US Army Corps
of Engineers

Little Rock District

MAY BRANCH

FORT SMITH, ARKANSAS

FEASIBILITY STUDY

HYDROLOGIC AND HYDRAULIC ANALYSIS

AUGUST 2004

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1. Introduction

A hydrologic and hydraulic study of May Branch, a tributary of the Arkansas River, located within the city limits of Fort Smith, Arkansas was initiated in 1999. Historically, this basin has suffered numerous floods due to increased urbanization, insufficient storm sewer capacity, and an undersized levee outlet. The purpose of this study is to determine the feasibility of flood reduction alternatives for the May Branch watershed. This report presents a description of the analytical approach, analyses performed, and the results obtained for a detailed hydrologic and hydraulic study of an approximately 2.8 mile reach of May Branch that passes through the city and empties into the Arkansas River. Results of this study include water surface profiles for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year return period flow events for without-project (existing) conditions and for three respective with-project alternative conditions.

2. General

2.1 Scope of Work

An interior flooding coincident frequency analysis was performed which was used for existing condition downstream ponding water surface elevation landward of the levee. For each respective flow event analyzed, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year return period, the study entailed development of an existing condition hydrologic and hydraulic model using EPA Storm Water Management Model (SWMM) and a hydraulic model (HEC-RAS) for each respective with-project alternative condition analyzed.

2.2 Watershed Description

The entire drainage area of May Branch is within the city limits of Fort Smith, Arkansas. The basin is 100 percent urbanized. Development in the basin includes areas of low density housing, high density housing, commercial areas, and industrial areas. Basin slope ranges from relatively mild within the Arkansas River floodplain to fairly steep in the headwater areas.

2.3 Available Historical Data

No historical stream flow data was available for the stream reach and associated drainage basins addressed in this study. Data from several rainfall reporting stations in the area is available but was not used in this study. Synthetic rainfall for seven storms was developed and used.

2.4 Previous Studies

May Branch has been previously studied by both the Corps of Engineers and by private engineering firms. Previous studies are listed in Table 1.

TABLE 1
Select Previous Studies of May Branch

1. Fort Smith Flood Protection – April, 1947 – U.S. Army Corps of Engineers, LRD – Analysis of Design for Pumping Stations, Sewer Relief Structures, Levee, Walls, and Drainage Structures.
2. North "P" Street Combined Sewer – August, 1970 – Mickle Associates – Recommend additions to the "P" Street Drainage System.
3. Fort Smith, Arkansas, Flood Study – May, 1983 – U.S. Army Corps of Engineers, LRD – Hydrologic and Hydraulic Analysis.
4. Fort Smith, Arkansas, Type 19 Flood Insurance Study – August, 1986 – U.S. Army Corps of Engineers, LRD – Hydrologic and Hydraulic Analysis.
5. May Branch, Fort Smith, Arkansas, Section 205 – March 1992 – U.S. Army Corps of Engineers, LRD - Reconnaissance Report
6. Fort Smith Stormwater Management Plan – 1993 – Camp Dresser & McKee.
7. May Branch, Fort Smith, Arkansas – May 1996 - U.S. Army Corps of Engineers, LRD - Feasibility Study

3. Interior Flooding Analysis

3.1 Purpose

The purpose of these analyses is to develop coincident event stage-exceedance probability functions for the interior ponding area near the mouth of May Branch. The interior ponding elevations resulting from these analyses are dependent on the probability of Arkansas River stages, the probability of interior runoff, pond storage capacity, and outlet capacity. Stage-exceedance probability curves are developed for existing conditions and for two proposed project alternatives.

3.2 General

The May Branch interior ponding area is formed by the Fort Smith Levee and Floodwall that provide protection against backwater flooding from the Arkansas River. The interior ponding area is drained through the P-Street pumping station, which provides a 12 foot diameter pipe culvert gravity outlet and a peak pumping capacity of 400 cfs. The levee will overtop near the P-Street pumping station when the water surface elevation exceeds EL 419.5 feet (NGVD). At this elevation the interior ponding area has a surface area of approximately 350 acres and extends upstream (southeast) along the route of the P-Street storm sewer to the vicinity of 8th Street. Just below 4th Street the interior ponding area is bisected into an upper and lower pond by the Missouri-Pacific Railroad embankment. For ponding elevations below 415.0 feet the P-Street storm sewer provides the only flow connection between the upper and lower ponds. For ponding elevations above 415.0 feet the Missouri-Pacific Railroad embankment is overtopped.

3.3 Approach

Independence of hydrologic events implies that the physical and meteorological processes of the events are unrelated. The assumption of independence of interior and exterior events is generally valid for relatively small interior areas adjacent to large rivers, and is used here as the basis for application of coincident frequency methodology in the development of the interior ponding area stage-exceedance probability functions.

1) A stage-duration function for exterior (Arkansas River) stages at the mouth of May Branch was developed and divided into segments such that the middle value of each segment represents an exterior stage likely to affect interior ponding stages for either existing conditions or the proposed project alternatives. The segment interval, P(Bi), for each duration represents the probability of the interval and is associated with the middle value for that interval. The sum of the probabilities for all intervals equals 1, i.e., $\sum P(Bi) = 1$. The selected values are shown in Table 2.

Table 2
Arkansas River Stage/Probability

Arkansas River Stage [ft] (Bi)	392.4	394.6	396.0	397.8	400.1	403.0	410.7
Probability P(Bi)	0.7	0.1	0.05	0.05	0.08	0.015	0.005

Use of the stage-duration function as a method of assigning probabilities to exterior stages that might coincide with interior events is assumed to be more accurate than the use of a stage-frequency function because the coincident probability of peak exterior stage with peak interior runoff is very low. For example, the probability of the 100-yr. return period exterior stage coinciding with the 100-yr. return period interior event is (0.01*0.01) = 0.0001 (joint probability theorem). Equivalently stated, such coincidence of events would have a return period frequency of 10,000 years.

2) A series of hypothetical frequency precipitation events occurring over the interior area were modeled for each of the respective exterior stage conditions. An interior stage-frequency function, P(A/Bi) was then developed for each respective exterior stage condition. Implicit in this method of stage-frequency function development is the assumption that interior stage-frequency is directly related to precipitation event frequency (e.g., the 1% interior stage for a given exterior stage condition is the direct result of the 1% storm event over the interior area).

3) A coincident event, interior stage vs. exceedance probability function was then developed from this set of conditional probability functions using the total probability theorem,
$P(A) = \sum_{i=1,n} (P(A/Bi) \times P(Bi))$
where:
P(A) = probability of exceeding a given interior ponding elevation
P(Bi) = probability that the exterior (Arkansas River) is at the ith specific stage interval, where "i" assumes the full range of "n" values that have an effect on pond elevation
P(A/Bi) = probability of exceeding a given interior pond elevation if the river stage is at the ith stage interval

3. 4 Description of Analyses

The HEC-IFH computer model was used for the analyses, with the results of the computer runs providing the required data for development of the probability curves (P(A/Bi)) and (P(A)) previously described in paragraph 3.

The HEC-IFH computer program was not designed to directly model complex, multi-basin hydrologic systems. It provides hydrologic modeling capabilities for relatively simple systems consisting of a maximum of two sub-basins, an "upper" and a "lower", with one interior ponding area allowed in the lower sub-basin only. The modeling of pumps and gravity outlets is also restricted to the lower sub-basin only. More complex hydrologic systems may be modeled indirectly by importing previously computed hydrographs for routing through an interior ponding area. This capability was utilized to model the May Branch interior ponding area.

a) The SWMM computer model was used to model the hypothetical 2-, 5-, 10-, 25-, 50-, 100-, and 500-year precipitation events for the May Branch watershed. The resulting runoff hydrographs representing inflow to the interior ponding area were then imported into HEC-IFH to perform the reservoir routings through the interior pond. The inflow hydrographs for the existing condition analyses reflected routing through available storage upstream of the Missouri-Pacific Railroad embankment and were thus routed only through the portion of the interior pond lying below the railroad embankment. The inflow hydrographs for proposed project conditions reflected routing through available storage upstream of 7th Street and were routed through all available pond storage.
b) The HEC-IFH program used the average end-area method to calculate incremental interior pond storage volumes based on elevation-area data digitally planimetered from contour mapping provided by the City of Fort Smith, dated 1989. For the existing condition analyses the storage volumes were modified to reflect an estimate of fill material placed to the southwest of the P-Street sewer relief structure after the date of survey. For proposed project condition analyses the storage volumes were further modified to account for the increase in storage volume due to channel excavation.
c) The HEC-RAS hydraulic model was used to model the 12 feet diameter pipe culvert gravity outlet and develop discharge vs. interior pond elevation ratings for each of the respective exterior stage conditions. For existing conditions the ratings were developed based on the reach extending from the outlet to the sewer relief structure located about 1000 feet upstream from the P-Street pumping station at the low point of the interior pond. The sewer relief structure is a significant inlet that facilitates flow from the interior pond into the pipe culvert. For proposed project conditions, with interior pond elevations up to 408.0 feet, the ratings were based on the reach extending from the outlet to a point about 320 feet upstream of the sewer relief structure where the existing pipe culvert would tie in to the proposed project open channel. Above 408.0 feet, the sewer relief structure overflow weir elevation, the ratings were based on the reach extending from the outlet to the sewer relief structure.
d) The HEC-RAS hydraulic model was used to model the proposed project condition channel outlet and develop discharge vs. interior pond elevation ratings for each of the respective exterior stage conditions.
e) The P-Street pumping station was modeled as designed. Outflow is via the gravity outlet alone for exterior stages below 408.0 feet. For exterior stages at or above 408.0 feet, outflow is via either gravity outlet or pumping depending on the differential between interior pond

water surface elevation (headwater) and exterior stage (tailwater). When the tailwater elevation exceeds the headwater elevation the outlet gate is closed and outflow is via pumping only. When the headwater minus tailwater differential is such that gravity outlet capacity exceeds available pumping capacity (about 1 feet for 400 cfs pump capacity) the outlet gate is opened and outflow is via gravity outlet only. The design of the P-Street pumping station is such that the pumps may not be operated simultaneously with the gravity outlet. Outlet gates for the proposed project channel were modeled consistent with the operation of the P-Street pumping station.

