Water System Design and Planning

Group A Transient Non-Community Water System Design Guidelines

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Washington State Department of HEALTH

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CHAPTER 1 Introduction

The Washington State Department of Health, Office of Drinking Water (DOH) developed these Group A-Transient Non-Community (TNC) Water System Design Guidelines. They explain how to design Group A-TNC water systems to ensure safe, adequate, and reliable drinking water for those the water system will serve. They will also help you prepare a complete *Group A-TNC Design Workbook* 331-677, which you must submit for approval before you start constructing new or expanding your Group A-TNC public water system.

We recommend you review these guidelines and the general water system design information in our *Water System Design Manual* 331-123 before beginning your Group A-TNC water system design. We organized the chapters in this document by subject matter (basic water system information, estimating water demand, source of supply, and so forth).

The Appendices contain helpful references, such as how to perform and report the results of a well pump test using special well pump controls, an outline for a water users' agreement, and how to complete an inventory of your proposed water system.

Group A public water system information is available on our Surface Water FAQ webpage.

Group A-TNC Design Workbook

These guidelines help you prepare and complete a *Group A-TNC Design Workbook* 331-677 that efficiently meets each applicable requirement of Chapter 246-290 WAC, and reflects sound water system design practices and public health principles. Submit the workbook to us for approval.

Make copies of all plans, design drawings, worksheets, equipment information, operations and maintenance manuals, legal documents, and forms before you send your completed workbook to us. Keep this information with your other project documents. It will help you and others manage and operate the new water system successfully.

Online Group A-TNC Resources

We developed many resources applicable to Group A-TNC water systems. These resources (such as fact sheets and guidance documents) help you from the pre-submittal stage of your water system design through operation and maintenance.

The online Group A resources most applicable to Group A-TNC water systems include:

- *Project Approval Application Form* 331-149.
- Our TNC Water System webpage helps you understand the regulatory requirements for ongoing operations of Group A-TNC water systems.
- *Small Water System Management Program for Non-Community Water Systems* 331-474.
- *Preventive maintenance program: Guide for small public water systems using groundwater* 331-351.
- *Owning and Managing a Group A Water System* 331-084.

Regulations

Before starting your design, become familiar with Washington's Group A water system rule (Chapter 246-290 WAC) and the information in these guidelines.

If you have questions about these guidelines or the State Board of Health rules on Group A Water Systems (Chapter 246-290 WAC), contact the state Department of Health (see Section 1.7, Table 1.1).

1.0 Purpose and Scope

These guidelines help design engineers meet the approval requirements for a new or expanding Group A-TNC public water system by:

- Establishing uniform concepts for very small water system designs.
- Meeting the submittal requirements described in Chapter 246-290 WAC.
- Helping DOH regional engineers apply consistent review procedures.

1.0.1 Expanding Systems

Unless otherwise noted, these guidelines apply to new and expanding systems. For example, you are successfully operating an existing Group A-TNC water system that was approved to serve four non-residential connections, and now you want to add two more buildings. To expand the system to serve additional connections, your existing system **must** meet all current regulatory requirements, regardless of past approval (Chapter 246-290 WAC). You must prepare a complete workbook for review and approval by DOH before expanding your water system.

Design engineers may use design approaches other than those in these guidelines as long as the alternate approach does not conflict with Chapter 246-290 WAC and engineer provides appropriate justification for taking an alternate approach.

1.1 "Must" versus "Should"

Throughout these guidelines we use the terms "must," "will," "shall," or "required" when design practice is sufficiently standardized to permit specific delineation of requirements, or where safeguarding the public health justifies definitive criteria or action (for example, when a state statute or rule mandates a requirement). The terms "should" or "recommend" indicate procedures, criteria, or methods that are not required. You can approach these with some degree of flexibility. Designers and design engineers need to explain the basis of the altered approach or, in specific circumstances, why another approach may be more applicable.

1.2 Jurisdiction and Standards

1.2.1 Project Location

The location of your project affects whether you can create a new Group A-TNC water system and the standards that apply to its design and approval. Before beginning your Group A-TNC design, we strongly recommend that you **determine whether the proposed Group A-TNC water system is located within:**

1. An area the Department of Ecology (Ecology) has closed or established limits to all future appropriation of groundwater, including gallon per day limits on small groundwater

withdrawals that are normally exempt from the water right permitting process. If so, this could significantly affect the feasibility, scope, cost, and timing of your project.

2. **A critical water supply service area, as established under the Public Water System Coordination Act of 1977.** If so, you must request service from the existing water utility serving the area of your proposed Group A-TNC water system.
3. **An area served by one or more Satellite Management Agency (SMA).** If so, an available SMA must own or manage and operate your proposed new Group A-TNC water system before DOH can approve the water system.
4. **A tribal reservation**. If so, contact the tribe for guidance on approval requirements. DOH has no authority to approve Group A-TNC water systems located entirely within a tribal reservation, even if located on fee-simple land.

1.3 Basic Design Standards

The following standards apply to DOH approval of a Group A-TNC water system workbook under Chapter 246-290 WAC.

1. All supply sources for new and expanding Group A-TNC systems should be drilled wells that meet the requirements of Chapter 173-160 WAC, or an agency-approved intertie with an approved Group A water system. We will consider approval of alternate sources on a case-by-case basis if a drilled groundwater well is not feasible. Examples of alternate water sources include surface water, spring, groundwater well under the direct influence of surface water (GWI), rainfall catchment, or seawater source. All alternate sources require treatment of the water. This document does not address the type of treatment necessary when using these alternate drinking water sources. Refer to DOH's Water System Design Manual (331-123).
2. LHJ or DOH staff **must** inspect the location (well site) of any existing or proposed well. You must submit the inspector's written well site inspection report with the water system workbook [WAC 246-290-130(4)(e)]. The well site inspection needs to be done prior to drilling the well, per WAC 173-160.
3. Applicants for a new or expanding water system **must** receive written approval of the workbook from DOH before starting any construction [WAC 246-290-120(2)].
4. New and expanding Group A-TNC water systems **must** be designed by a professional engineer licensed in Washington State (WAC 246-290-040).
5. New or expanding water systems designed and intended to serve ten or more homes, home-like cabins, or other dwelling units that could be used as permanent residences **must** follow the Group A Community public water system approval process, beginning with preparation and submittal of a Water System Plan [WAC 246-290-010(190) and WAC 246-290-100].
6. The design needs to demonstrate source capacity of at least the non-residential usage plus 750 gallons per day per residential dwelling unit for systems located west of the Cascade Mountain crest, and non-residential usage plus 1,250 gallons per day per residential dwelling unit east of the Cascade Mountain crest. Alternatively, the design engineer may use the concepts our *Water System Design Manual* 331-123 to calculate an alternate system-specific demand forecast.

7. If an SMA is available in the location of a new Group A-TNC water system, then the workbook **must** document that an SMA will either own or manage and operate the water system [WAC 246-290-035(1)]. If all SMAs serving the area were contacted and declined to provide service, provide copies of all the rejection correspondence in the approval package. This requirement **does not apply** to an existing Group A-TNC water system seeking to expand its number of approved connections.
8. If a proposed Group A-TNC water system is in a Critical Water Supply Service Area, then the workbook **must** show that you requested water service from the water utility operating in the area of the proposed system (WAC 246-293-190). This requirement **does not apply** to an existing Group A-TNC water system seeking to expand its number of approved connections if the new connections are in the Group A-TNC's existing service area.
9. Conducting a well-site inspection and undertaking review of a new or expanding Group A-TNC water system workbook are fee-supported activities. DOH charges fees for these activities in accordance with WAC 246-290-990. Local Health Jurisdictions (LHJs) charge a fee for wellsite inspections they conduct. The well site inspection needs to be done prior to drilling the well, per WAC 173-160.

1.4 Project Submittals

You **must** submit a complete Group A-TNC workbook to DOH for written approval before construction begins whenever you develop a new Group A-TNC water system, and whenever you seek to increase the number of approved connections in an existing Group A-TNC water system (an expanding system) (WAC 246-290-110 and -120).

Construction of a new or expanding water system may be subject to local permits or approvals, including a local government finding of physical and potable water availability. Compliance with DOH requirements does *not* guarantee full compliance with local rules. You must also satisfy and follow the local approval process. You can get information about local approval processes from most county building departments and environmental health programs.

If your design submittal meets all applicable requirements, you will receive an approval letter. The letter will refer to the lot(s) the approved system serves, and include a statement such as:

> The department's approval of your water system design does not confer or guarantee any right to a specific quantity of water. The approved number of service connections is based on your representation of available water quantity. If the Washington Department of Ecology, a local planning agency, or other authority responsible for determining water rights and water system adequacy determines that you have use of less water than you represented, the number of approved connections may be reduced commensurate with the actual amount of water and your legal right to use it.

The design engineer must verify that construction was completed according to the approved plans and specifications. The designer or inspecting engineer must complete a [*Construction Completion Report* 331-121] and submit it to us within 60 days of project completion and before providing water to the public [WAC 246-290-120(5)].

If the design engineer considers significant changes from the approved project plans during construction, they **must** submit to us a description of the changes and justification for them. We must approve the proposed changes before they are constructed [WAC 246-290-120 (4)(d)]. Significant change means:

- Size, number, elevation, depth, material, and/or capacity of water system components that are different from those described in the approved workbook.
- Testing procedures differ from those described in the approved workbook.

1.5 Requirements for a Professional Engineer

The design report workbook **must** be prepared by a professional engineer licensed in Washington State (WAC 246-290-040).

1.6 Other Referenced Documents and Standards

We cite other waterworks-related laws, guides, standards, and documents in these guidelines to provide appropriate references. These references form a part of these guidelines, but it is not our intent to duplicate them.

All water system designs **must** comply with locally adopted national model codes, such as the International Building Code (IBC) and Uniform Plumbing Code (UPC), and conform to other applicable industry standards and guidance, such as that from the American Water Works Association (AWWA), American Society of Civil Engineers (ASCE), and the American Public Works Association (APWA) (WAC 246-290-200).

1.7 Department of Health Contacts

The design engineer should contact us with questions or design concerns. Our contact information is in Table 1.1. You can also refer to the Office of Drinking Water staff contact information web page.

Table 1.1

Office of Drinking Water Regional Offices

Eastern Regional Office	**Serving**
Phone: 509-329-2100 **Fax:** 509-329-2104	Adams, Asotin, Benton, Chelan, Columbia, Douglas, Franklin, Ferry, Garfield, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman, and Yakima counties.
Northwest Regional Office	**Serving**
Phone: 253-395-6750 **Fax:** 253-395-6760	Island, King, Pierce, San Juan, Skagit, Snohomish, and Whatcom counties.
Southwest Regional Office	**Serving**
Phone: 360-236-3030 **Fax:** 360-664-8058	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Kitsap, Lewis, Mason, Pacific, Skamania, Thurston, and Wahkiakum counties.

CHAPTER 2 Basic Water System Information

Chapter 2 covers basic water system information required for most submittals. This includes location, size, system classification, and future ownership and management of the water system.

2.0 Public Water System Classification

Different types of water systems are subject to different regulations. Start by establishing whether your proposed water system is a public water system. Next, determine the system classification.

A public water system is any system providing water for human consumption, excluding a system serving only one single-family residence, or a system with four or fewer service connections, all of which serve residences on the same farm. See the complete definition and a flowchart for determining a public water system's classification in WAC 246-290-020.

A Group A-TNC public water system supplies 15 or more service connections and has the following service population characteristics.

- Twenty-five or more different people/day for 60 or more days/year, or
- Twenty-five or more of the same people/day for less than 180 days/year and for more than 60 days/year; or
- One thousand or more people for two or more consecutive days.

These guidelines cover design standards applicable to Group A-TNC public water systems. Typical Group A-TNC water systems include restaurants, resorts, campgrounds, RV parks, farmworker housing, and the like. It is important to evaluate the proposed usage for the specific water system going through the approval process against the criteria in WAC 246-290-020. For example, if a proposed farmworker housing water system expects to serve 25 or more of the same people living on the system for 180 or more days per year, the system would be a Group A Community water system. The applicant needs to prepare and submit a Water System Plan in accordance with WAC 246-290-100.

See our *Water Facilities Inventory Form Instructions* 331-621 for guidance on properly documenting the number of connections and population that the water system will serve. Additional guidance is provided in the sections below.

2.0.1 Connections Served

Determine the total number of connections by counting each single-family home, each dwelling unit in a multifamily building, and each nonresidential building that the water system serves. The complete definition of "service connection" is in WAC 246-290-010.

In the following examples, we apply the definitions of service connection in WAC 246-290-010.

- A system serving a store, two duplexes being used less than 180 days/year, and two full-time single-family homes has one commercial connection, four part-time residential connections, and two full-time residential connections.
- A system serving a restaurant and four single-family homes has one commercial connection and four full-time residential connections.
- A system serves three single-family homes. One home has an attached shop with piped water that serves as a place of employment for people from outside the home. The other two homes

each have a separate structure with piped water that serves as a retail or commercial business open to customers or clients. This system has three residential connections plus three nonresidential connections, for a total of six connections.

2.0.2 Population Served

The population you must count is the number of people that have **access** to piped water for human consumption. The population served is either residential (people living in a residence), or nonresidential (tourists, customers, employees) entering the premises and given the opportunity to access tap water. Our data system uses the information you provide on your *Water Facilities Inventory Form* (WFI) to calculate a daily average for each calendar month. (See Section 2.7)

2.0.2.1 Residential Population

For the purposes of design, and to identify the appropriate water system approval standards, 2.5 residents **must** be assigned to each dwelling unit [WAC 246-290-010(190)]. Therefore, if your proposed system serves ten or more dwelling units, your proposal falls under the approval standards for Group A Community public water systems, and you will need to submit a Water System Plan (WAC 246-290-100) instead of a Group A-TNC Approval Workbook.

2.0.2.2 Nonresidential Population

Here are two examples of estimating non-residential population based on access.

A Post Office has a restroom and a coffee bar or sink located behind the customer counter, where only employees can access these facilities. There is no water service provided in the visitor or customer service area of the Post Office. The number of people served by this water system is the number of people who work at the Post Office. Do not count visitors.

A commercial business has a restroom accessible to the public. The estimated service population should be based on the estimated number of customers per day multiplied by the number of access days, plus employees. Count everyone expected to enter the business.

2.1 Project Approval Application Form

On the *Project Approval Application Form* 331-149, the design engineer provides the information necessary to review and process the application properly. This information includes:

- Contact information for both the water system and person submitting the project.
- The number and type of connections the system serves or will serve.
- The type of project.

2.2 Service Area Map and Location

Applicants for a new or expanding water system **must** also provide a scaled map of the proposed service area [WAC 246-290-110(4)]. You can use the same map submitted with a land use application or one that is similarly detailed. The map you use should include the boundaries of the proposed service area, roads, property lines, parcel numbers, and other features helpful in locating the project and individual features. You can use the same map to show the proposed distribution system or use a separate map.

2.3 Public Water System Coordination Act

The *Public Water System Coordination Act of 1977* (RCW 70.116) requires applicants seeking development of a new public water system to determine whether the proposed system is in the future service area of an existing utility. The intent of the Coordination Act is to avoid creating new water systems whenever an existing water system is available and willing to provide service.

If your project is in a Public Water System Coordination Act planning area, identify the utility providing service. You **must** request water service from that utility. If the utility can provide service in a timely and reasonable manner, you must obtain water service from the utility and abandon plans to develop a new water system (WAC 246-293-190). This requirement does not apply to an existing Group A-TNC water system seeking to expand its number of approved connections if the new connections are in the Group A-TNC's existing service area.

To ensure compliance with this statute, you **must** include a written record of the request for water service and the water supplier's written response to that request in your workbook (WAC 246-290-110). An example of a letter requesting water service is in the Appendix A.

If your project is outside a Public Water System Coordination Act planning area, you may develop a new water system. However, your application is subject to the Satellite Management Agency requirement (WAC 246-290-035[1]).

2.4 Satellite Management Agency

A Satellite Management Agency (SMA) is an individual, water system, or other entity approved by DOH to own or operate public water systems on a regional or countywide basis. The law requires an approved SMA to own or operate all new water systems if one is available (RCW 70A.125.060). The intent of the SMA requirement is to place ownership, or operations and management, of all new public water systems in the hands of experienced water suppliers whenever possible. This requirement **does not apply** to an existing Group A-TNC water system seeking to expand its number of approved connections.

All counties have at least one approved SMA. You should choose the SMA that best meets your needs by checking our approved online SMA list.

If your project is in the service area of one or more approved SMA, ask each one whether it is available to provide ownership or management services to your proposed public water system. We provide an example of a letter requesting SMA services in Appendix B.

You **must** either provide a copy of an SMA agreement with your project submittal or proof that no approved SMA is available [WAC 246-290-035(1)].

- If an SMA **is available** to own the proposed water system or provide operation and management services, you must provide a copy of the agreement with the project submittal.
- If an SMA **is not available** (i.e. all the SMAs serving the area of the proposed water system have been contacted and they all declined to provide service), you must provide a written record of each SMA rejection with your project submittal.

Your SMA may require you to submit your water system design to them for review and acceptance before you submit your application to us for approval, particularly if the SMA will be the owner of the new water system.

SMA operational and management services may include:

- Creating and updating standard operating procedure and routine maintenance procedures.
- Reviewing and updating water system governance documents, including policies.
- Input on capital investment and infrastructure planning.
- Budgeting assistance and billing services.
- Sampling and treatment plant (if any), data collection, and evaluation.
- Periodic inspection of sanitary control area, reservoir, and other infrastructure.
- Input on water main break, pump, and power failure response protocols.
- Response to complaints, water outages, and water quality emergencies.

Please review our Satellite Management Agencies webpage .

2.5 Protective Covenants

Protective covenants are required to secure the area around a public drinking water supply from future use and development that may threaten water quality and public health [WAC 246-290-135(2)]. Section 4.3 explains how to provide legal protection for the area around a public drinking water supply well. When submitting your workbook, provide a copy of the actual protective covenants recorded with the county auditor for each public drinking water supply well.

2.6 Water Users' Agreement

It may be beneficial to establish a water users' agreement for new Group A-TNC water systems serving multiple property owners. All owners of the water system should sign the users' agreement when the system is constructed and operational. A water users' agreement outline is in Appendix C.

You may need to complete your water system design before you can finalize your water users' agreement.

2.7 Water Facilities Inventory

Include a completed *Water Facilities Inventory Form* (WFI) with your Group A-TNC workbook. To ensure the information in our data system is correct, answer all the questions on the WFI. Instructions for Group A-TNC systems and a sample WFI form are in Appendix D. If you plan to submit a workbook for an expanding Group A-TNC system, please submit a marked-up version of your existing WFI form.

2.8 Easements

Your Group A-TNC workbook **must** show the location and dimension of easements you intend to secure in order to adequately access and maintain all distribution system components, reservoirs, wells, and pumping stations (WAC 246-290-110).

CHAPTER 3 Estimating Water Demands

Chapter 3 explains how to estimate expected Maximum Daily Demand (MDD) and Peak Hour Demand (PHD) for your proposed water system. Engineers need water demand estimates to size pumping equipment, transmission lines, distribution mains, and water storage facilities properly.

Demand estimates combined with information about your water supply source ensures the water system can meet all the demands you expect it to meet over the year. Establishing the expected MDD also determines whether you need a water right (RCW 90.44.050).

If you do need a water right, you must obtain the appropriate documents from the Department of Ecology, complete a *Water Rights Self-Assessment form* 331-372, and include the documentation in your workbook [WAC 246-290-130(4)].

If we believe you need a water right, but you don't provide a copy with your submittal, we may return your submittal to you. We will also explain our decision and recommend that you consult with Ecology before resubmitting your design.

3.0 Water Rights

3.0.1 Water Right Permit Exempt Wells

The Department of Ecology administers the regulatory and permitting processes for water rights. Most Group A-TNC water systems use the groundwater permit exemption (RCW 90.44.050) rather than obtaining a permit from Ecology prior to using water. Note that in accordance with our Joint Review Procedures agreement with Ecology, we will send them a copy of this submittal to verify the water rights adequacy.

Depending on the watershed, the owner of a permit-exempt well may withdraw up to 5,000 gallons per day for group domestic use and 5,000 gallons per day for industrial, and/or commercial uses. In addition, the owner may have a separate allowance of any amount of water to irrigate up to a half-acre of lawns or noncommercial gardens, so long as the water is put to beneficial use.

Depending on the watershed, the owner of a permit-exempt well may have a specified maximum daily withdrawal allowance lower than the statutory permit exemption. This limitation may include all uses from the permit-exempt well, including irrigation.

For a complete description of the legal uses of a permit-exempt well, consult with Ecology about water availability or visit their groundwater permit exemption webpage.

Permit-exempt wells are exempt only from the duty to obtain a permit to use groundwater, and are not exempt from the other provisions of the Water Code. A water right established through a permit-exempt well has the same legal effect and must abide by the same requirements of prior appropriation and state regulation of water resources as a permitted withdrawal. In other words, the use of water from a permit-exempt well must be regulated or curtailed where necessary, to prevent impairment to a water user with an older water right.

