January 28, 2020

Casey Ballard
Engineer, Aurora Water
City of Aurora
15151 E Alameda Parkway
Aurora, CO 80012

RE: ***Overlook at Sorrel Ranch – Water Main Conformance Letter***

Dear Mr. Ballard:

The intent of this letter is to demonstrate that the public water main for the proposed Overlook at Sorrel Ranch development is in compliance with the Sorrel Ranch Master Utility Study dated August 14, 2002. The proposed site will be in conformance with the Sorrel Ranch Master Utility Study.

A water model was created using EPANET modeling software. The model consisted of the proposed water main extension from its connection points to the existing water main. Tie-in locations were designated as reservoirs and the Total Head was calculated using existing elevations and existing pressure data that was provided by the city for hydrants located near these connection points. There were 4 scenarios that were run using the flow model: one for Average Daily Flow, one for Maximum Hour Flow, one for Maximum Day Flow and one for Maximum Day Flow with Fire Flow Demand. Criteria to determine these flows came from Section 5.02 of the Aurora Water: Water, Sanitary Sewer & Storm Drainage Infrastructure Standards and Specifications, Effective January 1, 2020. After performing an analysis of each situation, the water main meets all requirements of Section 5.02. Please see the attached sheets for EPANET results, coefficients and demand calculations.

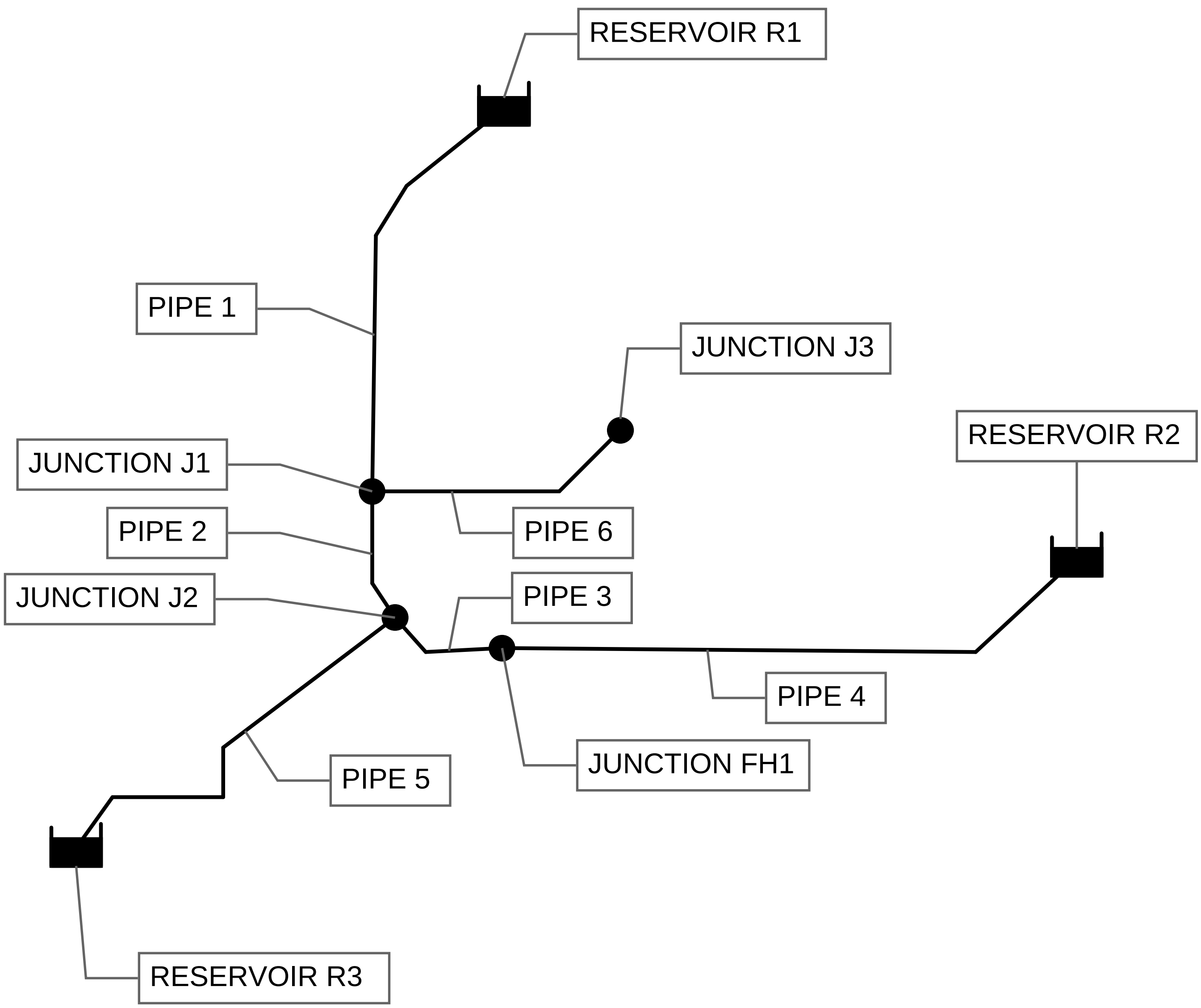
Should you have any questions or comments, feel free to contact me at (303) 773-1605.

