Galloway
Planning. Architecture. Engineering.

December 18, 2014

City of Casper
Community Development Department
Attn: Craig Collins
200 N. David, Room 203
Casper, WY 82601

Re: The Enclave at Greenway Park

This letter is intended to discuss drainage design conformance to the approved 'Final Drainage Study for the Preserve Apartments at Greenway Park, revised May 17, 2012.

Description & Location

The site is located in Section 14, Township 33 North, Range 79 West, City of Casper, County of Natrona, State of Wyoming. The site lies east of the Existing Jasper Drive, south of the proposed Pinyon Parkway extension and north of the existing 21st street.

The site is approximately 13.6 acres of undeveloped land (natural vegetation) that slopes from east to west with slopes of approximately 15-25% which is intended to be developed as a multifamily residential site. Another 5± acres exists as a part of this project which will be developed into 10,000 square foot residential lots.

Approved Drainage Design

The approved drainage study for the property includes the site within basin OS-1 and assumes a developed condition for the property. Based on the report assumptions, the basin is designed to developed runoff coefficients of 0.57 and 0.64; 10-yr and 100-yr respectively. The runoff coefficients indicate a developed flow rate of 19.14 cfs (10-yr) and 33.04 cfs (100-yr) and the flows are directed to a single storm outfall located in the northwest corner of the site which is sized to handle the developed flows for the 10-yr event.

The approved study allows the free release of developed storm flows from our site along with the adjacent development flows to Sage Creek with no onsite detention or storage. It is anticipated in the approved report that the combination of existing natural channels, Pratt Pond, and the City Park Reservoir are adequate to handle the developed flows.

Proposed Drainage

The site is designed largely as anticipated in the original drainage study as a multifamily site. Drainage will follow natural patterns from east to west and ultimately to the existing storm sewer infrastructure system. Based on the conceptual site plan the site imperviousness and runoff coefficients are calculated to be as follows.

Runoff Coefficients

Basin	Land Use	10-yr Runoff Coefficient	Area (FT^2)	Area (Ac.)	Area * Coefficient 10-yr	Area * Coefficient 100-yr
Prop. Apartments Development Site	Paved Areas	0.95	158,765	3.64	3.46	4.33
	Roofs	0.95	110,747	2.54	2.42	3.02
	Ground	0.25	98,818	2.27	0.57	0.71
	Turf	0.4	100,000	2.30	0.92	1.15
	TOTAL	**0.68**	**468,330**	**10.751**	**7.36**	**9.20**
				Runoff Coefficients	***0.68***	***0.86***

Basin	Land Use	10-yr Runoff Coefficient	Area (FT^2)	Area (Ac.)	Area * Coefficient 10-yr	Area * Coefficient 100-yr
Offsite Basins	Single Family (10k lot)	0.52	125,237	2.88	1.50	1.87
	Open space (ground)	0.25	0	0.00	0.00	0.00
	TOTAL	**0.52**	**125,237**	**2.875**	**1.50**	**1.87**
				Runoff Coefficients	***0.52***	***0.65***

Basin	Land Use	10-yr Runoff Coefficient	Area (FT^2)	Area (Ac.)	Area * Coefficient 10-yr	Area * Coefficient 100-yr
Combined	Prop. Apartments	0.68	468,330	10.75	7.36	9.20
	Prop. Single Family	0.52	125,237	2.88	1.50	1.87
	TOTAL	**0.65**	**593,567**	**13.627**	**8.86**	**11.07**
				Overall Runoff Coefficients:	***0.65***	***0.81***

Based on the calculation above the developed site has a 10-yr runoff coefficient of 0.65 which is an increase of approximately 14% for the approved drainage report which identifies the development property as having a developed runoff coefficient of 0.57.

The increase in the runoff coefficient directly correlates to an increase in storm runoff during an event. An analysis of the existing system (based on the approved report) indicates the anticipated flow for the basin is 19.14 cfs with the capacity of the inlet pipe assumed to be 85% full (calculated at 71.3% for outfall pipe). The full flow capacity of the inlet pipe is indicated to be 22.59 cfs. With the increase in the runoff coefficient the proposed flow based on the conceptual design is 21.8 cfs. While this represents an increase in flow, the carrying pipe will move from the assumed 85% full from the report to 96.8% full (the outfall pipe is calculated at 81.8% full – see appendix) and still be below the full flow capacity of the pipe.

Conclusion

In conclusion, the proposed development should see a minor increase in runoff associated with the conceptual site development plan used in this analysis. It appears, based on the existing approved drainage study for the region that the existing system has available capacity to carry the storm runoff flows as indicated above to the Sage Creek Basin without negatively impacting the downstream properties and storm drain system.

If any questions arise, feel free to contact me directly.