Local government must ensure an adequate potable water supply exists before issuing a building permit. Before developing a permit-exempt well check with local authorities on their criteria for establishing an adequate potable water supply for your planned water system.

When assessing the need for a water right, you should assume that the **domestic in-home portion** of your total system maximum daily demand (MDD) will be at least **350 gallons per day (gpd) per dwelling unit**. The domestic in-home demand is the portion of the total system MDD that counts toward the 5,000-gallon-per-day limit described above.

3.0.2 Basins Closed to Further Appropriation

Ecology may close a basin to all further appropriation or establish reservations of water for permit-exempt wells to protect senior water right holders and minimum instream values.

However, Ecology may create a pathway for an applicant of a new public water system to follow a basin-specific process to secure permission to withdraw groundwater to supply the system.

A basin-specific process may involve developing and implementing a mitigation plan. To determine whether your project is located in a closed basin, contact Ecology. If it is, you must submit Ecology's written permission to withdraw the groundwater you need with your Group A-TNC water system workbook. While such permission, if granted, is not a "water right," we apply the requirement of WAC 246-290-130(3)(b) to such circumstances.

3.0.3 Multiple Permit-Exempt Withdrawals

The rule permits only one exemption for any one project, no matter how many wells and separate small systems are established to supply the project.

If you intend to develop two or more separate, contiguous Group A-TNC water systems, you might not have the legal authority to do so. Contact Ecology for guidance on this issue.

3.0.4 Group A-TNC Applicants with a Water Right

A water right may state the number of connections that can be served. With one exception (see below), the number of connections shown on the water right is a limiting factor for a new or expanding system intended to serve fewer than 15 residential connections. In other words, if the water right specifies that it is for serving six single-family homes, then the maximum number of homes that can be served by the water system is six, even if the instantaneous and annual volume permitted under the right could supply more homes.

The one exception is when an existing *municipal water supplier* owns the new or expanding Group A-TNC system. Applicants who want to know whether their organization is a *municipal water supplier* should contact their DOH regional office.

3.1 Residential Water Demand

3.1.1 Residential MDD

The MDD is the maximum single-day demand the water supply must meet. It consists of in- home domestic demand (see Section 3.0.1), outdoor demand, nonresidential demand, and distribution system leakage. It's important to establish the proposed water system's MDD before you drill and test the water supply well.

Table 3.1 specifies the default MDD for residential service connections. If you wish to do a more detailed analysis to estimate residential MDD, please reference Part 1 of Chapter 3 in DOH's *Water System Design* Manual 331-123.

Table 3.1

Default Standards for Residential Service Connection MDD

County	Gallons per day per dwelling unit
Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skamania, Skagit, Snohomish, Thurston, Wahkiakum, and Whatcom	750
Adams, Asotin, Benton, Chelan, Columbia, Douglas, Ferry, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman, and Yakima	1,250

Because residential MDD includes inside and outside uses, the actual demand could be considerably higher than the minimum values listed in Table 3.1. In general, the demand for water increases along with lot size, home size, and average summer temperatures. Other site- specific considerations may also affect water demand, such as:

- The development's Covenant, Conditions, and Restrictions;
- Cost of water;
- Soil type; and,
- Irrigation system technology.

The designer and design engineer should strongly consider whether the minimum values in Table 3.1 are sufficient to meet the expected demands of future customers. The effect of under-estimating the MDD includes low pressure, summertime water rationing, dissatisfied customers, and increased vulnerability to back-siphonage of non-potable water into the distribution system.

3.1.2 Residential PHD

It's important to establish peak hourly demand (PHD) before designing the system of wells, pumps, pipes, and pressure tanks. The relationship between PHD, sustained well yield, and well pump capacity will determine whether the proposed water system requires atmospheric storage to supplement the supply source(s) to meet the expected PHD. See Chapter 5 for details.

Table 3.2 provides guidance on establishing the minimum PHD for residential demand. For the same reasons cited in 3.1.1 above, the actual PHD of the customers your proposed Group A-TNC system will serve could be considerably higher than the values in Table 3.2. The effect of under-estimating the PHD includes low pressure, dissatisfied customers, and increased vulnerability to back-siphonage of non-potable water or other potential contaminants into the distribution system.

Table 3.2

Guide for Minimum Residential Peak Hourly Demand

Number of dwelling units	Peak Hour Demand (in gallons per minute)
2	23
3	26
4	28
5	31
6	34
7	36
8	39
9	41

Source: Adapted from *Water System Design Manual* 331-123.

3.2 Nonresidential Water Demand

3.2.1 Nonresidential MDD

Table 3.3 provides guidance on nonresidential maximum daily demand (MDD). We use the values here as guidance with the following assumptions:

- Unit nonresidential demand will vary little from day to day.
- MDD is based on a full facility (the campsite or hotel is fully occupied, or the school is operating at capacity).

Table 3.3

Guide for Nonresidential Maximum Daily Demand

Type of Establishment	Maximum Daily Demand (in gallons per day)
Bathhouse (per bather)	10
Boardinghouse (per boarder)	50
Additional kitchen requirements for nonresident boarders	10
Camp	
Construction, semi-permanent (per worker)	50
Day, no meals served (per camper)	15
Luxury (per camper)	100–150
Resort, day and night, limited plumbing (per camper)	50
Tourist, central bath and toilet facilities (per person)	35
Factory (gallons per person per shift)	15–35
Highway rest area (per person)	5
Hotel	
Private baths (two persons per room)	50
No private baths (per person)	50
Institution other than hospital (per person)	75–125
Laundry, self-serviced (gallons per washing (per customer))	50
Motel	
Bath, toilet, and kitchen facilities (per bed space)	50
Bed and toilet (per bed space)	40
Park	
Overnight, flush toilets (per camper)	25
Trailer, individual bath units, no sewer connection (per trailer)	25
Trailer, individual baths, connected to sewer (per person)	50
Picnic	
Bathhouses, showers, and flush toilets (per picnicker)	20
Toilet facilities only (gallons per picnicker)	10
Restaurant	
Toilet facilities (per patron)	7–10
No toilet facilities (per patron)	2 ½–3
Bar and cocktail lounge (additional quantity per patron)	2
School	
Day, cafeteria, gymnasiums, and showers (per pupil)	25
Day, cafeteria, no gymnasiums or showers (per pupil)	20
Day, no cafeteria, gymnasiums or showers (per pupil)	15
Service station (per vehicle)	10
Store (per toilet room)	400
Worker	
Construction (per person per shift)	50
Day (school or offices, per person per shift)	15

Sources: Adapted from Design and Construction of Small Water Systems American Water Works Association, 1984; and Planning for an Individual Water System. American Assoc. for Vocational Instruction Materials, 1982.

3.2.2 Nonresidential PHD

Tables 3.4 and 3.5 provide guidance on establishing nonresidential PHD.

Table 3.4
Demand Weight in Fixture Units

Fixture Type	Weight in Fixture Units per Fixture Type
Shower	2
Kitchen sink	1.5
Urinal	3
Toilet (flushometer)	5
Toilet (tank flush)	2.5
Bathroom sink (lavatory)	1
Clothes washer	4.0
Drinking fountain	0.5
Dishwasher	1.5
Hose Bibb	2.5

Source: Adapted from the 2009 Uniform Plumbing Code, Appendix A, Table A-2.

After determining the total number of fixture units (sum of fixture type times fixture weight), round the total to the next highest value given in Table 3.5 and determine the peak hourly demand.

Table 3.5 Nonresidential Peak Hourly Demand
Based on Total Fixture Units

Total Number of Fixture Units	PHD (gpm)
10	8
15	12
20	15
25	18
30	20
35	22
40	25
50	29
60	32
70	35
80	38
90	41
100	43

Source: Adapted from the 2009 Uniform Plumbing Code, Appendix A.

3.3 Fire Suppression

You must consult with the local fire authority to determine what, if any, fire suppression capacity it requires from the proposed water system (WAC 246-290-235).

3.3.1 Design for Individual Structure Sprinkler Systems

If the water system will provide the direct supply of water to individual sprinkler systems in homes or other nonresidential structures, you **must** include the added supply and pressure requirements these sprinkler systems demand (WAC 246-290-200).

References

WSDOH, 2019. Water System Design Manual, DOH 331-123, Washington State Department of Health, Olympia, WA.

American Association for Vocational Instructional Materials. 1982. Planning for an Individual Water System, 4th Edition, American Association for Vocational Instructional Materials, Athens, GA.

AWWA. 1984. *Design and Construction of Small Water Systems*, American Water Works Association, Denver, CO.

Chapter 4 Sources of Supply

Chapter 4 covers design considerations for your water source(s). The first consideration, and a potential limiting factor in small water system design, is the capacity of the source(s). The goal of your water system design is to provide the quantity of water needed to reliably meet expected maximum day and peak hourly demands of your future customers.

If you intend to supply your proposed water system with an intertie, please refer to Section 4.4. The rest of this chapter is devoted exclusively to using a well as your Group A-TNC water supply. If you are considering a different source of supply, please refer to Chapter 5 of DOH's *Water System Design* Manual 331-123.

4.0 Well Construction

In your workbook, you **must** demonstrate that your Group A-TNC groundwater supply:

- Is a drilled well, constructed according to Chapter 173-160 WAC. We will not approve a dug well as a Group A-TNC water supply. If the well is potentially under the influence of surface water (potentially GWI), it will need to be evaluated for GWI before it can be approved for use by DOH (see section 5.7 of the *Water System Design* Manual 331-123).
- Is capable of reliably delivering the maximum day demand (MDD) of the water system [WAC 246-290-222(4)].
- May be used in compliance with Washington's Water Code and other applicable regulations [WAC 246-290-130(3)(b)]. See the water right discussion in Chapter 3.
- Is physically connected to the distribution system. Trucked or hauled water is not an acceptable permanent public water supply, regardless of the trucked water source.
- Meets all applicable primary water quality standards without treatment, otherwise a design for appropriate treatment must be included with the submittal. Note that DOH requires the water system to retain the services of a certified Water Treatment Plant Operator for most treatment systems other than simple chlorination.
- Is protected adequately from potential contamination sources. Protective covenants establishing the minimum sanitary control area **must** be filed for each source [WAC 246- 290-135(2)(f)].
- Converting an existing well for use in a public water system is possible if the well meets the same sanitary control area requirements as a newly drilled well would and if enough information is available about the construction details and current condition of the well and casing from well logs and/or a video log. Existing wells need to meet **all** source approval requirements in WAC 246-290-130.

A totalizing source meter and sample tap are **required** on each new supply source (WAC 246- 290-130(3)(d) and -300(1)(d)]. In addition, we recommend individual service meters on each service connection.

The well casing **must** extend at least six inches above the finished ground surface, or at least six inches above the pump house finished floor, and your submitted workbook must document this. Further, the top of the well casing must be at least 24 inches above the 100-year flood elevation

(Chapter 173-160 WAC). You may find flood-mapping information at your local planning office. If your well is in the 100-year flood plain, you must note this on your drawings. (See Section 5.3.)

The pitless adaptor or pitless unit, and the well cap **must** be manufactured according to Standard PAS-97 (latest published version).

4.1 Source Water Quantity

Groundwater wells are the most common form of public drinking water supply in Washington State. Your groundwater source(s) **must** provide sufficient water to meet the Maximum Daily Demand (MDD) for your water system [WAC 246-290- 222(4)]. If your well can produce the MDD, but not the Peak Hour Demand (PHD), you **must** provide equalizing water storage [WAC 246-290-235(2)].

4.1.1 Well Log

The well log, otherwise known as a "water well report," provides important information about the construction of your well and its vulnerability to contamination. It also contains information about your aquifer and sometimes your well capacity and pump setting. You **must** include a copy of the well log in the workbook, even when the design intends to use an existing well [WAC 246-290-130(4)(f)].

If a well log is not available, we may not approve the source, or we may require additional information before considering the source for approval.

4.1.2 Pump Tests

All wells submitted for approval **must** be pump tested [WAC 246-290-130(3)(c)(iii)]. The goal of the pump test is to demonstrate the source's capacity to meet or exceed proposed water system demand during a range of conditions likely to occur over the course of a year and the life of the well. See Appendix F for detailed pump test guidance.

The pump test must provide the:

- Static water level.
- Sustainable yield.
- Drawdown.
- Recovery rate.
- Duration of pumping.

To demonstrate sustainable yield, a successful pump test must show the proposed well (or combination of wells) can provide a sustainable and reliable yield equal to or exceeding the minimum supply requirements in WAC 246-290-222(4). In addition, the water level in the proposed well must recover to 95 percent or more of the pre-test water level within a normal 24-hour operational period.

A successful pump test will provide data needed for source approval, well design, and water system planning decisions. By analyzing the pump test data, you can:

- Identify the capacity and reliability of your well.

- Establish well pump settings (depth and discharge rate).
- Define the area of influence of your well.

4.1.2.1 Elements of a Pump Test

A pump test is an aquifer and well stress test. The test subjects the well to a series of controlled pump and recovery (rest) challenges. Pumping rates and the water level in the well are monitored and recorded. The designer can use an analysis of the data to identify aquifer characteristics, such as transmissivity, hydraulic capacity, and specific yield.

A design engineer can use the capacity of the well (in gallons per minute), established from the pump test and the required pump head (in feet), to select the proper pump size, pump placement, and determine overall well efficiency.

Because aquifer conditions vary, Appendix E describes three different pump test procedures, each suited for different hydrologic conditions.

Test Procedure	Application
Standard Step Drawdown/Constant Rate	Complex or unknown hydrologic settings
Extended Step Drawdown	Small systems with low demand located in high yield aquifers
Alternating Pump and Recovery	Very small systems in very low yield aquifers

Every pump test must include regularly recorded pumping and water level measurements taken before the test begins (pre-pumping conditions), during the pumping phase (drawdown), after the pump is shut off, and as water levels return to pre-pumping or near normal conditions (recovery). Pre-pumping and recovery water level measurements are as important as measurements taken during the pumping phase of a test.

A pump test must be long enough to demonstrate that the well can sustainably produce- together with the rest of the water system system's sources- the maximum day demand of the water system and recover to at least 95 percent of pre-pumping levels within a normal 24-hour operational period. The length of an individual pump test will vary based on the structure of the test and the aquifer conditions. Pump tests may take longer than 24 hours to complete and still be considered successful. It is the analysis of the data collected during the pump and recovery tests that demonstrates sustainable operating conditions. The designer is responsible for ensuring that a pump test provides sufficient data to achieve its objectives.

At a minimum, the pump test must be conducted at a flow rate of at least the intended flow rate for when the well is put into regular service. The duration of the pump test must be at least the length of time that it takes for the water level drawdown to stabilize and remain stabilized for four to six hours. Then the water level recovery must be documented until it reaches 95 percent of the original static level.

If not already present, the designer **must** install an access port permitting "depth to water" measurement prior to the pump test (WAC 173-160). We recommend that you measure water levels to the nearest 0.01 ft. However, not all measuring devices have the same level of accuracy. Many electric tapes and loggers can provide accuracy of 0.01 ft. Sonic loggers may not show the same level of accuracy (typically 0.1 ft) but can provide more frequent and consistent measurements. To ensure recovery data is accurate, the designer should install check valve(s) to prevent water in the riser pipe from flowing back into the well when the well shuts off.

If aquifer conditions are unknown or hydrologically complex, you should consider getting help from a hydrogeologist or licensed water resource professional. Before conducting a pump test in areas subject to seawater intrusion, contact the local health jurisdiction (LHJ). The LHJ may have pump test requirements or standards in addition to those in these *Guidelines*.

4.1.2.2 Low Well-Yield Water Supply Contingency Plan

If the pump test indicates the well yield is 5.0 gpm or less, the design should include a contingency plan describing short-term and long-term measures to restore water to consumers if the supply is ever inadequate to meet demand (WAC 246-290-420). When the supply begins with such a low yielding well, any decline in well yield of even a few gallons per minute significantly affects the water system's ability to satisfy demand.

4.1.3 Water Rights

Unless the new well falls under the groundwater water rights exemption (discuss this with Washington Department of Ecology or visit their Groundwater Permit Exemption webpage) you must provide Ecology documentation that permits the planned withdrawal. This documentation must include a *Water Rights Self-Assessment form* 331-372. See the more extensive discussion on the topic of water rights in Section 3.0 of this document.

4.2 Source Water Quality

All supply sources used for public water system service **must** meet minimum public health water quality standards. These standards are set forth in WAC 246-290-310. A state accredited lab **must** analyze all source samples to ensure they meet these standards [WAC 246-290-300(1)(c)]. Check this list of labs certified to analyze drinking water samples.

Source water sample taps **must** be provided [WAC 246-291-200(9)]. We recommend you install the sample tap as close to the source as practical. If your design requires treatment, install a second sample tap after treatment and prior to entry to the distribution system [WAC 246-290-300(1)(d)].

4.2.1 Coliform Bacteria

All groundwater sources **must** be disinfected, flushed, and subsequently tested for coliform bacteria, and you must include the coliform bacteria test results with the workbook [WAC 246-290-130(3)(g)(i)].

4.2.2 Inorganic and Volatile Organic Contaminants

All groundwater sources submitted for approval must be tested for complete inorganic chemicals (IOCs) and volatile organic chemicals (VOCs) [WAC 246-290-130(3)(g)(ii) and (iii)]. If your proposed groundwater source exceeds an IOC or VOC primary water quality standard, you must collect a second (confirmation) sample. If the average of the two samples exceeds the drinking water standard, we will require an appropriate treatment design to be included with the approval workbook.

If your proposed groundwater source exceeds an IOC or VOC primary maximum contaminant level (MCL), or exceeds the secondary MCL for iron or manganese, your workbook **must** include treatment for its effective removal [WAC 246-290-130(5)]. See Chapter 9 and Appendix F of DOH's *Water System Design* Manual 331-123 for guidance on treatment selection and design.

4.2.2.1 **Groundwater** with High Initial Turbidity

While not a regulated contaminant, turbidity is commonly included in a complete inorganic chemical analysis. A new well may show high turbidity in the post-pump test IOC sample. If so, you should thoroughly purge and pump the well to remove any construction residuals. High turbidity can be an indication of a poorly developed well. Iron or manganese may also cause high turbidity.

Turbidity can cause distribution-related problems and customer complaints. Turbidity in groundwater, and particularly turbidity without any reasonable or logical explanation, can be a significant concern. The design engineer should contact DOH staff for additional guidance.

4.2.3 Per- and Polyfluoroalkyl Substances (PFAS)

You must test all groundwater sources submitted for approval for PFAS by either EPA Method 533 or EPA Method 537.1. If PFAS is detected, you will need to take follow-up actions as directed by DOH.

4.2.4 Other Site-Specific Contaminants

DOH may require you to sample the well for synthetic organic chemicals or radionuclides if your proposed Group A-TNC groundwater source is in an area of known or suspected contamination [WAC 246-290-130(3)(g)(iv)]. If the initial sample shows the well exceeding a public health water quality standard, you must take a confirmation sample. You will need to take further action as directed by DOH based on the results.

4.2.5 Potential Groundwater under the Direct Influence of Surface Water

If your proposed groundwater supply is within 200 feet of surface water **and** the first open interval (top of well screen, first perforations in the well casing, and so on) is less than 50 feet below the ground surface, then your proposed groundwater supply is considered a potential groundwater under the direct influence of surface water (GWI). You **must** evaluate all sources that meet the definition of potential GWI before submitting your completed Group A-TNC design for approval [WAC 246-290-130(3)(d)].

We will not approve a potential GWI source until a licensed hydrogeologist or engineer completes a hydrogeologic evaluation that determines the source is not GWI [WAC 246-291-125(1)]. DOH will charge a separate fee to review your GWI evaluation.

4.2.6 Seawater Intrusion

Wells developed close to seawater are potentially vulnerable to seawater intrusion. You should avoid supply sources at risk of seawater intrusion.

Wells are at risk for seawater intrusion if they are:

- Within one-half mile of the shoreline and pump water from a depth below sea level.
- Within one-half mile of a ground4.2.5water source with chloride concentrations over 100 mg/L.

Ecology may condition water right permits to provide for reduced pumping rates, or even to require sources be abandoned if seawater intrusion threatens senior water right permits. In addition, several counties have policies or ordinances that affect water systems in areas vulnerable to seawater intrusion. You should contact Ecology and the local health jurisdiction for current policies and rules on well development where seawater intrusion may be a concern.

4.2.7 Treatment

If treatment is proposed to resolve a water quality health or aesthetic issue, the engineer must provide a project report, design/construction documents, and an operations and maintenance plan. For design guidance and requirements, refer to Chapter 10 and Appendix E of the *Water System Design* Manual 331-123.

4.3 Source Protection

You **must** have your well site inspected and approved before submitting your design for approval [WAC 246-290-130(4)(e)]. We strongly recommend that you have the well site inspected before drilling a new well (WAC Chapter 173-160). Ask your local health jurisdiction if they offer this service. If not, DOH will conduct the well site inspection. DOH charges a separate fee for well site inspections.

