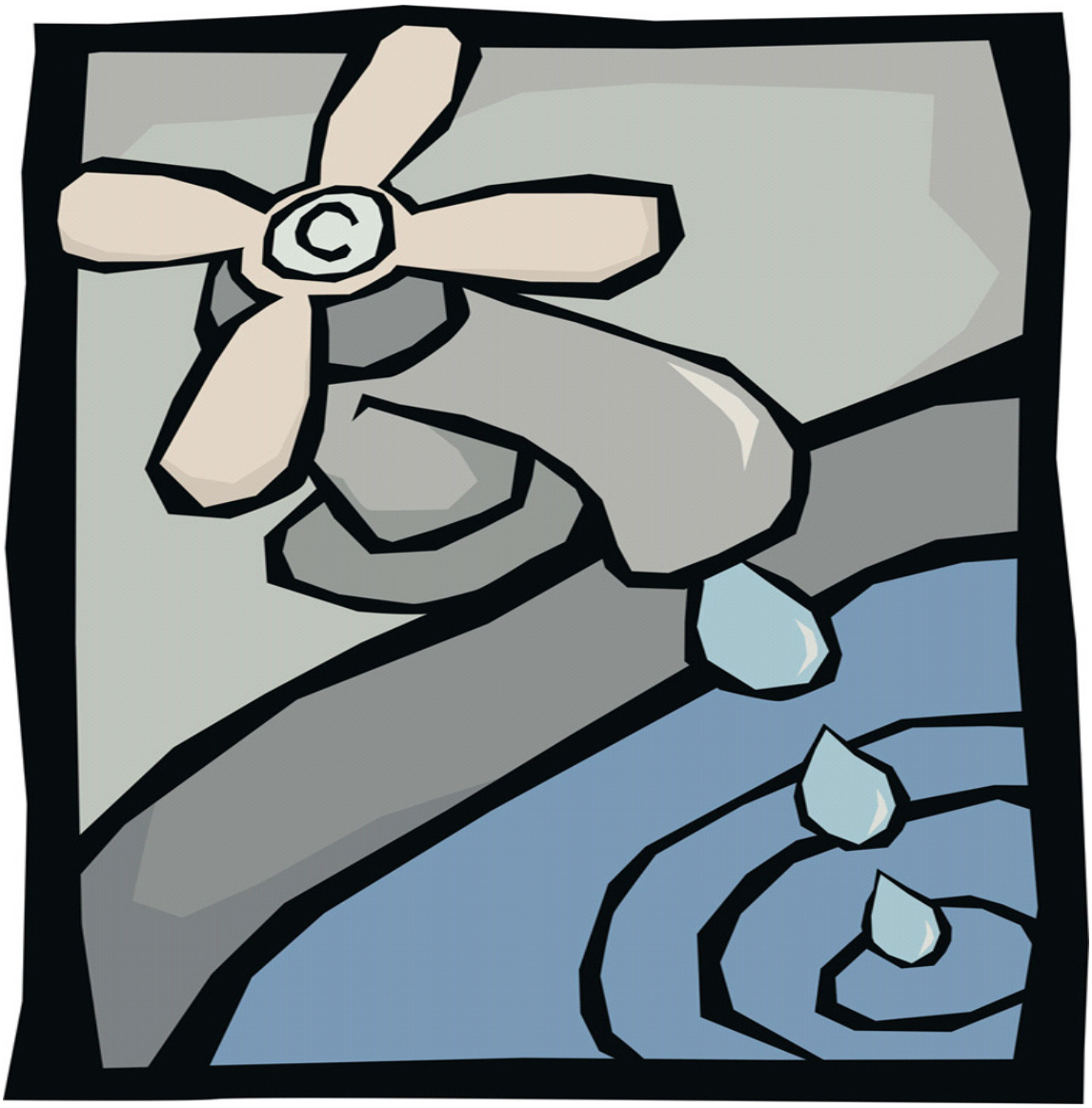
Technical Manual for Determining Reliable Yield for Nontransient Noncommunity Public Water Systems



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July 2010

Prologue

The New Jersey Safe Drinking Water Act Regulations (N.J.A.C. 7:10-13 et seq.) require all newly constructed[1] nontransient noncommunity water system[2] to demonstrate Technical, Managerial, and Financial (TMF) capacity. Technical capacity means that all nontransient noncommunity water systems must demonstrate that the water system has a reliable yield of potable water to meet its needs. The purpose of this document is to provide guidance for owners and/or operators of nontransient noncommunity public water system to demonstrate technical capacity as set forth at N.J.A.C. 7:10-13 et seq.

