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Developing a Comprehensive Rural Water Supply

Executive Development

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CERTIFICATION STATEMENT

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ABSTRACT

The Addison Township Fire Department, a rural fire district in Michigan, can not provide adequate fire flow resulting in a risk to property and firefighters' safety. The department uses a combination of tanker shuttle and relay pump operations to meet water supply needs but does not have a method of determining needed fire flow or a guideline as to the type of water supply operation to use. A literary review, surveys and action based research were used to determine key elements, preferred operational methods and guidelines necessary for an adequate rural water supply system. Tanker shuttle and relay pump training evolutions were conducted and used to determine the efficiency and effectiveness of each type of operation, which determined that for the ATFD a relay pumping operation provided a high capacity water supply and was a more efficient use of manpower than a tanker shuttle operation. Recommendations from this project included determining an acceptable formula for calculating needed fire flow and implementing an automatic mutual aid system. It was also recommended to use the new fire flow requirements and available mutual aid as a guide to create a water supply solution for each of the significant fire risks within the fire district. Each water supply solution contains the units responding, the water source to be used, the type of water supply operation and a detailed description of what each unit will do within the water supply system. Updating the standard operating guideline was also recommended to clarify when a relay pump and when a tanker shuttle will be used for occupancies without a water supply solution.

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INTRODUCTION

Water has been the main stay or primary means of extinguishing fire since the beginning of time. Since the organization of the first fire services in the United States the movement of water to the fire scene has been a major logistical concern. In areas supplied by municipal water systems, the concern or responsibility for delivering water lies with the water department utilizing a costly infrastructure consisting of water storage tanks, large pumps connected to water mains, and fire hydrants. In rural areas where this level of infrastructure has not been developed or can not be afforded the challenge of water delivery falls squarely on the fire service.

The current problem is that the Addison Township Fire Department can not provide adequate fire flow resulting in a risk to property and firefighters' safety. The Addison Township Fire Department currently uses a combination of tanker shuttle and relay pump operations to meet water supply needs as detailed in ATFD Standard Operating Guideline # 440, #441 and #442 (appendix A). The department does not have a method to determine needed fire flow requirements nor does the department have an SOG to indicate when to relay pump and when to shuttle.

The purpose of this research project is to identify key elements, preferred operational methods, and produce a standard operating guideline (SOG) describing what operational method to use in order to meet needed fire flow requirements. An action research methodology will be used to answer the following questions.

1. What are the key elements of a rural water supply system?
2. When should relay pump operations be used?
3. When should tanker shuttle operations be used?
4. What guidelines are other area departments using regarding rural water supply?

BACKGROUND AND SIGNIFICANCE

Addison Township Fire Department

The Addison Township Fire Department was organized in 1949 when the Village of Leonard and Addison Township entered into an agreement to provide fire service for area residence. Addison Township, which encompasses the Village of Leonard, is located in southeastern Michigan approximately 40 miles north of Detroit. Located in Oakland county, Addison is a rural fire district covering 36 square miles protecting a population of 6,767 (South East Michigan Council Of Governments 2008). Addison provides fire protection and advanced life support services with a staff consisting of four career and 30 paid on call members, and operates two engines companies, a ladder company, two tankers, two brush units, two ALS ambulances and a special response unit out of two fire stations. The department responded to 479 incidents in 2007, 5 of which were structure fires. Primarily a bedroom community Addison protects 2368 households (South East Michigan Council of Governments 2008). The department is planning to challenge the communities Insurance Service Office (ISO) rating in the near future the department currently has an ISO, public protection classification (PPC) of 9.

Infrastructure and Geography

Infrastructure within the fire district consists of 137.1 miles of public roadways of which 16.3 miles are paved, 120.8 are gravel with an additional 10.5 miles of minimally maintained natural beauty roads. Addison contains 25% of the natural beauty roads in Oakland County (Oakland county road commission 2008). Gravel roads in the district are narrow with high shoulders and have a great deal of natural overgrowth. These narrow roads both at ground level and the resulting tree canopy above often restrict fire apparatus to “one way traffic” situations due to the inability of apparatus to pass one another and cause difficulty during tanker shuttle operations. There are no municipal or private water systems capable of providing water for fire protection purposes within the district resulting in all industrial, commercial and residential occupancies to depend on individual private wells and septic systems.

Although challenged with narrow roads and no municipal water system Addison does have an abundance of natural sources of ground water. The department has qualified water supply points into two categories identified as primary and secondary water sources. Primary water sources are within 70’ of an improved roadway and can be obtained by drafting with an engine or tanker. Secondary water sources are beyond 70’ of an improved roadway and requiring portable pumps or Turbo Draft devices (SOG #442, appendix A).

In 2007 the fire department identified and cataloged 55 primary and 45 secondary water supply points within or near the fire district. These supply points along with 27 dry hydrants are the backbone of Addison’s current rural water supply system. Thirty-nine of the primary water supply points and dry hydrants where certified in January 2008 by Municipal Engineering Services (appendix B), a Michigan engineering company, to comply with ISO requirements as listed by Stevens (2004) for water source.

Mutual Aid and Surrounding Departments

Addison also benefits from strong mutual aid agreement’s including the use of automatic mutual aid (AMA) on all confirmed structure fires. Agreements exist with 16 departments that will provide either mutual aid or automatic mutual aid resulting in a total of 18 tankers and 7 engines available either on a mutual aid or automatic mutual aid basis. All units are less than13 road miles away from the nearest Addison fire district border (DeLorme 2004). The department is also contemplating a special automatic mutual aid on confirmed commercial and industrial fires. Special AMA calls could bring more units than are currently sent on a standard AMA response in order to meet the higher needed fire flow requirements for the department’s commercial and industrial occupancy on the first alarm.

By determining key elements of a rural water supply system, answering when to relay pump and when to tanker shuttle should be used, and by determining fixed and mobile assets required for a rural water supply solution, this research project will meet the requirement of executive fire officers (EFO’s) “to use research to solve real world problems in their work environments” (NFA, 2006, p. SM 12-4). By providing a more robust water supply this research project will also meet the United States Fire Administration (USFA) operational objective “to reduce the loss of life from fire of firefighters” (NFA, 2005 p. II-2).

LITERARY REVIEW

To develop a foundation from which to work, a review of the ATFDs current water supply SOGs (appendix A) was initially conducted. NFPA 1142 Standard on Water Supplies for Suburban and Rural Fire Fighting, The Fire Department Water Supply Handbook by William Eckman, Your Next ISO Rating by Larry Stevens, a review of periodicals, the internet, and other fire departments' rural water supply procedures were also evaluated for review.

Elements of a water supply

At first, the elements of a rural water supply may seem simple-- water and moving it to the fire scene. However, when setting up a water supply system the department must first identify how much water is needed. To determine needed fire flow a fire department or district should determine what standard to use. In reviewing the available literature two standards were prevalent: the NFPA standard 1142 and the Insurance Service Office (ISO) requirements as described by Stevens (2004).

The NFPA standard describes a minimum water supply for structures. After measuring the building dimensions the volume or cubic footage of the building is determined. Total volume of the structure is divided by the building's occupancy hazard classification (a number from 3 to 7), then multiplied by the construction classification (a number from .5 to 1.5). This determines the minimum water supply for structures without exposures. Volume of structure (length x width x height) divided by building occupancy # x construction classification = minimum water supply NFPA 1142 5-2.

$$\text{Minimum Water Supply} = \frac{\text{Total volume of structure}}{\text{Occupancy hazard classification number}} \times \text{construction classification number}$$

This requirement represents the total minimum amount of water to be delivered to the fire scene and does not stipulate the rate or gallons per minute (GPM) at which the water supply is to be delivered.

The ISO calculations describe a water supply necessary to meet ISO's requirements regardless of the occupancies urban, suburban or rural setting. The square footage of the ground floor of the building must first be determined, and then the square root of this area is multiplied by 18. This number is then multiplied by the construction classification (a number from 0.6 to

1.5), followed by multiplication by the occupancy hazard classification (a number from .75 to 1.25). The result is the GPM to be delivered to the fire scene. (Square root of the square footage x 18 x construction classification x occupancy hazard classification = GPM delivery rate.) An additional 50% is then added for each floor above the ground floor. The total water supply is then determined by multiplying flow of 2500 GPM or less by 120 minutes and for flows of more than 2500 GPM by 180 minutes to calculate the water needed for either a 2 or 3 hour flow respectively (Stevens 2004). The ISO formula determines total water supply and delivery rate in gallons per minute for urban, suburban and rural settings.

Water sources

Rural departments need to identify where the water is located. NFPA 1142 states, “The Water Supply Officer (WSO) should survey the district and the surrounding area for available water for firefighting purposes”. NFPA also indicates that the department WSO should develop a water source card that describes the water source. These cards should include type of source (lake, pond, stream etc.), point of access, gallons available, minimum flow rate, and any particular problems that can make the source unusable. The WSO should further maintain a map showing the location and amount of water available at each qualified water source. Hanley & Murchison (2000) state that “fire departments must develop a plan that will enable them to access a reliable water source and transport the water to the fire scene.” In emphasizing the importance of water source knowledge Steven (2004) stated “If you are willing to divide the district into bite size pieces and break your membership into groups of two with a series of maps you can very quickly get the flow and water supply info in just one drill period.”

Of the water sources available for rural water supply operations the literature reviewed divides them into two categories: natural occurring water supplies and developed or man made water supplies. Whether the natural occurring water source is a lake, pond, river or stream it needs to be considered reliable and available for use when needed. NFPA 1142 states that the reliability of either an impounded or a flowing source of water should be certified by a registered or licensed professional engineer to ensure its availability during a drought with an average 50 year frequency. Stevens (2004) also states that “You’ll also need an engineer to certify 50 year drought and freeze cycles and flow for all static water supplies like streams, ponds and ditches.” Stevens further indicates that minimum storage or usable capacity will be necessary for each water source if you would like the ISO to consider your sources under the Fire Department Supply or FDS portion of the ISO rating schedule.

Methods in determining water available in static bodies of water such as ponds and lakes are described in NFPA 1142 as follows: determine the square footage of the body of water (length x width); multiply by the usable depth and by the conversion factor for square feet of water to gallons of 7.5 to determine the total gallons available for use (length x width x usable depth x 7.5 = usable gallons). Also according to NFPA 1142 the method to determine the water available in rivers or streams is similar. Measure width and depth of the stream, creek or river and then measure and mark a 10 foot section of the body of water. Use a light floating object such as a cork and determine the time in seconds it takes the object to travel 10 feet. (((Wide x depth x distance = cubic feet of water) divided by seconds of travel x 60 = Cubic feet per minute) x 7.5 = gallons per minute). This calculation determines the estimated amount of water traveling through the area at the time of the test.

The literature reviewed indicates that developed or man made water sources primarily consist of above ground tanks, below ground tanks also known as cisterns, swimming pools and livestock watering tanks. Just as with natural water, developed water sources also need to be measured for capacity and usable amount. The reliability of these man made sources should also be tracked and recorded to ensure water availability when needed. Water sources primarily designed for fire protection should allow easy access to the water by the responding fire department. Other sources such as swimming pools and watering tanks where fire protection is not the source's primary use will need a means for the fire department to access the water. It is a common theme in the reviewed literature that the danger of damage or collapse exists when using any water source that is not primarily designed for the rigors of fire department use and that caution should be used whenever obtaining water from these sources.

