LINCOLN AD HOC WATER COMMITTEE
MEETING MINUTES
OCTOBER 1, 2020 – 3:00PM
LINCOLN TOWN HALL - 148 MAIN STREET, LINCOLN, NH

APPROVED

Water Committee Members Present: Selectman, OJ Robinson, Town Manager Burbank, Paul Beaudin, Joe Conn, and Fire Chief Ron Beard
Town Staff Present: Town Planner, Carole Bont
Water Committee Members Present via Zoom: DPW Director, Nate Hadaway, Water Plant Operator, Dave Beaudin, Water Plant Operator, Zachary Vigneault, Renee Blood, Ken Mack, Cynthia Lloyd, Jay Scambio, and Selectman Tamra Ham
Weston & Sampson Engineers present via Zoom: Jeff Provost, Project Engineer, Sam Kenney, Senior Project Engineer, and Jeffrey McClure, P.E., Senior Associate

I. CALL TO ORDER

Chairman Robinson called the meeting to order at 3:00 p.m.

II. REVIEW AND APPROVAL- MINUTES OF THE PREVIOUS MEETING

Chairman Robinson postponed the approval of the meeting minutes until later on in the meeting.

MOTION: "To approve the meeting minutes of August 13, 2020 as presented."
Motion: Ron Beard **Second: Nate Hadaway** **Motion carries.**

III. WESTON & SAMPSON PRESENTATION

Sam Kenney (Weston & Sampson Senior Project Engineer) introduced Jeffrey McClure, Senior Associate, and Jeff Provost, Project Engineer for Weston & Sampson (WS) and opened up the presentation with a PowerPoint discussion *(see attached)*. Kenney explained that the town engaged WS to provide engineering services to evaluate the town's water storage tank capacity, and to provide a storage assessment for a future water storage tank (if needed). Kenney explained that there were three (3) main project goals: (1) assess storage capacity within the Main Pressure Zone (MPZ), (2) update hydraulic model, and, (3) examine three primary pressure zones and distribution system flow patterns. Kenney explained that there are three (3) storage types that are all relative to the storage assessment and based on elevation:

1. **Equalization Storage**: Provides domestic pressure (35 psi min.)
    - Buffer for peak demands
2. **Fire Storage**: Determined by ISO
    - Provides fire flow (20 psi min.)
3. **Emergency Storage**: Water main breaks, equipment failure, raw water contamination

Kenney noted several of the storage assessment conclusions as follows: (1) the *Storage Assessment Results* showed that each of the three (3) main pressure zones (Loon Village, Indian Head, & Main) have storage deficits, and the Main pressure zone has nearly reached its equalization storage requirement with only a 17,000-gallon surplus remaining *(see chart below)*.

Storage Assessment Results

Pressure Zone	Main (MG)	Loon Village (MG)	Indian Head (MG)
Equalization Requirement (25% of MDD)	0.214	0.119	0.036
Fire Flow Requirement*	0.63	0.54	0.30
Emergency Storage (Volume Equal to ADD)	0.45	0.25	0.075
Total Required Storage	1.29	0.909	0.411
Total Storage Available	1.00	0.500	0.146
Available Storage	0.294 deficit	0.409 deficit	0.265 deficit

*as required by ISO

(2) the most effective solution for the town's storage deficit is to construct new storage tanks in all three pressure zones to eliminate this condition and provide a storage surplus to the individual service areas for the foreseeable future which will entail high capital costs amongst other issues, and/or (3) explore other short-term alternatives such as the Hydraulic Model Update (town's water distribution system) which consists of multiple system improvements that can be explored to increase the effectiveness of the water system without the need to construct three (3) new storage tanks *(see below)*.

Hydraulic Model Update

Kenney reviewed potential water system improvements that the town could pursue to increase the available fire flows and pressures within the water system instead of increasing storage within each of the individual pressure zones:

1. Installation of a Pressure Reducing Valve (PRV) between the Loon Village and Main pressure zones.
2. Remove a portion of Crooked Mountain Road from the Main pressure zone.
3. Optimize available fire flow in Route 3 east of Rout 93, and in the Indian Head pressure zone.
4. Prioritize an increase in available storage within the primary pressure zones.

