NFPA®

1142

Standard on Water Supplies for Suburban and Rural Firefighting

2022

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NFPA® 1142

Standard on

Water Supplies for Suburban and Rural Firefighting

2022 Edition

This edition of NFPA 1142, *Standard on Water Supplies for Suburban and Rural Firefighting*, was prepared by the Technical Committee on Wildland and Rural Fire Protection. It was issued by the Standards Council on May 24, 2021, with an effective date of June 13, 2021, and supersedes all previous editions.

This edition of NFPA 1142 was approved as an American National Standard on June 13, 2021.

Origin and Development of NFPA 1142

This document originally was issued in 1968 as a tentative document titled NFPA 25, *Recommended Practices for Water Supply Systems for Rural Fire Protection*. It was reissued in 1969 without the tentative status. In 1975, the document was changed to a standard and renumbered and retitled as NFPA 1231, *Standard on Water Supplies for Suburban and Rural Fire Fighting*.

The standard continued to be maintained and enhanced with 1984, 1989, and 1993 editions. The 1999 edition was renumbered as NFPA 1142, in keeping with the committee's plan to group all its documents within a number range.

The 2001 edition incorporated much of the information about the design of dry hydrants, formerly found in the annexes, into the requirements to encourage improved design and performance.

The 2007 edition was completely revised to better organize the requirements in the standard and to better differentiate between alternative water supplies for firefighting and municipal-type water systems. The material in Annex A on designing dry hydrant systems was reorganized and updated into a separate Annex I. The other annexes were reviewed and updated to reflect current practices.

In the 2012 edition of NFPA 1142, the Technical Committee updated several definitions to be consistent with the *NFPA Glossary of Terms*. Substantial changes in the 2012 edition included new material with guidance on bridge access to water sources, clarification of the working space surrounding dry hydrants, and additional annex material regarding water eductors and ejectors.

In the 2017 edition, the technical committee developed new text for alternative methods, modifications to the standard, and unit and formula consistency. The committee added text for alternative water supplies from storage tanks; however, the committee also specified that the storage tanks needed to be inspected and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. It was clarified that before combustibles can be brought to the site location, water supplies for fire protection systems need to be established. The technical committee removed significant text and tables relative to fire flow requirements, and instead opted to use the Verisk Analytics website (ISO) information. Finally, Annex J, Geospatial Support for Water Supply Planning, was added.

The 2022 edition incorporates several updates and clarifications with particular focus on water availability and availability studies.

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Committee Scope: This committee shall have the primary responsibility for documents on fire protection in wildland, rural, and suburban areas.

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NFPA 1142

Standard on

Water Supplies for Suburban and Rural Firefighting

2022 Edition

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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 Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex K.

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard identifies a method of determining the minimum requirements for alternative water supplies for structural firefighting purposes in areas where the authority having jurisdiction (AHJ) determines that adequate and reliable water supply systems for firefighting purposes do not otherwise exist.

1.1.2 An adequate and reliable municipal-type water supply is one that is sufficient every day of the year to control and extinguish anticipated fires in the jurisdiction, particular building, or building group served by the water supply.

1.2* Purpose. The purpose of this standard is to assist the AHJ to establish the minimum water supply necessary for structural firefighting purposes in those areas where it has been determined that there is no water or inadequate water for firefighting.

1.3 Application.

1.3.1 This standard does not address fireground operational procedures dealing with the rate or method of water application.

1.3.2* This standard does not apply to the calculation of 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.

1.3.3 This standard does not exclude the use of this water for other firefighting or emergency activities.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety in place of those prescribed by this standard, provided technical documentation is submitted to the AHJ to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

1.5 Alternatives. The specific requirements of this standard shall be permitted to be altered by the AHJ to allow alternative methods that will secure equivalent fire safety, but in no case shall the alternative afford less fire safety, in the judgment of the AHJ, than that which would be provided by compliance with the provisions contained in this standard.

1.6 Modifications. The AHJ is authorized to modify any of the provisions of this standard upon application in writing by the owner, a lessee, or a duly authorized representative where there are practical difficulties in the way of carrying out the provisions of the standard, provided that the intent of the standard shall be complied with, public safety secured, and substantial justice done.

1.7 Units and Formulas. In this standard, values for measurement in U.S. units are followed by equivalents in SI units. Either set of values can be used, but the same set of values (either U.S. units or SI units) shall be used consistently.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 2022 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,* 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2020 edition.

NFPA 220, *Standard on Types of Building Construction,* 2021 edition.

NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components,* 2019 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 2019 edition.

2.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code,* 2021 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 2022 edition.

NFPA *101*®, *Life Safety Code*®, 2021 edition.

NFPA 1140, *Standard for Wildland Fire Protection,* 2022 edition.

NFPA 1600®, *Standard on Continuity, Emergency, and Crisis Management,* 2019 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.

NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles,* 2017 edition.

NFPA 1925, *Standard on Marine Fire-Fighting Vessels,* 2018 edition.

NFPA 1961, *Standard on Fire Hose,* 2020 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2021 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary,* 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Shall. Indicates a mandatory requirement.

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

3.2.5 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Alternative Water Supply. Water supplies provided to meet the minimum fire flow/duration requirements where no municipal-type water system exists or to supplement an inadequate municipal-type water supply.

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

3.3.3* Availability. The average fraction of time for any given year that a defined usable volume is exploitable for structural firefighting purposes.

3.3.4* Availability Study. An evaluation of a water source performed by a qualified professional to assess the overall availability, inclusive of all adverse weather, seasonal variations, and operational conditions, of a defined usable volume of water.

3.3.5 Building. Any structure used or intended for supporting or sheltering any use or occupancy. [***101,*** 2021]

3.3.6 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.

3.3.7 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 firefighting purposes and that utilizes the drafting (suction) capability of a fire department pump.

3.3.8 Dwelling. Any detached building, or any part of a townhouse, back-to-back townhouse, or stacked townhouse structure that is separated from the remainder of the townhouse structure with fire resistance rated assemblies in accordance with local building code, that contains no more than two dwelling units intended to be used, rented, leased, let, or hired out to be occupied or that are occupied for habitation purposes. [**13D,** 2022]

3.3.9 Dwelling Unit. One or more rooms arranged for complete, independent housekeeping purposes, with space for eating, living, and sleeping; facilities for cooking; and provisions for sanitation. [**5000,** 2021]

3.3.10 Eductor. A device that uses the Venturi principle to siphon a liquid in a water stream. [**1925,** 2018]

3.3.11 Ejector. A siphon device used to fill an engine's tank when the water source is below or beyond the engine's drafting capability.

3.3.12* 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.

3.3.13* Fire Department. An organization providing fire suppression, rescue, and related activities.

3.3.14* Large Diameter Hose. A hose of 3½ in. (90 mm) or larger size. [**1961,** 2020]

3.3.15 Lift. The vertical height that water must be raised during a drafting operation, measured from the surface of a static source of water to the centerline of the pump intake. [**1911,** 2017]

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

3.3.17 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. [**1901,** 2016]

3.3.18 Municipal-Type Water System. A system having water pipes servicing fire hydrants and designed to furnish, over and above domestic consumption, a minimum of 250 gpm (950 L/min) at 20 psi (138 kPa) residual pressure for a 2-hour duration. [**1140,** 2022]

3.3.19* Mutual Aid/Assistance Agreement. A prearranged agreement between two or more entities to share resources in response to an incident. [**1600,** 2019]

3.3.20 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.

3.3.21 Qualified Person. A person that has the experience and training to perform a given task, as acceptable to the AHJ.

3.3.22 Qualified Professional. A registered professional engineer, hydrologist, geologist, soil conservationist, federal surface water specialist, or similarly qualified person.

3.3.23 Recognized Water Supply. A legally and physically accessible water source demonstrated to furnish a minimum flow rate of 250 gpm (950 L/min) for a 2-hour duration from a defined usable volume, as demonstrated by means of an availability study.

3.3.24 Reducer. A fitting used to connect a small hose line or pipe to a larger hose line or pipe.

3.3.25 Rural. Those areas that are not unsettled wilderness or uninhabitable territory but are sparsely populated with densities below 500 persons per square mile.

3.3.26 Structure. That which is built or constructed; an edifice or building of any kind, or any piece of work artificially built up or composed of parts joined together in some definite manner.

3.3.27* Suburb or Suburban. Those moderately inhabited areas with population densities of at least 500 persons per square mile but less than 1000 persons per square mile.

3.3.28* Usable Volume. The portion of a water source's total capacity that is available to support structural firefighting, considering the method of extraction, including required equipment clearances, as well as points of access.

3.3.29 Water Delivery Rate. The minimum amount of water per minute (in gpm or L/min), required by this standard or the AHJ, to be delivered to the fire scene via mobile water supply apparatus, hose lines, or a combination of both.

3.3.30* Water Supply Officer (WSO). The fire department officer or designee responsible for providing water for firefighting purposes.

Chapter 4 Calculating Minimum Water Supplies

4.1 General.

4.1.1 Prior to calculating the minimum water supply for a structure, the structure shall be surveyed to obtain the following information:

(1) Occupancy hazard
(2) Type of construction
(3) Structure dimensions (length, width, and height)
(4) Exposures, if any

4.1.1.1 For new construction, plans shall be submitted to the fire department or the AHJ for determination of the minimum water supply required before construction is started.

4.1.1.2 Changes made in the structural design, dimensions, occupancy, or contents of a planned or existing structure that affect the occupancy hazard or the construction type shall require that the structure be resurveyed to determine if changes are necessary in the minimum water supply required.

4.1.1.3 If there are changes in automatic fire suppression systems in a structure that would affect the protection afforded, the property owner(s) shall notify the AHJ in writing of such changes, including temporary impairment.

4.1.2* The methodology in this chapter shall be used to calculate the required minimum water supply necessary for structural firefighting purposes.

4.1.3* The minimum requirements shall be subject to increase by the AHJ to compensate for particular conditions such as the following:

(1) Limited fire department resources
(2) Extended fire department response time or distance
(3) Potential for delayed discovery of the fire
(4) Limited access
(5) Hazardous vegetation
(6) Structural attachments, such as decks and porches
(7) Unusual terrain
(8) Special uses and unusual occupancies

4.1.4 The AHJ shall be permitted to specify how the water supplies required in this document are provided, giving consideration to local conditions and need.

4.1.5 For the purpose of calculating minimum water supply requirement, a structure shall be considered an exposure hazard under the following conditions:

(1) It is 100 ft^2 (9.3 m^2) or larger in area and is within 50 ft (15.24 m) of another structure.
(2) The structure, regardless of size, is of occupancy hazard classification 3 or 4 as determined in Chapter 5 and is within 50 ft (15.24 m) of another structure.

4.2 Structures Without Exposure Hazards.

4.2.1* For structures with no exposure hazards, the minimum water supply, in gallons (liters), shall be determined by calculating the total enclosed volume, in cubic feet (cubic meters), of the structure, including any attached structures, dividing by the occupancy hazard classification number as determined from Chapter 5, and multiplying by the construction classification number as determined from Chapter 6 as follows:

[4.2.1]

$$WS_{min} = \frac{VS_{tot}}{OHC}(CC)$$

where:

WS_{min} = minimum water supply in gal (For results in L, multiply by 3.785.)
VS_{tot} = total volume of structure in ft^3 (If volume is measured in m^3, multiply by 35.3.)
OHC = occupancy hazard classification number
CC = construction classification number

4.2.2 The minimum water supply required for any structure without exposure hazards shall not be less than 2000 gal (7600 L).

4.3 Structures with Exposure Hazards.

4.3.1* For structures with unattached structural exposure hazards, the minimum water supply, in gallons (liters), shall be determined by calculating the total enclosed volume, in cubic feet (cubic meters), of the structure, dividing by the occupancy hazard classification number as determined from Chapter 5, multiplying by the construction classification number as determined from Chapter 6, and multiplying by 1.5 as follows:

[4.3.1]

$$WS_{min} = \frac{VS_{tot}}{OHC}(CC) \times 1.5$$

where:

WS_{min} = minimum water supply in gal (For results in L, multiply by 3.785.)
VS_{tot} = total volume of structure in ft^3 (If volume is measured in m^3, multiply by 35.3.)
OHC = occupancy hazard classification number
CC = construction classification number

4.3.2 The minimum water supply required for a structure with exposure hazards shall not be less than 3000 gal (11,355 L).

4.4* Structures with Automatic Sprinkler Protection.

4.4.1 The AHJ shall be permitted to reduce the water supply required by this standard for manual firefighting purposes when a structure is protected by an automatic sprinkler system that fully meets the requirements of NFPA 13, NFPA 13D, or NFPA 13R. *(See Annex F.)*

4.4.2 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.

4.5 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 4.4, the AHJ shall determine the minimum water supply required for firefighting purposes.

4.6 Water Delivery Rate to the Fire Scene.

4.6.1 The minimum water supply determined using Sections 4.2 through 4.5 shall be delivered in accordance with Table 4.6.1.

Table 4.6.1 Water Delivery Rate

Total Water Supply Required		Water Delivery Rate	
gal	L	gpm	L/min
<15,000	<56,780	250	950
15,001–22,500	56,785–85,170	500	1,900
22,501–30,000	85,175–113,560	750	2,850
>30,000	>113,560	1,000	3,800

4.6.2 The AHJ shall be permitted to adjust the water delivery rate, giving consideration to local conditions and need.

4.6.3 The minimum water delivery rate shall not be less than 250 gpm (950 L/min).

4.7 Other Uses. Water supplies developed to meet this standard shall be permitted to be used for fighting fires in other than structures or for use during other emergency activities.

Chapter 5 Classification of Occupancy Hazard

5.1 General.

5.1.1 This chapter shall be used to determine the occupancy hazard classification number used in the calculation of water supply requirements in Chapter 4.

5.1.2 Where more than one occupancy is present in a structure, the occupancy hazard classification number for each occupancy shall be determined separately, and the classification number for the most hazardous occupancy shall be used for the entire structure.

5.2* Occupancy Hazard Classification Number.

5.2.1 Occupancy Hazard Classification Number 3.

5.2.1.1* Occupancy hazard classification number 3 shall be used for severe hazard occupancies.

5.2.1.2 Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 3:

(1) Cereal or flour mills
(2) Combustible hydraulics
(3) Cotton picking 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 particleboard 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

5.2.2 Occupancy Hazard Classification Number 4.

5.2.2.1* Occupancy hazard classification number 4 shall be used for high hazard occupancies.

5.2.2.2 Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 4:

(1) Barns and stables (commercial)
(2) Building materials supply storage
(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

5.2.3 Occupancy Hazard Classification Number 5.

5.2.3.1 Occupancy hazard classification number 5 shall be used for 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.

5.2.3.2 Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 5:

(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

5.2.4 Occupancy Hazard Classification Number 6.

5.2.4.1 Occupancy hazard classification number 6 shall be used for low hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively low rates of spread and heat release.

5.2.4.2 Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 6:

(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

5.2.5 Occupancy Hazard Classification Number 7.

5.2.5.1 Occupancy hazard classification number 7 shall be used for light hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively light rates of spread and heat release.

5.2.5.2 Occupancies having conditions similar to the following shall be assigned occupancy hazard classification number 7:

(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 6 Classification of Construction

6.1 General.

6.1.1 This chapter shall be used to determine the construction classification number used in the calculation of water supply requirements in Chapter 4.

6.1.2 Where more than one type of construction is present in a structure, the classification number for each type of construction shall be determined separately, and the higher construction classification number shall be used for the entire structure.

6.2* Construction Classification Number.

6.2.1 The construction classification number shall be as shown in Table 6.2.1 based on the construction of the structure as determined in accordance with Section 6.3.

6.2.2 For dwellings, the maximum construction classification number shall be 1.0.

6.3 Classification of Types of Building Construction.

6.3.1* Classification of types of building construction shall be in accordance with 6.3.3 through 6.3.7 and Table 6.3.1.

Table 6.2.1 Construction Classification Number

Construction Type	Classification Number
Type I (442 or 332)	0.5
Type II (222, 111, or 000)	0.75
Type III (211 or 200)	1.0
Type IV (2HH)	0.75
Type V (111 or 000)	1.5

6.3.2 If the type of construction of the structure has been determined using NFPA 220 that type of construction shall be permitted to be used in lieu of determining the type of construction in accordance with 6.3.3 through 6.3.7.

6.3.3 Type I (442 or 332) Construction.

6.3.3.1 Type I (442 or 332) construction shall be those types in which the fire walls, structural elements, walls, arches, floors, and roofs are of approved noncombustible or limited-combustible materials.

6.3.3.2 Structural members shall have fire resistance ratings not less than those specified in Table 6.3.1.

Table 6.3.1 Fire Resistance Ratings for Type I through Type V Construction (hr)

	Type I		Type II			Type III		Type IV	Type V	
	442	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	2	2	2	1	0
Supporting one floor only	4	3	2	1	0	2	2	2	1	0
Supporting a roof only	4	3	1	1	0	2	2	2	1	0
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*	1	0
Supporting one floor only	3	2	2	1	0	1	0	H*	1	0
Supporting roofs only	3	2	1	1	0	1	0	H*	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*	1	0
Supporting one floor only	2	2	2	1	0	1	0	H*	1	0
Supporting roofs only	2	2	1	1	0	1	0	H*	1	0
Floor Construction	2	2	2	1	0	1	0	H*	1	0
Roof Construction	2	1½	1	1	0	1	0	H*	1	0
Interior Nonbearing Walls	0	0	0	0	0	0	0	0	0	0
Exterior Nonbearing Walls†	0	0	0	0	0	0	0	0	0	0

Note: Shaded columns indicate those members that are permitted to be of approved combustible material.
*"H" indicates heavy timber members; see 6.3.6 for requirements.
†Exterior nonbearing walls meeting the conditions of acceptance of NFPA 285 are permitted to be used.

6.3.4 Type II (222, 111, or 000) Construction.

6.3.4.1 Type II (222, 111, or 000) construction shall be those types not qualifying as Type I construction in which the fire walls, structural elements, walls, arches, floors, and roofs are of approved noncombustible or limited-combustible materials.

6.3.4.2 Structural members shall have fire resistance ratings not less than those specified in Table 6.3.1.

6.3.5 Type III (211 or 200) Construction.

6.3.5.1 Type III (211 or 200) 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.

6.3.5.2 Fire walls, interior structural elements, walls, arches, floors, and roofs shall be permitted to be entirely or partially constructed of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited-combustible, or other approved combustible materials.

6.3.5.3 In addition, structural members shall have fire resistance ratings not less than those specified in Table 6.3.1.

6.3.6 Type IV (2HH) Construction.

6.3.6.1 Type IV (2HH) construction shall be that type in which fire walls, exterior walls, and interior bearing walls and structural elements that are portions of such walls are of approved noncombustible or limited-combustible materials.

6.3.6.1.1 Other interior structural elements, arches, floors, and roofs shall be of solid or laminated wood without concealed spaces and shall comply with the allowable dimensions of 6.3.6.5 through 6.3.6.10.

6.3.6.1.2 In addition, structural members shall have fire resistance ratings not less than those specified in Table 6.3.1.

6.3.6.2 Interior columns, arches, beams, girders, and trusses of approved materials other than wood shall be permitted, provided they are protected to provide a fire resistance rating of not less than 1 hour.

6.3.6.3 Certain concealed spaces shall be permitted in accordance with 6.3.6.7.4.

6.3.6.4 All dimensions in 6.3.6.5 through 6.3.6.10 shall be considered nominal.

6.3.6.5 Columns.

6.3.6.5.1 Wood columns supporting floor loads shall be not less than 8 in. (200 mm) in any dimension.

6.3.6.5.2 Wood columns supporting only roof loads shall be not less than 6 in. (150 mm) in width and not less than 8 in. (200 mm) in depth.

6.3.6.6 Beams.

6.3.6.6.1 Wood beams and girders supporting floor loads shall be not less than 6 in. (150 mm) in width and not less than 10 in. (250 mm) in depth.

6.3.6.6.2 Wood beams and girders and other roof framing supporting only roof loads shall be not less than 4 in. (100 mm) in width and not less than 6 in. (150 mm) in depth.

6.3.6.7 Arches.

6.3.6.7.1 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. (200 mm) in width or depth.

6.3.6.7.2 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. (150 mm) in width and not less than 8 in. (200 mm) in depth for the lower half of the member height, and not less than 6 in. (150 mm) in depth for the upper half of the member height.

6.3.6.7.3 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. (100 mm) in width and not less than 6 in. (150 mm) in depth.

6.3.6.7.4 Spaced members shall be permitted to be composed of two or more pieces not less than 3 in. (75 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. (50 mm) in thickness that is secured to the underside of the members.

6.3.6.8 Splice Plates. Splice plates shall be not less than 3 in. (75 mm) in thickness.

6.3.6.9 Floors. Floors shall be constructed of spline or tongue-and-groove plank not less than 3 in. (75 mm) in thickness that is covered with 1 in. (25 mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½ in. (12.5 mm) wood structural panel; or they shall be constructed of laminated planks not less than 4 in. (100 mm) in width, set close together on edge, spiked at intervals of 18 in. (460 mm), and covered with 1 in. (25 mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½ in. (12.5 mm) wood structural panel.

6.3.6.10 Roof Decks. Roof decks shall be constructed of spline or tongue-and-groove plank not less than 2 in. (50 mm) in thickness; or of laminated planks not less than 3 in. (75 mm) in width, set close together on edge, and laid as required for floors; or of 1⅛ in. (28.5 mm) thick interior wood structural panel (exterior glue); or of approved noncombustible or limited-combustible materials of equivalent fire durability.

6.3.7 Type V (111 or 000) Construction. Type V (111 or 000) 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 6.3.1.

Chapter 7 Water Supply

7.1 Approved Water Supply.

7.1.1* Any water supply source used to meet the requirements of this standard shall be of a quality approved by the AHJ.

7.1.2 Where required by the AHJ, the minimum water supply shall be available prior to combustibles being brought on site.

7.1.3 Water storage tanks shall be inspected, tested, and maintained in accordance with NFPA 25.

7.1.4 The water supply source shall be maintained and accessible on a year-round basis.

7.1.5 In locations where adequate municipal-type water systems are not provided and additional fire protection is needed, minimum water supplies shall be established in, or transportable to, the designated area.

7.1.6 Unless otherwise permitted by the AHJ, all approved nonpressurized water supply sources shall be accessible using dry hydrants that meet the requirements of this standard.

7.1.7 Water supply sources shall maintain a usable volume that is consistent with the minimum capacity and delivery requirements prescribed in this standard and that is of adequate availability, as demonstrated by an availability study.

7.1.7.1 The availability study shall consider all relevant adverse weather conditions or seasonal variations, corresponding, at a minimum, to a 20-year recurrence interval (5 percent annual exceedance probability), or an equivalent measure acceptable to the AHJ.

7.1.7.2 The availability study shall consider significantly adverse operational events and conditions applicable to the method of extraction, including those related to access, equipment reliability, and maintenance practices.

7.1.7.3 The total average availability on an annual basis shall be no less than 95 percent, or an equivalent measure acceptable to the AHJ.

7.1.8 Where required by the AHJ, a recognized water supply shall be provided in lieu of the minimum water supply, as determined in Chapter 4.

7.2* Water Use Agreements. If a private water supply source is to be used to meet the requirements of this standard, a legal agreement establishing access to and use of the water source shall be recorded.

7.3 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.

7.4 Fire Hose Connections. Any fitting provided at a water source to permit a fire apparatus to connect to the water source shall be approved by the AHJ and shall conform to NFPA 1963.

7.5* Access to Water Sources. Roads providing a means of access to any required water supply shall be constructed and maintained in accordance with the following:

(1) Roadways shall have a minimum clear width of 12 ft (3.7 m) for each lane of travel.
(2) Turns shall be constructed with a minimum radius of 100 ft (30.5 m) to the centerline.
(3) The maximum sustained grade shall not exceed 8 percent.
(4) All cut-and-fill slopes shall be stable for the soil involved.
(5) Bridges, culverts, or grade dips shall be provided at all drainageway crossings; roadside ditches shall be deep enough to provide drainage with special drainage facilities (tile, etc.) at all seep areas and high water-table areas.
(6) The surface shall be treated as required for year-round travel.
(7) Erosion control measures shall be used as needed to protect road ditches, cross drains, and cut-and-fill slopes.
(8)* Where turnarounds are utilized during firefighting operations, they shall be designed with a diameter of 120 ft (36.5 m) or larger, as required, to accommodate the equipment of the responding fire department.
(9) Load-carrying capacity shall be adequate to carry the maximum vehicle load expected.
(10) The road shall be suitable for all-weather use.
(11) When a bridge is required to be used as part of a fire apparatus access road, it shall be constructed and maintained in accordance with nationally recognized standards. [**1:**18.2.3.5.5.1]
(12) The bridge shall be designed for a live load sufficient to carry the imposed loads of fire apparatus. [**1:**18.2.3.5.5.2]
(13) Vehicle load limits shall be posted at both entrances to bridges where required by the AHJ. [**1:**18.2.3.5.5.3]

7.6* Mobile Water Supply Training. The AHJ shall determine what training is required of the fire department personnel involved in mobile water supply operations.

7.7 Records.

7.7.1* A record of each water supply shall be prepared and periodically updated.

7.7.2 The records shall be retained in accordance with the record retention policy of the jurisdiction or state.

7.7.3 Records developed to meet the requirements of this standard shall be retained for a minimum of 3 years after the agreement, facility, or equipment is no longer used for its original purpose.

Chapter 8 Dry Hydrants

8.1* Chapter Scope. This chapter covers the planning, permitting, design, installation, inspection, and maintenance of dry hydrants.

8.2 Planning and Permits. The planning, permitting, and design processes shall be completed before the actual construction begins.

8.2.1 Planning shall be coordinated among public and private entities that could be impacted by the installation of a dry hydrant.

8.2.2* Required permits to install a dry hydrant shall be obtained prior to installation.

8.3* Dry Hydrant Design.

8.3.1* The AHJ shall approve all aspects of the dry hydrant design and construction, including the type of materials, pipe size, system fittings to be used, and qualifications of the installers.

8.3.2* As a minimum, Schedule 40 pipe and component fittings shall be used.

8.3.3* All dry hydrant systems shall be designed and constructed to provide a minimum flow of 1000 gpm (3800 L/min) at draft.

8.3.4* The water supply source for the dry hydrant shall provide, on a year-round basis, the required quantity of water, as determined in Chapter 4, and the minimum flow as required in 8.3.3.

8.3.5* Dry hydrant systems shall be designed and constructed so that slope and piping configurations do not impede drafting capability.

8.3.6* All exposed surfaces and all underground metal surfaces shall be protected to prevent deterioration.

8.3.7* A minimum number of elbows shall be used in the piping system.

8.3.8 Suction hose connection(s) shall be compatible with the fire department's hard suction hose size and shall conform to NFPA 1963. The connection(s) shall include a protective cap. The cap and adapter shall be of materials that minimize rust and galvanic corrosion.

8.3.9 Dry hydrant system piping shall be supported and/or stabilized using approved engineering design practices.

8.3.10 Stabilization, pipe restraints, or equivalent protection shall be employed at elbows, joints, and other system stress points.

8.3.11 In addition to strength of materials and structural support criteria, design shall specify appropriate aggregates and soil materials to be used to backfill/cover piping during installation.

8.3.12 All connections shall be clean, and the appropriate sealing materials shall be used according to manufacturer's specifications so as to ensure that all joints are airtight.

8.3.13* System strainers shall be constructed to permit required fire flow.

8.4* Dry Hydrant Locations.

8.4.1 A minimum of 3 ft (0.9144 m) of clear, unobstructed space shall be provided around the dry hydrant.

8.4.2* Dry hydrants shall be located so that they are accessible under all weather conditions.

8.4.3 The dry hydrant system and access to the site shall be developed in a manner that allows the fire department pump to connect to the hydrant using not more than 20 ft (6 m) of hard suction hose.

8.4.4 Dry hydrants shall be located a minimum of 100 ft (30 m) from any structure.

8.4.5 No parking or other obstacles shall be allowed within 20 ft (6 m) of the access side of the hydrant.

8.4.6* Dry hydrants shall be protected from damage by vehicular and other perils, including freezing and damage from ice and other objects.

8.4.7* Dry hydrant locations shall be made visible from the main roadway by reflective marking and signage approved by the AHJ.

8.4.8 All identification signs shall be approved by the highway authority prior to installation if they are to be located on the right-of-way or are subject to state laws.

