NFPA 1142
Standard on Water Supplies for Suburban and Rural Fire Fighting

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Water Supplies for Suburban and Rural Fire Fighting

1999 Edition

This edition of NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, was prepared by the Technical Committee on Forest and Rural Fire Protection and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

This edition of NFPA 1142 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 1142

This text originally was NFPA 25, *Recommended Practices for Water Supply Systems for Rural Fire Protection*, as developed by the Subcommittee on Water Supply Systems for Rural Fire Protection of the Committee on Rural Fire Protection and Prevention. It received tentative adoption in 1969 and was further amended and adopted in May 1969 as NFPA 25.

The 1975 edition represented a complete revision of the previous document. This edition underwent a title change to *Water Supplies for Suburban and Rural Fire Fighting* and was renumbered NFPA 1231.

The 1984, 1989, and 1993 editions represented complete revisions to both mandatory and advisory material. The current edition represents a complete revision with some significant changes and additions and was renumbered to NFPA 1142.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on fire protection for rural, suburban, forest, grass, brush, and tundra areas. This Committee shall also have primary responsibility for documents on Class A foam and its utilization for all wildland and structural fire fighting. This excludes fixed fire protection systems.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

A reference in parentheses () at the end of a section or paragraph indicates that the material has been extracted from another NFPA document. The bold number in parentheses indicates the document number and is followed by the section number where the extracted material can be found in that document. The complete title and current edition of an extracted document can be found in the chapter on referenced publications.

Information on referenced publications can be found in Chapter 8 and Appendix H.

Chapter 1 Administration

1-1 Scope. This standard shall identify minimum requirements for water supplies for structural fire-fighting purposes in rural and suburban areas where adequate and reliable water supply systems for fire-fighting purposes, as determined by the authority having jurisdiction (AHJ), do not otherwise exist.

The minimum requirements identified in this standard shall be subject to increase by the AHJ to meet particular conditions such as the following:

(1) Limited fire department resources
(2) Extended fire department response time
(3) Delayed alarms
(4) Limited access
(5) Hazardous vegetation
(6) Structural attachments, such as decks and porches
(7) Unusual terrain
(8) Special uses

1-2* Purpose. The water supply requirements developed by this standard shall be performance oriented and the authority having jurisdiction shall specify how these water supplies are made available.

This standard shall not set forth fireground operational parameters.

This standard shall not provide details for calculating an adequate amount of water for large special fire protection problems, such as bulk flammable liquid storage, bulk flammable gas storage, large varnish and paint factories, some plastics manufacturing and storage, aircraft hangars, distilleries, refineries, lumberyards, grain elevators, large chemical plants, coal mines, tunnels, subterranean structures, and warehouses using high rack storage for flammables or pressurized aerosols.

This standard shall not exclude the use of this water for other fire fighting or emergency activities.

This standard shall not be an installation standard.

This standard shall not be used to calculate water supply for structures that are fully protected by an automatic fire sprinkler system installed in compliance with NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*; *or* NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.*

1-3 General.

1-3.1 The requirements of Chapters 5 and 6 shall be performance oriented and shall allow the authority having jurisdiction the option to specify how these water supplies are provided, which gives consideration to local conditions and need.

1-3.2 Although the water requirements developed by this standard are performance oriented, it must be emphasized that they shall be minimum in scope. The water must be delivered to the fire scene *(see Appendix B)*. The AHJ shall be permitted to determine that additional water supplies are warranted. *(See Appendix G for water supply recommendations that can be useful where the AHJ determines additional water supplies are necessary.)*

1-3.3 Fire apparatus and associated equipment shall be important components of the water transport process. *(See Appendixes C, D, and E of this standard, NFPA 1901, Standard for Automotive Fire Apparatus, and other applicable standards.)*

1-4 Definitions.

Adequate and Reliable Water Supply. A water supply that is sufficient every day of the year to control and extinguish anticipated fires in the municipality, particular building, or building group served by the water supply.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Automatic Aid. A plan developed between two or more fire departments for immediate joint response on first alarms.

Building. Any structure used or intended for supporting any occupancy.

Construction Classification Number. A series of numbers from 0.5 through 1.5 that are mathematical factors used in a formula to determine the total water supply requirements for the purposes of this standard only.

Dry Hydrant. An arrangement of pipe permanently connected to a water source other than a piped, pressurized water supply system that provides a ready means of water supply for fire-fighting purposes and that utilizes the drafting (suction) capability of fire department pumpers.

Exposure Hazard.* A structure within 50 ft (15.24 m) of another building and 100 ft^2 (9.3 m^2) or larger in area.

Fire Department.* The fire department serving a designated geographic area as identified by the authority having jurisdiction.

Large Diameter Hose.* A hose of $3^1/_2$-in. (90-mm) size or larger.

Minimum Water Supply. The quantity of water required for fire control.

Mobile Water Supply Apparatus (Tanker, Tender). A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes, to be applied by other vehicles or pumping equipment.

Municipal-Type Water System. A system having water pipes serving hydrants and designed to furnish, over and above domestic consumption, a minimum flow of 250 gpm (946 L/min) and 20 psi (139 kPa) residual pressure for a 2-hour duration.

Mutual Aid Plan.* A plan developed between two or more agencies to render assistance to the parties of the agreement.

Occupancy Hazard Classification Number. A series of numbers from 3 through 7 that are mathematical factors used in a formula to determine total water supply requirements of this standard only.

Secondary (Design) Water Supply. The estimated rate of flow [expressed in gpm (L/min) for a prescribed time period] that is necessary to control a major fire in a building or structure.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Structure. That which is built or constructed; an edifice or building of any kind.

Water Supply Officer (WSO). The fire department officer responsible for providing water for fire-fighting purposes.

Chapter 2 Structure Surveys

2-1 General.

2-1.1* The minimum water supply required under this standard shall be determined by obtaining the following information:

(1) Classification of occupancy hazard
(2) Classification of construction
(3) Structure dimensions
(4) Exposures, if any

2-1.2* A record of water supplies shall be prepared and periodically updated. Required water supplies shall be of suitable quality, maintained and accessible on a year-round basis, as approved by the AHJ.

2-1.3 The minimum fire-fighting water supply shall be determined (per Chapter 5) from the information collected in 2-1.1 and 2-1.2.

Chapter 3 Classification of Occupancy Hazard

3-1 General.

3-1.1* The authority having jurisdiction, in conjunction with the fire department, upon obtaining the information specified in 2-1.1, shall determine the occupancy hazard classification number from the sections of this chapter. These classification numbers shall range from 3 through 7.

3-1.2 Where more than one occupancy is present in a structure, the occupancy hazard classification number for the most hazardous occupancy shall be used for the entire structure.

3-2* Occupancy Hazard Classification Number.

3-2.1* Occupancy Hazard Classification 3.

3-2.1.1 Occupancies in this classification shall be severe hazard occupancies. In severe hazard occupancies, the quantity or combustibility of contents is expected to develop very high rates of spread and heat release.

3-2.1.2 When an exposing structure is of occupancy hazard classification number 3, it shall be considered an exposure hazard if within 50 ft (15.24 m), regardless of size.

3-2.1.3 Examples of this classification shall include occupancies having conditions similar to the following:

(1) Cereal or flour mills
(2) Combustible hydraulics
(3) Cotton picker and opening operations
(4) Die casting
(5) Explosives and pyrotechnics manufacturing and storage
(6) Feed and gristmills
(7) Flammable liquid spraying
(8) Flow coating/dipping
(9) Linseed oil mills
(10) Manufactured homes/modular building assembly
(11) Metal extruding
(12) Plastic processing
(13) Plywood and particle board manufacturing
(14) Printing using flammable inks
(15) Rubber reclaiming
(16) Sawmills
(17) Solvent extracting
(18) Straw or hay in bales
(19) Textile picking
(20) Upholstering with plastic foams

3-2.2* Occupancy Hazard Classification 4.

3-2.2.1 Occupancies in this classification shall be considered high hazard occupancies. In high hazard occupancies, the quantity or combustibility of contents is expected to develop high rates of spread and heat release.

3-2.2.2 When an exposing structure is of occupancy hazard classification number 4, it shall be considered an exposure hazard if within 50 ft (15.24 m), regardless of size.

3-2.2.3 Examples of this classification shall include occupancies having conditions similar to the following:

(1) Barns and stables (commercial)
(2) Building materials
(3) Department stores
(4) Exhibition halls, auditoriums, and theaters
(5) Feed stores (without processing)
(6) Freight terminals
(7) Mercantiles
(8) Paper and pulp mills
(9) Paper processing plants
(10) Piers and wharves
(11) Repair garages
(12) Rubber products manufacturing and storage
(13) Warehouses, such as those used for furniture, general storage, paint, paper, and woodworking industries

3-2.3* Occupancy Hazard Classification 5.

3-2.3.1 Occupancies in this classification shall be considered moderate hazard occupancies, in which the quantity or combustibility of contents is expected to develop moderate rates of spread and heat release. The storage of combustibles shall not exceed 12 ft (3.66 m) in height.

3-2.3.2 Examples of this classification shall include occupancies having conditions similar to the following:

(1) Amusement occupancies
(2) Clothing manufacturing plants
(3) Cold storage warehouses
(4) Confectionery product warehouses
(5) Farm storage buildings, such as corn cribs, dairy barns, equipment sheds, and hatcheries
(6) Laundries
(7) Leather goods manufacturing plants
(8) Libraries (with large stockroom areas)
(9) Lithography shops
(10) Machine shops
(11) Metalworking shops
(12) Nurseries (plant)
(13) Pharmaceutical manufacturing plants
(14) Printing and publishing plants
(15) Restaurants
(16) Rope and twine manufacturing plants
(17) Sugar refineries
(18) Tanneries
(19) Textile manufacturing plants
(20) Tobacco barns
(21) Unoccupied buildings

3-2.4* Occupancy Hazard Classification 6.

3-2.4.1 Occupancies in this classification shall be considered low hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively low rate of spread and heat release.

3-2.4.2 This classification shall include occupancies having conditions similar to the following:

(1) Armories
(2) Automobile parking garages
(3) Bakeries
(4) Barber or beauty shops
(5) Beverage manufacturing plants/breweries
(6) Boiler houses
(7) Brick, tile, and clay product manufacturing plants
(8) Canneries
(9) Cement plants
(10) Churches and similar religious structures
(11) Dairy products manufacturing and processing plants
(12) Doctors' offices
(13) Electronics plants
(14) Foundries
(15) Fur processing plants
(16) Gasoline service stations
(17) Glass and glass products manufacturing plants
(18) Horse stables
(19) Mortuaries
(20) Municipal buildings
(21) Post offices
(22) Slaughterhouses
(23) Telephone exchanges
(24) Tobacco manufacturing plants
(25) Watch and jewelry manufacturing plants
(26) Wineries

3-2.5* Occupancy Hazard Classification 7.

3-2.5.1 Occupancies in this classification shall be considered light hazard occupancies, in which the quantity or combustibility of contents is expected to develop a relatively light rate of spread and heat release.

3-2.5.2 This classification shall include occupancies having conditions similar to the following:

(1) Apartments
(2) Colleges and universities
(3) Clubs
(4) Dormitories
(5) Dwellings
(6) Fire stations
(7) Fraternity or sorority houses
(8) Hospitals
(9) Hotels and motels
(10) Libraries (except large stockroom areas)
(11) Museums
(12) Nursing and convalescent homes
(13) Offices (including data processing)
(14) Police stations
(15) Prisons
(16) Schools
(17) Theaters without stages

Chapter 4 Classification of Construction

4-1 General.

4-1.1 The authority having jurisdiction shall obtain the information specified in 2-1.1 and shall determine the classification number from the sections of this chapter.

4-1.2 For purposes of this standard, structures shall be classified by type of construction and shall be assigned a construction classification number.

4-1.3 Where more than one type of construction is present in a structure, the higher construction classification number shall be used for the entire structure.

4-2* Construction Classification Number.

4-2.1* Guide to Classification of Types of Building Construction. The types of construction include five basic types designated by roman numerals as Type I, Type II, Type III, Type IV, and Type V. This system of designating types of construction also includes a specific breakdown of the types of construction through the use of arabic numbers. These numbers follow the roman numeral notation where identifying a type of construction (e.g., Type I-443, Type II-111, Type III-200).

The arabic numbers following each basic type of construction (e.g., Type I, Type II) indicate the fire resistance rating requirements for certain structural elements as follows:

(1) First arabic number: Exterior bearing walls
(2) Second arabic number: Columns, beams, girders, trusses and arches, supporting bearing walls, columns, or loads from more than one floor
(3) Third arabic number: Floor construction (**220:** 1-3, A-1-3)

4-2.2 Type I (443 or 332) Construction — Construction Classification Number 0.5. Type I construction shall be that type in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table 4-2.2.

Table 4-2.2 Fire Resistance Ratings (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	**332**	**222**	**111**	**000**	**211**	**200**	**2HH**	**111**	**000**
Exterior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	$1^1/_2$	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls[3]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

[Shaded] Those members that shall be permitted to be of approved combustible material.
[1]See NFPA 220, A-3-1 (Table).
[2]"H" indicates heavy timber members; see NFPA 220 for requirements.
[3]Exterior nonbearing walls meeting the conditions of acceptance of NFPA 285, *Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus*, shall be permitted to be used.

4-2.3 Type II (222, 111, or 000) Construction — Construction Classification Number 0.75. Type II construction shall be that type not qualifying as Type I construction in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table 4-2.2.

4-2.4* Type III (211 or 200) Construction — Construction Classification Number 1.0. Type III construction shall be that type in which exterior walls and structural members that are portions of exterior walls are of approved noncombustible or limited-combustible materials, and interior structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are entirely or partially of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited-combustible, or other approved combustible materials. In addition, structural members shall have fire resistance ratings not less than those specified in Table 4-2.2.

4-2.5 Type IV (2HH) Construction — Construction Classification Number 0.75. Type IV construction shall be that type in which exterior and interior walls and structural members that are portions of such walls are of approved noncombustible or limited-combustible materials. Other interior structural members, including columns, beams, girders, trusses, arches, floors, and roofs, shall be of solid or laminated wood without concealed spaces and shall comply with the provisions of 4-2.5.1 through 4-2.5.5. In addition, structural members shall have fire resistance ratings not less than those specified in Table 4-2.2.

Exception No. 1: Interior columns, arches, beams, girders, and trusses of approved materials other than wood shall be permitted, pro-

vided they are protected to provide a fire resistance rating of not less than 1 hour.

Exception No. 2: Certain concealed spaces shall be permitted by the exception to 4-2.5.3.

4-2.5.1 Wood columns supporting floor loads shall be not less than 8 in. (203 mm) in any dimension; wood columns supporting roof loads only shall be not less than 6 in. (152 mm) in the smallest dimension and not less than 8 in. (203 mm) in depth.

4-2.5.2 Wood beams and girders supporting floor loads shall be not less than 6 in. (152 mm) in width and not less than 10 in. (254 mm) in depth; wood beams and girders and other roof framing, supporting roof loads only, shall be not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth.

4-2.5.3 Framed or glued laminated arches that spring from grade or the floor line and timber trusses that support floor loads shall be not less than 8 in. (203 mm) in width or depth. Framed or glued laminated arches for roof construction that spring from grade or the floor line and do not support floor loads shall have members not less than 6 in. (152 mm) in width and not less than 8 in. (203 mm) in depth for the lower half of the member height and not less than 6 in. (152 mm) in depth for the upper half of the member height. Framed or glued laminated arches for roof construction that spring from the top of walls or wall abutments and timber trusses that do not support floor loads shall have members not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth.

Exception: Spaced members shall be permitted to be composed of two or more pieces not less than 3 in. (76 mm) in thickness where blocked solidly throughout their intervening spaces or where such spaces are tightly closed by a continuous wood cover plate not less than 2 in. (51 mm) in thickness, secured to the underside of the members. Splice plates shall be not less than 3 in. (76 mm) in thickness.

4-2.5.4 Floors shall be constructed of splined or tongue-and-groove plank not less than 3 in. (76 mm) in thickness that is covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with $^1/_2$-in. (12.7-mm) plywood; or they shall be constructed of laminated planks not less than 4 in. (102 mm) in width, set close together on edge, spiked at intervals of 18 in. (457 mm), and covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with $^1/_2$-in. (12.7-mm) plywood.

4-2.5.5 Roof decks shall be constructed of splined or tongue-and-groove plank not less than 2 in. (51 mm) in thickness; or of laminated planks not less than 3 in. (76 mm) in width, set close together on edge, and laid as required for floors; or of $1^1/_8$-in. (28.6-mm) thick interior plywood (exterior glue); or of approved noncombustible or limited-combustible materials of equivalent fire durability.

4-2.6 Type V (111 or 000) Construction — Construction Classification No. 1.5. Type V construction shall be that type in which exterior walls, bearing walls, columns, beams, girders, trusses, arches, floors, and roofs are entirely or partially of wood or other approved combustible material smaller than material required for Type IV construction. In addition, structural members shall have fire resistance ratings not less than those specified in Table 4-2.2.

Chapter 5 Calculating Minimum Water Supplies

5-1 General.

5-1.1 After completing the structure survey and determining the construction classification number and the occupancy hazard classification number, the authority having jurisdiction shall compute the required minimum water supply.

5-1.2 A structure shall be considered an exposure hazard if it is 100 ft² (9.29 m²) or larger in area and is within 50 ft (15.24 m) of another structure. However, if a structure, regardless of size, is of occupancy hazard classification number 3 or 4, it shall be considered an exposure hazard if within 50 ft (15.24 m) of another structure.

5-2* Structures Without Exposure Hazards. For structures with no exposure hazards, the minimum water supply, in gallons, shall be determined by the total cubic footage of the structure, including any attached structures, divided by the occupancy hazard classification number, determined from Chapter 3, and multiplied by the construction classification number, as determined from Chapter 4.

$$\text{Minimum water supply} = \frac{\text{total volume of structure}}{\text{occupancy hazard classification number}} \times \text{construction classification number}$$

5-2.1 The minimum water supply required for any structure without exposure hazards shall not be less than 2000 gal (7570 L). *(See Table A-5-2.)*

5-2.2 The minimum water supply as determined for any structure specified in Section 5-2 and 5-2.1 shall be provided for emergency operations.

5-3 Structures with Exposure Hazards.

5-3.1* For structures with unattached structural exposure hazards, the minimum water supply, in gallons, shall be determined by the cubic footage of the structure, divided by the occupancy hazard classification number determined from Chapter 3, multiplied by the construction classification number as determined by Chapter 4 and multiplied by 1.5.

$$\text{Minimum water supply} = \frac{\text{total volume of structure}}{\text{occupancy hazard classification number}} \times \text{construction classification number} \times 1.5$$

5-3.2 The minimum water supply required for structure with exposure hazards specified in 5-3.1 shall not be less than 3000 gal (11,355 L). *(See Table A-5-2.)*

5-4 Structures with Automatic Sprinkler Protection.

5-4.1 The AHJ shall be permitted to waive the water supply required by this standard when a structure is protected by an automatic sprinkler system that fully meets the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*; or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential*

Occupancies up to and Including Four Stories in Height. (See Appendix F.)

5-4.2 If a sprinkler system protecting a building does not fully meet the requirements of NFPA 13, NFPA 13D, or NFPA 13R, a water supply shall be provided in accordance with this standard.

5-5 Structures with Other Automatic Fire Suppression Systems. For any structure fully or partially protected by an automatic fire suppression system other than as specified in Section 5-4, the AHJ shall determine the minimum water supply required for fire-fighting purposes.

Chapter 6 Water Supply

6-1 Water Source Approval. Any water source used to meet the requirement of this standard shall be of suitable quality as approved by the AHJ and maintained and accessible on a year-round basis.

6-2 Water Use Agreements. The AHJ shall enter into water-use agreements when a private source of water is used to meet the requirements of this standard.

6-3 Identifying Water Sources. A water source indicator approved by the AHJ shall be erected at each water point identifying the site for fire department emergency use.

6-4 Fire Department Connections. Any connection provided at a water source required by this standard shall be approved by the AHJ and shall conform to NFPA 1963, *Standard for Fire Hose Connections*.

6-5 Access to Water Sources. Means of access to any required water supply shall be constructed and maintained according to NFPA 299, *Standard for Protection of Life and Property from Wildfire;* NFPA 1141, *Standard for Fire Protection in Planned Building Groups;* and local regulations.

Chapter 7 Reports and Records

7-1 Plans for Proposed Construction.

7-1.1 Where the authority having jurisdiction requires plans to be submitted for review before construction is started, the plans shall be submitted to the fire department for review in accordance with 2-1.1.

7-1.2 Where plans are not required by the AHJ, the fire department shall request the property owner(s) to submit plans for proposed construction for the purpose of determining the minimum water supply requirements.

7-2 Reporting Requirements.

7-2.1 The AHJ shall make the results available to the owner(s) of surveyed structures.

7-2.2 If the authority having jurisdiction is not the fire department, the results of the structure survey shall be made available to the fire department.

7-3 Resurveying Property. In other than residential occupancies, changes made in the structural design, occupancy, or contents that affect the occupancy hazard classification number as specified in Chapter 3 shall require that the structure be resurveyed.

7-4 Changes on Automatic Fire Suppression Systems. The property owner(s) shall notify the AHJ in writing of any changes, including temporary impairment, that are made in any automatic fire suppression system that would affect the protection afforded.

7-5 Retention of Reports. The authority having jurisdiction shall retain copies of plans, reports, and surveys specified in this standard for a minimum of 3 years.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix H.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1999 edition.

NFPA 13R *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, 1999 edition.

NFPA 220, *Standard on Types of Building Construction*, 1999 edition.

NFPA 285,*Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus*, 1998 edition.

NFPA 299, *Standard for Protection of Life and Property from Wildfire*, 1997 edition.

NFPA 1141, *Standard for Fire Protection in Planned Building Groups*, 1998 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 1999 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1998 edition.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-2 In some areas, water supply systems have been installed for domestic water purposes only. These systems can be equipped with hydrants that might not be standard fire hydrants, with available volume, pressure, and duration of flow being less than needed for adequate fire-fighting purposes. Where such conditions exist, this standard and appendix should be applied in water supply matters.

For details regarding calculating adequate water requirements for special fire protection problems, consult appropriate NFPA standards.

A-1-4 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-4 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-4 Exposure Hazard. If a structure is a Class 3 or Class 4 occupancy hazard, it is an exposure hazard if within 50 ft (15.24 m) of another building, regardless of size.

A-1-4 Fire Department. The AHJ and the fire department having jurisdiction can be the same agency.

A-1-4 Large Diameter Hose. Supply hose is designed to be used at operating pressures not exceeding 185 psi (1275 kPa). Attack hose is designed for use at operating pressures of at least 275 psi (1895 kPa).

A-1-4 Mutual Aid Plan. Often the request for such aid to be rendered comes only after an initial response has been made and the emergency incident status has been determined.

A-2-1.1 Information needed to compute the minimum water supplies that should be collected during the building survey includes the following:

(1) Area of all floors, including attics, basements, and crawl spaces
(2) Height between floors or crawl spaces and in the attics from floor to ridgepole
(3) Construction materials used in each building, including walls, floors, roofs, ceilings, interior partitions, stairs, and so forth
(4) Occupancy (occupancies) of buildings
(5) Occupancy (occupancies) of yard areas
(6) Exposures to buildings and yard storage and distances between them
(7) Fire protection systems, such as automatic and manual protection systems, hydrants, yard mains, and other protection facilities
(8) On-site water supplies, including natural and constructed sources of water

A-2-1.2 In determining suitable water supply, the AHJ should consider potential environmental contaminates or particulate matter in the proposed source.

A-3-1.1 In addition to the storage of products that are potentially hazardous from the standpoint of increased fire load, farm properties present certain inherent dangers to the rural fire fighter that are not contemplated by the urban fire fighter. Storage of products that are potentially hazardous to fire fighters from the standpoint of increased fire volume, explosion, and toxicity exists at most rural fire locations. These hazards include the following:

(a) Bulk storage of petroleum fuels, more frequently fuel oil, but often gasoline and propane, can be hazardous. While some tanks are underground, many are aboveground and often located within 50 ft (15.24 m) of farm buildings.

(b) Many farmers use and store blasting agents, such as dynamite, that are often extended with ammonium nitrate (the latter having greater explosive impact per unit weight).

(c) Nearly all farms use and store different pesticides. Some of these chemical compounds give off very toxic fumes while burning. Two compounds that are safe where used independent of each other can be very hazardous to the fire fighter where mixed together in a fire situation.

(d) Localized problems also exist in corn growing areas; for example, anhydrous ammonia is stored and used in large amounts during the early growing season.

The rural fire department needs to work with the farmer to reduce the fire and life potential hazard of these products by storing them safely. However, fire fighters of the rural fire departments should know the potential hazards presented by the products and the appropriate fire-fighting precautions to be taken. The department membership should be aware of the hazards listed in (a) through (d) by means of the survey of the farm by the WSO or other inspector, and appropriate measures should be taken to protect the membership of the department from potential hazards.