Devices and appliances

Another aspect of the rural water supply fixed assets is the devices or appliances that fire departments use to obtain the water. Dry hydrants are the most described device used to move water from a water source to fire apparatus in the literature reviewed. As described by Hanley & Murchison (2000) "Dry hydrants are pipes permanently installed within a static water source, such as a pond, stream, river, or holding tank." While dry hydrants may on the surface appear to be very simple a review of the literature indicates that dry hydrants need to be well planned and engineered to meet local conditions and regulator requirements. According to NFPA 1142 "a strategically placed rural dry hydrant system, with all weather road access, significantly reduces water point set-up time and turnaround time to the fireground, improves the life safety of the fire fighter, and can reduce insurance costs." There are various recommendations for exact specifications both in published literature and locally. Cottet (2002) states that departments should "Make your dry hydrant threads the same size as that found on a standard wet hydrant steamer connection, 4 ½ inches." However Hanley & Murchison (2000) suggest that dry hydrants be designed to eliminate the use of adaptors. "Most six-inch diameter hard-suction hose consists of national standard thread with a female connection on one end and a male connection on the other. When the female end attaches to the pumper, the male end must attach to the dry hydrant. The dry hydrant must consist of a female connection and plug." The Addison Township fire department specification for water supplies and dry hydrants (appendix C) also requires six inch female dry hydrant connections on all dry hydrants in the fire district. This specification was designed to be consistent with the non published North Oakland Mutual Aid Associations recommendation for standardization of dry hydrants for rural water supply used within the mutual aid district of which the ATFD is a member.

Flow is also noted as a concern. Cottet (2002) states "you certainly do not want to end up with a dry hydrant that doesn't provide sufficient capacity to make the best use of your pumpers, tankers and LDH". Eckman (1991) echoes this concern while stating that "the (dry) hydrant should be capable of supplying enough water for the pumper to operate at its maximum rated capacity." Factors that limit a dry hydrant's flow capacity as indicated by Eckman are lift, atmospheric pressure, water temperature, and pipe size. NFPA 1142 states a static lift should not exceed 10 feet. ISO requirements for dry hydrants as indicated by Stevens (2004) state that the static lift should not exceed 15 feet. Hanley & Murchison (2000) indicate that the pumper can be repositioned to reduce the draft height. Atmospheric pressure is determined by the water source's elevation above sea level. The effect of water temperature on drafting or dry hydrant performance was also not found in any of the reviewed literature. Pipe size is covered extensively in fire service publications. All authors indicate that a 6 inch minimum pipe size is acceptable for a dry hydrant. The most extensive review was found in NFPA 1142 Appendices B-5.3 under dry hydrant design. The reader is guided through a design worksheet that will assist in determining size of pipe and fittings needed to flow the capacity of the pump intended to be used at the dry hydrant site. Pipe material is also mentioned for consideration in dry hydrant planning. NFPA 1142 states, “ Local preference and experience, along with access to material will among other factors determine pipe and fittings best suited for the job.” Materials used for dry hydrants can include brass, bronze, iron, steel, bituminous cement, schedule 40 and schedule 80 PVC.

Another man-made feature that can allow firefighters access to water is drafting basins. Davis (2007) describes an underground basin supplied by a large below the frost line pipe feed by a nearby pond. The basin opening is a large vertical corrugated pipe ending in a protected and secured wooden enclosure with a hinged wooden cover. When needed the drafting apparatus would open the cover and insert its hard suction down the corrugate vertical pipe into the basin and obtain a draft. The advantage as stated by Davis is “It doesn’t have to be airtight and the diameter of the supply pipe (horizontal pipe attaching the basin to the pond) allows a much higher flow.” This was the only reference to drafting basins found in the reviewed literature.

Mobile assets

In the literature reviewed mobile assets required for a rural water supply generally covered two major areas, namely appliances and apparatus. Water eductor devices take water under pressure (the motive) push it through the eductor which is located in a body of water and then returns the motive and excess water back to the pump for use. The Turbo Draft fire eductor manufactured by Schutle & Koerting (2003) is fed by a 2 ½” line and uses a 5” return line. When pumped at 190 psi Schutle and Koerting claim that the Turbo Draft will return 440 GPM at a 10 foot lift for fire flow use. This does not account for the motive. Stevens (2004) states “any water point within 400 feet of your truck can be used.” He also indicates that “ISO only credits draft sites to 15 feet of lift, but a turbo draft does not lift, it pumps.” Schutle and Koerting also claim that a Turbo Draft can be installed in excessive lift situations at the strainer or water source end of a dry hydrant and can provide 800 GPM at 30 feet and 250 GPM at 48 feet above the water level when pumped at 180 psi.

Other appliances necessary for rural operations and drafting are flexible hard suction in the amount and length required to obtain the water sources that the particular unit may be responsible for. Stevens (2004) indicates that draft engines should be equipped with a squirrel tail suction, possibly with the most commonly used strainer already hooked up. The reviewed literature also indicates that draft engines can obtain water supplies beyond the 20 feet of hard suction and 10 feet of lift. ATFD certified water source list (appendix B) shows water source using 70 feet of hard suction with 14 feet of lift and a flow of 900 GPM.

Strainers are also necessary for a rural source engine. A review of sale catalogs shows strainers in four categories: floating strainers, barrel strainers, low clearance strainers and ice strainers. The types and use of strainers for rural water supply operations is fundamental and will not be covered in detail. Stevens (2004) states that " It is essential you have the absolute best low lift (clearance) strainer or strainers on the market" indicating that lower quality strainers leave a great deal of unusable water in a drop tank. A low clearance strainer with a built in water transfer device utilizing a 1½" hose connection is also available. There are many different configurations and flow capacities for each type of strainer available.

Draft Assist Devices (DADs) are in line suction inducer equipped with a 1 ½" inlet reduced to a ¾" discharge orifice inside the suction stream directed toward the female threaded end of the device. ATFD SOG 442 (appendix A) DADs measure approximately 18" in length and have 6" National Standard Thread NST fixed male threads on one end and a 6" NST rotating female threads on the other end. DADs are designed to be inserted inline either directly in front of (toward the pump) the strainer or between the first and second pieces of hard suction. Similar in theory to a water transfer device used to move water from one portable tank to another, DADs are designed to assist in obtaining and help to maintain drafts in long hard suction situations. DADs can also be used to circulate water during drafting operations and can increase flow in such layouts by reducing friction loss in the suction layout. Created and prototyped by the author the ATFD has used these devices since 2004 and has not experienced a drafting failure while a DAD has been used. The author also had the Kochek company manufacture a DAD conforming to ATFD's specifications by reversing the nozzle discharge direction of a Kochek inline jet siphon transfer device JSI60 (Kochek 2008). By inducing water flow rather than relying entirely on the source engines ability to draft the water supply under vacuum, the ATFD has seen an increase in flow when DADs are inserted into the suction layout.

Large diameter hose LDH and the appliances used to support its operation are a fundamental portion of rural water supply operations. The literature reviewed indicates that it is not as much a matter of using LDH but what size to use, how much do you carry, and what type of appliances are needed to support its operations. The most commons sizes LDH in use by the fire service are 4”and 5” with some mention of 6” or larger in areas with unique or high needed fire flow requirements. Regarding the size of LDH Stevens (2004) states that “using 2 ½”, 3”, 3 ½” or 4” hose instead of 5” or larger could have profound negative results on fire flow potential. The wrong size hose guarantee a built in limitation.” NFPA 1142 appendices D-1.2.2 states “The size and amount of hose to be carried by the fire department should be selected to fit the needs of the area served and the financial resources of the department.” NFPA table D-1.2.2 shows that 1000 GPM can be pumped (at a 150 psi) through 684’ of 4” line and 2166’ of 5” line with 20 psi residual at the point receiving the flow.

Siamese, water thieves, and relay valves were the foremost mentioned appliances in the reviewed material. Davis (2006) illustrates the use of clappered siamese at the end of a supply line laid up a narrow access way or driveway to allow for an uninterrupted water supply. Davis (2008) also illustrates an inline relay valve dividing a split lay of LDH intended to allow a relay unit to be inserted into the relay without interrupting the flow of water.

Portable pumps although owned by many rural fire departments are heavy, difficult to move into place and produce lower volumes of water as compared to other means of obtaining water according to NFPA 1142 appendix E.

Portable tanks come in two major types: fold out frame tanks and self supporting tanks. Portable tanks come in many sizes and colors. NFPA 1142 (appendix C1.13) states, “each mobile water supply should carry a portable tank that is 40 percent greater than the capacity of the mobile water supply.” This allows the entire water load to be dumped in the tank so that the tanker can return to the fill site without delay. This also allows for minimal spillage if the tank is set on uneven ground. Although color may seem like an insignificant option in a portable tank the ATFD prefers to use different color tanks in multiple tank setups. This allows the officer in charge of the dump site to direct the tanker driver of which tank to dump into by color. Self supporting tanks were rarely mentioned in the material reviewed. According to Fol-Da-Tank (2008), a manufacturer of portable tanks self supporting tanks are lighter and store in smaller areas than fold out frame tanks. Self supporting tanks have a floating collar at the top of the tank. A drawback of this tank choice is that if a suction hose uses the top floatation ring as support, the ring will be pushed down by the weight of the suction hose and water will pour over the top of the tank where the support collar is pushed down. Suction must therefore be obtained through a bottom draft using an installed coupling in the tanks structure.

APPARATUS

According to the literature reviewed apparatus required for a rural water supply system can be broken down into three functional groups: Source engines, tankers and attack engines. Fire department units acting as source engines should be equipped with all the equipment necessary to achieve the capacity of the pumping unit and needed fire flow in the area that the unit will be expected to operate. This would include the necessary hard suction, strainers, water eductor and any other hose, appliances or equipment required to obtain a water supply. Once obtained the pumping unit will need to be able to supply the water to a system of LDH in a relay pump or set up a fill site in order to supply tankers in a water shuttle operation. When determining capacity of a source engine the department needs to match the source engine with the needed fire flow. If the needed fire flow is higher than the capacity of the source engine then a second source engine will need to be assigned to assist. Stevens (2004) states that “Today’s decision can severely hamstring the organization for a long time to come.” The general direction of Stevens work indicated that a department should purchase the highest capacity pump it can afford.

Tankers also come in many different configurations and sizes. NFPA 1901(2003) states that a tanker “must carry a minimum of 1,000 gallons of water.” According to a report from the USFA entitled Safe Operations of Tankers “The most common water capacities of tankers in the United States range from 1,500 to 3,000 gallons. However capacities of up to 5,000 gallons on a straight chassis and 10,000 gallons on a tractor trailer apparatus are not unheard of.” NFPA 1142 illustrates the importance of outlets of adequate size to empty the tank. In reviewing the ATFD tanker data, 16 of the 18 mutual aid tankers available to respond to ATFD incidents have large gravity rear or side dump valves. The two tankers without gravity dumps show longer unloading times.

Pumps are also a consideration when choosing equipment or capabilities for a tanker. Cottet (2000) states, “A pump on a tanker allows it to be more versatile and accomplish much more for the fire department.” The addition of a pump on a tanker would allow a vehicle to participate in a relay pump if the pump were of sufficient capacity. Stevens (2004) states that "Some chiefs have told me they can not insure the engine and tanker will always get together so they went with a pumper/tanker." Pumper/tankers would have a pump and hose bed capability to carry LDH for more versatility and capacity to participate in tanker shuttle or relay operations.

