UNIVERSITY OF NORTHERN COLORADO
Facilities Management
Campus Box 57
Greeley, CO 80639
970-351-1264 / 970-351-1170 (fax)

Utility Master Plan

Storm Drainage, Potable Water System, Sanitary Sewer and Informational Technology System – 10-Year Capital Construction Plan

November 2009

Prepared by:

J-U-B ENGINEERS, Inc.
3538 JFK Parkway, Suite 1
Fort Collins, CO 80525
970-377-3602 / 970-377-3925 (fax)
www.jub.com

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SECTION 1 – EXISTING FACILITIES

The purpose of Section 1 is to provide the University of Northern Colorado (UNC) a written summary of the campus' existing infrastructure system including: storm drainage, potable water, sanitary sewer, Informational Technology (IT) systems, electrical, and mechanical systems. In particular this section evaluates the individual systems' overall capacity and function as it relates to *current* campus demands. The findings contained in Section 1 will allow UNC to focus on specific infrastructure capital improvement requirements necessary to meet current demands irrespective of future anticipated facility improvements and provide the campus an accurate summary of its current infrastructure.

The information contained in this Section is based on a review of record drawings, field review of existing conditions, meetings with key UNC facilities management personnel, as well as an initial meeting with the Technical Advisory Committee (TAC) established for this project. Detailed field surveys were not completed as a part of this evaluation.

This section is broken into the following sections:

SECTION 1.1 – EXISTING STORM DRAINAGE SYSTEM

SECTION 1.2 – EXISTING POTABLE WATER SYSTEM

SECTION 1.3 – EXISTING SANITARY SEWER SYSTEM

SECTION 1.4 – EXISTING INFORMATIONAL TECHNOLOGY

SECTION 1.5 – EXISTING ELECTRICAL SYSTEM

SECTION 1.6 – EXISTING MECHANICAL HIGH TEMPERATURE HOT WATER AND CHILLED WATER SYSTEM

Section 2 presented later in this report outlines the anticipated future campus demands based on UNC's 10-Year Capital Construction Plan (10Yr CCP). Section 2 will include recommendations for infrastructure improvements (as needed) to meet these future demands including estimated opinion of probable construction costs and construction phasing for the improvements as needed.

SECTION 1.1 – EXISTING STORM DRAINAGE SYSTEM

1.1.1 Introduction/Background

The University of Northern Colorado (UNC) campus occupies approximately 279 acres in the eastern portion of the City of Greeley, Colorado. The main portions of campus are divided by 11^{th} Avenue and 20^{th} Street, two main thoroughfares, into what is commonly referred to as the Central Campus and the West Campus. The natural topography of the area causes runoff from the Central Campus and portions of the West Campus to flow to the north into the City's Downtown drainage basin, while runoff from the remaining portion of the West Campus flows south toward U.S. Highway 34, into the City's Central drainage basin.

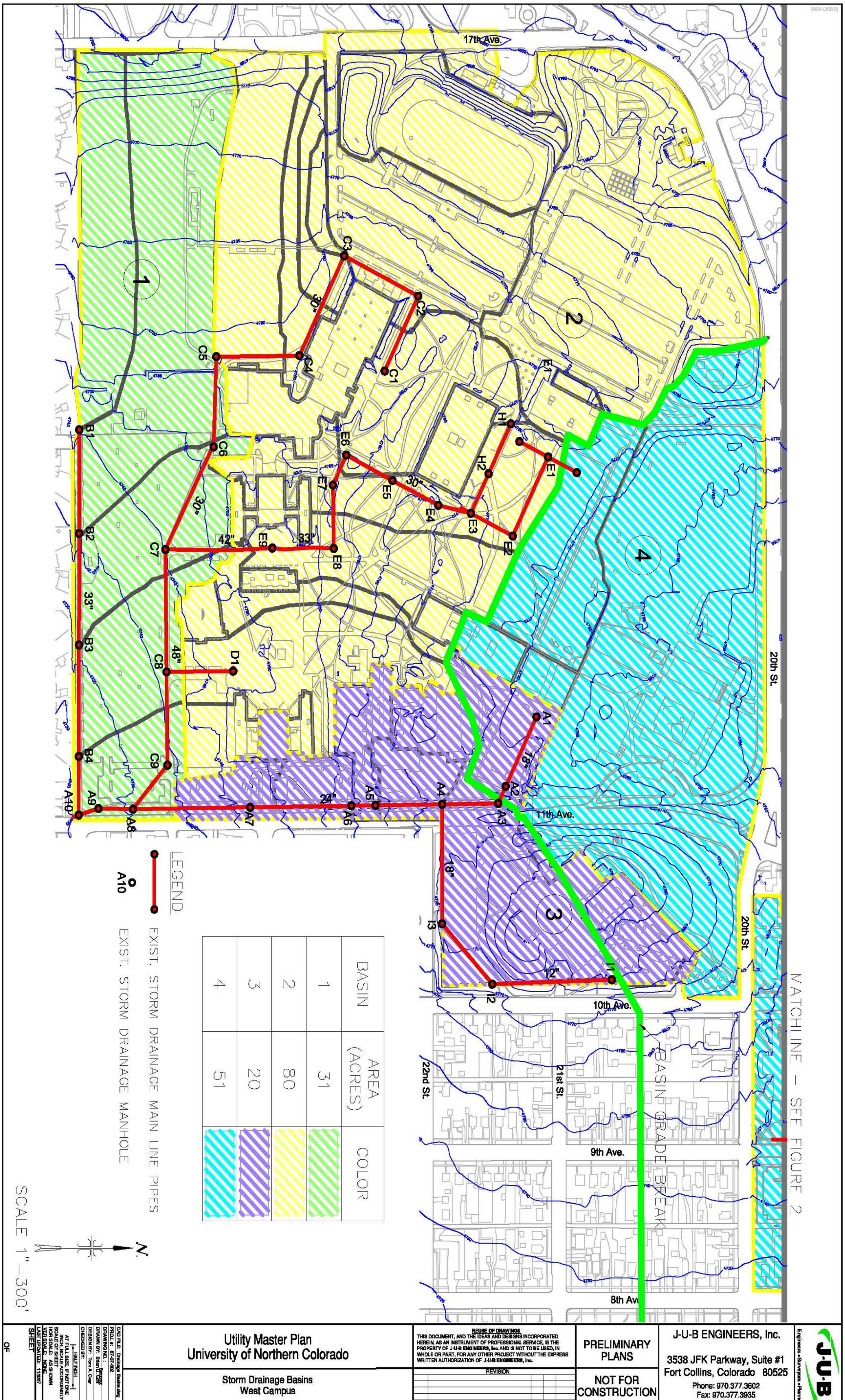
Campus runoff is generally captured by storm inlets and directed through underground piping to the City storm sewer system. Runoff that bypasses campus inlets, due to either inadequate inlet size or improper inlet location, generally flows overland to adjacent City streets, which experience occasional flooding during larger storm water runoff events.

J-U-B ENGINEERS, Inc. (J-U-B) has completed a hydraulic analysis of the existing storm sewer system on campus to identify potential problems. A summary of the results of this analysis is included.

1.1.2 Existing Drainage Basins

The UNC campus is located along a gentle ridge that runs roughly parallel to 20^{th} Street through the University Center, then south west through McKee Hall and Candelaria Halls. Drainage to the north of this ridgeline flows to the northeast, into the downtown area and eventually to the South Platte River. Drainage to the south of this ridge flows to the southeast to the U.S. Highway 34 right-of-way and eventually also to the South Platte River. There are four small storm water detention basins on the West Campus that mitigate some of the increased runoff effects due to the addition of impervious surfaces through previous campus development.

For purposes of analysis, the Campus was divided into six basins corresponding to six drainage systems serving the Campus with design points at various locations on the storm sewer system. (See Figures 1 and 2 on the following pages.) A brief description of each of the basins follows on page 11.


17th Ave.
20th St.
11th Ave.
10th Ave.
9th Ave.
8th Ave.
21st St.
22nd St.
MATCHLINE – SEE FIGURE 2
BASIN GRADE BREAK
LEGEND
EXIST. STORM DRAINAGE MAIN LINE PIPES
EXIST. STORM DRAINAGE MANHOLE
BASIN
AREA (ACRES)
COLOR
1 31
2 80
3 20
4 51
SCALE 1"=300'
N.
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University of Northern Colorado
Storm Drainage Basins
West Campus
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
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3538 JFK Parkway, Suite #1
Fort Collins, Colorado 80525
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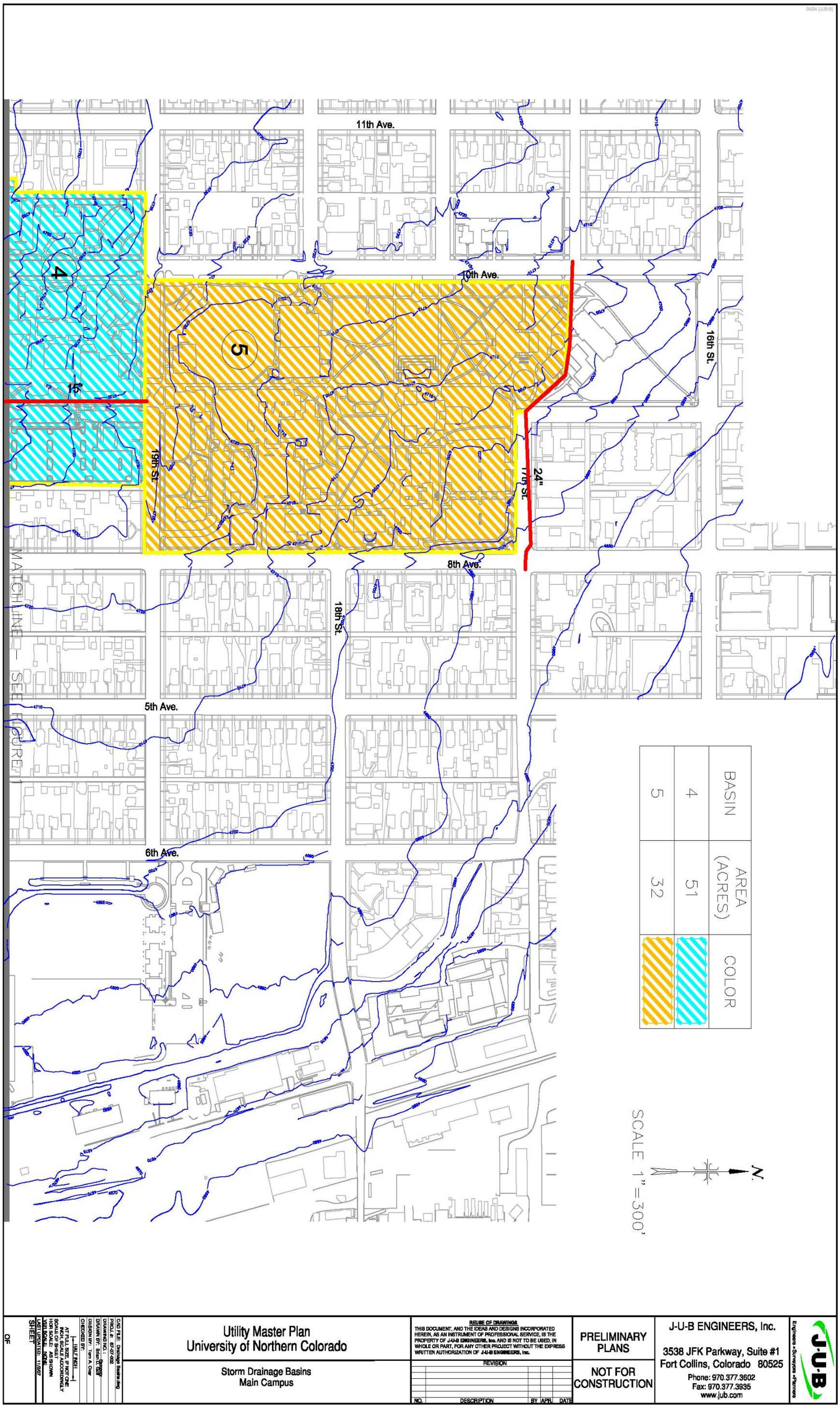
Fax: 970.377.3935
www.jub.com
REVISION
NO. DESCRIPTION BY APR. DATE

FIGURE 1


11th Ave.
10th Ave.
16th St.
15"
19th St.
17th St.
24"
8th Ave.
18th St.
5th Ave.
6th Ave.
MATCHLINE – SEE FIGURE 1
4
5
BASIN
AREA (ACRES)
COLOR
4
51
5
32
SCALE 1"=300'
N
Utility Master Plan
University of Northern Colorado
Storm Drainage Basins
Main Campus
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
REVISION
NO.
DESCRIPTION
BY
APR.
DATE
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SHEET
OF

FIGURE 2

Description of Existing UNC Drainage Basins

Basin 1 – Approximately 31 Acres of the West Campus

Basin 1 drains to a series of inlets along the south side of the student parking lot, south of Holmes Dining Hall. These grated inlets are connected to a 33 inch diameter pipe that discharges to the City storm sewer beneath 11th Avenue

Basin 2 – Approximately 80 Acres of the West Campus

Basin 2 drains through a non-potable water supply pond, grassed channels, a small detention pond, and underground storm sewers to the City's storm sewer beneath 11th Avenue

Basin 3 – Approximately 20 Acres around the University Center and along 11th Avenue

Basin 3 drains through three small detention ponds and into a 24 inch diameter underground pipe, then discharges to the City storm sewer beneath 11th Avenue

Basin 4 – Approximately 51 Acres

Basin 4 drains primarily by surface flow onto 19^{h} and 20th Streets and 10th and 11th Avenues. Street flows that are captured by street inlets flow into a 27-inch diameter pipe located beneath 19th Street.

Basin 5 – Approximately 32 Acres

Basin 5 drains to the City's 24 inch diameter storm sewer that runs across campus in line with 17th Street.

Basin 6 – Approximately 35 Acres

Basin 6 drains to the east into the Greeley No. 3 Ditch.

Basin Delineation and Runoff

Basins delineation was based on Campus topography. Runoff from each basin was calculated using the Rational Method in accordance with City of Greeley drainage criteria and rainfall intensity/duration charts. The Rational Method is based on the Rational Formula: Q = CIA. (See Table 1)

TABLE 1 – RATIONAL FORMULA

Symbol	Meaning
Q	The maximum rate of runoff (cubic feet per second (cfs))
C	A runoff coefficient that is the ratio between the runoff volume from an area and the average rate of rainfall depth over a given duration for that area
I	The average intensity of rainfall in inches per hour for a duration equal to the time of concentration
A	Area in acres

The runoff coefficient C is directly related to the percentage of impervious surface area within the basin. Through use of UNC's AutoCAD drawings of the campus, impervious surface areas, including those of buildings, paved parking lots and roads were compiled to determine an appropriate runoff coefficient. The percentage of impervious area on campus was determined to be approximately 40%, resulting in an average runoff coefficient of 0.35 in accordance with recommendations provided in Denver's Urban Drainage and Flood Control District Drainage Manual (UDFCD), Table RO-5.

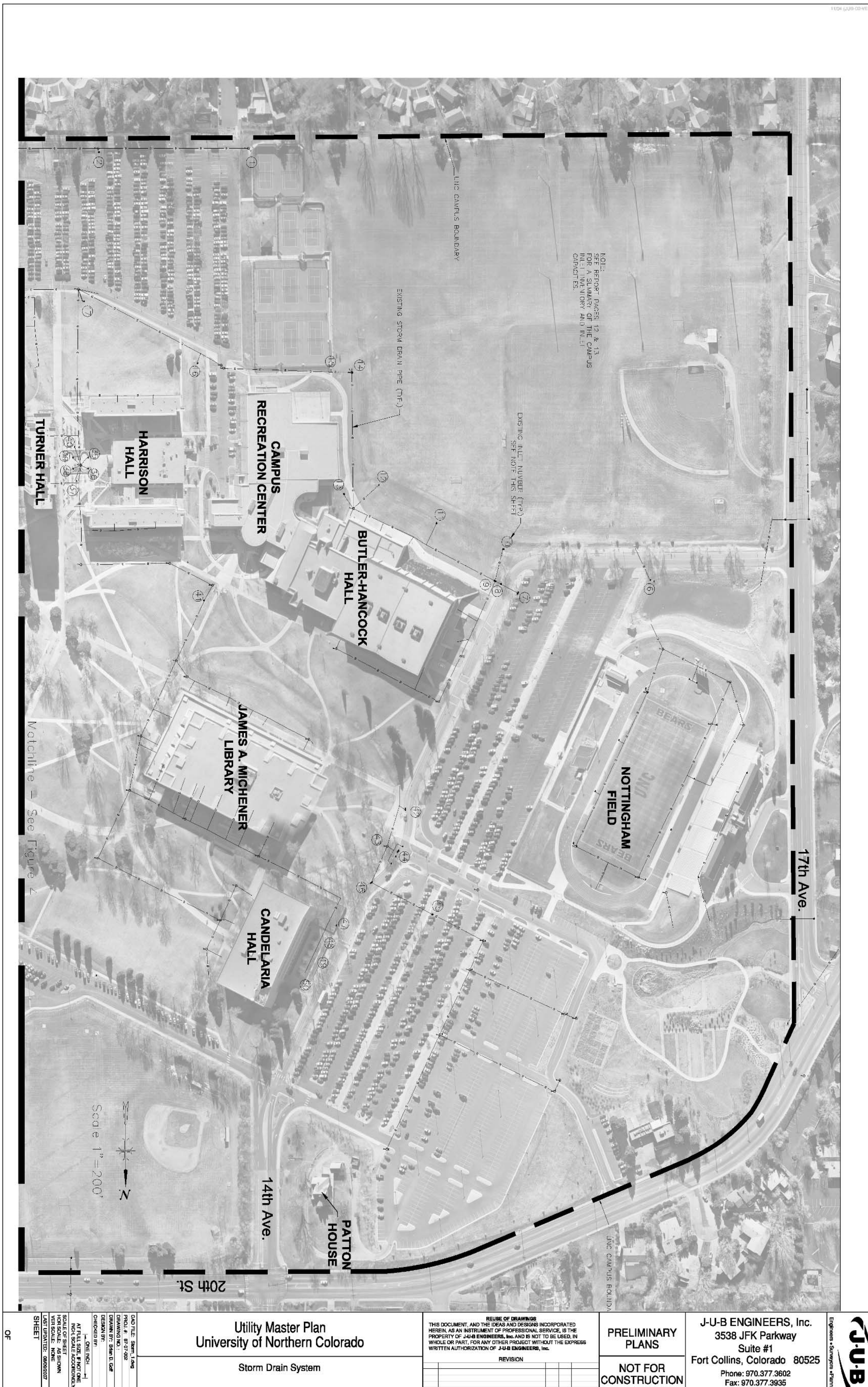
UNC topographic maps were used to delineate basins contributing runoff to designated design points along the storm sewer system. These areas were divided into "roofs" and "grounds" to better estimate the flows entering the storm sewer system. All runoff from roof drains was assumed to enter the storm sewer system, while the quantity of runoff from grounds was limited by existing inlet capacities within the sub-basin.

Rainfall Intensity-Duration-Frequency curves published by the City of Greeley were used to establish "I", the average intensity of rainfall. The 5-year recurrence curve was used for purposes of the report after consulting with the City's Stormwater Department. From this information, the maximum rates of runoff were calculated using the Rational Formula at the design points.

1.1.3 Storm Drainage Conveyance Network

The Campus storm drainage conveyance system consists of grassed channels, culverts, detention ponds, and underground storm sewers ranging in size from 8-inches to 48-inches in diameter. Runoff enters the storm sewer system through roof drains and grated inlets that are strategically located around the campus.

The West Campus underground storm sewer system is connected to a 38 inch x 60 inch rectangular pipe on the City's storm sewer system. Storm sewers on the Central Campus are connected to a 27 inch storm sewer located in 19th Street and a 24 inch storm sewer running through campus in line with 17th Street. The Campus storm sewer and storm inlet systems are shown on the following pages (See Figures 3,4,5, and 6 on the following pages).


TURNER HALL
HARRISON HALL
CAMPUS RECREATION CENTER
BUTLER-HANCOCK HALL
JAMES A. MICHENER LIBRARY
CANDELARIA HALL
NOTTINGHAM FIELD
PATTON HOUSE
17th Ave.
14th Ave.
20th St.
UNC CAMPUS BOUNDARY
EXISTING STORM DRAIN PIPE (TYP.)
Scale 1" = 200'
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Storm Drain System
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FIGURE 3

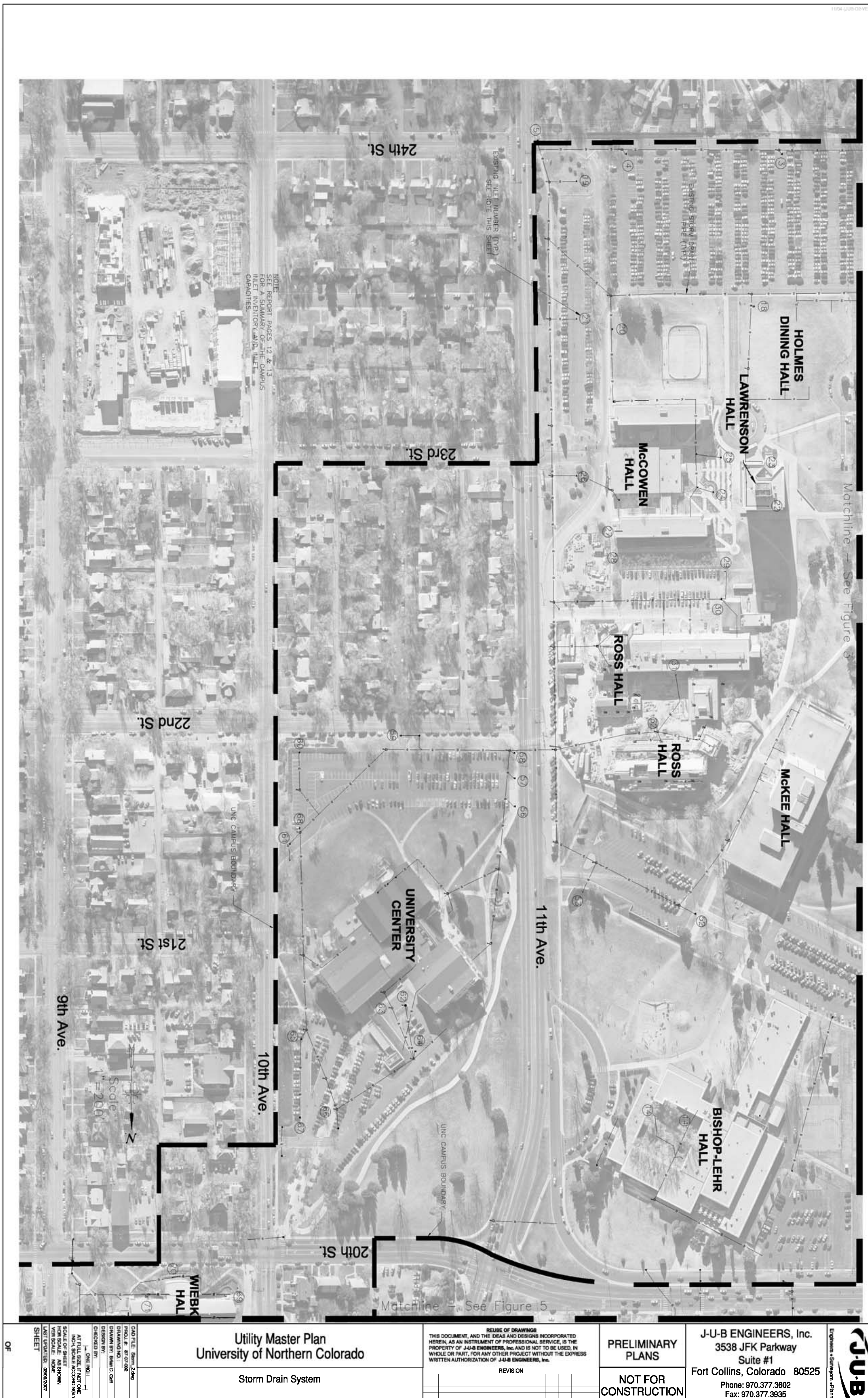
24th St.
23rd St.
22nd St.
21st St.
20th St.
9th Ave.
10th Ave.
11th Ave.
HOLMES DINING HALL
LAWRENSON HALL
McCOWEN HALL
ROSS HALL
McKEE HALL
UNIVERSITY CENTER
BISHOP-LEHR HALL
UNC CAMPUS BOUNDARY
Matchline – See Figure 3
Matchline – See Figure 5
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FIGURE 4


8th Ave.
9th Ave.
10th Ave.
11th Ave.
19th St.
18th St.
17th St.
16th St.
Cranford Pl.
SABIN HALL
WILSON HALL
SNYDER HALL
GORDON HALL
BELFORD HALL
DECKER HALL
TOBEY-KENDEL HALL
HANSEN-WILLIS HALL
SCOTT-WILLCOXON HALL
CASSIDY HALL
CANCER REHAB. INSTITUTE
VISITOR'S CENTER
BROWN HALL
LUTAN HALL
DICKERSON HALL
BOND HALL
ARTS ANNEX
GUNTER HALL
GRAY HALL
CRABBE HALL
ROUDEBUSH COTTAGE
GUGGENHEIM HALL
CARTER HALL
KEPNER HALL
FRASIER HALL
SKINNER MUSIC LIBRARY
EXISTING STORM DRAIN PIPE (TYP.)
EXISTING INLET NUMBER (TYP.) SEE NOTE THIS SHEET
UNC CAMPUS BOUNDARY
Matchline – See Figure 6
Scale 1" = 200'
N
Utility Master Plan
University of Northern Colorado
Storm Drain System
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FIGURE 5

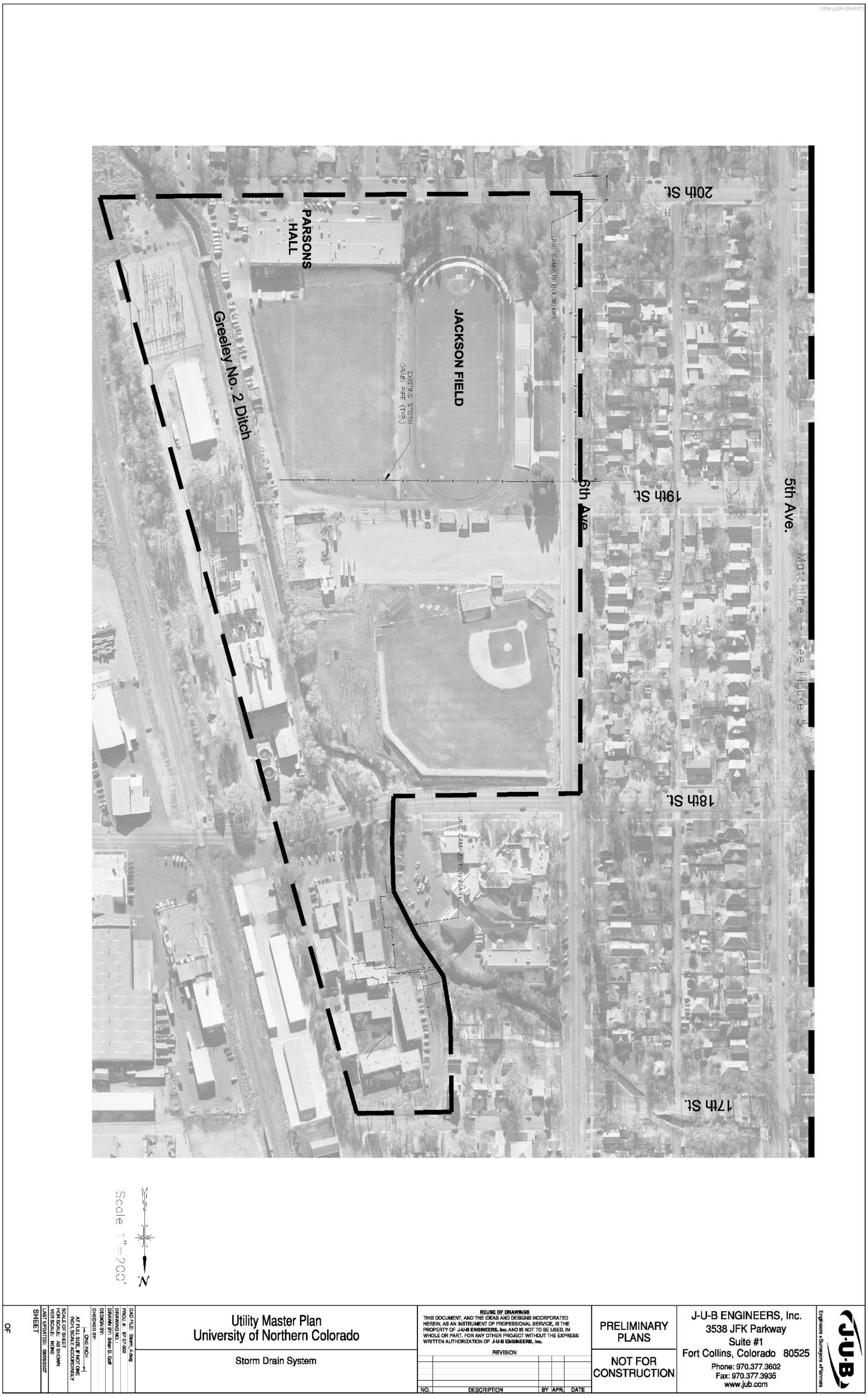
20th St.
19th St.
18th St.
17th St.
5th Ave.
6th Ave.
PARSONS HALL
JACKSON FIELD
Greeley No. 2 Ditch
EXISTING STORM DRAIN PIPE (TYP.)
UNC CAMPUS BOUNDARY
Matchline – See Figure 5
Scale 1"=200'
N
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FIGURE 6

Information regarding existing storm water inlets on campus was compiled through field measurements of grate size, type, and approximate opening area. Calculation of inlet capacities was made using two different sets of assumptions:

1. For maximum flow conditions into the underground storm sewer piping system, all inlets were assumed to be in sump condition with minimum ponding depth of 6 inches unless a more pronounced ponding depth was observed in the field. Also, no clogging factor was applied to the inlet capacity.
2. To evaluate the effectiveness of the inlet system on campus, a clogging factor of 50% was applied to the inlet capacity and the ponding depth was reduced to an average of 3 inches to take into account those inlets on grade rather than in sump condition. The orifice equation suggested in the UDFCD Manual for grated inlets in sump condition was used to calculate approximate inlet capacity : $Q=CA(2gd)^{0.5}$ (See Table 2)

TABLE 2 – ORIFICE EQUATION

Symbol	Meaning
Q	Inlet capacity (cfs)
C	Orifice discharge coefficient (0.67 for grated inlets)
A	Clear opening in square feet (sf)
d	Depth of water over grate (feet)
g	32.2 feet per second (fps)

Based on information provided on UNC drawings pertaining to the storm sewer system (including pipe size, length, and invert elevations), existing pipe capacities were calculated using Manning's Formula: $Q = (1.486/n)\ A(R^{2/3})(S^{1/2})$. (See Table 3)

TABLE 3 – MANNING'S FORMULA

Symbol	Meaning
n	Pipe roughness coefficient
A	Cross sectional area of flow
R	Hydraulic radius = A/P
P	Wetted perimeter of the pipe
S	Pipe slope

Estimated inlet capacities for the 87 inlets located during field observations and a review of UNC topographic drawings are tabulated on the following pages in Table 4 (two pages) of this report for both cases 1 and 2 respectively as described above.

TABLE 4 - STORM SEWER INLET INVENTORY AND CAPACITIES (PAGE 1 OF 2)

Inlet Number	Type	Length (ft)	Width (ft)	Diameter (ft)	Area (sf)	% Open Area	Case 1-Maximum flow conditions			Case 2-Normal flow conditions			Downstream Design Point	Comments
							Clogging Factor (% flow thru)	Assumed depth of flow (ft)	Est. Inlet Capacity (cfs)	Clogging Factor (% flow thru)	Assumed depth of flow (ft)	Est. Inlet Capacity (cfs)		
1	Grate	1.66	1.66		2.76	50	100	0.50	10.48	50	0.25	3.70	B1	
2	Grate	1.66	1.66		2.76	50	100	0.50	10.48	50	0.25	3.70	B2	
3	Grate	1.66	1.66		2.76	50	100	0.50	10.48	50	0.25	3.70	B3	
4	Grate	1.66	1.66		2.76	50	100	0.50	10.48	50	0.25	3.70	B4	
5	Grate	2.66	1.58		4.20	50	100	0.50	15.98	50	0.25	5.65		
6a	Grate	5.66	3.42		19.36	75	100	0.50	73.59	50	0.25	26.02	C3	
6b	Grate	2.66	1.58		4.20	50	100	0.50	15.98	50	0.25	5.65	C3	
7	Grate + CI	7.00	2.00		14.00	50	100	0.50	53.23	50	0.50	26.61	C3	
8	vert. pipe			0.833	0.54	80	100	1.00	2.93	50		0.00	C3	
9	Grate	5.50	3.33		18.32	80	100	0.50	69.63	50	0.25	24.62	C3	
10	Culv. Inlet				0.00		100	2.50	16.00	50		16.00	C3	
11	Grate	2.50	2.00		5.00	50	100	0.50	19.01	50	0.25	6.72	C4	
12	Grate	2.50	2.00		5.00	50	100	0.50	19.01	50	0.25	6.72	C4	
13	Grate	2.08	1.42		2.95	60	100	0.50	11.23	50	0.25	3.97	C4	
14	Grate	1.47	1.47		2.16	50	100	0.50	8.22	50	0.25	2.90	C5	
15													C5	not found
16	Grate	0.44	0.44		0.19	50	100	1.25	1.16	50		0.00	C6	
17													C7	not found
18													C8	not found
19	Grate	1.00	1.00		1.00	50	100	0.50	3.80	50	0.25	1.34	C9	
20													C9	not accessible
21														det pond outlet
22	Pl.w/holes	1.17	1.17		1.37	10	100	0.50	5.20	50	0.25	1.84	D1	
23	Grate	6.50	1.92		12.48	50	100	0.50	47.45	50	0.25	16.78	D1	
24	Grate	0.92	0.92		0.85	50	100	0.50	3.22	50	0.25	1.14	C9	
25	Grate	0.92	0.92		0.85	50	100	0.50	3.22	50	0.25	1.14	C9	
26														det pond outlet
27	Grate	3.17	1.83		5.80	50	100	0.50	22.06	50	0.25	7.80	A6	
28	Grate	3.17	1.83		5.80	50	100	0.50	22.06	50	0.25	7.80	A6	
29	8"X11"chase				0.00		100		0.00	50		0.00		
30	Grate	3.25	1.92		6.24	50	100	0.67	27.46	50	0.67	13.73	A6	
31	Grate	2.00	2.00		4.00	50	100	1.00	21.51	50	1.00	10.75	A4	
32	Grate			1.830	2.63	50	100	1.00	14.13	50	1.00	7.07	A4	
33	Grate	3.25	1.92		6.24	50	100	2.00	47.45	50	2.00	23.72	C7	
34	Grate	18.00	1.58		28.44	50	100	1.00	152.91	50	1.00	76.46	C7	
35	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
36	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
37	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
38	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
39	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
40	Grate	0.75	0.75		0.56	50	100	1.50	3.70	50	1.50	1.85	E9	
41	Grate	2.67	2.67		7.13	50	100	4.25	79.02	50	4.25	39.51	E6	
42	Grate + CI	7.00	2.00		14.00	50	100	0.50	53.23	50	0.50	26.61	J8	
43	NONE				0.00	50	100	0.50	0.00	50	0.25	0.00	J7	

TABLE 4 - STORM SEWER INLET INVENTORY AND CAPACITIES (PAGE 2 OF 2)

Inlet Number	Type	Length (ft)	Width (ft)	Diameter (ft)	Area (sf)	% Open Area	Case 1-Maximum flow conditions			Case 2-Normal flow conditions			Downstream Design Point	Comments
							Clogging Factor (% flow thru)	Assumed depth of flow (ft)	Est. Inlet Capacity (cfs)	Clogging Factor (% flow thru)	Assumed depth of flow (ft)	Est. Inlet Capacity (cfs)		
44	Grate + CI	5.33	1.58		8.42	50	100	0.50	32.02	50	0.50	16.01	J7	
45	Grate	3.00	1.58		4.74	50	100	0.50	18.02	50	0.25	6.37	J5	
46	Grate + CI	7.00	2.00		14.00	50	100	0.50	53.23	50	0.50	26.61	J6	
47	Grate	0.75	0.75		0.56	50	100	0.50	2.14	50	0.25	0.76	H1	
48	Grate	0.50	0.50		0.25	50	100	0.50	0.95	50	0.25	0.34	H1	
49	Grate	0.50	0.50		0.25	50	100	0.50	0.95	50	0.25	0.34	H1	
50	Grate	0.50	0.50		0.25	50	100	0.50	0.95	50	0.25	0.34	H1	
51														
52	Grate	1.92	1.92		3.69	50	100	0.50	14.02	50	0.25	4.96	A1	
53	Grate	1.08	1.08		1.17	50	100	0.50	4.43	50	0.25	1.57	A2	
54														not accessible
55														not accessible
56	Grate	1.92	1.33		2.55	50	100	0.50	9.71	50	0.25	3.43	A4	
57	Grate	1.92	1.33		2.55	50	100		0.00	50		0.00	A4	
58	Grate	1.92	1.33		2.55	50	100		0.00	50		0.00	A4	
59	Grate	1.92	1.33		2.55	50	100		0.00	50		0.00	A4	
60	Grate	1.83	1.25		2.29	50	100		0.00	50		0.00	A4	
61	Grate	1.33	1.08		1.44	50	100	0.50	5.46	50	0.25	1.93	A4	
62	Grate			2.000	3.14	50	100	0.50	11.94	50	0.25	4.22	A4	
63	Grate			1.670	2.19	50	100	0.50	8.32	50	0.25	2.94	A4	
64	Grate	1.50	1.33		2.00	50	100	0.50	7.58	50	0.25	2.68	A4	
65	Grate & CO	3.25	1.83		5.95	60	100	0.50	22.61	50	0.50	11.31	A4	
66	Grate & CO	3.25	1.83		5.95	60	100	0.50	22.61	50	0.50	11.31	A4	
67	Grate & CO	3.25	1.83		5.95	60	100	0.50	22.61	50	0.50	11.31	A4	
68	Grate & CO	2.25	1.42		3.20	50	100	0.50	12.15	50	0.50	6.07	A4	
69	Grate & Trench			0.833	0.54	50	100	0.50	2.07	50	0.25	0.73		
70	Grate & Trench			0.833	0.54	50	100	0.50	2.07	50	0.25	0.73		
71	Grate & Trench				0.00	90	100	0.50	0.00	50	0.25	0.00		
72	Grate			0.920	0.66	50	100	0.50	2.53	50	0.25	0.89		
73														
74	Grate	3.25	2.00		6.50	50	100	0.50	24.71	50	0.25	8.74		
75	Grate	3.25	2.00		6.50	50	100	0.50	24.71	50	0.25	8.74		
76	Grate w/CO	3.25	1.83		5.95	50	100	0.50	22.61	50	0.25	7.99		
77	Grate	1.83	1.58		2.89	50	100	0.50	10.99	50	0.25	3.89		
78	Grate	3.25	1.83		5.95	50	100	0.50	22.61	50	0.25	7.99		
79	Grate	3.25	1.93		6.27	50	100	0.50	23.85	50	0.25	8.43		
80	Grate			1.920	2.89	70	100	0.50	11.00	50	0.25	3.89		
81	Grate	2.17	2.17		4.71	40	100	0.50	17.90	50	0.25	6.33		
82	Grate	2.17	2.00		4.34	70	100	0.50	16.50	50	0.25	5.83		
83	Grate	1.00	1.00		1.00	50	100	0.50	3.80	50	0.25	1.34		
84	Grate	1.00	1.00		1.00	50	100	0.50	3.80	50	0.25	1.34		
85	Grate	1.00	1.00		1.00	50	100	0.50	3.80	50	0.25	1.34		
86	Grate	2.00	2.00		4.00	50	100	0.50	15.21	50	0.25	5.38		
87	Grate			1.750	2.40	50	100	0.50	9.14	50	0.25	3.23		

A summary of the calculated runoff flows (5-year design storm recurrence) at the selected design points based on Manning's equation are shown below in Table 5.

TABLE 5 – DRAINAGE FLOW COMPUTATIONS

Design Point	Contributing Area (acre)				Composite Runoff Coefficient "C"	Travel Time (min)			Total Time Of Concentration (min)	Rainfall Intensity (in/hr)	Approx. Q5 (cfs)	
	Roofs	Grounds	∑ Roofs	∑Grounds		Overland Travel Time (min)	Channelized Travel Time (min)	Pipe Travel Time (min)			Roofs	Grounds
A1	1.25	2.89	1.25	2.89	0.35	5.00	0.00	0.00	5.00	5.20	2.28	5.26
A2	1.25	2.89	1.25	2.89	0.35	5.00	0.00	0.40	5.40	5.20	2.28	5.26
A3	1.25	2.89	1.25	2.89	0.35	5.00	0.00	0.60	6.00	4.90	2.14	4.96
A4	2.45	9.99	3.70	12.88	0.35	5.00	0.00	1.30	6.30	4.90	6.35	22.09
A5	0.33	1.20	4.03	14.08	0.35	5.00	0.00	1.60	6.60	4.60	6.49	22.67
A6	0.40	1.23	4.43	15.31	0.35	5.00	0.00	1.70	6.70	4.60	7.13	24.65
A7	0.40	1.13	4.83	16.44	0.35	5.00	0.00	2.20	7.20	4.60	7.78	26.47
A8	8.00	72.27	12.83	88.71	0.35	5.00	0.00	2.80	7.80	4.40	19.76	136.61
A9			12.83	88.71	0.35	5.00	0.00	3.00	8.00	4.40	19.76	136.61
B1		5.49		5.49	0.35	38.00	0.00	0.00	38.00	2.10	0.00	4.04
B2		12.47		17.96	0.35	38.00	0.00	0.50	38.50	2.00	0.00	12.57
B3		5.15		23.11	0.35	38.00	0.00	1.10	39.10	2.00	0.00	16.18
B4		4.34		27.45	0.35	38.00	0.00	1.70	39.70	2.00	0.00	19.22
C1	1.60		1.60		0.35	5.00	0.00	0.00	5.00	5.20	2.91	0.00
C2	1.60		1.60		0.35	5.00	0.00	1.60	6.60	4.60	2.58	0.00
C3		18.20	1.60	16.60	0.35	9.00	2.00	3.00	14.00	3.50	1.96	20.34
C4		3.51	1.60	20.11	0.35	9.00	2.00	2.80	13.80	3.50	1.96	24.63
C5	1.40	6.12	3.00	26.23	0.35	9.00	2.00	4.30	15.30	3.40	3.57	31.21
C6		6.35	3.00	32.58	0.35	9.00	2.00	4.90	15.90	3.30	3.47	37.63
C7	0.66		7.27	62.93	0.35	10.00	2.00	10.00	22.00	2.80	7.12	61.67
C8	0.21	6.08	7.48	69.01	0.35	10.00	2.00	10.00	22.00	2.80	7.33	67.63
C9	0.50	0.92	8.00	70.00	0.35	9.00	2.00	10.00	22.00	2.80	7.84	68.60
D1	0.21	5.90	0.21	5.90	0.35	7.00	0.00	0.30	7.30	4.60	0.34	9.50
E1	0.73		0.73		0.35	5.00	0.00	0.00	5.00	5.20	1.33	0.00
E2	0.73		0.73		0.35	5.00	0.00	0.00	5.00	5.20	1.33	0.00
E3	1.42	0.23	2.15	0.23	0.35	5.00	0.00	0.00	5.00	5.20	3.91	0.42
E4			2.15	0.23	0.35	5.00	0.00	0.30	5.30	5.20	3.91	0.42
E5		25.17	2.15	25.40	0.35	10.00	2.00	9.00	21.00	2.90	2.18	25.78
E6			2.15	25.40	0.35	10.00	2.00	9.40	21.40	2.90	2.18	25.78
E7			2.15	25.40	0.35	10.00	2.00	9.60	21.60	2.80	2.11	24.89
E8	0.94		3.11	25.40	0.35	10.00	2.00	10.10	22.10	2.80	3.05	24.89
E9	0.50	4.95	3.61	30.35	0.35	10.00	2.00	10.40	22.40	2.80	3.54	29.74
F1	0.73		0.73		0.35	5.00	0.00	0.00	5.00	5.20	1.33	0.00
G1	0.73		0.73		0.35	5.00	0.00	0.00	5.00	5.20	1.33	0.00
H1	1.42	0.23	1.42	0.23	0.35	5.00	0.00	0.00	5.00	5.20	2.58	0.42
H2	1.42	0.23	1.42	0.23	0.35	5.00	0.00	0.00	5.00	5.20	2.58	0.42

These runoff flows were then compared to the summation of maximum inlet capacities upstream of the design location as determined in Table 4 to estimate the maximum flow in the section of pipe between the design points. This calculation is shown on the following page in Table 6.

Maximum pipe flow capacities were then compared to the estimated maximum pipe flows to determine excess capacity, if any. These calculations are presented in Table 7 of this report.

TABLE 6 – ESTIMATED MAXIMUM PIPE FLOW RATES

Design Point	Approx. Q5 (cfs)		∑ Max Grounds Inlet Cap. Upstream	Approx. Max Pipe Flow (cfs)	Design Point	Approx. Q5 (cfs)		∑ Max Grounds Inlet Cap. Upstream	Approx. Max Pipe Flow (cfs)
	Roofs	Grounds				Roofs	Grounds		
A1	2.28	5.26	7.00	7.53	C6	3.47	37.63	194.20	41.09
A2	2.28	5.26	9.20	7.53	C7	7.12	61.67	345.30	68.80
A3	2.14	4.96	9.20	7.10	C8	7.33	67.63	345.30	74.96
A4	6.35	22.09	95.60	28.43	C9	0.00	0.00	348.50	0.00
A5	6.49	22.67	95.60	29.16	D1	0.34	9.50	24.20	0.80
A6	7.13	24.65	131.30	31.78	E1	1.33	0.00	0.00	1.33
A7	7.78	26.47	131.30	34.24	E2	1.33	0.00	0.00	1.33
A8	19.76	136.61	479.80	156.37	E3	3.91	0.42	2.60	4.33
A9	19.76	136.61	479.80	156.37	E4	3.91	0.42	2.60	4.33
B1	0.00	4.04	5.20	4.04	E5	2.18	25.78	39.50	27.96
B2	0.00	12.57	10.40	10.40	E6	2.18	25.78	39.50	27.96
B3	0.00	16.18	15.60	15.60	E7	2.11	24.89	39.50	27.00
B4	0.00	19.22	20.80	19.20	E8	3.05	24.89	39.50	27.94
C1	2.91	0.00	0.00	2.91	E9	3.54	29.74	50.90	33.28
C2	2.58	0.00	0.00	2.58	F1	1.33	0.00	0.00	1.33
C3	1.96	20.34	163.80	22.30	G1	1.33	0.00	0.00	1.33
C4	1.96	24.63	189.50	26.59	H1	2.58	0.42	2.60	3.00
C5	3.57	31.21	193.60	34.78	H2	2.58	0.42	2.60	3.00

TABLE 7 – ESTIMATED MAXIMUM PIPE FLOW RATES

Storm Sewer Line Segment		Upstream Elev.	Downstream Elev.	Line Size	Length ft	Slope ft/ft	"n" Factor	Pipe Capacity (cfs)	Velocity (ft/sec)	Travel Time (min)	Pipe Flow (Q5 cfs)	Excess Capacity (cfs)
From	To											
A1	A2	4764.25	4760.43	18	223	0.017	0.012	14.92	8.45	0.44	7.5	7.39
A2	A3	4760.43	4758.83	18	106	0.015	0.012	14.01	7.93	0.22	7.5	6.47
A3	A4	4758.83	4757.54	18	210	0.006	0.012	8.94	5.06	0.69	7.1	1.84
A4	A5	4757.14	4752.19	24	234	0.021	0.012	35.71	11.37	0.34	28.4	7.28
A5	A6	4752.19	4750.03	24	101	0.021	0.012	35.91	11.44	0.15	29.2	6.75
A6	A7	4750.03	4739.29	24	401	0.027	0.012	40.19	12.80	0.52	31.8	8.40
A7	A8	4739.29	4728.83	24	425	0.025	0.012	38.52	12.27	0.58	34.2	4.28
A8	A9	4728.83	4725.24	38X60	130	0.028	0.012	319.00	20.20	0.11	156.4	162.63
A9	A10	4725.24	4723.3	38X60	100	0.019	0.012	267.00	16.90	0.10	156.4	110.63
B1	B2			33	360	0.012	0.012	62.89	10.59	0.57	4.0	58.86
B2	B3			33	380	0.012	0.012	62.89	10.59	0.60	10.4	52.49
B3	B4			33	380	0.012	0.012	62.89	10.59	0.60	15.6	47.29
B4	A10	4727.23	4723.72	33	198	0.018	0.012	76.44	12.88	0.26	20.8	55.64
C1	C2	4756.24	4754.62	8	275	0.006	0.012	1.01	2.88	1.59	2.9	-1.91
C2	C3	4754.54	4753.09	12	307	0.005	0.012	2.66	3.38	1.51	2.9	-0.24
C3	C4	4753.02	4750	30	380	0.008	0.012	39.69	8.09	0.78	22.3	17.40
C4	C5	4748.99	4745.5	30	312	0.011	0.012	47.09	9.60	0.54	26.6	20.50
C5	C6	4745.5	4742.34	30	308	0.010	0.012	45.10	9.19	0.56	34.8	10.32
C6	C7	4738.71	4737.5	30	385	0.003	0.012	24.96	5.09	1.26	41.1	-16.13
C7	C8	4737.5	4733.3	48	396	0.011	0.012	160.61	12.79	0.52	68.8	91.81
C8	C9	4733.3		48	339		0.012				75.0	
C9	A8		4728.83	48	200		0.012				0.0	
D1	C8	4739.8	4733.3	15	170	0.038	0.012	13.71	11.18	0.25	0.8	12.91
E1	E2	4763.08	4757.67		326	0.017	0.012				1.3	
E2	E3	4757.25	4753.54		173	0.021	0.012				1.3	
E3	E4	4753.46	4752.46	30	128	0.008	0.012	39.36	8.02	0.27	4.3	35.02
E4	E5	4752.46	4749.42	30	192	0.016	0.012	56.03	11.42	0.28	4.3	51.69
E5	E6	4748.83	4746.95	30	194	0.010	0.012	43.83	8.93	0.36	28.0	15.87
E6	E7	4746.95	4745.99	30	114	0.008	0.012	40.86	8.33	0.23	28.0	12.90
E7	E8	4745.87	4744.66	30	213	0.006	0.012	33.56	6.84	0.52	28.0	5.56
E8	E9	4744.37	4740.88	33	230	0.015	0.012	70.72	11.91	0.32	28.0	42.72
E9	C7	4740.88	4737.5	42	404	0.008	0.012	99.91	10.39	0.65	33.3	66.63
G1	E1	4767.37	4763.35		85	0.047	0.012				1.3	
H1	H2	4761.08	4759.98		197	0.006	0.012				3.0	
H2	E3	4760.06	4753.48		150	0.044	0.012				3.0	

Only two sections of pipe were found to be undersized based on the calculations and analysis assumptions. Where excess capacities appear as negative numbers, the existing pipe capacity is undersized for the anticipated flow reaching the pipe segment. The calculations shown in the table also provide a sense of which pipe segments have excess capacity and can handle additional flow if the inlet capacities contributing to the pipe segment were increased.