A-3-2 The occupancy hazard classification number is a mathematical factor to be used in calculating minimum water supplies. The lowest occupancy hazard classification number is 3 and is assigned to the highest hazard group. The highest occupancy hazard classification number is 7 and is assigned to the lowest hazard group. For SI metric unit calculations, the total volume of the structure in cubic meters must be divided by the SI metric unit conversion factor for the occupancy classification for the structure, which is shown in Table A-3-2.

A-3-2.1 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 3, which is 0.0224.

A-3-2.2 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 4, which is 0.0299.

A-3-2.3 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 5, which is 0.0373.

A-3-2.4 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 6, which is 0.0448.

Table A-3-2 SI Metric Unit Conversion Factors for Occupancy Classifications

Occupancy Classification Number	SI Metric Unit Conversion Factor
3	.0224
4	.0299
5	.0373
6	.0448
7	.0523

A-3-2.5 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 7, which is 0.0523.

A-4-2 The construction classification number is a mathematical factor to be used in calculating minimum water supplies. The slowest burning or lowest hazard type of construction, fire resistive, is construction classification number 0.5. The fastest burning or highest hazard type of construction, wood frame, is construction classification number 1.5. All dwellings should be assigned a construction classification number of 1.0 or lower where construction is noncombustible or fire resistive.

A-4-2.1 Specific fire resistance ratings are found in Table 4-2.2 of this standard, and additional information is found in NFPA 220, *Standard on Types of Building Construction*.

A-4-2.4 Due to cost savings, many Type III (ordinary) and Type V (wood frame) constructed buildings can have wood trusses as a lightweight pre-engineered framing system used in the roof and floors. As long as the integrity of all members of the unit is intact, the unit is a stable building item. However, this might not be the case if one of the outer members is destroyed or damaged. If this happens during a fire, the roof or floor supported by the unit can be weakened to the point where it will be unsafe to support fire fighters.

Another weak point found in the lightweight pre-engineered truss during a fire is the joint formed by metal gussets. The use of metal gussets has reduced the cost and increased production of wood trusses; however, the metal gussets might not retain their strength and integrity where exposed to heat or fire.

Therefore, during the survey of the buildings for water requirements, fire prevention, or prefire planning purposes, the fire department should be aware of such structural fire-fighting hazards, take appropriate steps to make all fire fighters aware of the condition, and plan alternate fire tactics.

A-5-2 *Structures Without Exposure Hazards.* The following are examples for calculating minimum water supply.

(a) *Residential Calculations (U.S. customary units)*

Dwelling: 50 ft × 24 ft; 2 stories, 8 ft each; pitched roof, 8 ft from attic floor to ridgepole; wood frame construction (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 50 \times 24 = 1200 \text{ ft}^2$$
$$\text{Height} = 8 + 8 + 4 = 20 \text{ ft}$$
$$\text{Total volume} = 1200 \times 20 = 24{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Construction classification number: 1.0, frame dwelling *(See 4-2.4.)*

$$(24{,}000 \div 7) \times 1.0 = 3429 \text{ gal}$$
$$\text{Minimum water supply} = 3429 \text{ gal}$$

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft (15.24 m), regardless of size. *(See 5-3.1.)* For a dwelling, the construction classification number is no larger than 1.0.

Residential Calculations (SI metric units)

Dwelling: 15 m × 8 m; 2 stories, 3 m each; pitched roof, 3 m from attic floor to ridgepole; wood frame construction (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 15 \times 8 = 120 \text{ m}^2$$
$$\text{Height} = 3 + 3 + 3 = 7.5 \text{ m}$$
$$\text{Total volume} = 120 \times 7.5 = 900 \text{ m}^3$$

Occupancy hazard classification number: 7

Occupancy hazard classification metric conversion number: 0.0523 *(See A-3-2.5.)*

Construction classification number: 1.0, frame dwelling *(See 4-2.4.)*

$$(900 \div 0.0523) \times 1.0 = 17{,}208 \text{ L}$$
$$\text{Minimum water supply} = 17{,}208 \text{ L}$$

(b) *Commercial Calculations (U.S. customary units)*

Farm equipment shed: 125 ft × 100 ft; 14 ft in height; 1 story; flat roof; noncombustible construction:

$$\text{Area} = 125 \times 100 = 12{,}500 \text{ ft}^2$$
$$\text{Height} = 14 \text{ ft}$$
$$\text{Total volume} = 12{,}500 \times 14 = 175{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 5 *(See 3-2.3.)*

Construction classification number: 0.75 *(See 4-2.3.)*

$$(175{,}000 \div 5) \times 0.75 = 26{,}250$$
$$\text{Minimum water supply} = 26{,}250 \text{ gal}$$

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft (15.24 m), regardless of size.

Commercial Calculations (SI metric units)

Farm equipment shed: 40 m × 30 m; 3.5 m in height; 1 story; flat roof; noncombustible construction:

$$\text{Area} = 40 \times 30 = 1200 \text{ m}^2$$
$$\text{Height} = 3.5 \text{ m}$$
$$\text{Total volume} = 1200 \times 3.5 = 4200 \text{ m}^3$$

Occupancy hazard classification number: 5 *(See 3-2.5.)*

Occupancy hazard classification metric conversion number: 0.0373 *(See A-3-2.3.)*

Construction classification number: 0.75 *(See 4-2.3.)*

$$(4200 \div 0.0373) \times 0.75 = 84{,}450 \text{ L}$$
$$\text{Minimum water supply} = 84{,}450 \text{ L}$$

(c) *Multiple Structure Calculations (U.S. customary units)*

Church: 130 ft × 60 ft; 25 ft in height to ridgepole (15 ft from ground to eaves, with pitched ridgepole 10 ft above the eaves); brick construction with fire-resistive constructed office building within 40 ft of church (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 130 \times 60 = 7800 \text{ ft}^2$$
$$\text{Height} = 15 + \frac{10}{2} = 20 \text{ ft}$$
$$\text{Total volume} = 7800 \times 20 = 156{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 6 *(See 3-2.4.)*

Construction classification number: 1.0 *(See 4-2.4.)*

$$(156{,}000 \div 6) \times 1.0 = 26{,}000$$

Because the church is exposed by a brick office building, multiply by the exposure factor of 1.5:

$$26{,}000 \times 1.5 = 39{,}000$$
$$\text{Minimum water supply} = 39{,}000 \text{ gal}$$

Fire-resistive office building: 175 ft × 100 ft; 2 stories, each floor 10 ft in height; flat roof:

$$\text{Area} = 175 \times 100 = 17{,}500 \text{ ft}^2$$
$$\text{Height} = 10 + 10 = 20 \text{ ft}$$
$$\text{Total volume} = 17{,}500 \times 20 = 350{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Construction classification: 0.5 *(See 4-2.2.)*

$$(350{,}000 \div 7) \times 0.5 = 25{,}000$$
$$\text{Minimum water supply} = 25{,}000 \text{ gal}$$

Because this is a multiple structure location served from a single water point, with the supply computed from the structure having the larger water supply requirement, the church will control the water supply requirement:

$$\text{Water supply for church} = 39{,}000 \text{ gal}$$
$$\text{Water supply for office} = 25{,}000 \text{ gal}$$

The church has the larger water supply requirement.

Minimum water supply
for these multiple structures = 39,000 gal

Multiple Structure Calculations (SI metric units)

Church: 45 m × 20 m; 7.5 m in height to ridgepole (5 m from ground to eaves, with pitched ridgepole 3.5 m above the eaves); brick construction with fire-resistive constructed office building within 13 m of church:

$$\text{Area} = 45 \times 20 \text{ m}^2$$
$$\text{Height} = 5 + \frac{3.5}{2} = 6.75 \text{ m}$$
$$\text{Total volume} = 900 \times 6.75 = 6075 \text{ m}^3$$

Occupancy hazard classification number: 6 *(See 3-2.4.)*

Occupancy hazard classification metric conversion number: 0.0448 *(See A-3-2.4.)*

Construction classification number: 1.0 *(See 4-2.4.)*

$$(6075 \div 0.0448) \times 1.0 = 35{,}603 \text{ L}$$

Because the church is exposed by a brick office building, multiply by the exposure factor of 1.5:

$$136{,}824 \times 1.5 = 203{,}404$$
$$\text{Minimum water supply} = 203{,}404 \text{ L}$$

Fire-resistive office building (metric): 50 m × 30.5 m; 2 stories, each floor 4 m in height; flat roof:

$$\text{Area} = 50 \times 30 = 1500 \text{ m}^2$$
$$\text{Height} = 4 + 4 = 8 \text{ m}$$
$$\text{Total volume} = 1500 \times 8 = 12{,}000 \text{ m}^2$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Occupancy hazard classification metric conversion number: 0.0523 *(See A-3-2.5.)*

Construction classification: 0.5 *(See 4-2.2.)*

$$(12{,}200 \div 0.0523) \times 0.5 = 114{,}723$$
$$\text{Minimum water supply} = 114{,}723 \text{ L}$$

Because this is a multiple structure location served from a single water point, with the supply computed from the structure having the larger water supply requirement, the church will control the water supply requirement:

$$\text{Water supply for church} = 203{,}404 \text{ L}$$
$$\text{Water supply for office} = 114{,}723 \text{ L}$$

The church has the larger water supply requirement.

Minimum water supply for
these multiple structures = 203,404 L

Precalculated Water Supply. Table A-5-2 provides a quick method for determining the water requirements of this standard for structures without exposures.

To use the table, first determine the total volume in cubic feet of the structure. Then, locate the closest corresponding volume in the left-hand column and read across (to the right) to find the total gallons of water required for the occupancy hazard classification and the construction classification of the structure.

For structures with exposures, multiply the water requirements in Table A-5-2 by 1.5.

Table A-5-2 Precalculated Minimum Water Supplies by Occupancy Hazard and Construction Classification (no exposures)

Occupancy Hazard Classification	3				4				5				6				7			
Construction Classification	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**
Cubic Feet Gallons	**Gallons**				**Gallons**				**Gallons**				**Gallons**				**Gallons**			
8,000		2,000	2,667	4,000			2,000	3,000				2,400				2,000				
1,000	2,000	3,000	4,000	6,000		2,250	3,000	4,500			2,400	3,600			2,000	3,000				2,571
16,000	2,667	4,000	5,333	8,000	2,000	3,000	4,000	6,000		2,400	3,200	4,800		2,000	2,667	4,000			2,286	3,429
20,000	3,333	5,000	6,667	10,000	2,500	3,750	5,000	7,500	2,000	3,000	4,000	6,000		2,500	3,333	5,000		2,143	2,857	4,286
24,000	4,000	6,000	8,000	12,000	3,000	4,500	6,000	9,000	2,400	3,600	4,800	7,200	2,000	3,000	4,000	6,000		2,571	3,429	5,143
28,000	4,667	7,000	9,333	14,000	3,500	5,250	7,000	10,500	2,800	4,200	5,600	8,400	2,333	3,500	4,667	7,000	2,000	3,000	4,000	6,000
32,000	5,333	8,000	10,667	16,000	4,000	6,000	8,000	12,000	3,200	4,800	6,400	9,600	2,667	4,000	5,333	8,000	2,286	3,429	4,571	6,857
36,000	6,000	9,000	12,000	18,000	4,500	6,750	9,000	13,500	3,600	5,400	7,200	10,800	3,000	4,500	6,000	9,000	2,572	3,857	5,143	7,714
40,000	6,667	10,000	13,333	20,000	5,000	7,500	10,000	15,000	4,000	6,000	8,000	12,000	3,333	5,000	6,667	10,000	2,857	4,286	5,714	8,571
44,000	7,333	11,000	14,667	22,000	5,500	8,250	11,000	16,500	4,400	6,600	8,800	13,200	3,667	5,500	7,333	11,000	3,143	4,714	6,286	9,429
48,000	8,000	12,000	16,000	24,000	6,000	9,000	12,000	18,000	4,800	7,200	9,600	14,400	4,000	6,000	8,000	12,000	3,429	5,143	6,857	10,286
52,000	8,667	13,000	17,333	26,000	6,500	9,750	13,000	19,500	5,200	7,800	10,400	15,600	4,333	6,500	8,667	13,000	3,715	5,571	7,429	11,143
56,000	9,333	14,000	18,667	28,000	7,000	10,500	14,000	21,000	5,600	8,400	11,200	16,800	4,667	7,000	9,333	14,000	4,000	6,000	8,000	12,000
60,000	10,000	15,000	20,000	30,000	7,500	11,250	15,000	22,500	6,000	9,000	12,000	18,000	5,000	7,500	10,000	15,000	4,286	6,429	8,571	12,857
64,000	10,667	16,000	21,333	32,000	8,000	12,000	16,000	24,000	6,400	9,600	12,800	19,200	5,333	8,000	10,667	16,000	4,572	6,857	9,143	13,714
68,000	11,333	17,000	22,667	34,000	8,500	12,750	17,000	25,500	6,800	10,200	13,600	20,400	5,667	8,500	11,333	17,000	4,857	7,286	9,714	14,571
72,000	12,000	18,000	24,000	36,000	9,000	13,500	18,000	27,000	7,200	10,800	14,400	21,600	6,000	9,000	12,000	18,000	5,143	7,714	10,286	15,429
76,000	12,667	19,000	25,333	38,000	9,500	14,250	19,000	28,500	7,600	11,400	15,200	22,800	6,333	9,500	12,667	19,000	5,429	8,143	10,857	16,286
80,000	13,333	20,000	26,667	40,000	10,000	15,000	20,000	30,000	8,000	12,000	16,000	24,000	6,667	10,000	13,333	20,000	5,715	8,571	11,429	17,143
84,000	14,000	21,000	28,000	42,000	10,500	15,750	21,000	31,500	8,400	12,600	16,800	25,200	7,000	10,500	14,000	21,000	6,000	9,000	12,000	18,000
88,000	14,667	22,000	29,333	44,000	11,000	16,500	22,000	33,000	8,800	13,200	17,600	26,400	7,333	11,000	14,667	22,000	6,286	9,429	12,571	18,857
92,000	15,333	23,000	30,667	46,000	11,500	17,250	23,000	34,500	9,200	13,800	18,400	27,600	7,667	11,500	15,333	23,000	6,572	9,857	13,143	19,714
96,000	16,000	24,000	32,000	48,000	12,000	18,000	24,000	36,000	9,600	14,400	19,200	28,800	8,000	12,000	16,000	24,000	6,857	10,286	13,714	20,571
100,000	16,667	25,000	33,333	50,000	12,500	18,750	25,000	37,500	10,000	15,000	20,000	30,000	8,333	12,500	16,667	25,000	7,143	10,714	14,286	21,429
104,000	17,333	26,000	34,667	52,000	13,000	19,500	26,000	39,000	10,400	15,600	20,800	31,200	8,667	13,000	17,333	26,000	7,429	11,143	14,857	22,286
108,000	18,000	27,000	36,000	54,000	13,500	20,250	27,000	40,500	10,800	16,200	21,600	32,400	9,000	13,500	18,000	27,000	7,715	11,571	15,429	23,143
112,000	18,667	28,000	37,333	56,000	14,000	21,000	28,000	42,000	11,200	16,800	22,400	33,600	9,333	14,000	18,667	28,000	8,000	12,000	16,000	24,000
116,000	19,333	29,000	38,667	58,000	14,500	21,750	29,000	43,500	11,600	17,400	23,200	34,800	9,667	14,500	19,333	29,000	8,286	12,429	16,571	24,857

(continues)

Table A-5-2 Precalculated Minimum Water Supplies by Occupancy Hazard and Construction Classification (no exposures) *(Continued)*

Occupancy Hazard Classification	3				4				5				6				7			
Construction Classification	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
Cubic Feet Gallons	Gallons				Gallons				Gallons				Gallons				Gallons			
120,000	20,000	30,000	40,000	60,000	15,000	22,500	30,000	45,000	12,000	18,000	24,000	36,000	10,000	15,000	20,000	30,000	8,572	12,857	17,143	25,714
124,000	20,667	31,000	41,333	62,000	15,500	23,250	31,000	46,500	12,400	18,600	24,800	37,200	10,333	15,500	20,667	31,000	8,857	13,286	17,714	26,571
128,000	21,333	32,000	42,667	64,000	16,000	24,000	32,000	48,000	12,800	19,200	25,600	38,400	10,667	16,000	21,333	32,000	9,143	13,714	18,286	27,429
132,000	22,000	33,000	44,000	66,000	16,500	24,750	33,000	49,500	13,200	19,800	26,400	39,600	11,000	16,500	22,000	33,000	9,429	14,143	18,857	28,286
136,000	22,667	34,000	45,333	68,000	17,000	25,500	34,000	51,000	13,600	20,400	27,200	40,800	11,333	17,000	22,667	34,000	9,715	14,571	19,429	29,143
140,000	23,333	35,000	46,667	70,000	17,500	26,250	35,000	52,500	14,000	21,000	28,000	42,000	11,667	17,500	23,333	35,000	10,000	15,000	20,000	30,000
144,000	24,000	36,000	48,000	72,000	18,000	27,000	36,000	54,000	14,400	21,600	28,800	43,200	12,000	18,000	24,000	36,000	10,286	15,429	20,571	30,857
148,000	24,667	37,000	49,333	74,000	18,500	27,750	37,000	55,500	14,800	22,200	29,600	44,400	12,333	18,500	24,667	37,000	10,572	15,857	21,143	31,714
152,000	25,333	38,000	50,667	76,000	19,000	28,500	38,000	57,000	15,200	22,800	30,400	45,600	12,667	19,000	25,333	38,000	10,857	16,286	21,714	32,571
156,000	26,000	39,000	52,000	78,000	19,500	29,250	39,000	58,500	15,600	23,400	31,200	46,800	13,000	19,500	26,000	39,000	11,143	16,714	22,286	33,429
160,000	26,667	40,000	53,333	80,000	20,000	30,000	40,000	60,000	16,000	24,000	32,000	48,000	13,333	20,000	26,667	40,000	11,429	17,143	22,857	34,286
175,000	29,167	43,750	58,333	87,500	21,875	32,813	43,750	65,625	17,500	26,250	35,000	52,500	14,583	21,875	29,167	43,750	12,500	18,750	25,000	37,500
200,000	33,333	50,000	66,667	100,000	25,000	37,500	50,000	75,000	20,000	30,000	40,000	60,000	16,667	25,000	33,333	50,000	14,286	21,429	28,571	42,857
225,000	37,500	56,250	75,000	112,500	28,125	42,188	56,250	84,375	22,500	33,750	45,000	67,500	18,750	28,125	37,500	56,250	16,071	24,107	32,143	48,214
250,000	41,667	62,500	83,333	125,000	31,250	46,875	62,500	93,750	25,000	37,500	50,000	75,000	20,833	31,250	41,667	62,500	17,857	26,786	35,714	53,571
275,000	45,833	68,750	91,667	137,500	34,375	51,563	68,750	103,125	27,500	41,250	55,000	82,500	22,917	34,375	45,833	68,750	19,643	29,464	39,286	58,929
300,000	50,000	75,000	100,000	150,000	37,500	56,250	75,000	112,500	30,000	45,000	60,000	90,000	25,000	37,500	50,000	75,000	21,429	32,143	42,857	64,286
325,000	54,167	81,250	108,333	162,500	40,625	60,938	81,250	121,875	32,500	48,750	65,000	97,500	27,083	40,625	54,167	81,250	23,214	34,821	46,429	69,643
350,000	58,333	87,500	116,667	175,000	43,750	65,625	87,500	131,250	35,000	52,500	70,000	105,000	29,167	43,750	58,333	87,500	25,000	37,500	50,000	75,000
375,000	62,500	93,750	125,000	187,500	46,875	70,313	93,750	140,625	37,500	56,250	75,000	112,500	31,250	46,875	62,500	93,750	26,786	40,179	53,571	80,357
400,000	66,667	100,000	133,333	200,000	50,000	75,000	100,000	150,000	40,000	60,000	80,000	120,000	33,333	50,000	66,667	100,000	28,571	42,857	57,143	85,714
425,000	70,833	106,250	141,667	212,500	53,125	79,688	106,250	159,375	42,500	63,750	85,000	127,500	35,417	53,125	70,833	106,250	30,357	45,536	60,714	91,071
450,000	75,000	112,500	150,000	225,000	56,250	84,376	112,500	168,750	45,000	67,500	90,000	135,000	37,500	56,250	75,000	112,500	32,143	48,214	64,286	96,429
475,000	79,167	118,750	158,333	237,500	59,375	89,063	118,750	178,125	47,500	71,250	95,000	142,500	39,583	59,375	79,167	118,750	33,929	50,893	67,857	101,786
500,000	83,333	125,000	166,667	250,000	62,500	93,751	125,000	187,500	50,000	75,000	100,000	150,000	41,667	62,500	83,333	125,000	35,714	53,571	71,429	107,143
525,000	87,500	131,250	175,000	262,500	65,625	98,438	131,250	196,875	52,500	78,750	105,000	157,500	43,750	65,625	87,500	131,250	37,500	56,250	75,000	112,500
550,000	91,667	137,500	183,333	275,000	68,750	103,126	137,500	206,250	55,000	82,500	110,000	165,000	45,833	68,750	91,667	137,500	39,286	58,929	78,571	117,857
575,000	95,833	143,750	191,667	287,500	71,875	107,813	143,750	215,625	57,500	86,250	115,000	172,500	47,917	71,875	95,833	143,750	41,071	61,607	82,143	123,214

(continues)

Table A-5-2 Precalculated Minimum Water Supplies by Occupancy Hazard and Construction Classification (no exposures) *(Continued)*

Occupancy Hazard Classification	3				4				5				6				7			
Construction Classification	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
Cubic Feet Gallons	Gallons				Gallons				Gallons				Gallons				Gallons			
600,000	100,000	150,000	200,000	300,000	75,000	112,501	150,000	225,000	60,000	90,000	120,000	180,000	50,000	75,000	100,000	150,000	42,857	64,286	85,714	128,571
625,000	104,167	156,250	208,333	312,500	78,125	117,188	156,250	234,375	62,500	93,750	125,000	187,500	52,083	78,125	104,167	156,250	44,643	66,964	89,286	133,929
650,000	108,333	162,500	216,667	325,000	81,250	121,876	162,500	243,750	65,000	97,500	130,000	195,000	54,167	81,250	108,333	162,500	46,429	69,643	92,857	139,286
675,000	112,500	168,750	225,000	337,500	84,375	126,563	168,750	253,125	67,500	101,250	135,000	202,500	56,250	84,375	112,500	168,750	48,214	72,321	96,429	144,643
700,000	116,667	175,000	233,333	350,000	87,500	131,251	175,000	262,500	70,000	105,000	140,000	210,000	58,333	87,500	116,667	175,000	50,000	75,000	100,000	150,000
725,000	120,833	181,250	241,667	362,500	90,625	135,938	181,250	271,875	72,500	108,750	145,000	217,500	60,417	90,625	120,833	181,250	51,786	77,679	103,571	155,357
750,000	125,000	187,500	250,000	375,000	93,750	140,626	187,500	281,250	75,000	112,500	150,000	225,000	62,500	93,750	125,000	187,500	53,571	80,357	107,143	160,714
775,000	129,167	193,750	258,333	387,500	96,875	145,313	193,750	290,625	77,500	116,250	155,000	232,500	64,583	96,875	129,167	193,750	55,357	83,036	110,714	166,071
800,000	133,333	200,000	266,667	400,000	100,000	150,001	200,000	300,000	80,000	120,000	160,000	240,000	66,667	100,000	133,333	200,000	57,143	85,714	114,286	171,429
825,000	137,500	206,250	275,000	412,500	103,125	154,688	206,250	309,375	82,500	123,750	165,000	247,500	68,750	103,125	137,500	206,250	58,929	88,393	117,857	176,786
850,000	141,667	212,500	283,333	425,000	106,250	159,376	212,500	318,750	85,000	127,500	170,000	255,000	70,833	106,250	141,667	212,500	60,714	91,071	121,429	182,143
875,000	145,833	218,750	291,667	437,500	109,375	164,064	218,750	328,125	87,500	131,250	175,000	262,500	72,917	109,375	145,833	218,750	62,500	93,750	125,000	187,500
900,000	150,000	225,000	300,000	450,000	112,500	168,751	225,000	337,500	90,000	135,000	180,000	270,000	75,000	112,500	150,000	225,000	64,286	96,429	128,571	192,857
925,000	154,167	231,250	308,333	462,500	115,265	173,439	231,250	346,875	92,500	138,750	185,000	277,500	77,083	115,625	154,167	231,250	66,071	99,107	132,143	198,214
950,000	158,333	237,500	316,667	475,000	118,750	178,126	237,500	356,250	95,000	142,500	190,000	285,000	79,167	118,750	158,333	237,500	67,857	101,786	135,714	203,571
975,000	162,500	243,750	325,000	487,500	121,875	182,814	243,750	365,625	97,500	146,250	195,000	292,500	81,250	121,875	162,500	243,750	69,643	104,464	139,286	208,929
1,000,000	166,667	250,000	333,333	500,000	125,000	187,501	250,000	375,000	100,000	150,000	200,000	300,000	83,333	125,000	166,667	250,000	71,429	107,143	142,857	214,286

Note: For structures with exposures, multiply results by 1.5 for water supply requirements.
For SI units, 1 gal = 3.785 L; 1 ft^3 = 0.0283 m^3.

