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TO: Division of Drinking Water Staff

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SUBJECT: Permits & Project Review – Design Capacity Evaluation of Waterworks

Delete: WM 534, 787 (section 20.04), 833

Summary Statement
The hydraulic capacity must be determined for all permitted waterworks. The evaluation is included in the Engineering Description Sheet for the Construction and Operation Permits.

1. Definition of Capacity
   A. Community Systems:
      The *Waterworks Regulations* define an Equivalent Residential Connection (ERC) as the amount of water used by one residential connection, equal to 400 gallons/day (gpd), unless supportive data indicates otherwise. (If flow usage figures are available and reliable, they may be used to define an ERC.)
      Capacity shall be expressed in both ERC and gpd for community waterworks. This gives the water purveyor an estimate of the number of structures that can be built before the design capacity is reached, when flow usage figures are not available. The ERC term shall be defined in terms easily understood by the permit holder – for example,
         1 mobile home connection = 300 gpd = 0.75 ERC
         1 residential connection = 400 gpd = 1 ERC
      If a community waterworks consists of a variety of users, then estimate the total gpd usage and divide by 400 gpd/ERC, to determine the ERC value.

   B. Noncommunity Systems:
      The Design Basis for waterworks with non-residential water use must also be clearly defined – for example:
         Factory A: 25 gpd / person / 8-hr shift
         Hospital B: 300 gpd / bed
         School C: 10 gpd/person (students + staff)
      Capacity for non-community waterworks shall be defined in terms of gpd and the measurement units appropriate to the use (persons, beds, seats, etc.)

2. Source
   A. Wells

Groundwater well source capacity is determined from the well yield test results and the well pump performance characteristics. The pump should be sized not to exceed the well yield test results. If the pump capacity is less than the well yield (which often occurs in coastal plain aquifers), then the pump capacity is the critical value in determining the source capacity.

General Exception to Yield Test Duration Requirements:
Waterworks Regulations § 12 VAC 5-590-840 B6 requires a yield and drawdown test to be conducted over 48 hours. This period may be reduced to 24 hours for community systems, provided that the following conditions are met:

1. Wells must be located in confined aquifers east of the Fall line.
2. Supplemental calculations must be submitted with data which project the maximum available drawdown, the corresponding well yield at the maximum available drawdown (based on pumping duration of 2880 minutes and 100,000 minutes), and the maximum predicted well yield. The maximum predicted well yield is limited to the more stringent of the following: 1) Twice the pump test rate for the 24-hour test or 2) 80% of available drawdown.
3. The specific capacities of the well at 500, 1000 and 1440 minutes must be within 10% of each other.

The Regulations allow Noncommunity systems to reduce the yield test to no less than 8 hours, if source capacity requirement is 3 gpm or less. The minimum 8 hr test duration should only be considered for Transient Noncommunity systems.

Nontransient Noncommunity systems such as schools and commercial areas that do not operate 24 hours a day may reduce the yield test to 24 hours (or 12 hours in the Coastal Plain), provided that the well drawdown reaches equilibrium during the reduced test period.

Yield Calculation:

- Community (multiple sources are required to serve > 49 connections)
  Q gpm (over a __hr test) / 0.5 gpm/ERC = ___ERC
  ___ ERC * 400 gpd/ERC = ___ gpd

  Systems serving > 49 residential connections must provide at least one additional well with a capacity of ≥ 20% of the total required capacity.

- Non-community
  Q gpm (over a __hr test) * 1440 min/day = ___ gpd
  ___gpd / ___gpd/person = ___ persons
  ___gpd / ___gpd/bed = ___ beds, etc.

B. Springs - Source Yield
 Q gpm (yield) * 1440 min/day = ___ gpd
community systems: ___ gpd / usage rate (gpd/ERC) = ___ ERC
noncommunity systems:
___ gpd / usage rate (gpd/person, gpd/bed, etc.) = ____ persons, beds, etc.

C. Pump Performance:
Critical capacity = Q gpm, as determined from the pump performance curve at the design head requirements, or for existing systems, by actual observed pump output.