You **must** maintain a sanitary control area of at least 100 feet around each well, unless adequate engineering justification is provided, to protect against existing or potential sources of contamination [WAC 246-290-135(2)].

For each well that will serve the Group A-TNC system, you must complete a susceptibility assessment form (Publication 331-274-F) [WAC 246-290-130(3)(c)(i)] and include it with the water system design package. For guidance on completing the form, please refer to the instructions (see Appendix F of the *Wellhead Protection Program Guidance Document* 331-018. For more information on source water protection, see Section 5.2 in the *Water System Design* Manual 331-123, and also see DOH's Source Water Protection webpage.

You must prepare and file legal documents with the county auditor to protect the sanitary control area from sources of contamination [WAC 246-290-135(2)]. Information explaining how to file these legal documents, known as covenants, is in *Covenants for Public Water Supply Protection* 331-048. General guidance on sanitary control area protection is in *Sanitary Control Area Protection* 331-453.

4.4 Interties

An intertie is a connection between a wholesale (supplying) public water system and a consecutive (receiving) public water system, permitting the exchange or delivery of water between those systems. There are two types of interties.

1. **Non-emergency intertie:** The piped connection supplies water from the wholesaler to meet the routine day-to-day needs of the consecutive system. If you plan to supply your proposed system through a non-emergency intertie, see the pertinent regulations in WAC 246-290-132.
2. **Emergency intertie:** The piped connection provides a standby water supply from the wholesaler to the consecutive system necessary to meet the emergency water supply needs of the consecutive system. This may include help providing fire flow or serving as back up if one or more of the consecutive system's own sources fail. The regulatory requirements

concerning emergency interties with another approved public water system are in WAC 246-290-132.

This section describes considerations you should make when designing your Group A-TNC water system as a consecutive system **supplied by a non-emergency intertie**.

4.4.1 Effect on Wholesale Purveyor

The wholesale system must demonstrate that it has enough department-approved capacity to serve the total number of connections contemplated by your proposal. If the wholesale system does not have enough approved capacity to accommodate its own customers **plus** your proposed customers, the wholesale purveyor **must** submit the appropriate planning and design documents to DOH for written approval. The wholesale system will have to construct any needed improvements before we will complete reviewing your workbook.

Your workbook **must** include an analysis of the wholesaler's capacity. The analysis must show the wholesale system can deliver the water supply your proposed system demands while maintaining minimum acceptable service in the wholesale system [WAC 246-290-230(5) and WAC 246-290-200].

The wholesale system **must** meet all the applicable planning, engineering, and design requirements in WAC Chapter 246-290. It may take the wholesale system considerable time to meet these requirements.

4.4.2 Intertie Agreement

The intertie agreement has particular significance. If the intertie agreement between you and the wholesale purveyor cannot satisfy all the water supply requirements you identify in Chapter 3, you **must** show how your proposed system will meet the MDD and PHD reliably and consistently (WAC 246-290-222).

If the intertie agreement is not valid in perpetuity, your completed workbook **must** identify the alternative source(s) your system will use when the intertie agreement expires [WAC 246-290- 132(3)]. In other words, planning your supply around an intertie agreement that is not valid in perpetuity requires you to spend the resources necessary to secure your own source that complies with the requirements of Chapter 246-290 WAC before getting approval to be supplied by the intertie.

4.5 Obtaining DOH Source Approval to use a Well

Adding a new water supply source to a Group A public water system requires approval by DOH. WAC 246-290-130(1) states:

> Every purveyor shall obtain drinking water from the highest quality source feasible. No new source, previously unapproved source, or modification of an existing source shall be used as a public water supply without department approval. No intake or other connection shall be maintained between a public water system and a source of water not approved by the department.

This guidance is intended to assist public water systems in gaining DOH source approval for adding a groundwater well to a Group A-TNC public drinking water system. We want to alert you to some of the more important steps in the process and give you a general outline for the order that they should be done and provide you with forms and other resources so that you can complete the process efficiently.

The drinking water regulations specific to source approval are found in WAC 246-290-130. DOH's *Water System Design* Manual 331-123 contains guidance on designing public water system sources in Chapter 5, checklists for the source approval package and construction document submittals in Appendix A.3.2, and guidance on conducting pump tests in Appendix E.

Converting an existing well for use in a public water system is possible if the well meets the same sanitary control area requirements as a newly drilled well would and if enough information is available about the construction details and current condition of the well and casing from well logs and a video log. Existing wells need to meet all source approval requirements in WAC 246-290-130.

Below is a recommended typical sequence of steps to pursue approval of your planned water supply.

Hire a licensed professional engineer. The source approval submittal and associated construction documents are required to be prepared and submitted by a professional engineer (PE) licensed in the State of Washington, and the submittals must bear the PE's stamp and signature. It is a good idea to bring on the PE as early as possible in the project so they can help make good early design decisions.

If the needed pumping rate of the new well has not been determined through some other process such as a water system planning document, the PE must provide analysis and calculations that identify the needed pumping rate. That analysis, along with documentation such as water rights and the well site inspection, needs to be included with the source approval documents as described below.

Assemble water right documents. Unless the new well falls under the water rights exemption (discuss this with Ecology or visit their groundwater website), you must provide Ecology documentation such as a water right permit or certificate that permits the planned withdrawal. This documentation must include a *Water Rights Self-Assessment form* 331-372. If you are wishing to use the well permit exemption, you need to provide documentation of the water system usage demands to demonstrate that the permit exemption criteria are met.

Well site inspection. Schedule a well site inspection with the local health jurisdiction or DOH before drilling your well. Most local health jurisdictions have contracted with DOH to conduct well site inspections. The well site inspection identifies any potential contaminant sources (existing or planned) that are near proposed well. See the DOH fact sheet *Sanitary Control Area Protection* 331-453 regarding keeping the sanitary control area around the well free of potential sources of contamination. If the well is drilled before the well site is approved, DOH is under no obligation to approve the new well as a public water supply.

Drill the well and conduct testing. The water quality testing for Group A-TNC well source approval includes coliform bacteria, an IOC analysis, and a VOC analysis. Other analyses may be required based on site-specific conditions, refer to Section 4.2 for more detail. Guidance for pump testing in Appendix E. We recommended that you collect required water quality samples at the end of the pump test, to assure a representative sampling of the aquifer water quality. We also recommend that you deliver the samples to the lab on the same day they were collected. If that is not feasible, be sure to meet all sample preservation and hold time requirements.

Complete source approval documents package. In addition to the above items, complete and submit all other documentation necessary (see the checklist in Appendix A.3.2 of the *Water System Design* Manual 331-123). Other documents needed to complete the source approval package include:

- *Susceptibility Assessment form* 331-274-F and instructions (see Appendix F of the *Wellhead Protection Program Guidance Document Publication* 331-018). For more information on source water protection, see Section 5.2 in the *Water System Design* Manual 331-123, and also see our Source Water Protection webpage.
- *Covenants for Public Water Supply Protection* 331-048— see the fact sheet, which explains how to establish land use protection for the sanitary control area of the well.
- Template forms for Declaration of Covenant and Restrictive Covenant- included as Appendix H.
- The source approval documents package needs to include an evaluation of the corrosion potential of the new source's water quality on the system.

Design infrastructure improvements. Design and submit construction documents for all improvements associated with the new well, including pipes, valves, controls, treatment (if necessary), buildings, and the like (see the checklist in Appendix A.3.2 of the *Water System Design* Manual 331-123). Please reference Water Systems Council Standard PAS-97 (2019) in selecting the pitless unit and well cap. Include specifications for the disinfection and testing once construction of the new facilities is complete.

Submit source approval documents and construction documents. Submit a *Project Approval Application form* 331-149 and source approval documents package under the stamp and signature of the PE to us for written approval. We will forward the water rights portion of your submittal to Ecology for their review and comment.

After obtaining DOH approval, begin construction of well improvements. Before starting construction on the physical improvements necessary to connect the well to the water system and make it operational, you need to have received written DOH approval of the construction documents. This is required by WAC 246-290-120(2).

Submit the Construction Completion Report and Revise Water Facilities Inventory. Upon completing construction of the new source and associated infrastructure, but prior to use, submit a *Construction Completion Report* 331-121 and an updated water facilities inventory with the new well and any other relevant updates.

References

AWWA, 1999. *Design and Construction of Small Water Systems*, 2nd Edition, American Water Works Association, Denver, CO.

USEPA, 1991. *Manual of Small Public Water Supply Systems*, EPA 570/9-91-003.

WSDOH, 2007. Covenants for public water supply protection, DOH 331-048, Washington State Department of Health, Olympia, WA.

WSDOH, 2019. *Water System Design Manual*, DOH 331-123, Washington State Department of Health, Olympia, WA.

CHAPTER 5 Well Pump, Bladder Tanks, and Pump House

Chapter 5 explains how to make well pumps and pressure tanks work together as a single system capable of reliably providing safe drinking water to customers of new Group A-TNC water systems.

5.0 Well Pump

The design engineer's task is to select a well pump suited to the specific needs of your proposed water system. It's not enough to consider the horsepower rating of the pump motor (such as "*I need a 5-hp pump*"). In fact, before you select the pump motor size you must properly identify your well's correct pump.

5.0.1 Calculate Minimum Well Pump Discharge Rate

Begin your well pump selection process by referencing how much water your well can produce, as determined by your pump test (Section 4.1.2). If your well can produce up to the PHD determined for your proposed system (Sections 3.1 and 3.2), we recommend you select your well pump based on the PHD. A well pump capable of meeting the PHD of the proposed water system eliminates the need for equalizing storage (Section 7.1.4). If there is no requirement to provide fire suppression, then a well and well pump capable of supplying the PHD enables you to design your Group A-TNC water system using only one pump (the well pump) and pressurized storage (Section 5.1). This is the simplest, least expensive design option.

If your well cannot produce at least the PHD, then your design needs to include additional equipment, including an atmospheric storage tank and possibly a booster pump. This equipment adds considerable cost to constructing your water system. In this instance, selecting a well pump that takes maximum advantage of the well capacity minimizes the size of your atmospheric storage tank.

5.0.2 Calculate Minimum Required Well-Pump Discharge Pressure

After you determine the well-pump discharge rate, you must determine the pressure that the well pump must generate at the selected discharge flow rate. When you know the pump discharge rate and the pressure the pump must generate, you can begin the process of selecting the appropriate well pump.

There are two well-pump design scenarios.

1. **A simple system** consists of only a well pump and bladder tanks; the well pump is the only pump in the system. The well pump **must** generate enough flow and pressure to supply at least the PHD, and to provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system [WAC 246-290-230(5)].
2. **A complex system** consists of a well pump and an atmospheric storage tank. The well pump must generate enough pressure to lift the water to fill the atmospheric tank. In some

designs, the storage tank is next to or near the well, and the system will include a booster pump to move the water from the storage tank to the distribution system. In other designs, the storage tank will be on top of a hill or elevated sufficiently high above the service area so that the reservoir provides adequate pressure to serve customers without a booster pump.

The pressure the well pump must generate is sometimes measured in "feet," as in "feet of head." Water at a depth of 2.31 feet creates exactly 1 psi of pressure. In other words, if you had a pressure gauge connected to the bottom of a water tank, and the gauge read 30 psi, you'd know that there is 69 feet of water standing inside the water tank (30 x 2.31 = 69). Some well pump manufacturers specify a pump's discharge capacity in gpm relative to the "feet," of head that it is pumping against, rather than the gpm the pump will produce relative to the psi.

The following describes the design considerations for a simple system consisting of a well pump capable of delivering the PHD and one or more pressure tanks. This is the most common design scenario.

Total Dynamic Head

The total dynamic head of a pump is the sum of the total static head, pressure head, and friction head. We explain these terms below.

Equation 5-1: TDH = SH + FH + PH

Where

TDH	=	Total Dynamic Head, measured in feet
SH	=	Static Head, measured in feet
FH	=	Friction Head, measured in feet
PH	=	Pressure Head, measured in feet

Static Head

The total SH is the difference in elevation between the **water surface** in the well while the well pump is running (not the elevation of the pump itself) and your customers. This is a major factor in determining the pressure your well pump must generate, so be sure to base it on accurate measurements. To calculate the difference in elevation, you must know both:

- The difference in elevation between the top of your well casing and the water surface in the well at the selected well pump discharge rate (this distance is measured during the pump test).
- The difference in elevation between the top of your well casing and the ground surface along the planned distribution system piping to your customers.

Pressure Head

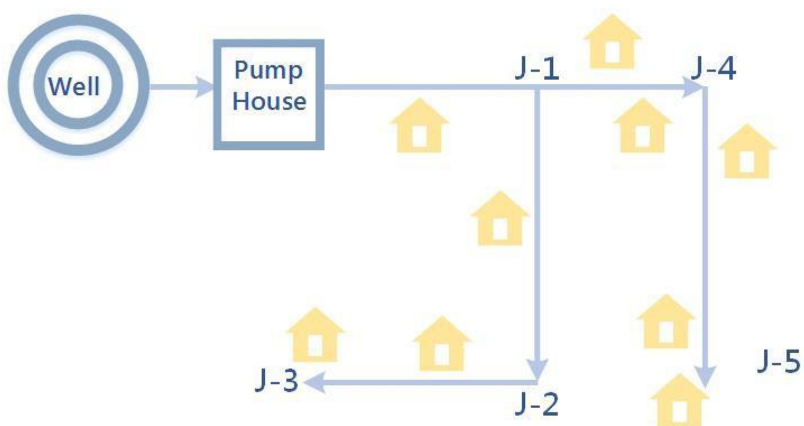
Public water systems **must** be designed to provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system [WAC 246-290-230(5)]. You can convert the pressure head at any point along the distribution pipeline from pressure (psi) to pressure head (feet) by multiplying the pressure by 2.31. For example, 30 psi is equal to 30 x 2.31 = 69 feet of head. This means that the minimum allowable value for the pressure head is 69 feet.

Friction Head

Your well pump moves water up the discharge pipe in the well, through all the pipes and valves in your pump house, and then out into the distribution system to your customers. While on this journey, the water is constantly losing energy due to friction of the water flowing inside the pipes, fittings, and valves. This energy loss is described as the loss of "feet," as in "*at 50 gpm, water flowing through a two-inch Schedule 40 PVC pipe results in 4.2 feet of head loss per 100 feet of pipe.*" The 4.2 feet of head loss is equal to about 2 psi.

The friction head for a piping system is the sum of all the friction losses from the well to the end-user. Friction loss occurs through valves, meters, and fittings in greater proportion than through an equal length of pipe. To accommodate these added sources of friction loss, Worksheet 5-1 on page 38 provides an allowance of 10 feet of friction loss (4 psi) for these common well-house features.

Use the information from Table 5.1 and 5.2 to complete Worksheet 5-1. Estimating friction head loss in the piping system requires estimating the flow through each pipe segment. We recommend using the values in Table 3.2 and 3.3 and assigning water demand at the end of each pipe segment equal to the number of houses or nonresidential uses within and downstream of the end of the pipe segment. See the diagram and table below for an example.



Pipe Segment	Homes Downstream	Flow (gpm)
Well to Pump House	9	50
Pump House to J-1	9	50
J-1 to J-2	3	29
J-2 to J-3	2	24
J-1 to J-4	5	37
J-4 to J-5	3	29

Alternatively, you can use a computer-based hydraulic model to identify the total dynamic head required to maintain the minimum pressures throughout the distribution system. EPANET, distribution system hydraulic modeling software, is available free at epa.gov/water-research/epanet. There are also other more sophisticated hydraulic modeling software tools available for purchase.

Table 5.1

Head loss, ft/100 ft of pipe For PVC Pipe Schedule 40

	Pipe Size (inches)						
Flow Rate, gpm	**1**	**1 ¼**	**1 ½**	**2**	**2 ½**	**3**	**4**
5	1.7	0.4	0.2	**Not meaningful**			
10	6.0	1.6	0.7	0.2			
15	12.8	3.3	1.5	0.5			
20	21.8	5.6	2.6	0.8	0.3		
25	**Not recommended**	8.5	4.0	1.2	0.5		
30		11.9	5.5	1.6	0.7	0.2	
35		15.8	7.4	2.2	0.9	0.3	
40		20.2	9.4	2.8	1.2	0.4	
45			11.7	3.4	1.4	0.5	
50			14.3	4.2	1.8	0.6	0.2
60			20.0	5.8	2.5	0.9	0.2
70				7.8	3.3	1.1	0.3

Table 5.2

Head loss, ft/100 ft of pipe For PVC Pipe Schedule 80

	Pipe Size (inches)						
Flow Rate, gpm	**1**	**1 ¼**	**1 ½**	**2**	**2 ½**	**3**	**4**
5	2.6	0.7	0.3	**Not meaningful**			
10	9.6	2.3	1.0	0.3			
15	20.4	4.9	2.2	0.6			
20	**Not recommended**	8.3	3.8	1.1	0.4		
25		12.6	5.7	1.6	0.7		
30		17.6	8.0	2.3	0.9	0.3	
35		23.4	10.6	3.0	1.3	0.4	
40			13.6	3.8	1.6	0.5	
45			16.9	4.8	2.0	0.7	
50			20.5	5.8	2.4	0.8	0.2
60				8.1	3.4	1.1	0.3
70				10.8	4.5	1.5	0.4

Worksheet 5-1 (included with Group A-TNC Workbook) Total Dynamic Head Calculation

Friction Head Calculation								Static Head Calculation, Assume top of well casing elevation is 0 ft.				
Pipe Segment	From	To	Pump or Flow Rate, gpm	Pipe Size, inches	Friction Loss per 100 ft	Pipeline Length, ft	Pipe Segment Friction Loss, ft	Top of well casing to water while pumping, ft	Ground Elev. at "to"	Elevation difference, ft	Min. Pressure Head, ft	Min. Total Dynamic Head, ft
1	Well pump	Top of well casing									69	
2	Top of well casing										69	
3											69	
4											69	
5											69	
6											69	
7											69	
8											69	
9											69	

With a simple system consisting of only a well pump and bladder tanks, the well pump is the only pump in the system. Without a storage tank, the well pump **must** generate enough flow and pressure to supply at least the PHD, and to provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system.

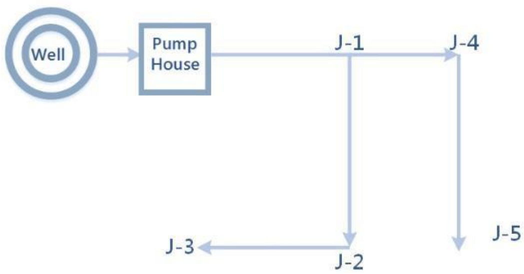
For the segment that includes the well house, **add 10 feet of friction loss** to account for losses related to fittings and valves. If you intend to use a cycle control valve, **add additional friction loss** per manufacturer's data (Section 5.0.6)

Total up the "pipe segment friction loss" for each pipe segment + "elevation difference" + "minimum pressure head" values. The highest Total Dynamic Head (TDH) is the minimum pressure, expressed in "feet of head" that the well pump must generate while pumping the peak hourly demand. You may wish to select a pump with a TDH greater than the required minimum.

Example 5-1 Total Dynamic Head

Friction Head Calculation								Static Head Calculation, Assume top of well casing elevation is 0 ft.			Min. Pressure Head, ft	Min. Total Dynamic Head, ft
Pipe Segment	From	To	Pump or Flow Rate, gpm	Pipe Size, inches	Friction Loss per 100 ft	Pipeline Length, ft	Pipe Segment Friction Loss, ft	Top of well casing to water while pumping, ft	Ground Elev. at "to"	Elevation difference, ft		
1	Well pump	Top of well casing	50	2	5.8	160	9.3	119.3	0	119.3	69	197.6
2	Top of well casing	Exit pump house	50	2	5.8	75	4.3 +10 = 14.3	119.3	0	119.3	69	211.9
3	Exit pump house	Junction #1	50	3	0.8	400	3.2	119.3	20	139.3	69	235.1
4	Junction #1	Junction #2	29	2	2.3	300	6.9	119.3	30	149.3	69	252.0
5	Junction #2	Junction #3	24	2	1.6	250	4.1	119.3	50	169.3	69	276.
6	Junction #1	Junction #4	37	2	3.0	500	15	119.3	30	149.3	69	260.1
7	Junction #4	Junction #5	29	2	2.3	500	11.5	119.3	10	129.3	69	251.6

Objective: Determine minimum TDH required at the end of each pipe segment. Choose the highest TDH value. Conclusion: The well pump must be capable of producing at least 276 feet of TDH at 50 gpm. See below.



Pump lift from water level in the well to the top of the well casing = 119.3 ft

Elevation change (increase) from top of well casing to Junction #3 = 50 ft

Total Static Head (SH) from well pump to Junction #3 = 169.3 ft

Total Friction Head (FH) between well pump and Junction #3

= 9.3 + 14.3 + 3.2 + 6.9 + 4.1 = 37.8 ft

Total (minimum) Pressure Head (PH) required at Junction #3 = 69 ft (provides 30 psi at the customer)

Eq. 5-1: TDH = SH + FH + PH

TDH **=** 169.3 + 37.8 + 69 = 276.1 ft (equal to 119 psi at the pump itself) at 50 gpm

5.0.3 Well Pump Selection and Controls with Pressure Tanks

With bladder tanks and no storage tank, a pressure switch located in the pump house, near the bladder tank(s), will control the well pump. The "pump-on" pressure **must** be set so that the pressure is at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system, just before the well pump comes on to recharge the pressure tanks [WAC 246-290-230(5)].