8.5* Strainer Clearance.

8.5.1 There shall be not less than 2 ft (0.6 m) of water above the strainer and not less than 1 ft (0.3 m) below the strainer, unless otherwise authorized by the AHJ.

8.5.2 Placement of the strainer shall be established in consideration of the availability study in accordance with 7.1.7 to ensure the availability of water.

8.6* Installation Procedure for Dry Hydrant System. The AHJ shall ensure that the installation meets all design criteria.

8.7 Inspection, Testing, and Maintenance of Dry Hydrants.

8.7.1* Dry hydrants shall be inspected at least quarterly and maintained as necessary to keep them in good operating condition.

8.7.2 Thorough surveys shall be conducted, to reveal any deterioration in the water supply situation in ponds, streams, or cisterns.

8.7.3 Vegetation shall be cleared for a minimum 3 ft (0.9 m) radius from around hydrants.

8.7.4 The reflective material marking the hydrant and signage shall be inspected at least annually to verify that it is being maintained in accordance with 8.4.7.

8.7.5 Hydrant risers shall be protected from ultraviolet (UV) degradation by painting or other measures.

8.7.6* The hydrants shall be flow tested at least annually with an approved pump to ensure that the minimum design flow is maintained.

8.7.7 Inspection, testing, and maintenance of dry hydrants shall be performed by a qualified person.

8.8* Records for Dry Hydrants. The AHJ shall maintain, in a safe location, maps and records of each dry hydrant installation and the subsequent tests, inspections, maintenance, and repairs to the dry hydrant.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex 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 could be equipped with hydrants that might not have the volume, pressure, and duration of flow needed for adequate firefighting purposes. Where such conditions exist, this standard and annex should be applied in water supply matters.

A.1.3.2 Locations such as these require individual evaluations to determine the minimum water supply to protect the hazards present.

A.3.2.1 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.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, 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.3.3.3 Availability. Factors that can reduce the availability of a defined usable volume of water include adverse weather conditions and seasonal variations (e.g., drought, freezing temperatures, and flooding). Additionally, based on the method of extraction, adverse operational conditions, including those as a result of reliability issues and maintenance practices, might need to be considered. Consideration should be given as to how accessibility can vary or be precluded during certain times of the year.

A.3.3.4 Availability Study. There are many different types of bodies of water that can be used as water sources for alternative water supplies. Therefore, one type of study cannot apply to all water sources.

In some instances, a detailed analysis is required. In other instances, the fire department's methods of operation and the limitations of those operations can be reviewed in conjunction with the historical low-water records for the water source to determine if an acceptable amount of water can be acquired.

The following types of water sources and evaluation methods provide additional guidance on the recognition and recertification process.

Impounded Ponds. These very small reservoirs are created by damming minor perennial or intermittent streams. A typical example would be a small pond created for livestock or irrigation purposes on an agricultural property. Water supply levels in these ponds can be highly dependent on runoff from the feeding watershed, although some inputs from direct precipitation and groundwater infiltration are possible. These are further differentiated from other types of reservoirs by the fact that the water level is not actively managed, although a maximum water level can be maintained by means of pipe outlets or spillways. Significant water loss can occur through evaporation, transpiration, and irrigation.

These ponds can be effectively modeled by using the United States Department of Agriculture's (USDA) Natural Resources Conservation Service's (NRCS) Reservoir Operations (RESOP), the Soil, Plant, Atmosphere, Water (SPAW) program, or other similar water-budget methods. The main parameters of these programs to be considered include the inflow of water sources such as ground wells, precipitation, and runoff from watershed areas, as well as the outflow caused by evaporation, transpiration, seepage, irrigation, and livestock demands. High storage and low storage limitations of the pond should not be dismissed in the evaluation. The low water stage storage elevation should be identified and compared to the fire department's methods of operation to determine the recognition status.

For initial recognition, estimates of minimum usable volume and allowable extraction rates and durations should be obtained from a qualified professional. Special attention should be given to the impacts of freezing and drought on usable water volume and accessibility. Documentation of how the water will be extracted (e.g., dry hydrants or pumping apparatus) and access permission should be provided by the fire department. Regular annual recertification of these sources is done by visually observing low water occurrences. This process is critical, due to their small size and dynamic nature. Volume must be re-assessed, and documentation of annual dry hydrant flow tests and extended periods of low water stage storage events must be documented, maintained, and evaluated for continued recognition by the fire department.

Irrigation Wells. Drawing from groundwater, these systems have an effectively unlimited volume, but the flow rate and duration will vary. Data concerning the flow rate, flow duration, and any potential limitations should be obtained from the results of a well drawdown test or an analysis from a ground water flow model. For initial recognition, the availability of the water source and pumping operations, estimates of the minimum usable volume, allowable extraction rates and durations should be evaluated by a qualified professional. The recertification of the sources should be based on the performance of the wells, or as determined by the AHJ. A well that produces plenty of water, recovers quickly, and has a small drawdown might need only routine checks. Other wells might need to be monitored constantly.

Large Inland Lakes. Some very large lakes occurring far from the coast, such as the Great Lakes, have characteristics of both post-glacial water bodies and inland seas. These massive freshwater lakes are unique in terms of volume and stability and generally represent excellent sources of fire protection water. Some features, such as a long and gradually-tapering littoral zone, can make the installation of dry hydrants challenging when considering beach areas for supply sources. Where deep inlets exist or have been created, local depth profiles may be excellent for dry hydrant installations. It is difficult to consider these lakes in a general fashion because, like the sea, their characteristics are highly dependent on local littoral conditions. Detailed bathymetric data is often readily available from National Oceanic and Atmospheric Administration (NOAA) and state agencies to facilitate local assessments. The volume of these lakes is essentially unlimited, but accessibility can still be an issue due to tidal influences or during freezing conditions. Special attention should be paid to the location and viability of any dry hydrants or other drafting points used for access. Volume will likely require recertification, but the documentation of annual flow tests for any dry hydrants should be provided in order to ensure continued serviceability.

Large Reservoirs. These are large-scale water bodies created by the impoundment of one or more major perennial streams. The dams used to create these reservoirs are typically large-scale, and can often include significant amounts of concrete, although some parts can be of earthen construction.These large, deep-water bodies, have water column zonation like natural lakes. This category is meant to capture those large reservoirs created by the Tennessee Valley Authority (TVA), United States Army Corps of Engineers, and similar agencies. These are generally multi-use reservoirs that supply drinking and irrigation water, provide recreation, and provide protection from floods. Active management of water levels is the hallmark of this category, and full-time staff is normally involved in managing these reservoirs and dams. Modeling of depth for fire protection purposes will be simplified by the fact of this active and intentional management. Accessibility can still be an issue when water levels are lowered, or during freezing conditions. Documentation of volume estimates can be provided by the owning agency, but special attention should be paid to the location and viability of any dry hydrants or other drafting points used for access. Volume will likely not require recertification, but documentation of annual flow tests for any dry hydrants should be provided to ensure continued serviceability.

Seawater. In coastal areas, the ocean can represent an abundant and readily accessed source of fire protection water. Volume is not an issue, although depth can be highly variable due to local tidal and littoral characteristics. Due to highly variable local conditions, it is difficult to consider maritime areas in a general way. Detailed bathymetric and tide data is often readily available from NOAA and state agencies to facilitate local assessments. Special attention should be paid to the location and viability of any dry hydrants or other drafting points used for access. Documentation of annual flow tests for any dry hydrants should be provided to ensure continued serviceability.

Storage Tanks. The initial recognition of the availability study should include an examination of the design and installation by a qualified professional. This should be done to include an assessment of the filling mechanism's reliability and flow capacities. Recertification should include the verification of regular flow testing to ensure that the capability of the source has not declined due to corrosion, encrustation, or siltation. Recertification should also include an examination of the filling mechanism to ensure that it is still valid.

Streams. These are naturally-occurring water bodies that convey runoff and groundwater from higher to lower elevations within a watershed. Many streams have been dramatically modified from their natural conditions, but all still follow the same general course from headwaters to outlets. Included in this category are water bodies bearing diverse local names: river, creek, branch, run, brook, and fork, among others. Since there is no universally-accepted naming convention, and because the size and flow of streams varies considerably along their course, they are all grouped together under the term "stream." Streams can be perennial with a base flow at all times, or intermittent with seasonal periods of no flow. Water volume and flow is maintained by a combination of overland runoff and groundwater inputs. The flow can be highly variable in many streams due to seasonal fluctuations in precipitation. Extraction of water for industrial or irrigation purposes could reduce flow considerably over expected volumes.

Only perennial streams should be considered for recognition, since intermittent and ephemeral streams have no flow at certain times. For perennial streams, overall volume is essentially infinite, but the rate at which it can be extracted can be dictated by the flow. Where available, low-flow estimates from the United States Geological Survey (USGS) StreamStats model, as interpreted by a qualified professional, should be used to determine the suitability of a proposed draft site for recognition. Where StreamStats low- flow estimates are not available, local conservation district or USDA NRCS staff should be able to provide reliable estimates in gaged reaches of the stream. In ungaged reaches, a qualified hydrologist will be required. Dry hydrants can be installed in the stream bed or mounted on bridges over the stream. In the case of bridge-mount dry hydrants that are stowed out of the water, documentation of ice-free conditions during an extended cold period should be provided. Specialized dry hydrant components can operate in low-depth conditions and can allow for successful installations in somewhat shallow stream reaches. Although stream volume is essentially infinite, the usable flow will dictate the frequency of the recertification interval. Any major new withdrawals from the stream, such as those done for new irrigation systems, should trigger an early recertification assessment. Exploitable volumes and flow duration must be determined by a qualified professional. Documentation of annual flow tests for any dry hydrants should also be provided to ensure continued serviceability.

A.3.3.12 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.3.3.13 Fire Department. The AHJ and the fire department having jurisdiction can be the same agency. The term *fire department* includes any public, governmental, private, industrial, tribal, or military organization engaging in this type of activity.

A.3.3.14 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 up to at least 275 psi (1895 kPa).

A.3.3.19 Mutual Aid/Assistance Agreement. 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.3.3.27 Suburb or Suburban. Suburban areas can include populous towns or large villages or be located outside the official limits of a densely settled city of 2500 to 50,000 people per census block, or those areas that interface with the outer rim of an urban cluster (UC). Suburban communities usually exist within commuting distance of urban areas but exhibit their own jurisdictional autonomy.

A.3.3.28 Usable Volume. Usable volume is typically the portion of water storage that is above the required clearance level of a strainer and below the maintained or historically low stage storage elevation of the water body. Note that the accessibility to the usable volume can be greatly influenced by fluctuating water boundaries (e.g., shorelines) as well as the fire department's methods of operation.

A.3.3.30 Water Supply Officer (WSO). Many progressive rural fire departments depend on a water supply officer (WSO). The

WSO is the individual who implements the water supply pre-fire planning. The work of a properly trained and equipped WSO makes it possible for the officer supervising the actual fire attack to operate on the basis of reliable water supply information, to coordinate the attack with the available water supplies, and to avoid diverting his or her attention from the attack to the logistics of backing it up with an adequate water supply.

The WSO's overall responsibilities are to determine water supply requirements of the targeted structures, to plan availability of and access to water sources, and to ensure sufficient water is provided at each fire site. The WSO should maintain and have available a complete set of files, including locations of water sources and lists of available automatic and mutual aid mobile water supply apparatus. Modern technology in computers makes it feasible for even a relatively low-budget department to reduce this data to electronic files that can be maintained at the fire alarm communication center and provided at the scene of every fire.

The WSO participates in the pre-fire planning and in calculating the water supply requirements for the various buildings in the area under the department's jurisdiction. To satisfy these water supply requirements, the WSO should survey the district and the surrounding areas for available water for firefighting 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. The WSO maintains close coordination with the fire department training officer and provides 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.

A list of all apparatus, equipment, and personnel available to the WSO's department should be developed. Arrangements should be developed for specific apparatus and personnel to respond under an automatic aid agreement (first alarm response) or a mutual aid agreement (called as needed). Needs will be dictated by the nature of the structure(s) involved and the quantity of water required.

At the fire scene, the WSO's duty is to maintain continuous fire streams by establishing several water-hauling facilities, assembling water-carrying equipment of automatic and mutual aid departments, and calculating estimated arrival times of mobile water supply apparatus, through a thorough knowledge of available water supplies throughout a wide area of fire department jurisdiction.

Developing and sustaining large fire flow requires the use of several water sources as well as several drop tanks where water can be dumped. Therefore, reliable and effective communication is necessary in directing mobile water supplies so that time is not lost at the fill and the dump points. To obtain water supply efficiency, a radio frequency separate from that used for the fireground operations should be assigned to the WSO and the water supply site and the mobile water supply apparatus. The WSO will also require efficient communication with the incident commander.

The WSO (or designee) meets with property owners and others to secure their permission to use the water supply, to develop an all-weather road to the supply, and to install dry hydrants. The installation of roads to, or dry hydrants in, navigable water or wetlands might require a permit from appropriate local, state, or national agencies. The WSO should also consult with the owner in the design of a water source on a property to be protected.

A.4.1.2 Information needed to compute the minimum water supplies that should be collected during building surveys 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(ies) of buildings
(5) Exposures to the structure from other buildings or yard storage and separation distances
(6) Fire protection systems — automatic and manual protection systems, hydrants, yard mains, and other protection facilities
(7) On-premises water supplies, including natural and constructed sources of water

A.4.1.3 The water supply for firefighting purposes, as specified in Chapter 4, is considered the minimum water supply. The AHJ could determine that a municipal-type water supply is warranted (*see Annex G*). This determination might be made as a result of on-site survey of buildings by the fire department having jurisdiction or by review of architectural plans of proposed construction and planned development.

A.4.2.1 Annex H provides tables with precalculated minimum water supplies by occupancy hazard and construction classification where no exposures are present.

A.4.3.1 See Annex H for sample calculations for structures with exposure hazards.

A.4.4 The following information on permitted reductions of fire flow and other fire flow provisions is based on NFPA 1, Section 18.4.

One- and Two-Family Dwellings. The minimum fire flow and flow duration requirements for one- and two-family dwellings having a fire flow area that does not exceed 5000 ft^2 (334.5 m^2) should be at 1000 gpm (3785 L/min) or 500 gpm (1900 L/min) when an approved automatic sprinkler system is installed throughout and/or separated from other buildings by a minimum of 30 ft (9.1 m). The minimum fire flow duration is 1 hour.

A reduction in required fire flow of 50 percent is permitted where the building is provided with an approved automatic sprinkler system.

A reduction in the required fire flow of 25 percent is also permitted where the building is separated from other buildings by a minimum of 30 ft (9.1 m).

The reduction for an approved automatic sprinkler system and/or separated from other buildings cannot reduce the required fire flow to less than 500 gpm (1900 L/min).

Fire flow and flow duration for dwellings having a fire flow area in excess of 5000 ft^2 (334.5 m^2) cannot be less than that specified for buildings other than one- and two-family dwellings.

Buildings Other Than One- and Two-Family Dwellings. The minimum fire flow and flow duration for buildings other than one- and two-family dwellings should not be less than 1000 gpm (3785 L/min) or 600 gpm (2270 L/min) when the building is protected throughout by an approved automatic sprinkler system and quick response sprinklers are utilized throughout.

A reduction in the required fire flow of 75 percent is permitted when the building is protected throughout by an approved automatic sprinkler system.

A reduction in the required fire flow of 75 percent is permitted when the building is protected throughout by an approved automatic sprinkler system, which utilizes quick response sprinklers throughout. The resulting fire flow should not be less than 600 gpm (2270 L/min).

A.5.2 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 it is assigned to the highest hazard group. The highest occupancy hazard classification number is 7, and it is assigned to the lowest hazard group.

A.5.2.1.1 In severe hazard occupancies, the quantity or combustibility of contents is expected to develop very high rates of spread and heat release.

A.5.2.2.1 In high hazard occupancies, the quantity or combustibility of contents is expected to develop high rates of spread and heat release.

A.6.2 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 0.5. The fastest burning or highest hazard type of construction, wood frame, is construction classification 1.5.

A.6.3.1 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-442, 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

Specific fire resistance ratings are found in Table 6.3.1, and additional information is found in NFPA 220.

A.7.1.1 Although most water is acceptable for firefighting purposes, there might be suspended particulates or contaminants that could prove harmful to the fire pump systems or firefighting agents being used and should be avoided.

A.7.2 During pre-fire planning, the fire department should make arrangements with the owners of water supplies to use the water during an emergency. Such agreements should be made in writing in close cooperation with legal counsel.

The agreements should identify who will build, service, and maintain necessary access roads to the supplies, including such functions as snow plowing in certain areas of the country. Figure A.7.2 shows a sample water usage agreement.

A.7.5 Most artificial lakes are constructed with heavy earthmoving equipment. In order for the property owner to construct a roadway for fire department use, the AHJ should make the property owner aware of the needs of the fire department while the heavy equipment is still on the job.

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 such purposes as to generate power, for flood control, or to regulate the flow of a river. During certain periods of the year (droughts, drawdowns, etc.), such bodies of water can 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.

A.7.5(8) Where a 120 ft (36.5 m) diameter turnaround or other means for the mobile water supply apparatus to exit the water supply location is not feasible, a large underground pipe transmission line can be laid from the water supply to the highway and the mobile water supply apparatus filled on the highway right-of-way. However, a turnaround or looped facility could still be needed if the mobile water supply apparatus needs to return to the fire scene over the same roads used to reach the water supply site.

A.7.6 The training of fire department personnel involved in mobile water supply is essential to ensure a safe and efficient operation at fire scenes involving mobile water supply operations. NFPA 1001, NFPA 1451, and Section C.9 should be consulted to develop a training program focused on mobile water supply operations.

A.7.7.1 The records could include, but might not be limited to, the following:

(1) Location of the water supply source
(2) Access and water usage agreement(s) for private water supplies (if applicable)
(3) Inspection, testing, and maintenance documentation
(4) Plans and design specifications for the original installation
(5) Unique characteristics of the water supply source that could impact fire department operations

SAMPLE WATER USAGE AGREEMENT

It is understood by the owner(s) and the ________________ government (hereinafter called the ________________ ________________ Fire Department) that this agreement is subject to the following conditions:

1. The owner(s) are permitted to terminate this agreement by written notice if the ______________ Fire Department breaches any terms and conditions contained in this agreement.

2. Neither this agreement nor any right or duty in whole or in part by the owner(s) under the agreement will be assigned, delegated, or subcontracted without the written consent of the owner(s).

3. All items placed on the property of the owner(s) by the ________________ will remain the property of the ________________ . If this agreement is terminated, the owner(s) will permit the ________________ adequate time to remove said property and return the land to its natural state.

4. Any and all debris that is created by and during the establishment of the drafting site will be disposed of by the ________________ .

5. No cutting or trimming of trees will be done on the property of the owner(s) unless the ________________ Fire Department states that such cutting is/will be necessary to provide uninterrupted and clear travel to the site; however, in no case will such cutting be actually completed without prior approval of the owner(s).

6. The ________________ will maintain the area covered by this agreement in a safe condition at all times. This maintenance will also include the groundskeeping around the site.

7. The ________________ agrees to save, keep harmless, defend, and indemnify the owner(s) and all its officers, employees, and agents, against any and all liability claims, costs of whatever kind and nature, for injury and death of any person or persons, and for loss or damage to any property occurring in connection with or in any way incidental to or arising out of the occupancy, use, service, operation, or performance of work in connection with this agreement or omissions of the ________________ 's employees, agents, or representatives. THIS PROVISO DOES NOT AND WILL NOT APPLY TO ANY EVENTS INVOLVING AN ACTUAL FIRE IN THE STRUCTURE(S) OF THE OWNER(S).

8. The owner(s) as well as any heirs, executors, administrators, and assigns do hereby remise, release, and forever discharge the ________________ and any officer, agent, or employee thereof of any liability at law to any person, firm, or legal entity for any act of omission, or any injuries, damages, or deaths claimed to have arisen from the [describe the work to be performed at the site] unless the act of omission amounts to willful misconduct. This waiver is entered into for and in consideration of the drafting site and access roadway. The sufficiency of this consideration is acknowledged by the owner's(s') signature(s) below.

9. The owner(s) grant the rights to the ________________ and ________________ Fire Department to enter the property cited in this agreement only for the express purpose as stated by owner(s).

________________________ (Owner)	________________________ (______________ Fire Dept.)
________________________ (Owner)	________________________ (______________ Road Supt.)
________________________ (Date)	________________________ (Head of local government)
	________________________ Attorney (ies)]

 NFPA 1142

FIGURE A.7.2 Sample Water Usage Agreement.

A.8.1 Factors to consider when determining the need and location for a dry hydrant system should include, but not be limited to, the following:

(1) Current and future population and building trends
(2) Property values protected
(3) Potential for loss
(4) Proximity to structures [e.g., not closer than 100 ft (30 m) from a structure it is designed to protect]
(5) Fire history of the area protected
(6) Current water supply systems
(7) Potential water supply sources and reliability (i.e., constructed or natural)
(8) Cost of project
(9) Other factors of local concern

The Volunteer Fire Assistance program provides grants to rural fire departments for training, organizing, and equipment serving communities with a population of 10,000 or less. The U.S. Forest Service sponsors and funds this program, which is delivered by the State Forester in each state.

Grants may be available through the State Forester's office on a cost-sharing basis. It is appropriate to seek funding from the Volunteer Fire Assistance program for material for dry hydrants since rural fire departments provide much of the initial attack on wildland fires. More information about the Volunteer Fire Assistance program can be found on the USDA Forest Service website at www.fs.fed.us/fire/partners/vfa/. Click on VFA Desk Guide. Contact your local State Forester's office for application procedures. The name and contact information for State Foresters can be found on the National Association of State Foresters website at stateforesters.org.

A.8.2.2 Permits to install a dry hydrant should be obtained from the AHJ. These can include local, state, and federal agencies charged with fire protection, zoning, water, environmental protection, agriculture and resource conservation, among others.

A.8.3 Since there might be resources available to assist in the planning and installation of dry hydrants, it is desirable to identify and consult with the persons responsible for those resources early in the process.

A.8.3.1 Factors including local topography, climatic conditions, and access to materials will 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 flow, in gpm (L/min) will affect the pipe size that should be used.

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 suction hose connections, along with iron, steel, and bituminous cement pipe and fittings, are being used for dry hydrant installations.

A.8.3.2 Many fire service hose appliance manufacturers now offer pre-manufactured and pre-assembled PVC suction screens, hydrant heads, and supports that come ready to attach to the pipe *[see Figure A.8.3.2(a)]*.

Figure A.8.3.2(b) is an example of a dry hydrant installation showing a minimum 6 in. (150 mm) pipe and screen. Installations can involve larger pipes and screens.

A.8.3.3 System design requirements should allow for required fire flow, atmospheric pressure, lift, vapor pressure, length of required pipe run, coefficient of materials (C factor), piping configuration, and other design factors that approved engineering practices would necessitate.

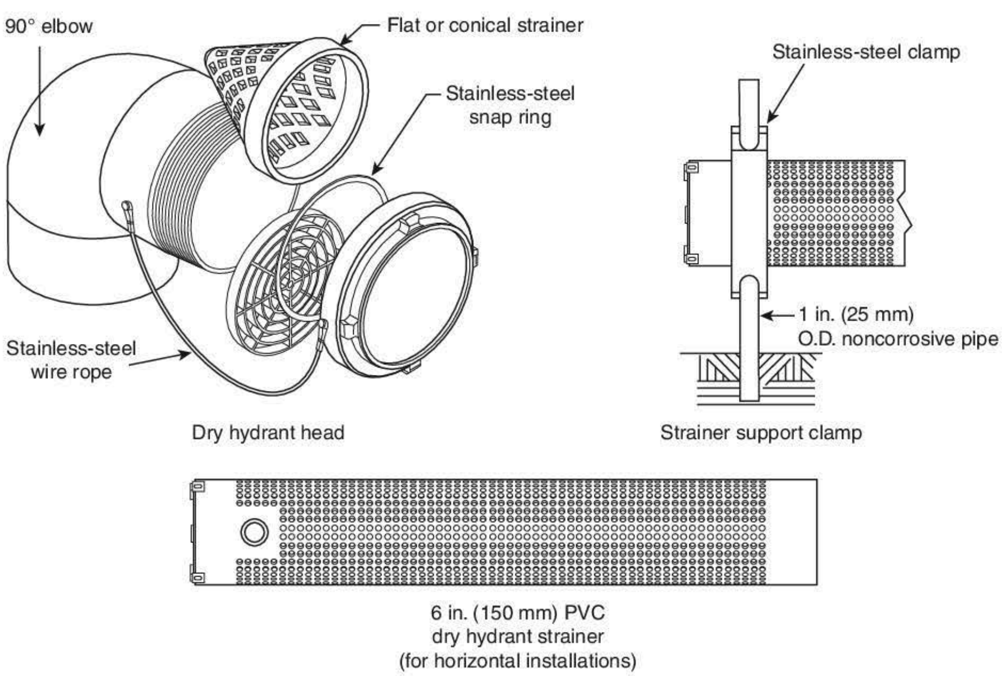


FIGURE A.8.3.2(a) Commercially Available Dry Hydrant Components.

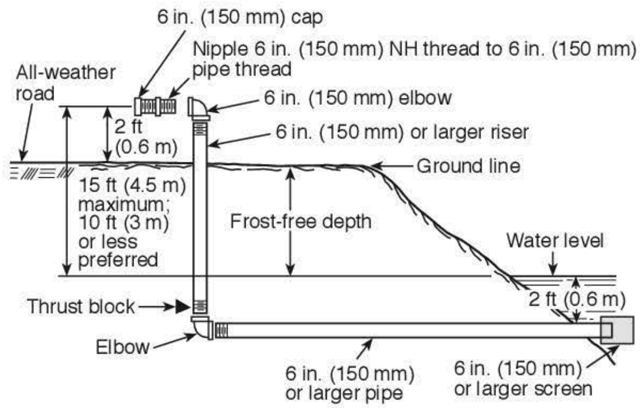


FIGURE A.8.3.2(b) Exploded View of Dry Hydrant Construction.

The following are some factors that should be considered when a dry hydrant system is designed:

(1) Lift should be as low as possible and not exceed 10 ft to 12 ft (3.1 m to 3.7 m), if possible. This loss cannot be overcome by enlarging the pipe size.
(2) Total head loss should not exceed 20 ft (6.1 m), or the pump might not supply its rated gpm (L/min). If the fire department will be using portable pumps on the dry hydrant, those pumps generally have less capability to create a vacuum and head loss needs to be as low as possible.

A.8.3.4 The required flow at the dry hydrant can exceed the delivery flow shown in Chapter 4 to allow for rapidly filling mobile water supply fire apparatus.

A.8.3.5 See Annex I for information on dry hydrant design.

Figure A.8.3.5 shows a typical dry hydrant installation where freezing is not a concern. During seasonal droughts, more of the pipe will be empty, requiring the primer on the pump to be operated longer before water reaches the pump.

A.8.3.6 Metal piping and exposed PVC pipe surfaces should be primed and painted to prevent deterioration.

A.8.3.7 Preferably no more than two 90-degree elbows should be used. It might be desirable to have a wide-sweep elbow [using two 45-degree elbows and a 2 ft (0.6 m) length of pipe] installed at the bottom of the riser where the lateral run connects. In the event of a broken-off hydrant connection, this could permit sections of 2½ in. (65 mm) suction hose to be inserted down the 6 in. (150 mm) pipe to the water and would permit drafting to continue, although at a much reduced rate of flow.

A.8.3.13 Strainers or screens have been locally fabricated by drilling sufficient ⅜ in. (10 mm) holes in a length of pipe to equal 4 times the cross-sectional area of the pipe and capping the end with a removable or hinged cover. Remember to leave a solid strip of pipe approximately 4 in. to 5 in. (100 mm to 125 mm) wide along the top to act as a baffle to prevent whirlpooling during periods of low water.

A.8.4 Each dry hydrant site should be evaluated by the fire department to determine the best way, within the fire department's means, for using the water supply. Figure A.8.4(a) and Figure A.8.4(b) show two examples of how dry hydrant installations can be adapted to support the water supply needs of the fire department for specific situations.

A.8.4.2 It is the responsibility of the AHJ to make inspections of all water sources as often as conditions warrant to note any changes and take appropriate action. This is particularly true during adverse weather conditions, such as droughts, very wet periods, heavy freezing, and following snowstorms.