A technical capacity approval for a new nontransient noncommunity water system is required prior to the system initiating operations, and is evaluated by utilizing a "system delivery test" as outlined in this document. The system delivery test is required in Central and Northern regions of New Jersey, including Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Morris, Passaic, Sussex, Union and Warren Counties because of the greater likelihood of areas within these counties experiencing an unreliable water supply.

The system delivery test is not an aquifer test *per se* and is not designed to yield estimates of all aquifer properties. It cannot guarantee that the well will deliver sufficient water when groundwater levels are lower than normal, such as during a drought. The system delivery test does, however, serve as a surrogate to indicate the likelihood that the well being tested will reliably produce water under normal conditions to fulfill its intended purpose for the population to be served.

Questions regarding the system delivery test may be directed to the Bureau of Safe Drinking Water Technical Assistance at 609-292-5550, or by correspondence to New Jersey Department of Environmental Protection (NJDEP), Bureau of Safe Drinking Water Technical Assistance, 401 East State Street, P.O. Box 420, Trenton, NJ 08625-0420.

[1] A nontransient noncommunity water system constructed after August 21, 2000.

[2] A nontransient noncommunity water system means a public water system that is not a public community water system and that regularly serves at least 25 of the same persons, at least 4 hours per day, at least 4 days each week and is in operation for more than six months in any given calendar year.

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Section I: Definitions

"Average Daily Water Demand" means the volume of water that is needed by a water system to effectively serve drinking water to the persons of an establishment on a daily basis.

"Constant head test" means a test of a potable well where it is pumped at a rate of Q_{cht} or greater to evaluate the drawdown within the well. The pumping rate is adjusted to a rate which results in no change in water level. If water levels stabilize (defined as a change in water level of less than 6 inches per hour for 2 successive hours) within 24 hours, then the well passes this test. The constant head test begins immediately at the end of the peak demand test.

"Drawdown" means the difference measured in feet between the static and dynamic water levels.

"Dynamic water level" means the level of water in the well during the pump test.

"Gallons per day (gpd)" means gallons per day.

"Gallons per minute (gpm)" means gallons per minute.

"N_{fix}" means the number of water demand fixtures in the facility and the estimated flow rate at each fixture.

"Nontransient noncommunity water system" means a public water system that is not a public community water system and that regularly serves at least 25 of the same persons, at least 4 hours per day, at least 4 days each week and is in operation for more than six months in any given calendar year.

"Peak Water Demand" means the maximum amount of water to be utilized by a water system during specific intervals.

"Peak demand test" means a test where the well is pumped at the rate Q_{peak} for the time T_{peak}. The test rate and test time are based on the anticipated water demand during a peak demand time, with safety-factors added. If the well and pump can deliver the test rate throughout the test time, the well passes this part.

"Peak Demand Time" means the period of time that a water system uses its peak water demand.

"Q_{cht}" is the rate at which the well is pumped during the constant head test. This is defined as $3(V_{daily})/1440$. This rate is equivalent to three times the estimate daily demand. The factor 3 is used in this calculation as a safety factor as directed by N.J.A.C. 7:10-12.6(b)2. The factor 1440

(minutes) is a conversion factor and equivalent to 24 hours. This rate is expressed in gallons per minute.

"Q_{fix}" is the flow rate of water demand fixtures, and it can be assumed that Q_{fix} is equal to 3 gpm (unless documentation is submitted to show otherwise).

"Q_{peak}" is the rate at which water will be delivered during the peak demand time. It is generally N_{fix} (the number of fixtures) multiplied by Q_{fix} (flow rate from the fixtures). However, Q_{peak} cannot be greater than Q_{pump}, the rate at which the pump can deliver water. This rate is expressed in gallons per minute.

"Q_{pump}" means the final pump capacity and is the maximum rate at which the permanent pump will produce water at adequate pressure. This rate is expressed in gallons per minute.

