Section 575

Wastewater Lift Stations

PART 1: General

1.1 *Purpose* - Lift stations shall be provided at any point in a proposed sewage collection system where the upstream gravity collection system cannot be physically connected to the existing collection system in a manner to permit gravity flow. System extensions shall be designed to avoid lift stations as much as possible.

1.1.1 In general, lift stations may lift flows to a higher elevation, transport flow horizontally or combine lifting and horizontal transport.

1.1.2 In general, lift stations shall utilize submersible pumps placed in a below-ground wet well, unless otherwise noted.

1.2 *Location and Design* - Lift station location and design capacity shall be compatible with the ECUA Collection System Master Plan. Lift stations shall be designed to operate effectively at initial flows as well as at ultimate design flows. To that end, each lift station design must address several interrelated elements including, but not limited to:

1.2.1 Wet well size (diameter and depth)

1.2.2 Force main size and lift station piping

1.2.3 Pump and control selection

1.2.4 Flow quantity and lift station appurtenances

1.3 *Calculations* - Lift station design calculations submitted to ECUA for approval shall include all design considerations and assumptions. (See Lift Station Design Worksheet, at the end of this section.)

PART 2: Design Flows

2.1 *Flow Requirements* - Lift station design flow requirements shall be developed in accordance with Section 570- Sanitary Sewer Collection System, Part 3 of ECUA's Engineering Manual. In addition, flows shall be estimated for each of the following conditions:

2.1.1 Peak hourly flow for initial, intermediate, and ultimate periods

2.1.2 Average flow for initial, intermediate, and ultimate periods

2.1.3 Minimum flow for initial, intermediate, and ultimate periods

PART 3: Design Parameters and Functional Criteria

3.1 *Lift Station Siting* - Lift station shall be located so as to permit sewage collection by means of gravity flow from the largest feasible drainage area. Consideration may be given to locating lift stations to permit continuing future downstream gravity sewer system development where possible and consistent with ECUA's Collection System Master Plan.

3.1.1 *General Location* - Lift station top elevation shall be above the 100 year flood level as designated by FEMA Flood Maps. In no case should the lift station be placed in an area subject to prolonged periods of flooding. In no case shall the lift station parcel be subject to prolonged periods of flooding.

3.1.2 *Access* - Lift station access shall be readily accessible to maintenance vehicles at all times. Parcels not fronting on public rights-of-way shall be provided with a dedicated access easement at least 20 feet in width and with adequate provisions for turn-around and gate access. Driveways shall be 12 feet wide minimum and may be either paved (2" Asphalt, 6" graded aggregate base, 12" sub-grade stabilization) or rock surface (8" graded aggregate base, 12" sub-grade stabilization) capable of supporting H-20 traffic loading.

3.1.3 *Parcel Requirements* - The lift station site shall be 50 feet in width and 50 feet in depth, at a minimum. A larger parcel may be required if necessary to accommodate additional equipment or access. Title to the lift station site shall be conveyed to ECUA in accordance with ECUA policy. The site shall be fenced in accordance with ECUA requirements unless specifically exempted. The parcel and any associated access driveways shall be designed to permit proper drainage away from the lift station.

3.1.4 *Other Considerations* - The lift station electrical power service shall be three phase. The potable water service shall be 2-inch in diameter with a backflow preventer and 1½ -inch meter.

3.2 *Functional Criteria* -

3.2.1 *Redundancy* - Lift stations shall contain a minimum of 2 pumps with each pump capable of pumping a minimum 250 gallons per minute or peak hourly flow, whichever is greater based on the design point using the calculated system head curve Peak hourly flow shall be determined using the curve or formula in Appendix E-2 (page 575.9).

3.2.2 *Wet Well Sizing* - Wet well volume shall be calculated based on the projected ultimate peak flows with consideration for initial peak flows, or a peak hourly flow rate of 250 gallons per minute (62.5 gpm, average daily flow using a 4.0 peaking factor), whichever is greater.