Attack engines are the means by which a rural water supply puts the water on the fire. Davis (2004) indicates that "The water transport system moves water from the source to the intake of the fire apparatus working at the fire ground." Davis also states that "When evaluating the fire attack system we need to focus on achieving the highest delivery rate required while using the minimum amount of time, people and hardware." Cook (2000) states that "Rural firefighting operates basically the same as city firefighting except for one major difference: Rural fires have a better head start." Cook then goes on to explain that "one of the most time-efficient, water-saving, effective techniques to stop a fire in its tracks is the blitz attack". Cook describes a blitz attack as a large caliber handline or master streams delivering 400 GPM. The literature reviewed indicated that a rural attack engine must have the ability to quickly apply water to a large fire and knock it down before it grows beyond the capabilities of rural water supply. An attack engine may start the fire attack with its tank water (typically a larger tank than an urban engine) and if necessary the water from the first tanker arriving with it. ATFD SOG's (appendix A) have both engine companies set up to act in both the attack and supply roles depending on unit arrival order. Also both ATFD engine companies are equipped with one 2 ½" perconnect capably of 350 GPM, a perconnected TFT Blitz fire portable master stream device capable of 500 GPM, an Akron portable master stream device capable of 800 GPM and an Akron deck gun capable of 1000 GPM.

Type of operations

After reviewing the equipment necessary for rural water supply operations the question is now how do we move the water. Davis (2004) states that the water delivery system is "dependent on the relationship between three components: the hardware (apparatus and equipment) needed, the people expected to use the hardware; and the written or unwritten SOP's outlining the procedure by which people are to use the hardware." A review of the literature indicates there are two main methods of moving water after it is acquired; relay pumping operations and tanker shuttles operations.

Eckman (1994) describes a relay pump as “fire pumps are connected into supply lines at intervals to compensate for pressure losses that occur as water moves through the fire hose from the water source to the fire”. Relays may be set up as forward lays, reverse lays or a combination of both. Hanley and Murchison (2000) state that “locating a pumper at the hydrant and one that the fire scene and connecting them with large diameter hose demonstrates a much more efficient operation” (as compared to a tanker shuttle operation). Dickerson (2001) states that “laying large diameter hose may work better than a tanker shuttle. Once you put the LDH into service, it provides a constant water flow without much work.” He also states that “For a distance of roughly 3000 feet to a water source LDH may be an option.” Cavette (2007) states that “many fire departments have found that LDH relays are a more efficient way to move water for a distance up to 2500 feet, while tanker shuttles are more efficient for distances more than 5000 feet. For distances in between, either method can work well.” The literature reviewed repeatedly indicates that the limitation of a relay pumping operations will be the availability of LDH, the capacity and number of the pumpers involved in the relay and the friction lose created in the hose.

Tanker shuttle or water shuttle operations are defined as “A system using transport tankers to deliver a constant flow from a water source to an attack engine” Eckman (1994). A general review of the literature indicates that a tanker shuttle or water shuttle operation consists of three major components: fill site to fill the tankers, tankers to move the water, and a dump site to unload the water. Fill sites will be established at a water source with a source engine or other means of putting the water into the tanker. Eckman (1994) indicates that fill rates of 1000 GPM are the minimum requirement for a high capacity water shuttle. “A 1000 GPM pumper rarely can supply a 1000 GPM water shuttle. It often is not possible to sustain an average flow rate that exceeds 75% of the peak flow from the fill site.” Eckman also indicates that each fill site should have two filling stations (area where a tanker is parked, hose attached and filled with water) and that another fill site should be set up for each 500 GPM of needed capacity. In another note on tankers, Davis (2008) emphasizes the need for standardization whether in your department or in your local/county mutual aid group. “Call it standardization or simplification but it works“.

Eckman (1994) describes dump sites as either pumping the tankers off in low capacity water shuttles requiring less than 500 GPM or unloading tankers into portable tanks in high capacity water shuttles of 1000 GPM or more. Also noted is that in a high capacity operation "you should select a dump site where you can store at least enough water to operate the water supply pumper for three minutes without a tanker unloading." Davis (2007) concurs "When it comes time to move big water (1000 GPM or more) with a water on wheels (WOW) operation, the mode that works best is the dump and run mode". NFPA 1142, Appendix C-1.11 describes in detail a rather complicated method of determining water carrying capacity of tankers. Stevens(2004) addresses the calculations in a more straight forward method (Dump time + Fill time + Distance (miles x 1.7 + .65) divided by 90% of tanker capacity = GPM) Example: if an ATFD tanker with a tank capacity of 2500 gallons has a fill time of 2.1 minutes, a dump time of 2.0 minutes and is 1 mile from a fire.

1 mile x 1.7 +.65 = (travel time) 2.35 + 2.0 + 2.35 + 2.1 = 8.8 divided by 2250 (90% of capacity) = 255 GPM.

Limitations for tanker shuttle operations were noted in a number of different articles reviewed. Eckman (1994) lists four water shuttle limitations as follows:

1. Distance and road conditions from the water source to the scene.
2. The maximum capacity of the water source and the fill pumper. (Authors note, the maximum capacity of the water source will be a limitation using any water supply method)
3. The amount, type, size and efficiency of the mobile water supply units that are available to haul water.
4. The time required for mobile water supply units to arrive at the scene.

Hanley & Murchison (2000) state that "Narrow and winding roads make securing and maintaining an adequate water supply challenging for the fire department". It is also indicated that tanker shuttle operations can "create a nightmare on roads not intended to sustain this degree of traffic of large and heavy vehicles". Safety is one of Eckman's concerns regarding tanker shuttle operations.

> "Water shuttle operations can be dangerous. Personnel can be injured, and apparatus and equipment damaged. Water shuttles require a lot of movement of personnel and heavy equipment, often including maneuvers in restricted spaces and travel across highways at

> high rates of speed. If this is allowed to take place haphazardly, the probability of injury to personnel and damage to equipment is high".

Eckman has also indicated that "water shuttle require minimal personnel to operate, an important consideration given shortages of on duty personnel, both in volunteer and paid departments."

Davis and Eckman both indicate that planning and standard operating procedures are necessary for any water supply system to work. Davis describes a three component system required to deliver water. The elements are the hardware, the people, and "The written or unwritten SOP's outlining the procedures by which the people are to use the hardware." Eckman devotes an entire chapter in his book to standard operating procedures. "Water supply should always be included in the SOP's. In addition to the incident command structure, a separate water supply organization should be part of the procedure, and used in every situation where it is applicable".

Also reviewed were the ATFD SOG's regarding water supply (appendix A) and guidelines that ATFD mutual aid and automatic mutual aid (AMA) departments are using. In reviewing the current ATFD SOG's (appendix A) three methods of rural water supply operations are discussed. The first is series pumping for smaller needed fire flows such as room and content fire that can be handled with less than 10,000 gallons of total water. Relay pump and tanker shuttle operations are also described for use in higher needed fire flow situations. However the current SOG's do not detail when to use a specific type of supply operation other than when more than 10,000 gallons of water is needed.

Of the eight departments that the ATFD uses for AMA none have a written rural water supply guideline, policy or procedure available for review. Although the Dryden fire department forwarded extensive material on pumper, tanker and portable tank training they also did not have a policy or guideline on rural water operations. ATFD uses eight other departments for mutual aid, six of which are primarily rural and two that are primarily suburban/urban and do not use rural water supply operations. Of the six primarily rural departments, two forwarded written water supply procedures. The Groveland Township Fire Department (GTFD) SOPs regarding water supply detail that the department's tanker shuttle and long hose lay procedures. GTFD does state that if a fire is within 2000' of a water source that they will utilize a relay pump operation. If beyond 2000' GTFD will use a tanker shuttle operation involving portable tanks and AMA tankers. The White Lake Fire Department (WLFD) water supply operations book details that department's relay pump and tanker shuttle operations in a training base format. The SOP's state that a relay pump should be used when there is a large water demand but does not indicate how far a relay pump operation will be set up for or if distance is a determining factor for deciding on relay pumping versus tanker shuttle operations.

Review

During the literary review the author was able to determine the basic components of rural water supply. One aspect of water supply is determining how much water will be needed and then preplanning before the incident to deliver it. Accessible water and a reliable means to obtain it were well documented. Besides dry hydrants other devices both commercially and locally available were discussed. Mobile assets were also examined in detail with flexibility and developing units suited for the particular fire district emerging as the prevalent theme.

Methodology was also reviewed with tanker shuttle and relay pumping operations analyzed. One of the interesting contradictions found in the review were Eckman's statement regarding tanker shuttle operations requiring less manpower and Dickson stating that an LDH relay essentially requires less effort (manpower) once its set up. With Stevens indicating that relays can be established within five minutes at a rate of 250 GPM and then increased to the maximum GPM desired to be credited by ISO within 15 minutes there seems to be a need for research in the area of what is the most efficient way to use manpower and still deliver (needed fire flow) an adequate water supply.

One of the outwardly important aspects of water supply that can not be overlooked as Davis puts it is "The written or unwritten SOP's outlining the procedures by which the people are to use the hardware". The ATFD procedures detail the type of water supply operation to use regarding estimated needed fire flow. Other SOG's from surrounding departments also describe the tanker shuttles and relay pumping operations and only GTFD has determined exactly when and how far they will relay pump.

PROCEDURES

The procedures used to develop this ARP began by developing problem and purpose statements along with research questions while attending the National Fire Academy executive development class. A literary review was then conducted to lay the ground work to answer the first three research questions. Sources included past and current periodicals, ARPs from NFA, Eckman's and Stevens' books and the current AFTD SOG's. A questionnaire type survey was used to assist in answering questions two and three and primarily used to answer question four. To assist in answering research questions two and three original research in the form of two training evolutions were conducted by the ATFD during the spring of 2008 regarding water supply operations. One training evolution involved a tanker shuttle operation and another at the same location using the same apparatus utilizing a relay pump operation.

An eight question questionnaire (appendix G) was developed and sent to similar and like departments in Michigan. The questionnaire was limited to departments in Michigan that are subject to similar weather and climatic conditions, road conditions as the ATFD. The questionnaire was organized into three sections. The first section identified the department, the individual filling out the questionnaire and contact information in case clarifications were necessary. Section two confirmed the size and composition of the department. Section three contained eight questions regarding the department's rural water supply operations, what type of operations they perform and how far each department will relay pump. Questionnaires were either emailed or faxed to 50 similar and like department in Michigan and 34 were returned.