Sincerely,

HCL Engineering and Surveying, LLC

Andrew Renner, PE
Project Engineer

OVERLOOK AT SORREL RANCH
WATER MAIN LAYOUT



AVERAGE DAY FLOW

Network Table - Nodes

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc J1	5984.0	3.59	6206.95	96.60
Junc FH1	5981.2	0.00	6206.46	97.61
Junc J3	5981.2	0.78	6206.95	97.82
Junc J2	5981.5	3.59	6206.36	97.43
Resvr R1	6208.3	-459.78	6208.30	0.00
Resvr R2	6208.3	-433.13	6208.30	0.00
Resvr R3	6205.8	884.94	6205.80	0.00

AVERAGE DAY FLOW

Network Table - Links

Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor
Pipe 1	384.31	8	150	459.78	2.93	3.51	0.018
Pipe 4	603.72	8	150	-433.13	2.76	3.04	0.017
Pipe 6	188.61	8	150	0.78	0.00	0.00	0.000
Pipe 2	167.43	8	150	455.41	2.91	3.54	0.018
Pipe 3	21.49	8	150	-433.13	2.76	4.91	0.028
Pipe 5	299.04	12	150	884.94	2.51	1.86	0.019

MAXIMUM DAY FLOW

Network Table - Nodes

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc J1	5984.0	10.06	6206.93	96.60
Junc FH1	5981.2	0.00	6206.45	97.60
Junc J3	5981.2	2.18	6206.93	97.81
Junc J2	5981.5	10.06	6206.35	97.43
Resvr R1	6208.3	-463.56	6208.30	0.00
Resvr R2	6208.3	-434.43	6208.30	0.00
Resvr R3	6205.8	875.69	6205.80	0.00

MAXIMUM DAY FLOW

Network Table - Links

Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor
Pipe 1	384.31	8	150	463.56	2.96	3.57	0.017
Pipe 4	603.72	8	150	-434.43	2.77	3.06	0.017
Pipe 6	188.61	8	150	2.18	0.01	0.00	0.574
Pipe 2	167.43	8	150	451.32	2.88	3.48	0.018
Pipe 3	21.49	8	150	-434.43	2.77	4.93	0.028
Pipe 5	299.04	12	150	875.69	2.48	1.83	0.019

MAXIMUM HOUR FLOW

Network Table - Nodes

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc J1	5984.0	16.17	6206.91	96.59
Junc FH1	5981.2	0.00	6206.44	97.60
Junc J3	5981.2	3.50	6206.91	97.80
Junc J2	5981.5	16.17	6206.34	97.42
Resvr R1	6208.3	-467.10	6208.30	0.00
Resvr R2	6208.3	-435.65	6208.30	0.00
Resvr R3	6205.8	866.91	6205.80	0.00