3.2.2.1 Minimum liquid level in the wet well shall be 2 feet above the top of the pumps minimum or in accordance with the manufacturer's requirements for the pump selected, whichever is greater.

3.2.2.2 Cycle time, to pump down and refill, shall be not less than 10 minutes nor more than 15 minutes at 1/2 peak hourly flow.

3.2.2.3 The spacing between 'lead pump on' and 'lead pump off' shall be a minimum of 2 feet. Levels will be field adjusted to match calculations.

3.2.2.4 The spacing between 'lead pump on' and 'lag pump on' shall be a minimum of 1 foot.

3.2.2.5 The high level alarm shall be set not less than 1 foot above 'lag pump on', and at sufficient depth to provide a minimum of 30 minutes storage, calculated at average flow, below the lowest influent line.

3.3 *Velocities* - The lift station discharge force main (riser piping) velocity at the initial pumping rate shall be not less than 5 fps. The velocity in the discharge force main (riser piping) at the design pumping rate shall be not more than 10 fps. If flow monitoring is required, the riser piping velocity shall be maintained through the flow meter. The force main velocity in the remaining parts of the proposed transmission system (downstream of the the above-grade plug valves or flow meter) shall not be less than 2.5 fps at the initial peak hourly design pumping rate.

3.4 *Downstream Impacts* - Engineer shall coordinate with ECUA Engineering staff to analyze downstream capacities. ECUA staff will assist the engineer to the extent possible with the analyses noted below.

3.4.1 When the force main will manifold into an existing force main the impact on that line and all existing pump stations that utilize that line must be evaluated by the Engineer and ECUA staff.

3.4.2 When the force main could either discharge to an existing lift station or manifold into that station's force main, an analysis shall be made to determine which alternative is in the best long-term interest of ECUA.

3.5 System Head: Calculate system head: static, friction and velocity. Select pumps. (See Worksheet, pages 575.6 and 575.7). Pump curves shall show range and efficiencies, horsepower draw, and shall include the system curve(s) at the initial, intermediate, and ultimate design periods. The maximum system pressure shall not exceed 60 psi (138 feet of head).

3.6 *Wet Well Design* - The minimum wet well size shall be 8-feet in diameter. The wet well shall be sized by determining the combination of diameter and depth most suitable to handle the intended maximum design capacity with adequate provision for emergency storage.

3.6.1 *Elevations:* Based on location constraints, functional criteria, and the approximate wet well size, the following design elements shall be established:

3.6.1.1 Ground elevation at wet well.

3.6.1.2 Lowest influent elevation of gravity system.

3.6.1.3 "High level alarm" elevation.

3.6.1.4 "2nd Lag pump on" elevation (for triplex lift stations).

3.6.1.5 "Lag pump on" elevation.

3.6.1.6 "Lead pump on" elevation.

3.6.1.7 "All pumps off" elevation.

3.6.1.8 Wet well bottom elevation.

3.6.2 *Future Needs*: When the wet well and force main are oversized for future requirements, the station piping, electrical service, and controls shall be sized accordingly. When it is anticipated that a third pump is to be installed in the future, the station shall be designed to accommodate through-wall piping in the wet well top, a manifold into the discharge force main, and appropriate equipment in the control panel.

3.6.3 *Optimization*: Compute design elements for larger and/or smaller diameter wet wells, then select optimum size to meet initial and future demands. Wet well sizing, force main sizing and pump selection may require several iterations to arrive at optimum design for sound economic selection over the proposed design period.

PART 4: <u>Appurtenances</u>

4.1 *Fencing* - The lift station site shall be fenced in accordance with ECUA specifications unless specifically waived by ECUA's Engineer.

4.1.1 The fence shall enclose an area sufficient to protect the lift station and all appurtenances. Minimum size of parcel shall be 50' by 50'.