D. Surface Water
1. Safe Yield
The *Regulations* refer to the safe yield of surface water reservoirs as the minimum daily withdrawal rate determined by the worst drought of record since 1930. For run-of-the-stream intakes, the safe yield is the 1Q30 flow, which is statistically a flow that occurs on average one day every 30 years.
2. Withdrawal Permits
Withdrawal restrictions are typically established through a Virginia Water Protection (VWP) permit, issued by the Virginia Department of Environmental Quality (DEQ). The permit is sometimes issued jointly by DEQ, the Virginia Marine Resources Commission, and the U.S. Army Corps of Engineers, and is referred to as a "Joint Permit". The VWP permit may restrict the withdrawal rate under certain conditions and times of the year, and may specify different maximum daily and maximum annual withdrawal rates. The details of the VWP permit restrictions must be included in the capacity evaluation of the surface water source.
3. Intake Pump Capacity
The intake pump capacity shall be determined with the largest pump out of service (the "firm" pump capacity). At least two pumps are required.
Q gpm * 1440 min/day = ___ gpd

3. Treatment
All major treatment units shall be evaluated for hydraulic capacity. Examples include:

Flocculation:
 Q gpm = Floc. Basin Volume (gal) * Detention Time (min)
 Q gpm * 1440 min/day = ___ gpd

Filtration:
 Q gpm = Surface loading rate (gpm/sf) * surface area (sf)
 Q gpm * 1440 min/day = ___gpd

Ion Exchange:
Hydraulic capacity: Q gpm = Surface loading rate (gpm/sf) * surface area (sf)
Loading rate: Grains of filter capacity / grains/gal of constituents = ___ gal treated prior to regeneration. A realistic regeneration frequency should be established.

Membrane Filter Capacity:
 Q gpm = permeate flow rate
 Q gpm * 1440 min/day = ___ gpd
If unfiltered water is blended with permeate, then this amount is added to Q to determine the total capacity.

4. Delivery
   A. Booster Pump Capacity (groundwater facilities using ground storage, and hydropneumatic storage)
      At least two pumps are required.
      Capacity is the combined pump capacity with all pumps in service.
      The required capacity must meet the *peak* hour demand.
      For small community systems (less than 1000 residential connections) the *peak* hour demand is Q (gpm) = 11.4 $N^{0.544}$, where N = ERC = number of residential connections.

      For noncommunity systems, the *peak* hour demand must be provided by the owner's engineer.

   B. Transfer Capacity (groundwater well pump and hydropneumatic tank; no booster pumps)
      Transfer capacity is the capacity of the well pump output over 1 hour.
      For example, a well source having a capacity of 44 gpm yields a transfer capacity of: (44 gpm * 60 min) = 2640 gal.
      If the *peak* hourly demand is 50 gpm, the required capacity is:
      *50 gpm * 60 min = 3000 gal. Therefore the transfer capacity is NOT adequate.*

   C. High Service Pump Capacity (surface water facilities), Distribution Booster Pump Capacity (serving separate pressure zone or consecutive waterworks)
      At least two pumps are required.
      Capacity is determined with the largest pump out of service (the "firm" pump capacity).
      Q gpm * 1440 min/day = ___ gpd
      Pumps designed for storage transfer and not diurnal demand should have a minimum capacity to meet maximum day demand of the downstream service area.

5. Effective Storage
   The *Waterworks Regulations* require a minimum effective storage of 200 gallons/ERC at minimum pressure (20 psi) and maximum daily water demand. Noncommunity systems are excepted from this minimum storage requirement, provided that sufficient delivery capacity is available to meet the peak hour demand (12 VAC 5-590-1250.A.).

   A. Atmospheric Tanks
      The definition for "total effective storage volume" in the *Regulations* is the volume available to store water in the distribution reservoir, measured as the difference between the reservoir's overflow elevation and the minimum water elevation. The minimum storage elevation is that elevation that can provide a minimum pressure of 20 psi to the highest elevation served (by gravity) within the reservoir's service area under maximum daily water demands. If additional volume is provided for fire flow, this volume can be counted as effective storage. Ground storage tanks that serve as reservoirs for booster pumps may have a minimum water elevation determined by pump controls.