"Recovery" means the difference in feet between the post test static water level and the dynamic water level. The recovery test measures how water levels in the aquifer rise immediately after the end of the constant head test. If the levels recover 90% of the maximum drawdown observed during the previous two tests after 24 hours (or less) of no pumping, then the well passes this part.

"Reliable yield" means that maintainable yield of water from a ground water source(s) which is available continuously during projected future conditions without creating either undesirable water quality and/or well construction effects as determined by the Department.

"Static water level" means the level of water in the well before the pump test.

"System delivery test" means an indicator test of certain aquifer's characteristics and a test of the permanent pump and installed water-delivery system.

"V_{daily}" means the total daily water demand based on the type and size of the facility as calculated by using the NJ Safe Drinking Water Act Regulations at N.J.A.C. 7:10-12.6. This volume is expressed in gallons per day (or gpd).

"V_{peak}" means the volume of water needed during each peak demand period expressed in gallons.

"T_{peak}" is the duration of the peak demand period in minutes. It is defined as $3(V_{peak})/Q_{peak}$. A factor of 3 is used in this calculation as a safety factor as directed by N.J.A.C. 7:10-12.6(b)2.

"Water demand fixture" is a device which is part of a system to deliver water, such as a faucet, spigot, toilet, water fountain, shower head or other similar device.

Section II: The System Delivery Test

The goal of the "system delivery test" is to ensure that the pump and well can meet peak demands and that the aquifer can supply the average daily demand on a sustained basis, and meet the technical capacity requirements of the Technical, Managerial, and Financial (TMF) Capacity approval.

The system delivery test is a test of the aquifer's characteristics and a test of the permanent pump and installed water-delivery system. This test mimics the anticipated water demand during a water system's peak demand time. It also evaluates the aquifer's ability to supply water.

Before performing the system delivery tests, the water system owner/operator needs to determine basic system demands by utilizing the steps outlined in Table A.

Once the water system owner/operator completes the "Define Basic System Demands" steps, proceed with determining the type of system delivery test to perform.

Two paths to passing the system deliver test

The system delivery test has two paths:

- **The Pre-Built Path and;**
- **The As-Built Path**

The first path, the 'pre-built path,' is used when a permanent pump has not yet been installed in the well. This means that the well driller installs a temporary pump and withdraws water at variable rates while accurately measuring the pumping rate and water levels in the well.

The second path, the 'as-built path,' is used when a permanent pump has been installed in the well. In this case, the pump cannot deliver water at a variable rate the user can control. Additionally it may not be possible to measure the water level in this well. These limitations mean that the ability of the aquifer to deliver water cannot be fully evaluated by conventional methods. Instead the as-built path tests the well on five successive days and assumes that if it delivers the water every day over 5 days it can do so reliably over a longer period of time.

Please see Appendix A of this document for a flow chart of the system delivery test procedures.