A.8.4.6 In areas where frost is a problem, the design should ensure that no frost will reach the water in the pipe. One method of preventing the frost from reaching the water in the pipe is to bury the pipe below the frost line and mound up the soil over the pipe and around the riser. Another method is to place an insulating barrier, such as Styrofoam, between the pipe and the surface as shown in Figure A.8.4.6(a) to prevent the frost from reaching the water in the pipe.

A third method is 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. This method requires an air pressure gauge and air chuck to be installed in the cap of the hydrant by drilling and tapping into the metal. *[See Figure A.8.4.6(b).]* The air pressure gauge should read from 0 psi to 10 psi (0 kPa to 69 kPa), as it is important to be able to accurately monitor the air pressure. In most cases, the air pressure will not read over 5 psi to 6 psi (34 kPa to 41 kPa). If there is a chain for the hydrant cap, it should be removed. Teflon® tape is applied to the threads of the gauge and air chuck.

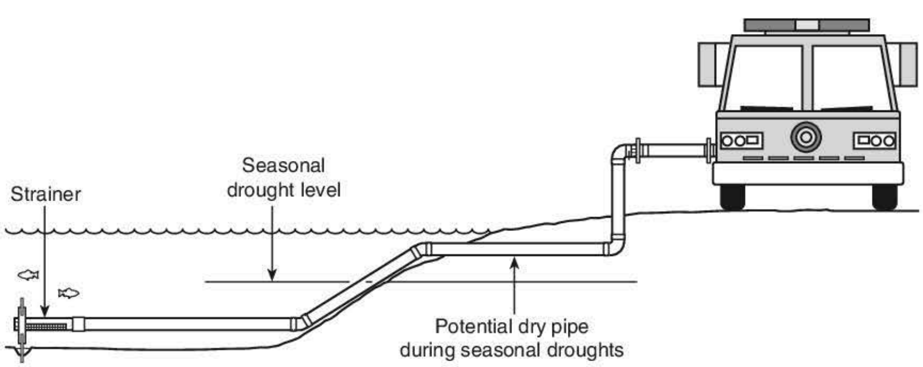


FIGURE A.8.3.5 Typical Dry Hydrant Installation Showing Impact of Seasonal Drought.

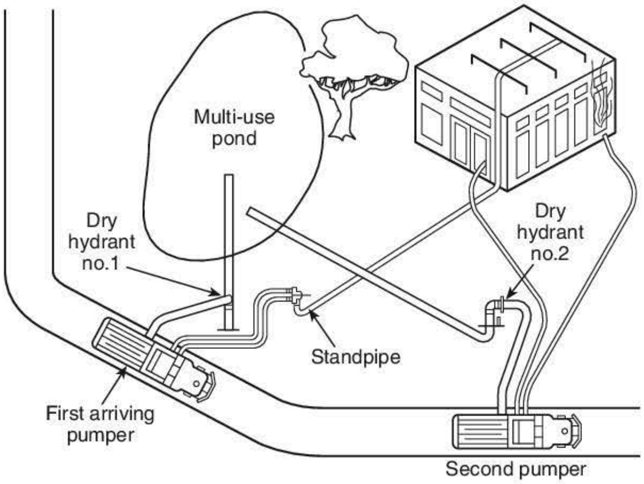


FIGURE A.8.4(a) Multiple Water Supply Points for an Industrial Occupancy.

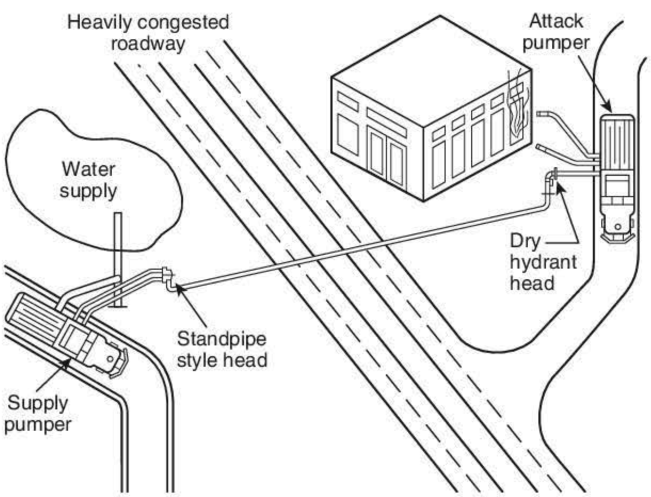


FIGURE A.8.4(b) Overcoming Roadway Obstructions in Supplying Water to a Building.

Air is injected into the hydrant until it bubbles out of the suction screen or the air pressure gauge no longer rises. *[See Figure A.8.4.6(c).]* 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 pressure gauge should be checked periodically to be sure the water remains displaced in the hydrant. This method requires periodic repressurization. Also, if damage has occurred to cause loss of air pressure, freezing and blockage can occur immediately, making the system unusable in an emergency. The advantage of this method is that if the air chuck or gauge is damaged, it will not affect the airtight integrity of the hydrant while drafting, because the cap is removed for drafting.

It is important in any installation where freezing could occur that the suction screen is placed deep enough in the body of water to ensure that ice will not reach the screen. In such cases, divers might be needed to assist in proper screen placement.

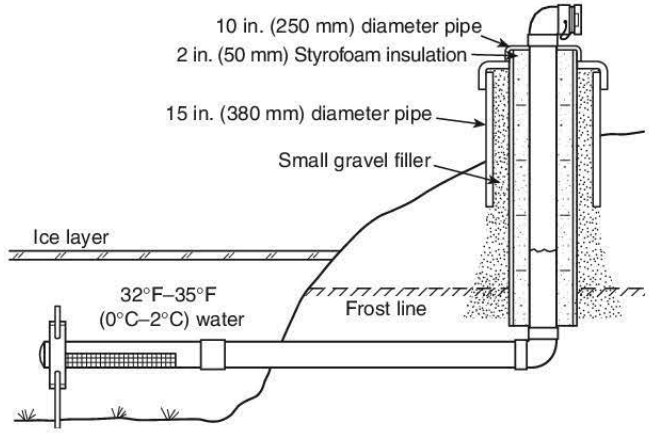


FIGURE A.8.4.6(a) Example of Freeze Protection for Dry Hydrant Subject to Severe Freezing Conditions.

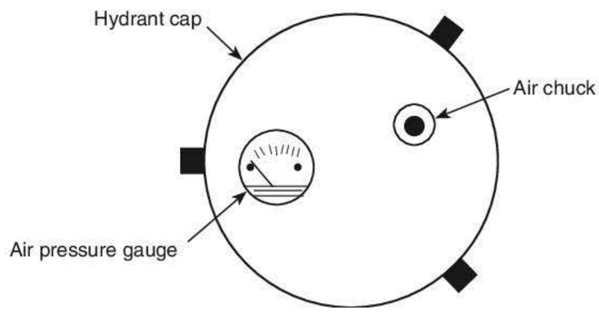


FIGURE A.8.4.6(b) Cap Design for Air Injection System.

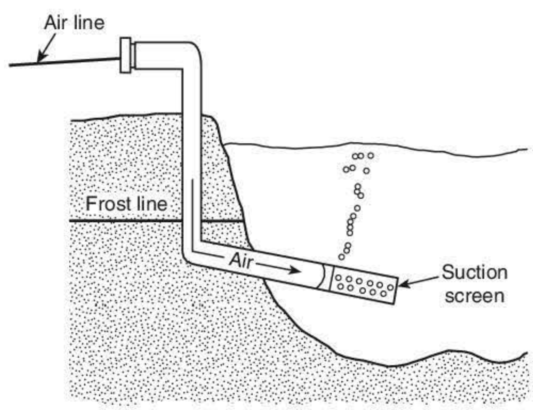


FIGURE A.8.4.6(c) Air Injection Frost-Proofing System.

A.8.4.7 The AHJ 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 ½ in. (13 mm) stroke, and reflective, as allowed by state and local regulations.

A.8.5 The installation of dry hydrants calls for care in measuring water storage capacities. The useful 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 cannot be less than 2 ft (0.6 m) of water. This becomes a very important point where hydrants are installed on a body of water affected by tide, or on a lake that is lowered to maintain the flow of a river during drought conditions, to generate power, or that freezes over. Pump suction requires 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 anti-swirl 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.

In water sources where heavy sediment and silt could present a problem of clogged suction screens, the intake screens should be raised above the bottom. Figure A.8.5(a) and Figure A.8.5(b) show two examples of how the strainer can be kept out of mud and silt conditions.

A.8.6 A typical installation process includes the need to excavate or trench soil that might be somewhat unstable and which is often on sloping terrain. Only persons with experience and proper equipment to install underground piping should endeavor to install dry hydrant systems.

A.8.7.1 There could be a need for more frequent inspections due to freezing and droughts. Particular attention should be given to streams and ponds where frequent removal of debris, dredging or excavation of silt, and protection from erosion might be required.

The 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.

A.8.7.6 Dry hydrants can be checked and tested by actual drafting as part of the fire department training program. If the tests do not produce the design flow, the fire department should determine what the problem is. It could be necessary to back flush the system to clear leaves and other debris. When a dry hydrant is back flushed, pump pressures should not exceed 20 psi.

A.8.8 Individual records should be kept for each water source. Each water source should also be noted on a master grid map of the area in a manner that will indicate the water source record that contains the pertinent data on that water source.

The water source record should include type of source (stream, cistern, domestic system, etc.), point of access [100 ft (30.5 m) north of barn, etc.], gallons available [flows minimum 250 gpm (950 L/min), 10,000 gal (37,850 L) storage, etc.], and any particular problem such as weather condition or seasonal fluctuations that can make a source unusable. It is good practice to attach a photograph of the water point to the record.

Figure A.8.8(a) shows one way of keeping the information needed on a water source record.

A map showing the location and amount of water available at each water site should be kept at the fire alarm dispatch center, and copies should be carried on the apparatus most likely to arrive first at the scene, with additional copies in the incident commander's vehicle and the WSO's vehicle.

The water source records 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. It is suggested that a separate record of inspection and maintenance be maintained on each dry hydrant. *[See Figure A.8.8(b).]*

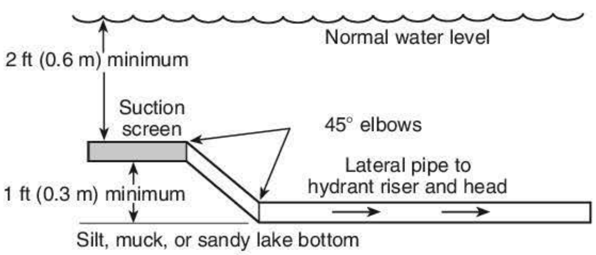


FIGURE A.8.5(a) Offset Screen Installation for Silt and Mud Conditions.

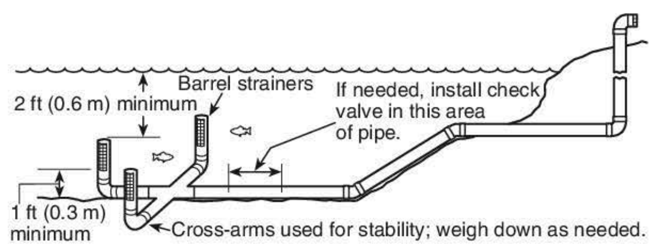
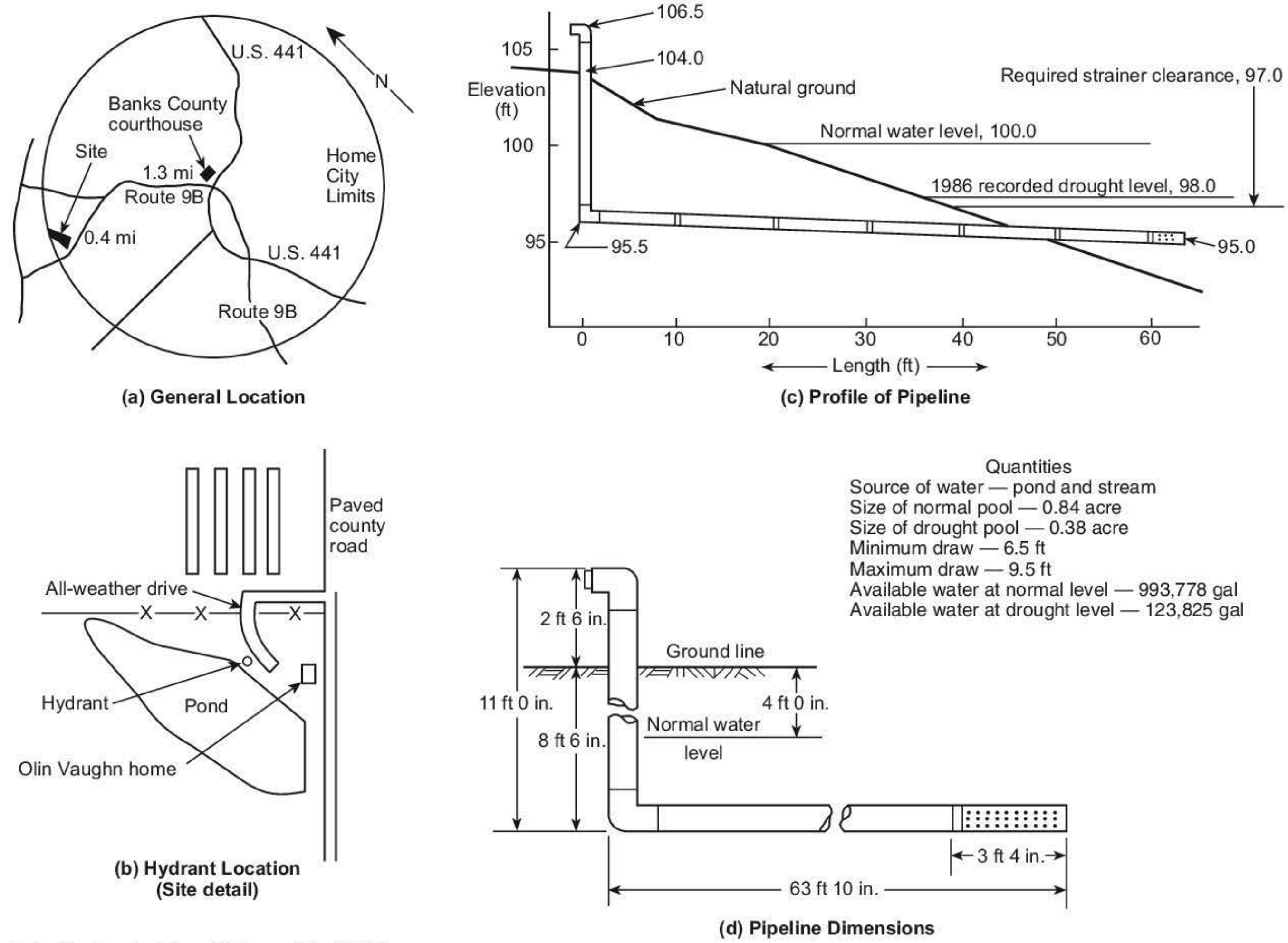


FIGURE A.8.5(b) Vertical Strainer Installation for Silt and Mud Conditions.

Dry Hydrant Water Source Record

Dry hydrant location: *On the north side of Rt. 9B, 1.7 miles west of US 441. All-weather access road runs 500 ft to hydrant location.*

Latitude/Longitude: *37.345/118.575* Datum: *NAD 83*
Dry hydrant ID number: *SFD 06* Design flow rate: 1000 gpm



Note: For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.

FIGURE A.8.8(a) Example of Dry Hydrant Water Source Record.

DRY HYDRANT INSPECTION AND MAINTENANCE RECORD

Dry hydrant location: ______________________________

____

Latitude/Longitude: __________ / __________ Datum: __________

Dry hydrant ID number: __________ Design flow rate: __________

Elevation of site above sea level: __________

Date of inspection: __________ By: __________

Depth of water from surface to top of strainer: __________

Amount of water available leaving 2 ft (0.6 m) over strainer: __________

Environmental conditions affecting hydrant (silting, debris, vegetation growth): __________

____

Erosion around hydrant, access road, bank of water supply: __________

____

System back flushed? ❑ Yes ❑ No Problems found: __________

____

____

Flow available by actual test: __________

Weed control measures taken: __________

____

Condition of access road, drainage: __________

____

____

Sign present? ❑ Yes ❑ No Accuracy and clarity of information on sign: __________

____

Maintenance performed, special observations, remarks: __________

____

____

____

____

____

____

____

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FIGURE A.8.8(b) Inspection and Maintenance Record for Dry Hydrant.

Annex B Alternative Water Supply

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

B.1 General. The fire department operating without a water system or with hydrants on a weak distribution system has the following three means of getting adequate water for firefighting:

(1) From supplies at or near the incident scene, which can be either constructed or natural supplies
(2) From supplies transported to the scene
(3) By relaying water from a source to the fire scene using large-diameter hose

B.2 Locating Water Sources. Aircraft and aerial photographs can be very helpful in a survey of static water availability. Such photographs are usually available from the county agriculture department or the county office of planning and zoning. Up-to-date topographical maps from the United States Geological Survey also can be of value in surveying an area for available water sources. Once sites are located, they should be prepared for use according to the recommendations of this annex.

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 assessing water from flowing streams as potential water sources, the fire department should consider the following factors:

(1) *Flowing Capacity.* The stream should deliver water in capacities compatible with those outlined in the water supply requirements of this standard. *(See Chapter 4.)*
(2) *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.
(3) *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 might be needed to obtain the water. Where roadways are provided to the water source, they should be constructed in accordance with Section 7.5.
(4) *Calculating the Flow of a Stream.* A simple method for estimating the flow of water in a stream is to measure the width and depth of the stream. Drop a cork or any light floating object into the water, and determine the time it takes the cork to travel 10 ft (3.1 m). To obtain complete accuracy, the sides of the stream should be perpendicular, the bottom 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, in a stream that is 4 ft (1.2 m) wide and 6 in. (150 mm) deep, the flow of water is such that it takes 45 seconds for a cork to travel 10 ft (3.1 m). Therefore the following formula should be used:

[B.3.1]

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

where:
W = width of 4 ft (1.2 m)
D = depth of 6 in. (150 mm) = $^1/_2$ ft (0.15 m)
TD = travel distance of 10 ft (3.1 m)

Calculate the flow of water as follows:

4 ft × ½ ft × 10 ft = 20 ft^3 (1.2 m × 0.15 m × 3.1 m = 0.56 m^3)

The cork takes 45 seconds to flow the 10 ft (3.1 m) distance. Divide the volume by the time as follows:

20 ft^3 (0.56 m^3)/45 sec = 0.44 ft^3/sec (0.0125 m^3/sec)

Convert the flow from seconds to minutes:

0.444 ft^3/sec (0.0125 m^3/sec)× 60 sec = 26.64 ft^3/min (0.75 m^3/min)

Using conversion factors [1 ft^3 = 7.48 gal (28.31 L); and 1 gal = 3.785 L], convert these values to gal/min (L/min):

26.64 ft^3/min × 7.48 = 199.27 gal/min (754 L/min)

For assistance in more accurately determining stream flow, contact the state department of natural resources, soil conservation service, county cooperative extension agents, or U.S. Geological Survey.

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 for assessing water from streams are pertinent to ponds, with the following items to be considered:

(1) Minimum annual level should be adequate to meet water supply needs of the fire potential the pond serves.
(2) Freezing of a stationary water supply, contrasted with the flowing stream, presents a greater problem.
(3) Silt and debris can accumulate in a pond or lake, reducing its actual capacity, while its surface area and level remain constant. These conditions can provide a deceptive impression of capacity and call for at least seasonal inspections. See Figure A.8.5(b) for an example of protective measures for silt and mud conditions.

B.3.3 Other Natural Sources. Other natural sources might include springs and artesian wells. Individual springs and occasional artesian water supplies exist in some areas and, again, while generally of more limited capacity, they can be a useful water supply, subject to reasonable application of the factors listed for ponds and streams. In many cases, it might be necessary to create a temporary natural pool or pond with a salvage cover for the purpose of collecting enough water for the fire department's use.

B.4 Cisterns.

B.4.1 General. Cisterns are one of the oldest sources of emergency water supply, both for firefighting and drought storage.

They are very important sources of water for domestic consumption, as well as for firefighting and drought storage in many rural and beach areas.

Cisterns should have a minimum usable volume as determined by the AHJ, based on the methods described in Chapter 4. There is no real limit to the maximum capacity. It is convenient for a cistern to be adjacent to a public right-of-way for winter maintenance and access. *[See Figure B.4.1(a).]* The dry hydrant associated with the cistern should be located at least 100 ft (30 m) from the closest structure.

The water level of a cistern can be maintained by rainfall, water pumped from a well, water hauled by a mobile water supply apparatus, or the seasonal high water of a stream or river. The top of the cistern should be a minimum of 2 ft (0.6 m) below grade.

Cisterns should be capped for safety, but they should have openings to permit inspections and use of suction hose when needed. *[See Figure B.4.1(b).]*

B.4.2 Construction of Cisterns. Construction of cisterns is governed by local conditions of soil and material availability. Some engineering considerations to be used in designing cisterns include the following:

(1) The base, walls, and roof should be designed for highway loading and for the prevailing soil conditions.
(2) If groundwater conditions are high, the cistern should not float when it is empty.

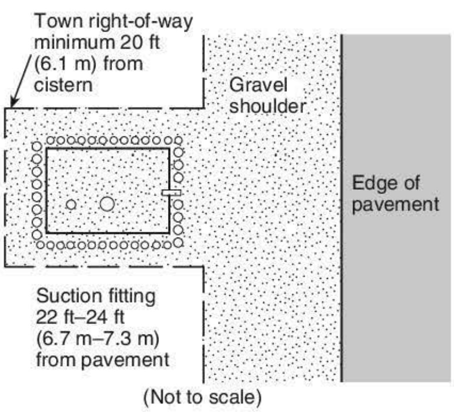


FIGURE B.4.1(a) Cistern Site.

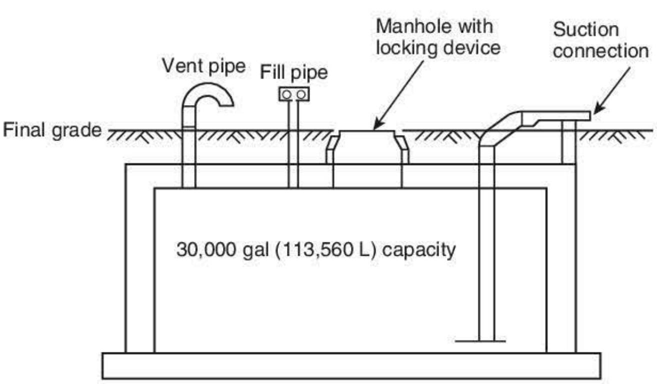


FIGURE B.4.1(b) Typical Cistern.

(3) Suction piping should be designed to minimize whirlpooling.
(4) Vent piping should be of sufficient size to allow drafting from the cistern at the maximum capability permitted by the suction piping.

Maintenance factors to be considered by the fire department include the danger of silting, evaporation or other low water conditions, and the freezing problems discussed in B.3.2.

B.4.3 Cistern Specifications. Some governing bodies require developers to provide cisterns with all subdivisions that are constructed, where on-site water systems are not available or adequate.

The following specifications for cistern design and construction are used by the New Boston Fire Department, New Boston, NH:

(1) Cisterns must be located no more than 2200 ft (671 m) truck travel distance from the nearest lot line of the furthermost lot.
(2) The design of a cistern must be trouble-free and last a lifetime.
(3) The cistern capacity must be 30,000 gal (113,560 L) minimum, available through the suction piping system.
(4) The suction piping system must be capable of delivering 1000 gpm (3800 L/min).
(5) The design of the cistern must be submitted to the AHJ for approval prior to construction. All plans must be signed by a licensed/registered professional engineer.
(6) The entire cistern must be rated for highway loading, unless specifically exempted by the AHJ.
(7) Each cistern must be sited to the particular location by a registered engineer and approved by the AHJ.
(8) Cast-in-place concrete must achieve a 28-day strength of a gauge pressure of 3000 psi (20,700 kPa). It must be placed with a minimum of 4 in. (100 mm) slump and vibrated in a professional manner.
(9) The concrete must be mixed, placed, and cured without the use of calcium chloride. Winter placement and curing must follow the accepted American Concrete Institute (ACI) codes.
(10) All suction and fill piping must be ASTM International Schedule 40 steel. All vent piping must be ASTM Schedule 40 PVC.
(11) All PVC piping must have glued joints.
(12) Any reducing fittings used in the piping must be an eccentric reducer.
(13) The final suction connection must be 4½ in. (115 mm) male National Standard hose thread and must be capped.
(14) The filler pipe siamese must have 2½ in. (65 mm) female National Standard threads with plastic caps.
(15) The entire cistern must be completed and inspected before any backfilling is done.
(16) All backfill material must be screened gravel with no stones larger than 1½ in. (38 mm) and must be compacted to 95 percent in accordance with ASTM D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)]*.
(17) Bedding for the cistern must consist of a minimum of 12 in. (300 mm) of ¾ in. to 1½ in. (20 mm to 40 mm) crushed, washed stone, compacted. No fill can be used under the stone.

(18) The filler pipe siamese must be 36 in. (900 mm) above final backfill grade.
(19) The suction pipe connection must be 20 in. to 24 in. (500 mm to 600 mm) above the level of the shoulder where vehicle wheels will be located when the cistern is in use.
(20) The suction pipe must be supported either to the top of the tank or to a level below the frost line.
(21) The base must be designed so that the cistern will not float when empty.
(22) The perimeter of the cistern at floor/wall joint must be sealed with 8 in. (200 mm) PVC waterstop.
(23) After backfilling, the cistern must be protected by fencing or large stones.
(24) Backfill over the tank must have one of the following characteristics:
   (a) 4 ft (1.2 m) of fill.
   (b) The top and highest 2 ft (0.6 m) of sides of the cistern must be insulated with vermin-resistant foam insulation and 2 ft (0.6 m) of fill.
   (c) All backfill must extend 10 ft (3.1 m) beyond the edge of the cistern, and have a maximum 3:1 slope, loamed and seeded.
(25) The bottom of the suction pipe to the pumper connection must not exceed 14 ft (4.25 m) vertical distance.
(26) The pitch of the shoulder and vehicle pad from the edge of the pavement to the pumper suction connection must be 1 percent to 6 percent downgrade.
(27) The shoulder and vehicle pad must be of sufficient length to permit convenient access to suction connection when the pumper is set at 45 degrees to road.
(28) All construction, backfill, and grading material must be in accordance with proper construction practices and acceptable to the AHJ.
(29) All horizontal suction piping must slope slightly uphill toward the pumper connection.
(30) The installer is responsible for completely filling the cistern and maintaining it full until the installation is accepted by the AHJ.

As an alternative where soil and groundwater level conditions permit, a properly designed well can be used to provide water. Figure B.4.3 illustrates a typical well with a dry hydrant installed. Local conditions must be considered in all cases. A high water table that allows a suction lift of not more than 10 ft (3 m) must be present. The well must be installed in gravel or sand, not clay.

The same design is suitable for a cistern if the bottom of the casing is not perforated.