Continuing with our Example 5-1, to maintain 30 psi at Junction #3 with the well pump off, the pressure in the well house must be 276.1 ft – 119.3 ft – 9.3 ft – 14.3 ft = 133.2 ft = **57 psi**. In our example, this is the pressure at which the well pump must come on ("pump-on" setting) to maintain a minimum of 30 psi everywhere in the distribution system.

The pump-off setting should be about 20 psi greater than the pump-on setting. In this example, **80 psi** as the pump-off setting would work fine. In our example, this corresponds to a "pump head" of:

> 80 psi x 2.31 = 185 feet (pressure head inside the pump house) + 119.3 (vertical distance from top of well casing to water level in the well) + 9.3 + 14.3 = 327.9 feet TDH (use 330 ft).

In this example, the pressure in the distribution system will not exceed 80 psi or fall below 30 psi between the "pump on" and "pump off."

5.0.4 Well Pump Selection and Control with a Storage Tank

The principles above also apply to determining the TDH of the well pump when pumping to a storage tank. Here are the major differences:

- When applying **equation 5-1**, the Pressure Head (PH) is zero because the storage tank is open to the atmosphere (unpressurized storage);

- The Static Head (SH) must include the difference in elevation between the water level in the well and the water level in the reservoir.

You may need to include a reservoir in your Group A-TNC water system design for many reasons. For example:

- The well and well pump cannot produce enough water to satisfy the PHD. Water stored in a reservoir can provide the supplemental supply needed to serve the distribution system.
- The owner of the water system seeks the higher level of service reliability that a reservoir offers.
- The water system must be capable of providing fire protection.

A reservoir design may supply water to the distribution system directly or by gravity. Gravity uses the elevation difference between the water in the reservoir and customers. This difference in elevation **must** provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system [WAC 246-290-230(5)]. Alternately, you may design a reservoir without sufficient difference in elevation between water in the reservoir and customers if the water is re-pumped from the reservoir into the distribution system so that the 30-psi standard is met.

The well may pump to a reservoir directly through a dedicated water main from well to reservoir or indirectly through the distribution system (where the pipe between the well pump and reservoir also serves customers). In either case, the level of the reservoir must control the well-pump function. The operating range between the "well pump off" and "well pump on" defines the "operating storage" volume in your reservoir (Section 7.0). Float switches in the reservoir usually control these two levels by sending a signal to the well-pump controller through direct wire or wireless (radio frequency) communication.

The basis of the well pump control system design is the reservoir volume between "pump on" and "pump off," and the well pump discharge. The reservoir design should provide the volume required to prevent excessive cycling (starting and stopping) of the pump motor. Unless the well-pump motor manufacturer specifically allows starts more frequently, the pump should not be called to fill the reservoir more than six times in an hour.

To simplify the well pump control system design, set the well "pump on" and "pump off" levels in the reservoir so that the volumetric difference between these two levels is equal to ten times the discharge rate of the well pump. For example:

Suppose the water system design presented in Example 5-1 has a 3,500-gallon polyethylene tank eight feet in diameter and ten feet tall. The well pump produces 50 gpm, and pumps directly to the reservoir. No pressure tanks are connected to the well pump discharge. The reservoir is right outside the well house, and the base of the tank is at the same elevation as the wellhead.

The TDH the well pump must pump against is equal to (see Example 5-1):

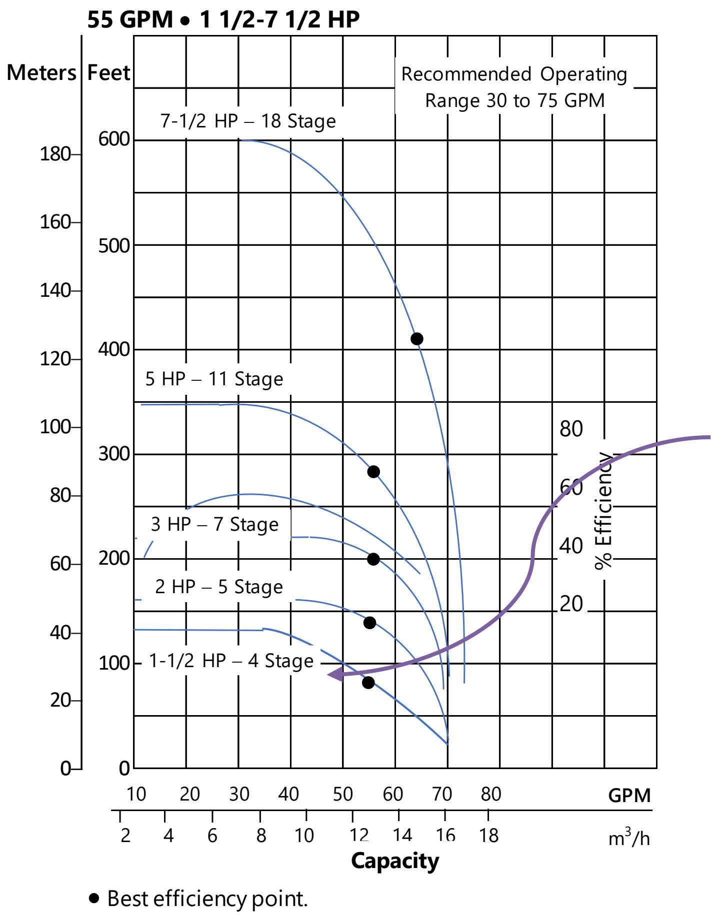
- The pipe segment friction loss for pipe segments 1 and 2 (9.3 ft + 14.3 ft = 23.6 ft).

- From the top of well casing down to the stabilized water level in the well while the pump is on (119.3 ft).
- From the top of the well casing to top of the 3,500-gallon tank (10 ft).
- TDH the well pump must overcome to produce 50 gpm is 23.6 + 119.3 + 10 = 152.9 ft.

The water in the reservoir will have to be re-pumped into the distribution system to provide at least 30 psi throughout the distribution system during peak hour demand (see Chapter 8 for booster pump design).

5.0.5 Well Pump Selection

In this section, we will use the example water system introduced in Example 5-1 above.



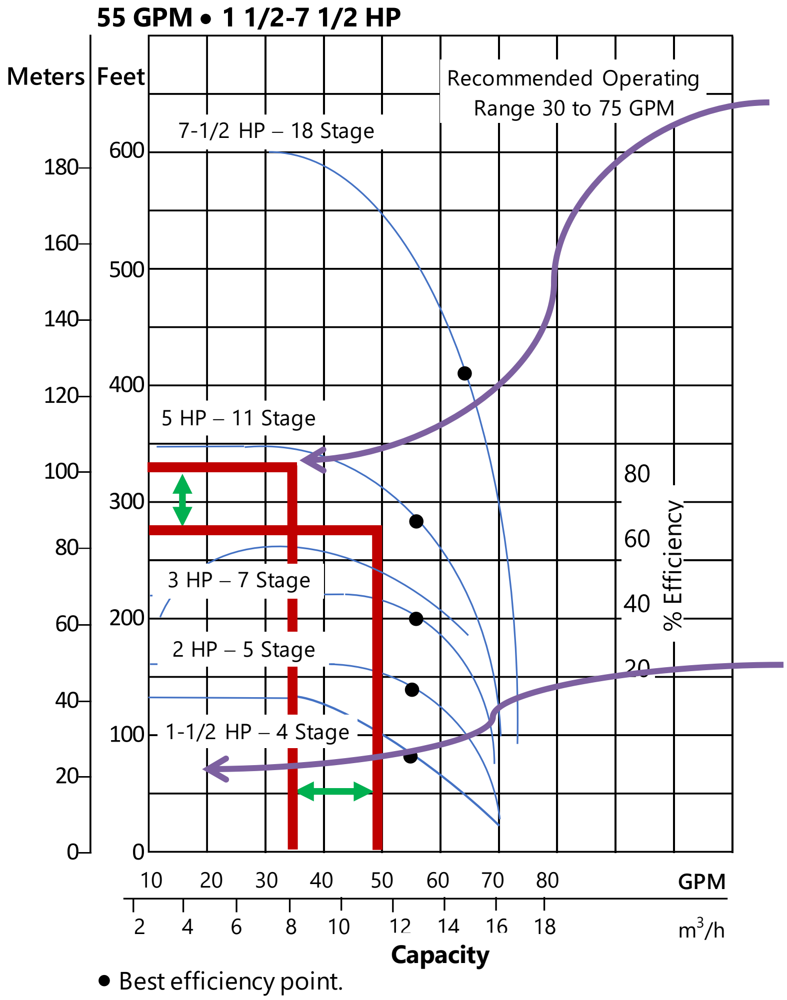
The figure at left is a family of pump curves, beginning with a 7½ hp pump (top) down to a 1½ hp pump (bottom).

A pump curve expresses the relationship between discharge pressure ("total head" or TDH) shown on the vertical axis, and discharge pumping capacity (gpm) shown on the horizontal axis.

For example, look at the 1½ hp pump curve. It shows this particular pump is capable of producing 50 gpm at 100 ft TDH.

The rising and falling curve in the middle of graph is the pump efficiency curve. As you can see, this family of pumps is most efficient between 35-60 gpm.

In our example, we are looking for a pump that can produce 50 gpm while generating at least 276 ft TDH. In the set of pump curves below, the 5 hp pump can produce 50 gpm at about 275–280 ft TDH (see C below). This same pump will produce about 35 gpm at 330 ft TDH (see A below). The operating pumping range for the 5 hp pump will be between 35 gpm (the "pump off" setting) and 50 gpm (the "pump on" setting—see B and D).



A. This 5 hp pump will generate 50 gpm at 276 ft TDH. This is the minimum TDH required in the example above and represents the "pump-on" set point for the pressure switch in the pump house.

B. In our example, the well pump will operate between 35 gpm (when the pump shuts off) and 50 gpm (the moment the pump is turned on).

C. This 5 hp pump will generate about 35 gpm at 330 ft TDH. This is the "pump off" set point for the pressure switch in the pump house in the example above.

D. In our example, the pressure switch is set so that the operating range of the 5 hp well pump is between 276 ft TDH and 330 ft TDH. This operating range for the well pump should provide a minimum of 30 psi at Junction #3. (See Section 5.1.

5.2 Pressure Tanks

Water systems use pressure tanks with well pumps and when re-pumping water, such as from a reservoir into a distribution system. Pressure tanks make it possible to deliver water within a selected pressure range without continuously operating pumps or having the pumps start every time there is a minor demand for water.

Two types of pressure tanks are used to protect water system pumps. Each has its own basic design procedures. ***Conventional tanks,*** also called hydropneumatic tanks**,** allow air-water contact. ***Bladder tanks*** have a membrane separating the air from the water.

5.2.1 Hydropneumatic Tanks

Design engineers use hydropneumatic tanks in well pump installations that are usually larger than necessary for Group A-TNC water systems. If you intend to design a hydropneumatic tank system, please see Chapter 9 of our *Water System Design* Manual 331-123.

5.2.2 Bladder Tanks

Bladder tank sizing depends on the number of "selected-size" tanks needed to provide pump protection. Bladder tanks have pre-charged air bladders with a pressure of two psi below the low operating (pump-on) pressure for the system. Engineers should call out this stipulation in the design specifications.

For more information, see the DOH Tech Tip *Troubleshooting Bladder Pressure Tanks* 331-342.

5.2.2.1 Bladder Tank Sizing Equation

Equation 5-2: $T_s \geq \dfrac{(R)(Q_p)}{(N_c)(V_B)}$

Where:

$$R = \frac{15(P_1 + 14.7)(P_2 + 14.7)}{(P_1 - P_2)(P_2 + 9.7)}$$ (or refer to Table 5.3)

V_B = The gross volume of an individual bladder tank in gallons, or bladder tank size ("86-gallon tank," for example).

T_s = The number of bladder tanks of gross volume V_B

P_1, P_2 = Pressures selected for water system operation in psig (gauge pressures). P_1 corresponds to the pump-off pressure and P_2 to the pump-on pressure

Nc = Number of pump operating cycles per hour. This should be the maximum number of pump motor starts per hour as justified and documented by the pump or motor manufacturers' warranty. Without such information, this should be no more than six cycles per hour.

Q_p = Pump delivery capacity in gallons per minute at a midpoint of the selected pressure range. Determine this by examining pump curves or tables. If this value is not used, the designer **must** use the Q_p that occurs at P_2 (pump-on).

5.2.2.2 Bladder Tank Design Procedure

1. Based on water system hydraulic requirements, select the operating range of pressure, P_1 (pump-off) and P_2 (pump-on). P_2 pressure **must** satisfy minimum system pressure requirements [WAC 246-290-230(5)].
2. Select the operating cycles per hour, N_c. The value for N_c should not exceed six cycles per hour unless documented manufacturers' warranties justify larger values. For multiple pump installations, N_c may be increased if an automatic pump switchover system is installed to automatically alternate pumps. The actual increase in N_c should be justified by documented manufacturers' warranties.
3. Determine the delivery capacity, Q_p, for the midpoint of the operating pressure range [$(P_1 + P_2)/2$]. The pump capacity **must** meet system requirements at P_2 pressure [see WAC 246-290-230(5)].
4. Select an appropriate gross volume, V_B, for each bladder tank (bladder tank size). This volume should be available from bladder tank manufacturers. Do not select bladder tank sizes larger than 120 gallons gross volume.
5. Calculate the value of **R**. For convenience, Table 5.3 gives **R**-values for several commonly used pressure ranges.
6. Use Equation 5-2 (see above).
7. Round up the value determined in Step 6 to the nearest whole number. This is the number of tanks, each with the selected volume, V_B, to be used for pump protection.

Table 5.3

R Values for Various Pressure Tank Ranges

	P_1 pump-off pressure (gauge)				
P_2 pump-on pressure (gauge)	**55 psi**	**60 psi**	**65 psi**	**70 psi**	**80 psi**
35 psi	58.1	49.8	44.3		
40 psi	76.7	61.7	52.6	46.6	
45 psi		81.5	65.2	55.5	
50 psi			86.4	68.8	51.3
60 psi					76.1

Example 5-2

For a mid-pressure range pumping rate, Q_p, of 40 gpm, a selected cycling of six cycles per hour, a bladder tank gross volume of 86 gallons, and a selected pressure range of 60/80, the number of 86-gallon tanks required is determined as follows:

$Q_p = 40$; $N = 6$; $V_B = 86$

Using Table 5.3 for $P_2/P_1 = 60/80$, $R = 76.1$ Using Equation 5-2:

$$T_s > \frac{(R)(Q_p)}{(N_c)(V_B)}$$

$$T_s > \frac{(76.1)(40)}{(6)(86)} = 5.9$$

Select six 86-gallon bladder tanks for pump protection, pre-charged to 58 psi (two psi below pump-on pressure).

5.2.3 Reduced Pressure Tank Sizing

Designs using Variable Frequency Drive (VFD) pumping systems or pump cycle control valves (CCV) reduces the pressurized storage needed to protect pumps from over-cycling while maintaining adequate pressure in the distribution system. The criteria used to size pressure tanks serving a closed pumping system employing a VFD or CCV differs from the approach described above.

CCVs and VFDs deliver water within controlled pressure ranges at flow rates much less than that required under a standard design approach (see Sections 5.1.2.1 through 5.1.2.2). Therefore, water systems using them can have smaller and fewer pressure tanks than those using a single-speed pump delivering the same maximum flow, controlled by an on-off pressure switch.

Cycle Control Valves. CCVs may be used to control the pressure in a distribution system. A CCV is intended to extend run time with minimal pressurized storage. It will maintain constant downstream pressure (the valve's set point) until demand downstream of the valve falls below the valve's prescribed low-flow level. At that point, the pressure will rise to the pressure switch pump-off set point. A mechanism in the valve prevents it the valve from restricting flow past its preset minimum.

Depending on the model used, the control valve will **stop** pump operation at a pre-set threshold flow of as little as 1 gpm or 2 gpm. At flows higher than this threshold, the valve will open or close in response to water system demands while the pump operates continuously. Design engineers who choose to use a CCV should include the head loss through the valve when determining the friction loss within the pump house and ensure that the valve is listed under NSF 61.

As described more fully in Appendix F, the CCV is designed to keep the pump operating nearly continuously. For most water systems, water demand will be very low during nighttime hours, resulting in prolonged pump operation at the upper end of its pump curve. This may cause early failure of the pump if the manufacturer did not design the pump and motor for prolonged operation at that point on the pump curve. We recommend design engineers consult directly with the pump vendor or manufacturer to make sure the pump and motor are compatible with the intended operating conditions.

Variable Frequency Drives. As described more fully in Appendix G, a VFD is an electronic controller that adjusts the pump motor speed by modulating frequency and voltage. VFDs match motor speed and therefore pump output to specific water demand through a pressure control feedback loop to the variable frequency controller.

5.2.4 Labor and Industries Standards for Pressure Tanks

RCW 70.79.080 (5) requires pressure vessels, including bladder tanks greater than 37.5 gallons in gross volume, to be constructed according to ASME standards [RCW 70.79.080 (5)]. The ASME standard is intended to promote a safe environment and protect against property damage, injury, and death caused by an abrupt tank failure.

5.2.5 General Agreement

In 2011, Washington State Department of Labor and Industries (L&I) added an exemption for non-ASME bladder tanks used in public water systems to a list of proposed changes to RCW 70.79.080. When legislation conflicts with practices that meet the intent of the rule (in this case, safe operation of bladder tanks used in public water systems), L&I can enter into a general agreement with another agency until the legislation is changed. Design engineers are responsible for addressing all applicable L&I requirements at the time of pressure tank design. Refer to current L&I rules and legislation.

A General Agreement between L&I and ODW requires that design of non-ASME bladder tank systems conform to the standards shown in the ODW Tech Tip *Pressure Relief Valves on Pressure Tanks* 331-429. The General Agreement does not apply to hydropneumatic tanks. All hydropneumatic tanks **must** be constructed according to the latest ASME specification code (RCW 70.79.080), regardless of size.

All pressure tanks greater than 37.5 gallons gross volume **must** have a properly sized and installed ASME Section VIII pressure relief valve (PRV) (WAC 296-104-316). Pressure tanks smaller than 37.5 gallons gross volume **must** have a properly sized and installed pressure relief device manufactured according to a recognized national standard, the specifications and certification of which must be provided. We strongly recommend using an ASME Section VIII PRV for pressure tanks smaller than 37.5 gallons gross volume. PRVs protect a pressure vessel from over-pressurization due to a failure in the pump control system, intense or over-heating of the water (during a fire), and pressure surge.

No valves may be between the PRV and the pressure tank. For other design requirements and guidance, see *Pressure Relief Valves on Pressure Tanks* 331-429.

The maximum allowable working pressure for a tank is on the nameplate attached to the tank. For nonstandard pressure vessels, engineers can determine the maximum allowable working pressure with the L&I formula in WAC 296-104-405. A properly sized ASME PRV should have a relieving capacity sufficient to prevent pressure in the vessel from rising more than 10 percent or 3 psi above the maximum design set pressure of the PRV, whichever is greater.

5.2.6 Locating Pressure Tanks

Locate pressure tanks above normal ground surface and house them completely. Buried pressure tanks are subject to floatation by high groundwater and allow external corrosion to go undetected. L&I standards require at least 18 inches of clearance around the tanks for proper inspection, maintenance, and repair access (WAC 296-104-260). In some cases, it may not be practical to provide this much clearance all the way around a pressure tank. Therefore, L&I developed a Boiler/Pressure Vessel Clearance Variance Request (F620-041-000).

5.3 Pump House Design and Construction Recommendations

The pump house design and construction should allow convenient, safe access for removal and service of equipment and include the following:

- Install a wall-mounted thermostat-controlled wall heater.
- Use PVC Schedule 80, galvanized iron, or copper piping for all internal piping.
- Support all internal piping properly.
- Install unions and isolation valves at pressure tanks, booster pumps, and other equipment to allow for equipment removal.
- Secure any booster pump to the floor.
- Install ASME pressure relief valve(s) properly sized based on flow.
- Install a totalizing source meter inside the pump house.

- Install all pressure tanks on the floor.
- Install the raw water tap at least 6-inches above the floor.
- Position pressure gauges so they are easily readable.
- Install an emergency generator transfer switch.
- Install security measures such as door locks.

