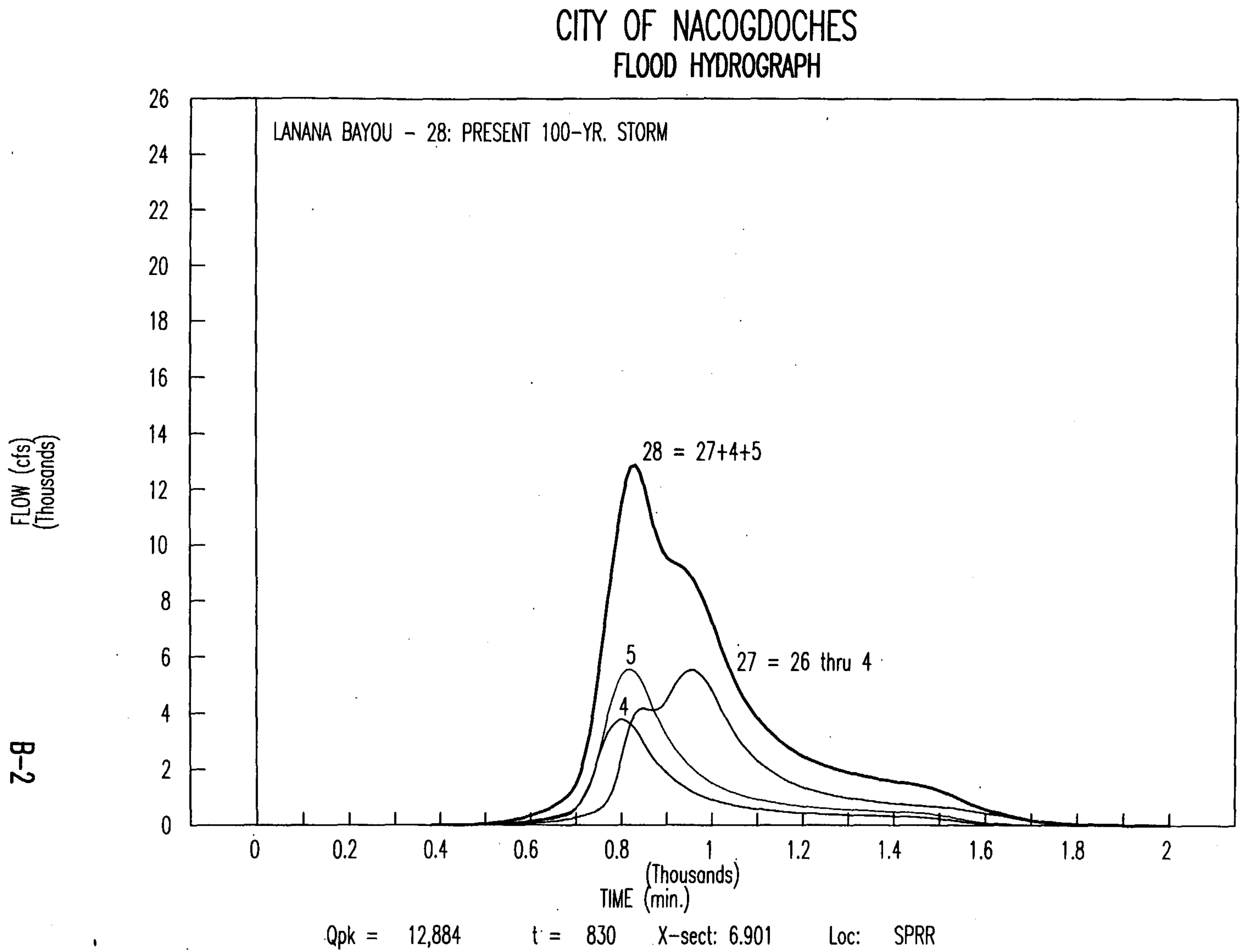
TABLE OF CONTENTS

LEGEND

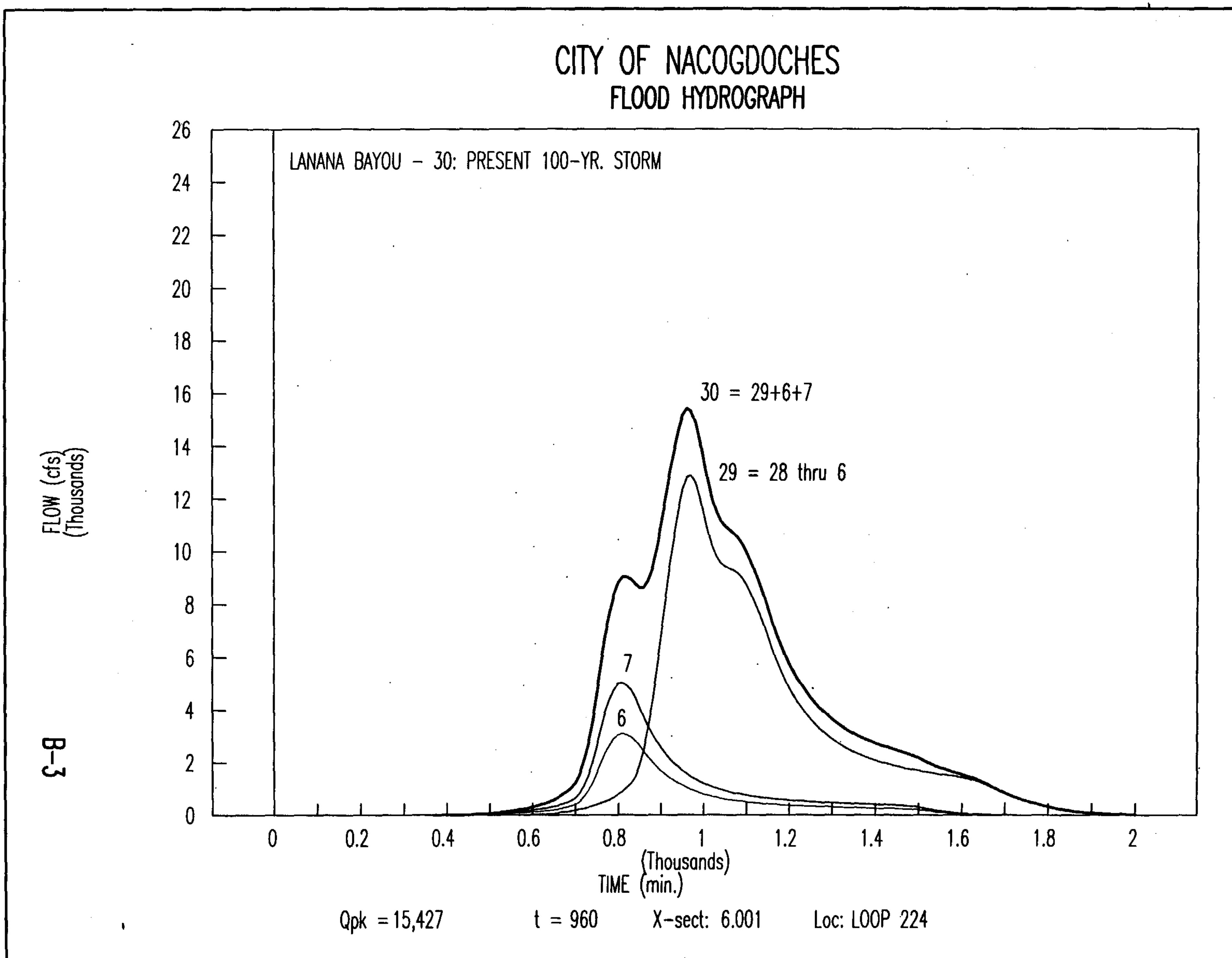
Qpk	=	Peak Flow (CFS)
t	=	Time to Peak Flow (Min.)
X-sect	=	HEC-2 Model Cross-Section Number
Loc.	=	Name of Crossing Structure At HEC-2 Cross Section

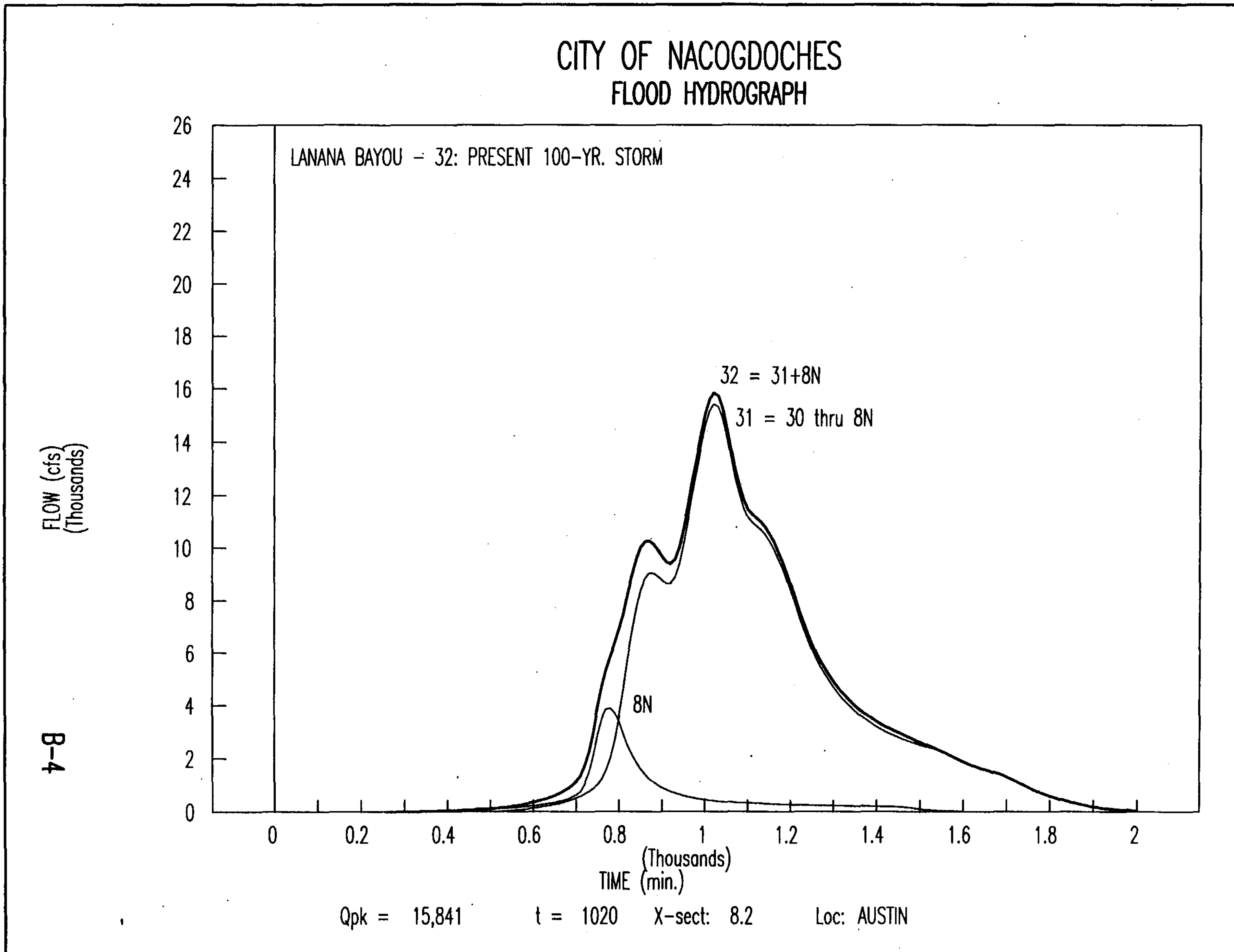


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU – 26: PRESENT 100-YR. STORM
FLOW (cfs) (Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
Combined Flood Hydrograph of Flood Hydrograph #1 Routed Thru Drainage Area #2 Plus Flood Hydrographs for Drainage Areas #2 & #3. (Typical)
Flood Hydrograph for Drainage Area #1 Routed Thru Drainage Area #2 (Typical)
Flood Hydrograph for Drainage Area #3 (Typical)
26 = 25+2+3
Drainage Areas #2 (Typical)
25 =1 thru 2
Flood Hydrograph for Drainage Area #2 (Typical)
Flood Hydrograph for Drainage Areas #1. (Typical)
3
2
Qpk = 5,542 t = 900 X-sect: 4.201

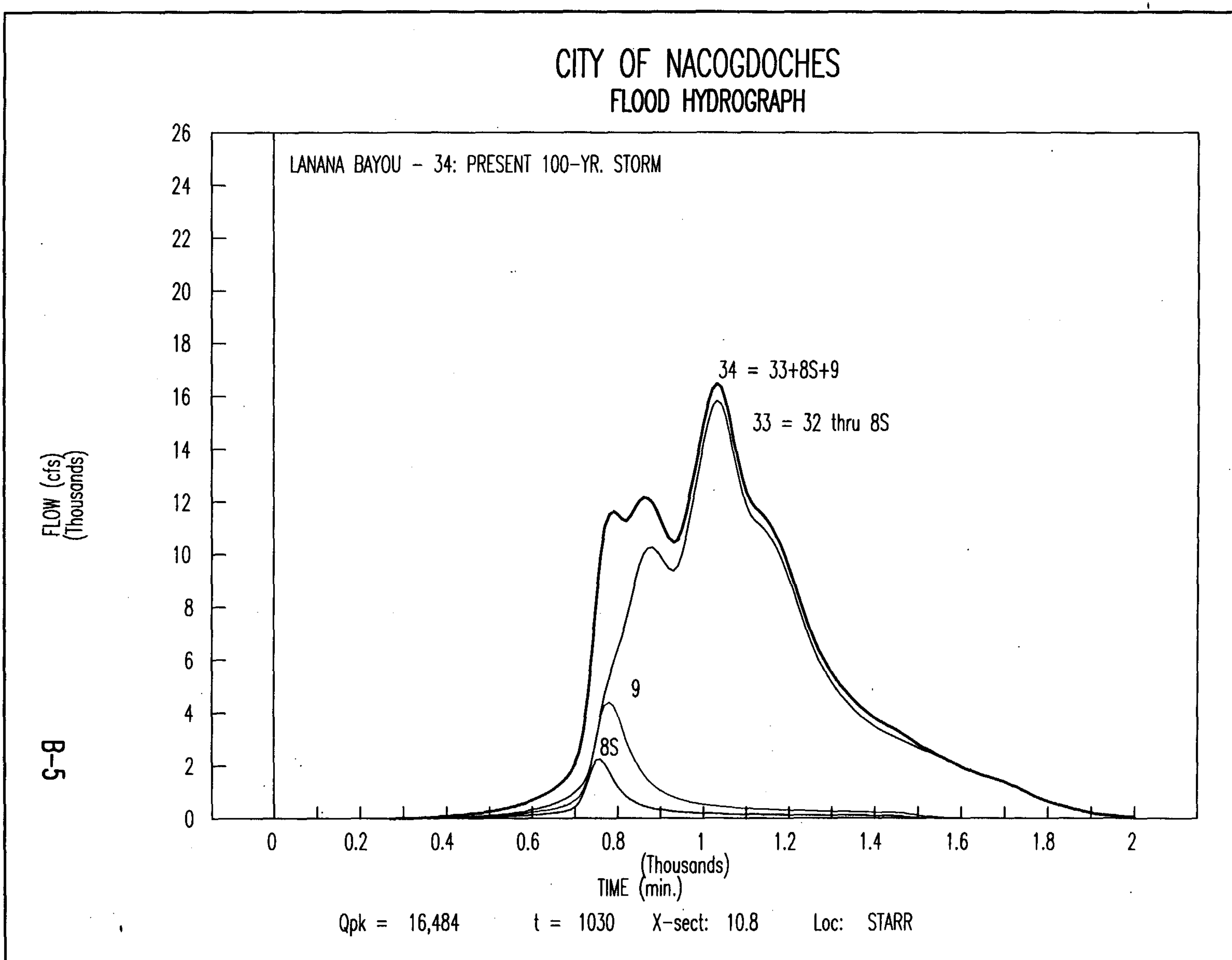


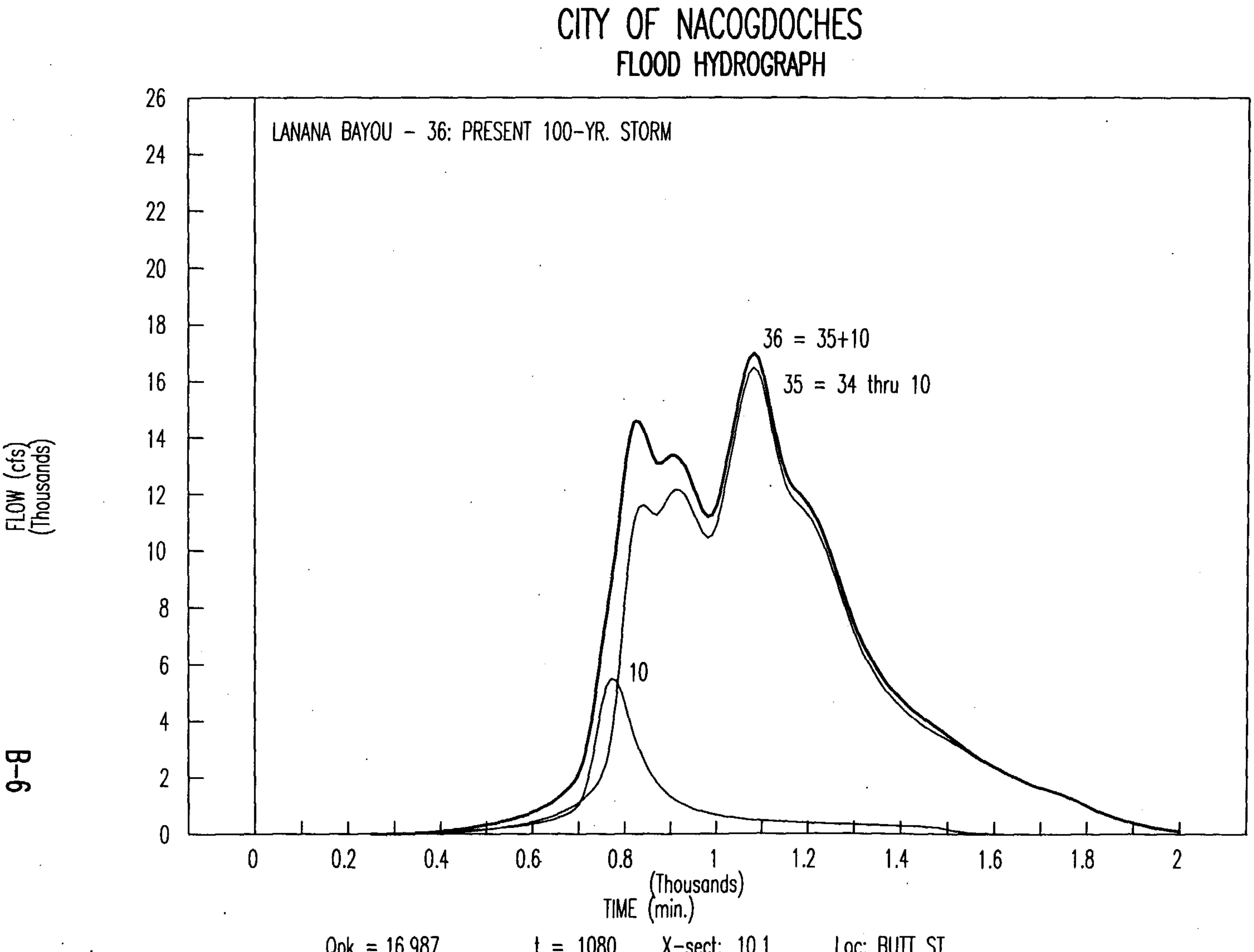
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 28: PRESENT 100-YR. STORM
28 = 27+4+5
27 = 26 thru 4
5
4
FLOW (cfs) (Thousands)
TIME (min.) (Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Qpk = 12,884
t = 830
X-sect: 6.901
Loc: SPRR


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 30: PRESENT 100-YR. STORM
30 = 29+6+7
29 = 28 thru 6
7
6
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Qpk = 15,427
t = 960
X-sect: 6.001
Loc: LOOP 224

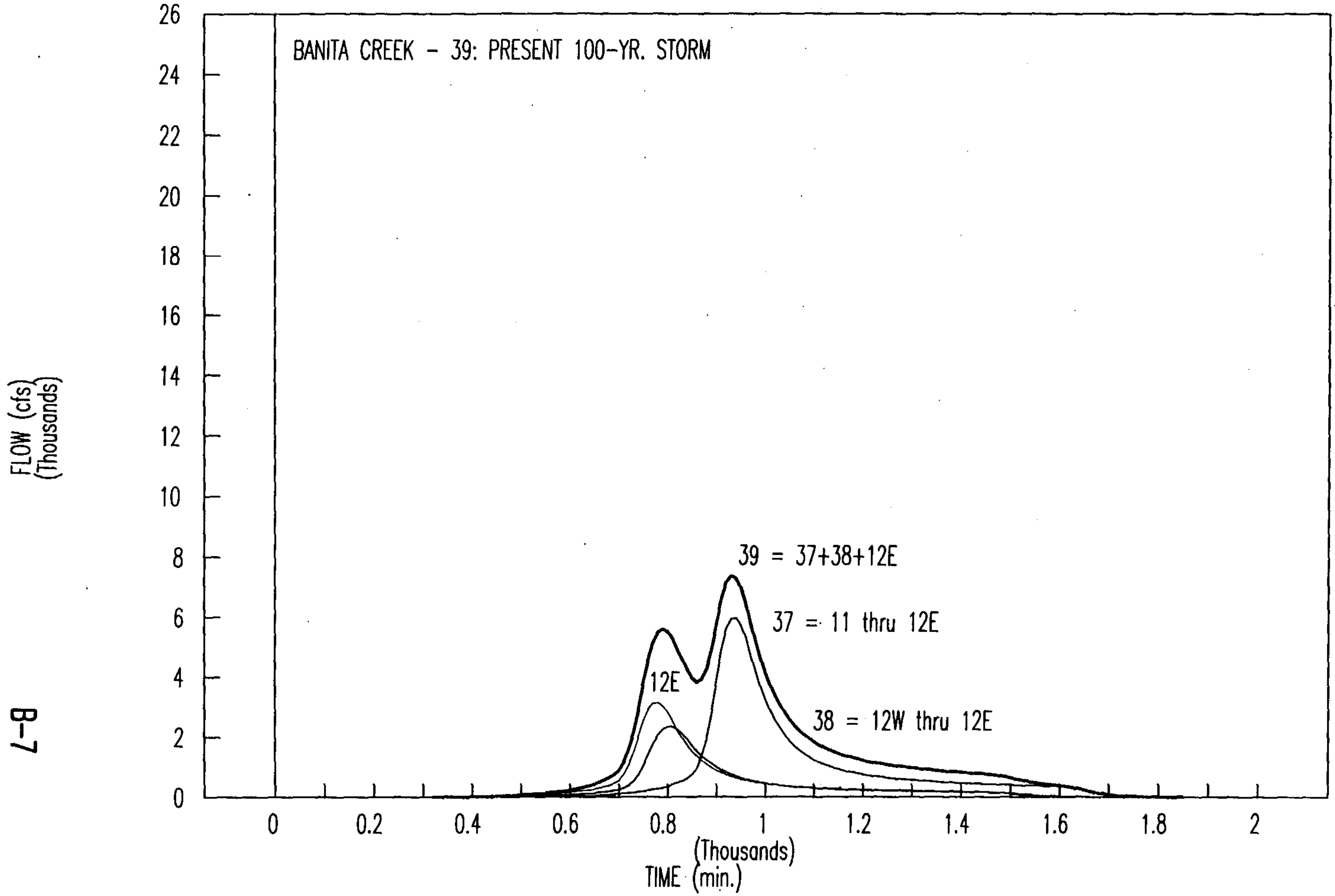


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 32: PRESENT 100-YR. STORM
32 = 31+8N
31 = 30 thru 8N
8N
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Qpk = 15,841
t = 1020
X-sect: 8.2
Loc: AUSTIN


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU – 34: PRESENT 100-YR. STORM
34 = 33+8S+9
33 = 32 thru 8S
9
8S
FLOW (cfs) (Thousands)
TIME (min.) (Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Qpk = 16,484 t = 1030 X-sect: 10.8 Loc: STARR

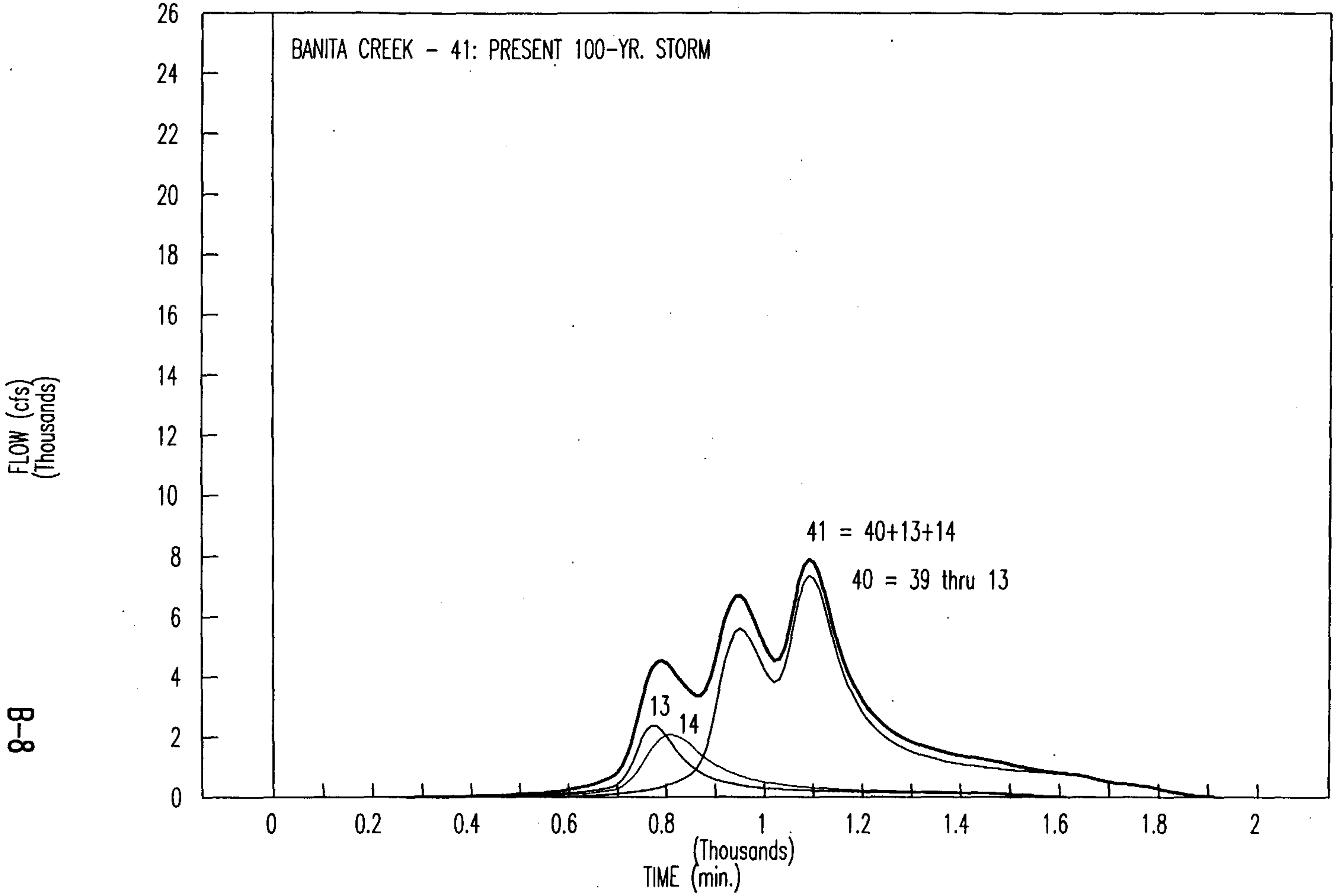

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 36: PRESENT 100-YR. STORM
36 = 35+10
35 = 34 thru 10
10
FLOW (cfs)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
Qpk = 16,987
t = 1080
X-sect: 10.1
Loc: BUTT ST.

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH

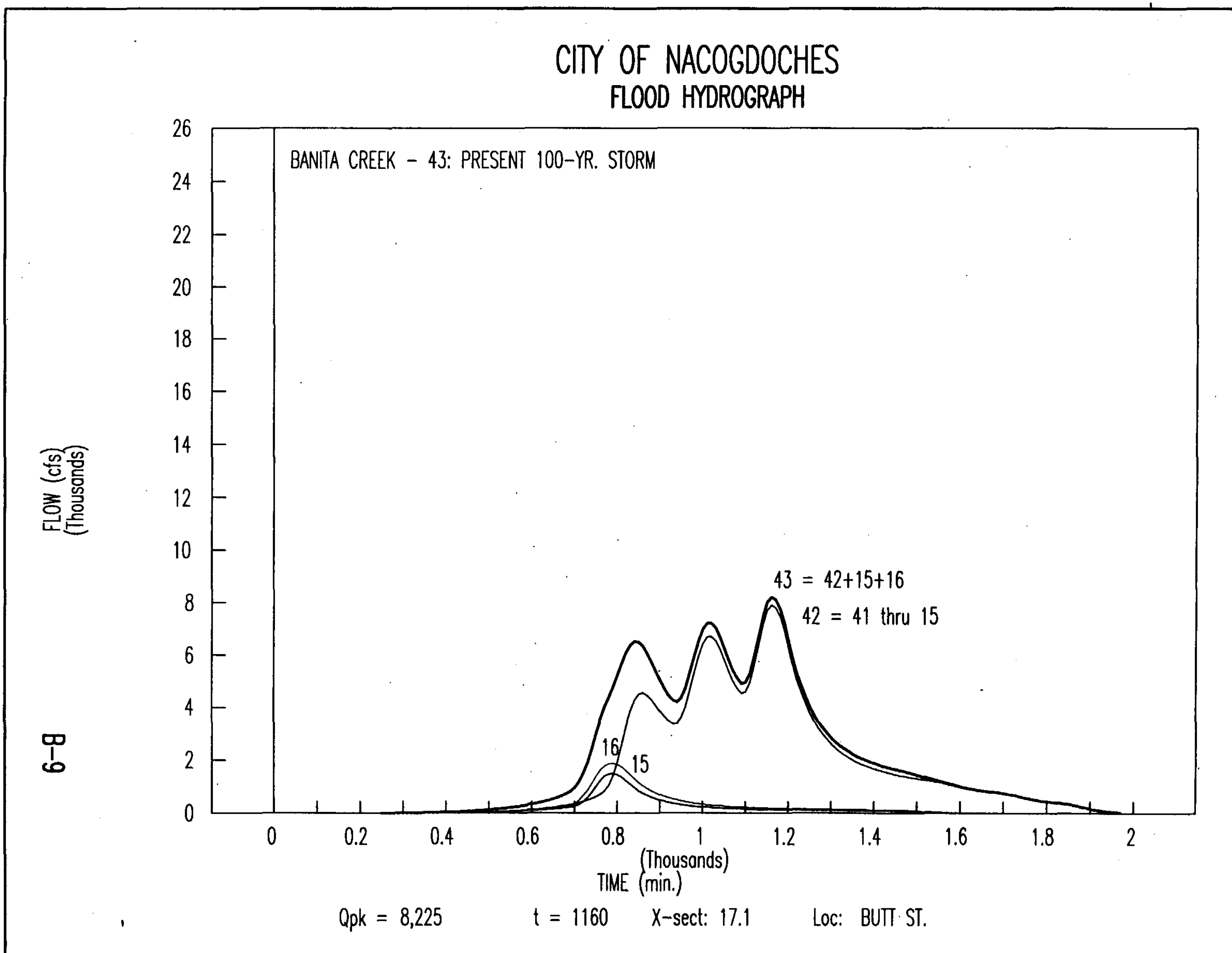


Qpk = 7,375 t = 930 X-sect: 12.1 Loc: TRIB. G

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH

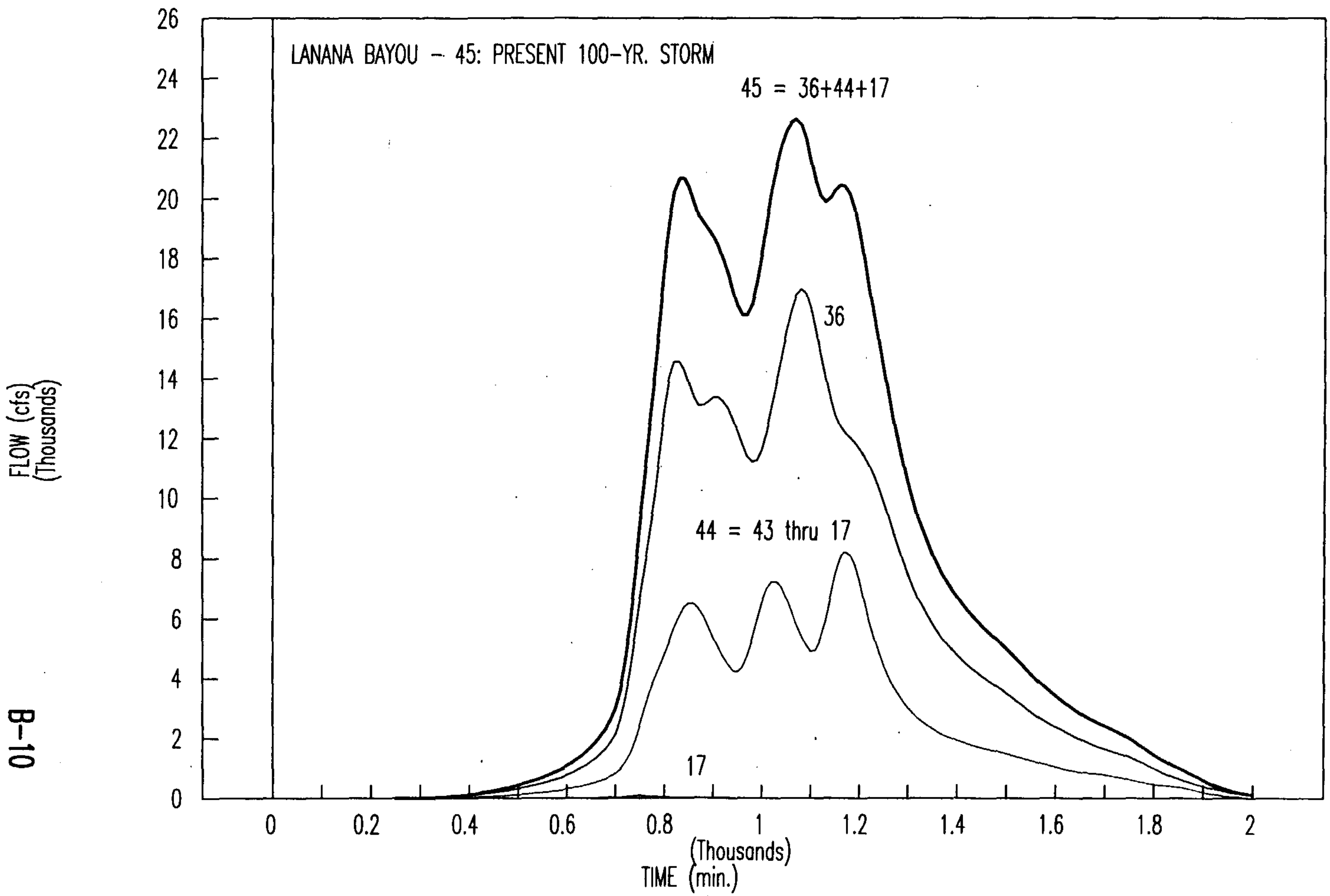


Qpk = 7,912 t = 1090 X-sect: 13.001 Loc: TRIB. C

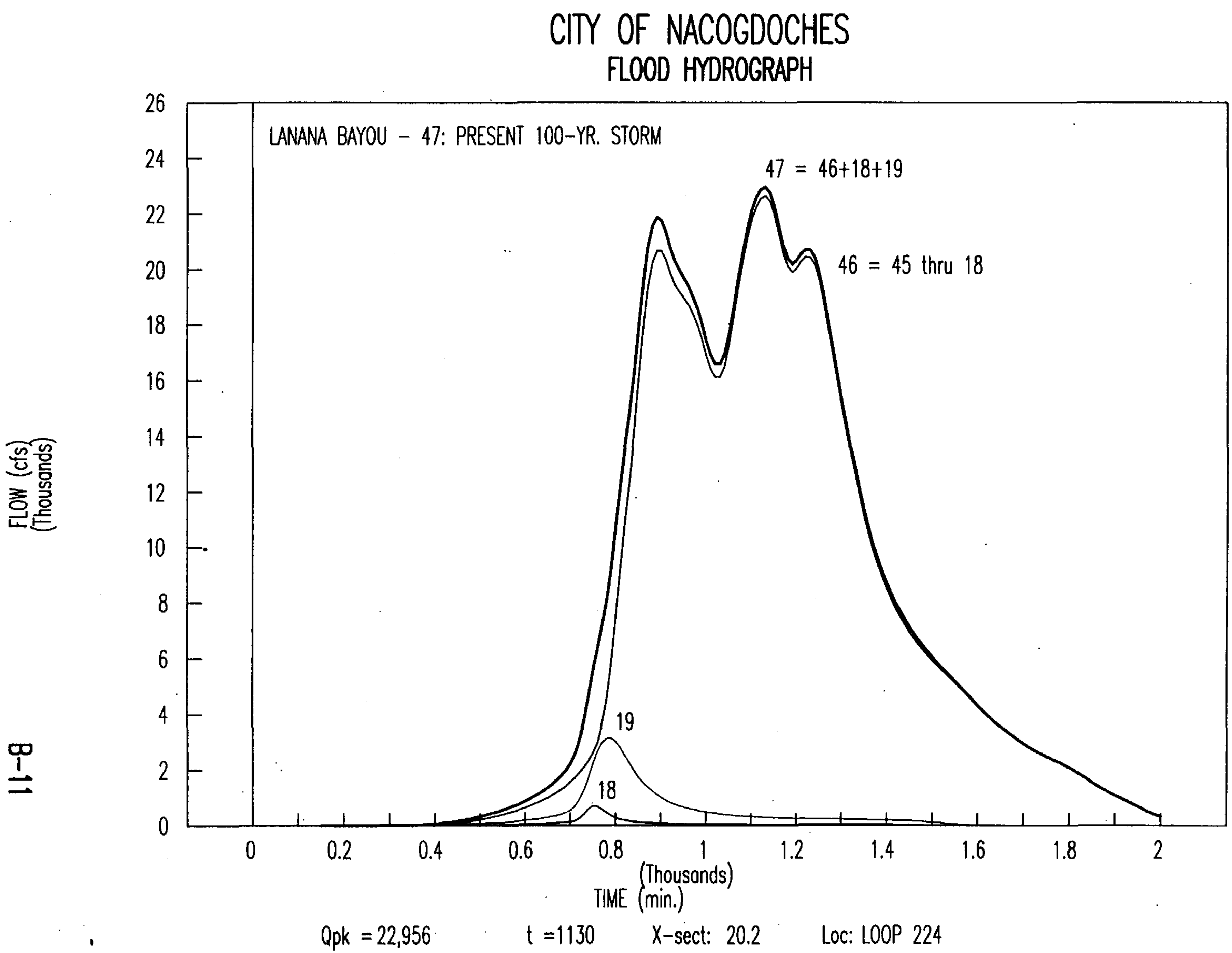


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK – 43: PRESENT 100-YR. STORM
FLOW (cfs)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
43 = 42+15+16
42 = 41 thru 15
16
15
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
Qpk = 8,225
t = 1160
X-sect: 17.1
Loc: BUTT ST.