MAXIMUM HOUR FLOW

Network Table - Links

Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor
Pipe 1	384.31	8	150	467.10	2.98	3.62	0.017
Pipe 4	603.72	8	150	-435.65	2.78	3.08	0.017
Pipe 6	188.61	8	150	3.50	0.02	0.00	0.223
Pipe 2	167.43	8	150	447.43	2.86	3.43	0.018
Pipe 3	21.49	8	150	-435.65	2.78	4.98	0.028
Pipe 5	299.04	12	150	866.91	2.46	1.79	0.019

MAXIMUM DAY PLUS FIRE FLOW

Network Table - Nodes

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc J1	5984.0	10.06	6206.46	96.39
Junc FH1	5981.2	1500.00	6205.22	97.07
Junc J3	5981.2	2.18	6206.46	97.60
Junc J2	5981.5	10.06	6205.67	97.13
Resvr R1	6208.3	-543.07	6208.30	0.00
Resvr R2	6208.3	-572.32	6208.30	0.00
Resvr R3	6205.8	-406.91	6205.80	0.00

MAXIMUM DAY PLUS FIRE FLOW

Network Table - Links

Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor
Pipe 1	384.31	8	150	543.07	3.47	4.79	0.017
Pipe 4	603.72	8	150	-572.32	3.65	5.11	0.016
Pipe 6	188.61	8	150	2.18	0.01	0.00	0.000
Pipe 2	167.43	8	150	530.83	3.39	4.71	0.018
Pipe 3	21.49	8	150	927.68	5.92	21.06	0.026
Pipe 5	299.04	12	150	-406.91	1.15	0.43	0.021

Demand Scenario Information

Total Site		
Lots	41	ea
People per Lot	2.77	people
Averade Day Per Capita Flow	101	gpd
Average Day Flow	11470.57	gpd
	7.97	gpm
[1]Maximum Day Flow	22.30	gpm
[2]Maximum Hour Flow	35.85	gpm
Fire Flow Demand	1,500	gpm

[1]Maximum Day Flow = Average Day Flow * 2.8

[2]Maximum Hour Flow = Average Day Flow * 4.5

Junction J3 (Cul-De-Sac)		
Lots	4	ea
People per Unit	2.77	people
Averade Day Per Capita Flow	101	gpd
Average Day Flow	1119.08	gpd
Average Day Flow	**0.78**	**gpm**
Maximum Day Flow	**2.18**	**gpm**
Maximum Hour Flow	**3.50**	**gpm**

Junction J1 and J2 (each)		
Lots	18.5	ea
People per Lot	2.77	people
Averade Day Per Capita Flow	101	gpd
Average Day Flow	5175.75	gpd
Average Day Flow	**3.59**	**gpm**
Maximum Day Flow	**10.06**	**gpm**
Maximum Hour Flow	**16.17**	**gpm**

EPANET Modeling Information

	Elevation	Pressure	Pressure Head	Total Head
22V-03	6008.9	89.10	205.7	6214.6
22V-04	6000.3	85.20	196.7	6197.0
			Average Head (Reservoir 3)	**6205.8**
22V-19	5987.6	95.60	220.7	6208.3
22V-24	5981.8	98.10	226.5	6208.3
22V-25	5975.5	100.80	232.7	6208.2
22V-26	5971.5	102.60	236.9	6208.4
22V-27	5975.9	100.70	232.5	6208.4
			Average Head (Reservoirs 1 & 2)	**6208.3**

Loss Coefficients	
Flanged Tee	0.2
Gate Valve	0.15
Flanged Elbow 45°	0.2
Flanged Elbow 90°	0.2

	Elevation
Junction J1	5984.0
Junction J2	5981.5
Fire Hydrant FH1	5981.2
Junction J3	5981.2

Specific Weight of Water	62.37	Lb/ft^3
	0.43	Lb/ft-in^2

	Start Node	End Node	Length	Size (inches)	Hazen Williams Coefficient	Loss Coefficient	Tee	Valve	45 Bend (or less)	90 Bend
Pipe 1	R1	J1	384.31	8	150	0.55	0	1	2	0
Pipe 2	J1	J2	167.43	8	150	0.35	0	1	1	0
Pipe 3	J2	FH1	21.49	8	150	0.35	0	1	1	0
Pipe 4	FH1	R2	603.72	8	150	0.35	0	1	1	0
Pipe 5	J2	R3	299.04	12	150	0.95	1	1	2	1
Pipe 6	J1	J3	188.61	8	150	0.55	1	1	1	0