Example. A farm storage building housing a barn (occupancy hazard classification 4) of ordinary construction (construction classification number 1.0) with a cubic area of 160,000 ft^3 (4480 m^3) will produce, using Table A-5-2, a water requirement of 40,000 gal (151,400 L).

A-5-3.1 *Structures with Exposure Hazards.* The following are examples for calculating minimum water supply.

(a) *Residential Calculations (U.S. customary units)*

Dwelling: 50 ft × 24 ft; 1 story, 8 ft in height; pitched roof, 8 ft from attic floor to ridgepole; brick construction and exposed on one side by a frame dwelling with a separation of less than 50 ft and with areas greater than 100 ft^2 (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 50 \times 24 = 1200 \text{ ft}^2$$
$$\text{Height} = 8 + 4 = 12 \text{ ft}$$
$$\text{Total volume} = 1200 \times 12 = 14{,}400 \text{ ft}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Construction classification number: 1.0, brick dwelling *(See 4-2.4.)*

$$(14{,}400 \div 7) \times 1.0 = 2057$$

Because the dwelling is exposed by a frame dwelling, multiply by the exposure factor of 1.5 *(see Section 5-3.1)*:

$$2057 \times 1.5 = 3086$$
$$\text{Minimum water supply} = 3086 \text{ gal}$$

Residential Calculations (SI metric units)

Dwelling: 17 m × 8 m; 1 story, 3.5 m in height; pitched roof, 2 m from attic floor to ridgepole; brick construction and exposed on one side by a frame dwelling with a separation of less than 14 m and with areas greater than 10.25 m^2:

$$\text{Area} = 17 \times 8 = 136 \text{ m}^2$$
$$\text{Height} = 3.5 + 1 = 4.5 \text{ m}$$
$$\text{Total volume} = 136 \times 4.5 = 612 \text{ m}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Occupancy hazard classification metric conversion number 0.0523 *(See A-3-2.5.)*

Construction classification number: 1.0, brick dwelling *(See 4-2.4.)*

$$(612 \div 0.0523) \times 1.0 = 11{,}702 \text{ L}$$

Because the dwelling is exposed by a frame dwelling, multiply by the exposure factor of 1.5:

$$11{,}702 \times 1.5 = 17{,}553 \text{ L}$$
$$\text{Minimum water supply} = 17{,}553 \text{ L}$$

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size. For a dwelling, the construction classification number is no larger than 1.0.

(b) *Commercial Calculations (U.S. customary units)*

Farm equipment shed: Identical to commercial occupancy in A-5-2, except with a 1-story, pitched-roof dwelling measuring 50 ft × 25 ft and located 45 ft from the equipment shed. The dwelling is larger than 100 ft^2 in area and is closer than 50 ft to the equipment shed. Therefore, the minimum water supply for the equipment shed (26,250 gal) is multiplied by 1.5:

$$26{,}250 \times 1.5 = 39{,}375 \text{ gal}$$
$$\text{Minimum water supply} = 39{,}375 \text{ gal}$$

The total water supply for the dwelling is:

$$\text{Area} = 50 \times 25 = 1250 \text{ ft}^2$$
$$\text{Height} = 8 + 4 = 12 \text{ ft}$$
$$\text{Total volume } 1250 \times 12 = 15{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Construction classification number: 1.0 *(See 4-2.4.)*

$$(15{,}000 \div 7) \times 1.0 = 2143 \text{ gal}$$

Because the equipment shed requires the larger minimum water supply, if these two buildings were to be protected by the same water supply, that minimum water supply would be 39,375 gal.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size. For a dwelling, the construction classification number is no larger than 1.0.

Commercial Calculations (SI metric units)

Farm equipment shed: Identical to commercial occupancy in A-5-2, except with a 1-story, pitched-roof dwelling measuring 16 m × 8 m and located 14.8 m from the equipment shed. The dwelling is larger than 10 m^2 in area and is closer than 16.4 m to the equipment shed. Therefore, the minimum water supply for the equipment shed (99,356 L) is multiplied by 1.5:

$$99{,}356 \times 1.5 = 149{,}034 \text{ L}$$
$$\text{Minimum water supply} = 149{,}034 \text{ L}$$

The total water supply for the dwelling is:

$$\text{Area} = 16 \times 8 = 128 \text{ m}^2$$
$$\text{Height} = 3 + 1.5 = 4.5 \text{ m}$$
$$\text{Total volume} = 128 \times 4.5 = 576 \text{ m}^3$$

Occupancy hazard classification number: 7 *(See 3-2.5.)*

Occupancy hazard classification metric conversion number: 0.0523 *(See A-3-2.5.)*

Construction classification number: 1.0 *(See 4-2.5.)*

$$(576 \div 0.0523) \times 1.0 = 11{,}013 \text{ L}$$

Because the equipment shed requires the larger minimum water supply, if these two buildings were to be protected by the same water supply, that minimum water supply would be 149,034 L.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 16.4 m, regardless of size. For a dwelling, the construction classification number is no larger than 1.0.

(c) *Multiple Structure Calculations (U.S. customary units)*

Row of five dwellings: Identical to the residential occupancy in A-5-2, except that one has a brick barn measuring 80 ft × 40 ft, located 35 ft from the dwelling. The barn is larger than 100 ft^2 in area and is closer than 50 ft to the dwelling. Therefore, the minimum water supply for this dwelling (3429 gal) should be multiplied by the exposure factor of 1.5:

$$3429 \times 1.5 = 5144 \text{ gal}$$

If the dwellings and barn are to be protected by the same water supply, as is likely, the water supply should be calculated on the structure that requires the largest minimum water supply, which in this case is the barn. Thus, if the barn has no hay storage and is 25 ft in height to the pitched ridgepole, and the ridgepole is 10 ft above the eaves, the calculations would be as follows (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 80 \times 40 = 3200 \text{ ft}^2$$
$$\text{Height} = 15 + 5 = 20 \text{ ft}$$
$$\text{Total volume} = 3200 \times 20 = 64{,}000 \text{ ft}^3$$

Occupancy hazard classification number: 4, for the barn with no hay storage *(See 3-2.2.)*

Construction classification number: 1.0 *(See 4-2.4.)*

$$(64{,}000 \div 4) \times 1.0 = 16{,}000$$
$$16{,}000 \times 1.5 \text{ (for exposure hazard: the dwelling)} = 24{,}000$$
$$\text{Minimum water supply} = 24{,}000 \text{ gal}$$

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size.

Multiple Structure Calculations (SI metric units)

Row of 5 dwellings: Identical to the residential occupancy in A-5-2, except that one has a brick barn measuring 24 m × 12 m, located 10.7 m from the dwelling. The barn is larger than 9.3 m^2 in area and is closer than 15.25 m to the dwelling. Therefore, the minimum water supply for this dwelling (45,889 L) should be multiplied by the exposure factor of 1.5:

$$45{,}889 \times 1.5 = 68{,}834 \text{ L}$$

If the dwellings and barn are to be protected by the same water supply, as is likely, the water supply should be calculated on the structure that requires the largest minimum water supply, which in this case is the barn. Thus, if the barn has no hay storage and is 7.6 m in height to the pitched ridgepole, and the ridgepole is 3 m above the eaves, the calculations would be as follows (for pitched roofs, calculate half the distance from attic floor to ridgepole):

$$\text{Area} = 24 \times 12 = 288 \text{ m}^2$$
$$\text{Height} = 7.6 + 1.5 = 9.1 \text{ m}$$
$$\text{Total volume} = 288 \times 9.1 = 2621 \text{ m}^3$$

Occupancy hazard classification number: 4, for the barn with no hay storage *(See 3-2.2.)*

Occupancy hazard classification metric conversion number: 0.0299, for the barn with no hay storage *(See A-3-2.2.)*

Construction classification number: 1.0 *(See 4-2.4.)*

$$(2621 \div 0.0299) \times 1.0 = 87{,}659 \text{ L}$$
$$87{,}659\ 1.5 \text{ (for exposure hazard: the dwelling)} = 131{,}488$$
$$\text{Minimum water supply} = 131{,}488 \text{ L}$$

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 16.4 m, regardless of size.

Appendix B Water Supply

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Water Supply.

B-1.1 General. The fire fighter operating without a water system with hydrants (or with a very limited number of hydrants) has two of the following means of getting water:

(1) From supplies on the fireground, which can be constructed or natural
(2) From supplies transported to the scene

This appendix discusses the variety and potential of these sources.

B-1.2 Water Supply Officer. Many progressive rural fire departments depend on a water supply officer (WSO). The work of a properly trained and equipped WSO makes it possible for the officer supervising the actual fire attack to plan it on the basis of reliable water supply information, to coordinate the attack itself with the available water supplies, and to help prevent the confusion inherent in fighting a major fire when the chief officer at the scene must divert too much personal attention from the attack to the logistics of backing it up.

B-1.2.1 Duties of the Water Supply Officer (WSO). The WSO is designated to perform the following functions:

(1) To provide sufficient water at the fire site
(2) To plan availability of additional water sources
(3) To determine water requirements at the various locations over the district

The WSO should maintain and even carry a complete set of files, which should include cards showing water points and lists of automatic and mutual aid mobile water supply apparatus available. Modern technology in optics and computers makes it feasible for even a relatively low-budget department to reduce this data to microfiche or photographic slides, which can be maintained in the fire alarm communication center and taken to the scene of every fire and used on small, hand-held viewers. The WSO is the individual who implements the water supply prefire planning.

As the WSO visits neighboring fire departments, a list of all apparatus, equipment, and personnel available to the WSO's department should be developed. At this time, arrangements can be made for certain apparatus and personnel to respond under an automatic aid agreement (first alarm response) or a mutual aid agreement (called as needed), depending on the needs of the department. These needs will be dictated by the nature of the structure(s) involved.

B-1.2.2 Duties at the Fire. At the fire scene, the WSO becomes the rural equivalent of the water department representative who responds to major municipal fires. The WSO's duty to maintain continuous fire streams in rural areas is frequently a very complicated task involving the following:

(1) Setting up several water-hauling locations
(2) Assembling water-carrying equipment from automatic and mutual aid departments
(3) Calculating estimated arrival times of mobile water supply apparatus
(4) Having a thorough knowledge of available water supplies throughout a wide area of fire department jurisdiction

B-1.2.3 Communication Coordination. In water supply operations, efficient radio communication is absolutely necessary. To develop and sustain large fire flow requires the use of several water sources as well as several drop tanks where water can be dumped. Therefore, good radio communication is necessary in readily directing mobile water supplies so that time is not lost at the fill and the dump points. To obtain this level of mobile water supply efficiency, a radio frequency separate from that used for the fireground operations needs to be assigned to the WSO, the water supply site, and the mobile water supply apparatus. The WSO also needs to have efficient communication with the incident commander.

B-1.2.4 Duties before the Fire. Before the fire, the WSO participates in the prefire planning and in calculating the fire flow requirements for the various buildings in the area under the department's jurisdiction.

To satisfy these water requirements, the WSO should survey the district and the surrounding areas for available water for fire-fighting purposes. Water supplies might exist on the property to be protected or might need to be transported. The WSO should develop preplans and see that the fire department is kept aware of all the water supplies available to the entire area. This means close coordination between the WSO and the fire department training officer and assistance in joint water supply training sessions with neighboring fire departments. The WSO should make periodic inspections of all water supplies and structural changes in the department's jurisdiction.

The WSO or designee must meet with the property owner(s) and secure their permission to use the water supply *(see B-1.2.6)*, to develop an all-weather road to the supply *(see Section B-6)*, and to install dry hydrants *(see Section B-5)*. The installation of roads to, or dry hydrants in, navigable water or wetlands might require a permit from appropriate local, state, or national agencies. Fire departments should contact these groups early in the planning process to avoid violations of the law.

If called upon, the WSO should be available to consult with the owner in the design of a water source on a property to be protected.

B-1.2.5 Water Source Cards. A recommended practice is to prepare individual water source cards for each water point. This is a job that lends itself ideally to the use of computers. There might be one or more water sources applicable to a given potential fireground. In addition to the computer, the water sources should be noted on a master grid map of the area. The grid map will show the index location of water source cards on which pertinent data will be noted. This data should include type of source (e.g., stream, cistern, domestic system), point of access [e.g., 100 ft (30.5 m) north of barn], gallons available [e.g., minimum flow rate of 250 gpm (946 L/min), 10,000-gal (37,850-L) storage], and any particular problem such as weather conditions or seasonal fluctuations that can make a source unusable. It is good practice to attach a photograph of the water point to the card. Also, it is advisable to note an alternate source.

These water source cards should be used as the basis of regular inspections to make sure the source continues to be available and to note any improvement or deterioration of its usefulness. A program to develop additional sources as needed, including water sources for new construction as it evolves, should be an ongoing program in an alert organization.

B-1.2.6 Water Usage Agreement. The WSO should establish a water usage agreement with the owner(s) of the water source before a fire develops. Such agreements should be made in writing in close cooperation with the municipal, town, or county attorney. Also, it is highly desirable that the agreement be reviewed by a representative of the highway or the county road department or other persons who will build, service, and maintain the access road to the supply, including persons who will perform such functions as snowplowing in certain areas of the country. The property owner also should have a copy of the agreement that will be used by several fire departments with the approval of their county or town attorneys. *(See Figure B-1.2.6.)*

Figure B-1.2.6 Sample water usage agreement.

Water Usage Agreement

I/We, the undersigned owner(s) of a lake or pond located at __________ do hearby grant the ___________ Fire Department permission to erect and maintain, at its expense, a dry hydrant and access roadway to said lake or pond to be utilized for emergency fire suppression purposes.

All other uses of said pond or lake shall be after notification and permission of the owner(s). The ___________ Fire Department shall be responsible for any and all damages to property resulting from fire department exercises.

This contract can be cancelled at any time by written notice 30 days in advance to the ___________ Fire Department located at ____________ ____________________ .

Owner ________________ Date ______ President ________________
__________Fire Department

Owner ________________ Date ______ Secretary ________________
__________Fire Department

Owner ________________ Date ______ Chief ________________
__________Fire Department

B-1.2.7 Water Map. Each WSO should maintain a map showing the location and amount of water available at each water site. A copy of this map should be located in the fire alarm dispatcher's headquarters, where such an alarm facility is available, and should be carried on at least one pumper, in the chief's car, and by the WSO. Any problems that are encountered at the supply should be recorded.

B-1.2.8 Inspection of Water Supplies. It is the responsibility of the WSO to make inspections of all water sources available as often as conditions warrant and to note any changes in the facilities. This is particularly true during adverse weather conditions, such as droughts, very wet periods, and heavy freezing and following snowstorms.

B-1.2.9 Reliability of an Impounded Supply. For an impounded supply, cistern, tank, or storage facility, the quantity of water to be considered available is the minimum available [at not over a 15-ft (4.6-m) lift] during a drought with an average 50-year frequency that has been certified by a registered or licensed professional engineer. The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at the site.

B-1.2.10 Reliability of a Flowing Stream. For a supply flowing from a stream, the quantity to be considered available is the minimum rate of flow during a drought with an average 50-year frequency as determined by a registered or licensed professional engineer, hydrologist, or other similarly qualified person. The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at the site.

Historical stream flow data is available for most streams from the United States Geological Survey (USGS) Water Resources Information. This data can also be accessed from their Internet World Wide Web site: http://www.usgs.gov. The USGS does not establish flow rates but provides historical data to assist with assessment. Additional assistance is available from individual state and organization contacts at the National Drought Mitigation Center (NDMC). The NDMC Directory of Drought Contacts can be accessed from their Internet World Wide Web site: http://enso.unl.edu/ndmc/index.html.

B-1.2.11 Signs. The WSO should ensure that an appropriate sign is erected at each water point identifying the site for fire department emergency use and including the name or a number for the water supply. Letters and numbers should be at least 3 in. (76 mm) high, with a $^1/_2$-in. (13-mm) stroke and should be reflective.

B-1.2.12 Water Operations. The WSO and the training officer in conjunction with the fire chief should develop standard operating procedures for hauling water to fires. The standard operating procedures should be put in motion for all structural fires; however, they can be discontinued after the officer in charge has evaluated the fire and determined that water-hauling capabilities will not be needed.

B-2 First-Aid Fire Protection Using On-Site Water Systems.

B-2.1 General. The individual domestic water supply system provided in many rural homes and business establishments, if properly equipped and maintained, is an effective "first-aid fire extinguisher." For large establishments, an elevated water storage tank or reservoir connected to hydrants and standpipes could provide substantial fire streams as well.

B-2.2 Domestic Water Systems. In order for domestic (farm) water systems to provide some degree of reliability in case of fire, the pump or pumps should be placed in a fire-resistive location. The electric power supply should have the maximum protection from de-energization by fire or other cause. In some cases, standby power and pumps can be justified.

B-2.3 Delivery of First-Aid Fire Protection. For first-aid fire protection to be effective, every portion of the dwelling and outlying buildings should be within reach of a hose stream. This might require some additional pipelines beyond those needed for other purposes. A garden hose long enough to reach any point in a structure is often valuable for fire-fighting use. Care should be taken so that water is drained from hose or pipes that could be subject to freezing weather.

B-2.4 In-Depth Fire Protection. To provide for in-depth fire protection, one of the following three types of water supplies might be needed:

(1) First aid via the domestic water system
(2) A bulk water supply at the property, which might be a stream, pond, elevated tank, ground-level tank, or cistern
(3) An area system of static water supplies with drafting points and means for transporting the water to the fire site

Alternative power supplies should be considered.

B-3 Natural Water Sources.

B-3.1 Streams. Streams, including rivers, bays, creeks, and irrigation canals, can represent a continuously flowing source of substantial capacity. Where considering water from flowing streams as potential water sources, the fire department should consider the following factors:

(a) *Flowing Capacity.* The stream should deliver water in capacities compatible with those outlined in the water requirements of this standard. *(See Chapter 5.)*

(b) *Climatic Characteristics.* Streams that deliver water throughout the year and are not susceptible to drought are desirable for fire protection. However, where such streams are not available, a combination of supplies might be necessary. In many sections of the country, streams cannot be relied on during drought seasons. If the stream is subject to flooding or freezing, special evolutions might be necessary to make the stream usable under such conditions. Similar circumstances might exist during wet periods or when the ground is covered with snow.

(c) *Accessibility.* A river or other source of water might not be accessible to the fire department for use during a fire. Distance and terrain from the all-weather road to the source should be such as to make the water readily available. In some cases, special equipment should be used to obtain the water. *(See B-6 and Appendix E, Portable Pumps.)* Where roadways to the water supply are provided, they should be constructed in accordance with B-6.2.

(d) *Calculating the Flow of a Stream.* A simple method for estimating the flow of water in a creek is to measure the width and depth of the creek, drop a cork or any light, floating object into the water, and then determine the time it takes the cork to travel 10 ft (3.1 m). To obtain complete accuracy, the sides of the creek should be perpendicular, the bottom should be flat, and the floating object should not be affected by the wind. Where the sides and bottom of the stream are not uniform, the width and depth can be averaged.

For example, consider a creek with a width of 4 ft (1.2 m) and a depth of 6 in. (15.2 cm) and where the flow of water is such that it takes 45 seconds for a cork to travel 10 ft (3.1 m). The following equation applies:

$$W \times D \times TD = \text{ft}^3\ (\text{m}^3) \text{ of water}$$

where:

W = width [f t (m)]
D = depth [ft (m)]
TD = travel distance [ft (m)]
T = time [sec]

$$4 \text{ ft} \times 0.5 \text{ ft} \times 10 \text{ ft} = 20 \text{ ft}^3 \text{ of water}$$
$$(1.2 \text{ m} \times 0.15 \text{ m} \times 3.1 \text{ m} = 0.56 \text{ m}^3 \text{ of water})$$

Since the cork takes 45 seconds to travel a 10-ft (3.1-m) distance:

ft^3 of water/time = ft^3/sec
(m^3 of water/time = m^3/sec)

20 ft^3/45 sec = 0.444 ft^3 of water/sec
(0.558 m^3/45sec = 0.0124 m^3 water/sec

0.444 ft^3 of water/0.00223 sec
= 199 gpm flowing in the creek
(0.0124 m^3 of water/0.00223 min
= 5.56 L/min) flowing in the creek

Therefore: 1 gal = 0.00223 ft^3/sec

For assistance in more accurately determining stream flow, contact the state Department of Natural Resources, Soil Conservative Service, or a county agent.

B-3.2 Ponds. Ponds can include lakes or farm ponds used for watering livestock, irrigation, fish culture, recreation, or other purposes while serving a secondary function for fire protection. Valuable information concerning the design of ponds can be obtained from county agricultural agents, cooperative extension offices, county engineers, and so forth. Most of the factors listed in B-3.1 relative to streams are pertinent to ponds, with the following items to be considered:

(a) The minimum annual level should be adequate to meet the water supply needs of the fire problem the pond serves.

(b) Freezing of a stationary water supply, contrasted with the flowing stream, presents a greater problem.

(c) Silt and debris can accumulate in a pond or lake, reducing its actual capacity, while its surface area and level remain constant. This can provide a deceptive impression of capacity and calls for at least seasonal inspections.

(d) Accessibility should always be considered. Many recreational lakes are provided with access by roads, driveways, and boat-launching ramps and are available for fire department use. Some large lakes, formed by a dam on a river, might have been constructed for purposes such as generating power, controlling floods, or regulating the flow of a river. During certain periods of the year, droughts, drawdowns, and so forth can cause such lakes to have very low water levels. The water under such conditions might not be accessible to the fire department for drafting by the fire department pumping unit, even where a paved road for boat launching has been provided and extended into the water at normal water levels for several feet or meters. Under such conditions, other provisions should be made to make the water supply fully accessible to the fire department.

B-3.3 Other Natural Water Sources. Other natural water sources might include springs and artesian wells. Individual springs and occasional artesian water supplies exist in some areas. These other natural water sources are generally of more limited capacity, but they can be useful for water supply, subject to reasonable application of the recommendations listed for ponds and streams. In many cases, it might be necessary to form a temporary natural pool or form a pond with a salvage cover, for example, to collect water for the use of the fire department where using a spring or an artesian well.

B-4 Developed Sources of Water.

B-4.1 General. The developed sources of water supplies adapted for fire fighting are limited only by the innovation of the fire department. Developed sources include cisterns, swimming pools, quarries, mines, automatic sprinkler system supplies, stationary tanks, driven wells, and dry hydrants. In some situations, fire fighters have drafted water used to fight the fire from basements of burning buildings.

B-4.2 Cisterns. Cisterns are one of the oldest sources of emergency water supply, both for fire fighting and drought storage. They are very important sources of water for fire fighting, domestic consumption, and drought storage in many rural and beach areas.

Cisterns should have a minimum usable volume as determined by the authority having jurisdiction, using the methods described in Chapter 5 of this standard, and there is no real limit to the maximum capacity. A cistern should be accessible to the fire apparatus or other pumping device, but it should be located far enough from the hazard that personnel and equipment are not endangered.

The water level of a cistern can be maintained by rainfall, water pumped from a well, water hauled by a mobile water supply, or by the seasonal high water of a stream or river. The cistern can present a freezing problem, since its surface is often relatively inaccessible and the water is stagnant. One method for minimizing freezing is to use a dry hydrant protruding into the water at a point below the local frost line.

Cisterns should be capped for safety, but they should have openings to allow inspections and use of suction hose where needed. *[See Figures B-4.6(e), B-4.6(f), and B-4.6(g).]*

B-4.3 Protection from Freezing. If a dry hydrant is not installed in a cistern, then, depending on local conditions, a heavy pipe or a pike pole can be adequate to break an ice formation. In fact, the weight of the suction hose itself can be sufficient, provided there is no danger of damaging the strainer, the hose, or hose threads.

There are several methods for providing an ice-free surface area in a cistern or other water source. These methods include, but are not limited to, the following:

(1) Floating a log, a bale of hay or straw, and so forth on the surface of the water
(2) Placing a partly filled, floating barrel on the surface of the water

B-4.4 Guide to Cistern Capacity. A ready guide to the capacity of circular cisterns with vertical sides is provided in Table B-4.7.

B-4.5 Construction of Cisterns. Construction of cisterns is governed by local conditions of soil and material availability. Practical information can be obtained from local governmental departments or agricultural agencies.

Some engineering considerations to be used in designing cisterns include the following:

(1) The base, walls, and roof should be designed for the prevailing soil conditions and for the loads encountered where heavy vehicles are parked adjacent.
(2) If groundwater conditions are high, the cistern should not float when empty.
(3) Suction piping should be designed to minimize whirlpooling.
(4) Vent piping should be of sufficient size.

Maintenance factors to be considered by the fire department include the danger of silting, evaporation or other low water conditions, and the freezing problems previously discussed.

B-4.6 Cistern Specifications. Some governing bodies, where water systems are not available and water for water-hauling fire departments is inadequate, require developers to provide cisterns with all subdivisions that are constructed. Since each cistern can provide fire protection for a number of buildings, the necessary capacity is rather large and represents a substantial investment. The following are specifications for cistern design and construction used by the New Boston Fire Department, New Boston, NH. *[See Figures B-4.6(a) through (h).]*

(1) Cisterns should be located no more than 2200 ft (671 m) travel distance by truck from the nearest lot line of the furthermost lot.