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH

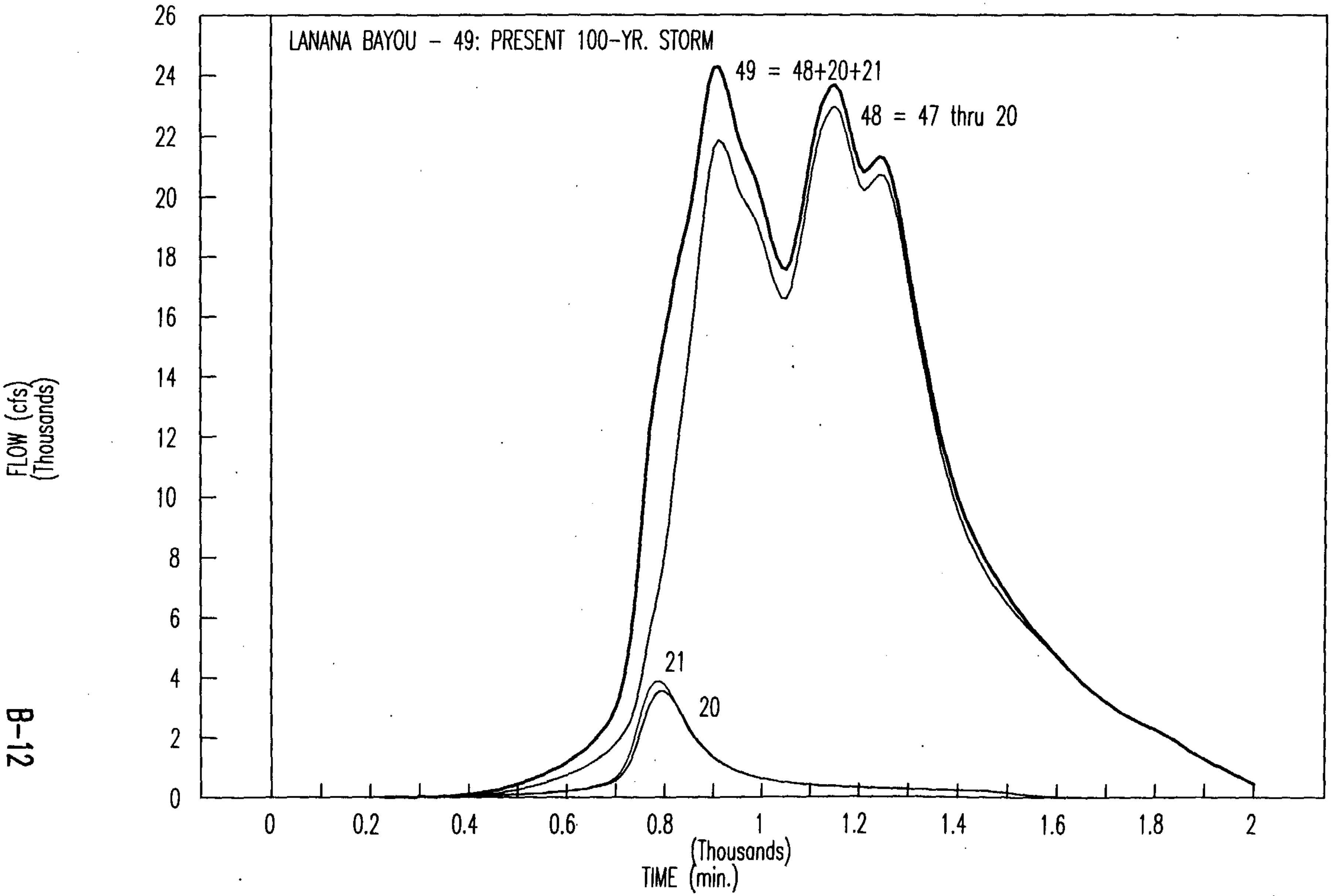


Qpk = 22,627 t = 1070 X-sect: 10.001 Loc: LANANA & BANITA

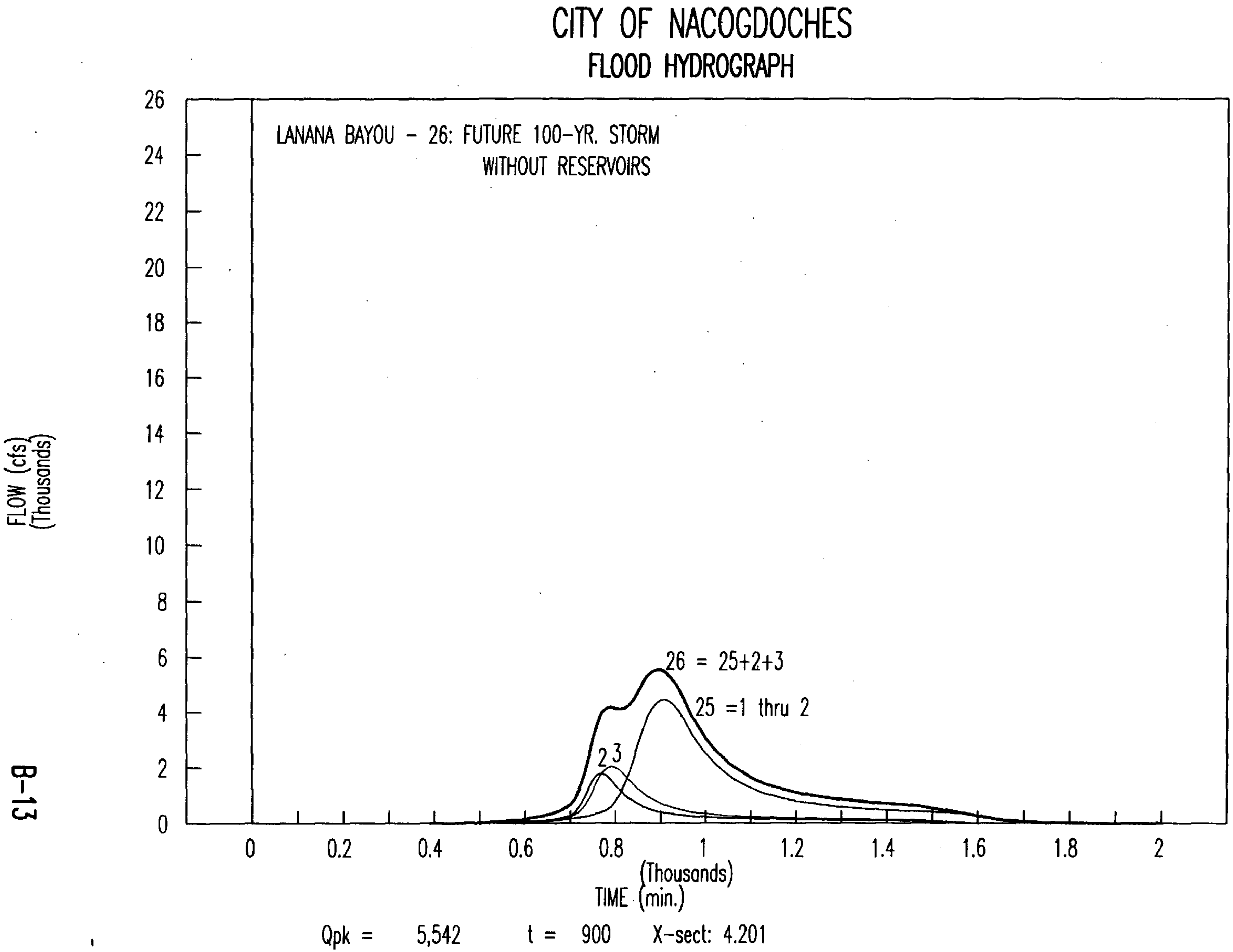


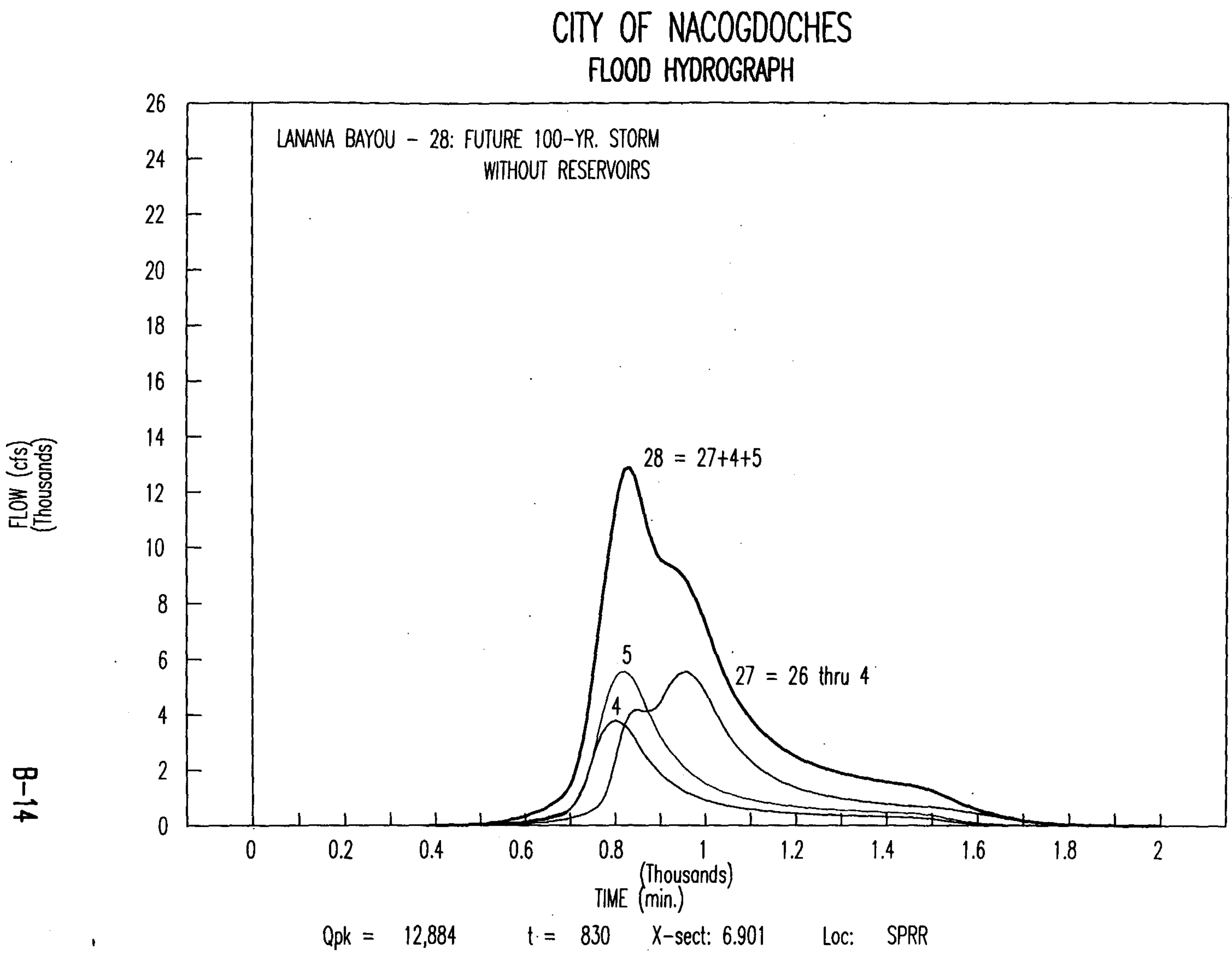
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 47: PRESENT 100-YR. STORM
47 = 46+18+19
46 = 45 thru 18
19
18
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Qpk = 22,956
t =1130
X-sect: 20.2
Loc: LOOP 224

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH

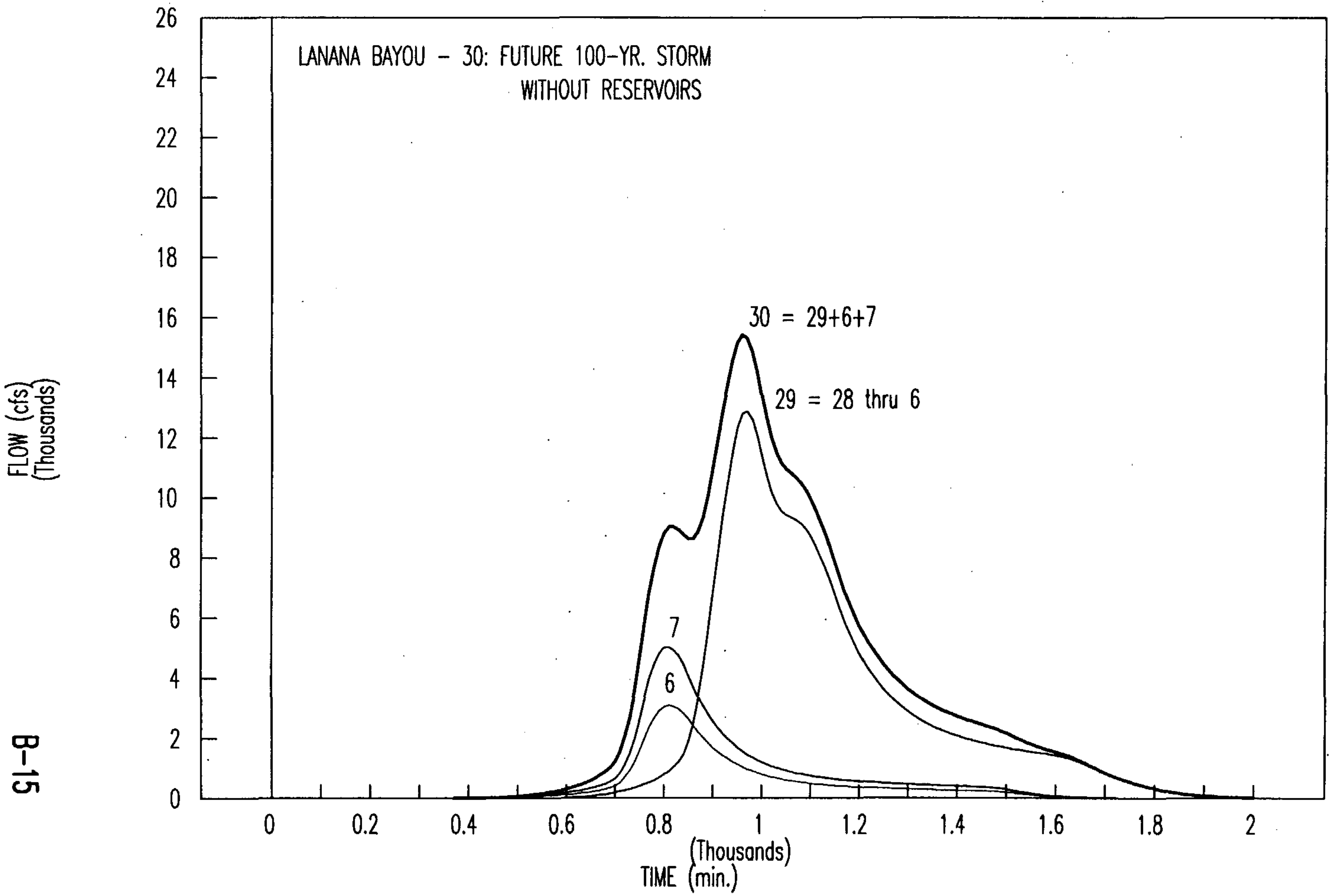


Qpk = 24,280 t = 910 X-sect: 20.001 Loc: EGGNOG

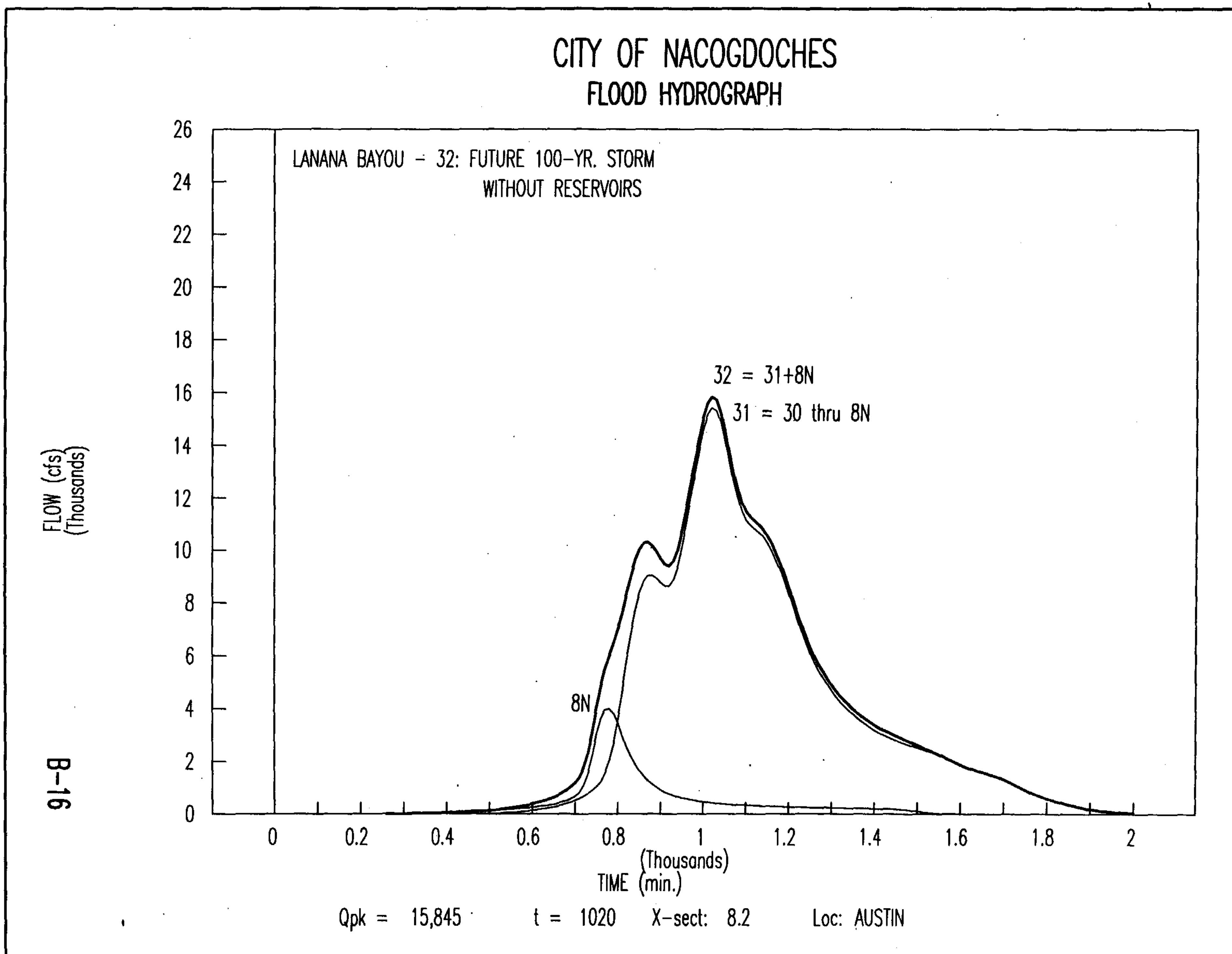

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 26: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
26 = 25+2+3
25 =1 thru 2
2
3
FLOW (cfs)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
Qpk = 5,542 t = 900 X-sect: 4.201


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 28: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
FLOW (cfs)
(Thousands)
28 = 27+4+5
5
4
27 = 26 thru 4
TIME (min.)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Qpk = 12,884
t = 830
X-sect: 6.901
Loc: SPRR

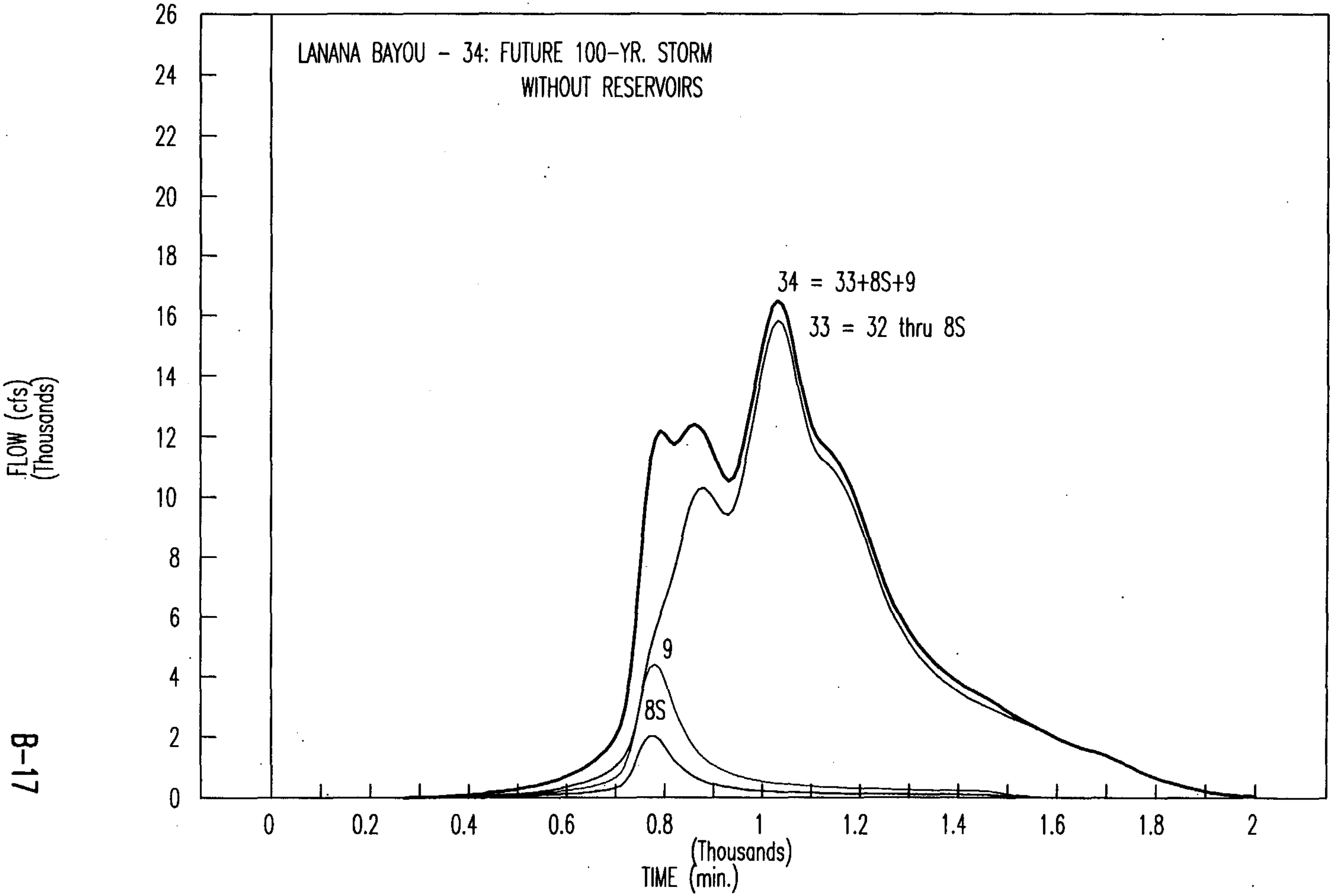
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



Qpk = 15,427 t = 960 X–sect: 6.001 Loc: LOOP 224

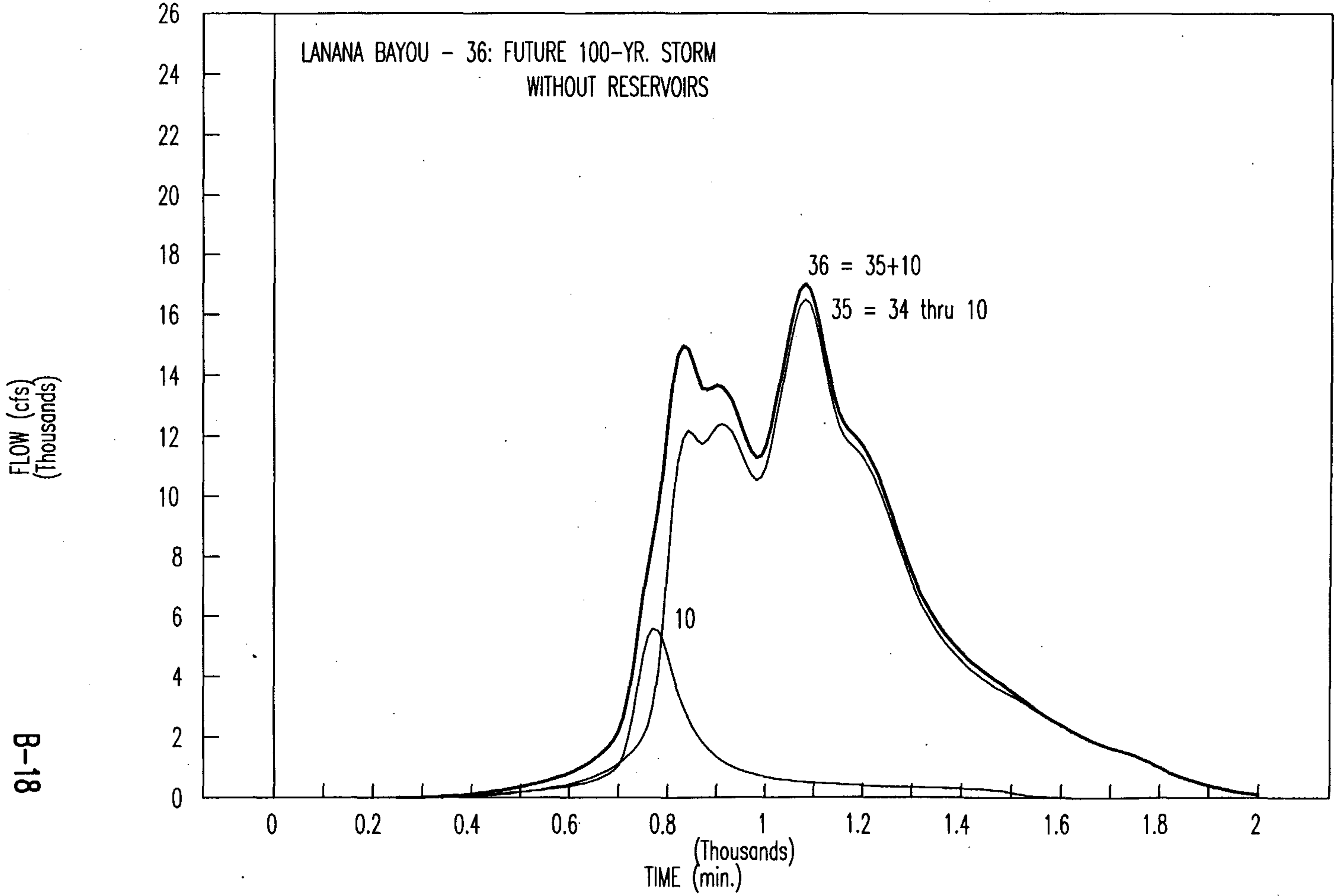

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 32: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
32 = 31+8N
31 = 30 thru 8N
8N
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
Qpk = 15,845
t = 1020
X-sect: 8.2
Loc: AUSTIN

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



Qpk = 16,505 t = 1030 X-sect: 10.8 Loc: STARR

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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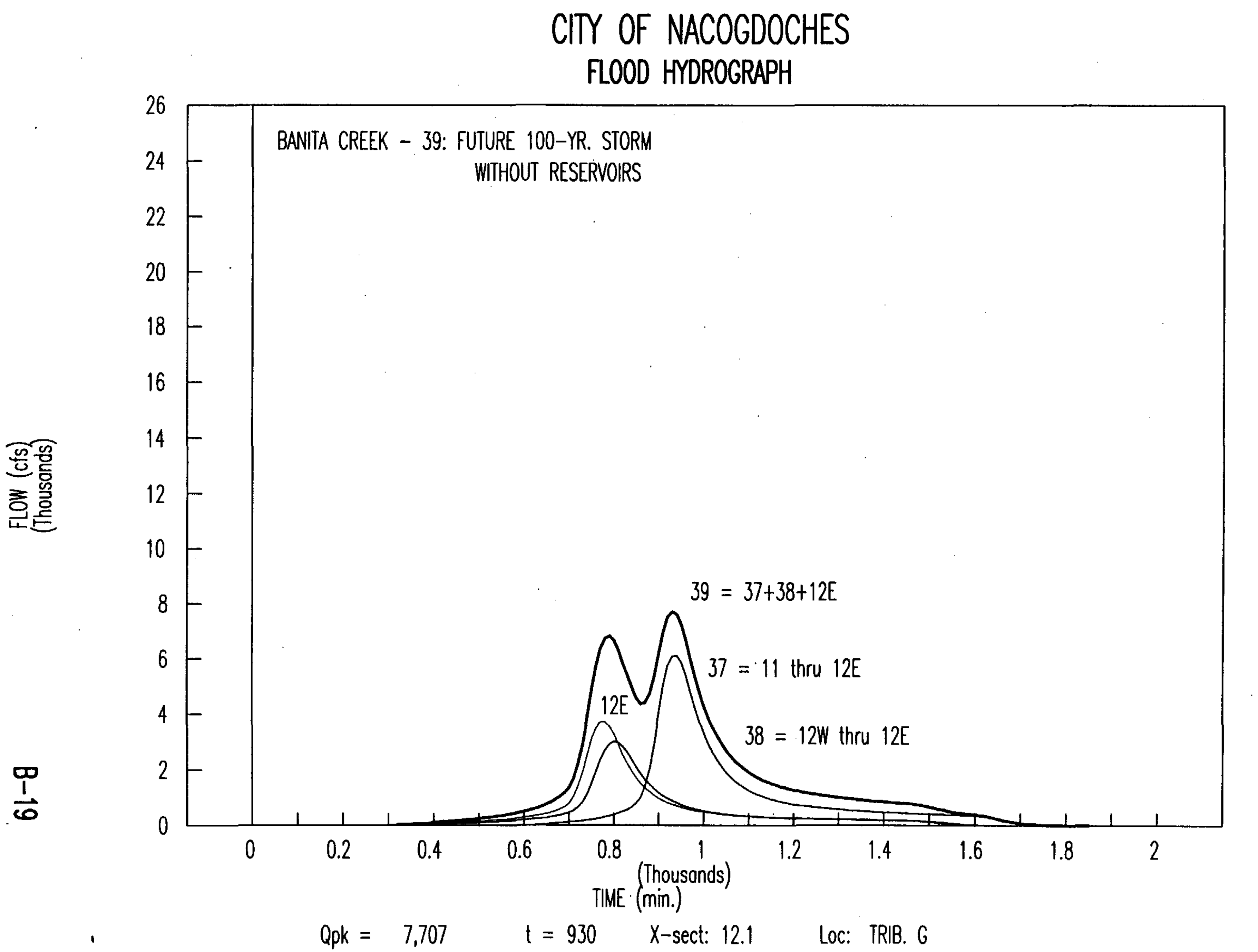
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK - 39: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
39 = 37+38+12E
37 = 11 thru 12E
38 = 12W thru 12E
12E
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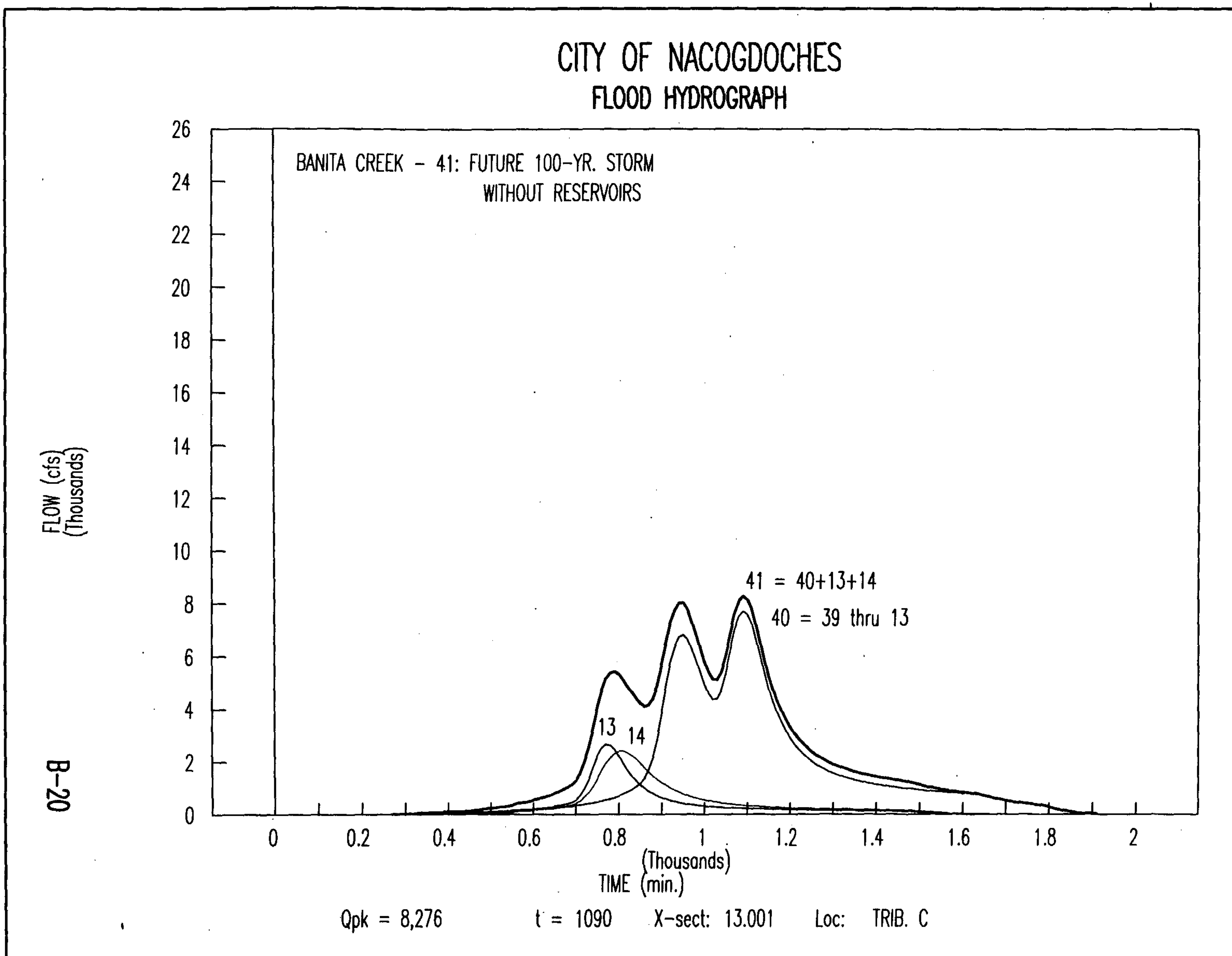
Loc: TRIB. G

B-19



CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK - 41: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
FLOW (cfs)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
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40 = 39 thru 13
13
14
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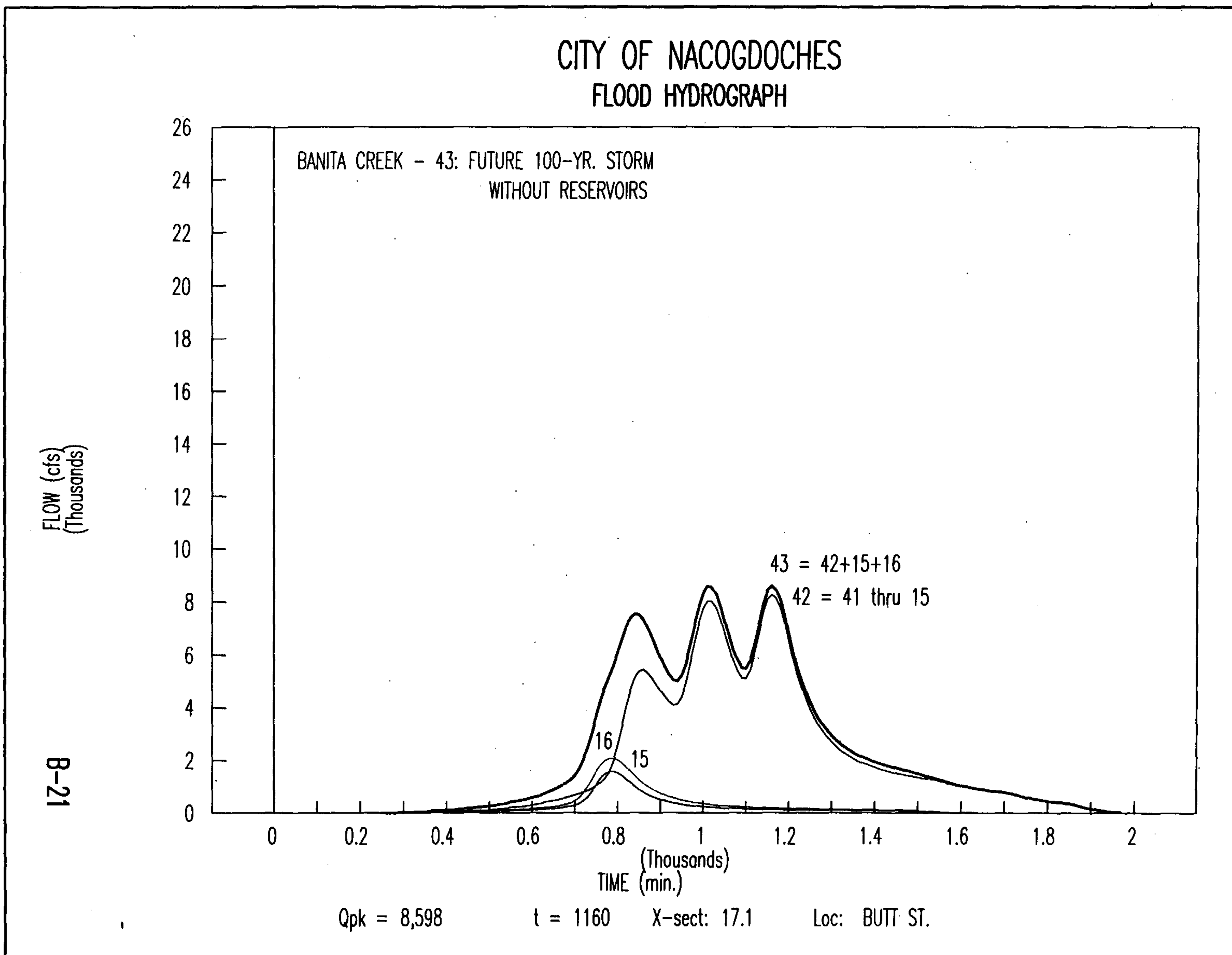
Loc: TRIB. C


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK – 43: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
43 = 42+15+16
42 = 41 thru 15
16
15
FLOW (cfs)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
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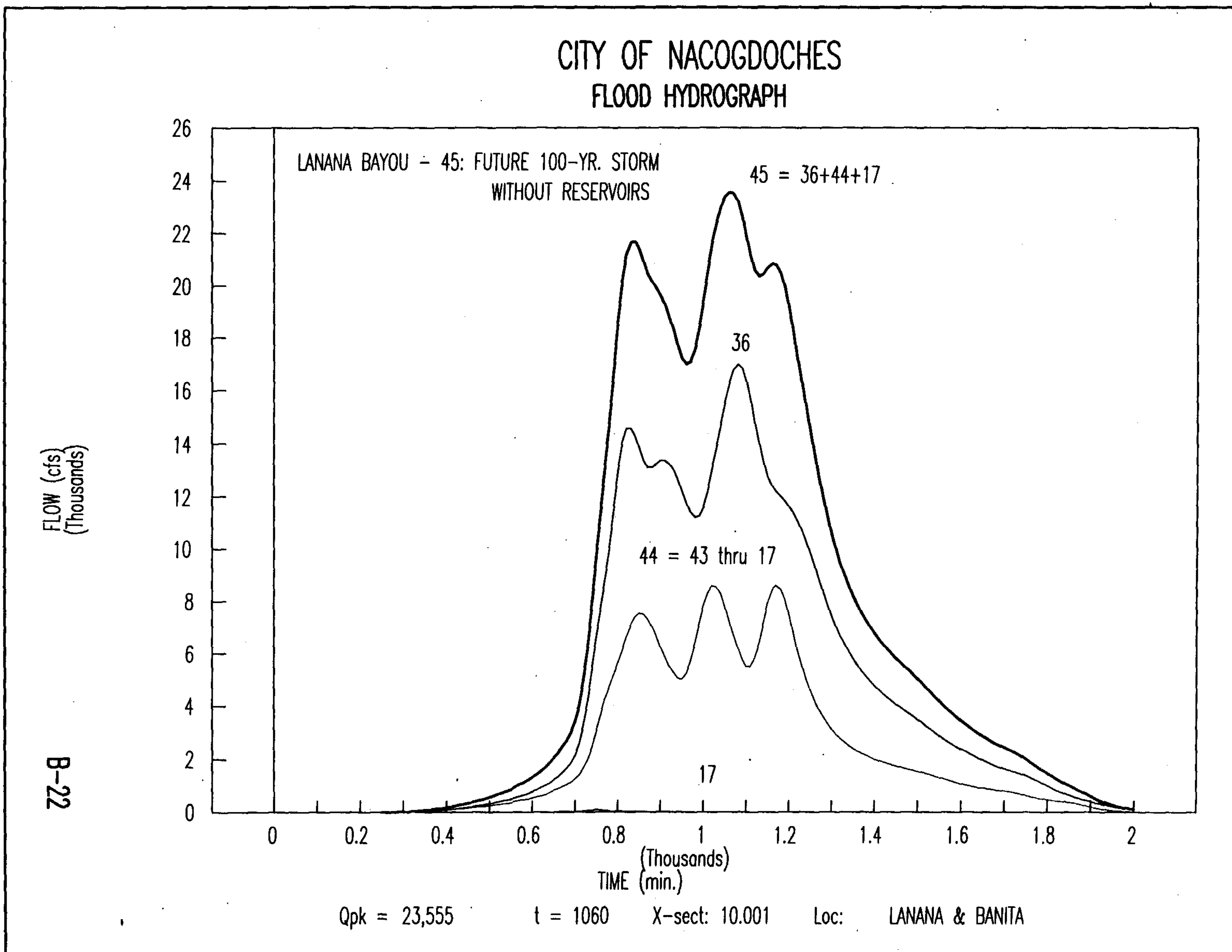
Loc: BUTT ST.



CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 45: FUTURE 100-YR. STORM
WITHOUT RESERVOIRS
45 = 36+44+17
36
44 = 43 thru 17
17
FLOW (cfs)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
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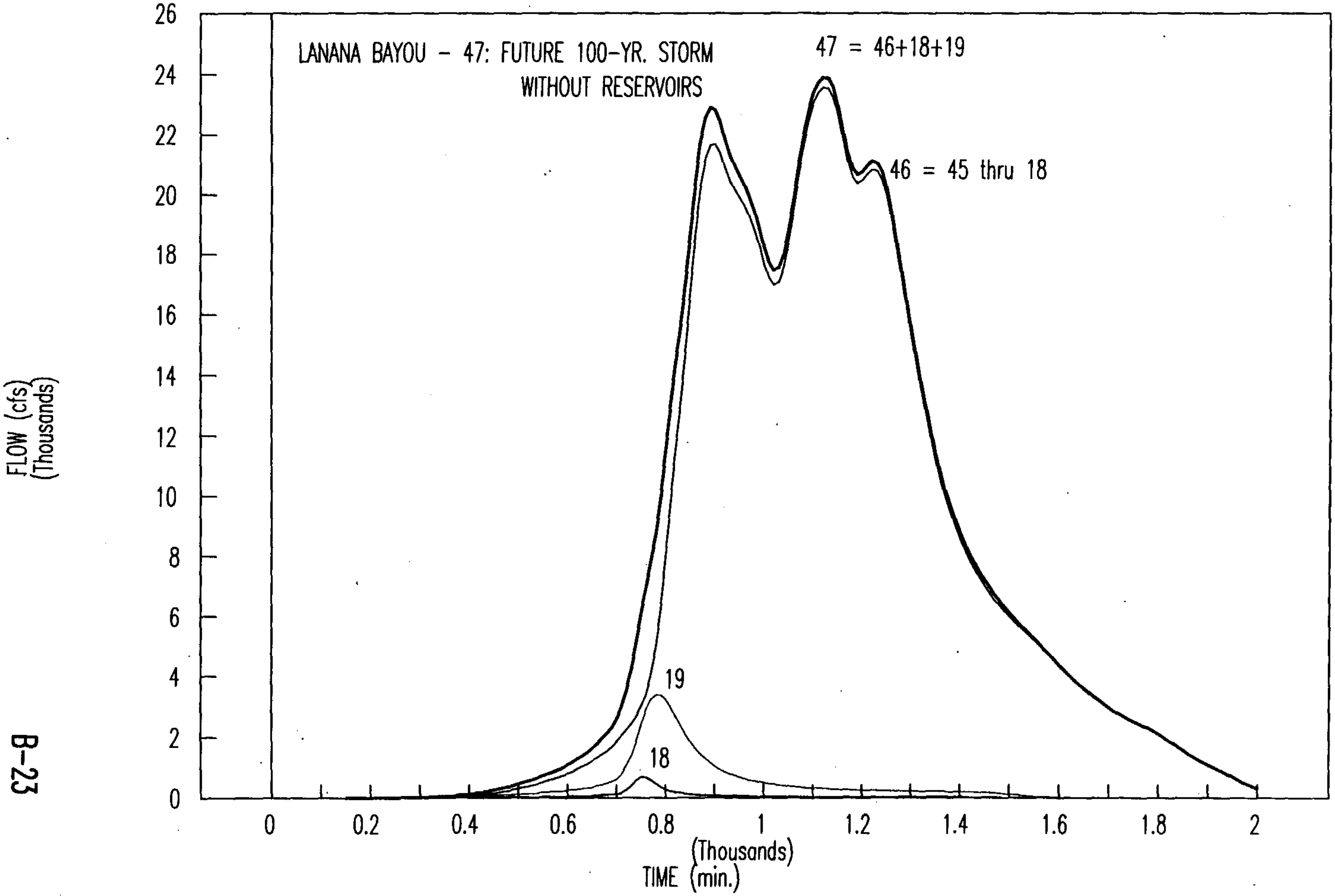
Loc: LANANA & BANITA

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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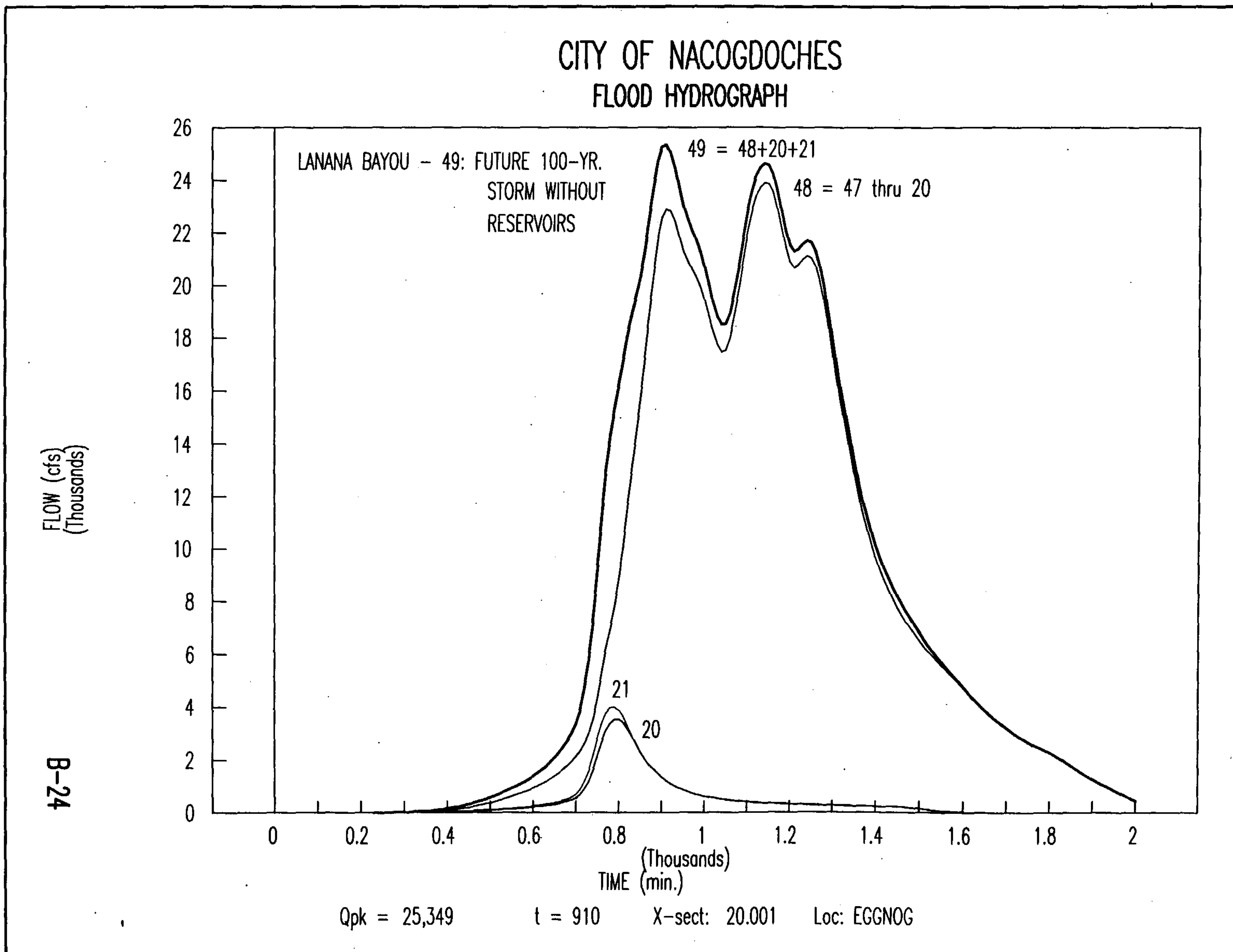
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 49: FUTURE 100-YR. STORM WITHOUT RESERVOIRS
49 = 48+20+21
48 = 47 thru 20
21
20
FLOW (cfs) (Thousands)
TIME (min.) (Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
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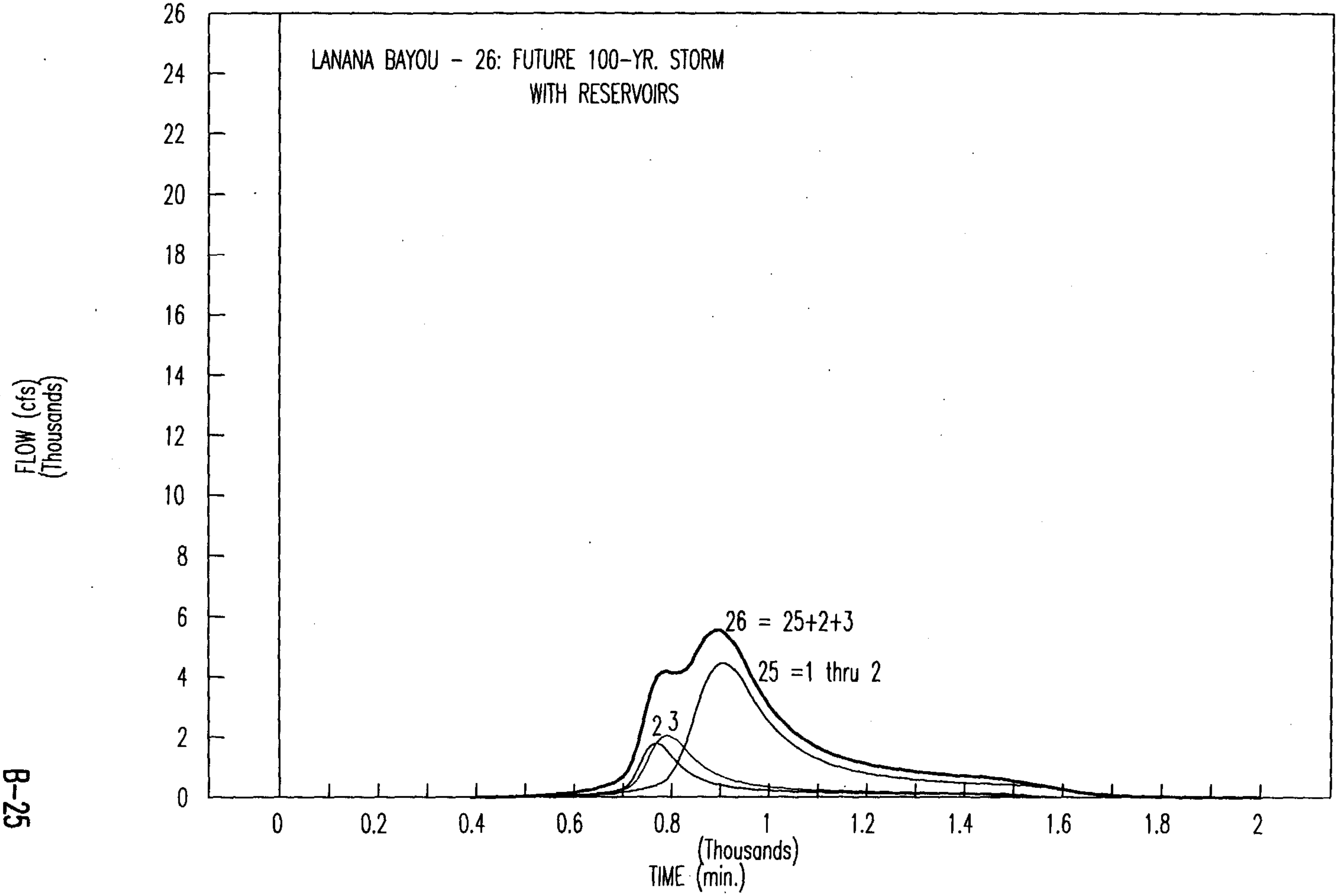
Loc: EGGNOG

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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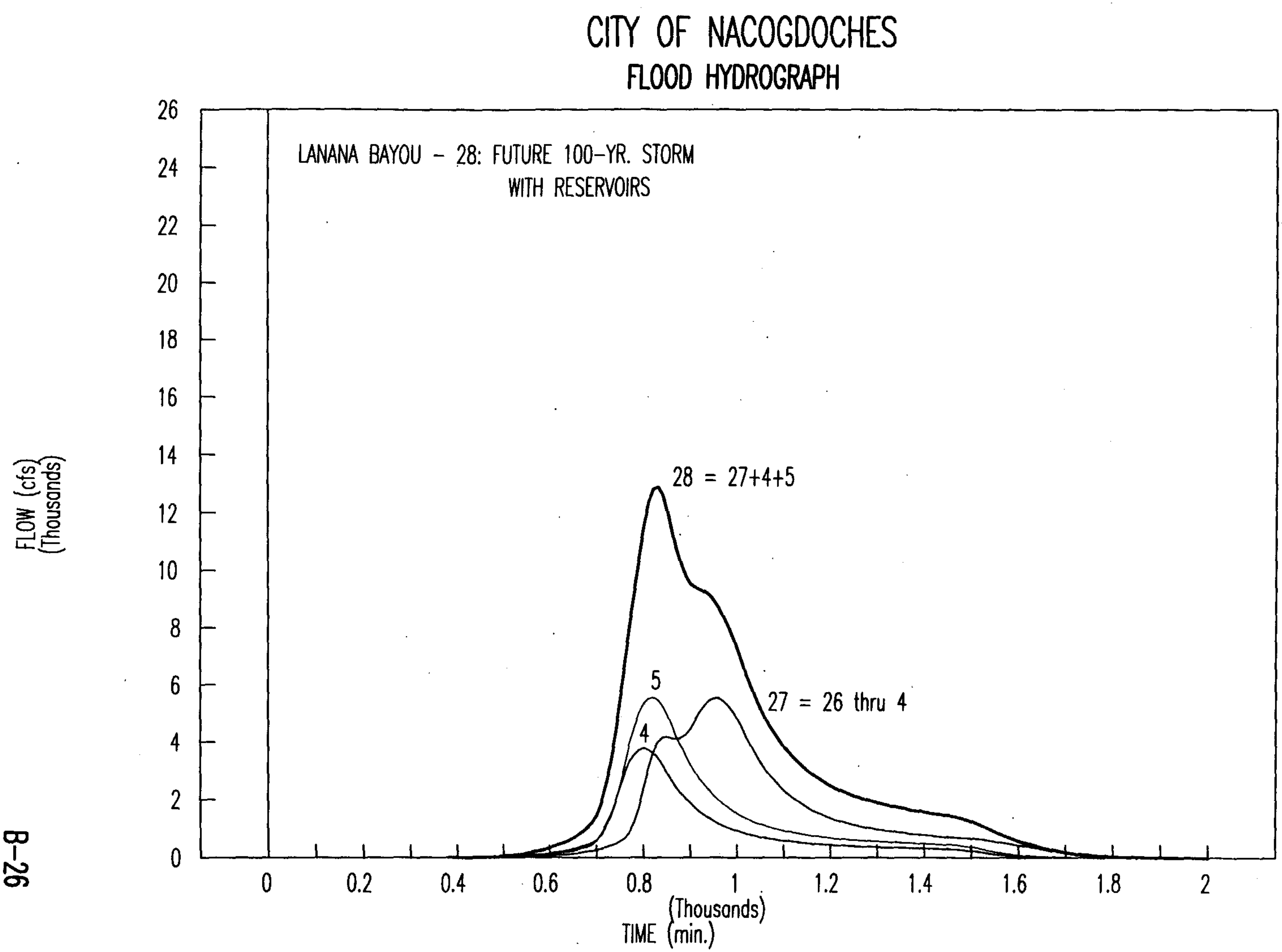

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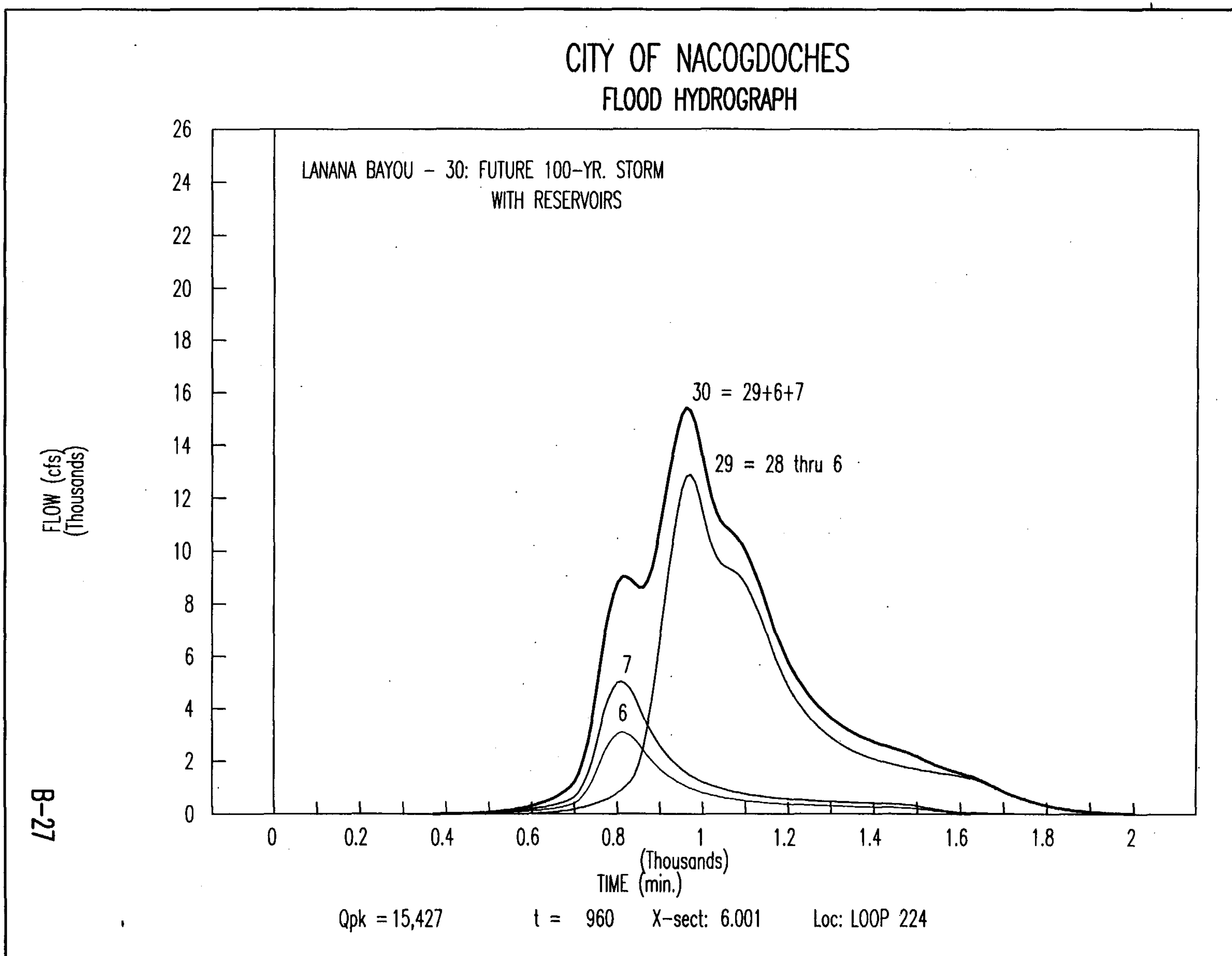

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 30: FUTURE 100-YR. STORM
WITH RESERVOIRS
30 = 29+6+7
29 = 28 thru 6
7
6
FLOW (cfs)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
1
1.2
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(Thousands)
TIME (min.)
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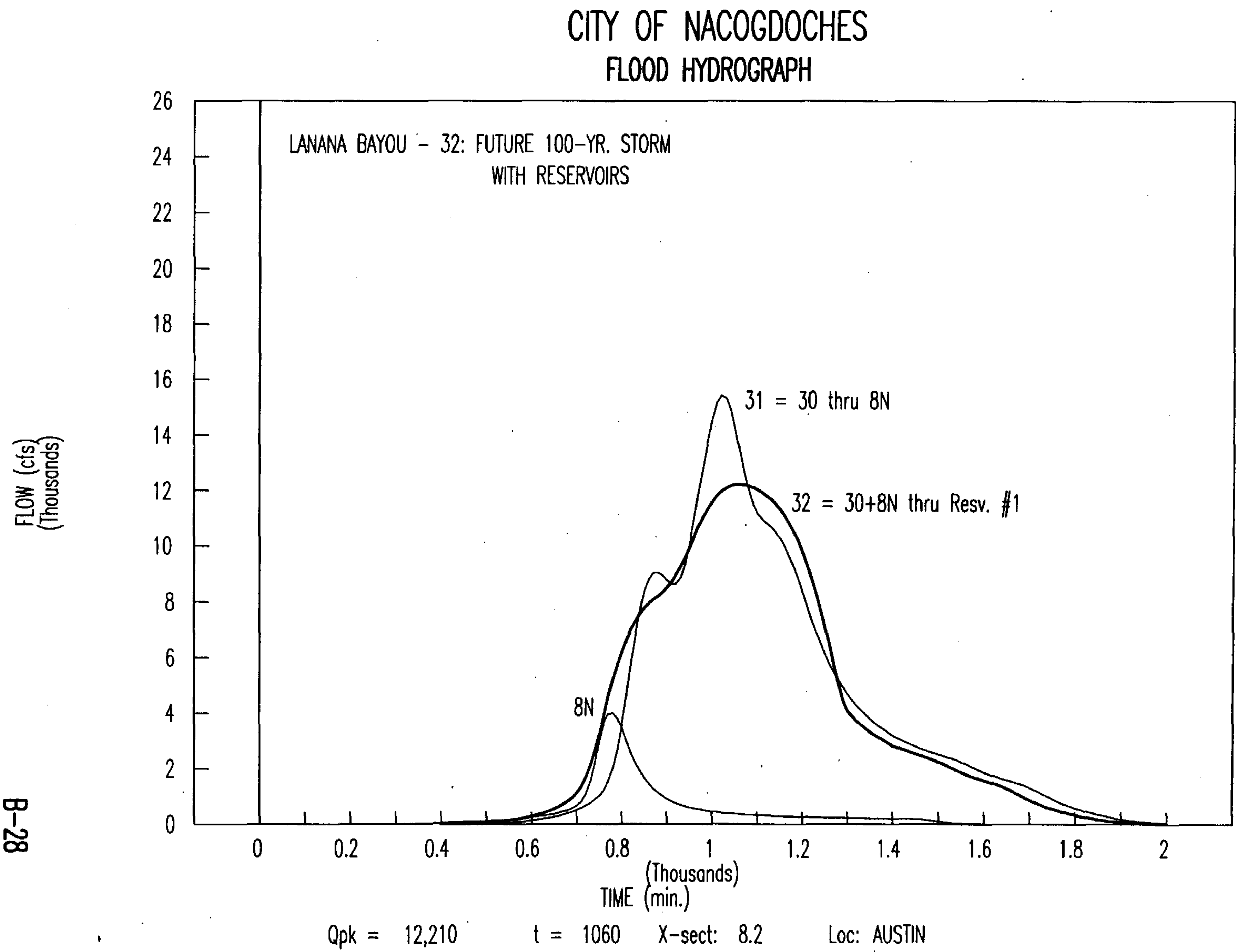
CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 32: FUTURE 100-YR. STORM
WITH RESERVOIRS
31 = 30 thru 8N
32 = 30+8N thru Resv. #1
8N
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
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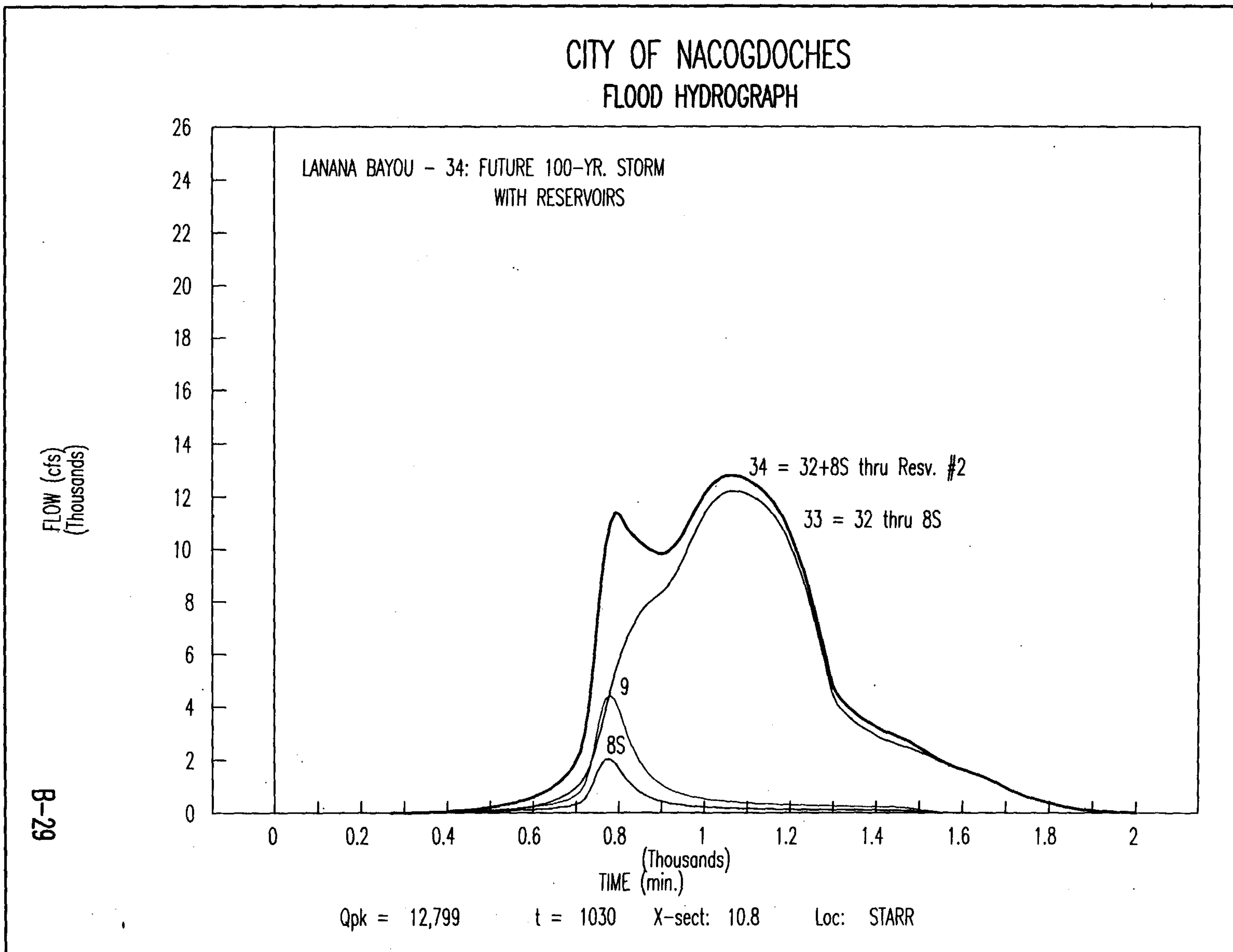
Loc: AUSTIN


CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 34: FUTURE 100-YR. STORM
WITH RESERVOIRS
34 = 32+8S thru Resv. #2
33 = 32 thru 8S
9
8S
FLOW (cfs)
(Thousands)
(Thousands)
TIME (min.)
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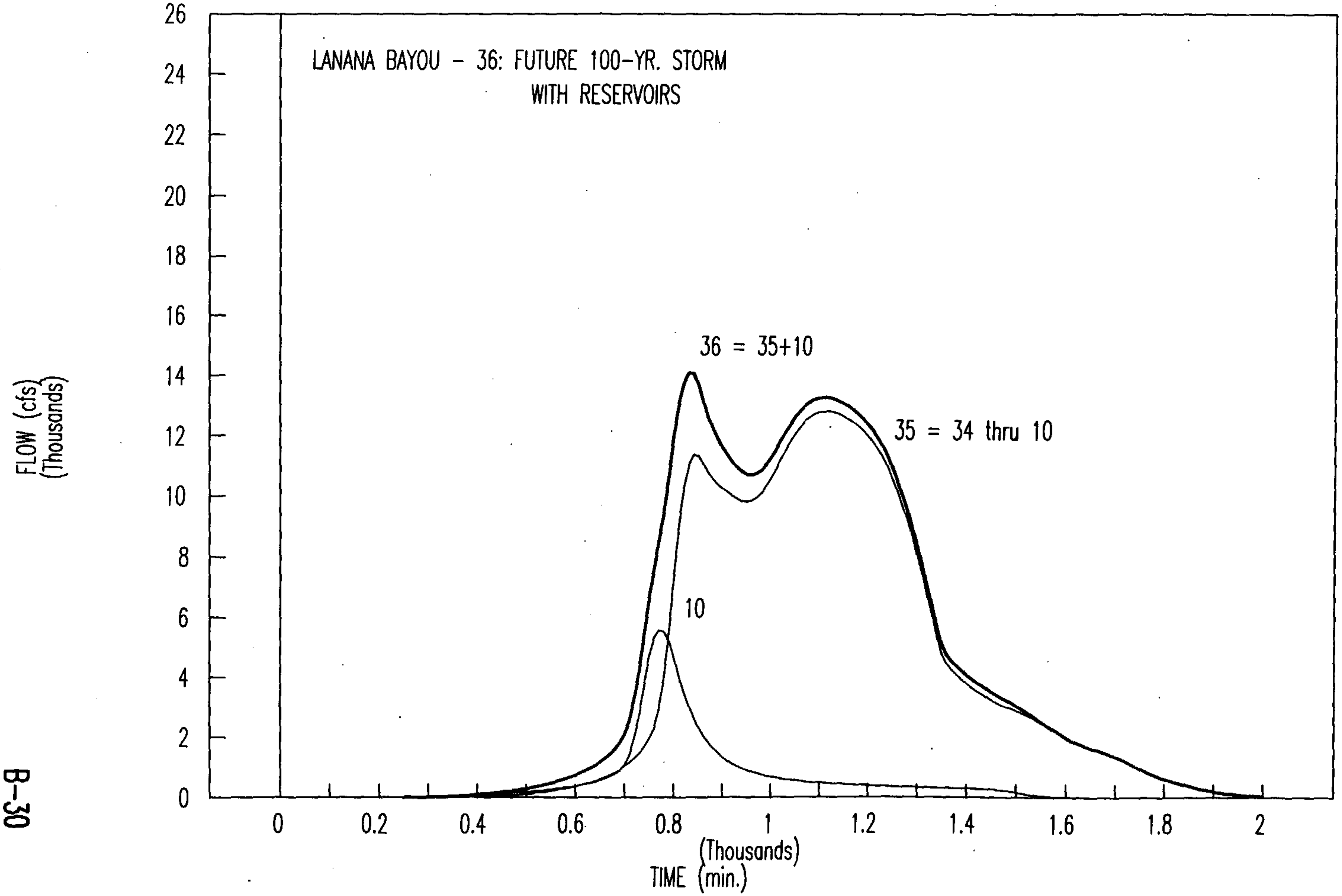
X-sect: 10.8
Loc: STARR

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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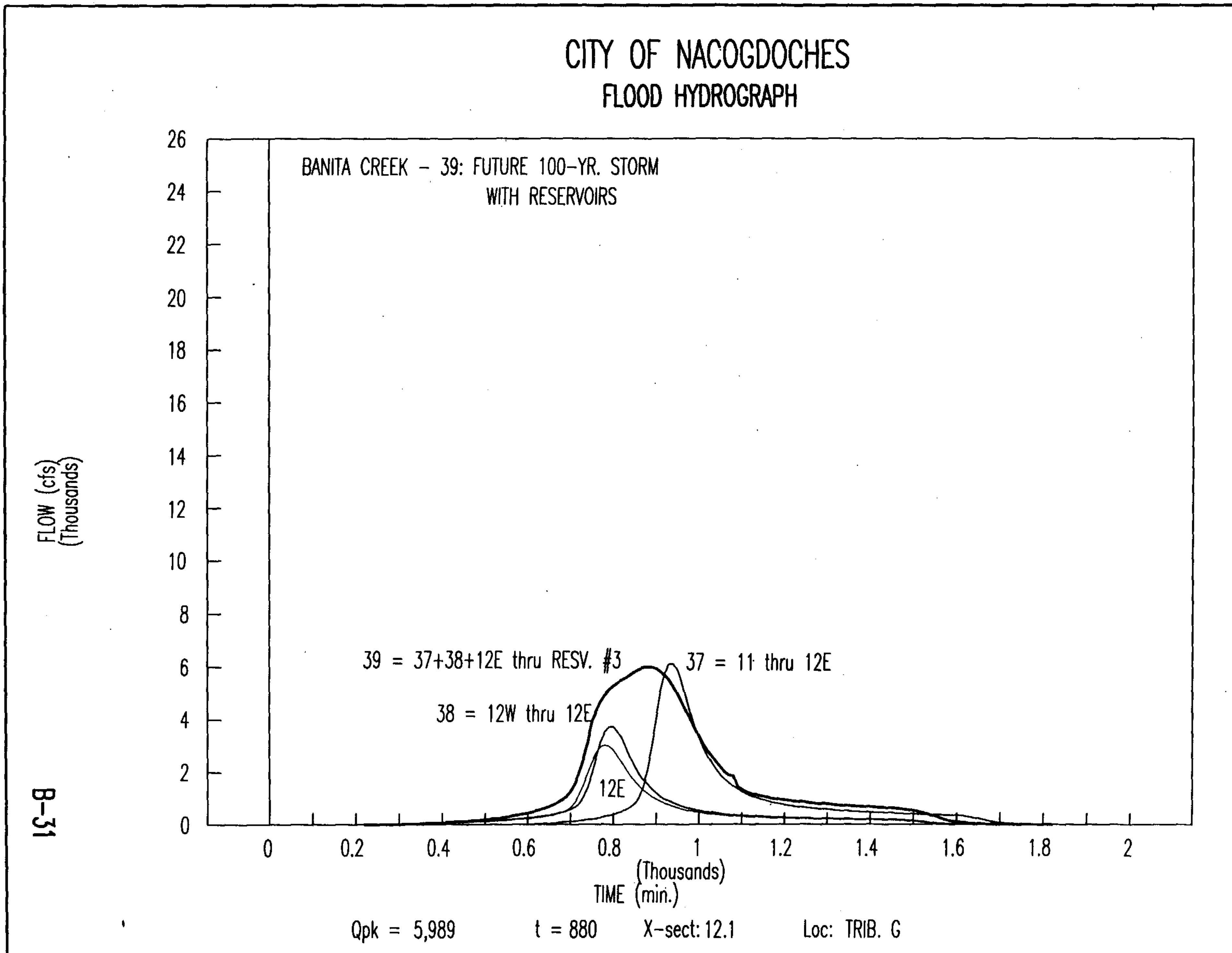

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK – 39: FUTURE 100-YR. STORM
WITH RESERVOIRS
FLOW (cfs)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
39 = 37+38+12E thru RESV. #3
37 = 11 thru 12E
38 = 12W thru 12E
12E
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
TIME (min.)
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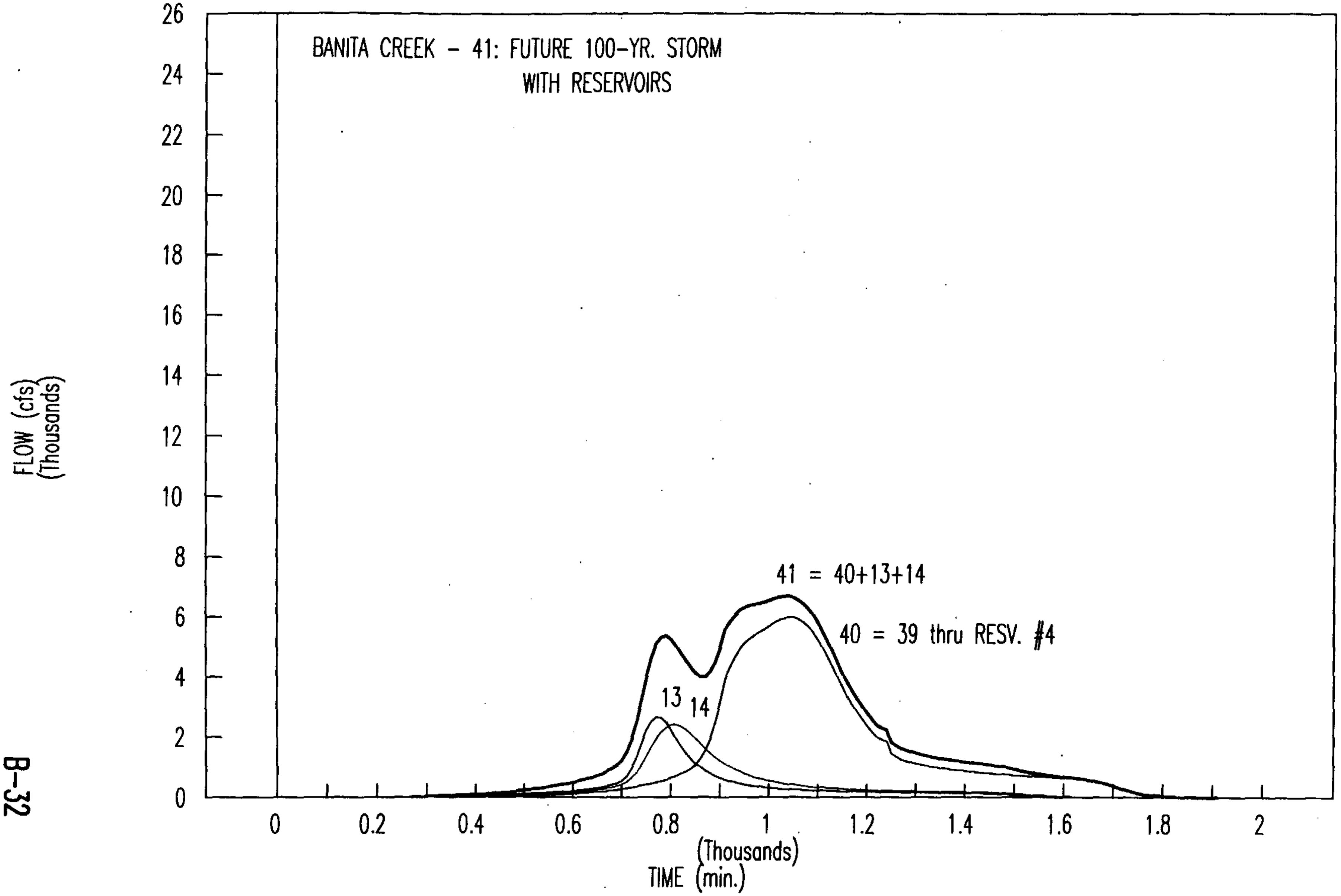
t = 880
X-sect: 12.1
Loc: TRIB. G

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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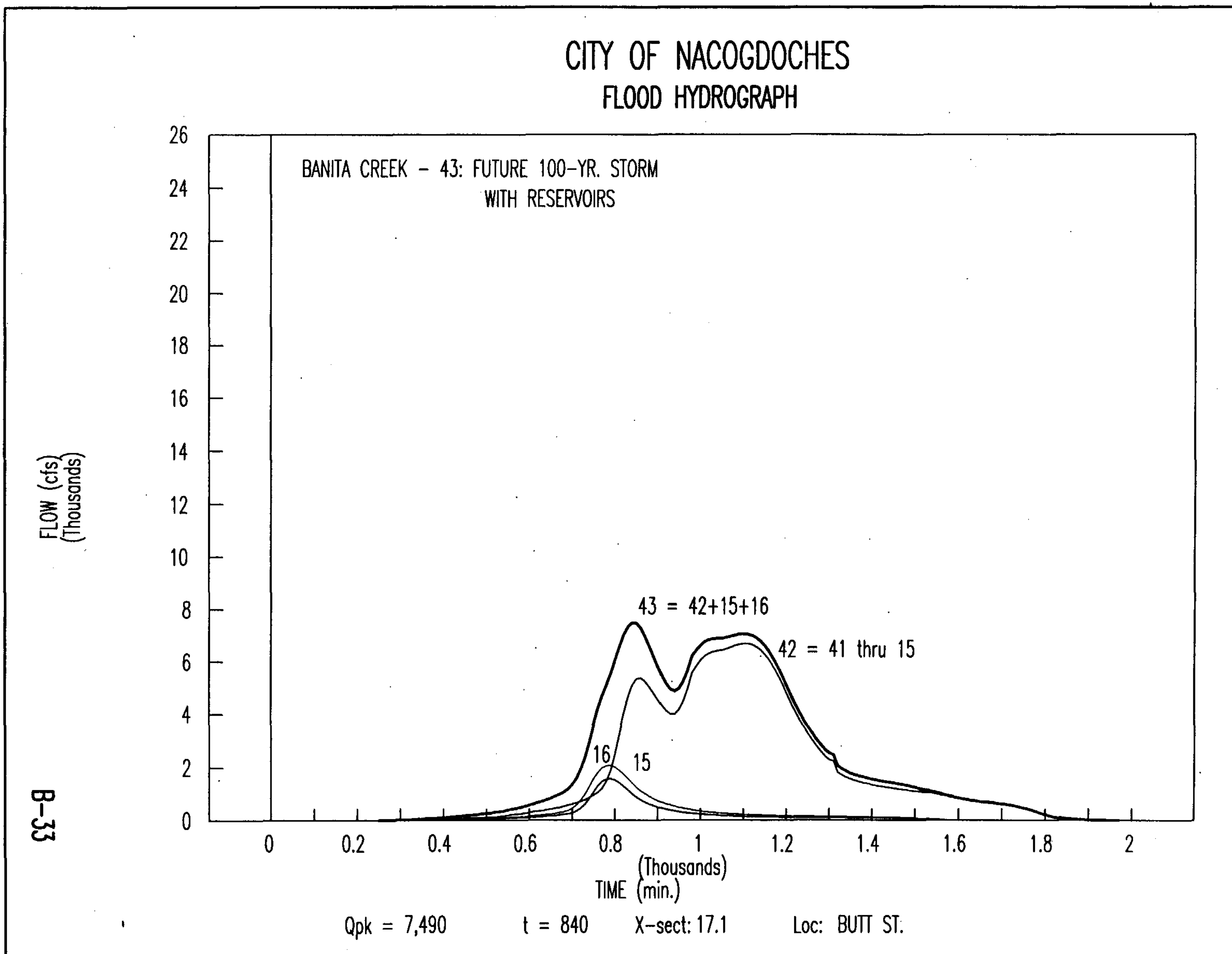

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
BANITA CREEK - 43: FUTURE 100-YR. STORM
WITH RESERVOIRS
43 = 42+15+16
42 = 41 thru 15
16
15
FLOW (cfs)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
0.2
0.4
0.6
0.8
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1.2
1.4
1.6
1.8
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(Thousands)
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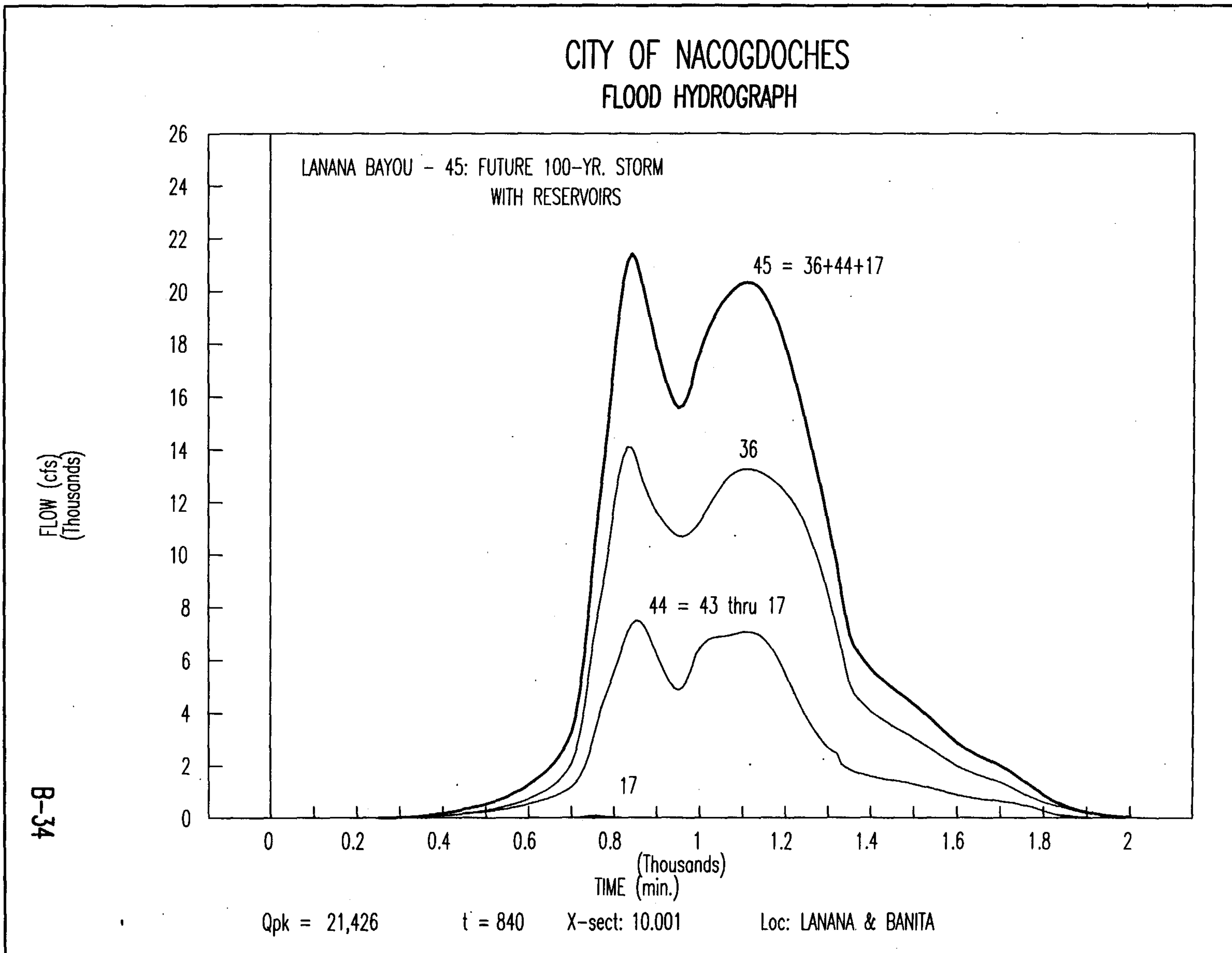