5.4 Well and Pump House Detailed Drawings and Specifications

The design submittal **must** include drawings of each project component, including location, orientation, and size [WAC 246-290-120(4)]. The drawing(s) and specifications of the well pump, pressure tank(s), and pump house appurtenances should include:

a. Pump-house building specifications.
b. A plan view with a scale of not more than ten feet to the inch. It must show the location of the well and proposed pump house, water mains, fittings, valves, construction and maintenance easements, sanitary control area, existing above ground and underground utilities (gas, electric, power, sewer, irrigation, and so forth), and other natural or man-made features important to the proper construction of the pump house.
c. Location, size, capacity, and construction materials of all pipes, pumps, valves, sample tap, water meter, pressure gauges, pressure switch, pressure tanks, pressure relief valves, and other key components inside the pump house.
d. Manufacturer's catalog information on the specific well pump showing operating pump-on and pump-off limits.
e. Manufacturer's catalog information on the specific bladder tanks and pressure switch.
f. Settings for the pressure switch, pressure relief valves, CCV (if any).
g. Elevation of the top of the well casing above the ground or pump house floor, and whether the wellhead is located in the 100-year flood plain.
h. Disinfection procedures for well-after-pump installation.

i. Disinfection and pressure testing procedures for all well and pump house piping and tanks.
j. Physical protection of the wellhead (if located outside the pump house).
k. Specification for well casing cap, well pitless adaptor, or pitless unit.
l. Typical details of thrust blocking or restraints for internal and below-building piping.
m. All other buried utilities, including storm and sanitary sewers, dry wells, telephone, natural gas, power, and TV cable lines in the project area (existing or proposed concurrent with pipeline construction) to the extent possible, given existing available records. Construction details should note that all buried utilities are to be field located prior to construction.

You **must** show the following accessories on the drawings:

- Source water meter [WAC 246-290-130(4)(g)].
- Source sample tap [WAC 246-290-300(1)(d)].
- Each pressure tank equipped with an isolation valve and an ASME pressure relief valve (WAC 296-104-316).
- A lock on the pump house door [WAC 246-290-415(9)].

References

WSDOH, 2019. *Water System Design Manual* 331-123, Washington State Department of Health, Olympia, Washington.

CHAPTER 6 Piping Design and Construction

Chapter 6 explains how to design and construct the distribution system so that it can deliver a safe and reliable water supply from the well to the system's customers. This guidance, combined with the information on friction loss and distribution system design from Chapter 5, assumes your proposed water system will not provide fire suppression (fire flow). If fire flow is included, see our *Water System Design Manual* 331-123.

6.0 Piping Material

When designing a water main, it is important to consider the type of pipe and the pressure needs of the system. Excessive system pressure can increase the risk of pipe failure and cause customers to wastewater. Distribution system pressure should not exceed 100 psi. All distribution piping should be rated to withstand the maximum pressure they may experience during operations and pressure testing.

PVC pipe is the most common pipe material used in small water systems. Other pipe material includes ductile iron, steel, High-Density Polyethylene (HDPE), and cross-linked polyethylene, abbreviated PEX or XLPE. The use of asbestos-cement, cast iron, or galvanized iron pipe in distribution system design is not recommended. In addition, the use of irrigation pipe, drainpipe, or other thin-walled pipe material is strictly prohibited for potable water systems. The designer or design engineer **must** use established standards, such as AWWA or ASTM, when justifying the material and class of pipe and pipefittings selected (WAC 246-290-200).

PVC pipe "schedule" refers to a specific ratio of the outside diameter of the pipe and the pipe wall thickness, known as the Dimensional Ratio (DR). PVC pipe "class" reflects the working pressure rating of the pipe. For example, PVC Schedule 80 pipe (DR 11) has a greater pressure rating than PVC Schedule 40 pipe (DR 16) because of a thicker pipe wall. Because both pipe schedules have the same Outside Diameter ("OD"), the Schedule 80 pipe (with the thicker pipe wall) has a smaller Inside Diameter ("ID"). The head loss difference between Tables 5.1 and 5.2 reflect the difference in the pipes' inside diameter. You should use flow rate, pressure, and allowable head loss as the basis for selecting a pipeline size and schedule.

We recommend using a minimum 1½-inch diameter and maximum DR 21 pipe in all distribution main designs. The recommended minimum size provides for conveyance without undue friction loss. Larger pipe sizes may be needed. The recommended maximum DR (measure of wall thickness) provides an allowance for hydrostatic testing pressure (Section 6.4), less than perfect installation (depth of bury, bedding, joints, expansion, and contraction), unusual pressure conditions (surge pressures, poorly controlled leak testing), and a general design factor of safety. Applying a maximum DR 21 excludes ASTM D2241 PVC Class 160 and AWWA C900 Class 100 pipe.

Any specified and installed pipe and pipe fittings **must** conform to material standards for contact with potable water, ANSI/NSF Standard 61 (WAC 246-290-220).

6.1 Pipe Burial, Bedding, and Thrust Blocks

Pipelines **must** be installed below the frost line and "bedded" with uniform material that does not present a risk to the pipe. PVC pipe is brittle and has little resistance to the forces of a sharp or heavy rock pressing on it or its fittings. Poor bedding material, and failure to compact the bedding material around the pipe, may result in pipeline failure. You should place, spread, and compact bedding at a minimum of six inches beneath, beside, and over the pipe.

Bury pipes below the frost line as determined by the most severe cold weather on record; otherwise, protect pipelines against freezing by some other means such as insulation or heat tracing). When determining proper depth, designers should evaluate temperature variations in the area, especially at high altitudes, in Eastern Washington, and beneath regularly plowed paved surfaces. The minimum fill depth over the top of the pipe should be at least 36 inches, even in temperate areas. The designer may justify another depth (for example, to avoid underground obstructions or rocky conditions). If providing less than 36 inches of cover, you should consider the pipe load rating and the location of the installation (to avoid crushing the pipeline due to traffic loads).

Depending on the pressure and size of the pipe, a change in pipe direction can cause substantial forces at pipefittings such as bends, tees, crosses, and dead-end caps. You should consider installing thrust blocks to protect the new pipeline from these forces. Thrust blocks are typically made of concrete poured in place between the fitting and the solid, undisturbed earth wall of the pipe trench. Restrained joint pipe may be used instead of thrust blocks to prevent pipe separation due to unequal hydraulic forces at pipefittings.

6.2 Isolation Valves, Flushing Hydrants, and Air Release Valves

Isolation valves provide a way to isolate sections of the distribution system. The Group A-TNC water system should have enough valves on water mains to minimize the number of customers without water service and minimize hazards during repairs. We recommend valves on each branch of pipeline "tees" and "crosses."

Pipelines should be flushed from time to time, especially dead-end lines. To flush a pipeline, you must generate sufficient flow velocity and have an appropriate egress point for the flushed water. The minimum effective flush velocity is three feet per second. For example, it takes about 19 gpm to generate 3 fps flow velocity in a 1½-inch pipeline, and it takes about 31 gpm to generate the same flushing velocity in a 2-inch diameter pipe. A small flushing device installed at the end of dead-end lines will facilitate pipeline flushing. To view options for flushing, conduct an Internet search under "yard hydrants" or "flushing hydrants."

You may not use yard hydrants that drain the riser into the ground. The weep hole presents a risk of contamination to the distribution system through a cross connection with contaminated groundwater. If you choose to use a yard hydrant, the Uniform Plumbing Code requires you to use a model that does not drain into the ground. Yard hydrants that conform to American Society of Sanitary Engineers Standard 1057 are acceptable because they do not drain into the ground.

You should provide a means to release accumulated air at high points on the distribution system. You may use an automatic air release valve, but you must install it in a traffic-rated concrete vault with a daylight drain if the pipe is within a road right of way. This can be very expensive to construct and requires periodic inspection and maintenance. The preferred way to vent air is manually, using a blow-off hydrant or even a service connection at high points. To the extent possible, slope the profile of the installed water main and locate it to create as few high points as possible. If accumulated air is not released, it can restrict or even completely block the flow of water through the pipe.

6.3 Distribution System Pipeline Easements

Distribution system pipelines **must** be installed in the public right-of-way or within private property easements. The water system owner must have access to maintain pipelines and all related components, such as valves, meters, flushing hydrants, and so on. Your design submittal must show all distribution system components either within the public right-of-way or within a private property easement. The easement must be wide enough to accommodate all work, such as excavation, equipment access, and turning radius. We recommend a width of at least 15-feet, with 7.5 feet on each side of the pipeline.

6.4 Pressure and Leakage Test

To check the quality of pipe joints and fittings, it is necessary to conduct a pressure and leakage test. The test **must** follow the testing procedures the designer or design engineer specified in the approved design submittal (WAC 246-290-200). The project engineer or the owner's representative should be present during this critical test to verify that it meets the specifications. Pressure testing standards are in the *Standard Specifications for Road, Bridge and Municipal Construction* (WSDOT/APWA 2012), available free on the WSDOT website. These standards state:

All water mains and appurtenances shall be tested in sections of convenient length under a hydrostatic pressure equal to 150 psi in excess of that under which they will operate, or in no case shall the test pressure be less than 200 psi.

6.5 Disinfection

Purveyors **must** properly disinfect all components of a new or expanding Group A-TNC water system before putting the new or expanded system into service. The disinfection process **must** meet the specifications approved for the water system, such as AWWA C651 or WSDOT/APWA (2012) for all sizes of water mains; AWWA C652 for water storage facilities; and AWWA C654 for well disinfection [WAC 246-290-451(1)].

6.6 Microbiological Testing

Each of the disinfection standards listed in Section 6.5 includes a requirement for coliform bacteria testing. Water systems **must** follow the standards for coliform testing done as part of disinfecting all the components of a new or expanding Group A-TNC system [WAC 246-290-451(1)(a)]. The engineer **must** attest to satisfying these coliform testing requirements and satisfactory coliform test results when completing the *Construction Completion Report* 331-121 form [WAC 246-290-120(5)]. To ensure the samples properly represent water quality in the water system, purveyors should take water samples after sufficiently flushing the new lines and equipment.

6.7 Separation from Nonpotable Piping Systems

The water system design should provide at least a 10-foot horizontal and 18-inch vertical separation above nonpotable pipelines, such as sanitary sewers, reclaimed water piping, irrigation lines, and the like. The 18-inch vertical separation should be the measured distance between the closest sides of the two pipes. For additional guidance on potable and nonpotable pipe separation, consult *Pipeline Separation Design and Installation Reference Guide* (WSDOE and DOH 2006).

6.8 Service Connections

6.8.1 Service meters and service lines

We recommend that you install the water service line at the same depth and with the same bedding as the water main. The water service line should be least 1-inch in diameter and be made of PVC, copper, HDPE, or PEX. Using a 1-inch service line instead of a ¾-inch service line decreases friction loss due to flow from the water main to the building by a factor of three. For many homeowners and businesses, installing a 1-inch service line is worthwhile because it noticeably improves the level of service.

Residential fire sprinkler systems demand higher flow and pressure. Therefore, a residence with fire sprinklers may require a larger diameter water service line. Consult your local building code for guidance.

You should install a separate curb or meter “stop” (valve) for each service connection. These valves allow system managers or the property owner to shut off an individual connection without interrupting service to other customers. A curb stop is a valve installed at the property line if there is no meter at the property line. You can operate a curb stop from the surface. A meter stop is a valve installed just upstream or downstream of the meter.

Service meters are not required for non-municipal systems [WAC 246-290-496(2)], but we recommend every design engineer include them because they enable the system manager to proportion the cost of service fairly and reduce the incidence of over-use at the expense of other consumers.

6.8.2 Cross-connection control

A cross-connection is any actual or potential physical connection between a public water system or a consumer's water system and any source of nonpotable liquid, solid, or gas that could contaminate the potable water supply by backflow. Because all water system users share a common distribution system, contamination from one connection has the potential to move about the distribution system and contaminate the water supply to other connections.

On certain premises, the contamination hazard associated with the plumbing and water use may require a cross-connection control assembly. This special valve assembly prevents water from flowing back into the distribution system. For guidance, see our document *Cross Connection Control for Small Water Systems* 331-234.

Many commercial properties involve water uses that pose a threat of a cross-connection. You should retain the services of a State-licensed Cross-Connection Control Specialist to determine what, if any, cross-connection control assembly is needed on a commercial customer's service line. To find someone who can help you with this, check our public list of available Cross-Connection Control Specialists.

Most single-family homes do not pose a high health cross-connection hazard to the Group A-TNC water system users. There is a potential for problems if single-family homes have access to a separate water supply. Your development's Covenants, Conditions, and Restrictions (CC & R) should require proper cross-connection control assemblies on service connections if your service area is supplied by a separate irrigation system, or individual homeowners are entitled to drill their own wells.

You must test all cross-connection control assemblies installed on service lines annually to ensure they continue to function properly. You should include the authority to require such testing in the development's CC & R, if applicable.

6.9 Individual Pressure Reducing Valves

If you anticipate that pressure at any service connection will exceed 80 psi, you are responsible for recommending that those customers install and maintain individual Pressure Reducing Valves (PRV) as delineated in the Uniform Plumbing Code (UPC). Water systems should install individual customer PRV only if they have a written agreement with the customer showing who is responsible for required PRV maintenance, repair, or replacement. The water system should check for local ordinances or service agreements on PRV use.

6.10 Distribution System Detail Drawings and Specifications

The workbook **must** include drawings of each project component, including location, orientation, and size [WAC 246-290-120 (4)(a)]. The drawing(s) and specifications of the distribution system should include the following:

a. A plan view with a scale of not more than 100 feet to the inch showing the location of the proposed water mains, fitting, valves, service meters, flushing hydrants, construction or maintenance easements, existing above-ground and underground utilities (gas, electric, power, sewer, irrigation), and other natural or man-made features important to the proper construction of the water main.
b. Location, size, capacity, and construction materials of all proposed pipelines in the project area. Show all flushing hydrants, valves, meters, air release valves, blow-off valves, and so on.
c. Identification of lots served under the project scope of work by new distribution mains serving plats or subdivisions.
d. Typical construction details of all new pipeline tie-ins to existing pipelines.
e. Typical details of pipeline trench cross-section indicating bedding, backfill, and compaction requirements.
f. Typical details of thrust blocking or other type of pipe restraint.
g. Disinfection and pressure-testing procedures for all new pipelines.
h. Service connection details, where appropriate.

i. All other buried utilities, including storm and sanitary sewers, dry wells, telephone, natural gas, power and TV cable lines in the project area (existing or proposed concurrent with pipeline construction) to the extent possible, given existing available records. Construction documents **must** clearly state that all buried utilities are to be field located prior to construction (RCW 19.122).

References

WSDOH, 2019. *Water System Design Manual* (331-123), Washington State Department of Health, Olympia, WA.

WSDOE, 2008. *Criteria for Sewage Work Design*. WSDOE Pub. 98-37. Washington State Department of Ecology, Olympia, WA.

WSDOE and DOH, 2006. *Pipeline Separation Design and Installation Reference Guide*. WSDOE Pub. 06-10-029. Washington State Department of Ecology, Olympia, WA.

CHAPTER 7 Atmospheric Storage Tanks

Chapter 7 covers the design and construction of an atmospheric storage tank (unpressurized storage). Group A-TNC water systems use atmospheric storage tanks to accomplish the following.

- Directly supply the distribution system by providing the minimum pressure requirement of 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system [WAC 246-291-230 (5)]. An example of this is a tank constructed on top of a hill, high above all the customers.
- Indirectly supply the distribution system by collecting water pumped from the well and supplying it to the distribution system via water pumped through a booster pump. An example is a tank constructed right outside the well and booster pump house.

Most Group A-TNC water systems construct atmospheric storage when the well and well pump are not able to supply the PHD, or if they must provide fire flow.

7.0 Operating Storage Volume

Operating storage (OS) is the volume of the reservoir devoted to supplying the water system while, under normal operating conditions, the source of supply (such as a well pump) is in “off” status. Every atmospheric reservoir needs OS.

OS volume will vary according to:

1. The sensitivity of the water level sensors controlling the supply pumps.
2. The geometry of the reservoir between the designated pump-off and pump-on water level set points.

Various water level sensors can be used to signal pump-off and pump-on levels, including float switches, ultrasonic sensors, and pressure switches. Some can detect water level changes as small as a fraction of an inch. Others require more than a foot. Tank designers must account for the type of level sensor they used to determine the vertical dimension needed for proper operation of the device.

The OS volume should be sufficient to avoid pump cycling in excess of the pump motor manufacturer's recommendation. In general, design engineers should limit the supply pump motors to no more than six starts per hour unless the pump motor manufacturer permits more frequent cycling. To limit pump starts to no more than six per hour, minimum OS volume can be conservatively calculated as the pump supply capacity (in gpm) times 2.5 minutes. The accuracy of the level control system may require a greater OS volume than is required for pump motor protection.

7.1 Equalizing Storage Volume and Elevation

7.1.1 Equalizing storage volume

When source pumping capacity cannot meet the peak hourly demand, the water system **must** provide equalizing storage (ES) [WAC 246-291-200(5)] to make up the difference. Generally, the most practical way to provide needed ES is to design atmospheric storage.

Designers are cautioned against attempting to provide ES with bladder tanks. Pressurized bladder tanks provide only a small volume of usable "drawdown" volume within a given pressure range. For example, an 86-gallon bladder tank will release about 18 gallons when the tank is drawn down from 80 psi to 60 psi. The design **must** provide for at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system *when equalizing storage volume is exhausted* [WAC 246- 291-200(4)]. It is considered impractical to provide ES with an array of bladder tanks.

Design engineers should use Equation 7-1 to estimate the ES requirement for the residential portion of the water system.

Equation 7-1

$$ES = (PHD - Q_S) \times T$$, but in no case less than zero

Where

ES	=	Equalizing storage, in gallons
PHD	=	Peak hourly demand, in gpm, as defined in Chapter 3
Q_S	=	The installed well pumping capacity at the "pump-on" pressure setting
T	=	See Table 7.1 below

For extremely small water systems, design standards suggest 30 percent of the MDD should be provided as ES when the source pumping rate (Q_S) matches the MDD pumping rate (assume 24-hour pumping at a constant rate). Any fraction of Q_S that is in excess of the MDD pumping rate will reduce ES from this baseline volume. The minimum "T" values shown in Table 7.1 convert the deficit between PHD and Q_S into ES volume. "T" increases with the number of connections, reflecting the higher probability of a longer period of overlapping demand among an increasing number of residential users.

Table 7.1

Number of Residential Connections	Minimum "T"
2	35
3	47
4	60
5	68
6	76
7	85
8	91
9	98

ES needs will vary greatly for nonresidential water systems, depending on the daily water demand pattern during the highest demand days. If the daily demand pattern can be predicted, use this information to determine an appropriate volume of ES. If not, designers should use Equation 7-2 to estimate ES for a nonresidential water system:

Equation 7-2

$$ES = [0.30 \times MDD] \times [1 - Qs/PHD] \times [1 + (MDD/1440)/PHD]$$

Where		
ES	=	Equalizing storage, in gallons
Q_S	=	The installed well pumping capacity at the "pump on" pressure setting
PHD	=	Peak hourly demand, in gpm, as defined in Chapter 3 of these Guidelines
MDD	=	System-wide maximum daily demand, in gallons per day

7.1.2 Equalizing storage elevation

An atmospheric storage tank supplying a system by gravity **must** provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system [WAC 246-291-230(5)]. To do so, there must be sufficient difference in elevation between the bottom of equalizing storage volume in the tank and the highest point in the distribution system, taking head loss into account.

7.2 Standby Storage Volume

Standby storage (SB) volume provides a measure of reliability in case sources fail or unusual conditions impose higher demands than anticipated. SB is not required and not usually provided in Group A-TNC system design. If you contemplate providing SB volume, we recommend you provide the volume equivalent to the MDD for your entire system.

7.3 Fire Suppression

The local fire protection authority or county fire marshal determines a fire flow requirement for water systems. Fire suppression storage (FSS) level depends on the maximum flow *rate* and *duration*. If your Group A-TNC water system must provide fire suppression capacity, the design **must** enable the water system to meet fire flow requirements while maintaining 20 psi pressure throughout the distribution system under MDD conditions [WAC 246-291-200(8)].

Water systems in areas governed under the *Public Water System Coordination Act of 1977* (Chapter 70.116 RCW) **must** meet the act's specified minimum flow rates and durations for residential, commercial, and industrial developments [WAC 246-290-230(6)]. The local fire protection authority, county fire marshal, or a locally adopted coordinated water system plan may specify greater FSS requirements.

For further guidance, please see Chapter 7 of our *Water System Design Manual* 331-123.

7.3.1 Minimum FSS Volume

The minimum FSS volume for water systems served by single or multiple supply sources is the product of the required flow rate (expressed in gpm) multiplied by the flow duration (expressed in minutes). See Equation 7-3.

Equation 7-3:

$$FSS = (FF)(t_m)$$

Where

FF = Required fire flow rate, expressed in gpm, as specified by fire protection authority or under WAC 246-293-640, whichever is greater

t_m = Duration of FF rate, expressed in minutes, as specified by fire protection authority or under WAC 246-293-640, whichever is greater

7.4 Dead Storage Volume

Dead Storage (DS) is the volume of stored water not available to all consumers at the minimum design pressures required under WAC 246-291-200 (30 psi during PHD conditions and 20 psi during MDD plus needed fire flow throughout the distribution system). Every atmospheric reservoir has some amount of DS due to the geometry of the outlet pipe and the tank bottom. For example, if the top of a reservoir outlet pipe is 12 inches above the reservoir floor, and an allowance of 6 inches is made to ensure the outlet pipe is always submerged, then the bottom 18 inches of the reservoir is "dead storage." The depth of DS is convertible to water volume based on the geometry of the tank (volume in gallons = area (sf) x depth (ft) x 7.48 gallons per cubic foot). The DS volume must be added to the OS and ES volumes determined above.

