FIRE RESCUE

Rural Fire Command

by

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H_2O On The Go

Varying pump capacity affects the required hoseline diameter

A Message the Author, Larry Davis

In October 2002, I started writing the monthly "Rural Fire Command" column for *FireRescue Magazine*. Since that time, the RFC column has been carried in just about every subsequent issue of the magazine.

As time has passed, several readers have contacted me about obtaining back issues of the column. Some expressed an interest in acquiring the articles in Powerpoint format for use in training programs.

This led to, my adaptation of the RFC columns to the PowerPoint format. These PowerPoint programs are being made available through the combined efforts of *FireRescue Magazine* and the Rural Firefighting Institute.

H_2O On the Go

Varying pump capacity affects the required hoseline diameter

Last month, I explained why rural departments should purchase the capacities of fire apparatus pumps needed to provide the delivery rates required by the hazards in the communities. I also explained the relationship between fire pumps and fire hose in water delivery. The truth: *Fire hose works both for us and against us. It serves as a conduit through which we can deliver water, but it also produces friction loss, which restricts our ability to deliver water.*

Figure 1. A 1000-gpm pumper supplies the attack pumper at a live-fire training session using an acquired structure. The objective in this operation was to deliver 1000 gpm a distance of 800 feet to the attack pumper. Operations such as this can be designed based on the method explained in this month's column.

Figure 2. Setting up a tanker (tender) fill site such as this requires planning (using the method explained in this column) to ensure that the 1000-gpm fill rate needed can be delivered from the source engine to the tankers.

A Training Officer's Dilemma

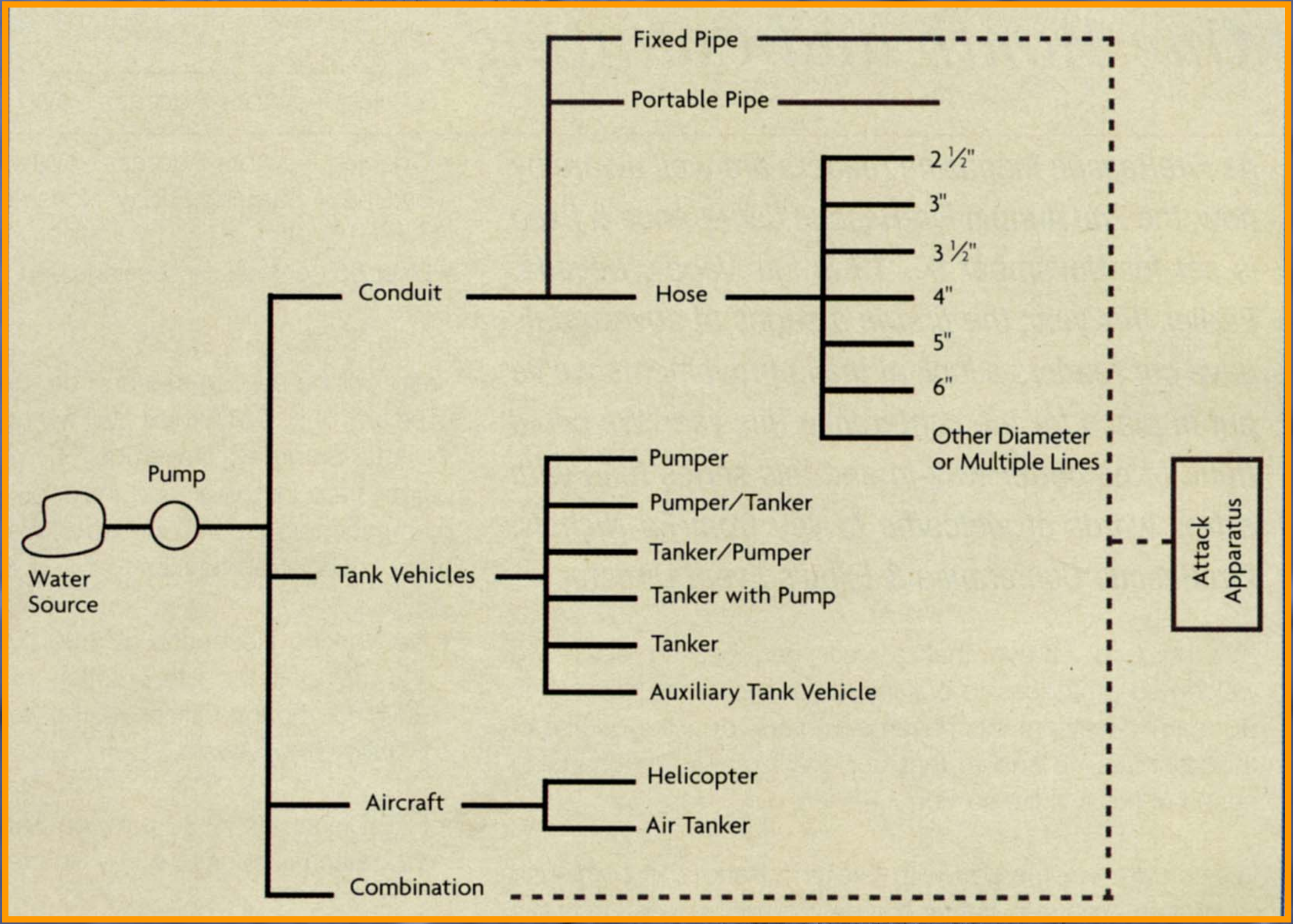
As I was putting the final touches on this month's column, I got a phone call from a training officer who works for a career fire department in the southeastern United States that serves both an urban area protected by hydrants and a rural area without hydrants.