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 45: FUTURE 100-YR. STORM
WITH RESERVOIRS
45 = 36+44+17
36
44 = 43 thru 17
17
FLOW (cfs)
(Thousands)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
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(Thousands)
TIME (min.)
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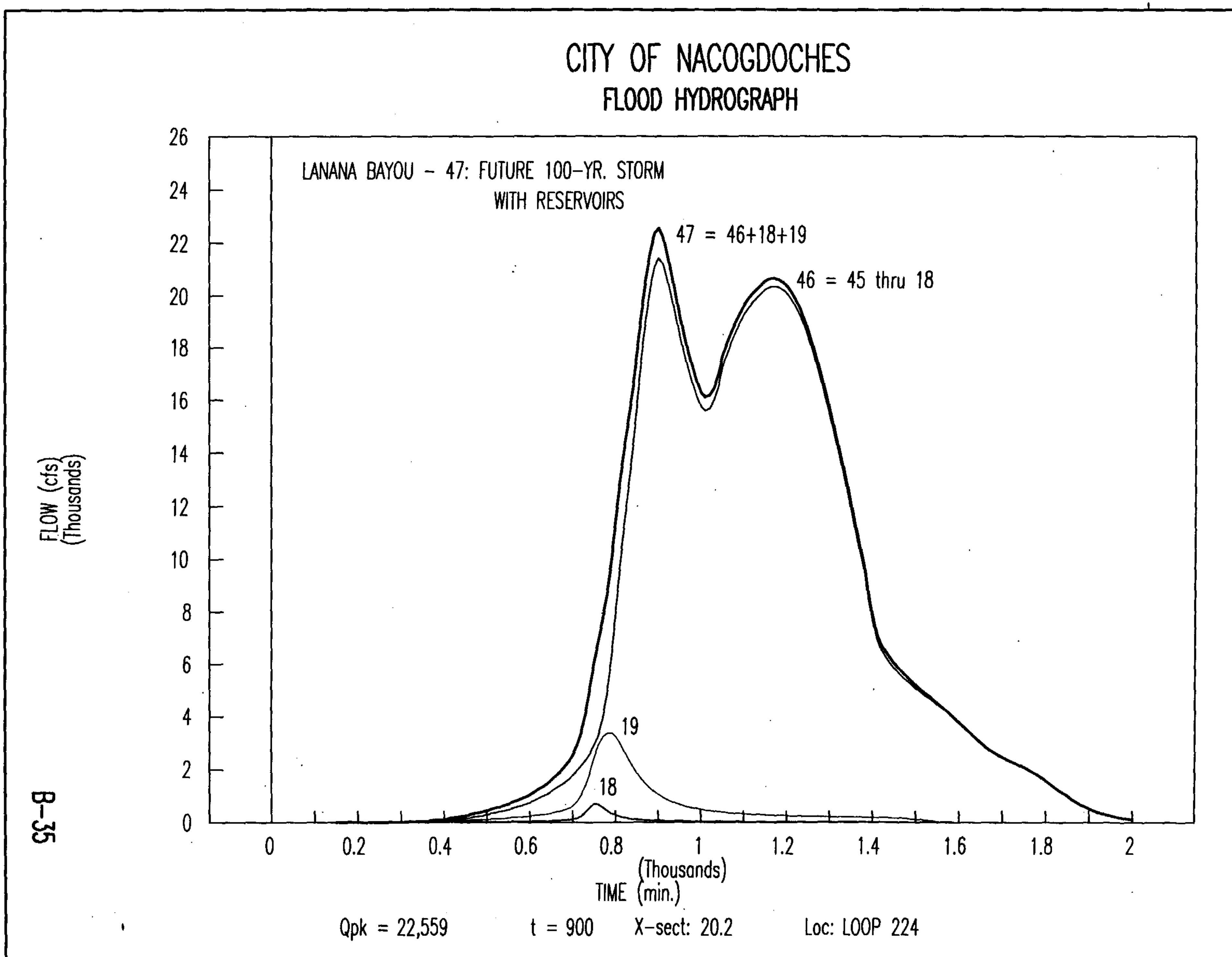
Loc: LANANA & BANITA



CITY OF NACOGDOCHES
FLOOD HYDROGRAPH
LANANA BAYOU - 47: FUTURE 100-YR. STORM
WITH RESERVOIRS
47 = 46+18+19
46 = 45 thru 18
19
18
FLOW (cfs)
(Thousands)
TIME (min.)
(Thousands)
0
2
4
6
8
10
12
14
16
18
20
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24
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0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
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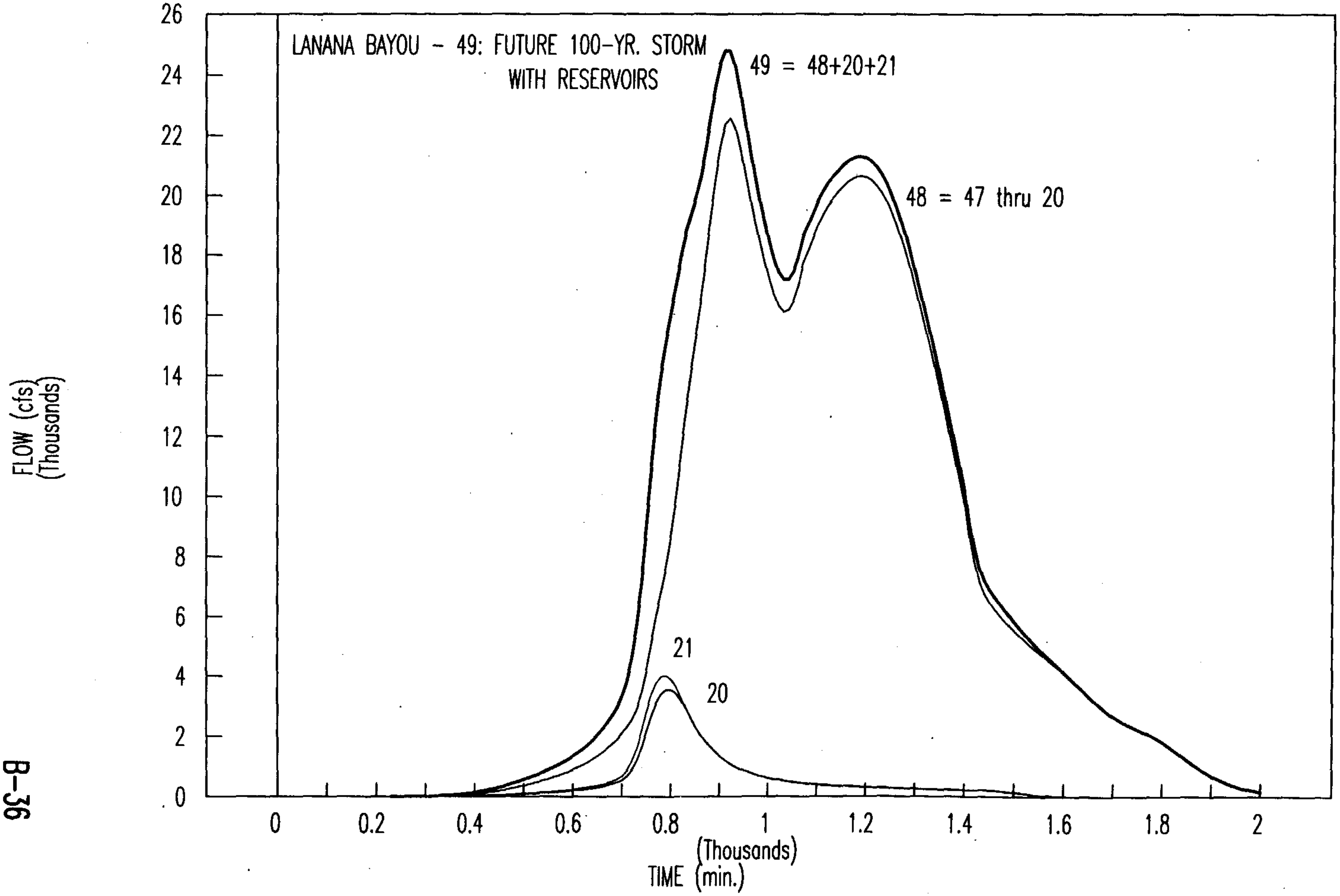
Loc: LOOP 224

CITY OF NACOGDOCHES
FLOOD HYDROGRAPH



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DMG

Evaluation of the Feasibility to Establish a Municipal Drainage Utility System for Nacogdoches, Texas

DRAFT

August 1995

DRAFT

DAVID M. GRIFFITH & ASSOCIATES, LTD.
Professional Services for the Public Sector
13601 Preston Road, Suite 400W
Dallas, TX 75240
(214) 490-9990

DMG

DAVID M. GRIFFITH & ASSOCIATES, LTD.
Professional Services for the Public Sector
13601 Preston Road, Suite 400 W
Dallas, Texas 75240
214•490•9990 Fax: 214•490•3040

August 9, 1995

DRAFT

Mr. Gordon Pierce
City Manager
City of Nacogdoches
202 East Pilar
Nacogdoches, TX 75963

Dear Mr. Pierce:

Enclosed is the draft of the final report titled, **Evaluation of the Feasibility to Establish a Municipal Drainage Utility System(MDUS)**, prepared by David M. Griffith & Associates, Ltd.(DMG). The report conveys the finding of our firm with respect to the establishment of a MDUS.

The report contains seven sections. Section I provides an executive summary that includes the key highlights of the study. Section II gives an overview of the objectives achieved with the analysis, as well as the process used to perform the engagement. Section III establishes the background and legal basis that authorizes cities to declare their stormwater management function a public utility and to establish dedicated user fees. Section IV explains the different levels of stormwater drainage costs DMG identified. Section V describes the results of our parcel analysis. Section VI provides revenue scenarios needed to fund the different levels of costs identified by DMG. Finally, Section VII contains the implementation plan we recommend to establish the MDUS.

We believe that the underlying assumptions provide a reasonable basis for management's forecast. However, some assumptions inevitably will not materialize and anticipated events and circumstances may not occur; therefore, the actual results achieved during the forecast periods will vary from the forecast, and the variations may be material.

We have appreciated the courtesies and professional relationships extended to us during this engagement by City management, staff, and the Commission.

Very truly yours,

Walt Huelsman

Walter Huelsman

TABLE OF CONTENTS

City of Nacogdoches
Evaluation of the Feasibility
to Establish a
Municipal Drainage Utility System(MDUS)
Draft Final Report

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Nacogdoches, TX has principal responsibility for stormwater management within its jurisdiction. This management responsibility allows the City to coordinate overlapping influence from Federal, State, and local government on watershed and runoff and environmental impacts on water quality. Stormwater management, within the context of this report, is concerned with one primary objective, which is to protect the health and welfare of the citizens from flooding conditions.

1.1.1 Problem Statement

The current level of ad valorem tax funding is inadequate to address the backlog of stormwater facility needs for stormwater drainage issues on a City wide basis. This municipal stormwater drainage utility system(MDUS) feasibility report is intended to develop a rationale and implementation funding plan for a comprehensive Stormwater Management Utility program.

1.1.2 The MDUS Concept

The MDUS concept was developed to provide a dedicated revenue source for funding stormwater management programs on a Citywide basis. The critical element in establishing a utility is fairness and equity in assuring that the benefits received are consistent with the allocation of cost.

1.1.3 Purpose of Report

The purpose of this report is provide the City Commission of Nacogdoches, Texas with information to make decisions related to the implementation of a Citywide Stormwater Management Utility(MDUS).

1.2 THE LEGAL FRAMEWORK

Findings related to the legal framework are as follows. The MDUS Act of 1987 and its subsequent amendments authorizes cities in Texas to establish MDUS utilities. This is not another layer of government, but is simply an enterprise fund, similar to the water and sewer fund. The MDUS Act authorizes Cities to establish user charges based on a methodology directly related to drainage and the levy must be nondiscriminatory, equitable, and reasonable. Charges can only be levied on developed property. The income from the user charge must be segregated and completely identifiable in City accounts, although operating and maintenance expenditures can remain to be budgeted and accounted for in the general fund. Any debt, however, that is sold using the MDUS user charges as a pledged revenue, must be budgeted for and accounted for within the accounts of the MDUS enterprise fund. Furthermore, the MDUS act gives cities the authority to exempt from the user charges federal, state, county, and school district properties.

Our survey of thirteen of the sixteen MDUS in Texas showed that few exempt any developed property within city limits. All billed the user charges monthly. All billed the user charge as an additional line on the water, sewer, and garbage bill, and charged penalty and interest equivalent to what they charged the water, sewer, and garbage customers.

1.3 COST OF SERVICE FINDINGS:

Costs associated with three levels of service were identified. These were:

- **Level 1 - Existing Level of Service.** Continue the maintenance level as it presently exists. Make no material improvements to the drainage system. The level of costs currently spent on drainage is about $250,000.

- **Level 2 - Enhanced Level of System Maintenance.** Provide the additional personnel and equipment needed to double the frequency of maintenance activities, and spend approximately $300,000 on small improvement projects to alleviate the most pressing drainage problems. The enhanced level of cost is about $378,879.

- **Level 3 - Funding of Capital Improvement Program.** Funding support for debt-financing of the drainage improvements identified by the Regional Stormwater Master Plan to minimize the effects of a 100 year storm event are implemented. Funding of the initial phase of the $20.768 capital improvement program through a $10.0 million dollar debt issue will be about $793,379 per annum.

1.4 CUSTOMER BASE FINDINGS

Preliminary findings related to the identification of the customer base for the user charges were:

- The preliminary value of an ERU is calculated to be 2,246 sq.ft. of impervious area.

- The total number of ERU's(preliminary) in the City is determined to be 14,213 with the institutional class and 11,853 without.

1.5 RESULTS OF THE REVENUE SCENARIOS

Table 6-1 from section VI presents the annual revenue potential at monthly rates ranging from $1.00 to $10.00 per ERU.

Table 6-1
Projected Annual MDUS Utility Revenues

Monthly Rate	With Institutions 14,213 ERUs	Without Institutions 11,853 ERUs
$1.00	$170,556	$142,236
2.00	341,112	284,472
3.00	511,668	426,708
4.00	682,224	568,944
5.00	852,780	711,180
6.00	1,023,336	853,416
7.00	1,193,892	995,652
8.00	1,364,448	1,137,888
9.00	1,535,004	1,280,124
10.00	1,705,560	1,422,360

As the result of discussions with staff, a decision was made to continue to fund service level 1 costs from the general fund during the initial establishment of the MDUS(1-5 years). Therefore, the required monthly rates per ERU to fund service levels 2 and 3 are:

Table 6-4
(Inserted from Section VI)
Summary of Findings - Revenue Scenarios

Service Level	With Institutions	Without Institutions
Estimated ERUs	**14,456**	**11,972**
Service Level 2:		
Monthly Charge:		
per ERU	**$2.25**	**$2.72**
Single Family:		
Less than 2,000 sq.ft.	**1.67**	**2.01**
2,000 sq. ft. & Greater	**3.24**	**3.92**
Service Level 3		
(includes Level II:		
Monthly Charge:		
per ERU	**$6.75**	**$8.23**
Single Family:		
Less than 2,000 sq.ft.	**5.00**	**6.09**
2,000 sq. ft. & Greater	**9.72**	**11.85**

1.5 MDUS IMPLEMENTATION PROGRAM - DECISIONS TO BE MADE

There are six steps involved in implementing a MDUS.

1) Develop a stormwater public awareness/education program.

2) Establish policies, procedures, and rules needed to implement a MDUS.

3) Develop an accurate customer/parcel database and billing system.

4) Provide a more accurate user charge for implementation.

5) Approve an ordinance declaring the stormwater management function a public utility.

6) Approve an ordinance establishing rates, etc.

Before the City Commission authorizes DMG to proceed to Phase II of the study, we respectfully request the City Commission to decide the following:

1) Should Nacogdoches establish a MDUS?

2) What level of service should initially be funded with the user fee?

3) Should some or all of the inistitutional class be included in the customer base?
   - State properties(SFA);
   - County properties;
   - School District properties;

4) Should a two-tiered residential rate, i.e., less than 2,000 sq.ft. vs., greater than 2,000 sq. ft. be established?

II. INTRODUCTION

2.1 STUDY OBJECTIVES

This report contains the findings related to the feasibility of establishing a Municipal Drainage Utility System(MDUS) for the City of Nacogdoches. The study was authorized by the City Commission to accomplish the following objectives:

- **Research the Legal Framework** - provide the support information and documents necessary, including a draft stormwater ordinance, to establish the legal framework for the City to develop a MDUS;

- **Identify the Cost of Service** - identify the cost of existing and future stormwater drainage services to be provided by the City of Nacogdoches:
  - existing level of service;
  - enhanced level of service;
  - cost of implementing first phase of master plan improvements

- **Estimate the Customer Base** - provide a preliminary estimate of the total quantity of impervious area of developed property within the City limits of Nacogdoches:
  - a preliminary estimate of the square footage to assign to an ERU;
  - a preliminary estimate of the number of ERUs with and without institutions
  - what will need to be done in Phase II to provide a more accurate count of ERUs

- **Develop the Revenue Scenarios** - Illustrate to the Commission the impact of the user charge funding of the different service levels;

- **Report Findings** - prepare and present a feasibility report which will summarize the data gathered and analyses performed.

2.2 FEASIBILITY STUDY PROCESS:

DMG has reviewed the stormwater management program needs of the City of Nacogdoches, Texas. DMG staff invested significant time in the investigation and understanding of stormwater management problems in the City. DMG met with the **City Manager, City Engineer, and the Public Works** Department staff to fully understand the issues facing the City. On the basis of this understanding and work, DMG has used a thorough project approach which addresses every aspect of the program to finance stormwater management expenses thorough a user fee alternative to the current ad valorem tax revenue. The evaluation focused primarily on the feasibility of establishing a MDUS to provide a dedicated funding source through the collection of user fees. The concept is based on establishing a fair and equitable funding method based on the impervious area of developed properties contributing to the stormwater drainage problems.

III. THE LEGAL FRAMEWORK

3.1 INTRODUCTION

The purpose of this section is to report the results of DMG's review of all existing state statutes and municipal ordinances relating to the establishment of a MDUS in Texas. DMG updated our 1994 review of stormwater ordinances used by other Texas cities. Following is the results of our review and analysis.

3.2 BACKGROUND

Stormwater drainage maintenance and improvements historically has been provided by government and funded through ad valorem taxes. The rationale for property tax funding is that higher-priced properties benefit more from stormwater drainage runoff management since they have a higher investment to protect, and therefore they shall pay in proportion to their value(investment).

With the utility approach of funding stormwater drainage runoff management through a user fee, the cause of the runoff is emphasized. Individual property owners are viewed as stormwater drainage runoff generators, and the role of the government is to control the discharges. Therefore, property owners pay user fee charges in amounts proportional to their discharges. Neither property values and the ability to pay nor perceived benefits and willingness to pay generally are considered.

There are three definitions that have evolved as a result of the user fee approach that have provided the legal framework for the establishment of a MDUS:

- *Users* are properties that generate stormwater drainage runoff to a system;
- *Beneficiaries* are properties that gain from stormwater drainage runoff management and control;
- *User charges* are dedicated fees paid by the generators of stormwater drainage runoff in proportion to the amount of runoff that leaves their property.

The establishment of a MDUS is the practical application of these definitions. The legal standard has been summarized as:

> Charges must be fair and reasonable and bear a substantial relationship to the cost of service and facilities[1].

This standard is important, since it says that localities must have a rational basis for making estimates of runoff contributions, but that runoffs from parcels need not be measured precisely. Reasonably accurate estimates will suffice. Equally important, user fees shall be based on costs, not benefits.

3.3 MUNICIPAL DRAINAGE UTILITY SYSTEMS ACT - THE LEGAL FRAMEWORK IN TEXAS

[1] Cyre, Hector J. "Developing and Implementing a Stormwater Management Utility". Paper presented at the International Public Works Congress and Equipment Show, New Orleans, LA., September 23, 1986.

III. THE LEGAL FRAMEWORK

Prior to the implementation of a MDUS, municipalities must adopt legislation that specifies the scope of the MDUS's activities, it's rate structure and charges, details of billing, penalties for late charges and non-payment, and other items. In Texas, the Municipal Drainage Utility Systems Act of 1987 provides the framework that authorizes municipalities to establish a MDUS.

The Municipal Drainage Utility Systems Act, Acts, 1987, 70th legislature, effective September 1, 1987, gave Texas cities with populations greater than 20,000 the authority to establish a municipal drainage utility system within the boundaries of the municipality, provide rules for the use, operation, and financing of the system, and to prescribe bases on which a MDUS may be funded .

Subchapter C of Local Government Code 402, pertaining to municipal drainage utility systems, was amended in 1989, to, among other things, eliminate the 20,000 population restriction. The subchapter C was further amended in 1991 to exempt from the regulations:

- property with proper construction and maintenance of a wholly sufficient and privately-owned drainage system;

- property held and maintained in its natural state, until such time that the property is developed and all of the infrastructure has been accepted by the municipality for maintenance; and

- a subdivided lot, until a structure has been built on the lot and a certificate of occupancy has been issued by the municipality having jurisdiction to adopt this subchapter and declare the drainage of the municipality to be a public utility.

- The 1991 amendment also gave permission to the municipality to exempt from the MDUS the state, county, municipality , and the school district users.

Furthermore, the subchapter authorizes the MDUS:

- to issue drainage improvement bonds;

- to establish a schedule of drainage charges against all real property subject to charges under the subchapter;

The municipality may charge a benefited property on any basis other than the value of the property, but the basis must be directly related to drainage and the levy must be nondiscriminatory, equitable, and reasonable. In assessing the charges to the property, the municipality may consider the size, in area, the topography, of the benefited property, and may change, adjust, and readjust the rates and charges from time to time.

The income from a MDUS must be segregated and completely identifiable in municipal accounts. Operations and maintenance(O&M) expenditures can remain budgeted and accounted for in the general fund, and the municipality may transfer the revenue to the general fund to reimburse for these O&M expenditures, except for that part pledged to retire any outstanding indebtedness, or, as a reserve for future construction, repair, or maintenance of the drainage system, or to fund future system improvements, including the replacement, new construction, or extension of the drainage system.

3.4 REPORT ON DMG'S SURVEY OF MDUS IN OTHER TEXAS CITIES

Thirteen of the seventeen cities in Texas that have MDUSs were surveyed and ordinances collected as part of this study process. The following key points can be summarized from our review:

- All of the MDUSs surveyed quoted Chapter 402, Subchapter C, as authority to establish the MDUS;
- All of the MDUSs surveyed billed the user fees monthly;
- Penalty and interest is equivalent to what is charged water and sewer customers;
- All utilities surveyed used the cutoff of other utilities such as water, sewer, and garbage as enforcement for non-payment.
- Some of the cities actually billed the persons shown on the water meter billing.

Table 3-1 summarizes which classifications of property is exempted:

Table 3-1
Summary of Properties Exempted from Stormwater Charges

	City-Owned Property	County-Owned Property	School-Owned Property	State-Owned Property
Allen	Exempt	Exempt	Exempt	Exempt
Arlington	Non-exempt	Non-exempt	Non-exempt	Non-exempt
Austin	Exempt	Exempt	Exempt	Exempt
Dallas	Non-exempt	Non-exempt	Non-exempt	Non-exempt
DeSoto	Exempt	Exempt	Exempt	Exempt
Euless	Non-exempt	Non-exempt	Non-exempt	Non-exempt
Gainesville	Non-exempt	Non-exempt	Non-exempt	Non-exempt
Garland	Non-exempt	Non-exempt	Exempt	Non-exempt
Irving	Non-exempt	Non-exempt	Non-exempt	Non-exempt
Lubbock	Exempt	Exempt	Exempt	Exempt
Mesquite	Non-exempt	Non-exempt	Non-exempt	Non-exempt
Plano	Non-exempt	Non-exempt	Non-exempt	Non-exempt
San Antonio	Non-exempt	Non-exempt	Non-exempt	Non-exempt

Finding:

Only 5 out of the 13 cities surveyed exempted some or all governmental entities. Austin exempts the University of Texas but Arlington does not exempt the University of Texas at Arlington.

III. THE LEGAL FRAMEWORK

Several of the cities surveyed said that their legal departments determined the drainage fee is just like water and sewer and that the non-payment of one fee can cause the others to be shut-off. Note - DMG will provide for the City a sample copy of an ordinance under separate cover.

Plan of Action - Decisions to be Made:
Since the MDUS statute gives Cities the authority to exempt County, State, and School properties from the user charge, the City Commission must decide if any of these categories should be exempted.

IV. COST OF SERVICE

4.1 INTRODUCTION

The purpose of this section is to provide the results of our analysis of the existing and future stormwater management costs. The existing and proposed stormwater drainage management programs for Nacogdoches, TX have been reviewed with City staff. The objective of the review was to develop an understanding of the City's long-term stormwater management program needs and to estimate the revenue, staffing, and organization required to meet the needs.

Preliminary capital improvement costs have been provided to DMG as a result of a Regional Stormwater Master Plan that is in the process of being finalized by the engineering firm of Schaumburg and Polk, Inc.

In order to estimate the total annual cost of the stormwater program to be undertaken by the MDUS under consideration, DMG first determined the levels of service which are to be provided in order to provide a framework for decision-making. It should be noted that the costs identified as eligible to be funded within the MDUS do not constitute a new level of government. Costs associated with service level 1, for example, are costs that are currently expended in various departments which will be described in this section.

After some evaluation and discussion with staff, three levels of service were analyzed. These are:

- **Level 1 - Existing Level of Service.** Continue the maintenance level as it presently exists, provide reimbursement to other departments, including and allocation of indirect costs for drainage - related activities, and make no material improvements to the drainage system.
- **Level 2 - Enhanced Level of System Maintenance.** Provide the additional personnel and equipment needed to double the frequency of maintenance activities, and spend approximately $300,000 per year more on small improvement projects to alleviate the most pressing drainage problems.
- **Level 3 - Funding of Capital Improvement Program.** Funding support for debt-financing of the implementation of the drainage improvements identified by the Regional Stormwater Master Plan to minimize the effects of a 100 year storm event.

Each of these service levels carry different price tags and consequently result in different drainage fees, discussed in Section VI.

4.2 SERVICE LEVEL 1 - EXISTING LEVEL OF SERVICE

4.2.1 Public Works

The Department of Public Works has the primary responsibility of existing stormwater facility operation and maintenance activities. This responsibility is currently assigned to the Street Department within Public Works. Stormwater routine maintenance problems are addressed through an allocation of Street Department crews and equipment on an as-needed basis. The Street Department also is responsible for the maintenance of the extensive network of City roads and bridges throughout the City and, due to a limited budget and the health and safety concerns associated with proper transportation facilities, stormwater issues may often receive secondary priority until heavy rainfall occurs.

There is no firm schedule for periodic maintenance of existing facilities and the Street Department's resources are typically assigned to stormwater management problems in response to complaints from the public and when rainfall dictates emergency cleanup response. The lack of funding and the increasing demands on departmental resources for both transportation facilities and stormwater systems has led to reduced service. These conditions have opened the door to potential criticism of City officials when recurrent stormwater problems are not resolved in a timely manner.

4.2.2 Street Department Services

The Street Department staffing is organized into two crews, one devoted entirely to street work, with the other crew averaging 25% of its time on drainage maintenance activities.

4.2.3 Engineering Services

The Engineering Department presently provides some drainage-related services. The Engineering Department performs development reviews, as well as construction inspection of drainage facilities. Furthermore, the Engineering Department is involved in administering the Street Capital Improvement Fund, which involves drainage improvements, as well as street improvements. The drainage improvement projects involve administering work on a list of projects that will minimize local flooding, reduce potential damage to private property and/or reduce maintenance costs. These projects will henceforth be referred to as "The Hit List".

4.2.4 Street Improvement Fund Drainage Improvements

In addition to drainage maintenance services performed by the Street Department, the Engineering Department oversees drainage improvements currently funded through ad valorem taxes levied specially for street and drainage improvements and accounted for in the Street Improvement Restricted Cash Fund.

Table 4-1
Recap of Existing Service Level Costs

Cost Center	Service Level 1 Costs
Engineering	**$ 7,382**
Public Works	**6,176**
Street Department	**189,763**
Street Imp. Fund	**47,106**
Total	**$250,427**

The current cost of the City's drainage operations is estimated to be about $250,000. Table 4-1 shows this amount is made up of $189,763 in the Street Department budget, an estimated $47,106 in expenditures by the Street Improvement Fund, $6,176 by the Public Works Department, and $7,382 in the Engineering Department.

4.3 SERVICE LEVEL 2 - ENHANCED LEVEL OF SYSTEM MAINTENANCE

The enhanced stormwater management program consists of the addition of 1 equipment operator and 1 laborer. Furthermore, the financing of a jet cleaning truck for inlet cleaning and street cleaning is included. This shall double the frequency of inlet cleaning to quarterly and will provide a vehicle for street cleaning that is non-existent now. This effort is based on an estimated 1,600 drainage inlets.

Table 4-2
Recap of Enhanced Service Level Costs
(Service Level 2)

Cost Center	Service Level 2 Costs
Equip. Operator	**$20,250**
Laborer	**15,141**
Fringes	**13,813**
Jet Cleaning Truck	**29,675**
Hit List	**300,000**
Total Annual Cost	**$378,879**

The cost of the jet cleaning truck is $125,000 which is to be lease-purchased over a seven year period for $29,675 annually. Finally, Service Level 2 consists of spending an additional $300,000 annually on the "hit list", which, as mentioned in a previous section, is a list of storm drainage improvement projects that will eliminate localized flooding.

4.4 SERVICE LEVEL 3 - FUNDING OF CAPITAL IMPROVEMENT PROGRAM

The firm of Schaumburg and Polk has identified a $20.768 million dollar capital improvement plan (preliminary) which is the result of a regional stormwater drainage master plan

Service level 3 consists of spending an additional $793,379 annually on debt service to finance about $10,000,000 of those projects identified as A1 or A priorities in the regional stormwater master plan. It should be noted that this is not the only approach to phasing in projects, but it is a feasible approach, since the master plan indicates that the drainage reservoirs (ranked A1) need to be part of the initial implementation of the capital improvement plan(CIP). These costs may change with the finalization of the master plan by Schaumburg and Polk.

Table 4-3
Stormwater Drainage Capital Improvement Plan

Description	Total CIP Costs	Rank	Bond Issue 1	Bond Issue 2
I. Reservoirs				
LaNana Reservoir # 1	$2,082,000	A1	$2,082,000	
LaNana Reservoir # 2	2,463,000	A1	2,463,000	
Bonita Reservoir	2,544,000	A1	2,544,000	
subtotal	$7,089,000		$7,089,000	
II. Selected Crossings				
Group A	$1,535,100	A	$1,535,100	
Group B	1,347,800	B		1,347,800
Group C	1,014,700	C		1,014,700
Group D	328,600	D		328,600
Group E	452,800	E		452,800
subtotal	$4,679,000		$1,535,100	$3,143,900
III. Other Selected Crossings	$4,000,000	E		$4,000,000
IV. Internal Storm Sewers	$2,000,000	A	$1,000,000	1,000,000
V. Channel Improvements	$3,000,000	E		$3,000,000
Total Estimated Costs	$20,768,000		$9,624,100	$11,143,900

Projects were staged A-E, with the bond issues timed approximately 5 years apart. The A1 projects are the reservoirs. A projects are those that will have the most immediate impact. Schaumburg and Polk have informed us that the most effective way to minimize the flooding problems in Nacogdoches is to build the drainage reservoirs. B projects are those that the City has identified as historically having flooding problems. C, D and E projects are comprised of several projects that will be further defined by the time Schaumburg and Polk finalize the master plan.

Summary of Findings:
The City is currently spending approximately $250,000 per year on stormwater maintenance. Furthermore, DMG identified an additional $378,000 in enhanced system maintenance costs as service level 2. Finally, the impact of funding the CIP established by the preliminary master plan under one scenario devised by DMG, and funded by debt, is about $794,000 annually.

Decisions to be made by City Commission:
The City Commission should decide which level of service, or combination of levels of service will be incorporated into the establishment of the initial user charge for the MDUS.

V. CUSTOMER BASE

5.1 INTRODUCTION

The purpose of this section is to describe the approach that was taken to provide:

- a *preliminary* estimate of the total amount of developed impervious area in the City,
- the value to assign to an Equivalent Residential Unit(ERU), and
- the total number of ERUs of impervious area within the City limits of Nacogdoches.

Multiple factors influence the characteristics of stormwater runoff exiting a particular parcel of land. These factors include parcel size, soil type, topography, amount of impervious area, and the parcel's development intensity. Analysis of extreme rainfall events used in stormwater management planning and design has shown that the amount of impervious area is the most important parameter affecting the quality and quality of stormwater runoff. Since this value is easily quantified, rate policies developed for MDUS utilities usually focus on the amount of impervious area of a parcel. Impervious area refers to surfaces covered with material (rooftops, pavement, etc.) that is highly resistant to the infiltration of water.

5.2 DETERMINATION OF THE AVERAGE IMPERVIOUS SQUARE FOOTAGE

Preparation of the *preliminary* estimate of the number of equivalent residential units(ERU) involved the use of data from several sources. A sample of the (Nacogdoches County Central Appraisal District)NCCAD tax rolls was performed, which enabled us to estimate the total quantity of impervious square footage in the City. The sample results are provided in Table 5-1.

Table 5-1
Determination of Average Impervious Square Footage

Landuse	Sample Sq. Ft.	÷	Sample Parcels	=	Sample Average Sq. Ft.	+	Additional Impervious Sq. Ft. per Parcel	=	Total Sample Average Impervious Sq. Ft
Single-Family:									
Less than 2,000 sq.ft.	434,105	÷	334	=	1,300	+	364	=	1,664
2,000 sq.ft. & Over	559,847	÷	194	=	2,886	+	364	=	3,250
subtotal	993,952	÷	528	=	1,882	+	364	=	2,246
Multi-Family	72,680	÷	43	=	1,690	+	324	=	2,014
Residential with Acreage	20,058	÷	8	=	2,507	+	364	=	2,871
Commercial	516,771	÷	81	=	6,380	+	4,134	=	10,514
Industrial	432,383	÷	20	=	21,619	+	14,009	=	35,628
Total without Institutional	2,035,844		680						
Institutionalal	5,300,329	÷	n/a	=	5,300,329	+	n/a	=	5,300,329
Total with Institutional	7,263,493								

V. CUSTOMER BASE

The following paragraphs describe our findings and analysis relative to the amount of building and pavement area within each of the various land use categories.

5.2.1 Single-Family

As shown in Table 5-1, the average single family structure in our sample contains 1,882 square feet(preliminary). In order to develop an estimate of the amount of paved driveway area, we drove through much of the City's single family residential areas.

From our observations, and from similar observations made in other studies of this nature performed by DMG, we concluded that the average home had an average paved driveway area of 364 square feet, making the total impervious area per dwelling unit of 2,246 square feet.

Note that our sample divided the single-family class into those that had an average impervious area of less than 2,000 sq.ft., and those that had 2,000 sq.ft. or more. The purpose behind this segregation is to give the Council the information necessary to decide if the single-family rate should vary, based upon the size of the structure.

Finding - the average impervious area per single-family dwelling unit in Nacogdoches is 2,246 square feet, which includes driveways. Therefore, 1 ERU = 2,246 square feet. The number of ERUs for the single-family class can be calculated:

Single family less than 2,000 sq.ft. = 1,664 sq.ft. ÷ 2,246 = .74 ERU
Single family 2,000 sq.ft. or greater = 3,250 sq.ft. ÷ 2,246 = 1.44 ERU

5.2.2 Multi-Family

The average impervious area per multi-family parcel was 2,014 sq.ft., which includes an additional 324 feet per parcel for sidewalks, swimming pools, roads, etc. The average additional impervious square feet per multi-family parcel is based on averages in other studies of this nature DMG has performed.

5.2.3 Commercial

Developed, nonresidential property is a very important customer class for any stormwater utility since a significant portion of utility revenue will be associated with these classes. In the City of Nacogdoches, the nonresidential customer classes make up only 11% of the total number of developed parcels, but contribute almost 50% percent of the impervious area. Our preliminary estimate of the commercial class, based on our sample, was 21,619 sq.ft. per parcel. An additional 35% of impervious area was added to allow for parking lots, etc., based on industry averages. It should be noted that in Phase II-Implementation, much of the work will involve the determination of the actual square footage of impervious area of multi-family, commercial, and all of the non-residential classes.

5.2.4 Industrial

DMG sampled 100% of the 20 industrial parcels in the City because of the high average impervious area contributed by each parcel.

5.2.5 Institutional

A total of 5,300,329 sq.ft. of impervious area is identified in this class, which consisted of state, county, and school district developed parcels.

5.3 DETERMINATION OF TOTAL IMPERVIOUS SQUARE FOOTAGE

Once the *preliminary* average impervious area was determined from the samples, we were then able to estimate the total amount of impervious area in the City, and from that the total number of ERUs with and without the Institution class. The results follow on Table 5-2:

Table 5-2
Determination of Total Impervious Square Footage in City

Landuse	Total Sample Average Impervious Sq. Ft	x	Total Parcels	=	Total Impervious Sq. Ft.	÷	Square Feet in One ERU	=	Total Number of ERUs
Single-Family:									
Less than 2,000 sq.ft.	1,664	x	n/a	=	n/a	÷	n/a		n/a
2,000 sq.ft. & Over	3,250	x	n/a	=	n/a	÷	n/a		n/a
subtotal	2,246	x	6,968	=	15,650,128	÷	2,246	=	6,968
Multi-Family	2,014	x	303	=	610,242	÷	2,246	=	272
Residential with Acreage	2,871	x	116	=	333,036	÷	2,246	=	148
Commercial	10,514	x	886	=	9,315,404	÷	2,246	=	4,148
Industrial	35,628	x	20	=	712,560	÷	2,246	=	317
Total without Institutional					26,621,370		2,246		11,853
Institutional	5,300,329	x	1	=	5,300,329	÷	2,246	=	2,360
Total with Institutional	7,263,493				31,921,699				14,213

Findings:

Table 5-2 shows there are an *estimated* 14,213 ERUs of impervious area in the City limits of Nacogdoches with the Institutional class and without, 11,853.

Plan of Action:

As indicated previously, before the MDUS is implemented there will need to be a more accurate determination of the parking and driveway areas for commercial, industrial, and institutional properties in order to finalize the number of ERUs.

It should be noted that many of the agencies that currently have MDUS systems have used GIS systems to accurately determine parking and driveway areas. Furthermore, as mentioned in Section III, a decision will have to be reached by the Commission as to whether tax-exempt property, i.e. Federal properties, County properties, School District Properties, and SFA University will be subject to the drainage fee.

VI. REVENUE SCENARIOS

6.1 INTRODUCTION

The revenue scenarios presented in this section are examples developed to illustrate the initial financial capabilities of the MDUS and rates that will be necessary to recover the costs of each service level presented in Section IV-Cost of Service. Costs, revenues, and the rates have been projected in this section over a five-year period. Assumptions made in developing the revenue scenarios are presented in the following subsections.

6.2 WHY NOT PROPERTY TAXES?

Every community in the country is forced to deal with stormwater runoff created when the soil cannot absorb the moisture created by rainfall. As mentioned in a previous section, stormwater management has historically been financed with revenues generated by ad valorem taxes. There are various reasons why local governments have moved away from ad valorem taxes as a revenue source for stormwater management financing and to user fees.

- **User fees are a dedicated source of revenues** - the stormwater function, when financed through ad valorem taxes, competes with other governmental services considered by many to be more important to the general welfare of local governments. Examples are the fire and police services. *Dedicated* means that the user charges or fees can *only* be used for stormwater management. A long-term stormwater management program cannot be effective unless it has a consistent, dedicated source of revenues on which it can rely. Stormwater projects and programs often take years to complete and require long-term planning and funding. Drainage problems are usually caused by singular incidents or seasonal storms and can be forgotten about until the occurrence of these events again increase public awareness of the need to manage drainage. When the stormwater management problem competes with other, more politically powerful general governmental services, funding may suffer or be inconsistent. A user fee funded program can budget programs and projects based on a realistic and dependable revenue stream with a well planned schedule.

- **User fees can be more equitable than ad valorem taxes** - Stormwater drainage runoff is largely a problem for which property owners and users are responsible, since improvements to their properties increase impervious area, and therefore increase the volume of rainfall that cannot be absorbed into the ground. With the user charge approach, individual property owners and users are viewed as generators of drainage runoff who should pay user charges in proportion to their stormwater runoff contribution, i.e., the estimated amount of water that leaves their property, regardless of property values or perceived benefits.

  An example of the contrast between ad valorem tax funding and user charge funding is as follows. The example will consist of two homeowners with homes that are approximately the same impervious area, 2,000 sq.ft., but one is much older than the other and therefore valued on the property tax rolls at $50,000 vs. $100,000 for the newer one. With a user charge approach, both homes will pay the same monthly user charge. With ad valorem taxes, the newer home valued at twice the value of the older home will pay twice as much property taxes, although each contributes an equal share of stormwater runoff.

6.3 REVENUE ASSUMPTIONS

Several assumptions have been made in developing the revenue scenarios. Only developed property will be considered for the MDUS. Vacant property will not be billed. Agricultural property containing only a house and related structures will only be charged as a single family residential parcel. Other agricultural parcels that are utilized for commercial purposes will be billed for only the impervious area contained on the property. Since the water, sewer, and solid waste bad debt collection rate is less than 1% of revenues billed, revenue projections assume a 100% collection rate. Table 6-1 presents the annual revenue potential at monthly rates ranging from $1.00 to $10.00 per ERU.

Table 6-1
Projected Annual MDUS
Utility Revenues

Monthly Rate per ERU	With Institutions 14,213 ERUs	Without Institutions 11,853 ERUs
$1.00	$170,556	$142,236
2.00	341,112	284,472
3.00	511,668	426,708
4.00	682,224	568,944
5.00	852,780	711,180
6.00	1,023,336	853,416
7.00	1,193,892	995,652
8.00	1,364,448	1,137,888
9.00	1,535,004	1,280,124
10.00	1,705,560	1,422,360

6.4 COST ASSUMPTIONS

Annual operations and maintenance expenditures are based on our understanding of the City's budget as of FY 94-95. Salaries and benefits are assumed to grow by 4% per annum and all other operations and maintenance costs are assumed to grow by 3% per annum.