Table A: Steps to Define Basic System Demands

Step	Description	Comment
A.1.	Calculate the average daily water demand of the facility. This is defined as V_{daily} (gpd).	Use the table in Appendix B to estimate V_{daily} based on type and size (projected population) of facility. Note: V_{daily} must be less than either 50,000 gpd (if the well is in the Highlands) or 100,000 gpd (if the well is outside the Highlands). If V_{daily} is greater, then the water system must apply for a water allocation permit from the Bureau of Water Allocation.
A.2.	Define the pump capacity as Q_{pump} (gpm).	The pump capacity (Q_{pump}) is the maximum rate at which final installed pump can supply water to the establishment's plumbing system.
A.3.	Estimate volume of water needed during the duration of peak demand. This volume is defined as V_{peak} (gal).	V_{peak} is a function of the type of establishment. For example, for a restaurant with 2 peak demand times, V_{peak} may be equal to $V_{daily}/2$. For a day school with a constant demand during the day, V_{peak} may be equal to V_{daily}. The water system owner should determine, and justify, reasonable values of V_{daily}. As a conservative approach, V_{peak} may be taken to be equal to V_{daily}.
A.4.	Determine the number of fixtures in the building and flow rate at each fixture. Define N_{fix} as number of fixtures and Q_{fix} as flow rate (gpm) from each fixture	Assume that Q_{fix} is equal to 3 gpm unless other documentation is submitted.
A.5.	Estimate the rate at which water will be delivered during the peak demand time. This is defined as Q_{peak} (gpm) where Q_{peak} is the smaller of two values, the number of fixtures times the fixture water-delivery rate or the pump capacity. Q_{peak} = minimum (N_{fix} x Q_{fix}, Q_{pump})	During the peak demand period it is assumed that water will be delivered from all of the fixtures in the establishment. If not all fixtures deliver water at the same rate, then Q_{peak} is the sum of the flow rates from each individual fixture. It is not practical to require a pumping rate greater than the capacity of the installed pump. For facilities with a relatively large number of fixtures, the pump capacity may be less than number of fixtures multiplied by the fixture flow rate. In these cases, the pump capacity is assumed to be the water delivery rate during peak demand times. It is not expected that during actual operation of the facility all fixtures will be running at the same time. However, this assumption results in a more rigorous test of the system with a greater assurance that the well and pump will be able to meet demands.
A.6.	Define the duration of the peak demand as T_{peak} (min), where $T_{peak} = 3(V_{peak})/Q_{peak}$	The volume of water needed is tripled as a safety factor as specified at N.J.A.C. 7:10-12.6(b)2.

The Pre-Built Path

The pre-built path consists of three tests done while a temporary, variable-speed pump is installed in the well, followed by a test after final construction. The initial three tests are a peak demand test, a constant head test and a recovery test. The well must allow direct measurements of water level during the first three tests if the well passes all three of these tests, then it is likely the aquifer can supply the requested volume of water during normal operating conditions. Once the facility is built and a permanent pump is installed in the well, a modified peak demand test is performed to make sure that the installed pump can supply the water demand. The modified peak demand test is the same as the peak demand test except that water level measurements in the well are not required.

The Bureau of Safe Drinking Water Technical Assistance strongly encourages water system owners to plan ahead and take the pre-built path. The pre-built path provides greater assurance that the well can reliably deliver the needed volume of water, and avoid potential problems associated with following the as-built path, such as introducing well contamination, possible damage to well pumping equipment, and the possibility of not properly measuring the constant head and/or well recovery.

Table B: Steps to Complete the Pre-Built Path

Step	Description	Comment
B.1.	Conduct a peak demand test (see Table C below).	If the well passes, go to step B.2. If not, then well must be altered to produce more water, or demand for water decreased. Repeat this process and the peak demand test until the well passes, then go to step B.2.
B.2.	Conduct a constant head test immediately after the peak demand test (see Table D below).	If the well passes, go to step B.3. If not, then well must be altered to produce more water, or demand for water decreased. If well is altered, return to step B.1.
B.3.	Conduct a recover test immediately after the constant head test (see Table E below).	If the well passes, then go to step B.4. If not, then well must be altered to produce more water, or demand for water decreased. If well is altered, return to step B.1.
B.4.	Install the final pump in the well and the plumbing in the system.	
B.5.	Conduct a modified peak demand test	If the well passes, it has passed the system deliver test. If not, either install a different pump or alter the demand for water, and then repeat this step until the well passes.

Table C: Steps to Complete the Peak Demand Test

During the peak demand period assume that all fixtures are supplying water at the same time. If this it not a reasonable assumption, provide documentation justifying the use of a lower number of fixtures operating simultaneously during the peak demand period.

Step	Description	Comment
C.1	Conduct the peak demand pump test by pumping the well at Q_{peak} for a duration of T_{peak}.	The well must not have been pumped for at least 24 hours before the peak demand test starts. (This step is not required for the 5-day sequence of tests for the as-built path). Measure water level in the well at the beginning and end of the peak demand test and at 10 minute intervals (or more frequently) throughout the test. The water level at the beginning of the test, just before pumping begins, is called the static water level. (This step is not required for the modified peak demand test.) Measure discharge volume.
C.2	**Peak Demand Test Evaluation:**	If the well and pump system can be pumped at a rate of Q_{peak} for a duration of T_{peak}, then the system passes the peak demand pump test portion of the system delivery test.