4.1.2 The electric supply meter shall be outside the fence or located so as to be read without entering the fence.

4.2 *Bypass Pumping* - Emergency bypass piping with plug valve and quick-connect coupling shall be the same size (up to 8-inch diameter) as the station piping, and shall be located within the valving area as shown on ECUA's Standard Lift Station Detail Sheet.

4.3 *Emergency Power* - Standby emergency power will be required as follows:

4.3.1 Lift stations that discharge through a 12-inch diameter or larger piping shall require an on-site emergency generator suitably located and wired for automatic transfer. Generator will be of sufficient size to run all of the station equipment. For duplex lift stations, the generator must be sized to run two pumps at a time. For triplex lift stations, the generator must be sized to run the remaining pump(s) with the largest pump out of service.

4.3.2 All lift stations shall be equipped with a manual transfer switch for connecting a portable generator. Engineer shall coordinate with ECUA to determine the best location for the additional manual transfer switch for lift stations that require an automatic transfer switch (ATS),

4.4 *Flow Measurement* - Flow measuring devices shall be provided with lift stations that have a design flow of 1,200 gpm or greater. Flow measurement device shall have instantaneous, totalizing, and recording capabilities.

4.5 *Chemical Feed Equipment* - Chemical feed equipment may be required at lift stations or elsewhere in the collection system if conditions develop causing generation of hydrogen sulfide and other gases. If chemical feed equipment is not required initially, access must be provided for possible future use.

LIFT STATION DESIGN - WORKSHEET

Project Name: ____________________________ **Date:______________________________**

Project Location: _________________________ **By: _______________________________**

REQUIRED CALCULATIONS FOR WET WELL DESIGN:

1. Estimate average daily flow (ADF):

Initial (first year) $(\_\_\_\_ ERC + \_\_\_\_ Acre\ X\ \_\_\_\_ \frac{ERC}{AC})\ X\ \frac{240}{1440} = \_\_\_\_ GPM$

Intermediate (this project) $(\_\_\_\_ ERC + \_\_\_\_ Acre\ X\ \_\_\_\_ \frac{ERC}{AC})\ X\ \frac{240}{1440} = \_\_\_\_ GPM$

Ultimate (build-out of lift station coverage area) $(\_\_\_\_ ERC + \_\_\_\_ Acre\ X\ \_\_\_\_ \frac{ERC}{AC})\ X\ \frac{240}{1440} = \_\_\_\_ GPM$

Note: 1 ERC = 240 GPM

2. Select appropriate peaking factor (see Appendix E-2) and determine Design Peak Flow:

Initial	Avg. X _____Peak =	_____gpm
Intermediate	Avg. X _____Peak =	_____gpm
Ultimate	Avg. X _____Peak =	_____gpm

3. Primary Operating Volume in gallons for a minimum cycle time of 12 minutes will be 3 X the pumping rate in gallons per minute. Note: The spacing between ‘lead pump on’ and ‘lead pump off’ shall be a minimum of 2 feet. Levels will be field adjusted to match calculations.

   Compute for Initial and Ultimate conditions.

4. Compute Primary Operating Range = Vol. required divided by Vol. per vertical foot. Compute for Initial, Intermediate, and Ultimate conditions.

5. Calculate Emergency Storage Time (see Section 575, Paragraph 3.2.2.5).

6. Calculate Emergency Storage Volume = Emergency Storage Time X QAV. Calculate for Initial and Ultimate Flow conditions. The minimum emergency storage volume shall be 1,880 gallons (5-feet of additional depth for 8-foot diameter wet well).

7. Calculate Alarm Time Range = Alarm Volume divided by volume per vertical foot.

8. Identify the lowest discharge (or spill) point assuming lift station has failed and system is surcharging.

9. Establish critical pump control elevations.

10. Check Flotation: Total weight - buoyancy force x 1.2 must be positive.

REQUIRED CALCULATION FOR FORCE MAIN DESIGN:

Compute System Curve

TDH shall be evaluated separately for discharge elevation and elevation of high points of the force main, and for initial and aged "C" factors. The typical “C” factors for PVC for initial and aged conditions shall be 140 and 100, respectively. Other “C” factors may be utilized as necessary when analyzing piping of various materials (e.g. ductile iron).