6.5 REVENUE AND COST COMPARISONS - SERVICE LEVEL 2

Table 6-2 displays the estimated costs of the City's enhanced stormwater management program over a five-year period and lists the monthly user fee to cover those costs. Based on discussions with the City Manager and Mayor, this scenario assumes the following:

- The City will continue to fund the service level 1 costs of Engineering, Public Works, Streets, and Street Improvements out of the ad valorem tax rate during the first five years;

- Any additional costs associated with the billing of stormwater drainage user fees will be funded out of the water and sewer fund, since the costs associated with this activity are expected to be minimal;

- In addition to the revenues generated from MDUS fees, any surplus generated is carried forward to the next fiscal year to minimize additional MDUS fee increases and to build operating reserves;

- The City will continue to fund the service level 2 enhanced level of maintenance out of the drainage user fee;

Table 6-2
Projection of Revenues & Expenditures
Service Level 2 Cost Funding Scenario

Item	FY 96	FY 97	FY 98	FY 99	FY 2000
ERUs(with institutions)	14,313	14,456	14,601	14,747	14,894
Monthly Rate per ERU		$2.25	$2.25	$2.25	$2.25
Sources of Funds:					
MDUS Fees		$390,312	$394,227	$398,169	$402,138
Uses of Funds:					
Salaries & Fringes		$49,204	$51,173	$53,219	$55,348
Lease Payments		29,675	29,675	29,675	29,675
Hit List Projects		300,000	300,000	300,000	300,000
Total Service Level 2		$378,879	$380,848	$382,894	$385,023
Sources minus Uses		11,433	13,379	15,275	17,115

Assumptions:
14,313 ERUs increasing 1% per annum.
MDUS User Fee of $2.25 per ERU per month:
Single-family residential less than 2,000 sq. ft. will be $1.67 per unit per month
Single-family residential 2,000 sq.ft. or larger will be $3.24 per unit per month.
Institutions will be included.

6.6 REVENUE AND COST COMPARISONS - SERVICE LEVEL 3

Table 6-3 presents a scenario where capital improvements identified by Schaumburg & Polk Consulting Engineers are financed through bonds. This scenario assumes the following:

- A bond issue of $10.0 million dollars will be issued in Year 2 of the initial five-year start-up period of the utility, after the City has had a year to demonstrate a dedicated funding source for the utility;

- It is assumed the initial bonds will be cross-pledged with the tax base; however, funds to pay for the issue will be dedicated solely from the MDUS fees;

- The bond life is assumed to be 20 years, with an average interest rate of 6%;

Table 6-3
Projection of Revenues & Expenditures
Service Level 3 Cost Funding Scenario

Item	FY 96	FY 97	FY 98	FY 99	FY 2000
ERUs(with Institutions)	14,313	14,456	14,601	14,747	14,894
Monthly Rate per ERU		$2.25	$6.75	$6.75	$6.75
Sources of Funds:					
MDUS Fees		$390,312	$1,182,681	$1,194,507	$1,206,404
Uses of Funds:					
Salaries & Fringes		$49,204	$51,173	$53,219	$55,348
Lease Payments		29,675	29,675	29,675	29,675
Hit List Projects		300,000	300,000	300,000	300,000
Total Service Level 2		$378,879	$380,848	$382,894	$385,023
Debt Service		-	$793,379	$793,379	$793,379
Total Uses of Funds		$378,879	$1,174,227	$1,176,273	$1,178,402
Sources - Uses		11,433	8,454	18,234	28,002

Assumptions:
14,313 ERUs increasing 1% per annum.
MDUS User Fee of $6.75 per ERU per month:
Single-family residential less than 2,000 sq. ft. will be $5.00 per unit per month
Single-family residential 2,000 sq.ft. or larger will be $9.72 per unit per month.
Institutions will be included.

Findings:

The following summarizes the required monthly rates per ERU to fund service levels 2 and 3 :

Table 6-4
Summary of Findings - Revenue Scenarios

Service Level	With Institutions	Without Institutions
Estimated ERUs	**14,456**	**11,972**
Service Level 2:		
Monthly Charge:		
per ERU	**$2.25**	**$2.72**
Single Family:		
Less than 2,000 sq.ft.	**1.67**	**2.01**
2,000 sq. ft. & Greater	**3.24**	**3.92**
Service Level 3:		
Monthly Charge:		
per ERU	**$6.75**	**$8.23**
Single Family:		
Less than 2,000 sq.ft.	**5.00**	**6.09**
2,000 sq. ft. & Greater	**9.72**	**11.85**

The preliminary drainage fees estimated in Table 6-4 to fund service level 2 are in line with others established across the state of Texas and Florida(next page). It should be noted, however, that the majority of drainage utilities are in the early stages and are not yet funding large capital projects which are part of a master plan.

Table 6-5
Survey of Stormwater Utility Fees

City/County	Single-family	ERU (sq.ft.)	Monthly Rate
Arlington, TX		3,000	$1.00
Altamonte Springs, FL		2,492	2.25
Austin, TX		n/a	3.82
Cape Coral, FL		2,823	2.50
Dallas,TX	0-5,000 sq.ft.		1.20
	5,001 - 10,000 sq.ft.		1.60
	10,001-21,800 sq.ft.		2.35
	21,801-43,600 sq.ft.		4.10
	Over 43,600 sq.ft.		7.15
Daytona, FL		1,661	1.75
Deland, FL		2,500	2.00
Dunedin, FL		1,708	3.00
Euless, TX		4,791	1.50
Gainesville, FL		2,300	3.75
Gainesville, TX		1,895	0.50
Garland,TX	0-7,000 sq.ft.		1.00
	7,001-10,000 sq.ft.		2.00
	Greater than 10,000 sq.ft.	3,500	3.00
Hillsborough County, FL		1,806	1.00
Irving, TX	0-5,000 sq.ft.	n/a	0.68
	Greater than 5,000 sq.ft.		0.94
Kissimmee, FL		1,730	2.00
Largo, FL		2,257	1.50
Lee County, FL		2,218	3.00
Lubbock, TX		4,791	1.71
Mesquite,TX		2,539	2.00
Miami, FL		1,191	2.50
N. Richland Hills,TX		n/a	3.00
Ocala, FL		1,948	2.00
Orlando, FL		2,000	1.80
Plano,TX	0-1,749 sq.ft.		1.50
	1,750-3,450 sq.ft.	2,539	2.00
	Greater than 3,450 sq.ft.		2.75
Port Orange, FL		3,050	3.00
Port St. Lucie, FL		2,280	3.33
St. Petersburg, FL		2,719	4.50
San Antonio,TX	0-4,999 sq.ft.		1.50
	Greater than 4,999 sq.ft.		1.99
Sarasota County, FL		2,582	3.50
Tallahassee, FL		2,650	2.48
Tavares, FL		3,000	2.00
Winter Park, FL		2,324	3.00

VII. MDUS IMPLEMENTATION

7.1 INTRODUCTION

The purpose of this section is to identify the decisions to be made by the Commission and the steps that must be taken if the Commission decides to proceed to Phase II of the study, which is the implementation of the MDUS.

There are six steps involved in implementing a MDUS.

1) Develop a stormwater public awareness/education program.

2) Establish policies, procedures, and rules needed to implement a MDUS.

3) Develop an accurate customer/parcel database and billing system.

4) Provide a more accurate user charge for implementation.

5) Approve an ordinance declaring the stormwater management function a public utility.

6) Approve an ordinance establishing rates, etc.

Before these steps can be implemented, the City Commission must make the following decisions:

1) Should Nacogdoches establish a MDUS?

2) What level of service should initially be funded with the user fee?

3) Should some or all of the institutional classes be included in the customer base?
   - State properties(SFA);
   - County properties;
   - School District properties;

4) Should a two-tiered residential rate, i.e., less than 2,000 sq.ft. vs., greater than 2,000 sq. ft. be established?

7.2 DEVELOP A STORMWATER PUBLIC AWARENESS/EDUCATION PROGRAM

Public understanding and acceptance of the City's MDUS program will be an important factor in determining how aggressively the City of Nacogdoches can move forward in efforts to satisfy drainage and flood control needs. This step will be addressed in Phase II through the further development of brochures and newspaper articles. Educational programs and materials will be implemented on a community-wide basis through a coordinated pubic information program which may include print, radio, and television media. Appropriate interaction with the public through open forum discussions and workshops is important to the program's success.

7.3 ESTABLISH POLICIES, PROCEDURES, AND RULES NEEDED TO IMPLEMENT A MDUS.

Before a MDUS is fully implemented, policies and procedures will have to be developed for stormwater activities, including the interaction with the permit process, variances, enforcement, and penalties.

7.3.1 Credit Issues

As part of the implementation process, policies will have to be finalized regarding the credit process. Factors to consider when evaluating the issues of credits are:

- Will the credits be based on any avoided cost to the City's MDUS? Does any onsite drainage system result in the City performing less maintenance than planned;

- How will credits be administered? Credits can take the many forms. Examples are a lump sum payment, or a reduction in the utility bill equal to some fraction of the portion of the utility bill assigned to the capital improvements; or a reduction in the utility bill for a negotiated length of time.

7.3.2 Billing System Policies & Procedure Issues

As part of the implementation process, a long-term data management procedure will be developed to update the MDUS customer file records as undeveloped parcels are developed and existing developments are changed. As new building permits are issued, applicants shall be required to report total impervious area and parcel identification information. Once verified by building inspectors and/or utility personnel, the MDUS utility files will be updated with the new information.

A procedure will be outlined where the Utilities Department will also have to notify the Public Works Department of the parcel identification number and/or site address, and type of service of any new or modified water or sewer account to determine whether there has been any change in impervious area. Procedures will be developed during implementation of the MDUS so that data on new development can be entered into the utility files. This shall eliminate the time consuming process of backtracking and field verifying the information. Once this procedure is in place, the information for new accounts shall be obtained when either a water or sewer account is established or building permit is issued.

Note- a GIS system can be enhanced with property tax address information which will allow the Engineering Department to enter and revise information on new development and to have the capability of making decisions pertaining to credit issues and then coordinating changes with utility billing.

7.4 DEVELOP AN ACCURATE CUSTOMER/PARCEL DATABASE AND BILLING SYSTEM.

An issue of overriding importance in any billing system is accuracy. An inaccurate bill can result in increased costs for research and corrections, hostile customers, and a damaged reputation. These concerns provide strong incentive for the billing system to consistently calculate an accurate bill for each customer based on the best information available. A billing system that provides good functional relationships through adequate analysis and reporting features will facilitate the control and accuracy of the customer information contained within the system and help in maintaining an accurate database.

The nonresidential database development effort is a labor intensive process involving a case-by-case review of the impervious area appraisal board record information, existing utility records, aerial photographs, and site inspections. The effort is worthwhile since each nonresidential parcel's fee is based on the specific impervious area of that parcel. A GIS system that includes property information can facilitate this effort, and is particularly useful to revise property information in the future. Specifically, the following subtasks must be performed in Phase II:

- Verification of impervious area for nonresidential parcels;
- Verification of residential dwelling unit counts for multifamily parcels;
- Verification of development of status of vacant parcels;
- Matching of existing utility accounts and parcels identification numbers;
- Integration of MDUS property address utility information into the existing billing systems; and
- General coordination and administration.

7.4.1 Billing System Recommendations

Since New World has indicated that the new utility software will be linked to the property tax database from the appraisal district, DMG recommends the City bill the user fee as an additional linei tem on the utility bill, billed to the property owner. It should be emphasized that property-owners will have to be billed, rather than occupants.

7.5 ORDINANCE FOR MDUS

A MDUS Ordinance declares the stormwater management function of the City a public utility and establishes the legal procedures for developing just and equitable user rates. The ordinance identifies the rate policy for defining the utility fees. Provisions are made for any customer to appeal the charge for their property as established by the utility.

7.6 RATE ORDINANCE ESTABLISHING RATES

While the ordinance establishes the MDUS and the procedures for implementing the utility program, the rate ordinance establishes the specific rate ($/ERU/month) and square footage of the base unit (ERU). Adoption of the rate ordinance must occur before the first billing. Separation of the two pieces of legislation is recommended because the rate ordinance can be revisited as needed without reconsideration of the general MDUS policies in the ordinance.

APPENDIX D

EXHIBITS

EXHIBITS

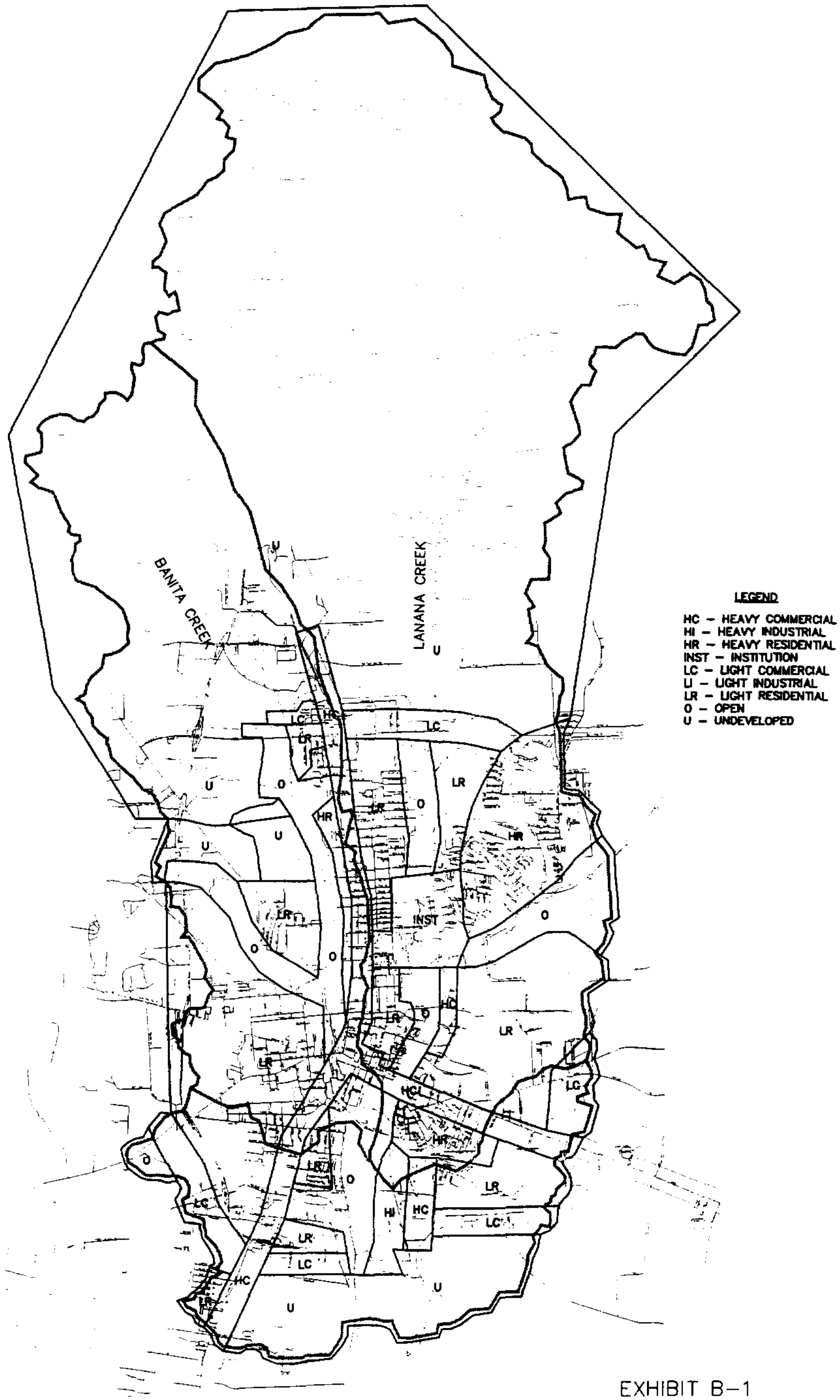
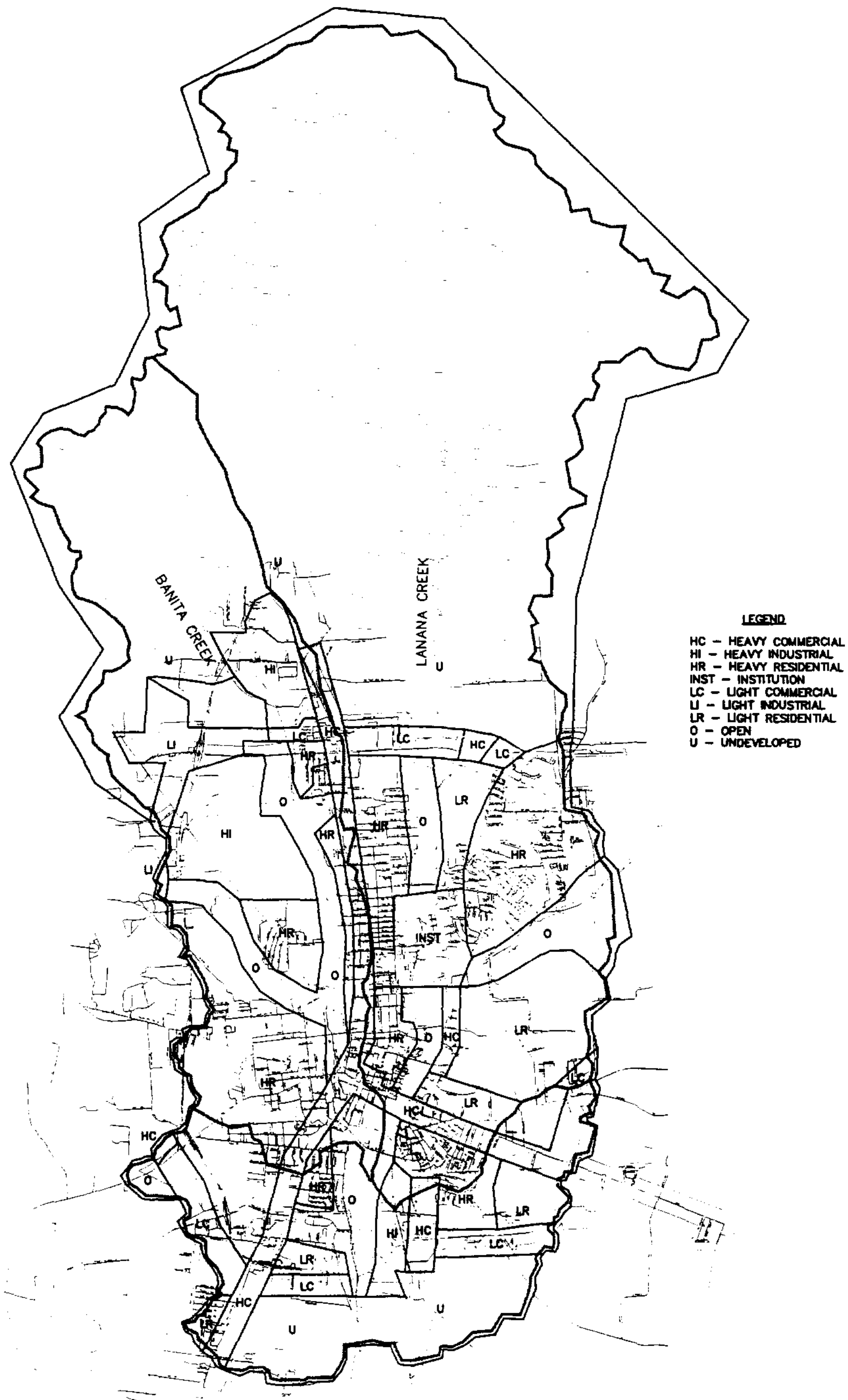


EXHIBIT B–1
LAND USE
PRE–DEVELOPMENT
CITY OF NACOGDOCHES, TEXAS
REGIONAL FLOOD CONTROL STUDY
LANANA AND BANITA CREEK
WATERSHEDS

SCHAUMBURG & POLK, INC.



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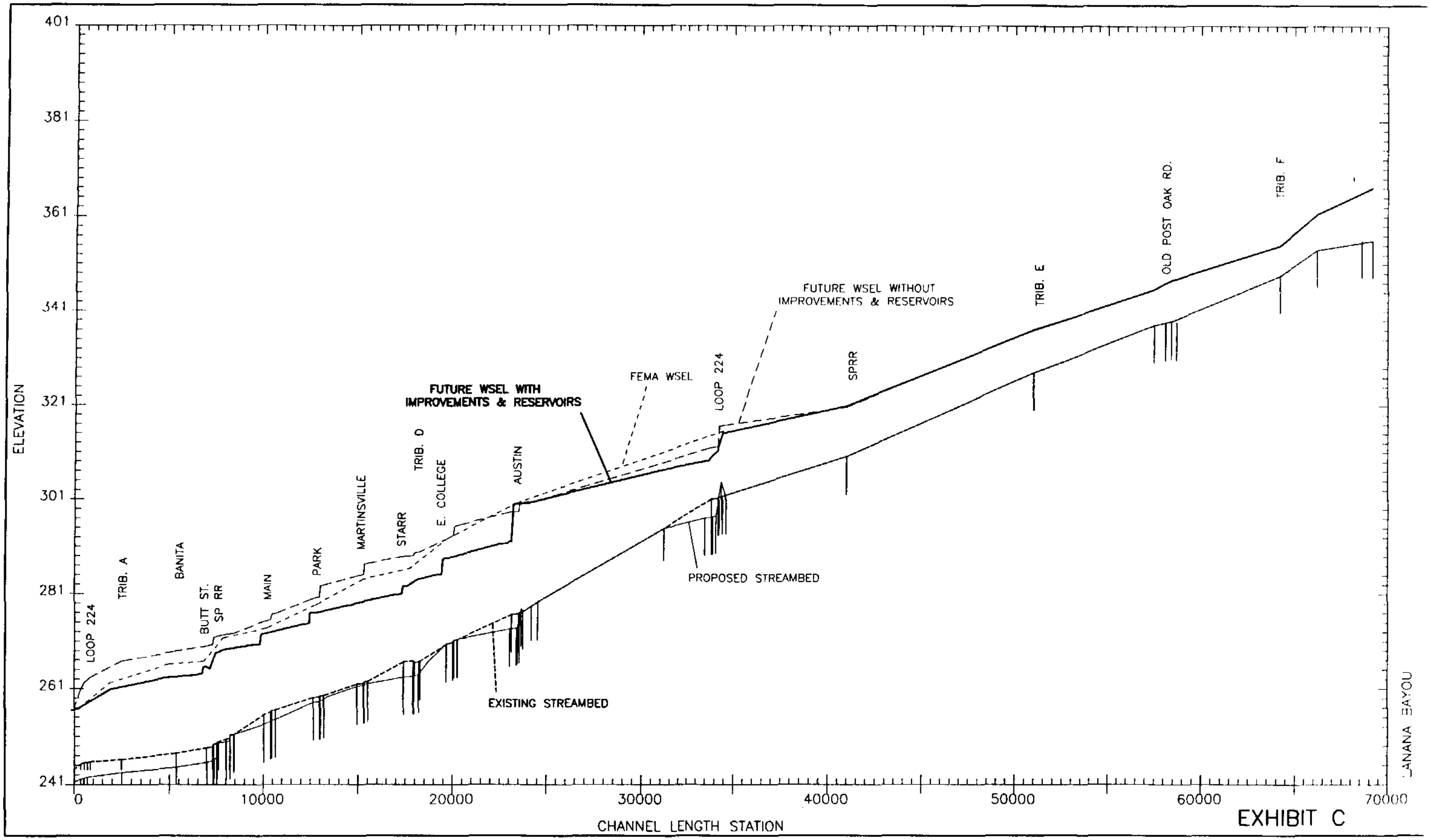
LAND USE
POST–DEVELOPMENT
CITY OF NACOGDOCHES, TEXAS
REGIONAL FLOOD CONTROL STUDY
LANANA AND BANITA CREEK
WATERSHEDS

SCHAUMBURG & POLK, INC.



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60000
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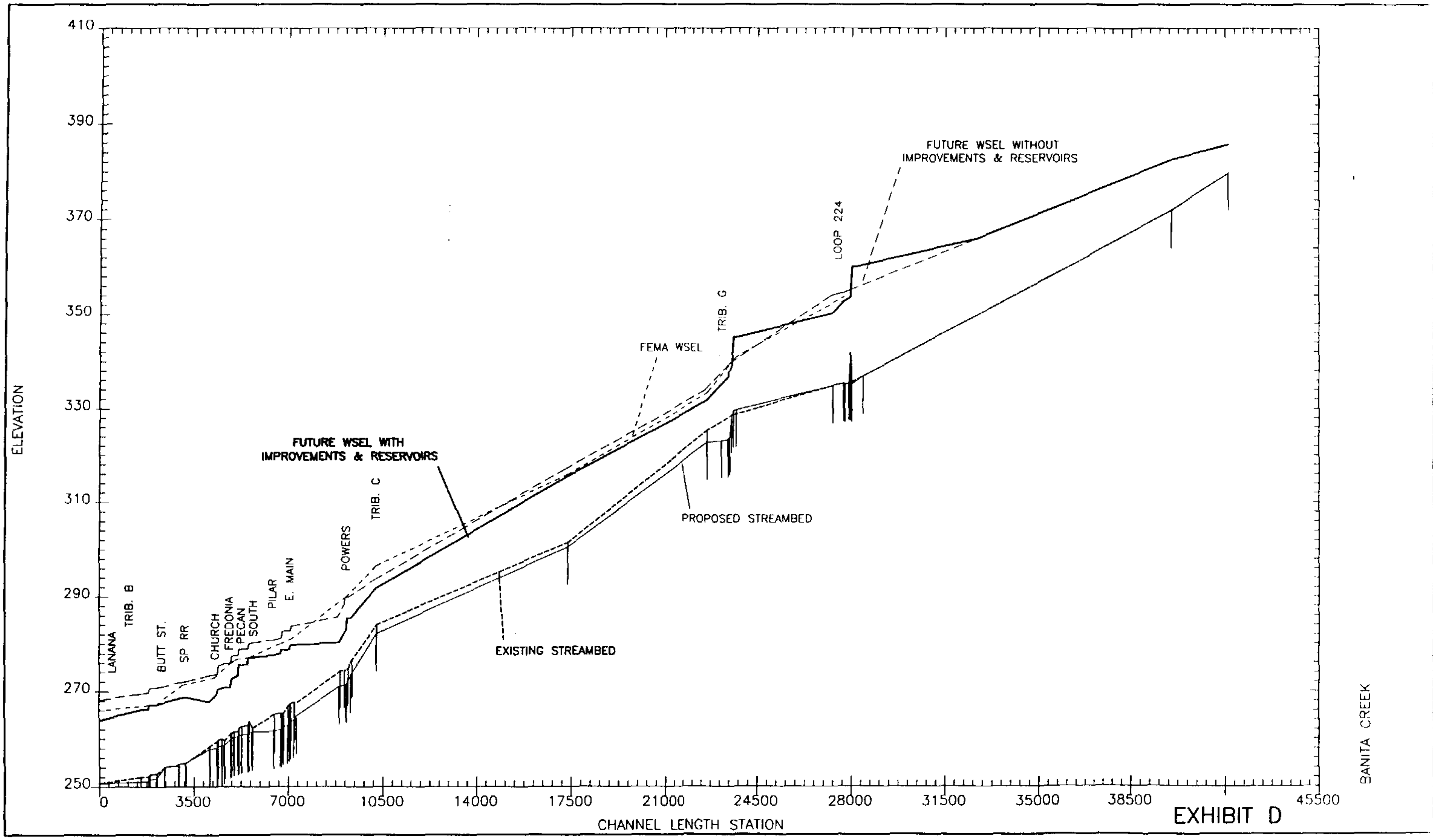
LOOP 224
TRIB. A
BANITA
BUTT ST.
SP RR
MAIN
PARK
MARTINSVILLE
STARR
TRIB. D
E. COLLEGE
AUSTIN
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
FEMA WSEL
LOOP 224
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
SPRR
TRIB. E
OLD POST OAK RD.
TRIB. F
PROPOSED STREAMBED
EXISTING STREAMBED
LANANA BAYOU

EXHIBIT C



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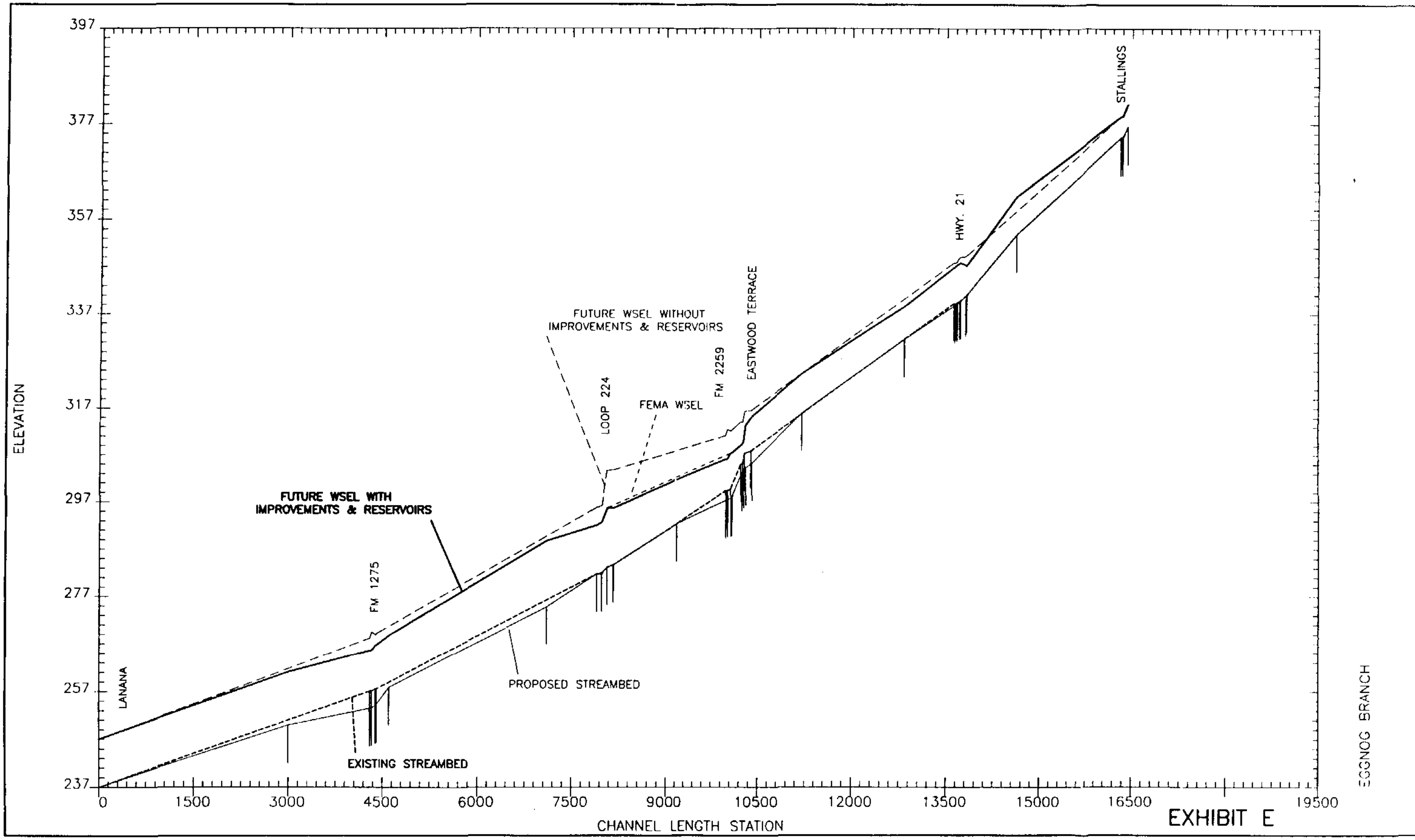
28000
31500
35000
38500
45500
CHANNEL LENGTH STATION
LANANA
TRIB. B
BUTT ST.
SP RR
CHURCH
FREDONIA
PECAN
SOUTH
PILAR
E. MAIN
POWERS
TRIB. C
TRIB. G
LOOP 224
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
FEMA WSEL
PROPOSED STREAMBED
EXISTING STREAMBED
BANITA CREEK

EXHIBIT D



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317
297
277
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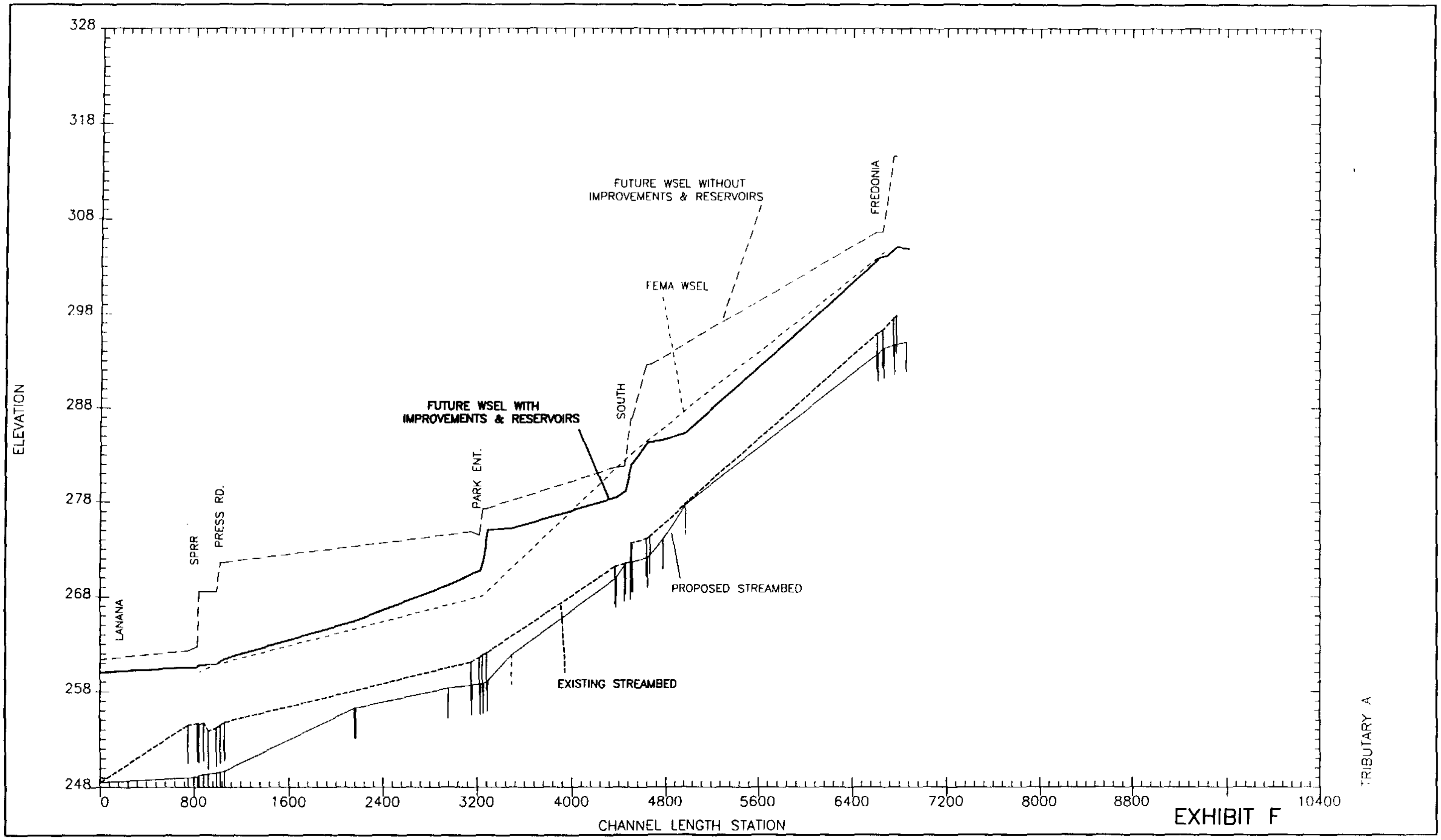
13500
15000
16500
19500
CHANNEL LENGTH STATION
LANANA
FM 1275
LOOP 224
FM 2259
EASTWOOD TERRACE
HWY. 21
STALLINGS
FUTURE WSEL WITHOUT IMPROVEMENTS & RESERVOIRS
FEMA WSEL
FUTURE WSEL WITH IMPROVEMENTS & RESERVOIRS
PROPOSED STREAMBED
EXISTING STREAMBED
EGGNOG BRANCH

EXHIBIT E



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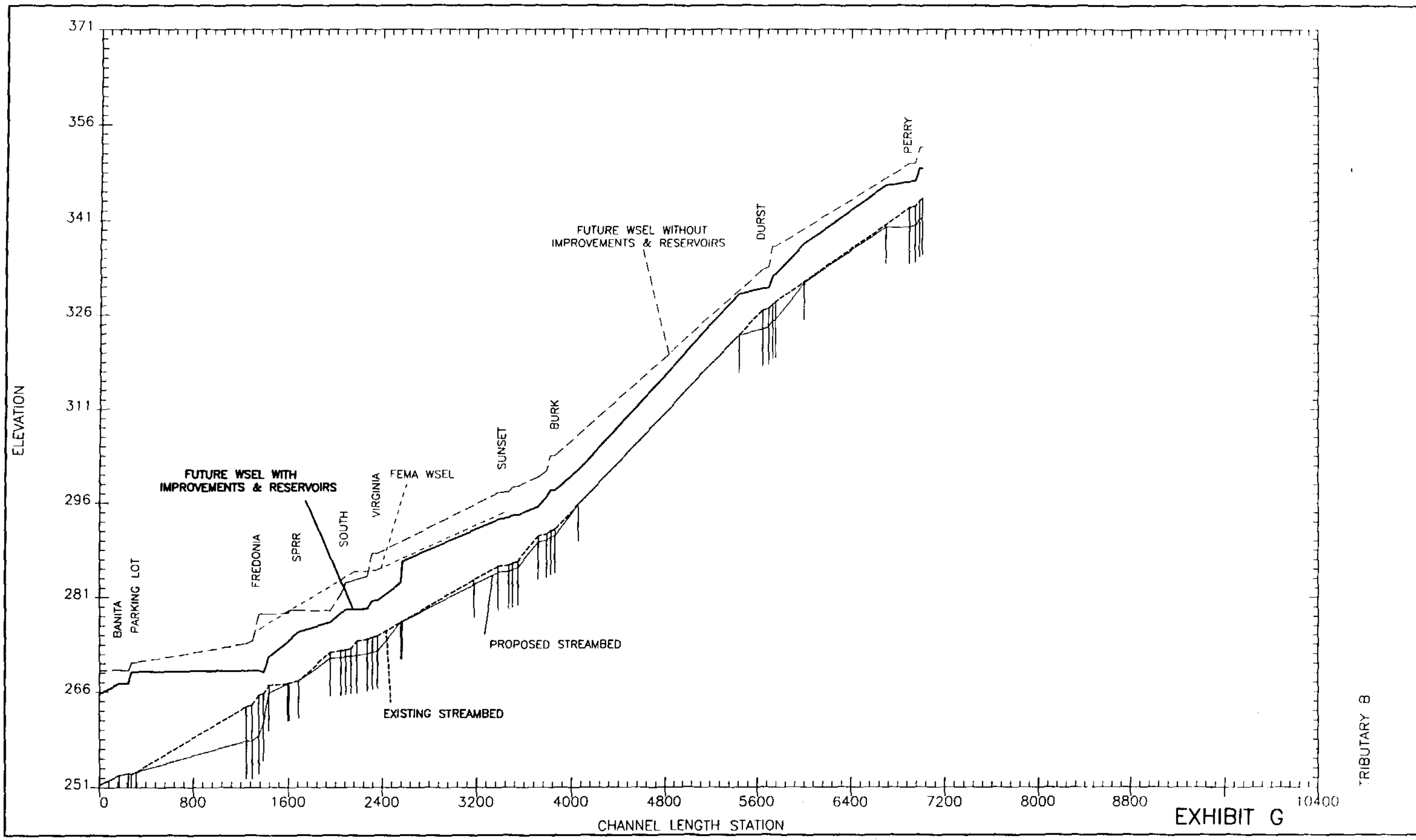
4000
4800
5600
6400
7200
8000
8800
10400
CHANNEL LENGTH STATION
LANANA
SPRR
PRESS RD.
PARK ENT.
SOUTH
FREDONIA
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
FEMA WSEL
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
PROPOSED STREAMBED
EXISTING STREAMBED
TRIBUTARY A

EXHIBIT F



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326
311
296
281
266
251
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1600
2400
3200
4000
4800
5600
6400
7200
8000
8800
10400
BANITA
PARKING LOT
FREDONIA
SPRR
SOUTH
VIRGINIA
SUNSET
BURK
DURST
PERRY
FUTURE WSEL WITH IMPROVEMENTS & RESERVOIRS
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PROPOSED STREAMBED
EXISTING STREAMBED
TRIBUTARY B