Sincerely,
Galloway

Randy Smith, PE
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Attachments:

Final Drainage Study for the Preserve Apartments at Greenway Park, revised May 17, 2012
- Runoff Coefficients Calculations
- StormCAD output, 10-Yr Flow

City of Casper, Stormwater Management Design Manual
- Recommended runoff coefficients
- Frequency Factors for the Ration Formula

Page taken from the approved Final Drainage Study for the Preserve Apartments at Greenway Park, revised May 17, 2012

RUNOFF COEFFICIENTS

Project: Preserve Apartments at Greenway Park - Phase II

Calculated by: JRK March 23, 2012 JOB NO: BRCAW4/ 070944

Land Use	Runoff Coeff. 10-yr	Runoff Coeff. 100-yr
Ground:		
Flat, 0-1%	0.10	0.13
Average, 1-3%	0.20	0.25
Hilly, 3-10%	0.25	0.31
Steep, 10% +	0.30	0.38
Pavement, Roofs	0.95	1.00
Turf:		
Flat, 0-1%	0.25	0.31
Average, 1-3%	0.35	0.44
Hilly, 3-10%	0.40	0.50
Steep, 10% +	0.45	0.56

Basin No	Land Use	Area (AC)	Area*Coeff. 10-yr	Area*Coeff. 100-yr	Composite Runoff Coeff. 10-yr	Composite Runoff Coeff. 100-yr (10-yr*1.25)
SAGE	Roofs	**0.46**	0.44	0.46		
	Roads/Trail	**0.64**	0.61	0.64		
	Turf	**0.41**	0.16	0.21		
	Ground	**4.51**	1.13	1.41		
	Total	**6.02**	2.34	2.71	**0.39**	**0.45**
OS-1	*Roofs*	**2.98**	2.83	2.98		
	Roads	**2.62**	2.49	2.62		
	Ground	**4.59**	1.15	1.43		
	Turf	**3.79**	1.52	1.90		
	Total	**13.98**	7.98	8.93	**0.57**	**0.64**
P-1	*Roads*	**0.23**	0.22	0.23		
	Turf	**0.15**	0.06	0.08		
	Total	**0.38**	0.28	0.31	**0.73**	**0.80**
P-2	*Roads*	**0.23**	0.22	0.23		
	Turf	**0.16**	0.06	0.08		
	Total	**0.39**	0.28	0.31	**0.72**	**0.79**
P-3	*Roads*	**0.09**	0.09	0.09		
	Turf	**0.05**	0.02	0.03		
	Total	**0.14**	0.11	0.12	**0.75**	**0.82**
P-4	*Roofs*	**0.09**	0.09	0.09		
	Roads	**0.10**	0.10	0.10		
	Turf	**0.28**	0.11	0.14		
	Total	**0.47**	0.29	0.33	**0.62**	**0.70**
P-5	*Roads*	**0.28**	0.27	0.28		
	Turf	**0.14**	0.06	0.07		
	Total	**0.42**	0.32	0.35	**0.77**	**0.83**
P-6	*Roofs*	**0.16**	0.15	0.16		
	Roads	**0.32**	0.30	0.32		
	Turf	**0.68**	0.27	0.34		
	Total	**1.16**	0.73	0.82	**0.63**	**0.71**
A-1	*Roofs*	**0.35**	0.33	0.35		
	Roads	**0.49**	0.47	0.49		
	Turf	**0.29**	0.12	0.15		
	Total	**1.13**	0.91	0.99	**0.81**	**0.87**

proposed development basin

Page taken from the approved Final Drainage Study for the Preserve Apartments at Greenway Park, revised May 17, 2012

Proposed development inlet pipe

Full Flow capacity

STORMCADD OUTPUT - 10-Year Flow

PROJECT: Preserve Apartments at Greenway Park - Phase II
DATE: March 23, 2012
CALCULATED BY: JRK