Table 8 shown below compares the estimated runoff rates at the design points to the summation of grounds inlet capacities upstream of the design point taking into account normal clogging and slope which summarizes the estimated "uncaptured" flows.

TABLE 8 – ESTIMATED UNCAPTURED FLOWS

Design Point	Approx. Q5 (cfs)		∑ Normal Grounds Upstream Inlet Capacity (cfs)	Est. Uncaptured Flows (cfs)
	Roofs	Grounds		
A1	2.28	5.26	2.50	2.76
A2	2.28	5.26	3.30	1.96
A3	2.14	4.96	3.30	1.66
A4	6.35	22.09	43.20	0.00
A5	6.49	22.67	43.20	0.00
A6	7.13	24.65	57.90	0.00
A7	7.78	26.47	57.90	0.00
A8	19.76	136.61	216.20	0.00
A9	19.76	136.61	216.20	0.00
B1	0.00	4.04	1.90	2.14
B2	0.00	12.57	3.80	8.77
B3	0.00	16.18	5.70	10.48
B4	0.00	19.22	7.60	11.62
C1	2.91	0.00	0.00	0.00
C2	2.58	0.00	0.00	0.00
C3	1.96	20.34	71.30	0.00
C4	1.96	24.63	80.50	0.00
C5	3.57	31.21	82.00	0.00
C6	3.47	37.63	82.00	0.00
C7	7.12	61.67	158.30	0.00
C8	7.33	67.63	158.30	0.00
C9	0.00	0.00	158.30	0.00
D1	0.34	9.50	0.20	9.30
E1	1.33	0.00	0.00	0.00
E2	1.33	0.00	0.00	0.00
E3	3.91	0.42	1.00	0.00
E4	3.91	0.42	1.00	0.00
E5	2.18	0.40	1.00	-0.60
E6	2.18	25.78	20.80	4.98
E7	2.11	24.89	20.80	4.09
E8	3.05	24.89	20.80	4.09
E9	3.54	29.74	26.20	3.54
F1	1.33	0.00	0.00	0.00
G1	1.33	0.00	0.00	0.00
H1	2.58	0.42	1.00	0.00
H2	2.58	0.42	1.00	0.00

1.1.4 Technical Advisory Committee

A meeting was held with the Technical Advisory Committee (TAC) on September 12, 2007 to discuss initial findings from the design team related to the existing infrastructure and to receive input from UNC regarding concerns about the existing utility system. With respect to the storm drainage system, the UNC Staff identified the following concerns:

1. Replace the existing "homemade" drop inlet located southwest of Butler-Hancock that is an on-going maintenance concern.
2. Flooding has been noted during larger storm water events in a grassy drainage area located near Harrison / Turner hall.
3. Minor flooding has been observed in the existing utility tunnel crossing location at 19th Street in close proximity to existing City catch basins in that area.
4. Flat topographic areas near the University Apartments and adjacent to Guggenheim Hall that have experienced minor ponding during stormwater runoff events.
5. Flooding in the "crawl tunnel" north of 19th Street (may be the result of broken irrigation lines as opposed to surface storm water runoff).

1.1.5 Storm Water System Summary and Recommended Improvements

Based upon the data collection and engineering calculations referenced above, the following improvements are recommended to UNC's existing storm water system to meet current storm water runoff needs.

1. Replace existing 30 in pipe – The segment of storm sewer pipe between design points C6 and C7 is undersized for the 5 yr. storm event. The total length of this 30" pipe is 385 feet, located south of Harrison Hall. The pipe capacity is controlled by the existing relatively flat slope, 0.0031 ft. per ft. The result is that upstream inlets may pond temporarily and/or some of the runoff will likely bypass the inlets, flowing onto the parking lot south of Harrison Hall and eventually onto 11th Ave. To improve this pipe section to design capacity, the pipe should be replaced with a 36 inch diameter pipe. The estimated opinion of probable construction cost for this improvement is $59,750.
2. Improve existing inlet capacities – In general, the existing inlet capacities appear to be sufficient to meet design storm runoff requirements with the exception of the following locations:
    i. The area east of McKee Hall
    ii. The area north of Harrison Hall
    iii. Along the south side of the parking area south of Holmes Dining Hall.
    iv. Uncaptured flows from these areas flow directly onto 11th Ave. resulting in additional flooding impacts to the City's roadway. The addition of approximately (9) inlets in these areas would improve campus drainage and reduce the volume of runoff flowing onto 11th Avenue. The estimated opinion of probable construction cost of adding these inlets is $45,500.
3. Replace the existing "homemade" drop inlet in the sidewalk area, southwest of the Butler-Hancock building with a standard curb opening/grated inlet in the street gutter line. Re-grade the sidewalk to drain toward the street. The estimated opinion of probable construction cost of adding these inlets is $5,200.
4. Re-grade the area north of Turner Hall creating a detention area with inlet and pipe connection to the existing storm sewer. The estimated opinion of probable construction cost of adding these inlets is $13,500.
5. Request City to inspect and seal their inlets and piping in vicinity of tunnel, and crack seal the asphalt pavement above the tunnel. UNC maintenance personnel should inspect the tunnel for cracks during the next rain event and seal the cracks accordingly as a part of regular maintenance practices. There is no anticipated cost to UNC for this project.

SECTION 1.2 – EXISTING POTABLE WATER SYSTEM

1.2.1 Introduction / Background

UNC's existing culinary/potable water system is an extensive network connecting service from the City' mainlines in the surrounding streets to supply fire hydrants, buildings, and landscaping sprinklers on campus (see Figure 7 - UNC Existing Potable Water Utility System Map – 3 Sheets). The system consists primarily of cement mortar lined, ductile iron water mains.

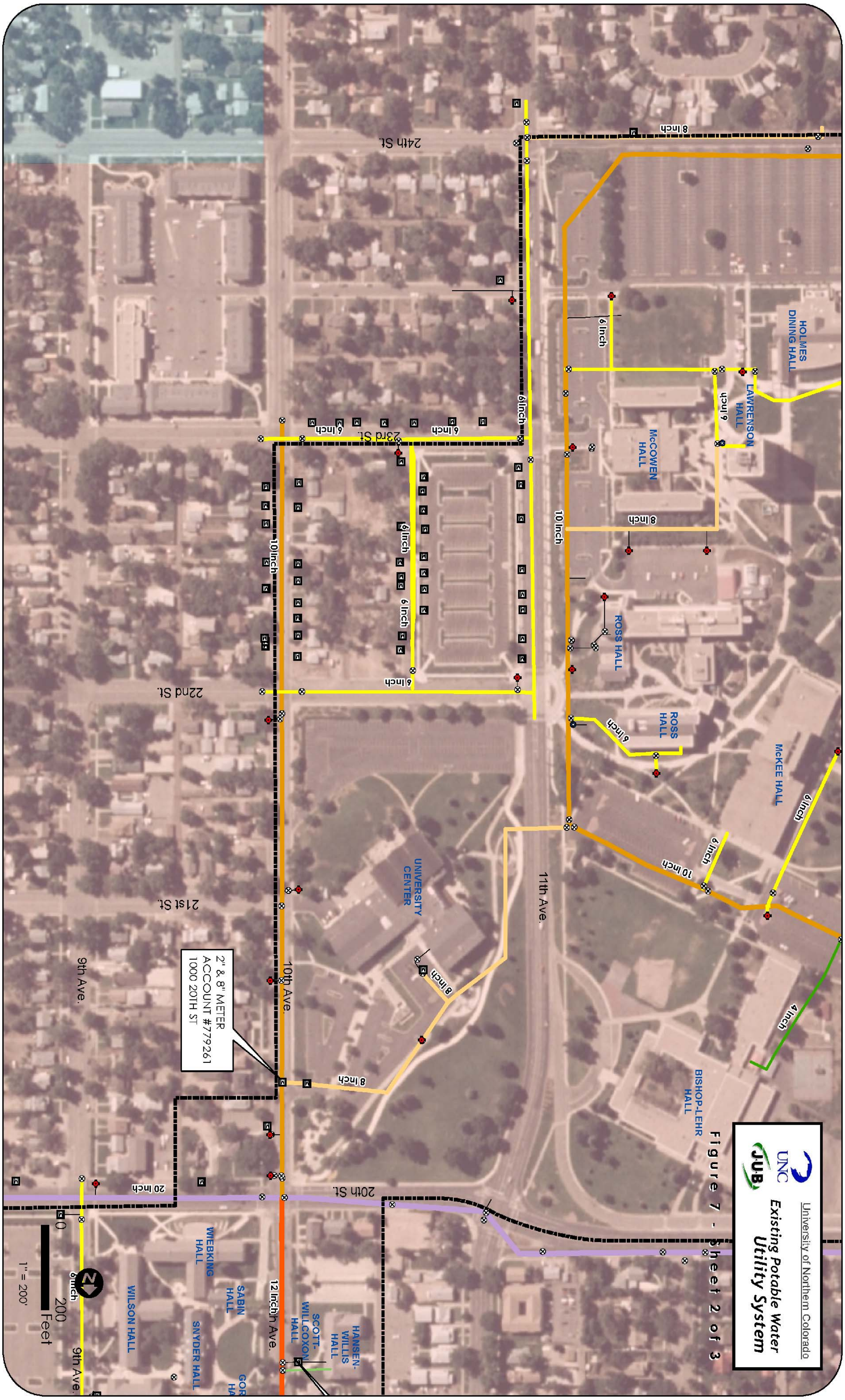
A few of the mains date as far back as the 1930's and are still in operation today as indicated in Table 9. Table 9 shows that a majority of the existing infrastructure on Campus is over 40 years old. The older mainlines tend to be at Central Campus and the northeast portion of West Campus with the newer mainlines being at the west side of West Campus. The older mainlines tend to be brittle and calcify which decreases efficiency of the pipeline, however, no problems of this nature were mentioned in conversations with UNC maintenance personnel.

As shown on Figure 7, the campus is located within two City pressure zones, Zone 1 and Zone 2. Central Campus is primarily contained within Zone 1 while West Campus is completely located within Zone 2. The Central Campus Residence Halls and the Visitor Parking and nearby landscaping are located in Zone 2. The City operating levels of Zone 1 and Zone 2 are 4830 ft and 4950 ft, respectively. Central Campus Zone1 topography ranges from about 4685 ft to 4728 ft resulting in static pressures ranging from 44 psi to 63 psi, meeting City criteria. City criteria states that the static pressure should be between 43 psi and 125 psi. Zone 2 topography ranges from about 4730 ft to 4805 ft resulting in static pressures from 63 psi to 95 psi, also meeting City criteria.

The City of Greeley recently completed a separate project to identify the feasibility of converting Central and West Campus irrigation to non-potable irrigation water. This study included recommendations to the City that, if implemented, could save 25.8 million gallons (MG) per year of potable water use for West Campus and 20.2 MG per year of potable water use for Central Campus. Potable demands during traditionally peak use periods would also be reduced and therefore pressures would increase.

The purpose of this section is to present the results of the existing water use and infrastructure data analysis, the hydraulic WaterCAD model summary, and highlight possible deficiencies in the system. Section 2 will address anticipated improvements to the water system to meet building demands outlined in the future master plan.


University of Northern Colorado
Existing Potable Water Utility System
UNC
JUB
Figure 7 - Sheet 1 of 3
Legend
Pipes
By Size
Unknown
1"
2"
3"
4"
5"
6"
8"
10"
12"
20"
30"
City of Greeley Pressure Zones
Zone 1
Zone 2
Valves
Meters
Manholes
Fire Hydrants
0
200
Feet
1" = 200'
6" & 10" METER
ACCOUNT #749634
1100 20TH ST
14th Ave.
17th Ave.
20th St.
20 inch
10 inch
8 inch
6 inch
4 inch
2 inch
TURNER HALL
HARRISON HALL
CAMPUS RECREATION CENTER
BUTLER HANCOCK HALL
JAMES A. MICHENER LIBRARY
CANDELARIA HALL
NOTTINGHAM FIELD
PATTON HOUSE


University of Northern Colorado
Existing Potable Water Utility System
Figure 7 - Sheet 2 of 3
UNC
JUB
2" & 8" METER
ACCOUNT #779261
1000 20TH ST
24th St.
23rd St.
22nd St.
21st St.
20th St.
9th Ave.
10th Ave.
11th Ave.
12 Inch
8 Inch
6 Inch
10 Inch
4 Inch
20 Inch
HOLMES DINING HALL
LAWRENSON HALL
McCOWEN HALL
ROSS HALL
McKEE HALL
UNIVERSITY CENTER
BISHOP-LEHR HALL
WEBKING HALL
WILSON HALL
SABIN HALL
SNYDER HALL
SCOTT-WILCOXON HALL
HANSEN-WILLIS HALL
1" = 200'
0
200
Feet

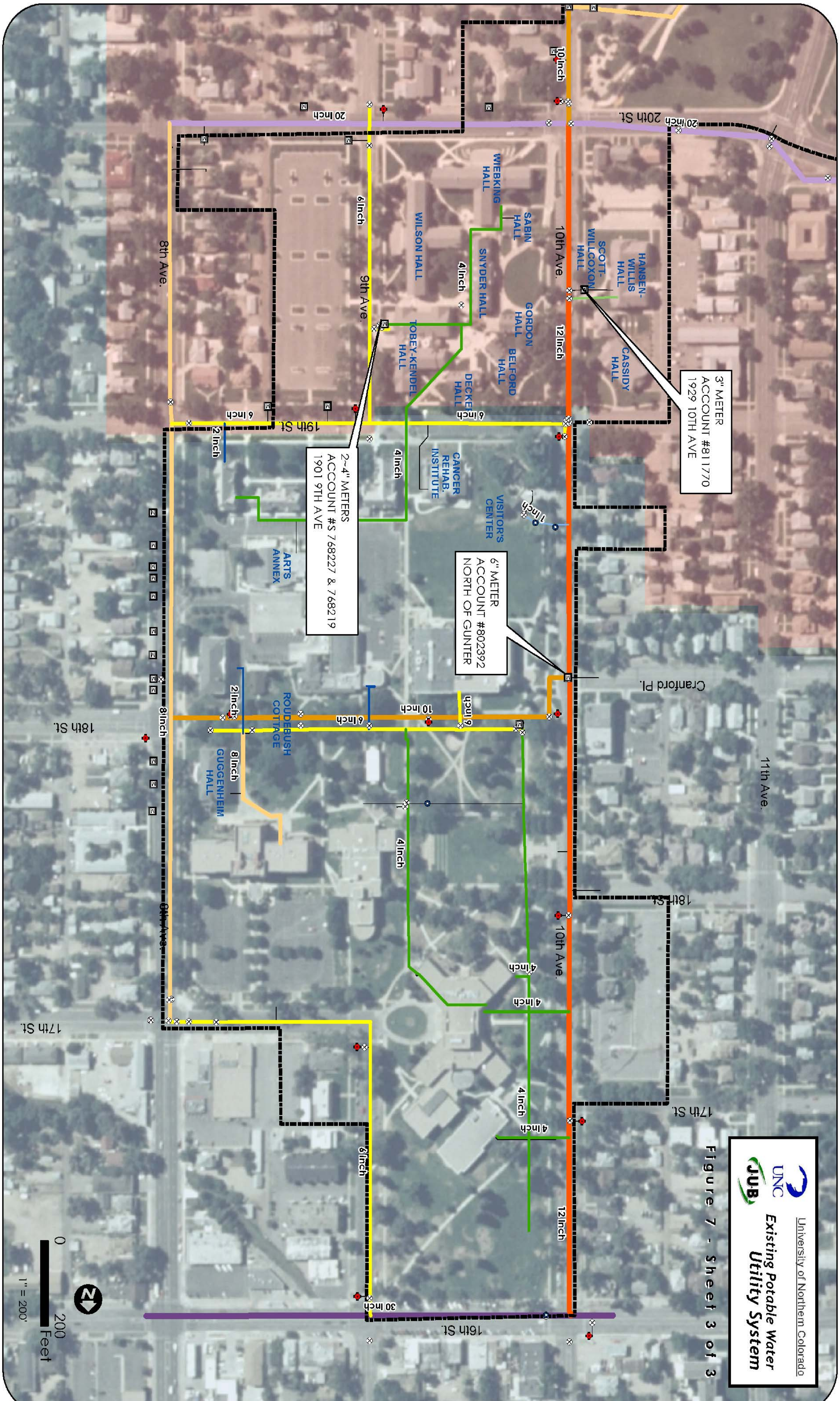

University of Northern Colorado
Existing Potable Water Utility System
Figure 7 - Sheet 3 of 3
3" METER
ACCOUNT #811770
1929 10TH AVE
2~4" METERS
ACCOUNT #S 768227 & 768219
1901 9TH AVE
6" METER
ACCOUNT #802392
NORTH OF GUNTER
WIEBKING HALL
SABIN HALL
WILSON HALL
SNYDER HALL
GORDON HALL
BELFORD HALL
DECKER HALL
TOBEY-KENDEL HALL
SCOTT-WILLCOXON HALL
HANSEN-WILLIS HALL
CASSIDY HALL
CANCER REHAB. INSTITUTE
VISITOR'S CENTER
ARTS ANNEX
ROUDEBUSH COTTAGE
GUGGENHEIM HALL
8th Ave.
9th Ave.
10th Ave.
11th Ave.
20th St.
19th St
18th St.
17th St.
16th St.
Cranford Pl.
20 inch
10 inch
12 inch
6 inch
4 inch
2 inch
8 inch
30 inch
1 inch
0
200
Feet
1" = 200'

TABLE 9 – SUMMARY OF CAMPUS WATER LINES WITH ESTIMATED AGES

Installation Year	Age (years)	Size	Length (LF)	% of Total Water Lines
		1"	129	
		6"	1570	
1928-1937	***70-79***	***Subtotal***	***1699***	***8.0%***
		2"	225	
1938-1947	***60-69***	***Subtotal***	***225***	***1.1%***
		4"	33	
1948-1957	***50-59***	***Subtotal***	***33***	***0.2%***
		2"	1214	
		3"	118	
		4"	740	
		5"	73	
		6"	504	
		8"	1169	
		10"	4232	
1958-1967	***40-49***	***Subtotal***	***8050***	***37.9%***
		6"	1640	
		10"	2109	
1968-1977	***30-39***	***Subtotal***	***3749***	***17.6%***
		8"	325	
1978-1987	***20-29***	***Subtotal***	***325***	***1.5%***
		4"	1208	
		6"	86	
		8"	2746	
		10"	1160	
1988-1997	***19-Oct***	***Subtotal***	***5200***	***24.5%***
		3"	121	
		4"	1176	
		6"	677	
1998-2007	***0-9***	***Subtotal***	***1974***	***9.3%***
Estimated Total Length			**21255**	**100%**

1.2.2 Infrastructure and Usage

Central Campus

The infrastructure providing water to Central Campus consists of multiple, smaller service lines connected to the surrounding City mainlines in the streets. The City's existing main sizes range from 8" to 30" around the campus perimeter. The existing City owned system has not been hydraulically modeled in WaterCAD due to complexity of modeling multiple connection points with unknown City system constraints. City staff has informed J-U-B that a model of the City system is in process but the model data is unavailable at this time.

A recent fire hydrant test was received from Union Colony Fire Rescue which shows that near the lower elevation of campus (17th St and 8th Ave) the static pressure was 58 psi and a residual pressure of 24 psi was obtained during the fire flow test at 873 gpm (see Exhibit 1 in the Appendix). As this test was at the lower end of Central Campus, it indicates that existing City fire flows are below City criteria of a minimum 1500 gpm at 20 psi residual in Zone 1.

Meter data, fixture counts, and building information have also been obtained from UNC. Monthly data for Central Campus in 2006 is shown on the following page in Table 10. A cumulative graphical summary of the flows from January 2006 to January 2007 is shown in Figure 8. In addition, the City provided half-hour meter readings and monthly readings for some locations on Central Campus. This data will be used in determining a significant portion of the future individual meter and building demands that will be outlined in Section 2.

West Campus

West Campus has two service points of connection to the City's system; a combined 10" high flow and 6" mid flow meter located at 20th Street and 14th Avenue and a combined 8" high flow and 2" low flow meter on 10th Ave near 20th St. A schematic drawing of the 14th Avenue meter configuration is shown in figure 7A on the following page. Typically the smaller meters are used to measure average flows and the larger meters are used to measure peak demand or fire flows. The campus infrastructure consists of several large (8" and 10") looped mainlines with smaller laterals to hydrants, irrigated areas, and buildings. Most mains are ductile iron except for a few PVC lines on the west side of West Campus leading to Nottingham Field.

J-U-B obtained data for more than 20 private fire hydrant tests completed by UNC staff in 2006 (see Exhibit 2 in the Appendix). Each test provided approximate flows, static pressures, and residual pressures at different hydrants on West Campus. This data was used to calibrate a WaterCAD model for the campus (see Exhibits 3 thru 6 in the Appendix).

Meter data records, fixture counts, and building information was also obtained for West Campus. Based on this data, West Campus used approximately 96 MG of water in 2006 (Table 10). Of this amount, 47 MG has been calculated to be used for irrigation in addition to that supplied by an existing non-potable irrigation system.

The peak month of reviewed meter data from UNC for June 2005 through June 2007 was 20 MG in July of 2005. Most of this flow is assumed to be irrigation water due to low campus water use during summer months. This peak demand was used in conjunction with City data to produce a maximum day flow of 540 gpm for West Campus. The calibrated WaterCAD model was then used to perform a maximum day + fire flow analysis on the existing system to check for deficiencies.

FIGURE 7A – EXISTING 14TH AVENUE METER VAULT

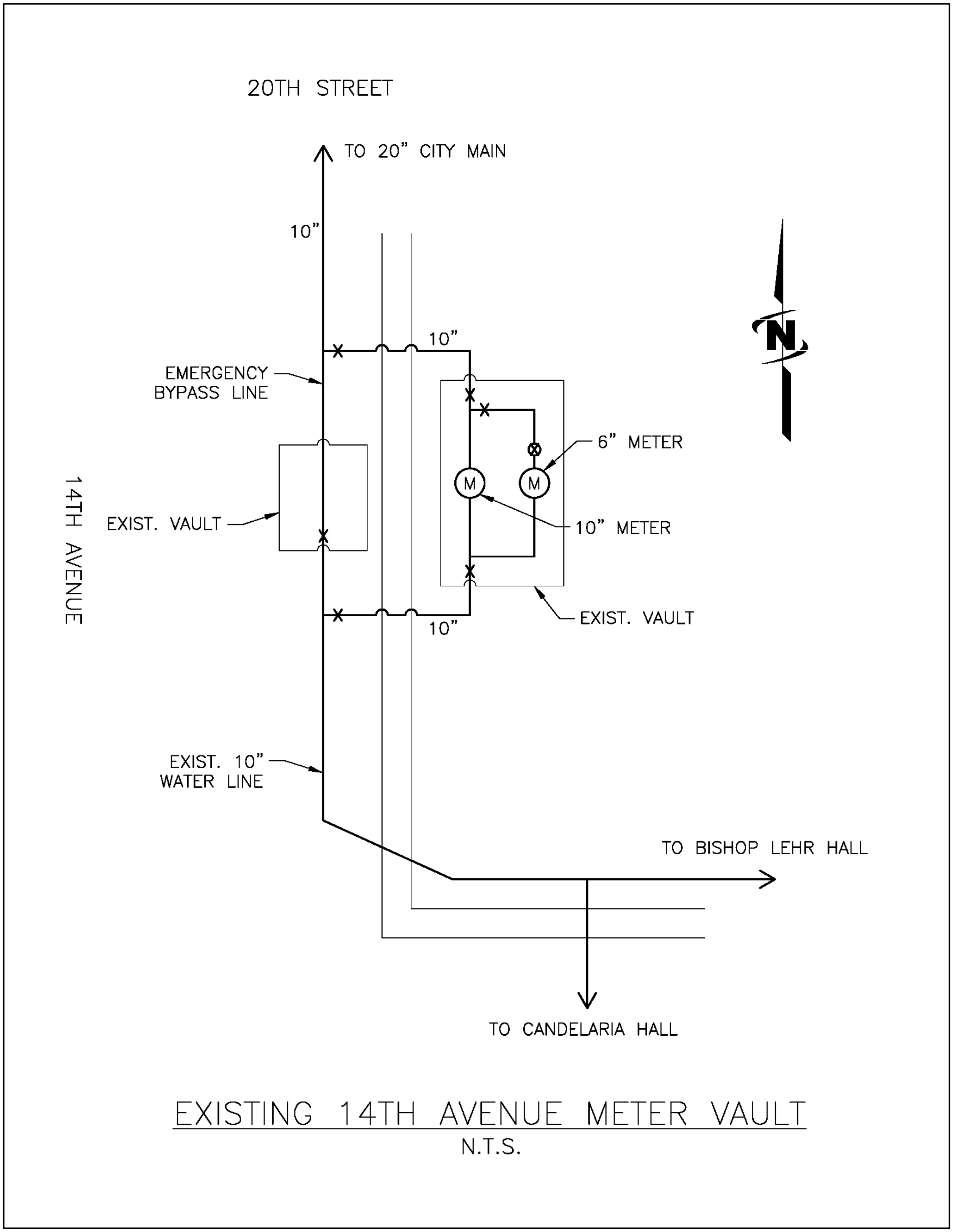


TABLE 10 – 2006 UNC METER BILLING RECORDS

2006 Monthly Water Usage (1000 gal)

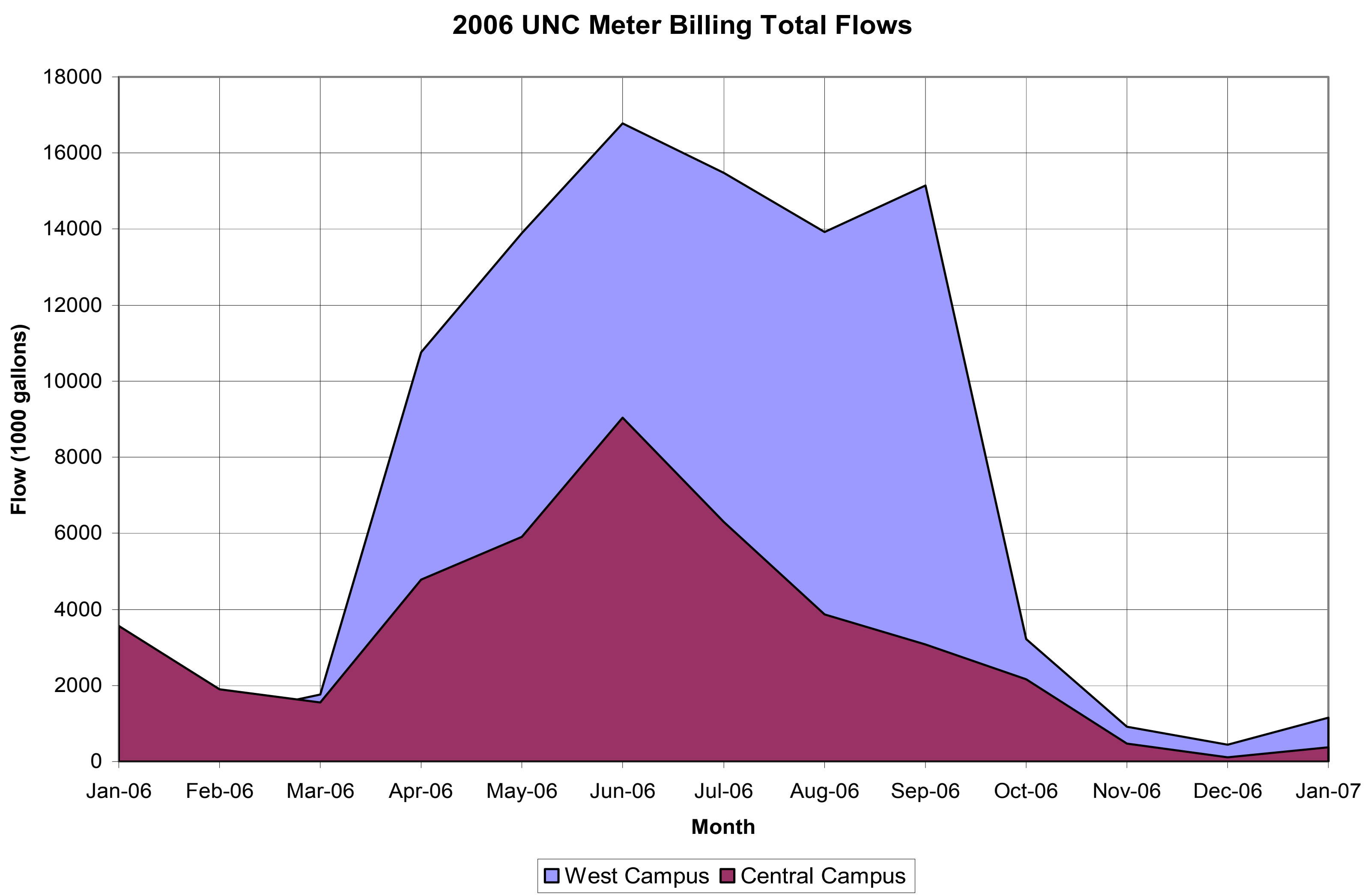
Meter/Month	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Total Gallons
749634-1100 20th St-WC-6,10	415	435	268	4244	6270	7717	5856	9030	8136	1300	307	208	1009	45,195
768227-1901 9th Ave-CC-4	1818	0	1	372	602	571	1209	734	332	21	0	0	0	5,660
768219-1901 9th Ave-CC-4	1100	1167	844	1376	890	2184	1551	2569	2240	1452	275	33	110	15,791
779261-1000 20th St-WC-2,8	947	753	1496	6517	7622	9056	9614	4898	7003	1917	603	240	141	50,807
811770-1929 10th Ave-CC-3	59	66	48	168	355	426	396	378	267	137	60	22	51	2,433
802392-NORTH GUNT.-CC-6	586	670	667	2865	4063	5861	3146	187	243	556	138	56	209	19,247
West Campus Total	**96,002,000**	**Gallons**												
***Central Campus Total**	**43,131,000**	**Gallons**												
*Some meter billing data not available														

LEGEND

WC = West Campus

CC= Central Campus

FIGURE 8 – 2006 UNC METER BILLING TOTAL FLOWS



1.2.3 Existing System Deficiencies and Limitations

Central Campus

A hydraulic analysis was not performed for Central Campus due to insufficient City system information as stated previously. However, the City fire flow test provided good insight into the mainline pressures at best case around campus.

It is anticipated that City fire flow requirements are also not met throughout much of Central Campus. Since the low pressures are in the City mainlines off campus and not onsite, future construction may require booster pumps and/or additional storage for new buildings. These system upgrade requirements will be discussed further in Section 2.

West Campus

A WaterCAD model was calibrated and a maximum day plus fire flow analysis was performed for the system (Appendix). Since residual pressure in the City system was not known, the fire hydrant tests were each used to back-calculate the residual pressure at the main point of connection. The average residual elevation obtained was 4913 ft. This residual pressure was then modeled as a reservoir and checked with the hydrant test results. Following calibration, the maximum day flow of 540 gpm during the peak month of July was distributed among the system and 1500 gpm was applied to each hydrant in the system.

Calibration results indicated that the pressures at each hydrant were within a standard deviation from tested pressures of 7 psi. This was deemed acceptable given the anticipated accuracy variation witnessed in an operational fire flow test.

As shown in Appendix Exhibit 5, all hydrants meet the minimum pressure of 20 psi at 1500 gpm even when subtracting the standard deviation of 7 psi *except hydrants 20 and 21*. These hydrants are the two hydrants west of Nottingham Field and are at the highest point of West Campus. In addition, the most direct path to the City main consists of 2” and 4” PVC pipes causing large friction losses associated with smaller pipes and high flow.

1.2.4 Technical Advisory Committee

The September 12th, 2007 technical advisory committee meeting discussed the following topics/concerns for the potable water system:

1. Master meter locations for West Campus and Central Campus. It was indicated that an empty meter vault was located on the main at the south end of West Campus that could possibly be used to meet future demands.
2. The City pressure zone locations for Main Campus and West Campus need to be shown and indicate which buildings connect to which zone. Please see Section 1.2.1 for further discussion.
3. A recent concrete lining of the primary east-west water main for Central Campus has helped boost Central Campus pressures. Pressures for Central Campus had previously been a problem – UNC has not had any known issues since then.
4. A 4” water line had been installed for irrigation along 10th Avenue at Central Campus.

5. Concerns were brought up regarding an existing 2” water main running from near Candelaria Hall of West Campus to Nottingham Field. Please see Section 1.2.5 for further discussion.

1.2.5 Water System Summary and Short Term Recommended Improvements

Central Campus water mains are located in the City’s lower pressure zone and a recent fire hydrant test indicates that future fire flows may not be available without booster pumps and/or additional storage. Central Campus contains several of the oldest water mains on Campus. As indicated by UNC staff, the primary east-west mainline has been concrete lined recently which has improved pressures.

It is anticipated that the ages of the pipes could be a significant potential for future building connections. However, since the pipes are in operation and significant problems have not been reported, recommended improvements for older pipelines will only be required for future construction and will be shown in Section 2 along with fire flow recommendations for Central Campus.

West Campus is located in the City’s higher pressure zone and pressures are good throughout campus. West Campus does contain older mainlines, but again are working well in operation today. An existing meter vault is available for an additional connection to the City if needed in the future.

Two hydrants west of Nottingham field were modeled and do not currently meet existing City criteria. J-U-B recommends that 800 LF of 2” main and 700 LF of 4” main be replaced with 1,500 LF of 8” DI main in this area for a cost of approximately $128,000. A summary of the cost estimate is listed below. Installation of this new mainline will increase flows to these hydrants to the minimum 1,500 gpm and maintain a pressure of at least 20 psi residual.

SECTION 1.3 – EXISTING SANITARY SEWER SYSTEM

1.3.1 Introduction / Background

The UNC sanitary sewer system consists of approximately 17,500 feet of underground pipe ranging in size from 4 inch to 15 inches in diameter. Some segments of the system date back to 1906. The West Campus system generally flows from west to east and discharges into the City's sewer system in 11th Ave. Portions of the West Campus system, a trunk line located south of the Butler-Hancock Bldg and Holmes Dining Hall, carries sewer flow from non-campus facilities west of 17th Street, and is maintained by the City of Greeley. All other campus sewer lines are maintained by UNC maintenance personnel.

The Central Campus sewer systems generally flow from south to north and discharge into City sewer mains in 6th, 8th, 9th and 10th Avenues.

As a part of this study of the existing sanitary sewer system, J-U-B has conducted flow monitoring at selected locations within the sewer system and completed a hydraulic analysis of main lines within the system to identify potential problems.

1.3.2 Sanitary Sewer Monitoring

UNC does not have individual building water meters and instead relies on "master meters" at various locations throughout campus. In order to more accurately understand current sanitary sewer flows, flow monitors were placed by J-U-B at various locations in the sanitary sewer system for the purpose of determining representative flow rates from various types of facilities on campus and obtaining information on non-campus flows entering the system.

Hach Scientific Flow Monitors which measure depth of flow and velocity were placed in the manholes at design points labeled A5, A12, A13 and J9 as shown on Figure 9 (4 pages) between September 24th and October 11th, 2007. Readings were electronically recorded every 15 minutes during the monitoring period.

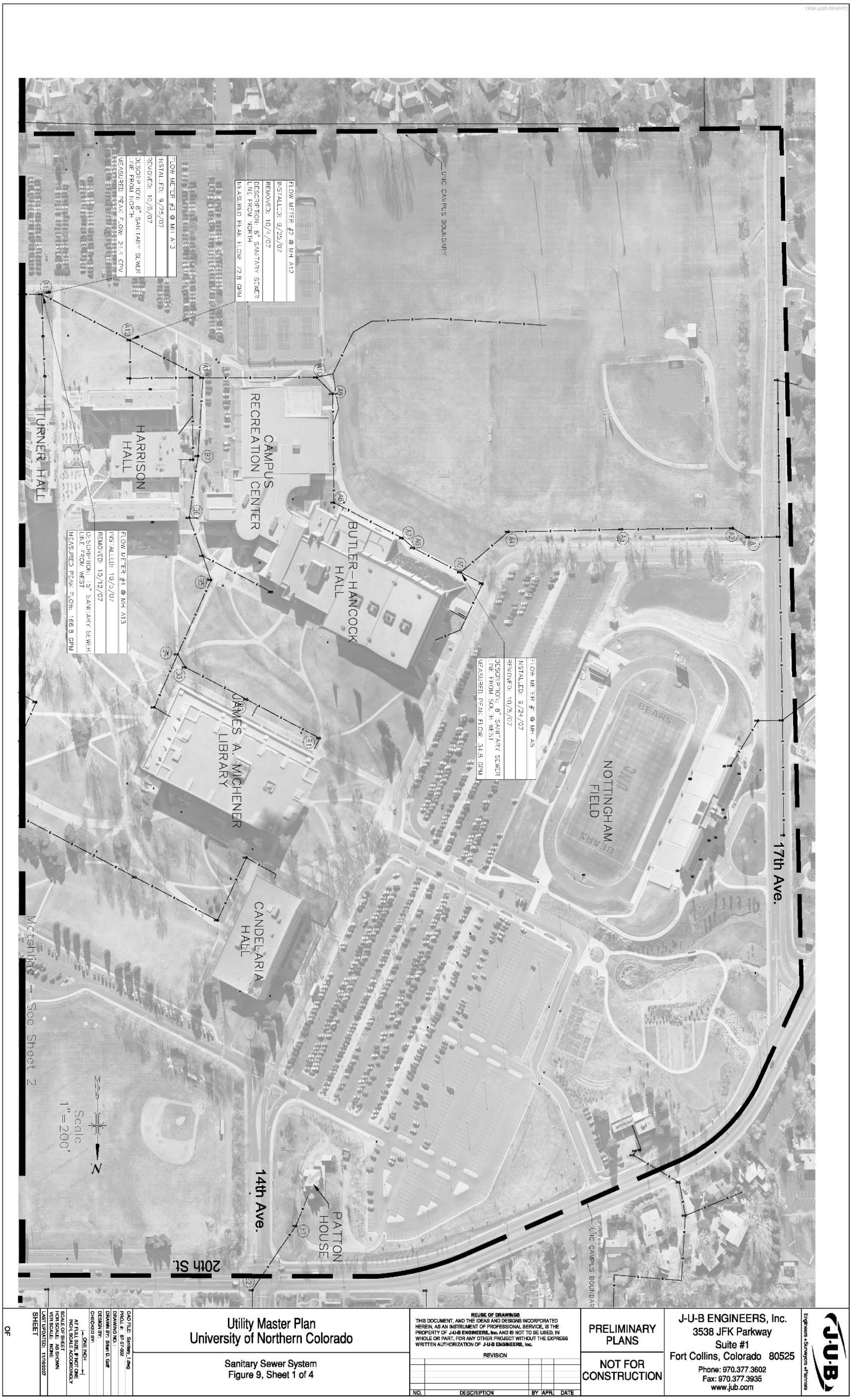


FIGURE 9 (1 of 4)

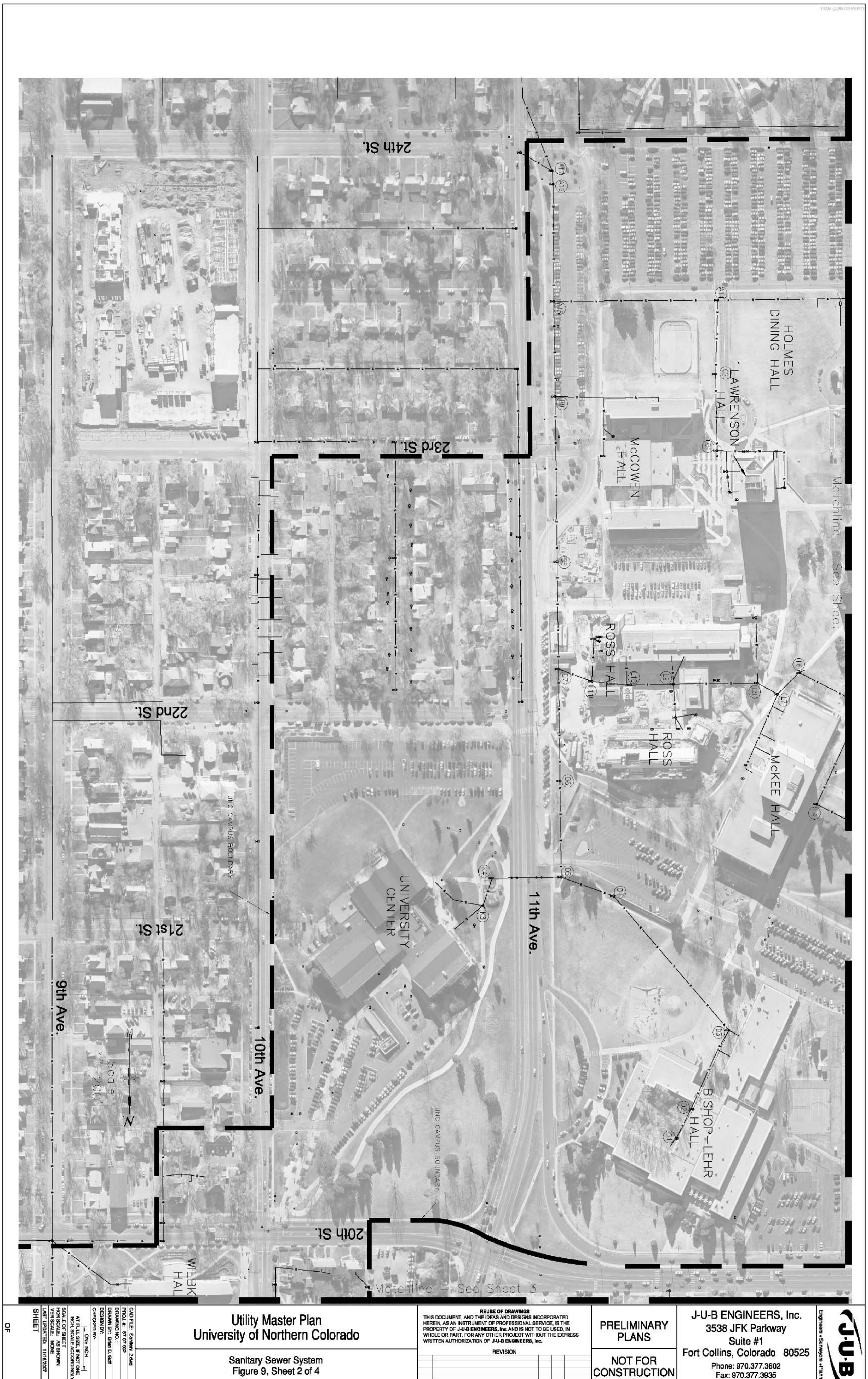


FIGURE 9 (2 of 4)

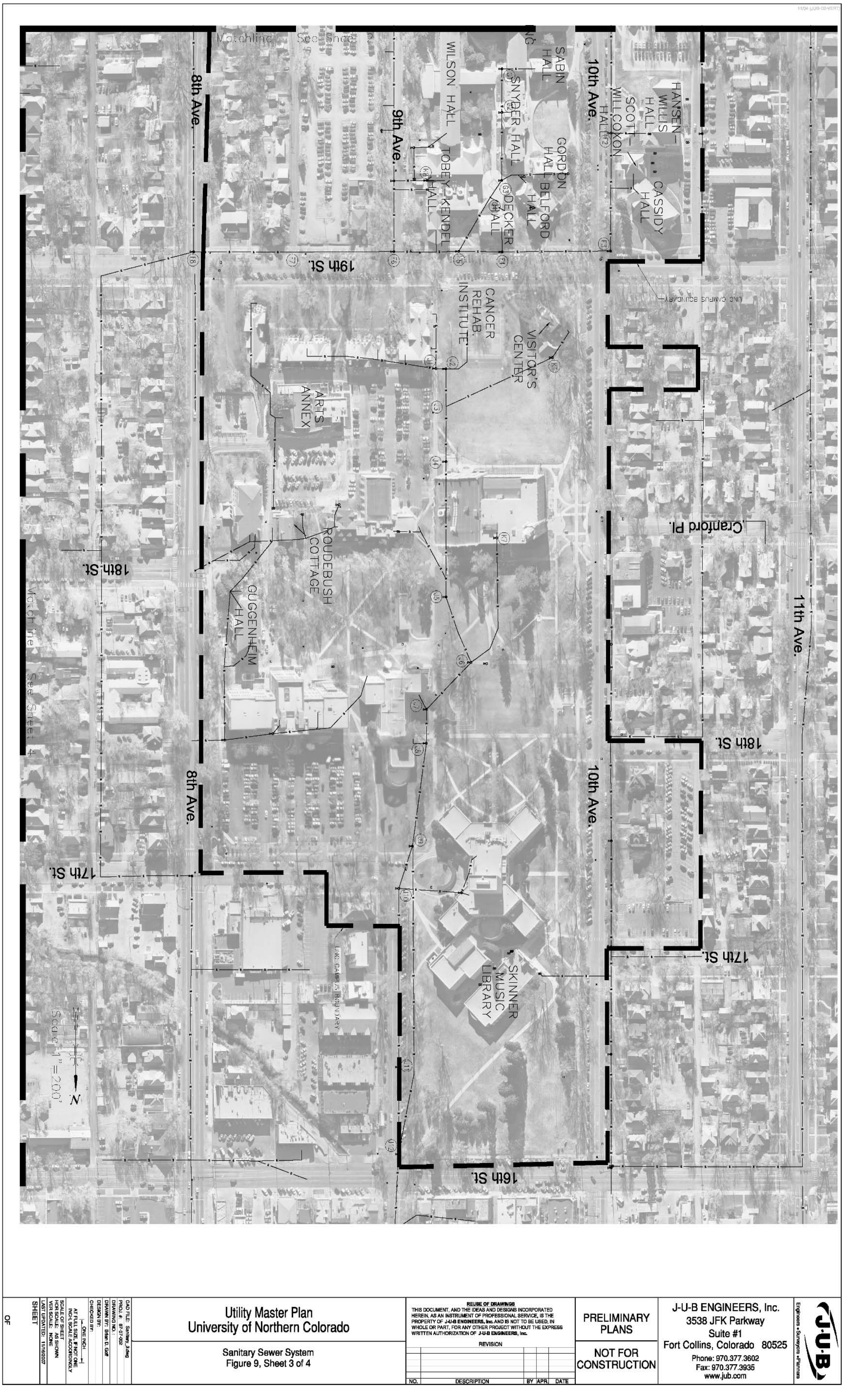


FIGURE 9 (3 of 4)

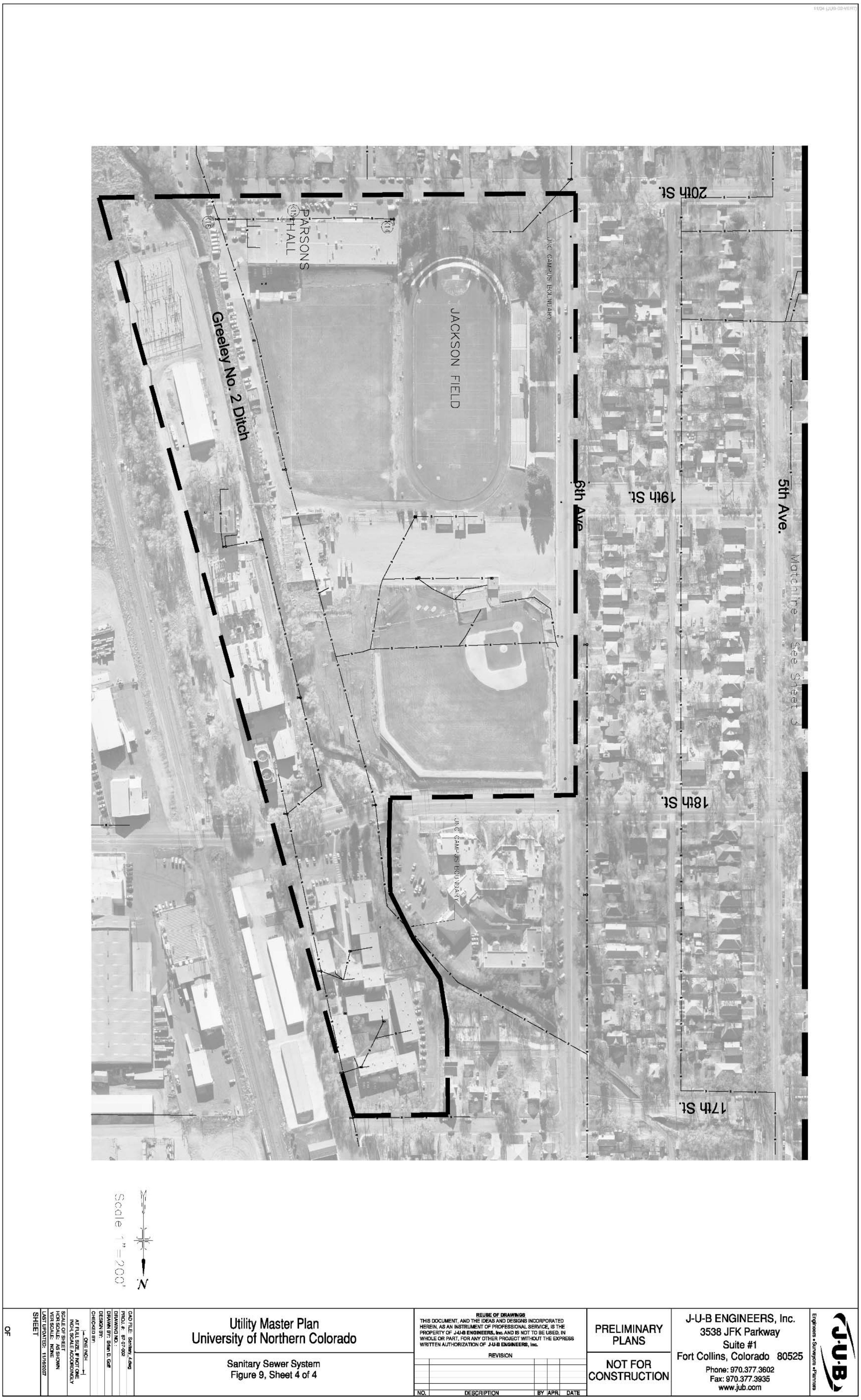
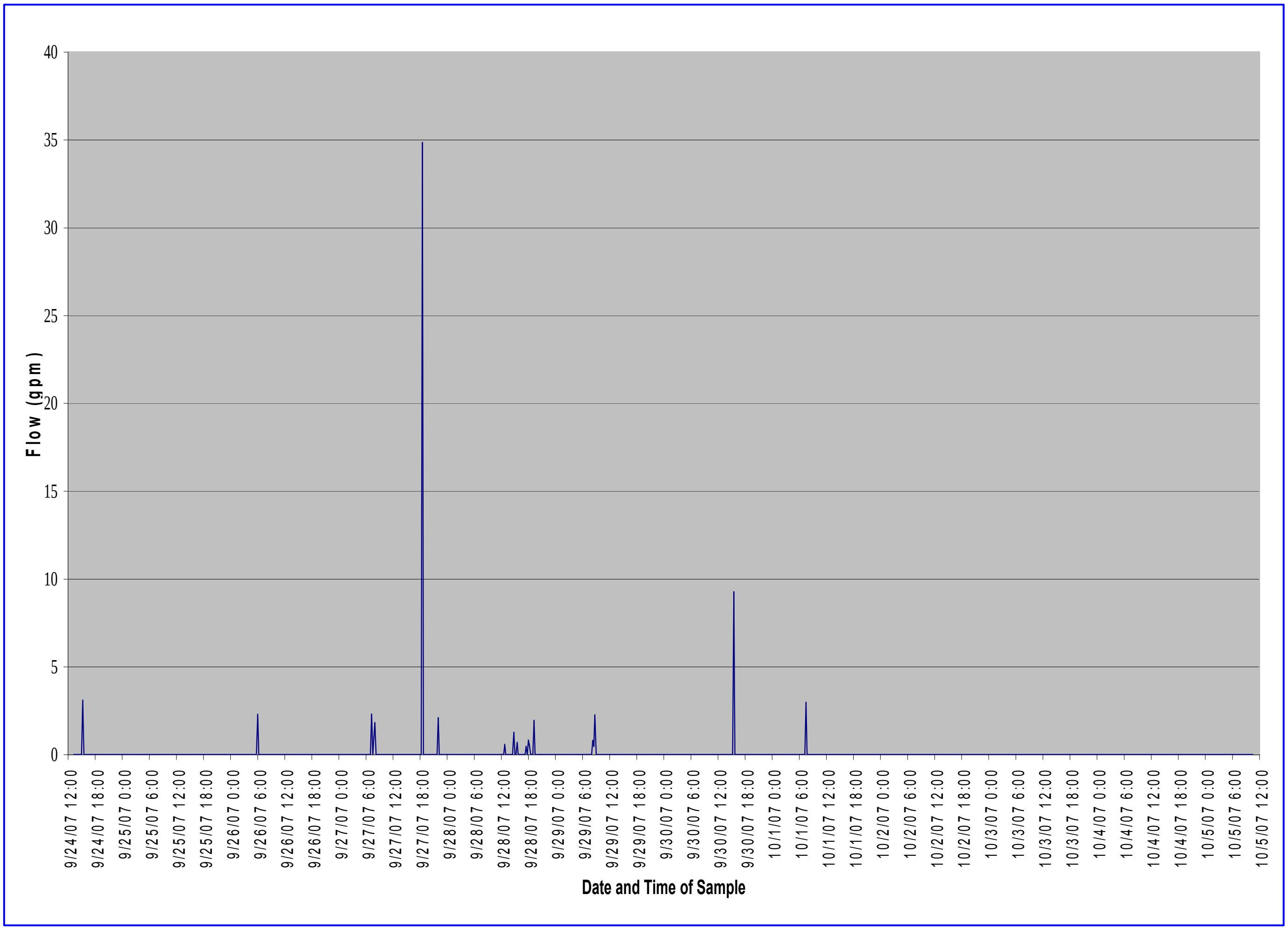


FIGURE 9 (4 of 4)

Flow Monitoring Locations and Results

Manhole A5: A flow monitor was placed in the 8 inch diameter line entering the manhole from the southwest, which brings campus flows from Nottingham Field facilities and non-campus flows from west of 17th Street into the system. The purpose of this meter was to identify the significance and influence of "off-campus" flows on UNC's existing system. The monitor was in place from September 24 thru October 5, a period of 11 days. The results are shown on the graph marked Figure 10. A maximum peak flow of approximately 35 gallons per minute was recorded during one monitoring period, however the average peak flow appears to be in the 2-3 gpm range, indicating that off campus flows have very little impact on the UNC sewer system. Figure 10 shows a graphical summary of the recorded flows.