Action based research was conducted during two training evolutions conducted on 3-29-2008 and 4-26-2008 at Hamilton-Parsons elementary school in Addison Township. The school is located 4400' away from the closest certified water supply. Crews at both training evolutions were given identical instructions: to establish a water supply at Hamilton-Parsons elementary school following ATFD SOG's utilizing a tanker shuttle operation on 3-29-2008 (appendix E) and a relay pump operation on 4-26-2008 (appendix D). Each evolution used the same apparatus starting at the staging area .5 miles from the school with the same arrival time delays that are typical of an actual response to this location. A minimum water flow rate of 250 GPM was started at the 05:00 minute mark and the flow was increased before the 15:00 minute mark to determine what the maximum sustainable flow for each water supply operation was. The total number of personnel initially involved in setting up the water supply operation was recorded as well as the number of personnel required to maintain the operation. This number was determined by the minimum number of personnel required to safely set up and maintain the specific type of water supply operation within the time frame indicated. A WSO was included in each training evolution as well as a drive/operator for each of the four vehicles used to move water. The member riding the officer’s seat or second position assisted the operator in obtaining a draft and then transitioned into the WSO position during the relay pump operation. During the tanker shuttle operation, the second position on the source engine, in this case a firefighter, was used to connect and disconnect LDH used to fill each tanker. During the tanker shuttle operations this firefighter was referred to as the “hooker”. The member riding the officer’s seat or second position on the attack engine during the tanker shuttle operation after assisting in setup transitioned into the WSO. A gallon per minute per person calculation was then determined in an effort to evaluate manpower efficiency of each type of water supply operation. (Table’s 2 & 3) The training evolutions used in this research closely resemble evolutions described by Steven (2004) established to demonstrate water flow capabilities of departments challenging the ISO fire department supply rating schedule.

RESULTS

Research Questions

Research Question 1: What are the key elements of a rural water supply system?

The first element needed is the water itself. Not only does the water need to be located and cataloged but it needs to be certified by an engineer as to quantity and availability if the department wants the water supply to be considered as a water source for ISO. The amount of needed fire flow is also required so that suitable planning can be put in place in order to develop a rural supply system. The NFPA fire flow formula determines minimum total water needed whereas the ISO formula determines both total water supply needed and the GPM in which it shall be delivered.

An example of fixed assets would be dry hydrants that are the most documented device used to obtain rural water. The ATFD dry hydrants rated capacity regarding flow and total water available are listed in appendix B. Flow rates range from 800 GPM to 1250 GPM for dry hydrants and from 800 GPM to 1350 GPM for non dry hydrant sources. Other man made fixed assets are all weather roads built to gain access to the water and man made water supplies such as cisterns and above ground water tanks. Other man made devices that are used as a fire department water supply are pools and livestock water tanks. These devices are not primarily designed for the rigors of fire department use and need to be used with great caution.

Mobile devices necessary to obtain water in rural situations are Turbo drafts and portable pumps. Although most departments in rural settings posses portable pumps they are heavier and more difficult to put into operation than turbo draft devices. Additionally, Turbo drafts use is credited by ISO.

Other mobile equipment necessary for rural water supply operations include hard suction hose required to draft water from static sources or move water between portable tanks, strainers used to protect the pump from large debris and control water draw height, portable tanks used to store water before its use, and water transfer devices used to move water between portable tanks. Large diameter hose is used by all of the departments surveyed. Of the departments surveyed (Table 4) 53% are currently using 5” LDH and 47% are using 4” LDH.

Engines are used as either source engines or attack engines. Due to longer response times and limited manpower rural engines need the able to deploy high GPM attacks with limited manpower. Typical rural engines carry 1000 gallons of water to sustain a longer tank water attacks until a water supply is established. The departments surveyed ran an average of 3.2 engines per department.

Tankers for rural fire operations come in a number of different configurations. Most tankers in the United States carry between 1500 and 3000 gallons. Tanker should have (NFPA 1142) a means to rapidly unload their water. This can include large gravity dumps or jet dumps which can unload to the rear or the sides of the vehicle thus increasing vehicle flexibility. Some tankers do not have pumps, some have small pumps to assist in loading or offloading and some tankers have larger class A fire pumps and carry all of the equipment required on an engine. Pumper/tankers equipped as engines can shuttle water as well as serve as attack or source engine. Tankers with large pumps and hose beds can assist in relay pump operations.

Table #1

ATFD Vehicle	Year & make	Pump size & type	Water tank capacity	Amount & size of LDH	Portable tank size
Engine 1	1991 Spartan/Darley	1250 GPM Darley	1000 Gallons	1200' of 5" in a split load	2250 Gallons
Engine 2	1997 Peirce	1250 GPM Waterous	1000 Gallons	1200' of 5" in a split load	2250 Gallons
Tanker 1	1982 GMC/Peirce	1000 GPM Waterous	2500 Gallons with a 10" sq. rear dump	1200' of 5"	2500 Gallons
Tanker 2	1987 GMC/Darley	1250 GPM Darley	2500 Gallons with a 10" sq rear dump	1200' of 5"	2500 Gallons

Above table shows the ATFDs basic vehicle specifications

Planning and SOG's are also key elements of a rural water supply. Davis's description of a water supply system consisting of the hardware, the people and the software is a very descriptive method of viewing rural water supply. The "software" or SOGs are required so that the personnel know how and when to use the hardware.

Research Question 2: When should relay pump operation be used?

Relay pump operations can be used when a water supply is within range of the LDH available to the responding department. If a relay is designed to use LDH not carried on the first alarm assignment a delay in establishing a water supply will occur. Availability of apparatus capable of participating in a relay pump is also a determining factor in the relay pump decision. LDH size as it relates to GPM carrying capacity will affect how far a department can relay pump and will determine how many relay pumpers will be required. NFPA 1142 Table D-1.2.2 indicates that 4" will flow 1000 GPM 684', 5" will flow 1000 GPM 2166' and 6" will flow 1000 GPM 5200'. Relay pumping can be used in areas that do not offer or that have limited accessibility to tankers due to insufficient road conditions. Table #2 shows the results of the ATFD training evolution involving relay pumping operations in regards to time, GPM flow and the number of personnel involved in the water supply.

Table #2

Relay Pump Operation ATFD training evolution			
Time(min)	Flow (GPM)	# of Personnel	GPM/FF
5:00	253 GPM	5	50.6
10:00	1014 GPM	5	202.8
15:00	1066 GPM	5	213.2
20:00	1024 GPM	5	204.8
25:00	1074 GPM	5	214.8
30:00	1014 GPM	5	202.8
35:00	1066 GPM	5	213.2
40:00	1024 GPM	5	204.8
45:00	1014 GPM	5	202.8
50:00	1066 GPM	5	213.2
55:00	1066 GPM	5	213.2
60:00	1024 GPM	5	204.8
65:00	1074 GPM	5	214.8
Averages	983 GPM	5	196.6 GPM/FF

Relay pumping apparatus used 5” LDH and pumped the supply line with tank water before receiving relay water from the source engine.

The ATFD research shows that relay pumping provided a beginning flow of 250 GPM at the 5 minute mark and increased the flow to 1000+ GPM at the 10 minute mark. The evolution consisted of a relay established within 10 minutes of the beginning of the evolution at a distance of 4400’ away from an ATFD primary water supply point using a 1250 GPM pumper at draft with 22’ of a hard suction preconnect and a float dock strainer.

Research Question 3: When should tanker shuttle operations be used?

When a department is outside the range of their relay pump operation, then a tanker shuttle operation is the choice to provide an adequate water supply. Tanker shuttle operations need a large open area in which to operate. The area required to set up the attack engine, portable tanks and tanker dump lane during the ATFD training evolution was 36’ of road/parking lot width. Tanker turn around at the dump site used a parking lot and a 92’ turn around diameter. Fill site used Tee type intersection near the fill site to accommodate tankers using a three point turn around. Table #3 show the results of the ATFD training evolution involving tanker shuttle operations in regards to time, GPM flow and the number of personnel involved in the water supply.

Table #3

Tanker shuttle Operation ATFD training evolution			
Time(min)	Flow (GPM)	# of Personnel	GPM/FF
5:00	253 GPM	8	31.6
10:00	253 GPM	7	36.1
12:00	503 GPM	6	83.8
14:00	448 GPM	6	74.6
15:00	426 GPM	6	71.0
20:00	404 GPM	6	67.3
25:00	396 GPM	6	66.0
30:00	396 GPM	6	66.0
35:00	396 GPM	6	66.0
40:00	388 GPM	6	64.6
45:00	380 GPM	6	63.3
50:00	396 GPM	6	66.0
55:00	396 GPM	6	66.0
60:00	396 GPM	6	66.0
65:00	412 GPM	6	68.6
Averages	399 GPM	6.2	64.4 GPM/FF

Tankers involved in this training evolution have a 2500 gallon tank capacity and utilize an electrically actuated 10” square rear dump valve and a 90 degree chute extensions in order to side dump. (See table #1 for ATFD vehicle specifications)

The ATFD research shows that tanker shuttle evolution provided a beginning flow of 250 GPM at the 5 minute mark and increased the flow to an average of 400 GPM at the 12 minute mark. Tanker shuttle evolution was conducted at a distance of 4400’ away from an ATFD primary water supply point using a 1250 GPM pumper at draft with 22’ of perconnected hard suction and a float dock strainer. Due to the distance between the dump site and the turn around area used the tanker one way trip to the fill site was 5200’. Due to the ability to use two way traffic during the training evolution the same route was used from the fill site to the dump site. Using the tanker capacity formula from NFPA and Stevens the combined flow rate for the ATFD tankers at this distance should be 508 GPM. If two additional mutual aid tankers were added to the evolution that had similar capacity and capability as the ATFD tankers the flow would be increased. If the numbers from the ATFD evolution were used the flow could theoretically be sustained at 798 GPM while using the NFPA formula the flow could be as high as 1016 GPM.

Research Question 4: What guidelines are other departments using regarding rural water supply?

Of the departments surveyed all have engines, tankers and LDH. All departments indicate that they will use both relay pumping and tanker shuttle operations for rural water supply operations. 9% of departments have a SOG or guidelines regarding when to use relay pumping operations and when to use tanker shuttle operations. Some department guidelines are written specifically around certain occupancies while other departments use distance from water sources and needed fire flows as their guides to operational methods.

Table #4

Rural water supply Questionnaire results			
	Lower range	Upper range	Average
# of calls	280	2000	1078
# of personnel	20	75	37
# of Engines	5	2	3.2
# of Tankers	3	1	1.5
City/Rural water system coverage	0/100 % coverage	70/30 % coverage	16/84 % coverage
LDH on 1st Alarm	2000’	7200’	3900’
Relay distance	1000’	Beyond 5000’	2625’
47% departments use 4” LDH 53% of departments use 5“ LDH 12% of departments will relay beyond 5000’ 12% of departments will relay pump all LDH available on a 1st alarm 3% of departments will relay pump farther than the LDH available on a 1st alarm			

The averages of the departments surveyed carry 3900’ of LDH to a fire on their first alarm assignments and will relay pump an average of 2625’ away from a water source. ATFD carries 4800’ of LDH on a first alarm assignment and will relay pump up to 4800’. 12% of departments surveyed will stretch all of the LDH carried on their first alarm assignment, 3% of departments will relay pump farther than the amount of LDH carried on their first alarm assignment. No departments surveyed use 6” or larger supply line.

DISCUSSION

As examined in the literature and determined by practical application key elements for a rural water supply system consist of the hardware, the people who use the hardware and the SOG's or software that guide the people in the use of the hardware. (Davis 2004)

The need for water or how much water is needed (needed fire flow) should be the first determination in the planning of a rural water supply for fire departments. Part of the planning process is determining by occupancy surveys the potential amount of water that will be needed and where it will be needed in the fire district. The NFPA formula determines the minimum amount of water necessary while the ISO formula determines the amount and the GPM flow required. If improving the fire districts' ISO public protection classification is planned in the future then the ISO formula is indicated. If not, then the ATFD needs to make a choice between a pure quantitative or a quantitative and qualitative formula to determine needed fire flow.