3.5 Results of Analysis

Summary results of the analyses are presented in Table 3 and shown graphically on the chart that follows, Plate 1.

Table 3
Interior Flooding Results

		Interior Pond Elevation [ft]		
Return Period [yrs]	**Exc. Prob.**	**Existing**	**10-YR Channel w/ 400 cfs Pump**	**10-YR Channel w/ 600 cfs Pump**
2	0.5	404.5	400.9	400.9
5	0.2	405.8	403.4	403.4
10	0.1	408.3	404.9	404.9
25	0.04	411.4	406.5	406.5
50	0.02	412.9	407.4	407.4
100	0.01	414.0	408.7	408.7
200	0.005	414.8	411.2	410.5
500	0.002	415.9	413.0	412.6

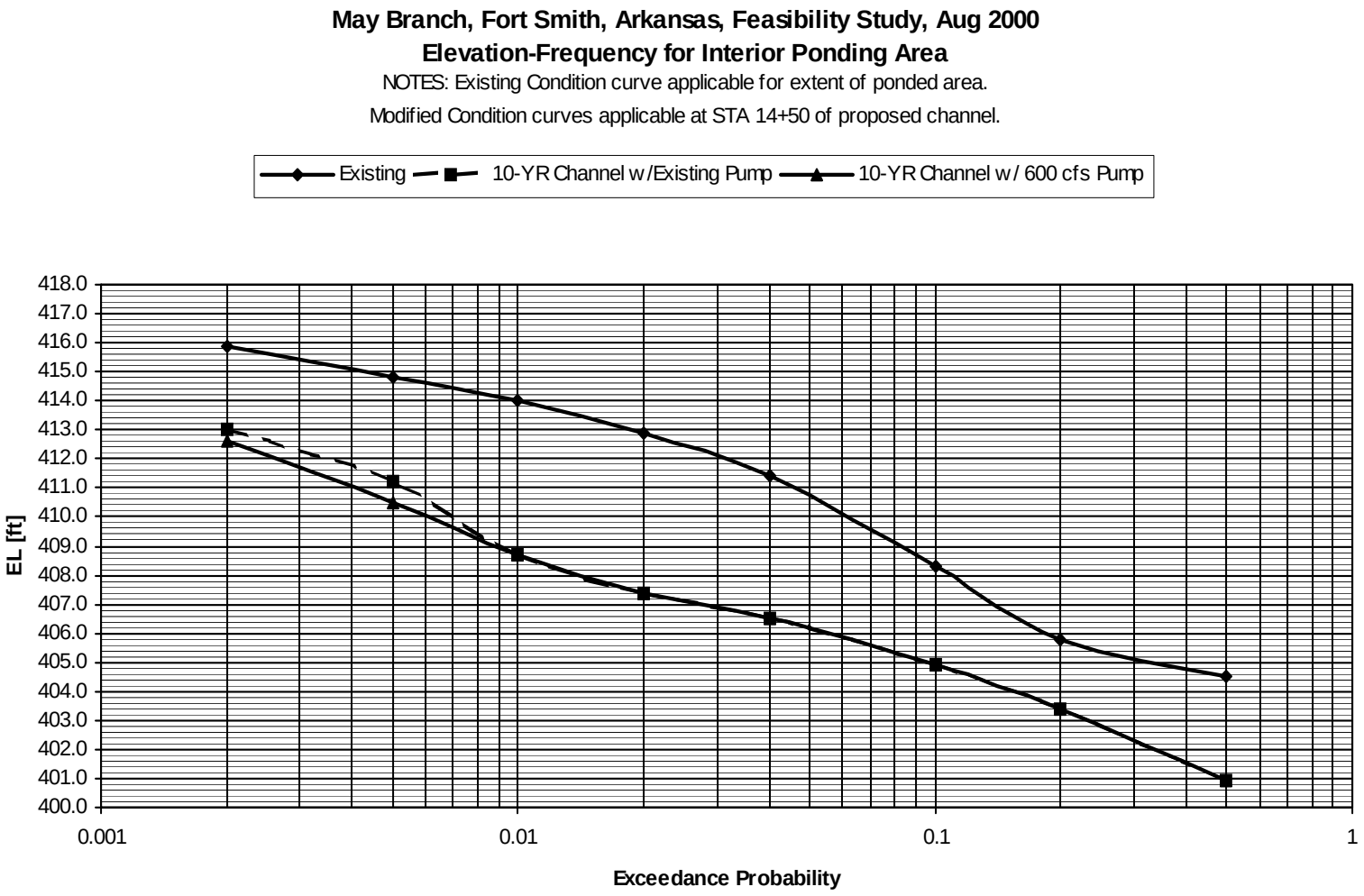


Plate 1

4. Existing Condition Analysis

4.1 Scope of Study

An existing SWMM model for the May Branch channel-culvert system was provided by the City of Fort Smith. Camp Dresser & McKee (CDM) developed the existing model for the City's Stormwater Management Plan published in 1993. The scope of the current study was:

- Determine if any modifications were necessary to the CDM model hydrology to reflect changes from the 1992 conditions to the current conditions;

- Replace the precipitation values used in the CDM study with values developed using HEC-1 for the target events (2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood events);

- Run the City's SWMM model with these precipitation values; and

- Generate water surface elevations for the target events.

It was assumed that the City's SWMM model included the correct geometry for the current system (e.g., no physical or structural changes had been made by the City that would impact the geometry in the model).

4.2 Watershed Changes

Based on reconnaissance of the area on July 21 and August 17, 1999 and discussions with City personnel, it was determined that no modifications were necessary to the watershed characteristics used in the 1993 SWMM model developed by Camp Dresser & McKee (CDM) for the City's Stormwater Management Plan.

4.3 Precipitation Method Changes

In order to conform to the methodology for hypothetical precipitation used by the Corps of Engineers, new precipitation values and distributions were developed for the seven storms to be analyzed using HEC-1 and 24-hour frequency precipitation data from TP-40 (NWS 1961). Table 4 compares the total storm precipitation values used by CDM with those used in this study.

Table 4
Comparison of Precipitation Values

Recurrence Interval (yrs)	Event Frequency (%)	CDM Rainfall Depth* (inches)	FTN Rainfall Depth (inches)
2	50	N/A	3.66
5	20	N/A	5.11
10	10	6.30	6.29
25	4	7.38	7.35
50	2	8.24	8.19
100	1	9.17	9.09
500	0.2	11.70	11.11

* Taken from City of Fort Smith Stormwater Management Plan, Camp Dresser & McKee, December 22, 1993

4.4 Simulation Considerations

All simulations for this project were run using XP-SWMM, Version 6.3, 1999, by XP Software, Inc.

4.5 Backwater Effects

In order to take into account backwater effects from the Arkansas River, the downstream boundary conditions (starting water surface elevations) were set to the coincident frequency elevation values in Table 5 as agreed upon by the City and the Corps. These values are based on a coincident frequency analysis completed in 2000 (different from interior analysis discussed earlier and only used as starting conditions). The FIS elevations, shown for comparison, were taken from the July 1991, City of Fort Smith, Arkansas, Flood Insurance Study (FEMA 1991)

profile at the May Branch confluence with the Arkansas River. Normal pool elevation for the Arkansas River at the confluence with May Branch is 392 feet (NGVD).