(2) The cistern should be designed to be trouble-free, and it should last a lifetime.

(3) The cistern capacity should be 30,000 gal (113,550 L) minimum, available through the suction piping system.

(4) The suction piping system should be capable of delivering 1000 gpm (3800 L/min) for three-quarters of the cistern capacity.

(5) The design of the cistern should be submitted to the authority having jurisdiction for approval prior to construction. All plans should be signed by a registered professional engineer.

(6) The entire cistern should be rated for highway loading, unless specifically exempted by the authority having jurisdiction.

(7) Drawings of the design are for estimating general requirements and design purposes only and are not intended for use as design.

(8) Each cistern should be sited to the particular location by a registered engineer and approved by the authority having jurisdiction.

(9) Cast-in-place concrete should achieve a 28-day strength of 3000 psi (20,700 kPa). It should be placed with a minimum of 4-in. (10.2-cm) slump and vibrated in a professional manner.

(10) Cast-in-place concrete should be mixed, placed, and cured without the use of calcium chloride. Winter placement and curing should follow the applicable American Concrete Institute (ACI) codes.

(11) All suction and fill piping should be American Society for Testing and Materials (ASTM) Schedule 40 steel. All vent piping should be ASTM Schedule 40 PVC with glued joints.

(12) All PVC piping should have glued joints.

(13) The 8-in. × 5-in. (203-mm × 127-mm) eccentric reducer is available from suppliers.

(14) The final suction connection should be a minimum of $4^1/_2$ in. (114 mm). It should be capped.

(15) The filler pipe siamese should have $2^1/_2$-in. (64-mm) National Standard female threads with plastic caps.

(16) All backfill material should be screened gravel with no stones larger than $1^1/_2$-in. (38 mm) and should be compacted to 95 percent of its original volume in accordance with ASTM D 1557, *Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)]*.

(17) The entire cistern should be completed and inspected before any backfilling is done.

(18) Bedding for the cistern should consist of a minimum of 12 in. (305 mm) of $^3/_4$-in. (19-mm) to $1^1/_2$-in. (38-mm) crushed, washed stone, compacted. No fill should be used under stone.

(19) The filler pipe siamese should be 36 in. (914 mm) above final backfill grade.

(20) Suction pipe connection should be 20 in. to 24 in. (508 mm to 610 mm) above the level of the gravel where vehicle wheels will be located when cistern is in use.

(21) Suction pipe should be supported either to the top of the tank or to a level below frost.

(22) The base should be designed so that the cistern will not float when empty.

(23) The perimeter of the tank at the floor/wall joint should be sealed with 8-in. (203-mm) PVC waterstop.

(24) After backfilling, the tank should be protected by fencing or large stones.

(25) The backfill over the tank should meet the following:

a. Four ft (1.2 m) of backfill should be used.

b. The top and highest 2 ft (0.6 m) of sides of cistern should be insulated with vermin-resistant foam insulation and 2 ft (0.6 m) of backfill.

c. All backfill should extend 10 ft (3.1 m) beyond the edge of the cistern, and then have a maximum 3:1 slope, loamed and seeded.

(26) The distance from the bottom of the suction pipe to the pumper connection should not exceed 14 ft (4.25 m) vertical.

(27) The pitch of the shoulder and vehicle pad from the edge of the pavement to the pumper suction connection should be 1 percent to 6 percent downgrade.

(28) The shoulder and vehicle pad should be of sufficient length to allow convenient access to the suction connection when the pumper is set at 45 degrees to the road.

(29) All construction, backfill, and grading material should be in accordance with proper construction practices and should be acceptable to the authority having jurisdiction.

(30) All horizontal suction piping should slope slightly uphill toward the pumper connection.

(31) The installer is responsible for completely filling the cistern until the cistern is accepted by the authority having jurisdiction.

Figure B-4.6(a) Cistern site. (Courtesy of New Boston Fire Department, New Boston, NH)

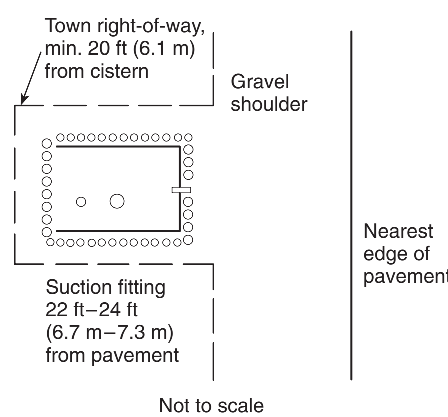


Figure B-4.6(b) Cistern. (Courtesy of New Boston Fire Department, New Boston, NH)

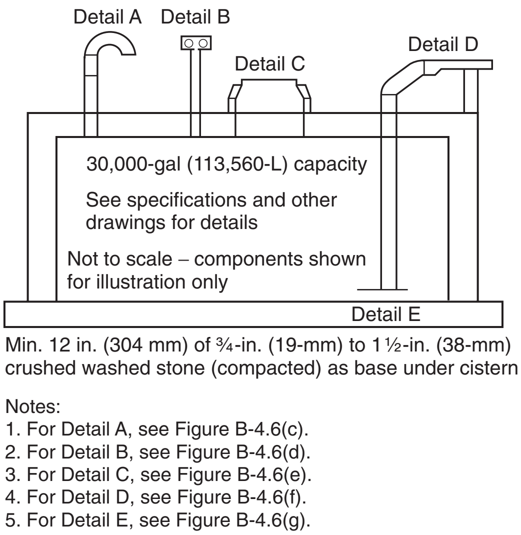


Figure B-4.6(c) Detail A — vent pipe. (Courtesy of New Boston Fire Department, New Boston, NH)

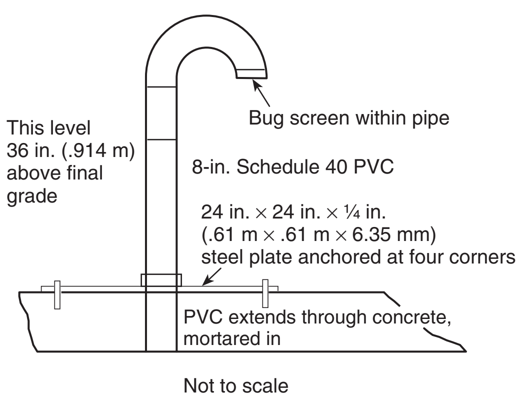


Figure B-4.6(d) Detail B — fill pipe. (Courtesy of New Boston Fire Department, New Boston, NH)

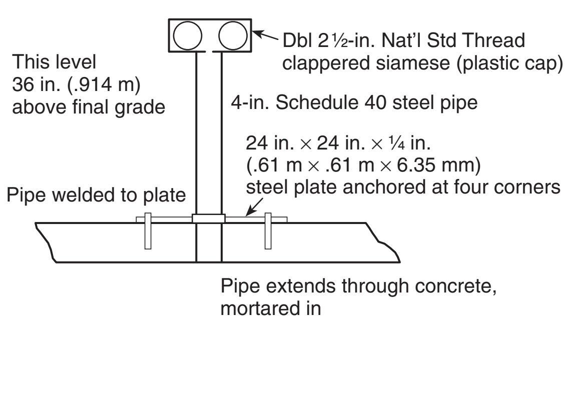


Figure B-4.6(e) Detail C — manhole. (Courtesy of New Boston Fire Department, New Boston, NH)

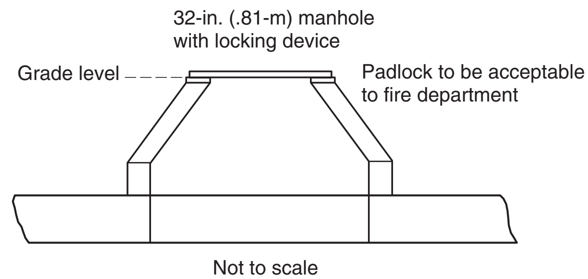


Figure B-4.6(f) Detail D — upper suction pipe. (Courtesy of New Boston Fire Department, New Boston, NH)

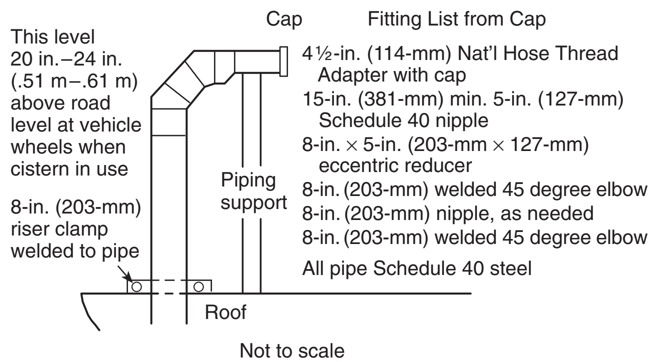


Figure B-4.6(g) Detail E — lower suction pipe. (Courtesy of New Boston Fire Department, New Boston, NH)

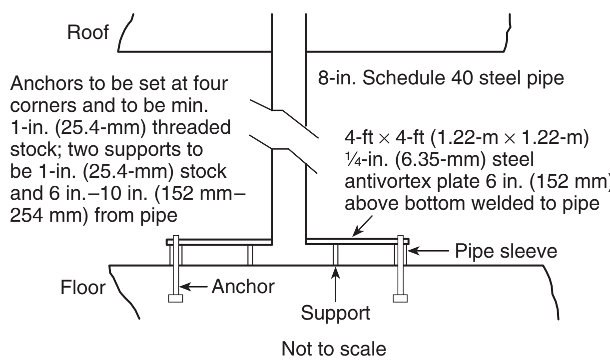
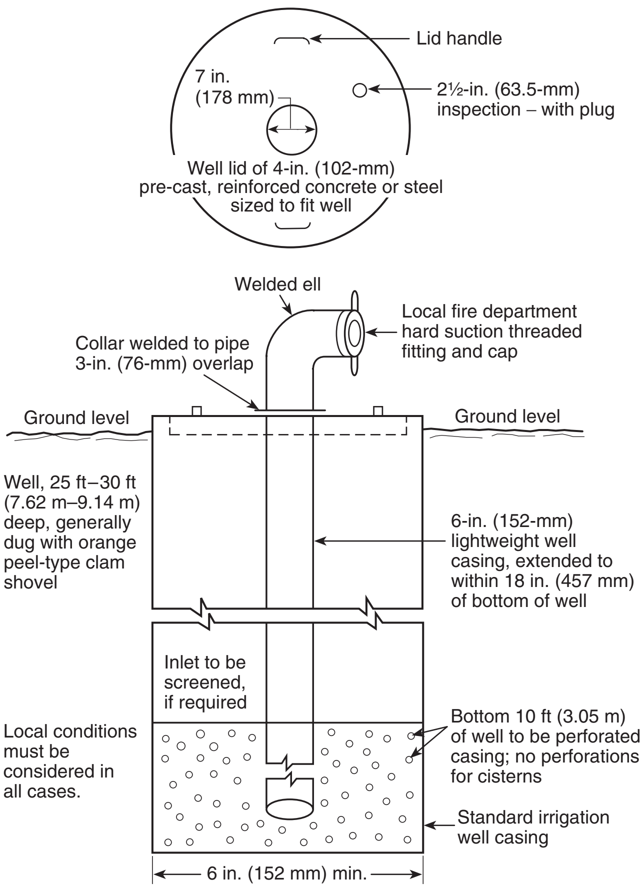


Figure B-4.6(h) Typical well (cistern) with dry hydrant installed. (For calculating usable water depth, see B-4.12.) (Courtesy of New Boston Fire Department, New Boston, NH)



B-4.7 Guide to Circular Cistern Storage Capacity. A ready guide to the storage capacity of circular cisterns with vertical sides is provided in Table B-4.7.

Table B-4.7 Cistern Storage Capacity

Inside Diameter		Storage Capacity per Foot of Depth	
ft	**m**	**gal**	**L**
6	1.8	212	802
7	2.1	288	1090
8	2.4	376	1423
9	2.7	476	1801
10	3.0	588	2226

The formula for calculating the storage capacity of a rectangular cistern is the same as the formula for pool capacity. *(See B-4.8.2.)*

B-4.8 Swimming Pools. Swimming pools are an increasingly common source of water for fire protection. Even in some areas with normally adequate hydrant water supplies, swimming pools have been a factor in providing protection, such as in cases in which water demands have exceeded availability because of wildfire disasters. Swimming pools provide an advantage in that they are sources of clean water, but they have major drawbacks due to the weight of fire department vehicles and poor accessibility for large apparatus. There are some areas of the country in which swimming pool distribution is better than hydrant distribution. If the WSO intends to use a swimming pool as a water supply, it is good practice to develop these water sources through working with property owners and preplanning.

B-4.8.1 Pool Accessibility. If fire department accessibility is considered when designing the pool, a usable water supply should be available to the fire department for supplying direct hose lines or a source of water for mobile water supply filling. Most swimming pools are built in areas requiring security fencing or walls, and these can complicate accessibility. Fences and walls can be designed for fire department use or, depending on construction, can be entered forcibly.

In most cases, a solution to the problems of accessibility can be achieved through preplanning and might call for long lengths of suction hose, portable pumps, dry hydrants, siphon ejectors, or properly spaced gates. Portable (or floating) pumps designed for large-volume delivery at limited pressures deliver water to portable folding tanks or fire department pumpers and are frequently ideal for use where accessibility problems exist. *(See E-1.2.)*

A swimming pool located virtually under the eaves of a burning house can be a very poor location from which to pump if there are problems of fire exposure to the work area, and so forth. Pumping from a neighboring pool, if it is close enough, or setting the water-hauling program in motion is frequently preferable to pumping from the pool of the burning house. *(See Figure B-4.8.1.)*

Figure B-4.8.1 Pool accessibility.

B-4.8.2 Pool Capacity. A short-form method of estimating pool capacity is as follows:

$L \times W \times D \times 7.5$ gal (1000 L) =
estimated capacity in gallons (liters)

where:

L = length [ft (m)]
W = width [ft (m)]
D = estimated average depth [ft (m)] from water line [ft (m)]

These dimensions should be estimated or rounded off if the pool is of stylized construction. 1 ft^3 = 7.5 gal (1 m^3 = 1000 L)

Consideration should be given to providing more suction hose on fire apparatus responding in areas dependent on swimming pools. Fast rigging of such suction hose demands special training. Using long lengths of hose over walls and other obstacles typical of swimming pools demands techniques other than those used for drafting from ponds or streams. Adequate prefire planning requires familiarity with individual pools so that the method of obtaining water at the property is known. Lightweight or flexible-type suction hose can be advantageous for this purpose.

B-4.8.3 Exercising Care in Use of Pools. Care must be exercised to ensure that structural damage will not occur to a pool and the surrounding area if the water is used for fire fighting. Lightly built cement, Gunite®, or poured concrete pools can be subject to structural damage, cracking, or collapse when drained. In addition, a pool in extremely wet soil will tend to float upwards when drained; therefore, it might be necessary to refill the pool as soon as the fire is under control and mobile water supply apparatus can be released from fire duties.

Some pools are holes of compacted earth covered by a plastic surfacing or light-gauge metal panels placed against such earth or a special fill. Such pools can collapse internally if emptied. It might be possible to use a limited portion of such water sources but not possible to use the entire available water supply. It might be prudent not to use these pools at all.

Another consideration is whether the ground surrounding a pool will support the weight of a fire department vehicle without collapsing. The WSO should study and know the various pool limitations within the area served by consulting with the builders and installers of these pools.

B-4.9 Livestock Watering Ponds and Tanks. Many farms have livestock watering tanks, ponds, and other similar facilities. If the owner is aware of the water needs for the farm's buildings for fire-fighting purposes, such tanks and ponds should be sized to be adequate in volume for both farm and fire department use and should be located to be readily available to the fire department. Tanks should be placed on the edge of the barnyard and on a side accessible to the fire department, with the pumper or pump taking suction through a connection on the tank or by suction hose. These watering tanks and ponds are often filled and maintained by a pump operated by a windmill or by an electric pump.

Where a well fitted with an electric pump is used for irrigation or industrial use, the fuses can be pulled for periods of time when the farm or plant does not need the water supply. Therefore, the fire department should carry fuses for all of the pumps in the district, and provisions should be made for an electrician or a power company employee or individual knowledgeable of pumps to respond on all alarms of fire.

B-4.10 Sprinkler Systems. In some rural areas, the only large water supply might be that provided for use of a sprinklered building. The supply might be from an underground water distribution system, a pond or suction tank with pumps, an elevated tank, or a combination of these. In many cases, preplan arrangements for use of the water can be made. Preplan arrangements are most feasible if the property owner is contacted before installation of sprinkler protection, as it might be necessary to increase the capacity of the storage or to install a hydrant that is accessible to the fire department and connected to the private yard distribution system.

Extreme care should be exercised in the use of water supplies provided for sprinkler systems. A certain amount of water should be retained in these systems for minimum sprinkler protection. A careful study and preplan should be made to determine if such use is possible and can provide the water supply necessary for fire-fighting purposes.

Some states and municipalities might have special ordinances requiring sprinkler protection for certain properties such as nursing homes. Frequently, the water supplies for these systems are minimal and are from pressure tanks of limited capacity. Where this is the case, it is recommended that the fire department not consider such supplies in their planning, as the rural fire department should take care that it does not disrupt the protection at such a property. *(See Appendix F for additional information on sprinkler systems.)*

B-4.11 Driven Wells. Wells and well systems are becoming increasingly popular as water supplies for fire-fighting purposes at industrial properties, shopping centers, subdivisions, and farmhouses located in rural areas beyond the reach of a municipal water distribution system.

In areas with suitable soil conditions — for instance, areas that have soils of a very sandy nature — it might be possible to use driven wells or water-jetted wells to obtain water for fire fighting. These wells are, in essence, pipes, usually with perforations about the base to allow entry of water, that have been driven into the ground. From the threaded pipe head (or a fitting attached to the body of the pipe), a pump connection can be made to draft water, much as from a well hydrant. A high water table is a prerequisite to using this method. Fire-fighting units in areas conducive to this technique should have the necessary equipment for such installations.

Some state and local governments have regulations or licensing requirements that govern construction of a well. Such restrictions will probably increase in the future.

B-4.12 Reference is made to water depths in cisterns, swimming pools, streams, lakes, and other sources in a number of places in this appendix. It should always be remembered that the depth with which the fire fighter is concerned is the usable depth. In a cistern, a bottom bed of gravel protecting a dry hydrant inlet, for instance, reduces the usable depth of the area above the gravel.

B-5 Dry Hydrants.

B-5.1 General. As the installation of rural dry hydrants using constructed or natural water sources increases, an understanding of the planning, permit, design criteria, and construction processes becomes evident. 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. *(See Figure B-5.1.)*

Figure B-5.1 Dry hydrant.

B-5.2 Planning and Permits. The planning, permit, and design processes should be completed before the actual construction begins. Planning should involve all affected agencies and private concerns so a coordinated effort can be undertaken. Some factors to consider in determining the need and locations for a dry hydrant system are as follows:

(1) Current and future population and building trends
(2) Property values of the area protected
(3) Potential for loss
(4) Fire history of the area protected
(5) Current water supply systems
(6) Potential water supply sources — constructed or natural
(7) Cost of project
(8) Other factors of local concern

B-5.2.1 Permits. Permits to install a dry hydrant should be obtained from the authorities having jurisdiction, which can include, among others, local, state, and federal agencies, such as those covering zoning, water, and environmental protection as well as resource departments and agriculture and conservation districts.

B-5.3 Dry Hydrant Design. Local topography, climatic conditions, and access to materials will, among other factors, determine the design characteristics of each installation. Distance to the water combined with the difference in elevation between the hydrant head and the water source and the desired gallon-per-minute (liter-per-minute) flow will affect the pipe size that needs to be used. All installations should use, as a minimum, 6-in. (152-mm) pipe. With longer lateral runs and higher volume flow, 8-in. or 10-in. (203-mm or 254-mm) pipe sizes can become necessary.

Local preferences and experience, along with access to materials, will determine the type of pipe and fittings best suited for the job. In some parts of the country, brass and bronze caps and steamer connections, along with iron, steel, and bituminous cement pipe and fittings are being used for hydrant materials. *[See Figure B-5.3(a).]* However, in many parts of the country, Schedule 40 or Schedule 80 PVC pipe, fittings, and connections are becoming more common. *[See Figure B-5.3(b).]* Many fire service manufacturers are now offering premade and preassembled PVC suction screens, hydrant heads, and supports that come ready to attach to the pipe. *[See Figure B-5.3(b).]* Steamers should be compatible with the fire department's hard suction hose size and thread type.

B-5.3.1 Design Criteria. The design of dry hydrant installations has been carefully planned to incorporate several factors that are advantageous in maintaining the installation of the PVC dry hydrants within the personnel and financial resources of a large number of rural fire departments or property owners. The design criteria are provided here to simplify the understanding of the design of the dry hydrant.

Design criteria for dry hydrants are as follows:

(1) It is recommended that all dry hydrants be constructed of 6-in. (152-mm) or larger pipe and fittings.
(2) Only Schedule 40 or heavier PVC should be used in PVC systems.
(3) All exposed PVC or metal surfaces and all underground metal surfaces should be primed and painted to prevent deterioration of the material.
(4) A minimum number of 90-degree elbows, preferably no more than two, are recommended for use in the total system. It might be desirable to have a wide-sweep elbow installed at the bottom of the riser where the lateral run connects. If a hydrant connection breaks, such an elbow arrangement could allow sections of $2^1/_2$-in. (64-mm) suction hose to be inserted down the 6-in. (152-mm) pipe to the water and would allow drafting to continue, although at a much reduced rate of flow. A wide-sweep elbow can be constructed using two 45-degree elbows and a 2-ft (0.6-m) length of pipe.
(5) All connections should be clean and the appropriate sealing materials should be used according to manufacturer's specifications so as to ensure all joints are airtight.

Figure B-5.3(a) Dry hydrant construction using iron, steel, or PVC pipe.

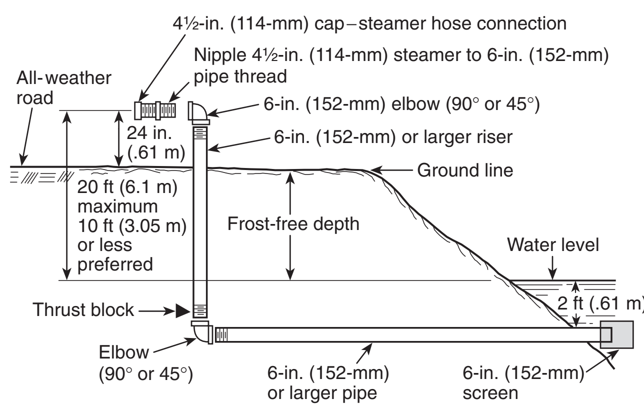
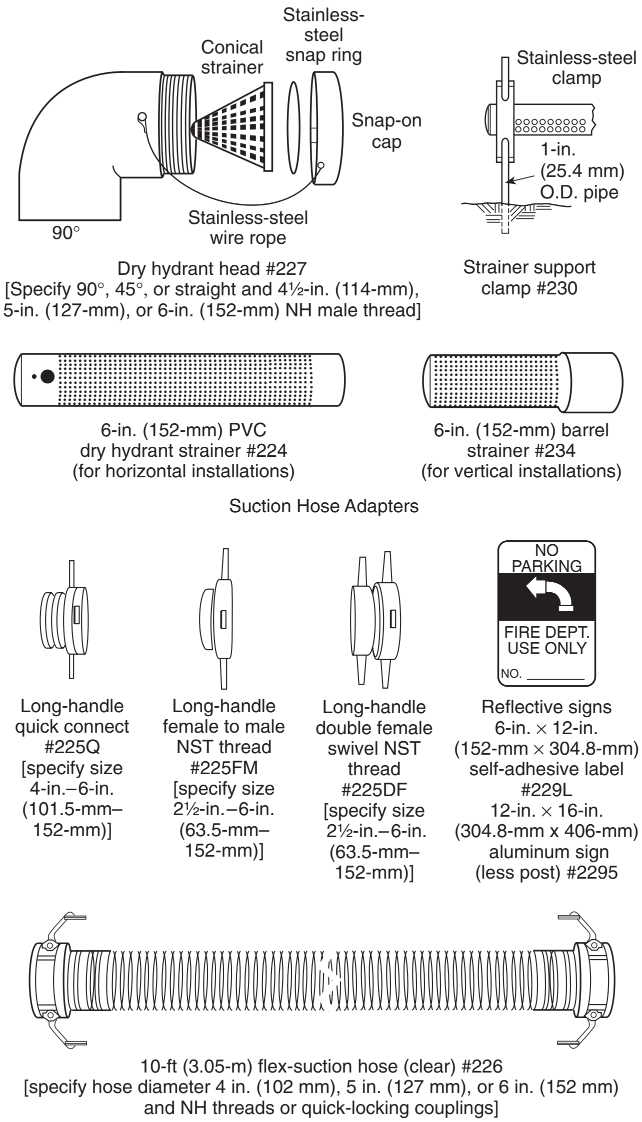


Figure B-5.3(b) Commercially available dry hydrant components. (Courtesy of Wisconsin Department of Natural Resources)



Strainers or screens can be handmade by drilling 1000 holes that are $^{5}/_{16}$-in. (8-mm) in diameter into the length of the pipe and capping the end with a removable or hinged cover. A solid strip of pipe approximately 4 in. to 5 in. (102 mm to 127 mm) wide along one side should be left intact to act as a baffle to prevent whirlpooling during periods of low water.