The training officer called to get information he could use to convince the members of his department that 5" supply line is much more practical than the dual 2-1/2" hose beds they've been using for years. He also needed to convince the city's water department that using 5" hose wouldn't cause the city's water mains to collapse. Like training officers in many other departments, this fellow was hired to help facilitate change within his department, but every attempt he's made to change "the way we do things here" has met resistance. Sound familiar?

Coincidentally, the intent of this month's column is to provide readers with information they can use to plan and design water transport systems for incidents within their communities. The objective of a water transport system is to achieve the delivery rate (gpm) needed for the attack apparatus to accomplish its objective.

Figure 3 shows the *Water Transport System* and the various options available to transport water from water sources to fire attack apparatus. The most common water transport option is that in which a pumper takes water from a static source, which requires drafting, or a pressure source in the form of a hydrant, and then delivers that water via some conduit to attack apparatus. While the conduit can be a hoseline, or a portable or fixed pipeline, the most common method is to use one or more hoselines.

Figure 3. The Water Transport System



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2-1/2” vs. 5” Hose

Unfortunately, most firefighters and fire officers aren’t big fans of hydraulics, which is one reason why the training officer I mentioned previously is having trouble convincing his people that 5" hose is better than two 2-1/2" lines. One argument he faces supports the idea that since 2-1/2 + 2-1/2 = 5, two 2-1/2" hoselines have the same water flow capability as one 5" line. Of course, that’s not the way things work — doubling the diameter of a hoseline ***increases its area four times***. In other words, a 5” line has about the same capability as four 2-1/2” lines.

Fire hose works both for us & against us. It serves as a conduit through which we can deliver water, but it also produces friction loss, which restricts our ability to deliver water.