Start Node	Stop Node	Diameter (in)	Length (Unified) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (Calculated) (ft/ft)	Velocity (Average) (ft/s)	Flow (ft^3/s)	Capacity (Full Flow) (ft^3/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
INL-P2	INL-P1	15	29	5,250.00	5,249.72	0.01	3.91	1.13	6.35	5,250.42	5,250.08
INL-P1	15" FES	15	46.9	5,248.72	5,244.40	0.092	10.63	2.25	19.6	5,249.32	5,244.69
54" CULVERT UPSTREAM	PIPE CONNECTION	54	47.5	5,245.60	5,245.08	0.011	12.41	87.54	205.74	5,248.34	5,248.20
INL-P6	MH-P3	15	20.6	5,257.00	5,256.79	0.01	4.92	2.41	6.52	5,257.93	5,257.93
INL-P5	MH-P3	15	14.4	5,257.00	5,256.86	0.01	4.07	1.3	5.37	5,257.93	5,257.93
24" FES	INL-P8	24	30.1	5,275.00	5,274.70	0.01	8.07	19.14	22.59	5,276.57	5,276.14
INL-P8	INL-P7	24	29.2	5,274.60	5,274.31	0.01	8.12	20.27	22.56	5,276.22	5,275.81
INL-P7	MH-P5	24	37.9	5,274.21	5,273.83	0.01	8.2	21.46	22.65	5,275.87	5,275.39
MH-P5	MH-P4	24	313.1	5,273.73	5,259.34	0.046	14.96	21.39	48.5	5,275.39	5,260.27
INL-8	MH-2	15	118.6	5,273.00	5,262.45	0.089	7.15	0.61	19.27	5,273.30	5,262.60
MH-2	MH-P4	15	47	5,261.07	5,259.90	0.025	4.53	0.6	10.19	5,261.37	5,260.90
MH-P4	MH-P3	24	151	5,259.24	5,256.37	0.019	10.7	21.42	31.19	5,260.90	5,257.59
MH-P3	MH-P2	30	218.9	5,256.27	5,254.08	0.01	8.65	23.66	41.02	5,257.93	5,255.44
INL-P3	MH-P2	15	14.5	5,256.20	5,256.06	0.01	2.98	0.45	6.35	5,256.46	5,256.28
AD-9	AD-8	12	84.8	5,261.01	5,257.62	0.04	0	0	9.26	5,261.01	5,257.62
AD-8	INL-P4	12	19.2	5,257.62	5,257.42	0.01	0	0	4.73	5,257.62	5,257.42
INL-7	INL-6	15	195.9	5,262.86	5,258.94	0.02	4.3	0.65	9.14	5,263.17	5,259.28
INL-6	INL-P4	15	36.7	5,258.84	5,256.42	0.066	7.9	1.22	16.59	5,259.28	5,256.65
INL-P4	MH-P2	15	20.5	5,256.22	5,256.02	0.01	4.64	2.07	6.38	5,256.79	5,256.51
MH-P2	MH-P1	30	137.9	5,253.98	5,252.58	0.01	8.81	24.96	41.33	5,255.68	5,253.98
MH-P1	PIPE CONNECTION	30	264.8	5,252.48	5,246.00	0.024	12.24	24.89	64.16	5,254.18	5,248.20
PIPE CONNECTION	54" FES	54	62.5	5,245.08	5,244.40	0.011	13.19	112.33	205.11	5,248.20	5,246.99
INL-5	INL-4	15	183.7	5,266.51	5,257.34	0.05	8.95	2.63	14.43	5,267.16	5,258.10
INL-4	INL-3	15	182.3	5,257.24	5,250.50	0.037	9.32	4.5	12.42	5,258.10	5,251.39
INL-3	INL-2	18	171	5,250.40	5,248.69	0.01	6.28	6.58	10.5	5,251.39	5,249.74
INL-2	MH-1	18	64.6	5,248.59	5,247.82	0.012	7.14	8.78	11.44	5,249.74	5,248.81
AD-7	AD-6	12	108.1	5,271.41	5,268.71	0.025	4.31	0.24	7.32	5,271.61	5,268.84
AD-6	AD-5	12	161.3	5,268.71	5,260.01	0.054	5.57	0.24	10.76	5,268.91	5,260.39
AD-5	AD-4	12	145.7	5,260.01	5,252.16	0.054	8.13	0.84	10.75	5,260.39	5,252.59
AD-4	AD-3	12	65.5	5,252.16	5,251.51	0.01	4.76	1.05	4.62	5,252.59	5,251.97
AD-3	AD-2	12	66.5	5,251.51	5,250.84	0.01	4.94	1.19	4.64	5,251.97	5,251.19
AD-2	AD-1	12	53.5	5,250.84	5,250.31	0.01	4.91	1.17	4.63	5,251.30	5,250.84
AD-1	MH-1	12	50.7	5,250.31	5,249.80	0.01	5.34	1.58	4.63	5,250.84	5,250.20
MH-1	INL-1	18	141.5	5,247.72	5,246.31	0.01	6.76	9.83	10.5	5,248.93	5,247.46
INL-1	18" FES	18	66.3	5,245.02	5,241.71	0.05	13.6	12.9	23.47	5,246.37	5,242.54