Dry hydrants are the apparent choice for moving large volumes of water from a static source to the source engine. Dry hydrants offer year around accessibility and minimize effort of the source engine crew in obtaining a draft, especially in inclement weather. However many of the ATFD dry hydrants listed in appendix B flow less than the capacity of the source engine that will use it. Eckman states that “the dry hydrant should be capable of supplying enough water for the pumper to operate at its maximum capacity”.

Other equipment found to be beneficial if the water source is beyond the range of the source engines ability to draft are Schutle & Koerting's Turbo Draft device. Lighter and more mobile than portable pumps, Schutle & Koerting claim that Turbo Drafts will provide water to a source engine up to 400' away(Schutle & Koerting 2008). Other equipment needed include strainers that will work in the sources that the ATFD has to contend with. Since the department has a great deal of non dry hydrate water supply points (appendix B) then float docks and low clearance strainers are necessary. Other strainers such as an ice strainer for use during inclement weather are also indicated in the ATFD equipment list if the water supply points are to be used to their full potential.

For tanker shuttle operations portable tanks are another requirement. Of the two types of portable tanks available, the fold out frame tank is the best option for ATFD operations. The fact that self supporting tanks do not allow for over the top, tank to tank water movement make these tanks unfeasible for ATFD tanker shuttle operations. The ATFD research reiterates Davis's observation that "When it comes time to move big water (1000 GPM or more) with a water on wheels (WOW) operation, the mode that works best is the dump and run mode". To dump and run, portable tanks are required. The ATFD has a portable tank on each engine and tanker (see table #1) however the size of the portable tanks do not meet the NFPA 1142 recommendation of portable tank capacity being 40% larger than that of the tanker. Due to storage area limitations it is not possible to carry larger portable tanks on any of the current ATFD apparatus. Water transfer devices are also necessary for the use of multiply portable tanks. The ATFD currently uses water transfer devices built into a low clearance strainer allowing for maximum portable tank water usage.

For relay pumping operations LDH and pumpers with the capability to pump the desired capacity are required. LDH size is a primary consideration when planning a relay pumping operation or on a larger scale the entire rural water supply system. For many years, the ATFD operated with 4" LDH. Echoing Steven's remarks regarding pump size, "Today's decision (in this case to use 4" LDH) can hamstring the organization for a long time to come." The ATFD recently concluded a three year program to upgrade the departments 4" LDH to 5" LDH. Without this change the flows noted on table #2 detailing the relay pump training evolution would have been theoretically reduced from over 1000 GPM to less than 650 GPM using the same layout. Steven remarks have already been realized regarding pump size on ATFD tanker 1 which during the same layout described in table 2 was the limiting factor in the total maximum flow. ATFD tanker 1 is on a 35 year replacement schedule and is due to be replaced in 2017.

Cavette's 2007 quote stating "LDH relays are a more efficient way to move water for a distance up to 2500 feet, while tanker shuttles are more efficient for distances more than 5000 feet. For distances in between, either method can work well," is a good place to start when examining the question of when the ATFD should relay pump. The ATFD training evolutions have shown that for distances of up 4400' and theoretically up to 4800' that relay pumping is more efficient regarding both gallons per minute delivery and manpower utilization during the first 10 to 15 minutes of the operation.

Road conditions also have been shown to play a critical factor in the decision to relay pump or tanker shuttle. Hanley & Murchison (2000) statement that “Narrow and winding roads make securing and maintaining an adequate water supply challenging for the fire department” and that tanker shuttle operations can “create a nightmare on roads not intended to sustain this degree of traffic of large and heavy vehicles” reinforces this author’s personnel experience within the ATFD’s fire district. With 10.5 miles of natural beauty roads and a large number of high banked narrow dirt roads that do not permit two-way fire department traffic, relay pumping offers a more reliable means of supplying water.

Safety regarding tanker shuttle operations is another consideration. Eckman (1994) mentions that, “Water shuttle operations can be dangerous. Personnel can be injured, and apparatus and equipment damaged.” He also states that “If this is allowed to take place haphazardly, the probability of injury to personnel and damage to equipment is high”. The safety issues and the ever present possibility that operations in Michigan will take place during inclement weather further support the use of relay pumping if the department is within range of its LDH and the capabilities of the relay pumps to support the operation.

The current ATFD SOGs do not specifically direct the department when to tanker shuttle or relay pump in regards to distance from a water source. The current data indicates that relay pumping operations can be established in a timely manner and can establish significant flow rates using fewer firefighters. Considering these facts and the safety concerns presented by a tanker shuttle operation if a sustainable water supply is needed within 4800’ of a water source, relay pumping is the operation of choice.

Currently the ATFD operates one engine and one tanker out of each station. If the engine is first due, it is the attack engine, and if second due it is the source engine. Therefore the ATFD engines are equipped to operate as either attack or source engines. Tankers although equipped with class A pump’s are not equipped to act as engine companies due to limited available space in compartments. If multiple engine companies ran out of each station it would be feasible to designate a specific source and attack engine for each incident. When compared with other similar and like area departments the ATFD has a higher than average number of tankers. The department is scheduled to receive a rescue pumper in late 2008 with a 2000 GPM pump,1200’ of 5” hose, and 48’ of hard suction to facilitate this new unit’s use as a source engine.

Tanker shuttle operations are the next best choice if the ATFD is in need of a sustainable water supply beyond 4800'away from a water source as limited by the current range of our LDH relay capability. Davis and Eckman both have indicated that when a high capacity water supply is needed in a tanker shuttle operation that is using "a dump and run", portable tank operation is the most efficient way to operate. This reinforces ATFD SOG 440 (appendix A)which directs the department to use a series pumping operation (a lower capacity operation which pumps the tankers off) for flows of less than 750 GPM and total water usage of less than 10,000 gallons, or use a relay pump or tanker shuttle operation for fires requiring more than 10,000 total gallons of water.

Although not substantiated in the data collected due to the limit number of tankers used in the ATFD training evolutions, high flow tanker shuttle operations are possible with mutual aid tankers. Using the tanker capacity formula (NFPA 1142) two similar mutual aid tankers would theoretically double the total GPM capability, with five total tankers increasing the total GPM to a rate beyond the capacity of the fill site. Determining the maximum possible gallon per minute flow during a tanker shuttle operation would be a logical next step in water operation evaluation.

Space required to set up a high capacity tanker shuttle operation is another consideration. The ATFD training evolution required 36' of road/parking lot width to set up an attack engine, portable tank and a lane to side dump a tanker. Tanker turn around at the dump site used a parking lot and a 92' turn around diameter. If the space is not available then tankers must use three point turn around causing them to back up. This will extend tanker travel time and increasing the chance of personnel injury or vehicle damage.

It should be noted that all of the factors supporting relay pump operations shall be taken into consideration when operating a tanker shuttle operation. The safety issues regarding tanker operations on the road, at fill sites and dump site must be taken into account.

The research indicated that all departments both in the ATFD's mutual aid group and in the area use both relay pumping and tanker shuttle operations in their rural water supply operations. Therefore other departments' tankers or pumpers responding to incidents in the ATFD's district will be familiar with these types of rural water supply operations. Only one of the departments surveyed have SOP's that indicated exactly how far they will relay pump. However all departments surveyed indicated that they will relay pump with an average relay distance of 2625'. This would indicate that the total distance that a department will relay may not belong in an SOG but could be detailed in preplanning documents for each of the fire districts' occupancies that pose a significant risk. If this type of preplanning is combined with an appropriate needed fire flow calculation, an actual water supply solution could be developed for each commercial, industrial or high risk occupancy that pose a significant risk. If made available to first due units it would take any question or hesitation away for the arriving company officer as to which type of water supply operation to use.

RECOMMENDATIONS

Six recommendations have been developed based on the research done for this project.

First, the ATFD needs to adopt the ISO needed fire flow formula that determines fire flow in a qualitative and quantitative manner. This will allow the fire department to identify where the water will need to be, at what rate the water will be needed and the total amount required. It will also match the requirements that ISO applies to a department challenging the fire department supply portion of the ISO rating schedule.

Next, the ATFD needs to add a performance requirement to the current dry hydrant specification last updated in 2000. The specification should state a minimum flow requirement for all dry hydrants of 1250 GPM. The upper level of dry hydrant performance should be based on the ISO needed fire flow formula of the occupancies that will utilize the dry hydrant as a water source.

In order to reduce confusion during initial fire scene operations, a water supply solution should be created for all commercial, industrial and large fire risk occupancies in the fire district. Water supply solutions will determine the needed fire flow using the ISO formula, determine the closest water supply points by using the ATFD certified water source list, and the water supply method to be used. The water supply solution should/will describe which automatic mutual aid units will be dispatched and a detailed description of how they will be used in the water supply system.

Additionally, the ATFD needs to implement an Automatic Mutual Aid policy to ensure that the units required to meet the needed fire flow requirements described in the water supply solutions will respond in a timely manner. Automatic mutual aid agreements shall be made with all departments listed on a compiled list from the water supply solutions for the units required to meet needed fire flows.

The ATFD will also need to update SOG 440 to include a distance that can be utilized while operating in a relay pumping water supply mode. This will be helpful in residential areas where all occupancies do not have a separate water supply solution and in mutual aid responses outside of the fire district where ATFD officers are given Water Supply Officer responsibilities.

Lastly, the ATFD should take the next evolutionary step to determine how much water can be flowed during a high capacity tanker shuttle operation involving automatic mutual aid tankers. This can be done by using the same training evolution guidelines at the same location as the tanker shuttle evolution performed for this research project. By adding up to four automatic or mutual aid tankers to the evolution, a maximum flow could be established as well as increasing familiarity with ATFD equipment and procedures used during a rural water supply operation. Furthermore, regularly scheduled automatic and mutual aid water supply training evolutions should be scheduled quarterly using both relay pumping and tanker shuttle operations to confirm compatibility with ATFD operations and to become familiar with mutual aid departments' equipment and personnel.

When done efficiently and effectively, rural water supply more accurately resembles a highly choreographed dance with all the elements working together and complimenting one another for optimum results. Any department wishing to improve their rural water supply operations will need both relay pumping and tanker shuttle operations as a tool in their water supply tool box. The literature presently available is an excellent resource to discover ways to maximize the capabilities of the equipment a department already owns. If an ISO challenge is on a department's horizon, Stevens' material will be a great asset to the personnel and department involved. Planning is an essential but sometimes overlooked aspect of a rural water supply system. Although developing a water supply solution for each district's risks seems daunting, it can be accomplished with a great deal of perseverance. The reward of having a plan to rely on when responding to that once in a career "big one" can be very comforting and is a major concern removed from the incident commander check list. Training is the life blood of any organization and the more we train with our equipment and our neighbors the better we will be able to meet the challenges that the rural fire service will provide for us tomorrow.

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Appendix A

ADDISON TOWNSHIP FIRE DEPARTMENT
STANDARD OPERATING GUIDELINE

CATEGORY:	FIRE/RESCUE	S.O.G. #	440 Supersedes N/A
SUBJECT:	WATER SUPPLY OPS	EFFECTIVE DATE:	06-18-2006
APPROVED BY:	CHIEF GEORGE SPENCER	PAGE:	1 of 2

440.1 **SCOPE:** Will apply to all fire department operations requiring a water supply. .

440.2 **PURPOSE:** To establish a consistent and efficient method of providing a water supply for any situation that may be encountered.

