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 *Oversizing* – Lift stations often offer oversizing opportunities due to ECUA system growth patterns and the need to accommodate such growth with efficient planning and design of proposed stations. Oversizing options for lift stations include but are not limited to parcel size, pumping rate, wetwell size, force main size, etc. All oversizing decisions should be made by ECUA during the design process in accordance with Procedure 6 – Oversizing, and shall be documented in the Utility Service Agreement for the applicable project.

1.3 *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:

1.3.1 Wet well size (diameter and depth)

1.3.2 Force main size and lift station piping

1.3.3 Pump and control selection

1.3.4 Flow quantity and lift station appurtenances

1.4 *Calculations* – Lift station design calculations submitted to ECUA for approval shall include all design considerations and assumptions. See ECUA's Lift Station Design Worksheet.

1.5 *Lift Station Pump Overview Chart* – As a general overview of the pump characteristics suitable to ECUA and as compiled from ECUA lift station specifications Section 2575-"Wastewater Lift Stations", the Engineer-of-Record (EOR) is encouraged to review ECUA's Lift Station Pump Overview Chart prior to initiating design.

1.6 *Lift Station Manufacturer's Contact List* – ECUA has compiled a list of ECUA approved lift station component manufacturers, along with contact information. This information can be seen in ECUA's Lift Station Approved Manufacturers and Sales Contacts List.

1.7 *Pump Selection Worksheet* – Once the initial pump coordination with ECUA has been completed, the system design has been performed, and the pump requirements have been determined, the EOR shall contact each of ECUA's approved pump manufacturers and request them submit their best pump available for the application. The EOR shall then utilize ECUA's Pump Selection Worksheet in order to determine a group of pumps that are acceptable to the ECUA. In determining the appropriate group of pumps, the EOR shall analyze the technical, performance, efficiency, cost, future flow capacity, future head capacity, future impeller upgrades and other related data such that the selected pumps are deemed equivalent to each other within the group and as a group better suited to the project application than the non-selected pumps. The EOR should strive to create a manageable list of at least two equivalent pumps, preferably three, with four being the maximum unless the data shows more pumps are suitable. Said document shall be signed by the EOR, ECUA Project Engineer, and ECUA Lift Station Representative thus certifying the pumps on the worksheet are suitable for use on project. Said pump selection information shall then be recorded in the pump chart on the lift station detail sheet thus making any of the pumps available for use on the project.

PART 2: Design Parameters and Functional Criteria

2.1 *Flow Requirements* – Lift station design flow requirements shall be developed in accordance with Section 570-"Gravity Sewer Collection Systems" 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

2.2 *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.

2.2.1 *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.

2.2.2 *Access* – Lift station parcels shall be located to provide sufficient accessibility for maintenance vehicles at all times. Accessibility includes, but is not limited to, adequate space for vehicles to perform turn-around maneuvers if needed, gate access, etc. Parcels shall be located adjacent to roadway right-of-way as much as possible. Parcels not adjacent to roadway right-of-way shall be provided with a 20 foot wide parcel that connects the lift station parcel to the roadway right-of-way. Driveways shall be 12 feet wide minimum and may be either paved (2-inch asphalt, 6-inch graded aggregate base, 12-inch sub-grade stabilization) or rock surface (8-inch graded aggregate base, 12-inch sub-grade stabilization) capable of supporting H-20 traffic loading.

2.2.3 *Parcel Requirements* – The lift station parcel shall be 50 feet in width and 50 feet in depth. Should this size or configuration present a hardship, then up to a 20 percent reduction in parcel size may be allowed provided the reduced site has adequate room for operation and maintenance, and provided access to the lift station site is not restricted. Any changes greater than the 20 percent reduction will require written justification from the EOR and written approval of the Director of Engineering and the Director of Utility Operations and Maintenance.

Depending on the lift station and its needs, parcels larger than 50 feet x 50 feet 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 the plans unless specifically exempted. The parcel and any associated access driveways shall be designed to permit proper drainage away from the lift station.

2.2.4 *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.

2.3 *Functional Criteria* –

2.3.1 *Redundancy* – Lift stations shall contain a minimum of 2 pumps with each pump capable of pumping a minimum 100 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 *Ten States Standards* peaking formula.

2.3.2 *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 100 gallons per minute, whichever is greater.

2.3.2.1 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.

2.3.2.2 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.

2.3.2.3 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.

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

2.3.2.5 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.

2.4 *Velocities* – The lift station discharge force main (riser piping) minimum velocity at the initial pumping rate is 2.5 fps, although 5 fps is preferred. 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 above-grade plug valves or flow meter) shall not be less than 2.5 fps at the initial peak hourly design pumping rate.

2.5 *Pump Efficiencies* – Pump efficiency is just one of the criteria used in determining the list of recommended pumps for each project. Smaller stations by nature are not as efficient as larger stations, therefore it is un-realistic for ECUA to set high goals for minimum efficiencies of said small stations. For small stations, the EOR shall balance efficiencies with other functional criteria as part of the analysis and selection of recommended pumps. For larger lift stations, as determined by ECUA, or those stations that are anticipated to have a total daily runtime greater than 5 hours, the EOR shall utilize either a minimum efficiency approach or specify pumps that operate at a certain percentage of BEP as part of the analysis and selection of recommended pumps.

2.6 *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.

2.6.1 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.

2.6.2 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.

2.7 *System Head* – Calculate system head: static, friction and velocity. Select pumps. Pump curves shall show range and efficiencies, horsepower draw, and shall include the system curve(s) at the initial, intermediate, and ultimate design periods.

2.8 *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.

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

2.8.1.1 Ground elevation at wet well

2.8.1.2 Lowest influent elevation of gravity system

2.8.1.3 "High level alarm" elevation

2.8.1.4 "2nd Lag pump on" elevation (for triplex lift stations)

2.8.1.5 "Lag pump on" elevation

2.8.1.6 "Lead pump on" elevation

2.8.1.7 "All pumps off" elevation

2.8.1.8 Wet well bottom elevation

2.8.2 *Future Need* – 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.

2.8.3 *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 3: Appurtenances

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

3.1.1 The fence shall enclose an area sufficient to protect the lift station and all appurtenances.

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

3.2 *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.

3.3 *Emergency Power* – Standby emergency power will be required as follows:

3.3.1 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.

3.3.2 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),

3.4 *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.

3.5 *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.

APPENDIX 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-2)

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-2

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

Flowrate (gallons/min)	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	
	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 (feet/sec)**	**Loss (ft/100 ft)**							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									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