Static Head High Point _____ or Discharge Elevation_____- Pump Off_____=_____ft.

Pump Selection:

PERIOD	PUMP			MOTOR				PERFORMANCE		
	MAKE	MODEL	IMPELLER	MODEL	HP	RPM	ELEC.	GPM	TDH	EFFIC.
Initial										
Intermediate										
Ultimate										

ADDENDIX E-1

Lift Station Design Reference Data

Capacity of Force Mains at Given Velocity Q = AV gpm

VELOCITY	FORCE MAINS - NOMINAL SIZE - INCHES DIAMETER										
fps	2"	3"	4"	6"	8"	10"	12"	14"	16"	20"	24"
2	20	40	80	180	310	490	700	960	1250	1960	2820
2.5	25	60	100	220	390	610	880	1200	1570	2450	3520
3	30	70	120	260	470	730	1060	1440	1880	2940	4230
4	40	90	160	350	630	980	1410	1920	2510	3910	5640
5	50	110	200	440	780	1220	1760	2400	3130	4890	7050
6	60	130	230	530	940	1470	2110	2880	3760	5870	8460
7	70	150	270	620	1100	1710	2470	3360	4380	6850	9860
8	80	180	310	700	1250	1960	2820	3840	5010	7830	11270
9	90	200	350	790	1410	2200	3170	4320	5640	8810	12680
10	100	220	390	880	1570	2450	3520	4800	6260	9790	14090

(for friction losses and full chart see Appendix E-3)

PIPE VOLUME (Gal/100 FT):												
Diam.	2"	3"	4"	6"	8"	10"	12"	14"	16"	20"	24"	36"
Vol.	19	42	70	153	259	405	573	800	1044	1632	2350	5284

Manhole or Wet Well Volume per Vertical Foot in Gallons

DIAMETER (FT)	4	5	6	8*	10	12	14
VOL. (GAL)	94.0	147.0	211.5	376.0	587.5	846.0	1151.5

(adjust for reduced diameters for sidewall taper at bottom)

** smallest wet well diameter allowed for lift stations*

APPENDIX E-3

Friction Loss per 100 Feet Length of Pipe. Based on Hazen-Williams Formula Using "C" Factor Of 140. Sizes of Standard Pipe in Inches.