B.4.4 Guide to Cistern Capacity. The following formula can also be used to calculate the usable amount of water in a round cistern with vertical sides:

[B.4.4a]

$$23.56\times\left(\frac{D_f}{2}\right)^2\times H_f = \text{capacity in gallons}$$

[B.4.4b]

$$3141.6\times\left(\frac{D_m}{2}\right)^2\times H_m = \text{capacity in liters}$$

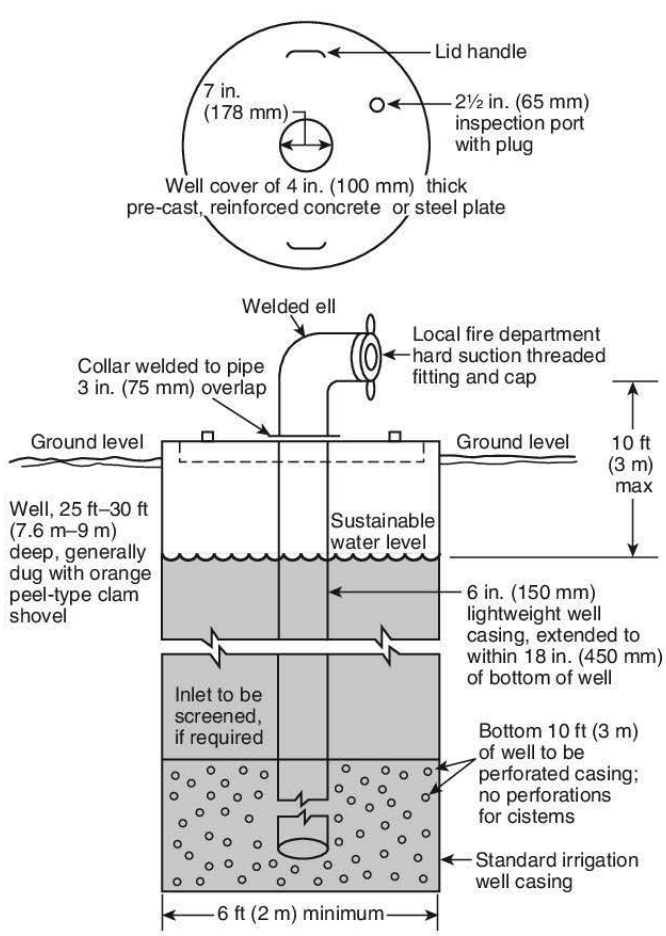


FIGURE B.4.3 Typical Well or Cistern with Dry Hydrant Installed.

where:
D_f = inside diameter of the cistern in feet, or D_m inside diameter in meters
H_f = usable depth of water in the cistern in feet, or H_m = usable depth of water in meters

The following formula can be used to calculate the usable amount of water in a rectangular cistern:

[B.4.4c]

$$L_f\times W_f\times H_f\times\ 7.5\ \text{gal} = \text{capacity in gallons,}$$

or

[B.4.4d]

$$L_m\times W_m\times H_m\times\ 1000\ \text{L} = \text{capacity in liters}$$

where:
L_f = length in feet, or L_m = length in meters
W_f = width in feet, or W_m = width in meters
H_f = usable depth of water in feet, or H_m = usable depth of water in meters

When reference is made to water depths in cisterns, swimming pools, streams, lakes, and other sources, it should always be remembered that the depth with which the firefighter 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 Fiberglass Underground Storage Tanks. Some fire departments are using new fiberglass underground storage tanks to store water for fire protection. This application is very similar to using a cistern, except that the tanks are manufactured off site whereas a cistern is built on site. These tanks are fitted with suction and fill piping and placed strategically around the community. *(See Figure B.5.)*

B.6 Swimming Pools. Swimming pools are an increasingly common source of water for fire protection. Even in some areas with normally adequate water supplies from hydrants, pools have been a factor in providing protection, such as where water demands have exceeded availability because of wildfires or natural disasters. Swimming pools provide an advantage in that they are sources of clean water, but a major drawback is their poor accessibility for large, heavy fire apparatus. There are some areas of the country in which there are more swimming pools than fire hydrants. If the fire department intends to use a swimming pool as a supply of water, it is a good practice to work with the pool owner and preplan how the water will be accessed.

B.6.1 Pool Accessibility. If fire department accessibility is considered at the time the pool is designed, a usable water supply should be available to the fire department for directly supplying hose lines or filling mobile water supply apparatus. 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 problem of accessibility can be achieved through preplanning. A solution might call for long lengths of suction hose, portable pumps, dry hydrants, siphon ejectors, or properly spaced gates. Lightweight or flexible-type suction hose can be advantageous in these situations. Portable (or floating) pumps designed for large-volume delivery at limited pressures can deliver water to portable folding tanks or fire department pumpers and are frequently ideal where accessibility problems exist. *(See Section E.3.)*

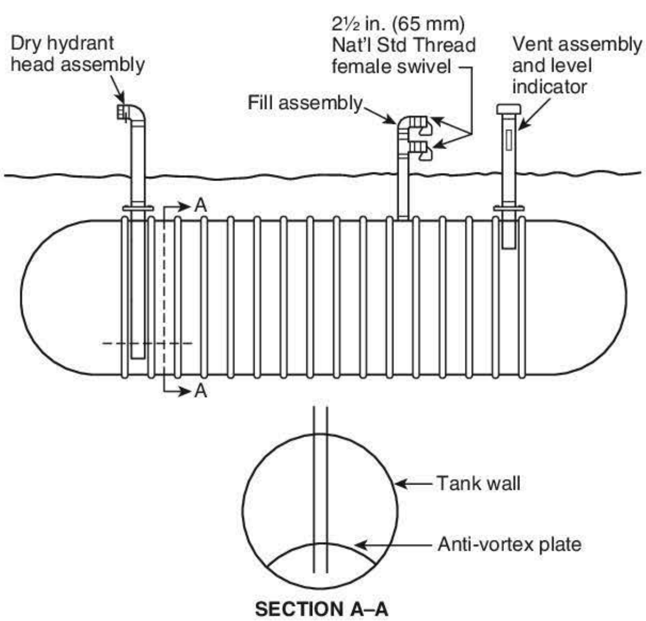


FIGURE B.5 Example of Construction of Water Cisterns Using an Underground Fiberglass Storage Tank.

A swimming pool located virtually under the eaves of a burning house can be a very poor location from which to pump if there is fire exposure to the work area. Pumping from a neighboring pool if it is close enough or using a water-hauling program is frequently preferable to pumping from a pool adjacent to the burning house.

B.6.2 Pool Capacity. The following formula is a short-form method of estimating pool capacity:

[B.6.2a]

$$L_f \times W_f \times D_f \times 7.5 \text{ gal/ft}^3 = \text{estimated capacity in gallons}$$

or

[B.6.2b]

$$L_m \times W_m \times D_m \times 1000 \text{ L/m}^3 = \text{estimated capacity in liters}$$

where:

L_f = length in feet or L_m = length in meters
W_f = width in feet or W_m = width in meters
D_f = estimated average depth from water line in feet or D_m = estimated average depth from water line in meters

Note that the dimensions used in the formula should be an average if the pool is of a stylized construction.

Consideration should be given for 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 areas around swimming pools demands techniques other than those used for drafting from ponds or streams. Adequate pre-fire planning will provide knowledge of individual pools so that the method of obtaining water at the property is known.

B.6.3 Care in Use of Pools. Care has to be exercised to be sure structural damage will not be done to a pool and the surrounding area if the water is used for firefighting. Lightly built cement, Gunite®, or poured concrete pools can present a danger of structural damage, cracking, or collapse when drained. If a pool is located in extremely wet soil, it will tend to float upwards when drained. In these cases, the pool should be refilled as soon as the fire is under control and mobile water supply apparatus can be released from fire duties.

Some pools are 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 depth apparently available. 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 fire department should consult with the builder or installer of any pool being considered as a water source to determine the various pool limitations.

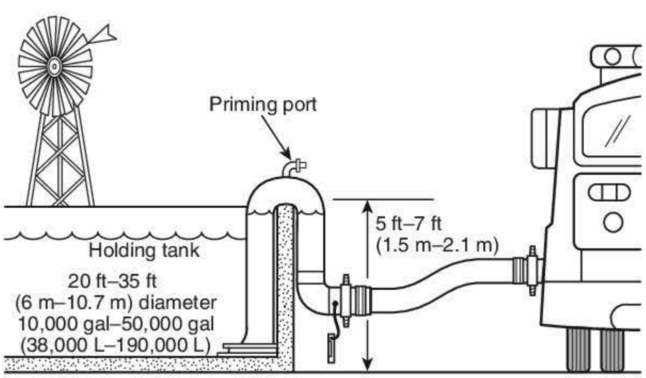
B.7 Livestock Watering Ponds and Tanks. Many farms have livestock water tanks and other similar water facilities. If the owner is made aware of the water needs for firefighting on the farm, such tanks and ponds can be sized to provide adequate volume for both farm and fire department use and located to be readily available to the fire department. Tanks should be placed on the edge of the barnyard where they are accessible for fire apparatus to take suction through a connection on the tank or with suction hose directly into the tank. These watering tanks and ponds are often filled and maintained full by a pump operated by a windmill or by an electric pump. Figure B.7 illustrates a dry hydrant system for holding tanks and procedures for successfully using the system as a water source.

B.8 Stored Water for Sprinkler Systems. In some rural areas, the only large water supply might be the storage provided for the sprinkler system in a 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, pre-plan arrangements can be made to use some of the stored water for fire protection away from the property. This is particularly true if the property owner is contacted before installation of the sprinkler protection, as it might be necessary to increase the storage capacity 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 protection. Unless the water supply has been specifically designed to provide water for fire protection away from the property, it should not be used. *(See Annex F for additional information on sprinkler systems.)*

B.9 Driven Wells. Wells, well systems, and irrigation pumps are becoming increasingly popular as water supplies for firefighting purposes at industrial properties, shopping centers, subdivisions, and farmhouses located in rural areas beyond the reach of a municipal-type water distribution system.

In areas with suitable soil conditions such as those of a very sandy nature, it might be possible to use driven wells or water-jetted wells to obtain water for firefighting. These wells are, in essence, pipes driven into the ground, usually with perforations about the base to permit entry of water. From the threaded pipe head (or a fitting attached to the body of the pipe), a pump connection can be made to draft water the same as from a well head hydrant. A high water table is a prerequisite to using this method. Firefighting units in areas where well head hydrants are available should have the necessary adapters to utilize such sites.



(1) Connect hard suction
(2) Open apparatus tank valve and flood suction hose
(3) Connect hand priming pump to priming port
(4) Operate priming pump until water is flowing from priming pump
(5) Engage the fire pump and open needed discharge lines

FIGURE B.7 Drafting Procedure for Farm Holding Tanks.

B.10 Pre-Fire Planning for Water Supply Operations. Once the water supply requirements have been calculated and the water sources identified, the type and amount of fire equipment needed to respond on the first alarm to deliver that requirement should be determined. The objective should be to have the response of fire apparatus match the need to deliver a constant flow at least equal to the water flow requirements. The fire department should develop standard operating guidelines for hauling or relaying water to fires. The guidelines should be verified under training conditions prior to a fire emergency. Training exercises should include locating fire equipment at a fire scene to protect the fire property and the exposures, establishing operations at the water source to either fill water tanks on fire apparatus or pump into a relay, designating fire lanes or routes between the water source and the incident scene, and reviewing and modifying the operations to meet unusual conditions. Once implemented, the standard operating guidelines should be initiated for all reported structure fires, recognizing that they can be discontinued or canceled after the officer in charge has evaluated the fire and determined that additional water supply will not be needed.

Annex C Mobile Water Supply Apparatus

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

C.1 General. The fire service has often experienced fire control difficulties in isolated areas. Although difficulties vary, one of the major problems encountered 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 many fire officials and a factor that significantly influences their firefighting tactical decisions. Fire department training should emphasize the need to maintain an effective water supply from source to application.

A limited water supply condition during a working fire can adversely affect all phases of firefighting. This annex discusses the options and procedures for moving water where municipal-type water distribution systems are nonexistent or are substandard. When the water supply is provided from a dry hydrant, a lake, a cistern, a swimming pool, or other static source, operating procedures should include those activities required for transporting the water from the supply site to the fire. Fire departments generally commit to the draft or supply location using fire department pumper(s) with a pump capacity of 750 gpm (2850 L/min) or more, and a minimum booster tank size of 500 gal (1900 L).

In some departments, pumping apparatus assigned to water supply functions require little equipment beyond the apparatus pumps, the hose for filling mobile water supply apparatus, and some preconnected hand lines. There are many water source pumping options, and they vary widely depending on need and available resources.

Apparatus used to haul water have reflected a great deal of ingenuity, but in some instances at the risk of firefighter safety. In the interest of improving operational flexibility and safety, some rural and suburban fire departments now use standard pumpers and mobile water supply apparatus with tanks in the 1000 gal to 1500 gal (3800 L to 5700 L) range. Techniques for loading and unloading mobile water supply apparatus have also seen significant improvements. The goal during every fire evolution is to maintain the required fire flow throughout the entire firefighting operation.

Mobile water supply apparatus serve as a necessary asset in many suburban and rural fire departments. When the necessary water-carrying capacity exceeds local capability, a sound mutual or automatic aid program can provide the necessary resources.

Such arrangements are far superior to the use of unsafe makeshift equipment that is not designed for emergency service. Departments that build apparatus that are not in compliance with NFPA 1901 should give serious consideration to the safety, reliability, and serviceability of the equipment in question. A department that depends on an assortment of mobile water supply apparatus primarily designed for other uses should seek expert assistance to check the operational safety of the equipment.

The design and construction of a mobile water supply apparatus requires those involved to determine the gross vehicle weight rating (GVWR) of a chassis necessary to safely carry the maximum load and the resulting weight distribution, the engine horsepower needed to adequately perform on the road and at the fire scene, the appropriate brake system, and gear train combination best suited for operations in that specific locale. Apparatus components, such as tank baffling, venting, loading and off-loading systems, and the center of gravity, are just as important as the engine, axles, and other driveline components.

Some fire departments that have pumpers equipped with large water tanks have retrofitted their apparatus with some form of a quick-dump system (large gravity dump, jet-assist device, etc.).

Today's commercial mobile water supply apparatus can be designed to employ one of two possible technologies (or a combination of both) for loading, and four alternatives for unloading. Mobile water supply apparatus can be equipped with standard centrifugal fire pumps, positive displacement pressure/vacuum pump systems, or a combination of pumping equipment configurations.

C.2 Specifications for Mobile Water Supply Apparatus. Careful attention should be paid to ensure that engine, chassis, water tank baffling, vehicle center of gravity, and brakes are adequate for mobile water supply apparatus. NFPA 1901 covers mobile water supply apparatus, and it is recommended that the standard be 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 how the mobile water supply apparatus will discharge its water to the receiving vehicle, portable tank, or other equipment as rapidly as possible. It is essential that the mobile water supply apparatus get back on the road, reload, and bring another load of water to the fireground rapidly. Some departments install large gravity dump valves, while other departments use 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 mobile water supply apparatus.

It is suggested that, for a mobile water supply apparatus with a capacity greater than 1500 gal (5700 L), it might be necessary to utilize tandem rear axles or a semitrailer, depending on tank size and chassis characteristics. It is further recommended that the maximum water tank capacity for mobile water supply apparatus not exceed 4800 gal (18,200 L) or 20 tons (18,200 kg) of water. The cost of two smaller mobile water supply apparatus might cost about the same as one large mobile water supply apparatus. Mobility, cost of upkeep, personnel availability and costs, state weight restrictions, and bridge weight restrictions are factors to consider in the selection of mobile water supply apparatus.

The weight of the vehicle plus the load carried should not be greater than the rated capacity of the tires. Compliance should be determined by weighing the loaded apparatus.

C.3 Regulations and Restrictions. Regardless of rear axle configuration, specific consideration should be given to the state's legal weight-per-axle requirement. Government entities can have single-axle weight limits, which are imposed based on road surface conditions and the longevity of highways. The need for commercial driver's license, vehicle registration, insurance coverage, and other issues should be addressed.

The load capacity of roads and bridges is a serious consideration when planning purchases of fire apparatus. Mobile water supply apparatus have to be restricted to a load capacity that will not cause overloading of roads and bridges. A good policy for every fire department is to check the bridge load restrictions before purchasing a new apparatus.

C.4 Mobile Water Supply Capacity. Many departments find that a minimum tank capacity of 1000 gal (3800 L) facilitates meeting the minimum water requirements outlined in this standard where water supplies are readily available.

C.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. Careful consideration should be given to baffles by the designers and builders of tanks. *(See NFPA 1901.)*

C.6 Plumbing. It is important to have an outlet of adequate size to empty the tank quickly. Table C.6 illustrates the emptying time for a 1600 gal (6060 L) water tank by gravity flow using different outlet sizes.

Adequately sized plumbing is also important in those mobile water supply apparatus equipped with a pump with a jet dump arrangement. Many jet dump arrangements are capable of discharging at a rate of 1000 gpm (3800 L/min) or more.

Proper venting is imperative for safe and rapid filling and emptying of tanks. 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 the tank is emptying.

If the mobile water supply apparatus is equipped with a fire pump, adequately sized pump-to-tank plumbing is also essential to provide for rapid discharge of water through the pump. In a mobile water supply operation in which the emphasis is placed on rapid, low-pressure emptying of a tank, undersized plumbing can be a major limitation to efficiency.

Mobile water supply apparatus should be designed to fill and empty completely. Applicable NFPA standards such as NFPA 1901 contain data on adequate plumbing.

C.6.1 Fill Line Couplings. Often, time wasted at mobile water supply fill locations is due to difficulties in connecting and disconnecting the threaded couplings on the hose between the fill pumper and the water tank fill connection on the mobile water supply apparatus. 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 disconnect), a specially designed large-diameter fill pipe, or a rapid-fill device that drops into the fill opening at the top of the tank, thus providing quick breakaway from the fill supply.

C.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 in 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.

C.8 Turning Radius and Wheelbase. An important consideration in mobile water supply shuttle operations is the area available for turning. Because the mobile water supply apparatus might be called on to reverse direction or to maneuver for position at the water source or the fire site, multiple single-axle straight chassis mobile water supply apparatus, each with a 12 in. (300 mm) gravity dump or a 6 in. (150 mm) jet dump, might actually move more water to the fire location than longer wheelbase tractor trailers and dual wheel, tandem-axle, mobile water supply apparatus.

C.9 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 apparatus will probably have driving characteristics very different from other apparatus, and driver training is extremely important. Individual state operator licensing requirements should be met. NFPA 1002 and NFPA 1451 should both be used when developing programs to train and validate drivers of emergency fire apparatus.

Table C.6 Emptying Time for 1600 Gal (6060 L) Mobile Water Supply by Gravity Flow

Outlet Size		Discharge Time
in.	mm	(min)
2½	65	20
4½	115	7
6	150	5
10	250	1⅔
12	300	1½

C.10 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 where they have a maximum continuous flow capability (a sustained fire flow) of 1000 gpm to 2000 gpm (3800 L/min to 7600 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 scene. 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 amount of time for the apparatus to travel from the fire to the water source (T_1) might be different from 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.

The maximum continuous flow capability at the fire scene is calculated as follows:

[C.10a]

$$Q = \frac{V}{A + T_1 + T_2 + B} \times k$$

where:
Q = maximum continuous flow capability [gpm (L/min)]
V = tank volume of the mobile water supply apparatus in gal (L)
A = time (min) for the mobile water supply apparatus to drive 200 ft (61 m), dump water into a drop tank, and return 200 ft (61 m) to starting point
T_1 = time (min) for the mobile water supply apparatus to travel from fire to water source
T_2 = time (min) for the same mobile water supply apparatus to travel from water source back to fire
B = time (min) for the mobile water supply apparatus to drive 200 ft (61 m), fill mobile water supply at water source, and return 200 ft (61 m) to starting point
k = 1.0 for vacuum/pressure mobile water supply apparatus; 0.9 for all other mobile water supply apparatus 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:

[C.10b]

$$T = 0.65 + XD$$

where:
T = time (min) of average one-way trip travel
X = average speed factor = 60/average speed *[see Table C.10(a)]*.
D = one-way distance (miles)

The factor 0.65 represents an acceleration/deceleration constant 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 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 speed should be reduced.

Using an average safe constant speed of 35 mph (56 km/hr), the *X* factor is calculated as follows:

[C.10c]

$$X = \frac{60}{\text{average speed}} = \frac{60}{35 \text{ mph}} = 1.7$$

Precalculated values of *X* using various speeds in miles per hour and kilometers per hour are shown in Table C.10(a). When the distance is inserted into the formula for travel time ($T = 0.65 + XD$), the results are as indicated in Table C.10(b).

The formulas in this annex 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 has to be transported to the fire scene, consider the following situation:

(1) The water tank capacity (V) is 1500 gal (5678 L).
(2) The time (A) to fill the mobile water supply apparatus with water is 3.0 minutes.
(3) The time (B) to dump the water into a portable tank is 4.0 minutes.
(4) The distance (D_1) from the fire to the water source is 2.1 mi (3.4 km).
(5) The distance (D_2) from the water source is 1.8 mi (2.9 km), as the mobile water supply apparatus returns by a different road.

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

Due to good weather and road conditions, the average mobile water supply apparatus speed traveling from the fire to the water source is 35 mph (56 km/hr).

Use the travel time formula as follows:

[C.10d]

$$T = 0.65 + XD$$

where:

$X = 1.7$

$D_1 = 2.1$

and where at an average speed of 35 mph (56 km/hr):

$T_1 = 0.65 + 1.7D_1$

$T_1 = 0.65 + 1.7 \times 2.1$

$T_1 = 0.65 + 3.57$

$T_1 = 4.22$

At an average speed of 35 mph (56 km/hr), a mobile water supply traveling 2.1 mi (3.4 km) will take 4.22 minutes. Due to traffic lights, the average mobile water supply apparatus speed between the water source and the fire is 30 mph (48 km/hr).

Use the travel time formula as follows:

[C.10e]

$$T = 0.65 + XD$$

where:

$X = 2.0$

$D_2 = 1.8$

and where at a constant speed of 30 mph (48 km/hr):

$T_2 = 0.65 + 2.0D_2$

$T_2 = 0.65 + 2.0 \times 1.8$

$T_2 = 0.65 + 3.60$

$T_2 = 4.25$

Use the following formula for calculating the maximum continuous flow capability:

[C.10f]

$$Q = \frac{V}{A + T_1 + T_2 + B} \times k$$

where:

Q = maximum continuous flow capability [gpm (L/min)]
V = 1500 gal (5678 L)
A = 3.0
T_1 = 4.22
T_2 = 4.25
B = 4.0
k = 0.9

Therefore,

[C.10g]

$$Q = \frac{1500}{3.0 + 4.22 + 4.25 + 4.0} \times 0.9$$

[C.10h]

$$Q = \frac{1500}{15.47} \times 0.9$$

[C.10i]

$$Q = 97 \times 0.9 = 87 \text{ gpm } (330 \text{ L/min})$$

The maximum continuous flow capacity available from this 1500 gal (5678 L) mobile water supply is 87 gpm (330 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.10).*

(3) Develop and provide additional fill points, thus reducing travel time.
(4) Reduce the dump time.
(5) Use additional mobile water supply apparatus.

The number and size of mobile water supply apparatus available to the department is of importance 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 of water and the fire. The distance can be reduced by increasing the number of water supply points, the number of drafting points at a given supply, or both.

C.11 Mobile Water Supply Apparatus Filling and Off-Loading. During mobile water supply operations, filling and off-loading water delivery rates directly affect the fire flow capabilities established for the fire scene. Local needs usually determine mobile water supply configurations and procedures. A wide variety of off-loading and filling systems are currently in use.

Table C.10(a) Precalculated Values of X

Speed (mph)	*X*	Speed (km/hr)	*X*
15	4.0	25	2.4
20	3.0	30	2.0
25	2.4	40	1.5
30	2.0	50	1.2
35	1.7	60	1.0

Table C.10(b) Time–Distance Table Using an Average Speed of 35 mph (56 km/hr)

Distance		Time	Distance		Time
mi	km	(min)	mi	km	(min)
0.0	0.00	0.00	4.50	7.24	8.30
0.1	0.16	0.82	4.75	7.64	8.72
0.2	0.32	0.99	5.00	8.05	9.15
0.3	0.48	1.16	5.25	8.45	9.57
0.4	0.64	1.33	5.50	8.85	10.00
0.5	0.80	1.50	5.75	9.25	10.42
0.6	0.97	1.67	6.00	9.65	10.85
0.7	1.13	1.84	6.25	10.06	11.27
0.8	1.29	2.01	6.50	10.46	11.70
0.9	1.45	2.18	6.75	10.86	12.11
1.0	1.61	2.35	7.00	11.26	12.55
1.25	2.01	2.78	7.25	11.66	12.97
1.50	2.41	3.20	7.50	12.07	13.40
1.75	2.82	3.62	7.75	12.47	13.82
2.00	3.22	4.05	8.00	12.87	14.25
2.25	3.62	4.47	8.25	13.27	14.67
2.50	4.02	4.90	8.50	13.68	15.10
2.75	4.42	5.31	8.75	14.08	15.52
3.00	4.83	5.75	9.00	14.48	15.95
3.25	5.23	6.17	9.25	14.88	16.37
3.50	5.63	6.60	9.50	15.29	16.80
3.75	6.03	7.02	9.75	15.69	17.22
4.00	6.44	7.45	10.0	16.09	17.65
4.25	6.84	7.87			

FIGURE C.10 Example of a Quick Connect Coupling That Can Help to Reduce the Fill Time.

Some departments prefer to pump-off their water into portable tanks, while others off-load mobile water supply apparatus using gravity dump valves, jet-assisted dump devices, or air pressurization systems. Some departments still utilize a nursing operation by connecting water supply vehicles via hard suction or supply line directly to the firefighting apparatus at the scene. The use of gravity dump valves, jet-assisted dump devices, or positive displacement air-pressurization (blower)/vacuum pump systems, in concert with large portable dump tanks at the fire scene has provided additional operational flexibility and has greatly reduced the overall turnaround time associated with mobile water supply apparatus off-loading.

Every fire department needs to evaluate and decide which system for filling and off-loading apparatus provides the optimal advantages in terms of water delivery rate effectiveness, efficiency, and overall compatibility with other water delivery segments. During a comprehensive water delivery evaluation, many factors must be considered. Travel distances, fill and off-loading locations, and topography greatly affect the turnaround time periods associated with transporting water. *(See Section C.10.)* Usually, the greatest amount of time can be saved during the filling and off-loading segments of a water shuttle operation.

As with other segments of fireground operations, strategic preplanning is vital to mobile water supply 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. Backing up of vehicles has caused a significant number of personal injuries associated with emergency vehicle operations and also requires extra time. The use of flexible discharge tubes or side dumps during off-loading, in conjunction with properly set up dump sites, can reduce or eliminate the necessity of backing up the vehicles.

C.11.1 Mobile Water Supply Apparatus Equipped with Large Gravity Dumps. A growing trend among fire departments using mobile water supply apparatus is to increase the size of the gravity discharge dumps to reduce the time necessary to empty the water tank. Gravity dump arrangements with discharge valves of 10 in. (250 mm), 12 in. (300 mm), or larger are often used. Dump valve discharge rates will decrease as the depth of the water in a given tank decreases. Adequate air intakes and tank baffle cuts should be provided to avoid possible tank damage and inefficient operations. To check the efficiency of a dump system, weight tests should be conducted to determine discharge rates. *(See Section C.12.)*

C.11.2 Mobile Water Supplies Equipped with Jet-Assisted Dumps. A water 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 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 apparatus can more than double its off-loading efficiency. Effective jet-assisted arrangements have exceeded a 1000 gpm (3800 L/min) discharge rate when using 6 in. (150 mm) discharge piping and valves. Pumps supplying such jet arrangements should be capable of delivering a minimum of 250 gpm (950 L/min) at a gauge pressure of 150 psi (1035 kPa). Some departments have obtained good results with pumps that deliver flows at a gauge pressure of less than 150 psi (1035 kPa) where larger discharge openings are provided. The size and design of the nozzle and the diameter and length of the dump valve piping directly affect unit efficiency.

C.11.2.1 Traditional In-Line Jet-Assisted Arrangement. Figure C.11.2.1(a) illustrates how the traditional jet is installed. A smooth-tipped nozzle is usually supplied by a pump capable of delivering at least 250 gpm (950 L/min) at a gauge pressure of 150 psi (1035 kPa). Nozzle tips range in size from ¾ in. to 1¼ 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.

Before a jet-assisted 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 1½ 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. (100 mm to 300 mm). Normally, a 6 in. or 8 in. (150 mm or 200 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. (150 mm) from the center of the discharge opening, other effective designs have included placement of the nozzle inside the discharge piping. Figure C.11.2.1(b) details how the traditional jet arrangement can be externally added to an existing dump valve. A short length of 1½ 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.

To properly operate, a jet should be able to produce a discharge gauge pressure at the nozzle between 50 psi and 150 psi (345 kPa and 1035 kPa). Higher pressures normally increase operational effectiveness. The diameter of the jet selected should be appropriate for the capabilities of the pump being utilized. Also important is the size of the piping and valves that make up the jet-assisted dump system. The major advantage of external jets is reduced maintenance. Disadvantages include the need for adequate air exchange during water flow, and the additional time for the initial setup in order to attach hose and affix appliances.