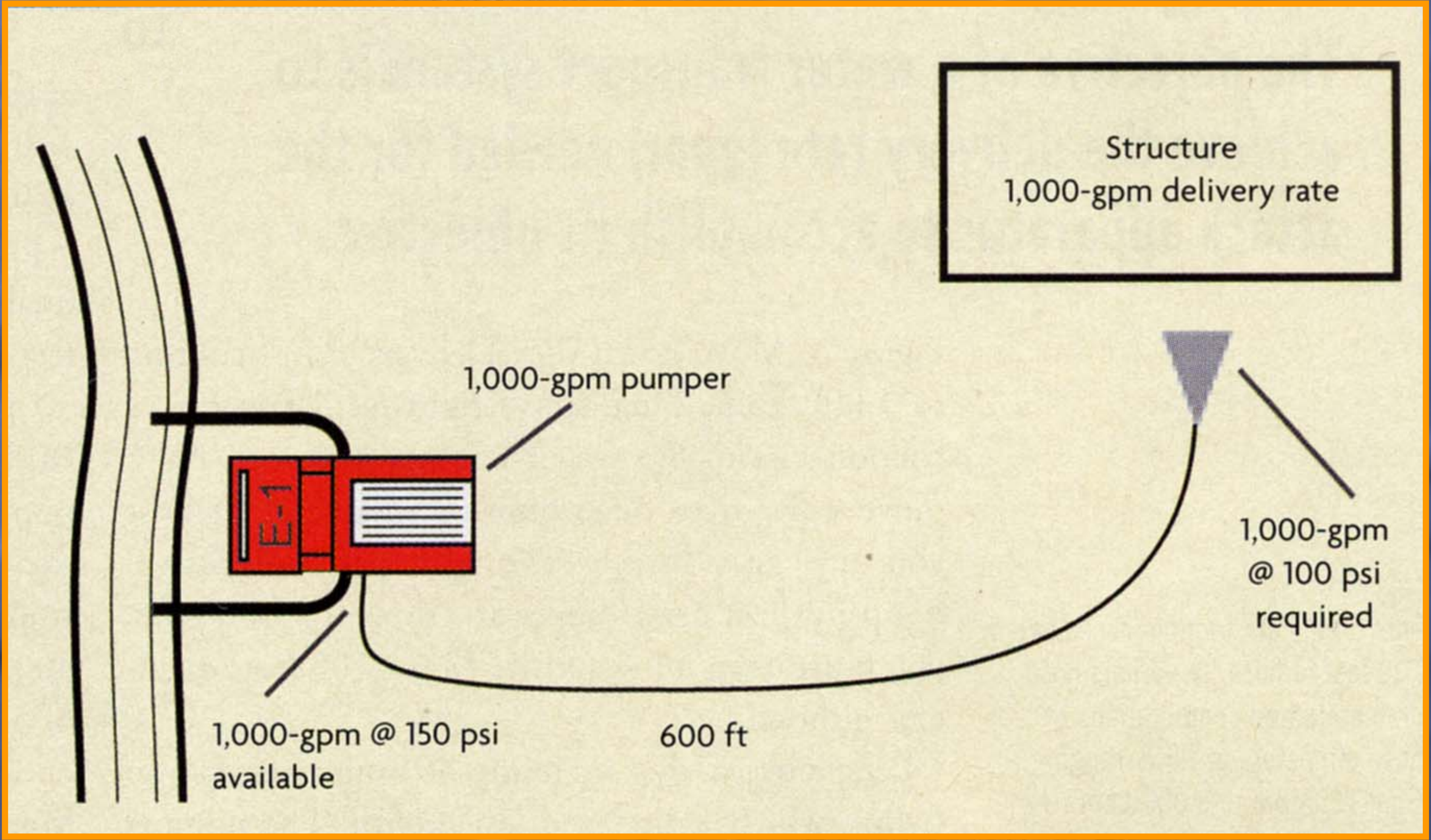
Determining the Diameter of Hoseline Required

One way to understand a hoseline's effect on pump capabilityand to determine the diameter of hose required to transport a given delivery rate under a given set of circumstances is to use the *maximum friction loss (MFL) method*.

Figure 4 shows a 1000-gpm pumper drafting from a stream to deliver 1000 gpm to the fireground 600 feet away. In this case, the pumper is actually the attack pumper, and is to supply a 1000-gpm master stream device that requires 1000 gpm at a nozzle pressure of 100 psi.

The task is to determine what diameter(s) of hose must be used between the pumper and the master stream to deliver the 1000 gpm to the nozzle at 100 psi. To achieve this, you must first determine the MFL available to move the water through the hoseline.

What diameter hose is needed to transport 1000 gpm 600 feet?



The Maximum Friction Loss (MFL) Method

You can calculate the MFL by subtracting the required outlet pressure (OP) from the available source pressure (SP), or:

$$MFL = SP - OP$$

In the example shown in Figure 4, SP represents the pressure at the pump discharge, and OP represents the pressure required at the master stream nozzle. With a standard draft set-up (10' lift, 20 feet of suction), the pumper can discharge 1000 gpm at 150 psi. Thus, SP = 150 psi. Since the required OP is 100 psi, MFL equals 150 psi -100 psi, or 50 psi.