(6) In areas where frost is a problem, the design should incorporate one of the following methods to ensure that no frost will ever reach the water in the pipe:

a. The pipe should be buried below the frost line and the soil should be mounded up over the pipe and around the rise.

b. An insulating barrier, such as styrofoam, should be placed between the pipe and the surface to prevent the frost from reaching the water in the pipe.

Placement of the suction screen in the body of water should be deep enough to ensure that ice will not reach the screen. Divers might be needed to assist in proper screen placement.

(7) The use of thrust blocks should be considered at the elbow joint both to resist hydraulic forces and to steady the installation in unstable soils.

B-5.3.2 Usable Depth of Water Sources. Careful note should be made of the fact that the installation of dry hydrants, as described in Section B-5, calls for care in measuring water storage capacities. The usable depth of a lake with a dry hydrant installation, for instance, is from the minimum foreseeable low-water surface level to the top of the suction strainer, not to the bottom of the lake, and must be not less than 2 ft (0.6 m) of water. Awareness of the usable depth is important where hydrants are installed on a body of water affected by tides, or on a lake whose water level has been lowered to maintain the flow of a river during drought conditions, or on a lake that generates power or freezes over.

Pump suction requires a submergence below the water surface of 2 ft (0.6 m) or more, depending on the rate of pumping, to prevent the formation of a vortex or whirlpool. Baffle and antiswirl plates should be added to minimize vortex problems and allow additional water use. The vortex allows air to enter the pump, which can cause the loss of the pump prime. Therefore, pumping rates should be adjusted as the water level is lowered. This factor should be considered by the WSO when estimating the effective rate at which water can be drawn from all suction supplies.

B-5.3.3 Design Worksheet and Charts for PVC Dry Hydrant Installations. The worksheet shown in Figure B-5.3.3 and Tables B-5.3.3(a), (b), (c) can be used to assist in the design of a dry hydrant installation. Tables B-5.3.3(a) through (c) will help determine the size of pipe and fittings that will be needed to flow the capacity of the pumps being used at the hydrant site. Some factors to consider in designing the dry hydrant are as follows:

(a) Static lift should not exceed 10 ft to 12 ft (3.1 m to 3.7 m), if possible. This is dead lift and cannot be overcome by enlarging the pipe size. The static lift should be kept as low as possible.

(b) Total head loss should not exceed 20 ft (6.1 m), or the pump might not supply its rated gallons per minute (liters per minute). If using portable pumps on the dry hydrant, total head loss should be kept as low as possible.

Tables B-5.3.3(a) through (c) and the worksheet in Figure B-5.3.3 should be used as follows:

(1) Add the total length of straight pipe to be used at the site (screen length + lateral run length + riser height = straight pipe). Record this figure on the design worksheet at step 1.

(2) Using Table B-5.3.3(a), add the total number of feet of straight pipe equivalent for all fittings used to make up the hydrant (elbows + hydrant adapter + any reducers = straight pipe equivalent for fittings). Record this figure on the design worksheet at step 2.

(3) Add together the figures for straight pipe and straight pipe equivalent for fittings from step 1 and step 2 to obtain the total straight pipe equivalent of the hydrant. Record this figure on the design worksheet at step 3.

Figure B-5.3.3 Design worksheet for PVC dry hydrant installations.

Design Worksheet

FIRE DEPARTMENT ________________________

DRY FIRE HYDRANT LOCATION ________________________

Step 1

Screen length ________________________

Lateral run length ________________________

Riser height ________________________

Straight pipe = ________________________

Step 2

Use Table B-5.3.3(a) to fill in the following values:

Hydrant adapter ____________ Reducer ____________

Elbow ____________ Elbow ____________

Elbow ____________ Elbow ____________

Straight pipe equivalent for fittings = ____________

Step 3

Straight pipe + Straight pipe equivalent for fittings =

________ + ________ = ________ (Total straight pipe equivalent of hydrant)

Step 4

Desired gpm flow = ________ (Rated pump capacity)

Step 5

Use the figures from Steps 3 and 4 and Table B-5.3.3(b) to determine head loss for pipe and fittings.

Head loss for pipe and fittings = ________________________

Step 6

Use Table B-5.3.3(c) to determine suction hose head loss for length of suction hose used to connect the pump to the hydrant.

Suction hose head loss = ________________________

Step 7

Static lift = ________________

Step 8

Add the figures from Steps 5, 6, and 7 together to get total head loss.

#5 ________ + #6 ________ + #7 ________ = Total head loss

If total head loss is greater than 20 ft to 25 ft (6.1 m to 7.6 m), the pump might not be able to flow its rated gpm.

(4) Determine the desired maximum gallons-per-minute (liters-per-minute) hydrant flow, which is usually the pumping capacity of the pump or pumper used at a particular hydrant. Record this figure on the design worksheet at step 4.

(5) Using Table B-5.3.3(b), determine the head loss due to friction per 100 ft (30.5 m) of pipe (the total straight pipe equivalent from step 3) based on the gallons per minute (liters per minute) from step 4. If there is over or under 100 ft (30.5 m) of total straight pipe equivalent (from step 3), adjust head loss using Table B-5.3.3(b). For example, if the total straight pipe equivalent is 75 ft (22.9 m) and the desired volume is 1950 gpm (7441 L/min), the head loss from the chart is 20 ft/100 ft (6.1 m/30.5 m) of pipe. In this example, there would be a head loss of 15 ft (4.6 m) [20 ft × 75 ft/100 ft (6.1 m × 22.9 m/30.5 m) = 15 ft (4.6 m)]. Record this figure as head loss for pipe and fittings on the design worksheet at step 5.

(6) Using Table B-5.3.3(c), figure the head loss due to friction in the suction hose to be used on the hydrant. Record this on the design worksheet as suction hose head loss at step 6.

(7) Determine static lift. Static lift is the vertical distance from the water's surface in the hydrant pipe and the pump or pumper intake. Use the lowest water level as it will represent the maximum lift needed. Record this figure on the design worksheet as static lift at step 7. If possible, do not exceed 8 ft to 10 ft (2.4 m to 3.1 m). Static lift is a vertical measurement and represents "dead" lift.

(8) Record the figures from steps 5, 6, and 7 on the design worksheet at step 8. The total of these figures is the total head loss. Do not exceed 20 ft to 25 ft (6.1 m to 7.6 m) of total head loss at the pump intake; otherwise, all the pump capacity will be used for suction (or lift), and the pump might not flow its rated capacity.

Table B-5.3.3(a) Straight Pipe Equivalents for Fittings (ft)

Fitting	PVC Pipe Diameter						
	2.5 in.	3.0 in.	4.0 in.	5.0 in.	6.0 in.	8.0 in.	10.0 in.
90-degree elbow, standard	6.5	8.5	11.0	14.0	16.0	22.0	27.0
90-degree elbow, medium sweep	5.5	7.0	9.5	12.0	14.0	18.0	22.0
90-degree elbow, long sweep	4.5	5.5	7.0	9.0	11.0	14.0	18.0
45-degree elbow	3.0	4.5	5.0	6.5	7.5	10.0	13.0
Hydrant adapter (6 in. × 4.5 in.)	—	—	—	—	2.5	—	—
Reducer (8 in. × 6 in.)	—	—	—	—	—	3.5	—

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.
Source: Handbook of PVC Pipe.

Table B-5.3.3(b) Head Loss (ft/100 ft of PVC pipe)

Gallons per minute	Pipe Size						
	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	10 in.
100	2.4	0.6	0.2	0.1	—	—	—
200	8.6	2.1	0.7	0.3	0.1	0.1	—
250	13.0	3.2	1.1	0.5	0.1	0.1	—
300	18.2	4.5	1.5	0.6	0.2	0.2	0.1
350	24.2	6.0	2.0	0.8	0.3	0.2	0.1
400	30.9	7.6	2.6	1.1	0.4	0.3	0.1
500	46.8	11.5	3.9	1.6	0.8	0.4	0.1
600	65.6	16.2	5.5	2.2	1.1	0.6	0.2
700	87.2	21.5	7.3	3.0	1.4	0.7	0.2
750	99.1	24.4	8.3	3.4	1.6	0.8	0.3
800	111.7	27.5	9.3	3.8	1.8	0.9	0.3
900	138.9	34.3	11.6	4.8	2.3	1.2	0.4
1000	168.8	41.6	14.1	5.8	2.7	1.4	0.5
1100	201.4	49.7	16.8	6.9	3.3	1.7	0.6
1200	236.7	58.4	19.7	8.1	3.8	2.0	0.7
1300	274.5	67.7	22.9	9.4	4.4	2.3	0.8
1400	314.9	77.7	26.2	10.8	5.1	2.7	0.9
1500	357.7	88.5	29.8	12.3	5.8	3.0	1.0
1600	403.2	99.5	33.6	13.8	6.5	3.4	1.2
1700	451.1	111.3	37.6	15.5	7.3	3.8	1.3
1800	501.5	123.7	41.8	17.2	8.1	4.2	1.4
1900	554.3	136.7	46.1	19.0	9.0	4.7	1.6
2000	609.5	150.4	50.8	20.9	9.9	5.2	1.7
2100	667.2	164.6	55.6	22.9	10.8	5.6	1.9
2200	727.2	179.4	60.6	24.9	11.8	6.2	2.1
2300	789.6	194.8	65.8	27.1	12.8	6.7	2.3
2400	854.4	210.7	71.2	29.3	13.8	7.2	2.4
2500	921.4	227.3	76.7	31.6	14.9	7.8	2.6
2600	990.9	244.4	82.5	34.0	16.1	8.4	2.8

Table B-5.3.3(b) Head Loss (ft/100 ft of PVC pipe) ***(Continued)***

Gallons per minute	Pipe Size						
	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	10 in.
2700	1062.6	262.1	88.5	36.5	17.2	9.0	3.0
2800	1136.6	280.4	94.7	39.0	18.4	9.6	3.2
2900	1213.0	299.2	101.0	41.6	19.7	10.3	3.5
3000	1291.6	318.6	107.6	44.3	21.0	10.9	3.7

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m; 1 gpm = 3.786 L/min.
The charts are for PVC Schedule 40 pipe. Other types of pipe material have similar charts that should be consulted when other pipe is used.

Table B-5.3.3(c) Head Loss (ft/100 ft of hard rubber suction hose)

Gallons per Minute	Hose Size					
	$1^1/_2$ in.	$2^1/_2$ in.	4 in.	$4^1/_2$ in.	5 in.	6 in.
100	84.1	7.0	0.7	0.4	0.2	0.1
200	303.6	25.3	2.6	1.4	0.9	0.4
250	459.0	38.2	3.9	2.2	1.3	0.5
300	643.3	53.6	5.4	3.1	1.8	0.8
350	855.9	71.3	7.2	4.1	2.4	1.0
400	1,096.0	91.3	9.3	5.2	3.1	1.3
500	1,656.9	138.0	14.0	7.9	4.7	1.9
600	2,322.4	193.4	19.7	11.1	6.6	2.7
700	3,089.7	257.3	26.1	14.7	8.8	3.6
800	3,956.6	329.5	33.5	18.9	11.3	4.7
900	4,921.0	409.9	41.6	23.5	14.1	5.8
1,000	5,981.4	498.2	50.6	28.5	17.1	7.0
1,100	7,136.1	594.4	60.4	34.0	20.4	8.4
1,200	8,383.8	698.3	71.0	40.0	24.0	9.9
1,300	9,723.5	809.9	82.3	46.4	27.8	11.4
1,400	11,153.9	929.0	94.4	53.2	31.9	13.1
1,500	12,674.2	1,055.6	107.2	60.5	36.2	14.9
1,600	14,283.3	1,189.6	120.9	68.1	40.9	16.8
1,700	15,980.5	1,331.0	135.2	76.2	45.7	18.8
1,800	17,765.0	1,479.6	150.3	84.7	50.8	20.9
1,900	19,635.9	1,635.5	166.2	93.7	56.1	23.1
2,000	21,592.7	1,798.5	182.7	103.0	61.7	25.4
2,100	23,634.7	1,968.5	200.0	112.8	67.5	27.8
2,200	25,761.2	2,145.7	218.0	122.9	73.6	30.3
2,300	27,971.7	2,329.8	236.7	133.4	80.0	32.9
2,400	30,265.7	2,520.8	256.1	144.4	86.5	35.6
2,500	32,642.5	2,718.8	276.2	155.7	93.3	38.4
2,600	35,101.9	2,923.7	297.0	167.5	100.3	41.3
2,700	37,643.1	3,135.3	318.5	179.6	107.6	44.3
2,800	40,265.8	3,353.8	340.7	192.1	115.0	47.4
2,900	42,969.6	3,579.0	363.6	205.0	122.8	50.6
3,000	45,753.9	3,810.9	387.1	218.3	130.7	53.8

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m; 1 gpm = 3.786 L/min.

B-5.3.4 Step-by-Step Installation Procedures for a Dry Hydrant. The following are step-by-step procedures for installing a dry hydrant:

(1) Check for any underground or overhead utilities before digging. Contact the appropriate authorities, such as those responsible for water, power, telephone, cable, and gas service.

(2) Using a backhoe or excavator, dig in the trench, starting at the point where the suction screen will be placed in the water.

(3) Maintain a uniform level trench cut all the way from the screen location to the point where the riser begins.

(4) Assemble the horizontal run and vertical riser portion of the hydrant (screen, lateral run, and riser) and place into the trench and water source as one piece.

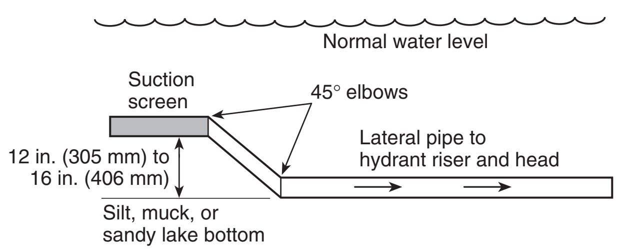
(5) Sink the screen end and allow the assembly to sink into the bottom of the trench. WARNING: It is critical that at no time should anyone be allowed into or close to the trench.

(6) When it is certain that the suction screen has been placed correctly, start backfilling the trench at the riser, keeping the riser pipe vertical, and backfill out into the water, being careful not to cover the suction screen.

(7) Mound and tamp the dirt slightly, as settling will occur over time. Mounding the dirt will also help to keep frost away from the water in the pipe.

(8) Place a cement block or use a commercial or manufactured strainer support under the suction screen to support the screen and keep it above the bottom of the trench. If the installation is in a fast-moving waterway, several blocks or supports might have to be attached to the screen to prevent the current from moving the screen. The pipe and screen will also have to have special protection from any debris washing downstream and hitting the pipe or screen. In silty- or sandy-bottomed lakes or ponds, the strainer and screen might need to be offset by adding 45-degree elbows to keep the screen above the bottom of the trench. (*See Figure B-5.3.4.*)

Figure B-5.3.4 Offset screen installation (Courtesy of Weyerhaeuser Volunteer Fire Department, WI)



(9) Cut off the vertical riser and attach the hydrant connection, making sure that the top of the hydrant connection is below the bottom of the pump intake. It is important that the pump intake remain slightly above the hydrant connection to prevent an air lock in the suction line.

(10) Set the guards and hose supports. Level, seed, and mulch the area to prevent erosion.

(11) Test pump the hydrant.

B-5.4 Maintenance of Dry Hydrants. Dry hydrants require periodic checking, testing, and maintenance at least quarterly. Checking and testing by actual drafting should be a part of fire department training and drills. Thorough surveys should be conducted to reveal any deterioration in the water supply situation in ponds, streams, or cisterns.

Particular attention should be given to streams and ponds. Such water sources might need frequent removal of debris, dredging or excavation of silt, and protection from erosion. The hydrants should be tested at least annually with a pumper. Back flushing, followed by a test at a maximum designed flow rate, with records kept of each test, is recommended. Tests of this kind will not only verify operating condition but also keep the line and strainer clear of silt and the water supply available for any fire emergency.

A pond should be maintained as free of aquatic growth as possible. At times it might be necessary to drain the pond to control this growth. Helpful information is available from such sources as the county agricultural extension agent or the U.S. Department of Agriculture.

Inspections should be conducted to verify safety measures such as posted warning signs and the availability of life preservers, ropes, and so forth. Particular attention should be given to local authorities' regulations governing such water points.

It is important to consider the appearance of this water point. Grass should be kept trimmed and neat. Weed control should be according to the department's SOP. Chemicals are not recommended for the control of weeds. The hydrant should be painted as needed. The cap can be painted a reflective material to improve visibility during emergencies. All identification signs should be approved by the U.S. Department of Transportation prior to installation if they are to be located on the right-of-way or are subject to state laws. Vegetation should be cleared for a minimum 3-ft (0.9-m) radius from around hydrants.

B-5.4.1 Maintenance Record for Dry Hydrants. It is recommended that a record of inspection be maintained with a separate card on each dry hydrant. *(See Figure B-5.4.1.)*

B-5.4.2 Map and Location/Detail Drawing. An official record should be kept of all pertinent information recommended for each dry hydrant area. An example of one type is shown in Figure B-5.4.2. The record will provide invaluable information whenever required.

Figure B-5.4.1 Sample maintenance record for dry hydrant.

Location and direction: ______________________

____

Depth of water above intake: ____________

Date: ____________

Date of Insp.	By	Depth of Water[1]	Amount of Water Available[2]	Condition of Water[3]	Erosion[4]	Dry Hydrant		Weed Control[7]	Road Condition[8]	Sign[9]	Remarks[10]
						Test[5]	Flow[6]				

[1] Record depth of water from the surface to the top of strainer.

[2] Record amount of water available calculated from surface to at least 2 ft (0.61 m) above top of strainer.

[3] Record a condition, the deterioration of which, over time, will reduce the water available. Special attention should be given to such items as silting, debris, and aquatic growth.

[4] Record erosion of the areas around the hydrant, access road, and bank of the water supply.

[5] Record by noting pumper used for the test, thereby indicating that the dry fire hydrant was back-flushed and that the end cap is in place, screen is clear of any stoppage, and supports or gravel, or both, is in place. Any problems corrected are recorded under "Remarks."

[6] Record of the actual test of the hydrant in gpm (L/min) following the department's standard operating procedure for testing dry fire hydrants. Care should be taken to use the same test procedures during each test.

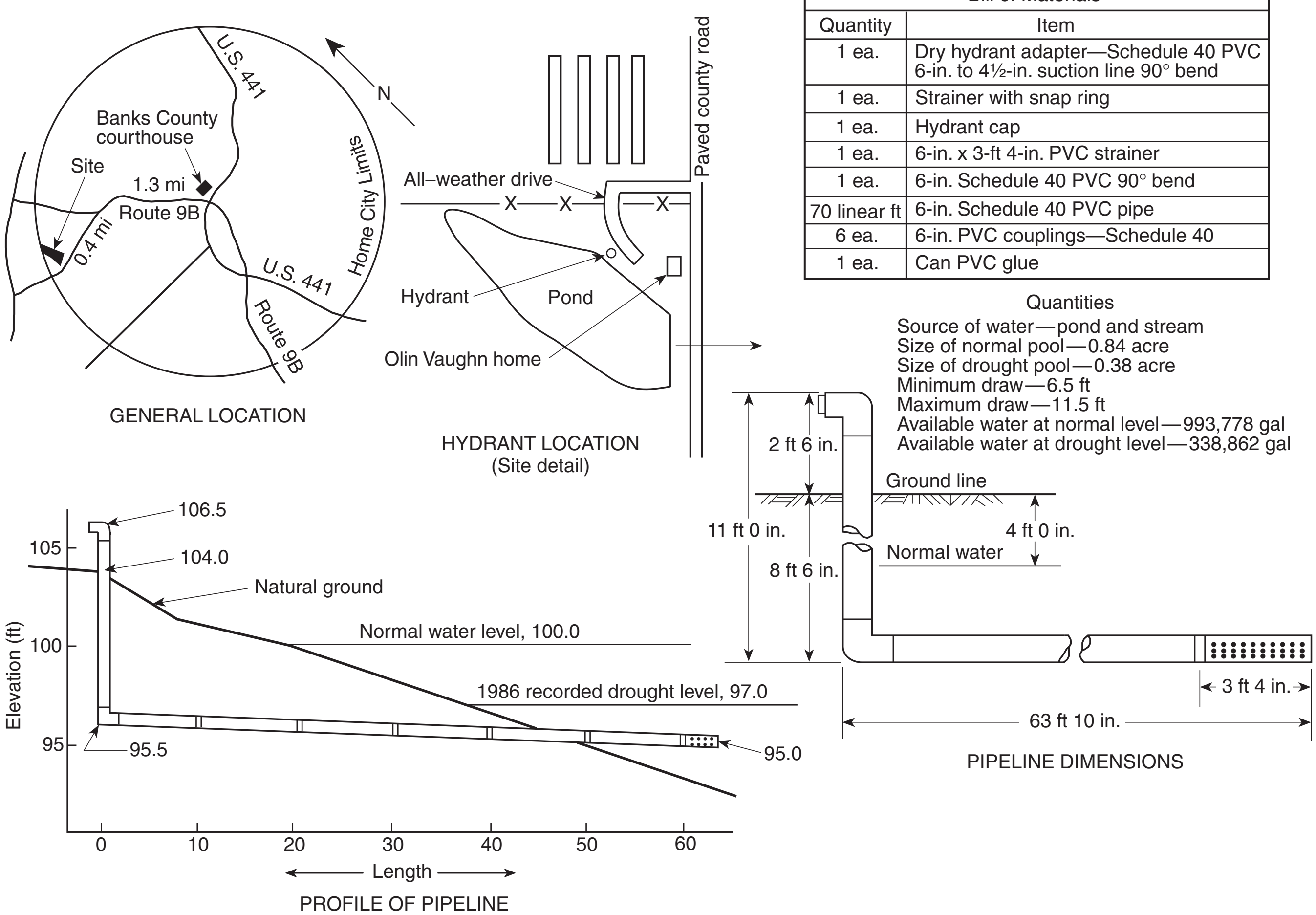
[7] Record complete information on chemicals and process used, where applicable.

[8] Record condition of roadway, drainage, and so forth.

[9] Record information pertaining to accuracy and clarity of information on sign (e.g., repainted or replaced).

[10] Record general information about the dry fire hydrant as found at the time of inspection.

Figure B-5.4.2 Example map and location/detail drawing.



Bill of Materials	
Quantity	Item
1 ea.	Dry hydrant adapter—Schedule 40 PVC 6-in. to 4½-in. suction line 90° bend
1 ea.	Strainer with snap ring
1 ea.	Hydrant cap
1 ea.	6-in. x 3-ft 4-in. PVC strainer
1 ea.	6-in. Schedule 40 PVC 90° bend
70 linear ft	6-in. Schedule 40 PVC pipe
6 ea.	6-in. PVC couplings—Schedule 40
1 ea.	Can PVC glue

B-5.5 Pressurized Dry Hydrant Sources. There are two types of pressurized dry hydrants — those that flow through a dam (or dike) and those that flow from an uphill water source, emptying at a point downhill from the source. Although an uphill water source can be of extreme advantage when flowed to a downhill source, a major disadvantage could be the necessity of burying of the pipe below the frost level. For a pressure hydrant, the pipe should be sloped downhill to the hydrant riser and should be fitted with a gate valve. Where the supply line passes through the dike of a pond, anti-seep collars should be attached to the pipe to prevent water from seeping and channeling beside the pipe.

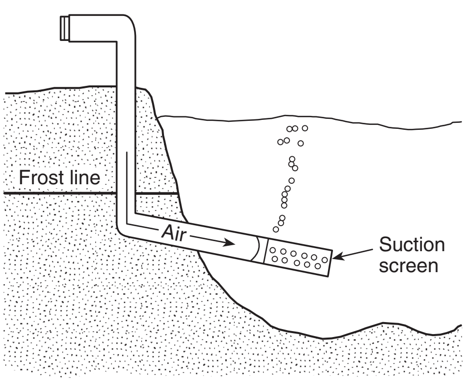
B-5.6 Variations in Dry Hydrant Design. There are numerous adaptations to the basic design of a dry hydrant. Various designs have been developed to overcome local or regional problems and can have applications over a large geographical area. A dry hydrant innovation has eliminated the top 90-degree or 45-degree elbow on each hydrant. *[See Figures B-5.6(a) and (b).]*

Figure B-5.6(a) Dry hydrant innovation that has eliminated top 90-degree or 45-degree elbow. (Courtesy of Nahunta Volunteer Fire Department, NC)

Figure B-5.6(b) Hard suction hose is connected to the pumper. The driver maneuvers the truck as the fire fighter walks the suction end of the hose to the dry hydrant. An "O" ring in the plastic "L" provides a right fit and allows the operator to draft. This is a quick and simple method to connect the pumper to a dry hydrant. It is critical that a good seal be obtained with the "O" ring to prevent any air leakage, or the pump will fail to prime. (Courtesy of Nahunta Volunteer Fire Department, NC)

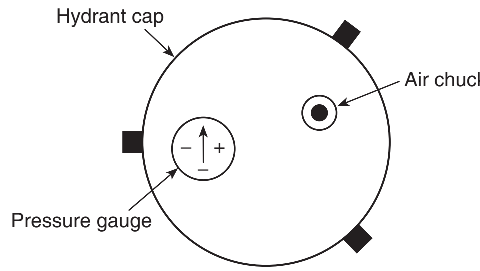
Dry hydrants can be installed in areas where the frost line would freeze the water in the hydrant pipe. An air injection frostproofing system is designed to inject air into the hydrant and displace the water to prevent freezing. With the water displaced below the frost line, the hydrant is usable year-round for drafting purposes. Air is injected into the hydrant until it bubbles out of the suction screen, or until the air pressure gauge no longer rises. This low-pressure air should not cause a safety problem, but all personnel should be advised to remove the hydrant cap slowly to prevent any possible injury. The air gauge should be checked periodically to be sure the water remains displaced in the hydrant. *[See Figure B-5.6(c).]*

Figure B-5.6(c) Air injection frostproofing system. (Courtesy of Wascott Volunteer Fire Department, WI)



An air pressure gauge and an air chuck should be installed in the cap of the hydrant by drilling and tapping into the metal. The chain for the hydrant cap will have to be removed. Teflon® tape should be used on the threads of the gauge and chuck. The advantage of this method is that, if the chuck or gauge is damaged, it will not affect the airtight integrity of the hydrant while drafting because the cap is removed. *[See Figure B-5.6(d).]*

Figure B-5.6(d) Cap design for air injection system.