C.11.2.2 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

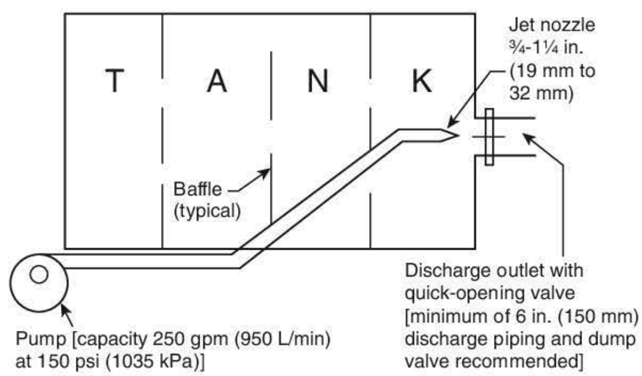


FIGURE C.11.2.1(a) Traditional Internal Jet-Assisted Dump.

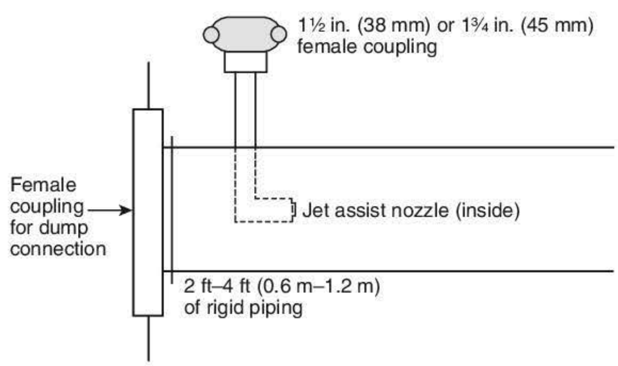


FIGURE C.11.2.1(b) Traditional External Jet-Assisted Dump.

2000 gpm (7600 L/min) have been obtained using a 300 gpm (1136 L/min) pump to supply two ¾ in. (19 mm) nozzles in a 6 in. (150 mm) dump valve configuration. Figure C.11.2.2(a) and Figure C.11.2.2(b) represent two views of a typical installation.

C.11.2.3 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 portable 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. (100 mm) PVC and aluminum piping have been used for such devices, 6 in. (150 mm) units usually are more practical. Using a ½ in. (13 mm) jet-assist nozzle supplied by a 1½ in. (38 mm) hose makes possible transfer flows of 500 gpm (1900 L/min). *[See Figure C.11.2.3(a).]* Some departments have built a metal sleeve with a jet-assist nozzle that can be merely added to a length of suction hose. *[See Figure C.11.2.3(b).]*

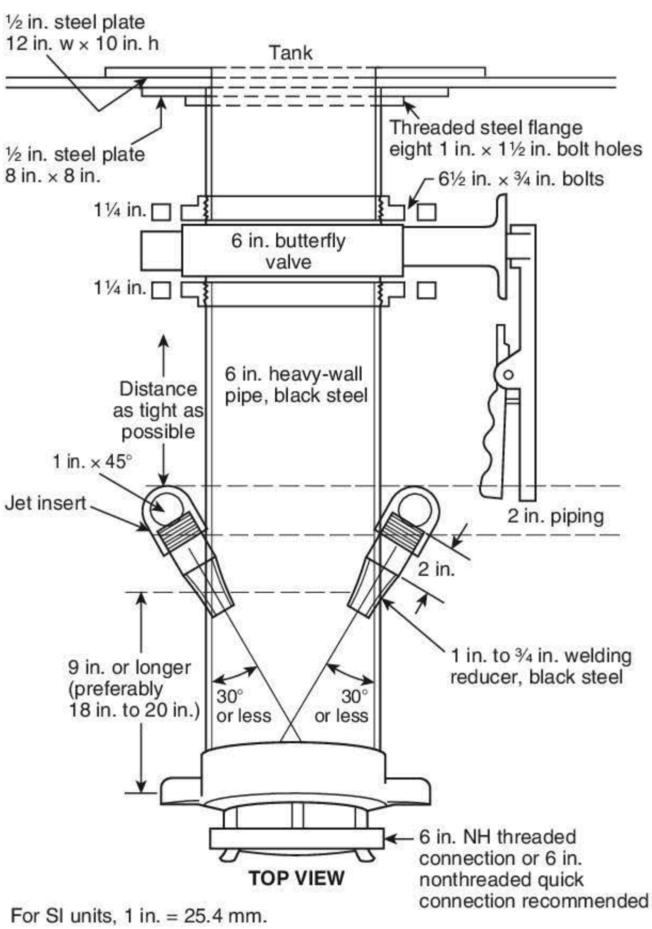


FIGURE C.11.2.2(a) Peripheral Jet-Assist Installation (Top View).

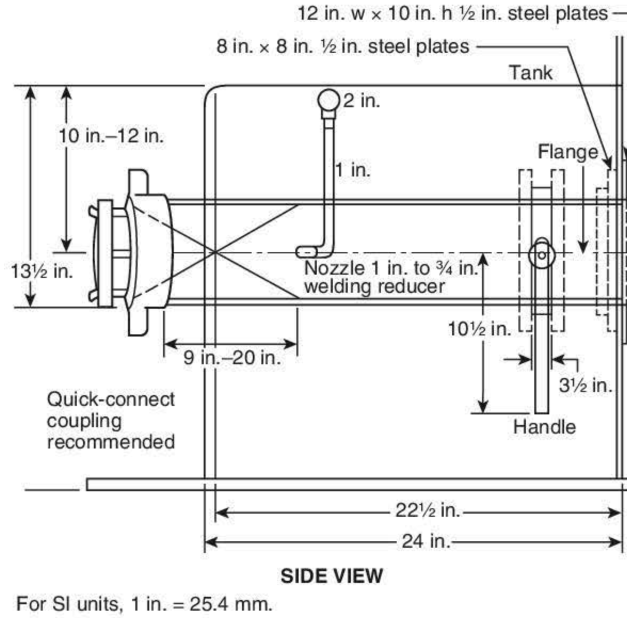


FIGURE C.11.2.2(b) Peripheral Jet-Assist Installation (Side View).

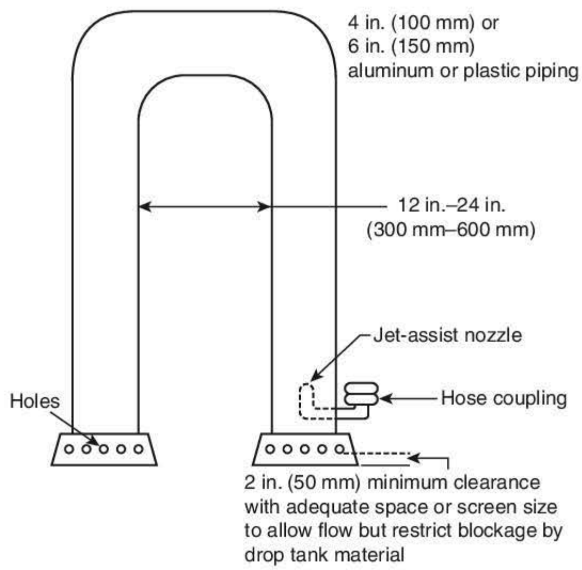


FIGURE C.11.2.3(a) Jet-Assist Transfer Siphon.

C.11.2.4 Water Eductors/Ejectors. Water eductors (also known as water ejectors) that use the jet principle are commercially available *[see Figure C.11.2.4(a)]*. These devices can provide access to static water supply sources (lakes, ponds, streams, irrigation ditches, and swimming pools) up to 250 ft (76 m) away from a pump or as much as 100 ft (30 m) below it. They can draw water from sources only a few inches deep, and devices are available in a variety of sizes up to 2½ in. (65 mm) motive hose and a 5 in. or 6 in. (125 mm or 150 mm) supply hose.

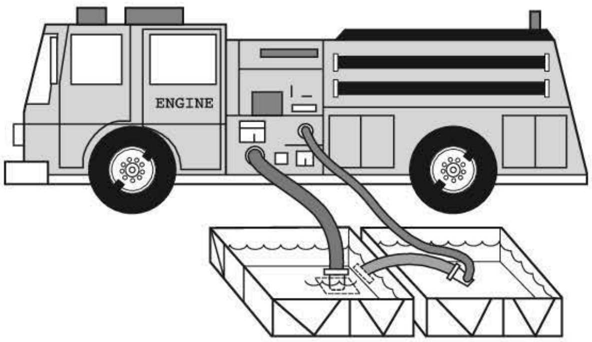


FIGURE C.11.2.3(b) Modified Hard Suction Jet Siphon.

A discharge hose referred to as the motive supply line is run from the pump discharge to feed the ejector, while a larger-diameter supply hose runs from the ejector to a valved pump intake or an open tank fill inlet, as shown in Figure C.11.2.4(b). When the ejector is set up, the motive hose line is charged with water from the water tank on the fire apparatus or other source. As the water from the motive hose passes through the eductor, water is drawn from the static water source as a result of the suction force created by the flow through the eductor's venturi *[see Figure C.11.2.4(c).]* Once the air is bled from the supply line back to the pump, the bleeder is closed and the valve on the pump intake is opened. At this point, or when the supply line into the tank fill is flowing freely, the water supply has been established.

Ejectors are available in various sizes and capacities. Ejectors with a 1 in. (25 mm) inlet and a 1½ in. (38 mm) outlet have input capacities up to 44 gpm (167 L/min), output capacities of up to 117 gpm (443 L/min), and weigh from 1.2 lb to 3.7 lb (0.54 kg to 1.68 kg). Ejectors with a 1½ in. (38 mm) inlet and 2½ in. (63 mm) outlet have input capacities near 150 gpm (568 L/min), output capacities over 250 gpm (946 L/min), and weigh from 4.8 lb to 11.0 lb (2.18 kg to 4.99 kg). Even larger ejectors are available, with 2½ in. (63 mm) inlets and 5 in. (125 mm) outlets, with output capacities over 650 gpm (2461 L/min), and weighing over 50 lb (22.68 kg). One drawback to water eductors/ejectors is that 25 percent to 30 percent of the water delivered by the supply hose must be pumped back into the motive hose in order to maintain water flow. However, in situations where hydrants are not available and drafting is impossible, this is a small trade-off for the ability to use a static water supply.

C.11.2.5 Hard Suction Jet-Assist Devices. In-line jets have also been developed to reduce suction losses during drafting operations. In-line and peripheral jets supplied by 1½ in., 1¾ in., or 2½ in. (38 mm, 44 mm, or 65 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. The design characteristics of strainers used during such application should permit adequate water flow capacity.

C.11.3 Mobile Water Supply Apparatus Equipped for Air Pressurization/Vacuum Operations. Fire apparatus are available with a pressure/vacuum system (sometimes referred to as a blower/vacuum system) to fill and empty the water tank. When filling the water tank, the system operates by rapidly extracting air from the water tank, allowing water to be drawn into the

FIGURE C.11.2.4(a) Water Ejector with Combination Foot/Valve Strainer Attached.

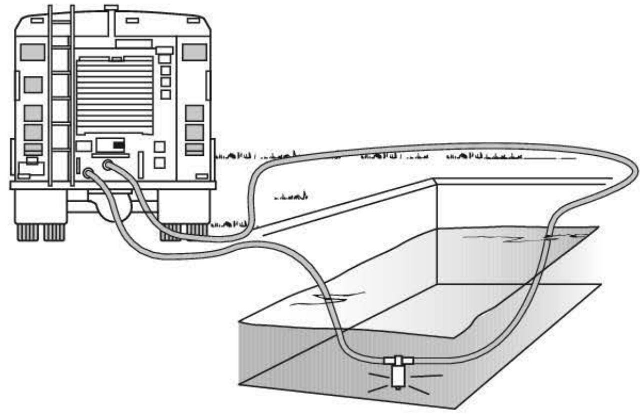


FIGURE C.11.2.4(b) Ejector Use from the Street to a Back Yard Swimming Pool.

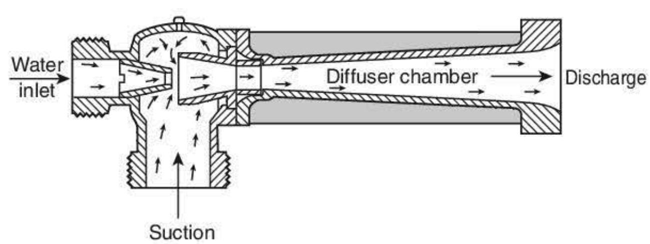


FIGURE C.11.2.4(c) Cross-Section of Water Ejector Showing Motive Line Water Inlet, Suction Inlet, and Supply Line Discharge.

tank from the water source through suction hose. To empty the tank, the process is reversed and air pressure is exerted on the water in the tank, forcing the water out the discharge outlet(s). The intake and discharge connections to the tank can be the same connection.

The system consists of a large positive-displacement rotary vane pump that can either pressurize the water tank with air to pressures between 5 psi and 12 psi (34 kPa and 83 kPa) or develop a negative pressure in the tank up to 26 in. Hg

(88 kPa) vacuum. The water tank must be "air tight," so the vacuum is maintained while the entire capacity [generally between 2000 gal to 4000 gal (7600 L to 15,200 L)] is filled with water. Water tanks used with pressurization/vacuum systems are usually round (oval) with dished heads and are specifically designed to withstand the air pressure and vacuum force placed upon them. The water tank must be properly baffled with "swash plates" and have an adequate pressure relief system.

The type of vacuum pump used for pressure/vacuum mobile water supply apparatus usually has the capability of "reversing itself," so the same pump that creates the vacuum can also be used to pressurize the tank for rapid discharge of water during off-loading. Mobile water supply apparatus with pressure/vacuum systems need to meet all applicable federal regulations and NFPA standards.

To provide handline capability and increased transfer flexibility, fire departments often install a fire pump with a 500 gpm at 150 psi (1900 L/min at 1035 kPa) or larger capacity or a large portable pump capable of supplying handline volumes and pressures on the mobile water supply apparatus.

Manufacturers indicate that pressure/vacuum-equipped units provide the same capabilities as other mobile water supply apparatus, with or without a fire pump or with or without jet-style dump valves. Apparatus equipped with pressure/vacuum systems can utilize long runs of suction hose to remote water sources and overcome a draft height (vertical lift distance) greater than apparatus with a standard fire pump and primer arrangement. Benefits that manufacturers claim are associated with the use of pressure/vacuum technology include the following:

(1) Water tanks completely fill at intake flow rates up to 2000 gpm (7600 L/min).
(2) The unit lifts water to heights of 28 ft to 30 ft (8.5 m to 9 m) and maintains effective draft capability for extended distances from the fill site. It can also be effectively filled from a hydrant or other positive pressure source.
(3) There is no water spillage during transport.
(4) The same inlets/discharges located on the right, left, and rear provide both fill and dump options.
(5) Pressurizing the water tank permits rapid off-loading using one outlet. The pressurized tank facilitates water discharge at a delivery rate in excess of normal dump valve arrangements that rely on standard atmospheric pressure and some jet-assist dump devices.

C.12 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 each mobile water supply apparatus in use. Generally accepted procedures for determining flow capacities have been developed and should be accomplished as follows:

(1) Determine the useful water-carrying capability of the apparatus as follows:
    (a) Fill the water tank and weigh the mobile water supply apparatus. This is the full weight (*FW*).
    (b) Empty the water tank using the dump valve using only gravity and reweigh the apparatus. This is the empty weight (*EW*).
    (c) Determine the water carrying capacity (*Q*) of the apparatus as follows:

[C.12a]

$$Q \text{ in gallons} = \frac{FW(\text{lb}) - EW(\text{lb})}{8.33}$$

$$Q \text{ in liters} = FW(\text{kg}) - EW(\text{kg})$$

where:
FW = weight of apparatus with tank full
EW = weight of apparatus with tank empty
Q = water-carrying capacity of apparatus

(2) Determine the dump rate through the dump valve when only gravity is used as follows:
    (a) Fill the water tank.
    (b) Off-load the water for 1 minute through the dump valve using gravity only.
    (c) Weigh the apparatus to determine the gravity-only dumped weight (*GDW*).
    (d) Determine the dump rate when only gravity is used (*GDR*) as follows:

[C.12b]

$$GDR_{\text{gal/min}} = \frac{FW(\text{lb}) - GDW(\text{lb})}{8.33}$$

$$GDR_{\text{L/min}} = FW(\text{kg}) - GDW(\text{kg})$$

where:
GDR = dump rate when only gravity is used
FW = weight of apparatus with tank full
GDW = weight of apparatus after 1 minute of dumping water using gravity only

(3) If the tank is equipped with a jet-assist dump, determine the dump rate through the dump valve when the jet assist is used as follows:
    (a) Fill the water tank.
    (b) Off-load the water for 1 minute through the dump valve with the jet assist being used.
    (c) Weigh the apparatus to determine the jet assist dumped weight (*JDW*).
    (d) Determine the dump rate when a jet-assist is used (*JDR*) as follows:

[C.12c]

$$JDR_{\text{gal/min}} = \frac{FW(\text{lb}) - JDW(\text{lb})}{8.33}$$

$$JDR_{\text{L/min}} = FW(\text{kg}) - JDW(\text{kg})$$

where:
JDR = dump rate when jet dump assist is used
FW = weight of apparatus with tank full
JDW = weight of apparatus after 1 minute of dumping using jet dump assist

(4) If the apparatus is equipped with a pump, determine the dump rate when pumping the water off as follows:
    (a) Fill the water tank.
    (b) Off-load the water for 1 minute through the tank to pump plumbing using the pump on the apparatus and one or more 2½ in. (65 mm) discharges.

(c) Weigh the apparatus to determine the pumping dumped weight (*PDW*).

(d) Determine the dump rate when a pump is used (*PDR*) as follows:

[C.12d]

$$PDR_{gal/min} = \frac{FW(\text{lb}) - PDW(\text{lb})}{8.33}$$

$$PDR_{L/min} = FW(\text{kg}) - PDW(\text{kg})$$

where:

PDR = dump rate when pump is used

FW = weight of apparatus with tank full

PDW = weight of apparatus after 1 minute of pumping water from the tank

Initially it is important to know how much water the tank is really capable of delivering. Poor tank discharge arrangements and misunderstanding of the tank's capacity often result in a tank that cannot carry as much water as thought. An effective jet-assisted dump arrangement should be capable of off-loading at least twice the volume that would be expected when off-loading by gravity for a given period of time and should exceed the volume off-loaded using the pump only. Whether using gravity dumps or jet dump arrangements, turnaround drop times and ease of operations should be the primary considerations.

C.13 Portable Drop Tanks. Generally, the three types of portable drop tanks are the following:

(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. Tanks are available with an inlet or outlet, or both, built into the side of the tank. Tanks are available in a wide range of capacities with 1500 gal to 2000 gal (5678 L to 7600 L) tanks being those used most often.

Each mobile water supply apparatus should carry a portable drop tank that has a 40 percent greater capacity than the water tank of that apparatus. The strainer on suction hose used when drafting from a portable tank should be designed to minimize whirlpooling and allow the fire department to draft to a depth of 1 in. to 2 in. (25 mm to 51 mm) from the bottom.

Annex D Large-Diameter Hose

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

D.1 General. The use of large-diameter hose 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. Where delivery rates need to exceed 500 gpm (1900 L/min) and water is being moved long distances, large-diameter hose provide a most efficient means of minimizing friction losses and developing the full potential of both the water supply and the pumping capacity. NFPA defines large-diameter hose as hose with an inside diameter of 3½ in. (89 mm) or larger.

D.2 Characteristics of Large-Diameter Hose. Large-diameter hose is available in either single-jacketed or double-jacketed construction, generally in the following sizes:

(1) 3½ in. (89 mm)
(2) 4 in. (100 mm)
(3) 5 in. (125 mm)
(4) 6 in. (150 mm)

Large-diameter hose is available as either supply hose or attack hose. Supply hose will have a design service test pressure of 200 psi (1380 kPa) for an expected normal highest operating pressure of 185 psi (1280 kPa). Some older large-diameter hose might only have been rated for a service test pressure of 150 psi (1035 kPa). Attack hose will have a design service test pressure of at least 300 psi (2070 kPa). At that service test pressure, the expected normal highest operating pressure would be 275 psi (1900 kPa).

The lower friction loss characteristics of such hose for a given quantity of water increases the usable distance between the water source and the fire. The department unable to use water sources more than 1000 ft (305 m) from a potential fire site using 2½ in. (65 mm) hose could flow approximately twice as much water 3000 ft (914 m) or more through 4 in. (100 mm) hose with the same friction loss.

The basic reason large-diameter hose moves water more effectively is its larger size. The relationship can be explained by studying the carrying capacities and friction loss factors shown in Table D.2(a) and Table D.2(b).

Table D.2(a) Relative Water Capacity of Different Size Fire Hose per Unit Length

Nominal Diameter of Hose (in.)	Nominal Diameter of Hose (in.)						
	2½	3	3½	4	4½	5	6
2½	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
3½	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
4½	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

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.
Note: The values in the table are based on the Hazen–Williams equation.

Table D.2(b) Approximate Friction Losses in Fire Hose (psi/100 ft)

Flow (gpm)	Nominal Diameter of Hose (in.)					
	2½	3	3½	4	5	6
250	13	5	2	1	—	—
500	50	20	8.5	5	2	1
750	—	45	19	11	5	3
1000	—	80	34	20	8	5
1500	—	—	77	45	18	11
2000	—	—	—	80	32	20

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

D.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 hose line. Table D.2(a) provides a comparison of the carrying capacity between different diameter hose lines.

To use Table D.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 5 in. (125 mm) diameter hose has 6.2 times the carrying capacity of 2½ in. (65 mm) hose, 3.83 times the carrying capacity of 3 in. (76 mm) hose, 2.56 times the carrying capacity of 3½ in. (89 mm) hose, and so on. In other words, it would require over six lines of 2½ in. (65 mm) hose to equal the capacity of only one line of 5 in. (125 mm) hose.

Large-diameter hose also has less friction loss per flow rate than smaller diameter hose. Table D.2(b) shows the relative friction loss of 2½ in. (65 mm) to 6 in. (152 mm) diameter hose for the various flow rates (in gpm). The values in the table are based on the Hazen–Williams equation. *(See NFPA Fire Protection Handbook, Section 13, Chapter 3 for information on Fire Streams.)*

D.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.2.2 can be used to assist in hose selection. A pumper rated 750 gpm (2850 L/min) at 150 psi (1035 kPa) operating from draft can relay 750 gpm (2850 L/min) through only 650 ft (200 m) of 3½ in. (89 mm) fire hose and have a 20 psi (138 kPa) intake pressure at the receiving pump. If 6 in. (150 mm) hose is used, that same pumper could move 750 gpm (2850 L/min) through 4300 ft (1300 m) of hose. While moving water this distance is theoretically possible, another factor is how much hose a pumper or other fire apparatus can carry. Trying to carry 4300 ft (1300 m) of 6 in. (150 mm) hose is certainly not practical. The table is designed to apply primarily to situations in which a fire department is relaying water with pumps discharging at 150 psi (1035 kPa) and wants 20 psi (138 kPa) residual pressure at the point receiving the flow.

D.3 Load Capacity. Another important advantage associated with large-diameter hose is that 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.

Table D.2.2 Maximum Hose Length in Feet with 130 psi (900 kPa) Loss

Internal Diameter of Hose (in.)	Quantity of Water (gpm)					
	250	500	750	1,000	1,500	2,000
2½	1,000	250	—	—	—	—
3	2,600	650	250	150	—	—
3½	6,500	1,450	650	350	150	—
4	—	2,600	1,150	650	300	150
5	—	6,500	2,600	1,600	700	400
6	—	13,000	4,300	2,600	1,150	650

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.4 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.4.)*

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

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

D.5 Fittings. Large-diameter hose is available with either standard threaded couplings or nonthreaded couplings that eliminate the male-female feature and, consequently, many adapters.

Special fittings, as described in D.5.1 through D.5.5, have been developed to be used with large-diameter hose.

D.5.1 Clappered Siamese Connection. During major fires, it is often desirable to supplement a water supply. If a clappered siamese is inserted into the large-diameter hose line at the source, a second pumper can provide an additional supply line at the water source. With the siamese in place, this second source can be added without interrupting the flow from the first supply. *(See Figure D.5.1.)*

D.5.2 Four-Way Hydrant Valve. A four-way hydrant 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.5.2(a) and Figure D.5.2(b)].*

FIGURE D.4 Apparatus with Reels for Large-Diameter Hose. ***(Courtesy of LLNL Fire Department)***

FIGURE D.5.1 Clappered Siamese Connection. *(Courtesy of Dan MacDonald, New Boston, NH Fire Department)*

FIGURE D.5.2(a) Four-Way Hydrant Valve. *(Courtesy of Kocheck Co., Inc.)*

D.5.3 Distributor Valve. A distributor valve contains a 4 in. (100 mm) or 5 in. (125 mm) opening and waterway with two 2½ in. (65 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 on the discharge side plus an adjustable dump valve on the intake side. *(See Figure D.5.3.)*

D.5.4 Intake Gated Relief Valve. An intake 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

FIGURE D.5.2(b) Four-Way Hydrant Valve in Use. *(Courtesy of Kochek Co., Inc.)*

FIGURE D.5.3 Distributor Valve. *(Courtesy of Kocheck Co., Inc.)*

slow-operating valve, an automatic air bleeder, and an adjustable dump valve. The gated valve allows the supply line to be connected while the pumper is 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 pressure surges. *(See Figure D.5.4.)*

D.5.5 Air Bleeder. An air bleeder, whether automatic or manually operated, is needed at all points where a large-diameter hose is connected to a pump inlet or at any distribution point.

FIGURE D.5.4 Intake Gated Relief Valve.

D.6 Irrigation Piping. Irrigation piping shares the same characteristics as large-diameter hose, the capability of transferring large volumes of water at relatively low friction loss. The use of irrigation in the farming community has increased throughout the country, resulting in lightweight aluminum pipe being available to the fire service. It can be carried on vehicles or used where available on the fireground.

The coupling arrangement for irrigation pipe usually will not permit its use for drafting. The pipe does provide a relatively permanent installation for long-duration firefighting. Generally, irrigation pipe is an excellent tool for major disaster situations but is less often used for conventional firefighting evolutions, since it takes longer to set up than large-diameter fire hose.

Departments working in areas in which piped irrigation systems are going to be used to supply firefighting water should be aware that adapters are needed to interconnect conventional agricultural fittings with fire hose fittings. Adapters used to change the pipe coupling to fire department hose threads can be easily fabricated in local machine shops. Care must be taken in such fabrication to ensure that the resulting adapter is safe to be used at any pressure the water supply system might be subjected to, including sudden pressure surges. Such adapters are not offered by either pipe or fire hose manufacturers. At least one adapter for use at the supply end of the pipe and one adapter for use at the discharge end of the pipe should be available. An example might include an adapter with four 2½ in. (65 mm) female inlets with National Hose (NH) thread adapting to a pipe coupling and an adapter from a pipe coupling to four 2½ in. (65 mm) NH gated male outlets. Another example would be adapters to connect large-diameter hose to either end of the pipe.

Additional fittings to provide a fire hose connection at 100 ft to 300 ft (30 m to 90 m) intervals [one or more 2½ in. (65 mm) NH per pipe section] might be desirable.

Annex E Portable Pumps

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

E.1 General. Both diesel-driven and gasoline-driven portable pumps are available. The use of portable pumps is a common method for moving water by rural fire departments. All rural firefighters should be able to place all portable pumps used by their department in operation, obtain draft, and perform each procedure in a minimal amount of time.

E.2 Description of a Portable Pump. A portable pump in the fire service means a pump that can be carried to a source by firefighters, sometimes over difficult terrain. In general, two people should be able to conveniently carry the pump. It should weigh no more than 175 lb (79 kg) and be capable of supplying at least two 1½ in. (38 mm) handlines. It should also have handles and should be constructed to be carried in a compartment in the apparatus. Heavier pumps, perhaps trailer- or truck-mounted or otherwise made mobile, are valuable but used less commonly.

Although a number of rural fire departments have used portable-type pumps that are securely mounted on their apparatus as the sole means of pumping, few fire departments consider this arrangement to be permanent, and most of those departments plan to buy a fire department pumper, in addition to the portable pump(s), when finances permit.