	1/2 -inch		3/4 -inch		1 -inch		1 1/4 -inch		1 1/2 -inch		2 -inch		2 1/2 -inch		3 -inch		4 -inch		5 -inch		6 -inch	
Flowrate (gallons/min)	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**Velocity (feet/sec)**	**Loss (ft/100 ft)**
2	2.11	4.07	1.20	1.03	0.74	0.32	0.43	0.08	0.32	0.04	0.19	0.01	0.13	0.00	0.09	0.00	0.05	0.00	0.03	0.00	0.02	0.00
4	4.23	14.69	2.41	3.73	1.49	1.15	0.86	0.30	0.63	0.14	0.38	0.04	0.27	0.02	0.17	0.01	0.10	0.00	0.06	0.00	0.04	0.00
6	6.34	31.13	3.61	7.91	2.23	2.44	1.29	0.64	0.95	0.30	0.57	0.09	0.40	0.04	0.26	0.01	0.15	0.00	0.10	0.00	0.07	0.00
8	8.46	53.04	4.82	13.48	2.97	4.16	1.72	1.10	1.26	0.52	0.77	0.15	0.54	0.06	0.35	0.02	0.20	0.01	0.13	0.00	0.09	0.00
10	10.57	80.18	6.02	20.38	3.71	6.29	2.15	1.66	1.58	0.78	0.96	0.23	0.67	0.10	0.43	0.03	0.25	0.01	0.16	0.00	0.11	0.00
12	12.69	112.38	7.22	28.56	4.46	8.82	2.58	2.32	1.89	1.10	1.15	0.33	0.80	0.14	0.52	0.05	0.30	0.01	0.19	0.00	0.13	0.00
15	15.86	169.89	9.03	43.18	5.57	13.34	3.22	3.51	2.37	1.66	1.44	0.49	1.01	0.21	0.65	0.07	0.38	0.02	0.24	0.01	0.17	0.00
18	19.03	238.13	10.84	60.52	6.69	18.70	3.86	4.92	2.84	2.33	1.72	0.69	1.21	0.29	0.78	0.10	0.45	0.03	0.29	0.01	0.20	0.00
20			12.04	73.56	7.43	22.72	4.29	5.98	3.15	2.83	1.91	0.84	1.34	0.35	0.87	0.12	0.50	0.03	0.32	0.01	0.22	0.00
25			15.05	111.20	9.29	34.35	5.37	9.05	3.94	4.27	2.39	1.27	1.68	0.53	1.09	0.19	0.63	0.05	0.40	0.02	0.28	0.01
30			18.06	155.86	11.14	48.15	6.44	12.68	4.73	5.99	2.87	1.78	2.01	0.75	1.30	0.26	0.76	0.07	0.48	0.02	0.33	0.01
35					13.00	64.06	7.51	16.87	5.52	7.97	3.35	2.36	2.35	1.00	1.52	0.35	0.88	0.09	0.56	0.03	0.39	0.01
40					14.86	82.03	8.59	21.60	6.31	10.20	3.83	3.03	2.68	1.27	1.74	0.44	1.01	0.12	0.64	0.04	0.44	0.02
45					16.72	102.03	9.66	26.87	7.10	12.69	4.31	3.76	3.02	1.58	1.95	0.55	1.13	0.15	0.72	0.05	0.50	0.02
50							10.73	32.66	7.88	15.43	4.78	4.57	3.35	1.93	2.17	0.67	1.26	0.18	0.80	0.06	0.56	0.02
60							12.88	45.77	9.46	21.62	5.74	6.41	4.02	2.70	2.61	0.94	1.51	0.25	0.96	0.08	0.67	0.03
70							15.02	60.90	11.04	28.77	6.70	8.53	4.69	3.59	3.04	1.25	1.77	0.33	1.12	0.11	0.78	0.05
80	**8 -inch**						17.17	77.98	12.62	36.84	7.65	10.92	5.36	4.60	3.47	1.60	2.02	0.43	1.28	0.14	0.89	0.06
90							19.32	96.99	14.19	45.81	8.61	13.58	6.03	5.72	3.91	1.99	2.27	0.53	1.44	0.18	1.00	0.07
100	**Velocity**	**Loss**							15.77	55.69	9.57	16.51	6.71	6.95	4.34	2.42	2.52	0.64	1.60	0.21	1.11	0.09
110	**(feet/sec)**	**(ft/100 ft)**							17.35	66.44	10.52	19.70	7.38	8.30	4.78	2.88	2.77	0.77	1.77	0.26	1.22	0.10