Perform the "Constant Head Test" by using the following steps:

Table D: Steps to Complete the Constant Head Test

Step	Description	Comment
D.1	Define the pumping rate during the constant head test at Q_{cht} (gpm), where $Q_{cht} = 3(V_{daily}) /1440$	Q_{cht} is equivalent to the rate at which the aquifer must supply water to the well, over a 24-hour period, to produce enough water to meet the facility's average daily water demand. The volume of water needed is tripled as a safety factor as specified at N.J.A.C. 7:10-12.6(b)2.
D.2	Pump the well at rate equal to or greater than Q_{cht} until the water level in the well stabilizes.	Begin the constant head test immediately after finishing the peak demand test. Measure water level in the well at the end of the peak demand test and at 10 minute intervals (or more frequently) throughout the constant head test. The discharge volume must not vary by more than 10% during the final two hours of the test. Water-level stabilization is defined as when water level in the well changes by 6 inches (0.5 feet) or less an hour for two consecutive hours.
D.3	**Constant Head Test Evaluation:**	If water level in the well stabilizes (to 90% of the static water level) within 24 hours, then the well passes the constant head test.

Perform the “Recovery Test” by using the following steps:

Table E: Steps to Complete the Recovery Test

Step	Description	Comment
E.1	Conduct the recovery test by observing water level rise in the well for 24 hours after the pump is turned off.	Begin the recovery test immediately after finishing the constant head test. Do not pump the well during the recovery test. Measure water level in the well at the beginning and end of the constant head test and at 30 minute intervals (or more frequently) throughout the test.

The As-Built Path

This test assumes the well already has a permanent pump installed and it may not be practical to withdraw this pump and install a variable-speed pump. This test also assumes that it will be difficult, or impossible is some cases, to measure water levels in the well while the permanent pump is operating. A pre-built system delivery test may be performed by the water system owner to complete the technical capacity requirements of the TMF application, however, it is not recommended due to the possibility of well contamination, possible damage to well pumping equipment, and the possibility of not properly measuring the constant head and/or well recovery.

If the pump has been delivering a volume of water smaller than that projected to be needed for the system to meet the average daily water demand, or has not been in use for more than a year, or has not been used before, then the as-built path requires a modified peak demand test on five successive days. The modified peak demand test is the same as the peak demand test except that water level measurements in the well are not required. Further, on each day of the five day test there must be as many *modified peak demand tests* as *projected peak demands periods* for the new use. For example, if a restaurant is projected to have two peak demand periods each day, then there must be two peak demand tests on each of the five days. If the well and pump successfully produce an adequate volume of water on each day then it passes the system delivery test.

Begin the As-Built Path with the water system owner/operator making an evaluation to "Define Basic System Demands" by following the steps outlined in Table A:

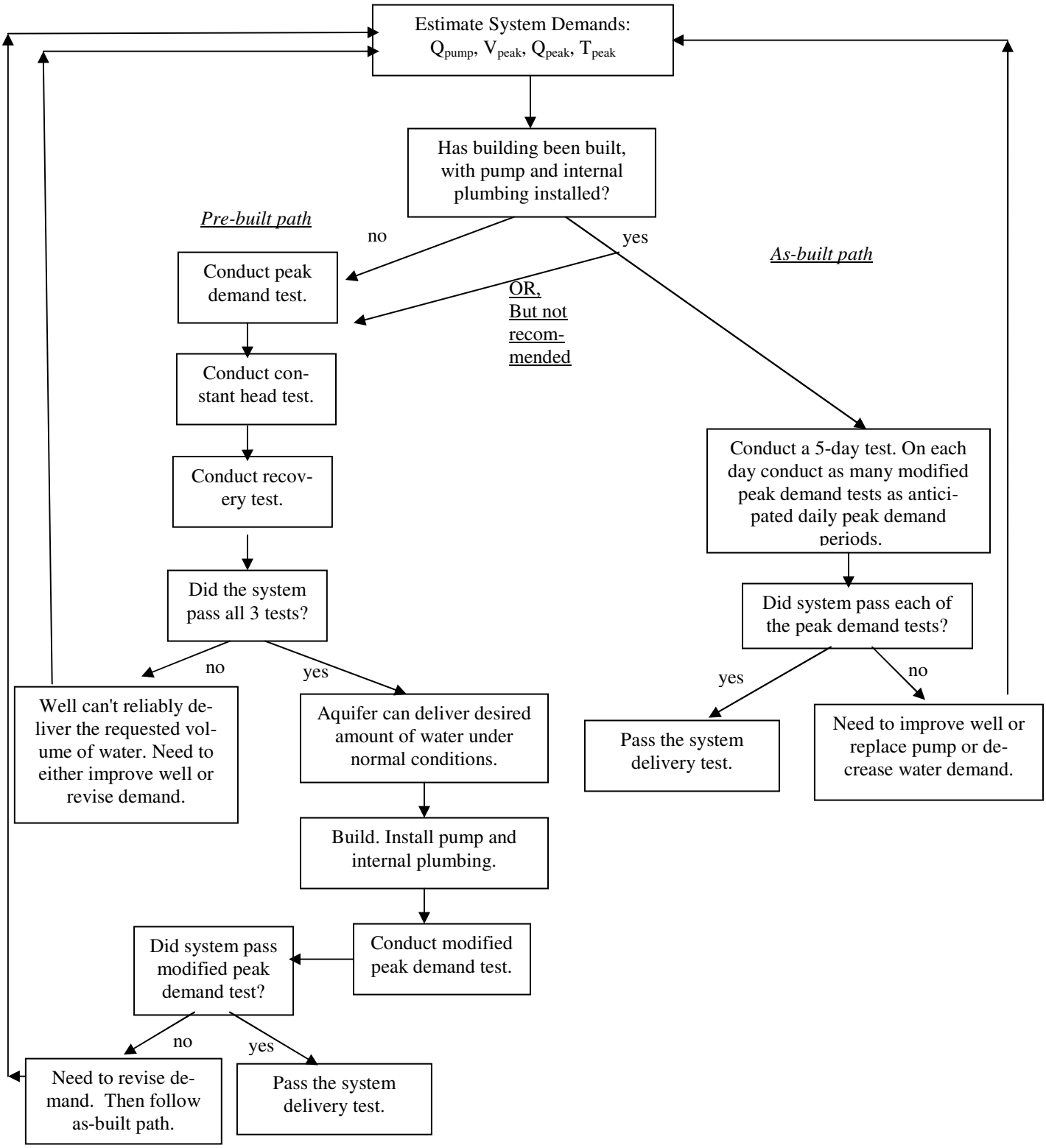
Once the applicant completes "Define Basic System Demands" steps, proceed with the "Steps to complete As-Built Path**"** as outlined in Table F.

Table F: Steps to complete As-Built Path

Step	Description	Comment
F.1.	Day 1. Conduct modified peak demand test. (see Table C above)	Conduct as many modified peak demand tests as there are estimated peak demand periods for the facility. If well supplies the desired volume of water go to step F.2. If the well cannot supply enough water, then revise the water demand or replace pump or redevelop well and then repeat step F.1.
F.2.	Day 2. Conduct modified peak demand test.	Conduct as many modified peak demand tests as there are estimated peak demand periods for the facility. If well supplies the desired volume of water go to step F.3. If the well cannot supply enough water, revise the water demand, replace pump, or develop well and return to step F.1
F.3.	Day 3. Conduct modified peak demand test.	Conduct as many modified peak demand tests as there are estimated peak demand periods for the facility. If well supplies the desired volume of water go to step F.4. If the well cannot supply enough water, revise the water demand, replace pump, or develop well and return to step F.1
F.4.	Day 4. Conduct modified peak demand test.	Conduct as many modified peak demand tests as there are estimated peak demand periods for the facility. If well supplies the desired volume of water go to step F.5. If the well cannot supply enough water, revise the water demand, replace pump, or develop well and return to step F.1
F.5.	Day 5. Conduct modified peak demand test.	Conduct as many modified peak demand tests as there are estimated peak demand periods for the facility. If well supplies the desired volume of water on this fifth day of test then it passes the system delivery test. If the well cannot supply enough water, revise the water demand, replace pump, or develop well and return to step F.1

APPENDIX A

Flow Chart of System Delivery Test Procedures



APPENDIX B

AVERAGE DAILY WATER DEMAND FOR PUBLIC NONCOMMUNITY WATER SYSTEMS (Excerpt from N.J.A.C. 7:10A -12.6(b)2)