TABLE 2-1

Recommended Runoff Coefficients

Land Use	Runoff Coefficient	
Business		
Downtown	0.70 to	0.95
Neighborhood	0.50 to	0.70
Residential		
Single-family	0.30 to	0.50
20,000 sq. ft.	0.49	
10,000 sq. ft.	0.52	
8,500 sq. ft.	0.57	
Multi-units, detached	0.40 to	0.60
Multi-units, attached	0.60 to	0.75
Residential (ranch-type)	0.25 to	0.40
Apartment	0.50 to	0.70
Industrial		
Light	0.50 to	0.80
Heavy	0.60 to	0.90
Parks and Cemeteries	0.10 to	0.25
Playgrounds	0.20 to	0.35
Railroad Yard	0.20 to	0.35
Unimproved	0.10 to	0.30

TABLE 2-2

Suggested Runoff Coefficients for Surface Types

Character of Surface	Runoff Coefficients
Pavement	
Asphaltic and Concrete	0.95
Brick	0.85
Roofs	0.95
Turf	
Flat, 0 to 1%	0.25
Average, 1 to 3%	0.35
Hilly, 3 to 10%	0.40
Steep, 10%+	0.45
Cultivated Ground	
Flat, 0 to 1%	0.10
Average, 1 to 3%	0.20
Hilly, 3 to 10%	0.25
Steep, 10%+	0.30

The coefficents in these two tables are applicable for a 10-year storm. These coefficients are based on the assumption that the design storm does not occur when the ground surface is frozen or covered by melting snow. Table 2-3 presents correction factors to adjust the above runoff coefficient for the 100-year storm.

TABLE 2-3

Frequency Factors for the Rational Formula

Recurrence Interval (years)	Adjustment Factor C_f
10	1.00
100	1.25*

*$C x C_f$ should not exceed 1.0

Rainfall Intensity

Rainfall intensity, i, is the average rate of rainfall, in inches per hour. Intensity is selected on the basis of design frequency of exceedence, a statistical parameter established by design criteria, and rainfall duration. For the rational method, the critical rainfall intensity is the rainfall having a duration equal to the time of concentration of the drainage basin.

Rainfall intensity can be determined for the 10-year and 100-year return periods from Figure 2-1. This figure was compiled from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Precipitation- Frequency Atlas of the Western United States, Volume II - Wyoming (1973). These curves are applicable for durations from 5 to 120 minutes.

Time of Concentration

One of the basic assumptions underlying the rational method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most hydraulically remote point of the drainage basin to the point under consideration. Time of concentration is usually computed by determining the travel time through the watershed. Overland flow, storm sewer or road gutter flow, and channel flow are the three phases of direct flow commonly used in computing travel time.

Overland Flow

The travel time for overland flow consists of the time it takes water to travel from the uppermost part of the watershed to a defined channel or inlet of the storm sewer system. Overland flow is significant in small watersheds because a high proportion of travel time is due to overland flow. The velocity of overland flow can vary greatly with the surface cover and tillage. If the slope and land use of the overland flow segment are known, the travel time can be read from Figure 2-2 or calculated using the following equation:

Assumed Developed Flow from Approved Report

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01000	ft/ft
Diameter	2.00	ft
Discharge	19.14	ft³/s

Approved report assumed flow rate from apartments site

Results

Normal Depth	1.41	ft
Flow Area	2.37	ft²
Wetted Perimeter	3.99	ft
Hydraulic Radius	0.59	ft
Top Width	1.82	ft
Critical Depth	1.57	ft
Percent Full	70.6	%
Critical Slope	0.00775	ft/ft
Velocity	8.08	ft/s
Velocity Head	1.01	ft
Specific Energy	2.43	ft
Froude Number	1.25	
Maximum Discharge	24.33	ft³/s
Discharge Full	22.62	ft³/s
Slope Full	0.00716	ft/ft
Flow Type	SuperCritical	

Pipe % full

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	70.58	%
Downstream Velocity	Infinity	ft/s

Assumed Developed Flow from Approved Report

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.41	ft
Critical Depth	1.57	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.00775	ft/ft

Apartments Developed Flow in Outfall Pipe

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.013	
Channel Slope	0.01000	ft/ft
Diameter	2.00	ft
Discharge	22.59	ft^3/s

Calculated flow rate from apartments site

Results

Normal Depth	1.64	ft
Flow Area	2.75	ft^2
Wetted Perimeter	4.52	ft
Hydraulic Radius	0.61	ft
Top Width	1.54	ft
Critical Depth	1.69	ft
Percent Full	81.8	%
Critical Slope	0.00944	ft/ft
Velocity	8.21	ft/s
Velocity Head	1.05	ft
Specific Energy	2.68	ft
Froude Number	1.08	
Maximum Discharge	24.33	ft^3/s
Discharge Full	22.62	ft^3/s
Slope Full	0.00997	ft/ft
Flow Type	SuperCritical	

Pipe % full

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	81.84	%
Downstream Velocity	Infinity	ft/s

Apartments Developed Flow in Outfall Pipe

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.64	ft
Critical Depth	1.69	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.00944	ft/ft