Table 5
Starting water surface elevation conditions

Recurrence Interval (yrs)	Event Frequency (%)	Coincident Arkansas River Elevation at 'P' Street Sewer Outfall	FIS Arkansas River Elevation (ft)
2	50	394.08	N/A
5	20	394.31	N/A
10	10	394.58	409.8
25	4	394.96	N/A
50	2	395.12	415.2
100	1	395.27	417.5
500	0.2	395.86	419.8

4.6 Pump Station Operation

A pump station exists at the downstream end of May Branch that is operated to control interior flooding during high stages on the Arkansas River. Under low Arkansas River flow conditions, the May Branch/'P' Street sewer drains to the Arkansas River through a 12 foot diameter pipe through the levee. When the Arkansas River reaches an elevation of 408 feet near the outlet of the May Branch, a gate is closed on the sewer to prevent additional backwater flooding upstream from the Arkansas River, and pumping is initiated to drain the interior areas. For these simulations, the coincident frequency elevation of the Arkansas River was lower than 408, therefore, the May Branch was considered as pipe flow to the Arkansas River, rather than a pumped condition.

4.7 Job Control

Based on recommendations from the SWMM software developers, several job control parameters were modified to smooth numerical oscillations.

4.8 Geometry Changes

During a review of the results a limited review of the hydraulics of the CDM SWMM model was conducted. During this review several connections and nodes were questioned. In addition, it was noted that the existing SWMM model did not include a pump station at the downstream end of the model. After discussing the conditions with City personnel, the following changes were made to the geometry file used for this analysis. A schematic diagram of the existing conditions system model is attached as Plate 2.

- Moved link 10151 from between nodes 1011n/1015n to between nodes 1013n/1015n. Renamed new link MUL510.

- Added link 10131 between nodes 1011n/1013n. Renamed new link MUL511. Link 10131 has the following parameters:
  Trapezoidal channel section
  Length = 1086'
  Bottom Width = 200'
  Side Slope = 1V:50H
  Depth = 8'
  Manning's 'n' = 0.035
  Upstream invert = 414.86
  Downstream invert = 414.50

- Moved overland flow link 12301 from between nodes 1230n/1015n to between nodes 1230n/1013n. Renamed the new link MUL100. Changed downstream invert from 410.60 to 414.86 to match the overland flow elevation at node 1013n, as directed by City personnel.

- A weir diversion (link 1005) was added at node 9n. This weir diversion connects to a new node, 10n. With this change, the storage node data originally at node 9n was moved to node 10n. In addition, the pipe invert at node 9n was changed from 392.5 to 396 so that the weir crest elevation of 408 is at the same elevation as the pipe crown.

- Loss coefficients at Park Street were modified slightly to eliminate crossing water surface profiles just upstream of Park Avenue.

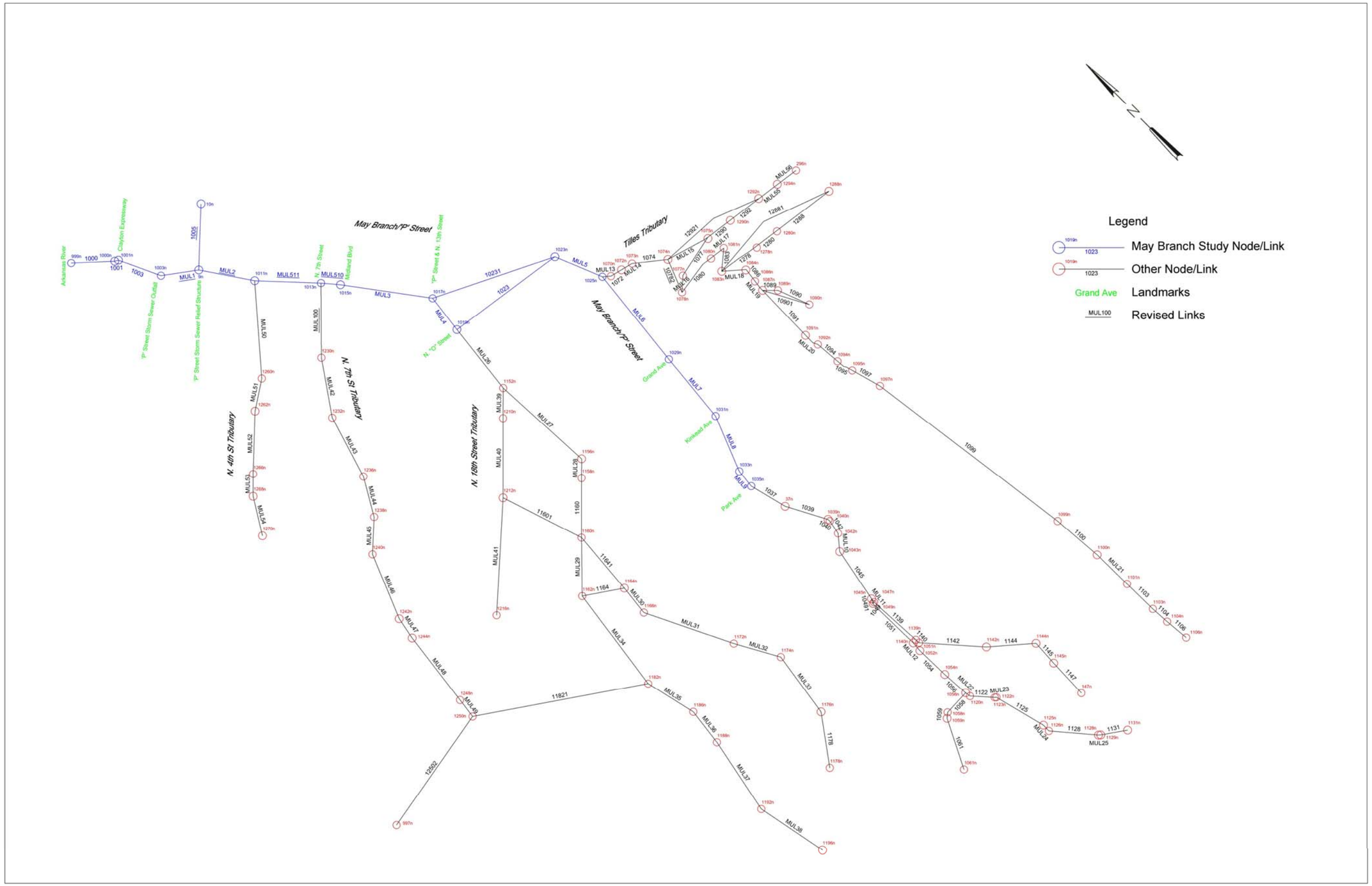
- Link 10782 was moved from between nodes 1042n & 1074n to between nodes 1078n & 1074n based on discussions with City of Fort Smith personnel.

- Node 1042n minimum node elevation was changed to 463.3 based on discussions with City of Fort Smith personnel.

4.9 Results

4.9.1 Hydrology

Table 6 presents the peak flows at various locations along May Branch for the seven frequency events modeled. The flows are not necessarily cumulative at confluences and junctions because SWMM allows for the variation of flow with time and therefore adds the hydrograph ordinates into the system at the time that they occur rather than adding peaks together as is commonly done with a steady state model. The SWMM model also includes several storage areas at nodes that serve to decrease the peak flow as it goes downstream. The flow in the pipe through the


Legend
May Branch Study Node/Link
Other Node/Link
Grand Ave Landmarks
MUL100 Revised Links
May Branch/'P' Street
Tilles Tributary
N. 7th St Tributary
N. 4th St Tributary
N. 16th Street Tributary
Arkansas River
Clayton Expressway
'P' Street Storm Sewer Outfall
'P' Street Storm Sewer Relief Structure
N. 7th Street
Mustard Blvd
'P' Street & N. 13th Street
N. 'O' Street
Grand Ave
Kinwood Ave
Park Ave

levee downstream of the ‘P’ Street relief structure is larger than in previous studies due to SWMM modeling the pipe with pressure flow rather than a free flow condition. The area downstream of the relief structure is modeled as a storage area to represent the ponding that occurs in this area. The overland flow link in this area is configured only to have flow if the elevations are high enough to overtop the levee, which does not occur in any of these simulations.

Table 6.
Existing Conditions Peak Flow Summary

Event Frequency	Location (SWMM Link)	Mouth (Arkansas R – 1000)	P Street Sewer Relief Structure (MUL1 – 1009/10091)	N. 4th Street (MUL2 – 1011/10111)	N. 7th Street (MUL511 – 1013/10131)	Midland Blvd (MUL510 – 1015/10151)	Tilles Tributary (MUL5 – 1025/10251)	Grand Ave nue (MUL6 – 1029/10291)	Kinkead Avenue (MUL7 – 1031/10311)	Blackburn Avenue (MUL8 – 1033/10331)	Park Avenue (MUL9 – 1035/10351)
		Flow (cfs)									
50%	Pipe	1056	1046	942	920	685	422	448	341	322	322
	Overland	N/A	0	0	0	0	221	0	0	0	0
	Combined*	1056	1046	942	920	685	506	448	341	322	322
20%	Pipe	1207	1195	1063	989	738	400	519	427	439	473
	Overland	N/A	0	0	0	322	574	157	172	115	131
	Combined*	1207	1195	1063	989	912	868	672	580	554	572
10%	Pipe	1311	1311	1303	1001	733	400	538	426	441	473
	Overland	N/A	0	0	378	946	800	314	385	309	292
	Combined*	1311	1311	1303	1252	1429	1114	841	770	731	733
4%	Pipe	1501	1489	1460	1000	731	399	548	425	441	473
	Overland	N/A	0	136	1099	1438	1015	474	525	429	412
	Combined*	1501	1489	1513	1743	1850	1346	1021	899	852	853
2%	Pipe	1658	1656	1443	1000	580	399	551	424	440	473
	Overland	N/A	0	612	1553	1752	1207	598	634	541	525
	Combined*	1658	1656	1814	2166	2120	1553	1148	1006	965	967
1%	Pipe	1845	1845	1423	992	567	398	553	424	440	473
	Overland	N/A	0	1401	2006	2120	1456	722	813	726	655[⊥]
	Combined*	1845	1845	2168	2602	2475	1820	1274	1180	1152	1097
0.2%	Pipe	2058	2058	1291	833	577	394	558	424	440	473
	Overland	N/A	0	2562	2869	2853	1839	1052	974	822	824[⊥⊥]
	Combined*	2058	2058	3137	3425	3209	2224	1604	1333	1247	1296[⊥⊥]

* In some cases, the peaks in the storm sewer pipe and corresponding overland channel were not coincident. The combined peak was computed by taking the maximum of the coincident sum of flows.