Type of Establishment	Gallons per Person
1. Cottage	100
2. Single family dwelling	100
3. Multiple family dwelling (apartment)	75
4. Rooming house	50
5. Boarding house*	75
a. For each nonresident boarder	15
6. Hotel*	50-75
7. Motel or tourist cabin	50-75
8. Mobile home park	100
9. Restaurant**	
a. Sanitary demand	5
b. Kitchen demand	5
c. Kitchen and sanitary demand	10
10. Camp***	
a. Barracks type	50
b. Cottage type	40
c. Day camp (no meals served)	15
11. Day school	
a. No cafeteria or showers	10
b. With cafeteria and no showers	15
c. With cafeteria and showers	20
d. With cafeteria, showers and laboratories	25
12. Boarding school*	100
13. Health care institution other than hospital	75-125
14. Hospital (depending on type)	150-250
15. Industrial facility (8 hour shift)	25
16. Picnic grounds or comfort station	
a. With toilet only	10
b. With toilet and showers	15
17. Swimming pool or bathhouse	10
18. Club house*	
a. For each resident member	60
b. For each nonresident member	25
19. Nursing home	150
20. Campground	
a. Without individual sewer hook-up	75 per site
b. With individual sewer hook-up	100 per site
c. With laundry facility and individual sewer hook-up	150 per site
21. Store, office building	0.125 gal/sq. ft
22. Self-service laundry	50 gal/wash

* Includes kitchen demand at 10 gallons per person per day. If laundry demand is anticipated, the estimated water demand shall be increased by 50 percent.

** Demand projections shall be calculated by multiplying the certified seating capacity of the establishment by the applicable water usage in gallons per person under 9a, b or c above, and by a factor of 1, 2, or 3 reflecting the hours of operation, as follows: one to six hours (1), seven to 12 hours (2), or more than 12 hours (3).

*** When the establishment will serve more than one use, the multiple use shall be considered in determining water demand.

APPENDIX C

Capacity Development Program – Two-Part Pump Test Form for New Non-Transient Non-Community Public Water Systems

System Name: _____

Public Water System Identification (PWS ID) Number (if assigned): _____

Date of Pump Test: _____

NOTE: Both pump tests must be performed during one continuous testing session.

Part I - Peak Demand Pump Test Requirements

Peak Water Demand/Pumping Rate:
Calculate Average Daily Demand (ADD) in accordance with NJAC 7:10-12.6(b) = _____ gpd
Divided by 1440min/day (or appropriate operational timeframe) = _____ gpm x 3 = _____

Peak Water Flow Rate (Maximum water flow rate through fixtures):

Determine # of fixtures _____ @ 3gpm per fixture = _____ gpm

Peak Demand Time (Length of peak use period in minutes):

$$\frac{\text{Peak Water Demand (gal)}}{\text{Peak Water Flow Rate (gpm)}} = \frac{\text{\_\_\_\_\_ gal}}{\text{gpm}} = \text{\_\_\_\_\_ minutes}$$

The well must be pumped at a minimum of _____ gpm (peak demand pumping rate) for _____ minutes (peak demand time) to demonstrate the ability to meet peak water demands.

Part II - Constant Head Pump Test Requirements

Calculate ADD Pumping Rate: _____gpd/1440min/day = _____gpm

Note: The well pumping capacity must meet or exceed the average daily demand pumping rate at a constant head condition to demonstrate the ability to meet the average daily demand.

The well must be pumped **at a minimum** of _____ gpm (average demand pumping rate) until a constant head condition is established to demonstrate the ability to meet average daily water demands.

Note: The Constant Head Pump Test can be performed at higher pumping rates to demonstrate a better well yield as long as a constant head condition can be established.

- Constant Head Condition exists when the pumping rate is held steady and the water level changes at a rate of less than 6 inches (0.5 ft.) per hour (minimum of two consecutive hours).
- A record of well yield (flow rate) and drawdown must be made at ½ hour intervals during the test.
- A record of water levels during the recovery period must also be made.
- Recovery Period: well recovers to at least 90% of static water level (prior to test) within 24 hours.