B-6 Access to Water Supplies.

B-6.1 General. The fact that an adequate water supply is in sight of the main road does not ensure that the water can be used for fire-fighting purposes. Many times, it is necessary that a suitable approach be provided to reach within 10 ft (3.1 m) of the water supply.

Access should be provided, and the department should be trained in the use and limitations of the water supply before a fire occurs. A suitable approach might call for a roadway. However, at some sites and in some areas of the country, it might not be necessary that a roadway be constructed, due to soil conditions. Other sites might already have roadways provided or pavement installed, with the construction of an entranceway or a gate necessary to provide access to the water supply. Other sites can be reached by foot only and can necessitate that a path be constructed and maintained so that portable pumps can be carried to the site. Each site should be evaluated by the WSO to determine the best way, within the fire department's means, for using the water supply.

B-6.2 Roadway Access. Most artificial lakes are constructed with heavy earth-moving equipment. In order for the property owner to construct a roadway for fire department use, the WSO should make the property owner aware of the needs of the fire department while the heavy equipment is still on the job. Table B-6.2 details considerations that should be kept in mind when planning access.

B-6.2.1 While the roadway to the water supply is being developed, consideration should be given to providing a 90-ft (27.4-m) diameter turnaround for the mobile water supply apparatus. Where conditions at the supply do not make a turnaround feasible, a large underground pipe transmission line can be laid from the water supply to the highway, and the mobile water supply apparatus can be filled on the highway right-of-way. However, a turnaround or looped facility will still need to be provided at the fill point on the right-of-way.

B-6.2.2 Bridges Used as Water Points. In some states, a fire department cannot use a bridge to park a mobile water supply while it is being filled, thereby blocking traffic on a road. However, the fire department might be able to use the water source by moving the fill point off of the bridge and to the right-of-way. The fire department needs to check with the state department of transportation and abide by the appropriate laws governing the situation.

B-6.3 Dry Hydrant with Suction Line. In some cases, it will be desirable to install a dry hydrant with a suction line in lieu of an access road. Such cases exist in marsh or swamp areas. In marsh or swamp areas, the fire department will have access to the hydrant from the shoulder of the main road. So as not to block the road during pumper operations, a suitable parking

Table B-6.2 Recommendations for Roads to Water Supplies

Road Feature	Recommendation
Width	Roadbed — 12 ft (3.7 m)
	Tread — 8 ft (2.4 m)
	Shoulders — 2 ft (0.6 m)
Alignment	Radium centerline curvature — 50 ft (15.2 m)
Gradient	Maximum sustained grade — 8 percent
Side slopes	All cut-and-fill slopes to be stable for the soil involved
Drainage	Bridges, culverts, or grade dips at all drainageway crossings
	Roadside ditches deep enough to provide drainage
	Special drainage facilities (e.g., tile) at all seep areas and high water table areas
Surface	Treatment as required for year-round travel
Erosion control	Measures as needed to protect road ditches, cross drains, and cut-and-fill slopes
Turnaround	Designed to handle the equipment of the responding fire department with a minimum diameter of 90 ft (27.4 m)
Load-carrying capacity	Adequate to carry maximum vehicle load expected
Condition	Suitable for all-weather use

area on the shoulder of the road should be provided. The basic recommendations in Table B-6.2 can be useful in the design of such an area so that pumpers can be used efficiently and safely.

B-7 Bridges.

B-7.1 General. A large number of bridges in the U.S. are very old. Many rural bridges originally built for farm-to-market use now carry greatly increased traffic loads in suburban and urban areas. As a result, the general condition of bridges in most states is poor.

The deterioration of the nation's bridges gained public attention as early as the late 1960s, with the collapse of a large bridge. Furthermore, many states did not provide complete bridge inspection and maintenance programs.

B-7.1.1 Federal Legislation. As a result of bridge failures, the Federal Highway Act of 1968 required, among other things, that all states, counties, and cities receiving federal highway funding implement a program to inspect each bridge in the federally funded system every two years. Additional bridge collapses prompted amendment of this law in 1976 to include all bridges on the public roads system.

B-7.1.2 Bridge Inspection Programs. During the last few years, a number of states have set up bridge inspection programs, and the current safe tonnage is now being posted. Throughout the entire country, a large number of bridges have been restricted to below the legal weight limit for which the road and bridge were originally designed.

One state with over 15,000 bridges reported that 50 percent of all its bridges are now posted below the original maximum load limits, and 25 percent of these bridges are unsafe for use by a fully loaded school bus or normal fire department equipment.

B-7.1.3 Repair Programs. Highway departments are doing what is possible with the money available to improve bridge safety. Priority is given to bridge upkeep on primary roads, with bridges on less-traveled roads being improved with the funds that are left. Some highway departments are upgrading or raising the tonnage on their bridges as much as possible through repairs; however, many cannot be brought up to standard without complete rebuilding. Most states do not have money available for such an overhaul program.

In some states, the state highway department has consulted fire officials, explained the situation, and required that the fire department list the unsafe bridges in order of their importance to the fire service. The highway departments then attempt to upgrade these bridges on the basis of fire department priority.

B-7.1.4 Effect on the Fire Service. The long-range nature of the bridge problem makes it a matter for serious consideration when planning purchases of apparatus. Mobile water supply size must be restricted to volumes that will not cause overloading.

State law determines whether a fire service is held financially responsible for damage to a bridge; however, a good policy for every rural fire department is to check the bridge load restrictions before purchasing a new piece of apparatus. The lighter the equipment, the more bridges the department can use.

B-7.1.5 Fire Department Responsibility. The fire department should check every bridge in its response districts, both primary response and mutual aid, to ensure that all bridges will safely carry the fire department load. This might not be the overwhelming task that it appears. In view of the current use of computers by state highway departments to inventory their bridges, load limits should be readily available.

The fire department will need to make whatever special provision is indicated to protect an area that is accessible only by using an unsafe bridge. Examples include providing temporary station-to-house equipment in the isolated area, using a pumper taking suction from the river to pump water across the bridge through large hose lines, or servicing the area from another station that has a safe bridge to the area or, ideally, does not have to use a bridge to respond.

B-8 Preplanning Water Supply. Structures within the district of responsibility of the fire department should be surveyed in accordance with Chapter 2. The water requirement should be calculated, and the type and amount of equipment that should respond on first alarm should be designated. The response of fire apparatus, in conjunction with the capacity of mobile water supply apparatus, the travel distance to haul water, and the volume of water supply, can then be arranged so that a constant flow to equal the water flow requirements is obtained. The procedure should be verified under training conditions prior to a fire emergency. This training exercise should include the spotting of equipment to protect the fire property and the exposures, exploration of the water sources, designation of fire lanes or routes, and review and modification of the operations to meet unusual conditions.

Aircraft and aerial photographs can be very helpful in the survey of static water availability. Such photographs are usually available from the county agriculture department or the county office of planning and zoning. Topographical maps from the United States Geological Survey also can be of value in this survey. However, the value should be determined by the date that the map was made or revised because an out-of-date map can prove to be of little value. Once sites are located, they need to be prepared for use according to the recommendations of this section.

Appendix C Water Hauling

This appendix is not a part of the requirements of this NFPA document but is included for information purposes only.

C-1 Mobile Water Supplies.

C-1.1 General. The fire service has always experienced fire control difficulties in isolated areas. The difficulties are many and varied, but one of the major problems is the lack of an adequate water supply. The availability of an adequate amount of water for control and extinguishment is a major consideration for most rural fire chiefs and a factor that influences the majority of their fire-fighting decisions. A portion of the training of a rural fire department emphasizes the need for the conservation of the meager water supply that is available in many areas.

A limited water supply condition at a working fire in a rural area challenges all phases of fire fighting. This appendix discusses the procedures for moving water in those areas where there are no municipal-type water distribution systems with fire hydrants.

If the water supply is a dry hydrant, a lake, a cistern, a swimming pool, and so forth, some means must be provided for transporting the water from the supply to the fire. Most fire departments use a fire department pumper with a pump capacity of at least 750 gpm (2842 L/min) and a minimum 500-gal (1895-L) tank.

Since the pumper is always assigned to the supply, some departments provide it with little equipment beyond the pumps, the necessary hose for loading, and some preconnected handlines.

Several departments report that they have developed shallow water supplies into which the pumper is actually driven. Others have developed a trailer with a pump, and the trailer is pulled to the water supply. Still other departments have received good service from a permanently installed pump at the supply.

Over the years, rural departments depending on hauled water have tended to utilize any means to carry water and have exercised a great deal of ingenuity in doing so. Recently, there has been a trend in fire departments in rural areas to use standard pumpers and mobile water supply apparatus with tanks in the 1000-gal to 1500-gal (3785-L to 5678-L) range. Significant progress has been made in such mobile water supply apparatus techniques as loading and unloading, and in maintaining a continuous fire stream, based on the fire flow study, during the entire fire-fighting operation.

Mobile water supply apparatus are necessary for most rural departments and can be a major asset to a department having a weak municipal-type water system. While specially built and designed mobile water supply apparatus are ideal, many fire chiefs are forced to fight fires without adequate standard equipment. Since the job of putting out fires will require, on occasion, water-carrying capacity far above normal capability, a sound mutual or automatic aid program is necessary and far superior to makeshift equipment that is not designed for emergency service and is unsafe.

In building and buying nonstandard apparatus, serious consideration should be given to the safety and serviceability of the equipment as well as the safety of the members of the department. A department that depends on an assortment of mobile water supply apparatus designed primarily for other use might need expert assistance in checking the equipment for safety before putting it in service.

If satisfactory service is to be obtained from mobile water supply apparatus, the size of chassis necessary to safely carry the load, the horsepower of the engine necessary to perform on the road and at the fire site, the completed vehicle's weight distribution, and the gear train combination best suited for the operation in that specific locale are factors that should be carefully considered in the purchase or construction of the apparatus. The apparatus components, such as the baffling of the tank and the center of gravity, are just as important as the engine, axles, and other driveline components and should not be overlooked.

Some fire departments that have pumpers equipped with large booster tanks have retrofitted these pumps with a dump system.

C-1.2 Purchase or Construction of a Mobile Water Supply Apparatus. When purchasing or constructing a mobile water supply apparatus, careful attention should be paid to ensure that engine, chassis, baffling, center of gravity, and brakes of adequate specifications are obtained. NFPA 1901, *Standard for Automotive Fire Apparatus*, covers mobile water supply apparatus, and it is recommended that this standard be carefully followed.

The tank should be properly constructed and baffled. Particular attention should be paid to flow rates to and from the tank. Consideration should be given to discharging the mobile water supply apparatus to the receiving vehicle, portable tank, or other equipment as rapidly as possible so that the mobile apparatus can get back on the road and bring another load of water to the fireground. Some departments are installing very large dump valves with gravity flow, while other departments are providing a dump with a jet dump arrangement to reduce the emptying time.

The terrain, weather, and bridge and road conditions expected should be considered when buying or building safe mobile water supply apparatus.

It is suggested that, for a mobile water supply apparatus with a capacity greater than 1500 gal (5678 L), it might be necessary to utilize a semitrailer or tandem rear axles, depending on tank size and chassis characteristics. Consideration should be given to utilizing limited slip differential or all-wheel drive capabilities. Certain types of chassis might not provide safe carrying capabilities and could result in a dangerous vehicle. Equipment that at least meets the minimum standards is necessary.

It is further recommended that the maximum water tank capacity for mobile water supply apparatus should not exceed 4800 gal (18,168 L) or 20 tons of water. In some cases, it might even be found that the cost of two smaller mobile water supply apparatus will be little more, if any, than the cost of one large mobile water supply. The mobility, cost of upkeep, state weight restrictions, and highway bridge weight restrictions can convince many rural fire departments of the need to restrict the weight of their mobile water supply. The weight of the vehicle plus the load carried should not be greater than the rated capacity of the tires.

When apparatus is loaded, each load-bearing tire and rim of the apparatus should carry a weight not in excess of the recommended load for truck tires of the size used as specified by the tire manufacturer's rating. Compliance should be determined by weighing the loaded apparatus.

C-1.3 State Regulations. Regardless of rear axle configuration, specific consideration should be given to the state's legal weight-per-axle requirement. All states have single-axle weight limits, which are imposed based on road surface conditions and the longevity of highways. Although axles are designed to carry their rated weight, and vehicle and fire department planners can specify precise chassis requirements that fall within the safe tolerances of total vehicle operation and weight, such specifications do not legally permit the fire apparatus to exceed the state's legal weight rating per axle. Since some single-axle weight ratings are 26,000 lb (11,778 kg), the consideration given and attention paid to state single-axle weight limits can be significant.

The use of dead (or dummy) axles serves only to reduce the weight per axle load (on weighing scales). In no manner does it allow the engineering parameters of motor, transmission, drive shaft, brakes, and so forth, designed for the gross vehicle weight rating (GVWR) of the chassis to be functional. Using a nonworking axle for load-carrying purposes does not make a chassis road-safe.

C-1.4 Mobile Water Supply Capacity. In general terms, mobile water supply vehicles are units made for specific water-hauling requirements. In some wildland areas, where fire fighting is performed off the road and up steep grades, a 200-gal (757-L) slip-on unit is a mobile water supply. East of the Mississippi River, there is a trend in fire departments in rural areas to use mobile water supplies in the 1000-gal to 1500-gal (3785-L to 5678-L) range. In flat areas west of the Mississippi, fire departments successfully use mobile water supply apparatus with capacities of 3000 gal to 5000 gal (11,355 L to 18,925 L) and, occasionally, more.

In many parts of the country, terrain and bridge and road weight restrictions limit the capacity of mobile water supplies to the 1000-gal to 1500-gal (3785-L to 5678-L) range *(see B-7.1)*. However, a department operating mobile water supplies with capacities of 1000 gal (3785 L) or more will normally find it easy to meet the minimum water requirements outlined in this standard where water supplies are readily available.

It is desirable to use mobile water supplies of similar fill and discharge capability and equal water-carrying capacities to prevent them from "stacking" at the fill and discharge points.

C-1.5 Tank Baffles. The tank baffle or swash partition is often considered to be the weakest and most dangerous area of fire engine and mobile water supply design and construction. Considerable improvements have been made in baffles since the advent of the computer age. Poor baffling has been responsible for many accidents and accounts for a number of deaths throughout the country each year. Careful consideration should be given to baffles by the designers and builders of tanks.

C-1.6 Plumbing. It is important to have an outlet of adequate size to empty the tank. The reason is evident when the time needed to empty a 1600-gal (6056-L) mobile water supply apparatus by gravity flow is considered. *(See Table C-1.6.)*

Table C-1.6 Emptying Time for 1600-Gal (6056-L) Mobile Water Supply by Gravity Flow

Outlet Size		Discharge Time
in.	mm	(minutes)
$2^1/_2$	65	20
$4^1/_2$	114	7
6	152	5
10	200	$1^2/_3$
12	305	$1^1/_2$

Adequately sized plumbing is also important in those mobile water supply apparatus equipped with a pump with a jet dump arrangement. Many jet dump mobile water supply apparatus are capable of discharging at the rate of 1000 gpm (3785 L/min) or more.

Proper venting is a prerequisite for filling and emptying tanks, but it is imperative for rapid filling and discharging of tanks. There must be adequate provision for air to be driven from the tank when it is being filled with water and for air to enter the tank when that tank is being emptied. As a minimum, the vent opening should be four times the cross-sectional area of the inlet. Inadequate venting can cause the tank to bow outward when it is being filled rapidly, or can impair the discharge flow when emptying.

An 8 in. × 8 in. (203 mm × 203 mm) vent extending upward for approximately 12 in. (305 mm) is an adequate vent size. This overflow pipe located in the vent pipe area works as a venting source when the vent top is closed.

Adequate pump-to-tank plumbing size is also essential to provide for rapid discharge of water from a mobile water supply through its pump. Many pieces of fire apparatus are in service that cannot deliver the full capacity of their pumps from their tanks because of undersized tank-to-pump plumbing. In a mobile water supply operation in which the emphasis can be placed on rapid, low-pressure emptying of a tank, undersized plumbing can be a major limitation to efficiency.

A major concern in a water-hauling system involving mobile water supply apparatus is the fact that the mobile water supply might not be completely filled at the water supply source or completely emptied at the fire. Some mobile water supplies are so designed that as little as 10 gal (38 L) of water is left in the tank while others can have 100 gal (379 L) or more left in the tank.

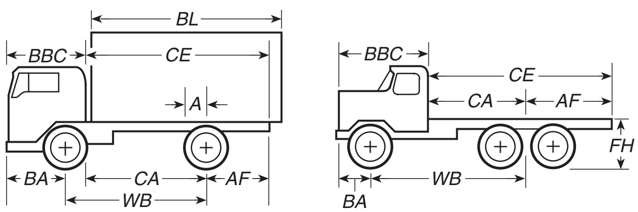
Applicable NFPA standards such as NFPA 1901, *Standard for Automotive Fire Apparatus*, contain data on adequate plumbing. Many departments are now exceeding the nominal pipe size requirements for their pumps in order to overcome friction loss and increase their capability to rapidly empty a tank by use of the pump.

C-1.6.1 Fill Line Couplings. Often, time wasted at mobile water supply fill locations is due to difficulties in coupling and uncoupling the threaded couplings between the fill pumper and the mobile water supply. If such difficulties exist, considerable time can be saved by using either a quarter-turn coupling (or some type of flexible hose with a quick discharge), a specially designed large-diameter fill pipe, or a rapid-fill device that drops into the tank fill opening, thus providing quick breakaway from the fill supply.

C-1.7 Weight Distribution. Weight distribution is all-important in the handling of a heavy piece of fire apparatus and should be properly designed into the unit and then verified by weighing each axle. Even the slightest change in the load carried or the distribution of the load can cause the design limits of the truck to be exceeded and turn a safe vehicle into an unsafe vehicle.

Figure C-1.7 provides information necessary to calculate accurate weight distribution.

Figure C-1.7 Weight distribution for mobile water supplies.



Dimensions
BBC = bumper to back of cab
BA = bumper to centerline of front axle
CE = back of cab to end of frame
CA = back of cab to centerline of rear axle or tandem suspension
AF = centerline of rear axle to end of frame
FH = frame height
BL = body length
A = distance from centerline of rear axle to centerline of body or payload (centerline of body at ½ body length)
WB = wheelbase distance — distance between centerlines of front and rear axle or tandem suspension

Terms
Chassis — basic vehicle cab, frame, and running gear
Curb weight — weight of chassis only

Gross vehicle weight rating (GVWR) — total of curb, body, and payload weights

Formulas
The weight carried by the front and rear axles can be calculated from the following formulas:

$$\frac{(B + PL)\,A}{WB} = FA \qquad (B + PL) - FA = RA$$

where:
B = body weight — weight of complete body to be installed on chassis
PL = payload weight — weight of commodity to be carried
A = distance from centerline of rear axle to centerline of body or payload (centerline of body at ½ body length)
WB = wheelbase distance — distance between centerlines of front and rear axle or tandem suspension
FA = front axle weight
RA = rear axle weight

The measurements to be used in the weight distribution calculation are the "as is" weights of the chassis to be used, dimensions of the chassis, and weights to be placed on the chassis. "As is" weights are best determined by weighing the chassis, with separate weights obtained on front and rear axles. If the unit has dual rear axles, they should be weighed together. In some cases, particularly where using a new chassis, data for calculation of weight distribution can be obtained from the agency providing the chassis, but it should be noted that such items as changes in tire size, lengthening, shortening, or reinforcement can alter standard factory-provided data. Consequently, it is preferable to weigh the chassis when starting construction planning.

Dimensional data is easily obtained by using a tape measure or carpenter's ruler. This data might be available from the source providing the chassis but should be verified.

The weight of the body to be added to the chassis is primarily the weight of the steel and other materials used in the body, the water in the tank itself, and any associated components. Components include such items as any reels, hose, or miscellaneous equipment expected to be used. While it is not necessary to make an individual calculation for minor items (minor in terms of weight), it is certainly important to calculate weight distribution of items of a few hundred pounds or more.

This appendix does not attempt to provide complete information on mobile water supply construction or the weight distribution of such a mobile water supply. The chassis manufacturer's recommended weight distribution — generally expressed as a percentage of total weight, including both the weight of the chassis and the weight placed on the chassis for front and rear axle(s) — is a prudent guideline for the final weight distribution desired. Component weights should be obtained from the manufacturers of the components. Steel weights should be obtained from the steelyard providing the material.

C-1.8 Turning Radius and Wheelbase. An important consideration in mobile water supply shuttle operations is the area available for turning. Since the mobile water supply might be called on to reverse direction or to maneuver for position at the water source or the fire site, a multiple of small, single-axle, mobile water supplies with 12-in. (305-mm) quick dump or 6-in. (152-mm) jet dump might actually move more water to the fire location than longer-wheelbase tractor trailers and dual, tandem-axle, mobile water supply apparatus.

C-1.9 Modification of Nonwater Tankers for Use as Mobile Water Supply Apparatus. Special care should be used when modifying a tanker built for a purpose other than for mobile water supply use, such as the prevalent practice of adapting an oil tanker for use as a mobile water supply apparatus. The majority of oil or gasoline tankers are constructed to carry a volatile liquid whose specific gravity is less than that of water. When utilized as a mobile water supply apparatus, the weight might exceed the manufacturer's permissible gross vehicle weight limits. For this reason, it might be preferable to reduce the tank's size to avoid undesirable effects on weight distribution. In doing so, special attention should be paid to any alteration in the vehicle's center of gravity that could affect its safety when turning corners.

Special attention should be paid to the baffling of such modified mobile water supply apparatus, and the truck should be rejected if it does not meet the demands of cornering, braking, and acceleration required by the fire service.

Other special factors to be considered where modifying nonwater tankers follow:

(a) A stainless steel milk tanker might be made out of very light gauge metal with no baffling and might be difficult to baffle crosswise and lengthwise.

(b) The steel used in gasoline tankers will corrode extremely fast due to the uncoated interior of such tanks. In addition, the steel used is not of the copper-bearing or stainless type used in most fire apparatus tanks.

(c) Aluminum fuel oil tanks have been found to be subject to corrosion from chlorinated water and corrosive rural water supplies. They can have a life expectancy less than that of steel if not properly coated and protected.

(d) An inherent danger in modifying gasoline tankers is the possibility of an explosion. All gasoline tanks should be thoroughly steam cleaned before modifications requiring welding are started.

(e) Gasoline and milk tankers are usually designed to be filled each morning for distribution of the product during the day under normal traffic conditions rather than emergency conditions, as is the case with fire equipment. It is not necessary for an oil tanker or milk tanker to stand in the station fully loaded day after day. (*See Table C-1.9.*)

Table C-1.9 Weights of Various Fluids

	Weights	
Fluids	**lb/gal**	**kg/L**
Milk	8.5	1.02
Water	8.3	0.99
Gasoline	6.2	0.74

C-1.10 Driver Training. An important consideration frequently overlooked by the rural fire department is that of driver training. Few people are trained to drive a tractor-trailer combination under emergency conditions, and the fire department planning to use such a vehicle should provide specific training for drivers of this type of apparatus. Even a two- or three-axle vehicle used as a mobile water supply will probably have driving characteristics very different from other apparatus, and driver training is extremely important. Individual state operator licensing requirements should be met.