E.3 Evaluating Portable Pump Needs. In order to get the maximum benefit from portable pumps, the officers of the rural fire department should carefully study the needs of the department, taking into consideration the potential fire hazard, the available water supplies, and the capabilities of the department to use portable pumps. The accessibility and the reliability of water supplies determine the need for and use of portable pumps. Many rural fire departments have found that both a low-pressure pump and a high-pressure pump are required to fill their needs.

The portable pump selected should fit the firefighting system of which it is to be a component; if direct hose streams are to be taken from a portable pump, the nozzles and hose size determine the required pump discharge versus pressure characteristics.

E.4 Classifications or Types of Portable Pumps. Portable pumps come in a variety of pressure/volume combinations. It is important that the fire department study their needs and select a pump that will accomplish the objective.

E.4.1 Small Volume — Relatively High Pressure. A small-volume pumping unit should be capable of pumping 20 gpm (76 L/min) at 200 psi (1380 kPa) net pressure through a 1 in. (25 mm) discharge outlet while taking suction through a 1½ in. (38 mm) suction inlet. This class of portable pump is especially useful to fire departments for forest firefighting, which frequently requires long ¾ in. to 1½ in. (19 mm to 38 mm) hose lines and uphill pumping in rugged terrain.

E.4.2 Medium Volume — Medium Pressure. A medium-volume pumping unit should be capable of discharging 60 gpm (227 L/min) at 90 psi (621 kPa) net pressure and 125 gpm (473 L/min) at 60 psi (414 kPa) net pressure through a 1½ in. (38 mm) discharge outlet while taking suction through a 2½ in. (65 mm) suction inlet.

E.4.3 Large Volume — Relatively Low Pressure. A large-volume pumping unit should be capable of supplying 125 gpm (475 L/min) at 60 psi (414 kPa) net pressure and 300 gpm (1136 L/min) at 20 psi (138 kPa) net pressure through a 2½ in. (65 mm) discharge outlet while taking suction through a 3 in. or 4 in. (75 mm or 100 mm) suction inlet.

E.5 Common Types of Pumps. The common types of pumps used are described in E.5.1 through E.5.4.

E.5.1 Low-Pressure Centrifugal Portable Pumps. Low-pressure centrifugal portable pumps (high volume) generally are rated at 200 gpm to 300 gpm (757 L/min to 1136 L/min) and are capable of discharge at pressures of 50 psi to 80 psi (345 kPa to 552 kPa). Usually these pumps will not discharge their rated capacity when they operate with a suction lift in excess of 5 ft (1.5 m).

Some low-pressure centrifugal portable pumps do not use running rings or seal rings. These types of pumps do not have close tolerances, so they can be used in dirty water where some debris or abrasives are encountered. These pumps require little maintenance.

Other types of low-pressure centrifugal portable pumps do have water or seal rings. If these pumps are pumping water containing substantial amounts of abrasive materials, the water or seal rings will not last as long as might be normally expected.

At lower discharge pressures, this type of pump can deliver larger volumes, which at times have been metered at 400 gpm to 600 gpm (1514 L/min to 2272 L/min), with adequate-size hard suction hose at very low discharge pressures and high pump rpm (e.g., relay from portable pump into fire pump on apparatus or portable drop tank; or relay from water source to drop tank where mobile water supply is filled for relay to fire site).

Operation of these pumps depends on centrifugal force to move water, and they are very effective for relay operations to pumper or for booster tank or mobile water supply filling. There are no special operating problems to watch out for, and these types of pumps will not heat up as rapidly as others if run without water.

E.5.2 High-Pressure Centrifugal Portable Pumps. High-pressure centrifugal portable pumps (small volume) generally have a small capacity, with an average of 30 gpm to 40 gpm (114 L/min to 151 L/min) discharge and operating pressures in the 125 psi to 250 psi (862 kPa to 1724 kPa) range.

The impeller is usually geared twice as fast as the engine to achieve single-stage pressure. This type of pump uses running rings or seal rings that are the same as those used for larger fire pumpers and usually incorporates closed volutes in the impeller.

E.5.3 Floating Pumps. A floating pump is a portable pump that primes and pumps automatically when it is placed in water. The pump is constructed to sit inside a float that resists breakage and needs no maintenance. Some entire units weigh under 50 lb (23 kg), including fuel, and provide 60 minutes to 90 minutes of operating time from the 5 qt (4.73 L) fuel tank.

The pump serves a need for a lightweight, easy-to-operate, portable fire pump that can be placed in the water and does not need suction hose or strainers. However, such pumps tend to pick up leaves and other trash that can block the nozzles and strainers downstream. *(See Figure E.5.3.)*

E.5.4 High-Lift Pumps. High-lift pumps are small, portable pumps that use water to drive a water motor, which in turn drives an impeller and pumps water to high elevations and into a fire pumper for relay into hose lines for firefighting.

The high-lift pump is designed to obtain a water supply from a river, lake, stream, swimming pool, and so forth, where the source is not accessible for drafting operations using a pumper or a conventional portable pump.

The water used to power the water motor of a high-lift pump is taken from the booster tank of the pumper and discharged at high pressure through the fire pump into the hose to the high-lift pump water motor. Pressurized water, in turn, drives the water motor, which is connected to the high-lift pump impeller, thus forcing volumes of water back into the intake side of the fire pump and on into the firefighting hose lines.

High-lift pumps can be hooked into hose lines and placed into water sources at lower levels without firefighting personnel having to go down to such sources to set the pump.

E.5.5 Floating Submersible Source Pumps. Floating submersible source pumps (FSSP) are hydraulically-driven centrifugal pumps that are designed for low-pressure, high-volume applications in open-water sources. These pumps differ from portable pumps in terms of their power, capacity, and their position in the water. FSSPs are partially exposed on the surface and their suction inlets are located completely below the water's surface. Typically, these pumps are for fire department use and can provide a water supply from 2000 gpm to 3000 gpm (7570 lpm to 11,350 lpm) from any open water source. These pumps do not have the restrictions associated with fire department drafting operations. The power unit can be mounted on a 4x4 or a similar type of apparatus. The pump itself can be deployed over a wide variety of terrain and infrastructure configurations over

FIGURE E.5.3 Floating Pump with 1½ in. (38 mm) Discharge Line. ***(Courtesy of LLNL Fire Department)***

100 ft (30.5 m) away by use of its hydraulic umbilical connection, allowing the power unit to remain on stable ground and remote from the water source. The primary benefit of FSSPs is their true access to remote water. With drafting fire pumper apparatus rated to standard 10 ft (3 m) suction heights and equipped with 20 ft (6 m) suction lines, a dry-hydrant system or near direct access to the water is required. Otherwise, fire departments must accept large flow derates on their pumps.

FSSP systems can be used in conjunction with primary response fire pumper apparatus and tanker shuttle operations. With a FSSP system in the water source, it can provide continuous filling operations to tankers (at a very fast fill rate) and portable tanks alike. When located in proximity to the fireground, they can provide high-volume water directly to supply the fire pumper apparatus at the fire scene.

E.6 Methods of Using Portable Pumps.

E.6.1 General. Some of the many problems of supplying water in rural areas can frequently be overcome through the use of the proper portable pump. Many departments, through area pre-fire planning, locate water sources where portable pumps are the only suitable means of using the water supply for filling mobile water supply apparatus or for supplying firefighting hose lines.

Departments should, when locating a pumping site for portable pumps, determine whether the site is available year-round or whether it can be used only during certain times of the year. Further determination should be made as to the site's availability under the weather conditions anticipated. If such conditions could make use of the site difficult, a plan to prepare the site for all-weather utilization should be established.

Centrifugal pumps are usually preferred over other types because of their ability to handle dirt and abrasives with less damage and because of their desirable volume–pressure ratio. Similarly, four-cycle engines are considered more suitable for fire service use, although two-cycle or the new turbine-driven pumps can be used. However, four-cycle engines should be used with the engine in a level position or the engine will be damaged, whereas two-cycle engines can be used with the engine in any position (as long as fuel is available to the engine) without damage to the engine.

A wood pallet or other firm base can be useful under soft ground conditions.

E.6.2 Uses of Portable Pumps. Portable pumps can be used in single or multiple combinations to accomplish the following:

(1) Filling truck tanks where no fire department pumper is available
(2) Relaying water from a source in a variety of combinations or hookups

There are many factors to consider in deciding which size and type of portable pump will best fit a fire department's needs. Consideration should be given to the capabilities of the pump and its uses.

E.6.3 Relay to Mobile Water Supply Apparatus. Under conditions where a fire department pumper cannot get to a source of water and there is considerable distance (several miles) between the source and the fire, low-pressure portable pumps of larger volume have proved to be very satisfactory where they are used to relay water to a mobile water supply apparatus that shuttles water to a portable drop tank at the fire. A fire department pumper takes suction from the portable drop tank for discharge onto a fire. *(See Section C.13.)*

E.6.4 Single Relay from Portable Pump to Pumpers. Under conditions where a standard fire truck cannot get to a source of water, low-pressure portable pumps of larger volume have proved to be very satisfactory where they are used to relay water to pumpers. This method becomes feasible at a greater distance from water if large-diameter hose is used. *(See Figure E.6.4.)*

A single portable pump often can supply enough water to keep a pumper supplied with effective fire streams. The portable pump can be at the water source and a line laid from the portable pump to the pumper.

One of the big advantages of the portable pump is that it can be placed close to the water supply for operation at minimum lift and minimum friction loss in the suction hose, provided adequate-size suction hose is used. Regular pumpers can accept water from portable pumps and increase water pressure for fire streams or use the water in a combination of fire streams and booster tank filling.

A method commonly used is for a pumper to lay hose lines from the fire to the water supply and start pumping from the booster tank into the hose line and onto the fire while the portable pump is being placed and water supply and hose lines from the portable to the regular pumper are being hooked up. *(See Figure E.6.4.)*

E.6.5 Use of Portable Pumps to Fill Mobile Water Supply Apparatus or Booster Tanks. Many rural fire departments are overcoming problems of limited water supply by using mobile water supply apparatus to relay water to pumpers working at a fire. If the water supply is a stream with a small flow, for instance, 150 gpm (568 L/min), or if the water supply is inaccessible by fire apparatus, the water can be obtained with a portable pump placed at the water supply. This pump supplies a portable folding tank that is used to stockpile water, and mobile water supply apparatus are filled from the portable folding tank for shuttle to the fire. At the fire, the mobile water supply apparatus discharges its water into another portable folding tank that is used to stockpile water from which the pumper(s) takes suction and discharges water onto the fire. *(See Section C.13 and Figure E.6.5.)*

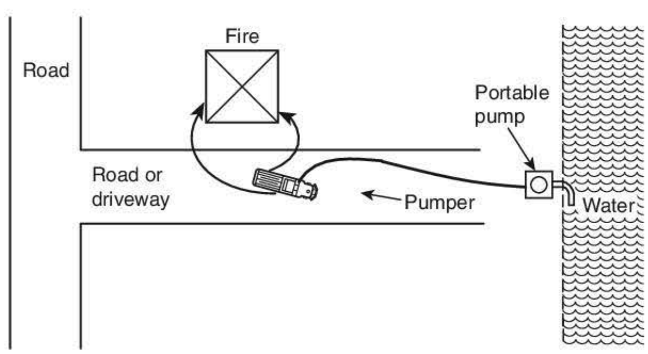


FIGURE E.6.4 Single Relay from Portable Pump to Pumper.

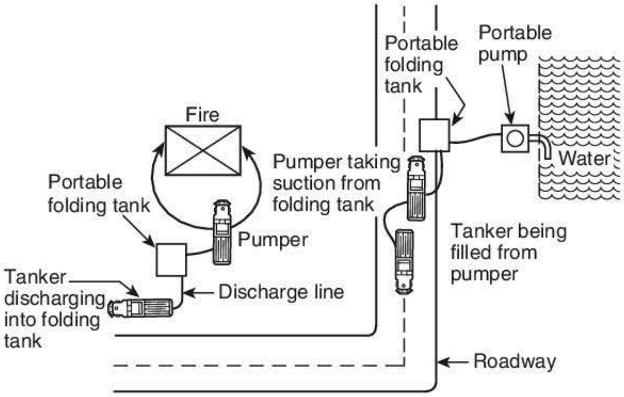


FIGURE E.6.5 Portable Pump Filling Portable Folding Tank.

It is not prudent to put the discharge line from portable pumps into the tops of booster tanks or mobile water supply apparatus unless there is no other way to fill the tank or a special filling device is provided. Placing lines into the tops of mobile water supply apparatus or booster tanks is a slow way of filling the tank and can be dangerous to those working on apparatus. Hooking the portable pump discharge line directly into intake piping of large pumpers or mobile water supply apparatus has proved to be the quickest and safest method of filling tanks.

Any of the portable pumps can be used in place of a pumper for filling mobile water supply apparatus; however, the low-pressure, high-volume-type pumps do the job more quickly than others. Where water is being pumped into tanks, strainers should be used to prevent the passage of trash and debris. Floating strainers have proved to be very effective.

Where the water supply has the capacity, multiple portable pumps for filling mobile water supply apparatus can increase filling efficiency. A 200 gpm to 300 gpm (757 L/min to 1136 L/min) rate results in a slow filling time; therefore, two or three portable pumps should be moved into the operation as mutual-aid mobile water supply apparatus arrive to achieve a 500 gpm (1900 L/min) filling rate. Multiple portable pumps also act as a backup in case of engine failure.

Annex F Automatic Sprinkler Protection

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

F.1 Sprinkler Protection of Rural Buildings. With an increase in sprinklered buildings being constructed in rural areas, many rural fire departments are beginning to understand the value of automatic sprinkler protection. The sprinkler system provides built-in fire protection, lessening the fire suppression burden and the water supply need on the fire department. Also, the record of the automatic sprinkler system performance is superior. NFPA records show that 96 percent of all fires in sprinklered buildings are controlled or extinguished by the sprinkler system, with a large percentage of these fires controlled by no more than two or three sprinkler heads. In the 3 percent to 4 percent of automatic sprinkler systems reported to have unsatisfactory performance, the following human failures have been noted:

(1) The sprinkler system was shut off and not in service.
(2) The fire department shut off the water to the sprinkler heads before the fire was completely extinguished.
(3) Fire department operations robbed the sprinkler system of its water supply.
(4) The fire department did not use the fire department connection.
(5) The sprinkler system was not designed to protect the existing hazards.

F.2 Water Supply for Automatic Sprinkler System. Sprinklered buildings are usually provided with a water supply such as an elevated tank, ground-level suction tank, or pond equipped with a fire pump. In a number of cases, a distribution system with hydrants is also provided.

F.3 The Fire Department and the Sprinkler System.

F.3.1 Installation of Water Supplies. Water supplies for the automatic sprinkler system referred to in Section 4.4, which consist of pumps and tank combinations feeding yard mains and a hydrant system, should be installed in accordance with NFPA 20, NFPA 24, and NFPA 22.

F.3.2 Applicable NFPA Standards. The following NFPA standards should be referenced where applicable:

(1) NFPA 13
(2) NFPA 13D
(3) NFPA 13R
(4) NFPA 15
(5) NFPA 11

In addition, the fire department should be aware of the recommendations in NFPA 13E.

F.3.3 Use of Fire Department Connection. The standard operating procedures (SOPs) of each rural fire department should require one of the first-response pumpers to pump to the fire department connection of the sprinkler system. In this way, water pressure and volume to the system can be increased, making the sprinklers more effective. Also, the fire department connection should tie into the system beyond all valves that might be shut off; therefore, even with the valve controlling the water supply to the sprinkler system shut off, sprinkler heads could be supplied with water through the fire department connection. After assessment by the officer in charge, a decision to charge the system might be warranted. The pressure available from the fire department pumper will not burst the piping or heads of the sprinkler system, as all parts of the system are designed and tested to withstand at least 200 psi (1380 kPa).

F.3.4 Shutting Off Sprinkler System After the Fire. The sprinkler system should not be shut down until the officer in charge is convinced that the fire is extinguished or controlled and handlines are in place for overhauling operations. Even then, the fire department pumper should not be disconnected from the fire department connection to the sprinkler system until the officer in charge is certain that the fire is out. A person should be stationed at the control valve of the sprinkler system, ready to reopen the valve in case of a flare-up during fire department mop-up operations.

Annex G Municipal-Type Water System

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

G.1 General. The water supply for firefighting purposes, as specified in Chapter 4, is considered the minimum water supply necessary for basic firefighting. It is assumed that the water is made available at the fire scene from a single water point such as a dry hydrant, often using a mobile water supply shuttle in conjunction with a portable folding tank(s) or a water supply relay.

The AHJ can determine that a municipal-type water system is warranted. This determination might be made as a result of an on-site survey of buildings by the fire department having jurisdiction or by review of architectural plans of proposed construction and planned development.

G.2 Need for Municipal-Type Water System. The determination of the need of a municipal-type water system is based on anticipation of a large-scale fire situation in a commercial building or a large area residential building. Such a situation would require a water supply delivery system that can best be achieved by a water system that includes hydrants, a distribution system, storage, and a source of supply capable of delivering a minimum flow of 250 gpm (950 L/min) at a gauge pressure of 20 psi (140 kPa) residual pressure for a 2-hour duration.

G.3 Developing Fire Flow Requirements for a Municipal-Type Water System. The *Guide for Determination of Needed Fire Flow* is available from the Insurance Service Office (ISO) and can be of assistance in determining the needed fire flow (NFF) of commercial and residential structures. The guide can be accessed or requested from the Verisk Analytics website at https://www.isomitigation.com/ppc/technical/needed-fire-flow/.

Annex H Calculating Minimum Water Supplies

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

H.1 General. This annex provides examples of calculations of minimum water supplies as required in Chapter 4, and precalculated minimum water supply tables by occupancy hazard classification and construction classification where no exposures are present.

H.2 Structures Without Exposure Hazards. The examples in H.2.1 through H.2.3 show calculations of minimum water supplies for structures where there are no exposures.

H.2.1 Residential. A dwelling has the following characteristics: (1) a ground floor of 50 ft × 24 ft; (2) two stories of 8 ft each; (3) a pitched roof, 8 ft from attic floor to ridgepole; and (4) wood frame (Type V) construction. The calculations for minimum water supply are as follows:

Ground floor area = 50 ft × 24 ft = 1200 ft^2

Height = 8 ft + 8 ft + 4 ft = 20 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 1200 ft^2 × 20 ft = 24,000 ft^3

The occupancy hazard classification number is 7 *(see 5.2.5)*. The construction classification number is 1.0, maximum for a frame dwelling *(see 6.2.2)*, resulting in the following calculations:

[H.2.1]

$$\frac{24{,}000}{7} \times 1.0 = 3429 \text{ gal}$$

The minimum water supply equals 3429 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

H.2.2 Commercial. A farm equipment shed has the following characteristics: (1) a ground floor of 125 ft × 100 ft; (2) height of 14 ft; (3) one story; (4) flat roof; and (5) noncombustible (Type II) construction. The calculations for minimum water supply are as follows:

Ground floor area = 125 ft × 100 ft = 12,500 ft^2

Height = 14 ft

Total volume = 12,500 ft^2 × 14 ft = 175,000 ft^3

The occupancy hazard classification number is 5 *(see 5.2.3)*, and the construction classification number is 0.75 *(see Table 6.2.1)*, resulting in the following calculations:

[H.2.2]

$$\frac{175{,}000}{5} \times 0.75 = 26{,}250 \text{ gal}$$

The minimum water supply equals 26,250 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

H.2.3 Multiple-Structure Calculations. A property has two structures on it, a church and an office, which are 60 ft apart, so there is no exposure hazard. However, the two buildings will be served by a single water source, which will need to be sized for the largest demand.

The church has the following characteristics: (1) a ground floor of 130 ft × 60 ft; (2) height of 25 ft to ridgepole (15 ft from ground to eaves, with pitched roof 10 ft above the eaves); and (3) brick (Type III) construction. The calculations for minimum water supply are as follows:

Ground floor area = 130 ft × 60 ft = 7800 ft^2

Height = 15 ft + 5 ft = 20 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 7800 ft^2 × 20 ft = 156,000 ft^3

The occupancy hazard classification number is 6 *(see 5.2.4)*, and the construction classification number is 1.0 *(see Table 6.2.1)*, resulting in the following calculation:

[H.2.3(1)]

$$\frac{156{,}000}{6} \times 1.0 = 26{,}000 \text{ gal}$$

The minimum water supply for the church equals 26,000 gal.

The office building has the following characteristics: (1) a ground floor of 175 ft × 100 ft; (2) two stories, each story 10 ft high; (3) a flat roof; and (4) fire-resistive (Type I) construction. The calculations for minimum water supply are as follows:

Ground floor area = 175 ft × 100 ft = 17,500 ft^2

Height = 10 ft + 10 ft = 20 ft

Total volume = 17,500 ft^2 × 20 ft = 350,000 ft^3

The occupancy hazard classification number is 7 *(see 5.2.5)*, and the construction classification number is 0.5 *(see Table 6.2.1)*, resulting in the following calculations:

[H.2.3(2)]

$$\frac{350{,}000}{7} \times 0.5 = 25{,}000 \text{ gal}$$

The minimum water supply for the office equals 25,000 gal.

This is a multiple-structure location served from a single water source, with the supply determined by the structure having the larger water supply requirement. The water supply for the church is 26,000 gal, and the water supply for the office is 25,000 gal. Therefore, the church has the larger water supply requirement and the minimum water supply for the site equals 26,000 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

H.2.4 Precalculated Water Supply. Table H.2.4(a) through Table H.2.4(c) provide a quick method for determining the water supply requirements of this standard for structures without exposures.

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

For example, a farm storage building such as a barn (occupancy hazard classification 4) of ordinary (Type III) construction (construction classification 1.0) with a total volume of 160,000 ft^3 (4480 m^3) will produce, using Table H.2.4(a), a water supply requirement of 40,000 gal (151,400 L).

H.3 Structures with Exposure Hazards. Examples of calculations for minimum water supply for structures with exposure hazards are shown in H.3.1 and H.3.2.

H.3.1 Residential. A dwelling has the following characteristics: (1) a ground floor of 50 ft × 24 ft; (2) one story, 8 ft high; (3) pitched roof, 8 ft from attic floor to ridgepole; (4) Type III construction; and (5) exposed on one side by a frame (Type V construction) dwelling with an area greater than 100 ft^2 and a separation of less than 50 ft. The calculations for minimum water supply are as follows:

Ground floor area = 50 ft × 24 ft = 1200 ft^2

Height = 8 ft + 4 ft = 12 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 1200 ft^2 × 12 ft = 14,400 ft^3

The occupancy hazard classification number is 7 *(see 5.2.5)*, and the construction classification number is 1.0 *(see Table 6.2.1)*, resulting in the following calculation:

[H.3.1]

$$\frac{14{,}400}{7} \times 1.0 = 2057 \text{ gal}$$

The dwelling exposure is a frame dwelling; therefore, multiply by the exposure factor of 1.5 as follows:

2057 gal × 1.5 = 3086 gal

The minimum water supply equals 3086 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

H.3.2 Multiple-Structure Calculations. The following are examples of minimum water supply calculations where there are multiple structures.

Example 1. A row of five dwellings is identical to the dwelling in H.2.1, except that one dwelling has a brick barn (Type III construction) measuring 80 ft × 40 ft that is located 35 ft from the dwelling. The barn is larger than 100 ft^2 in area and is less than 50 ft from the dwelling. Therefore, the minimum water supply for this dwelling, 3429 gal, should be multiplied by 1.5 for the exposure:

3429 gal × 1.5 = 5144 gal

If the dwellings and barn are to be protected by the same water supply, as is likely, the water supply should be calculated based on the structure that requires the largest minimum water supply. 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:

Ground floor area = 80 ft × 40 ft = 3200 ft^2

Height = 15 ft + 5 ft = 20 ft (For pitched roofs, use half the distance from attic floor to ridgepole.)

Total volume = 3200 ft^2 × 20 ft = 64,000 ft^3

The occupancy hazard classification number is 4 for the barn with no hay storage *(see 5.2.2)*, and the construction classification number is 1.0 *(see Table 6.2.1)*, resulting in the following calculations:

[H.3.2a]

$$\frac{64{,}000}{4} \times 1.0 = 16{,}000 \text{ gal}$$

16,000 × 1.5 for exposure hazard = 24,000 gal

The minimum water supply equals 24,000 gal. Since this is larger than the 5144 gal required for the dwelling, 24,000 gal would be the minimum water supply for the barn and dwelling.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Table H.2.4(a) Precalculated Minimum Water Supplies (in Gallons) for Occupancy Hazard Classifications 3 and 4 by Construction Classification (No Exposures)

	Occupancy Hazard Classification 3				Occupancy Hazard Classification 4			
	Construction Classification				Construction Classification			
Volume (ft^3)	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
8,000	2,000	2,000	2,667	4,000	2,000	2,000	2,000	3,000
10,000	2,000	3,000	4,000	6,000	2,000	2,250	3,000	4,500
16,000	2,667	4,000	5,333	8,000	2,000	3,000	4,000	6,000
20,000	3,333	5,000	6,667	10,000	2,500	3,750	5,000	7,500
24,000	4,000	6,000	8,000	12,000	3,000	4,500	6,000	9,000
28,000	4,667	7,000	9,333	14,000	3,500	5,250	7,000	10,500
32,000	5,333	8,000	10,667	16,000	4,000	6,000	8,000	12,000
36,000	6,000	9,000	12,000	18,000	4,500	6,750	9,000	13,500
40,000	6,667	10,000	13,333	20,000	5,000	7,500	10,000	15,000
44,000	7,333	11,000	14,667	22,000	5,500	8,250	11,000	16,500
48,000	8,000	12,000	16,000	24,000	6,000	9,000	12,000	18,000
52,000	8,667	13,000	17,333	26,000	6,500	9,750	13,000	19,500
56,000	9,333	14,000	18,667	28,000	7,000	10,500	14,000	21,000
60,000	10,000	15,000	20,000	30,000	7,500	11,250	15,000	22,500
64,000	10,667	16,000	21,333	32,000	8,000	12,000	16,000	24,000
68,000	11,333	17,000	22,667	34,000	8,500	12,750	17,000	25,500
72,000	12,000	18,000	24,000	36,000	9,000	13,500	18,000	27,000
76,000	12,667	19,000	25,333	38,000	9,500	14,250	19,000	28,500
80,000	13,333	20,000	26,667	40,000	10,000	15,000	20,000	30,000
84,000	14,000	21,000	28,000	42,000	10,500	15,750	21,000	31,500
88,000	14,667	22,000	29,333	44,000	11,000	16,500	22,000	33,000
92,000	15,333	23,000	30,667	46,000	11,500	17,250	23,000	34,500
96,000	16,000	24,000	32,000	48,000	12,000	18,000	24,000	36,000
100,000	16,667	25,000	33,333	50,000	12,500	18,750	25,000	37,500
104,000	17,333	26,000	34,667	52,000	13,000	19,500	26,000	39,000
108,000	18,000	27,000	36,000	54,000	13,500	20,250	27,000	40,500
112,000	18,667	28,000	37,333	56,000	14,000	21,000	28,000	42,000
116,000	19,333	29,000	38,667	58,000	14,500	21,750	29,000	43,500
120,000	20,000	30,000	40,000	60,000	15,000	22,500	30,000	45,000
124,000	20,667	31,000	41,333	62,000	15,500	23,250	31,000	46,500
128,000	21,333	32,000	42,667	64,000	16,000	24,000	32,000	48,000
132,000	22,000	33,000	44,000	66,000	16,500	24,750	33,000	49,500
136,000	22,667	34,000	45,333	68,000	17,000	25,500	34,000	51,000
140,000	23,333	35,000	46,667	70,000	17,500	26,250	35,000	52,500
144,000	24,000	36,000	48,000	72,000	18,000	27,000	36,000	54,000
148,000	24,667	37,000	49,333	74,000	18,500	27,750	37,000	55,500
152,000	25,333	38,000	50,667	76,000	19,000	28,500	38,000	57,000
156,000	26,000	39,000	52,000	78,000	19,500	29,250	39,000	58,500
160,000	26,667	40,000	53,333	80,000	20,000	30,000	40,000	60,000
175,000	29,167	43,750	58,333	87,500	21,875	32,813	43,750	65,625
200,000	33,333	50,000	66,667	100,000	25,000	37,500	50,000	75,000
225,000	37,500	56,250	75,000	112,500	28,125	42,188	56,250	84,375
250,000	41,667	62,500	83,333	125,000	31,250	46,875	62,500	93,750
275,000	45,833	68,750	91,667	137,500	34,375	51,563	68,750	103,125
300,000	50,000	75,000	100,000	150,000	37,500	56,250	75,000	112,500
325,000	54,167	81,250	108,333	162,500	40,625	60,938	81,250	121,875
350,000	58,333	87,500	116,667	175,000	43,750	65,625	87,500	131,250
375,000	62,500	93,750	125,000	187,500	46,875	70,313	93,750	140,625
400,000	66,667	100,000	133,333	200,000	50,000	75,000	100,000	150,000
425,000	70,833	106,250	141,667	212,500	53,125	79,688	106,250	159,375
450,000	75,000	112,500	150,000	225,000	56,250	84,376	112,500	168,750
475,000	79,167	118,750	158,333	237,500	59,375	89,063	118,750	178,125

(continues)

Table H.2.4(a) *Continued*

Volume (ft^3)	Occupancy Hazard Classification 3				Occupancy Hazard Classification 4			
	Construction Classification				Construction Classification			
	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
500,000	83,333	125,000	166,667	250,000	62,500	93,751	125,000	187,500
525,000	87,500	131,250	175,000	262,500	65,625	98,438	131,250	196,875
550,000	91,667	137,500	183,333	275,000	68,750	103,126	137,500	206,250
575,000	95,833	143,750	191,667	287,500	71,875	107,813	143,750	215,625
600,000	100,000	150,000	200,000	300,000	75,000	112,501	150,000	225,000
625,000	104,167	156,250	208,333	312,500	78,125	117,188	156,250	234,375
650,000	108,333	162,500	216,667	325,000	81,250	121,876	162,500	243,750
675,000	112,500	168,750	225,000	337,500	84,375	126,563	168,750	253,125
700,000	116,667	175,000	233,333	350,000	87,500	131,251	175,000	262,500
725,000	120,833	181,250	241,667	362,500	90,625	135,938	181,250	271,875
750,000	125,000	187,500	250,000	375,000	93,750	140,626	187,500	281,250
775,000	129,167	193,750	258,333	387,500	96,875	145,313	193,750	290,625
800,000	133,333	200,000	266,667	400,000	100,000	150,001	200,000	300,000
825,000	137,500	206,250	275,000	412,500	103,125	154,688	206,250	309,375
850,000	141,667	212,500	283,333	425,000	106,250	159,376	212,500	318,750
875,000	145,833	218,750	291,667	437,500	109,375	164,064	218,750	328,125
900,000	150,000	225,000	300,000	450,000	112,500	168,751	225,000	337,500
925,000	154,167	231,250	308,333	462,500	115,265	173,439	231,250	346,875
950,000	158,333	237,500	316,667	475,000	118,750	178,126	237,500	356,250
975,000	162,500	243,750	325,000	487,500	121,875	182,814	243,750	365,625
1,000,000	166,667	250,000	333,333	500,000	125,000	187,501	250,000	375,000

For SI units, 1 m^3 = 35.3 ft^3, 1 gal = 3.785 L

Note: For structures with exposures, multiply the water supply requirements in the table by 1.5.