Next, you must determine the highest friction loss per 100 feet of hose (FL/100 ft) that you can have when flowing 1000-gpm. The FL/100’ can be calculated by dividing the MFL by the number of 100' lengths of hose in the hoselay. In this example, six 100-ft lengths of hose are required. The FL/100 ft is then:

$$FL/100\text{ ft} = 50\text{ psi} \div 6 = 8.3\text{ psi}/100\text{ ft}$$

Determining Hose Diameter

To determine the diameter of hose you should use to transport the 1000-gpm delivery rate a distance of 600 feet with a friction loss of no more than 8.3 psi/100 ft, the friction loss tables shown in Figure 4 must be used.

Starting at the top of the “Delivery Rate” column, move downward to 1000 gpm. Then move right until you find a friction loss of 8.3 psi or less per 100 feet. Now, move upward to determine the diameter of hose that must be used.

The diameter of hose that must be used in the example is 5” since the FL/100 ft at 1000 gpm flow is 8 psi/100 ft in 5”.

Figure 4. Friction Loss per 100 Feet of Hose (Q = gpm ÷ 100)

Delivery Rate (gpm)	2½" ($2Q^2$)	3" ($.8Q^2$)	Two 2½" ($.5Q^2$)	3½" ($.34Q^2$)	2½" & 3" ($.33Q^2$)	Two 3" ($.2Q^2$)	4" ($.2Q^2$)	Two 3½" ($.09Q^2$)	5" ($.08Q^2$)	Two 4" ($.05Q^2$)	6" ($.05Q^2$)
100	2 psi	1 psi	1 psi	—	—	—	—	—	—	—	—
200	8	3	2	1 psi	1 psi	1 psi	1 psi	—	—	—	—
250	13	5	3	2	2	2	1	—	—	—	—
300	18	7	5	3	3	2	1	1 psi	1 psi	—	—
400	32	13	8	5	5	3	3	1	1	1 psi	1 psi
500	50	20	13	9	8	5	5	2	2	1	1
600	72	29	18	12	12	7	7	3	3	2	2
700	98	39	25	17	16	10	10	4	4	3	3
750	113	45	28	19	19	11	11	5	5	3	3
800	128	51	32	22	21	13	13	6	5	3	3
900	162	65	41	28	27	16	16	7	7	4	4
1,000	200	80	50	34	33	20	20	9	8	5	5
1,100	242	97	61	41	40	24	24	11	10	6	6
1,200	288	115	72	49	48	29	29	13	12	7	7
1,250	313	125	78	53	52	31	31	14	13	8	8
1,300	338	135	85	58	56	34	34	15	14	9	9
1,400	392	157	98	67	65	39	39	18	16	10	10
1,500	450	180	113	77	74	45	45	20	18	11	11
1,600	512	205	128	87	85	51	51	23	21	13	13
1,700	578	231	145	98	95	58	58	26	23	15	15
1,750	613	245	153	104	101	61	61	28	25	15	15
1,800	648	259	162	110	107	65	65	29	26	16	16
1,900	722	289	181	123	119	72	72	33	29	18	18
2,000	800	320	200	136	132	80	80	36	32	20	20
2,100	882	353	221	150	146	88	88	40	35	22	22
2,200	968	387	242	165	160	97	97	44	39	24	24
2,250	1,013	405	253	172	167	101	101	46	41	25	25
2,300	1,058	423	265	180	175	106	106	48	42	27	27
2,400	1,152	461	288	196	190	115	115	52	46	29	29
2,500	1,250	500	313	213	206	125	125	56	50	31	31
2,600	1,352	541	338	230	223	135	135	61	54	34	34
2,700	1,458	583	365	248	241	146	146	66	58	37	37
2,800	1,568	627	392	267	259	157	157	71	63	39	39
2,900	1,682	673	421	286	278	168	168	76	67	42	42
3,000	1,800	720	450	306	297	180	180	81	72	45	45

Water Horsepower Losses in Hose

Let's look at this example in terms of water horsepower (whp), which I discussed last month. The pumper delivering 1000 gpm at 150 psi is delivering 87.5 whp [(1000 gpm x 150 psi) ÷ 1714]. The output at the master stream equals 58.3 whp [(1000 gpm x 100 psi) ÷ 1714]. Thus, the loss in water horsepower in 600 feet of 5" hose equals 29.2 whp.