[⊥] According to output, max flow = 1586 cfs, but considered a numerical anomaly.

[⊥⊥] Computed using average of max. total flow (1260) downstream with total max flow upstream (1332) = 1296 cfs, overland flow = 1296-473

4.9.2 Hydraulics

The results of the simulations are presented in profile form (Plate 3) showing the maximum hydraulic grade line elevations along May Branch or coincident ponding elevation, whichever is higher. The profiles also show the approximate invert and top of pipe for the 'P' Street Sewer and the natural ground profile for the 1991 City of Fort Smith FIS profile. Table 7 summarizes the maximum hydraulic grade line elevations along May Branch.
These SWMM "profiles" cannot be interpreted the same as HEC-2 or HEC-RAS water surface profiles because the SWMM model simulates pipe flow which includes pressure flow in pipes, not just open channel flow. The elevations output from the SWMM model represent the hydraulic grade line elevation and not necessarily the water surface elevation. For evaluation purposes, existing conditions hydraulic grade lines were used as water surface elevations.

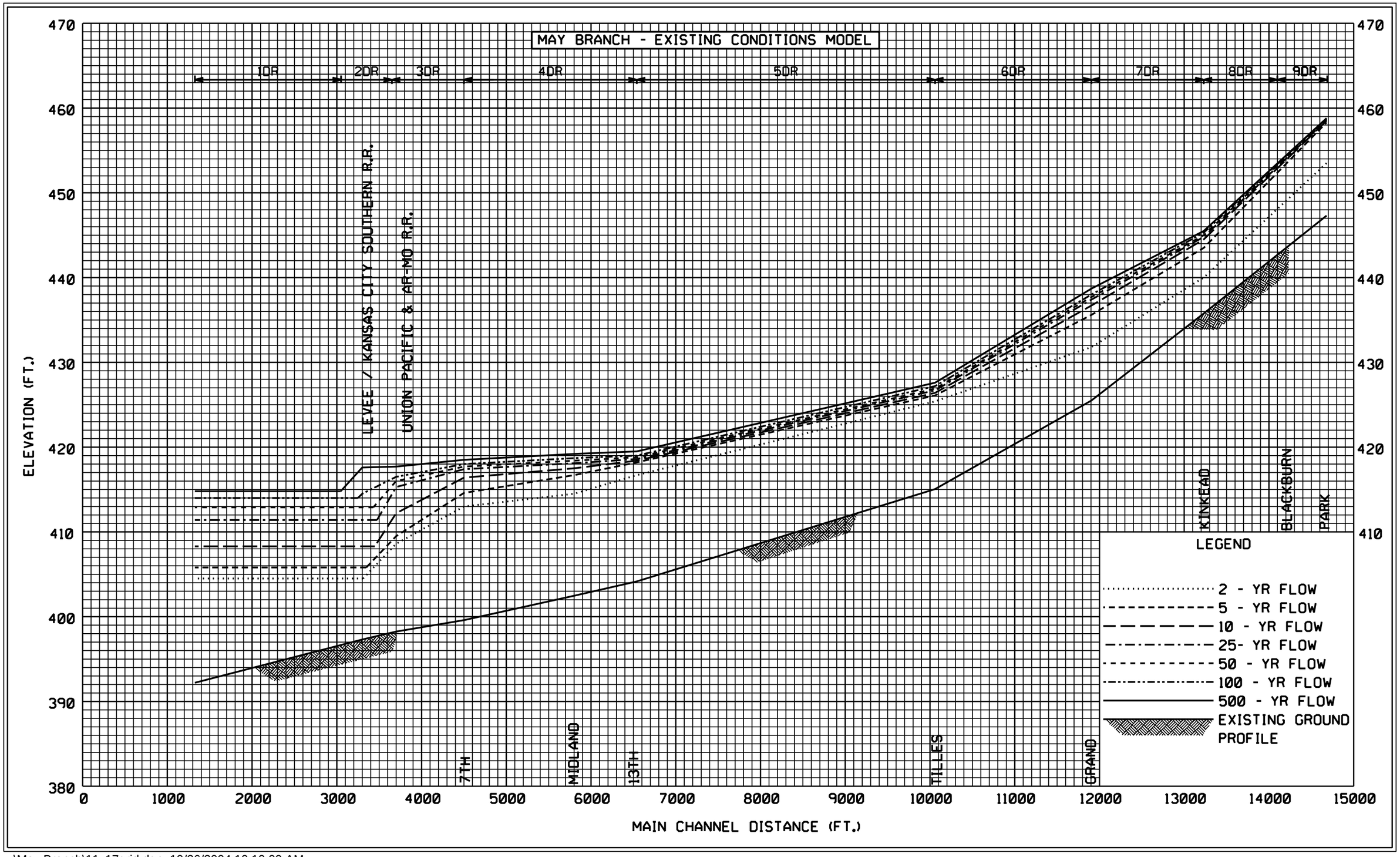
Table 7
Maximum hydraulic grade line elevations (Existing Conditions)

May Branch Location	SWMM Node	Event Frequency 50%	20%	10%	4%	2%	1%	0.2%
		Hydraulic Grade Line (ft)						
Mouth (Arkansas R)	999n	394.1	394.3	394.6	395.0	395.1	395.3	395.9
P St. Sewer Relief Structure	9n	404.4	405.3	406.0	408.4	411.4	414.5	417.6
Just U/S of Missouri-Pacific/Union-Pacific RR	1011n	408.6	409.5	412.2	415.3	416.0	416.5	417.7
N. 7th Street	1013n	413.0	414.6	416.4	417.4	417.7	418.0	418.5
Midland Blvd	1015n	414.5	416.7	417.5	418.1	418.4	418.7	419.2
P St. & N. 13th	1017n	416.7	418.2	418.4	418.6	418.8	419.0	419.5
Tilles Tributary	1025n	425.4	426.1	426.4	426.7	426.9	427.2	427.6
Grand Avenue	1029n	431.8	435.6	436.7	437.4	437.7	438.0	438.7
Kinkead Avenue	1031n	440.0	443.5	444.5	444.8	445.0	445.3	445.5
Park Avenue	1035n	453.5	458.3	458.5	458.6	458.7	458.8	458.8

5 Analysis of Project Alternatives

5.1 General

The purpose of the analysis was to develop 10-, 50-, and 100-year design channels to maintain water elevations below "Start of Damages" elevations along the study reach. The study reach is from the confluence with the Arkansas River upstream to Park Avenue, approximately 3 miles. The upstream limit of Federal interest, the point where the 10-year flow equals 800 cfs, is just upstream of Grand Avenue, as shown in Table 6, Existing Conditions Peak Flow Summary. The downstream project limit is the confluence with the Arkansas River. Flood flow from May Branch is minimal compared to any condition of the Arkansas River and would be insignificant to any Arkansas River condition.



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5.2 Background

The City of Fort Smith (City) contracted with FTN Associates, Ltd. to develop the existing conditions profiles for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events (with frequencies of 50%, 20%, 10%, 4%, 2%, 1%, and 0.2%, respectively) for the existing "P" Street storm sewer system. The City provided FTN with an existing SWMM model of the system that was developed by Camp, Dresser & McKee in 1993 for the City's Stormwater Management Plan. FTN applied the design rainfall, based on TP-40, to the existing SWMM model and prepared profiles for the existing condition.

5.3 Pre-Selected Channel

The existing conditions SWMM model was modified to develop a pre-selected design channel for the proposed May Branch improvement project. Assumptions made in the SWMM analysis included:

1. Allowing additional capacity in several of the downstream laterals that feed into the existing "P" Street system (assuming the City improves these laterals in the future);

2. Providing three lateral connections between the original "P" Street system and the new channel (at the oxbow just upstream of the existing pump station, near North 7th Street, and near the intersection of "P" Street and 13th Street); and

3. The existing "P" Street system would remain in place and fully functional from just upstream of the North "O" Street crossing downstream to the Arkansas River.