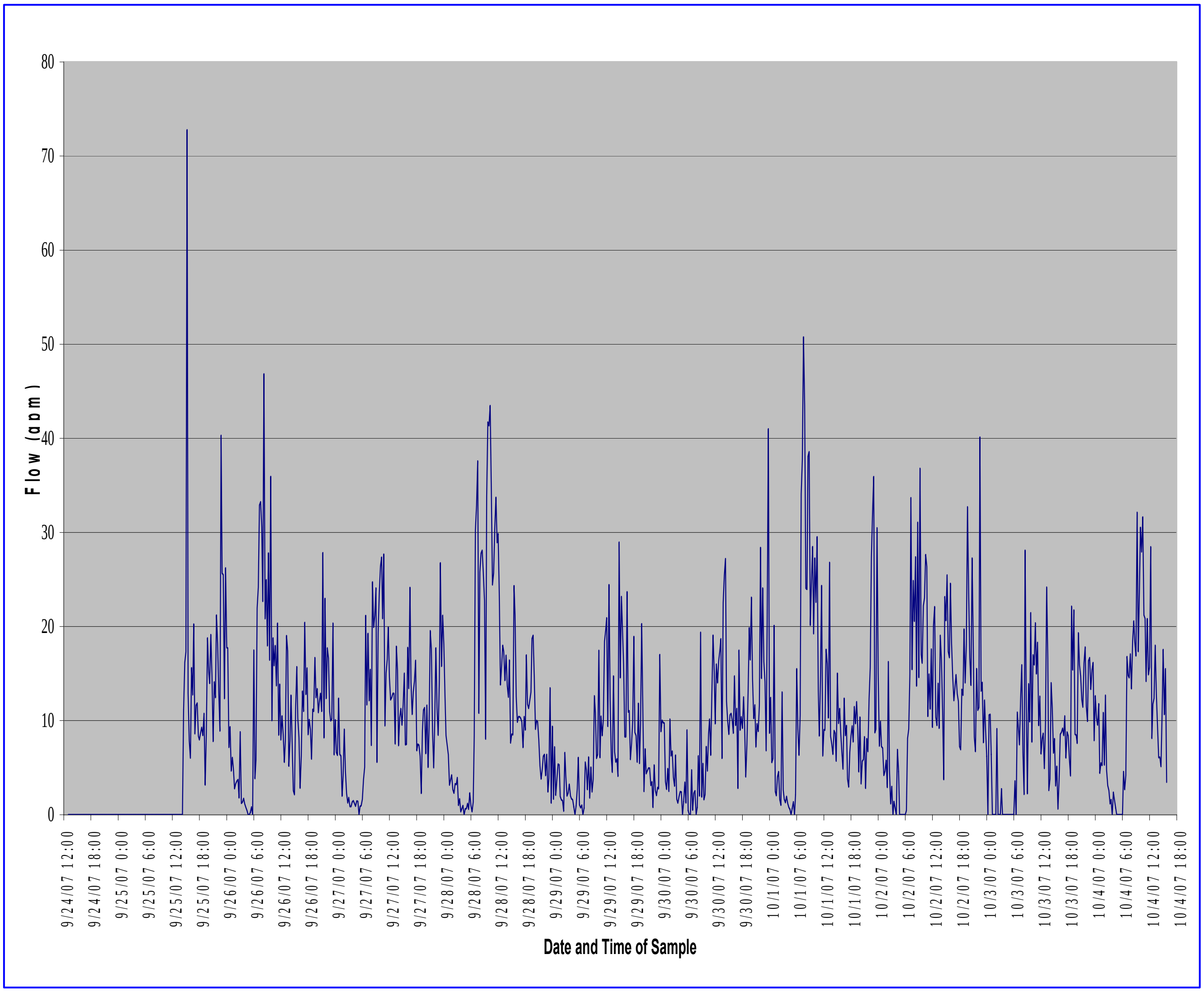
FIGURE 10 - SANITARY SEWER FLOW DATA, MANHOLE A5, 8" LINE FROM SOUTHWEST (RESIDENTIAL AREA)



Manhole A12: A second flow monitor was placed in the 8-inch diameter line serving Harrison Hall. As Harrison Hall does not have a separate water meter, the purpose of this meter was to specifically identify water/sewer use coming directly from this residence hall and subsequently calculate an average water use per resident figure that can be used in other areas of campus that are also un-metered.

This meter was in place from September 25 thru October 5, a period of 10 days. The results are shown below on the graph marked Figure 11. Readings from this monitor show an average peak flow in the 40 – 50 gpm range, with one peak attaining approximately 73 gpm. During this monitoring period there were 492 residents assigned to Harrison Hall according to UNC staff.

FIGURE 11 - SANITARY SEWER FLOW DATA, MANHOLE A12, 8" LINE FROM HARRISON HALL



Manhole A13: A flow monitor was placed in the 8 inch diameter line serving Turner Hall. The flow monitor was in place from September 25 thru October 5, a period of 10 days. The results are shown on the graph marked Figure 12. Readings from this flow monitor indicate an average peak flow in the 20-25 gpm range. During this period there were 591 residents assigned to Turner Hall according to UNC staff.

On October 5, the flow monitor was removed from the 8 inch diameter line serving Turner Hall and placed in the 15 inch diameter line serving Michener Library, Butler-Hancock, the Recreation Center and Harrison Hall. The results are shown on the graph marked Figure 13. Readings from this flow monitor show a peak flow of approximately 165 gpm.

FIGURE 12 - SANITARY SEWER FLOW DATA, MANHOLE A13, 8" LINE FROM TURNER HALL

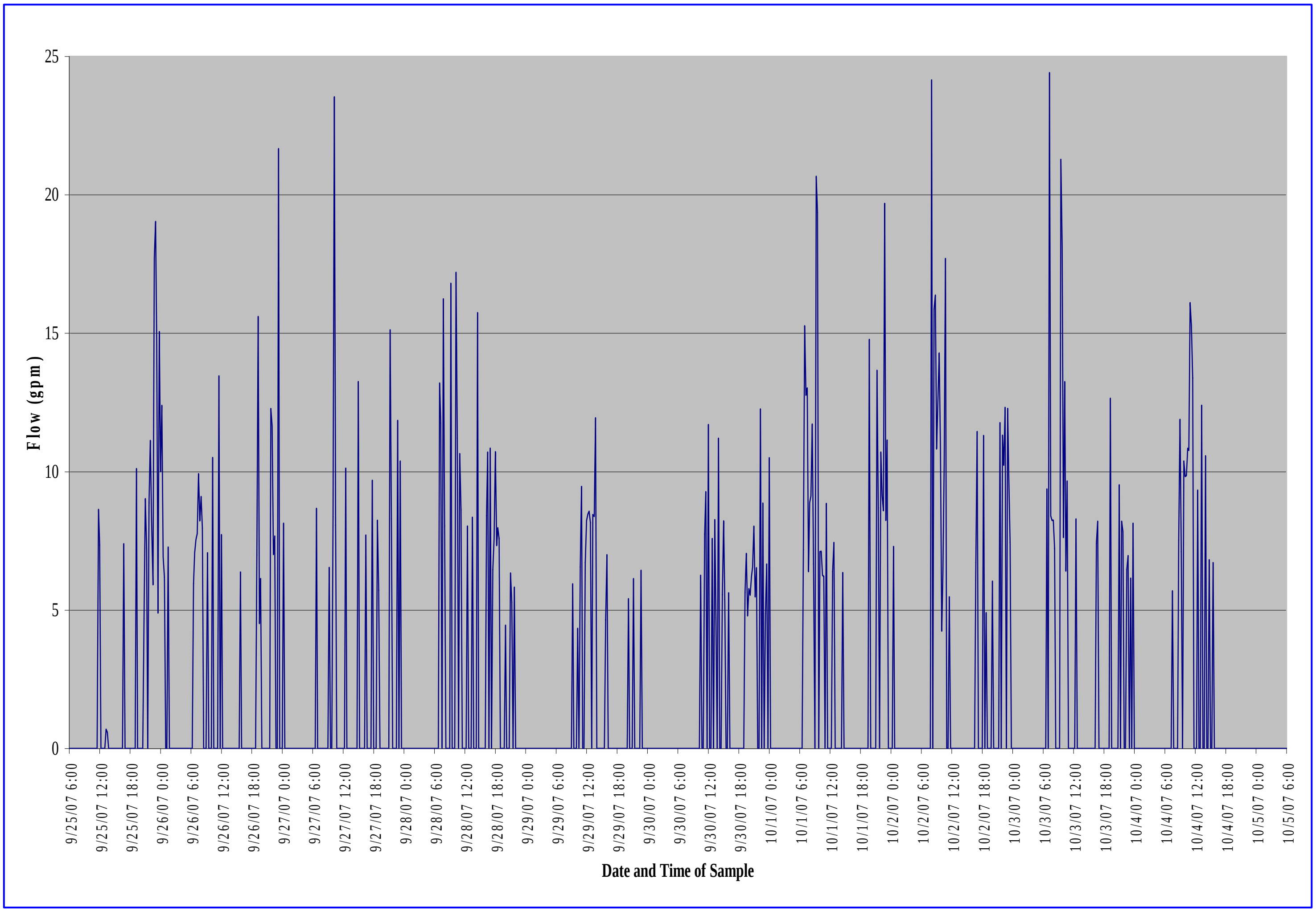
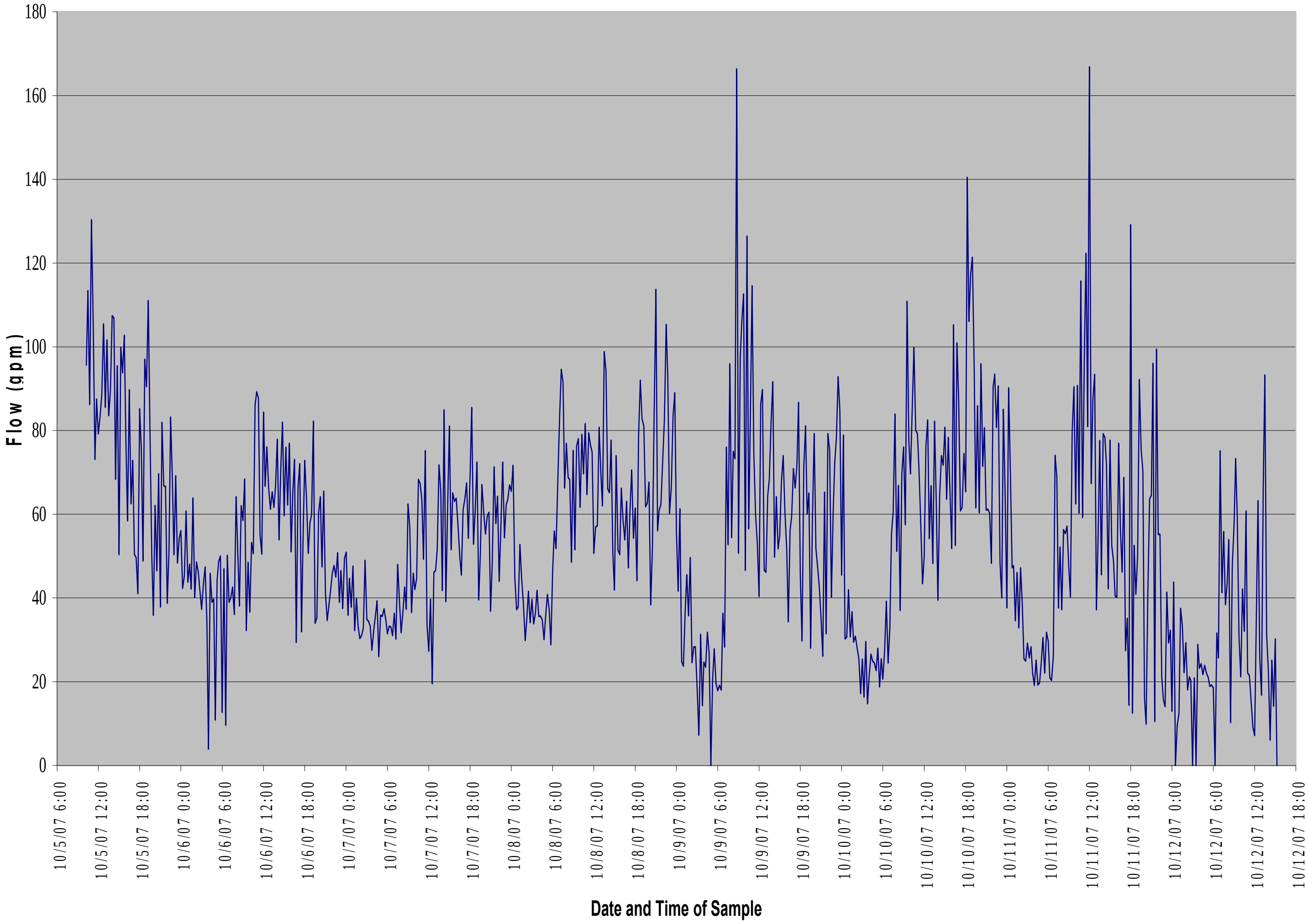


FIGURE 13 - SANITARY SEWER FLOW DATA, MANHOLE A13, 15" MAIN LINE FROM WEST



Manhole J9: A monitor was also placed on Central Campus in the 8 inch diameter line serving Carter Hall, Gunter Hall, Gray Hall, Brown Hall, Lujan Hall, Dickerson Hall, Cancer Rehab Institute Bldg. and the Visitor's Center. This monitor was in place from September 25 thru October 11, a period of 16 days. The purpose of this monitor was to evaluate the existing flows on central campus and verify the capacity of the main line that services these facilities prior to discharge to the City's system. The results are shown on the graph marked Figures 14 and 15. Readings from this flow monitor show peak flows of 67 gpm.

FIGURE 14 - SANITARY SEWER FLOW DATA, MANHOLE J9, 8" LINE FROM SOUTH (9/25/07-10/5/07)

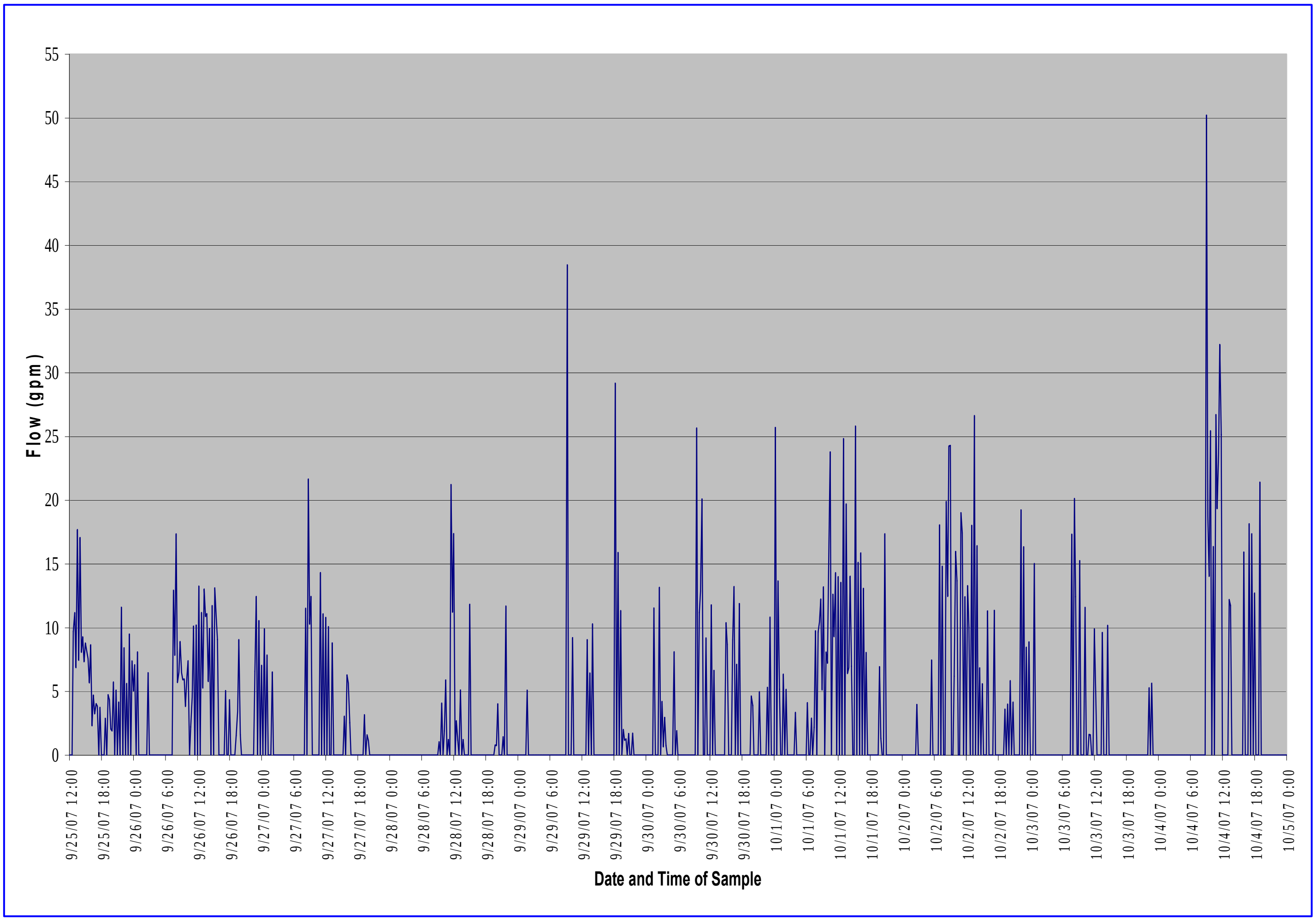
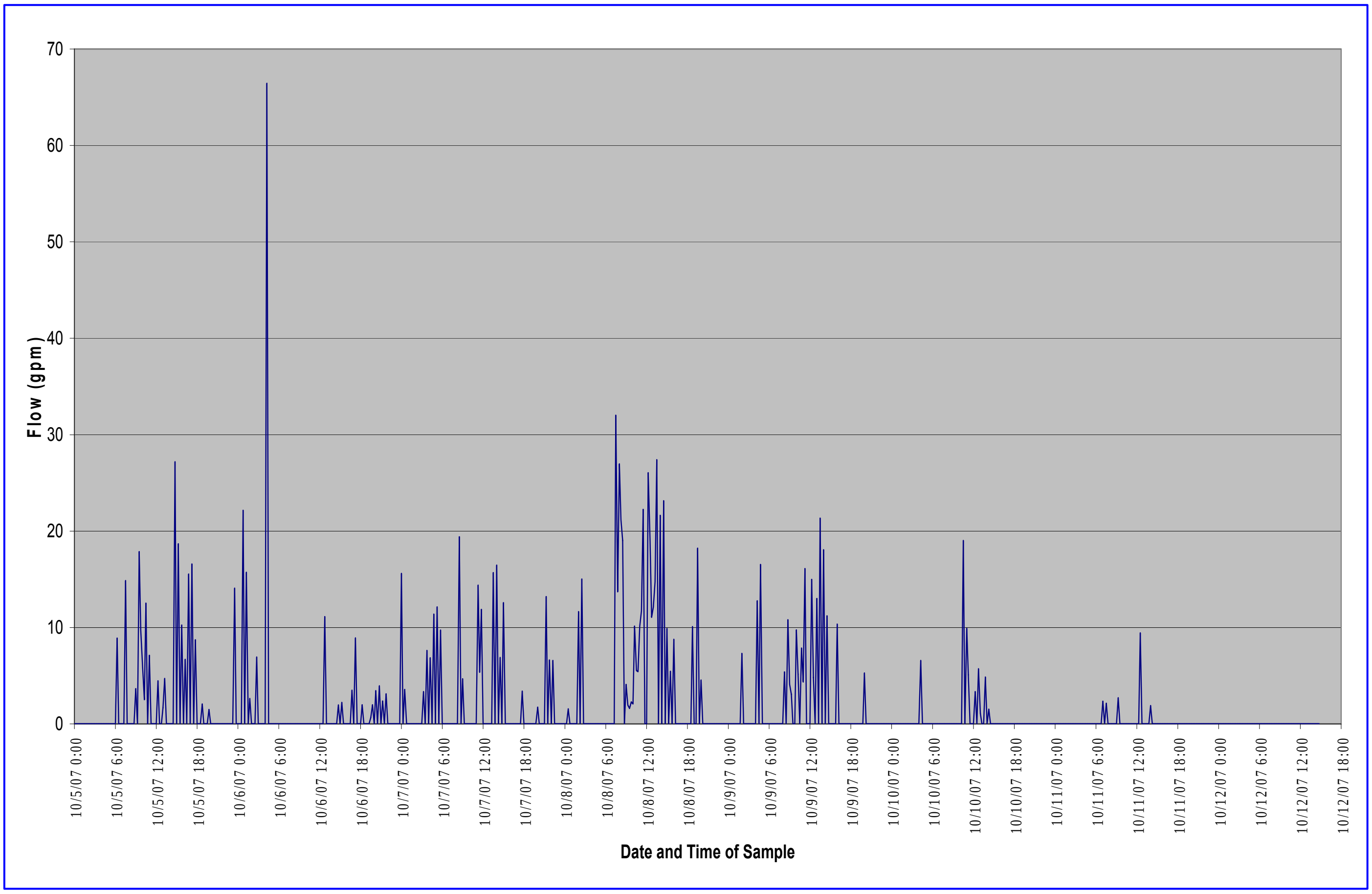


FIGURE 15 - SANITARY SEWER FLOW DATA, MANHOLE J9, 8" LINE FROM SOUTH (10/5/07-10/11/07)



1.3.3 Design Flow Rates

Residence Halls and Apartments

Peak flow rates determined from the in-line monitoring described above were compared to typical wastewater flow rates published in EPA 625/R-00/008 for similar types of facilities to obtain design flow rates used in the analysis of the system. Typical wastewater flow rates for apartment houses, boarding houses, and boarding schools taken from the referenced publication are 50 gallons/person/day, 40 gallons/person/day and 75 gallons/person/day respectively. Based on City of Greeley sanitary sewer design criteria, the peaking factor used to increase the average daily flow rate to account for peak flows is taken from the American Society of Civil Engineers, Gravity Sanitary Sewer Design and Construction, Manuals and Reports on Engineering Practice No. 60, 1982. :

$$\text{Peak Factor} = \frac{18 + (P)^{0.5}}{4 + (P)^{0.5}}$$

Where P = population in thousands

Assuming on an estimated student population of approximately 11,000, the peaking factor is calculated to be 2.91.

Based on this peaking factor and the measured average peak flow rate of 45 gpm from Harrison Hall during the monitoring period, the average daily flow rate per resident is calculated to be 45 gallons, which is midway between the published typical flow rate of 50 gallons/person/day for apartment houses and 40 gallons/person/day for boarding houses.

The measured peak flow rate from Turner Hall, however, was significantly lower at approximately 24 gpm, resulting in an average daily flow rate per resident of 20 gallons. This could be due to several factors including more water efficient fixtures in the newer facility, and/or possibly a higher absentee rate in residents during the monitoring period.

Based on the information presented above, a typical “design” flow rate of 50 gallons/resident/day and a rounded peaking factor of 3.0 were used in the hydraulic analysis of the sewer system for residence halls and apartments on campus.

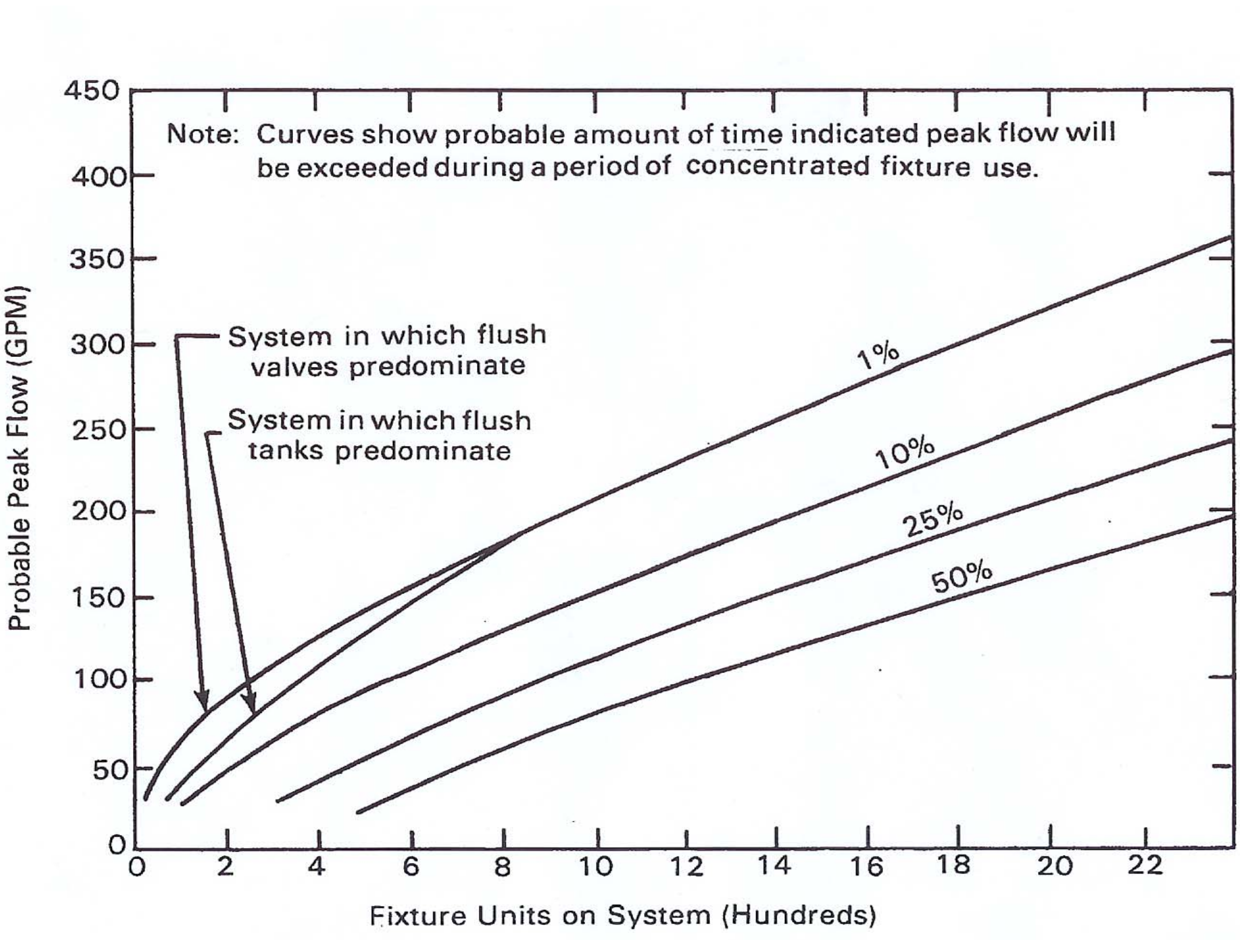
<u>Non-residence Facilities</u>

For non-residence facilities a method of determining typical peak flow rates based on number of plumbing fixtures within the facility was compared to flow monitoring data obtained at design points A13(15” dia.) and J9. EPA publication 625/1-80/012 provides a graphical correlation between peak flow rate and number of fixture units present in the facility. (See Table 11 and Figure 16 on the following pages)

TABLE 11 – FIXTURE UNITS VS. FIXTURE TYPE

Fixture Type	Fixture-Units
One bathroom group consisting of tank-operated water closet, lavatory, and bathtub or shower stall	6
Bathtub (with or without overhead shower)	2
Bidet	3
Combination sink-and-tray	3
Combination sink-and-tray with food-disposal unit	4
Dental unit or cuspidor	1
Dental lavatory	1
Drinking Fountain	1/2
Dishwasher, domestic	2
Floor drains	1
Kitchen sink, domestic	2
Kitchen sink, domestic, with food waste grinder	3
Lavatory	1
Lavatory	2
Lavatory, barber, beauty parlor	2
Lavatory, surgeon's	2
Laundry tray (1 or 2 compartments)	2
Shower stall, domestic	2
Showers (group) per head	3
Sinks	
Surgeons	3
Flushing rim (with valve)	8
Service (trap standard)	3
Service (P trap_	2
Pot, scullery, etc.	4
Urinal, pedestal, syphon jet, blowout	8
Urinal, wall lip	4
Urinal stall, washout	4
Urinal trough (each 2-ft section)	2
Wash sink (circular or multiple) each set of faucets	2
Water closet, tank-operated	4
Water closet, valve operated	8

FIGURE 16 – FIXTURE UNITS VS. FIXTURE TYPE



From information obtained from UNC staff on the number of fixtures in each of the non-residence facilities on campus, design peak flows were established for use in the analysis of the sewer system. Fixture counts are presented in Table 12 on the following page. Peak flow rates measured at monitoring points A13 (15") and J9 were compared with calculated peak flow rates using the above method for non-resident facilities and the average daily flow rate of 45 gallons/resident/day with a peaking factor of 2.91 for resident facilities upstream of the monitoring location. The peak flow rate measured at monitoring point A13 (15") is 165 gpm compared to the calculated flow rate of 278 gpm using the above method.

The peak flow rate measured at monitoring point J9 is 50 gpm compared to the calculated flow rate of 156 gpm using the above method.

Although conservative, the fixture unit method appears to be the most rational method of determining wastewater flows from non-resident buildings and is used in the hydraulic analysis of the UNC sewer system. Estimated peak flow rates for residence and non-residence facilities are summarized in Table 13.

TABLE 12 – UNC BUILDING FIXTURE COUNT SUMMARY

Building	No. of Tank Type Water Closets	No. of Valve Type Water Closets	Urinals	Lavs	Shower	Lab Sinks	No. of Fixture Units
Parsons Hall		4	3	4	2		56
Recreation Center							
Butler Hancock		42	26	36	30		572
Nottingham Field House							
Michener Library		30	9	19			314
Ross Hall		21	10	22		87	426
Candelaria Hall	23		10	18			168
McKee Hall							
Bishop-Lehr		48	28	43	1		584
University Center		32	13	40			388
Cassidy Hall		10		32			144
Tobey-Kendel		16	4	22			188
Ben Nighthorse Campbell							
Arts Annex		3	2	4			40
Gunter		34	16	25			386
Gray		10	4	10			116
Crabbe	3	5	2	6			72
Guggenheim		6	3	5			70
Carter		8	2	8			88
Kepner		16	4	16			176
Frasier		32	6	20			320
Music Tech Center							
Skinner Music Library		6	2	8			72
Foundation Hall	2	6	2	5			74
Jackson Field							

Other Facilities	No.of Fixture Units	Peak Flow Rate (gpm)	Peak Flow Rate (cfs)
Parsons	56	55	0.12
Butler-Hancock	572	155	0.35
Michener	314	110	0.25
Ross	426	140	0.31
Candelaria	168	80	0.18
Bishop-Lehr	584	155	0.35
University Center	388	125	0.28
Cassidy	144	75	0.17
Tobey Kendel	188	85	0.19
Arts Annex	40	50	0.11
Gunter	386	125	0.28
Gray	116	70	0.16
Crabbe	72	60	0.13
Guggenheim	70	60	0.13
Carter	88	65	0.14
Kepner	176	75	0.17
Frasier	320	115	0.26
Skinner Music Library	72	60	0.13
Foundation	74	60	0.13

TABLE 13 – UNC BUILDING FIXTURE COUNT SUMMARY

Residence Facilities	No. of Residents	Estimated Daily Flow (gal/day/resident)	Peaking Factor	Peak Flow Rate (cfs)	Peak Flow Rate (gpm)
Harrison	542	50	3.0	0.13	57
Turner	612	50	3.0	0.14	64
Lawrenson	510	50	3.0	0.12	53
McCowen	504	50	3.0	0.12	53
Arlington Appartments	725	50	3.0	0.17	76
Wiebking	246	50	3.0	0.06	26
Hansen-Willis	108	50	3.0	0.03	11
Sabin	33	50	3.0	0.01	3
Wilson	282	50	3.0	0.07	29
Snyder	103	50	3.0	0.02	11
Gordon	28	50	3.0	0.01	3
Belford	52	50	3.0	0.01	5
Decker	28	50	3.0	0.01	3
Warren House	11	50	3.0	0.00	1
Martin House	10	50	3.0	0.00	1
Young House	11	50	3.0	0.00	1
Brown	34	50	3.0	0.01	4
Lujan	34	50	3.0	0.01	4
Dickerson	56	50	3.0	0.01	6
Bond	51	50	3.0	0.01	5
Perry House	10	50	3.0	0.00	1
Farr House	10	50	3.0	0.00	1
Harry House	10	50	3.0	0.00	1
Union Ave Apartments	392	50	3.0	0.09	41
New West Campus Housing	721	50	3.0	0.17	75

Infiltration / Inflow

Sewer systems are subject to infiltration from water that may be present in the ground outside of the buried pipes, and entering the system thru leaking joints or taps. The City of Greeley accounts for this possible inflow into the system by adding 100 gallons per day / inch diameter of pipe / mile of pipe to the other design flows. Based on the lengths of pipe involved in the analysis, infiltration was found not to be a significant factor in the analysis.

1.3.4 Sewer System Inventory and Capacity Analysis

The main lines of the sanitary sewer system were previously shown on Figure 9 (4 sheets), with design points assigned to manholes on the system. Manhole rim elevations, pipe invert elevations, pipe sizes, lengths and materials have been tabulated on the spreadsheet labeled Table 14 on the following pages. With this information pipe slopes and maximum pipe flow capacities have been calculated using Manning's Formula. (This formula is further described under the section of the report addressing the storm drainage system.) In accordance with the City of Greeley Design Criteria for Sanitary Sewer Systems, the roughness coefficient used in formula is 0.013, and the maximum depth of flow is one-half of the pipe diameter per. The flow depth limitation of one-half the pipe diameter provides necessary air space to transfer sewer gasses.

The design calculations are also presented in Table 14. Negative numbers in the column under the heading "Excess Capacity" indicate that the theoretical capacity of the pipe segment will be exceeded under peak flow conditions.

Based on the above design parameters, one segment of the sanitary sewer system was found to be slightly undersized. This segment is between design points B6 and B7 with an estimated peak design flow of 0.43 cfs compared with a calculated pipe capacity of 0.38 cfs. Since the full flow capacity of the pipe is double the 0.38 cfs value, or 0.76 cfs, and since peak flows occur only occasionally throughout the day, this segment should function satisfactorily with regard to the transfer of sewer gasses above the flowing liquid.

TABLE 14 – UNC SANITARY SEWER CAPACITY SUMMARY (PAGE 1 OF 2)

Upstream Manhole			Downstream Manhole			Pipe Length (ft)	Pipe Dia. (in.)	Pipe Area (ft^2)	Calculated Pipe Slope (ft/ft)	Pipe Material	Estimated Manning's "n"	Calculated Pipe Capacity (cfs)	Estimated Pipe Flow (cfs)	Excess Capacity (cfs)
Manhole #	Rim Elev.	Inv. Out	Manhole #	Rim Elev.	Inv. In									
A1	4781.38	4774.30	A2	4778.41	4773.45	45	8	0.35	0.019	PVC	0.013	0.83	0.08	0.75
A2	4778.41	4773.35	A3	4770.9	4766.76	275	8	0.35	0.024	PVC	0.013	0.94	0.08	0.86
A3	4770.9	4766.7	A4	4764.81	4759.53	282	8	0.35	0.025	PVC	0.013	0.97	0.08	0.89
A4	4764.81	4757.38	A5	4761.78	4756.77	151	8	0.35	0.004	PVC	0.013	0.39	0.08	0.31
A5	4761.78	4755.86	A6	4761.16	4754.74	130	8	0.35	0.009	PVC	0.013	0.56	0.43	0.13
A6	4761.16	4754.54	A7	4761.77	4754.12	35	8	0.35	0.012	PVC	0.013	0.66	0.43	0.23
A7	4761.77	4753.96	A8	4762.14	4750.26	189	8	0.35	0.020	PVC	0.013	0.85	0.43	0.42
A8	4762.14	4750.12	A9	4756.69	4745.99	250	8	0.35	0.017	PVC	0.013	0.78	0.43	0.35
A9	4756.69	4745.93	A10	4755.8	4745.25	55	10	0.55	0.012	PVC	0.013	1.22	0.43	0.79
A10	4755.8	4745.18	A11	4752.23	4743.7	282	10	0.55	0.005	PVC	0.013	0.80	0.43	0.37
A11	4752.23	4737.71	A12	4749.08	4735.71	201	15	1.23	0.010	PVC	0.013	3.23	0.98	2.25
A12	4749.08	4735.5	A13	4744.89	4733	243	15	1.23	0.010	PVC	0.013	3.28	1.11	2.17
A13	4744.89	4733	A14	4742.22	4729.17	366	15	1.23	0.010	PVC	0.013	3.31	1.3	2.01
A14	4742.22	4729.17	A15	4739.2	4724.9	399	15	1.23	0.011	PVC	0.013	3.35	1.42	1.93
A15	4739.2	4724.35	A16	4733.53	4722.67	270	15	1.23	0.006	PVC	0.013	2.55	2.57	-0.02
A16	4733.53	4722.67	A17	4732.73	4722.3	30	15	1.23	0.012	PVC	0.013	3.60	2.57	1.03
B1	4763.4	4752.02	B2	4763.67	4747.77	201	8	0.35	0.021	PVC	0.013	0.88	0.25	0.63
B2	4763.67	4747.71	B3	4763.49	4745.69	169	8	0.35	0.012	PVC	0.013	0.66	0.25	0.41
B3	4763.49	4745.74	B4	4762.25	4744.41	36	8	0.35	0.037	PVC	0.013	1.16	0.25	0.91
B4	4762.25	4743.98	B5	4756.8	4741.94	190	10	0.55	0.011	PVC	0.013	1.14	0.25	0.89
B5	4756.8	4741.8	B6	4756.95	4741.14	60	10	0.55	0.011	PVC	0.013	1.15	0.25	0.90
B6	4756.95	4741.13	B7	4754.66	4739.77	95	10	0.55	0.014	PVC	0.013	1.31	0.43	0.88
B7	4754.66	4739.74	B8	4752.45	4739.57	144	10	0.55	0.001	PVC	0.013	0.38	0.43	-0.05
B8	4752.45	4739.4	A11	4752.23	4739.03	180	10	0.55	0.002	PVC	0.013	0.50	0.43	0.07
C1	4749.59	4732.55	C2	4746.12	4731.75	177	8	0.35	0.005	VCP	0.013	0.41	0.12	0.29
C2	4746.12	4731.65	A14	4742.22	4730.97	171	8	0.35	0.004	VCP	0.013	0.38	0.12	0.26
D1			D2			77	8	0.35	0.004	VCP	0.013	0.38		0.38
D2			D3	4764.9	4747.84	202	8	0.35	0.004	VCP	0.013	0.38		0.38
D3	4764.9	4747.94	D4	4766.68	4745.25	418	8	0.35	0.006	VCP	0.013	0.49		0.49
D4	4766.68	4745.05	D5	4774.82	4745.22	135	12	0.79	0.00126	VCP	0.013	0.63		0.63
D5	4774.82	4745.22	D6			222	15	1.23	0.004	VCP	0.013	2.05	0.28	1.77
D6			D7	4766.79		258	15	1.23	0.004	VCP	0.013	2.05	0.28	1.77
D7	4766.79		D8	4755.9	4741.05	247	15	1.23	0.004	VCP	0.013	2.05	1.03	1.02
D8	4755.9	4740.95	D9	4745.13	4733	381	15	1.23	0.021	VCP	0.013	4.68	1.03	3.65
D9	4745.13	4732.9	A15	4739.2	4724.4	220	15	1.23	0.039	VCP	0.013	6.37	1.15	5.22
E1	4782.45	4777.78	E2	4772.02	4763.94	183	8	0.35	0.076	PVC	0.013	1.67		1.67
G1	4741	4735.25	G2	4737.7		101	6	0.20	0.004	VCP	0.013	0.18	0.08	0.10
G2	4737.7		G3	4733.78	4726.22	158	6	0.20	0.004	VCP	0.013	0.18	0.1	0.08
G3	4733.78	4726.12	G4	4732.3	4724.4	49	6	0.20	0.035	VCP	0.013	0.53	0.12	0.41
G4	4732.3	4721.7	F1	4727.2	4720.7	148	6	0.20	0.007	VCP	0.013	0.23	0.12	0.11

TABLE 14 – UNC SANITARY SEWER CAPACITY SUMMARY (PAGE 2 OF 2)

Upstream Manhole			Downstream Manhole			Pipe	Pipe	Pipe	Calculated		Estimated	Calculated	Estimated	Excess
Manhole #	Rim Elev.	Inv. Out	Manhole #	Rim Elev.	Inv. In	Length (ft)	Dia. (in.)	Area (ft^2)	Pipe Slope (ft/ft)	Pipe Material	Manning's "n"	Pipe Capacity (cfs)	Pipe Flow (cfs)	Capacity (cfs)
J1	4719.52	4710.04	**J2**	4719.61	4710.51	25	6	0.20	0.019	VCP	0.013	0.39	0.03	0.36
J2	4719.61	4710.46	**J4**	4713.42	4707.67	216	6	0.20	0.013	VCP	0.013	0.32	0.04	0.28
J4	4713.42	4707.65	**J5**	4710.31	4704.41	314	6	0.20	0.010	VCP	0.013	0.29	0.06	0.23
J5	4710.31	4704.41	**J6**	4712.17	4703.57	164	6	0.20	0.005	VCP	0.013	0.20	0.22	-0.02
J6	4712.17	4703.32	**J7**	4709.51	4700.44	156	8	0.35	0.018	VCP	0.013	0.82	0.5	0.32
J7	4709.51	4700.4	**J8**	4708.96	4699.36	79	8	0.35	0.013	VCP	0.013	0.70	0.64	0.06
J8	4708.96	4699.34	**J9**	4705.68	4698.35	241	8	0.35	0.004	VCP	0.013	0.39	0.64	-0.25
J9	4705.68	4698.35	**J10**	4700.7	4692.77	104	8	0.35	0.054	VCP	0.013	1.40	0.64	0.76
K1	4761.21	4746.68	**B6**	4758.95	4741.14	190	8	0.35	0.029	VCP	0.013	1.03	0.35	0.68
K2	4765	4744.94	**B4**	4744.03	4744.41	134	8	0.35	0.004	VCP	0.013	0.38	0.25	0.13
K3	4780.51	4767.36	**K4**	4776.18	4766.43	67	8	0.35	0.014	VCP	0.013	0.71	0.28	0.43
K4	4776.18	4753.38	**D5**	4774.82	4751.6	168	8	0.35	0.011	VCP	0.013	0.62	0.28	0.34
K5	4798.47	4789.85	**K6**	4797.69	4788.58	130	8	0.35	0.010	VCP	0.013	0.60	0.01	0.59
K7	4719.63	4707.43	**J6**	4712.17	4703.57	320	8	0.35	0.012	VCP	0.013	0.67	0.28	0.39
K8	4730.36	4724.76	**K9**	4730.4	4723.93	83	8	0.35	0.010	VCP	0.013	0.61	0.26	0.35
K10	4720.21	4717.21	**J3 ("Y")**			290								0.00
K11	4750.42	4738.85	**K12**	4753.91	4736.92	155	8	0.35	0.012	VCP	0.013	0.68	0.13	0.55
K12	4753.91	4736.92	**A12**	4749.08	4735.95	88	8	0.35	0.011	VCP	0.013	0.64	0.13	0.51
K13	4761.15	4756.66	**A5**	4761.78	4755.88	60	8	0.35	0.013	VCP	0.013	0.69	0.35	0.34
K14	4696.01	4683.22	**K15**	4695.25		430	8	0.35	0.004	VCP	0.013	0.38	0.12	0.26
K15	4695.25		**K16**	4684.6	4677.99	185	8	0.35	0.004	VCP	0.013	0.38	0.12	0.26
L1	4779.69	4759.02	**L2**			160	10	0.55	0.004	PVC	0.013	0.69	0.18	0.51
L2			**L3**	4777.7	4756.65	227	10	0.55	0.004	PVC	0.013	0.69	0.18	0.51
L3	4777.7	4756.65	**L4**	4775.08	4754.42	397	10	0.55	0.006	PVC	0.013	0.82	0.18	0.64
L4	4775.08	4754.31	**L5**	4768.82	4752.73	254	10	0.55	0.006	PVC	0.013	0.87	0.18	0.69
L5	4768.82	4752.77	**L6**	4771.16	4752.11	170	10	0.55	0.004	PVC	0.013	0.68	0.18	0.50
L6	4771.16	4752.11	**L7**	4773.44	4751.22	73	12	0.79	0.012	VCP	0.013	1.97	0.18	1.79
L7	4773.44	4751.22	**L8**	4773.45	4749.55	55	12	0.79	0.030	VCP	0.013	3.11	0.43	2.68
L8	4773.45	4749.55	**L9**	4774.9		204	12	0.79	0.004	VCP	0.013	1.13	0.74	0.39
L9	4774.9		**L10**	4775.24		104	12	0.79	0.004	VCP	0.013	1.13	0.74	0.39
L10	4775.24		**L11**			95	12	0.79	0.004	VCP	0.013	1.13	0.74	0.39
L11			**D7**			86	12	0.79	0.004	VCP	0.013	1.13	0.74	0.39

COLOR LEGEND

- UNC owned, City maintained lines
- City owned and maintained lines
- Over Capacity
- Assumed minimum pipe slope of 0.4%
- Assumed pipe diameter

1.3.5 Sanitary Sewer Service Life and Maintenance

The first segments of the UNC sanitary sewer system were installed in 1906 according to University records. Vitrified clay pipe (VCP) was used then and throughout the years as the University expanded, until the mid 1990's when polyvinyl chloride (PVC) pipe was used for new expansions and replacements. Approximately 3,600 lineal feet or 20% of the sewer system on campus is over 75 years old, with 990 lineal feet over 100 years old. The manufacturer of vitrified clay pipe places the service life of their product at "over 100 years" as has been proven by some of the pipe on campus.

Although highly resistant to corrosion and abrasion, VCP pipe installations as others are subject to breakage due to a number of factors, and root intrusion. Many times these problems go unnoticed until a blockage occurs causing an unsanitary backup along with costly cleanup and repair.

A list of locations for annual jetting or power flushing was provided to J-U-B by UNC maintenance staff. From the list, it appears that only 4 inch service lines are being routinely cleaned. Generally, municipal sanitary sewer maintenance operations include the cleaning of all main lines at least every two years, but annually if possible. Lines should also be televised periodically to identify potential problems before a blockage occurs.

1.3.6 Technical Advisory Committee Comments

A meeting was held with the Technical Advisory Committee on September 12, 2007, to discuss initial findings from the design team related to the existing infrastructure and to receive input regarding concerns about the existing utility systems. With regard to the sanitary sewer system the UNC Staff identified the following concerns:

- The sewer line south of the dining hall had a significant amount of flow and may be near capacity based on staff's observations during a recent sewer hook-up in that area.
- Concern was expressed over potential sewer pipe deterioration at the University Center based on past experiences with the sewer pipe inside the building.
- Minor sewer flooding problems have occurred in the past at McKee Hall in the basement.

1.3.7 Summary / Recommended Improvements

Based upon the data collection and engineering calculations referenced above, only one segment of sanitary sewer system appears to be slightly over capacity, a segment of sewer line between design points B6 and B7 which lies west of Harrison Hall. This 144 ft. segment is a relatively new (1995) 10-inch diameter PVC line which was laid on a very flat grade of approximately .001 ft per ft. Unless additional facilities are added upstream of this segment that will increase the flow rate, this segment should function satisfactorily and it is not recommended that it be replaced with a larger diameter line.

Routine sewer cleaning and televising are recommended to prevent blockages and sewer backups. Televising may reveal broken pipes or faulty joints that if replaced will result in overall cost savings to the University.