7.5 Total Storage Volume

The total atmospheric storage tank volume is the sum of OS, ES, SB, FSS, and DS. See Equation 7-4.

Equation 7-4: $TS = OS + ES + SS + FSS + DS$

Where TS = Total Storage volume, in gallons.

7.5.1 Water Quality Concerns with Excessive Storage

Water stored in a reservoir for an extended time will undergo physical, chemical, and biological changes, causing deterioration in water quality. Excessive water age can be caused by under- utilization (water is not cycled through the tank), and poor mixing within the reservoir. Such changes include temperature increases, microbial growth, and changes in color, taste, and odor.

Numerous factors contribute to these changes. For example, temperature, system hydraulics, mixing, and nutrient availability all affect the microbial growth rate. Aged, stale water provides an environment conducive to the growth and formation of taste and odor-causing microorganisms and substances. (USEPA, *Finished Water Storage Facilities*, 2002).

Standards for the states of Georgia, Virginia, and Ohio call for a minimal daily "turnover" rate of 20 to 33 percent. Turnover refers to the portion of stored water exchanged with new water.

To avoid deterioration of water quality in the reservoir, we recommend operating the tank so that one-fifth to one-third of the tank volume is exchanged with new water each day. To prevent poor mixing, we recommend designing the inlet and outlet tank piping to maximize mixing of the water stored in the reservoir.

7.6 Reservoir Design Requirements and Considerations

The design submittal **must** include drawings of each project component, including location, orientation, and size [WAC 246-290-120 (4)(a)]. Several companies manufacture prefabricated concrete, plastic (polyethylene, polypropylene), and fiberglass potable water storage tanks that meet National Sanitation Foundation Standard 61. If you choose to use a prefabricated tank, make sure the manufacturer's drawing(s) and specifications demonstrate compliance with the requirements below.

7.6.1 Reservoir Design Requirements

The following are **mandatory** elements of reservoir design:

1. If the reservoir is large, confirm the geotechnical suitability of the site (WAC 246-290-110).
2. Designed and installed overflow pipe with atmospheric discharge or other suitable means to prevent cross connection contamination. Overflows **must** be covered with a 24-mesh non-corrodible screen or mechanical device, such as a flap valve or duckbill valve, to keep animals, insects, or other contamination sources out of the reservoir [WAC 246-290-235(1)(a)].
3. Tank materials in contact with potable water **must** meet ANSI/NSF Standard 61 (WAC 246- 290-220).
4. Locate and show other buried utilities, including storm and sanitary sewers, dry wells, telephone, natural gas, and power and TV cable lines in the project area (existing or proposed concurrent with pipeline construction) to the extent possible, given existing available records. Construction documents **must** clearly state that all buried utilities are to be field located prior to construction (RCW 19.122).
5. Designed and installed drain facilities that drain to daylight (WAC 246-290-235).
6. Tank roof atmospheric vent, with a non-corroding 24-mesh insect screen [WAC 246-290-235(1)(a)]. See the ODW Tech Tip Sanitary Protection of Reservoirs—Vents 331-250.
7. Locking mechanism on each point of access into the reservoir [WAC 246-290-235(1)(a)]. See the ODW Tech Tip Sanitary Protection of Reservoirs—Hatches 331-249.
8. Weatherproof, insect-proof access hatch and vent [WAC 246-290-235(1)(a)].
9. Leakage testing and disinfection per accepted standards, such as AWWA C652 [WAC 246-290-451(1)].

10. Reservoir isolation valve(s), which permit isolating the tank from the water system [WAC 246-290-235(1)(a)].
11. Smooth-nosed sample tap on the tank side of the isolation valve [WAC 246-290-235(1)(a) and -(c)].
12. Design calculations identifying the elevation at the bottom of the equalizing storage volume necessary to provide at least 30 psi during PHD conditions along property lines adjacent to distribution mains and at the point of service to each customer connected to the distribution system, if gravity storage provides equalizing storage.
13. Design calculations identifying the elevation at the bottom of the fire-suppression storage volume necessary to provide 20 psi throughout the distribution system under needed fire flow plus MDD conditions, if gravity storage provides fire suppression storage.

7.6.2 Reservoir Design Considerations

We **recommend** the storage tank design include:

1. High- and low-level alarm system that directly notifies operations personnel.
2. Access ways and ladders necessary to provide access for safe maintenance.
3. A silt-stop on the outlet pipe to keep sediment from entering the distribution system.
4. The slope of the reservoir roof should be at least 2 percent (¼-inch per foot).

7.6.3 Reservoir Plan Submittal

The drawings and specifications for a reservoir should be prepared as follows.

1. A plan view and a profile (elevation) view with a scale of not more than ten feet to one inch showing the location and dimensions of the proposed tank, water mains, drain, overflow, and valves.
2. Indicate the elevation of the tank bottom and tank overflow level.
3. Identify easements and property lines.
4. Describe the tank level control system.
5. Provide manufacturer's information, construction details, and specifications for the reservoir roof hatch and vent.
6. Provide details on the foundation design and requirements to prepare the site for installation of the foundation.
7. Locate existing above ground and underground utilities (gas, electric, power, sewer, irrigation, and so forth), and other natural or man-made features important to the proper construction and operation of the tank.

For further guidance on atmospheric storage tank design, please see Chapter 7 of our *Water System Design Manual* 331-123.

References

WSDOH. 2019. *Water System Design Manual* (331-123), Washington State Department of Health, Olympia, WA.

USEPA. 2002. *Finished Water Storage Facilities,* prepared by AWWA and Economic and Engineering Services, Inc., for U.S. Environmental Protection Agency Office of Ground Water and Drinking Water Standards and Risk Management Division

CHAPTER 8 Booster Pumps

For most Group A-TNC water systems, booster pumps are designed to pressurize water taken from a storage tank to maintain a consistent pressure range in the distribution system. In that regard, the booster pump acts just like the well pump, working to pressurize water taken from a well to maintain a consistent pressure range in the distribution system. The design of a booster pumping system should follow the same, general principles described for well pumps in Chapter 5.

If you intend to design a booster pump station, please see our *Water System Design Manual* 331-123.

8.0 Booster Pump Station Detailed Drawings and Specifications

The design submittal **must** include drawings of each project component, including location, orientation, and size [WAC 246-290-120(4)(a)]. The drawing(s) and specifications of the booster pumps and appurtenances should include:

1. Booster pump station building specifications (only if the building is separate from the pump house addressed in Sections 5.2 and 5.3).
2. A plan view with a scale of not more than 10 feet to one inch showing the location of the booster pump station, water mains, fittings, valves, construction and maintenance easements, existing above ground and underground utilities (gas, electric, telephone, cable TV, power, storm and sanitary sewers, irrigation, dry wells and so on), and other natural or man-made features important to the proper construction of the pump house. Construction documents **must** clearly state that all buried utilities are to be field located prior to construction (RCW 19.122).
3. Location, size, capacity, and construction materials of all pipes, pumps, valves, sample tap, water meter, pressure gauges, pressure switch, pressure tanks, pressure relief valves, and other key components inside the booster pump station.
4. Manufacturer's catalog information on the specific booster pumps, with the operating limits (pump on, pump off) identified.
5. Manufacturer's catalog information on the specific bladder tanks and pressure switch to be installed.
6. Settings for the pressure switch, pressure relief valves, and cycle control valve (if any).
7. Alarm conditions (if any), and alarming system.
8. Disinfection and pressure testing procedures for all piping and tanks.
9. Typical details of thrust blocking or restraints for internal and below-building piping.

References

WSDOH. 2019. *Water System Design Manual*, 331-123, Washington State Department of Health, Olympia, WA.

APPENDICES

A Public Water System Coordination Act

- **A.1** Sample letter to request water service for a Group A-TNC project located inside a Public Water System Coordination Act planning area and a water utility's future service area (Section 2.3)
- **A.2** Sample letter to request water service for a Group A-TNC project located inside a Public Water System Coordination Act planning area and outside any water utility's future service area (Section 2.3)

B Sample letter requesting the services of a Satellite Management Agency (Section 2.4)

C Outline for Water Users' Agreement (Section 2.6)

D Water Facilities Inventory form (Section 2.7)

- **D.1** Water Facilities Inventory form (Section 2.7)
- **D.2** Water Facilities Inventory instructions (Section 2.7)

E Pump Test Procedure (Section 4.1)

- **E.1** Group A-TNC Pump Test Guidance
- **E.2** Step Draw Down/Constant Rate Pump Test Procedure
- **E.3** Extended Step Draw Down Pump Test Procedure
- **E.4** Alternating Pump and Recovery Test

F Cycle Control Valves (Section 5.1.3)

G Variable Frequency Drive (Section 5.1.3)

H Template Declaration of Covenant and Restrictive Covenant Forms (Section 4.3)

Appendix A.1 Sample Letter to Request Water Service

Group A-TNC Project Located in a Public Water System Coordination Act planning area and Inside a Water Utility's Future Service Area

(See Section 2.3)

Date

Dear Local Purveyor,

I am pursuing approval of a project that requires approval of a new public water system, or approval of an existing public water system not yet approved by the state Department of Health.

Under the Public Water System Coordination Act, I am required to request water service from you because my project lies within your utility's future service area. Details concerning my project, including its exact location and its water supply and fire suppression requirements, are attached for your reference.

Please provide me with a written response to my request for water service within 30 days of the date of this letter. In your response, please let me know if your utility can provide water service. If not, I will proceed with the design and/or approval of a Group A-TNC public water system.

If there are requirements that my project connect with your utility in the future, when such a connection is feasible, please provide me with whatever legal agreement you require me to sign before I may operate a new public water system within your future service area.

If you have any questions, please contact me at ________________________ or ________________________.

Thank you in advance for your response to this inquiry.

Sincerely,

Appendix A.2 Sample Letter to Request Water Service

Group A-TNC Project Located in a Public Water System Coordination Act planning area and Outside any Water Utility's Future Service Area

(See Section 2.3)

Date

Dear Local Purveyor,

I am pursuing approval of a project that requires approval of a new public water system, or approval of an existing public water system not yet approved by the state Department of Health.

Under the Public Water System Coordination Act, I am required to request water service from the nearest water supplier when my project is located outside of any purveyor's future service area. Details concerning my project, including its exact location and its water supply and fire suppression requirements, are attached for your reference.

Please provide me with a written response to my request for water service within 30 days of the date of this letter. In your response, please let me know if your utility can provide water service. If not, I will proceed with the design and approval of a Group A-TNC public water system.

If you have any questions, please contact me at ______________________ or _________________________.

Thank you in advance for your response to this inquiry.

Sincerely,

Appendix B Request for Satellite Management Services

(See Section 2.4)

Date

Dear Satellite Manager,

I am pursuing approval of a project that requires approval of a new public water system.

Under the Satellite Management Agency regulations, I am required to obtain the services of an approved Satellite Management Agency (SMA) to own or operate my water system, if one is available. In order to gain approval of my water system without the services of an SMA, I must demonstrate that I have requested SMA services from all approved SMAs in my project area, and each SMA has declined my request for service.

Please provide me with a written response to my request for SMA services within 30 days of the date of this letter. In your response, please let me know if you can provide ownership or operation and management services.

If you are available to provide SMA services to my water system, please provide me with information about the scope and cost of your services. I will consider your information as I explore all my options for compliance with the SMA requirement.

If you are not available to provide SMA services to my water system, please send me a note with your SMA name, signature, and date, and reference to this letter.

If you have any questions, please contact me at ______________________ or ____________________________.

Thank you in advance for your response to this inquiry.

Sincerely,

Appendix C Outline for Water Users' Agreement

(See Section 2.6)

I. Ownership

A. Governing Board

B. Election of Officers

C. Responsibilities

D. Authorities

E. Communication with customers

F. Transferring ownership

II. Decision-Making

A. Quorum

B. Annual meeting

C. Special meeting

D. Meeting announcement

III. Annual Operating Budget

A. Basis for collecting revenue to cover the full cost of service

B. Rate-setting basis

C. Frequency of budgeting process

D. Responsible parties

E. Process for setting and approving an annual budget

F. Financial and accounting controls

IV. Long-Term Capital Budget

A. Provision for special assessment

B. Provision for annual assessment

V. Fees

A. Connection fees

B. Other fees and charges

VI. Recordkeeping

A. Original (approved) design documents

B. Equipment catalog information

C. Water production and water consumption records

D. "As-built" construction documents, including all easements and covenants

E. Water quality sampling results

F. Complaints

VII. Standard design and Construction Details

A. Service connection, service meter, service valves, location, and so on.

B. Pipes

C. Valves

D. Easements

VIII. Reporting to Customers

VIII. Authorized Parties to Perform Maintenance and Repair

X. Prohibited Practices

XI. Heirs, Successors, and Assigns

XII. Enforcement of Agreement on Nonconforming Parties and Properties

XIII. Changing the Water Users' Agreement

Appendix D Group A-TNC Water Facilities Inventory (WFI) Form

INSTRUCTIONS (See WFI Form on Page 82)

Cross out outdated information on the WFI, and then write corrections in any adjacent space available.

	Field Number and Field Name	Instruction
ADDRESSES & PHONE NUMBERS	**6. PRIMARY CONTACT NAME & MAILING ADDRESS**	Enter the name of the person we should contact about the water system's day-to-day operations. Most DOH mailings will be sent to this person. Enter only the mailing address in this part of the box Do **not** combine a PO Box with a street address). Enter the *Physical Delivery Address* for the contact person if it is different than the normal mailing address. (This address will be used to ship sampling containers or other materials that cannot be delivered to a P.O. Box). Example: Name & Mailing Address ANN SMITH ATTN (optional) P O BOX 3030 ANYTOWN WA 98000 Physical Delivery Address, if different from Above ATTN (Optional) 1231 MAIN ST ANYTOWN WA 98000
	7. OWNER NAME & MAILING ADDRESS	Enter the name of the person or organization that is the legal owner of the water system. Follow the directions and example in field 6 (above). I*f the owner is an organization, you must list an individual as the contact for the organization.*
	9. 24 HOUR PRIMARY CONTACT INFORMATION	Enter phone and fax numbers including area code (and extension, if applicable) for the primary contact for the water system. The email address may be for the system or the primary contact.
	10. OWNER CONTACT INFORMATION	Enter the phone and fax numbers including area code (and extension, if applicable) for the owner of the water system.
CHECKBOXES	**11. SATELLITE MANAGEMENT AGENCY (SMA)**	If the system is NOT owned or managed by a Satellite Management Agency (SMA), check "Not Applicable" and go to12. If the system IS owned or managed by a SMA, check the applicable box and enter the name of the SMA. *The SMA number is assigned by DOH.*
	12. WATER SYSTEM CHARACTERISTICS	Mark **ALL** boxes that apply to your system. You may check more than one box for each service. For example, a restaurant may be "Food Service" and "Commercial." * **Agricultural:** Commercial crop irrigation/Farming * **Commercial / Business:** Office & retail complexes, nurseries, golf courses. * **Day Care:** Child or adult care facilities (in home or stand-alone where the clients do not live 24 hrs. per day). * **Food Service/Food Permit:** Restaurant, coffee shop, bakery, tavern, catering facility, deli, grocer, mini mart. * **1,000 or more-person event for 2 or more days per year:** Major event that significantly effects your system, such as a fair, town festival, or major concert. * **Hospital/Clinic**: Medical / Dental office or clinic, Surgery Center, Emergency Care Facility. * **Industrial:** Manufacturing, assembly facility, food processing facility. * **Licensed Residential Facility:** Nursing home, adult boarding home, foster home. * **Lodging:** Hotel, motel, inn, bed and breakfast, resort. * **Recreational / RV Park:** Connections serving parks, beaches, ball fields,

		playground, campgrounds, picnic areas, ski areas, transient recreational vehicle facilities. * **Residential:** Units designed to house one or more family (such as single-family houses, apartments, duplexes, condominiums, mobile home parks, etc.) no matter how many days per year they are occupied. * **School:** K-12 grades, community college, technical training facility, colleges. * **Temporary Farm Worker Housing / Labor Camp:** Facility that provides temporary facilities for workers and their families. May or may not meet the criteria for DOH Temporary Worker Housing licensing. * **Other:** If choosing "other," please write a brief description in the blank provided (fire station, fraternal organization, grange).
	13. WATER SYSTEM OWNERSHIP	*Mark only one* type of organization that best describes the owner of the water system. **Association:** A non-government water system owned by its consumers (sometimes called "members"). It includes "mutual" water companies. **City / Town:** A city or town that has been incorporated according to the applicable RCW. **County:** A water system owned by county government, such as a county park, or public works maintenance facility. **Federal:** A water system owned by the federal government, such as a veterans' hospital, national park, forest service facility. **Investor:** A privately owned water system operated with the intent of making profit. The owner may be regulated (or potentially regulated) by the Washington Utilities and Transportation Commission (WUTC). **Private:** A privately owned water system, not including Associations, that is not operated with the intent of making a profit. Examples are water systems serving mobile home parks, stores, industries, and so on. **Special District:** A special purpose district created according to applicable RCW, such as a Water or Sewer District, Public Utility District, School District, Fire District or Port District. **State:** A water system owned by the state, such as a state park, correctional facility, or a Department of Transportation rest area or maintenance facility.
	14. STORAGE CAPACITY	Enter the total storage capacity (in gallons) available for distribution to users (if 1,000 gallons or greater). Do not include pressure tank(s) in the total.
SOURCES	**16. SOURCE NAME**	Enter your name for the source (such as, Park Well). If the source is purchased or an intertie, list the name of the system providing the water. Each well in a well field or spring in a spring field must be identified. Please provide Well Tag number if available.
	17. INTERTIE	Enter the ID number of the system providing purchased water or intertie. If you do not know the ID number, contact your DOH regional office.
	18. SOURCE CATEGORY	Mark the box that best describes this source. Each source can have only one code. Each well in a well field, and spring in a spring field must be identified individually.
	19. USE	Mark the box that best describes how this source is used. **Permanent:** A source that is used regularly each year for more than 3 consecutive months within a 12-month period. For systems that are in operation for 3 or less months, their sources shall also be considered permanent. **Seasonal:** A source that is used on a regular basis and does not meet the definition of either permanent or emergency source. Seasonal source *could* be used to supply peak demand. **Emergency:** A source that has been approved by DOH for emergency use and is *not* used for routine or seasonal peak water demands.
	20. SOURCE METERED	Mark this box if this source has a water meter installed.

	21. TREATMENT	If this source is not treated, mark "none," otherwise mark the box(es) for each type of treatment provided for this source. If a well in a well field or a spring in a spring field has its own individual treatment, mark the appropriate box. If all the wells in a well field or springs in a spring field are treated together at one location, mark the appropriate box on the well or spring field line. Treatment for an intertie refers only to additional treatment by the receiving system.
	22. DEPTH TO FIRST OPEN INTERVAL	For cased wells, enter depth to top of uppermost well screen or perforated casing; for wells completed in rock, enter depth to bottom of sealed casing; for dug wells, enter depth to first unsealed casing joint below the well seal; and for well fields, enter depth of shallowest well. Round off to the nearest whole number.
	23. CAPACITY	Enter the actual current capacity of the source, in gallons per minute (gpm) that is available to enter the distribution system under operating conditions. For example, if the source is a well with a pump test of 100 gpm, but only has a 20-gpm pump installed, enter 20 gpm.
	24. SOURCE LOCATION	Enter the quarter / quarter designation, section number, township and range location for each source. For Example, SE/SW, Sec.1, T18N, R3E. Source locations can be found on well logs, water right documents, or property descriptions.
CONNECTIONS	**25-A. FULL TIME SINGLE-FAMILY RESIDENCES**	Enter the number of single-family residences (including mobile homes) occupied any 180 days or more a year that are served by the water system. If you enter a number in this field, you also need to enter a number for the corresponding population residing in these connections in field 29. A connection is considered active until it is physically disconnected from the water system.
	25-B. PART TIME SINGLE-FAMILY RESIDENCES	Enter the number of single-family residences (including mobile homes) occupied less than 180 days a year that are served by the water system. (These part-timers most likely inhabit vacation homes that are not used as a primary residence) If you enter a number in this field, you also need to enter data for the corresponding population residing in these connections in rows 30A and 30B. A connection is considered active until it is physically disconnected from the water system.
	26-A. APARTMENT BUILDINGS, CONDOS, OTHER MULTIFAMILY BUILDINGS, BARRACKS, DORMS	Enter the number of apartment buildings, condominium buildings, duplex buildings, barracks, and dormitory buildings, and so on served by your water system.
	26-B. FULL TIME RESIDENTIAL UNITS	*If the water system serves multifamily residential buildings*, enter the total number of residential units that are occupied any 180 days or more a year. If you enter a number in this field, you also need to enter a number for the corresponding population residing in these connections in field 29.
	26-C. PART TIME RESIDENTIAL UNITS	*If the water system serves multifamily residential buildings*, enter the number of individual dwelling units that are occupied less than 180 days a year. If you enter a number in this field, you also need to enter data for the corresponding population residing in these connections in rows 30A and 30B.
	27-A. RECREATIONAL SERVICES OR TRANSIENT ACCOMMODATIONS CALL YOUR REGIONAL OFFICE IF YOU ARE UNSURE WHETHER YOURS IS A COMMUNITY, NONCOMMUNITY, OR GROUP B SYSTEM	**COMMUNITY SYSTEMS**: Leave this field empty. Include in field 27B the actual number of RV parks, campgrounds, hotels, motels, and so on served. **NONCOMMUNITY and GROUP B SYSTEMS**: Enter the actual number of RV sites, campsites, spigots, etc., and hotel/motel/overnight units that are served by the water system. Enter the corresponding nonresidential population and use-days in rows 31A and 31B.