C-1.11 Calculating Water-Carrying Potential. The following are two primary factors to be considered in the development of tank water supplies:

(1) The amount of water carried on initial responding units

(2) The amount of water that can be continuously delivered after initial response

A number of fire departments have developed water-hauling operations to the point where they have a maximum continuous flow capability (a sustained fire flow) of 1000 gpm to 2000 gpm (3785 L/min to 7570 L/min) at the fire scene. Such continuous flow requires several mobile water supply apparatus to haul such large quantities of water, with a developed water source near the fire site. To improve the safety factor by reducing congestion on the highways, the departments often send the mobile water supply apparatus to the water source by one road and use another route for the mobile water supply apparatus to return to the fire scene. Therefore, the time for the department to travel from the fire to the water source (T_1) might be a different time than the travel time back to the fire (T_2). The reduction of congestion on the highway provides for a safer operation and can increase the actual amount of water hauled.

Calculate the maximum continuous flow capability at the fire scene as follows:

$$Q = \frac{V}{A + (T_1 + T_2) + B} - 10\%$$

where:

Q = maximum continuous flow capability [gpm (L/min)]

V = mobile water supply capacity [gal (L)]

A = time in minutes for the mobile water supplies to drive 200 ft (61 m), dump water into a drop tank, and return 200 ft (61 m) to starting point

T_1 = time in minutes for the mobile water supply to travel from fire to water source

T_2 = time in minutes for the same mobile water supply to travel from water source back to fire

B = time in minutes for the mobile water supply to drive 200 ft (61 m), fill mobile water supply at water source, and return 200 ft (61 m) to starting point

–10% = amount of water supply (mobile water supply capacity) considered unavailable due to spillage, underfilling, and incomplete unloading

The dumping time, *A*, and filling time, *B*, for the formula should be determined by drill and by close study of water sources. Equipment does not have to be operated under emergency conditions to obtain travel time, *T*, which is calculated using the following equation:

$$T = 0.65 + XD$$

where:

T = time in minutes of average one-way trip travel

D = one-way distance

The factor 0.65 represents an acceleration/deceleration constant based on miles per hour developed by the Rand Corporation.

Where an apparatus is equipped with an adequate engine, chassis, baffling, and brakes, a safe constant speed of 35 mph (56.3 km/hr) can generally be maintained on level terrain, in light traffic, and on an adequate roadway. Where conditions will not permit this speed, the average safe constant speed should be reduced.

Using an average safe constant speed of 35 mph (56.3 km/hr), the *X* factor is calculated as follows:

$$X = \frac{60}{\text{average safe constant speed}} = \frac{60}{35\text{ mph}} = 1.70$$

Precalculated values of X using various speeds, in miles per hour, have been inserted into the formula for travel time ($T = 0.65 + XD$) as indicated in Table C-1.11(a) and Table C-1.11(b):

Table C-1.11(a) Precalculated Values of X

Speed (mph)	X	Speed (kph)	X
15	4.000	24.135	2.486
20	3.000	32.180	1.865
25	2.400	40.225	1.492
30	2.000	48.270	1.243
35	1.714	56.315	1.065

Table C-1.11(b) Time–Distance Table Using an Average Safe Constant Speed of 35 mph ($T = 0.65 + 1.7\ D$)

Distance		Time in
miles	km	minutes
0.0	0.00	0.00
0.1	0.16	0.82
0.2	0.32	0.99
0.3	0.48	1.16
0.4	0.64	1.33
0.5	0.80	1.50
0.6	0.97	1.67
0.7	1.13	1.84
0.8	1.29	2.01
0.9	1.45	2.18
1.0	1.61	2.35
1.1	1.77	2.52
1.2	1.93	2.69
1.3	2.09	2.86
1.4	2.25	3.03
1.5	2.41	3.20
1.6	2.57	3.37
1.7	2.74	3.54
1.8	2.90	3.71
1.9	3.06	3.88
2.0	3.22	4.05
2.1	3.39	4.22

Table C-1.11(b) Time–Distance Table Using an Average Safe Constant Speed of 35 mph ($T = 0.65 + 1.7\ D$) *(Continued)*

Distance		Time in
miles	km	minutes
2.2	3.54	4.39
2.3	3.70	4.56
2.4	3.86	4.73
2.5	4.02	4.90
2.6	4.18	5.07
2.7	4.34	5.24
2.8	4.51	5.41
2.9	4.67	5.58
3.0	4.83	5.75
3.1	4.99	5.92
3.2	5.15	6.09
3.3	5.31	6.26
3.4	5.47	6.43
3.5	5.63	6.60
3.6	5.79	6.77
3.7	5.95	6.94
3.8	6.11	7.11
3.9	6.28	7.28
4.0	6.44	7.45
4.1	6.60	7.62
4.2	6.76	7.79
4.3	6.92	7.96
4.4	7.08	8.13
4.5	7.24	8.30
4.6	7.40	8.47
4.7	7.56	8.64
4.8	7.72	8.81
4.9	7.88	8.98
5.0	8.05	9.15
5.1	8.21	9.32
5.2	8.37	9.49
5.3	8.53	9.66
5.4	8.69	9.83
5.5	8.85	10.00

Table C-1.11(b) Time–Distance Table Using an Average Safe Constant Speed of 35 mph ($T = 0.65 + 1.7\ D$) *(Continued)*

Distance		Time in
miles	km	minutes
5.6	9.01	10.17
5.7	9.17	10.34
5.8	9.33	10.51
5.9	9.49	10.68
6.0	9.65	10.85
6.1	9.81	11.02
6.2	9.98	11.19
6.3	10.14	11.36
6.4	10.30	11.53
6.5	10.46	11.70
6.6	10.62	11.87
6.7	10.78	12.04
6.8	10.94	12.21
6.9	11.10	12.38
7.0	11.26	12.55
7.1	11.42	12.72
7.2	11.58	12.89
7.3	11.75	13.06
7.4	11.91	13.23
7.5	12.07	13.40
7.6	12.23	13.57
7.7	12.39	13.74
7.8	12.55	13.91
7.9	12.71	14.08
8.0	12.87	14.25
8.1	13.03	14.42
8.2	13.19	14.59
8.3	13.35	14.76
8.4	13.52	14.93
8.5	13.68	15.10
8.6	13.84	15.27
8.7	14.00	15.44
8.8	14.16	15.61
8.9	14.32	15.78
9.0	14.48	15.95
9.1	14.64	16.12
9.2	14.80	16.29
9.3	14.96	16.46
9.4	15.12	16.63
9.5	15.29	16.80
9.6	15.45	16.97
9.7	15.61	17.14
9.8	15.77	17.31
9.9	15.93	17.48
10.0	16.09	17.65

The formulas in this appendix make it possible to determine water availability at any point in an area. As an example of how to calculate the water available from a supply where the water must be trucked to the fire scene, consider the following applications of the formula:

If tank capacity *(V)* is 1500 gal (5678 L), the time *(A)* to fill the mobile water supply with water is 3.0 minutes, and the time *(B)* to dump the water into a portable tank is 4.0 minutes.

The distance (D_1) from the fire to the water source is 2.10 miles (3.38 km). As the mobile water supply returns by a different road, the distance (D_2) from the water source is 1.80 mi (2.9 km).

First, solve for T_1, the time for the mobile water supply to travel from the fire to the water source, and then solve for T_2, the time for the mobile water supply to travel from the water source back to the fire.

Due to good weather and road conditions, the constant mobile water supply speed traveling from the fire to the water source is 35 mph (56.3 km/hr).

Use the travel time formula:

$$T = 0.65 + XD_1$$

where:

$X = 1.7$
$D_1 = 2.10$

At a constant speed of 35 mph (56.3 km/hr), therefore,

$T_1 = 0.65 + 1.7\ D_1$
$T_1 = 0.65 + 1.7 \times 2.10$
$T_1 = 0.65 + 3.57$
$T_1 = 4.22$

[See also Table C-1.11(b).]

At a constant speed of 35 mph (56.3 km/hr), a mobile water supply traveling 2.10 mi (3.8 km) will take 4.22 minutes. Due to traffic lights, the average mobile water supply speed between the fire and the water source is 30 mph (48.3 km/hr).

Use the time travel formula:

$$T = 0.65 + XD_2$$

where:

X = 2.0
D_2 = 1.80

At a constant speed of 30 mph (48.3 km/hr),

$T_2 = 0.65 + 2.0\ D_2$
$T_2 = 0.65 + 2.0 \times 1.8$
$T_2 = 0.65 + 3.60$
$T_2 = 4.25$

Use the formula for calculating the maximum continuous flow capability:

$$Q = \frac{V}{A + (T_1 + T_2 + B)} - 10\%\ V$$

where:

Q = maximum continuous flow capability (gpm)
V = 1500
A = 3.0
T_1 = 4.22
T_2 = 4.25
B = 4.0

Therefore,

$$Q = \frac{1500}{3.0 + (4.22 + 4.25) + 4.0} - 10\%\quad V$$

$$Q = \frac{1500}{3.0 + 8.47 + 4.0} - 10\%\quad V$$

$$Q = \frac{1500}{15.47} - 10\%\quad V$$

$$Q = 97 - 10\% = 87 \text{ gpm (329.3 L/min)}$$

The maximum continuous flow capacity available from this 1500-gal (5678-L) mobile water supply is 87 gpm (329.3 L/min).

To increase the maximum continuous flow capability of a mobile water supply, any of the following changes can be made:

(1) Increase the capacity of the mobile water supply.
(2) Reduce the fill time. *(See Figure C-1.11.)*
(3) Develop and provide additional fill points, thus reducing travel time.
(4) Reduce the dump time.

With rural fire response distances normally being very long, the number and size of mobile water supply apparatus available to the department is of paramount importance. This information will assist the department in calculating the probable mobile water supply volume that will be available at various fire locations. Equally important in increasing the maximum continuous flow capability of a mobile water supply is the reduction of the distance between the source and the building or fire. The distance can be reduced by increasing the number of water supplies, the drafting points, or both.

Figure C-1.11 Example of a quick coupling that can help to reduce the fill time.

C-1.12 Filling and Discharging the Mobile Water Supply. During water-hauling operations, mobile water supply dump/fill rates directly affect the fire flow capabilities established at the fire scene. Local needs usually determine mobile water supply configuration and the water-hauling procedures. A wide variety of off-loading and filling systems are currently in use. Some departments prefer to pump off their water into portable tanks, while others utilize a nursing operation. An increasing number of fire departments are incorporating the use of large dump valves or jet-assisted dump arrangements. Deciding which system is best requires an evaluation of effectiveness, efficiency, and overall compatibility with other segments of the water delivery.

During a comprehensive evaluation, many factors should be considered. Travel distances, operating site location, and topography greatly affect water-hauling turnaround time periods. Usually, the greatest amount of time can be saved during the filling and discharge segments of the shuttle operation. Normally, greater quantities of water are made available as filling/discharge rates increase. Of course, increased quantities should be logistically supported by ample water source locations and tanking vehicles.

As with other segments of fireground operations, strategic preplanning is vital to water-hauling evolutions. Preplanning and practice reduce unnecessary actions and minimize unsafe practices. For example, a properly established dump site should eliminate or substantially reduce the need to back up vehicles (an act that not only requires precious time but causes 33 percent of all vehicle accidents). The use of flexible discharge tubing or side dumps in conjunction with properly set up dump sites can often eliminate the necessity of backing up the vehicles to the water supply.

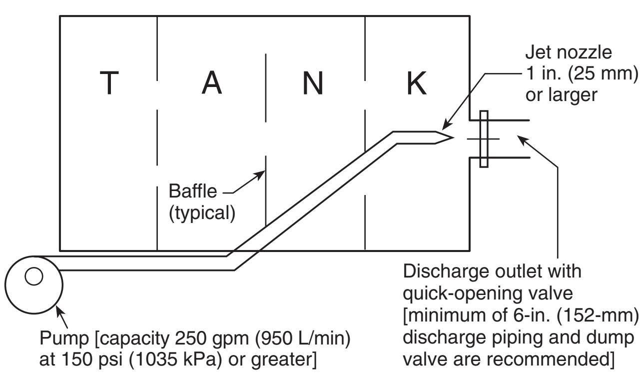
Because two of the key periods for saving time during water-hauling operations center around mobile water supply filling and discharge, many fire departments have incorporated the use of large gravity dump valves or jet dump valve arrangements.

C-1.12.1 Mobile Water Supplies Equipped with Large Gravity Dumps. A number of rural fire departments have increased the size of their gravity discharge dumps to reduce the time necessary to empty other water-hauling mobile water supply apparatus. Gravity dumping with discharge valves of 10 in. (254 mm), 12 in. (301 mm), or larger are often used. Dump valve discharge rates will vary as the depth of the water in a given tank decreases. Adequate air intakes and tank baffle cuts should be provided, or inefficiency and possible tank damage can result. To check the efficiency of a dump system, weight tests should be conducted to determine discharge rates.

C-1.12.2 Mobile Water Supplies Equipped with Jet-Assisted Dumps. Basically, a jet is a pressurized water stream used to increase the velocity of a larger volume of water that is flowing by gravity through a given size dump valve. The water jet principle used to expel water from mobile water supply apparatus has also been effectively applied to several other devices that can transfer water between portable dump tanks, fill mobile water supply apparatus from static water sources, and reduce suction losses at draft. Water jets properly installed in the discharge piping of a mobile water supply or fire apparatus can more than double their water-hauling efficiency. Effective jet-assisted arrangements have exceeded a 1000-gpm (3785-L/min) discharge rate when using 6-in. (152-mm) discharge piping and valve. Pumps supplying such jet arrangements should be capable of delivering a minimum of 250 gpm (946 L/min) at a gauge pressure of 150 psi (1034 kPa). Some departments have obtained good results with pumps that deliver flows at a gauge pressure of less than 150 psi (1034 kPa) where larger discharge openings are provided. The size and design of the jet nozzle and the diameter and length of the dump valve piping directly affect unit efficiency.

C-1.12.3 Traditional In-line Jet-Assist Arrangement. Figure C-1.12.3(a) illustrates how the traditional jet is installed. A smooth-tipped jet nozzle is usually supplied by a pump capable of delivering at least 250 gpm (946 L/min) at a gauge pressure of 150 psi (1034 kPa). Nozzle jets range in size from $^3/_4$ in. to $1^1/_4$ in. (19 mm to 32 mm). The diameter of the tip will be determined by the capacity of the pump being used and the diameter of the discharge piping and dump valve.

Figure C-1.12.3(a) Traditional internal jet dump.



Before a jet dump is installed, questions including, but not limited to, the following should be answered:

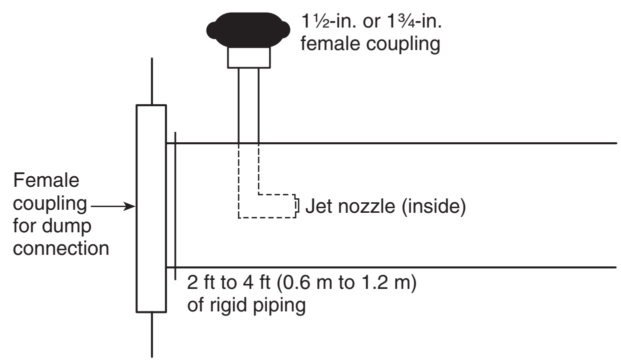
(1) In what location will the dump prove to be most useful, the side or the back?
(2) Will the fixed piping need to be $1^1/_2$ in. (38 mm) in diameter or 2 in. (51 mm) in diameter?
(3) What is the preferable location for the jet, in-line or at the rear of the tank?

In the interest of site versatility, many departments are utilizing lightweight flexible discharge tubes equipped with quick-lock or quarter-turn couplings. Such tubing arrangements allow rapid discharge of water to either side of the vehicle and reduce the need for hazardous backing at the dump site.

The rate of discharge will be governed by the size of the dump valve and piping, which can range from 4 in. to 12 in. (102 mm to 301 mm). Normally, a 6-in. or 8-in. (152-mm or 203-mm) diameter dump configuration permits adequate flow capacities where water jet systems are employed. Again, it is stressed that adequate air exchange and water flow passages should be provided for a jet-assisted dump arrangement to function properly. Tanks can collapse where air exchange is restricted. Lack of adequate gravity water flow to the jet area will also adversely affect the discharge efficiency of the water-hauling unit.

Although some authorities recommend that the nozzle of the in-line jet be up to 6 in. (152 mm) from the center of the discharge opening, other effective designs have included placement of the nozzle inside the discharge piping. Figure C-1.12.3(b) details how the traditional jet arrangement can be externally added to an existing dump valve. A short length of $1^1/_2$-in. (38-mm) hose is attached to the female coupling on the jet device. The length of the added dump piping can range from 2 ft to 4 ft (0.6 m to 1.2 m), depending on whether a flexible tube is utilized during the dump process.

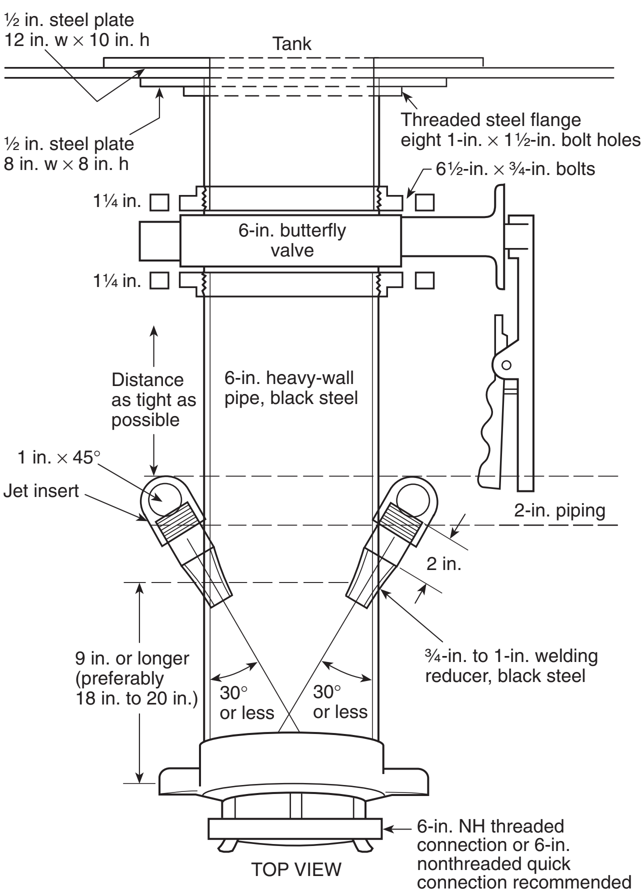
Figure C-1.12.3(b) Traditional external jet dump.



To properly operate, a jet should be able to produce between a gauge pressure of 50 psi and 150 psi (345 kPa and 1034 kPa). Higher pressures normally increase operational effectiveness. The diameter of the jet selected should be appropriate for the capacity and pressure capabilities of the pump being utilized. Also important is the size of the piping and valves that make up the jet dump system. External jets do have several advantages over internally fixed units, particularly with respect to system maintenance. Disadvantages might include the need to provide for adequate air exchange during water flow, more time necessary for the initial setup in order to affix appliances, the restriction of movement around the vehicle, and the general appearance of the jets themselves.

C-1.12.4 Peripheral Jet-Assist Arrangement. The peripheral application of jet-assist nozzles has proved highly effective. This arrangement utilizes two or more jets installed in the sides of the discharge piping just outside the quick-dump valve. In addition to the reported discharge advantages of peripheral jet streams, the externally fed system is easier to plumb and has fewer maintenance problems. The jets, installed 25 degrees to 30 degrees from the piping wall, contact more surface area of the discharging water, thereby increasing water discharge efficiency. Because the water is drawn through the dump valve, less turbulence is created, and the eddy effect often present with traditional in-line jets is overcome. Nozzles made of welding reducer pipe fittings work very effectively as jets. Flow rates of 2000 gpm (7570 L/min) have been obtained using a 300-gpm (1136-L/min) pump to supply two $^{3}/_{4}$-in. (19-mm) nozzles in a 6-in. (152-mm) dump valve configuration. Figures C-1.12.4(a) and C-1.12.4(b) represent two views of a typical installation.

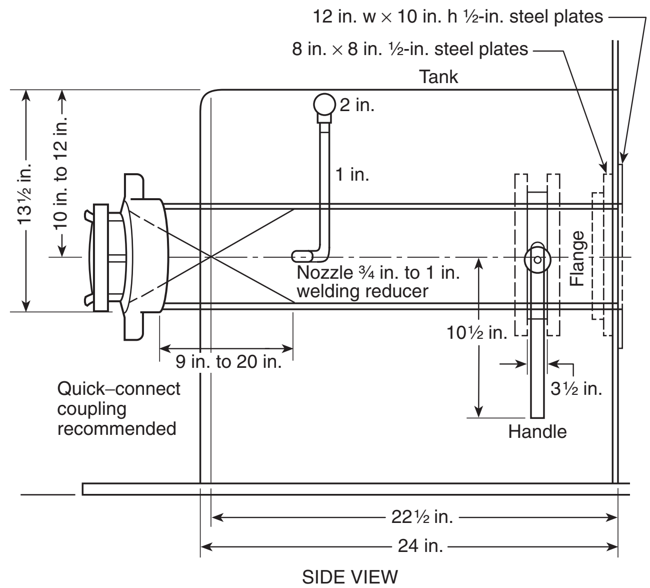
Figure C-1.12.4(a) Peripheral jet-assist installation (top view).



For SI units, 1 in. = 2.54 cm.

C-1.12.5 Other Jet-Assist Devices. Innovative fire organizations have put siphons and jet-related devices to good use. Some siphons use only water-level differential to transfer water from one tank to another. Normally constructed of PVC pipe, such siphons are placed between portable tanks to equalize water levels. Transfer is initiated by filling the U-shaped tubing with water, placing the caps on the tubing until it is put in place, and then removing the caps to allow water flow. Such an arrangement, though useful, has often proved too slow for the type of transfer operations required. A modification of the siphon transfer piping using a jet was developed and has proved useful to many departments. Although 4-in. (102-mm) PVC and aluminum piping have been used for such devices, 6-in. (152-mm) units usually are more practical. Using a $^{1}/_{2}$-in. (13-mm) jet nozzle supplied by a $1^{1}/_{2}$-in. (38-mm) hose makes possible transfer flows of 500 gpm (1890 L/min). Some departments merely add the jet to a length of suction. *[See Figures C-1.12.5(a) and C-1.12.5(b).]*

Figure C-1.12.4(b) Peripheral jet-assist installation (side view).



For SI units, 1 in. = 2.54 cm.

Siphons that use the jet principle are commercially available and are, in some cases, supplied by $2^{1}/_{2}$-in. (64-mm) hose. These devices are used to remove water from basement areas or increase the water supply to fire department pumpers.

In-line jets have also been developed to reduce suction losses during drafting operations. In-line and peripheral jets supplied by $1^{1}/_{2}$-in., $1^{3}/_{4}$-in., or $2^{1}/_{2}$-in. (38-mm, 44-mm, or 64-mm) hose lines can increase the output capacity of a centrifugal pump at draft up to 40 percent. The jets are placed at the intake and at every 10 ft (3.1 m) of suction in use. *[See Figure C-1.12.5(a).]* The design characteristics of strainers used during such application should permit adequate water flow capacity.

Some departments have developed a jet system for delivering water from a static source to mobile water supply apparatus through 4-in. or 6-in. (102-mm or 152-mm) lightweight pipe. This supply piping concept is used to fill mobile water supply apparatus through their discharge gates or via top loading or large inlets capable of filling mobile water supply apparatus at the rate of 1000 gpm (3785 L/min) or greater.

Figure C-1.12.5(a) Jet-assisted transfer siphon.

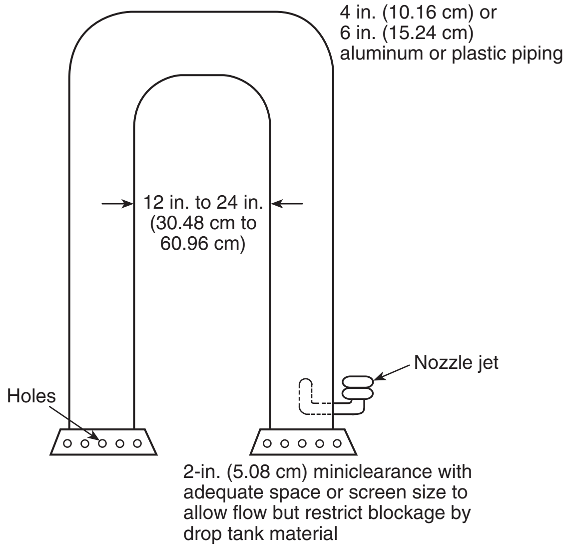
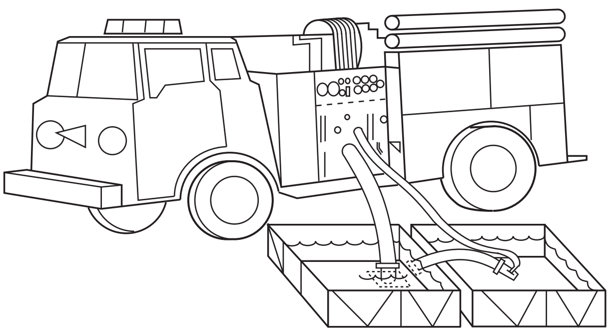


Figure C-1.12.5(b) Modified hard suction jet siphon.