440.3 **BASIC OPERATIONAL METHODS**

Three basic methods or mode of operations will be used for water supply operations. The IC will determine after initial size up which method to use and announce this for incoming apparatus. Ray road command confirming a room and contents fire

- Series pump operations
- Relay pump operations
- Tanker shuttle operations

440.4 **SERIES PUMP OPERATIONS**

Series pump operations will be used for water supply needs of less than 750 GPM and fires which are small fires requiring less than the amount of water carried to the scene, such as room & contents fires. Fires requiring more than 10,000 gallons total should not use a series pump operation.

Fire attack will begin with the 1st due Engines tank water and each arriving apparatus will pump its tank water through LDH to the steamer intake of the truck in front of if. Truck receiving water will continue the fire attack or pump to the truck in front of it and top off it's water tank The series pump concept may have 3 or more trucks hooked "in series" with only the last unit in line having a tank that is less than full.

Appendix A (continued)

440.5 **RELAY PUMP OPERATIONS**

Relay pump operations will be used for water supply needs exceeding that of a series pump operations capability (10,000 gallons) within close proximity of a primary water supply. The first due or attack Engine will typically forward lay to the fire with each successive arriving unit reverse laying back to the primary water supply.

A relay pump is a very reliable water supply method and should be considered when operating in areas where tanker access is limited due to narrow roads or inclement weather conditions.

440.6 **TANKER SHUTTLE OPERATION**

Tanker shuttle operations will be used for water supply needs exceeding that of a series pump operations capability (10,000 gallons) and not within close proximity of a primary water source. The first due or attack Engine will typically begin the fire attack with tank water and set up portable tank operations with at least 2 tanks. The second due Engine may assist with scene operations or set up a fill site for tanker.

ADDISON TOWNSHIP FIRE DEPARTMENT

STANDARD OPERATING GUIDELINE

CATEGORY:	FIRE/RESCUE	S.O.G. #	441 Supersedes N/A
SUBJECT:	WATER SUPPLY/SCENE OPERATIONS	EFFECTIVE DATE:	06-18-2006
APPROVED BY:	CHIEF GEORGE SPENCER	PAGE:	1 of 1

441.1 **SCOPE:** Will apply to all fire department operations requiring a water supply. .

441.2 **PURPOSE:** To establish consistent and efficient water supply scene operation for the 3 water supply methods used by the department.

Appendix A (continued)

441.3 **SCENE OPERATIONS, SERIES PUMP**

Fire attack will begin with the 1st due Engines tank water and each arriving apparatus will pump its tank water through LDH to the steamer intake of the truck in front of if.

If necessary the attack Engine may forward lay up a narrow driveway or in areas with limited access. Truck receiving water will continue the fire attack or pump to the truck in front of it and top off it's water tank The series pump concept may have 3 or more trucks hooked "in series" with only the last unit in line having a tank that is less than full.

441.4 **SCENE OPERATIONS, RELAY PUMP**

The first due or attack Engine will typically forward lay to the fire and begin to attack with tank water. Each successive arriving unit will reverse laying back to the primary water supply up to the end of their LDH. The unit will them pump the supply line with their tank water. If responding on a "Special Automatic Mutual Aid" refer to the water supply solution in the preplan book or check with the water supply officer for discharge pressure. (if in doubt start @ 100 psi)

A relay pump is a very reliable water supply method and should be considered when operating in areas where tanker access is limited due to narrow roads or inclement weather conditions.

441.5 **SCENE OPERATIONS, TANKER SHUTTLE**

The first due or attack Engine will typically begin the fire attack with tank water and set up portable tank operations with at least 2 tanks. The second due Engine may assist with scene operations or set up a fill site for tanker. If responding on a "Special Automatic Mutual Aid" refer to the water supply solution in the preplan book or check with the water supply officer for vehicle assignments. If necessary the attack Engine may forward lay up a narrow driveway or in areas with limited tanker accessibility. If so the second due Engine will act as the dump sight or supply engine and the IC must special call an additional Engine to supplement the AMA response.

Appendix A (continued)

441.6 **WATER SUPPLY OFFICER**

Operations utilizing a relay pump or tanker shuttle operation will require the IC to appoint a Water Supply Officer or WSO. The WSO will supervise and coordinate all aspect of the water supply operation including fill sites, dump or unload sites, tanker traffic pattern's, fill and dump site assignments will assist the IC in determining if water flow is sufficient and what to do if it is not.

ADDISON TOWNSHIP FIRE DEPARTMENT

STANDARD OPERATING GUIDELINE

CATEGORY:	FIRE/RESCUE	S.O.G. #	442 Supersedes N/A
SUBJECT:	WATER SUPPLY/SUPPLY SITE OPERATIONS	EFFECTIVE DATE:	03-05-2007
APPROVED BY:	CHIEF GEORGE SPENCER	PAGE:	1 of 2

442.1 **SCOPE:** Will apply to all fire department operations requiring a water supply.

442.2 **PURPOSE:** To establish consistent and efficient water supply, supply site operation for primary, secondary, dry hydrant and turbo draft operations.

442.3 **PRIMARY WATER SUPPLY OPERATIONS**

Primary water supplies are a lake, pond or stream within 70' of a road or improved roadway surface that can be reached using hard suction. Primary water supplies will support at least 800 GPM. Units establishing a water supply will use the appropriate length of hard suction, (listed on certified water list) a DAD (at the strainer or the first section of hard suction from the water source) supplied by the TAC line and a float dock strainer. During winter operation a hand operated 8" ice drill and ice strainer will be used. The pump operator will notify the IC or the WSO when a water supply is established.

Appendix A (continued)

442.4 **SECONDARY WATER SUPPLY OPERATIONS**

Secondary water supplies are a lake, pond or stream farther than 70'from a road or improved roadway surface that can not be reached using hard suction. Secondary water source are obtained by using turbo drafts or portable pumps that are discharged directly into a portable tank that an Engine or Tanker will draft from. A minimum of 2 portable pumps should be utilized with the preferred number of 3, 2 working and 1 on standby.

442.5 **DRY HYDRANT OPERATIONS**

Dry hydrants are primary water supplies within 10' of an improved roadway surface. Units establishing a water supply will use 1 or 2 lengths of hard suction to hook the dry hydrant, back flush the hydrant and establish a draft. The pump operator will notify the IC or the WSO when a water supply is established.

442.6 **TURBO DRAFT OPERATIONS**

Turbo drafts are used to establish a water supply from a secondary water source or to supplement a primary water source/dry hydrant thereby increasing the flow. Turbo drafts are typically used in pairs, are feed by a 2 ½" line pumped at 200psi. The turbo draft is place in at least 18 to 24" of water with a 5" return line attached. The return line is feed directly into a portable tank using a 5" direct fill device (Lego's). The supply Engine/Tanker will then draft from the portable tank. The supply Engine/Tanker may then set up a fill site or relay pump. The pump operator will notify the IC or the WSO when a water supply is established.

442.7 **HYDRANT/WATER SYSTEM OPERATIONS**

When using a pressurized hydrant system as a water supply it is recommended to discharge the hydrant directly into a portable tank using a 5" direct fill device (Lego's). The supply Engine/Tanker will then draft from the portable tank in order to maximize fill rates.

Appendix A (continued)

442.8 DRAFT ASSIST DEVICES

Draft assist devices (DADs) will be used with difficult or long suction hose layouts beyond 40 feet. The DAD will be inserted into the suction line at the strainer or as close to the strainer as possible. The DADs on the low clearance strainer should always be used with the TAC (100’ 1 ¾” Trash And Car) line to recirculate water and ensure a draft if the connections are not tight or in case of a primer failure.

Appendix B
ATFD certified water supply list

ID #	Location	GPS metric	Water Source	GPM	Lift	Gallons available	Type
29-3 CW	2485 LAKEVILLE	42.816853 83.183438	POND	1,000	2'	384,000	Floatdock
21-3 CW	2500 LAKE GEORGE	42.833378 83.166916	POND	900	14'	326,000	Floatdock
29-4 CW	LAKE GEORGE N/O HEIDI	42.816736 83.166902	POND	1,050	8'	817,000	Hydrant
30-1 CW	HONEYBEE LANE	42.816760 83.200042	POND	1,000	10'	598,000	Floatdock
31-1	3232 BLK INDIAN LAKE	42.800036 83.200071	Indian Lake	925	6'	102 million	Hydrant
22-2	ARMY W/O KINGSTON	42.850153 83.150181	Lakeville lk	1250	5'	519 million	Hydrant
27-3	COVE DRIVE	42.831444 83.160555	Lakeville lk	800	8'	577 million	Turbo draft (2)
27-1	LAKEVILLE/ROCHESTER	42.816747 83.150272	Lakeville lk	1,100	6'	577 million	Hydrant
27-4 CW	ROCHESTER/BETTS	42.800270 83.133594	Stoney creek	1,200	6'	816,400	Floatdock
26-1 CW	870 ROCHESTER	42.816668 83.133417	Stoney creek	1,000	12'	3603 Gallons per minute	Floatdock
26-2 CW	STONEY CREEK / 610 BREWER	42.816916 83.116850	Stoney creek	1,000	12'	3740 Gallons per minute	Floatdock
25-3 CW	1940 TOWNSEND	42.816853 83.116731	POND	1,000	8'	405,000	Floatdock
25-2	BREWER/TOWNSEND	42.800250 83.116686	Stoney creek	800	8'	6013 Gallons per minute	Hydrant
20-1 CW	2750 FARMBROOK	42.833341 83.183541	POND	1,000	7'	736,000	Floatdock
18-2 CW	3350 RAY	42.833535 83.200168	POND	1,350	6'	476,000	Floatdock
18-1	AUDOBON TRAIL	42.833494 83.200275	POND	950	10'	1.6 million	Hydrant
25-4 CW	DEQUINDRE/BREWER	42.800254 83.083604	Stoney creek	1,200	10'	5926 Gallons per minute	Floatdock
23-1	GARLAND FARMS	42.833371 83.116873	POND	1,000	14'	3,000,000	Hydrant
27-5 CW	VERNIER	42.816765 83.133489	Lakeville lk	1,000	5'	187 million	Floatdock

Appendix B (continued)
ATFD certified water supply list

7-6 CW	PENINSULA	42.816861 83.133499	Lakeville lk	1,000	5'	216 million	Floatdock
13-1 CW	75101 DEQUINDRE	42.833530 83.100020	POND	1,200	12'	427,000	Floatdock
11-2	FIRE STATION # 1	42.850148 83.133.472	POND	925	12'	361,000	Hydrant
11-2 CW	FIRE STATION # 1	42.850148 83.133.472	POND	400	12'	361,000	Turbo draft (1)
10-2 CW	74 CENTER (BERKLIG POND)	42.850275 72.133516	POND	1,050	10'	218,000	Floatdock
21-1	MEADOW LN/NORTH	42.833337 83.166670	POND	900	18'	315,000	Hydrant
14-1	3939 HAGERMAN	42.851152 83.116748	POND	1200	8'	460,000	Hydrant
02-1	HAGERMAN/MCKAIL	42.866902 83.116740	LAKE	1100	9'	8 million	Hydrant
10-1	HAVEN/LEONARD	42.850240 83.150178	Lake George	1100	6'	15 million	Hydrant
9-1 CW	4408 LAKE GEORGE	42.850225 83.166937	POND	1,150	5'	327,000	Floatdock
07-1	OAKWOOD W/O HOSNER	42.866736 83.200108	POND	800	10'	605,371	Hydrant
7-2 CW	3530 NOBLE (MULBERRY HILLS)	42.850117 83.200232	POND	1,150	6'	996,000	Floatdock
33-1,2 or 3	ADDISON OAKS	42.800068 83.166701	LAKE	1,000	10’	40 million	Hydrant
33-5 CW	ADDISON OAKS	42.800068 83.166701	LAKE	1,150	10'	40 million	Floatdock
22-1	SALVATION ARMY	42.833392 83.150169	Lakeville lk.	900	5'	721 million	Hydrant
13-1 CW	76955 DEQUINDRE	42.850086 83.100031	POND	600	6'	470,000	Floatdock
1-1 CW	5145 SECORD LAKE	42.866788 83.100210	Secord lk	1,250	6'	93 million	Floatdock
2-2 CW	5030 BOARDMAN	42.883410 83.133476	POND	800	14'	448,000	turbo draft (2)
5-1 CW	5870 HOSNER	42.883346 83.200048	POND	1,050	10'	482,000	Floatdock
35-3 CW	MILLER LAKE		LAKE	1150	14"	8.29 million	Floatdock

Appendix C

Training Today for Tomorrow's Challenge

ADDISON TOWNSHIP FIRE DEPARTMENT

1442 Rochester Road - Leonard, Michigan 48367 - (248) 628-5600 - FIRE CHIEF, George Spencer

ADDISON TOWNSHIP FIRE DEPARTMENT
DRY HYDRANT SPECIFICATIONS

All dry hydrants installed in Addison Township will conform to the following specifications.