With regard to concerns expressed by UNC Staff at the TAC Committee mtg. of September 12, 2007:

The sewer line south of Holmes Dining Hall is a 15-inch diameter line as measured in the manhole at design point A13. (The City of Greeley maps show this line as an 18-inch diameter line.) Based on hydraulic calculations and design flow assumptions described in the sections above, the capacity of the line is well in excess of current flow rates and those anticipated from the new West Campus Housing project currently under construction.

According to UNC records, the buried sewer lines serving the University Center are vitrified clay pipes installed in 1966. Historically, vitrified clay pipes have shown themselves to be durable with respect to corrosion and abrasion, and are considered to have a life expectancy of 100 years or more. Unless there are unknown conditions such as a break in the line, these pipes should provide many more years of dependable service. If specific maintenance problems are being encountered in the pipes, televising should be employed to identify the cause of the problem.

The McKee Hall service lines should be televised to identify problem areas, if any, and a repair plan developed based on conditions revealed by the televising.

SECTION 1.4 – EXISTING INFORMATION TECHNOLOGY

1.4.1 Introduction / Background

Technology Plus met with the UNC Information Technology (IT) department on several occasions to develop an understanding of the distribution points, type, and quantity of communication cabling supplying each building and the quantity of used and available cabling. As a part of this report, detailed site plans (shown in Section 2.4) have been prepared along with a hierarchical table included with each figure for UNC's information and review. Summarized below are the findings based on the aforementioned conversations with IT department and a review of the existing buildings. Upgrade recommendations to the communication system are provided in Section 2.4 portion of the master plan.

Main Points:

- Carter Hall and Gray Hall serve as the primary distribution points for voice and data communication connections for the Central Campus and McKee and Ross Hall serve as the primary distribution points for the West Campus.
- Carter Hall is the main focal point as this houses the Data Center for the campus.
- The main Point of Presence (POPS) for Qwest is through Gray Hall.
- The majority of the underground connections utilize 62.5MM fiber
- There are a few locations that are fed with 8.3SM and 50MM laser optimized fiber along with (3) locations being fed with copper cabling.
- The fiber connection from the 6th Avenue and 19th Street manhole to the heating plant indicate a total of 24 strands of 8.3 fiber with 18 strands being used and 6 strands being damaged.
- The fiber from Carter Hall to Gray has a high strand count of both multi-mode and single-mode fiber but no indication of used or available strands.

1.4.2 Summary and Conclusion

The site plans included in the Section 2.4 (Figures 32 – 40) represent a schematic view of connectivity and do not indicate exact path or entrance to any of the building entrances. The tables shown on each figure were assembled in a hierarchical nature to represent the flow of cabling from building to building. The figures represent the design team's understanding of connectivity and were reviewed by the UNC IT department for content.

SECTION 1.5 – EXISTING ELECTRICAL SYSTEM

1.5.1 Introduction / Background

Primary Services

UNC's existing electrical distribution system utilizes a series of underground service laterals that start out from 12.47Kv (12,470 volts) primary distribution points supplied by Public Service Company (PSCo) from three primary and one sub-branch locations. The West and Central Campus primary services originate from overhead service drops and quickly transition to either underground utility corridors or direct buried feeders. In the case of the West Campus, UNC-owned, above-ground, primary switch cabinets feed into a centrally buried utility corridor which in turn allows for numerous branch feeders that supply power to pad-mounted transformers at individual building locations. These branch feeders leave the utility corridor and are usually routed in tunnels or occasionally in duct banks to the transformers. The East Campus is served from a UNC owned direct buried primary line that routes north through the site to pad mounted transformers adjacent to various facility buildings. All primary power is 12.47Kv distributed from 15Kv primary cables. Once PSCo has delivered the power to the various campuses, and with the exceptions of Nottingham, Foundation Hall, Farr Center, and various houses, UNC owns all portions of the distribution system beyond that point including transformers, switchgear, and cables. All power to the UNC campus is primary metered from PSCo. MKK Consulting Engineers has met several times with PSCo to review the specifics of their power distribution network, the capacity of the network, and to review past issues associated with power outages or failure of portions of the network. In addition, MKK has reviewed the future needs of the UNC campus and the impact these future loads will have on the existing PSCo infrastructure.

Transformers

With the exceptions noted above, transformers serving building loads belong to UNC. In our review of these existing transformers it appears that West Campus units are in most cases newer than those of the Central Campus. In our interviews with UNC maintenance personnel we did not learn of any outstanding operational issues regarding transformers of the West Campus. Transformers serving the Central Campus appear to be in good overall condition with the exception of three older units on the north end [two (2) at Carter Hall and one (1) at Crabbe Hall] that, while having no operational issues, are rusted and appear much older than most other units. Transformers serving the needs of the East Campus are generally new with the exception of the University Apartments complex including Hargrove, Toussaint, Dickerson, Ninemires, White Cave, and West Halls. These units are "on their last legs" according to maintenance personnel. Generally, most of these units are leaking oil and are heavily rusted, a visual indication of their histories of overheating. Continual overheating can cause a breakdown in the insulation of the core windings eventually leading to a total failure. It is recommended that the insulation values of the transformer windings in the University apartments be tested for manufacturer’s values and an assessment of the overall remaining life expectancy be conducted. The transformers identified here have outward visible signs of wear and heating, however, only a full assessment and testing will identify specific areas of weakness.

Transient Voltage Protection (TVSS)

MKK and UNC personnel conducted a survey of the existing campus structures to determine the status of TVSS protection afforded each electrical service. TVSS protection is intended to stop harmful voltage "spikes" from damaging delicate electronic equipment such as computers and digital-based control systems such as mechanical controls. In interviews with UNC maintenance personnel it became apparent that the biggest issue regarding the lack of TVSS protection involved damage to building HVAC control systems. This issue occurred in all three areas of the UNC campus but appears to be a larger issue on the West and Central campuses. TVSS protection takes two forms: building-wide protection that starts at the main switchgear and individual equipment protection that usually involves protection to a single piece of equipment or an electrical panel that serves many pieces. Of 74 structures reviewed, 24 or approximately 31% have active TVSS protection. For a more complete list of survey results see Section 2.5 of this report.

UNC Electrical Distribution System

The West Campus of the UNC complex is served through four (4) primary circuits that originate from within a UNC-owned 600-amp 12.47Kv primary switchgear cabinet located adjacent to the 24th Street driveway into the south parking lots. These four (4) circuits form two (2) primary loops, which in turn serve high-voltage switches that establish radial feeds to transformers adjacent to various buildings in the West Campus. The transformers step the voltage down from 12.47Kv to 277/480 volt at Candalara Hall, Michner Library, the Student Recreation Building, Butler-Hancock Hall, Harrison Hall, the University Center, McKee Hall, and Ross Hall. The new residence Halls, Lawrenson Hall, Turner Hall, Holmes Dining and Bishop-Lehr Hall are all served from 120/208-volt transformers.

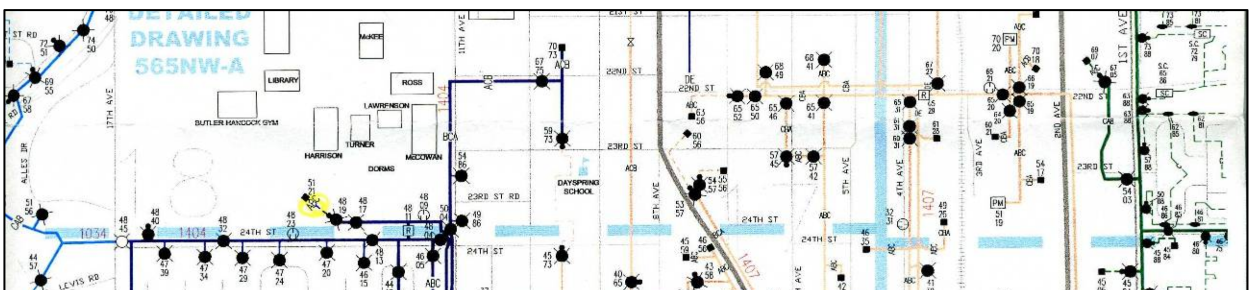


FIGURE 17 - ROSEDALE SUBSTATION DISTRIBUTION

The Central Campus is fed from a high voltage switch cabinet located in the open grass area adjacent to the Garden Theater. From this cabinet, two loops of direct buried feeders serve transformers with internal switching that in turn serve the academic and residence hall buildings.

1.5.2 Existing PSCo Distribution Network

West Campus

The PSCo feeders that serve the West Campus primary switchgear originate from the "Rosedale Substation" located approximately one mile to the southeast. The Rosedale Substation shown in Figure 17 on the previous page serves several primary loops that pass through adjoining neighborhoods to the east and south of the campus as well as one loop that serves the West Campus. This loop, identified as the 1404 loop, travels from the Rosedale Substation, along 28th Street to 11th Avenue turning north along 11th Avenue to 24th Street, west to 16th Avenue and then south back to 28th Street where it back feeds the "Evans Substation" located at 28th Street and 17th Avenue.

In our discussions with PSCo it was learned that the 1404 loop, while serving the Farr Park neighborhood, primarily serves the needs of the UNC's West Campus from an overhead service drop located along 24th Street. In addition, one small branch from the 1404 loop continues north along 11th Avenue before turning east into the neighborhoods along 22nd and 23rd Streets west of 9th Avenue. We were able to find two additional, very small feeders that originate from the Greeley Substation that also feed buildings within the West Campus. These small branches come from PSCo's 1034 feeder and serve the Judy Farr Center, Nottingham Field, and the Patton House. In summer 2009, a new UNC owned primary switch cabinet was added to this line. Located in parking lot “J”, this switch serves the recently completed structures in this area.

Central Campus

The Central Campus primary service originates from the "Greeley Substation" located at 23rd Avenue and 10th Street, about one mile northwest of the UNC campus (please refer to Figure 18 on the following page). Similar to the Rosedale Substation, the Greeley Substation serves the needs of neighborhoods to the north, south, east and west including one loop known as the 1037 loop; which in turn serves the Central Campus as part of an overhead service drop located between 10th and 11th Avenues along 15th Street. This branch follows the alleyway south to 20th Street where it dead-ends. At Cranford Place the overhead line transitions to a buried underground feeder that terminates into a UNC-owned primary switch cabinet located to the northeast of Gunter Hall. Originally, medium voltage power distribution was routed to the buildings of the Central Campus via an underground utility tunnel that routes north-south through the campus. However, that distribution network was abandoned and primary power now serves the Central Campus through direct buried feeders that radiate from the primary switch cabinet to pad mounted transformers that serve individual or grouped buildings located throughout the Central Campus.

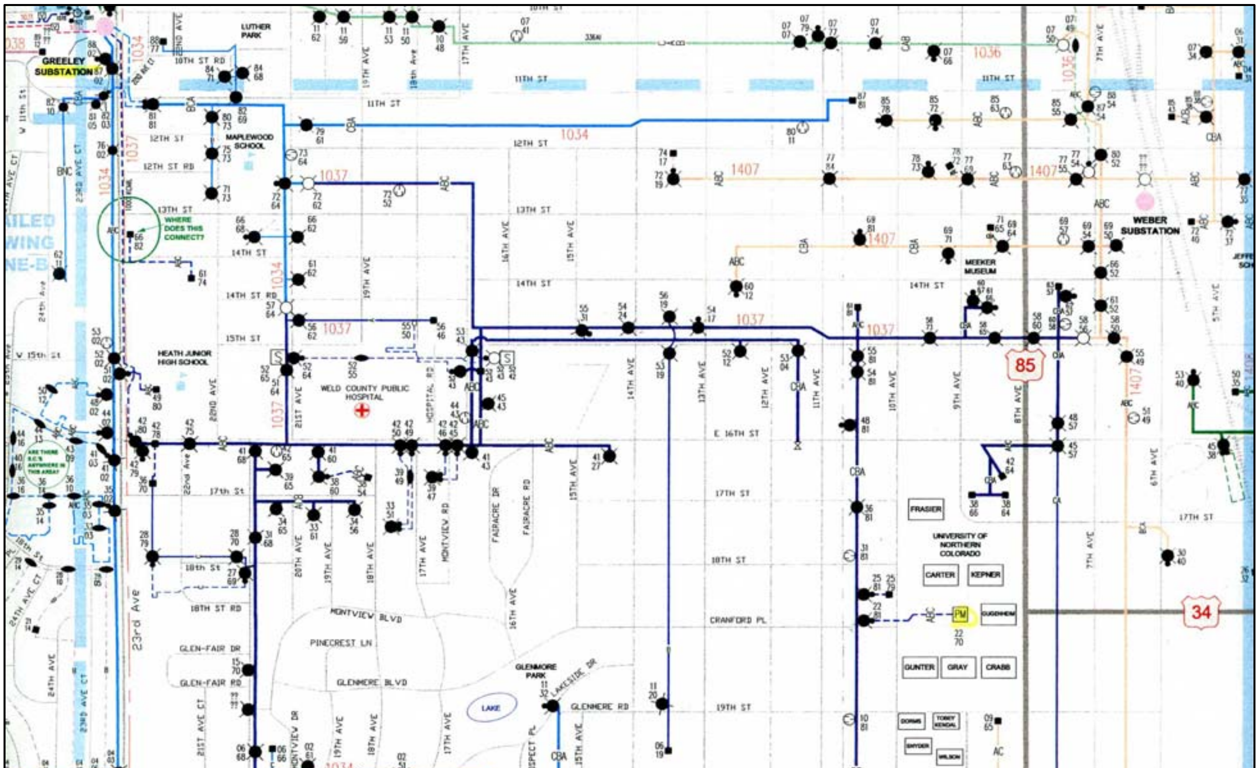


FIGURE 18 - GREELEY SUBSTATION DISTRIBUTION

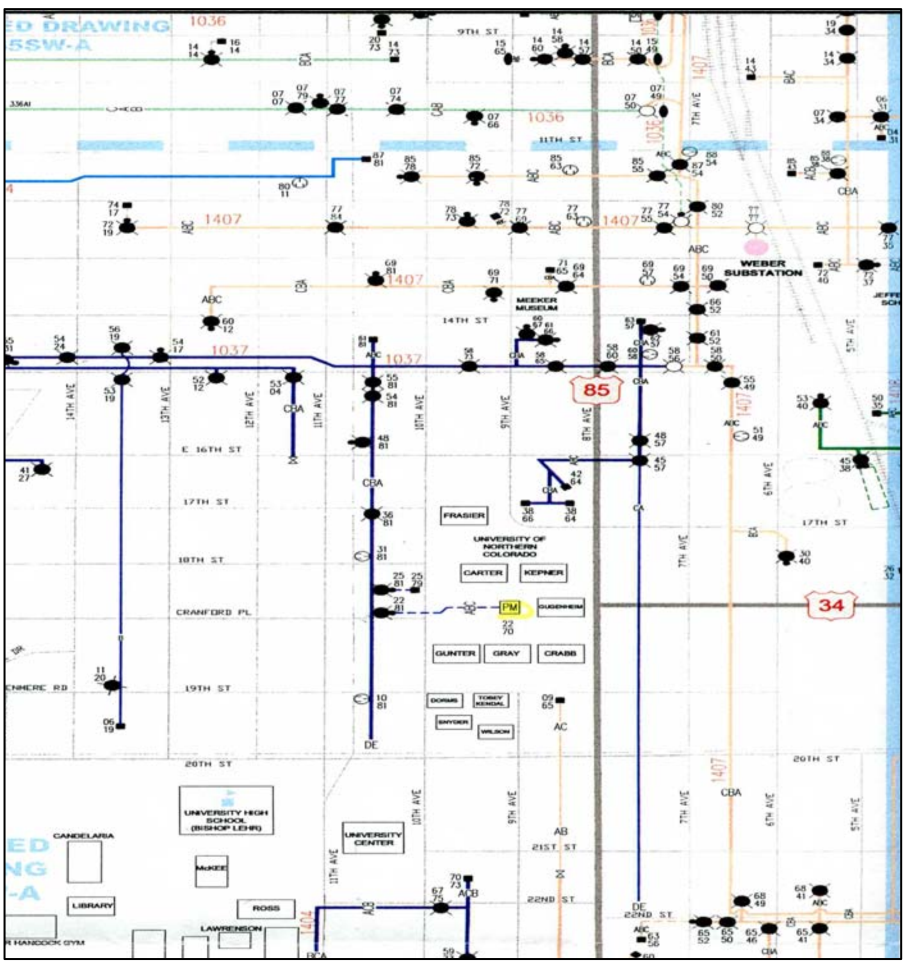


FIGURE 19 - WEBER SUBSTATION DISTRIBUTION

East Campus

A third PSCo primary loop serves the East Campus from the "Weber Substation" located between 6th and 7th Avenue along 13th Street. This substation is different from the others in that it only seems to serve one primary loop, known as the 1407 loop. The 1407 loop is the largest (in terms of distance) loop of the three and serves an extensive array of neighborhoods from Hillside Mall (28th Street) to the south, to areas north of 8th Street, east to 1st Avenue and west to 14th Avenue. An overhead service lateral located just west of 4th Avenue and 20th Street transitions to an underground feeder that passes under 20th Street and serves the East Campus from a UNC-owned, direct-buried, primary feeder that serves all the buildings in the East Campus and the UNC-owned "University Apartments" complex north of 18th Street.

1.5.3 Existing PSCo Distribution System Capacity

West Campus

The existing PSCo distribution system serving the West Campus utilizes conductors rated for 600 amps. PSCo reports that the peak demand seen on this loop is approximately 4500 KW. When addressing peak demands it is necessary to apply a power factor (PF) to all loads given in KW. The power factor is the amount of system inefficiency derived from loads such as fluorescent lights, motors, and computer-based equipment that does not fully utilize the energy consumed. Typically, a PF of .85 is used when addressing these issues. Therefore, (4500/0.85) = 5294 KVA. Transformers and most electrical calculations are addressed in terms of KVA. Table 15 below summarizes the peak KW and KVA loads on the known primary PSCo feeders serving UNC.

TABLE 15 - PEAK ENERGY USAGE ON PSCO LINES SERVING THE UNC CAMPUS

Location	Peak Demand KW	Power Factor	Peak Demand KVA
West Campus	4500 KW	.85	5294 KVA
Central Campus	2000 KW	.85	2352 KVA
East Campus	341 KW	.85	415 KVA

When converted to 12.47 KV amps, the West Campus or 1401 loop has experienced a peak load of 245.399 amps leaving a remaining "spare" of approximately 354.601 amps (600-245.4) or 40.9%. As stated in the introduction, the UNC West Campus utilizes most of this power with the remainder going to the residential neighborhoods to the east and south. MKK has taken this information and converted it to watts per square foot (WSF), which is summarized in Table 16 on the following page.

WSF numbers are derived from square footage simulation of UNC buildings on the West Campus. The total square footage is then divided by the total peak demand as stated above to arrive at a working number based on actual demand. These numbers will also be helpful in making decisions regarding future building needs and in evaluating the validity of WSF numbers stated in previous UNC's master plan studies. Based on the above information, the historical peak WSF for the West Campus has been 3.40 WSF. However, this is the true load and therefore no "safety factor" has been applied, typically this would be at a minimum 25% of the peak number. For consistency, this report addresses the true loads when discussing the impact these loads have now and in the future. For purposes of future planning, this safety factor would need to be applied when discussing any changes required for UNC or PSCo primary lines.

Central Campus

The existing PSCo distribution system serving the Central Campus utilizes #2 PDC conductors rated for 200 amps. PSCo reports that the peak demand seen on the loop is approximately 2000 KW (2000/0.85) = 2352 KVA.

When converted to 12.47 KV amps, the Central Campus has experienced a peak load of 109.0 amps leaving a remaining "spare" of approximately 91 amps (200-109) or 46%. As stated in the introduction, the UNC Central Campus utilizes a sub feed from the primary feeder. The information given here addresses this specific sub-feed and not the overall 1037 loop. MKK has taken this information and converted it to watts per square foot (WSF), which is summarized in Table 16. WSF numbers are derived from square footage simulation of UNC buildings on the Central Campus. The total square footage is then divided by the total peak demand as stated above to arrive at a working number based on actual demand. These numbers will also be helpful in making decisions regarding future building needs and in evaluating the validity of WSF numbers stated in previous UNC's master plan studies. Based on the above information, the historical peak WSF for the Central Campus has been 2.85 WSF.

East Campus

The existing PSCo distribution system serving the East Campus utilizes conductors which are rated at 240 amps. PSCo reports that the peak demand seen on the loop is approximately 341 KW (341/0.85) = 401.18 KVA..

When converted to 12.47 KV amps, the East Campus has experienced a peak load of 18.6 amps leaving a remaining "spare" of approximately 221.4 amps (240-18.6) or 93%. As stated in the introduction, the UNC East Campus utilizes a sub-feed from the primary feeder. The information given here addresses this specific sub-feed and not the overall 1407 loop. MKK has taken this information and converted it to watts per square foot, as shown in Table 16. Based on the above information, the historical peak WSF for the East Campus has been 1.6 WSF.

The combined total of existing watts per square foot and new, anticipated, watts per square foot are summarized in Table 17 below. Of particular note is the fact that the combined existing load for the West and Central campuses is too large now to be incorporated into a "tie-breaker" distribution system where one campus primary feeder is used to back feed another campus feeder in the event that one or the other feeders are lost. The combined maximum demand of the West and Central campuses is over 354 amps; if the future loads are taken into consideration the combined total exceeds 434.2 amps. As noted above, the Central Campus is served from a 200-amp feeder so the overload would exceed 212%. As discussed in Section 1.5.4 below, voltage sags and voltage drop issues already exist at the terminal ends of the West Campus primary distribution system. Adding additional load at that end of the system would compound the issues.

TABLE 16 - PEAK WATTS PER SQUARE FOOT USAGE FOR EXISTING AND FUTURE UNC CAMPUS

Location	Existing Sq. Footage*	Total w/sf based on KVA Loads given in table 16 (KVA / WSF)	Future Sq. Footage**	Potential new KVA needs per Sq. Foot based on Historical average
West Campus	1,554,887	3.40	350,000	1190 KVA
Central Campus	824,713	2.85	191,000	544 KVA
East Campus	259,243	1.6	25,000	40 KVA

Note: Sq. footage numbers from UNC Building Inventory list dated 03/01/02
Note: Sq. footage numbers from UNC 10 year Capital Construction Plan

TABLE 17 - PRIMARY AMPS PER DISTRIBUTION SYSTEM FOR EXISTING AND FUTURE UNC CAMPUS BUILDINGS

Location	Combined Peak and future loads	Primary amps with Existing Loads	Future UNC Primary system load in amps as derived from Table 17	New PSCO Primary load in amps with future buildings
West Campus	6484 KVA	245 Amps	55.2 Amps	300.2 Amps
Central Campus	2544 KVA	109 Amps	25.0 Amps	134.0 Amps
East Campus	455 KVA	18.6 Amps	1.9 Amps	20.5 Amps
Total loads	**9483 KVA**	**372.6 Amps**	**82.10 Amps**	**454.7 Amps**

1.5.4 Electrical Quality of Service Issues

Existing power quality issues

During the summer of 2007, and for the previous three summers before, the UNC West Campus has experienced several bouts of voltage "sag" during peak operating hours. Several buildings have been affected; some greater than others. Maintenance personnel reported that the University Center Building is particularly susceptible to voltage drops between 5% and 10%, while Bishop-Lehr, McKee, and Ross halls are affected to a lesser extent.

Voltage drop issues usually occur from one of three sources: the incoming utility, voltage drop due to long distances involving the service conductors, or sudden input of large current drawing loads such as large motors. We can eliminate the third option in this case as there are no motors large enough in the West Campus to cause a voltage drop across the primary distribution system.

MKK checked with PSCo regarding the most recent power outages and found that a construction project unrelated to the UNC was taking place this past summer that required the 1404 loop be re-routed through an older, established neighborhood. Once the power was re-routed off the main loop, the older section of the existing power grid could not hold the full current and subsequently failed. These failures would occur intermittently as the power fluxed up and down through the grid. The effect was sporadic failures of individual phase legs and voltage fluxuations over the course of days. However, the PSCo representative did not think there were any other issues involving voltage fluxuations. UNC maintenance personnel have a differing opinion regarding under-voltage conditions noting that the effect appears to be system wide for buildings fed from the West Campus primary loop, and it appears to occur the late summer and early fall. These are indications indicative of the problem being introduced into the UNC primary distribution system from PSCo, at the source, as opposed to isolated buildings within the UNC system.

However, we should note that the University Center building is at the tail end of the UNC West Campus primary distribution system. Its location, and the highest number of reported low-voltage conditions, suggests that voltage drop through the UNC primary system is affecting the "end-of-line" structures greater than at the beginning. This is an important consideration given that the existing voltage drop issues make it more difficult to extend the UNC West Campus primary beyond this point.

PSCo reports that the Central Campus has experienced a few instances of fuses blowing at the tap point from the 1037 loop in the alley fed serving the Central Campus. On occasion, one or more of these fuses have blown which results in a "single-phase" condition across the distribution system. In a single-phase condition, one of the three power leads serving the distribution system is removed leaving its work to handled by the remaining two phases. In the case of motors, damage can occur if the motor experiences a sudden and maintained increase in the amount of power (amps) it draws upon to continue operating on only two windings. The result is a burnt-out motor. Similar issues were reported for the West Campus, but these appeared to be the caused by the aforementioned construction project. Issues of single phasing have also been reported for the East Campus most recently when a squirrel found its way into the electrical system.

Impact of existing and future loads on the primary lines serving the UNC campuses

MKK was directed to look at the possibility of combining the Central and West Campuses onto one primary feeder with a mid-point, throw-over switch that would allow one campus to serve the other in the event the PSCo service to either was disrupted. As we have addressed in section 1.5.3 above, the existing PSCo primary line that serves the Central campus (1037 loop) does not have the capacity to serve itself and the West campus. Likewise, the West campus PSCO primary (1404 Loop) does not have the capacity to serve itself, the surrounding neighborhoods, and the Central Campus. The problem is compounded when future building loads are taken into consideration.

In addition, the PSCo made it abundantly clear to MKK that it is against their corporate policies to allow the user to tie two of the utilities loops together from its (UNC's) own switchgear. This creates the possibility that someone could accidentally re-energize a PSCo loop feeder when the utility believes it is de-energized and has workman working on the line. Further, should the UNC want to peruse this matter though other avenues, namely the back feeding of the existing West and Central campuses through other PSCo primary lines, it would have to be accomplished by bring new primary feeders from existing PSCo substations. In the case of the West Campus a new feeder would come out of the Evans Substation and all costs associated with the new loop feeder would be borne by UNC. The same situation applies for the Central Campus; however, PSCo informs MKK that the Greeley substation could not be the back-up source as it is already committed to being the back-up loop for the Northern Colorado Medical Center. Any back-up power would have to come from the Weber Substation.

PSCo has informed MKK that if UNC wants to pursue this matter, they will also have to pay a monthly charge for the power held within the substations to accommodate the back-up provisions addressed here. PSCo did not disclose that amount to us but they did state that it would be very expensive.

Lastly, as addressed in Section 1.5.4 above, there is a history of voltage drop issues associated with the existing West Campus UNC primary line. MKK has asked PSCo to investigate the cause of these issues as they seem to be system wide and this suggests that the voltage drop may be occurring prior to the power entering the UNC distribution system. This issue would be greatly compounded if the existing Primary feeders were to be utilized as part of a loop fed system without first correcting the existing problem.

SECTION 1.6 – EXISTING MECHANICAL HIGH TEMPERATURE HOT WATER AND CHILLED WATER SYSTEM

1.6.1 Introduction / Background

MKK Consulting Engineers reviewed the evolution of the University of Northern Colorado's (UNC) High Temperature Hot Water (HTHW) system, capacity of the Central Heating Plant (CHP), Chilled Water System (CWS), and pinch points or restrictions within the existing distribution systems that may have adverse effects on UNC future growth plans. Information gathered for this report was derived from personal interviews with UNC staff, review of previous studies, review of UNC provided monitoring results and several personal site visits from MKK personnel. Information from these sources is utilized herein to gain understanding of the systems, their limitations, capacities, and operational efficiencies with regard to satisfying the existing and future needs of UNC.

Background

In 1959, the Central Heating Plant (CHP) was installed in its current location on the east side of the East Campus. Early walk-through utility tunnels dating back to the 1920's (along with some direct buried piping with gilsulate insulation) were utilized for the distribution piping that included connection to the original steam systems. HTHW is currently distributed throughout the campus and is utilized by steam generators, heat exchangers, domestic hot water generators, and absorption chillers.

In 1962, a second water tube boiler was added to the CHP, with a third boiler (manufactured by Riley Union) added in 1972. The HTHW system was expanded from the Central Campus to the West Campus in the early 1960’s. This expansion coincided with the construction of a new walk-through tunnel system for the West Campus. The West Campus walk-through tunnel system was expanded further in the late 1980's with an extension to the University Center.

In 1996, Boiler # 2 in the CHP was replaced with a new unit manufactured by English Boiler & Tube, Inc. and the primary distribution system pumps were modified. In 1998, new 10" mains were installed in the tunnel from the 19th Street vault to Bishop Lehr. In 2004 and 2005, Boiler #1 in the CHP was replaced with the new International Boiler, manufactured by George Marker & Sons, and the CHP was converted to a primary/secondary pumped system (with the "primary" pumps circulating flow within the CHP and the "secondary" pumps circulating flow out to the Campus). In 2006, the existing 10" mains from the CHP to the 19th Street vault were replaced with new double wall, direct buried 14" mains. Prior to this work being completed, it required the operation of only one of the pumps all the time with the additional two distribution pumps running to meet UNC's peak season flow and heating demand requirements.

The campus HTHW system is connected to a cogeneration plant which is a privately owned facility on leased UNC property. The plant began commercial operation in September 1988 and is capable of meeting the entire HTHW demand for the campus. Waste heat from the generation of electricity via gas turbine engines, is used to heat the campus HTHW system. HTHW is pumped through the Cogen plant heat exchangers for pumps in the UNC Central Heating plant. All of the electricity generated by the Cogen plant is sold to public service.

The CoGeneration (CoGen) Plant has been operated by Primary Energy since 1988. From 1988 through 2003, the CoGen Plant operated 24 hours per day, 7 days per week, and provided the majority of HTHW for the UNC campus. After the original 15-year agreement expired, the Public Service Company (PSCo) reduced the hours of operation for the plant from 24/7 to five (5) days per week (excluding holidays), six (6) hours per day between October 15 and April 14, and five (5) days per week, seven (7) hours per day from April 15 through October 14. The hours of operation typically correspond to the "peak" operating hours of 11:00 am to 6:00 pm during the summer months and 4:00 pm to 10:00 pm during the winter months.

During the hours of operation, the agreement between Primary Energy and UNC requires that a minimum of 80% of the CoGen's "waste" energy generated from the plant be available for use with the UNC heating system and absorption chillers. Even though the "waste" heat is still utilized, with the greatly reduced daily operational period now in use, the ability to use "free" energy has been reduced.

According to the Primary Energy personnel, the following facts related to the CoGen also apply:

- The natural gas to the CoGen plant is currently provided by Duke Energy, with Atmos Energy providing natural gas to the UNC CHP and purchased through third parties. The natural gas pressure at the primary turbines is rated at 550 psi, with 30 psi gas provided to the boilers.
- Two (2) jet engines (roughly the equivalent of DC 10's) provide the primary energy to the electric generators and heat to the boiler plant and heat exchangers.
- It reportedly requires less than one hour for the plant to come on line and start generating power.
- The current contract with PSCo reportedly expires in 2013, at which time they may be able to re-negotiate hours of operation or fee structure. One item that is reportedly being discussed is to have the plant available as "dispatchable" power, which would require that they be available to come on line at any time to help shave Peak demand or supplement energy needs.

1.6.2 High Temperature Hot Water System (HTHW)

In our discussions with UNC personnel, it became apparent that the modifications completed in 2006 to the HTHW distribution system have greatly improved the operational parameters of the system. Issues identified in 2005 associated with restrictions in flow at the far end of the distribution system appear to have been satisfied with the completion of the new 14" distribution main from the CHP to the 19th street vault. MKK looked at several other aspects of the HTHW system, these issues are addressed below.

Boilers / HTHW Generators

As stated above, there are (3) three water tube heat generators ("boilers") that individually or together provide high temperature water to the existing campus wide HTHW distribution system. Boiler #1 was replaced in 2004 and utilizes a stack mounted tube heat exchanger as an economizer to preheat the return water using the flue exhaust. This device, coupled with the latest technology associated with the gas train, VFD on the power burner, continuous gas sensors used to optimize the heat exchange and optimize safety, allow this boiler to operate at roughly 5 % higher efficiency to the other two boilers. For these reasons, Boiler #1 (the northernmost unit in the CHP) is typically the "lead" heat generator.

Boiler #2 was replaced in 1996 and utilizes similar safety and optimization controls as Boiler #1, but does not have the energy recovery unit on the stack.

Boiler #3 was originally installed in 1972 and is now about 36 years old. The boilers have been well maintained so we expect them all to last at least 50 years each. This leaves Boiler #3 approaching about 75% of its expected life span. Boiler #3 is reportedly unable to utilize diesel fuel oil and therefore cannot be tied into the UNC's standby fuel oil system. It also utilizes an antiquated gas train technology and is only used as a stand-by. Doug Burman (the Heating Plant Supervisor) is concerned that the lack of use of this unit may actually be detrimental to the remaining life expectancy of the unit and noted that temperature control contractors are concerned with the older technology "safety" features associated with the system (which require manual purging of gas during start up). All boilers operate off of natural gas in the normal mode. Natural Gas is supplied to the UNC from Atmos energy.

Table 18 below summarizes the capacities and design specifics of the existing boilers as well as the combined actual output of the three systems, totaling approximately 180,000 MBH. According to UNC personnel, Boiler #3 is rarely used and is held as a back up to the two newer, more efficient, boilers. UNC personnel did note that they would anticipate replacing the boiler in future funding requests. UNC personnel have found that the optimum supply temperature for the HTHW system is about 350^o F with the return temperature ranging between 197^o F and 230^o F, depending on the campus load and flow rate in the system.

TABLE 18 - CENTRAL PLANT CAPACITY

SYSTEM COMPONENT	**HEATING CAPACITY**		**WATER FLOW**		
	Input Capacity (MBH)	Actual Output Capacity (MBH)	Design Flow (GPM)	Inlet Temp. (°F)	Outlet Temp. (°F)
BOILERS					
B-1	75,000	60,000	812	200 - 230	350
B-2	75,000	60,000	812	200 - 230	350
B-3	75,000	60,000	812	200 - 230	350
PUMPS					
PRIMARY HTHW					
P-4	N/A	N/A	980	350	-
P-5	N/A	N/A	980	350	-
P-6	N/A	N/A	980	350	-
P-7	N/A	N/A	980	350	-
SECONDARY HTHW					
P-1	N/A	N/A	980	350	-
P-2	N/A	N/A	980	350	-
P-3	N/A	N/A	980	350	-

In most cases, only one boiler is required to meet the demands of the UNC campuses. Doug Burman noted that the average winter utilization is between 40 to 50 million BTUH, with a Peak of up to 80 million BTUH during extreme conditions (i.e. -20^o F with extreme wind chills and classes in session). In our review of future anticipated heating loads (as listed in the 10-year Capital Construction Plan and as noted on the attached drawings), MKK found that the total future load equates to approximately 1/3 the capacity of one boiler (i.e. roughly 20 million BTUH). As a result, we do not foresee any significant issues that need to be addressed with regard to the total plant capacity.

Section 2.6 of this report evaluates the energy consumption ramifications of possibly discontinuing the use of the Co-Gen plant (due to diminished efficiencies and age), converting from the absorption chillers to more efficient "mechanical" chillers with economizer capabilities, a smaller boiler / HTHW generator to accommodate "shoulder" months and allow for more efficient operations when used in combination with the existing generators, etc.

The energy consumption ramifications of possibly discontinuing the use of the Cogen plant (due to diminished efficiencies and age), converting from the absorption chillers to more efficient "mechanical" chillers with economizer capabilities, and a smaller boiler/HTHW generator to accommodate "shoulder" months and allow for more efficient operations when used in combination with the existing generators are included as part of the Future Recommendations in Section 2 of this report.

Pumps and Controls

There are four (4) primary and three (3) secondary pumps utilized in the HTHW distribution system. All of the primary and secondary pumps utilize variable frequency drives (VFD) to aid in balancing and to allow a "soft" start to minimize "shock" to the hydronic and electric systems. During the summer months, these VFD's (which are integrated through the use of the DDC system) have reportedly experienced over-heating and dust contamination as a consequence of their location in the "open" CHP environment. Maintenance personnel identified the need for adding air conditioned enclosures for the VFD's to address the over heating and dust issues identified above. A rough estimate to provide these enclosures is estimated at roughly $30,000 at this time.

As need dictates, a differential pressure switch (set at 15 psi) located near Candelaria Hall controls the flow of HTHW from the CHP to the UNC campuses. While there were no significant issues identified from

PHOTOS OF CHP VFD'S

UNC personnel regarding this switch, the existing control system does not allow for individual building metering for all buildings. The existing temperature control system is not remotely adjustable and does not allow UNC to practice a more proactive approach with regard to being able to monitor flow rates, temperatures, BTUH rates on individual buildings, optimize system capacity, foresee shortages, and choke points within the distribution system.

MKK concurs with the assessment of the November 2005 Campus HTHW System Hydraulic Analysis and recommend that flow meters be installed at each building to help monitor demand and energy usage. The estimated cost of approximately $3,000 plus installation for each vortex shedding meters and ultrasonic meters (at $8,000 each plus installation) still seems reasonable.

Controls

The switch over from the CHP HTHW generators to Co-Gen (and back) is primarily accomplished through manual means and is dependant upon the discharge water temperature from the Co-Gen and the load being experienced though out the Campus. However, as previously stated the use of the Co-Gen plant is now greatly reduced, which directly impacts how much the HTHW generators are operated.

Even though the operation of the boiler plant is still primarily a “manual” operation, an energy management software is in place to allow “real time” viewing of such items as the natural gas pressure, HTHW inlet and outlet temperatures, flow rate, MBTU/Hour, and position of the draft at each of the Generators, as well as the total flow rate, HTHW supply and return temperatures and MBTU/Hour to the entire campus. A web based graphic package showing the operation of the primary supply pumps, differential pressure at Candelaria Hall, and specific inlet, return, flow rate and MBTU/Hour at the Cogen plan was also observed in the Boiler Plant control room.

Should individual monitoring devices be added to each building on campus to aid in the building automation and energy management process in the future, we would recommend that the existing control system be upgraded or replaced to match the demands of the intended operation.

HTHW Distribution Piping and Capacity

With the increase in the distribution mains from 10" to 14" leaving the CHP to the 19th street vault, previous difficulties experienced in maintaining adequate flow to areas of the existing UNC Campuses have been eliminated. Modifications to the HTHW distribution piping mains serving the West Campus have accommodated the added load associated with the new Residence Halls.

We agree with the recommendations provided in the Campus High Temperature Water System Hydraulic Analysis prepared by Schendt Engineering Corporation in November 2005, which noted four (4) separate priorities as related to the HTHW distribution in the West Campus and how it relates to the projected additions of defined buildings in the future.

According to this previously completed report, the recommendations included:

- *Priority 1:* Increase the size of the two (2) - 5" mains from the Lawrenson/Turner junction to the branch take-off at Lawrenson Hall to two (2) 6" mains. As part of the new West Campus Housing project in 2008, the two (2) - 5" mains were actually supplemented with two additional 5" mains in this section of the tunnel.
- *Priority 2:* This was just a note in the original report stating that the existing distribution system appeared adequate to support the proposed addition to Butler-Hancock. We concur with this note, especially if the proposed Indoor Practice Facility is not provided with cooling from the Central Plant.
- *Priority 3:* This was a reference to the adequacy of the distribution system for a proposed building near the University Center. The installation of the building is not reflected in the 2008 projections.
- *Priority 4:* The existing distribution system piping may be adequate to support the new academic building if Bishop-Lehr is removed from the system. If Bishop-Lehr is to remain, there are two options available to meet the flow requirements under all phases of construction. We recommend the following options:

1. Upsize the 8" mains and the pair of 6" mains to 10" mains from the Bishop-Lehr valve vault to where they split and go to the Residence Halls/Butler Hancock junction. Upsize the 6" mains to 8" mains from the Residence Hall/Butler Hancock junction to the Lawrenson/Turner junction.
2. Install 8" looped mains from the Bishop-Lehr vault to the tunnel at Candelaria. Upsize the 6" mains to 8" mains from the Residence Hall/Butler Hancock junction to the Lawrenson/Turner junction.

An Opinion of Probable Cost was prepared in the original report to replace the HTHW distribution piping mains running south from the Butler-Hancock valve vault. The estimated cost of construction for Priority 4 was $1.5 million in 2005, which we would anticipate escalating at roughly 4% per year to $1.7 million in 2008/2009 dollars.

Flow rates for the various buildings throughout the UNC campuses are summarized in Table 19 below. Based on the data, the CHP and HTHW distribution system MBH and GPM rates are well within the capacity of the existing system. The 10" mains within the CHP are all in good shape and should be sufficient to handle the future growth needs. At present, the CHP can produce about 120 million BTUH with two (2) of the boilers in operation and 60-million BTUH with only one (1) boiler and one (1) secondary pump tied into the 10" mains. Future BTUH needs are thought to total about 25-million BTUH.

TABLE 19 - HTHW AND COOLING FLOW RATES

	HTHW HEATING SYSTEM LOAD		**ABSORPTION COOLING LOAD**			**DOMESTIC HW**	
BUILDING NAME	EST'D LOAD (MBH)	EST'D FLOW (GPM)	RATED CAPACITY (TON)	EST'D LOAD (TON)	EST'D FLOW (GPM)	EST'D LOAD (MBH)	EST'D FLOW (GPM)
EAST CAMPUS							
CENTRAL PLANT	550	10					
PARSONS HALL	750	14				900	15
(2) UNIVERSITY APARTMENTS	1,378	32				650	10
HARGROVE HALL							
WEST HALL							
CAVE HALL							
WHITE HALL							
TOUSSAINT HALL							
DICKERSON HALL							
NINEMIRES HALL							
JACKSON SOCCER COMPLEX	2 at 700 mbh/ea	2 at 12/ea				2,063	33
EAST CAMPUS TOTALS	**4,078**	**80**				**3,613**	**58**
CENTRAL CAMPUS							
MUSIC LIBRARY	387	7					

TABLE 19 - HTHW AND COOLING FLOW RATES

BUILDING NAME	HTHW HEATING SYSTEM LOAD		ABSORPTION COOLING LOAD			DOMESTIC HW	
	EST'D LOAD (MBH)	EST'D FLOW (GPM)	RATED CAPACITY (TON)	EST'D LOAD (TON)	EST'D FLOW (GPM)	EST'D LOAD (MBH)	EST'D FLOW (GPM)
FRASIER HALL	2,485	57					
CARTER HALL	1,250	31					
KEPNER HALL	1,500	48	242	218	96		
GUGGENHEIM HALL	525	12					
CRABBE HALL	700	23					
GRAY HALL	750	13					
ARTS ANNEX	290	16					
GUNTER HALL	1,527	64	225	152	52	1,119	47
CAMPBELL CENTER	186	12				175	13
(1) TOBEY-KENDEL HALL	7,681	165	800	432	172	2,304	68
RESIDENCE HALLS							
SNYDER HALL							
WILSON HALL							
SABIN HALL							
WIEBKING HALL							
DECKER HALL							
BELFORD HALL							
GORDON HALL							
CASSIDY HALL							
SCOTT-WILLCOXON HALL							
HANSEN-WILLIS HALL							
CENTRAL CAMPUS TOTALS	**17,281**	**448**	**1,267**	**802**	**320**	**3,598**	**128**
WEST CAMPUS							
BISHOP-LEHR HALL	2,800	39				1,200	18
CANDELARIA HALL	1,750	27	182	164	101	100	2
MICHENER LIBRARY	4,800	72	321	289	124		
BUTLER-HANCOCK HALL	3,603	56				400	14
HARRISON HALL (2 w/ 100% standby)	6,600	95				2-1,500	44

TABLE 19 - HTHW AND COOLING FLOW RATES

	HTHW HEATING SYSTEM LOAD		ABSORPTION COOLING LOAD			DOMESTIC HW	
BUILDING NAME	EST'D LOAD (MBH)	EST'D FLOW (GPM)	RATED CAPACITY (TON)	EST'D LOAD (TON)	EST'D FLOW (GPM)	EST'D LOAD (MBH)	EST'D FLOW (GPM)
WEST CAMPUS DINNING	2,737	91				1,375	19
McCOWEN HALL	3,500	81				833	33
LAWRENSON HALL	2,600	40	273	246	120	1,600	24
TURNER HALL	2,600	40	307	276	105	1,600	24
ROSS HALL	3,063	77	830	598	170	2,000	42
McKEE HALL	2,000	30	289	260	94	100	2
UNIVERSITY CENTER	3,200	48	438	296	102	1,384	20
WEST CAMPUS TOTALS	**39,253**	**696**	**2,640**	**2,129**	**816**	**13,592**	**242**
CAMPUS TOTALS	**60,612**	**1,224**	**3,907**	**2,931**	**1,136**	**20,803**	**428**

TABLE KEYED NOTES:

(1) TOTALS REPRESENT THIS BUILDING AND THE BUILDINGS BELOW IT.

(2) GROUP NAME FOR BUILDINGS BELOW, TOTALS ARE FOR ENTIRE GROUP.

*ESTIMATED WINTER LOAD (MBH) = ((TOTAL HEATING LOAD)+(TOTAL DOMESTIC HW LOAD))*105% = 98,177*
ESTIMATED WINTER FLOW (GPM) = (HEATING GPM)+(DOMESTIC HW GPM) = 1,630

*ESTIMATED SUMMER LOAD (MBH) = ((TOTAL COOLING LOAD)+(TOTAL DOMESTIC HW LOAD))*105% =72,737*
ESTIMATED SUMMER FLOW (GPM) = (COOLING GPM) + (DOMESTIC HW GPM) =1,543

Boiler Make up Water

Records indicate that about 300 gallons a day are used for make up water to the boilers for the HTHW distribution network. This water is conditioned through water softeners and these softeners appear to be relatively old. The 2" make up water line and the capacity of the water softeners is adequate to handle the existing load, however, increases in make up water in the future will depend upon the limits of the existing system. Water treatment is accomplished through the introduction of sulfide treatment. MKK has not learned of any significant existing issues regarding the availability of conditioned replacement water.

Diesel Fuel Oil System

During disruptions to normal utility supplied gas, two of the three boilers serving the UNC campuses are backed up from diesel fuel oil (DFO) that is stored in two (2) 30,000 gallon, single wall, under ground storage tanks (UST). These tanks are constructed from steel and were installed in the early 1970's. The tanks were reportedly last tested in 2006 and no signs of leakage were found. The tanks do not have automated inventory systems, leak detection, water detection, and automated cycling or circulation systems to avoid microbial contamination. All measurements are achieved through the use of manual stick inventory. Three (3) old UST tanks are reportedly located adjacent to the two addressed above; these have been filled with slurry and abandoned in place.

In our discussions with UNC personnel we found that maximum diesel fuel flow rate consumed by the boilers was about 800 gallons an hour, and that the system is used only once or twice a year. Eight hundred gallons an hour equates to about 75 hours of continuous maximum output from the boilers. However, as noted above, it typically only requires (1) one boiler to meet most of the needs of UNC's heating demand (to temperatures to 20 degrees), so the maximum number of hours could be doubled under "normal" conditions. We noted that the tanks are located in immediate proximity to an existing irrigation canal. Contamination into or out of the fuel oil tanks is a distinct possibility going forward and should be considered.

If the UST's were deemed to require replacement in the future, an estimated cost for a similar capacity of either buried or above ground tanks would be approximately $8/gallon or $480,000, including the removal of old UST's.

Emergency Power at the Central Plant

A backup emergency power generation system does not currently exist for the CHP. Even though this type of extreme outage is reportedly rare, a means of providing emergency power to at least critical components should be considered in the future.

1.6.3 Chilled Water and Air Conditioning Systems

UNC currently utilizes several different methods to cool their facilities. The primary systems and equipment include:

- Absorption chillers that are connected to the Central Heating Plant.
- Air cooled chillers.
- Water cooled chillers with cooling towers.
- Packaged rooftop units with DX cooling.
- Split systems air handlers with DX cooling.
- Window mounted air conditioners.
- Natural draft ventilation (i.e. "open the windows").

Absorption Chillers

In an effort to optimize all aspects of the CoGen Plant, a number of absorption chillers were installed that utilize the "free" HTHW, which is the byproduct of the electric generation process. The initial benefit to this approach was the fact that the water used to "cool" the CoGen turbines was just a natural byproduct that was available for use by UNC. HTHW distribution piping was also in place to transport the "thermal energy" required to power the absorption chillers. Even though several absorption machines were in operation prior to the CoGen plant coming online, the 24/7 operation of the CoGen plant made this approach even more economically feasible.

In discussions with UNC personnel and as noted in the above Table 19 and the following Table 20, it currently requires nearly as much pump capacity to operate the absorption chillers (and domestic hot water generators) during the summer as it does to generate heating water in the winter. According to historical "logs" generated at the CHP, the "peak" demand in July 2007 reflected a boiler output at 53-million BTUH, with a low (i.e., night) load of 5-million BTUH and an average of roughly 35-million BTUH.

According to UNC facilities personnel, there are several of the absorption chillers that require a large amount of maintenance and may need to be replaced in the near future.

TABLE 20 - ABSORPTION CHILLERS

BUILDING	YEAR BUILT/ MFG.	RATED CAPACITY (TON)	RATED FLOW (GPM)	ESTIMATED LOAD (TON)	ESTIMATED FLOW (GPM)
Kepner Hall	1986/TRANE	242	106	218	96
Gunter Hall	1994/CARRIER	225	78	152	52
Tobey-Kendel Hall (2)	1996/CARRIER	400 ea.	159 ea.	432	172
Candelaria Hall	1997/CARRIER	182	113	164	101
Michener Library	1993/CARRIER	321	137	289	124
Lawrenson Hall	2000/CARRIER	273	134	246	120
Turner Hall	1992/TRANE	307	116	276	105
Ross Hall	2000/TRANE	830	236	598	170
McKee Hall	1991/CARRIER	289	105	260	94
University Center	1995/CARRIER	438	151	296	102

Mechanical Cooling

After touring the campus with UNC personnel, a number of mechanical chillers were observed. As noted on the following Table 21, a combination of air-cooled screw, reciprocating, and scroll compressors are used to serve separate buildings (or portions of buildings) in the Central and West Campus.