Example 2. A farm equipment shed is identical to commercial occupancy in H.2.2, except that it has a one-story, pitched-roof frame dwelling (Type V Construction) measuring 50 ft × 25 ft that is located 45 ft from the equipment shed. The dwelling is an exposure because it is larger than 100 ft^2 in area and is less than 50 ft from the equipment shed. Therefore, the minimum water supply for the equipment shed is 26,250 gal × 1.5, or 39,375 gal.

The minimum water supply for the farm equipment shed equals 39,375 gal.

The total water supply for the dwelling is calculated as follows:

Ground floor area = 50 ft × 25 ft = 1250 ft^2

Height = 8 ft + 4 ft = 12 ft

Total volume = 1250 ft^2 × 12 ft = 15,000 ft^3

The occupancy hazard classification number is 7 *(see 5.2.5)*, and the construction classification number is 1.0 *(see 6.2.2)*, resulting in the following calculation:

[H.3.2b]

$$\frac{15,000}{7} \times 1.0 = 2143 \text{ gal}$$

The dwelling has an exposure from the farm equipment shed; therefore, multiply by the exposure factor of 1.5 as follows:

2143 gal × 1.5 = 3215 gal

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

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Example 3. If the church and office building described in H.2.3 are less than 50 ft from each other, they would be exposures to each other. Therefore, the required water supply for the church would be 26,000 gal × 1.5 for the exposure factor, or 39,000 gal. Likewise, the water supply for the office building would be 25,000 gal × 1.5 for the exposure factor, or 37,500 gal. The larger amount would dictate the minimum water supply requirement for the site, which in this case would be 39,000 gal.

For SI units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Table H.2.4(b) Precalculated Minimum Water Supplies (in Gallons) for Occupancy Hazard Classifications 5 and 6 by Construction Classification (No Exposures)

	Occupancy Hazard Classification 5				Occupancy Hazard Classification 6			
	Construction Classification				Construction Classification			
Volume (ft^3)	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
8,000	2,000	2,000	2,000	2,400	2,000	2,000	2,000	2,000
10,000	2,000	2,000	2,400	3,600	2,000	2,000	2,000	3,000
16,000	2,000	2,400	3,200	4,800	2,000	2,000	2,667	4,000
20,000	2,000	3,000	4,000	6,000	2,000	2,500	3,333	5,000
24,000	2,400	3,600	4,800	7,200	2,000	3,000	4,000	6,000
28,000	2,800	4,200	5,600	8,400	2,333	3,500	4,667	7,000
32,000	3,200	4,800	6,400	9,600	2,667	4,000	5,333	8,000
36,000	3,600	5,400	7,200	10,800	3,000	4,500	6,000	9,000
40,000	4,000	6,000	8,000	12,000	3,333	5,000	6,667	10,000
44,000	4,400	6,600	8,800	13,200	3,667	5,500	7,333	11,000
48,000	4,800	7,200	9,600	14,400	4,000	6,000	8,000	12,000
52,000	5,200	7,800	10,400	15,600	4,333	6,500	8,667	13,000
56,000	5,600	8,400	11,200	16,800	4,667	7,000	9,333	14,000
60,000	6,000	9,000	12,000	18,000	5,000	7,500	10,000	15,000
64,000	6,400	9,600	12,800	19,200	5,333	8,000	10,667	16,000
68,000	6,800	10,200	13,600	20,400	5,667	8,500	11,333	17,000
72,000	7,200	10,800	14,400	21,600	6,000	9,000	12,000	18,000
76,000	7,600	11,400	15,200	22,800	6,333	9,500	12,667	19,000
80,000	8,000	12,000	16,000	24,000	6,667	10,000	13,333	20,000
84,000	8,400	12,600	16,800	25,200	7,000	10,500	14,000	21,000
88,000	8,800	13,200	17,600	26,400	7,333	11,000	14,667	22,000
92,000	9,200	13,800	18,400	27,600	7,667	11,500	15,333	23,000
96,000	9,600	14,400	19,200	28,800	8,000	12,000	16,000	24,000
100,000	10,000	15,000	20,000	30,000	8,333	12,500	16,667	25,000
104,000	10,400	15,600	20,800	31,200	8,667	13,000	17,333	26,000
108,000	10,800	16,200	21,600	32,400	9,000	13,500	18,000	27,000
112,000	11,200	16,800	22,400	33,600	9,333	14,000	18,667	28,000
116,000	11,600	17,400	23,200	34,800	9,667	14,500	19,333	29,000
120,000	12,000	18,000	24,000	36,000	10,000	15,000	20,000	30,000
124,000	12,400	18,600	24,800	37,200	10,333	15,500	20,667	31,000
128,000	12,800	19,200	25,600	38,400	10,667	16,000	21,333	32,000
132,000	13,200	19,800	26,400	39,600	11,000	16,500	22,000	33,000
136,000	13,600	20,400	27,200	40,800	11,333	17,000	22,667	34,000
140,000	14,000	21,000	28,000	42,000	11,667	17,500	23,333	35,000
144,000	14,400	21,600	28,800	43,200	12,000	18,000	24,000	36,000
148,000	14,800	22,200	29,600	44,400	12,333	18,500	24,667	37,000
152,000	15,200	22,800	30,400	45,600	12,667	19,000	25,333	38,000
156,000	15,600	23,400	31,200	46,800	13,000	19,500	26,000	39,000
160,000	16,000	24,000	32,000	48,000	13,333	20,000	26,667	40,000
175,000	17,500	26,250	35,000	52,500	14,583	21,875	29,167	43,750
200,000	20,000	30,000	40,000	60,000	16,667	25,000	33,333	50,000
225,000	22,500	33,750	45,000	67,500	18,750	28,125	37,500	56,250
250,000	25,000	37,500	50,000	75,000	20,833	31,250	41,667	62,500
275,000	27,500	41,250	55,000	82,500	22,917	34,375	45,833	68,750
300,000	30,000	45,000	60,000	90,000	25,000	37,500	50,000	75,000
325,000	32,500	48,750	65,000	97,500	27,083	40,625	54,167	81,250
350,000	35,000	52,500	70,000	105,000	29,167	43,750	58,333	87,500
375,000	37,500	56,250	75,000	112,500	31,250	46,875	62,500	93,750
400,000	40,000	60,000	80,000	120,000	33,333	50,000	66,667	100,000
425,000	42,500	63,750	85,000	127,500	35,417	53,125	70,833	106,250
450,000	45,000	67,500	90,000	135,000	37,500	56,250	75,000	112,500
475,000	47,500	71,250	95,000	142,500	39,583	59,375	79,167	118,750

(continues)

Table H.2.4(b) *Continued*

Volume (ft³)	Occupancy Hazard Classification 5				Occupancy Hazard Classification 6			
	Construction Classification				Construction Classification			
	0.5	0.75	1.0	1.5	0.5	0.75	1.0	1.5
500,000	50,000	75,000	100,000	150,000	41,667	62,500	83,333	125,000
525,000	52,500	78,750	105,000	157,500	43,750	65,625	87,500	131,250
550,000	55,000	82,500	110,000	165,000	45,833	68,750	91,667	137,500
575,000	57,500	86,250	115,000	172,500	47,917	71,875	95,833	143,750
600,000	60,000	90,000	120,000	180,000	50,000	75,000	100,000	150,000
625,000	62,500	93,750	125,000	187,500	52,083	78,125	104,167	156,250
650,000	65,000	97,500	130,000	195,000	54,167	81,250	108,333	162,500
675,000	67,500	101,250	135,000	202,500	56,250	84,375	112,500	168,750
700,000	70,000	105,000	140,000	210,000	58,333	87,500	116,667	175,000
725,000	72,500	108,750	145,000	217,500	60,417	90,625	120,833	181,250
750,000	75,000	112,500	150,000	225,000	62,500	93,750	125,000	187,500
775,000	77,500	116,250	155,000	232,500	64,583	96,875	129,167	193,750
800,000	80,000	120,000	160,000	240,000	66,667	100,000	133,333	200,000
825,000	82,500	123,750	165,000	247,500	68,750	103,125	137,500	206,250
850,000	85,000	127,500	170,000	255,000	70,833	106,250	141,667	212,500
875,000	87,500	131,250	175,000	262,500	72,917	109,375	145,833	218,750
900,000	90,000	135,000	180,000	270,000	75,000	112,500	150,000	225,000
925,000	92,500	138,750	185,000	277,500	77,083	115,625	154,167	231,250
950,000	95,000	142,500	190,000	285,000	79,167	118,750	158,333	237,500
975,000	97,500	146,250	195,000	292,500	81,250	121,875	162,500	243,750
1,000,000	100,000	150,000	200,000	300,000	83,333	125,000	166,667	250,000

For SI units, 1 m^3 = 35.3 ft^3, 1 gal = 3.785 L

Note: For structures with exposures, multiply the water supply requirements in the table by 1.5.

Table H.2.4(c) Precalculated Minimum Water Supplies (in Gallons) for Occupancy Hazard Classification 7 by Construction Classification (No Exposures)

Volume (ft^3)	Occupancy Hazard Classification 7 Construction Classification			
	0.5	0.75	1.0	1.5
8,000	2,000	2,000	2,000	2,000
10,000	2,000	2,000	2,000	2,571
16,000	2,000	2,000	2,286	3,429
20,000	2,000	2,143	2,857	4,286
24,000	2,000	2,571	3,429	5,143
28,000	2,000	3,000	4,000	6,000
32,000	2,286	3,429	4,571	6,857
36,000	2,572	3,857	5,143	7,714
40,000	2,857	4,286	5,714	8,571
44,000	3,143	4,714	6,286	9,429
48,000	3,429	5,143	6,857	10,286
52,000	3,715	5,571	7,429	11,143
56,000	4,000	6,000	8,000	12,000
60,000	4,286	6,429	8,571	12,857
64,000	4,572	6,857	9,143	13,714
68,000	4,857	7,286	9,714	14,571
72,000	5,143	7,714	10,286	15,429
76,000	5,429	8,143	10,857	16,286
80,000	5,715	8,571	11,429	17,143
84,000	6,000	9,000	12,000	18,000
88,000	6,286	9,429	12,571	18,857
92,000	6,572	9,857	13,143	19,714
96,000	6,857	10,286	13,714	20,571
100,000	7,143	10,714	14,286	21,429
104,000	7,429	11,143	14,857	22,286
108,000	7,715	11,571	15,429	23,143
112,000	8,000	12,000	16,000	24,000
116,000	8,286	12,429	16,571	24,857
120,000	8,572	12,857	17,143	25,714
124,000	8,857	13,286	17,714	26,571
128,000	9,143	13,714	18,286	27,429
132,000	9,429	14,143	18,857	28,286
136,000	9,715	14,571	19,429	29,143
140,000	10,000	15,000	20,000	30,000
144,000	10,286	15,429	20,571	30,857
148,000	10,572	15,857	21,143	31,714
152,000	10,857	16,286	21,714	32,571
156,000	11,143	16,714	22,286	33,429
160,000	11,429	17,143	22,857	34,286
175,000	12,500	18,750	25,000	37,500
200,000	14,286	21,429	28,571	42,857
225,000	16,071	24,107	32,143	48,214
250,000	17,857	26,786	35,714	53,571
275,000	19,643	29,464	39,286	58,929
300,000	21,429	32,143	42,857	64,286
325,000	23,214	34,821	46,429	69,643
350,000	25,000	37,500	50,000	75,000
375,000	26,786	40,179	53,571	80,357
400,000	28,571	42,857	57,143	85,714
425,000	30,357	45,536	60,714	91,071
450,000	32,143	48,214	64,286	96,429
475,000	33,929	50,893	67,857	101,786

(continues)

Table H.2.4(c) *Continued*

	Occupancy Hazard Classification 7			
	Construction Classification			
Volume (ft^3)	0.5	0.75	1.0	1.5
500,000	35,714	53,571	71,429	107,143
525,000	37,500	56,250	75,000	112,500
550,000	39,286	58,929	78,571	117,857
575,000	41,071	61,607	82,143	123,214
600,000	42,857	64,286	85,714	128,571
625,000	44,643	66,964	89,286	133,929
650,000	46,429	69,643	92,857	139,286
675,000	48,214	72,321	96,429	144,643
700,000	50,000	75,000	100,000	150,000
725,000	51,786	77,679	103,571	155,357
750,000	53,571	80,357	107,143	160,714
775,000	55,357	83,036	110,714	166,071
800,000	57,143	85,714	114,286	171,429
825,000	58,929	88,393	117,857	176,786
850,000	60,714	91,071	121,429	182,143
875,000	62,500	93,750	125,000	187,500
900,000	64,286	96,429	128,571	192,857
925,000	66,071	99,107	132,143	198,214
950,000	67,857	101,786	135,714	203,571
975,000	69,643	104,464	139,286	208,929
1,000,000	71,429	107,143	142,857	214,286

For SI units, 1 m^3 = 35.3 ft^3, 1 gal = 3.785 L

Note: For structures with exposures, multiply the water supply requirements in the table by 1.5.

Annex I Dry Hydrant Design

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

I.1 The dry hydrant design worksheet shown in Figure I.1(a) and the dry hydrant hardware layout worksheet shown in Figure I.1(b) in conjunction with Table I.1(a) through Table I.1(h) can be used to assist in the design or evaluation of a dry hydrant installation. The tables allow for flow calculations and conversions between various pipe materials to assist in determining the size of pipe and fittings that will be needed to match the dry hydrant system design and the capability of the pumps expected to be used at the dry hydrant site.

Start with the dry hydrant design worksheet *[see Figure I.1(a)]*.

The process of designing a dry hydrant system discussed in this Annex and the values shown in Table I.1(a) through Table I.1(h) are based on calculations in U.S. units. Values in metric units must be converted to U.S. units prior to being used with worksheets shown in Figure I.1(a) and Figure I.1(b).

Lines 1–3: Enter the name of the fire department and the location and identification of the dry hydrant. Include the latitude and longitude of the site in decimal degrees format and the map datum being used. Examples of map datum include the North American Datum (NAD) 83, the World Geodetic System (WGS) 84, or the Universal Transverse Mercator (UTM). Use the map datum that is compatible with your GIS platform.

Line 4: Determine and record the flow rate that the completed system is expected to flow. NFPA 1142 requires a minimum flow rate of 1000 gpm.

Line 5: Determine the elevation above sea level of the site where the dry hydrant is to be installed and record that elevation.

Line 6: From Table I.1(a), determine and record the normal atmospheric pressure at that elevation. This is the theoretical pressure loss that could occur in the system if a pump connected to the dry hydrant could create a perfect vacuum. Because the pumps on fire apparatus are not 100 percent efficient, all of the available atmospheric pressure cannot be used to offset the pressure loss in the dry hydrant system and to move water within the system.

Line 7: Determine the lift from the surface of the water to the center of the pump intake that will be connected to the dry hydrant. Account for times of drought in determining the height of the surface of the water. Be sure the measurement is to the center of the pump intake, not just to the center of the outlet on the dry hydrant system. The outlet on the dry hydrant system should never be higher than the inlet on the pump intake. Record this measurement in feet and multiply it by 0.434 to get the credited pressure loss.

Line 8: Vapor pressure, a part of the total site pressure loss, is based on the temperature of the water. Determine the maximum temperature the water is expected to reach during the hottest part of the year. Then using Table I.1(b), find and record the vapor pressure.

Line 9: A pressure loss constant of 5 psi is used as the loss from the water passing through the entrance to the pump and the pump's intake system, including the loss due to internal turbulence in the intake system.

Line 10: Subtract the sum of the lift (line 7), the vapor pressure (line 8), and the pressure loss in the pump's intake system (line 9) from the atmospheric pressure (line 6) and record the result. This result is the available site pressure or the pressure that is available to overcome the pressure loss in the designed dry hydrant system and in the suction hose for the chosen water flow rate.

Line 11: Using the dry hydrant hardware layout worksheet *[see Figure I.1(b)]*, record the size and description in column A of each component in the dry hydrant system, except fittings that produce a sudden reduction in diameter, which will be calculated later on the dry hydrant design worksheet line 12. Six-inch or larger pipe is recommended due to the reduction in friction loss and to the increase in water supply, for very little incremental cost.

Start at the strainer and work to the pump intake connection. A value of 5 ft of pipe is shown on the dry hydrant hardware layout worksheet *[see Figure I.1(b)]* for the strainer with the assumption that the sum of the area of all holes in the strainer is equal to at least four times the cross-sectional area of the pipe. For each fitting that does not reduce the pipe size, use Table I.1(c) to determine the equivalent feet of straight pipe represented by the fitting and record that value in column B. If the pipe or fitting has a C value other than 150, use Table I.1(d) to determine the conversion to C = 150 for the material involved. For example, if the pipe is cement-lined cast iron with a "C" value of 140, the conversion value is 1.14 to equate it to a C value of 150. Multiply the length of the pipe or the noted equivalent lengths by the conversion factor and record that value in column C.

Next, using Table I.1(e), determine the friction loss per foot of pipe for the size of the pipe. Multiply the friction loss by the feet of pipe or equivalent to get the loss in psi in that component of the piping system. Record that value in column D.

A value of 1 ft is shown for the connection between the adapter where the suction hose connects to the dry hydrant system and the elbow at the vertical end of the dry hydrant system. Add the values in column D to get the loss in the piping system. Now return to the dry hydrant design worksheet *[see Figure I.1(a)]* and enter the same on line 11 as just recorded on Figure I.1(b).

Line 12: Record each fitting that reduces the pipe size; for example, a 6 in. × 5 in. reducer. Using Table I.1(f), determine the pressure loss for each reduction where two different diameter pipe sizes are used or where a reducer is used for the suction hose connection adapter at the dry hydrant head.

Line 13: Record the pressure loss due to velocity head that is created when water begins to move from being at rest. In the case of a dry hydrant, this flow is from a static pressure of 0 psi. Table I.1(g) provides the velocity head in psi for different pipe sizes and flow rates. If two sizes of pipe are used in the dry hydrant system, the value for the smaller pipe should be used.

Line 14: Begin by recording the size and length of suction hose that will be used to connect the fire department pump to the dry hydrant. Using Table I.1(h), determine the pressure loss in the suction hose used to connect the pumper to the dry hydrant. Note that the loss is per 10 ft section of suction hose, so it is necessary to adjust the loss if more than 10 ft of suction hose will need to be used. Record the loss.

Line 15: Add the loss in the pipe and fittings (line 11), the loss from sudden reductions (line 12), the velocity head (line 13), and the head loss in the suction hose (line 14). This result is the pressure needed to overcome the piping and water movement loss. Record that value on line 15.

Line 16: Subtract the total loss (line 15) from the available site pressure (line 10) and record that value on line 16. If the result is a positive number, the user can repeat the process using a greater flow to get an idea of the potential capability of the dry hydrant. If the result on line 16 is a negative number, the capability of the dry hydrant is not equal to the desired flow rate shown on line 4 of the dry hydrant design worksheet, and adjustments might need to be made. If the system is already installed or limited to the piping arrangement used in the calculation, this will mean revising the design flow rate downward and repeating the calculations. If the design can be changed and the result in line 16 is negative by 3.00 or greater, it will probably be advantageous to use a larger diameter pipe.

Line 17: Record any comments about the system that are important to document as well as any special situations pertinent to the system.

Once the system is installed, backflush the system to ensure that there is no blockage or foreign matter in the system. The system should be backflushed at no more than 20 psi. Then the system should be flow tested to determine that the calculated flow can be obtained. If there is a significant difference between the calculated flow and the actual flow, and the actual flow is lower, there could be a design error, a leak in the system, a pump equipment problem, or a restriction in the system.

Figure I.1(c) and Figure I.1(d) show an example of a completed dry hydrant design worksheet and dry hydrant hardware layout worksheet. The Sampletown Fire Department is planning to install a dry hydrant at 123 Country Lane at latitude 37.345 and longitude 118.575 on the NAD 83 datum. This will be dry hydrant SFD 06. The elevation at the area is 2500 ft, and the design is for a 1000 gpm flow. In laying out the system, there is a need for 25 ft of horizontal 6 in. pipe and 10 ft of vertical pipe with two 90-degree long-sweep elbows. PVC pipe and fittings will be used for this installation. A 6 in. × 5 in. reducer will be used where the suction hose will connect to the dry hydrant. A 10 ft length of 5 in. suction hose will be used to connect the pumper to the dry hydrant. The distance from the surface of the water to the centerline of the pump is 6 ft.

Table I.1(a) Normal Atmospheric Pressure at Different Elevations

Elevation (ft)	Normal Atmospheric Pressure, Absolute (psi)
0	14.70
1,000	14.20
2,000	13.70
3,000	13.20
4,000	12.70
5,000	12.20
6,000	11.80
7,000	11.30
8,000	10.90
9,000	10.50
10,000	10.05
11,000	9.70
12,000	9.35

For SI units, 1 ft = 0.305 m; 1 psi = 6.895 kPa.

Table I.1(b) Vapor Pressure for Water

Water Temperature		Vapor Pressure (psi)
°F	°C	
32	0.0	0.089
50	10.0	0.180
60	15.6	0.260
65	18.3	0.310
70	21.1	0.360
75	23.9	0.430
80	26.7	0.520

For SI units, 1 psi = 6.895 kPa.

Table I.1(c) Straight Pipe Equivalents for Fittings (ft)

	Pipe Diameter (in.)			
Fitting	6	8	10	12
45-degree elbow	10.49	12.08	15.05	18.01
90-degree elbow standard	18.92	26.90	33.06	40.58
90-degree elbow long sweep	13.57	19.61	24.05	27.13
Tee (cross) flow turned 90 degrees	30.10	52.67	75.24	90.29
Gate valve	4.56	6.04	7.52	9.01
Butterfly valve	15.10	18.10	28.61	31.58
Swing check valve	48.11	66.58	82.77	97.18

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.

Note: Coefficient (C) = 150.

Table I.1(d) Coefficient (C) Values for New Pipe

Pipe Material	C	Conversion Factor to C = 150
Cast iron, unlined	120	1.5
Cast iron, cement-lined	140	1.14
Cast iron, bitumastic enamel-lined	140	1.14
Average steel, new	140	1.14
Reinforced concrete	140	1.14
Plastic (PVC)	150	1.0

Table I.1(e) Friction Loss Per Foot of Pipe (psi)

	Pipe Diameter (in.)			
gpm	6	8	10	12
500	0.0086	0.0021	—	—
600	0.0122	0.0029	—	—
650	0.0141	0.0033	—	—
700	0.0162	0.0038	—	—
750	0.0184	0.0043	—	—
800	0.0207	0.0049	0.0017	—
850	0.0231	0.0055	0.0018	—
900	0.0258	0.0060	0.0020	—
950	0.0283	0.0066	0.0023	—
1000	0.0312	0.0073	0.0025	—
1050	0.0342	0.0080	0.0027	—
1100	0.0373	0.0088	0.0032	—
1200	0.0438	0.0102	0.0035	—
1250	0.0472	0.0111	0.0038	—
1300	0.0508	0.0119	0.0041	0.0017
1400	0.0583	0.0137	0.0047	0.0019
1500	0.0662	0.0157	0.0054	0.0022
1600	0.0757	0.0174	0.0060	0.0025
1700	0.0834	0.0195	0.0069	0.0027
1750	0.0880	0.0212	0.0071	0.0030
1800	0.0928	0.0218	0.0074	0.0031
1900	0.1015	0.0241	0.0082	0.0034
2000	0.1094	0.0265	0.0091	0.0038

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m; 1 gpm = 3.785 L/min; 1 psi = 6.895 kPa.

Note: Coefficient (C) = 150.

Table I.1(f) Pressure Loss Due to Sudden Reduction (psi)

	Flow (gpm)*						
Reduction	**500**	**750**	**1000**	**1250**	**1500**	**1750**	**2000**
6 in. × 5 in.	0.03	0.08	0.15	0.25	0.40	0.55	0.76
6 in. × 4½ in.	0.09	0.20	0.37	0.63	0.90	1.30	1.70
6 in. × 4 in.	0.25	0.44	1.0	1.53	2.2	2.39	—
Bell Reducers†							
8 in. × 6 in.	0.03	0.06	0.12	0.18	0.26	0.36	0.50
10 in. × 6 in.	0.07	0.14	0.26	0.40	0.57	0.76	0.99
12 in. × 6 in.	0.08	0.18	0.31	0.47	0.67	0.89	1.15

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 6.895 kPa.
*Interpolate for other gpm flows.
†Used when dry hydrant system has two different diameter pipe sizes.
Note: Coefficient (C) = 150.

Table I.1(g) Velocity Head in Suction Pipe (psi)

	Pipe Diameter (in.)			
gpm	**6**	**8**	**10**	**12**
500	0.22	0.07	0.03	0.014
600	0.31	0.10	0.04	0.020
700	0.43	0.14	0.06	0.027
750	0.49	0.15	0.06	0.031
800	0.56	0.18	0.07	0.035
900	0.70	0.22	0.09	0.044
1000	0.87	0.28	0.11	0.054
1250	1.36	0.43	0.18	0.085
1500	1.95	0.62	0.25	0.122
1750	2.66	0.84	0.34	0.166
2000	3.47	1.10	0.45	0.217

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psi = 6.895 kPa.