These assumptions were made to provide a conservative (high) estimate of the flow that the new channel would need to accommodate. This pre-selected design channel was used to establish design flows for use in preparing an HEC-RAS model of the proposed channel to determine preliminary design sizes for the channel, bridge openings, and culverts for the Little Rock District. The flow values used in the HEC-RAS models are presented in Table 8. The modified condition SWMM schematic is shown as Plate 4.

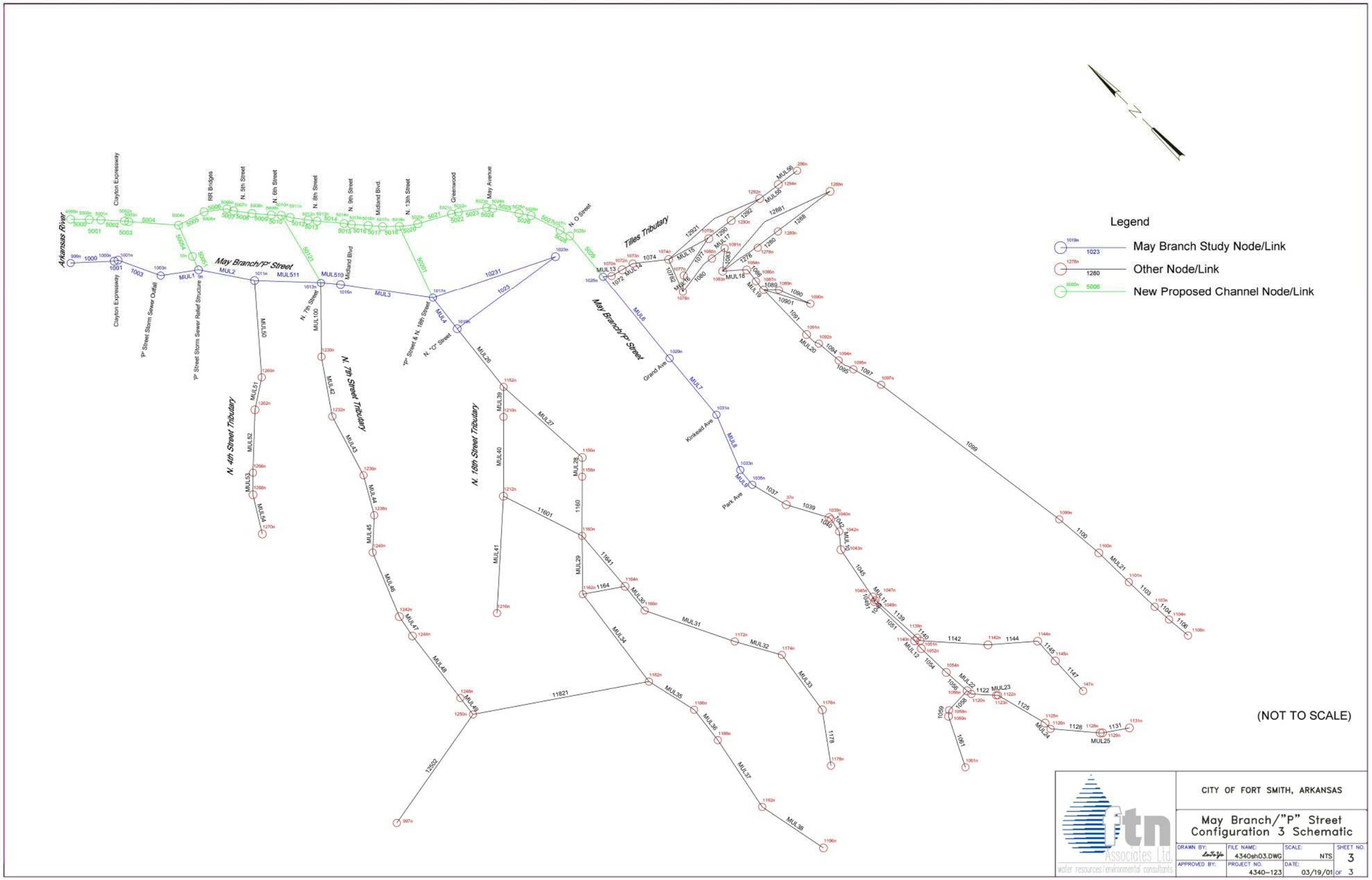

Legend
May Branch Study Node/Link
Other Node/Link
New Proposed Channel Node/Link
(NOT TO SCALE)
Arkansas River
Clayton Expressway
RR Bridges
N. 5th Street
N. 6th Street
N. 8th Street
N. 9th Street
Midland Blvd.
N. 12th Street
Greenwood
May Avenue
N. O Street
May Branch/"P" Street
"P" Street Storm Sewer Outfall
"P" Street Storm Sewer Relief Structure
N. 7th Street
"P" Street & N. 16th Street
N. "O" Street
Tiles Tributary
Grand Ave
Kinkead Ave
Park Ave
N. 4th Street Tributary
N. 7th Street Tributary
N. 16th Street Tributary
CITY OF FORT SMITH, ARKANSAS
May Branch/"P" Street
Configuration 3 Schematic
DRAWN BY:
FILE NAME: 4340sh03.DWG
SCALE: NTS
SHEET NO. 3
APPROVED BY:
PROJECT NO. 4340-123
DATE: 03/19/01
OF 3
water resources/environmental consultants

Plate 4

Table 8
Flow values (cfs) used in HEC-RAS design models (Modified Conditions)

Location	Station (ft)	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)	0.2% (500-year)
U/S Limit	158+20	140	215	270	340	400	450	575
Kinkead Ave U/S Face	144+40	240	375	465	600	685	785	1000
Grand Ave U/S Face	131+30	390	600	750	955	1100	1250	1585
Just D/S of Tilles Trib	112+00	555	830	1140	1310	1460	1725	2415
Just D/S of N 18th St extension	75+90	910	1365	1680	2025	2280	2600	3550
Just D/S of N 7th St extension	53+30	1670	2475	3000	3565	3840	4090	5025

5.4 Design Channels

The basic parameters for determining the size of the new channels and structures included the following:

- The models would use starting water surface elevations from the coincident frequency analysis,
- No levee gate or pump station would be modeled in the system along the new channel,
- Trapezoidal channels would have 3H:1V side slopes stabilized with rip rap (Manning's 'n' value equals 0.040),
- Manning's 'n' values would not be modified from 0.040 based on velocities in the channels,
- Concrete vertical-walled channels would have a Manning's 'n' value of 0.013,
- Bridges would be used for structures from North 6th Street to the mouth,
- Box culverts would be used for all structures upstream of North 6th Street (box culverts would be standard highway type with 18 to 33 degree flared wingwalls),
- At least 1 foot between top of road and interior top of box culvert (crown) would be maintained at all crossings,
- The channel through Clayton Expressway to just upstream of the Fort Smith levee would have vertical sides and be made of concrete (Manning's 'n" equals 0.013), (changed to trapezoid channel through Clayton Expressway)

- The channel between May Avenue and North “O” Street would have vertical sides and be made of concrete (Manning’s ‘n’ value equals 0.013) including the two structures and one access crossing at the Arkhola Plant, (changed to vertical sides from May Avenue to Arkhola Bridge behind plant)

- The channel invert and slope would approximate the existing invert and slope of the “P” Street system,

- The channels would be designed such that the water surface elevations are below the provided “Start of Damages” elevations (Table 9) and with minimal or no roadway inundation, and

- Overbank points would be obtained from a drawing provided by the District.

Manning’s ‘n’ values were set to 0.04 for the overbank areas upstream of the Union Pacific Railway crossing at approximately station 48+00. Downstream of this crossing, the overbanks are wooded and a Manning’s ‘n’ value of 0.10 was assumed for the overbank areas.

Table 9
Start of Damages station-elevation

Station	“Start of Damages” Elevation	Station	“Start of Damages” Elevation
14+50	416.8	82+50	422.0
28+00	413.0	88+00	422.2
33+00	412.5	93+50	424.4
38+00	416.8	105+00	424.2
42+50	412.8	110+00	424.7
48+00	413.2	115+00	426.8
52+00	413.9	120+00	428.4
56+00	414.4	122+50	430.5
62+00	415.4	127+50	432.2
65+00	413.2	133+00	436.3
70+00	415.9	138+00	440.4
74+00	419.0	149+00	446.4
77+00	416.1	157+00	453.9

5.5 RESULTS OF DESIGN ANALYSIS

Results of the design analyses are shown on profiles for the proposed May Branch channel as PLATES 4 - 7. The various plans were designed to maintain respective water surface elevations below the “start of damage” elevations as shown in Table 9.