EXHIBIT G

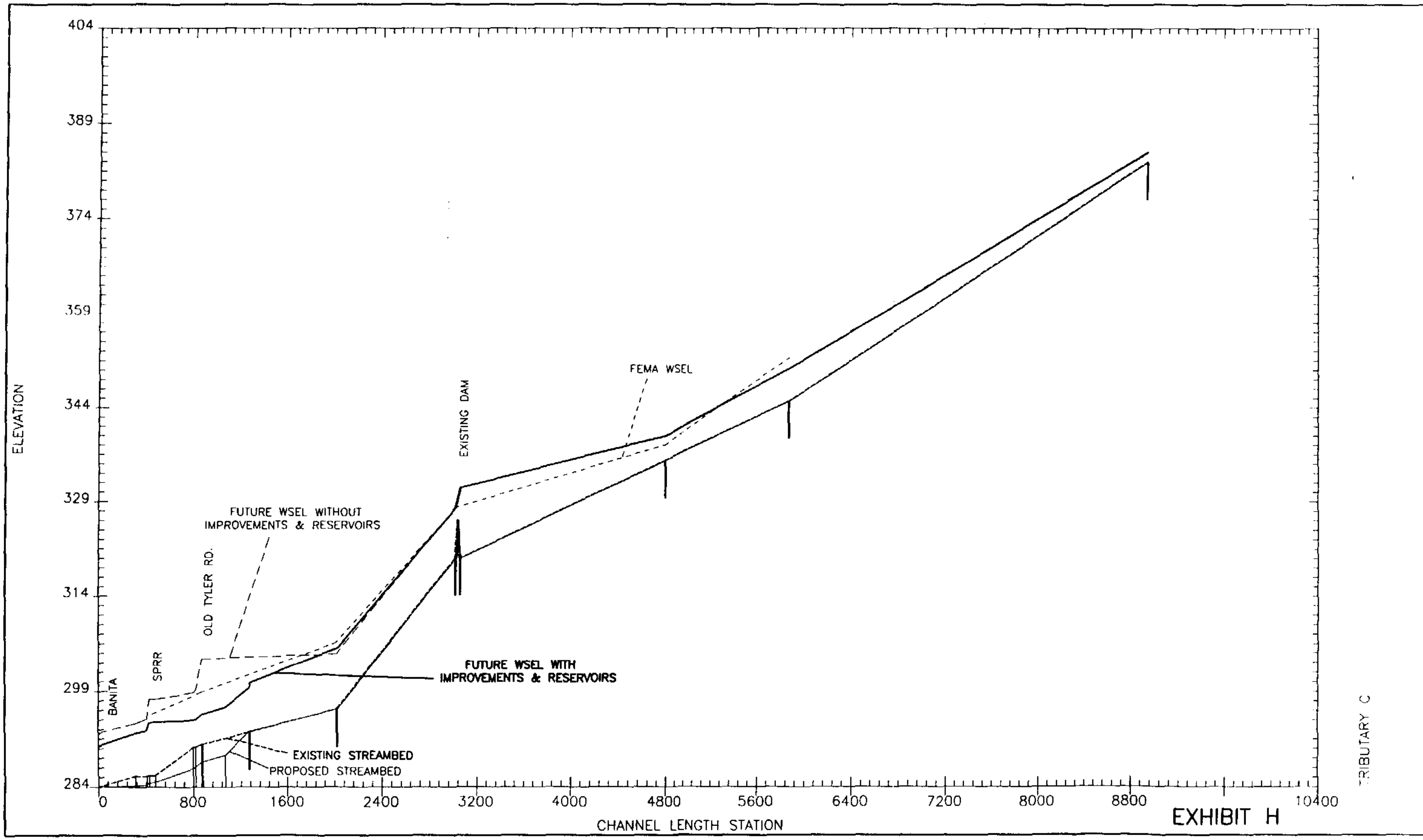

EXHIBIT H

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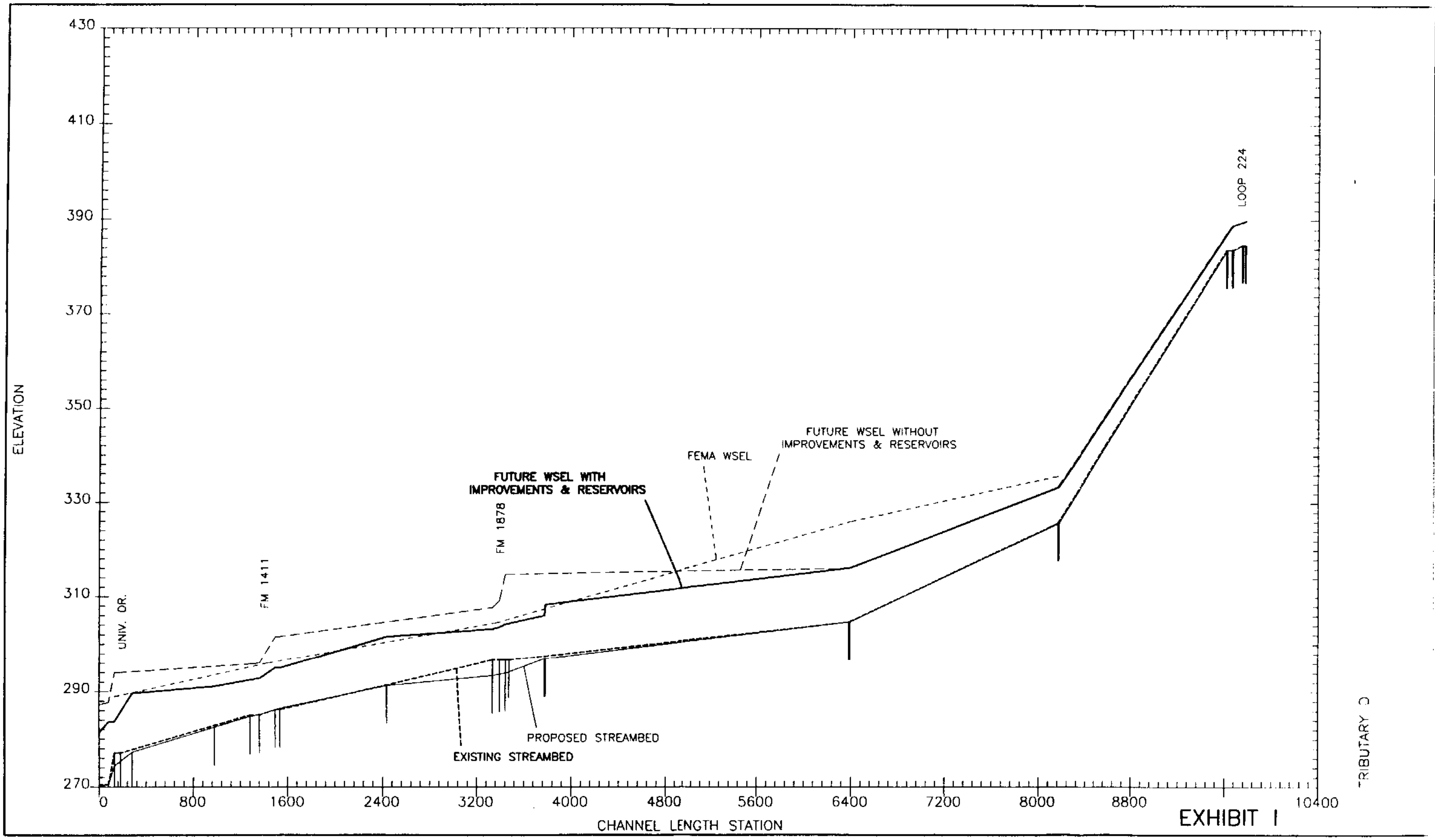

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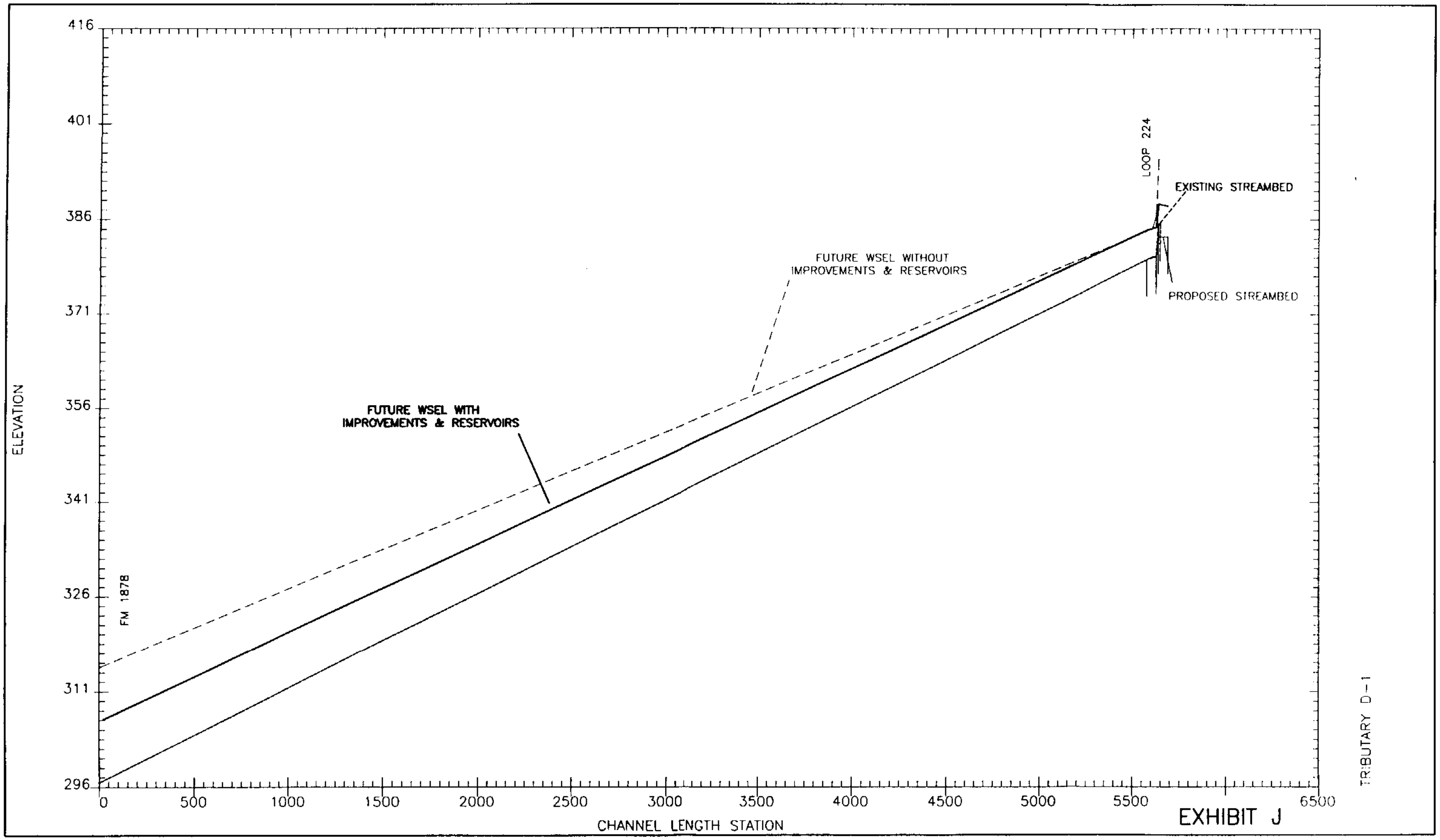
6400
7200
8000
8800
10400
CHANNEL LENGTH STATION
UNIV. DR.
FM 1411
FM 1878
LOOP 224
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
FEMA WSEL
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
PROPOSED STREAMBED
EXISTING STREAMBED
TRIBUTARY D

EXHIBIT I



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2000
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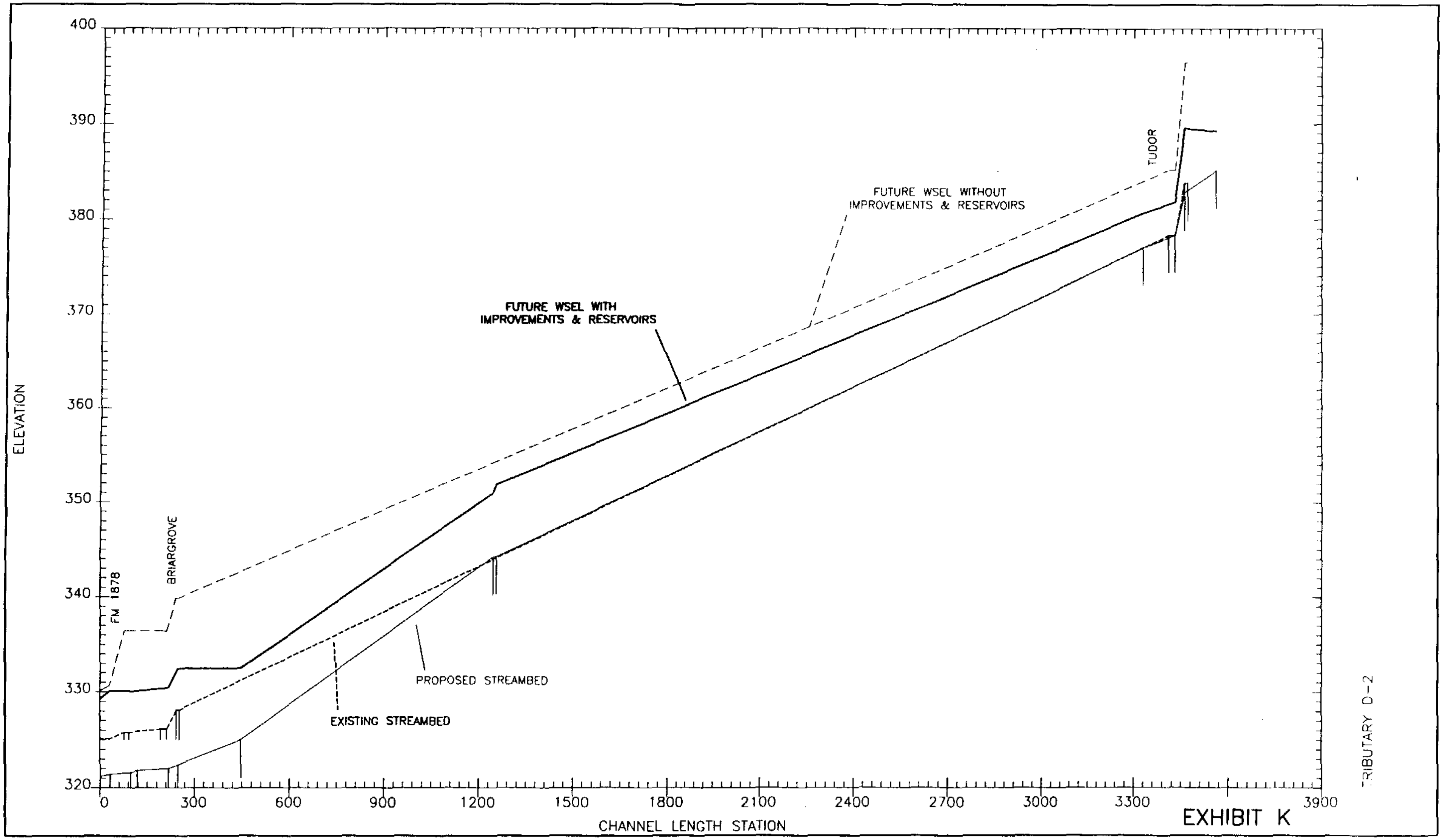
4000
4500
5000
5500
6500
CHANNEL LENGTH STATION
LOOP 224
EXISTING STREAMBED
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
PROPOSED STREAMBED
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
FM 1878
TRIBUTARY D-1

EXHIBIT J



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340
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320
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600
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1500
1800
2100
2400
2700
3000
3300
3900
CHANNEL LENGTH STATION
FM 1878
BRIARGROVE
TUDOR
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
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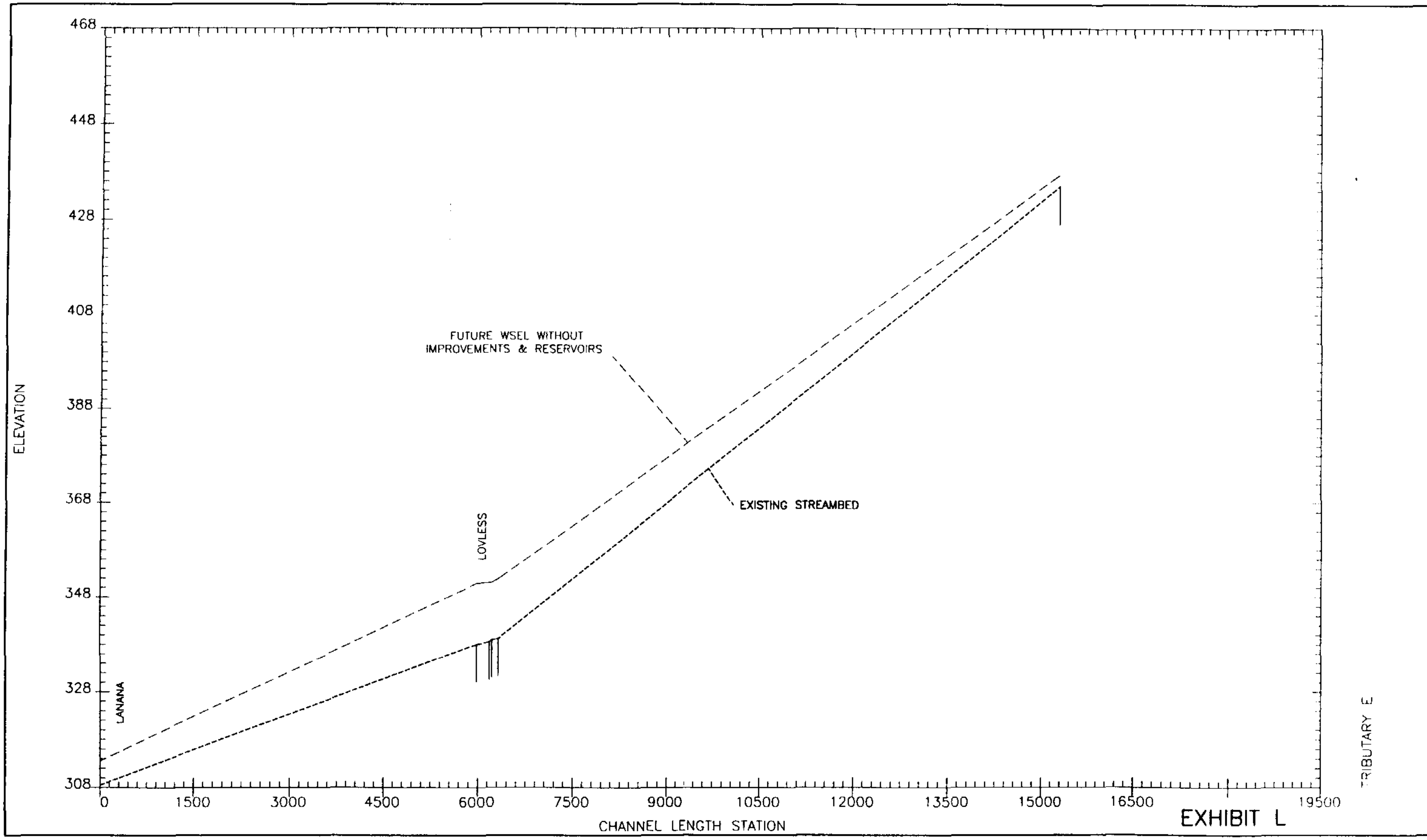
PROPOSED STREAMBED
EXISTING STREAMBED
TRIBUTARY D-2

EXHIBIT K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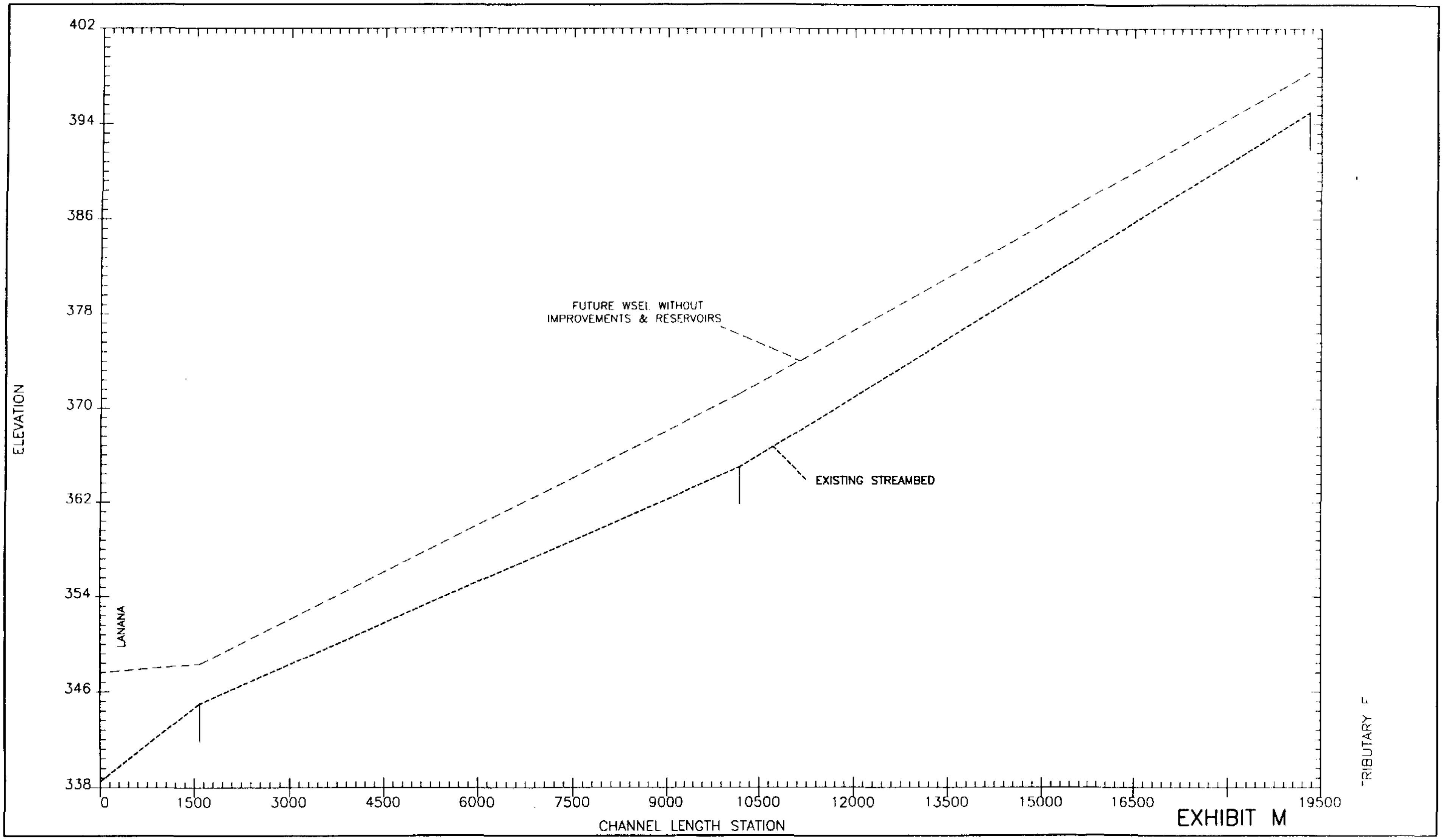
12000
13500
15000
16500
19500
CHANNEL LENGTH STATION
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
EXISTING STREAMBED
LOVLESS
LANANA
TRIBUTARY E

EXHIBIT L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386
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370
362
354
346
338
ELEVATION
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
EXISTING STREAMBED
LANANA
TRIBUTARY F
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12000
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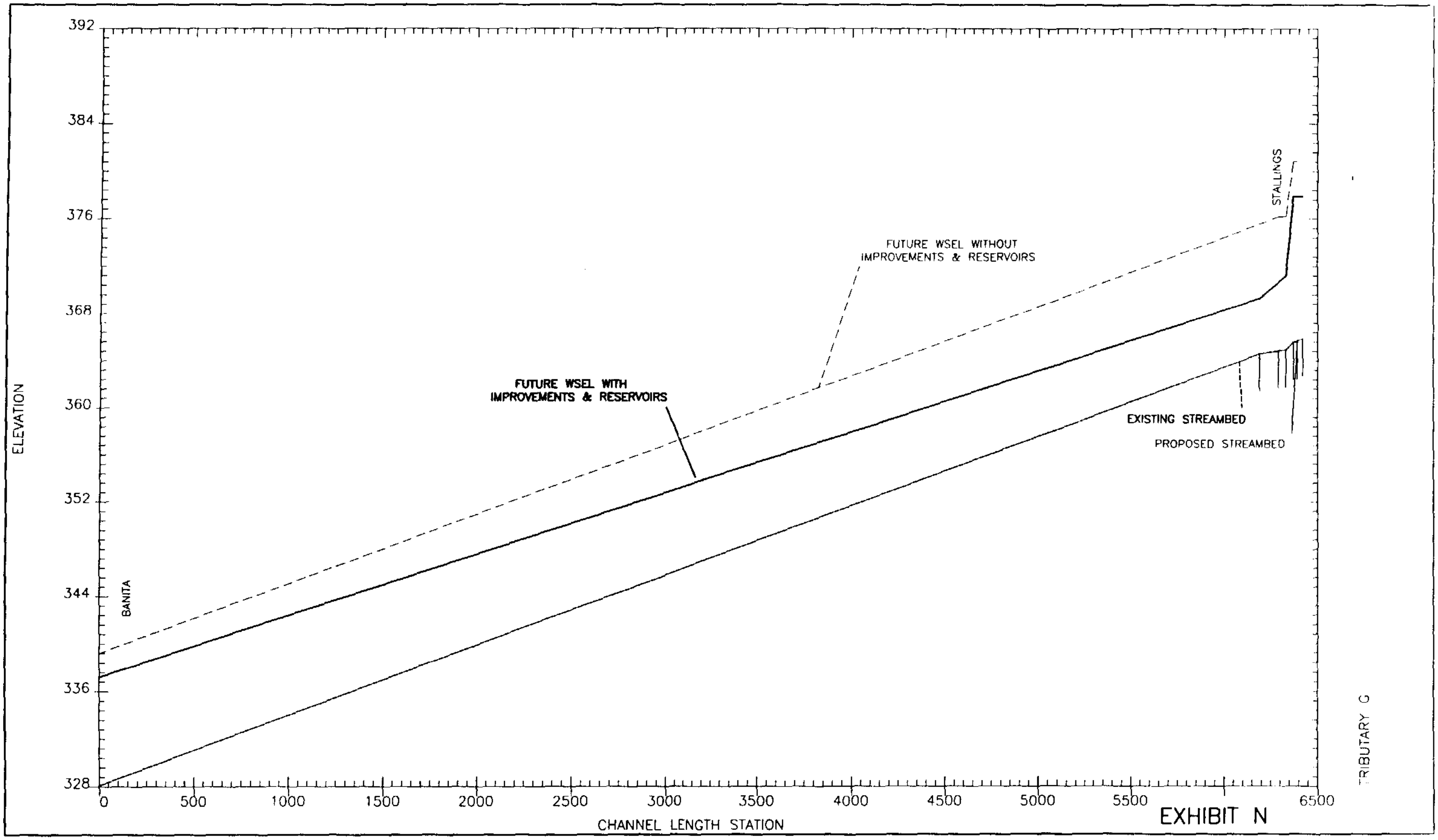
15000
16500
19500
CHANNEL LENGTH STATION

EXHIBIT M



ELEVATION
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1000
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2000
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3000
3500
4000
4500
5000
5500
6500
CHANNEL LENGTH STATION
BANITA
STALLINGS
FUTURE WSEL WITHOUT
IMPROVEMENTS & RESERVOIRS
FUTURE WSEL WITH
IMPROVEMENTS & RESERVOIRS
EXISTING STREAMBED
PROPOSED STREAMBED
TRIBUTARY G

EXHIBIT N

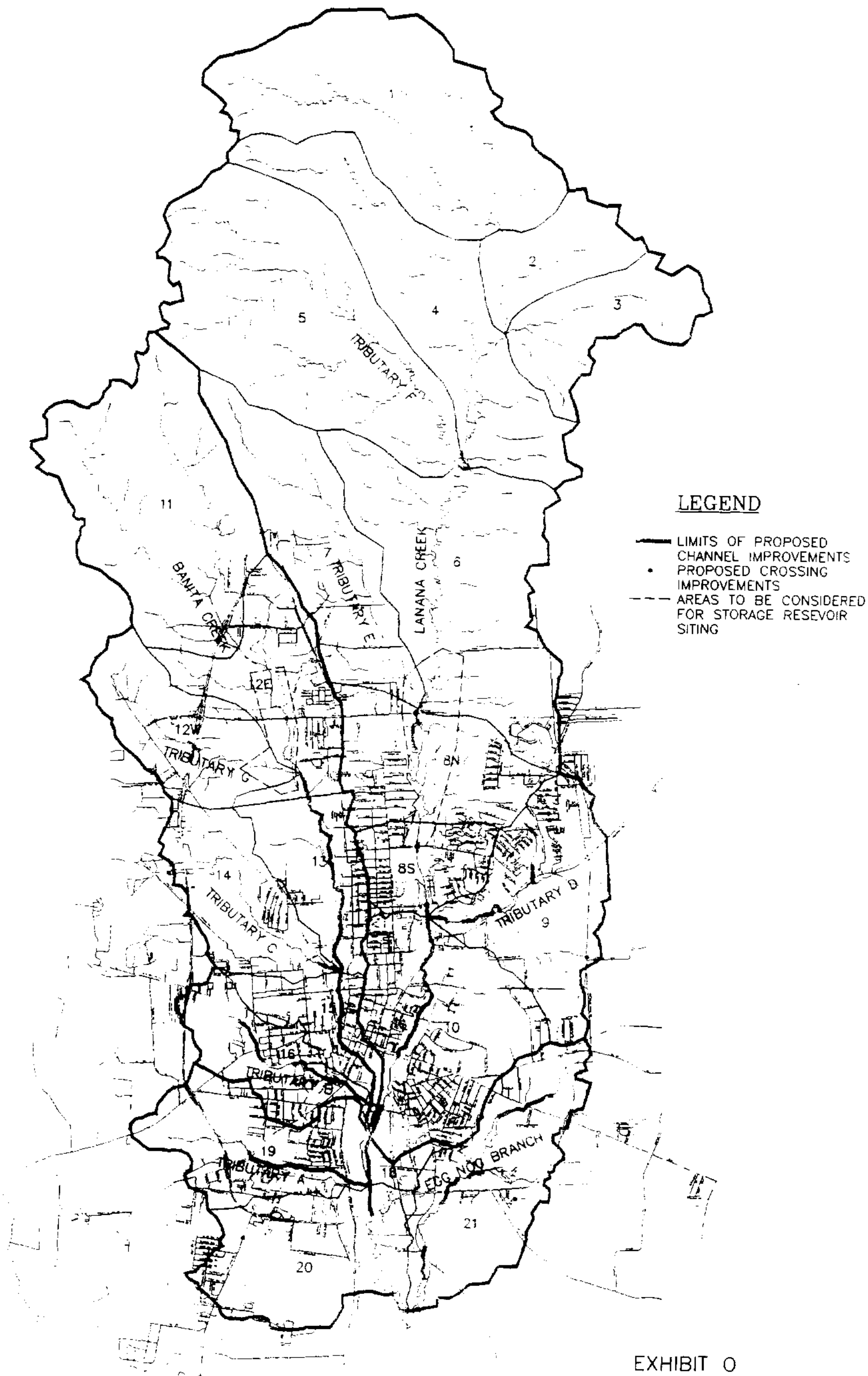


EXHIBIT O
PROPOSED IMPROVEMENTS
FLOOD CONTROL STUDY AREA
CITY OF NACOGDOCHES, TEXAS
REGIONAL FLOOD CONTROL STUDY
LANANA AND BANITA CREEK
WATERSHEDS

PREPARED BY:
SCHAUMBURG & POLK, INC.
CONSULTING ENGINEERS
8865 COLLEGE STREET
BEAUMONT, TEXAS 77707
(409) 866-0341

APPENDIX E

Environmental Information

Tables 1 - 4

References

Correspondence:

Initial Mailout List for Early Contact (October 19, 1995)

Fact Sheet and Map for Early Contact (October 19 and 31, 1995)

Letters to Agencies

Agency Comments and Engineer's Responses (when available)

ENVIRONMENTAL INFORMATION

A. DESCRIPTION OF STUDY AREA

The planning area for the regional flood protection study consists of a portion of Nacogdoches County along the LaNana Creek watershed, including most of the City of Nacogdoches. The study area extends north to the headwaters of LaNana Creek and its main tributary, Banita Creek. The area extends south for a short distance outside Nacogdoches.

Nacogdoches has a 1995 population estimated at 31,500. Other communities located within the study area include most of the city of Appleby (pop. 449, 1990) and the unincorporated communities of Central Heights and Mahl.

B. CURRENTLY EXISTING ENVIRONMENT WITHOUT THE PROPOSED PROJECT

1. Geological Elements

a. Topography. The study area lies within the Piney Woods region of East Texas.[1] The region is characterized by hills forested with pine and hardwood forest. The elevation of the study area varies from 220 feet to 610 feet above sea level. The ground surface has slopes varying from zero in valleys and floodplains to 25% or more on hillsides adjacent to the valleys.[2] The entire county, including the study area, lies inside the drainage basin of the Neches River.

b. Soil Types

(1) Mapping Units. A 1980 soil survey by the U. S. Department of Agriculture (USDA) shows four general mapping units within the study area.[3]

(a) Nacogdoches-Trawick - loamy upland soils with moderately slow permeability. In the south part of the study area, this unit follows strips adjacent to the floodplains of LaNana and Banita Creeks. Farther north, the unit follows the upstream end of the Banita Creek floodplain and then the headwaters of the creek. The portion of the unit along LaNana Creek widens out considerably to the north, encircling the upstream floodplain limits of LaNana Creek and a small upstream tributary.

(b) Lilbert-Darco - sandy upland soils with moderately slow and moderate permeability;; located to the east and west of the relatively narrow strip containing the floodplains and the Nacogdoches-Trawick soils; also covers an area east of Banita Creek north of Nacogdoches.

(c) Cuthbert-Tenaha: - sandy upland soils, with moderately slow and moderate permeability; extend into south end of study area as a narrow strip just east of LaNana Creek floodplain.

(d) Tuscosso-Hannahatchee - loamy bottomland soils with moderately slow and moderate permeability; located in the floodplains of LaNana and Banita Creeks and an upstream tributary of LaNana Creek except at extreme upstream ends of floodplain limits.

(2) General Characteristics. Drainage *(during soil formation)* for the various soils is noted as well drained except for the moderately well drained Tuscosso-Hannahatchee soils. Reactions for most of the soils are listed as acid for surface soils and subsoils, with strength varying from slightly acid to very strongly acid. One exception is neutral surface soils in the Trawick soils.

The USDA lists fifteen of the 68 detailed soil mapping units in the county as being prime farmland *(provided they are not located in urbanized or otherwise developed areas)*[4]. These soils are listed in Table E-1. Most of these units are represented in the study area.

The soils qualifying for prime farmland are scattered extensively throughout the portion of the planning area north of Nacogdoches. Within the City, they occur only in limited areas, mainly along Banita Creek and its tributaries in the north part of town, plus a few areas along LaNana Creek and its tributaries to the east. *(The urban areas are generally excluded from prime farmland classification because of development, although the undevelopable floodplain areas may be considered.)* South of the City, some prime farmland can be found, mainly on the fringes of the LaNana Creek floodplain.

The prime farmland soils are noted as occurring in topography ranging from floodplains to broad interstream divides.[3] The prime areas do not generally fall immediately adjacent to major streams such as LaNana Creek, but in terraces along the edge of the floodplains.

Of the various detailed mapping units which would potentially constitute prime farmland, two (Nacogdoches fine sandy loam and Nacogdoches clay loam) cover significant portions of the general area for the Banita Creek basins. These soils, however, are found mainly on interstream divides and may fall outside the impoundment area, or else close enough to its upstream limits to be affected only infrequently. Two other such units, the Attoyac fine sandy loam and the Chireno clay loam, cover lesser areas but are closer to the creek. The Nacogdoches fsl (fine sandy loam) also occurs in a small area of the LaNana Creek basin area. In summary, little prime farmland is located so as to be affected by basin construction.

Along the streams proposed for channel or stream crossing improvements, most prime farmland does not extend close enough to the streams to be included in the work areas.

Two of the general mapping units -- Nacogdoches-Trawick and Cuthbert-Tenaha -- are noted as eroding easily, thus limiting their suitability for crop land. Also, the Nacogdoches and Trawick soils, as well as the Hannahatchee and Tuscosso bottomland soils, have been noted by the USDA as being unstable in pits and road banks because of their low shear strength.[5]

All project elements along LaNana and Banita Creeks fall into the Tuscosso-Hannahatchee unit. In addition, the basins will extend away from the creeks into the Nacogdoches-Trawick unit and possibly into the Lilbert-Darco unit. Most elements along tributary streams will be in the Lilbert-Darco, with some possibly in the other two units. No work falls into the Cuthbert-Tenaha unit.

See Table E-2 for further information regarding the soils within each mapping unit.

c. Geologic Structures. The principal subsurface rocks in the study area are classified as Cenozoic, within the Paleogene subclass.[6] Predominant surface rocks in the area are of the Claiborne Group, including in descending order the Stone City Formation,. the Sparta Sand, the Therill Formation, and the Weches Formation.

East Texas lies within a structural province known as the Gulf of Mexico Basin. The geological structures in East Texas are represented by two major elements, the East Texas Embayment and the Sabine Uplift. Nacogdoches lies within the East Texas Embayment, which covers approximately 90% of East Texas with a north-south axis running through Cherokee County *(west of Nacogdoches)*. The Sabine Uplift, covering all or part of several counties, is located just northeast of Nacogdoches.

A major fault system in the Nacogdoches vicinity is the Elkhart-Jarvis-Mount Enterprise fault which runs east and west approximately twenty miles north of Nacogdoches (nine miles north of the study area). More localized fault lines occur in the northeastern portion of the study area and from just east of the study area (near Nacogdoches) for eleven miles to the east-northeast.

2. Hydrological Elements

a. Streams. The two major streams within the study area are LaNana Creek and its main tributary, Banita Creek. Both of these streams head in northern Nacogdoches County at the beginning of the study area and flow south. Banita Creek turns to the east-southeast in Nacogdoches and flows into LaNana Creek. LaNana Creek continues southward to the Angelina River just upstream from Sam Rayburn Reservoir. Several miles of the LaNana Creek channel within Nacogdoches were straightened during the 1970's.

Stream flow in LaNana Creek at the Nacogdoches wastewater treatment plant *(south of the City, downstream from Banita Creek)* averages 56.8 cfs, with monthly averages as low as 1.5 cfs during dry years. Instantaneous flows up to 25, 650 cfs have occurred.[7]

Other named streams within the study area are Toliver Branch, Mill Branch, and Egg Nog Branch.

The streams within the study area are not affected by any significant wastewater discharges until they reach the Nacogdoches wastewater treatment plant. That plant receives flows from the entire City including local industries. The area north of Nacogdoches is affected to some extent by natural erosion *(which may be aggravated in some areas by clear cutting of timber)* and by some agricultural runoff. The streams within and downstream from Nacogdoches are also affected by urban runoff.

b. Lakes. There are several small lakes on minor tributary streams in the study area, none of which covers over 15 acres[2]. The existing lakes cover only a negligible portion of the study area and have little effect on flood control.

c. Aquifers. The Carrizo Sand supplies all of the ground water used by the City of Nacogdoches. This aquifer outcrops in a band across the northern and northeastern parts of Nacogdoches County. The top of the formation in the immediate Nacogdoches area varies from 400 to 500 feet below ground, and the aquifer is generally 60 to 90 feet thick in this area.[8]

The Carrizo sand contains water of a generally good quality. The water is generally soft from Nacogdoches southward, including the City's south well field. The portion of the aquifer north of Nacogdoches (including the city's north well field) contains significant amounts of iron, but the iron can be removed economically for domestic use of the water.

It was noted several years ago that Nacogdoches pumped an average of 4.5 mgd of ground water, representing approximately 55% of the City's water usage. The remainder comes from Lake Nacogdoches ten miles west of town (outside the study area). Ground water pumpage is expected to diminish in the future as existing wells reach the end of their useful lives. The reduction in ground water usage will be replaced by an increase in surface water use.

In addition to the Carrizo Sand, aquifers favorable for producing water for small users within the study area include the Wilcox Group and the Sparta Sand. Other aquifers in the area include the Reklaw Formation, the Queen City Sand, the Weches Formation, and the Alluvium along LaNana Creek. The aquifers other than the Carrizo contain a number of small shallow wells, but are not used for major water supplies.

d. Springs. At least two springs are known to exist in the immediate Nacogdoches area, near the fringes of the study area.

3. Floodplains and Wetlands. Floodplains occur as relatively narrow strips along streams in the study area. Within the City of Nacogdoches, where a detailed floodplain study has been performed by FEMA, the 100 year floodplain along LaNana Creek generally varies between 1000 and 2000 feet wide. The width increases above 2500 feet or narrows to 500 feet or less in a few places. The Banita Creek floodplain generally varies between 700 and 1000 feet wide within the City.

Within the City, 100 year flood elevations along LaNana Creek vary from 255 to 316 feet. Banita Creek, which has a steeper gradient, has flood elevations up to 354 feet. Future flood levels calculated for this report *(based on increased development through 2020)* are generally one to seven feet higher than the FEMA levels in the absence of a project. With the proposed project, the flood levels generally remain at FEMA levels or up to five feet lower.

The study area does not contain significant amounts of wetlands outside the immediate vicinity of streams.

4. Climatic Elements

a. General. The study area is located in the humid sub-tropical region of Central East Texas. The average rainfall as shown in the Texas Almanac is 47.5 inches. Annual climatological data from the U. S. Department of Commerce (1967-1987) shows annual precipitation varying from 31 to 71 inches. The amount of snow and sleet varied from zero to 4 inches annually.

Average maximum temperature in July is 94° F, with an average minimum temperature of 39° F in January. Record high and low temperatures are 100° F and – 4° F. Annual mean temperature is 65.8° F.

The study area has a growing season of approximately 243 days which, coupled with the generous amounts of rainfall, makes the area highly suitable for agriculture.

The region experiences quite rapid fluctuations in both temperature and wind direction during the fall, winter, and summer months because of the interaction of the cool, continental weather systems and warm, moist air from the Gulf of Mexico. The prevailing wind direction for the area during the summer months is influenced mainly by the warm Gulf air currents from the south and southeast. The winter months are mainly characterized by winds from the northerly direction resulting from the influence of Arctic or Pacific cool fronts.

Summers are warm and humid. The month of July has a mean temperature of 84°F.

Rainfall is abundant during the summer months. Thunderstorms are most frequent during July and August.

b. Air Quality. The nearest air monitoring stations to the study area are reported to be located at Tyler and Longview, Texas and Shreveport, Louisiana. The Tyler and Shreveport areas, which are likely to have similar characteristics to the study area, are in attainment for ozone concentration. The Longview area is out of attainment, however[9]. This problem may result from certain industries in that immediate area *(refineries, at least one petrochemical industry, and a brewery)* which either generate ozone or create conditions conducive to its formation. Because of the lesser amount of industrialization *(lack of those types of industries)* and the large rural areas in the Nacogdoches area, it is not expected that there are any major air pollution violations except as the result of periodic clear cutting of timber.

5. Biological Elements

a. Plant Communities. Nacogdoches falls into the vegetational area known as the Piney Woods[1], which covers almost all of East Texas. Most of the undeveloped land within the study area is forested, with second growth pines being dominant. Hardwoods are also found in the area. Hardwoods which are potentially important commercially include sycamore, black walnut, sweet gum, eastern cottonwood, green ash, cherrybark oak, water oak, red oak, white oak, and willow oak.[3]

Understory vegetation varies with the many soil types contained within the study area. This vegetation in various portions of the county includes longleaf uniola, Indiangrass, sedge, various bluestems and panicum, purpletop, threeawn, giant cane, switchgrass, Canada wildrye, carpetgrass, holly, paspalum, gayfeather, greenbriar, hawthorn, cutover muhly, toothachegrass, plumegrass, Carolina jointtail, and knotroot bristlegrass. The understory sometimes supports grazing in wooded areas.[3]

b. Animal Communities. Mammal life in the Nacogdoches area varies from small animals such as rats and mice to larger animals such as coyotes and bobcats. Mammal, bird, reptile, and aquatic life (including white tail deer) are shown in Table E-3[10,11].