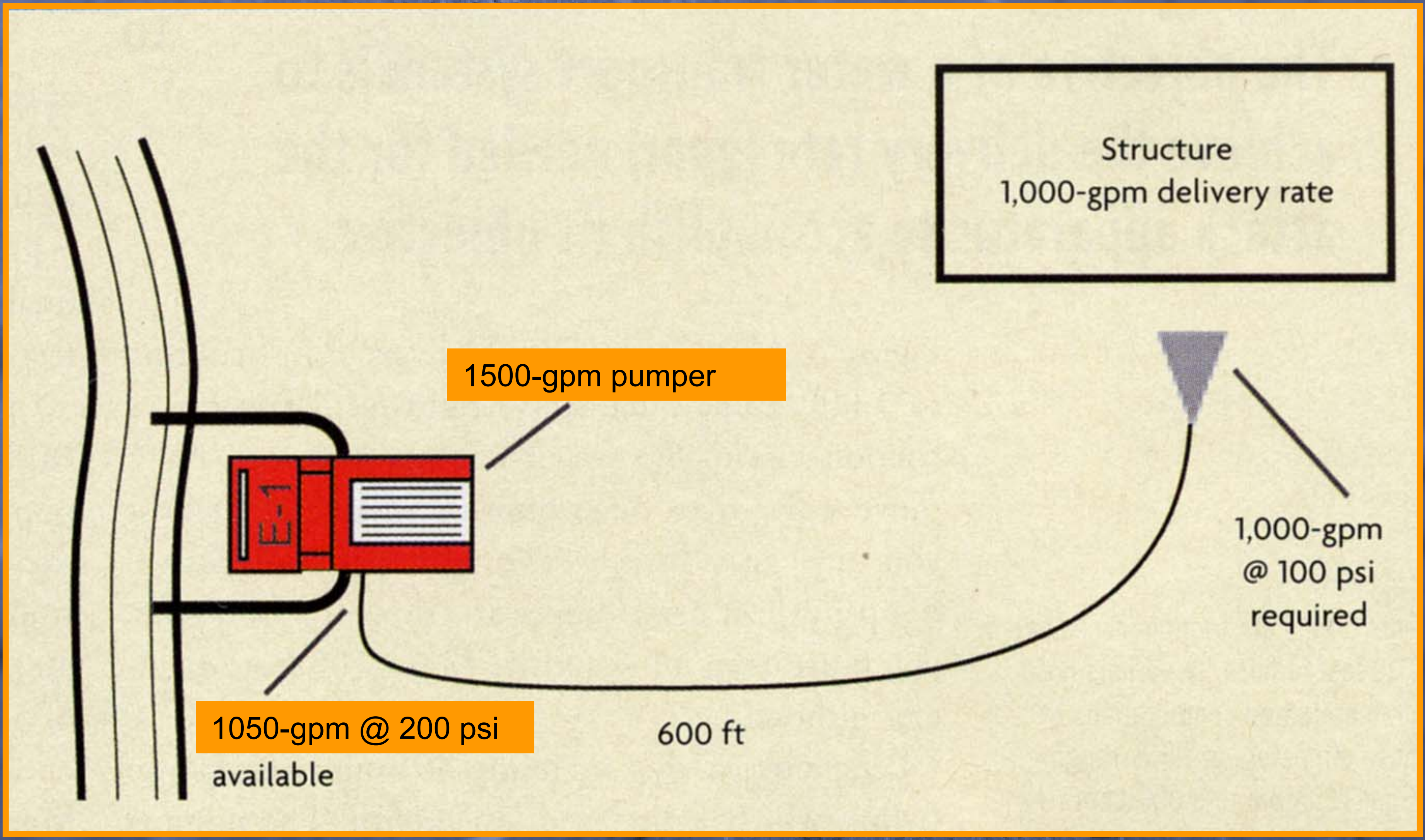
What If Dual 2-1/2” Lines Were Used?