5.5.1 10-Year Design

The bottom width of the 10-year design trapezoidal channel varies from 10 feet to 4 feet wide (Table 10). The channel bottom width from the mouth of May Branch to May Avenue is 10 feet. From May Avenue along the back of Arkhola the channel has vertical walls with a 12 foot bottom width. From Arkhola crossing to "L" Street the bottom width is 6 feet and from "L" Street to Park Street the bottom width is 4 feet. Box culvert sizes range from 3 - 10'Wx10'H to 2 - 6'Wx6'H (Table 11). The 10-year design channel profile is shown as Plate 5.

Table 10
10-year design channel data.

Section Type	Station*		10-Year Design Channel Data	
	Start Station	End Station	Bottom Width (ft)	Side Slope
Trapezoid	0+00	80+80	10	3H:1V
Rectangular	82+20	86+35	12	N/A
Trapezoid	86+80	90+80	6	3H:1V
Trapezoid	100+60	105+10	6	2H:1V
Trapezoid	106+30	112+60	4	2H:1V
Trapezoid	117+50	145+30	4	3H:1V

- Gaps in stationing are locations of transition sections and structures.

Table 11
10-year design structure data.

Structure Type	Location	Center line Station	10-Year Design Structure Data			
			Length (ft)	Number of Boxes	Bottom Width or Span (ft)	Rise (ft)
RCBC*	Clayton Expressway/Levee	13+25	140	2	10	10
RCBC	Missouri-Pacific RR	28+25	83	3	10	10
RCBC	Unnamed Railroad and Union Pacific Railroad	33+70	42	3	10	10
RCBC	Arkansas-Missouri RR	34+75	68	3	10	10
RCBC	Union Pacific RR	36+50	45	3	10	10
Bridge	North 6th Street	41+45	N/A	N/A	N/A	N/A
RCBC	Midland Blvd	58+00	120	2	8	12
RCBC	Greenwood Avenue	76+75	86	2	8	8
Bridge	Arkhola Crossing	86+10	N/A	N/A	N/A	N/A
RCBC	North 'O' Street	92+00	90	2	8	10
RCBC	Grand Avenue	119+05	102	3	6	6
RCBC	Kinkead Avenue	132+30	90	2	6	6
RCBC	Park Avenue	146+14	85	2	6	6

*Reinforced concrete box culvert

5.5.2 50-Year Design

The bottom width of the trapezoidal portion of the 50-year design channel varies from 24 feet to 4 feet wide (Table 12). The channel bottom width from the mouth of May Branch to the levee is 20 feet. In the reach between the levee and Midland Blvd., the channel bottom width increases to 24 feet. From Midland to May Avenue the bottom width is 16 feet. From May Avenue along the back of Arkhola the channel has vertical walls with a 14 foot bottom width. From Arkhola crossing to "L" Street the bottom width is 16 feet, from "L" Street to Grand Avenue 8 feet, and from Grand Avenue to Park Street the bottom width is 4 feet. Box culvert sizes range from 4 - 10'Wx10'H to 2 - 6'Wx6'H (Table 13). The 50-year design channel profile is shown as Plate 6.

Table 12
50-year design channel data.

Section Type	Station		50-Year Design Channel Data	
	Start Station	End Station	Bottom Width (ft)	Side Slope
Trapezoid	0+00	12+00	20	3H:1V
Trapezoid	14+50	56+55	24	3H:1V
Trapezoid	59+10	80+80	16	3H:1V
Rectangular	82+20	86+35	14	N/A
Trapezoid	86+80	90+80	16	3H:1V
Trapezoid	100+60	105+10	16	2H:1V
Trapezoid	106+30	112+60	8	2H:1V
Trapezoid	117+50	118+15	8	3H:1V
Trapezoid	119+75	145+30	4	3H:1V

Table 13
50-year design structure data.

Structure Type	Location	Center line Station	50-Year Design Structure Data			
			Length (ft)	Number of Boxes	Bottom Width or Span (ft)	Rise (ft)
RCBC*	Clayton Expressway/Levee	13+25	140	2	10	10
RCBC	Missouri-Pacific RR	28+25	83	4	10	10
RCBC	Unnamed Railroad and Union Pacific Railroad	33+70	42	4	10	10
RCBC	Arkansas-Missouri RR	34+75	68	4	10	10
RCBC	Union Pacific RR	36+50	45	4	10	10
Bridge	North 6th Street	41+45	N/A	N/A	N/A	N/A
RCBC	Midland Blvd	58+00	120	2	8	12
RCBC	Greenwood Avenue	76+75	86	2	8	10
Bridge	Arkhola Crossing	86+10	N/A	N/A	N/A	N/A
RCBC	North 'O' Street	92+00	90	2	8	10
RCBC	Grand Avenue	119+05	102	3	6	6
RCBC	Kinkead Avenue	132+30	90	3	6	6
RCBC	Park Avenue	146+14	85	2	6	6

5.5.3 100-Year Design

The bottom width of the trapezoidal portion of the 100-year design channel varies from 24 feet to 4 feet wide (Table 14). The channel bottom width from the mouth of May Branch to the levee is 20. In the reach between the Levee and Midland Blvd., the channel bottom width increases to 24 feet. From Midland to May Avenue the bottom width is 16 feet. From May Avenue along the back of Arkhola the channel has vertical walls with a 14 foot bottom width. From Arkhola crossing to "L" Street the bottom width is 16 feet, from "L" Street to Grand Avenue 8 feet, and from Grand Avenue to Park Street the bottom width is 4 feet. Box culvert sizes range from 5 - 10'Wx10'H to 3 - 6'Wx6'H (Table 15). The 100-year design channel profile is shown as Plate 7.

Table 14
100-year design channel data.

Section Type	Station*		100-Year Design Channel Data	
	Start Station	End Station	Bottom Width (ft)	Side Slope
Trapezoid	0+00	12+00	20	3H:1V
Trapezoid	14+50	56+55	24	3H:1V
Trapezoid	59+10	80+80	16	3H:1V
Rectangular	82+20	86+35	14	N/A
Trapezoid	86+80	90+80	16	3H:1V
Trapezoid	100+60	105+10	16	2H:1V
Trapezoid	106+30	112+60	8	2H:1V
Trapezoid	117+50	118+15	8	3H:1V
Trapezoid	119+75	145+30	4	3H:1V

*Gaps in stationing are locations of transition sections and structures.
**Several sections in this reach were modified to have vertical right banks to avoid buildings in the area. See plans tables for data.

Table 15
100-year design structure data.

Structure Type	Location	Center line Station	100-Year Design Structure Data			
			Length (ft)	Number of Boxes	Bottom Width or Span (ft)	Rise (ft)
RCBC*	Clayton Expressway/Levee	13+25	140	2	10	10
RCBC	Missouri-Pacific RR	28+25	83	5	10	10
RCBC	Unnamed Railroad and Union Pacific Railroad	33+70	42	5	10	10
RCBC	Arkansas-Missouri RR	34+75	68	5	10	10
RCBC	Union Pacific RR	36+50	45	5	10	10
Bridge	North 6th Street	41+45	N/A	N/A	N/A	N/A
RCBC	Midland Blvd	58+00	120	3	8	12
RCBC	Greenwood Avenue	76+75	86	2	8	10
Bridge	Arkhola Crossing	86+10	N/A	N/A	N/A	N/A
RCBC	North 'O' Street	92+00	90	2	8	10
RCBC	Grand Avenue	119+05	102	3	6	6
RCBC	Kinkead Avenue	132+30	90	3	6	6
RCBC	Park Avenue	146+14	85	3	6	6

5.5.4 200-Year Design

The bottom width of the trapezoidal portion of the 100-year design channel varies from 26 feet to 4 feet wide (Table 16). The channel bottom width from the mouth of May Branch to the levee is 20. In the reach between the Levee and Midland Blvd., the channel bottom width increases to 26 feet. From Midland to May Avenue the bottom width is 16 feet. From May Avenue along the back of Arkhola the channel has vertical walls with a 14 foot bottom width. From Arkhola crossing to "L" Street the bottom width is 16 feet, from "L" Street to Grand Avenue 8 feet, and from Grand Avenue to Park Street the bottom width is 4 feet. Box culvert sizes range from 6 - 10'Wx10'H to 3 - 6'Wx6'H (Table 17). The 200-year design channel profile is shown as Plate 8.