The U. S. Fish and Wildlife Service has identified two federally listed endangered species found in Nacogdoches County. One species, the bald eagle, is found along major rivers and reservoirs and is expected to be well away from the study area. The red-cockaded woodpecker, however, tends to nest in stands of pine timber over sixty years old. Such timber is found in a number of locations within the study area.

No special investigation has been made as to whether such stands of large pine timber are located in or near the basin sites. However, preliminary observations of the areas from nearby highways do not indicate the presence of such timber.

c. Habitats of Endangered Species. The habitat of the bald eagle mentioned above is believed to be outside the study area. No specific information is available on local woodpecker nest locations.

Several species of endangered plants are listed by the University of Texas[12] as occurring in Nacogdoches County (Table E-4) , but no specific habitats are listed.

d. Preserves in Area. One city park, Pioneer Park in the southern part of Nacogdoches, is a type of natural preserve *(approximately 100 acres)* which is barely developed. An unnamed stream passes through the park, and proposed improvements include replacing an existing park entrance bridge as well as deepening and widening the channel throughout the entire area. However, the improvements will be confined to a narrow strip along the stream. A slightly wider working area will be required for access by heavy equipment access and possibly for hauling out excavated material. The areas temporarily and permanently impacted by the project should cover only a small portion of the width of the park.

A private organization owns a nature conservancy site within the City where Rusk Street ends at Banita Creek. Any effects of the project on this area should be similar to the effects on Pioneer Park, or possibly lesser.

Portions of the Angelina National Forest extend into the southwestern and southeastern portions of the county, but lie far outside the study area.

6. Cultural Resources. Agencies contacted regarding cultural or historic resources were the Texas Historical Commission, the Texas Antiquities Committee, and the Texas Water Development Board *(Engineering Division, Staff Archeologist)*. The responses, if any, from these agencies will be included in attached correspondence. It should be noted that the Nacogdoches area is noted for historic sites, since Nacogdoches is one of the oldest towns in the state. Previous correspondence from the Texas Antiquities Committee for a wastewater project also indicated a high potential for archeological sites within the Nacogdoches area..

7. Economic Conditions. Nacogdoches, one of the oldest towns in Texas, is both a university town and a diversified industrial center. Stephen F. Austin State University *(fall 1995 enrollment of 11, 770[13])* is by far the largest employer in the community. Its almost 3700 students living on campus[13] make up over 11% of the City's population.

Local industries include manufacturers of valves, outdoor furniture, feed and fertilizer, processed poultry, transformers, business forms, motor homes, industrial sealing products, poultry coops, cooling coils, oriented strand board, millwork and commercial fixtures, soft drinks, candy, flanges, and various wood products.

Other significant employers include the U. S. Postal Service; city and county governments; the school district; two hospitals; large retailers; and a construction company.[14] Unemployment is generally low in comparison with the East Texas area 4.6%, December 1995, down from 6.4% in July[15].

Nacogdoches County has considerable timber resources, with ⅔ of the county covered by commercial timber. Many county residents are employed in timber production; livestock production, including cattle, hogs, and poultry; oil and gas production; and tourism.[14]

For Nacogdoches County, the per capita income for 1989 was $13,208. Average weekly wage rate was $300.74 in 1990, with retail sales over $300 million and tax value over $1.6 billion.[1]

Nacogdoches has many opportunities for cultural and recreational activities, including theater groups, art galleries, museums, libraries, parks, swimming pools, golf courses, and tennis courts. Several lakes in the region offer fishing and water sports, including Lake Nacogdoches, Sam Rayburn Reservoir, and Lake Stryker. The surrounding timber land offers considerable hunting opportunities.[14]

Nacogdoches residents tend to have a higher level of education than the nation as a whole. The 1980 census showed that over 48% of all residents 18 years and older had completed at least one year of college. For residents 25 years and older, the percentage was over 41%.

Population projections for the City, taken from a 1994 master plan for the City[16], are as follows:

1990 (census)	30,881
1995 (estimated)	31,522
2000	33,858
2005	35,500
2010	37,229
2020	40,053
2030	41,477

Education through high school is provided by the Nacogdoches Independent School District and by the Central Heights ISD.

Nacogdoches has two general hospitals.

8. Land Use. Nacogdoches has had zoning within the City since 1970. Zoning designations include several categories of residential, business, and industrial use, as well as medical, agricultural, planned development, and floodplain zones. The applicable City ordinances, including the Floodplain Ordinance, place significant restrictions on further development within floodplains, including requirements for special permits and flood protection measures. New structures must generally be located with the lowest habitable floor at least a foot above the 100 year flood level, and cannot generally be located within the floodway.

   In the event of annexation of some land within the study area, zoning for the annexed area is expected to be similar to existing zoning patterns.

   Land in the study area outside Nacogdoches is primarily covered with timber, with some agricultural use including crops, pasture, and chicken houses. A small portion of the study area includes portions of the city of Appleby as well as residential communities and commercial development (mainly along major highways). At least one industry is located in the study area outside Nacogdoches, a creosote plant at Mahl.

Population within floodplains within the study area is reported at 284 within Nacogdoches, with an estimated 120 additional residents outside the City.

9. Other Programs. The general effect of various public and private programs in Nacogdoches is to promote continued growth in the area. The most significant programs are those which encourage industrial and business growth. These programs include industrial revenue bonds issued by the Nacogdoches Industrial Authority, Inc., the Nacogdoches Health Facilities Development Corporation, and the Nacogdoches Housing Authority. All three entities are nonprofit organizations managed by the Nacogdoches County Chamber of Commerce.

   Small businesses may obtain financial assistance through the Small Business Administration and the Deep East Texas Regional Certified Development Corporation. Technical assistance is available through the Small Business Institute at SFA University.[14]

   The Nacogdoches Area Industrial Park, a nonprofit organization, has purchased property at the north end of the city to facilitate industrial development.[14]

   The City of Nacogdoches had a study of its water system performed in 1985, with a further analysis reflected in a comprehensive plan prepared for the City in 1994. The study outlined a twenty year program for upgrading water storage and distribution facilities. The City also plans to expand the capacity of its surface water intake and distribution facilities on Lake Nacogdoches.

   The City has also been implementing a major improvement program for its wastewater collection and treatment facilities. Portions of the program are covered by SRF funding, with some portions funded by TDHCA grants.

TABLE E-1

PRIME FARMLAND

Detailed Soil Mapping Units Listed by USDA as Prime Farm Land:

6. Attoyac fsl *(fine sandy loam)*, 0-4% slopes
   Broad terraces *(old alluvial plains)* near major streams

9. Bernaldo fsl, 0-3% slopes
   Broad terraces near major streams

10. Bernaldo-Bessner complex
    Broad terraces

13. Bowie fsl, 0-8% slopes
    Broad, slightly convex interstream divides

15. Chireno clay loam, 0-2% slopes
    Colluvial areas on lower slopes in Redland Belt

27. Iuka fsl, occasionally flooded
    Bottomlands of small streams

32. Kullit fsl, 0-3% slopes
    Uplands and terrace divides (concave areas, heads of drainageways)

40 Mollville-Besner complex (Bessner soils only)
   Stream terraces, mainly along Angelina River; Bessner on mounds surrounded by Mollville.

42. Nacogdoches fsl, 0-8% slopes
    Broad interstream divides

43. Nacogdoches gravelly fsl, 0-8% slopes
    Broad convex areas in Redland Belt

44. Nacogdoches clay loam, 0-8% slopes
    Broad, convex interstream divides

46. Nacogdoches gravelly clay loam, 0-8% slopes
    Convex ridges

54. Ruston fsl, 0-8% slopes
    Broad interstream divides

67. Woden fsl, 0-4% slopes
    Broad upland terraces

Total detailed mapping units 68 (2 through 69). Source: USDA, Nacogdoches, Texas

TABLE E-2

SOIL TYPES

The Nacogdoches-Trawick soils are loamy upland soils, well drained, gently sloping to moderately steep, with moderately slow permeability.

- Nacogdoches soils, located on interstream divides:
  - ~ 6 inches of fine sandy loam, dark reddish-brown*
  - Dark red clay subsoil to a depth of ~ 70 inches
  - Medium acid surface layer; strongly acid subsoil.

- Trawick soils, on hills and side slopes (8-20% slope):
  - ~ 6 inches of fine sandy loam, dark red*
  - Red clay subsoil to a depth of ~ 46 inches, with bits of yellowish glauconite in lower part
  - Neutral surface layer; medium acid to strongly acid subsoil.

  *Gravelly surface layer in some places.

Other Nacogdoches-Trawick soils include the following:

- Alto soils, on saddles and colluvial foot slopes, loamy.

- Chireno soils, located similar to Alto, clayey.

- Bub soils, on side slopes of hills and ridges, gravelly and clayey.

The Lilbert-Darco soils are sandy upland soils, well drained, gently sloping to sloping, with moderately slow and moderate permeability.

- Lilbert soils, located on low convex areas and ridges
  - ~ 28 inches of loamy fine sand, dark grayish-brown in upper part, pale brown in lower part
  - Brown sandy clay loam subsoil *(mottled with yellowish-red entire depth, also light brownish-gray in lower part)* to a depth of ~ 72 inches
  - Medium acid to very strongly acid surface layer; very strongly acid subsoil.

- Darco soils, on interstream divides:
  - ~ 48 inches of loamy fine sand, brown and pale brown
  - Yellowish-red sandy clay loam subsoil *(with brown mottles in lower part)* to a depth of ~ 72 inches
  - Medium acid surface layer; strongly acid subsoil.

Other Lilbert-Darco soils, all sandy, include the following:

- Briley soils, located on slightly convex areas.

- Betis soils, located on broad interstream divides.

- Rentzel soils, in concave areas near small drainageways.

The Cuthbert-Tenaha soils are loamy and sandy upland soils, well drained, sloping to moderately steep, with moderately slow and moderate permeability.

- Cuthbert soils, located on side slopes adjoining drainageways
  - ~ 8 inches of fine sandy loam, dark gray in upper part and brown in lower part
  - Red clay subsoil *(with brown and light brownish-gray mottles in lower part)* to a depth of ~ 29 inches
  - Strongly acid surface layer; very strongly acid subsoil.

- Tenaha soils, on hills and side slopes:
  - ~ 22 inches of loamy fine sand, brown in upper part and pale brown in lower part
  - Yellowish-red sandy clay loam subsoil *(with brown mottles in upper part and red mottles in lower part)* to a depth of ~ 46 inches
  - Slightly acid surface layer; very strongly acid subsoil.

Other Cuthbert-Tenaha soils include the following:

- Briley soils, located on interstream divides, sandy.

- Ruston soils, located on interstream divides. loamy.

- Kirvin soils, in convex areas, loamy.

The Tuscosso-Hannahatchee soils are loamy bottomland soils, moderately well drained, with moderately slow and moderate permeability, in floodplains that drain the Redland Belt.

- Tuscosso soils, in floodplains of major creeks:
  - ~ 8 inches of clay loam, dark reddish-brown
  - Yellowish-red subsoil, silty clay for top 7 inches; remainder clay with mottles *(grayish-brown upper, gray lower)* to a depth of ~ 53 inches
  - Neutral to very strongly acid surface layer; medium acid to very strongly acid subsoil.

- Hannahatchee soils, in floodplains of smaller streams:
  - ~ 9 inches of loam, reddish-brown
  - Yellowish-red subsoil, loam upper and sandy clay loam lower to a depth of ~ 45 inches
  - Medium acid surface layer and subsoil.

Also included are the Iuka soils, loamy soils in bottomlands of small streams.[3]

TABLE E-3

ANIMAL LIFE, NACOGDOCHES COUNTY

A. MAMMAL LIFE

Opossum	Florida freetailed bat	Bobcat	White-footed mouse
Eastern mole	Raccoon	Eastern Gray squirrel	Golden mouse
Short tail shrew	Mink	Fox squirrel	Northern rice rat
Least shrew	River otter	Eastern flying squirrel	Hispid cotton rat
Georgia bat	Striped skunk	Plains pocket gopher	Florida wood rat
Red bat	Gray fox	Hispid pocket mouse	Pine vole
Evening bat	Coyote	Fulvous harvest mouse	Nutria
Rafinesque's big-eared bat			

Note: All mammals above are specifically noted in the referenced source as occurring in Nacogdoches County. Several other mammals, not listed above, were noted as occurring in regions which included Nacogdoches.

Source: The Mammals of Texas, William B. Davis (Professor Emeritus, Texas A & M University), Texas Parks and Wildlife Department, Revised 1974.

B. BIRD, AQUATIC, AMPHIBIAN, AND REPTILE LIFE.

Bird Life:

Breeding Locally	Migrant
Red-shouldered hawk	Red-tailed hawk
Yellow-billed cuckoo	Kestrel
Barred owl	American woodcock
Pileated woodpecker	Winter wren
Blue jay	Robin
Common crow	Cedar waxwing
Carolina chickadee	Rusty blackbird
Yellow-throated vireo	
Swainson's warbler	
Cardinal	

Aquatic Life:

Bass	Killifish
Gar	Mosquito fish
Minnow	Darter
Pirate Perch	

Amphibians and Reptiles:

Turtles	Lizards
Frogs	American alligator
Snakes	

Source: Environmental Impact Statement for Bayou Loco Dam and Reservoir, Nacogdoches, Texas, SFA University, 1972. Only a portion of the species listed in the referenced source are included in the table. The referenced source dealt only with the Bayou Loco watershed in the western part of the county and consequently is not all-inclusive for the county.

TABLE E-4

ENDANGERED PLANTS, NACOGDOCHES COUNTY

Brachyelytrum erectum, Bearded Shorthusk

Carex atlantica, Atlantic Sedge

Carex nigromarginata, Florida Sedge

Cypripedium calceolus, Yellow Ladies' Slipper

Isotria verticillata, Whorled Pogonia

Panicum ensifolium, Sword-leaf Panic Grass

Parnassia asarifolia, Grass-of-Parnassus

Rhynchospora mixta, Mingled Beakrush

Solidago salicina, Willow Goldenrod

Trillium recurvatum, Prairie Trillium

Trillium texanum, Texas Trillium

Source: "Rare and Endangered Plants Native to Texas,", University of Texas at Austin, Rare Plant Study Center, May 1974.

REFERENCES

1. Texas Almanac, 1992-1993.

2. Quadrangle maps, U. S. Geological Survey: Appleby, Nacogdoches North, Nacogdoches North, Trawick, and Woden.

3. Soil Survey of Nacogdoches County, Texas, USDA Soil Conservation Service, February 1980.

4. USDA Natural Resource Conservation Service *(formerly Soil Conservation Service)*, Nacogdoches, Texas, list "Soil Survey Legend and Interpretive Groups," 1/25/92.

5. USDA Soil Conservation Service, Nacogdoches, Texas, letter to Kimberly Sain of Schaumburg & Polk,.Inc.. May 18, 1988.

6. Rock and Mineral Resources of East Texas , W. C. Fisher, Bureau of Economic Geology, University of Texas, June 1965.

7. United States Geological Survey, "08037050 Bayou LaNana at Nacogdoches, Texas," 1981. Values multiplied by 1.9 reflecting size of drainage area at treatment plant location.

8. Groundwater Conditions in Angelina and Nacogdoches Counties, Texas, Report 110, Texas Water Development Board, March 1970.

9. Conversation between David Eaves, P. E. of Schaumburg & Polk, Inc. and EPA Region VI, Air Quality, Dallas on September 29, 1995.

10. The Mammals of Texas, William B. Davis (Professor Emeritus, Texas A & M University), Texas Parks and Wildlife Department, Revised 1974.

11. Environmental Impact Statement for Bayou Loco Dam and Reservoir, Nacogdoches, Texas, SFA University, 1972.

12. "Rare and Endangered Plants Native to Texas,", University of Texas at Austin, Rare Plant Study Center, May 1974.

13. Conversations between David Eaves, P. E. of Schaumburg & Polk, Inc. and SFA University on September 29, 1995.

14. Nacogdoches Profile, Spring 1988, Nacogdoches County Chamber of Commerce.

15. Texas Employment Commission, quoted in Light and Champion, Center, Texas, September 26, 1995 and later in late January 1996.

16. Nacogdoches Comprehensive Plan, J. Dennis Wilson & Associates, Dallas; Barton-Aschman Associates, Inc., Dallas; and Schaumburg & Polk, Inc., Beaumont; 1994.

The following meetings were held during the progress of the project to solicit comments from the public, Steering Committee and other interested parties and agencies:

Date	Comment
JAN. 1, 1995	Public meeting during initial stage of project to discuss the proposed Study and solicit Public input and comments.
MAR. 21, 1995	Municipal Drainage Utility System (MDUS) Discussed at City Commission meeting.
JUN. 19, 1995	David M. Griffith & Assoc. presentation of MDUS at Lions Club meeting.
AUG. 15, 1995	Public hearing - Received briefing and report on Regional Flood Control Study and Feasibility for creation of MDUS - Received Public input.
SEPT. 5, 1995	Discussed Regional Flood Control Study and advise on final draft at Commission Meeting.
SEPT. 19, 1995	Public Meeting on Regional Flood Control Study - Discussed options and development of final draft.
NOV. 29, 1995	Steering committee meeting - Discussed details of Flood Control Study.

AGENCY CORRESPONDENCE

ADDRESS LIST

Mr. Dale Allred
Building Official and
Floodplain Administrator
City of Nacogdoches
P. O. Box 630648
Nacogdoches, Texas 75963-0648

Mr. Leroy Biggers
Texas Natural Resource Conservation Commission
Region 5
2916 Teague
Tyler, Texas 75701

Ms. Shannon Breslin
Texas Parks and Wildlife Department
Resource Protection Division
Texas Natural Heritage Program
4200 Smith School Road
Austin, Texas 78744

Mr. Walter Diggles
Deep East Texas Council
of Governments
P. O. Box 1170
Jasper, Texas 75951

Mr. Derhyl Hebert, Hazard Mitigation Specialist (MT)
Federal Emergency Management Agency
Region VI, Natural and Technological Hazards Division
Federal Center
800 North Loop 288
Denton, Texas 76201-3698

Mr. Chris Jurgens
Texas Water Development Board
Engineering Division, Staff Archeologist
P. O. Box 13231, Capitol Station
Austin, Texas 78711-3231

Copies to:

Texas Historical Commission
P. O. Box 12276, Capitol Station
Austin, Texas 78711-2276

Texas Antiquities Committee
P. O. Box 12276, Capitol Station
Austin, Texas 78711-2276

Mr. Wayne Lea
U. S. Army Corps of Engineers
Fort Worth District
Regulatory Branch
CESWF-OD-R
P. O. Box 17300
Fort Worth, Texas 76102-0300

Mr. Mike Lynn, P. E.
Texas Water Development Board
Water Engineering Division
P. O. Box 13231, Capitol Station
Austin, Texas 78711-3231

Mr. Robert Short, Field Supervisor
U. S. Department of the Interior
Fish and Wildlife Service
Division of Ecological Services
711 Stadium Drive East, Suite 252
Arlington, Texas 76011

Mr. Bob Spain, Chief
Texas Parks and Wildlife Department
Resource Protection Division
Habitat Assessment Branch
4200 Smith School Road
Austin, Texas 78744

Mr. Chuck Thomas
Angelina-Neches River Authority
P. O. Box 387
Lufkin, Texas 75902

The Honorable O. C. Westmoreland
County Judge, Nacogdoches County
101 W. Main
Nacogdoches, Texas 75961

FACT SHEET

CITY OF NACOGDOCHES
FLOOD CONTROL STUDY

The City of Nacogdoches (population 30,000 ±) is located in Nacogdoches County in central East Texas. The City is conducting a flood control study for the two main streams within the City *(LaNana Creek and its main tributary, Banita Creek)* in view of alleviating periodic flooding problems for residents of the floodplain. The study is financed partially through a Texas Water Development Board grant.

The study area is located in Nacogdoches County extending north from the City to the headwaters of the streams and south for a short distance. The study area includes most of the City of Nacogdoches, part of the City of Appleby, and large unincorporated areas. The area is very hilly outside the floodplains, and most of the unincorporated area is heavily wooded.

All proposed improvements are based on flow rates corresponding to the 100 year, 24 hour storm event.

As a result of the study, the City proposes drainage improvements of the following types:

- Detention basins on selected streams. These basins can be described as small flood control reservoirs, except that the areas outside the stream channels will remain dry during dry weather and minor rains. Basins will be designed for the 100 year, 24 hour storm event with a corresponding maximum downstream flood level designed to protect existing residential areas.

  A simplified description of basin operation is as follows:

  - Low flows compatible with downstream flood protection will flow through the basin unimpeded.

  - During storm events which would (if uncontrolled) cause downstream flood damage, water will be discharged from the basins at the maximum allowable design rate, with flows in excess of that amount impounded within the basins. Water would rise in the basins until it reaches equilibrium, or until a preset maximum level near the top of the levees is reached.

  - For a storm event in excess of the design storm, as the water in the basins approaches the design high level, all excess flows would automatically be discharged regardless of downstream flooding. Otherwise, the basins would cause unacceptable upstream flooding outside the basin limits, and/or the levees could fail and cause even more damage downstream. By definition, this problem should occur less than once every 100 years.

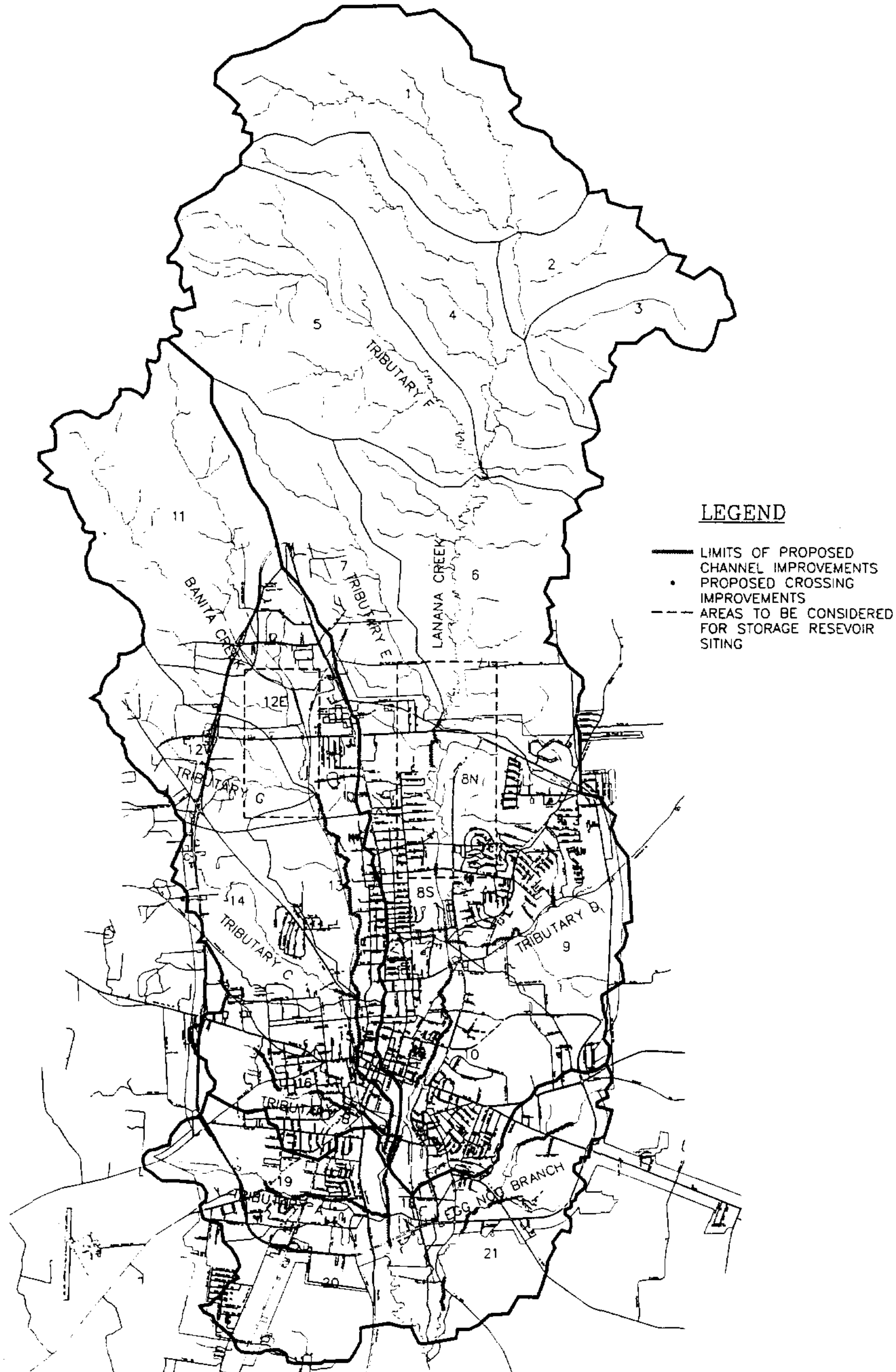
  - Each basin will gradually drain after the storm flows have subsided.

  In essence, by allowing the runoff from upstream to reach the flood-prone neighborhoods at a lower controlled rate rather than all at once, the basins will prevent the flood waters from rising high enough to cause flood damage within the neighborhoods.

- Channel improvements such as widening, straightening, and/or concrete lining of selected portions of streams.

- Improvements to selected road crossings of streams, where these crossings form bottlenecks. Such improvements could include additional culvert barrels, replacement of existing culverts with larger culverts or bridges, relief culverts, increased bridge length to replace existing fill, and/or channel improvements at the crossing.

Attached is a map showing the study area, the existing drainage patterns, and the proposed channel and road crossing improvements. Proposed detention basins, pending final site selection, are shown only in terms of the general areas in which they will be located.



PROPOSED IMPROVEMENTS
DRAINAGE AREAS

CITY OF NACOGDOCHES, TEXAS
REGIONAL FLOOD CONTROL STUDY
LANANA AND BANITA CREEK
WATERSHEDS

PREPARED BY
SCHAUMBURG & POLK, INC.
CONSULTING ENGINEERS
8865 COLLEGE STREET
BEAUMONT, TEXAS 77707
(409) 866-0341

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Dale Allred
Building Official and
Floodplain Administrator
City of Nacogdoches
P. O. Box 630648
Nacogdoches, Texas 75963-0648

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Allred:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

Almost all of the proposed improvements, including most of the basins, fall within the City. As the administrator of floodplain policy for the City of Nacogdoches, you may be primarily concerned with the proposed detention basin sites, although the channel and stream crossing improvements, being within floodplains, will be of some concern.

Please provide any comments which may be appropriate at this stage regarding proposed construction in the floodplain.

Various other local, state, and federal agencies, including FEMA and the county floodplain coordinator, are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Leroy Biggers
Texas Natural Resource Conservation Commission
Region 5
2916 Teague
Tyler, Texas 75701

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Biggers:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

Please provide any comments which may be appropriate at this stage regarding the project.

Various other local, state, and federal agencies are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Ms. Shannon Breslin
Texas Parks and Wildlife Department
Resource Protection Division
Texas Natural Heritage Program
4200 Smith School Road
Austin, Texas 78744

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Ms. Breslin:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. In order to satisfy the environmental concerns of the TWDB, we need comments from environmental agencies, particularly state and federal wildlife agencies as well as the Corps of Engineers.

The areas which appear to be of most concern to your agency are the proposed detention basin sites, although the channel and road crossing improvements will be of some concern.

Please provide any comments which may be appropriate at this stage, including any information on endangered species in the area of the potential project elements.

Environmental Letter
DF:C:\DOC\NACOG\8024-4\BRESLIN.LET\
Nacogdoches--Flood Control Study
101895

The U. S. Fish and Wildlife Service and also the Habitat Assessment Branch of your agency are also being contacted with regard to any possible impacts on endangered species. Also, this project may possibly be on the agenda of a joint project meeting with the Corps of Engineers and wildlife agencies in the future.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Walter Diggles
Deep East Texas Council
of Governments
P. O. Box 1170
Jasper, Texas 75951

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Diggles:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

Please provide any comments which may be appropriate at this stage regarding the project.

Various other local, state, and federal agencies are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments on the water project as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Derhyl Hebert, Hazard Mitigation Specialist (MT)
Federal Emergency Management Agency
Region VI, Natural and Technological Hazards Division
Federal Regional Center
800 North Loop 288
Denton, Texas 76201-3698

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Hebert::

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

The areas which appear to be of most concern to your agency are the proposed detention basin sites, although the channel and stream crossing improvements, being within floodplains, will be of some concern.

Please provide any comments which may be appropriate at this stage regarding proposed construction in the floodplain.

The floodplain coordinators for Nacogdoches County and for the City of Nacogdoches are being contacted concurrently regarding proposed floodplain construction.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Chris Jurgens
Texas Water Development Board
Engineering Division, Staff Archeologist
P. O. Box 13231, Capitol Station
Austin, Texas 78711-3231

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Jurgens:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. Although an archeological study may not be required at this time, it may be necessary later in connection with a TWDB loan to finance the construction.

Both categories of construction may be of significant concern to your agency--the detention basins because of the large areas of periodic impoundment, and the channel and stream crossing improvements because of the potential for archeological materials adjacent to streams.

Please provide any comments which may be appropriate at this stage regarding archeological and historic elements in the area of the anticipated project elements.

The Texas Historical Commission and the Texas Antiquities Committee are receiving copies of this letter.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches
Texas Historical Commission
Texas Antiquities Committee

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Wayne Lea
U. S. Army Corps of Engineers
Fort Worth District
Regulatory Branch
CESWF-OD-R
P. O. Box 17300
Fort Worth, Texas 76102-0300

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Lea:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected.

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the environmental concerns of the TWDB, we need comments from environmental agencies, particularly state and federal wildlife agencies as well as the Corps of Engineers.

Both categories of construction may be of significant concern to your agency--the detention basins because of the necessary fill within floodplains, and the channel and stream crossing improvements because of the modifications stream channels.

Please verify whether an individual Section 10 or 404 permit, or other form of Corps approval, would be required for the detention basins and/or any of the channel modifications.

The U. S. Fish and Wildlife Service and also the Texas Parks and Wildlife Department are also being contacted with regard to any possible impacts on endangered species. Also, this project may possibly be on the agenda of a joint project meeting with the Corps of Engineers and wildlife agencies in the future.

In light of the information in the fact sheet and also the schedule for the completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Mike Lynn, P. E.
Texas Water Development Board
Water Engineering Division
P. O. Box 13231, Capitol Station
Austin, Texas 78711-3231

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Lynn:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. Although your section will review the project more thoroughly at that time and possibly again after plans and specifications are prepared, we would welcome any comments which you may have at this time.

Please provide any comments which may be appropriate at this stage in view of TWDB funding for the study and possibly the construction also.

Environmental Letter
DF:C:\DOC\NACOG\8024-4\LYNN.LET\
Nacogdoches Flood Control Study
101895

The archeological staff of your agency is being contacted in regard to the project and has been requested to conduct any necessary archeological surveys. Various public and environmental agencies, including the Corps of Engineers, the U. S. Fish and Wildlife Service, and the Texas Parks and Wildlife Department are also being contacted with regard to any possible impacts of the project.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Robert Short, Field Supervisor
U. S. Department of the Interior
Fish and Wildlife Service
Division of Ecological Services
711 Stadium Drive East, Suite 252
Arlington, Texas 76011

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Short::

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. In order to satisfy the environmental concerns of the TWDB, we need comments from environmental agencies, particularly state and federal wildlife agencies as well as the Corps of Engineers.

The areas which appear to be of most concern to your agency are the proposed detention basin sites, although the channel and stream crossing improvements will be of some concern.

Please provide any comments which may be appropriate at this stage, including any information on endangered species in the area of the potential project elements.

The Texas Parks and Wildlife Department is also being contacted with regard to any possible impacts on endangered species. Also, this project may possibly be on the agenda of a joint project meeting with the Corps of Engineers and wildlife agencies in the future.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Bob Spain, Chief
Texas Parks and Wildlife Department
Resource Protection Division
Habitat Assessment Branch
4200 Smith School Road
Austin, Texas 78744

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Spain:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. In order to satisfy the environmental concerns of the TWDB, we need comments from environmental agencies, particularly state and federal wildlife agencies as well as the Corps of Engineers.

The areas which appear to be of most concern to your agency are the proposed detention basin sites, although the channel and stream crossing improvements will be of some concern.

Please provide any comments which may be appropriate at this stage, including any information on endangered species in the area of the potential project elements.

The U. S. Fish and Wildlife Service and also the Resource Protection Division of your agency are also being contacted with regard to any possible impacts on endangered species. Also, this project may possibly be on the agenda of a joint project meeting with the Corps of Engineers and wildlife agencies in the future.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

Mr. Chuck Thomas
Angelina-Neches River Authority
P. O. Box 387
Lufkin, Texas 75902

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Thomas:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

As the designated river authority for the area, your agency should be interested primarily in the detention basins, but also in the channel and stream crossing improvements.

Please provide any comments which may be appropriate at this stage regarding the project.

Various other local, state, and federal agencies are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 19, 1995

The Honorable O. C. Westmoreland
County Judge, Nacogdoches County
101 W. Maine
Nacogdoches, Texas 75961

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Judge Westmoreland:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected..

The attached fact sheet provides additional information about the City and the project.

By the end of October, we plan to submit to the Texas Water Development Board a draft of a Flood Protection Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public and environmental agencies may wish to make in regard to the project.

As the administrator of floodplain policy for Nacogdoches County, you may be primarily concerned with the proposed detention basin sites, although the channel and stream crossing improvements, being within floodplains, will be of some concern.

Please provide any comments which may be appropriate at this stage regarding proposed construction in the floodplain.

Environmental Letter
DF:C:\DOC\NACOG\8O24-4\WSTMRLD.LET\
Nacogdoches Flood Control Study
101895

Various other local, state, and federal agencies, including FEMA and the floodplain coordinator for the City of Nacogdoches, are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

October 31, 1995

Mr. John Conner
Director of Parks and Recreation
City of Nacogdoches
P. O. Box 630648
Nacogdoches, Texas 75963-0648

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Conner:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached project map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected.. Also attached is an excerpt from a map of City parks which you sent Schaumburg & Polk, Inc. in 1989 in connection with a wastewater project.

The attached fact sheet provides additional information about the City and the project.

We sent out our initial early contact letters earlier this month, and then upon closer examination discovered that several City parks are located adjacent to various channel improvement, as follows:

Hoya Soccer Complex
Pioneer Park *(channel improvements pass through middle of park)*
Pecan Acres
Banita Creek Park North
Banita Creek Park South and Kiwanis

Some of these parks have received grants from the Land and Water Conservation Fund.

There may also be one or new parks constructed within the last six years which may adjoin work elements.

Today we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

As the City official in charge of City parks, you will be concerned with any impacts which the channel and stream crossing improvements may have on adjacent parks. We anticipate that the channel work will cover only narrow corridors along the streams, although additional clearing may be required in Pioneer Park for access and material hauling.

Please provide any comments which may be appropriate at this stage regarding proposed construction within or adjacent to City parks.

Various other local, state, and federal agencies, including the National Park Service and the Texas Parks and Wildlife Department, are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E.
Project Engineer

TH/DE

encl.

cc (w/encl.): David Smith, City of Nacogdoches

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341

October 31, 1995

Mr. Eldon Reyes (PPE-SWR)
Associate Regional Director,
Planning and Resources Management
U. S. Department of Interior
National Park Service, Southwest Region
P. O. Box 728
Santa Fe, New Mexico 87504-0728

Re: City of Nacogdoches
Nacogdoches County, Texas
Flood Control Study
Proposed Reservoirs and
Channel Improvements

Dear Mr. Reyes:

The above referenced City proposes to construct improvements of several types for flood protection--detention basins to contain runoff from major storms until downstream segments can handle the water, and channel and stream crossing improvements in selected locations. The attached project map shows proposed channel and crossing improvements, as well as general areas in which the various basin sites will be selected.. Also attached is an excerpt from a map of City parks which the City sent Schaumburg & Polk, Inc. in 1989.

The attached fact sheet provides additional information about the City and the project.

We sent out our initial early contact letters earlier this month, and then upon closer examination discovered that several City parks are located adjacent to various channel improvement, as follows:

Hoya Soccer Complex
Pioneer Park *(channel improvements pass through middle of park)*
Pecan Acres
Banita Creek Park North
Banita Creek Park South and Kiwanis

Some of these parks have received grants from the Land and Water Conservation Fund.

Today we plan to submit to the Texas Water Development Board a draft of a Flood Control Study for the project, followed in the next few months by a final report. In order to satisfy the agency's environmental concerns, we are seeking any comments which public or environmental agencies may wish to make in regard to the project.

As an official in the National Park Service, you will be concerned with any impacts which the channel and stream crossing improvements may have on parks which have received the L&WCF funds. We anticipate that the channel work will cover only narrow corridors along the streams with the possible exception of Pioneer Park, which we understand did not receive such funding. For that park, which is a type of natural preserve, some additional clearing may be required for equipment access and material hauling.

Please provide any comments which may be appropriate at this stage regarding proposed construction within or adjacent to City parks covered by L&WCF funds.

Various other local, state, and federal agencies, including the City Parks and Recreation Department and the Texas Parks and Wildlife Department, are being contacted concurrently regarding the study.

In light of the information in the fact sheet and also the schedule for completion of the report as discussed above, we request your initial comments as soon as possible.

Please contact me or Gary Graham, P. E. of this office if you have any questions.

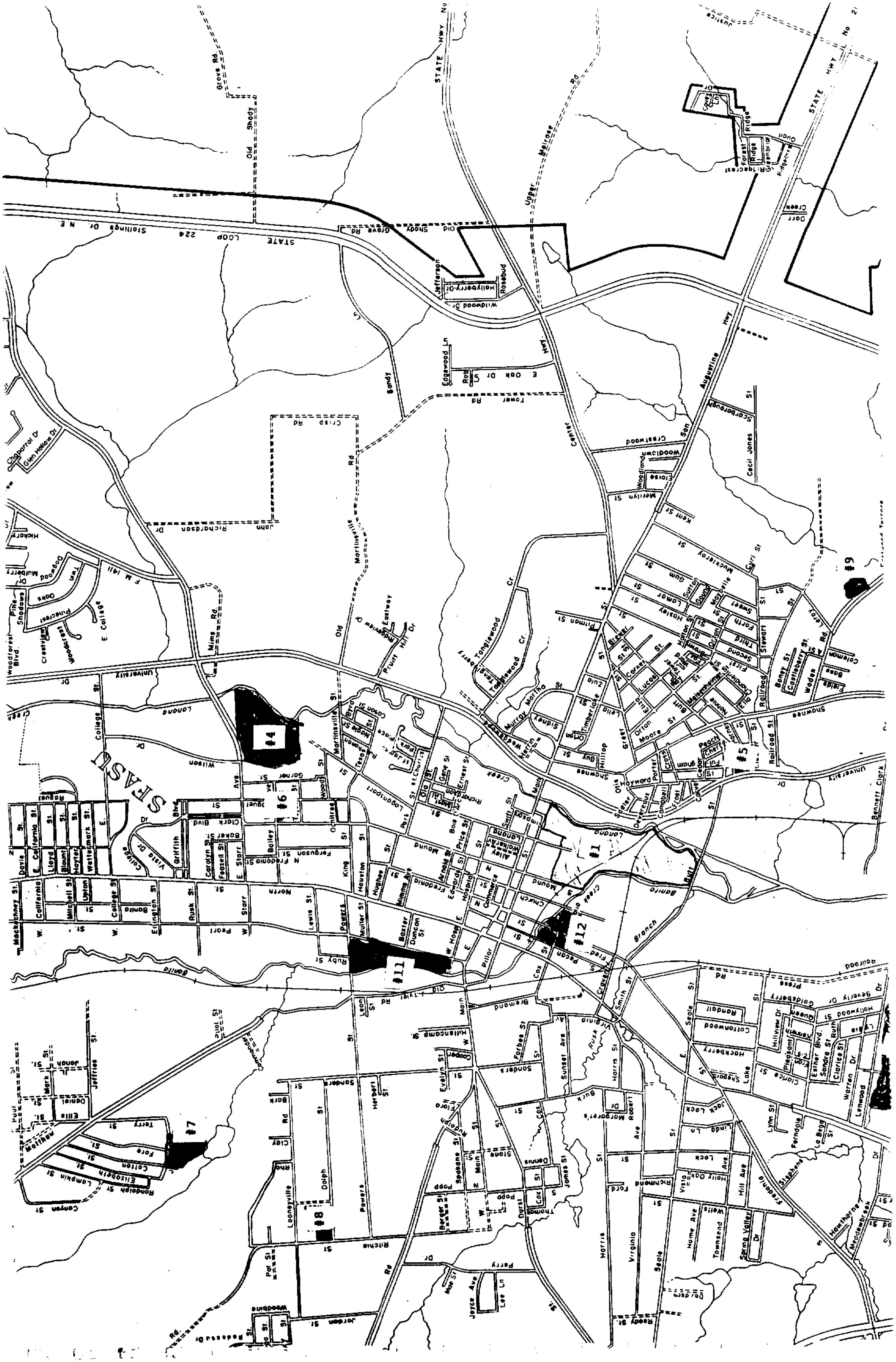
Sincerely,
Schaumburg & Polk, Inc.