<table>
<tr><td></td><td>27-B. INSTITUTIONAL, COMMERCIAL, OR INDUSTRIAL SERVICES</td><td><u>COMMUNITY SYSTEMS</u>: Enter the number of all service connections not used for residential purposes. Include RV parks, campgrounds, hotels, motels, etc. in your count of commercial connections. If you enter a number in this field, enter the corresponding non-resident population and use-days in rows 31A, 31B, 32A, and 32B.</td><td><u>NONCOMMUNITY and GROUP B SYSTEMS</u>:
Enter the number of all service connections not used for residential purposes and not otherwise accounted for in field 27A. If you enter a number in this field, enter the corresponding non-resident population and use-days in rows 31A, 31B, 32A, and 32B.</td></tr>
<tr><td rowspan="8">POPULATIONS</td><td>29. FULL TIME RESIDENTIAL POPULATION</td><td colspan="2">Enter the total number of residents that are served by the water system for any 180 days or more per year.</td></tr>
<tr><td>30-A. PART TIME RESIDENTS PER MONTH</td><td colspan="2">Enter the TOTAL number of seasonal or weekend <u>residents</u> that are present each month. (These part-timers most likely inhabit vacation homes that are not used as a primary residence).</td></tr>
<tr><td>30-B. PART TIME RESIDENT USE DAYS PER MONTH</td><td colspan="2">Enter how many days part-time residents are present each month.</td></tr>
<tr><td>31-A. TEMPORARY & TRANSIENT USERS PER MONTH</td><td colspan="2">Enter the TOTAL number of temporary or transient users served by the water system each month. This includes all visitors, attendees, travelers, campers, patients, or customers with access to establishments connected to the water system. Visitors must be counted for every day that they have access to the water system. For example, an individual attending a weeklong camping session (seven days) must be counted seven times.</td></tr>
<tr><td>31-B. TEMPORARY & TRANSIENT USE DAYS PER MONTH</td><td colspan="2">Enter the TOTAL number of days per month this system is accessible or available to the public.</td></tr>
<tr><td>32-A. REGULAR NONRESIDENTIAL USERS PER MONTH</td><td colspan="2">Enter the number of students, daycare children, and all employees that are served by the water system during each month.</td></tr>
<tr><td>32-B. REGULAR NONRESIDENTIAL USE DAYS PER MONTH</td><td colspan="2">Enter the number of days per month that students, daycare children, and employees have access to the water.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="2">SIGNATURE</td><td>35. REASON FOR SUBMITTING THE WFI</td><td colspan="2">Check the appropriate box.
If you are submitting this WFI as requested by DOH, please refer to the instructions in the letter.</td></tr>
<tr><td>36. CERTIFICATION</td><td colspan="2">Please sign and print your name and the date you are signing the WFI. Please include your title or relationship with this water system.</td></tr>
</table>

Washington State Department of Health
Environmental Public Health
Office of Drinking Water

New Group A-TNC Water Facilities Inventory (WFI) Form

For new Group A-TNC water systems only

ONE FORM PER SYSTEM

1. SYSTEM ID NO.	2. SYSTEM NAME	3. COUNTY	4. GROUP	5. TYPE

6. PRIMARY CONTACT NAME & MAILING ADDRESS	7. OWNER NAME & MAILING ADDRESS / 8. Owner Number:
ORGANIZATION NAME	ORGANIZATION NAME
PRIMARY CONTACT NAME TITLE:	NAME TITLE:
ADDRESS	ADDRESS
CITY STATE ZIP	CITY STATE ZIP
STREET ADDRESS IF DIFFERENT FROM ABOVE	**STREET ADDRESS IF DIFFERENT FROM ABOVE**
ADDRESS	ADDRESS
CITY STATE ZIP	CITY STATE ZIP

9. 24-HOUR PRIMARY CONTACT INFORMATION	10. OWNER CONTACT INFORMATION
Primary Contact Daytime Phone:	Owner Daytime Phone:
Primary Contact Evening Phone:	Owner Evening Phone:
Primary Contact Mobile/Cell Phone:	Owner Mobile/Cell Phone:
Fax: Email:	Fax: Email:

WAC 246-290-420()) requires water systems to provide 24-hour contact information for emergencies.

11. SATELLITE MANAGEMENT AGENCY – SMA (check only one)

- ☐ **Not applicable (Skip to #12)**
- ☐ **Owned and Managed** **SMA NAME:**____________ **SMA Number:**
- ☐ **Managed Only**

12. WATER SYSTEM CHARACTERISTICS (mark ALL that apply)

- **Agricultural Commercial**
- **/ Business Day Care**
- **Food Service/Food Permit**
- **1,000+ person event on 2 or more days/yr**
- **Hospital/Clinic**
- **Industrial**
- **Licensed Residential Facility**
- **Lodging**
- **Recreational / RV Park**
- **Residential**
- **School**
- **Temporary Farm Worker Other**
- **(church, fire station, etc.):** ________

13. WATER SYSTEM OWNERSHIP (mark only one)

- **Association**
- **City / Town**
- **County**
- **Federal**
- **Investor**
- **Private**
- **Special District**
- **State**

14. STORAGE CAPACITY (gallons)

15.	16. SOURCE NAME	17. INTERTIE	18. SOURCE CAPACITY									19. USE			20.	21. TREATMENT					22. DEPTH	23.	24. SOURCE LOCATION			
	LIST UTILITY'S NAME FOR SOURCE AND WELL TAG ID NUMBER. Example: WELL #1 XYZ456 IF SOURCE IS PURCHASED OR INTERTIED, LIST SELLER'S NAME Example: SEATTLE	INTERTIE SYSTEM ID NUMBER	WELL	WELL FIELD	WELL IN A WELLFIELD	SPRING	SPRING FIELD	SPRING IN A SEAWATER	SEAWATER	SURFACE WATER	RANNEY INF. GALLERY	OTHER	PERMANENT	SEASONAL	EMERGENCY	SOURCE METERED	NONE	CHLORINATION	FILTRATION	FLUORIDATION	IRRADIATION (UV)	(DEPTH TO FIRST OPEN INTERVAL)	CAPACITY GALLONS PER MINUTE	¼, ¼ SECTION	SECTION NUMBER	TOWNSHIP	RANGE
S01																											
S02																											
S03																											
S04																											
S05																											
S06																											
S07																											

	ACTIVE SERVICE CONNECTIONS	DOH USE ONLY! CALCULATED ACTIVE CONNECTIONS	DOH USE ONLY! APPROVED CONNECTIONS
25. SINGLE FAMILY RESIDENCES (How many of the following do you have?)			
A. Full-Time Single-Family Residences (Occupied 180 days or more per year)			
B. Part-Time Single-Family Residences (Occupied less than 180 days per year)			
26. MULTIFAMILY RESIDENTIAL BUILDINGS (How many of the following do you have?)			
A. Apartment Buildings, condos, duplexes, barracks, dorms			
B. Full-Time Residential Units in Apartments, Condos, Duplexes, Dorms that are occupied more than 180 days/year			
C. Part-Time Residential Units in the Apartments, Condos, Duplexes, Dorms, that are occupied less than 180 days/year			
27. NONRESIDENTIAL CONNECTIONS (How many of the following do you have?)			
A. Recreational Services (Campsites, RV Sites, Spigots, etc.)			
B. Institutional, Commercial/Business or Industrial Services			
28. TOTAL SERVICE CONNECTIONS			

29. FULL-TIME RESIDENTIAL POPULATION

How many residents are served by this system 180 or more days per year? ____________________

30. PART-TIME RESIDENTIAL POPULATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. How many part-time residents are present each month?												
B. How many days per month are they present?												

31. TEMPORARY & TRANSIENT USERS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. How many total visitors, attendees, travelers, campers, patients, or customers have access to the water system each month?												
B. How many days per month is water accessible to the public?												

32. REGULAR NONRESIDENTIAL USERS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. If you have schools, daycares, or businesses connected to your water system, how many students, daycare children, or employees are present each month?												
B. How many days per month are they present?												

Comments:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
33. ROUTINE COLIFORM SCHEDULE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	QUARTERLY	ANNUALLY	ONCE EVERY 3 YEARS
34. GROUP A-TNC NITRATE SCHEDULE	N/A	N/A	N/A

35. REASON FOR SUBMITTING WFI:

☐ New System · Other________

36. I CERTIFY THAT THE INFORMATION STATED ON THIS WFI FORM IS CORRECT TO THE BEST OF MY KNOWLEDGE.

SIGNATURE: ______________________________ **DATE:** ______________________________

PRINT NAME: ______________________________ **TITLE:** ______________________________

Appendix E Group A-TNC Pump Test Guidance

Objective: To demonstrate that a proposed well (or wells) can provide sustainable and reliable water production equal to or exceeding the minimum supply requirements needed to supply the proposed design flow rate. The best way to demonstrate this is by conducting a pump test, which is a stress test of the well and localized aquifer. It involves recording and evaluating periodic measurement of pumping rate and water level changes during a series of controlled pump and recovery ("rest") test cycles. The results show how both the well and the localized aquifer react to periods of intense pumping. Evaluating the degree of water level drawdown and the rate of water level recovery helps to characterize the aquifer's yield and establish optimal well pump placement and operating conditions.

When executed correctly, a pump test provides sufficient information to demonstrate the capacity of a well or collection of wells to produce enough water in a 24-hour period to service the water system as designed.

- A successful pump test must show the proposed well (or combination of wells) can provide a sustainable and reliable production of water (yield) equal to or exceeding the design flow rate and recover to pre-pumping level within a normal 24-hour operational period.
- A failed pump test is one that cannot demonstrate the required level of production and recovery within a normal 24-hour operational period.

At a minimum, the pump test must be conducted at a flow rate of at least the intended flow rate for when the well is put into regular service. The duration of the pump test must be at least the length of time that it takes for the water level drawdown to stabilize and remain stabilized for four to six hours. Then the water level recovery must be documented until it reaches 95 percent of the original static level.

Part 1: Select and Run a Recommended Group A-TNC Pump Test

Pump Test Procedure	Recommended Conditions for Use
Standard Step Drawdown/Constant Rate Test **See Appendix E-1**	For sources located in: Fractured rock, shale, bedrock, or hard rock (consolidated) aquifers. Areas of known or suspected seawater intrusion. Aquifers with highly variable seasonal water tables. Aquifers with limited recharge. An area with nearby large capacity wells that could affect local water levels and well yields.
Extended Step Drawdown Test **See Appendix E-2**	Low projected water demand wells in a high-flow aquifer setting. *Most common for small Group A-TNC systems with proposed wells in sand and gravel aquifers.*
Alternating Pump and Recovery Test **See Appendix E-3**	Very small systems (2-6 connections), ***and*** Very low flow aquifer conditions, ***or*** Failure on other tests.

Part 2: Pump Test Report and Analysis

The Pump Test Report (See Appendix E-4) documents the results of the pump tests, provides an analysis of the well, and localized aquifer responses to the challenge of sustained pumping. The designer can use that data to estimate aquifer characteristics and determine pump and well operational factors and well efficiency.

Elements of a complete report should discuss:

- Well yield.
- Expected operational drawdown.
- Pumping rates and recommended pump operational cycles.
- Recommended pump placement.
- Estimate of well efficiency.
- An estimate of the aquifer's specific yield, hydraulic conductivity, or transmissivity (to support evidence of sustainability and aquifer capacity consistent with proposed use of the well).

If a pump test is unable to demonstrate a clear sustained yield as defined above, then the designer should re-run the test with different operational assumptions and conditions (lower pumping rate, add additional sources, or reduced total volume and associated connections). The designer might need to consider using an alternative test.

Part 3: Additional Considerations

In challenging aquifer settings, a pump test can provide a starting point in the analysis and potential mitigation of any localized aquifer conditions that could adversely affect long-term use of the well, including concerns about saltwater intrusion, declining aquifer levels, consolidated and fracture rock aquifers, aquifers with limited recharge, and high seasonal water level variability. The pump test report is an appropriate place to highlight those issues and discuss supply-related options.

Part 4: Recommended Pump Test Procedures

The following sections lay out step-by-step procedures for the three recommended pump tests. Site conditions and equipment must be factored into any pump test design and implementation. While we recommend these procedures, they are still guidelines so the designer may modify them based on professional expertise, experience, and on-site conditions. The result should be a test, analysis, and report that documents the sustainable use of the well as dictated by the water system design criteria.

In addition to the recommended pump test procedures, this Appendix includes data collection templates for both the drawdown and recovery phases of a pump test. A successful test will likely require multiple pages of each.

Appendix E.1 Step Drawdown/Constant Rate Pump Test Procedure

Phase 1: Step Drawdown Pump Test

Objective: To evaluate well performance and identify successful pumping conditions for phase two of the pump test (constant rate). This information will allow a determination of the optimal pump settings (depth and pumping rate) and well efficiency for the well.

Elements

1. We recommend that a qualified water professional (hydrogeologist or engineer) oversee testing of the well and review data analysis and interpretations.
2. An access port to allow depth-to-water measurements must be installed, if not already present, and maintained (WAC 173-160-355).
3. The step drawdown test should include at least four consecutive constant rate discharge steps as described below, with a higher pumping rate used for each step. Each step should be at least 60 minutes long.
4. The third step of the drawdown test should use a flow rate no less than the intended pumping rate from the well when put into regular service. The remaining pumping rates should be determined by multiplying this flow rate (in gallons per minute) by 0.50, 0.75, and 1.25.
5. Drawdown should be measured in the pumped well at least as frequently as the following.

Time after pumping started	Time Intervals
0 to 10 minutes	1 minute
10 to 60 minutes	5 minutes
60 to 240 minutes	15 minutes
240 to 600 minutes	60 minutes
600 to 1,440 minutes	120 minutes

1. Recovery should be measured beginning at the end of the last step (immediately after the pump is turned off) and ending when the water level returns to at least 95 percent of the initial, pre-pumping static water level. Measurement frequency should follow the specifications in the table above measured from the moment when pumping stopped. Initial measurement intervals will be short and expand as recovery progresses. The pump should not be removed until the water level returns to 95 percent of the pre-pumping static water level.
2. Determine the maximum pumping rate and pumping depth as established from the step drawdown test. Use these values for conducting the constant rate discharge test, if the test is applicable.

Phase 2: Constant Rate Pump Test

Objective: To determine the capacity of the well and aquifer to provide a reliable yield of water at the desired rate. The pumping and recovery data from the test can be used to estimate aquifer transmissivity and a sustainable yield for the well. This test procedure is recommended for sources in complex hydrologic settings where the nature of the aquifer could adversely affect long-term continuous use of the source. Sources with the potential for seawater intrusion should also conduct the additional elements provided at the end of this document.

Elements

1. We recommend that a qualified water professional (hydrogeologist or engineer) oversee testing of the well.
2. An access port to allow depth to water measurements must be installed, if not already present, and maintained (WAC 173-160-355).
3. The source should be pump tested at no less than the maximum rate determined from the step drawdown test. The constant rate discharge test should not be conducted until after the water levels in the aquifer have achieved at least 95 percent recovery from the step drawdown test pre-pumping static water level conditions.
4. The constant rate discharge test should be at least 24 hours long. If, at 24 hours, four hours of stabilized drawdown have been observed, the pump may be shut off and measurements of recovery begun. If stabilized drawdown has not been observed within a total of 36 hours, the pump may be shut off and recovery measurements begun. Stabilization is defined as a drop in water level of less than or equal to 0.1 feet per hour.
5. Drawdown should be measured in the pumped well at the following frequencies.

Time after pumping started	Time intervals
0 to 10 minutes	1 minute
10 to 60 minutes	5 minutes
60 to 240 minutes	30 minutes
240 to 600 minutes	60 minutes
600 to 1440 minutes	120 minutes

1. Proper sampling procedures must be used to collect water quality samples from the source and a DOH-certified lab must analyze them. Water quality samples should be taken within the last 15 minutes of pumping and analyzed for the following water quality parameters:
    - Coliform bacteria.
    - Inorganic Chemicals (IOCs) and Volatile Organic Chemicals (VOCs).
    - Per- and Polyfluoroalkyl Substances (PFAS).
    - Additional Synthetic Organic Chemicals (SOCs), radionuclides, or other analyses, if required by DOH because the well is in areas of known or expected contamination.
2. After pumping, you should collect recovery data until 95 percent recovery of the pre-pumping static water level is achieved. You should measure recovery in the same manner

and at the same frequency as the table above. To facilitate accurate recovery data collection, the pump test piping should incorporate backflow check-valve(s) that prevent water within the riser pipe from flowing back into the well when the pump is shut off.

3. When the pumping test is completed, you should compile the data into a report and submit it to DOH. The report should include the following:

- All data on pumping rates and water levels (including static water levels) from the pumping test and recovery period, and appropriate graphical presentations of the data.
- An estimate of the aquifer's specific yield, hydraulic conductivity, and transmissivity (to support evidence of sustainability and aquifer capacity consistent with proposed use of the well).
- A map and description (Quarter, Quarter, Section, Township, Range) accurately indicating the well location, and the land surface elevation to the nearest foot above sea level. Address and parcel number should be provided.
- Summary, conclusions, and recommendations on pump settings, operational regimes, and source reliability.
- A well construction report (well log) for the pumping well and all observation wells (if any).
- Distance, to the nearest foot, from pumping well to all observation wells and a map indicating all well locations.
- A copy of all laboratory test results.

Additional Steps for Potential Seawater Intrusion Areas

1. For the source well (the well pumped during the aquifer test), chloride and conductivity samples should be collected at the following intervals.
   a. One sample during the initial 30 to 60 minutes.
   b. One sample during the sixth hour (360 to 420 minutes).
   c. One sample during the twelfth hour (720 to 780 minutes).
   d. One sample within the last 15 minutes of the aquifer test pumping phase.
2. An observation well, if one is available, should be pumped by an amount equal to three times the volume of water inside its well casing before collecting chloride and conductivity samples. Following collection of these samples, an observation well should be given adequate time to recover to static water level before initiating the production well aquifer test (pump test). At the completion of the production well aquifer test (including complete recovery), another set of chloride and conductivity samples should be collected from the observation well. Note: We recommend that a field test kit be used to monitor chloride levels within the pumping well during the pumping phase.
3. The report should include, 1) tidal influence on the pumping well—data on pumping water levels, chlorides, and tidal fluctuations, corrected to point, should be plotted on a single graph with respect to time—and 2) potential for seawater intrusion into this or other seaward wells.

Appendix E.2 Extended Step Drawdown Pump Test Procedure

Objective: To evaluate well performance and determine whether a source over an aquifer with an expected high yield can produce a sustainable yield. The test results can be used to determine optimal pump settings and well efficiency. The extended pumping and recovery data are used to estimate aquifer transmissivity and confirm that there are no underlying aquifer conditions likely to adversely affect long term use of the source. This test is most appropriate for sources with a small demand within a high yield aquifer.

Elements

1. We recommend that a qualified water professional (hydrogeologist or engineer) oversee testing of the well and review data analysis and interpretations.
2. An access port to allow depth to water measurements **must** be installed, if not already present, and maintained (WAC 173-160-355).
3. The step drawdown test should include at least four consecutive constant rate discharge steps, with a higher pumping rate used at each step. The first three steps should be at least 60 minutes long. The fourth step is extended until four hours of stabilization occurs or until 12 hours total pumping time has elapsed. Stabilization means less than 0.1 foot of drawdown fluctuation per hour in four hours of drawdown measurements.
4. The third step of the drawdown test should use a flow rate no less than the intended pumping rate from the well when put into regular service. The remaining pumping rates should be determined by multiplying this flow rate (in gallons per minute) by 0.50, 0.75, and 1.25.
5. Drawdown should be measured in the pumped well at least as frequently as the following.

Time After Pumping Started	Time Intervals
0 to 10 minutes	1 minute
10 to 60 minutes	5 minutes
60 to 240 minutes	15 minutes
240 to 600 minutes	60 minutes
600 to 1440 minutes	120 minutes

6. You must use proper sampling procedures to collect water quality samples from the source and a DOH-certified lab must analyze them. Water quality samples should be taken within the last 15 minutes of pumping and must be analyzed for the following water quality parameters:
   a. Coliform bacteria.
   b. Inorganic Chemicals (IOCs) and Volatile Organic Chemicals (VOCs).
   c. Per- and Polyfluoroalkyl substances (PFAS).

d. Additional Synthetic Organic Chemicals (SOCs), radionuclides, or other analyses, if required by DOH because the well is in areas of known or expected contamination.