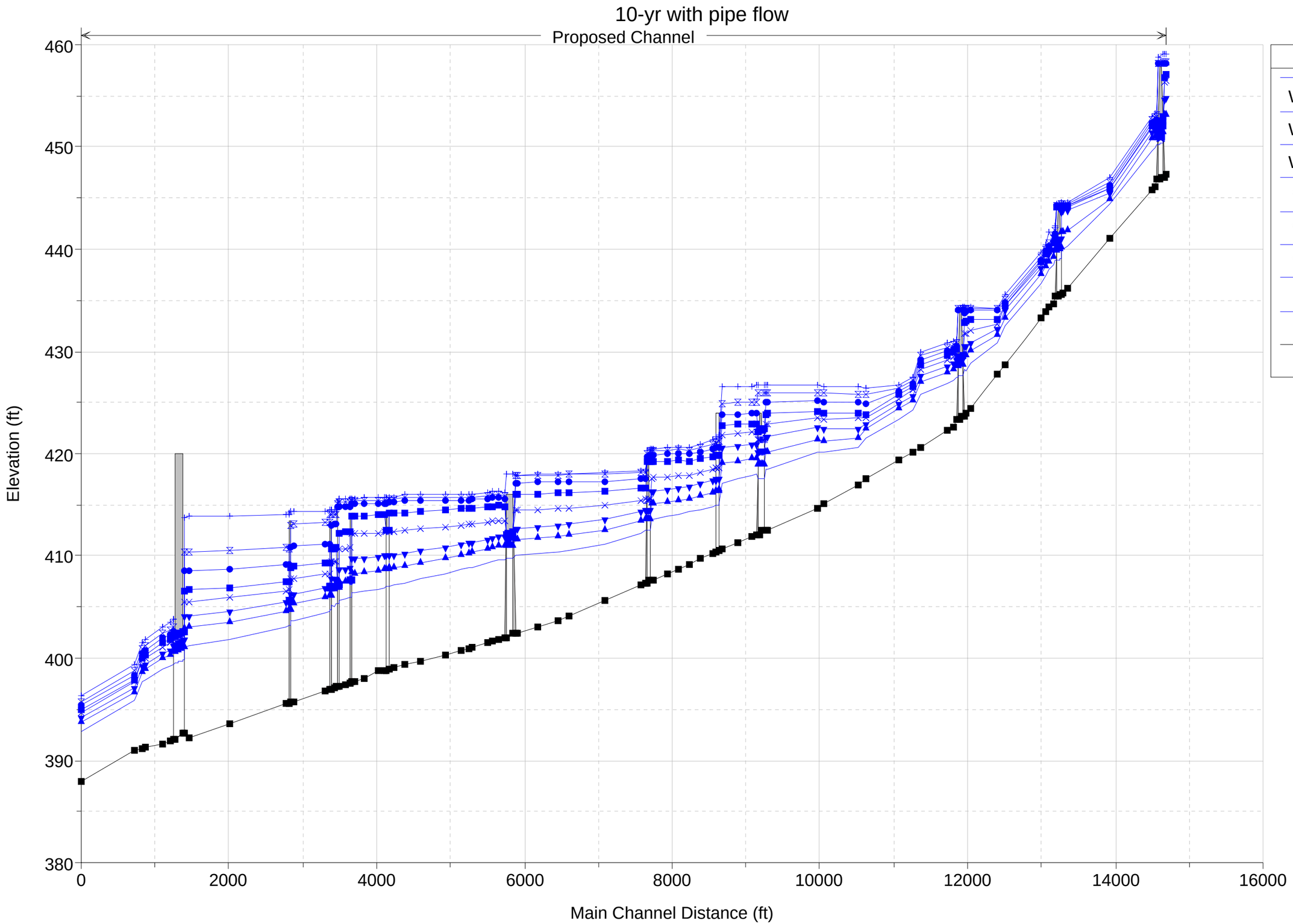
Table 16
200-year design channel data.

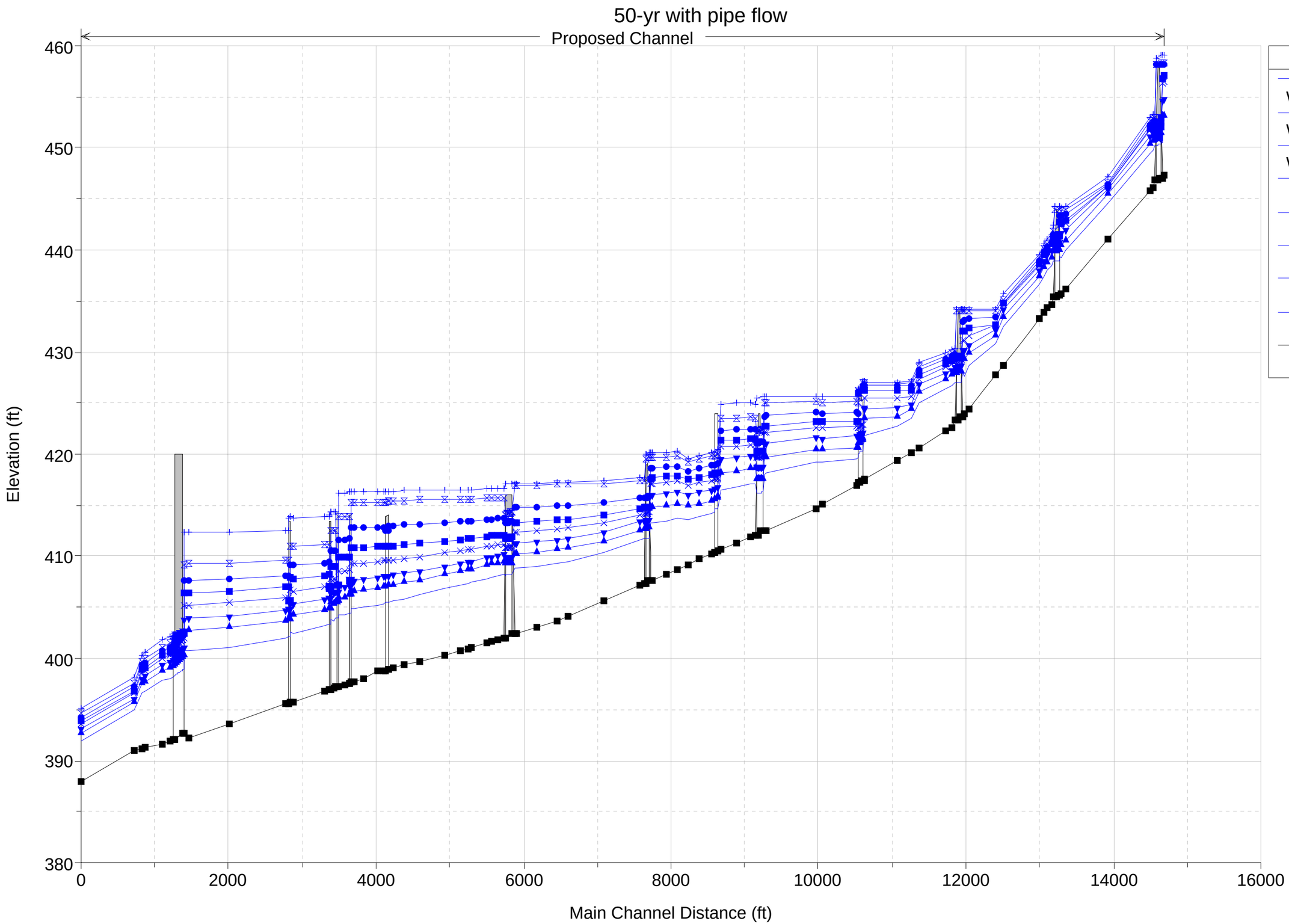
Section Type	Station*		200-Year Design Channel Data	
	Start Station	End Station	Bottom Width (ft)	Side Slope
Trapezoid	0+00	12+00	20	3H:1V
Trapezoid	14+50	56+55	26	3H:1V
Trapezoid	59+10	64+50	20	3H:1V
Trapezoid	66+05	80+80	16	3H:1V
Rectangular	82+20	86+35	14	N/A
Trapezoid	86+80	90+80	16	3H:1V
Trapezoid	100+60	105+10	16	2H:1V
Trapezoid	106+30	112+60	8	2H:1V
Trapezoid	117+50	118+15	8	3H:1V
Trapezoid	119+75	145+30	4	3H:1V

*Gaps in stationing are locations of transition sections and structures.

Table 17
200-year design structure data.