Just for kicks, let’s look at the results if dual 2-1/2" lines were used instead of the 5”. Using Figure 4, start at the top of the *Two 2-1/2”* column and move downward until the column intersects with the *1000-gpm Delivery Rate* row. The value at that intersection is 50 psi/100 ft, the FL/100 ft in dual 2-1/2” lines flowing 1000 gpm.

To deliver 1000 gpm through dual 2-1/2” lines 600 ft long requires an MFL of 300 psi (50 psi/100 ft x 6). To achieve this, the pumper must discharge 1000 gpm at 400 psi (300 psi friction loss + 100 psi nozzle pressure). If the pump could do this, the pump discharge of 1000 gpm at 400 psi would represent 233.3 whp. With an output of 58.3 whp (1000 gpm at 100 psi) at the nozzle, the water horsepower loss in 600 feet of dual 2-1/2" lines would equal 175 whp, or about six times the whp lost in the 5" line.

When the water horsepower loss in the dual 2-1/2” lines is compared to that of the 5” hose at the same flow, one can easily see how the hoseline diameter can dramatically eat up the whp a pump can deliver.

What diameter hose is needed with a 1500-gpm pumper?



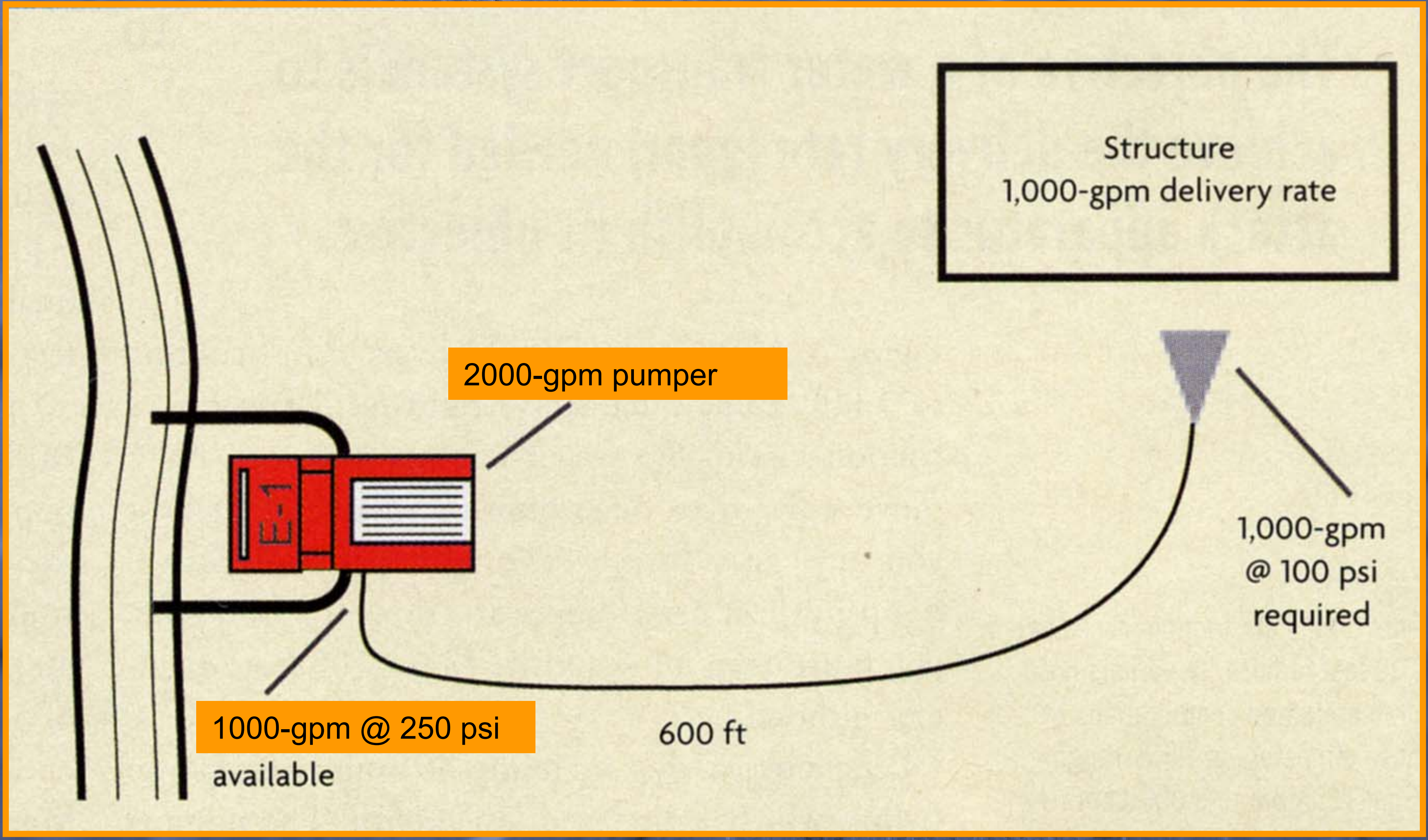
Using A 1500-gpm Pumper

What would happen if you used a 1500-gpm pumper instead of a 1000-gpm pumper in the same scenario? A 1500-gpm pumper must deliver 1050 gpm (70% of pump capacity) at a net discharge pressure of 200 psi. This discharge represents a pump output of 122.5 whp. Since the fire attack point would still require 1000 gpm at 100 psi, or 58.3 whp, the extra 35 whp provided by the 1500-gpm pump would impact the diameter of the hoseline(s) required to move the 1000 gpm 600 feet.

The MFL with the 1500-gpm pumper equals 100 psi (200 psi - 100 psi). The FL/100 ft then equals 16.7 psi/100 ft (100 psi ÷ 6). Using Figure 4 the closest FL/100 ft less than 16.7 psi is 9 psi, the friction loss for dual 3-1/2" hoselines. Thus dual 3-1/2" lines could be used to deliver the 1000 gpm with the 1500-gpm pumper.

As you can see, increasing pump capacity (whp) allows the use of smaller hoseline(s) to transport the 1000 gpm 600 feet.

What diameter hose is needed with a 2000-gpm pumper?