1. 6" NST female swivel Fire Department connection of either steel or PVC (steel preferred) with an internal screen.
2. Connection will be supported from the ground with a steel or wood support.
3. Painted red with a "Fire Department Dry Hydrant" sign (with Fire Department ID #) posted at the site.
4. Protected by a 4' by 4' concrete pad around the hydrant riser with a 4" concrete filled metal post on each corner of the concrete pad for additional protection.
5. Dry hydrant riser shall be a minimum of 6" PVC or steel (steel preferred) with either a 45° or 90° elbow depending on local conditions.
6. The riser will extend below the frost line (48").
7. All horizontal pipe runs will be ran slightly "up hill" to allow drainage.
8. Only schedule 40 or heavier PVC shall be used in PVC systems.
9. All exposed PVC or metal surfaces and all underground metal surfaces shall be primed and painted to prevent deterioration of the material.
10. A minimum number of elbows, preferably no more than two, are recommended for use in the total system.
11. All connections shall be clean and the appropriate sealing materials should be used according to manufacturer's specifications so as to ensure all joints are airtight.
12. The maximum gallons per minute should also be posted on the dry hydrant sign.
13. Total vertical lift shall not exceed 16'.
14. All dry hydrants shall be within 10' of an improved road surface able to support vehicles of 80,000 lb. G.V.W.
15. All dry hydrants shall be approved by the authority having jurisdiction (Addison Township Fire Department).

6-2000

Appendix C (continued)

Training Today for Tomorrow's Challenge

ADDISON TOWNSHIP FIRE DEPARTMENT

1442 Rochester Road - Leonard, Michigan 48367 - (248) 628-5600 - FIRE CHIEF, George Spencer

WATER SOURCES

CISTERNS

Cisterns are underground water tanks used for storage of fire protection water. All cisterns installed in Addison Township will conform to the following specifications.

1. Cisterns or underground water storage tank shall be constructed of concrete, steel, or fiberglass.
2. Will be at least 48" below final grade level.
3. Tanks shall have at least one man hole cover (per cell) for interior maintenance access.
4. Adequate ventilation shall be provided, recommended minimum of 15 square inches of ventilation for every 10,000 gallons of tank capacity and shall be screened.
5. Tank shall be secured to eliminate "floating" when empty.
6. All tanks shall have automatic refill at a minimum fill rate of 50 GPM.
7. All tanks shall have a tank level indicate near or within sight of the dry hydrant.
8. Tank will allow a minimum discharge (suction) rate of 1,000 GPM.
9. Suction pipe will be secured inside the tank.
10. Suction pipe shall have anti swirl protection.
11. A filler pipe will be provided, the pipe will be 4" with a 4" Stortz connection and cap.
12. The filler pipe will be no more than 30" above final grade with a 30° elbow.
13. The total rated capacity of the tank will be available from the suction pipe.
14. The total rated capacity of the tank will be listed below the FDID # on the dry hydrant sign.
15. The maximum gallon per minute flow available from the hydrant/cistern will also be listed on the dry hydrant sign.
16. The distance from the bottom of the suction pipe to the dry hydrant shall not exceed 16' of vertical lift.
17. The cistern should be designed to be trouble-free, and it should last a lifetime.
18. The design of the cistern shall be submitted to the authority having jurisdiction for approval prior to construction. All plans shall be signed by a registered professional engineer.
19. The entire cistern should be rated for highway loading, unless specifically exempted by the authority having jurisdiction.
20. Each cistern should be sited to the particular location and approved by the authority having jurisdiction.
21. All PVC piping shall have glued joints.

Appendix C (continued)

22. Suction pipe connection shall be 24” to 30” (508 mm to 610 mm) above the level of the surface where vehicle wheels will be located when cistern is in use.

LAKES AND PONDS

Lakes and ponds can be used as sources of water for Fire Protection. Ponds are usually man made excavations and are much smaller than lakes.

LAKES

1. Lakes shall be a minimum of 12’ deep.
2. Lakes when used for Fire Protection will have 50 year drought low level data.
3. The dry hydrant strainer will be at least 2’ below the low water level.
4. Suction screens or pick ups will be a minimum of 6” wide and 40” long with a minimum of 1,000 5/16” holes and a hinged pipe cap to allow large debris to be “back flushed” out of the pipe.
5. Placement of the suction screen will be deep enough to ensure that ice will not reach the screen.

PONDS

1. Ponds shall be a minimum of 12’ deep.
2. Ponds when used for Fire Protection will have a means of maintaining water level.
3. Water level will be maintained automatically above the low water level established by the authority having jurisdiction.
4. Dry hydrant strainer will be at least 2’ below the low water level.
5. Suction screens or pick ups will be a minimum of 6” wide and 40” long with a minimum of 1,000 5/16” holes and a hinged pipe cap to allow large debris to be “back flushed” out of the pipe.
6. Placement of the suction screen will be deep enough to ensure that ice will not reach the screen.
7. Ponds will maintain adequate amounts of water for Fire Protection year round.
8. Pond water level maintenance devices shall be protected from freezing.

Appendix C (continued)

STREAMS

Streams can be used to provide water for Fire Protection, but are the least desirable due to varying water levels.

1. Streams shall have a minimum flow of 750 GPM (W x D x FT/MIN x 7.5 = GPM).
2. To accommodate low water levels conditions, streams will have permanently installed water detention devices (piers or pilings) 6’ on center across the entire width of the stream 10’ downstream from the dry hydrant suction screen.
3. The dry hydrant strainer will be at least 2’ below the low water level, if possible.
4. Suction screens or pick ups will be a minimum of 6” wide and 40” long with a minimum of 1,000 5/16” holes and a hinged pipe cap to allow large debris to be “back flushed” out of the pipe.
5. Placement of the suction screen will be deep enough to ensure that ice will not reach the screen.

6-2000

Appendix D

Relay pump operation
Training evolution

Units Participating

Addison Engine 1 – Attack Engine
Addison Engine 2 – Source Engine
Addison Tanker 2 – In relay (1st Tanker)
Addison Tanker 1 – In relay (2nd Tanker)
Addison Captain 1 – Command
Unit 26 for data collection

General overview

This training evolution is designed to gather data to effectively evaluate the ATFD's relay pumping operations

All units will arrive at the drill location and report to the staging area @ Dequindre and 32 Mile.

Relay pump operations

We will be setting up our standard relay pump operation by stretching 5" supply line using;
Engine 1 with a crew of 2
Engine 2 with a crew of 2
Tanker 1 with a crew of 1
Tanker 2 with a crew of 1
See SOG 440 for details

Time Line

00:00 Engine 1 & Tanker 2 leave for school
02:00 Tanker 1 leaves for Tanker 2 location to reverse lay
03:00 Engine 2 leaves for tanker 1 location to reverse lay to draft site
04:30 Engine 1 charges 2½" and begins discharging water at 250 GPM by 05:00
10:00 Draft site set up and all units are in relay Engine 1 charges deck gun to determine maximum sustainable flow

Basic outline

Drill site will be on Dequindre between Brewer & 32 mile
Water supply point will be stoney creek near Brewer on the east side of the road
Engine 1 will drop their manifold at end of the school driveway and stretch 1200' of 5" to the school, pull 200' of 2½" line and discharge 250 GPM within 5 minutes
Tanker 2 will stretch 1200' of 5" from the manifold toward the draft site, and pump the supply line to Engine 1 with tank water
Tanker 1 will stretch 1200' of 5 from Tanker 2 toward the draft site, and then pump the supply line to Tanker 2 with tank water
Engine 2 will stretch 800' of 5" from Tanker 1 to the draft site, draft from Stoney creek and pump the line

Appendix D (continued)

Tips to remember

Safety is our first concern
Start discharging from the 2 ½ before the 05:00 mark
Bleed the air from supply line to avoid losing a prime if necessary
Do not discharge into a line until the truck receiving water is ready
When relay pumping the supply truck always shuts down first to avoid water hammer!

Predicted Hydraulic Calculations

E-2 (draft engine) 1250 GPM (waterous pump) Drafts with a 22' 6" suctions with 8' of lift & pumps the line @ 140 psi Pump Discharge Pressure or approximately 150 psi Net Pump Pressure discharging 1000+GPM . Friction loss = approximately 52 psi + 5 psi elevation loss for total FL of 57psi

T-1 (1st relay truck w 1000 GPM waterous pump) receives approximately 83 psi residual & pumps line @ 150 psi PDP or 67 psi NPP discharging 1000+GPM into 1200' of 5". Friction loss = approximately 78 psi + 5 psi elevation loss for a total FL of 83 psi

T-2 (2nd relay truck w 1250 GPM Darley pump) receives approximately 67 psi residual & pumps line @ 200 psi PDP or 133 psi NPP discharging 1000+GPM into 1200' of 5". Friction loss = approximately 78 psi hose line + 5 psi manifold + 78 psi for 1200' 5" line - 8 psi elevation loss for a total FL of 173 psi

E-1 (attack engine w 1250 GPM Darley pump) receives approximately 27 psi residual while flowing a 2 ½" line w 1 ¼" nozzle @ 50 psi on gauge & 30 psi on pitot also discharging the deck gun with an 1.3/4" tip 68 psi pitot = discharge of 253GPM (2 ½") + 750 GPM (deck gun) for total of 1003 GPM

(FL formula Q(Q+Q+1) X .031 for 5" GPM calculated using NFPA 1911 table B-1(d) with coefficients calculated)

This document converted from a power point presentation for an ATFD water supply training evolution on 4-26-2008

Appendix E

Tanker shuttle operations
Training evolution

General overview

This training evolution is designed to gather data to effectively evaluate the ATFD's tanker shuttle operations

All units will arrive at the drill location and report to the staging area @ Dequindre and 32 Mile.