Minor Loss Coefficients in Pipes and Tubes Components

Minor loss coefficients for common used components in pipe and tube systems

Minor head loss in pipe and tube systems can be expressed as

$h_{minor\_loss} = \xi v^2 / 2 g$ (1)

where

h_{minor_loss} = minor head loss (m, ft)

ξ = minor loss coefficient

v = flow velocity (m/s, ft/s)

g = acceleration of gravity (m/s^2, ft/s^2)

Minor loss coefficients for some of the most common used components in pipe and tube systems

Type of Component or Fitting	Minor Loss Coefficient - ξ -
Tee, Flanged, Dividing Line Flow	0.2
Tee, Threaded, Dividing Line Flow	0.9
Tee, Flanged, Dividing Branched Flow	1.0
Tee, Threaded , Dividing Branch Flow	2.0
Union, Threaded	0.08
Elbow, Flanged Regular 90^o	0.3
Elbow, Threaded Regular 90^o	1.5
Elbow, Threaded Regular 45^o	0.4
Elbow, Flanged Long Radius 90^o	0.2
Elbow, Threaded Long Radius 90^o	0.7
Elbow, Flanged Long Radius 45^o	0.2
Return Bend, Flanged 180^o	0.2
Return Bend, Threaded 180^o	1.5
Globe Valve, Fully Open	10
Angle Valve, Fully Open	2
Gate Valve, Fully Open	0.15
Gate Valve, 1/4 Closed	0.26
Gate Valve, 1/2 Closed	2.1
Gate Valve, 3/4 Closed	17
Swing Check Valve, Forward Flow	2
Ball Valve, Fully Open	0.05
Ball Valve, 1/3 Closed	5.5
Ball Valve, 2/3 Closed	200
Diaphragm Valve, Open	2.3
Diaphragm Valve, Half Open	4.3
Diaphragm Valve, 1/4 Open	21
Water meter	7

Hazen-Williams Coefficients

Hazen-Williams coefficients for common piping materials

Hazen-Williams coefficients are used in the Hazen-Williams equation calculate friction loss in ducts and pipes. Coefficients for some common materials used in ducts and pipes are indicated below:

Material	Hazen-Williams Coefficient - *c* -
ABS - Acrylonite Butadiene Styrene	130
Aluminum	130 - 150
Asbestos Cement	140
Asphalt Lining	130 - 140
Brass	130 - 140
Brick sewer	90 - 100
Cast-Iron - new unlined (CIP)	130
Cast-Iron 10 years old	107 - 113
Cast-Iron 20 years old	89 - 100
Cast-Iron 30 years old	75 - 90
Cast-Iron 40 years old	64-83
Cast-Iron, asphalt coated	100
Cast-Iron, cement lined	140
Cast-Iron, bituminous lined	140
Cast-Iron, sea-coated	120
Cast-Iron, wrought plain	100
Cement lining	130 - 140
Concrete	100 - 140
Concrete lined, steel forms	140
Concrete lined, wooden forms	120
Concrete, old	100 - 110
Copper	130 - 140
Corrugated Metal	60
Ductile Iron Pipe (DIP)	140
Ductile Iron, cement lined	120
Fiber	140
Fiber Glass Pipe - FRP	150
Galvanized iron	120
Glass	130
Lead	130 - 140
Metal Pipes - Very to extremely smooth	130 - 140
Plastic	130 - 150
Polyethylene, PE, PEH	140
Polyvinyl chloride, PVC, CPVC	150
Smooth Pipes	140
Steel new unlined	140 - 150
Steel, corrugated	60
Steel, welded and seamless	100
Steel, interior riveted, no projecting rivets	110
Steel, projecting girth and horizontal rivets	100
Steel, vitrified, spiral-riveted	90 - 110
Steel, welded and seamless	100
Tin	130
Vitrified Clay	110
Wrought iron, plain	100
Wooden or Masonry Pipe - Smooth	120
Wood Stave	110 - 120