Using A 2000-gpm Pumper

How much improvement would occur if the pumper were equipped with a 2000-gpm pump? A 2000-gpm pump must deliver 1000 gpm (50% of its rated capacity) at 250-psi net pump discharge pressure. This represents a whp of 145.8 [(1000 gpm x 250 psi) ÷ 1714], an increase of 23.2 whp over the 1500-gpm pump and 58.3 whp over the 1000-gpm pump.

The MFL in this case equals 250 psi - 100 psi, or 150 psi. The FL/100 ft then equals 25 psi (150 psi ÷ 6). Using Figure 4 the closest FL/100 ft less than 25 psi is 20 psi, the friction loss for dual 3" hoselines. Thus dual 3" lines could be used to deliver the 1000 gpm with the 2000-gpm pumper.

As was the case when the pump capacity was increased from 1000 gpm to1500 gpm, increasing the pump capacity to 2000 gpm allows smaller diameter hose to be used, to deliver the 1000 gpm 600 feet.

By using bigger pumps, you can get by with smaller hoselines.

Conclusion

The methods explained in this article can be used to determine the diameter of hoseline(s) required to accomplish any water transport operation that utilizes pumps and hose. Just substitute the required delivery rate, the pump capacity, the length of hose lay and the required outlet pressure.

Until next month, stay safe.

For Questions or comments on this or any of the Rural Fire Command articles, contact the author at ldavis@RFI411.org

About the Author

Larry Davis is a full member of the Society of Fire Protection Engineers, a Certified Fire Protection Specialist, and a Certified Fire Service Instructor II with more than 30 years experience as a fire service instructor. He is Vice President of GBW Associates, and Chairman of the Rural Firefighting Institute.

Davis has conducted more than 400 Rural Firefighting Tactics and Rural Water Supply Operations seminars throughout the United States and Canada. In addition, he has written numerous fire service texts, including *Rural Firefighting Operations*, books I, II, and III. Most recently, Davis co-wrote the *Rural Firefighting Handbook* and *Foam Firefighting Operations*, book I with Dominic Colletti.

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