Tony Humphrey, P. E
Project Engineer

TH/DE

encl.

cc (w/encl.): City of Nacogdoches:
David Smith, City Engineer
John Conner, Parks and Recreation



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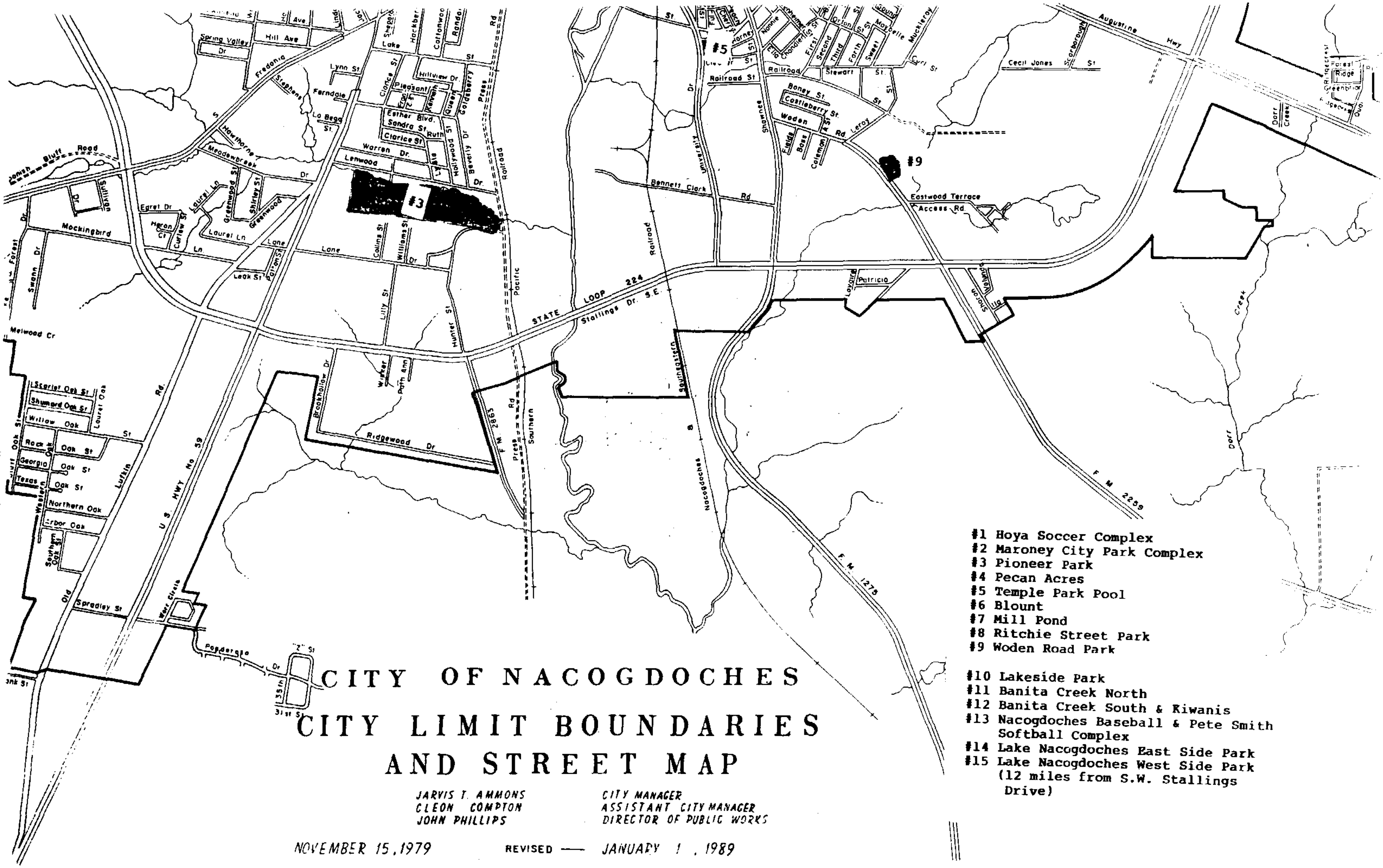

CITY OF NACOGDOCHES
CITY LIMIT BOUNDARIES
AND STREET MAP
JARVIS T. AMMONS CITY MANAGER
CLEON COMPTON ASSISTANT CITY MANAGER
JOHN PHILLIPS DIRECTOR OF PUBLIC WORKS
NOVEMBER 15, 1979 REVISED — JANUARY 1, 1989
#1 Hoya Soccer Complex
#2 Maroney City Park Complex
#3 Pioneer Park
#4 Pecan Acres
#5 Temple Park Pool
#6 Blount
#7 Mill Pond
#8 Ritchie Street Park
#9 Woden Road Park
#10 Lakeside Park
#11 Banita Creek North
#12 Banita Creek South & Kiwanis
#13 Nacogdoches Baseball & Pete Smith Softball Complex
#14 Lake Nacogdoches East Side Park
#15 Lake Nacogdoches West Side Park (12 miles from S.W. Stallings Drive)
STATE LOOP 224
U.S. HWY No 59
F.M. 2259
F.M. 1275
F.M. 2863

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Stadium Centre Building
711 Stadium Drive East, Suite 252
Arlington, Texas 76011

2-12-96-I-035

November 21, 1995

RECEIVED NOV 27 1995

Mr. Tony Humphrey
Schaumburg & Polk, Inc.
8865 College Street, Suite 100
Beaumont, Texas 77707

Dear Mr. Humphrey:

This responds to your October 19, 1995, request for comments on flood protection improvements proposed for the City of Nacogdoches, Nacogdoches County, Texas. Proposed flood protection improvements include channel and crossing modifications as well as water detention basins. Due to the general nature of the information provided, we are unable to provide substantial site-specific comments on the proposed action.

Threatened and Endangered Species

No federally listed threatened or endangered species are known to occur near the proposed action.

Comments

Impacts to existing woody riparian vegetation resulting from the widening, straightening, and/or concrete lining of selected portions of streams is of concern. We recommend a plan be developed which includes the wildlife and recreation potential of the floodways and floodplains within the city of Nacogdoches. Dikes and/or levees, floodwalls, bypass channels, etc. outside riparian areas should be considered instead of clearing vegetation and widening waterways. Structure buyouts and relocation is also a viable option which should be considered. Within the 100-year flood plain a linear park floodway recreation area could be established with hiking, biking and jogging trails interspersed throughout. In fact, the residents of Nacogdoches may be opposed to channelization when it requires removal of the large trees along the creek channel, especially since Nacogdoches (the oldest town in Texas) is known for its woodland beauty.

The proposed temporary detention basins could provide habitat for migratory waterfowl and shorebirds as well as neotropical migratory songbirds if serious consideration is given to managing these areas for wildlife habitat in conjunction with flood protection. The temporary detention basins could be a series of shallow water impoundments with control structures to regulate water depth. These areas would retain water during peak avian migratory periods while allowing for stormwater storage during heavy rainfall events. The limited planting of hardwood trees and establishment of emergent aquatic vegetation within these structures would enhance the wildlife potential without significantly restricting the storage area. These areas could also be utilized by recreational birdwatchers and as an outdoor laboratory for students attending Stephen F. Austin State University. Currently, the best place to observe waterfowl and shorebirds near Nacogdoches is at the city wastewater treatment plant.

Thank you for the opportunity to provide these comments. Should you have any questions, please contact Fish and Wildlife Biologist Jeffrey A. Reid of my staff at (409) 639-8546.

Sincerely,

Robert M. Short

Robert M. Short
Field Supervisor

Federal Emergency Management Agency
Region VI
Federal Regional Center
800 North Loop 288
Denton, TX 76201-3698

December 7, 1995

RECEIVED DEC 13 1995

Tony Humphrey, P.E.
Project Engineer
Schaumburg & Polk, Inc.
8865 College St., Suite 100
Beaumont, Texas 77707

RE: City of Nacogdoches Flood Protection Project

Dear Mr. Humphrey:

We have received your letter of October 19, 1995, in reference to the proposed detention basins and stream channelization project. Thank you for the opportunity to review and comment on the proposed project.

According to our records, the City of Nacogdoches, is participating in the National Flood Insurance Program (NFIP) and has adopted appropriate floodplain management ordinance for issuing development permits within the identified floodplains.

Since the City of Nacogdoches is participating in the NFIP, proper precautions should be taken in the construction of the storm water detention basins and installation of culverts and channel improvements. In accordance with the local adopted floodplain management requirements, the community must require within flood prone areas that the improvements be designed to minimize the impact of this proposed project on the floodplain, both in at the site and downstream.

In closing, we require compliance with all applicable local, state and federal laws prior to the commencement of these projects.

If we can be of further assistance, or additional information is required, please do not hesitate to contact this office at (817) 898-5358.

Sincerely,

Judy Little

Judy Little
Mitigation Specialist

NACOGDOCHES

RECEIVED DEC 18 1995

TRANSMITTAL

Date: December 15, 1995

To:

Mr. Gary Graham
Schaumburg & Polk, Inc.
8865 College St., Suite 100
Beaumont, TX 77707

cc:

From:

David Smith
Engineering Dept.

REMARKS: ☐ Urgent ☐ For your review ☐ Reply ASAP ☐ Please comment

Attached for your review and response: "Copy of letter from Natural Area Preservation Association, Inc. to Mr. Gordon Pierce". Thank you.

Transmitted by Carol Stewart - Dec. 15, 1995

City of Nacogdoches
P. O. Drawer 630648 • 202 E. Pilar • Nacogdoches, TX 75963-0648
409-564-4693 • Fax 409-560-5137

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

January 3, 1996

RECEIVED JAN 04 1996

Mr. Tony Humphrey, P.E.
Schaumburg & Polk, Inc.
8865 College Street, Suite 100
Beaumont, Texas 77707

Re: City of Nacogdoches, Nacogdoches County, Texas; Flood Control Study, Proposed Reservoirs and Channel Improvements

Dear Mr. Humphrey:

This letter is in response to your request for Department comments pertaining to the planning of the above referenced project. The following comments are provided.

A search of the Texas Biological and Conservation Data System (BCD) revealed special species presently known and possibly occurring in the vicinity of the proposed flood control study for the City of Nacogdoches. Following are habitat descriptions for each. Along with printouts for known nearby records, please find enclosed a list of presently computerized records, an incomplete list of rare vertebrates, and a list of state endangered and threatened species that possibly occur in Nacogdoches County.

This area is located in a major migratory bird corridor. Bottomland hardwoods provide vital stopover points for neotropical migrants and habitat for resident breeding species. The U.S. Fish and Wildlife Service (713/286-8282) and Cecilia Riley, Coordinator, Texas Partners in Flight, (512/389-4970) could provide information regarding avian species throughout this general area.

Federal and State Endangered--
- Haliaeetus leucocephalus (Bald Eagle) G3 S2 - contact Mark Mitchell, TPWD biologist, at 512/874-4401 or write P.O. Box 41, Lolita, Texas 77971 for current information on eagle localities
- Picoides borealis (Red-cockaded Woodpecker) G2 S2 - cavity nests in older pine (60 years +); forages in younger pine (30 years +); prefers longleaf, shortleaf, and loblolly pine

Federal Category 2 and State Endangered--
- Pituophis melanoleucus ruthveni (Louisiana Pine Snake) G5T3 S2 - mixed deciduous-longleaf pine woodlands; breeds April-September

Ursus americanus luteolus (Louisiana Black Bear) G5 T3? SR - very unlikely, but possible as transient; bottomland hardwoods

Federal Category 2 and State Threatened--

Aimophila aestivalis (Bachman's Sparrow) G3 S2 - open pine woods with scattered bushes or understory, brushy or overgrown hillsides, overgrown fields with thickets and brambles, grassy orchards; nests on ground against grass tuft or under low shrub

Macroclemys temminckii (Alligator Snapping Turtle) G3? S3 - deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October

Plecotus rafinesquii (Eastern Big-eared Bat) G3 S3 - cavity roosts in bottomland hardwoods

Federal Category 2--

Ammodramus henslowii (Henslow's Sparrow) G4 S? - open fields and meadows with grass interspersed with weeds or shrubby vegetation, especially in damp or low-lying areas, adjacent to salt marsh in some areas; nest well-hidden in grass, either at base of tuft or in stems of growing herbage

Cyperus grayioides (Mohlenbrock's umbrella sedge) G3G4 S3 -soils of sandhills in post oak woodlands and pine-oak sands and sandy soils in dry, almost barren openings in forests; flowering April-August

Cypripedium kentuckiense (southern lady's slipper) G3 S1 - the only in Cypripedium east Texas; dry to mesic forests in various topographic positions; flowering April-June

Myotis austroriparius (Southeastern Myotis) G4 S3 - cavity roosts in bottomland hardwoods

Prenanthes barbata (rattlesnake root) G3 S2 - moist sandy soils in mesic evergreen/deciduous forests and margins; flowering in fall (October-?)

State Threatened--

Cemophora coccinea copei (Northern Scarlet Snake) G5T5 S3 - mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-September

Elanoides forficatus (American Swallow-tailed Kite) G5 S2 - unlikely, but possible; lowland forested regions, especially swampy areas, ranging into open woodland; marshes, along rivers, lakes, and ponds; nests high in tall tree in clearing or on forest woodland edge, usually in pine, cypress, or various deciduous trees; please contact TPWD at 409/384-6894 or write 1342 South Wheeler, Jasper, Texas 75951 for current locality information

Other Special Species--

Bartonia texana (Texas screwstem) G2 S2 - endemic; saprophytic, in and around acid seeps in pine-oak forests on gentle slopes, often on clumps of bryophytes on tree bases, roots, logs, etc.; flowering September-November

Plethodon serratus (Southern Redback Salamander) G5 S1 - found under rocks, rotten logs, and mosses in forested areas; in dry summer months occurs in and near damp areas; most active in spring and fall

The BCD information included here is based on the best data currently available to the state regarding threatened, endangered, or otherwise sensitive species. However, these data do not provide a definite statement as to the presence or absence of special species or natural communities within your project area, nor can these data substitute for an on-site evaluation by qualified biologists. This information is intended to assist you in avoiding harm to species that occur on your site. **Please contact one of the Texas Parks and Wildlife Department's BCD Information Managers before publishing printout data or otherwise disseminating any specific locality information.**

In addition, there is a possibility that the above project may impact several park grant projects, including LWCF Project 48-0481 at Banita Creek and Local Park Fund Project 20-00145 at Hoya Athletic Complex. Please contact Tim Hogsett, Grants-in-Aid Chief at (512) 389-7124 for further coordination on these projects.

Thank you for the opportunity to comment. Please call me at (512) 389-4589 if you have any questions.

Sincerely,

M. Melissa Parker

M. Melissa Parker
Habitat Assessment Branch
Resource Protection Division

MMP:dab

CODE KEY

FEDERAL STATUS (USESA)

LE - Listed Endangered
LT - Listed Threatened
LELT - Listed Endangered in part of range, Threatened in a different part
PE - Proposed to be listed Endangered
PT - Proposed to be listed Threatened
E(S/A) or T(S/A) - Listed Endangered or Threatened on basis of Similarity of Appearance.
C1 - Candidate, Category 1. USFWS has substantial information on biological vulnerability and threats to support proposing to list as endangered or threatened. Data are being gathered on habitat needs and/or critical habitat designations.
C1* - C1, but lacking known occurrences
C1** - C1, but lacking known occurrences, except in captivity/cultivation
C2 - Candidate, Category 2. Information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. Further biological research and field study will be necessary to ascertain the status and/or taxonomic validity of the taxa in Category 2.
C2* - C2, but lacking known occurrences
C2** - C2, but lacking known occurrences, except in captivity/cultivation
3 - Taxa no longer being considered for listing as threatened or endangered. Three subcategories indicate the reasons for removal from consideration.
3A - Former Candidate, rejected because presumed extinct and/or habitats destroyed
3B - Former Candidate, rejected because not a recognized taxon; i.e. synonym or hybrid
3C - Former Candidate, rejected because more common, widespread, or adequately protected
XE - Essential Experimental Population.
XN - Non-essential Experimental Population.

STATE STATUS

E - Listed as Endangered in the State of Texas
T - Listed as Threatened in the State of Texas

GLOBAL RANK (GRANK)

G1 - Critically imperiled globally, extremely rare, 5 or fewer occurrences. [Critically endangered throughout range.]
G2 - Imperiled globally, very rare, 6 to 20 occurrences. [Endangered throughout range.]
G3 - Very rare and local throughout range or found locally in restricted range, 21 to 100 occurrences. [Threatened throughout range.]
G4 - Apparently secure globally.
G5 - Demonstrably secure globally.
GH - Of historical occurrence through its range.
G#NA - Accidental in North America.

G#NE - An exotic species established in North America.
G#T# - "G"= species rank; "T"= rank of variety or subspecies taxa.
GU - Possibly in peril range-wide, but status uncertain.
G#G# - Ranked within a range as status uncertain.
GX - Believed to be extinct throughout range.
Q - Qualifier denoting questionable taxonomic assignment.
? - Not ranked to date; or; Qualifier denoting uncertain rank.
C - Captive population exists.

STATE RANK (SRANK)

S1 - Critically imperiled in state, extremely rare, very vulnerable to extirpation, 5 or fewer occurrences.
S2 - Imperiled in state, very rare, vulnerable to extirpation, 6 to 20 occurrences:
S3 - Rare or uncommon in state, 21 to 100 occurrences.
S4 - Apparently secure in state.
S5 - Demonstrably secure in state.
SA - Accidental in state.
SE - An exotic species established in state.
SH - Of historical occurrence in state. May be rediscovered.
SN - Regularly occurring, non-breeding status.
SP - Potential occurrence in state.
SR - Reported, but without persuasive documentation.
SRF - Reported in error, but error persists in literature.
SU - Possibly in peril in state, but status uncertain.
SX - Apparently extirpated from State.
SZ - Migratory/transient in state to irregular/dispersed locations.
? - Not ranked to date; or, Qualifier denoting uncertain rank.
C - Captive population exists.

PRECISION

S - Second: Accuracy within 3-second radius of latitude/longitude.
M - Minute: Accuracy within 1-minute radius of lat/long, approx. 2 km or 1.5 mi radius.
G - Occurrence mapped general to quad or place name precision only, precision within about 8 km or 5 mi radius.
U - Unmappable record.

OCCURRENCE RANK

A - Excellent
B - Good
C - Marginal
D - Poor
E - Extant/Present
H - Historical/No Field Information
O - Obscure
X - Destroyed/Extirpated

AI - Excellent, Introduced
BI - Good, Introduced
CI - Marginal, Introduced
DI - Poor, Introduced
EI - Extant, Introduced
HI - Historical, Introduced
OI - Obscure, Introduced
XI - Destroyed, Introduced

MANAGED AREA - CONTAINED (code following managed area name)

Y - Element occurrence contained within the managed area boundaries.
N - Element occurrence is not entirely contained within the managed area boundaries.
? - Whether the element occurrence is wholly contained or not within the managed area boundaries is disputed.
blank - No information available.

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: PRENANTHES BARBATA
COMMON NAME: BARBED RATTLESNAKE-ROOT
OTHER NAME:
FEDERAL STATUS: C2
GLOBAL RANK: G3
IDENTIFIED: Y
TRACK: Y
STATE STATUS:
STATE RANK: S2
SENSITIVITY:
COUNTY: Nacogdoches

USGS TOPO MAPS:
APPLEBY
TOPO QUAD:
3109465
MARGIN #:
1

ELEMENT OCCURRENCE NUMBER: 003
PRECISION: G
OCCURRENCE RANK:
DATE LAST OBSERVED: 1941-10-04
DATE FIRST OBSERVED:
DATE SURVEYED:
SURVEY COMMENTS:

MANAGED AREAS:
CONTAINED:

DIRECTIONS:
8 MILES NORTHEAST OF NACOGDOCHES

DESCRIPTION:

QUALITATIVE/QUANTITATIVE DATA:

MANAGEMENT COMMENTS:

PROTECTION COMMENTS:

OTHER COMMENTS:
SPECIMEN AT SMU COLLECTED BY PARKS AT SAME SITE, SAME DATE HAS #RX1872.

SOURCE OF INFORMATION:
PARKS, H.B. (#RX 1373). 1941. SPECIMEN # ? TEX.

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: LEAVENWORTHIA TEXANA
COMMON NAME: TEXAS GOLDEN GLADE CRESS
OTHER NAME:
FEDERAL STATUS: C2
STATE STATUS:
GLOBAL RANK: G1
STATE RANK: S1
IDENTIFIED: Y
TRACK: Y
SENSITIVITY:
COUNTY: Nacogdoches

USGS TOPO MAPS: WODEN
TOPO QUAD: 3109455
MARGIN #: 1

ELEMENT OCCURRENCE NUMBER: 005
DATE LAST OBSERVED: 1987-04-02
PRECISION: S
DATE FIRST OBSERVED:
OCCURRENCE RANK: B
DATE SURVEYED: 1987-04-02
SURVEY COMMENTS: POPULATION INTRODUCED BY B. MAHLER & E. NIXON

MANAGED AREAS:
CONTAINED:

DIRECTIONS:
NORTH SIDE TX 21, ON SLOPE EAST OF CARRIZO CREEK, 3.95 MILES EAST OF INT. LOOP 224 IN NACOGDOCHES, 0.95 MILES WEST OF INT. FM 226 AT OAK RIDGE.

DESCRIPTION:
CALCAREOUS, FOSSILIFEROUS, GLAUCONITE STRATA OF THE WECHES FORMATION (CLAIBORNE GROUP - EOCENE AGE); BELOW ERODED OUTCROP, ON SEEPY, GRAVELLY, SUBSTRATE IN PASTURED AREA

QUALITATIVE/QUANTITATIVE DATA:
INTRODUCED POPULATION; LOCALLY ABUNDANT 200 - 300 PLANTS, 95% PAST FLOWERING ON 4-2-87, GROWING WITH OTHER NATIVE PLANT TAXA CHARACTERISTIC OF SOUTHEAST TEXAS WECHES OUTCROP

MANAGEMENT COMMENTS:

PROTECTION COMMENTS:

OTHER COMMENTS:
ORZELL #5022 TO BE DEPOSITED AT UNIVERSITY OF TEXAS, AUSTIN

SOURCE OF INFORMATION:
ORZELL, STEVE. 1987. FIELD SURVEY OF EAST TEXAS, 19 MARCH TO 3 APRIL 1987.

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: PLETHODON SERRATUS
COMMON NAME: SOUTHERN REDBACK SALAMANDER
OTHER NAME:
FEDERAL STATUS:
GLOBAL RANK: G5
IDENTIFIED: Y
TRACK: Y
COUNTY: Nacogdoches

STATE STATUS:
STATE RANK: S1
SENSITIVITY:

USGS TOPO MAPS:
NACOGDOCHES SOUTH

TOPO QUAD:
3109456

MARGIN #:
2

ELEMENT OCCURRENCE NUMBER: 001
PRECISION: M
OCCURRENCE RANK:

DATE LAST OBSERVED: 1949
DATE FIRST OBSERVED:
DATE SURVEYED:

SURVEY COMMENTS:

MANAGED AREAS:

CONTAINED:

DIRECTIONS:
FERN LAKE

DESCRIPTION:

QUALITATIVE/QUANTITATIVE DATA:

MANAGEMENT COMMENTS:

PROTECTION COMMENTS:

OTHER COMMENTS:

SOURCE OF INFORMATION:
SANDERS, O. & H.M. SMITH. 1949. SOME NOTEWORTHY RECORDS OF AMPHIBIANS IN TX. TRANS KANSAS ACAD SCI 52: 28-29.

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: PITUOPHIS MELANOLEUCUS RUTHVENI
COMMON NAME: LOUISIANA PINE SNAKE
OTHER NAME:
FEDERAL STATUS: C2 | STATE STATUS: E
GLOBAL RANK: G5T3 | STATE RANK: S2
IDENTIFIED: Y | TRACK: Y | SENSITIVITY:
COUNTY: Nacogdoches

USGS TOPO MAPS: NACOGDOCHES SOUTH
TOPO QUAD: 3109456
MARGIN #: 1

ELEMENT OCCURRENCE NUMBER: 002
PRECISION: G
OCCURRENCE RANK: C
DATE LAST OBSERVED: 1956
DATE FIRST OBSERVED:
DATE SURVEYED:
SURVEY COMMENTS:

MANAGED AREAS:
CONTAINED:

DIRECTIONS:
NACOGDOCHES

DESCRIPTION:

QUALITATIVE/QUANTITATIVE DATA:

MANAGEMENT COMMENTS:

PROTECTION COMMENTS:

OTHER COMMENTS:

SOURCE OF INFORMATION:
CONANT, R. 1956. A REVIEW OF TWO RARE PINE SNAKES FROM THE GULF COASTAL PLAIN. AMER MUS NOVITATES (1781): 1-31.

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: ROOKERY
COMMON NAME:
OTHER NAME: COLONY # 574-053, LANANA CREEK
FEDERAL STATUS: STATE STATUS:
GLOBAL RANK: STATE RANK:
IDENTIFIED: Y TRACK: Y SENSITIVITY:
COUNTY: Nacogdoches

USGS TOPO MAPS: NACOGDOCHES SOUTH
TOPO QUAD: 3109456
MARGIN #: 3

ELEMENT OCCURRENCE NUMBER: 262
PRECISION: S
OCCURRENCE RANK:
DATE LAST OBSERVED: 1974
DATE FIRST OBSERVED: 1974
DATE SURVEYED:
SURVEY COMMENTS:

MANAGED AREAS: CONTAINED:

DIRECTIONS:
LANANA BAYOU SOUTH OF NACOGDOCHES BETWEEN TWO RAILROAD LINES; SEWAGE DISPOSAL PONDS

DESCRIPTION:
BAYOU BOTTOM

QUALITATIVE/QUANTITATIVE DATA:
NESTING COLONY OF THE YELLOW-CROWNED NIGHT-HERON

MANAGEMENT COMMENTS:

PROTECTION COMMENTS:

OTHER COMMENTS:
COLONY NUMBER 574-053

SOURCE OF INFORMATION:
MULLINS, L.M. ET.AL. 1982. ET.SEQ. ATLAS & CENSUS OF TEXAS WATERBIRD COLONIES, 1973-1980. TX COLONIAL WATERBIRD SOCIETY. (AND SPECIAL ADMINISTRATIVE REPORT FOR 1989, 1988, 1987, AND 1986.)

TEXAS BIOLOGICAL AND CONSERVATION DATA SYSTEM
TEXAS PARKS AND WILDLIFE DEPARTMENT
07 DEC 1995

NAME: ROOKERY
COMMON NAME:
OTHER NAME: COLONY # 574-052, MILLARD DRIVE

FEDERAL STATUS:	STATE STATUS:
GLOBAL RANK:	STATE RANK:
IDENTIFIED: Y TRACK: Y	SENSITIVITY:

COUNTY: Nacogdoches

USGS TOPO MAPS:	TOPO QUAD:	MARGIN #:
NACOGDOCHES SOUTH	3109456	4

ELEMENT OCCURRENCE NUMBER: 263	DATE LAST OBSERVED: 1973
PRECISION: S	DATE FIRST OBSERVED: 1973
OCCURRENCE RANK:	DATE SURVEYED:

SURVEY COMMENTS:

MANAGED AREAS: CONTAINED:

DIRECTIONS:
LANANA BAYOU ADJACENT TO SOUTHEAST CORNER OF NACOGDOCHES; AT HIGHWAY 224

DESCRIPTION:
BAYOU DRAINAGE

QUALITATIVE/QUANTITATIVE DATA:
NESTING COLONY OF THE LITTLE BLUE HERON

MANAGEMENT COMMENTS:

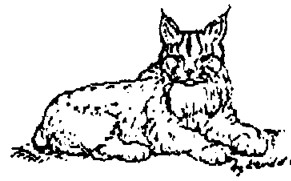
PROTECTION COMMENTS:

OTHER COMMENTS:
COLONY NUMBER 574-052

SOURCE OF INFORMATION:
MULLINS, L.M. ET.AL. 1982. ET.SEQ. ATLAS & CENSUS OF TEXAS WATERBIRD COLONIES, 1973-1980. TX COLONIAL WATERBIRD SOCIETY. (AND SPECIAL ADMINISTRATIVE REPORT FOR 1989, 1988, 1987, AND 1986.)

Natural Area Preservation Association, Inc.

601 Westlake Drive
Austin, TX 78746
512-327-4119
Fax 512-328-3399



- Bobcat -

December 14, 1955

Mr. Gordon Pierce, City Manager
P.O. Drawer 630648
Nacogdoches, TX 75963-0648

Dear Gordon:

Wayne Johnson and I enjoyed visiting with you and David when I was in Nacogdoches recently. We appreciated your loaning me the full flood control study. I have sent it back to you by UPS.

Attached are comments I have prepared for the City Commission concerning adopting the <u>Flood Control Study for the City of Nacogdoches, Texas</u>, prepared by Schaumburg and Polk, Inc., as the City's flood control Master Plan. I would appreciate your seeing that they are properly circulated to the Commission.

Thank you for offering us the opportunity to make comments. We, of course, will be interested to be notified of any future proposed activities on this subject.

Merry Christmas!

Janice Bezanson
President

cc: Wayne Johnson

Natural Area Preservation Association, Inc.

- Bobcat -
An inhabitant of the NAPA refuge

601 Westlake Drive
Austin, TX 78746
512-327-4119
Fax 512-328-3399

December 12, 1995

To: The City Commission of Nacogdoches
Attn: Gordon Pierce, City Manager

Fr: Janice Bezanson, President

COMMENTS ON THE DRAFT MASTER PLAN FOR FLOOD CONTROL

Natural Area Preservation Association offers the following comments on the Commission's intention to adopt as the City's Master Plan the Flood Control Study for the City of Nacogdoches, Texas, prepared by Schaumburg and Polk, Inc.

1. We strongly discourage the Commission from adopting a master plan until more detailed economic analysis is done, to determine whether benefits are commensurate with costs.

Although the costs of each step are assessed, the only attempt at indicating the benefits is a reference to how much damage was done by the 1975 flood.

A detailed economic study should show how both costs and benefits were calculated. Specifically, did the flood damage figure for 1975 make allowance for insurance? If it counted losses to insured property, then that would be double counting. If persons residing in the flood plain were able to acquire or build their structures at reduced cost because of the threat of flood (as is typical), then the "cost" of losing that structure has already been discounted in the market transaction and should not be labeled as a damage cost.

NAPA would like to know how the $37,277,100 figure for what it would cost to buy out all structures in the flood plain was calculated and how the $20,000,000 figure for the cost of the 1975 flood was determined. Adjusting for inflation, $37 million would have been approximately $12 million in 1975, substantially less than the amount calculated for damages in the 1975 flood. Yet the 1975 flood was only a 30-year flood and didn't reflect damage to the whole floodplain!

A detailed study of economics would include secondary costs as well as costs of construction. For example, flood control measures that rely even partially on channelization or other alteration to speed up flood flows do not actually "control" floods, but merely move them downstream. The costs of any increased flooding downstream of the city must be added to the costs of the flood control measures themselves. Similarly, lost uses, including recreational benefits, caused by alteration must be treated as real costs.

In other cases, we wonder whether gains would equal costs. When calculating a bridge extension, for example, we must recognize that the benefit would be only an incremental gain. When the current bridges were built, the builders were surely aware that it would cause flood flow restrictions, and an economic decision was made to forego the added flood flow in return for lower cost, i.e. shorter length bridges, no lining of streambed, etc. Any subsequent decisions should be made on the basis of economics also.

During the devastating floods that hit the upper Mississippi River two years ago, many persons complained that the levees and other engineering structures had not done their work. Yet, as I heard one engineer for the Army Corps of Engineers explain, most of the structures <u>did</u> accomplish/ what they were designed to do. But when they were built, the public had made <u>economic</u> decisions only to build to contain a certain level of flood. The recent flood was much larger than the design, so the levees and other structures didn't contain it.

While the engineering work is of course essential in any pulbic works project, actual decisions to conduct or not conduct projects are made (1) economically and (2) politically. NAPA feels strongly that the citizens of Nacogdoches or Nacogdoches County should not be called upon to fund flood control without being given a <u>vote</u> on decisions about which they have a clear understanding. If a hypothetical ballot were to read, "Do you vote yes or no to having every family of four in Nacogdoches pay nearly $3,000 over X amount of time to reduce flooding on Banita and Lanana Creeks for those people foolish enough to build in the floodplain?", I don't think you'd get many takers.

2. If the Commission implements any of the measures proposed in the study, it will mean a huge public expenditure for benefits that accrue strictly to private citizens -- in effect a subsidy of those citizens living in the floodplain. With respect to property, the public would get no benefit for its outlay. If the money were spent buying citizens out of the floodplain, however, it would still offer that private benefit but <u>also</u> give the public a huge benefit in lands acquired. It would be interesting

to see what would be the vote if our hypothetical ballot above were worded, "Would you rather pay $20 million to benefit only private citizens in the floodplain or $30 million to give those citizens that benefit plus acquire for Nacogdoches two of the largest urban parks in Texas?" My vote would go to the latter.

3. If the Flood Control Study is adopted as a master plan, we strongly urge that the Commission make clear that they are also adopting the priority of work as presented: first retention reservoirs, then bridge crossings, then only lastly deepening and widening of stream courses. Not only is this the proper order for getting greater benefit per dollar spent, it is also the proper order in terms of minimizing damage to the streams and their riparian and aquatic habitats.

4. We are concerned that there are no details given regarding the reservoirs other than a hard-to-determine general area of location and an overall cost figure. How big would the reservoirs be? Where would they be located and on property currently used for what purposes? Would the City have to buy the lands or could they negotiate flood easements so that the current owners could retain compatible uses in non-flood periods? How many structures would have to be abandoned or moved? Would the plan include any vegetation manipulation to enhance their flood control capacity? How much of the land could be acquired from willing sellers and how much would have to be condemned under eminent domain?

5. NAPA's incentive for concern about the Flood Control Study begins with our ownership of Banita Creek Reserve, donated to us by Mrs. Roger (Charlotte) Montgomery. But we would also hate to see the damage to natural plant ecosystems and wildlife habitat that other of the proposed actions would cause.

Most dramatically, we are concerned about the proposal to widen and deepen stream segments. Any form of channelization, even such partial channelization proposed here, has dramatic negative impacts on aquatic and riparian ecosystems. Such impacts have been studied. The Commission should make yourselves familiar with these problems long before you make decisions to construct any of the proposed work.

Even just changing the flood regime (which all the proposed work is aimed at) will affect the vegetation along the creek. Floodplain forests adapt to existing flood patterns and contain different trees at varying levels of flooding. An area such as Banita Creek Reserve could be greatly altered by the proposed flood control measures. The same is true also, of course, for the park along Lanana Creek and any other area with native vegetation.

6. The widespread use of the term "improvements" throughout the Flood Control Study reflects a mentality which misses much of the benefits of urban stream courses. When making any decision about flood control work, the Commission must give weight to the economic and quality of life benefits to Nacogdoches of having two lovely streams in the city limits that are still in a (somewhat) natural state.

I lived in Nacogdoches from 1974 through 1985 and know from my own experience and that of my friends there that the attractiveness of the city is a big draw to people considering relocating to the area. Major changes of the streams, particularly at the crossings (where the most people see them) and along the parks, trails, and natural areas, would reduce Nacogdoches' appeal to individuals and companies considering contributing to local growth.

Schaumburg & Polk, Inc.
CONSULTING ENGINEERS

8865 College St., Suite 100
Beaumont, Texas 77707
Phone (409) 866-0341
FAX (409) 866-0337

March 21, 1996

Ms. Janice Bezanson, President
National Area Preservation Association, Inc.
601 Westlake Drive
Austin, Texas 78746

RE: Flood Control Study
City of Nacogdoches, Texas

Dear Ms. Bezanson:

Thank you for you comments on the above referenced report. We certainly share your concerns over maintaining the natural aesthetic beauty of the creeks and tributaries traversing the City. The purpose of this study was, however, to quantitatively evaluate the existing facilities in regards to the selected design storm and determine size and capacity increases necessary to accommodate the predicted flows. The proposed plan outlines these needs and is intended as a overall general guide to accomplish the task. As you pointed out, the additional aesthetic factors and their benefits must be weighed by the elected officials against the merits of the proposed plan with the ultimate decision being theirs as to what plan modifications may or may not be justified to meet both goals.

In general response to your comments, we have added additional discussion in the report addressing these concerns. Proposed improvements within the upper limits of LaNana and Banita Creeks, as well as their tributaries may possibly allow modifications that would be more expensive yet meet the flood control needs as well as maintain specific stream segments in their natural state or minimize any changes. The lower segments of LaNana and Banita Creeks however, must transport very large flow rates and modifications to the proposed plan in these areas that would maintain both required capacity and the natural stream beauty do not appear possible. The following is in response to specific questions put forth in your letter:

1. On the questions regarding economics we did not differentiate from what pocket; property owner or insurance company; damage costs would come. Should the damage occur, the total replacement cost would have to be considered for equitable comparisons. Secondly, the estimated $20,000,000 of damages encompassed two storms during 1975 and was used only as an example to show that the magnitude of damage costs that can be expected is not a just prediction but something that has been experienced previously. Nor was the $20,000,000 used as the basis for predicted damages. The average value of insured property within the FEMA 100-year storm event flood plan is $128,100. This study found a total of 291 structures located between the flood limits of the 100-year storm event with and without the proposed improvements. The $37,277,100 is a product of the 291 structures and the $128,100 average value.

In addition, even if the city bought out the flood prone properties instead of making recommended improvements, the public would still be responsible for the cost to maintain (and rebuild if flood-damaged) substandard bridges and other drainage facilities. This is a problem the City deals with now and it will not be resolved by purchasing flood plain land.

2. In reference to downstream flooding, the increased channel and crossing sizes alone may result in this occurrence, but when combined with the effects of the reservoirs the result is a smaller peak flow occurrence downstream than would be experienced without any improvements. Unimpeded, a typical storm event produces a peak run-off rate that is very high in comparison to the average flow but only occurs over a very short period of time in comparison to the total storm duration. This peak flow is going to travel downstream regardless of obstructions. If a stream channel is too small or has rough flow characteristics, the water level will simply rise until sufficient cross-sectional area is attained for the stream velocity allowed by ground slope and terrain. The result for the design storm is overbank flow and flooding. Likewise, an under-capacity crossing will be totally inundated before sufficient flow area is attained.

   The method of determining the required capacity increases was two-fold: First, the impact of the reservoirs is to lower the magnitude of the peak flow rate and stretch out the time period over which the peak flow occurs. Secondly, the necessary channel and crossing sizes are then based on the dampened peak flows. The combined results are 1) lower peak flow rates downstream of the reservoir, and 2) reduced localized ponding and flooding along the channels and upstream of crossings.

3. The location of the proposed reservoirs have been generally sited with preliminary perimeters defined. Locations were selected that were most beneficial and economic to the total plan. Vague reference to sites was purposeful; until detailed facility design is accomplished the exact boundaries are unknown and there is a major concern as to the impact on land values prior to actual need for acquisition if even preliminary boundaries were shown in the study at this time.

4. This study was based on the best available data, techniques and design criteria currently available. I feel certain that the previous designers of existing crossing structures did the same, but this does not mean that the data, techniques and criteria were identical. Since this type of information is constantly being upgraded and improved, it would be very surprising to find current and previous methods and basis to be the same.

5. Your reference to the Mississippi levees is a prime example of the impact of selected design criteria. The costs of a system to accommodate a 50-year storm event would be much less than that of a 100-year storm, but the 50-year storm system would not provide protection against the 100-year storm event. Likewise, the proposed plan in the Flood Control Study will not provide protection against a 150-year or 200-year storm.

6. The impact of any construction will be evaluated by the State and Federal regulatory agencies responsible for protecting the environment, plant ecosystems and wildlife habitat. These agencies were notified of the intent of the plan as part of the study process and their comments have been included in the final draft of the report. These agencies will continue to have input during the design and construction phase of any projects proposed by this plan.

We anticipate the impact of construction to be as follows:

Channel Improvements (away from stream crossings): Most channel improvements will follow the existing stream alignments and will involve simple widening, with lining added when necessary. Only in cases where the existing alignment presents a hindrance to flow capacity will be channels be realigned.

Channels may need to be deepened slightly in some locations, such as immediately downstream from road crossings which in themselves involve deepening. Such channel deepening would be phased out downstream as the stream bed allows.

Channel lining will be needed in some locations to improve the flow capacity in lieu of additional stream widening. In all cases, the need for lining will be carefully assessed, with consideration for aesthetic factors. All linings will be designed to avoid future scour problems, and also to allow proper drainage from adjacent floodplain areas into the stream. One secondary benefit of any channel lining is protection from erosion, along with reduction of resulting siltation. Any reduction in siltation would benefit aquatic life.

The areas directly impacted by channel improvements would be minimized. Only small areas would be included in the actual channel widening, and working and access areas would be selected so as to avoid unnecessary damage to wooded areas. In areas where large trees are near the stream, the topography will be reviewed carefully to see whether the channel improvements can be aligned so as not to endanger the trees. Similar efforts will be made to keep access routes away from large trees. Only where necessary will large trees be removed, not only because of aesthetics but also because of the cost of removal.

It should be noted that some trees close to the existing banks are already in danger of being undermined through natural erosion. There may be some cases where a channel liner may prevent future erosion and thus protect the trees.

Where appropriate, heavy equipment may be required to use mats such as board roads for access to avoid permanent damage to areas adjacent to the stream banks.

Most harmful impacts of channel improvements will be only temporary, such as siltation and temporary destruction of vegetation. The environment is expected to recover from these impacts.

It should be noted that LaNana Creek is not presently in its natural state in most areas within Loop 224, which encloses the majority of the developed City. An estimated 60%-70% of the length of this stream within the loop has been realigned within the last 25 years to improve flow characteristics, but further improvements are still needed within this reach.

Stream Crossings: These include actual bridges, culverts, and trestles over streams, plus a short length of the stream channel upstream and downstream as required to make a transition from the cross section at the structure to the normal channel. The actual crossing areas, as well as much of the transitional areas, has already been removed from its natural state as at highway crossings.

Stream crossings are more likely to require lining and deepening but less likely to involve realignment. Much of the area involved in the stream crossings has already been cleared, as at highway and railroad crossings.

It should be pointed out that in some cases, the existing roadways present an impediment to stream flow because of long fill sections and short structure lengths. In many locations, the project would actually restore the crossings to a state closer to natural conditions by replacing existing fill with increased structure length or relief structures.

General: All improvements along streams will be coordinated with applicable environmental agencies, particularly wildlife agencies and the Corps of Engineers. Individual Corps permits may be required for much of the work along streams, especially LaNana Creek. The construction would necessarily follow the permit requirements.

The EPA requires a Pollution Prevention Plan (erosion control measures) for many projects. Such a plan, or its equivalent, would be required for all work elements which would involve a risk of erosion and/or stream siltation.

The project will contain measures for the protection of rare species and archeological and historical resources as appropriate.

Thank you again for your comments and please contact us should you have additional comments or questions.

Sincerely,

Tony Humphrey
P.E. No. 39999

CC: MR. DAVID SMITH, CITY OF NACOGDOCHES

FLOOD CONTROL STUDY
CITY AND COUNTY
OF NACOGDOCHES,
TEXAS

(3) LARGE SCALE MAPS LOCATED IN THE OFFICIAL FILE, MAY BE COPIED UPON REQUEST. May 1, 1996

Exhibit A - Lanana and Banita Creek Watersheds

Exhibit P - Limits of flood Reaches Lanana and Banita Creek Watersheds

Exhibit Q – Graphic Representation of a Segment of the Watershed Model – Confluence of Lanana And Banita Creeks

Please Contact Research and Planning Fund Grants Management Division at (512) 463-7926