120	0.77	0.03	**10 -inch**						18.92	78.05	11.48	23.14	8.05	9.75	5.21	3.39	3.03	0.90	1.93	0.30	1.33	0.12
130	0.83	0.04							20.50	90.53	12.44	26.84	8.72	11.31	5.65	3.93	3.28	1.05	2.09	0.35	1.44	0.14
140	0.89	0.04	**Velocity (feet/sec)**	**Loss (ft/100 ft)**							13.39	30.79	9.39	12.97	6.08	4.51	3.53	1.20	2.25	0.40	1.56	0.16
150	0.96	0.05									14.35	34.99	10.06	14.74	6.51	5.12	3.78	1.37	2.41	0.45	1.67	0.19
160	1.02	0.05	0.65	0.02	**12 -inch**						15.31	39.43	10.73	16.61	6.95	5.77	4.04	1.54	2.57	0.51	1.78	0.21
170	1.09	0.06	0.69	0.02							16.26	44.11	11.40	18.58	7.38	6.46	4.29	1.72	2.73	0.57	1.89	0.23
180	1.15	0.07	0.74	0.02	**Velocity (feet/sec)**	**Loss (ft/100 ft)**	**14 -inch**				17.22	49.04	12.07	20.65	7.82	7.18	4.54	1.91	2.89	0.64	2.00	0.26
190	1.21	0.07	0.78	0.03							18.18	54.20	12.74	22.83	8.25	7.93	4.79	2.11	3.05	0.70	2.11	0.29
200	1.28	0.08	0.82	0.03	0.57	0.01	**Velocity (feet/sec)**	**Loss (ft/100 ft)**			19.13	59.60	13.41	25.10	8.69	8.73	5.04	2.33	3.21	0.77	2.22	0.32
225	1.44	0.10	0.92	0.03	0.64	0.01					21.53	74.13	15.09	31.22	9.77	10.85	5.67	2.89	3.61	0.96	2.50	0.39
250	**1.60**	**0.12**	**1.02**	**0.04**	**0.71**	**0.02**	**0.52**	**0.01**			**23.92**	**90.11**	**16.76**	**37.95**	**10.86**	**13.19**	**6.30**	**3.52**	**4.01**	**1.17**	**2.78**	**0.48**
275	1.76	0.15	1.12	0.05	0.78	0.02	0.57	0.01	**16 -inch**				18.44	45.28	11.94	15.74	6.94	4.19	4.41	1.40	3.06	0.57
300	1.92	0.17	1.23	0.06	0.85	0.02	0.63	0.01					20.12	53.20	13.03	18.49	7.57	4.93	4.81	1.64	3.33	0.67
325	2.08	0.20	1.33	0.07	0.92	0.03	0.68	0.01	**Velocity (feet/sec)**	**Loss (ft/100 ft)**					14.11	21.44	8.20	5.72	5.22	1.90	3.61	0.78
350	2.24	0.23	1.43	0.08	0.99	0.03	0.73	0.02							15.20	24.60	8.83	6.56	5.62	2.18	3.89	0.89
375	2.40	0.26	1.53	0.09	1.06	0.04	0.78	0.02	0.60	0.01	**18 -inch**				16.29	27.95	9.46	7.45	6.02	2.48	4.17	1.01
400	2.55	0.30	1.64	0.10	1.14	0.04	0.83	0.02	0.64	0.01					17.37	31.50	10.09	8.40	6.42	2.80	4.44	1.14
425	2.71	0.33	1.74	0.11	1.21	0.05	0.89	0.02	0.68	0.01	**Velocity (feet/sec)**	**Loss (ft/100 ft)**			18.46	35.24	10.72	9.39	6.82	3.13	4.72	1.28
450	2.87	0.37	1.84	0.12	1.28	0.05	0.94	0.02	0.72	0.01					19.54	39.18	11.35	10.44	7.22	3.48	5.00	1.42
475	3.03	0.41	1.94	0.14	1.35	0.06	0.99	0.03	0.76	0.01	0.60	0.01	**20 -inch**		20.63	43.30	11.98	11.54	7.62	3.84	5.28	1.57
500	3.19	0.45	2.04	0.15	1.42	0.06	1.04	0.03	0.80	0.02	0.63	0.01					12.61	12.69	8.02	4.23	5.56	1.73