Table I.1(h) Pressure Loss in Suction Hose (psi/10 ft of Hose)

	Hose Size (in.)					
gpm	**2½**	**3**	**4**	**4½**	**5**	**6**
500	4.23	2.08	0.49	0.27	0.16	0.065
600	6.08	2.99	0.71	0.39	0.23	0.094
700	8.28	4.07	0.97	0.53	0.31	0.127
750	9.51	4.67	1.11	0.61	0.36	0.146
800	10.82	5.31	1.26	0.70	0.41	0.166
900	—	6.72	1.60	0.88	0.52	0.211
1000	—	8.30	1.97	1.09	0.64	0.260
1250	—	12.97	3.08	1.70	1.00	0.406
1500	—	—	4.43	2.45	1.44	0.585
1750	—	—	6.03	3.34	1.96	0.796
2000	—	—	7.88	4.36	2.56	1.04

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

DRY HYDRANT DESIGN WORKSHEET

1. Fire Department ________________________________

2. Dry hydrant location ________________________________
   Latitude/Longitude ____________ / ____________ Datum ________________

3. Dry hydrant ID number ________________________________

4. Design flow rate ________________ gpm

5. Elevation of site above sea level ________________ ft

6. Normal atmospheric pressure [from Table I.1(a)] ________________ psi

7. Lift ____________ ft × 0.434 ________________ psi

8. Water temperature ____________ °F
   vapor pressure [from Table I.1(b)] ________________ psi

9. Pressure loss at pump intake 5.0 psi

Available site pressure

10. Line 6 minus (line 7 + line 8 + line 9) ________________ psi

11. Pressure loss in pipe and fittings
    (from Dry Hydrant Hardware Layout Worksheet) ________________ psi

12. Pressure loss from sudden reduction [from Table I.1(f)]
    ________ × ________ ________________ psi
    ________ × ________ ________________ psi
    ________ × ________ ________________ psi

13. Velocity head [from Table I.1(g)] ________________ psi

14. Pressure loss in suction hose [from Table I.1(h)]
    Size ____________ in.
    No. of 10 ft length(s) ____________ × ____________ tabular value = ________________ psi

15. Pressure needed to overcome piping and water movement loss
    Add (line 11 + line 12 + line 13 + line 14) ________________ psi

16. Resulting calculation of available site pressure
    Enter line 10 minus line 15 ________________ psi

17. Comments ________________________________
    ____
    ____
    ____
    ____

For SI units: 1 gal = 3.785 L; 1 ft = 0.305 m; 1 in. = 25.4 mm; 1 psi = 6.895 kPa.

FIGURE I.1(a) Dry Hydrant Design Worksheet.

DRY HYDRANT HARDWARE LAYOUT WORKSHEET

A Description and Size	B Straight line equivalent feet of pipe[1]	C Conversion for pipe coefficient[2]	D Loss (psi)[3]
Strainer[4]	5		
1 ft of 6 in. pipe	1		

Pressure loss in piping system ______ psi

[1] See Table I.1(c).

[2] See Table I.1(d) if applicable for C less than 150.

[3] See Table I.1(e).

[4] The area of all holes must be at least four times the cross-sectional area of the pipe. A figure of 5 equivalent ft is used regardless of the strainer pipe diameter.

For SI units: 1 gal = 3.785 L; 1 ft = 0.305 m; 1 in. = 25.4 mm; 1 psi = 6.895 kPa.

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FIGURE I.1(b) Dry Hydrant Hardware Layout Worksheet.

DRY HYDRANT DESIGN WORKSHEET

1. Fire Department Sampletown Fire Department

2. Dry hydrant location 123 Country Lane
   Latitude/Longitude 37.345 / 118.575 Datum NAD 83

3. Dry hydrant ID number SFD 06

4. Design flow rate 1000 gpm

5. Elevation of site above sea level 2500 ft

6. Normal atmospheric pressure [from Table I.1(a)] 13.45 psi

7. Lift 6 ft × 0.434 2.6 psi

8. Water temperature 70 ΥF
   vapor pressure [from Table I.1(b)] 0.36 psi

9. Pressure loss at pump intake 5.0 psi

Available site pressure

10. Line 6 minus (line 7 + line 8 + line 9) 5.49 psi

11. Pressure loss in pipe and fittings
    (from Dry Hydrant Hardware Layout Worksheet) 2.12 psi

12. Pressure loss from sudden reduction [from Table I.1(f)]
    6 × 5 0.15 psi
    ___ × ___ ___ psi
    ___ × ___ ___ psi

13. Velocity head [from Table I.1(g)] 0.87 psi

14. Pressure loss in suction hose [from Table I.1(h)]
    Size 5 in.
    No. of 10 ft length(s) 1 × 0.64 tabular value = 0.64 psi

15. Pressure needed to overcome piping and water movement loss
    Add (line 11 + line 12 + line 13 + line 14) 3.78 psi

16. Resulting calculation of available site pressure
    Enter line 10 minus line 15 1.71 psi

17. Comments ___

For SI units: 1 gal = 3.785 L; 1 ft = 0.305 m; 1 in. = 25.4 mm; 1 psi = 6.895 kPa.

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FIGURE I.1(c) Example Using Dry Hydrant Design Worksheet.

DRY HYDRANT HARDWARE LAYOUT WORKSHEET

A Description and Size	B Straight line equivalent feet of pipe[1]	C Conversion for pipe coefficient[2]	D Loss (psi)[3]
Strainer[4]	5		0.156
25 ft of 6 in. PVC horizontal	25		0.78
6 in. long sweep elbow	13.57		0.42
10 ft of 6 in. PVC vertical	10		0.312
6 in. long sweep elbow	13.57		0.42
1 ft of 6 in. pipe	1		0.0312
Pressure loss in piping system			2.12 psi

[1] See Table I.1(c).

[2] See Table I.1(d) if applicable for C less than 150.

[3] See Table I.1(e).

[4] The area of all holes must be at least four times the cross-sectional area of the pipe. A figure of 5 equivalent ft is used regardless of the strainer pipe diameter.

For SI units: 1 gal = 3.785 L; 1 ft = 0.305 m; 1 in. = 25.4 mm; 1 psi = 6.895 kPa.

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FIGURE I.1(d) Example Using Dry Hydrant Hardware Layout Worksheet.

Annex J Geospatial Support for Water Supply Planning

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

J.1 General. A geospatial (or geographic) information system (GIS) is an integrated set of software and hardware for the collection, management and analysis of data with a spatial (locational) component. GIS technology allows different sets of data ("layers") to be overlaid spatially in order to perform comparative and relational analysis. GIS is often associated strictly with its mapping aspects, but equally important is its ability to manage large amounts of information about features. For example, the GIS records for a dry hydrant could include not only its physical location, but also data on its elevation, rate of flow, thread type, records of testing, accessibility, and any other information that could be of value in the planning process.

The use of a GIS in support of rural water supply planning offers great benefits to water supply officers and other fire protection planners. Many of the key elements of a rural water supply system must be spatially located and analyzed as part of the planning process: Water sources, supply routes, and values-at-risk. Using a GIS to manage locations and data associated with these elements and to geospatially analyze the relationships among them facilitates the development of effective and efficient water supply networks.

While a fire department might not have an in-house GIS capability, there are many potential partner agencies that do. Most counties and many municipalities have at least some dedicated GIS staff, and many colleges and universities have GIS faculty. Federal, state and local conservation agencies have in-house GIS capabilities, and many of these agencies have an overlapping interest in developing fire protection water supplies. Although less capable than commercial GIS software, there are a number of free GIS packages available that could be adopted by a fire department. A notable example of this is the Mapping Applications for Response, Planning, and Local Operational Tasks (MARPLOT) component of the Computer-Aided Management of Emergency Operations (CAMEO) Suite software package used by the hazardous materials community that is freely available for download from the U.S. Environmental Protection Agency.

J.2 Water Supply Network Assessment. Use of GIS in the water supply planning process allows the whole system to be analyzed as a network. Using a GIS, the water supply planner can readily determine coverage areas for a given water source in terms of both distance and travel time.

Without a GIS, water supply planners often attempt to estimate coverage areas by drawing concentric circles around water sources at 1-mile intervals (or similar distances). This technique, while providing a rough estimate, does not take into account actual road travel distances or potential obstacles (such as railroad crossings), and tends to overestimate the coverage areas for water sources.

Use of a GIS with a network analysis capability can provide a truer estimate of coverage areas by modeling the road network as traveled by fire apparatus, and can provide coverage estimates in terms of both distance and travel time. A similar assessment can theoretically be made manually, but only with painstaking effort, and the results are likely to be less accurate.

In order to conduct a network assessment, the planner will need to obtain access to a GIS software package with the ability to conduct a network analysis. These types of analyses are commonly used in the shipping industry to model the actual travel of vehicles along a road network, and can be readily adapted to fire service planning purposes.

Using GIS network analysis techniques, planners can assess the current state of the water supply system, generating mathematical polygons that show the true coverage area of existing water sources, and reveal areas of weak or nonexistent coverage. With detailed address or parcel data, the travel distance to all water sources for each address in a fire protection area can be rapidly estimated using GIS network analysis techniques. Factors hindering, or potentially hindering, travel of fire apparatus, such as steep slopes, difficult curves, bridge weight restrictions, and rail crossings can all be factored into the model, providing an accurate picture of the water supply network.

Once areas of inadequate water supply are determined, planners begin the search for potential water supply sources to improve the coverage network, with the search effort focused on identified areas of weakness. Use of GIS tools can be of great assistance in this process, with numerous potential sources of data available to assist in the search. Once candidate supply sites have been identified, planners can iteratively rerun the network analysis with the hypothetical sites included in order to determine the most effective configuration of the water supply network. The results of these hypothetical analyses can then be used to prioritize supply sites for development.

J.3 Stream Assessment. When assessing a site along a flowing stream as a potential fire protection water supply source, knowledge of basic hydrologic concepts will assist the planner in understanding the characteristics of the site. The following definitions, adapted from the U.S. Geological Survey, apply to this section.

(1) *Drainage Basin.* A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water. Colloquially, the term "watershed" is used interchangeably with this term.

(2) *Stream.* A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally as in the term *stream gaging*, it is applied to the water flowing in any channel, natural or artificial.

(3) *Streamflow.* The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word *streamflow* uniquely describes the discharge in a surface stream course. The term *streamflow* is more general than runoff, as streamflow can be applied to discharge whether or not it is affected by diversion or regulation.

(4) *Stream Gaging Station.* A gaging station where a record of discharge of a stream is obtained. Within the U.S. Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

(5) *Watershed.* Technically speaking, "watershed" refers to the divide separating one drainage basin from another and in the past has been generally used to convey this meaning. However, over the years, use of the term to signify drainage basin or catchment area has come to predominate.

"Drainage divide," or just "divide," is used to denote the boundary between one drainage area and another.

Hydrologists divide and subdivide the United States into standardized, successively smaller drainage basins, known as "hydrologic units." Each hydrologic unit is uniquely identified by a code consisting of an even number of digits, known as the "hydrologic unit code" or HUC. This system applies from the largest drainage systems (e.g. the Mississippi River Basin) down to the smallest streams in a nested fashion. Table J.3 provides an example of this system based on the Ohio River Basin.

In the United States, hydrologic data for any drainage basin and its associated streams will commonly be located by using the correct HUC designation. Data for the drainage basins at the 8-digit and 12-digit levels are most commonly used, often referred to by the shorthand "HUC-8" or "HUC-12."

Supplemental to the techniques presented in B.3.1, water supply planners might be able to take advantage of several resources that might be useful in assessing flowing streams as potential sources of fire protection water supply, which include the following:

(1) *StreamStats.* The U.S. Geological Survey, in cooperation with state and local agencies, provides the StreamStats tool as a freely-available, web-based tool to estimate stream flows in many parts of the United States. StreamStats uses hydrologic modeling to estimate streamflow for both gaged and ungaged streams, and is considered by hydrologists to provide very accurate estimates. The availability of StreamStats varies by state, as do the model outputs available. In some states, StreamStats provides low-flow estimates by month — data that will be immensely useful in water supply planning. For other states, however, StreamStats outputs are limited to peak flows, which will not be particularly useful for these purposes. The functionality of StreamStats is continually upgraded, state by state. Water supply planners in states without low-flow modeling capabilities should monitor the status of StreamStats for their state for upgrades, and consider engaging the local U.S. Geological Survey point of contact about getting the necessary functionality for their state. StreamStats can be accessed at http://water.usgs.gov/osw/streamstats.

(2) *Cooperative Stream Gage Network.* The U.S. Geological Survey, in cooperation with state and local agencies, manages a nationwide network of more than 7000 automated stream gages located at strategic locations along the country's waterways. Most of these gaging stations report streamflow data in near-real-time, and this data can be accessed via the National Streamflow Information Program (NSIP) website at http://water.usgs.gov/nsip. Many of the gaging stations in the network have compiled several decades' worth of streamflow data at their location. Even in cases where the stream under consideration is not gaged, planners should examine flow data from gaging stations in the immediate vicinity in order to understand seasonal hydrologic trends for the region. This will provide an idea of when low-flow conditions are likely to occur, and thus allow manual streamflow determinations (as described in B.3.1) to be conducted at the appropriate times to capture low-flow conditions.

(3) *State Environmental Protection Agencies.* State-level environmental protection agencies concerned with water quality monitoring often determine low-flow estimates for streams at the 12-digit hydrologic unit level. While data for every watershed will not be available, water supply planners should consider inquiring with their state's environmental protection agency to determine whether low-flow data are available for the watershed containing any potential water supply site being considered for further development.

Water supply planners should note that streamflow information from the U.S. Geological Survey and allied state and local agencies is often provided in cubic feet per second (cfs). These data can be converted to gallons per minute (gpm) for fire planning purposes by use of a conversion factor:

$$Q_{gpm} = Q_{cfs} \times 448.831169 \quad \textbf{[J.3]}$$

where:
Q_{gpm} is flow in gpm, and Q_{cfs} is flow in cfs.

Water supply planners should be careful to differentiate between total estimated streamflow and the proportion of that flow that can be captured and exploited for water supply purposes. Unless a stream is to be fully impounded, only a fraction of the total estimated flow will be exploitable, with the amount dependent on streambed characteristics and fire department drafting equipment capabilities. Methods described in this document yield total flow estimates, including, in some cases, flow occurring below the surface of the streambed. Further study of proposed drafting sites will be necessary to determine whether the site is truly suitable as a fire protection water supply source.

J.4 Pond Assessment. There are many manual techniques for estimating the depth and volume of water in ponds, lakes and similar water bodies. These manual methods have the disadvantage of providing generalized estimates for the entire water body, rather than detailed depth profile information. Using GIS when assessing ponds as potential water supply sources can yield detailed volume estimates as well as detailed depth profiles that can assist in locating dry hydrant placement sites.

Table J.3 Hydrologic Units

Hydrologic Unit Level	Hydrologic Unit Code (HUC)	Drainage Basin Name	Drainage Basin Area (square miles)
2-digit	05	Ohio River basin	189,422
4-digit	0508	Great Miami	5,368
6-digit	050800	Great Miami River	5,368
8-digit	05080001	Upper Great Miami River	2,480
10-digit	0508000115	Headwaters Mad River	135
12-digit	050800011501	Macochee Creek	19

Note: In this example, the 4- and 6-digit hydrologic units are the same; this is not always the case

The depth and volume of ponds and lakes tend to fluctuate seasonally within the year, as well as varying from one year to the next. For fire protection water supply planning purposes, it is important to collect depth and volume data representative of low-water (drought) conditions, when volumes are expected to be at their minimum. In order to most accurately reflect low-volume conditions, depth soundings should generally be collected when the pond or lake is at its seasonal low depth. Accessing U.S. Geological Survey streamflow data from gaging stations in the vicinity of the pond can help the planner to understand the seasonal hydrologic fluctuations affecting the region, and help plan the appropriate time to take soundings. Generally, when local streams are at their lowest seasonal flows, local ponds and lakes are also likely to be at their lowest levels.

When pond depth soundings are collected in conjunction with a geospatial position system (GPS) unit, the data (latitude, longitude, and depth) can be analyzed in any GIS system with a three-dimensional analysis capability to yield detailed volume estimates and depth contours (bathymetry). The depth contours developed with these tools can be used to guide placement of dry hydrants and other drafting facilitation devices.

While depth soundings have traditionally been collected manually using plumb lines or poles, these methods are inefficient, requiring considerable time to collect relatively few readings. Use of a portable recreational sonar unit ("fish finder") on a small watercraft, especially when combined with a GPS unit, can yield many more soundings of equal quality in a shorter period of time. With practice, more than 100 soundings per hour can be collected using this method. This is an important consideration when using a GIS system to develop bathymetry data for the pond. The more data collected in the field, the more accurate the resulting GIS-generated estimates will be.

J.5 Planning for Water Supply.

J.5.1 Water Supply Zones. The establishment of water supply zones (WSZ) driven by geography, needed fire flow (NFF) estimates, and water supply source capabilities, provides a framework for water supply planning and will be greatly facilitated by the use of GIS tools. Once NFF have been estimated for the planning area, properties can be grouped according to location and NFF requirements, and water supply can then be planned for the group. Properties with exceptionally high NFF requirements can be identified as target hazards and receive individual water supply planning attention, rather than attempting to plan fire protection for a larger area based on a single high-demand property.

J.5.2 Water Shuttle Routes. On rural road networks, it is beneficial to establish mobile water supply apparatus (tanker/tender) shuttle routes with one-way traffic flow where possible, thereby avoiding the need for fire apparatus to pass one another on narrow roadways. Shuttle routes can be readily preplanned using a GIS, ensuring that all properties in a fire protection area are linked to an established water supply source by a designated shuttle route. Generally, shuttle routes should be in the form of a loop beginning and ending at the water supply source, although out-and-back routes with two-way traffic flow might be unavoidable in some areas. Predesignated water shuttle routes can also form the basis for planning water supply zones, with all properties bordering a preplanned shuttle route grouped together in a zone.

J.5.3 Water Supply Designations. For every WSZ or target hazard in a fire protection area, planners should consider designating associated water supply sources as follows:

(1) *Primary Water Source.* This is the principal source expected to meet the estimated NFF requirements of the WSZ or target hazard. In most cases, this will be the developed water supply source closest to the WSZ, although in the case of target hazards with high NFF requirements, closer sources can be bypassed in favor of a more distant source with higher capacity. Primary sources should have no seasonal or access restrictions and should be designed with sufficient capacity to meet all NFF requirements of their assigned WSZ or target hazard. A given source can serve as the primary supply source for more than one WSZ. Primary supply sources should have the highest priority for allocation of water supply development effort and funding.

(2) *Secondary Water Source.* For each WSZ, one or more secondary water supply sources should be identified in addition to the primary source. Secondary sources, alone or in combination, should be able to meet the NFF requirements of the WSZ or target hazard. Secondary sources should be as reliable as primary sources, but might be less favorable due to distance or the need to combine multiple secondary sources to achieve the NFF requirement. They also serve as a back-up to the primary source in the event that the primary source is unavailable, and provide additional supply when needed. Secondary sources for one WSZ can serve as the primary source for a different WSZ or target hazard.

(3) *Supplemental Water Source.* Potentially usable water supply sources that do not meet the capacity or accessibility requirements to be designated as primary or secondary sources should still be assessed and planned as potential supplemental sources of supply. These sources could have seasonal limitations due to drought or freezing, have unacceptable volume or flow, or suffer from other limitations. Planners should not overlook the potential of these sources, under certain circumstances, to augment other water supplies or serve as an initial attack resource.

J.5.4 Water Supply Facilities. In addition to the development necessary at water supply sources to support access and stationary drafting, planners should also consider needs at the point of water delivery, commonly referred to as the dump site. For each WSZ, it might be beneficial to pre-identify areas with sufficient space to accommodate the portable tanks, drafting engines, and apparatus maneuver area necessary to support delivery of water at the dump site. Construction or expansion of hard surface areas for dump site operations might be necessary to support safe and effective dump site operations. Establishment of predesignated dump sites for a WSZ, with provisions for attack engine supply via a large-diameter hose (LDH) lay, might be a better option than attempting operations closer to an incident scene where there is limited space for portable tanks and apparatus maneuvering. Planning locations for these sites, along with estimates of needed LDH lays, will be greatly facilitated with the use of GIS tools.

J.6 Geospatial Technical Resources.

J.6.1 National-Level Geospatial Data Sources. The following geospatial datasets are in the public domain, are freely available for download, and are in file formats usable by all major GIS software systems. These datasets are maintained at the national level by federal agencies, but users can download smaller subsets for their area of interest.

(1) *National Hydrography Dataset (NHD).* A networked dataset of all known stream features, covering the entire United States. In addition to stream features, lakes, springs, wetlands, gages, dams, and other hydrologic features are included, although these data are less comprehensive than the stream data. The NHD can assist the planner in locating streams and understanding the local hydrologic environment. Further information and data downloads can be found at http://nhd.usgs.gov/.
(2) *Watershed Boundary Dataset (WBD).* A seamless dataset containing all hydrologic units (drainage basins), at all hierarchical levels (HUC-2 through HUC-12) for the United States. The WBD is maintained by the U.S. Geological Survey, and data are available for download in preconfigured sets by region or state. The WBD can assist the planner in understanding the local hydrologic environment, and in determining which drainage basins for which additional information on streamflow will be required. Further information and data downloads can be found at http://nhd.usgs.gov/wbd.html.
(3) *National Wetlands Inventory (NWI).* The U.S. Fish and Wildlife Service maintains the interagency National Wetlands Inventory (NWI) for the United States, which can also be of assistance in locating potential water supply sources. Not all identified wetlands will be suitable for development as water supply sources, but many are associated with ponds or other deep water bodies that might be suitable. In the near future, the NWI will be superseded by the Surface Waters Inventory (SWI), an improved system with expanded data. The NWI is accessible online at http://www.fws.gov/wetlands/.
(4) *National Agriculture Imagery Program (NAIP).* Under this program, the U.S. Department of Agriculture collects full-color aerial photography during the peak growing season ("leaf-on") at one-meter resolution, for purposes of conservation planning and program compliance monitoring. Imagery is collected on a state-by-state basis, with a new set collected every 2 to 3 years, generally. This imagery will be of assistance in locating potential water supply sources that are not visible from ground level when obscured by vegetation or topography. NAIP imagery is provided as county-level mosaic files, and can be downloaded at http://datagateway.nrcs.usda.gov/.
(5) *Land Cover Datasets.* Both the U.S. Department of Agriculture (USDA) and U.S. Geological Survey (USGS) maintain national land cover datasets derived from satellite imagery. The two datasets are complementary, with each emphasizing different land cover types. Both datasets contain information on water bodies and can be used to locate potential water supply sources not visible from ground level. The USDA National Agricultural Statistics Service CropScape dataset can be accessed at: http://nassgeodata.gmu.edu/CropScape/ and the USGS National Land Cover Dataset (NLCD) can be accessed at: http://landcover.usgs.gov/.
(6) *TIGER Files.* The U.S. Census Bureau maintains the topologically integrated geographic encoding and referencing (TIGER) files. TIGER is a comprehensive set of geospatial data covering all political boundaries, roads, census data collection units (tracts, blocks, etc.), landmarks, and other features in the United States. In many cases, TIGER geodata are not perfectly accurate when compared to more detailed local sources or aerial photos. However, where higher resolution data are not available, TIGER geodata will yield very acceptable results. TIGER datasets also have the advantage of being topologically integrated across political boundaries, making the road data especially well-suited for network analysis purposes. TIGER files are available for download at http://www.census.gov/geo/maps-data/data/tiger-line.html.

J.6.2 Local Geospatial Data Sources. The type and quality of geospatial datasets available from state, county, municipal, and private sector sources are widely variable in terms of content and quality, yet in many cases, these data sources will prove to be very valuable for the planning effort. Common local sources of geospatial data include, but are not limited to, the following:

(1) *Dispatch Centers.* Computer-assisted dispatch (CAD) systems are based on various GIS software platforms, and local dispatch centers generally have access to some of the most accurate road and addressing data available. These centers might be able to provide their geospatial data to water supply planners in exportable file formats for use in other GIS systems.
(2) *Engineering and Transportation Agencies.* State departments of transportation and county-level engineer offices often have extensive datasets regarding road networks, bridges, rail crossings, and other transportation network items.
(3) *Property Taxation Agency.* The local agency responsible for property tax valuation can be a source of detailed parcel and improvements data for use in GIS, data sources that can assist the planner in assessing the effectiveness of the water supply network. Additionally, these agencies often purchase high-resolution aerial photography of their jurisdiction to assist in property valuation, sometimes including oblique-angle imagery. In many cases, imagery acquired for these agencies will be among the highest quality and most current of all available sources.
(4) *Water Utilities.* Local and regional water utilities often maintain geospatial datasets on water mains, hydrants, and other water supply items.

J.6.3 Conservation Agencies. For planning rural water supply networks, conservation, natural resources, and environmental agencies at all levels of government can be of great assistance. These agencies have an interest in water resources and generally have a high degree of expertise on the subject, although agency staff might not be specifically versed in fire protection needs. Additionally, these agencies tend to have GIS expertise within their staffs and might be able to provide technical support. Water supply planners should make contact with the local representatives of the agencies listed below early in the planning process to determine what data and technical assistance might be available.

(1) *Federal Agencies.* The most ubiquitous federal agency with regard to water supply planning is the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The NRCS has a presence in nearly every county, and the agency has deep expertise in hydrology, water source development, engineering, and GIS. Normally, NRCS offices are colocated with local conservation districts [see J.6.3(3)], with staff of the various agen-

cies working cooperatively on conservation planning and related efforts. Other federal agencies that can be locally important include the USDA Forest Service; the land management agencies of the U.S. Department of the Interior (Bureau of Land Management, National Park Service, Fish and Wildlife Service, and Bureau of Indian Affairs); Department of Defense military installations; and others depending on their specific location.

(2) *State Agencies*. The state-level natural resources and environmental quality agencies can be a potential source of geospatial data and technical support, although capabilities and interests vary widely across the country. Water supply planners should familiarize themselves with their state's agencies and make contact to determine what assistance might be available.

(3) *Conservation Districts*. The more than 3,000 conservation districts in the United States are organized along county or watershed boundaries and provide local-level support to agricultural and natural resources conservation efforts in cooperation with NRCS and state agencies. Technicians and specialists working for these agencies are generally very well-versed in water source development and can be of great assistance in the development of water supply networks. The specific names for conservation districts vary from state to state, but planners can determine their local district at the following site: http://www.nacd.net/about/districts/directory.

(4) *Non-Governmental Organizations (NGOs)*. Certain conservation-oriented NGOs can be locally important to the water supply planning process, as some of these organizations have expertise in hydrology, wildland fire management, and GIS. Planners should familiarize themselves with locally active conservation NGOs, particularly those managing nature preserves and other protected lands, to determine what assistance they might be able to offer.

Annex K Informational References

K.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

K.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2021 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2022 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2022 edition.

NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 2020 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2022 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2022 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2022 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2022 edition.

NFPA 220, *Standard on Types of Building Construction*, 2021 edition.

NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, 2019 edition.

NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications*, 2017 edition.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 2016 edition.

NFPA *Fire Protection Handbook*, 20th edition, 2008.

K.1.2 Other Publications.

K.1.2.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lbf/ft^3(2,700 kN-m/m^3)]*, 2012.

K.1.2.2 ISO Publications. ISO 545 Washington Boulevard, 19–5, Jersey City, NJ 07310.

Guide for Determination of Needed Fire Flow, 2014.

K.1.2.3 NASF Publications. National Association of State Foresters, 444 North Capital Street NW, Suite 540, Washington, DC 20001.

www.stateforesters.org

K.1.2.4 U.S. Government Publications.

K.1.2.4.1 USDA Forest Service Publications. United States Department of Agriculture Forest Service, 2538 Depot St, Manchester Center, VT 05255.

www.fs.fed.us/fire

K.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

K.2.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1961, *Standard on Fire Hose*, 2020 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances*, 2018 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2019 edition.

K.2.2 Other Publications.

Handbook of PVC Pipe, Design and Construction, Fifth Edition, 2012. The Uni-Bell PVC Pipe Association, 201 E. John Carpenter Freeway, Suite 750, Irving, TX, 75062.

K.2.3 Other Resources.

K.2.3.1 Firewise Resources.

Using Water Effectively in the Wildland/Urban Interface (DVD or video), 2004.

K.2.3.2 Wisconsin DNR Publications. Wisconsin Department of Natural Resources, 101 South Webster Street, P.O. Box 7921, Madison, WI 53707-7921.

A Guide to Planning and Installing Dry Fire Hydrants, 2003.

K.3 References for Extracts in Informational Sections. (Reserved)

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