TABLE 21 - MECHANICAL COOLING

BUILDING	MECHANICAL COOLING & YEAR INSTALLED	EQUIP. CAPACITY (TON)	NOTES
East Campus			
Parsons Hall	Carrier Roof Top Unit - 2006	5	
	Trane Roof Top Unit - 1995	7.5	
	Trane Roof Top Unit - 2005	7.5	
	Trane Roof Top Unit - 1994	5	
	Trane Roof Top Unit - 1999	3	Conference Room
	Heat Controller, Inc. Roof Top Unit - 1990	3	
	Sanyo Split System 2 units - 1990	0.75 & 1.5	East Offices
Central Campus			
Music Library	Trane Screw Air Cooled Chiller - 1996	70	Serves one air handler
Music Tech.	McQuay Recip. Air Cooled Chiller - 1992	65	Serves five air handlers
Frasier Hall	York Air Cooled Chiller - 1999 (Auditorium Only)	40	
	36 Window AC Units	1 ea.	
Carter Hall	Trane Recip. Chiller w/ Cooling Tower - 1985	75	
	Chiller - 1970's	60	Very old stand-by only
Gray Hall	DX Split - Water Cooled	1-7.5	IT Area
	DX Split - Air Cooled	1-7.5	
	Roof Top Unit - 2002	5	AC Only, Office
	Roof Top Unit - 1999	20	HW Heat
	Roof Top Unit - 1994	5	HW Heat
	9 Window AC Units	1 ea.	
Crabbe Hall	14 Window AC Units	1 ea.	Steam Heat
Arts Annex	Roof Top Unit - 1994	5	HW Heat
	Roof Top Unit - 1994	7.5	HW Heat
	DX Split System - 2002	30	180 MBH Gas Fired Dom. WH
University Center	Trane Screw Chiller w/ Cooling Tower - 1988	130	Light Load Only
Visitor Center	DX Split - 1990	5	Stand Alone Gas-Fired Boiler
	DX Split - 1990	4	
Rehab Inst.	DX Split - 2003	30	531 MBH HTHW

TABLE 21 - MECHANICAL COOLING

BUILDING	MECHANICAL COOLING & YEAR INSTALLED	EQUIP. CAPACITY (TON)	NOTES
West Campus			
Harrison Hall	DX Split (Center bldg. Only)		
	6 Roof Top Units	2-5	
		2-10	
		1-15	
		1-20	
W. Campus Dining	York Air Cooled Chiller - 2004	150	
Butler-Hancock Hall	Trane Scroll Air Cooled Chiller - 1996	50	2nd Floor Center Area Only
Campus Rec. Center	McQuay Centrifugal Chiller w/ Cooling Tower - 2006	350	Serves six air handlers
West Campus Housing	Trane Centrifugal Chiller w/ Cooling Tower – 2008	300 (2 TYPICAL)	Under Construction

In addition to the air-cooled units, four (4) liquid-cooled chillers with cooling towers are utilized in Carter Hall, University Center (to supplement the large absorption chiller during light cooling loading), the Campus Rec Center, and two (2) 300-ton centrifugal units that are currently being provided for the new West Campus Housing units.

PHOTO – OLD CHILLER AT CARTER HALL

PHOTO – FRASIER HALL CHILLER

The new 350-ton McQuay centrifugal chiller installed in the Campus Rec Center in 2006 typically runs at roughly 30% of the rated capacity and reportedly has never run at more than 60% of its rated capacity. The fact that this system utilizes variable frequency drives allows for an efficient operation and could potentially allow the remaining capacity to be used for either future expansion or modifications to systems like the swimming pool (which does not incorporate cooling or other energy recovery equipment).

Proposed Buildings

Based on the size and location of the proposed construction projects noted in the Ten-Year Capitol Construction Plan (and as identified in Table 22 on the following page), it is envisioned that high-efficiency mechanical chillers with energy conserving items such as water side plate and frame heat exchangers and air side economizers be utilized. In Section 2 of this study, the prospect of a "central" cooling plant (or plants) is also evaluated.

TABLE 22 - ESTIMATED FUTURE LOADS

PROPOSED NEW BUILDING	APPROX. GROSS SQ. FT.	ESTIMATED COOLING (TON)	ESTIMATED HEATING (MBH)
West Campus Academic	80,000	200	3,200
Student Services/Admin.	80,000	200	3,200
Music Performance	18,000	45	720
Animal Facility Expansion	25,000	63	1,000
Art Museum	13,000	33	520
Frasier MIB	80,000	200	3,200
Athletic Indoor Practice	176,000	No Cooling **	7,040
NOTES:			
-Estimated Heating Load Based on 40 btu/ft^2			
-Estimated Cooling Load Based on 400 ft^2/ton			
-Historic Elect. Cooling Avg. 533 ft^2/ton*			
-Historic HTHW (Absorb. Chillers) Cooling Avg. 481 ft^2/ton*			
* Calculated from equipment capacity, not % capacity used. ** It is assumed that mechanical cooling will not be used for this facility due to the anticipated size, usage, and projected cost for the cooling equipment and associated operating expense.			

Building Automation

Based on conversations with Steve Dalvit (Long Technology), an brief evaluation was completed of the Building Automation Systems (BAS) that are currently being utilized at UNC. Mr. Dalvit did note that there are currently 26 buildings on the existing Tridium system and that in addition to the building HVAC systems, fire alarm, power monitoring, and lighting in parking lots and security areas are all monitored by the BAS. Even though Long does not have "control" over all of the buildings on campus (with Honeywell, Carrier West, and other venders currently being used), they do have the ability to communicate to the central system using an integration software.

Continued utilization (and upgrade) of the central BAS will allow the University personnel to be proactive in the optimization and maintenance of the heating and AC systems.

SECTION 2 – PROPOSED FACILITIES

The following section brings together the recommendations in Section 1 and includes recommended utility system improvements to meet the needs of the campus' 10-Year Capital Construction. Subsections include:

SECTION 2.1 – STORM DRAINAGE SYSTEM

2.1.1 Introduction and Background

Section 2 has been prepared to evaluate the impact of anticipated future campus development on existing infrastructure systems. In the case of the storm drainage system, the addition of new buildings or parking lots on campus will increase the amount of impervious surfaces and result in increased stormwater runoff. This runoff, if not properly planned for, may adversely affect downstream drainage facilities.

Section 1 examined the current storm drainage system and identified elements that are undersized for minor storms (i.e. storms that recur in the Greeley area every five years). Section 2 examines the storm drainage system with UNC's 10-year Capital Construction Plan in place.

2.1.2 Anticipated Capital Construction

The 10-year Capital Construction Plan has been based on the memorandum dated May 29, 2007, from Kirk Leichliter, Assistant Vice President, Facilities Management, to Andrew Carlson, Director, Capital Assets, Colorado Commission on Higher Education with supplemental information from UNC staff. The projects that add impervious surface area to the campus are listed below:

1) Athletic Strength and Conditioning Addition to Butler Hancock Hall

This project is anticipated to add 5,500 gsf to Butler Hancock Hall and 5,500 square feet of impervious area to the campus.

2) West Campus Academic Building

This project is anticipated to provide a new multi-story building just east of Candaleria Hall, with 80,000 gsf of floor space. Since the building function and size will be similar to that of Candelaria Hall, which has a floor space of 80,236 gsf and an impervious footprint area of approximately 31,600 square feet, an anticipated impervious footprint area for the new building of 31,600 square feet will be used for analysis.

3) Student Services / Administrative Center

This project is anticipated to provide a new multi-story building just north of the University Center, with 80,000 gsf of floor space. The building function will be similar to that of the University Center. Based on the University Center's ratio of impervious footprint area to gross square footage of floor space, it is anticipated that the new facility will result in 48,000 additional square feet of impervious area to the campus.

4) Music Performance Addition to Foundation Hall

This project is anticipated to add 18,000 gsf to the Foundation Hall and 18,000 square feet of impervious area to the campus.

5) Animal Facility Expansion

This project is anticipated to provide a new multi-story building south of McKee Hall, with 25,000 gsf of floor space. Based on existing buildings of similar size, namely the Gray, Crabbe, and Guggenheim buildings, and their ratio's of impervious footprint area to gross square footage of floor space, it is anticipated that the new building will result in 12,700 additional square feet of impervious area to the campus.

6) *Art Museum*

This project is anticipated to provide a new single-story building just east of the Arts Annex Building with 13,000 gsf of floor space and 13,000 square feet of additional impervious area to the campus.

7) *Frasier Music Instruction Building Addition*

This project is anticipated to provide a multi-story addition to Frasier Hall with 80,000 gsf of floor space. Based on Frasier Hall's ratio of impervious area footprint to gross square footage of floor space, it is anticipated that the new addition will add 28,000 square feet of impervious area to the campus.

8) *Athletic Indoor Practice Facility*

This project is anticipated to provide a new indoor sports facility south of Nottingham Field, with 176,000 gsf of floor space and 176,000 square feet of additional impervious area to the campus.

9) *West Campus Housing*

Based on plans for the new facility, which will replace McCowen Hall, it is anticipated that the new facility will add approximately 25,000 of impervious area to the campus.

The impervious areas described above will be used in the stormwater detention analysis that follows.

2.1.3 Stormwater Detention

The increased impervious surface area due to the 10-year Capital Construction Plan will increase stormwater runoff. The City of Greeley has indicated that drainage facilities downstream from the campus are currently overtaxed and any increase in stormwater runoff will exacerbate the problems. Stormwater detention has proven to be a cost effective solution for flooding problems and will be examined in this report as a solution to mitigate the projected increased runoff.

The method used to calculate stormwater detention volumes in this report is the Rational Formula Method described in the City of Greeley Drainage Design Manual, Section 11. Reference is also made to Denver's Urban Drainage and Flood Control District (UDFCD) Drainage Manual.

The required detention volume V is the maximum difference between the cumulative inflow (V_{in}) and the cumulative outflow (V_{out}) volumes, or:

$$V = \max (V_{in} – V_{out})$$

Where Vin = C I A T

C = runoff coefficient per UDFCD Drainage Manual (0.96 for developed conditions)
I = storm's intensity taken from City of Greeley Rainfall Intensity / Duration / Frequency curves, 100 year Storm
A = tributary area in acres
T = storm duration in seconds

And $V_{out} = kQ_{out}T$

Q_{out} = maximum outflow rate, cfs
k = outflow adjustment coefficient from Greeley Drainage Manual Fig. 11-1

The maximum outflow rate from the facility, Q_{out} is limited to the peak flow from a five-year storm assuming the upstream basin to be in an undeveloped or historic condition (runoff coefficient equal to 0.15, time of concentration equal to 10 minutes).

The tributary areas used in the calculations are the additional impervious areas calculated in Section 2.1.2 above, upstream from each basin.

Based on the locations of the projected 10-year Capital Construction Projects, six stormwater detention basins have been sized to capture the increased runoff. These tentative locations are shown on Figures 20 thru 22 (shown later in this section of the report). Calculations of required detention volumes for flood control purposes only are shown in Tables 23 thru 30 in this section.

2.1.4 Water Quality Enhancement

The National Pollutant Discharge Elimination System (NPDES) Phase II stormwater regulations issued by the Environmental Protection Agency require that measures be taken to enhance the quality of stormwater leaving the site of any new construction project where more than one acre of land has been disturbed. Both short-term measures (during construction) and long-term measures (after construction completion) are required to be implemented. These enhancement measures, referred to as Best Management Practices (BMPs), are features that can be incorporated into flood control measures that improve the quality of the stormwater leaving the site. BMPs that are commonly used for this purpose include the following as taken from the City of Greeley drainage criteria manual:

- Minimization of Directly Connected Impervious Areas
- Irrigated grass buffer strips
- Grass lined swales
- Extended detention basins (dry basins)
- Retention ponds (w/permanent pool)
- Constructed wetlands
- Modular block porous pavement

Since stormwater detention basins are projected to be used for flood control, the features of extended detention basins have been incorporated into their “preliminary” design for water quality enhancement. This requires that an additional volume of runoff, referred to as the Water Quality Control Capture Volume, be detained in the basin for a period of 40 hours to allow fine particulate pollutants to settle before draining completely. This additional volume is equivalent to about half the runoff from a two-year storm and is calculated using Figure 23 (shown later in this section) as taken from the UDFCD Drainage Manual. Special outlet design is required to extend the detention period.

A summary of the recommended flood control detention volumes and water quality control capture volumes for each basin is provided later in this section in Table 29.

Additional water quality enhancement features should be investigated during the planning stage of each of the individual projects listed in Section 2.1.2.

2.1.5 Extended Detention Basins

Extended stormwater detention facilities can be built in various configurations, depending upon the site constraints. Generally grassed side slopes are limited to four horizontal to one vertical with bottom slopes of at least one percent. For this report, water depth has been limited to three feet, with one additional foot of depth for freeboard. Basins are anticipated to include a concrete outlet structure that restricts the outflow to design requirements for flood control and water quality enhancement.

Using this model, the six extended detention basins shown later in this section in Figures 20 thru 22 are further described as follows:

- **Basin #1** will mitigate the addition of approximately 62,100 square feet or 1.43 acres of new impervious area due to the construction of the Athletic Strength and Conditioning Addition to Butler Hancock Hall, the Athletic Indoor Practice Facility, and the West Campus Housing, projects #1, #8, and #9 listed in Section 2.1.2, above. The required volume is approximately 14,000 cubic feet and the approximate surface area of the pond is 0.18 acre. Although runoff from the West Campus Housing Project will not reach the proposed basin, runoff from current upstream impervious surfaces can be directed into the basin, thereby compensating for that runoff from the new construction that is not captured.
- **Basin #2** will mitigate the addition of approximately 25,000 square feet or 0.57 acres of new impervious area due to the construction of the Animal Facility Expansion, project #5 in Section 2.1.2, above. The required volume is approximately 5,600 cubic feet and the approximate surface area required is 0.09 acre.
- **Basin #3** will mitigate the addition of approximately 31,600 square feet or 0.73 acres of new impervious area due to the construction of the West Campus Academic Building, project #2 in Section 2.1.2, above. The required volume is approximately 7,200 cubic feet and the approximate surface area required is 0.11 acre.
- **Basin #4** will mitigate the addition of approximately 48,000 square feet or 1.10 acres of new impervious area due to the construction of the new Student Services / Administrative Center, project #3 in Section 2.1.2, above. The required volume is approximately 11,000 cubic feet and the approximate surface area required is 0.15 acre.
- **Basin #5** will mitigate the addition of approximately 41,000 square feet or 0.94 acres of new impervious area due to construction of the Art Museum and the Frasier Music Instruction Building Addition to Frasier Hall, projects #6 and #7 in Section 2.1.2, above. The required volume is approximately 9,300 cubic feet and the approximate surface area required is 0.13 acre. The runoff from the Art Museum may not be readily captured due to its proposed location; however, runoff from current impervious surfaces on campus could be directed to the detention basin, thereby compensating for the new impervious surface that may not be captured.
- **Basin #6** will mitigate the addition of approximately 18,000 square feet or 0.41 acres of impervious area due to the Music Performance Addition to Foundation Hall, project #4 in Section 2.1.2, above. The required volume is approximately 4,000 cubic feet and the approximate surface area required is 0.07 acre (*not shown on Figures).*

2.1.6 Opinion of Probable Construction Cost

The approximate cost of construction for each of the extended detention basins listed above are shown in Table 30 and summarized below:

- Basin #1 - $28,132
- Basin #2 - $21,213
- Basin #3 - $22,602
- Basin #4 - $25,691
- Basin #5 - $24,255
- Basin #6 - $19,817
- **Total: $141,710**

2.1.7 Storm Drainage System Summary and Recommended Improvements

The planning for each new capital improvement project on campus should include provisions for drainage improvements. Drainage systems downstream of the campus are reported to be at capacity and any increased runoff due to the addition of impervious area will exacerbate the problems downstream.

Extended stormwater detention basins have been shown to be effective in the mitigation of increased runoff due to an increase in impervious area and for improving the quality of stormwater runoff leaving the site. The extended detention basins identified in this report have been sized using assumed impervious area footprints of the building projects identified in the university's 10-year Capital Construction Plan, and are useful for master planning purposes. Detailed design of stormwater detention and water quality enhancement facilities should be completed as the projected Capital Projects become better defined.

Several drainage improvements were discussed in Section 1 of this report to address current deficiencies in the campus drainage system. Some of these deficiencies could be addressed by proper placement and sizing of the extended detention basins discussed above.

More particularly, the current localized flooding problems experienced north of Harrison and Turner Halls could be solved with increased sizing and proper placement of Basin #2 identified in Section 2.1.5. Also, the drainage problems adjacent to Guggenheim Hall due to flat topography could be solved with an extended detention basin that could also serve to mitigate increased runoff from the future Art Museum construction.

TABLE 23 – BASIN #1 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	1.43	13.3	0.87	0.07	0.99	3982	258	3724
10	7.51	0.96	1.43	10.3	0.87	0.08	0.99	6186	516	5670
15	6.34	0.96	1.43	8.7	0.87	0.10	0.97	7833	758	7075
20	5.34	0.96	1.43	7.3	0.87	0.12	0.97	8797	1011	7786
25	4.74	0.96	1.43	6.5	0.87	0.13	0.96	9761	1251	8510
30	4.39	0.96	1.43	6.0	0.87	0.14	0.96	10848	1501	9347
35	3.99	0.96	1.43	5.5	0.87	0.16	0.95	11503	1733	9770
40	3.59	0.96	1.43	4.9	0.87	0.18	0.94	11828	1960	9868
45	3.35	0.96	1.43	4.6	0.87	0.19	0.94	12417	2205	10212
50	3.1	0.96	1.43	4.3	0.87	0.20	0.93	12767	2424	10343
55	2.94	0.96	1.43	4.0	0.87	0.22	0.93	13319	2666	10653
60	2.78	0.96	1.43	3.8	0.87	0.23	0.92	13739	2877	10862
65	2.63	0.96	1.43	3.6	0.87	0.24	0.92	14081	3117	10964
70	2.47	0.96	1.43	3.4	0.87	0.26	0.91	14241	3320	10921
75	2.32	0.96	1.43	3.2	0.87	0.27	0.91	14332	3557	10775
80	2.16	0.96	1.43	3.0	0.87	0.29	0.9	14233	3753	10480
85	2.07	0.96	1.43	2.8	0.87	0.31	0.9	14493	3987	10505
90	1.98	0.96	1.43	2.7	0.87	0.32	0.9	14678	4222	10456
95	1.88	0.96	1.43	2.6	0.87	0.34	0.89	14711	4407	10304
100	1.79	0.96	1.43	2.5	0.87	0.35	0.89	14744	4639	10105
105	1.72	0.96	1.43	2.4	0.87	0.37	0.88	14876	4816	10059
110	1.65	0.96	1.43	2.3	0.87	0.38	0.88	14950	5046	9904
115	1.57	0.96	1.43	2.2	0.87	0.40	0.88	14872	5275	9597
120	1.5	0.96	1.43	2.1	0.87	0.42	0.87	14826	5442	9385

Re: City of Greeley drainage manual - Section 11

Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A

C = 0.15 (UDFCD Table RO-5)

I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)

A = Basin area = 1.43 acres (Section 2 of Report)

Qo = CIA = (0.15) (4.05) (1.43) = 0.87 cfs

Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)

Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)

Area = Added impervious area in basin

Inflow Qp = CIA

Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)

Cumulative Inflow Volume = Qp X Rainfall Duration in seconds

Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient

Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 24 – BASIN #2 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	0.57	5.3	0.35	0.07	0.99	1587	103	1485
10	7.51	0.96	0.57	4.1	0.35	0.08	0.99	2466	206	2260
15	6.34	0.96	0.57	3.5	0.35	0.10	0.97	3122	302	2820
20	5.34	0.96	0.57	2.9	0.35	0.12	0.97	3506	403	3103
25	4.74	0.96	0.57	2.6	0.35	0.13	0.96	3891	499	3392
30	4.39	0.96	0.57	2.4	0.35	0.14	0.96	4324	598	3726
35	3.99	0.96	0.57	2.2	0.35	0.16	0.95	4585	691	3894
40	3.59	0.96	0.57	2.0	0.35	0.18	0.94	4715	781	3933
45	3.35	0.96	0.57	1.8	0.35	0.19	0.94	4949	879	4071
50	3.1	0.96	0.57	1.7	0.35	0.20	0.93	5089	966	4123
55	2.94	0.96	0.57	1.6	0.35	0.22	0.93	5309	1063	4246
60	2.78	0.96	0.57	1.5	0.35	0.23	0.92	5476	1147	4330
65	2.63	0.96	0.57	1.4	0.35	0.24	0.92	5613	1242	4370
70	2.47	0.96	0.57	1.4	0.35	0.26	0.91	5677	1323	4353
75	2.32	0.96	0.57	1.3	0.35	0.27	0.91	5713	1418	4295
80	2.16	0.96	0.57	1.2	0.35	0.29	0.9	5673	1496	4177
85	2.07	0.96	0.57	1.1	0.35	0.31	0.9	5777	1589	4187
90	1.98	0.96	0.57	1.1	0.35	0.32	0.9	5851	1683	4168
95	1.88	0.96	0.57	1.0	0.35	0.34	0.89	5864	1757	4107
100	1.79	0.96	0.57	1.0	0.35	0.35	0.89	5877	1849	4028
105	1.72	0.96	0.57	0.9	0.35	0.37	0.88	5929	1920	4010
110	1.65	0.96	0.57	0.9	0.35	0.38	0.88	5959	2011	3948
115	1.57	0.96	0.57	0.9	0.35	0.40	0.88	5928	2103	3825
120	1.5	0.96	0.57	0.8	0.35	0.42	0.87	5910	2169	3741

Re: City of Greeley drainage manual - Section 11

Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A

C = 0.15 (UDFCD Table RO-5)

I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)

A = Basin area = 0.57 acres (Section 2 of Report)

Qo = CIA = (0.15) (4.05) (0.57) = 0.35 cfs

Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)

Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)

Area = Added impervious area in basin

Inflow Qp = CIA

Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)

Cumulative Inflow Volume = Qp X Rainfall Duration in seconds

Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient

Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 25 – BASIN #3 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	0.73	6.8	0.44	0.07	0.99	2033	132	1901
10	7.51	0.96	0.73	5.3	0.44	0.08	0.99	3158	263	2894
15	6.34	0.96	0.73	4.4	0.44	0.10	0.97	3999	387	3612
20	5.34	0.96	0.73	3.7	0.44	0.12	0.97	4491	516	3975
25	4.74	0.96	0.73	3.3	0.44	0.13	0.96	4983	639	4344
30	4.39	0.96	0.73	3.1	0.44	0.14	0.96	5538	766	4771
35	3.99	0.96	0.73	2.8	0.44	0.16	0.95	5872	885	4987
40	3.59	0.96	0.73	2.5	0.44	0.18	0.94	6038	1000	5038
45	3.35	0.96	0.73	2.3	0.44	0.19	0.94	6339	1126	5213
50	3.1	0.96	0.73	2.2	0.44	0.20	0.93	6517	1237	5280
55	2.94	0.96	0.73	2.1	0.44	0.22	0.93	6799	1361	5438
60	2.78	0.96	0.73	1.9	0.44	0.23	0.92	7014	1469	5545
65	2.63	0.96	0.73	1.8	0.44	0.24	0.92	7188	1591	5597
70	2.47	0.96	0.73	1.7	0.44	0.26	0.91	7270	1695	5575
75	2.32	0.96	0.73	1.6	0.44	0.27	0.91	7316	1816	5500
80	2.16	0.96	0.73	1.5	0.44	0.29	0.9	7266	1916	5350
85	2.07	0.96	0.73	1.5	0.44	0.31	0.9	7398	2036	5363
90	1.98	0.96	0.73	1.4	0.44	0.32	0.9	7493	2155	5338
95	1.88	0.96	0.73	1.3	0.44	0.34	0.89	7510	2250	5260
100	1.79	0.96	0.73	1.3	0.44	0.35	0.89	7527	2368	5158
105	1.72	0.96	0.73	1.2	0.44	0.37	0.88	7594	2459	5135
110	1.65	0.96	0.73	1.2	0.44	0.38	0.88	7632	2576	5056
115	1.57	0.96	0.73	1.1	0.44	0.40	0.88	7592	2693	4899
120	1.5	0.96	0.73	1.1	0.44	0.42	0.87	7569	2778	4791

Re: City of Greeley drainage manual - Section 11

Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A

C = 0.15 (UDFCD Table RO-5)

I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)

A = Basin area =0.73 acres (Section 2 of Report)

Qo = CIA = (0.15) (4.05) (0.73) = 0.44 cfs

Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)

Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)

Area = Added impervious area in basin

Inflow Qp = CIA

Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)

Cumulative Inflow Volume = Qp X Rainfall Duration in seconds

Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient

Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 26 – BASIN #4 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	1.1	10.2	0.67	0.07	0.99	3063	198	2865
10	7.51	0.96	1.1	7.9	0.67	0.08	0.99	4758	397	4361
15	6.34	0.96	1.1	6.7	0.67	0.10	0.97	6026	583	5442
20	5.34	0.96	1.1	5.6	0.67	0.12	0.97	6767	778	5989
25	4.74	0.96	1.1	5.0	0.67	0.13	0.96	7508	962	6546
30	4.39	0.96	1.1	4.6	0.67	0.14	0.96	8345	1155	7190
35	3.99	0.96	1.1	4.2	0.67	0.16	0.95	8848	1333	7515
40	3.59	0.96	1.1	3.8	0.67	0.18	0.94	9098	1508	7591
45	3.35	0.96	1.1	3.5	0.67	0.19	0.94	9552	1696	7856
50	3.1	0.96	1.1	3.3	0.67	0.20	0.93	9821	1864	7956
55	2.94	0.96	1.1	3.1	0.67	0.22	0.93	10245	2051	8194
60	2.78	0.96	1.1	2.9	0.67	0.23	0.92	10568	2213	8355
65	2.63	0.96	1.1	2.8	0.67	0.24	0.92	10831	2398	8434
70	2.47	0.96	1.1	2.6	0.67	0.26	0.91	10955	2554	8401
75	2.32	0.96	1.1	2.4	0.67	0.27	0.91	11025	2736	8288
80	2.16	0.96	1.1	2.3	0.67	0.29	0.9	10949	2887	8062
85	2.07	0.96	1.1	2.2	0.67	0.31	0.9	11148	3067	8081
90	1.98	0.96	1.1	2.1	0.67	0.32	0.9	11291	3248	8043
95	1.88	0.96	1.1	2.0	0.67	0.34	0.89	11316	3390	7926
100	1.79	0.96	1.1	1.9	0.67	0.35	0.89	11341	3568	7773
105	1.72	0.96	1.1	1.8	0.67	0.37	0.88	11443	3705	7738
110	1.65	0.96	1.1	1.7	0.67	0.38	0.88	11500	3881	7619
115	1.57	0.96	1.1	1.7	0.67	0.40	0.88	11440	4058	7382
120	1.5	0.96	1.1	1.6	0.67	0.42	0.87	11405	4186	7219

Re: City of Greeley drainage manual - Section 11

Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A

C = 0.15 (UDFCD Table RO-5)

I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)

A = Basin area =1.10 acres (Section 2 of Report)

Qo = CIA = (0.15) (4.05) (1.10) = 0.67 cfs

Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)

Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)

Area = Added impervious area in basin

Inflow Qp = CIA

Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)

Cumulative Inflow Volume = Qp X Rainfall Duration in seconds

Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient

Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 27 – BASIN #5 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	0.94	8.7	0.57	0.07	0.99	2618	170	2448
10	7.51	0.96	0.94	6.8	0.57	0.08	0.99	4066	339	3727
15	6.34	0.96	0.94	5.7	0.57	0.10	0.97	5149	499	4651
20	5.34	0.96	0.94	4.8	0.57	0.12	0.97	5783	665	5118
25	4.74	0.96	0.94	4.3	0.57	0.13	0.96	6416	822	5594
30	4.39	0.96	0.94	4.0	0.57	0.14	0.96	7131	987	6144
35	3.99	0.96	0.94	3.6	0.57	0.16	0.95	7561	1139	6422
40	3.59	0.96	0.94	3.2	0.57	0.18	0.94	7775	1288	6487
45	3.35	0.96	0.94	3.0	0.57	0.19	0.94	8162	1449	6713
50	3.1	0.96	0.94	2.8	0.57	0.20	0.93	8392	1593	6799
55	2.94	0.96	0.94	2.7	0.57	0.22	0.93	8755	1753	7003
60	2.78	0.96	0.94	2.5	0.57	0.23	0.92	9031	1891	7140
65	2.63	0.96	0.94	2.4	0.57	0.24	0.92	9256	2049	7207
70	2.47	0.96	0.94	2.2	0.57	0.26	0.91	9361	2183	7179
75	2.32	0.96	0.94	2.1	0.57	0.27	0.91	9421	2338	7083
80	2.16	0.96	0.94	1.9	0.57	0.29	0.9	9356	2467	6889
85	2.07	0.96	0.94	1.9	0.57	0.31	0.9	9527	2621	6906
90	1.98	0.96	0.94	1.8	0.57	0.32	0.9	9648	2775	6873
95	1.88	0.96	0.94	1.7	0.57	0.34	0.89	9670	2897	6773
100	1.79	0.96	0.94	1.6	0.57	0.35	0.89	9692	3049	6642
105	1.72	0.96	0.94	1.6	0.57	0.37	0.88	9778	3166	6613
110	1.65	0.96	0.94	1.5	0.57	0.38	0.88	9827	3317	6510
115	1.57	0.96	0.94	1.4	0.57	0.40	0.88	9776	3467	6308
120	1.5	0.96	0.94	1.4	0.57	0.42	0.87	9746	3577	6169

Re: City of Greeley drainage manual - Section 11

Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A

C = 0.15 (UDFCD Table RO-5)

I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)

A = Basin area =0.94 acres (Section 2 of Report)

Qo = CIA = (0.15) (4.05) (0.94) = 0.57 cfs

Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)

Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)

Area = Added impervious area in basin

Inflow Qp = CIA

Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)

Cumulative Inflow Volume = Qp X Rainfall Duration in seconds

Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient

Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 28 – BASIN #6 DETENTION POND SIZING COMPUTATIONS

Rainfall Duration (min)	Rainfall Intensity (in/hrmin)	Runoff Coefficient "C"	Area (acres)	Inflow Qp (cfs)	Outflow Qo (cfs)	Qo/Qin	Outflow Adj. Coef. K	Cumulative Inflow Vol. (cf)	Cumulative Outflow Vol. (cf)	Detention Volume (cf)
5	9.67	0.96	0.41	3.8	0.25	0.07	0.99	1142	74	1068
10	7.51	0.96	0.41	3.0	0.25	0.08	0.99	1774	148	1626
15	6.34	0.96	0.41	2.5	0.25	0.10	0.97	2246	217	2028
20	5.34	0.96	0.41	2.1	0.25	0.12	0.97	2522	290	2232
25	4.74	0.96	0.41	1.9	0.25	0.13	0.96	2798	359	2440
30	4.39	0.96	0.41	1.7	0.25	0.14	0.96	3110	430	2680
35	3.99	0.96	0.41	1.6	0.25	0.16	0.95	3298	497	2801
40	3.59	0.96	0.41	1.4	0.25	0.18	0.94	3391	562	2829
45	3.35	0.96	0.41	1.3	0.25	0.19	0.94	3560	632	2928
50	3.1	0.96	0.41	1.2	0.25	0.20	0.93	3660	695	2966
55	2.94	0.96	0.41	1.2	0.25	0.22	0.93	3819	764	3054
60	2.78	0.96	0.41	1.1	0.25	0.23	0.92	3939	825	3114
65	2.63	0.96	0.41	1.0	0.25	0.24	0.92	4037	894	3143
70	2.47	0.96	0.41	1.0	0.25	0.26	0.91	4083	952	3131
75	2.32	0.96	0.41	0.9	0.25	0.27	0.91	4109	1020	3089
80	2.16	0.96	0.41	0.9	0.25	0.29	0.9	4081	1076	3005
85	2.07	0.96	0.41	0.8	0.25	0.31	0.9	4155	1143	3012
90	1.98	0.96	0.41	0.8	0.25	0.32	0.9	4208	1211	2998
95	1.88	0.96	0.41	0.7	0.25	0.34	0.89	4218	1264	2954
100	1.79	0.96	0.41	0.7	0.25	0.35	0.89	4227	1330	2897
105	1.72	0.96	0.41	0.7	0.25	0.37	0.88	4265	1381	2884
110	1.65	0.96	0.41	0.6	0.25	0.38	0.88	4286	1447	2840
115	1.57	0.96	0.41	0.6	0.25	0.40	0.88	4264	1512	2751
120	1.5	0.96	0.41	0.6	0.25	0.42	0.87	4251	1560	2691

Re: City of Greeley drainage manual - Section 11
<u>Calculation of Qo (Maximum Outlfow) using Rational Formula Q = C I A</u>
C = 0.15 (UDFCD Table RO-5)
I = 4.05 inches per hour (Figure 3-1, City of Greeley drainage manual using Tc = 10 minutes)
A = Basin area =0.41 acres (Section 2 of Report)
Qo = CIA = (0.15) (4.05) (0.41) = 0.25 cfs
Rainfall Intensity - City of Greeley Rainfall Table 3-3 (Linear Interpolation between points where not provided)
Runoff Coefficient C of developed surface = 0.96 (UDFCD Table RO-5)
Area = Added impervious area in basin
Inflow Qp = CIA
Outflow Adjustment Coefficient K (City of Greeley drainage manual, figure 11-1)
Cumulative Inflow Volume = Qp X Rainfall Duration in seconds
Cumulative Outflow Volume = Qo X Rainfall Duration in seconds X Outflow Adjustment Coefficient
Detention Volume = Maximum value of Cumulative Inflow Volume minus Cumulative Outflow Volume

TABLE 29 – SUMMARY OF STORMWATER / WATER QUALITY DETENTION VOLUMES

Basin Identification	Additional Impervious Area due to 10-year Capital Construction Plan (Acre)	Stormwater Detention Volume (CF)	Water Quality Capture Volume (CF)	Total Volume (CF)
Basin #1	1.43	10,964	3,115	14,079
Basin #2	0.57	4,370	1,241	5,611
Basin #3	0.73	5,597	1,590	7,187
Basin #4	1.1	8,434	2,396	10,830
Basin #5	0.94	7,207	2,047	9,254
Basin #6	0.41	3,143	893	4,036

TABLE 30 – DETENTION BASINS OPINION OF PROBABLE CONSTRUCTION COST

			Basin #1		Basin #2		Basin #3	
Construction Item	**Unit**	**Unit Price**	**Quantity**	**Total**	**Quantity**	**Total**	**Quantity**	**Total**
Remove Topsoil & Stockpipe On Site	CY	$ 6.00	145	$ 870.00	73	$ 438.00	89	$ 534.00
Earthwork & Grading	CY	$ 12.00	520	$ 6,240.00	207	$ 2,484.00	267	$ 3,204.00
Spread Topsoil	CY	$ 12.00	145	$ 1,740.00	73	$ 876.00	89	$ 1,068.00
Outlet Structure	Each	$ 5,500.00	1	$ 5,500.00	1	$ 5,500.00	1	$ 5,500.00
Outlet pipe	LF	$ 85.00	50	$ 4,250.00	50	$ 4,250.00	50	$ 4,250.00
Irrigation System	Each	$ 2,500.00	1	$ 2,500.00	1	$ 2,500.00	1	$ 2,500.00
Reseeding	Ac	$ 3,000.00	0.18	$ 540.00	0.09	$ 270.00	0.11	$ 330.00
			Sub-Total:	$ 21,640.00		$ 16,318.00		$ 17,386.00
			15% Construction Contingency:	$ 3,246.00		$ 2,447.70		$ 2,607.90
			15% Design and Construction Engineering:	$ 3,246.00		$ 2,447.70		$ 2,607.90
			Total Estimated Construction Cost:	**$ 28,132**		**$ 21,213**		**$ 22,602**

			Basin #4		Basin #5		Basin #6	
Construction Item	**Unit**	**Unit Price**	**Quantity**	**Total**	**Quantity**	**Total**	**Quantity**	**Total**
Remove Topsoil & Stockpipe On Site	CY	$ 6.00	121	$ 726.00	105	$ 630.00	56	$ 336.00
Earthwork & Grading	CY	$ 12.00	407	$ 4,884.00	344	$ 4,128.00	148	$ 1,776.00
Spread Topsoil	CY	$ 12.00	121	$ 1,452.00	105	$ 1,260.00	56	$ 672.00
Outlet Structure	Each	$ 5,500.00	1	$ 5,500.00	1	$ 5,500.00	1	$ 5,500.00
Outlet pipe	LF	$ 85.00	50	$ 4,250.00	50	$ 4,250.00	50	$ 4,250.00
Irrigation System	Each	$ 2,500.00	1	$ 2,500.00	1	$ 2,500.00	1	$ 2,500.00
Reseeding	Ac	$ 3,000.00	0.15	$ 450.00	0.13	$ 390.00	0.07	$ 210.00
			Sub-Total:	$ 19,762.00		$ 18,658.00		$ 15,244.00
			15% Construction Contingency:	$ 2,964.30		$ 2,798.70		$ 2,286.60
			15% Design and Construction Engineering:	$ 2,964.30		$ 2,798.70		$ 2,286.60
			Total Estimated Construction Cost:	**$ 25,691**		**$ 24,255**		**$ 19,817**

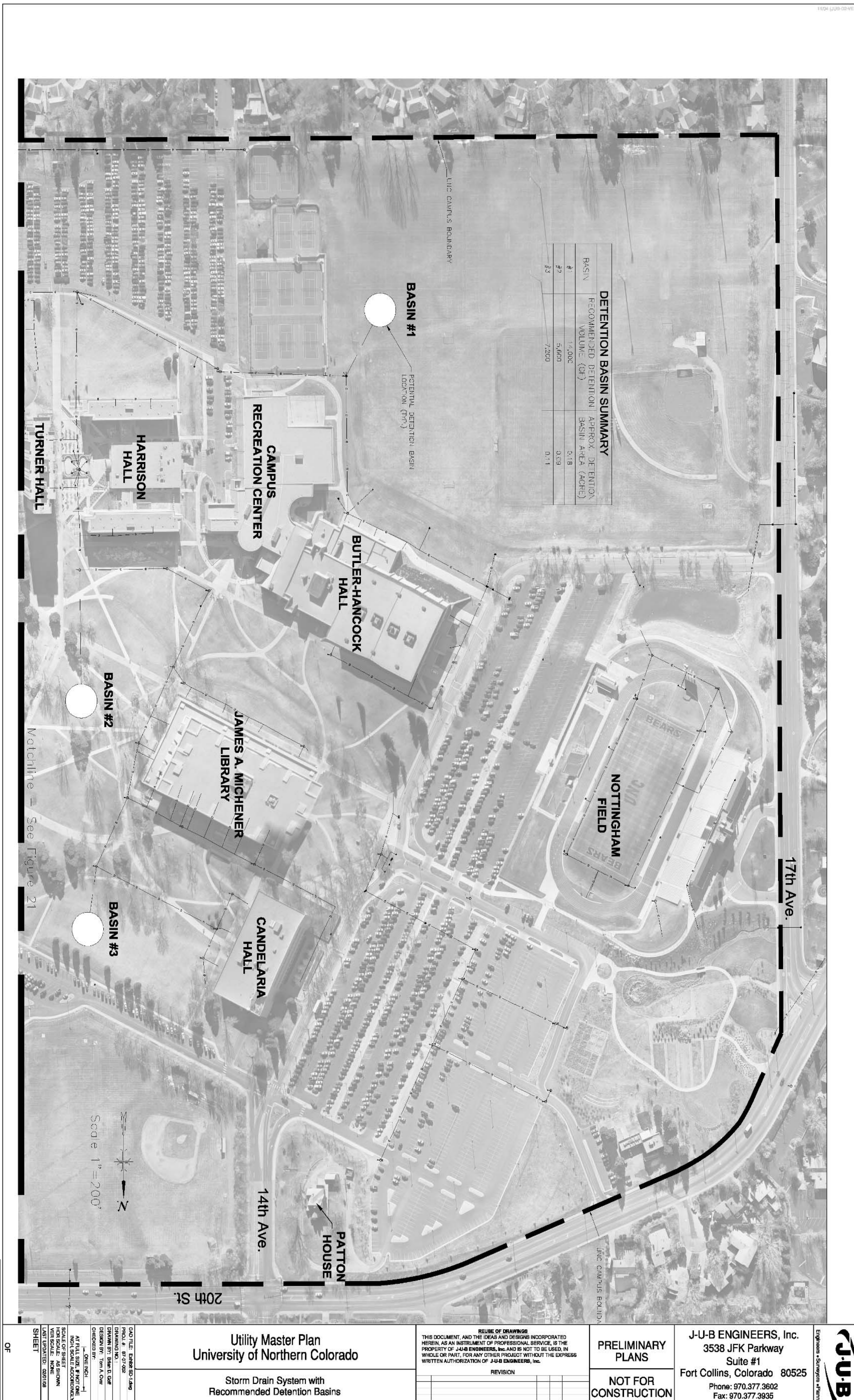

DETENTION BASIN SUMMARY
BASIN #1
BASIN #2
BASIN #3
UNC CAMPUS BOUNDARY
POTENTIAL DETENTION BASIN LOCATION (TYP.)
TURNER HALL
HARRISON HALL
CAMPUS RECREATION CENTER
BUTLER-HANCOCK HALL
JAMES A. MICHENER LIBRARY
CANDELARIA HALL
NOTTINGHAM FIELD
PATTON HOUSE
17th Ave.
14th Ave.
20th St.
Matchline – See Figure 21
Scale 1" = 200'
Utility Master Plan
University of Northern Colorado
Storm Drain System with Recommended Detention Basins
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
J-U-B ENGINEERS, Inc.
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com

FIGURE 20

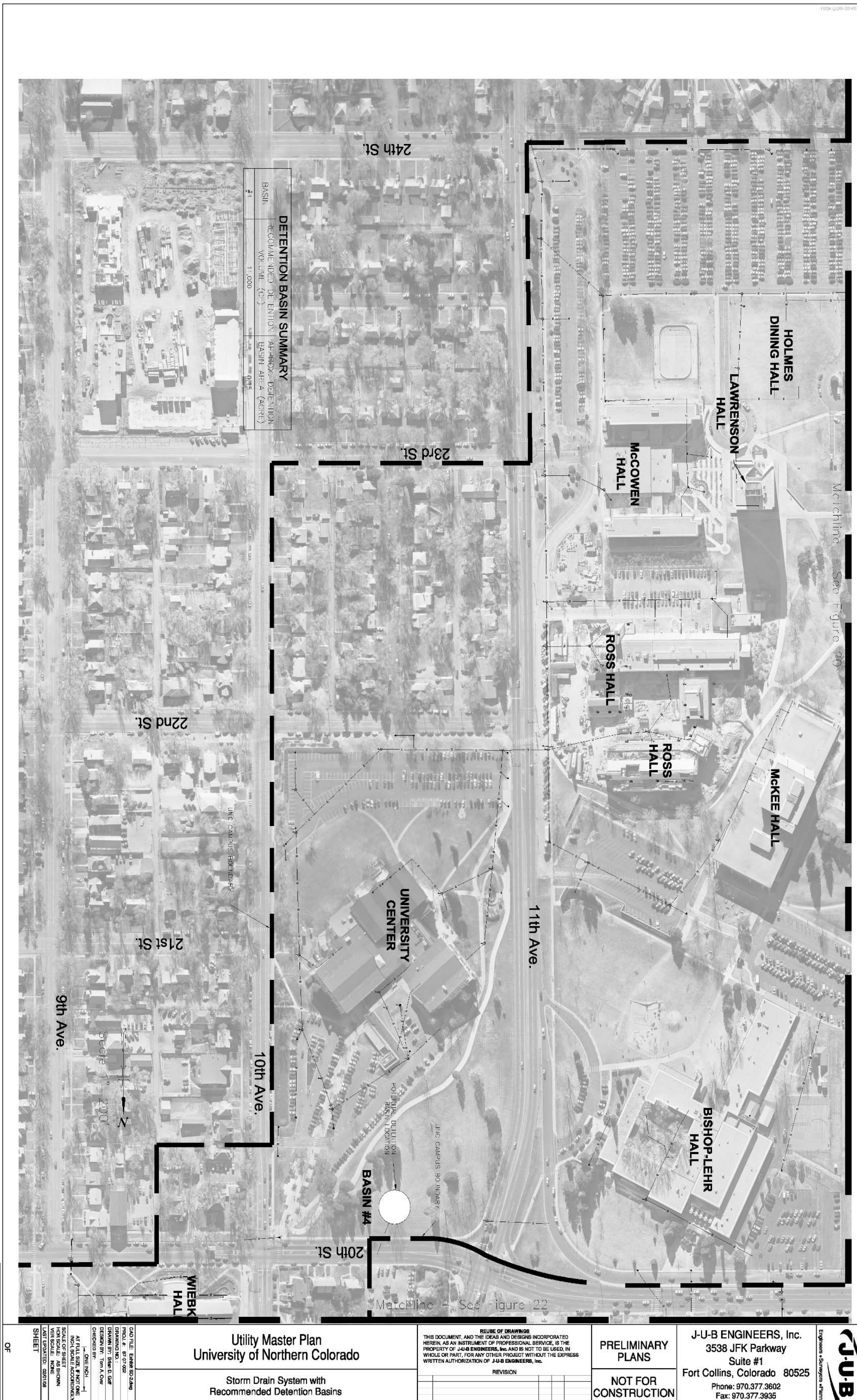

24th St.
23rd St.
22nd St.
21st St.
20th St.
9th Ave.
10th Ave.
11th Ave.
DETENTION BASIN SUMMARY
HOLMES DINING HALL
LAWRENSON HALL
McCOWEN HALL
ROSS HALL
McKEE HALL
UNIVERSITY CENTER
BISHOP-LEHR HALL
BASIN #4
Utility Master Plan
University of Northern Colorado
Storm Drain System with Recommended Detention Basins
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
J-U-B ENGINEERS, Inc.
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com

FIGURE 21

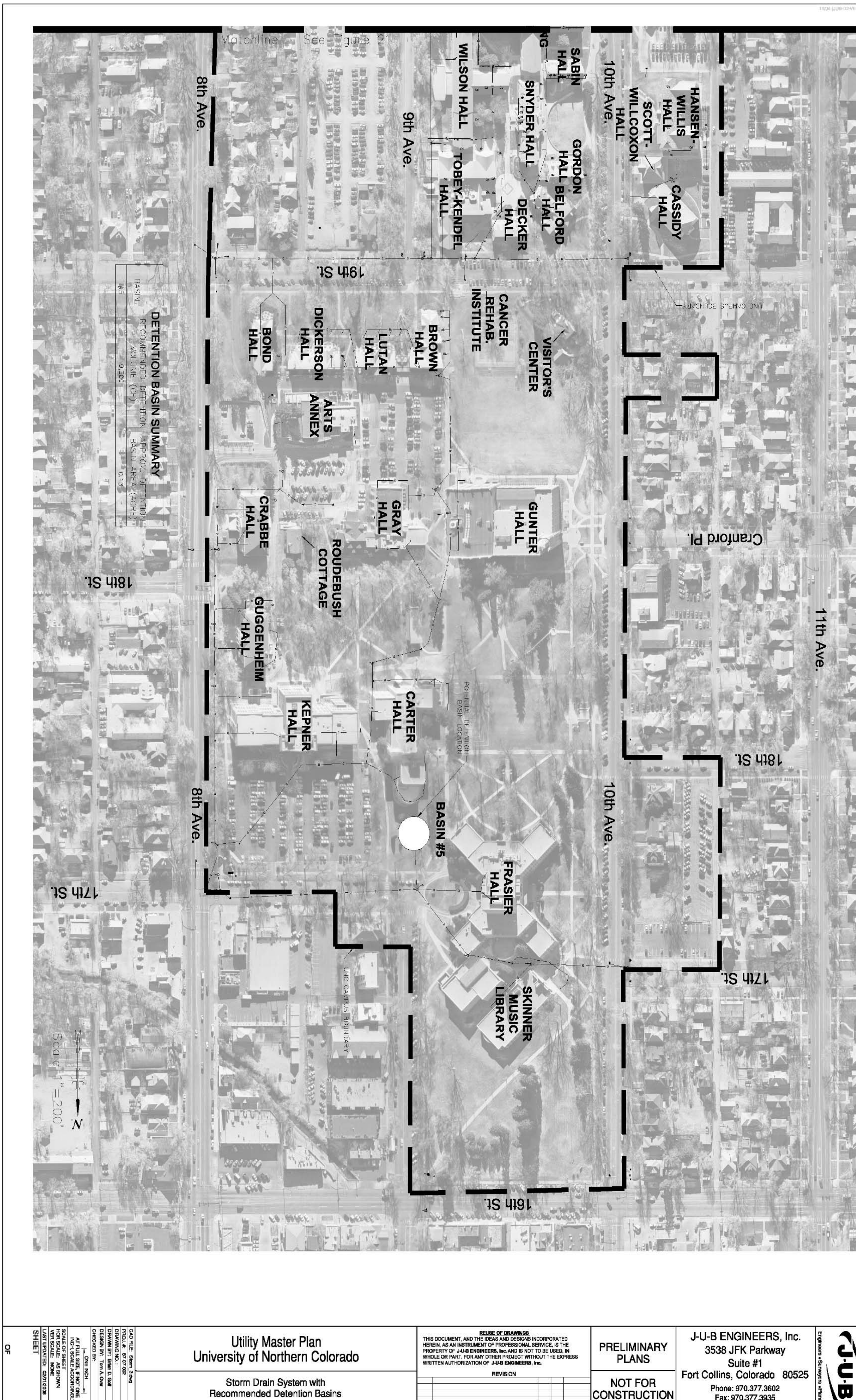
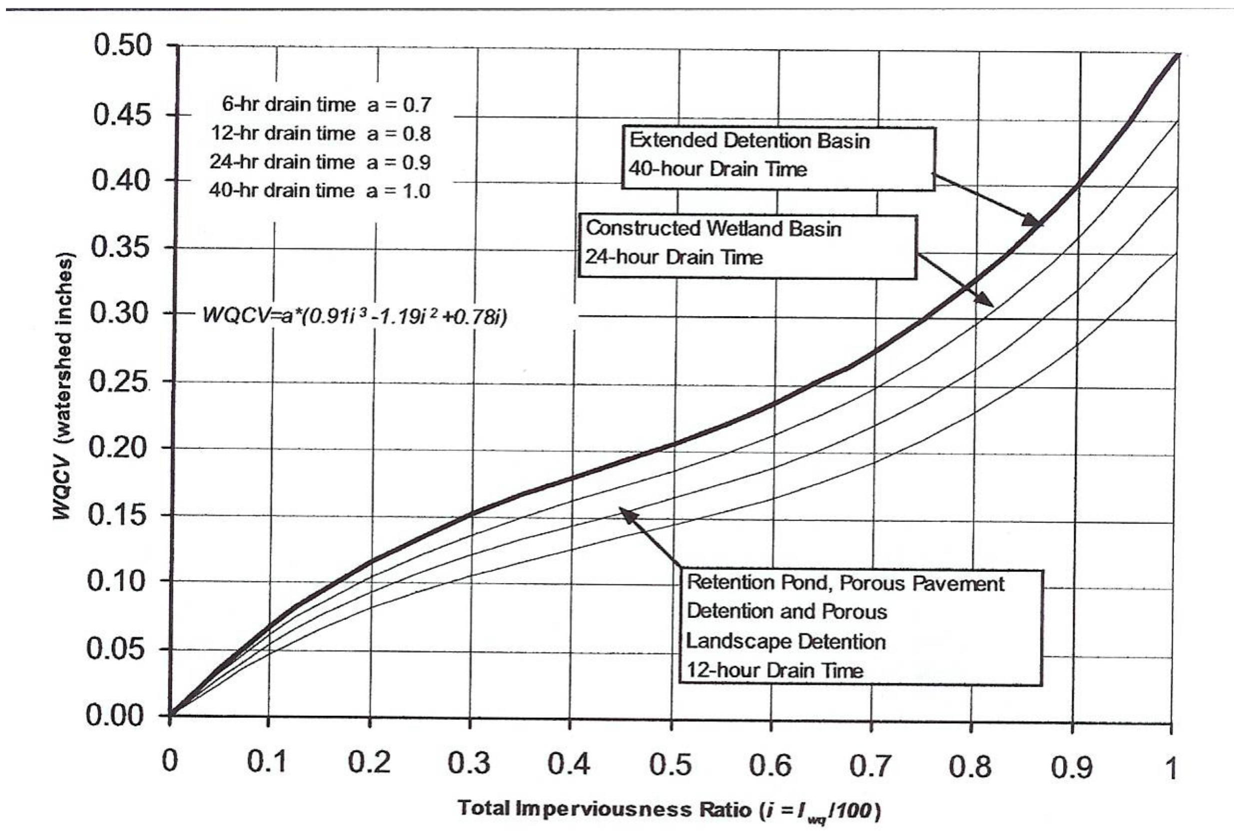

8th Ave.
9th Ave.
10th Ave.
11th Ave.
16th St.
17th St.
18th St.
19th St.
Cranford Pl.
WILSON HALL
SABIN HALL
SNYDER HALL
GORDON HALL
BELFORD HALL
DECKER HALL
TOBEY-KENDEL HALL
HANSEN-WILLIS HALL
SCOTT-WILLCOXON HALL
CASSIDY HALL
CANCER REHAB. INSTITUTE
VISITOR'S CENTER
BROWN HALL
LUTAN HALL
DICKERSON HALL
BOND HALL
ARTS ANNEX
GRAY HALL
GUNTER HALL
CRABBE HALL
ROUDEBUSH COTTAGE
GUGGENHEIM HALL
KEPNER HALL
CARTER HALL
BASIN #5
FRASIER HALL
SKINNER MUSIC LIBRARY
DETENTION BASIN SUMMARY
UNC CAMPUS BOUNDARY
Utility Master Plan
University of Northern Colorado
Storm Drain System with
Recommended Detention Basins
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
J-U-B ENGINEERS, Inc.
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com
REVISION
NO.
DESCRIPTION
BY
APR.
DATE
SHEET
OF

FIGURE 22

FIGURE 23 - URBAN DRAINAGE AND FLOOD CONTROL DISTRICT FIGURE EDB-2 - WATER QUALITY CAPTURE VOLUME (WQCV), 80TH PERCENTILE RUNOFF EVENT



SECTION 2.2 – WATER SYSTEM

2.2.1 Introduction and Background

Section 1 discusses the existing water system, deficiencies, and recommendations for Central Campus and West Campus. Overall the campus water system appears to be in generally good condition and can facilitate the proposed improvements contained in the 10-year Capital Improvement plan. The system contains some older mainlines, but problems have not been reported or documented.