600	3.83	0.63	2.45	0.21	1.70	0.09	1.25	0.04	0.96	0.02	0.76	0.01	**Velocity (feet/sec)**	**Loss (ft/100 ft)**			15.13	17.79	9.63	5.92	6.67	2.42
700	4.47	0.84	2.86	0.28	1.99	0.12	1.46	0.06	1.12	0.03	0.88	0.02					17.65	23.67	11.23	7.88	7.78	3.22
800	5.11	1.07	3.27	0.36	2.27	0.15	1.67	0.07	1.28	0.04	1.01	0.02	0.82	0.01	**24 -inch**		20.18	30.31	12.84	10.09	8.89	4.13
900	5.75	1.33		0.45	2.55	0.19	1.88	0.09	1.44	0.05	1.14	0.03	0.92	0.02					14.44	12.55	10.00	5.13
1000	6.39	1.62	4.09	0.55	2.84	0.23	2.09	0.11	1.60	0.06	1.26	0.03	1.02	0.02	**Velocity (feet/sec)**	**Loss (ft/100 ft)**			16.05	15.26	11.11	6.24
1100	7.03	1.94	4.50	0.65	3.12	0.27	2.29	0.13	1.76	0.07	1.39	0.04	1.12	0.02					17.65	18.20	12.22	7.44
1200	7.66	2.27	4.91	0.77	3.41	0.32	2.50	0.15	1.92	0.08	1.51	0.04	1.23	0.03	0.85	0.01			19.26	21.38	13.33	8.75
1300	8.30	2.64	5.31	0.89	3.69	0.37	2.71	0.17	2.08	0.09	1.64	0.05	1.33	0.03	0.92	0.01			20.86	24.80	14.45	10.14
1400	8.94	3.02	5.72	1.02	3.97	0.42	2.92	0.20	2.24	0.10	1.77	0.06	1.43	0.04	0.99	0.01	**36 -inch**				15.56	11.64
1500	9.58	3.44	6.13	1.16	4.26	0.48	3.13	0.23	2.40	0.12	1.89	0.07	1.53	0.04	1.06	0.02					16.67	13.22
1600	10.22	3.87	6.54	1.31	4.54	0.54	3.34	0.25	2.55	0.13	2.02	0.07	1.64	0.04	1.14	0.02	**Velocity (feet/sec)**	**Loss (ft/100 ft)**			17.78	14.90
1700	10.86	4.33	6.95	1.46	4.83	0.60	3.55	0.28	2.71	0.15	2.14	0.08	1.74	0.05	1.21	0.02					18.89	16.67
1800	11.50	4.82	7.36	1.63	5.11	0.67	3.75	0.32	2.87	0.17	2.27	0.09	1.84	0.06	1.28	0.02	0.57	0.00			20.00	18.53
1900	12.14	5.33	7.77	1.80	5.39	0.74	3.96	0.35	3.03	0.18	2.40	0.10	1.94	0.06	1.35	0.03	0.60	0.00				
2000	12.77	5.86	8.18	1.98	5.68	0.81	4.17	0.38	3.19	0.20	2.52	0.11	2.04	0.07	1.42	0.03	0.63	0.00				
2100	13.41	6.41	8.58	2.16	5.96	0.89	4.38	0.42	3.35	0.22	2.65	0.12	2.15	0.07	1.49	0.03	0.66	0.00				
2200	14.05	6.99	8.99	2.36	6.25	0.97	4.59	0.46	3.51	0.24	2.78	0.14	2.25	0.08	1.56	0.03	0.69	0.00				
2300	14.69	7.59	9.40	2.56	6.53	1.05	4.80	0.50	3.67	0.26	2.90	0.15	2.35	0.09	1.63	0.04	0.73	0.01				
2400	15.33	8.21	9.81	2.77	6.81	1.14	5.01	0.54	3.83	0.28	3.03	0.16	2.45	0.10	1.70	0.04	0.76	0.01				
2500	15.97	8.85	10.22	2.99	7.10	1.23	5.21	0.58	3.99	0.30	3.15	0.17	2.55	0.10	1.77	0.04	0.79	0.01				
2750	17.56	10.56	11.24	3.57	7.81	1.47	5.74	0.69	4.39	0.36	3.47	0.20	2.81	0.12	1.95	0.05	0.87	0.01				
3000	19.16	12.41	12.26	4.19	8.52	1.73	6.26	0.82	4.79	0.43	3.78	0.24	3.07	0.14	2.13	0.06	0.95	0.01				

"C" Factor:	Multiply Loss By:
130	1.15
120	1.33
110	1.56
100	1.86