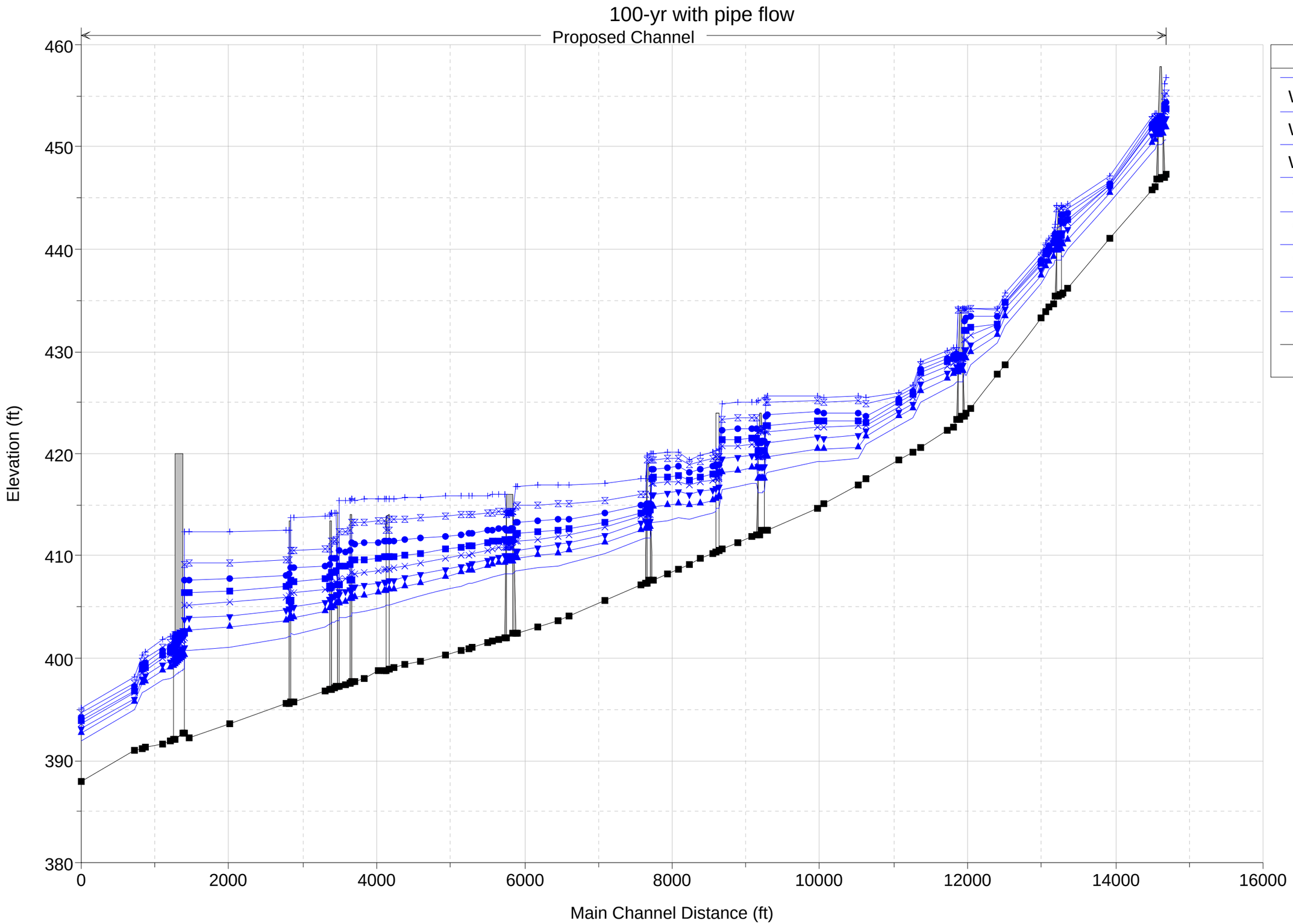
Structure Type	Location	Center line Station	200-Year Design Structure Data			
			Length (ft)	Number of Boxes	Bottom Width or Span (ft)	Rise (ft)
RCBC*	Clayton Expressway/Levee	13+25	140	2	10	10
RCBC	Missouri-Pacific RR	28+25	83	6	10	10
RCBC	Unnamed Railroad and Union Pacific Railroad	33+70	42	6	10	10
RCBC	Arkansas-Missouri RR	34+75	68	6	10	10
RCBC	Union Pacific RR	36+50	45	6	10	10
Bridge	North 6th Street	41+45	N/A	N/A	N/A	N/A
RCBC	Midland Blvd	58+00	120	3	8	12
RCBC	Greenwood Avenue	76+75	86	3	8	10
Bridge	Arkhola Crossing	86+10	N/A	N/A	N/A	N/A
RCBC	North ‘O’ Street	92+00	90	2	8	10
RCBC	Grand Avenue	119+05	102	3	6	6
RCBC	Kinkead Avenue	132+30	90	3	6	6
RCBC	Park Avenue	146+14	85	3	6	6

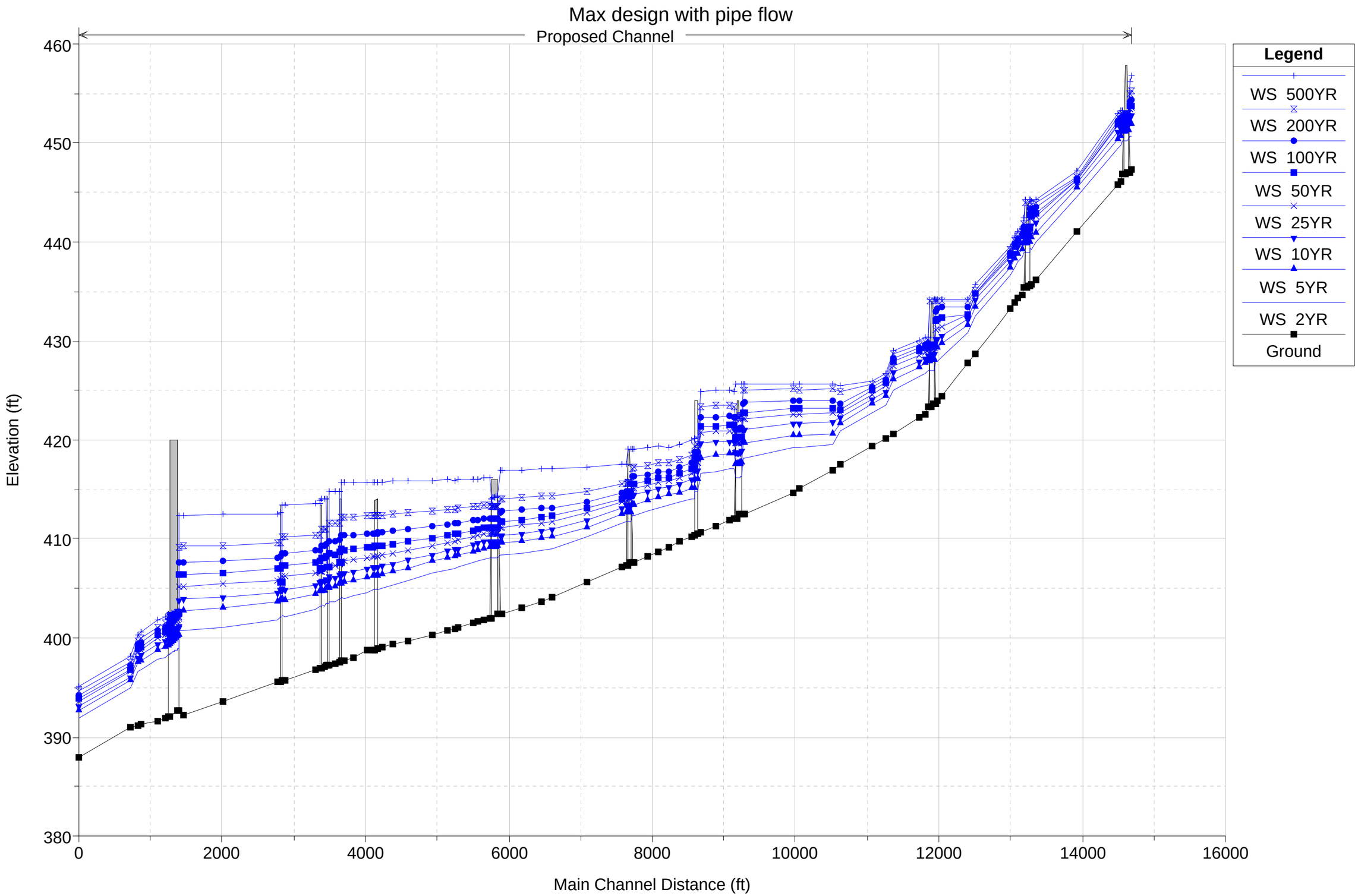

10-yr with pipe flow
Proposed Channel
Legend
WS 500YR
WS 200YR
WS 100YR
WS 50YR
WS 25YR
WS 10YR
WS 5YR
WS 2YR
Ground
Elevation (ft)
460
450
440
430
420
410
400
390
380
0
2000
4000
6000
8000
10000
12000
14000
16000
Main Channel Distance (ft)



50-yr with pipe flow
Proposed Channel
Legend
WS 500YR
WS 200YR
WS 100YR
WS 50YR
WS 25YR
WS 10YR
WS 5YR
WS 2YR
Ground
Elevation (ft)
Main Channel Distance (ft)
460
450
440
430
420
410
400
390
380
0
2000
4000
6000
8000
10000
12000
14000
16000

Plate 6


100-yr with pipe flow
Proposed Channel
Legend
WS 500YR
WS 200YR
WS 100YR
WS 50YR
WS 25YR
WS 10YR
WS 5YR
WS 2YR
Ground
Elevation (ft)
460
450
440
430
420
410
400
390
380
0
2000
4000
6000
8000
10000
12000
14000
16000
Main Channel Distance (ft)


Max design with pipe flow
Proposed Channel
Legend
WS 500YR
WS 200YR
WS 100YR
WS 50YR
WS 25YR
WS 10YR
WS 5YR
WS 2YR
Ground
Elevation (ft)
460
450
440
430
420
410
400
390
380
0
2000
4000
6000
8000
10000
12000
14000
16000
Main Channel Distance (ft)