A majority of Central Campus water mains are located in the City's lower pressure zone. Recent available fire hydrant test data indicates that City fire flows from smaller diameter lines east of Central Campus *were below* recommended flows needed to meet requirements in the International Fire Code (IFC). This test was conducted adjacent to an existing 6" city main located near 17th Street 8th Avenue. A more recent fire test located along the 10" City main running east-west through Central Campus near 8th Avenue shows that minimum recommended fire flows can be met for the 10-Year Capital Construction plan (a copy of this test is included in the appendix of this report). It is anticipated that the lower pressure test was due to higher friction losses associated with the smaller water main.

West Campus is located in the City's higher pressure zone and static pressures are generally good throughout campus (44 psi – 95 psi). West Campus does contain older mainlines, but they appear to be working well based on the calibrated water model output. An existing meter vault is available for an additional connection to the City if needed in the future to boost pressures.

Future building locations have been identified based on the aforementioned memorandum from Kirk Leichliter to Andrew Carlson on May 29, 2007 which outline the 10-Year Capital Construction Plan for UNC. UNC's website containing monitored future building locations was also used to schematically locate the future buildings.

Approximate future building sizes have been obtained from UNC staff and have been used to calculate the anticipated additional water and fire flow demands. Peak demands calculated for the Sanitary Sewer portion of this paper have been used to represent a maximum day water system demand for each new building.

Future fire flow requirements have been calculated in accordance with IBC 2003 for new construction only. For the purposes of this analysis, it was assumed that all buildings will be IBC 2003 Type IIA construction, and will have an internal fire sprinkler system. The fire flow and number of hydrants estimated in this paper will likely need to be adjusted and strategically located on a per project basis to reflect detailed conditions that exist at the time of construction as well as more specific future design data.

The governing scenario to ensure City requirements are met is the Fire Flow + Maximum Day demand scenario and thus will be the focus of this report. A Maximum Day scenario has been calculated and all pressure nodes within the model on West Campus are above 40 psi. J-U-B was unable to analyze these scenarios for Central Campus due to complexities of the City's system outside of this scope as well as lack of available City system information. As shown in Section 1 of this report, static pressures are within required limits for both Central Campus and West Campus.

Table 31 provides a summary of anticipated water / fire flow demands for the proposed facility projects contained in the 10-year Capital Construction Plan. Each building's recommended improvements are also presented and a summary table is provided at the end of Section 2.2 (Table 32).

2.2.2 Recommended Improvements (Figures 24 thru 26)

Upgrade Existing Pipe to Nottingham Hydrants

As discussed in Section 1 of this report, it is recommended that 1,500 lineal feet of 4” and 2” water lines be replaced with a new 8” water line to reduce friction losses and boost hydrant pressures just west of Nottingham. If it is impractical to construct this improvement sooner, it should be completed with the first building or phase of the 10-Year Capital Construction Plan. This project is urgent because available fire flows in the area currently do not meet the minimum fire code requirement of 1,500 gpm at 20 psi residual.

Upgrade Entrance Pipe to 12” (20th Street and 14th Avenue)

Approximately 600 lineal feet of existing 10” mainline should be upsized with a 12” line in conjunction with construction of the West Campus Housing (Project #9). This upgrade will allow UNC to meet the City of Greeley maximum velocity requirement of 10 fps to the project (currently 11fps) during fire flow conditions.

The minimum fire flow required for each wing of this project will be met without upsizing. However, the line will require upsizing with construction of the Athletic Indoor Practice Facility to meet the project’s minimum fire flow requirements of 2,750 gpm at 20 psi residual. Increasing this line size will also improve pressure for the entire West Campus.

As shown in Figure 7A (Section 1.2), the 10” line currently splits and feeds an existing 10” and 6” meter with the 6” meter primarily handling lower domestic flows. An existing 10” bypass line is also available for use for meter replacement and/or meter maintenance. As a part of this upgrade, both the 10” bypass line and 10” meter line should be replaced with a 12” pipeline.

The additional capital improvement projects on West Campus (1, 2, 5, 8, 9A & 9B) will add approximately 437 gpm of peak domestic flow (see Table 31), which theoretically would nearly double the current peak flows outlined in Section 1.2. However, as the current domestic peak flows are primarily related to irrigation flows during summer months it is not anticipated that the new flows would be directly additive. The hydraulic analysis indicates that the existing 6” (domestic flow) meter will still be sufficient to handle future build-out peak daily flows (outside of fire flow).

1) Athletic strength and conditioning addition Butler Hancock Hall (West Campus)

This project is anticipated to add 5,500 gross square feet to Butler Hancock Hall. The addition will add a calculated maximum day demand of 30 gpm to the system. The addition will require 1 fire hydrant and a minimum 1,500 gpm fire flow. Placement of the building will require 550 linear feet of 8” water line to be relocated / removed and 700 linear feet of new 8” water line installed around the addition.

2) West Campus Academic Building (West Campus)

This project is anticipated to provide a new multistory building just east of Candaleria Hall with 80,000 gross square feet of floor space. This building will add a calculated maximum day demand of 95 gpm to the system. The project will require 2 fire hydrants and a minimum 2,000 gpm fire flow. It is anticipated that 330 lineal feet of 8” water line will need to be added to the system for this project.

3) *Student Services/ Administrative Center (West Campus)*

This project is anticipated to provide a new multistory building just north of the University Center, with an estimated 80,000 gross square feet of floor space. This building will add a calculated maximum day demand of 100 gpm to the system. The project will require installation of 2 new fire hydrants and a minimum 2,000 gpm fire flow. Placement of the building will require 430 linear feet of 8” water line to be removed and 460 linear feet of 8” line installed around the addition.

4) *Music Performance Addition to Foundation Hall (Not shown on Exhibit) –*

This project is anticipated to add 18,000 gross square footage to the Foundation Hall. This building will add a calculated maximum day demand of 65 gpm to the system. The project will require 1 fire hydrant and a minimum 1,500 gpm fire flow. It is anticipated for budget purposes that 500 lineal feet of 8” water line will need to be added for this project.

5) *Animal Facility Expansion (West Campus)*

This project is anticipated to provide a new multistory building south of McKee Hall, with 25,000 gross square feet of floor space. This building will add a calculated maximum day demand of 65 gpm to the system. The project will require 1 fire hydrant and a minimum 1,500 gpm fire flow. It is anticipated that 450 lineal feet of 8” water line will need to be added for this project.

6) *Art Museum (Central Campus)*

This project will provide a new single story building just east of the Arts Annex Building with 13,000 gross square feet of floor space. This building will add a calculated maximum day demand of 50 gpm to the system. The project will require 1 fire hydrant and a minimum 1,500 gpm fire flow. Based on recent fire flow tests minimum fire flow requirements should be met by connecting to the City’s main in 8th Avenue without additional upgrades to the system.

7) *Frasier Music Instruction Building Addition (Central Campus)*

This project is anticipated to provide a multistory addition to Frasier Hall with 80,000 gross square feet of floor space. This building will add a calculated maximum day demand of 100 gpm to the system. The project will require 2 fire hydrants and a minimum 2,000 gpm fire flow. It is anticipated that 500 lineal feet of 8” water line will need to be added for this project. Also note that to maintain adequate fire flow pressures, this line should be connected to the existing 10” water line in 10th Avenue.

8) *Athletic Indoor Practice Facility (West Campus)*

This project is anticipated to provide a new indoor sports facility south of Nottingham field, with 176,000 gross square feet of floor space. This building will add a calculated maximum day demand of 225 gpm to the system. The project will require 3-5 fire hydrants and a minimum 3,000 gpm fire flow. It is anticipated that 1700 lineal feet of 8” water line will need to be added for this project.

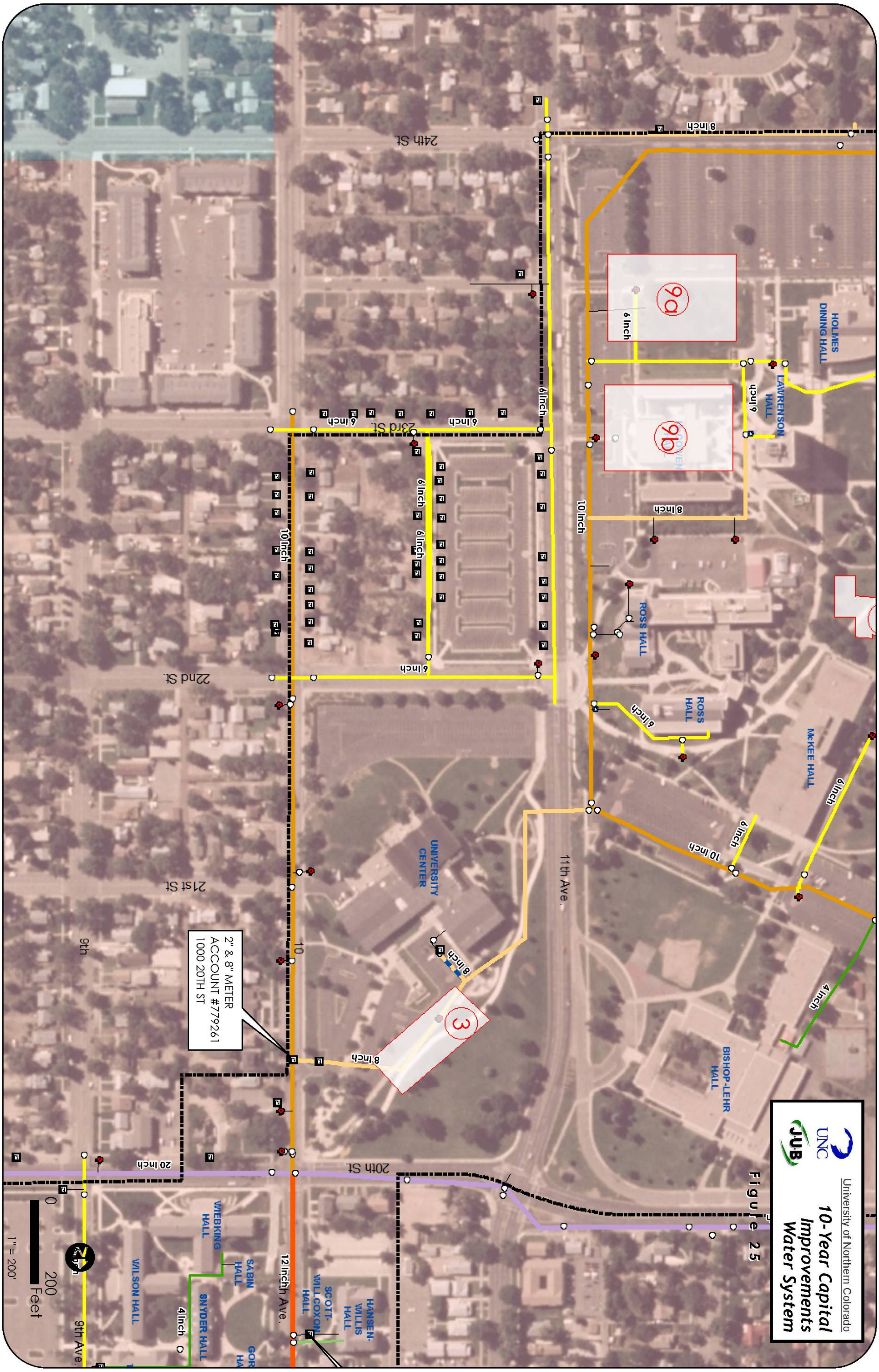
9) *West Campus Housing (West Campus)*

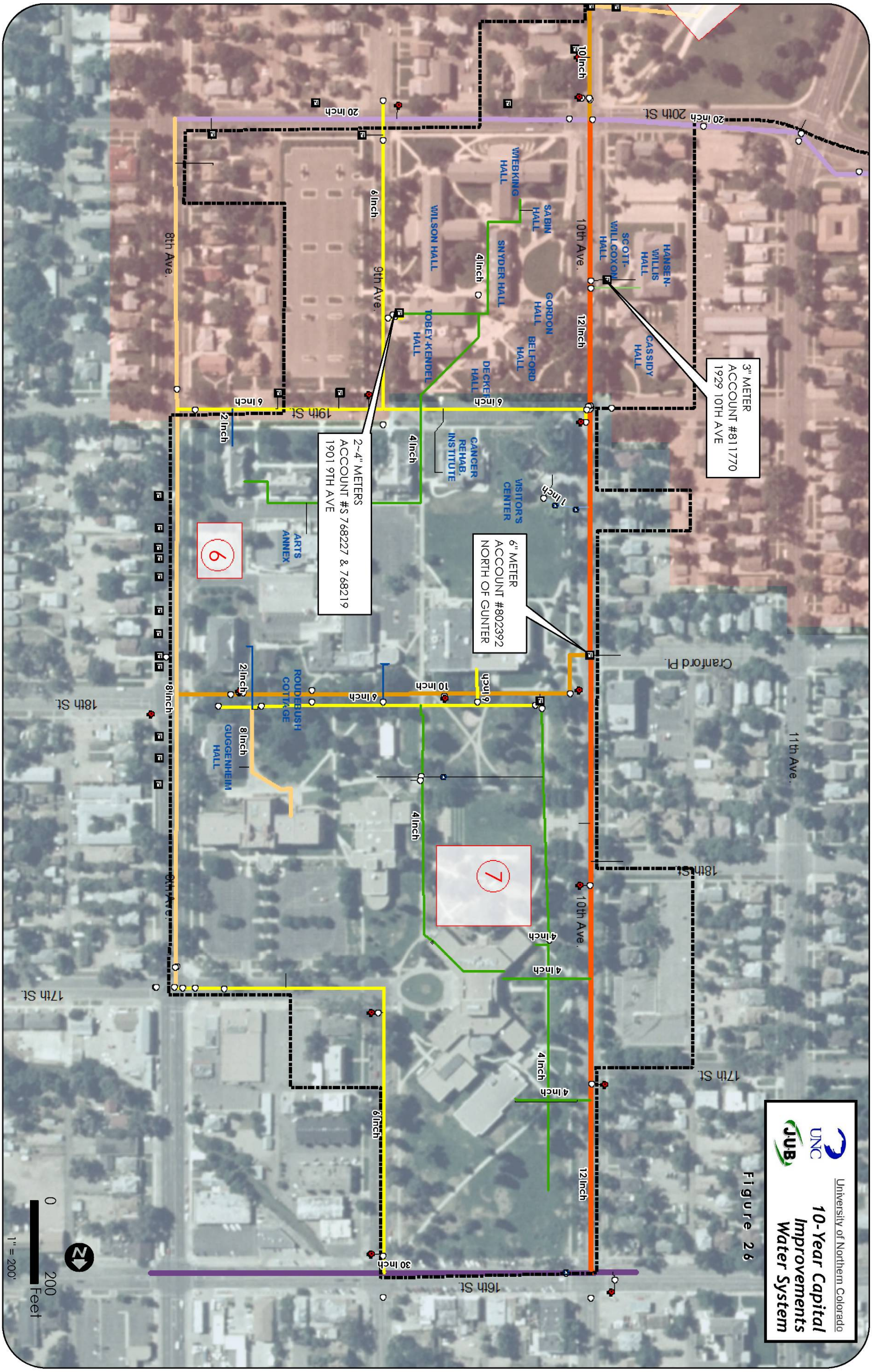
When both wings (north and south) of this new residence hall are completed they will house 721 students. These buildings will add a calculated maximum day demand of 22 gpm to the existing flows in addition to those already modeled for McCowen Hall which will ultimately be demolished as part of this project. The project will require 3 fire hydrants and a minimum 2,750 gpm fire flow for each wing. However, since plans for the utility sitework are underway these items have been included in the Fire analysis but have not been included in the cost estimate.

TABLE 31 – WATER AND FIRE DEMAND CALCULATIONS (10-YEAR CAPITAL CONSTRUCTION PLAN)

Location	New Construction Project	Square Footage (sf)	Additional Peak Flow (gpm)	IBC 2003 Constructio n Type	Sprinkler System	IFC 2003 Fire Flow (gpm)	No. IFC Fire Hydrants
1	Athletic Strength and Conditioning Addition to Butler Hancock Hall	5,500	30	IIA	Yes	1,500	1
2	West Campus Academic Building	80,000	95	IIA	Yes	2,000	2
3	Student Services, Administrative Center	80,000	100	IIA	Yes	2,000	2
4	Music Performance Addition to Foundation Hall	18,000	65	IIA	Yes	1,500	1
5	Animal Facility Expansion	25,000	65	IIA	Yes	1,500	1
6	Art Museum	13,000	50	IIA	Yes	1,500	1
7	Frasier Music Instruction Building Addition	80,000	100	IIA	Yes	2,000	2
8	Athletic Indoor Practice Facility	176,000	225	IIA	Yes	3,000	3
9A	West Campus Housing South	148,595	11	IIA	Yes	2,750	3
9B	West Campus Housing North	150,000	11	IIA	Yes	2,750	3-5


University of Northern Colorado
10-Year Capital Improvements Water System
Figure 24
Location
New Construction Projects
1 Athletic strength and conditioning addition to Butler Hancock Hall
2 West Campus Athletic Building
3 Student Services/Administrative Center
4 Music Performance Addition to Foundation Hall (Not Shown)
5 Animal Facility Expansion
6 Art Museum
7 Frasier Music Instruction Building Addition
8 Athletic Indoor Practice Facility
9a West Campus Housing South
9b West Campus Housing North
10a Upgrade Existing Pipe to Nottingham Hydrants
10b Upgrade Entrance Pipe to 12"
Legend
Pipes
By Size
8" New Pipes
12" New Pipes
Unknown
1"
2"
3"
4"
5"
6"
8"
10"
12"
20"
30"
City of Greeley Pressure Zones
Zone 1
Zone 2
Meters
Valves
Manholes
Fire Hydrants
0 200 Feet
1" = 200'
6" & 10" METER
ACCOUNT #749634
1100 20TH ST
CAMPUS RECREATION CENTER
HARRISON HALL
TURNER HALL
BUTLER HANCOCK HALL
JAMES A. MICHENER LIBRARY
CANDELARIA HALL
NOTTINGHAM FIELD
PATTON HOUSE
17th Ave.
14th Ave.
20th St.


University of Northern Colorado
10-Year Capital Improvements Water System
Figure 25
24th St.
23rd St.
22nd St.
21st St.
20th St.
11th Ave.
12 Inch Ave.
9th Ave.
HOLMES DINING HALL
LAWRENSON HALL
ROSS HALL
McKEE HALL
UNIVERSITY CENTER
BISHOP-LEHR HALL
WIEBKING HALL
SABIN HALL
WILSON HALL
SNYDER HALL
HANSEN-WILLIS HALL
SCOTT-WILLCOXON HALL
2" & 8" METER
ACCOUNT #779261
1000 20TH ST
9a
9b
3
8 Inch
6 Inch
10 Inch
20 Inch
4 Inch
0 200 Feet
1" = 200'


University of Northern Colorado
10-Year Capital Improvements
Water System
Figure 26
UNC
JUB
3" METER
ACCOUNT #811770
1929 10TH AVE
2~4" METERS
ACCOUNT #S 768227 & 768219
1901 9TH AVE
6" METER
ACCOUNT #802392
NORTH OF GUNTER
WIEBKING HALL
SABIN HALL
WILSON HALL
SNYDER HALL
GORDON HALL
BELFORD HALL
TOBEY-KENDEL HALL
DECKER HALL
HANSEN-WILLIS HALL
SCOTT-WILLCOXON HALL
CASSIDY HALL
CANCER REHAB. INSTITUTE
VISITORS CENTER
ARTS ANNEX
ROUDEBUSH COTTAGE
GUGGENHEIM HALL
8th Ave.
9th Ave.
10th Ave.
11th Ave.
16th St.
17th St.
18th St.
19th St.
20th St.
Cranford Pl.
6
7
0
200
Feet
1" = 200'

2.2.3 Water System Analysis

The West Campus water system was analyzed using Bentley's WaterCAD V8 XM hydraulic network analysis program utilizing the Hazen-Williams friction loss and energy equations. As discussed earlier, Central Campus was not analyzed in WaterCAD due to complexities of the system & unavailable City system data.

Existing water lines were modeled assuming a Hazen-Williams coefficient of friction of 135 for PVC water lines and 130 for concrete lined, ductile iron water lines. New water lines used a Hazen-Williams coefficient of friction of 130 for the 12" water line and 120 for the 8" water lines as required by the City of Greeley water standards for distribution mains.

Figure 27 shows the extents of the WaterCAD analysis. Figure 28 (2 pages) shows the controlling scenario results of the WaterCAD fire flow + max day analysis. The results from the model indicate that the existing water system with the proposed recommendations outlined in Section 2.2.2 will meet the anticipated peak day and fire flow demands for the building improvements shown in the 10-year Capital Improvement Plan.

2.2.4 Water System Summary

The University's 10-year Capital Construction Plan will add 7 new facilities to West Campus along with 2 additional improvements to the water system and 2 facilities to Central Campus. These projects will increase the demands placed upon the water system and a total probable estimated water system construction cost of $1,073,790 (see Table 32) will be necessary to service these projects.

It is recommended that some initial improvements be made that include upsizing the small diameter line that runs to Nottingham Field and upsizing the existing 10" line to 12" near 20th Street and 11th Avenue. Central Campus is located almost entirely in the City's lower pressure Zone 1. To maintain minimum fire flow requirements the Frasier Music Instruction Building will need to connect to the existing 12" City main in 10th Avenue. Future fire flows will be met for West Campus as well with the recommended improvements.

FIGURE 27 – FIRE FLOW AND MAXIMUM DAY ANALYSIS (1 OF 2)

Fire Flow Node FlexTable: Fire Flow Report (Current Time: 0.000 hours) (west campus.wtg)

Label	Flow (Total Needed) (gpm)	Flow (Total Available) (gpm)	Pressure (Calculated Residual Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Velocity of Maximum Pipe (ft/s)	Pipe w/Maximum Velocity
FH-1	1,500.00	1,501.00	44.3	39.9	782: J-47	6.73	1364: P-39
FH-10	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)
FH-11	1,500.00	1,501.00	53.4	37.2	782: J-47	6.36	1256: P-29
FH-12	1,500.00	1,501.00	54.2	37.0	782: J-47	5.79	1271: P-8
FH-13	1,500.00	1,501.00	53.3	37.9	782: J-47	5.82	1271: P-8
FH-14	1,500.00	1,501.00	54.0	37.7	782: J-47	5.63	1271: P-8
FH-15	1,500.00	1,501.00	44.8	39.1	782: J-47	9.58	1099: P-45
FH-16	1,500.00	1,501.00	29.1	38.8	782: J-47	17.03	1414: P-58
FH-17	1,500.00	1,501.00	54.4	39.1	782: J-47	5.55	1271: P-8
FH-18	1,500.00	1,501.00	51.6	39.2	782: J-47	5.76	1285: P-1001
FH-19	1,500.00	1,501.00	47.3	35.9	782: J-47	5.80	1065: P-2
FH-20	1,500.00	1,501.00	32.1	32.2	782: J-47	5.82	1285: P-1001
FH-21	1,500.00	1,501.00	31.5	31.9	782: J-47	5.83	1271: P-8
FH-3	1,500.00	1,501.00	41.1	38.7	782: J-47	17.03	1408: P-54
FH-30	1,500.00	1,501.00	51.7	38.6	782: J-47	6.35	1312: P-46
FH-4	1,500.00	1,501.00	51.8	38.8	782: J-47	5.45	1271: P-8

Title: west campus.wtg
Project Engineer:

west campus.wtg
Haestad Methods Solution Center
Bentley WaterCAD V8 XM Edition [08.09.165.12]

1/30/2008
27 Siemon Company Drive Suite 200 W Watertown, CT 06795
USA +1-203-755-1666
Page 1 of 2

FIGURE 27 – FIRE FLOW AND MAXIMUM DAY ANALYSIS (2 OF 2)

Fire Flow Node FlexTable: Fire Flow Report (Current Time: 0.000 hours) (west campus.wtg)

Label	Flow (Total Needed) (gpm)	Flow (Total Available) (gpm)	Pressure (Calculated Residual Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Velocity of Maximum Pipe (ft/s)	Pipe w/Maximum Velocity
FH-41	1,500.00	1,501.00	54.6	37.5	782: J-47	5.69	1271: P-8
FH-42	2,000.00	2,001.00	45.9	38.4	782: J-47	7.78	1507: P-81
FH-43	2,000.00	2,001.00	40.1	39.3	782: J-47	7.53	1364: P-39
FH-45	1,500.00	1,501.00	43.0	37.8	782: J-47	9.58	1499: P-75
FH-48	3,000.00	3,001.00	24.3	29.2	812: FH-20	9.99	1489: P-68
FH-49A	2,750.00	2,751.00	52.5	34.9	782: J-47	8.24	1285: P-1001
FH-49B	2,750.00	2,751.00	51.1	35.1	782: J-47	8.19	1271: P-8
FH-5	1,500.00	1,501.00	44.7	38.2	782: J-47	9.47	1089: P-28
FH-7	1,500.00	1,501.00	41.4	38.1	782: J-47	17.03	1440: P-61
FH-8	1,500.00	1,501.00	57.8	37.7	782: J-47	5.72	1271: P-8

Title: west campus.wtg

Project Engineer:

west campus.wtg

Haestad Methods Solution Center

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Page 2 of 2

TABLE 32 – WATER SYSTEM IMPROVEMENTS ESTIMATED OPINION OF PROBABLE CONSTRUCTION COSTS (SHEET 1 OF 2)

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL
Upgrade Existing Pipe to Nottingham Hydrants				
Remove Existing Water Line	1,500	LF	$ 15.00	$ 22,500
Install 8" Water Pipe w/Pavement Surface Repair	1,500	LF	$ 90.00	$ 135,000
Misc. Fittings and Appertanences	1	LS	$ 15,500.00	$ 15,500
Subtotal				*$ 173,000*
Upgrade Entrance Pipe to 12"				
Remove Existing Water Line	600	LF	$ 15.00	$ 9,000
Install 12" Water Pipe w/Pavement Surface Repair	600	LF	$ 100.00	$ 60,000
Misc. Fittings and Appertanences	1	LS	$ 7,200.00	$ 7,200
Subtotal				*$ 76,200*
1. Athletic Addition to Butler Hancock				
Remove Existing Water Line	550	LF	$ 15.00	$ 8,250
Install 8" Water Pipe w/Pavement Surface Repair	700	LF	$ 90.00	$ 63,000
Install Fire hydrants, assemblies, 6" line & valves	1	EA	$ 4,500.00	$ 4,500
Misc. Fittings and Appertanences	1	LS	$ 7,000.00	$ 7,000
Project 1 Subtotal				*$ 82,750*
2. West Campus Academic Building				
Install 8" Water Pipe w/Pavement Surface Repair	330	LF	$ 90.00	$ 29,700
Install Fire hydrants, assemblies, 6" line & valves	2	EA	$ 4,500.00	$ 9,000
Misc. Fittings and Appertanences	1	LS	$ 3,300.00	$ 3,300
Project 2 Subtotal				*$ 42,000*
3. Student Services/Administrative Center				
Remove Existing Water Line	430	LF	$ 15.00	$ 6,450
Install 8" Water Pipe w/Pavement Surface Repair	460	LF	$ 90.00	$ 41,400
Install Fire hydrants, assemblies, 6" line & valves	2	EA	$ 4,500.00	$ 9,000
Misc. Fittings and Appertanences	1	LS	$ 4,600.00	$ 4,600
Project 3 Subtotal				*$ 61,450*
4. Music Performance Addition to Foundation Hall				
Install 8" Water Pipe w/Pavement Surface Repair	500	LF	$ 90.00	$ 45,000
Install Fire hydrants, assemblies, 6" line & valves	1	EA	$ 4,500.00	$ 4,500
Misc. Fittings and Appertanences	1	LS	$ 5,000.00	$ 5,000
Project 4 Subtotal				*$ 54,500*
5. Animal Facility Expansion				
Install 8" Water Pipe w/Pavement Surface Repair	450	LF	$ 90.00	$ 40,500
Install Fire hydrants, assemblies, 6" line & valves	1	EA	$ 4,500.00	$ 4,500
Misc. Fittings and Appertanences	1	LS	$ 4,500.00	$ 4,500
Project 5 Subtotal				*$ 49,500*

TABLE 32 – WATER SYSTEM IMPROVEMENTS ESTIMATED OPINION OF PROBABLE CONSTRUCTION COSTS (SHEET 2 OF 2)

6. Art Museum				
Install Fire hydrants, assemblies, 6" line & valves	1	EA	$ 4,500.00	$ 4,500
Project 6 Subtotal				*$ 4,500*
7. Frasier Music Instruction Building				
Install 8" Water Pipe w/Pavement Surface Repair	500	LF	$ 90.00	$ 45,000
Install Fire hydrants, assemblies, 6" line & valves	2	EA	$ 4,500.00	$ 9,000
Misc. Fittings and Appertanences	1	LS	$ 5,000.00	$ 5,000
Project 7 Subtotal				*$ 59,000*
8. Athletic Indoor Practice Facility				
Install 8" Water Pipe w/Pavement Surface Repair	1,700	LF	$ 90.00	$ 153,000
Install Fire hydrants, assemblies, 6" line & valves	5	EA	$ 4,500.00	$ 22,500
Misc. Fittings and Appertanences	1	LS	$ 17,000.00	$ 17,000
Project 8 Subtotal				***$ 192,500***
OVERALL PROJECT (1-8) SUB-TOTAL				***$ 795,400***
MOBILIZATION (10%)				***$ 79,540***
CONSTRUCTION CONTINGENCY (10%)				***$ 79,540***
ENGINEERING DESIGN & CM (15%)				***$ 119,310***
TOTAL WATER SYSTEM IMPROVEMENT ESTIMATED COSTS				**$ 1,073,790**

SECTION 2.3 – SANITARY SEWER SYSTEM

2.3.1 Introduction / Background

The existing University of Northern Colorado (UNC) sanitary sewer system was examined in Section 1 and found to be adequate for current sewage flow conditions. Section 2 analyzes the impact of the new facilities identified in the 10-year Capital Construction Plan on the campus sewer system.

2.3.2 10-year Capital Construction Plan

As mentioned earlier in the report, the 10-year Capital Construction Plan has been based on the memorandum dated May 29, 2007, from Kirk Leichliter, Assistant Vice President, Facilities Management, to Andrew Carlson, Director, Capital Assets, Colorado Commission on Higher Education, with supplemental information provided by UNC staff.

The nine projects that will add sewage flow to the campus sewer system are briefly discussed below. Peak sewer flows for non-residence facilities have been estimated using the graph of “Probable Peak Flow” versus “Fixture Units on System”, published in EPA 625/1-80/012, peak flows from residence facilities have been estimated using the figure of 50 gallons / day / resident with a peaking factor of 2.91. (See Section 1 for further explanation.)

1) ***Athletic Strength and Conditioning Addition to Butler Hancock Hall***

This project is anticipated to add 5,500 gross square feet (gsf) to Butler Hancock Hall. Based on the ratio of number of fixture units (fu) to floor space in Butler Hancock Hall, 572 fu / 91,400 gsf or 6.25 fu / 1,000 gsf, the anticipated number of fixture units in the new addition is 34, which results in an estimated peak sewer flow from Figure 38 of 30 gallons per minute (gpm) or 0.07 cubic feet per second (cfs).

Note: Due to its planned location, this project will require the relocation of several segments of the sewer system between manhole A4 and A9.

2) ***West Campus Academic Building***

This project is anticipated to provide a new multi-story building just east of Candelaria Hall, with 80,000 gsf of floor space. Since the building function and size will be similar to that of Candelaria Hall, which has a floor space of 80,236 gsf and 215 fixture units, the new building is anticipated to have approximately 215 fixture units also, resulting in a peak sewer flow of 95 gpm or 0.21 cfs.

3) ***Student Services / Administrative Center***

This project is anticipated to provide a new multi-story building just north of the University Center, with 80,000 gsf of floor space. The building function will be similar to that of the University Center. Based on the University Center’s ratio of number of fixture units to floor space, 388 fu / 129,275 gsf, or 3.0 fu / 1,000 gsf, the anticipated number of fixture units in the new facility is 240 resulting in an estimated peak sewer flow of 100 gpm or 0.22 cfs.

4) ***Music Performance Addition to Foundation Hall***

This project is anticipated to add 18,000 gsf to the Foundation Hall. Based on the ratio of number of fixture units to floor space in the Foundation Hall, 74 fu / 14,349 gsf or 5.16 fu / 1,000 gsf, the anticipated number of fixture units in the new addition is 65 gpm or 0.14 cfs.

5) Animal Facility Expansion

This project is anticipated to provide a new multi-story building south of McKee Hall, with 25,000 gsf of floor space. Based on existing buildings of similar size, namely the Gray, Crabbe, and Guggenheim buildings, and the ratio of their total number of fixture units to their total gross square footage, 258 fu / 70,297 gsf or 3.67 fu / 1,000 gsf, the anticipated number of fixture units in the new facility is 92 resulting in a peak sewer flow of 65 gpm or 0.14 cfs.

6) Art Museum

This project is anticipated to provide a new single-story building just east of the Arts Annex Building with 13,000 gsf of floor space. Based on existing buildings of similar size, the Skinner Music Library, Arts Annex, and Foundation Hall, and their ratio of number of fixture units to their total gross square footage, 186 fu / 43,236 gsf or 4.3 fu / 1,000 gsf, the anticipated number of fixture units in the new facility is 56 resulting in a peak sewer flow of 50 gpm or 0.11 cfs.

7) Frasier Music Instruction Building Addition

This project is anticipated to provide a multi-story addition to Frasier Hall with 80,000 gsf of floor space. Based on Frasier Hall’s ratio of 320 fixture units per 112,332 gsf or 2.85 fu / 1,000, it is anticipated that the number of fixture units in the new facility will be 228 resulting in a peak sewer flow of 100 gpm or 0.22 cfs.

8) Athletic Indoor Practice Facility

This project is anticipated to provide a new indoor sports facility south of Nottingham field, with 176,000 gsf of floor space. Comparing this facility with the Butler Hancock Hall and its ratio of fixture units to gsf, 572 fu / 91,400 gsf or 6.25 fu / 1,000 gsf, the anticipated number of fixture units in the new facility is 1,100 resulting in a peak sewer flow of 225 gpm or 0.5 cfs.

9) West Campus Housing

When both wings of this new residence hall are completed they will house 721 students, which is 217 students more than the current facility, McCowen Hall, accommodates. Based on the number of additional students housed, it is anticipated that the new facility will generate an additional sewer flow of 22 gpm or 0.05 cfs over what was generated by McCowen Hall.

These projects along with their proposed connection points, except for #4, Music Performance Addition to Foundation Hall, are shown in Figures 29 thru 32.

It is anticipated that Projects #3, #4, #6, and #7 will connect directly to the city sewer system via new service lines and have no impact on the existing campus sewer system.

2.3.3 Sewer System Analysis

The additional peak sewer flow from each of the projects in the 10-year Capital Construction Plan has been added to the sewer system at locations shown on Figures 29 thru 32. Existing peak flow rates and pipe capacities were taken from the previously shown calculation spreadsheet, Table 14.

The impacts of the added sewer flows downstream of the connection points are shown in Table 33. The data in this table assumes the worse case condition that the peak flows from each of the contributing facilities are additive in the given segment of pipe at a particular point in time when in fact the peaks from each of the facilities will naturally be staggered somewhat, lessening the actual peak flow rate.

Pipe segments that carry more than the “one-half” full pipe capacity limit with the addition of the new facilities are discussed below. As mentioned in Section 1, sanitary sewer pipes are usually designed to flow at one-half full to provide air space above the flowing liquid for the transfer of sewer gasses.

Pipe Segment A10 – A11

Approximately 282 lf of 10-inch diameter PVC pipe. The estimated peak flow with the addition of projects #1 and #8 is 1.00 cfs. The “one-half” full pipe capacity is 0.8 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 5.9 inches. Full flow capacity is 1.60 cfs. This segment of pipe should function satisfactorily with the addition of the new facilities.

Pipe Segment A15 – A16

Approximately 270 lf of 15-inch diameter PVC pipe. The estimated peak flow rate with the addition of projects #1, #2, #5, #8, and #9 is 3.54 cfs. The “one-half” full pipe capacity is 2.55 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 9.3 inches. Full flow capacity is 5.0 cfs. Again noting that it is highly unlikely that all of the upstream facilities will add peak flows at the same time, this segment of pipe should function satisfactorily with the addition of the new facilities.

Pipe Segments L8 –L9

Approximately 204 lf of 12-inch diameter PVC pipe. The estimated peak flow rate with the addition of projects #2 and #5 is 1.09 cfs. The “one-half” full pipe capacity is 0.69 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 6.7 inches.

Full flow capacity is 1.38 cfs. This segment of pipe is only slightly over the “one-half” pipe capacity and should function satisfactorily with the addition of the new facilities.

Pipe Segment L9 –L10

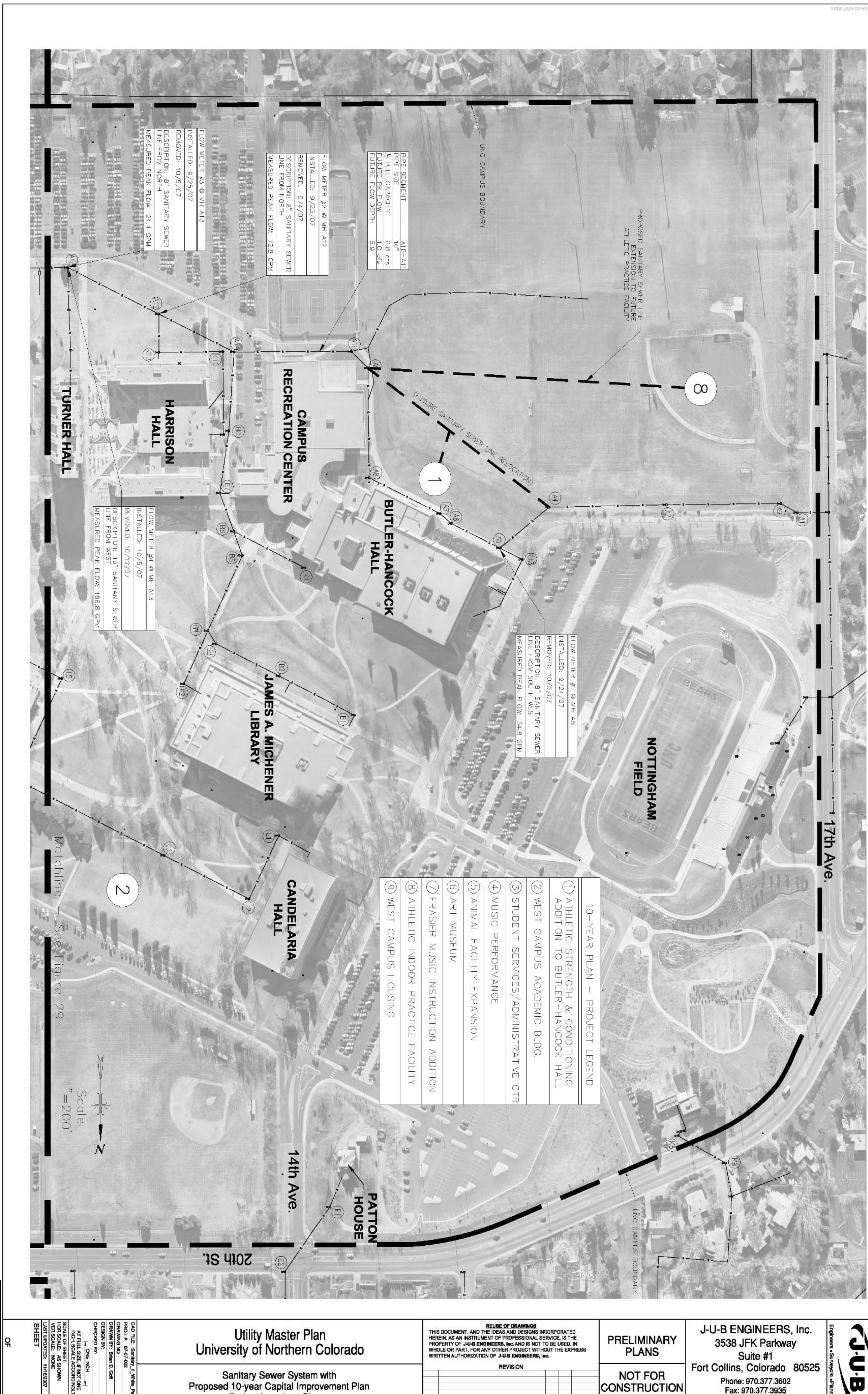
Approximately 104 lf of 12-inch diameter PVC pipe. The estimated peak flow rate with the addition of projects #2 and #5 is 1.09 cfs. The “one-half” full pipe capacity is 0.69 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 6.7 inches. Full flow capacity is 1.38 cfs. This segment of pipe is only slightly over the “one-half” pipe capacity and should function satisfactorily with the addition of the new facilities.

Pipe Segment L10 –L11

Approximately 95 lf of 12-inch diameter PVC pipe. The estimated peak flow rate with the addition of projects #2 and #5 is 1.09 cfs. The “one-half” full pipe capacity is 0.69 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 6.7 inches. Full flow capacity is 1.38 cfs. This segment of pipe is only slightly over the “one-half” pipe capacity and should function satisfactorily with the addition of the new facilities.

Pipe Segment L11-D7

Approximately 86 lf of 12-inch diameter PVC pipe. The estimated peak flow rate with the addition of projects #2 and #5 is 1.09 cfs. The “one-half” full pipe capacity is 0.69 cfs. At the estimated peak flow rate, the pipe will flow at a depth of approximately 6.7 inches. Full flow capacity is 1.38 cfs. This segment of pipe is only slightly over the “one-half” pipe capacity and should function satisfactorily with the addition of the new facilities.