C-1.12.6 Testing Dump Valve Capacity. Departments using large gravity dump valves or jet-assisted dump valve arrangements need to determine the flow rate at which they can dump and fill each mobile water supply in use. Generally accepted procedures for determining flow capacities, as found in *Rural Firefighting Operations (see Appendix H),* have been developed and should be accomplished as follows:

(1) Weigh the mobile water supply without any water on board.
(2) Weigh the mobile water supply again when it has been completely filled with water.
(3) Off-load the mobile water supply for 1 minute using only gravity.
(4) Weigh the mobile water supply and determine the gallons (liters) off-loaded by gravity.
(5) Refill the mobile water supply and weigh it.
(6) Off-load the mobile water supply for 1 minute using the jet arrangement.
(7) Weigh the mobile water supply and determine the gallons (liters) off-loaded via the jet.
(8) Make a comparison of the gallons (liters) used by gravity and those depleted using the jet.
(9) Refill the mobile water supply and weigh it.
(10) Off-load the mobile water supply for 1 minute by opening the gravity dump and pumping through a $2^1/_2$-in. (64-mm) discharge.
(11) Weigh the mobile water supply and then determine the number of gallons (liters) off-loaded by pumping and dumping.

An effective jet-assisted dump arrangement should produce at least twice the volume that would be expected when off-loading by gravity. A good jet arrangement will exceed the volume experienced during the dumping and pumping test. Whether using large dumps or jet dump arrangements, turnaround drop times and ease of operations should be the primary considerations.

C-1.13 Portable Drop Tanks. The following are, generally, the three types of drop tanks:

(1) Self-supporting tank
(2) Fold-out frame tank
(3) High-sided fold-out tank for helicopter bucket-lift mobile water supply service

The self-supporting tank is built with the sides reinforced to support the water inside the tank. The fold-out frame tank is similar to a child's wading pool — an open tank supported by a steel frame — and is the most common in fire service use. Tanks are available with an inlet or outlet, or both, built into the side of the tank. The capacities of drop tanks normally run from 1000 gal to 2500 gal (3785 L to 9463 L), with 1500-gal to 2000-gal (5676-L to 7570-L) tanks being those used most often.

The addition of the drop tank for "stockpiling" water has yielded highly desirable results. Stockpiling allows for the continuous operation of low-volume supplies and creates a source from which a pumper can draft for supplying hose lines during a direct fire attack. *[See Figures C-1.13(a) and (b).]*

Portable drop tanks should be simple to set up. Note the portable tank compartment (door open) on the mobile water supply in Figure C-1.13(a).

Figure C-1.13(a) Fire fighters set up portable drop tank. (Courtesy of Nahunta Volunteer Fire Department, NC)

Each mobile water supply should carry a portable tank that is 40 percent greater than the capacity of the mobile water supply. Note the strainer that minimizes whirlpooling and allows departments to draft to a depth of 1 in. to 2 in. (25 mm to 51 mm) in the portable tank in Figure C-1.13(b).

Figure C-1.13(b) Portable tank with strainer.

C-1.14 Use of Portable Drop Tanks and Mobile Water Supply Vehicles. The development of the portable drop tank or portable folding tank and the jet-assisted dump or large gravity dump to assist the mobile water supply in quickly discharging its load of water has enabled many rural fire departments to utilize isolated water supplies and, for the first time, to obtain sufficient water for effective fire fighting. The following is a brief outline of how the system is being employed by some departments.

When an alarm of fire is received, equipment is dispatched on a preplanned basis determined by such factors as fire flow needs, hazards involved, water supply available, and so forth *(see Chapter 5).* A minimum of one mobile water supply and one pumper respond to the fire, and the pumper begins the fire attack with water from its booster tank.

The first responding mobile water supply can act as a nurse unit or can set up a portable drop tank and begin discharging its load of water into the drop tank. With the use of a jet-type pump, discharging through a 5-in. or 6-in. (127-mm or 152-mm) discharge pipe, or a large 12-in. (305-mm) quick dump valve, the water in the mobile water supply can be transferred to the portable drop tank at a rate of approximately 1000 gpm (3785 L/min). A short piece of aluminum pipe with an "L" on one end gives the mobile water supply the flexibility to discharge into the drop tank with the mobile water supply backed up to the drop tank or with the drop tank located on either side of the mobile water supply. In Figure C-1.14, four hard suction hose lines are used to minimize any clogging of the strainers.

As soon as the mobile water supply has emptied its load, it immediately heads to the water supply. In the meantime, another fire department pumping unit has arrived at and connected to the water supply and primed its pump. When the empty mobile water supply apparatus arrives at the water supply, the pumper is ready to fill the mobile water supply apparatus. The refilled mobile water supply apparatus returns to the fire site, discharges its water, and the cycle is repeated.

It may be more efficient to fill one mobile water supply apparatus at a time rather than to fill two or more mobile water supply apparatus at a slower rate. Also, if all mobile water supply apparatus in the department have the same capacity, they will not stack up at the source of the supply or the fire while waiting for a large mobile water supply apparatus to be filled at the source or to discharge its water at the fire.

Although preplanned, each step of this hauling operation is under the direction of the WSO, and local conditions can dictate variations in this basic system.

As additional mobile water supply apparatus arrive at the fire site and dump their water, they fall into the water-hauling cycle. It might be necessary for the WSO to open up additional water supply points with additional pumpers. Portable pumps can sometimes be used in this operation if the additional supply is not readily accessible; however, refill time can be greatly increased. The WSO at the fire site needs to be in radio contact with the officer in charge of each water supply or suction point. The WSO will also advise the drivers of which route to take to the fire site. Wherever possible, an alternate route should be selected for returning vehicles so that emergency vehicles will not be meeting on sharp turns or narrow country roads.

It is possible that local fire departments will be unable to accommodate the demands of an initial alarm response to certain occupancies that require a large volume of water, based on the study producing the water flow requirements provided in C-1.11 and C-1.12. Automatic aid pumpers and mobile water supply apparatus can be set up to run automatically on first alarm, thereby conserving valuable time and delivering the fire flows calculated in Chapter 5.

Each mobile water supply should carry a portable drop tank with a capacity at least 40 percent greater than the capacity of the mobile water supply.

Figure C-1.14 Portable drop tank with "L"-shaped aluminum irrigation discharge pipe.

C-1.15 Chemical Additives and the Water Supply.

C-1.15.1 General. Fire departments are using chemicals to increase their fire-fighting capacity. This is important to the rural fire fighter working with a limited water supply, because these chemicals can provide more extinguishing capability per gallon (liter) of water. Since the chemical additives will create an additional expense, it becomes very important to be aware of the various capabilities and characteristics of chemical additives, as well as their advantages and disadvantages, relative to the types of fires encountered by each fire department.

C-1.15.2 Foam. Fire-fighting foams are used on surfaces where the cooling effect of water is needed and wherever a continuous foam blanket can provide the benefits of vapor suppression, insulation, delayed wetting, or reflection. Foam products are commercially available for Class A fuel fires and

Class B fuel fires (commonly referred to as Class A foam and Class B foam, respectively.)

Class A foam is designed for fighting fires involving wildland fuels, sawdust, cotton, paper, rubber, and other Class A fuels. Class A foam is a mechanically generated aggregation of bubbles having a lower density than water. The foam is made by introducing air into a mixture of water and foam concentrate. The bubbles adhere to the Class A fuels and gradually release the moisture they contain. The greater surface area-to-mass ratio of water in the foam of a bubble enables foamed water to absorb heat more effectively than unfoamed water.

Foam provides a barrier of oxygen, which is necessary to sustain combustion. The reduced rate of water release results in more efficient conversion of water to steam, providing enhanced cooling effects, and, along with surfactants contained in the solution, allows the water to penetrate the fuels and reach deep-seated fire sites. Foam also provides a protective barrier for unburned, exposed fuels by wetting and insulation. *(See NFPA 1150, Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas.)*

Class B foam is designed for fighting fires involving flammable or combustible liquids and is the only permanent extinguishing agent used on fires of this type. Class B foam is lighter than the aqueous solution from which it is formed and lighter than flammable liquids; therefore, it floats on all flammable or combustible liquids, producing an air-excluding, cooling, continuous layer of vapor-sealing, water-bearing material for purposes of halting or preventing combustion. *(See NFPA 11, Standard for Low-Expansion Foam.)*

The appropriate listings on the foam concentrate label should be consulted to determine proper application rates and methods. If there are no listings for application rates and methods, none should be assumed. However, the word “foam” appears in wetting agent instructions as well as in the instructions for the use of water expansion system (WES) units.

C-1.15.3 Other Water Additives (Wetting Agents). A wetting agent is a chemical compound that, when added to water in amounts indicated by the manufacturer, will materially reduce the water’s surface tension, increase its penetrating and spreading abilities, and might also provide emulsification and foaming characteristics. Decreased surface tension disrupts the forces holding the film of water together, thereby allowing it to flow and spread uniformly over solid surfaces and to penetrate openings and recesses over which it would normally flow. Water treated in this manner not only spreads and penetrates but displays increased absorptive speed and superior adhesion to solid surfaces. Therefore, leaks in plumbing and pump packing can occur that would not occur if the additive had not been used. Visual inspection should be made during wet water operations.

Water mixed with wetting agent, also known as “wet water,” should be applied directly to the surface of the combustible. These agents do not increase the heat absorption capacity of water, but the greater spread and penetration of the wet water increase the efficiency of the extinguishing properties of water, as more water surface is available for heat absorption and runoff is decreased.

Wetting agents are broadly defined as surfactants (surface-acting agents). All wetting agents (whether liquid or powder) are concentrated and are mixed with a liquid at varying percentages. The liquid into which it is mixed for fire-fighting purposes is water. With all wetting agents, hard water usually requires a greater amount of additive to produce the same results.

Wetting agents designed for fire department use will normally contain rust inhibitors to protect the tank, pump, piping, and valves. Generally, the mixture will lose some of its rust-inhibiting characteristics if left in the tank.

However, some wetting agents are sold primarily for use as a carrier for liquid fertilizers, fungicides, insecticides, and herbicides. These wetting agents can be used for fire-fighting purposes; however, they lack the additives that will protect tanks, pumps, valves, bushings, and so forth. Unused mixtures should be drained out of the tank and the pump and valves generously flushed with plain water.

Wetting agents are used as soaking or penetrating solutions for Class A fires involving wildland fuels, sawdust, cotton (bales, bedding, upholstery), rags, paper, and so forth. These solutions are used very effectively on smoldering or glowing combustibles.

Many of the wet water additive products include instructions to produce a foam by increasing the amount of the product mixed with water.

No additional equipment is needed for the production of this foam. Caution should be exercised, and on-site testing should be performed, in order to determine what the resultant foam will display in terms of extinguishment and fire fighter safety.

Additionally, a few wet water additives produce a foam through the use of a foam gun (generally a tube-type aerator and some nozzles). The instructions indicate this is generally a Class A fire-extinguishing agent. As stated previously, local on-site testing should be performed to determine the product’s capabilities.

There is available commercially a water additive that will suppress Class A and Class B fires. The product accomplishes the extinguishment of Class B fires by altering the water properties in such a manner that the increasing heat converts the water to a vapor, rather than steam, thereby cooling the fire.

Appendix D Large-Diameter Hose

This appendix is not a part of the requirements of this NFPA document but is included for information purposes only.

D-1 Transporting Water Through Large-Diameter Hose.

D-1.1 General. The advent of large-diameter hose as an accepted tool of fire fighting has major significance in the field of rural water supplies. This hose is viewed as an aboveground water main from a water source to the fire scene, and its use is growing in the United States. Where delivery rates exceed 500 gpm (1893 L/min) and water is moved long distances, large-diameter hose provide a most efficient means of minimizing friction losses and developing the full potential of both water supplies and pumping capacities. For practical purposes, NFPA defines large-diameter hose as hose with an inside diameter of $3^1/_2$ in. (89 mm) or larger.

D-1.2 Characteristics. Large-diameter hose is available in either single-jacketed or double-jacketed construction, generally in the following sizes:

(1) $3^1/_2$ in. (89 mm)
(2) 4 in. (102 mm)
(3) $4^1/_2$ in. (114 mm)
(4) 5 in. (127 mm)
(5) 6 in. (152 mm)

The lower friction loss characteristics of such hose increase the usable distance between the water source and the fire. The department unable to use water sources more than 1000 ft (304.8 m) from a potential fire site might find that 3000 ft (914 m) or more can become a reasonable distance where using large-diameter hose.

The basic reasons large-diameter hose moves water more efficiently are its larger size, its lower friction loss, and the relationship between these factors. The relationship can be explained by studying the carrying capacities and friction loss factors shown in Tables D-1.2(a) and D-1.2(b).

D-1.2.1 Carrying Capacity of Large-Diameter Hose. Large-diameter hose is superior to traditional standard fire hose in its ability to carry more water per section. Table D-1.2(a) shows, for example, that one 5-in (127-mm) hose line delivers a volume of water approximately equivalent to six $2^1/_2$-in. (64-mm) lines or four 3-in. (76-mm) lines at any given pressure or distance.

To use Table D-1.2(a), find the desired hose diameter in the left-hand column and read horizontally to find the corresponding hose size equivalent. For example, the table shows that one length of 5-in. (127-mm) diameter hose has the carrying capacity of 6.2 lengths of $2^1/_2$-in. (64-mm) hose, 3.83 lengths of 3-in. (76-mm) hose, 2.56 lengths of $3^1/_2$-in. (89-mm) hose, and so on. In other words, it would require over six lengths of $2^1/_2$-in. (64-mm) hose to equal the capacity of only one section of 5-in (127-mm) hose.

Table D-1.2(a) Relative Water Capacity of Fire Hose in Hose Lengths

Internal Diameter of Hose (in.)	Internal Diameter of Hose (in.)						
	$2^1/_2$	3	$3^1/_2$	4	$4^1/_2$	5	6
	Carrying Capacity in Hose Length(s)						
$2^1/_2$	1.00	0.617	0.413	0.29	0.213	0.161	0.1
3	1.62	1.0	0.667	0.469	0.345	0.261	0.162
$3^1/_2$	2.42	1.5	1.0	0.704	0.515	0.391	0.243
4	3.44	2.13	1.42	1.0	0.735	0.556	0.345
$4^1/_2$	4.69	2.90	1.94	1.36	1.0	0.758	0.469
5	6.20	3.83	2.56	1.8	1.32	1.0	0.619
6	10.00	6.19	4.12	2.9	2.13	1.61	1.0

Note: Table D-1.2(a) shows the relative carrying capacities of hose, $2^1/_2$ in. to 6 in. in diameter for the same friction loss. The values in the table are based on the Hazen-Williams equation.

Large diameter hose also has less friction loss per flow rate than smaller diameter hose. Table D-1.2(b) shows the relative friction loss of $2^1/_2$-in. (65-mm) to 6-in. (152-mm) diameter hose for the same flow rate (in gpm). The values in the table are based on the Hazen-Williams equation.

D-1.2.2 Selecting Large-Diameter Hose. The size and the 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. Table D-1.2.2 can be used to assist in hose selection. For example, a 750-gpm (2839 L/min) water flow is needed on a fire that is located 6500 ft (1981 m) from the water supply. A pumper rated 750 gpm (2839 L/min) at 150 psi (1034 kPa) can relay 750 gpm (2839 L/min) at 20 psi (138 kPa) discharge for a distance of only 650 ft (1981 m) if $3^1/_2$-in. (89-mm) hose is used or 8666 ft (2641 m) if 6-in. (152-mm) hose is used. Therefore, the department should consider using 6-in. (152-mm) hose to deliver its needed water requirements. The table is designed to apply primarily to situations in which a fire department is relaying water with pumps discharging at 150 psi (1034 kPa) and at 20 psi (138 kPa) residual pressure at the point receiving the flow.

Table D-1.2(b) Approximate Friction Losses in Fire Hose

Flow (gpm)	Internal Diameter of Hose (in.)					
	$2^1/_2$	3	$3^1/_2$	4	5	6
	Friction Loss (psi/100 ft)					
250	15	6	2	—	—	—
500	55	25	10	5	2	—
750	—	45	20	11	4	1.5
1000	—	77	36	19	6	2.5
1500	—	—	82	40	14	6.0
2000	—	—	—	70	25	10.0

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.

Table D-1.2.2 Distance a Hose Can Deliver Water Discharged at 150 psi (1034 kPa) Pump Pressure

Internal Diameter of Hose (in.)	Quantity of Water (gpm)					
	250	500	750	1000	1500	2000
	Distance (ft)					
$2^1/_2$	866	236	—	—	—	—
3	2166	520	288	168		—
$3^1/_2$	6500	1300	650	361	158	—
4	—	2600	1181	684	325	185
5	—	6500	3250	2166	928	520
6	—	—	8666	5200	2166	1300

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 ft = 0.305 m; 1 psi = 0.0689 bar.

D-1.3 Load Capacity. Another important advantage associated with large-diameter is hose load capacity. Most large-diameter hose is of a lightweight design. For example, a coupled 100-ft (30.5-m) length of 5-in. (127-mm) hose weighs approximately 105 lb (48 kg), a little heavier than a 100-ft (30.5-m) length of conventionally constructed $2^1/_2$-in. (64-mm) hose, which can weigh approximately 100 lb (45 kg).

One engine company laying large-diameter hose instead of multiple smaller lines is much more efficient in its water-moving capacity. The use of large-diameter hose with one engine speeds up the operation, which would otherwise need multiple smaller lines with additional pumpers, personnel, and equipment to accomplish the same job. *[See Figures D-1.3(a) and D-1.3(b).]* In Figure D-1.3(a), the apparatus straddles the hose. Note that the hose is loaded over the bar between the stanchions.

Figure D-1.3(a) Fire fighters reloading 5-in. (127-mm) hose.

D-1.4 Use of Large-Diameter Hose in Major Cities. Use of large-diameter hose is not limited to the rural fire service. Because of its increased water-carrying capacity and efficiency, 40 percent of the 200 largest cities in the United States now employ large-diameter hose, and it is one of the fastest growing items of technology in the fire service. It has demonstrated further utility as, literally, a portable pipeline used to bridge the gap in a water system when a main ruptures and is being repaired. It has further been used in some drought-stricken areas to bring water to the scene of a fire from a distant lake or stream, conserving municipal water supplies that would otherwise be used. Several communities have installed as much as 2 mi (3.2 km) of 5-in. (127-mm) hose for this purpose. While the large-diameter hose is being laid, the initial fire attack is made from hydrants. Where the large-diameter hose carrying the water from the lake is available at the fireground, the hydrants are shut down, and supplies in the municipal water system are conserved.

D-1.5 Powered Reel Trucks for Large-Diameter Hose. A number of trucks with powered hose reels with various hose load capacities are now in use. *(See Figure D-1.5.)*

Figure D-1.3(b) Large-diameter hose with a flat lay in the hose bed.

Figure D-1.5 Apparatus with reels for large-diameter hose.

Much of the lightweight large-diameter hose now available is of a construction that permits field cleaning and does not require drying. The use of the reel truck permits rapid reloading using a minimum number of personnel (two), and the unit is capable of service within minutes.

Double reels mounted in the hose bed of a reel truck can produce a carrying capacity for large-diameter hose of up to 6000 ft (1829 m). The large-diameter hose then becomes equivalent to over 1 mi (1.6 km) of aboveground water main.

Such reel trucks generally require special power-driven systems to rewind the hose. The size of the reels is not conducive to fitting on most standard fire department pump bodies. Therefore, trucks specially designed for this operation are generally used as hose reel vehicles.

D-1.6 Fittings. Large-diameter hose is available from many fire hose manufacturers with either standard threaded couplings or quick-connect hermaphrodite-type fittings that eliminate the male-female feature of couplings and, consequently, many adapters.

Special fittings *(see D-1.6.1 through D-1.6.7)* have been developed to be used with large-diameter hose.

D-1.6.1 Clappered Siamese Connection. A clappered siamese connection added to the supply line one length from the hydrant or pumper at draft allows for the addition of a second pumper without shutting down the flow of water. *(See Figure D-1.6.1.)*

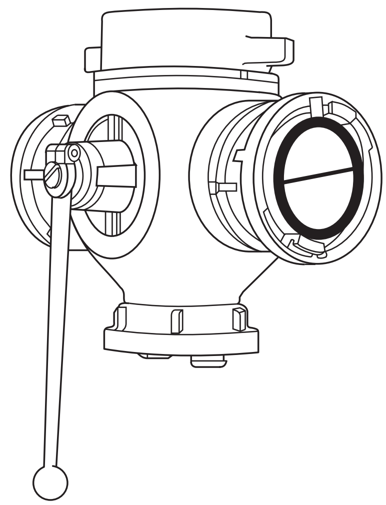
Figure D-1.6.1 Clappered siamese connection.

Figure D-1.6.2 Line relay valve.

D-1.6.2 Line Relay Valve. If relay pumping is required, a line relay valve is inserted during the hose lay. This valve has a straight-through waterway, so water delivery can be started upon completion of the lay. The valve contains a gated outlet and a clappered inlet. Upon arrival of the relay pumper, a line is attached from the gated outlet to the suction of the pump, with a discharge line connected from the pump discharge into the clappered inlet. The pump pressure closes the clapper, and the full flow is relayed to the fireground or another relay pumper. In addition, this valve contains an automatic air bleeder and a pressure dump valve set at 150 psi (1034 kPa). It is important to note that the relay pumper can be added to or removed from the line without shutting down the flow of water to the fireground. *(See Figure D-1.6.2.)*

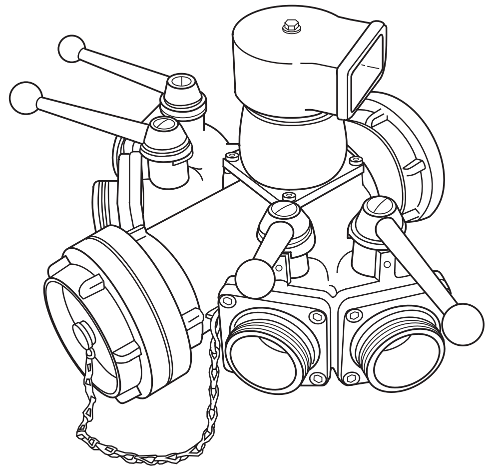
D-1.6.3 Hydrassist Valve. A hydrassist valve is a versatile valve that can be utilized on a hydrant where water is available but pressure is limited. The valve is attached to the hydrant and the normal lay of supply line is initiated. Where additional pressure is required, a pumper is attached to the valve and begins boosting pressure to the fire scene without interrupting the flow of water from hydrant to fire. In rural applications, this valve can be equipped to lie in a line during hose lay and to allow a pumper to hook into the line and boost pressure without interrupting flow to the fire scene. *(See Figure D-1.6.3.)*

Figure D-1.6.3 Hydrassist valve.



D-1.6.4 Manifold Valve. A manifold valve contains a 4-in. or 5-in. (102-mm or 127-mm) inlet and four $2^{1}/_{2}$-in. (64-mm), gated, threaded male or female outlets, as well as a gated 4-in. or 5-in. (102-mm or 127-mm) outlet. The manifold is available with a relief valve that is adjustable from 50 psi to 200 psi (345 kPa to 1379 kPa). A pressure gauge is optional. The manifold is portable, allowing the fire department to establish its own portable hydrant. *(See Figure D-1.6.4.)*

Figure D-1.6.4 Manifold valve.



D-1.6.5 Distributor Valve. A distributor valve contains a 4-in. (102-mm) opening and waterway with two $2^1/_2$-in. (64-mm) threaded male outlets. It is placed at the end of the supply line at the fireground, allowing distribution of water to one or more attack pumpers. The valve utilizes ball shutoffs plus an adjustable dump valve. *(See Figure D-1.6.5.)*

Figure D-1.6.5 Distributor valve.

D-1.6.6 Incoming Gated Relief Valve. An incoming gated relief valve is attached to the large suction inlet of the pumper. The supply line is connected directly to the valve. It is equipped with a fine-threaded, slow-acting gate valve, an automatic air bleeder, and an adjustable dump valve. The gate valve allows connection to the supply line while utilizing the booster tank water. It is also used to control the volume of water from the supply line to the pump. The dump valve helps protect the pumper and supply line against sudden pressure surges and water hammer. *(See Figure D-1.6.6.)*

D-1.6.7 Automatic Air Bleeder. An automatic air bleeder is needed at all points where a large-diameter hose is connected to an engine inlet or at any distribution point. *(See Figure D-1.6.7.)*

Figure D-1.6.6 Incoming gated relief valve.

Figure D-1.6.7 Automatic air bleeder.

D-1.7 Irrigation Piping. Irrigation piping shares the characteristics of low friction loss and capability of transferring large volumes of water with large-diameter hose. The use of irrigation is increasing throughout the country, which has resulted in much lightweight aluminum pipe becoming available to the fire service. It can be carried on vehicles or used where available on the fireground in farming areas. The fire department should be aware of the potential hazards to which an irrigation system might apply.

Irrigation pipe can be coupled, but usually the couplings are not of a type that permits drafting. The pipe has the advantage of being a relatively permanent installation for long-duration fire fighting and is not susceptible to the rupture problems of fire hose. Generally, it is an excellent tool for major disaster situations but is less often used for conventional fire-fighting evolutions, especially since the introduction of large-diameter fire hose.

Departments working in areas in which piped irrigation systems are used should be aware that adapters might be needed to turn conventional agricultural fittings into useful fireground fit-