   B. Pressure Tanks
      When a hydropneumatic tank is fed directly by a well (or wells), the effective storage volume is typically taken as one-third of the hydropneumatic tank gross volume. Effective storage can also be calculated directly from pump control settings.

When a hydropneumatic tank is fed from a ground storage tank, the total effective storage is the sum of the effective storage from the ground storage tank(s) and the hydropneumatic tank(s).

6. Example Calculations

A. Community System (groundwater)

A 40-home subdivision is served by a simple groundwater system consisting of one drilled well with a 48-hr test yield of 30 gpm, a 20 gpm submersible well pump, 20,000 gal atmospheric storage tank, two booster pumps with a combined capacity of 120 gpm, and a 5,000 gal hydropneumatic tank.

Design Basis: per Waterworks Regulations, one ERC = 400 gpd

1. Well Yield: 30 gpm / 0.5 gpm/ERC = 60 ERC
   60 ERC * 400 gpd/ERC = 24,000 gpd

   Well Pump Capacity: 20 gpm * 1440 min/day = 34,600 gpd

2. Booster Pump Capacity: combined capacity = 120 gpm
   Assigning $Q_{pk\ hr}$ = 120 gpm = 11.4 $N^{0.544}$
   Solving for N = ERC = 76
   76 ERC * 400 gpd/ERC = 30,400 gpd

3. Storage Tank Capacity: 20,000 gal + 5,000gal/3 = 21,700 gal
   21700 gal / 200 gal/ERC = 108 ERC
   108 ERC * 400 gpd/ERC = 43,300 gpd

Based on the calculations above, this waterworks is limited to a capacity of 24,000 gpd due to limited well yield. However, the number of connections shall not exceed 49 until an acceptable additional source is provided.

B. Nontransient-Noncommunity System

A school designed for 300 students and staff is served by a groundwater well with a reported yield test of 12 gpm, furnished with a 10 gpm submersible pump. One 2.0-ft diameter managanese greensand filter is supplied with sodium hypochlorite and permanganate feed systems. One 5,000 gal atmospheric storage tank, two booster pumps with a combined capacity of 30 gpm, and one 5,000 gal hydropneumatic tank are also provided.

Design Basis: per Waterworks Regulations, the average annual water demand of one student/staff is 16 gpd.
The peak hour demand is estimated as follows:

Estimated PF = (4)(24hrs/day/8hrs/day operation) = 12
(12) (300 persons)(16 gpd/person) = 57,600 gpd
57,600 gpd (1 hr) / 24 hr/day = 2,400 gal

{It would be preferable to get this value from the engineer (by fixture count estimates) rather than computing with peaking factor (PF) assumptions}.

1. Well Yield: 12 pm * 1440 min/day = 17,280 gpd
   Well Pump Capacity: 10 gpm * 1440 min/day = 14,400 gpd

2. Greensand Filter Capacity: (**π** * 4) sf * 3 gpm/sf = 9.42 gpm
   9.42 gpm * 1440 min/day = 13,600 gpd

   Chemical Feed Systems should be verified for feed capacity. (Do not include in Engineering Description Sheet).

3. Booster Pump Capacity: combined pump capacity = 30 gpm
   30 gpm * 1440 min/day = 43,200 gpd

4. Storage Tank Capacity: 5,000 gal + 5,000 gal/3 = 6,670 gal
   Noncommunity systems are excepted from this requirement, provided that delivery capacity is adequate to meet peak hour demand. A recommended storage capacity is one-half day's usage.

Estimated delivery capacity during 1 hour (including pressure storage):
Booster pumps = (43,200 gpd / 24 hr/day)(1 hr) = 1,800 gal
Hydro Tank = 5,000 gal/3= 1,700 gal
Total = 3,500 gal

Peak hour demand = 2,400 gal < 3,500 gal provided with storage

Based on the limiting value above, this waterworks is limited to a capacity of 13,600 gpd, and is adequate for the design capacity of 300 students and staff.