10-YEAR PLAN – PROJECT LEGEND
1 ATHLETIC STRENGTH & CONDITIONING ADDITION TO BUTLER-HANCOCK HALL
2 WEST CAMPUS ACADEMIC BLDG.
3 STUDENT SERVICES/ADMINISTRATIVE CTR
4 MUSIC PERFORMANCE
5 ANIMAL FACILITY EXPANSION
6 ART MUSEUM
7 FRASIER MUSIC INSTRUCTION ADDITION
8 ATHLETIC INDOOR PRACTICE FACILITY
9 WEST CAMPUS HOUSING
FLOW METER #3 @ MH A13
INSTALLED: 8/29/07
REMOVED: 10/5/07
DESCRIPTION: 8" SANITARY SEWER LINE FROM NORTH
MEASURED PEAK FLOW: 24.4 GPM
FLOW METER #2 @ MH A12
INSTALLED: 9/23/07
REMOVED: 10/4/07
DESCRIPTION: 8" SANITARY SEWER LINE FROM NORTH
MEASURED PEAK FLOW: 72.8 GPM
FLOW METER #4 @ MH A13
INSTALLED: 10/5/07
REMOVED: 10/12/07
DESCRIPTION: 15" SANITARY SEWER LINE FROM WEST
MEASURED PEAK FLOW: 166.8 GPM
FLOW METER #1 @ MH A5
INSTALLED: 8/24/07
REMOVED: 10/5/07
DESCRIPTION: 8" SANITARY SEWER LINE FROM SOUTH WEST
MEASURED PEAK FLOW: 34.8 GPM
PIPE SEGMENT A10-A11
PIPE SIZE 10"
FULL CAPACITY 0.8 cfs
FUTURE FLOW 1.0 cfs
FUTURE FLOW DEPTH 5.9"
UNC CAMPUS BOUNDARY
PROPOSED SANITARY SEWER LINE EXTENSION TO FUTURE ATHLETIC PRACTICE FACILITY
(FUTURE SANITARY SEWER LINE RELOCATION)
TURNER HALL
HARRISON HALL
CAMPUS RECREATION CENTER
BUTLER-HANCOCK HALL
JAMES A. MICHENER LIBRARY
CANDELARIA HALL
NOTTINGHAM FIELD
PATTON HOUSE
17th Ave.
14th Ave.
20th St.
Matchline – See Figure 29
Scale 1"=200'
N
Utility Master Plan
University of Northern Colorado
Sanitary Sewer System with
Proposed 10-year Capital Improvement Plan
Project Locations Shown
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
J-U-B ENGINEERS, Inc.
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com

FIGURE 28

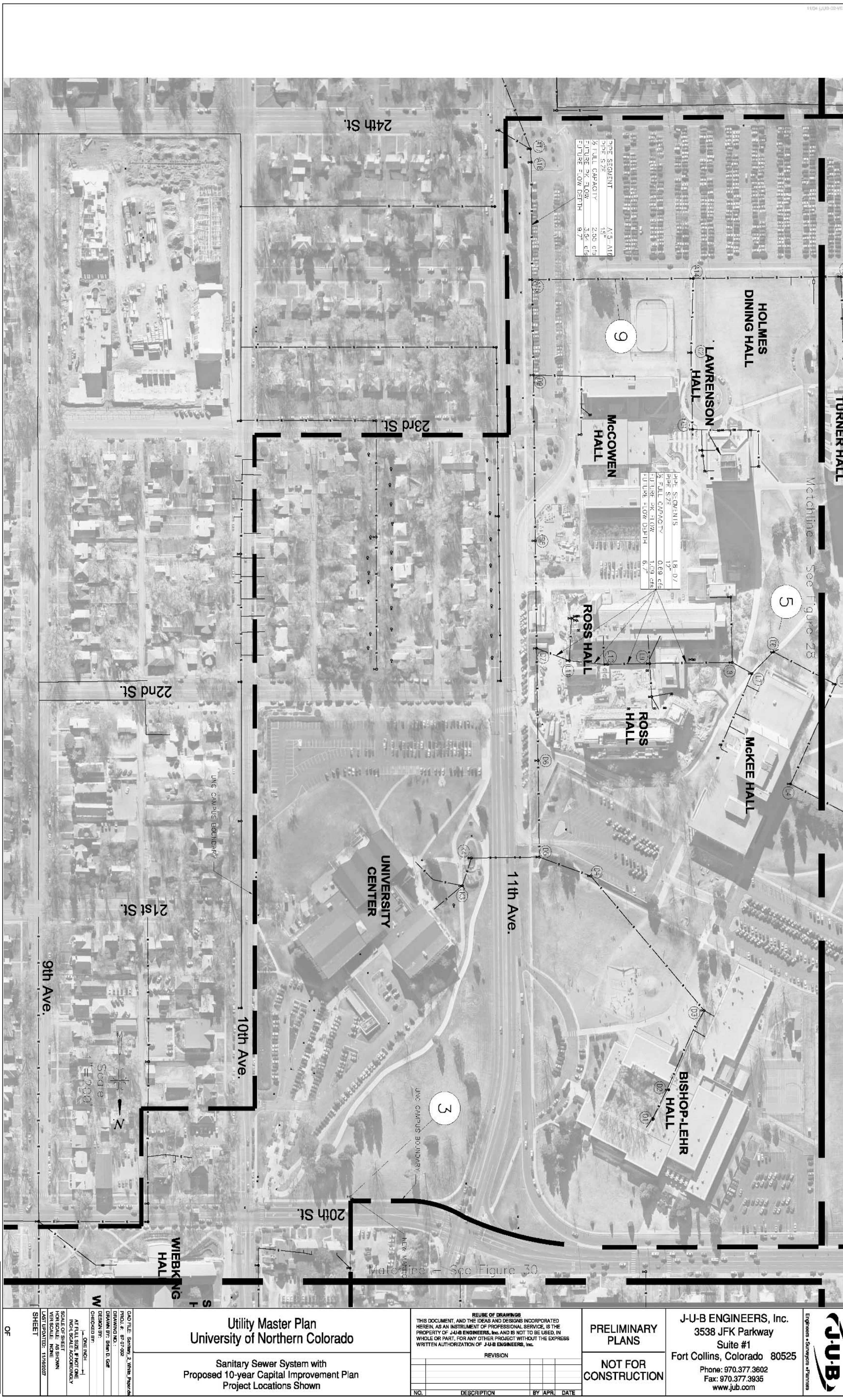
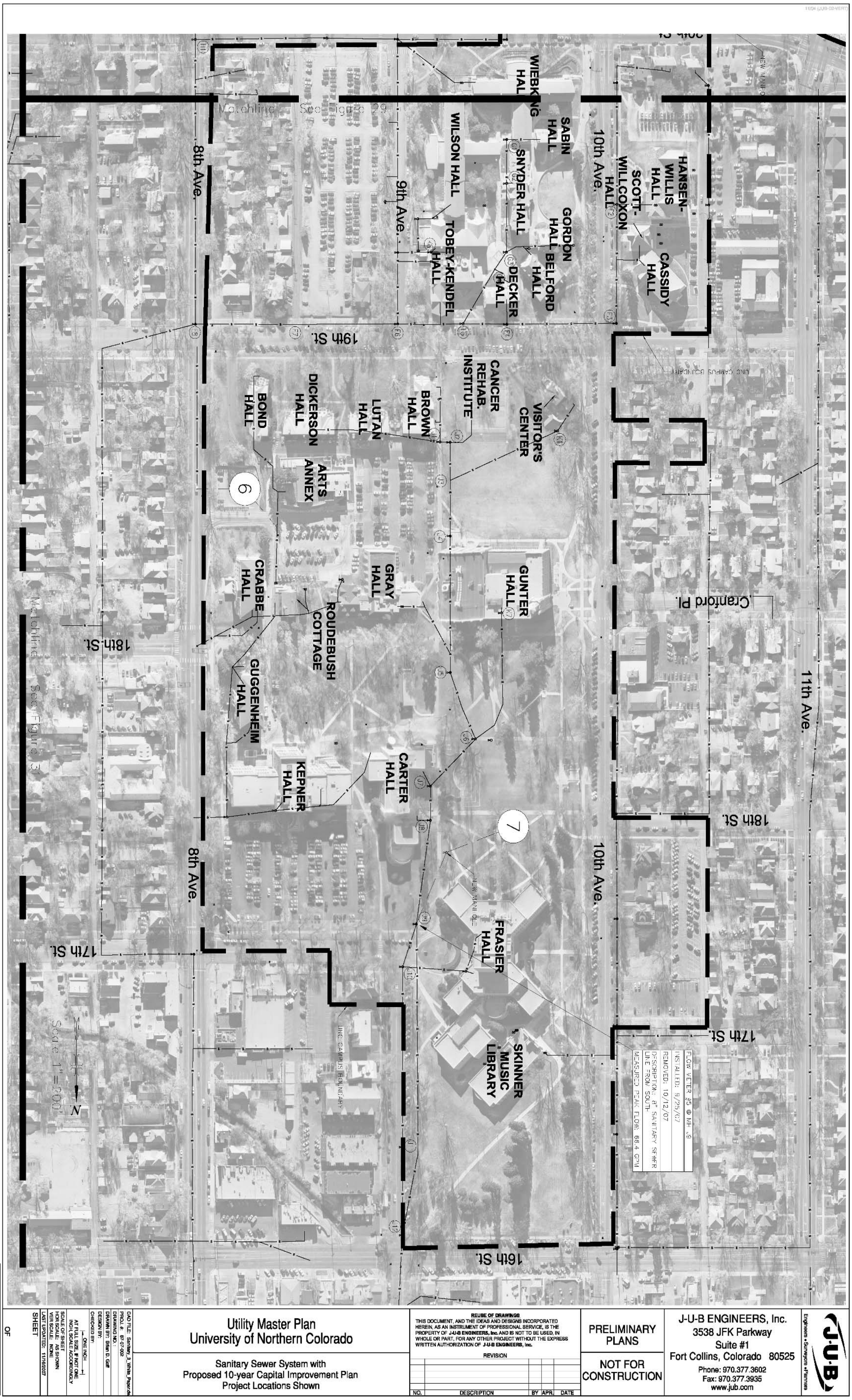

24th St.
23rd St.
22nd St.
21st St.
20th St.
9th Ave.
10th Ave.
11th Ave.
HOLMES DINING HALL
LAWRENSON HALL
TURNER HALL
McCOWEN HALL
ROSS HALL
ROSS HALL
McKEE HALL
UNIVERSITY CENTER
BISHOP-LEHR HALL
WIEBKING HALL
UNC CAMPUS BOUNDARY
Matchline — See Figure 28
Matchline — See Figure 30
Utility Master Plan
University of Northern Colorado
Sanitary Sewer System with
Proposed 10-year Capital Improvement Plan
Project Locations Shown
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
J-U-B ENGINEERS, Inc.
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com
REVISION
NO.
DESCRIPTION
BY
APR.
DATE

FIGURE 29


Matchline – See Figure 29
Matchline – See Figure 31
8th Ave.
9th Ave.
10th Ave.
11th Ave.
19th St.
18th St.
17th St.
16th St.
20th St.
Cranford Pl.
WIEBKING HALL
SABIN HALL
WILSON HALL
SNYDER HALL
GORDON HALL
BELFORD HALL
TOBEY-KENDEL HALL
DECKER HALL
HANSEN-WILLIS HALL
SCOTT-WILLCOXON HALL
CASSIDY HALL
CANCER REHAB. INSTITUTE
VISITOR'S CENTER
BROWN HALL
LUTAN HALL
DICKERSON HALL
BOND HALL
ARTS ANNEX
GRAY HALL
GUNTER HALL
CRABBE HALL
ROUDEBUSH COTTAGE
GUGGENHEIM HALL
KEPNER HALL
CARTER HALL
FRASIER HALL
SKINNER MUSIC LIBRARY
UNC CAMPUS BOUNDARY
6
7
FLOW METER #5 @ MH J9
INSTALLED: 9/25/07
REMOVED: 10/12/07
DESCRIPTION: 8" SANITARY SEWER LINE FROM SOUTH
MEASURED PEAK FLOW: 68.4 GPM
Scale 1"=200'
N
Utility Master Plan
University of Northern Colorado
Sanitary Sewer System with
Proposed 10-year Capital Improvement Plan
Project Locations Shown
REUSE OF DRAWINGS
THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF J-U-B ENGINEERS, Inc. AND IS NOT TO BE USED, IN WHOLE OR PART, FOR ANY OTHER PROJECT WITHOUT THE EXPRESS WRITTEN AUTHORIZATION OF J-U-B ENGINEERS, Inc.
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NO. DESCRIPTION BY APR. DATE
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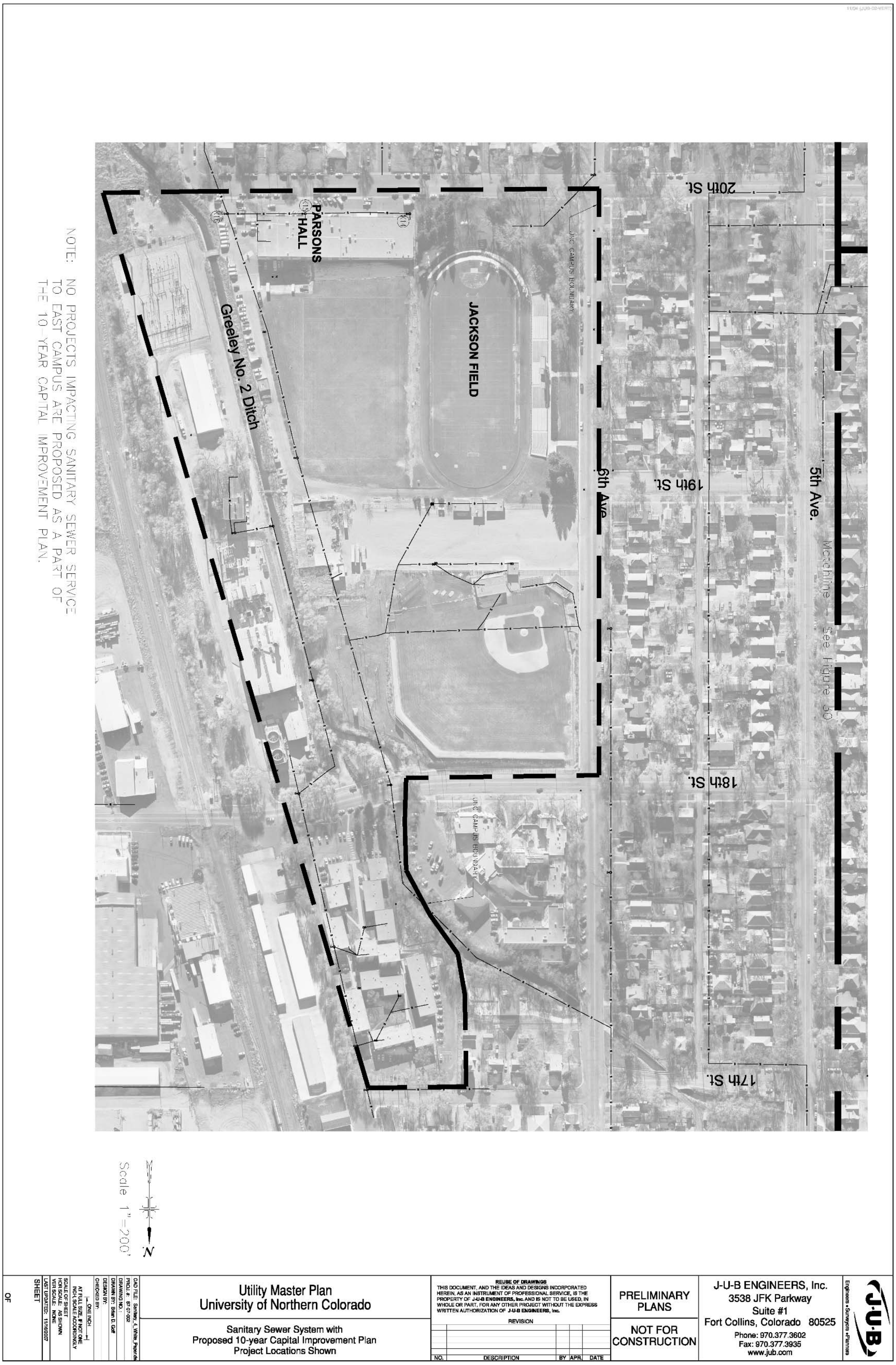
3538 JFK Parkway
Suite #1
Fort Collins, Colorado 80525
Phone: 970.377.3602
Fax: 970.377.3935
www.jub.com
SHEET
OF

FIGURE 30


NOTE: NO PROJECTS IMPACTING SANITARY SEWER SERVICE TO EAST CAMPUS ARE PROPOSED AS A PART OF THE 10-YEAR CAPITAL IMPROVEMENT PLAN.
PARSONS HALL
JACKSON FIELD
Greeley No. 2 Ditch
20th St.
19th St.
18th St.
17th St.
6th Ave.
5th Ave.
Matchline – See Figure 30
UNC CAMPUS BOUNDARY
Scale 1"=200'
N
Utility Master Plan
University of Northern Colorado
Sanitary Sewer System with
Proposed 10-year Capital Improvement Plan
Project Locations Shown
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
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Fort Collins, Colorado 80525
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Fax: 970.377.3935
www.jub.com

FIGURE 31

TABLE 33 – ADDITIONAL SEWER FLOW FROM 1O-YEAR CAPITAL CONSTRUCTION PLAN

Upstream Manhole	Downstream Manhole	Pipe Diameter (inches)	Existing Peak Flow Rate (cfs)	Add'l Peak Flow Rate (cfs)					Total Projected Flow Rate (cfs)	One-Half Full Pipe "Capacity (cfs)	Full Pipe Capacity (cfs)	% Full Flow Capacity	Depth of Flow (inches)
				Proj #1	Proj #2	Proj #5	Proj #8	Proj #9					
A9	A10	10	0.43	0.07			0.5		1.00	1.22	2.44	41	
A10	A11	10	0.43	0.07			0.5		1.00	0.8	1.60	63	5.9
A11	A12	15	0.98	0.07			0.5		1.55	3.23	6.46	24	
A12	A13	15	1.11	0.07			0.5		1.68	3.28	6.56	26	
A13	A14	15	1.3	0.07			0.5		1.87	3.31	6.62	28	
A14	A15	15	1.42	0.07			0.5	0.05	2.04	3.35	6.70	30	
A15	A16	15	2.57	0.07	0.21	0.14	0.5	0.05	3.54	2.55	5.10	69	9.7
D5	D6	15	0.28		0.21				0.49	2.05	4.10	12	
D6	D7	15	0.28		0.21				0.49	2.05	4.10	12	
D7	D8	15	1.03		0.21	0.14			1.38	2.05	4.10	34	
D8	D9	15	1.03		0.21	0.14			1.38	4.68	9.36	15	
D9	A15	15	1.15		0.21	0.14			1.50	6.37	12.74	12	
L3	L4	10	0.18		0.21				0.39	0.82	1.64	24	
L4	L5	10	0.18		0.21				0.39	0.87	1.74	22	
L5	L6	10	0.18		0.21	0.14			0.53	0.68	1.36	39	
L6	L7	10	0.18		0.21	0.14			0.53	1.21	2.42	22	
L7	L8	10	0.43		0.21	0.14			0.78	1.91	3.82	20	
L8	L9	12	0.74		0.21	0.14			1.09	0.69	1.38	79	6.7
L9	L10	12	0.74		0.21	0.14			1.09	0.69	1.38	79	6.7
L10	L11	12	0.74		0.21	0.14			1.09	0.69	1.38	79	6.7
L11	D7	12	0.74		0.21	0.14			1.09	0.69	1.38	79	6.7

Pipe capacity based on assumed minimum slope of 0.004 ft/ft (0.4%)

TABLE 34 – SUMMARY OF PIPE FLOWS GREATHER THAN 0NE-HALF FULL

Upstream Manhole	Downstream Manhole	Pipe Diameter (Inches)	Total Projected Flow Rate (cfs)	One-Half Full Pipe "Capacity (cfs)	Full Pipe Capacity (cfs)	% Full Flow Capacity	Depth of Flow (inches)
A10	A11	10	1.00	0.8	1.6	63	5.9
A15	A16	15	3.54	2.5	5	71	9.3
L8	L9	12	1.09	0.69	1.38	79	6.7
L9	L10	12	1.09	0.69	1.38	79	6.7
L10	L11	12	1.09	0.69	1.38	79	6.7
L11	D7	12	1.09	0.69	1.38	79	6.7

Pipe capacity based on assumed minum slope of 0.004 ft/ft (0.4%)

2.3.4 Summary and Conclusions

The University's 10-year Capital Construction Plan will add nine new facilities to the campus, which will increase the demands placed upon the sewer system. Based upon preliminary estimates of building size (gross square footage), building function, and, in the case of West Campus Housing, the number of additional residents to be housed, preliminary estimates of peak sewer flow rates were calculated using methods presented in Section 1. These peak flow rates were then introduced into the campus sanitary sewer system at logical connection points based availability of sewer capacity.

Since it is impossible to predict the time sequence of the peak flow from each facility, as a conservative approach the peak flows from all facilities that contribute to a point have been added together to provide the design peak flow at the point being analyzed.

A hydraulic analysis of the sewer system with the additional load from the new facilities indicates that several segments of the system may temporarily carry flow rates that exceed the pipe capacity based on the "one-half" full flow rate criteria. A summary of the pipe segments that fall into this category is shown previously in Table 34.

As can be seen, none of the segments carries more than the "full-flow" pipe capacity under peak flow conditions. Based upon the conservative manner in which the peak flow rates have been applied, the existing campus sanitary sewer system appears to be sufficient from a hydraulic standpoint to provide adequate service for the facilities projected to be constructed in the 10-year Capital Construction Plan. As more detailed planning develops, the actual number of fixtures in the case of non-residence facilities, and number of additional residents in the case of residence halls, should be compared with those projected in this report to validate these conclusions.

SECTION 2.4 – INFORMATIONAL TECHNOLOGY

2.4.1 Introduction / Background

Section 2 has been prepared to evaluate the current deficiencies and the anticipated future campus development on existing infrastructure systems. In the case of the technology systems, the addition of new buildings on campus will increase the amount of required backbone infrastructure to support these buildings. Site plans showing schematic views of campus connectivity are included at the end of this section for reference.

2.4.2 Technology System Analysis

The major technology campus backbone consists of four buildings with four main routers. They are as follows:

Carter Hall

Gray Hall

McKee Hall

Ross Hall

There is a multi-homing through Gray Hall to Carter Hall. The current Points of Presence (POPS) from the Local Exchange Carriers (LECS) are in Carter Hall and Gray Hall. Qwest fiber is within Carter Hall. Qwest copper and Level3 fiber is within Gray Hall.

2.4.3 Summary and Conclusions

The University's 10-year Capital Construction Plan will add nine new facilities to the campus, which will increase the demands placed upon the Technology System Backbone. Based upon meetings and report findings all new building projects shall have a minimum of 12-strand but should have 24-strands of Single Mode Fiber (8.3mm) installed to the respective support facility.

The following copper links should be replaced with single mode fiber they are as follows:

Judy Farr House to Patton House

Roudebush Cottage to Crabbe Hall

Davis House to Khol House

Hansen-Willis Hall to Khol House

To support network and other technologies the need to have single mode fiber:

Carter Hall to Foundation Hall

Carter Hall to Young House

Hansen-Willis Hall to Khol House

The following standards should be implemented going forwards for each new project:

All fiber shall be installed in innerduct.

Two fiber cables to be installed in independent paths.

West Campus:

One Fiber cable to McKee Hall

One Fiber cable to Ross Hall

Central Campus:

One Fiber cable to Carter Hall

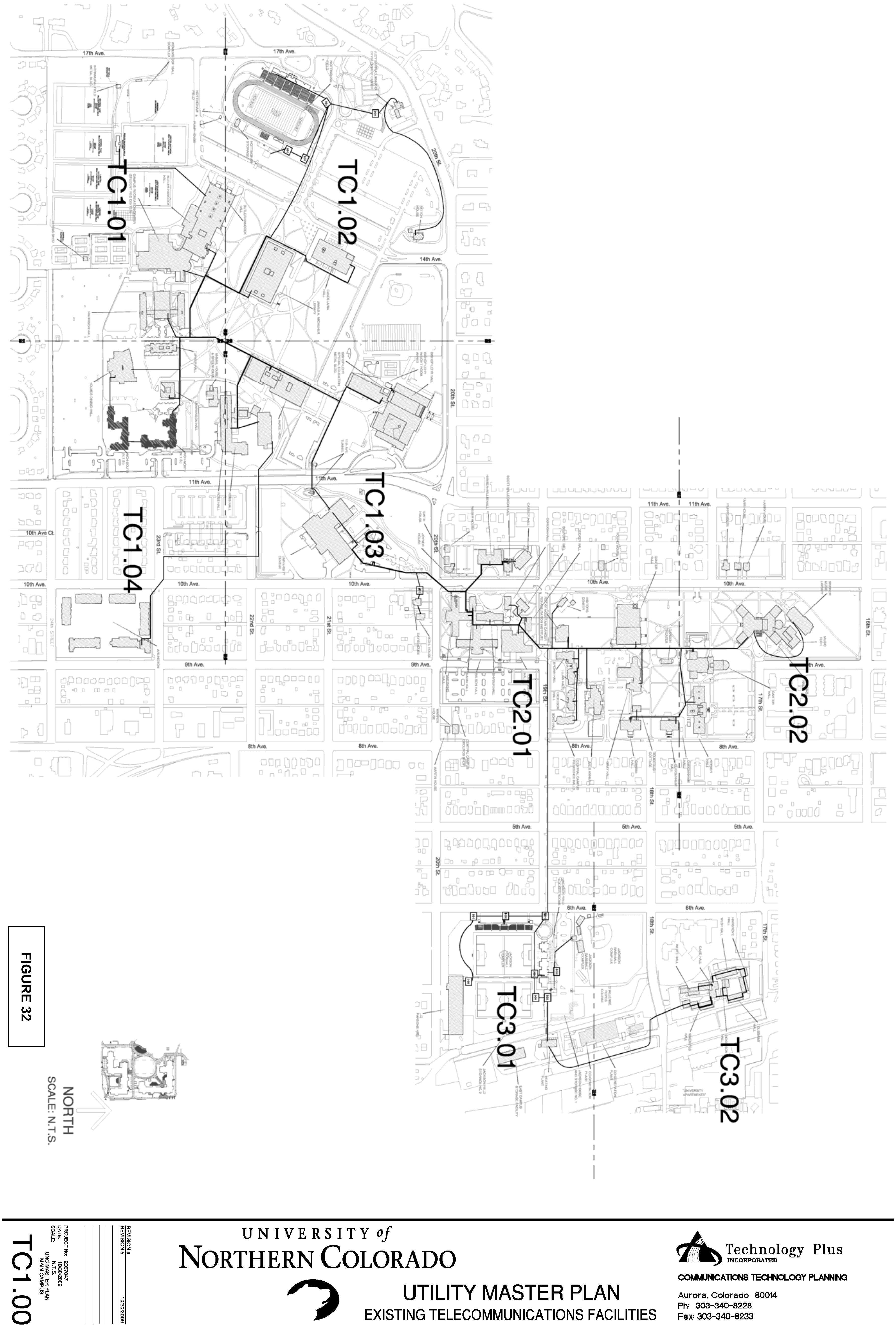
One Fiber cable to Gray Hall

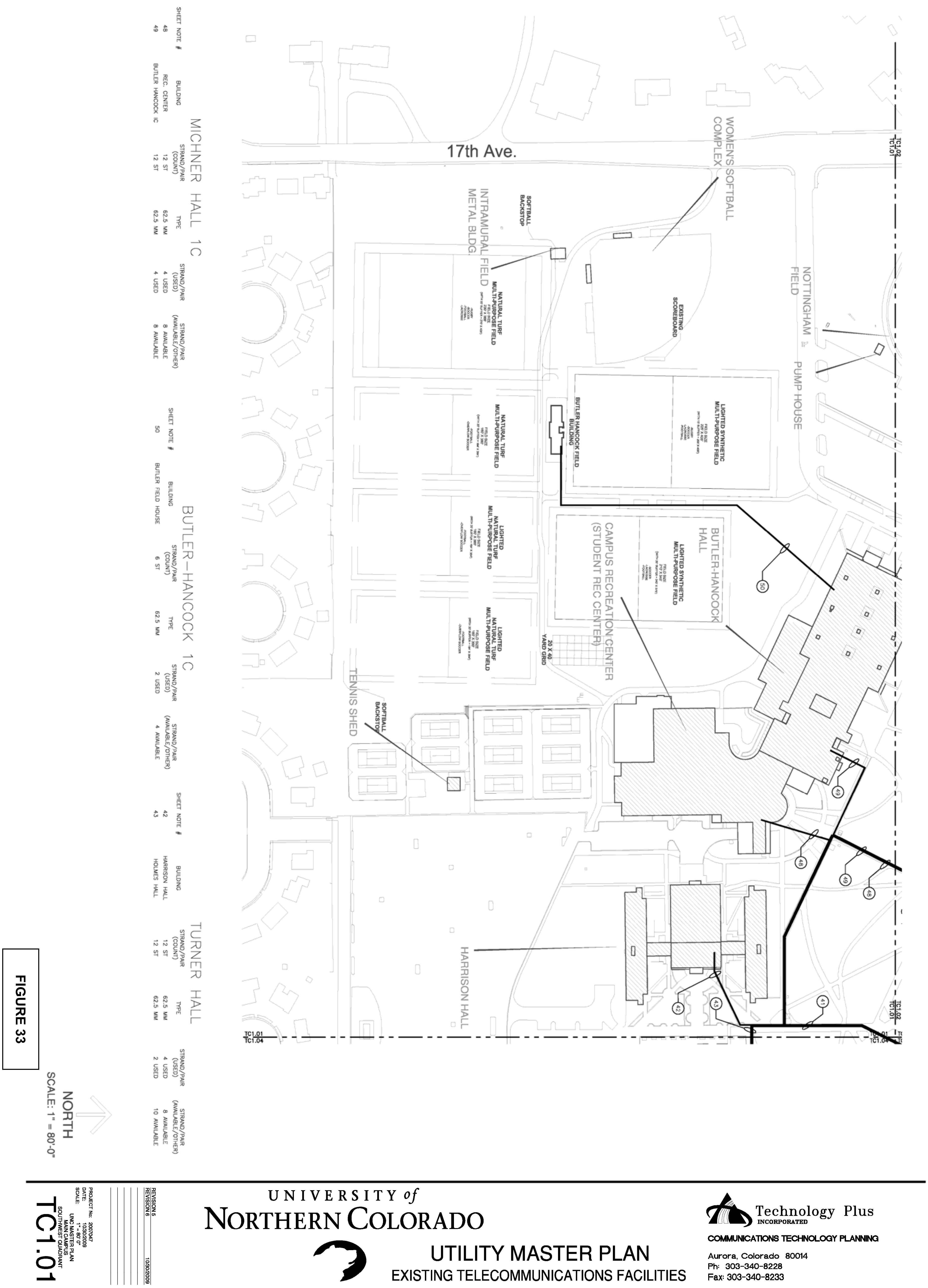
Minimum separation of cables should a minimum of 3 feet if possible.

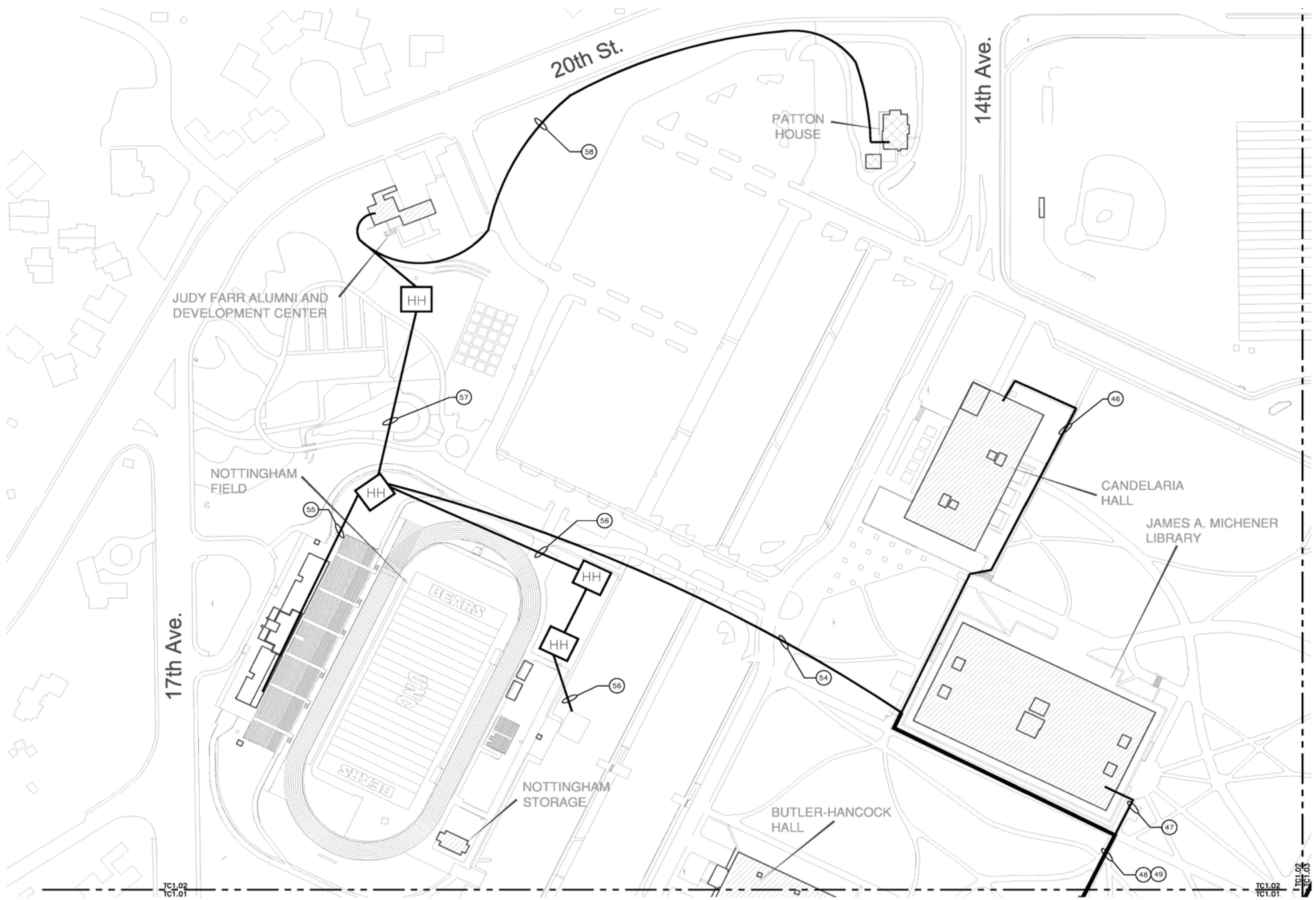
As more and more technologies depend on the network it is vital to have a robust backbone to carry the needs such as security, fire alarm, building automation, IPTV, data and VoIP. It is estimated that within two to three years the UNC campus will need a complete 10 gig backbone; this can only be accomplished via single mode fiber.

In conclusion the UNC IT department felt that deficiencies on the campus are more critical than repair. The IT department is in process of preparing a list of deficiencies and repairs needed and rank the project accordingly. Also IT is preparing a 1-2 year, a 3-5 year and a 5+ year plan that can be added as an appendix to this document when complete.

As the campus moves forwards with additional facilities more pathways will need to be built and single mode fiber installed in redundant pathways to the appropriate backbone facilities.


TC1.01
TC1.02
TC1.03
TC1.04
TC2.01
TC2.02
TC3.01
TC3.02
FIGURE 32
NORTH
SCALE: N.T.S.
UNIVERSITY of
NORTHERN COLORADO
UTILITY MASTER PLAN
EXISTING TELECOMMUNICATIONS FACILITIES
Technology Plus
INCORPORATED
COMMUNICATIONS TECHNOLOGY PLANNING
Aurora, Colorado 80014
Ph: 303-340-8228
Fax: 303-340-8233
TC1.00


17th Ave.
WOMEN'S SOFTBALL COMPLEX
NOTTINGHAM FIELD
PUMP HOUSE
INTRAMURAL FIELD METAL BLDG.
BUTLER-HANCOCK HALL
CAMPUS RECREATION CENTER (STUDENT REC CENTER)
TENNIS SHED
HARRISON HALL
MICHNER HALL 1C
BUTLER-HANCOCK 1C
TURNER HALL
FIGURE 33
NORTH
SCALE: 1" = 80'-0"
TC1.01
UNIVERSITY of NORTHERN COLORADO
UTILITY MASTER PLAN
EXISTING TELECOMMUNICATIONS FACILITIES
Technology Plus INCORPORATED
COMMUNICATIONS TECHNOLOGY PLANNING
Aurora, Colorado 80014
Ph: 303-340-8228
Fax: 303-340-8233



MCKEE HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
46	CANDELARIA HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
47	MICHENER HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
49	BUTLER HANCOCK IC	12 ST	62.5 MM	4 USED	8 AVAILABLE
54	NOTTINGHAM MANHOLE	12 ST	62.5 MM	12 USED	0 AVAILABLE
55	NOTTINGHAM FIELD HOUSE (WEST)	4 ST	62.5 MM	4 USED	0 AVAILABLE

NOTTINGHAM FIELD HOUSE (WEST)

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
56	NOTTINGHAM EAST	6 ST	62.5 MM	2 USED	4 AVAILABLE

MICHENER LIBRARY

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
48	REC. CENTER	12 ST	62.5 MM	2 USED	10 AVAILABLE

JUDY FARR

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
58	PATTON HOUSE		COPPER		

NORTH
SCALE: 1" = 80'-0"

FIGURE 34

UNIVERSITY of NORTHERN COLORADO

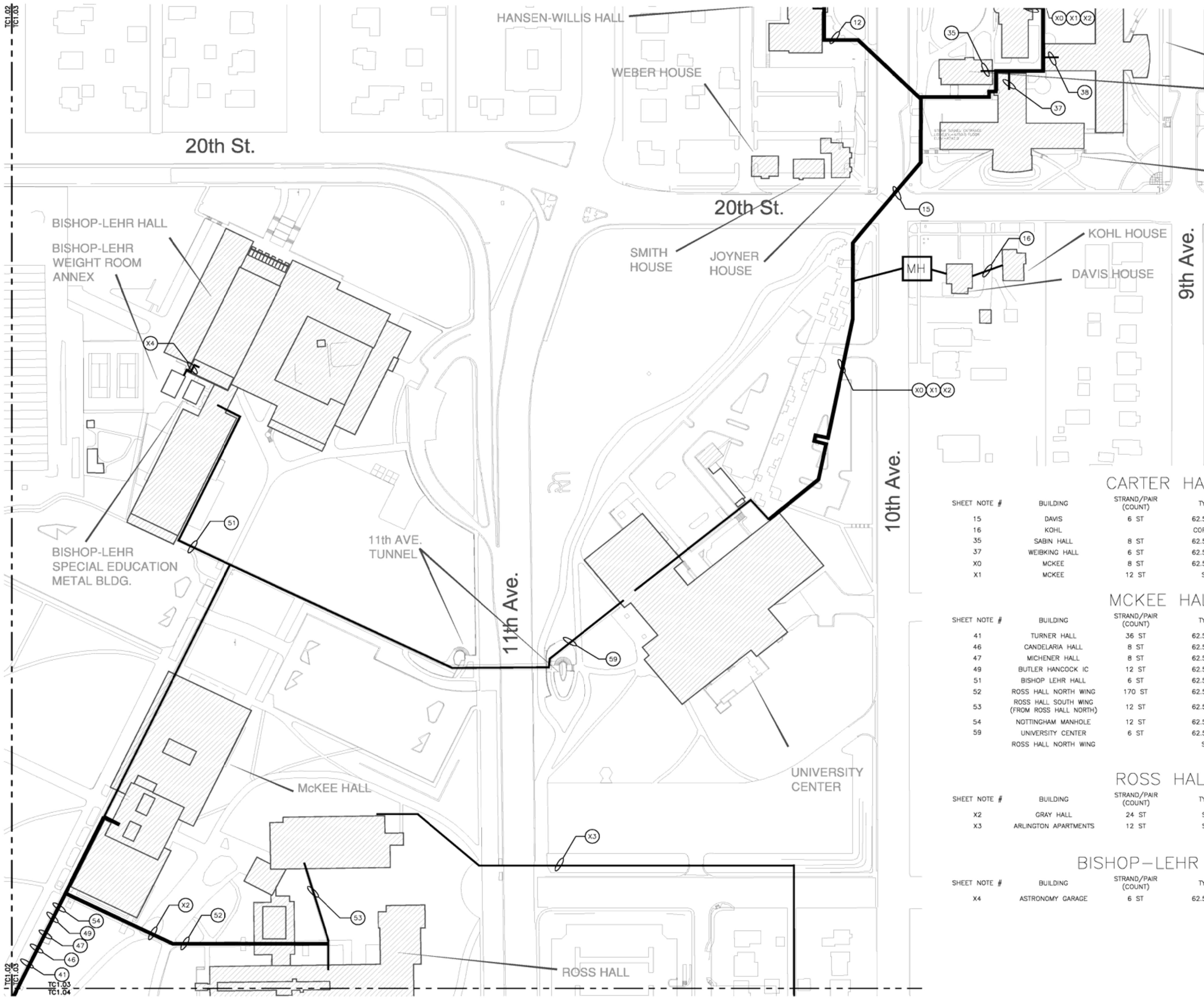
UTILITY MASTER PLAN
EXISTING TELECOMMUNICATIONS FACILITIES

Technology Plus INCORPORATED
COMMUNICATIONS TECHNOLOGY PLANNING
Aurora, Colorado 80014
Ph: 303-340-8228
Fax: 303-340-8233

REVISION 4
REVISION 5 10/30/2009

PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80' 0"
UNC MASTER PLAN
MAIN CAMPUS
NORTHWEST QUADRANT

TC1.02



CARTER HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
15	DAVIS	6 ST	62.5 MM	2 USED	4 AVAILABLE
16	KOHL		COPPER		
35	SABIN HALL	8 ST	62.5 MM	2 USED	6 AVAILABLE
37	WEIBKING HALL	6 ST	62.5 MM	2 USED	4 AVAILABLE
X0	MCKEE	8 ST	62.5 MM	0 USED	8 AVAILABLE
X1	MCKEE	12 ST	SM	8 USED	4 AVAILABLE

MCKEE HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
41	TURNER HALL	36 ST	62.5 MM	4 USED	32 AVAILABLE
46	CANDELARIA HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
47	MICHENER HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
49	BUTLER HANCOCK IC	12 ST	62.5 MM	4 USED	8 AVAILABLE
51	BISHOP LEHR HALL	6 ST	62.5 MM	6 USED	0 AVAILABLE
52	ROSS HALL NORTH WING	170 ST	62.5 MM	28 USED	142 AVAILABLE
53	ROSS HALL SOUTH WING (FROM ROSS HALL NORTH)	12 ST	62.5 MM	12 USED	0 AVAILABLE
54	NOTTINGHAM MANHOLE	12 ST	62.5 MM	12 USED	0 AVAILABLE
59	UNIVERSITY CENTER	6 ST	62.5 MM	4 USED	2 AVAILABLE
	ROSS HALL NORTH WING		SM		

ROSS HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
X2	GRAY HALL	24 ST	SM	4 USED	20 AVAILABLE
X3	ARLINGTON APARTMENTS	12 ST	SM	4 USED	8 AVAILABLE

BISHOP-LEHR HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
X4	ASTRONOMY GARAGE	6 ST	62.5 MM	2 USED	4 AVAILABLE

NORTH
SCALE: 1" = 80'-0"

FIGURE 35

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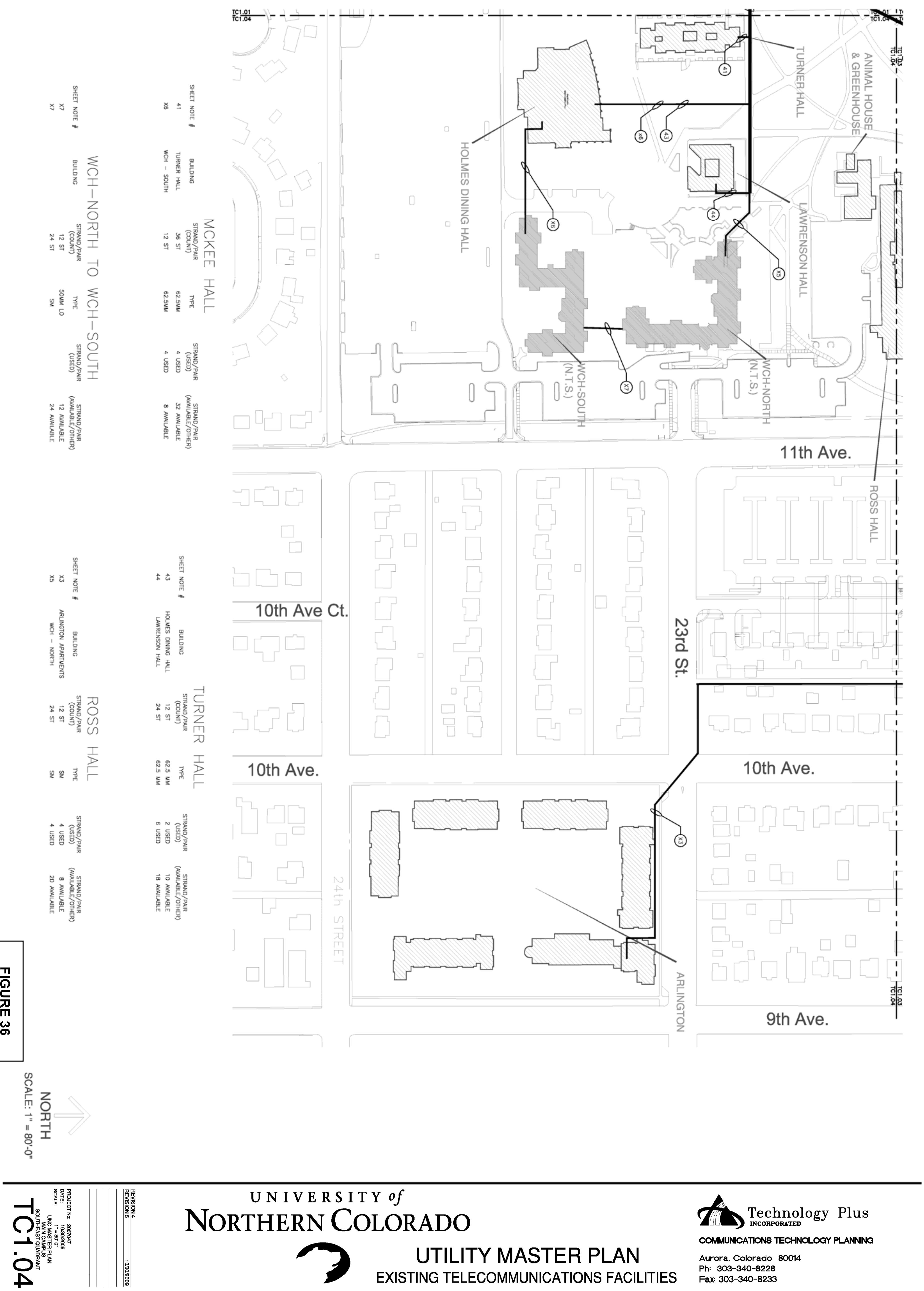
REVISION 5 10/30/2009

PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80' 0"
UNC MASTER PLAN
MAIN CAMPUS
NORTHEAST QUADRANT
TC1.03


MCKEE HALL
SHEET NOTE # | BUILDING | STRAND/PAIR (COUNT) | TYPE | STRAND/PAIR (USED) | STRAND/PAIR (AVAILABLE/OTHER)
41 | TURNER HALL | 36 ST | 62.5MM | 4 USED | 32 AVAILABLE
X6 | WCH - SOUTH | 12 ST | 62.5MM | 4 USED | 8 AVAILABLE
WCH–NORTH TO WCH–SOUTH
SHEET NOTE # | BUILDING | STRAND/PAIR (COUNT) | TYPE | STRAND/PAIR (USED) | STRAND/PAIR (AVAILABLE/OTHER)
X7 | | 12 ST | 50MM LO | | 12 AVAILABLE
X7 | | 24 ST | SM | | 24 AVAILABLE
TURNER HALL
SHEET NOTE # | BUILDING | STRAND/PAIR (COUNT) | TYPE | STRAND/PAIR (USED) | STRAND/PAIR (AVAILABLE/OTHER)
43 | HOLMES DINING HALL | 12 ST | 62.5 MM | 2 USED | 10 AVAILABLE
44 | LAWRENSON HALL | 24 ST | 62.5 MM | 6 USED | 18 AVAILABLE
ROSS HALL
SHEET NOTE # | BUILDING | STRAND/PAIR (COUNT) | TYPE | STRAND/PAIR (USED) | STRAND/PAIR (AVAILABLE/OTHER)
X3 | ARLINGTON APARTMENTS | 12 ST | SM | 4 USED | 8 AVAILABLE
X5 | WCH - NORTH | 24 ST | SM | 4 USED | 20 AVAILABLE
TURNER HALL
ANIMAL HOUSE & GREENHOUSE
HOLMES DINING HALL
LAWRENSON HALL
WCH-SOUTH (N.T.S.)
WCH-NORTH (N.T.S.)
ROSS HALL
11th Ave.
10th Ave Ct.
23rd St.
10th Ave.
24th STREET
ARLINGTON
9th Ave.
NORTH
SCALE: 1" = 80'-0"
UNIVERSITY of NORTHERN COLORADO
UTILITY MASTER PLAN
EXISTING TELECOMMUNICATIONS FACILITIES
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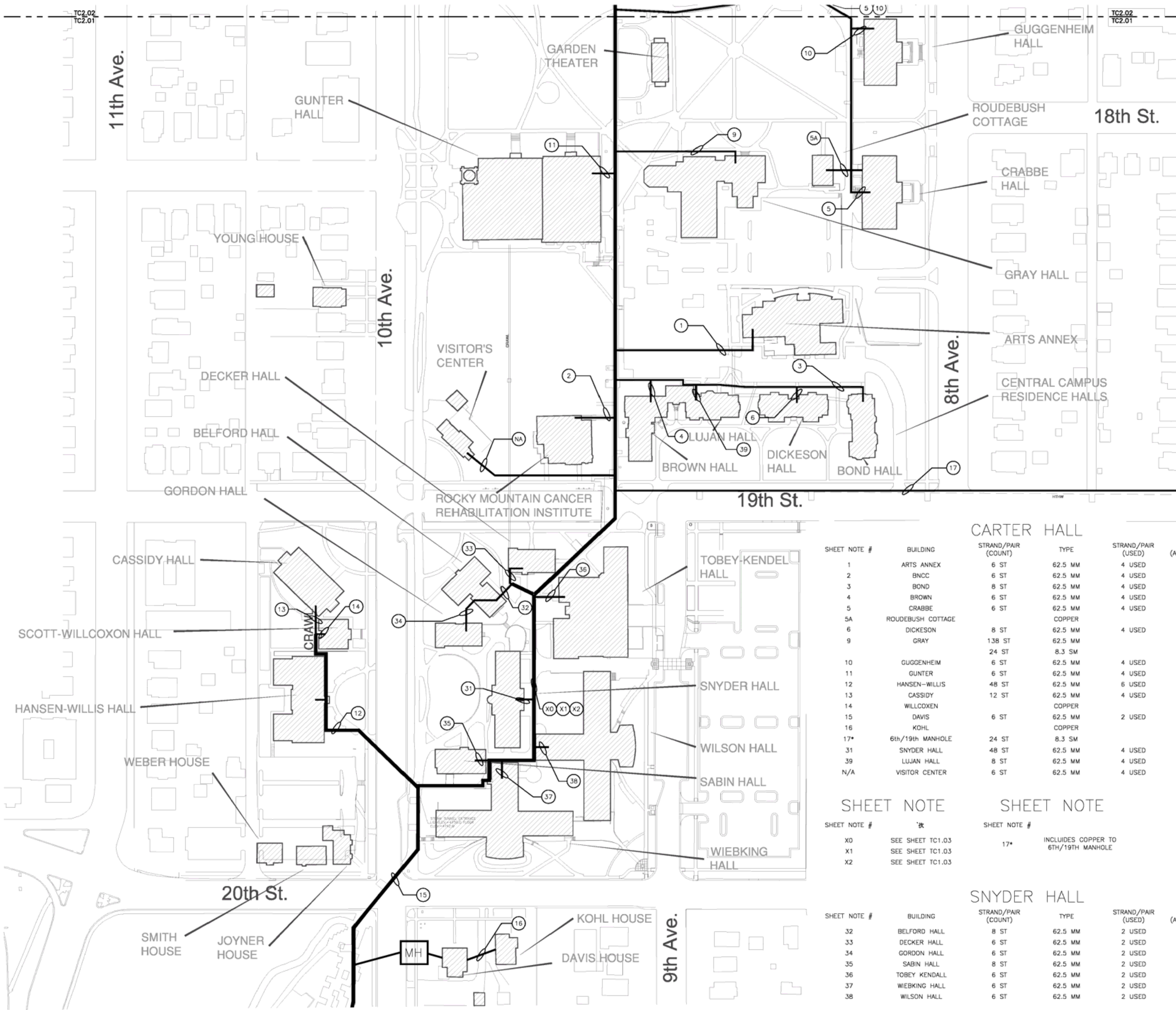
TC1.04

FIGURE 36



CARTER HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
1	ARTS ANNEX	6 ST	62.5 MM	4 USED	2 AVAILABLE
2	BNCC	6 ST	62.5 MM	4 USED	2 AVAILABLE
3	BOND	8 ST	62.5 MM	4 USED	4 AVAILABLE
4	BROWN	6 ST	62.5 MM	4 USED	2 AVAILABLE
5	CRABBE	6 ST	62.5 MM	4 USED	2 AVAILABLE
5A	ROUDEBUSH COTTAGE		COPPER		
6	DICKESON	8 ST	62.5 MM	4 USED	4 AVAILABLE
9	GRAY	138 ST	62.5 MM		
		24 ST	8.3 SM		
10	GUGGENHEIM	6 ST	62.5 MM	4 USED	2 AVAILABLE
11	GUNTER	6 ST	62.5 MM	4 USED	2 AVAILABLE
12	HANSEN-WILLIS	48 ST	62.5 MM	6 USED	42 AVAILABLE
13	CASSIDY	12 ST	62.5 MM	4 USED	8 AVAILABLE
14	WILLCOXEN		COPPER		
15	DAVIS	6 ST	62.5 MM	2 USED	4 AVAILABLE
16	KOHL		COPPER		
17*	6th/19th MANHOLE	24 ST	8.3 SM		
31	SNYDER HALL	48 ST	62.5 MM	4 USED	44 AVAILABLE
39	LUJAN HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
N/A	VISITOR CENTER	6 ST	62.5 MM	4 USED	2 AVAILABLE

SHEET NOTE

SHEET NOTE #	'X
X0	SEE SHEET TC1.03
X1	SEE SHEET TC1.03
X2	SEE SHEET TC1.03

SHEET NOTE

SHEET NOTE #	
17*	INCLUIDES COPPER TO 6TH/19TH MANHOLE

SNYDER HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
32	BELFORD HALL	8 ST	62.5 MM	2 USED	6 AVAILABLE
33	DECKER HALL	6 ST	62.5 MM	2 USED	4 AVAILABLE
34	GORDON HALL	6 ST	62.5 MM	2 USED	4 AVAILABLE
35	SABIN HALL	8 ST	62.5 MM	2 USED	6 AVAILABLE
36	TOBEY KENDALL	6 ST	62.5 MM	2 USED	4 AVAILABLE
37	WIEBKING HALL	6 ST	62.5 MM	2 USED	4 AVAILABLE
38	WILSON HALL	6 ST	62.5 MM	2 USED	4 AVAILABLE

FIGURE 37

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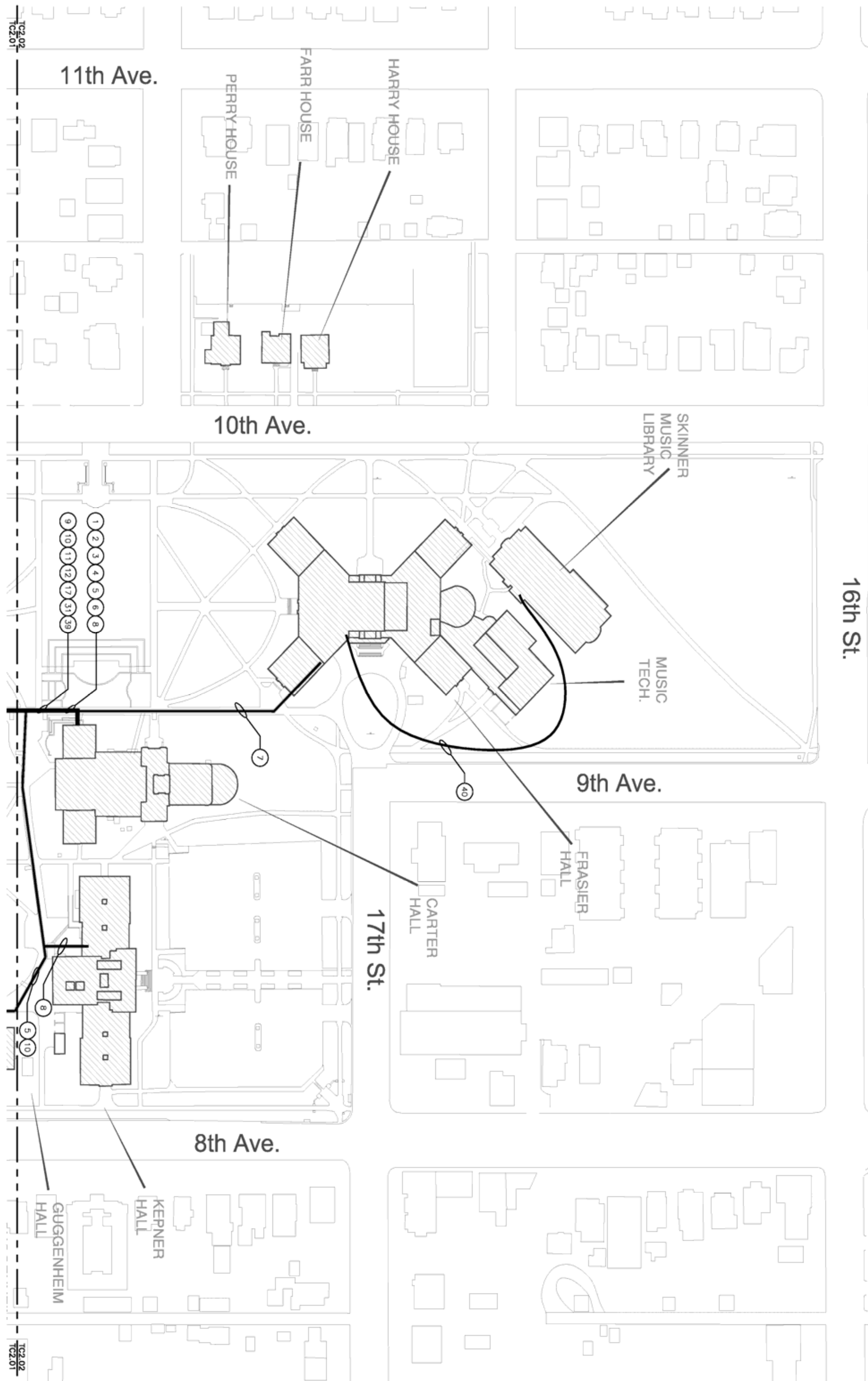
REVISION 4

PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80'-0"
UNC MASTER PLAN
CENTRAL CAMPUS
SOUTH HALF

TC2.01



CARTER HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
1	ARTS ANNEX	6 ST	62.5 MM	4 USED	2 AVAILABLE
2	BNCC	6 ST	62.5 MM	4 USED	2 AVAILABLE
3	BOND	8 ST	62.5 MM	4 USED	4 AVAILABLE
4	BROWN	6 ST	62.5 MM	4 USED	2 AVAILABLE
5	CRABBE	6 ST	62.5 MM	4 USED	2 AVAILABLE
6	DICKESON	8 ST	62.5 MM	4 USED	4 AVAILABLE
7	FRASIER	6 ST	62.5 MM	4 USED	2 DAMAGED
8	KEPNER	6 ST	62.5 MM	4 USED	2 AVAILABLE
9	GRAY	138 ST	62.5 MM		
		24 ST	8.3 SM		
10	GUGGENHEIM	6 ST	62.5 MM	4 USED	2 AVAILABLE
11	GUNTER	6 ST	62.5 MM	4 USED	2 AVAILABLE
12	HANSEN–WILLIS	48 ST	62.5 MM	6 USED	42 AVAILABLE
17	6th/19th MANHOLE	24 ST	8.3 SM		
31	SNYDER HALL	48 ST	62.5 MM	4 USED	44 AVAILABLE
39	LUJAN HALL	8 ST	62.5 MM	4 USED	4 AVAILABLE
40	MUSIC LIBRARY	12 ST	62.5 MM	4 USED	8 AVAILABLE

FIGURE 38

NORTH
SCALE: 1" = 80'-0"

REVISION 4

PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80' 0"
UNC MASTER PLAN
CENTRAL CAMPUS
NORTH HALF

TC2.02

UNIVERSITY of NORTHERN COLORADO

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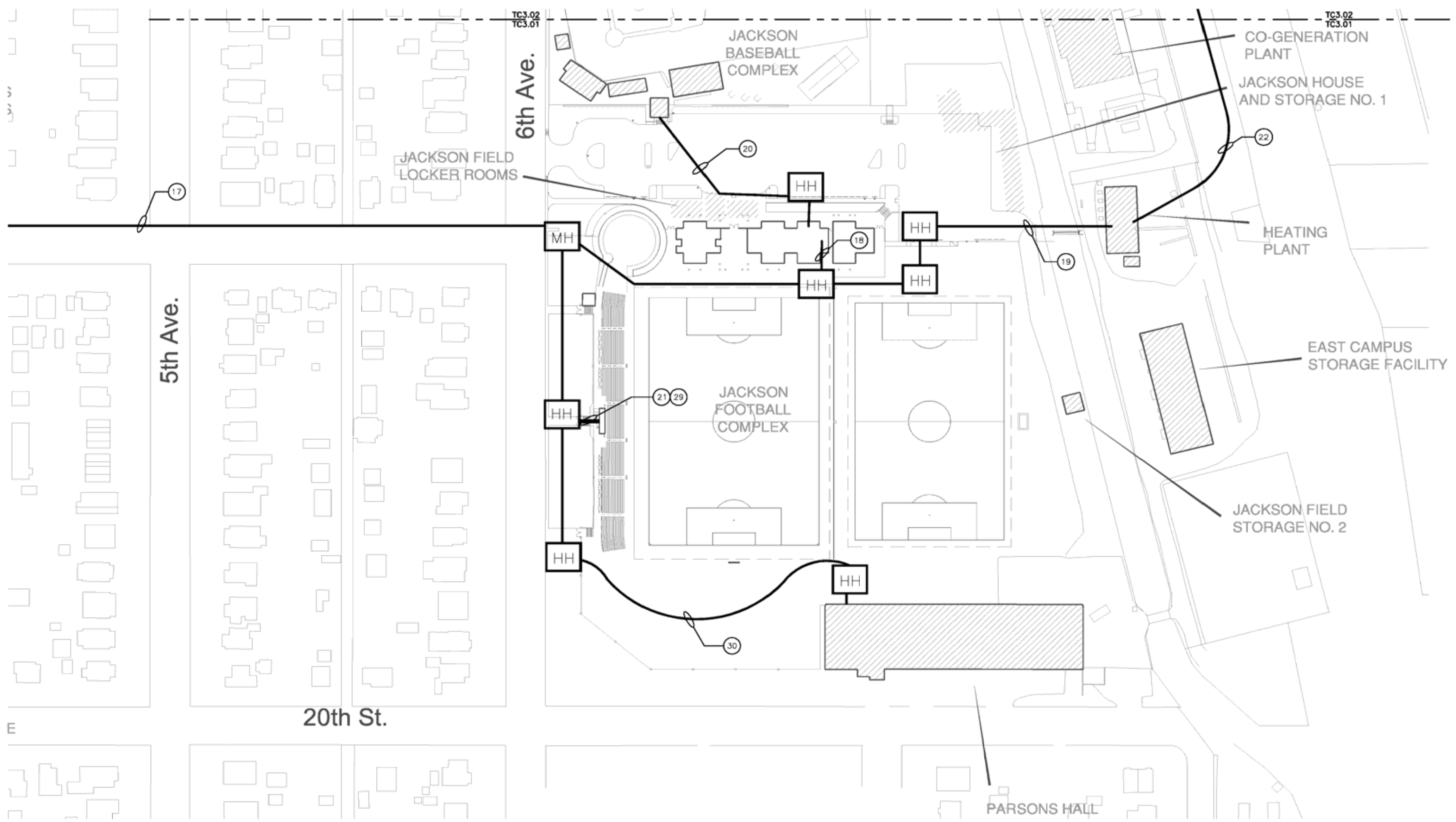

JACKSON FIELD HOUSE

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
19	HEATING PLANT	6 ST	8.3 SM	2 USED	4 AVAILABLE
20	BASEBALL PRESS	6 ST	8.3 SM	2 USED	4 AVAILABLE
22	CAVE HALL	12 ST	8.3 SM	4 USED	2 AVAILABLE / 6 DAMAGED
29	SOCCER PRESS	6 ST	8.3 SM	0 USED	6 AVAILABLE

CARTER HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
17	6TH/19TH MANHOLE	24 ST	8.3 SM		
18	JACKSON FIELD HOUSE	18 ST	8.3 SM	4 USED	14 AVAILABLE
21	SOCCER PRESS	6 ST	8.3 SM	4 USED	2 AVAILABLE

SOCCER PRESS

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
30	PARSONS HALL	12 ST	8.3 SM	4 USED	8 AVAILABLE

NORTH
SCALE: 1" = 80'-0"

FIGURE 39

UNIVERSITY *of* NORTHERN COLORADO

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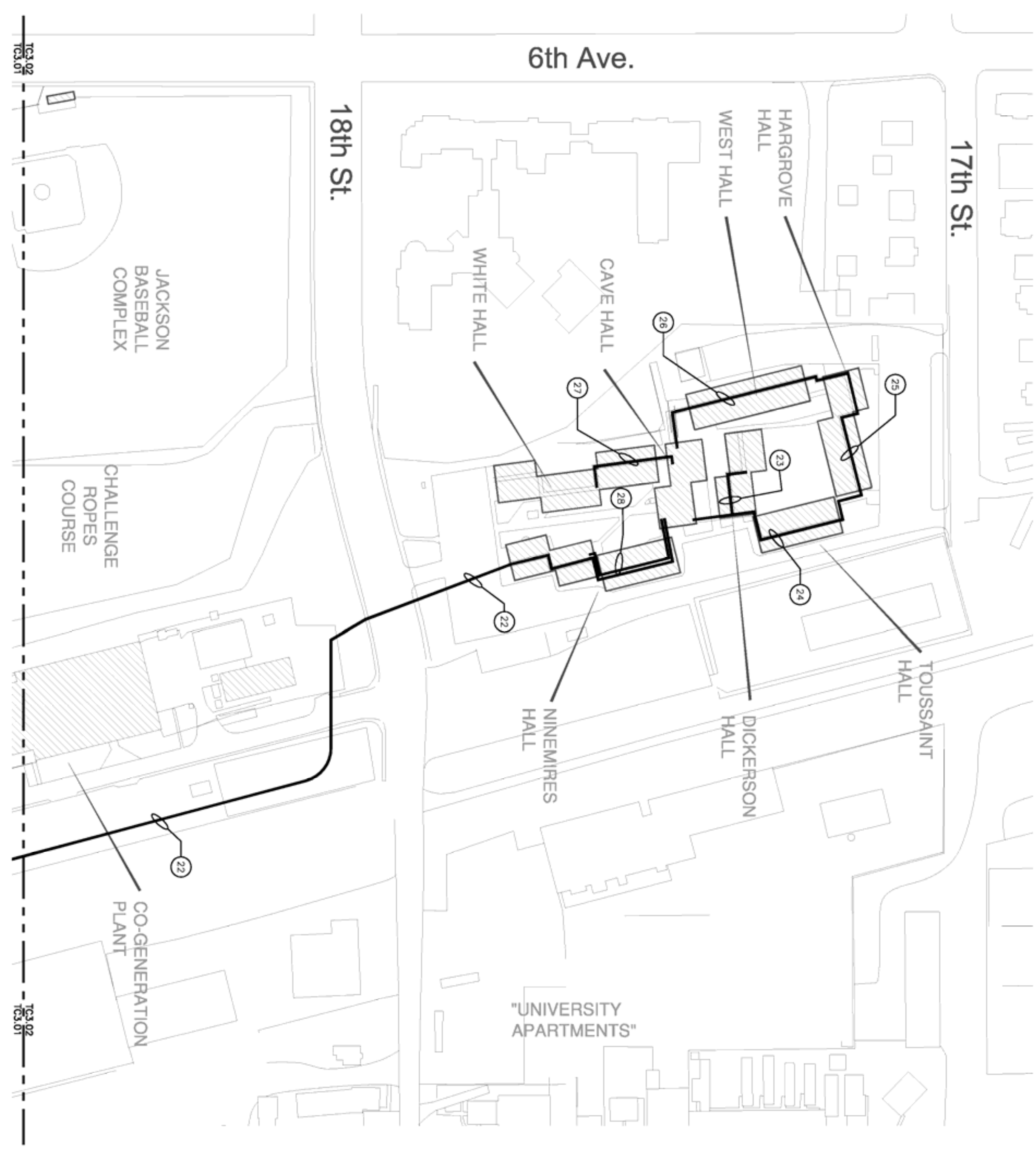
PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80' 0"
UNC MASTER PLAN
EAST CAMPUS
SOUTH HALF

TC3.01



JACKSON FIELD HOUSE

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
22	CAVE HALL	12 ST	8.3 SM	4 USED	2 AVAILABLE / 6 DAMAGED

CAVE HALL

SHEET NOTE #	BUILDING	STRAND/PAIR (COUNT)	TYPE	STRAND/PAIR (USED)	STRAND/PAIR (AVAILABLE/OTHER)
23	DICKERSON	6 ST	50.0 MM	2 USED	4 AVAILABLE
24	TOUSSAINT	6 ST	50.0 MM	2 USED	4 AVAILABLE
25	HARGROVE	6 ST	50.0 MM	2 USED	4 AVAILABLE
26	WEST	6 ST	50.0 MM	2 USED	4 AVAILABLE
27	WHITE	6 ST	50.0 MM	2 USED	4 AVAILABLE
28	NINEMIRES	6 ST	50.0 MM	2 USED	4 AVAILABLE

FIGURE 40

NORTH
SCALE: 1" = 80'-0"

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REVISION 4

PROJECT No: 2007047
DATE: 10/30/2009
SCALE: 1" = 80' 0"
UNC MASTER PLAN
EAST CAMPUS
NORTH HALF

TC3.02

SECTION 2.5 – ELECTRICAL SYSTEMS

2.5.1 Introduction / Background

In this section, the impact of future growth on the existing UNC electrical infrastructure is addressed, including areas of that infrastructure that may require replacement or modification.

Specific items to be addressed include: primary feeders and switch cabinets, existing transformers, TVSS protection, and single phase motor protection. Modifications or replacement of existing building electrical services due to proposed HVAC options are not specifically addressed here.

2.5.2 Future Improvement Recommendations

Primary Loop

The existing PSCo feed to the Central Campus should not need to be replaced before additional loads are added. As previously addressed, while peak loads experienced by the 1037 loop have exceeded 134 amps, this is within the 200 amps allowed on the existing conductors. The existing primary switch cabinet at Gunter Hall should be replaced to accommodate additional spare switches from which to feed future structures. This will also provide a means from which to serve additional HVAC loads, assuming that in the future the absorption chillers are replaced with new air cooled chillers.

An option under consideration with respect to the campus' mechanical cooling capabilities is to create a new central plant to handle the cooling loads (please see Section 2.6 for additional discussion). In this case individual structures would not need electrical upgrades; however, the load for the new plant may push the total load on the 1037 loop closer to 400 amps, which would require replacement of the existing UNC primary switchgear. Figures 41 and 42 shown on the following pages outline the existing schematic electrical one-line diagrams for West Campus and Central Campus respectively.

The utility primary feeder serving the West Campus will suffice for the future needs of UNC. The existing residential loads also sharing the PSCo feeder are scheduled to be removed and transferred to another substation in the next few years providing additional "spare" on the feeder. The UNC-owned primary loop system for the West Campus utilizes each of the four (4) individual 600 amp feeds. Based on the PSCo peak demands for the campus, no individual loop feeder is loaded close to capacity. However, the existing UNC 600-amp primary switch cabinet has no remaining spare switches. Future growth is limited to one (1) available spare switch served from P3 and P4 and located in the switches adjacent to Turner Hall. This will allow for only one (1) additional 400 amp feed. If possible, the addition of two new 600 amp switches (P5 and P6) in the main primary switchgear could allow for an additional primary lop which in turn could serve new sub-switch cabinets. This would, however, require modifications to the existing primary switch gear located at the West Campus.

Consideration should be given to adding an additional two (2) sections to the main outdoor pad-mounted switchgear to allow for one (1) additional loop to serve the future indoor practice facility through the placement of a new switch.

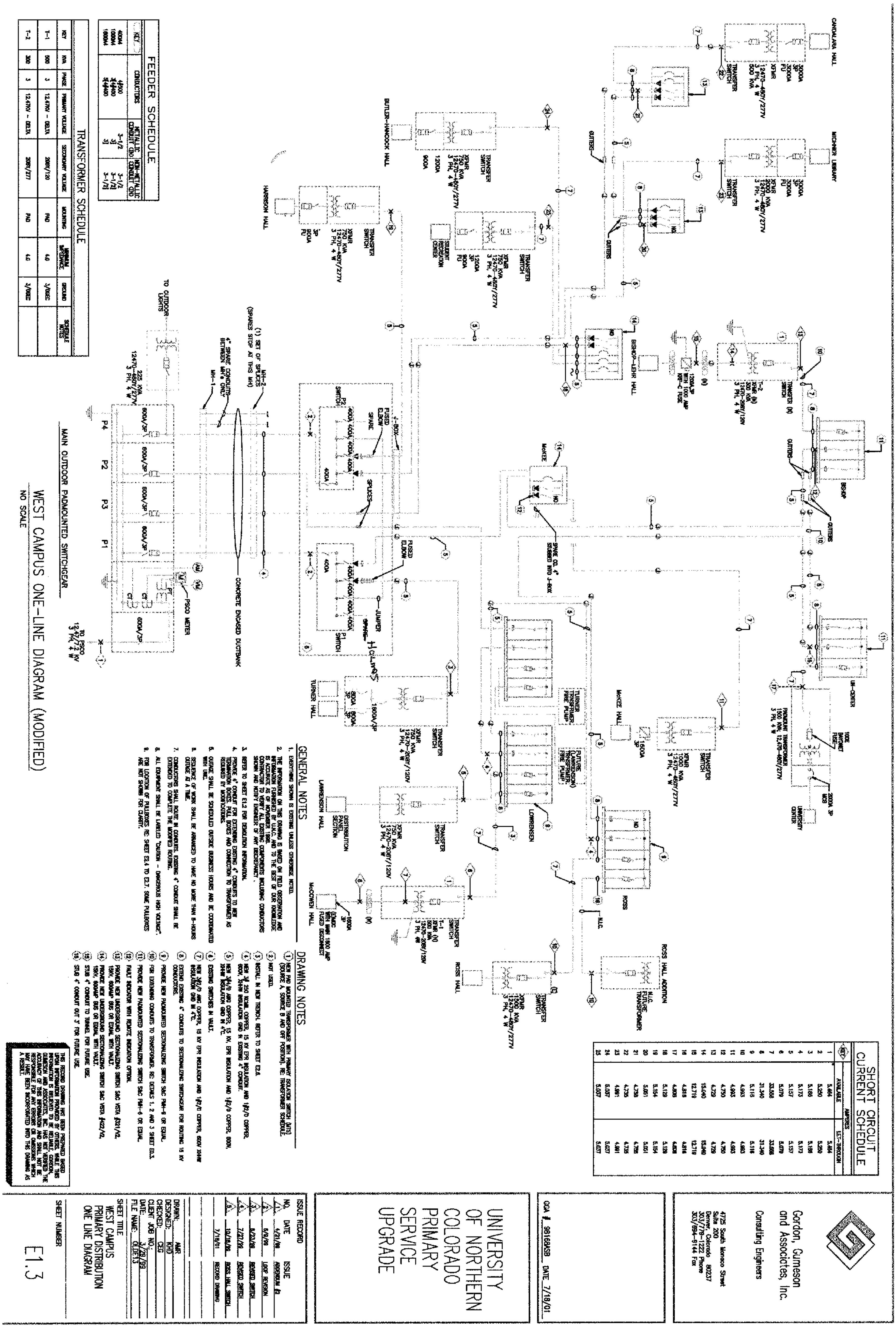
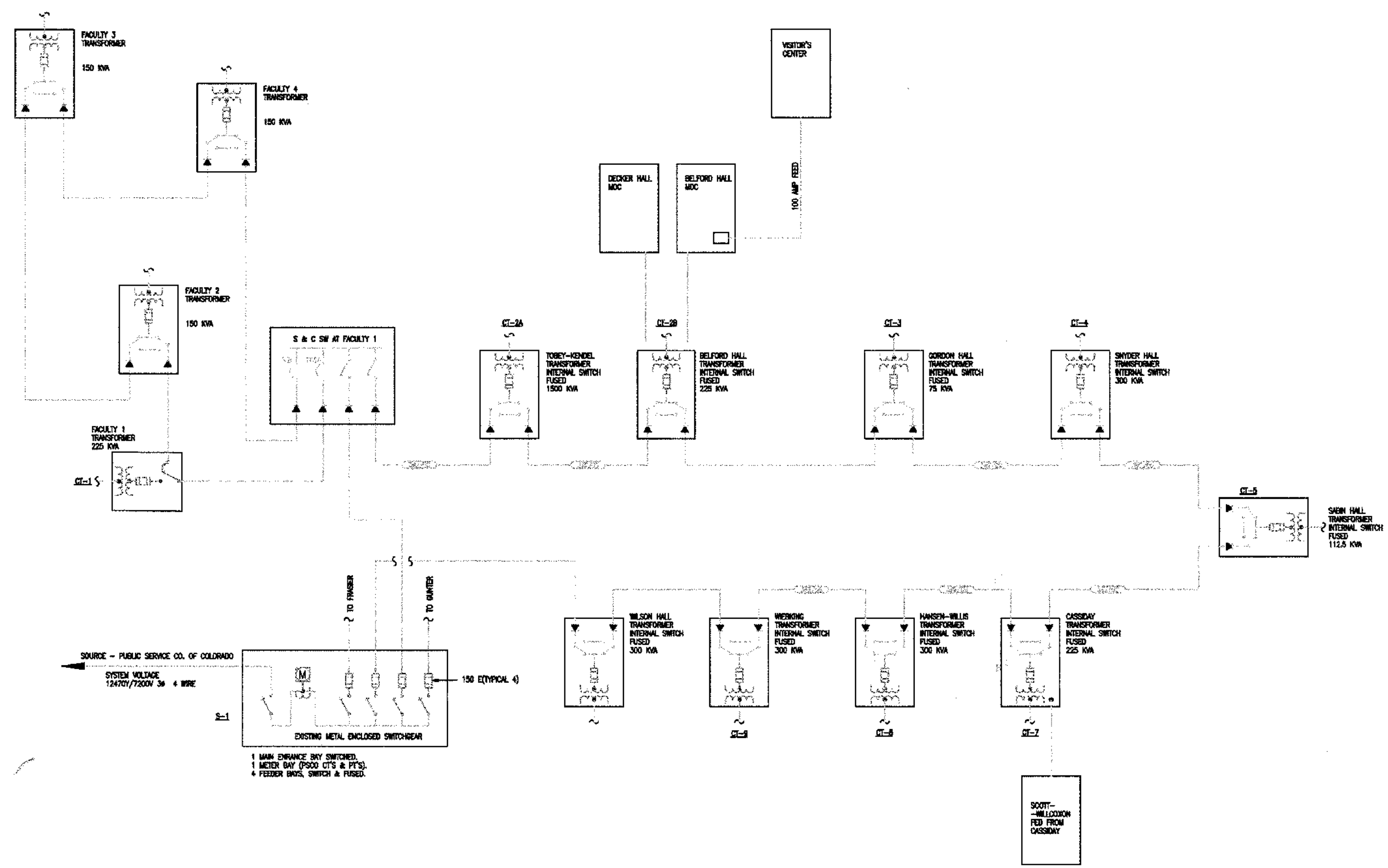

WEST CAMPUS ONE-LINE DIAGRAM (MODIFIED)
NO SCALE
MAIN OUTDOOR PADMOUNTED SWITCHGEAR
FEEDER SCHEDULE
TRANSFORMER SCHEDULE
GENERAL NOTES
DRAWING NOTES
SHORT CIRCUIT CURRENT SCHEDULE
Gordon, Gumeson and Associates, Inc.
Consulting Engineers
UNIVERSITY OF NORTHERN COLORADO PRIMARY SERVICE UPGRADE
SHEET TITLE
WEST CAMPUS PRIMARY DISTRIBUTION ONE LINE DIAGRAM
SHEET NUMBER
E1.3

FIGURE 41



CENTRAL CAMPUS PRIMARY UTILITY ELECTRICAL MODIFIED PARTIAL ONE-LINE DIAGRAM

NEW 15KV MV-105 TYPE (EPR) COPPER FEEDER SCHEDULE

KEY	CONDUCTORS	METALLIC CONDUIT (IN)	NON-METALLIC CONDUIT (IN)
3#2/0C	3 #2/0 AWG CU 15KV AND 1#1/0, 600V XHHN GND	4	4

October 01, 2008 9:30 a.m.
Drawing: E-2 REV 6-2008.DWG

FIGURE 42

Transformers

The existing transformers at the East Campus housing area need to be replaced along with the transformers at Carter and Crabbe Halls. Should the absorption chillers be eliminated and replaced with new air cooled chillers, the electrical services and perhaps transformers for any additional buildings could require replacement. If the new central plant approach is used, a new transformer to serve the loads of that facility will be required.

TVSS Protection

MKK recommends that service-rated TVSS equipment be provided for the buildings identified in Table 35 (shown on the following page) as presently not having that level of protection. Devices from "Current Technology" (i.e., TG-100) or equivalent have been found to be a very reliable means for providing protection at an affordable cost. Smaller, less expensive, units are available to protect individual HVAC control panels. An additional system review beyond the scope of this report is recommended to correctly identify these panels and the environments where they are located.

Single Phase Motor Protection

MKK recommends that a proactive program of single-phase motor protection be implemented for buildings without such protection now. In the course of this infrastructure investigation, it was discovered that many of the newer buildings have single-phase protection as part of the new construction design. It is the buildings without such protection for which we make this recommendation. Unfortunately, without a comprehensive survey of the buildings and systems it is not known as to the full extent of the problem or how many individual motors would be impacted.

TABLE 35 – TVSS AUDIT AND GENERAL NOTES FOR EXISTING UNC BUILDINGS (SHEET 1 OF 3)

Building Name	TVSS	Remarks
Arts Annex	Y	Complete Remodel 2002. Liebert TVSS on main gear.
Belford Hall	Y	
Bishop-Lehr Hall	N	Demo forth coming.
Bishop-Lehr Special Education Metal Building	N	
Bishop-Lehr Weight Room Annex	N	
Butler Hancock Hall	N	Remodel Pending
Campus Recreation Center	N	
Candelaria	N	
Carter Hall	Y	(2) Transformers Both Old
Cassidy Hall	Y	Feeds Scott Wilcoxon Building
Cave Hall	N	Old Transformer
Crabbe Hall	N	Old Transformer
Davis House	N	
Decker Hall	Y	Complete Remodel 2002. Liebert TVSS on main gear.
Dickerson Hall	Y	
East Campus Storage	N	
East Campus Storage	N	
Faculty Apartment #1	Y	Current Technology TG-100 TVSS
Faculty Apartment #2	Y	Current Technology TG-100 TVSS
Faculty Apartment #3	Y	Current Technology TG-100 TVSS
Faculty Apartment #4	Y	Current Technology TG-100 TVSS
Farr House	N	
Foundation Hall	N	
Fraiser Hall	Y	TVSS on Secondary Distribution Panels for HVAC Control Panels. Not on MDP.
Garden Theater	N	
Gordon Hall	Y	
Gray Hall	Y	
Guggenheim Hall	Y	Liebert TVSS
Gunter Hall	N	Remodel 95 / Lots of Equipment
Hansen-Willis Hall	N	
Hargrove Hall	N	
Harrison Hall	N	
Harry House	N	

TABLE 35 – TVSS AUDIT AND GENERAL NOTES FOR EXISTING UNC BUILDINGS (SHEET 2 OF 3)

Building Name	TVSS	Remarks
Heating Plant	N	
Intramural Field Metal Building	N	
Jackson Baseball Complex	N	
Jackson Field Storage #1	N	
Jackson Field Storage #2	N	
Jackson Football Complex	N	
Jackson House	N	
James A. Michener Library	N	
Joyner House	N	
Kepner Hall	Y	Upcoming TVSS Pending on Control Main
Khol House	N	
Lawrenson Hall	N	
Martin House	N	
McCowen Hall	N	To be Demo'd
McKee Hall	N	
Music Library	Y	
Ninemires Hall	N	
Nottingham Field	N	
Old Man Mountain	N	
Parsons Hall East	N	
Parsons Hall West	N	
Patton House	N	
Perry House	N	
Ross Hall	Y	
Roudebush Cottage	Y	
Sabin Hall	Y	
Scott-Willcoxon Hall	Y	Fed out of Cassidy
Smith House	N	
Snyder Hall	Y	Current Technology TVSS
Tobey-Kendel Hall	Y	Current Technology TVSS
Toussaint Hall	N	Old Transformer
Turner Hall	N	
University Center	N	
Visitors Center	N	
Warren House	N	

TABLE 35 – TVSS AUDIT AND GENERAL NOTES FOR EXISTING UNC BUILDINGS (SHEET 3 OF 3)

Building Name	TVSS	Remarks
Weber House	N	
West Hall	N	
White Hall	N	Old Transformer
Wiebking Hall	Y	Current Technology TVSS
Wilson Hall	Y	Current Technology TVSS
Women's Softball Complex	N	
Young House	N	

SECTION 2.6 – MECHANICAL HTHW AND CHILLED WATER SYSTEMS

2.6.1 Observations and Recommendations

Based on the analysis presented in section 1 of this report and the anticipated additional building loads outlined in the UNC Facilities Master Plan 10-year Capital Improvement Plan, the following mechanical HTHW and Chilled Water System recommendations are made to adequately serve the campus for its future needs.

HTHW - Heating

As previously noted, the heating side of the HTHW system has been reviewed on several occasions and appears to have a clearly defined approach that will carry UNC into the future. The primary focus includes:

- The replacement of Boiler #3 with a newer, more efficient heat generator with energy recovery and "safer" natural gas controls.
- The addition of a smaller (i.e., 20- to 25-million BTUH) heat generator to help carry the CHP through the "shoulder" seasons.
- The eventual replacement of the steam heating systems in Crabbe Hall, Frasier Hall, and any other small "original" buildings, with new hot water heating systems.
- Providing additional flow meters in each building to monitor HTHW demand and energy usage.
- Provide continued upgrades to the building automation and temperature control systems to allow a more proactive (and interactive) approach to energy management by UNC personnel.
- Replacement of older equipment (i.e., pumps, heat exchangers, air handlers, and terminal distribution units) with more efficient units as they start to wear out and maintenance costs become excessive.
- Provide an emergency generator at the CHP to provide a backup power supply to the critical components.

Cooling Systems

As previously noted in Table 20 (Section 1.6), there are a total of eleven (11) absorption chillers currently operating on the UNC campus with a combined rated capacity of roughly 3,907 tons of cooling. When combined with the estimated load associated with the domestic hot water system, the total boiler capacity required during the summer is equal to, or exceeds, the winter heating loads.

With the somewhat tenuous nature of the CoGen plant, we evaluated the pros and cons of continuing to operate the CHP during the summer if the reduced cost of HTHW via the CoGen plant was no longer available. The following concepts were considered:

1. *Absorption Chillers versus Mechanical Cooling*

As noted many times, the primary cost-effective benefit for absorption chillers is when they are used with "waste" heat (as is the case with the CoGen plants) or where extremely high electrical costs (or "peak" demand premiums) are prevalent. When evaluating the cost to operate the absorption machines without the opportunity for waste heat, we assumed that the total BTUH output of cooling is only about **47%** of the BTUH energy of natural gas input at the boiler plant. So for every 1000 BTUH of natural gas that is supplied to the boiler, only 470 BTUH of cooling output is seen from the chiller.

The following assumptions were made to derive this value:

- Boiler efficiency = 75% - 80%
- Piping and pump transmission loss = 5% to 7%
- Absorption efficiency (assumes 18 MBH input to derive 12 MBH output) = **0.67**
- Total loss = 70% x .067 = **0.47**

In addition to the efficiency losses noted above, the other negative aspects of an absorption machine include:

- Higher initial cost
- Higher cost to maintain an absorption machine
- Reports that the refrigeration industry is minimizing production of absorption chillers, thus limiting available new and replacement parts. According to our local Trane representative, Trane only had one plant in the **world** manufacturing either direct gas-fired or steam/HTHW absorption chillers with total sales of only three (3) to four (4) per month. They noted that due to the minimal sales, all production was scheduled to stop in the near future. The local Carrier representative echoed these numbers.

Even though it is not an exact correlation between the cost to convert natural gas via the CHP to cooling using absorption machines, the relative Energy Efficiency Ratio (EER) of a water-cooled chiller is at roughly 15.2 versus an absorption chiller at 0.21 to 0.30. The **higher** the EER, the more efficient the air conditioner. In order to make a true comparison of the energy consumed for both the HTHW/absorption chiller versus mechanical cooling with probable electrical upgrades, a detailed life cycle cost analysis of the system options would need to be performed.

2. *Central Cooling Plants*

Another possible option contemplated as a means to replace the absorption machines and aid in the consolidation of localized chilled water generation is to create a central chilled water plant for both the Central and West campuses. By combining the existing rated capacity for the mechanical cooling equipment (i.e., RTU's, DX units, window AC's, and electric driven chillers), absorption chillers and future buildings, the following total capacity would be required:

Central Campus

▪ Existing Load	=	565 tons
▪ Estimated Future Load	=	633 tons
▪ Absorption Chiller Replacement Load	=	1,267 tons
		2,465 tons

West Campus

▪ Existing Load	=	1,215 tons
▪ Estimated Future Load	=	263 tons *
▪ Absorption Chiller Replacement Load	=	2,640 tons
		4,118 tons

*Note that this does not include the AC load associated with the 2010 project to air condition Butler-Hancock Hall.

Even though the concept of consolidating the chilled water services would provide the benefit of centralizing the primary chilled water generating equipment into two (2) centralized locations, the initial cost to construct the plant, run several miles of chilled water piping (which could be direct buried similar to domestic water mains), and reconnect to the existing chilled water equipment, appears to be cost prohibitive upon initial review.

A very rough projection of probably cost could approach $60/linear foot for 8-inch diameter mains, with an estimated total run of roughly 15,000' to 20,000' for each of the two campuses. The chilled water plants could approach $5 to $10 million for the Central Campus to $10 to $15 million for the West Campus, excluding the electrical infrastructure or a building to house the systems.

Based on these rough projections, it appears that it will be more economical to continue evaluating possible energy saving alternatives to replace the older absorption chillers with "free cooling" economizers and energy efficient mechanical chillers with VFD's and other newer technology. By combining several buildings together, the optimal size of chiller systems with very low KW/ton ratings can also be used to help conserve energy, initial cost, and long-term maintenance expenses.

Domestic Hot Water Systems

As previously noted in Table 19 (Section 1.6), the total rated capacity of the domestic hot water currently being served from the CHP has a capacity of roughly 20,803 MBH, or roughly 45% of the total "rated" summer load on the boilers. It is assumed that the actual HW load requirements are dramatically less than the rated capacity however, just due to the reduced number of students in the summer.

Using the same logic noted above for the possible replacement of the absorption chillers (i.e., the possibility of not having the "waste" heat associated with the CoGen plant and looking at possibly minimizing the use of the CHP during the summer), an option could be to look at replacing the existing HTHW/domestic hot water heat exchangers with high-efficiency, gas-fired water heaters.

The primary benefits of using a condensing type water heater is an increase in efficiency from roughly 60% to 65% in using the CHP, transmission piping, and heat exchanger to as high as **96%** with an AO Smith Cyclone or similar unit. By manifolding several units together, even larger facilities such as the athletic or dormitories, could save energy with this concept.

APPENDIX

Exhibit 1

WATER FLOW TEST REPORT

Union Colony Fire/Rescue Authority
Community Services Division
1100 10th Street
Greeley, CO 80631
(970) 350-9510

HYDRANT # & LOCATION:	807 17th Street					DATE:	12/11/2006
TEST BY:	Fagler/Kreiling	Day or Week:	Monday	TIME OF DAY:	900	MIN. OF FLOW:	2

WATER SUPPLIED BY: Unknown

PURPOSE OF TEST: design criteria

DATA

FLOW HYDRANT(S)	A1	A2	A3
SIZE OPENING:	2.5		
COEFFICIENT:	0.9		
PITOT READING:	24		
GPM:	822	0	0

TOTAL FLOW DURING TEST: 822 GPM

STATIC READING: 58 PSI RESIDUAL: 24 PSI

RESULTS: AT 20 PSI RESIDUAL 873 GPM AT 0 PSI 1097 GPM

REMARKS:

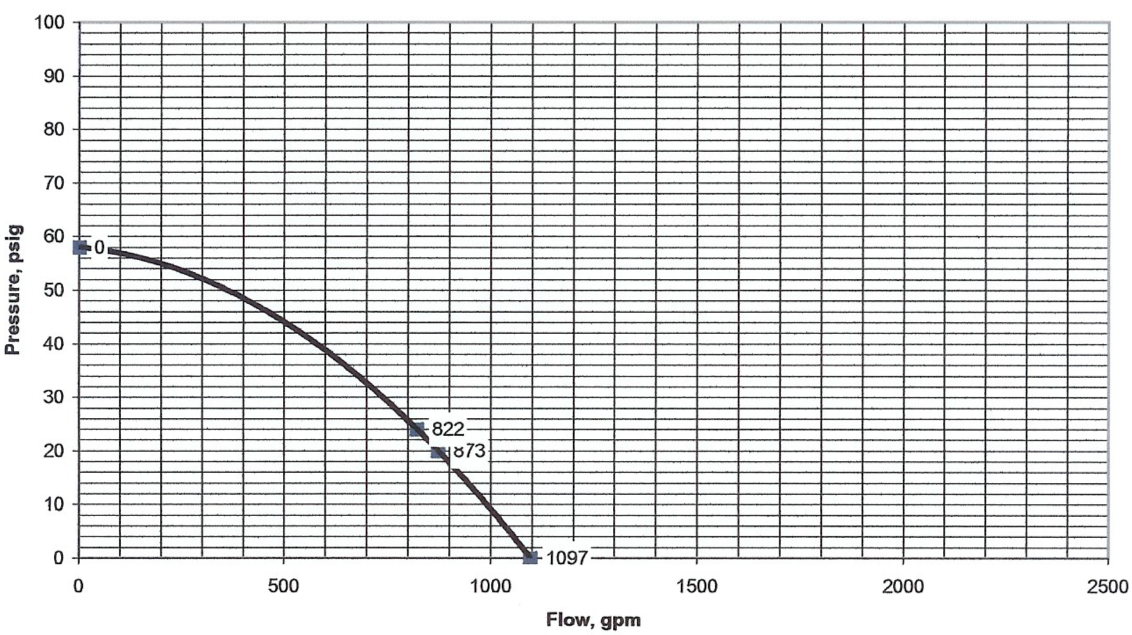


Exhibit 2

Annual Flushing Maintenance on UNC Private Hydrants
Performed 5/10 - 5/15/06

F.H. Location	F.H. Year/Make	PSI Static	PSI Dynamic	GPM Flow	Cl_2
1) University Center	1964 Mueller 4 1/2 improved	85	45	1130	0.5
2) 23 St & 11 Av	2003 Kennedy	105	70	1405	0.5
3) S/E of Bldg - Ross Hall	2000 Kennedy	100	55	1250	0.5
4) N/E of Bldg-front 22 St & 11 Av	1964 Mueller	95	45	1130	0.5
5) S/W of McCowen Hall	2003 Kennedy	~~110~~ 95	55	1130	0.5
6) S/sd of New Dining Facility	2003 Kennedy	100	55	1250	0.5
7) S/W of Turner Hall	2003 Kennedy	100	45	1130	0.5
8) E/sd of Student Recreation Center	1995 Kennedy	95	55	1250	0.5
9) Rec Center - N/W of Tennis Courts	1995 Kennedy	out of service			
10) Butler-Hancock Hall - S/sd of Bldg	1995 Kennedy	100	55	1250	0.5
11) Butler Hancock Hall - S/W bldg	1995 Kennedy	100	65	1350	0.5
12) Butler Hancock Hall - N/W bldg	1972 Mueller	90	45	1130	0.5
13) Michener Library - N/W bldg	1972 Mueller	90	55	1250	0.5
14) Michener Library - S/E bldg	1970 Mueller	100	45	1130	0.5
15) McKee Hall - W/sd of bldg	1970 Mueller	100	50	1190	0.5
16) Ross Hall - N/sd of bldg	2000 Kennedy	95	45	1130	0.5
17) S/E of Bishop Lehr Hall	1960 Mueller 4-1/2 improved	95	45	1130	0.5
18) N/W of Candelaria Hall	1960 Mueller	85	50	1190	0.5
19) Nottingham Field - E/sd- stadium	1994 Mueller	85	40	1060	0.5
20) Nottingham Field - S/W- stadium	1994 Mueller	75	35	1000	0.5
21) Nottingham Field - N/W- stadium	1994 Mueller	75	30	920	0.5

* These flow test were completed with the 10" meter off & the 6" meter on at the 14 Av. vault.

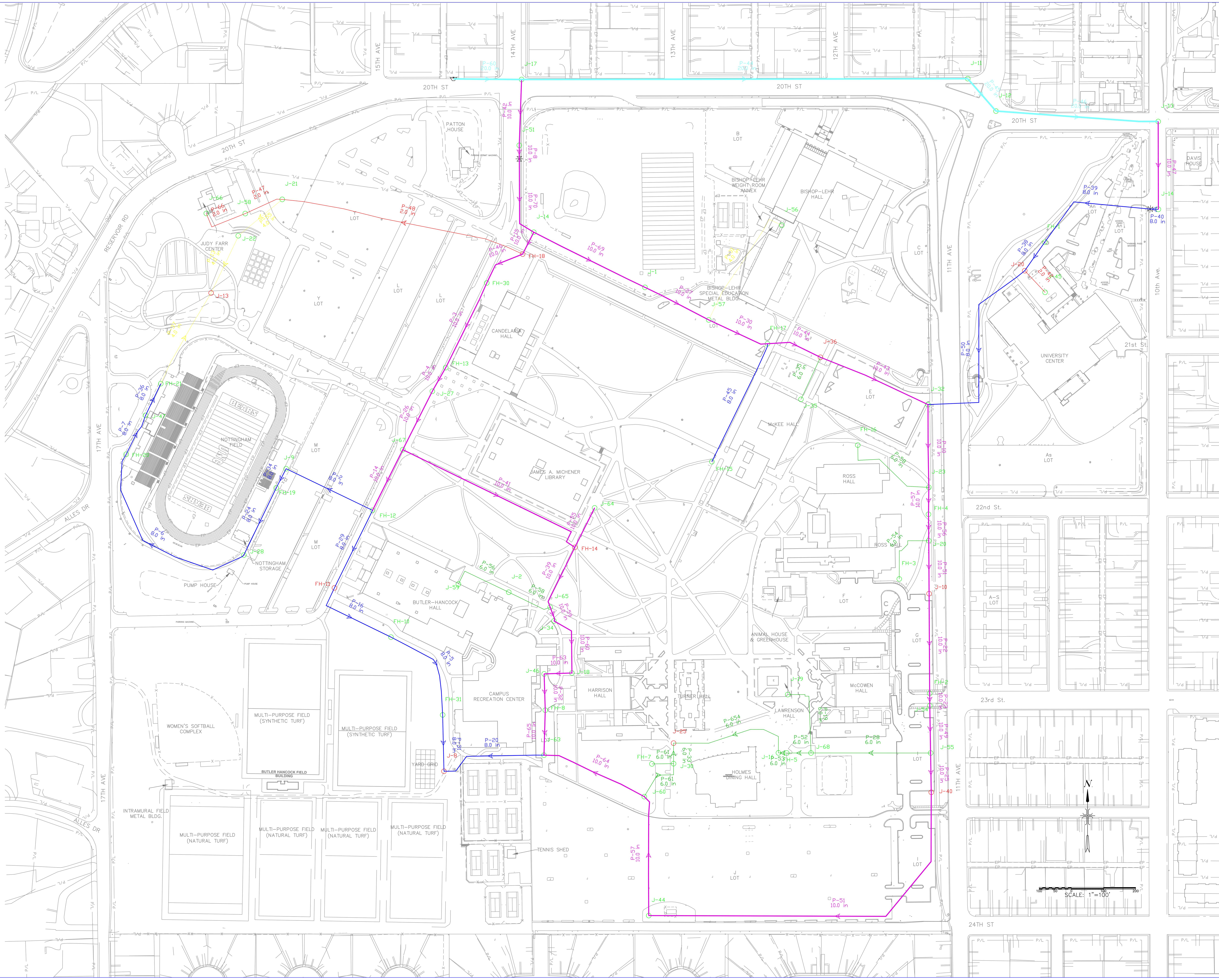


EXHIBIT 3

J-U-B

Engineers • Surveyors • Planners

EXHIBIT 3

WaterCAD Model Piping and Hydrant Node Map

Exhibit 4 - Calibration Spreadsheet

October 30, 2007

CAG

Test Hydrant	Location	(1) Hydrant Elevation (ft)	(2) Hydrant Static Pressure (psi)	(5) Hydrant Static Pressure (ft)	(3) Hydrant Residual Pressure (psi)	(4) Hydrant Pressure Drop (psi)	(5) Hydrant Residual Pressure (ft)	(6) % Residual Pressure Difference from Average	(7) Hydrant Test Flow (gpm)	(8) Estimated Meter Loss (psi)	(9) Adjusted Test Pressure (psi)	(10) Max System Flow @ 20 psi	(11) POC Test Residual Pressure (ft)	(12) POC Residual Pressure Needed (psi)	(13) % Pressure Difference from Average	(14) Change in Residual Pressures from Hydrant to POC	(15) Notes
FH-1	University Center	4,788	85	4,984	45	40	4,892	7%	1130	5	50	1825	4,909	58	-3%	10%	
FH-2a	23 St & 11 Ave	4,749	105	4,992	70	35	4,911	19%	1405	5	75	2466	4,932	68	14%	5%	
FH-2b	23 St & 11 Ave	4,749	98	4,975	80	18	4,934	36%	1363	5	85	3587	4,954	78	30%	6%	Fire Dept. Test
FH-3	Ross Hall - SE	4,763	100	4,994	55	45	4,890	4%	1250	5	60	1817	4,930	67	13%	-8%	Long 6" run
FH-4	22 St & 11 Ave - NE of Bldg	4,770	95	4,989	45	50	4,874	-9%	1130	5	50	1489	4,890	50	-16%	7%	
FH-5	McCowen Hall - SW	4,746	95	4,965	55	40	4,873	-8%	1130	5	60	1705	4,904	56	-6%	-2%	
FH-6	New Dining - S side	-	-		-	-	-	-	-	-	-	-	-	-	-	-	Can't Find
FH-7	Turner Hall - SW	4,752	100	4,983	45	55	4,856	-22%	1130	5	50	1456	4,883	47	-21%	0%	
FH-8	Rec Center - East	4,753	95	4,972	55	40	4,880	-4%	1250	5	60	1886	4,900	54	-9%	6%	
FH-9	Rec Center - NW of Tennis	-	-		-	-	-	-	-	-	-	-	-	-	-	-	Out of Service
FH-10	Butler-Hancock - S	4,760	100	4,991	55	45	4,887	2%	1250	5	60	1817	4,910	59	-2%	4%	
FH-11	Butler-Hancock - SW	4,761	100	4,992	65	35	4,911	21%	1350	5	70	2293	4,935	69	16%	5%	
FH-12	Butler-Hancock - NW	4,763	90	4,971	45	45	4,867	-15%	1130	5	50	1529	4,885	48	-20%	5%	
FH-13	Michener Library - NW	4,768	90	4,976	55	35	4,895	9%	1250	5	60	1975	4,912	60	0%	9%	
FH-14	Michener Library - SE	4,763	100	4,994	45	55	4,867	-15%	1130	5	50	1456	4,885	48	-20%	5%	
FH-15	McKee Hall - West	4,774	100	5,005	50	50	4,890	4%	1190	5	55	1624	4,948	75	26%	-21%	Long 6" run
FH-16	Ross Hall - North	4,775	95	4,994	45	50	4,879	-5%	1130	5	50	1489	4,924	65	8%	-13%	Long 6" run
FH-17	Bishop Lehr - SE	4,767	95	4,986	45	50	4,871	-12%	1130	5	50	1489	4,887	49	-19%	7%	
FH-18	Candelaria - NW	4,776	85	4,972	50	35	4,892	6%	1190	5	55	1807	4,907	57	-4%	10%	
FH-19	Nottingham - East	4,775	85	4,971	40	45	4,867	-16%	1060	5	45	1378	4,891	50	-16%	0%	
FH-20	Nottingham - SW	4,804	75	4,977	35	40	4,885	0%	1000	5	40	1276	4,921	63	6%	-6%	
FH-21	Nottingham - NW	4,805	75	4,978	30	45	4,874	-13%	920	5	35	1093	4,946	74	24%	-37%	Found pipe size error, fixed
Average		***4768***	***93***	***4983***	***51***	***43***	***4885***		***1176***		***56***	***1773***	***4913***	***60***			

Calculation Notes

(4) = (3) - (2)

(5) = [(4) * 0.43] + (1)

(6) = [(3) - ((Ave (5) - (1))*0.43)]/[(Ave (5) - (1))*0.43]

(9) = (3) + (8)

(10) = (7) * [(((2) - 20) / ((2) - (9))]^0.54)

(12) = [(11) - 4774.5] * 0.433

(13) = ((12) - Ave (12)) / Ave (12)

(14) = (13) - (6)

Exhibit 5

Fire Flow Node FlexTable: Fire Flow Report (Current Time: 0.000 hours) (west campus.wtg)

Label	Flow (Total Needed) (gpm)	Flow (Total Available) (gpm)	Pressure (Calculated Residual Lower Limit) (psi)	Pressure (Calculated System Lower Limit) (psi)	Junction w/Minimum Pressure (System)	Velocity of Maximum Pipe (ft/s)	Pipe w/Maximum Velocity
FH-20	1,500.00	1,368.86	20.0	19.7	782: J-47	8.76	1065: P-2
FH-21	1,500.00	1,260.02	20.0	21.1	782: J-47	8.07	1065: P-2
FH-16	1,500.00	1,501.00	28.9	38.1	782: J-47	17.03	1414: P-58
FH-3	1,500.00	1,501.00	40.8	38.0	782: J-47	17.03	1408: P-54
FH-7	1,500.00	1,501.00	41.0	36.9	782: J-47	17.03	1440: P-61
FH-19	1,500.00	1,501.00	42.4	29.2	782: J-47	9.71	1065: P-2
FH-15	1,500.00	1,501.00	44.3	38.5	782: J-47	9.58	1099: P-45
FH-5	1,500.00	1,501.00	44.4	37.1	782: J-47	9.47	1089: P-28
FH-1	1,500.00	1,501.00	44.7	39.7	782: J-47	6.44	1364: P-39
FH-18	1,500.00	1,501.00	50.7	38.5	782: J-47	6.36	935: P-15
FH-30	1,500.00	1,501.00	51.0	37.7	782: J-47	6.17	1271: P-8
FH-4	1,500.00	1,501.00	51.6	38.1	782: J-47	5.73	1285: P-70
FH-10	1,500.00	1,501.00	52.1	35.6	782: J-47	6.09	1271: P-8
FH-11	1,500.00	1,501.00	52.6	35.7	782: J-47	6.35	1256: P-29
FH-13	1,500.00	1,501.00	52.6	36.7	782: J-47	6.14	1285: P-70

Exhibit 6 - Calibration/Model Result Spreadsheet

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Label	Flow (gpm)	Test Pressure (psi)	Calculated Pressure (psi)	Difference (psi)	% Difference
FH-01	1130	45	47	2	4%
FH-02	1405	70	62	-8	-11%
FH-03	1250	55	48	-7	-13%
FH-04	1130	45	55	10	22%
FH-05	1130	55	55	0	0%
FH-07	1130	45	53	8	18%
FH-08	1250	55	61	6	11%
FH-10	1250	55	57	2	4%
FH-11	1350	65	56	-9	-14%
FH-12	1130	45	57	12	27%
FH-13	1250	55	55	0	0%
FH-14	1130	45	57	12	27%
FH-15	1190	50	49	-1	-2%
FH-16	1130	45	40	-5	-11%
FH-17	1130	45	56	11	24%
FH-18	1190	50	53	3	6%
FH-19	1060	40	50	10	25%
FH-20	1000	35	32	-3	-9%
FH-21	920	30	31	1	3%
Average		49	51	2.32	6%
Standard Deviation				7	14%