7. Measure recovery beginning at the end of the last step (immediately after the pump is turned off) and ending when the water level returns to within 95 percent of the initial, pre-pumping static water level. Measurement frequency should follow the specifications in the table above measured from the moment pumping stopped. Initial measurement intervals will be short and expand as recovery progresses. The pump should not be removed until the water level returns to 95 percent of the pre-pumping static water level.
8. Determine the maximum pumping rate and pumping depth as established from the step drawdown test. Use the data from this final step to plot the time (drawdown graph) and determine transmissivity, storage coefficient, and hydraulic conductivity.
9. When the pump test is complete, compile the data into a report and submitted to DOH. It should include the following:
    a. All data on pumping rates and water levels (including static water levels) from the pumping test and recovery period, and appropriate graphical presentations of the data.
    b. An evaluation of the aquifer's specific yield, hydraulic conductivity, and transmissivity (to support evidence of sustainability and aquifer capacity consistent with proposed use of the well).
    c. A map and description (Quarter, Quarter, Section, Township, Range) accurately indicating the well location and the land surface elevation to the nearest foot above sea level. Address and parcel number should be provided.
    d. Summary, conclusions, and recommendations on pump settings, operational regimes, and source reliability.
    e. A well construction report (well log) for the pumping well and all observation wells (if any).
    f. Distance, to the nearest foot, from pumping well to all observation wells and a map indicating all well locations.
    g. A copy of all laboratory test results.

Appendix E.3 Alternating Pump and Recovery Test

Objective: To evaluate whether a proposed source in a low-flow environment can produce the estimated daily demand and recover within a 24-hour operational period. You should use this test only when aquifer yield is low and cannot maintain the sustained periods of pumping needed for either a step-drawdown or a constant-rate test. The pumping and recovery data obtained during the test will help identify a sustainable operating regime that supports approval of a water source for the public water system.

Elements

1. Because of the complex and nonstandard nature of this test, we recommend that a licensed water resource professional direct the work needed to complete it.
2. An access port to allow depth-to-water measurements **must** be installed, if not already present, and maintained (WAC 173-160-355).
3. The test consists of a series of alternating pump and recovery cycles.
   a. Each pumping cycle should last for a standard period of time (usually two to six hours) at an intermediate flow rate. At the end of that time, the pump is turned off and water levels are allowed to recover to pre-pumping or near normal condition. During both pumping and recovery cycles, water levels are recorded at the time intervals described below.
   b. The pump and recovery cycles are continued for at least 24 hours or until the combined pumped volume equals or exceeds the maximum daily demand. Pumping rate and periods can be changed between cycles, but pumping rate must be constant within each cycle. Pumping time, volume pumped, and water level changes must be recorded for each cycle. Pumping periods should be no shorter than two hours. **The test is not complete until recovery occurs after the last pump cycle is completed.**
   c. It may be necessary to run the test longer than 24 hours to identify the appropriate combination of operational conditions that will produce maximum daily demand and still allow for recovery within a 24-hour operational regime.
4. Measure drawdown and recovery in the pumped well for each pump and recovery cycle at least as frequently as the following.

Time after pumping started	Time intervals
0 to 10 minutes	1 minute
10 to 60 minutes	5 minutes
60 to 240 minutes	15 minutes
240 to 600 minutes	60 minutes
600 to 1440 minutes	120 minutes

5. Water quality samples must be collected from the source using proper sampling procedures and analyzed by a DOH-certified laboratory. Water quality samples should be taken within the last 15 minutes of pumping and must be analyzed for the following water quality parameters:
    a. Coliform bacteria.
    b. Inorganic Chemicals (IOCs) and Volatile Organic Chemicals (VOCs).
    c. Per- and Polyfluoroalkyl substances (PFAS).
    d. Additional Synthetic Organic Chemicals (SOCs), radionuclides, or other analyses, if required by DOH because the well is in areas of known or expected contamination.
6. Recovery should be measured beginning at the end of each pump cycle (immediately after the pump is turned off) and ending when the water level returns to within 95 percent of the initial, pre-pumping static water level. Measurement frequency should follow the specifications in the table above.
7. Determine the maximum pumping rate and pumping depth and plot the time (drawdown graph) and recovery data to determine transmissivity, storage coefficient, and hydraulic conductivity.
8. When the pump test is complete, the data should be compiled into a report and submitted to DOH. The report should include:
    a. All data on pumping rates and water levels (including static water levels) from the pumping and recovery periods, and appropriate graphical presentations of the data.
    b. An evaluation of the aquifer's specific yield, hydraulic conductivity, and transmissivity (to support evidence of sustainability and aquifer capacity consistent with proposed use of the well).
    c. A map and description (Quarter, Quarter, Section, Township, Range) accurately indicating the well location and the land surface elevation to the nearest foot above sea level. Address and parcel number should be provided.
    d. Summary, conclusions, and recommendations on pump settings, operational regimes, and source reliability.
    e. A well construction report (well log) for the pumping well and all observation wells (if any).
    f. Distance, to the nearest foot, from pumping well to all observation wells and a map indicating all well locations.
    g. A copy of all laboratory test results.

Appendix E.4 Pump Test Data Collection Form

System ID:	Owner:	Well Tag No.:
DOH Source ID:	System Name:	Well Name:
Type of Test:	Conducted By:	Date:
Static Water Level (as measured from reference point):		County:
Observation Wells?		Well Elevation (MSL):
Distance of observation well (r) from pumped well (ft):		

Time	**Time (t) since pumping began (min)**	**Depth to Water Level (ft)**	**Drawdown (ft)**	**t/r^2**	**Pumping Rate (Q) [gpm]**	**Comments**

Recovery Data Collection Form

System ID:	Owner:	Well Tag No.:
DOH Source ID:	System Name:	Well Name:
Type of Test:	Conducted By:	Date:
Static Water Level (as measured from reference point):		County:
Observation Wells?		Well Elevation (MSL):
Distance of observation well (r) from pumped well (ft):		

Time	Time (t) since pumping began (min)	Time (t′) since pumping stopped (min)	t/t′	Depth to Water Level (ft)	Residual Drawdown (ft)	Comments

Appendix F Pump Cycle Control Valves

A pump cycle control valve (CCV) may be used to control the pressure in a distribution system. The CCV is intended to extend run time with minimal pressurized storage. It will maintain constant downstream pressure (i.e. the valve's set point) until demand downstream of the valve falls below the valve's prescribed low flow level, at which point the pressure will rise to the pressure switch pump-off set point. The valve is mechanically prevented from restricting flow past its preset minimum.

Pressurized storage is needed with the CCV to supply the distribution system when demand falls below the valve's minimum flow setting and pump operation gets shut down. The size of the pressure tank(s) will depend on several factors as described below, but the size and number always will be less than that required if a cycle control valve had not been installed. Designers should review manufacturer's recommendations to ensure all valve application requirements are met.

Advantages of using a CCV include:

1. Limiting well pump on-off cycling and the associated wear on water system components.
2. Reducing the size or number of pressure tanks required for any given installation.
3. Reducing the potential for damaging transient pressure waves ("water hammer") resulting from hard pump-start and pump-stop conditions.

Design considerations and challenges of using a CCV include:

- The valve must be listed under NSF Standard 61 for potable water supply use (see WAC 246-290-220)
- The control valve itself can impose significant energy loss ("head loss") at the high end of its flow range when fully open (a 1¼-inch control valve causes the loss of about 10 psi at 50 gpm). The well pump design must account for the head loss imposed by the control valve.
- It is difficult to predict whether the savings through limiting the number of "pump-start" events and reduced initial capital cost associated with fewer bladder tanks will offset the cost of the additional energy used in prolonging the pump-on portion of the cycle.
- Water quality may affect control valve performance. Particulate matter (sand) may adversely affect the performance of the control valve.
- At low flow conditions, the pressure on the upstream side of the control valve will be near the pump's shut-off head. You should pay attention to the design, material specifications, and construction of the pump to ensure it can operate near its shut-off head for extended periods, and to the pressure rating of the piping and valves on the upstream side of the control valve.
- CCV consumes greater amounts of energy per gallon pumped due to prolonged operation at low pump efficiency.

The CCV is usually installed between the pump(s) and the pressure tank(s). The valve's downstream pressure setting should fall between the pressure switch on and off pressure settings. As the demand in the water system varies, the cycle control valve adjusts the pressure generated by the pump by modulating the size of the valve opening. The pump-on phase of the pump cycle will continue until the water system demand drops below the valve's minimum flow setting. At this point, pump supply in excess of system demand goes into pressurized storage until the pressure tank reaches the pressure switch "pump-off" setting. If demand (including leaks) never drops below the valve's minimum flow setting, the pump will never shut off.

While the pump is off, all water demand is satisfied by water released from the pressure tank(s). The length of the "pump-off" period depends on water system demand and the available withdrawal volume of the pressure tank(s).

The number of pump starts per hour is important since excessive heat build-up from too-frequent starts may damage pump motors. In the absence of the pump motor manufacturer's specification, pump starts should be limited to no more than six (6) per hour.

In order to design the pressure tank system so pump starts are limited to no more than six starts per hour (or per the manufacturer's specification), designers should consider:

- The valve's minimum flow setting and pre-set downstream pressure setting;
- Pump-on and pump-off pressure setting; and
- Where the valve pressure set-point falls within the pump-on-off pressure range.

Example

Given

- Bladder tank system
- Pump on pressure = 40 psi
- Pump off pressure = 60 psi
- Cycling control valve pressure setting = 50 psi
- Pump control valve low-flow setting = 5 gpm

Find

- Volume ("V") of pressurized storage between 60 and 40 psi available to the distribution system while the pump is off to provide for a minimum pump cycle time of 10 minutes (equal to 6 cycles per hour)

Solution

- The shortest pressure tank fill time + tank draw time occurs when distribution system demand is approximately equal to one-half the low-flow valve setting (2.5 gpm in this example). System demand is "Y" and valve flow setting is "X".
- To simplify and remain conservative, assume the time to fill the pressure tank from the low-pressure pump-on setting (i.e. 40 psi in this example) to valve pre-set pressure

setting (i.e. 50 psi) is instantaneous. Also, assume pressurized volume from 40 psi to 50 psi is equal to the pressurized volume from 50 psi to 60 psi.

- Time to fill pressure tank from 50 psi to 60 psi:

  $\frac{0.5V}{X-Y}$

- Time to draw down pressure tank from 60 psi to 40 psi while pump is off:

  $\frac{V}{Y}$

- Solve this equation:

$$\frac{0.5V}{X-Y} + \frac{V}{Y} = 10 \text{ minutes} = 6 \text{ cycles per hour}$$

If X = 5 gpm and Y = 2.5 gpm, then V = 16.7 gallons

In the above example, the bladder tank system must provide at least 16.7 gallons of storage between 40 psi and 60 psi. Based on the following pressure tank manufacturer's information, the drawdown for a nominal 34-gallon pressure tank is 9.1 gallons from 40-60 psi. In order to provide 16.7 gallons, two 34-gallon pressure tanks are needed. Alternately, one 62-gallon pressure tank will satisfy the pressurized storage requirement.

IN-LINE MODELS

MODEL NUMBER	CAPACITY GALLONS	DRAWDOWN/GALLONS			HEIGHT INCH	DIAMETER INCH	SYSTEM CONNECTION	ASSEMBLY WEIGHT LBS.
		20-40 PSI	30-50 PSI	40-60 PSI				
WX-101	2.0	0.7	0.6	0.5	12-5/8	8	3/4" NPTM	5
WX-102	4.4	1.6	1.4	1.2	15	11	3/4" NPTM	9
WX-103	8.6	3.1	2.7	2.2	25	11	3/4" NPTM	15

STAND MODELS

MODEL NUMBER	CAPACITY GALLONS	DRAWDOWN/GALLONS			HEIGHT INCH	DIAMETER INCH	SYSTEM CONNECTION	ASSEMBLY WEIGHT LBS.
		20-40 PSI	30-50 PSI	40-60 PSI				
WW-20	20.0	7.3	6.2	5.3	31-5/8	15 3/8	1" NPTF	35
WW-32	32.0	-	9.9	8.5	46-3/8	15 3/8	1" NPTF	43
WX-201	14.0	5.1	4.3	3.7	23-7/8	15 3/8	1" NPTF	27
WX-202	20.0	7.3	6.2	5.4	31-5/8	15 3/8	1" NPTF	35
WX-203	32.0	-	9.9	8.6	46-3/8	15 3/8	1" NPTF	43
[illegible]	34.0	12.4	10.5	9.1	29-1/2	22	1-1/4" NPTF	61
WX-250	44.0	16.3	13.6	11.9	35-5/8	22	1-1/4" NPTF	69
[illegible]	62.0	22.9	19.2	16.7	46-3/4	22	1-1/4" NPTF	92
WX-252	86.0	34.6	29.2	24.9	62-1/4	22	1-1/4" NPTF	114
WX-255	81.0	34.6	29.2	24.9	56-13/16	22	1-1/4" NPTF	114
WX-302	86.0	34.6	29.2	24.9	46-13/16	26	1-1/4" NPTF	123
WX-350	119.0	44.0	36.9	32.1	61-7/8	26	1-1/4" NPTF	166

UNDERGROUND MODELS

MODEL NUMBER	CAPACITY GALLONS	DRAWDOWN/GALLONS			HEIGHT INCH	DIAMETER INCH	SYSTEM CONNECTION	ASSEMBLY WEIGHT LBS.
		20-40 PSI	30-50 PSI	40-60 PSI				
WX-202-UG	20.0	7.4	6.2	5.4	29-3/4	15 3/8	1" NPTF	33
WX-250-UG	44.0	16.3	13.6	11.9	33-3/8	22	1-1/4" NPTF	63

Appendix G Variable Frequency Drive Pumps and Motors

A variable-frequency drive (VDF) is an electronic controller that adjusts the speed of an electric motor by modulating frequency and voltage. VFDs provide continuous control by matching motor speed to the specific demands of the work being performed. VFDs allow operators to fine-tune pumping systems while reducing costs for energy and equipment maintenance.

Use in Potable Water Systems

VFDs are becoming more popular at water facilities, where the greatest energy demand generally comes from pump motors – an application particularly suited to variable-frequency drives. VFDs enable pumps to accommodate fluctuating demand, running pumps at lower speeds and drawing less energy while still meeting water system needs.

Benefits

Single-speed drives start motors abruptly, subjecting the motor to high torque and current surges up to ten times the full-load current. In contrast, variable-frequency drives offer a "soft start" capability, gradually ramping up a motor to operating speed. This lessens mechanical and electrical stress on the motor system, can reduce maintenance and repair costs, and extend motor life.

VFDs allow more precise control of processes, such as water production and distribution. They can also maintain pressure in water distribution systems to closer tolerances. Energy savings from VFDs can be significant. Affinity laws for centrifugal pumps suggest that a reduction in motor speed will generate energy savings. While motor speed and flow are proportional (e.g. 75% speed = 75% flow), motor speed and horsepower have a cubed relationship (e.g. 75% speed = 40% power consumption). Despite some of the VFD controller's additional energy requirements, VFDs can reduce a pump's energy use over many single-speed pumping applications.

Pumps may be designed and installed for the built-out condition and operate economically and efficiently for the many years it will take to reach the full demand design condition.

Disadvantages and Design Challenges

- Outdoor installations can be a problem, since VFDs cannot tolerate extremely cold weather. Check the manufacturer's specifications for ambient air temperature limitations.
- VFD controllers are sensitive to high temperature and particulates. The manufacturer should be consulted on the need for air conditioning and air filtering.
- Placing the controller more than 100 feet from the motor can be a problem without taking special provisions. Check with the VFD manufacturer for specific requirements.
- Power and control wires must be in separate conduits.
- VFDs only work on three-phase motors, except in very small pump applications.
- Pumps controlled by a VFD may not meet the minimum water flow required to keep the motor winding cool. Care should be taken to ensure that the pump is not operating

below this speed. Sleeving may also be an option to protect the pump motor. Confirm with the submersible pump manufacturer the minimum flow rate across the motor needed for motor cooling.

- The quality of the power coming into the VFD controller can have a significant impact on controller performance. Voltage fluctuations should be monitored prior to installing a VFD controller.
- Experienced electronics personnel will be required for maintenance and repair.

When Designing a VFD Pumping System

Certain rotational speeds may induce resonance and excessive vibration. Designers should check with the manufacturer the resonant frequency of the pump/motor, and whether that frequency could be induced by a speed within the predicted operating range of the pump.

The designer should reference the minimum flow requirements of the pump when establishing the operating range of the pumping system. Each manufacturer will have its own specific requirements for pressurized storage volume to ensure compatibility with the specific low-flow pump off discharge.

Appendix H Template Declaration of Covenant and Restrictive Covenant Forms

See the following two pages for the template forms.

Return Address:

____

____

____

DECLARATION OF COVENANT

I (we) the undersigned, owner(s) in fee simple of the land described herein, hereby declare this covenant and place same on record.

I (we) the grantor(s) herein, am (are) the owner(s) in fee simple of (an interest in) the following described real estate situated in ____________________ County, State of Washington; to wit:

____

____

____

on which the grantor(s) owns and operates a well and waterworks supplying water for public use located on said real estate, at:

____

____

and grantor(s) is (are) required to keep the water supplied from said well free from impurities which might be injurious to the public health.

It is the purpose of these grants and covenants to prevent certain practices hereinafter enumerated in the use of said grantor(s) water supply.

NOW, THEREFORE, the grantor(s) agree(s) and covenant(s) that said grantor(s), his (her) (their) heirs, successors and assigns will not construct, maintain, or suffer to be constructed or maintained upon the said land of the grantor(s) and within 100 (One Hundred) feet of the well herein described, so long as the same is operated to furnish water for public consumption, any potential source of contamination, such as septic tanks and drainfields, sewerlines, underground storage tanks, roads, railroad tracks, vehicles, structures, barns, feed stations, grazing animals, enclosures for maintaining fowl or animal manure, liquid or dry chemical storage, herbicides, insecticides, hazardous waste, or garbage of any kind or description.

These covenants shall run with the land and shall be binding to all parties having or acquiring any right, title, or interest in the land described herein or any part thereof, and shall inure to the benefit of each owner thereof.

WITNESS _______________hand ____________this _______________day of _____________, 19______.

____(Seal)

____(Seal)

Grantor(s)

State of Washington)

County of_______________________)

I, the undersigned, a Notary Public in and for the above named County and State, do hereby certify that on this _______________ day of ________________________, 19_______, personally appeared before me ____ to me known to be the individual described in and who executed the within instrument, and acknowledge that he (they) signed and sealed the same as free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal the day and year last above written.

____

Notary Public in and for the State of Washington, residing at _____________________

My Commission Expires: ____

Return Address:

____

____

____

RESTRICTIVE COVENANT

The grantor(s) herein is (are) the owner(s) of (an interest in) the following described real estate situated in ______________________________ County, State of Washington:

____

____

____

The grantee(s) herein, own(s) and operate(s) a well and waterworks supplying water for public use, located upon the following described real estate situated in __________________________ County, State of Washington:

____

____

which well and waterworks are in close proximity to the land of the grantor(s), and said grantee(s) is (are) required to keep the water supplied from said well free from impurities which might be injurious to the public health.

It is the purpose of these grants and covenants to prevent certain practices hereinafter enumerated in the use of the said grantor(s) land which might contaminate said water supply.

NOW, THEREFORE, the grantor(s) agree(s) and covenant(s) with said grantee(s), its successors and assigns, said covenants to run with the land for the benefit of the land of the grantee(s), that said grantor(s), his (her) (their) heirs, successors and assigns will not construct, maintain, or suffer to be constructed or maintained upon the said land of the grantor(s) and within 100 (One Hundred) feet of the well herein described, so long as the same is operated to furnish water for public consumption, any potential source of contamination, such as septic tanks and drainfields, sewerlines, underground storage tanks, roads, railroad tracks, vehicles, structures, barns, feed stations, grazing animals, enclosures for maintaining fowl or animal manure, liquid or dry chemical storage, herbicides, insecticides, hazardous waste, or garbage of any kind or description.

These covenants shall run with the land and shall be binding to all parties having or acquiring any right, title, or interest in the land described herein or any part thereof, and shall inure to the benefit of each owner thereof.

WITNESS _______________hand ____________this _______________day of _____________, 19______.

____(Seal)

____(Seal)

Grantor(s)

State of Washington)

County of_______________________)

I, the undersigned, a Notary Public in and for the above named County and State, do hereby certify that on this _______________ day of ________________________, 19_______, personally appeared before me ____ to me known to be the individual(s) described in and who executed the within instrument, and acknowledge that he (she) (they) signed and sealed the same as free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal the day and year last above written.

____

Notary Public in and for the State of Washington, residing at _____________________

My Commission Expires: ____