Units Participating

Addison Engine 1 – Attack Engine
Addison Engine 2 – Source Engine
Addison Tanker 2 – Shuttle (1st Tanker)
Addison Tanker 1 – Shuttle (2nd Tanker)
Addison Captain 1 – Command
Unit 26 for data collection

Tanker Shuttle operations

We will be setting up our standard tanker shuttle operation using;
Engine 1 with a crew of 2
Engine 2 with a crew of 2
Tanker 1 with a crew of 1
Tanker 2 with a crew of 1
See SOG 440 for details

Time Line

00:00 Engine 1 & Tanker 2 leave for school
02:00 Tanker 1 leaves for school
03:00 Engine 2 leaves for fill site
04:30 Engine 1 charges 2½" and begins discharging water at 250 GPM by 05:00
10:00 Fill site set up, Engine 1 charges deck gun to determine maximum sustainable flow

Dump Site

Start at staging area, Engine 1 with crew of 2 and Tanker 2 with crew of 1 proceed to school
On arrival put engine in gear and circulate
Pull tanker to designated spot, drop tank
Unload tanker, connect 6" with 1-1/2" DAD line
Pull 2nd tanker to designated spot, drop tank 2nd tank
Unload 2nd tanker, connect 6" with 1-1/2" DAD line for water transfer
Stretch 200' of 2-1/2" line and discharge water within 5 minutes
Increase flow without loosing a draft within 15 minutes of start

Appendix E (continued)

Fill Site

Start at staging area, Engine 2 with crew of 2 and proceed to fill site at + 02:00
Upon arrival put engine in gear and circulate
Pull 22' hard suction, connect Float dock then connect to engine
Obtain a draft and advise command
Prepare fill site by connecting 2 sections of LDH

Tips to remember

Safety is our first concern
As soon as you're empty, leave to refill
Only fill one tanker at a time
Use the direct tank fill, leave the caps off
The tanker drivers should never leave the drivers seat!

Predicted Hydraulic Calculations

Distance to fill site with turnarounds 1 mile

E-2 (draft engine) 1250 GPM (waterous pump) Drafts with a 22' 6" suctions with 8' of lift & has an engineers certified fill rate at this fill site of 1200 GPM.

T-1 1st Tanker to unload has a fill rate of 1250 GPM. (1000 GPM waterous pump and 2500 Gallon tank w/ direct tank fill) Fill time 2.1 minutes / return time 2.4 minutes / Dump time 2.1 minutes return to fill time 2.4 minutes. Total round trip time 9 minutes divided by 90% of a full load = 250 GPM

T-2 2nd Tanker to unload has a fill rate of 1250 GPM. (1250 GPM Darley pump and 2500 Gallon tank w/ direct tank fill) Fill time 2.1 minutes / return time 2.4 minutes / Dump time 2.0 minutes return to fill time 2.4 minutes. Total round trip time 8.9 minutes divided by 90% of a full load = 253 GPM

E-1 (attack engine w 1250 GPM Darley pump 1000 gallon tank) will draft from two 3000 gallon portable tanks (from tanker 1 & 2) with a water transfer device moving water from tank 2 to tank 1. E-1 will flow a 2 ½" line w 1 ¼" nozzle @ 50 psi on gauge & 30 psi on pitot discharging 253 GPM. Will also flow the deck gun with an 1 3/8" tip 20 psi pitot = discharge of 253GPM (2 ½") + 250 GPM (deck gun) for total of 503 GPM

(Time and distance formula T=0.65+1.7 D calculated from NFPA 1142 C-1.11(b)
GPM calculated using NFPA 1911 table B-1(d) with coefficients

This document converted from a power point presentation for an ATFD water supply training evolution on 3-29-2008

Appendix F

ADDISON TOWNSHIP FIRE DEPARTMENT

STANDARD OPERATING GUIDELINE (UPDATED)

CATEGORY:	FIRE/RESCUE	S.O.G. #	440 Supersedes N/A
SUBJECT:	WATER SUPPLY OPS	EFFECTIVE DATE:	06-18-2006 (revised 09-01-2008)
APPROVED BY:	CHIEF GEORGE SPENCER	PAGE:	1 of 2

440.1 **SCOPE:** Will apply to all fire department operations requiring a water supply. .

440.2 **PURPOSE:** To establish a consistent and efficient method of providing a water supply for any situation that may be encountered.

440.3 **BASIC OPERATIONAL METHODS**

Three basic methods or mode of operations will be used for water supply operations. The IC will determine after initial size up which method to use and announce this for incoming apparatus. Ray road command confirming a room and contents fire

- Series pump operations
- Relay pump operations
- Tanker shuttle operations

440.4 **SERIES PUMP OPERATIONS**

Series pump operations will be used for water supply needs of less than 750 GPM and fires which are small fires requiring less than the amount of water carried to the scene, such as room & contents fires. Fires requiring more than 10,000 gallons total should not use a series pump operation.

Fire attack will begin with the 1st due Engines tank water and each arriving apparatus will pump its tank water through LDH to the steamer intake of the truck in front of if. Truck receiving water will continue the fire attack or pump to the truck in front of it and top off it's water tank The series pump concept may have 3 or more trucks hooked "in series" with only the last unit in line having a tank that is less than full.

Appendix F (continued)

440.5 **RELAY PUMP OPERATIONS**

Relay pump operations will be used for water supply needs of more than 10,000gallons will be needed and the incident is within 4800’ of a primary water supply. The first due or attack Engine will typically forward lay to the fire with each successive arriving unit reverse laying back to the primary water supply.

A relay pump is a very reliable water supply method and should be considered when operating in areas where tanker access is limited due to narrow roads or inclement weather conditions. A relay pumper may be inserted at the attack engines manifold if necessary.

440.6 **TANKER SHUTTLE OPERATION**

Tanker shuttle operations will be used for water supply needs of more than 10,000 gallons and the closest primary water source is more than 4800’ away. The first due or attack Engine will typically begin the fire attack with tank water and set up portable tank operations with at least 2 tanks. This task will fall to the second due engine if narrow drives/road prohibit tanker movements at the attack engines location. The second due Engine may assist with scene operations or set up a fill site for tanker.

Appendix G

ADDISON TOWNSHIP FIRE DEPARTMENT

4026 Forest - Leonard, Michigan 48367 - (248) 628-5600 - FIRE CHIEF, George Spencer

5-15-2008

Dear questionnaire recipient,

I am distributing the following questionnaire as part of an applied research project regarding rural water supply operations for the executive development course at the National Fire Academy.

Please take a few moments to fill out the attached questionnaire, you can fax it back to me at 248-628-5770 or E-Mail me at cheifspencer@sbcglobal.net with the results. If you have any difficulty with the format or any questions please feel free to contact me at 248-343-5171.

Thank you in advance for your assistance in gathering information about rural water supply operations. If you wish I can share the details of the questionnaire with you when complete.

Regards,

George Spencer

Appendix G (continued)

Rural Water Supply Questionnaire

Department: ____________________

Name & Rank: ____________________

Address: ____________________

Telephone Number: ____________________

E-mail address: ____________________

Department Profile:

Coverage area [ ] Square miles

Number of runs in 2007 [ ]

Department type: (underline one) Paid on call Combination Career

Number of personnel: [ ] Number of Engines: [ ] LDH size: 4” 5” 6” (underline)

Number of Tankers (Tenders): [ ] Amount of LDH available on a 1st alarm [Feet]

1. Percentage of fire district that uses a (public or private) pressurized water system? [%]
2. Percentage of fire district that uses a rural water supply system? [%]
3. Does your department use tanker shuttle operations for rural water supply? (underline one)
   Yes No
4. Does your department use relay pumping operations for rural water supply? (underline one)
   Yes No
5. Does your department have a SOG/SOP defining when a relay pump or tanker shuttle operation is used? (underline one) Yes No If so please provide a copy
6. How far will your department relay pump from a water source? (underline one) 1000’ 2000’ 3000’ 4000’ 5000’ more than 5000’
7. Has your department been certified by ISO to use a Long Distance Hose Lay beyond 1000’ from a water source? (underline one) Yes No
8. If yes to question number 7: Distance [Feet] [GPM]

George Spencer, EFO Student @ NFA
chiefspencer@sbcglobal.net
248 343 5171

Appendix H

ATFD Water Supply Solution

4495 Forest Road
Distinctive designs
Wood product supplier

NEEDED FIRE FLOW: **1500 GPM**

Water supply operations:

Relay Pump

Responding Units
Station 1: Engine 1, Tanker 1, Ladder 26, Alpha 1
Station 2: Engine 2, Tanker 2, SRU 26

Responding Units Automatic Aid
Dryden station 1: Engine 12-21

Draft site #1 74 Center/Whitehead 700' away from fire scene

Rural water supply operations:

1. Addison Engine 1 response's to the scene & attacks fire
2. Addison Tanker 1 lay's 700' of LDH supply line to draft site at 74 Center, establishes a draft with float dock from pond & pumps the supply line @ 150psi.
3. Addison Engine 1 receives **1000 GPM** @ 65 psi residual.
4. Addison Engine 2 response's to the scene & attacks fire
5. Addison Tanker 2 lay's 700' of LDH supply line to draft site at 74 Center, Establishes a draft with float dock from pond & pumps supply line @ 150psi.
6. Addison Engine 2 receives **1250 GPM** @ 80 psi residual.
7. Ladder 26, SRU 26 and Alpha 1 arrive and begin operations.
8. Dryden Engine 12-21 arrives on scene to assist with operations.

This Water supply solution results in a fire flow of **2250 GPM** with 3 Engines, 1 Ladder, 1 service unit (SRU), and 1 alpha unit at the fire scene with 2 tankers at draft.

150% of Needed Fire Flow achieved

Appendix H (continued)

ATFD Water Supply Solution

3500 Lakeville Road
Lakeville Animal Clinic
Veterinarian Hospital

NEEDED FIRE FLOW: **1000 GPM**

Water supply operations:

Tanker Shuttle

Responding Units
Station 2: Engine 2, Tanker 2, SRU 26, Alpha 2
Station 1: Engine 1, Tanker 1, Ladder 26

Responding Units Automatic Aid
Oxford: Engine 3, Tanker 21-1, Tanker 21-2 Orion: Tanker 20

Fill site A #30-1CW on Honey Bee Lane 1.1 miles north Addison E-1

Rural water supply operations:
1. Addison Engine 2 arrives and attacks fire
2. Addison Tanker 2 arrives, drops portable tank and unloads
3. Addison Tanker 1 arrives, drops portable tank and unloads
4. Addison Engine 1 sets up fill site A on Honey Bee Lane #30-1CW
5. Addison Tanker 2 assigned fill site A & enters water cycle @ **9.5 min/236GPM**
6. Oxford T21-1 arrives and unloads
7. Addison Tanker 1 assigned fill site A and enters water cycle @ **9.6 min/234 GPM**
8. Oxford T21-1 assigned to fill site A water cycle @ **9.3 min/241 GPM**
9. Ladder 26, SRU 26 and Alpha 2 arrive and begin operations.
10. Oxford T21-2 arrives and unloads
11. Oxford Engine 3 arrives on scene and assists with operations

This Water supply solution results in a fire flow of **1209 GPM** with 2 Engines, 1 Ladder, 1 service unit (SRU), 1 alpha unit on scene 1 Source Engines at draft and 5 Tankers in shuttle.

120% of Needed Fire Flow achieved