Improvement 1: Install a PRV between Loon Village and Main Pressure Zone

Kenney explained that the town could explore supplementing the Main pressure zone by installing a piped connection and pressure reducing valve (PRV) between Loon Village and the Main pressure zones which are currently not connected in this manner, and there is no mechanism for water stored within Loon Village to supplement the Main pressure zone during a fire flow event. Kenney further explained that the

installation of a PRV to connect theses pressure zones will allow the Loon tank to serve as additional storage for the Main pressure zone during fire flow and emergency events [note: this improvement option presents a relatively low-cost mechanism to increase storage availability].

Improvement 2: Remove a portion of Crooked Mountain Road from Main pressure zone

Kenney explained that the 1000-foot-high service elevation within the pressure zone occurs at approximately four (4) homes located on Crooked Mountain Road (adjacent to the intersection of Hemlock Drive). Hemlock Drive is currently the only location served by the South Peak pump station. This option would reduce the tank's lack of available surplus equalization storage in the Main pressure zone and allow fire flow to be available at Crooked Mountain Road (if the town wants to extend this domestic service further west from South Peak to include the Pemi Base Camp, a 4" water main may be required).

Improvement 3: Optimize available fire flow in Route3 east of Route 93 and in the Indian Head pressure zone

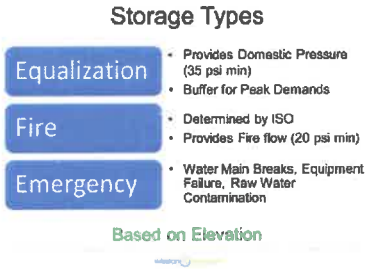
Kenney explained that WS examined the prioritization of storage, and feels that because Loon Village has the largest deficit out of all three pressure zones, and they would benefit most from the placement of a water storage tank. Kenney noted that geographically, the Loon Village system is closest to the core of the distribution system and not as geographically isolated as Indian Head, and could be linked to the main pressure zone with a PRV, and the water storage would be available to the Main pressure zone. Kenney further explained that after this, the prioritization of where the water tanks will go will be relative to where the town views the direction of future development.

Improvement 4: Prioritize an increase in available storage within the Primary Pressure Zones

Kenney explained that the most effective solution for the town to alleviate the storage deficit within all three (3) of the primary pressure zones is to construct new storage within these areas, however, this approach carries a high capital cost. Kenney recommended as an alternative method, the town could prioritize and sequence the construction of new storage tanks in the following pressure zones: (1) Loon Village, (2) Indian Head, and, (3) Main.

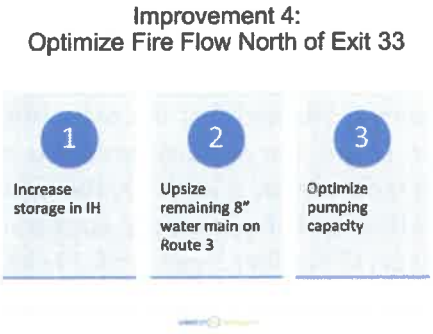
Kenney reviewed "next steps" and explained that the town's number one question is whether or not the town has the desire to increase storage at this time. Everything else will be contingent on how the town answers this question. They will then have to align the reports findings with the town's determined goals, as well as considering the town's available funding and Capital Improvement Plan.

There was a brief discussion on additional funding options that may be available to the town, and possible water tank locations. Chairman Robinson commented that back in 2006 there was an agreement for a mandated water tank to be built out of the South Peak project (Main Pressure Zone) and questioned how this would fit into the overall analysis currently being discussed. Town Manager Burbank clarified that as part of a Planning Board approval process back in 2006, it was determined that "eventually" a developer would have to put a tank in up at South Peak as properties were developed, and Burbank asked if a tank was put in now, if it would have an effect on the overall town's water system. Jeff McClure responded that it would have an effect and help, but it would take additional research on his part to determine exactly how much it would help. Kenney explained that 20 psi equates to approximately 40-feet of elevation and discussed the various types of storage with the committee. McClure explained that the number of homes in any given area are not what is important, but rather the elevation at which these homes are located (e.g., 975').



Paul Beaudin had two questions: (1) how would the installation of water meters save water when adding more water to the tanks, and, (2) and how would supplemented water sources for fire flow as outlined in the Got Big Water Report affect water storage. Chairman Robinson responded that this is off-topic from what the town requested of Weston & Sampson (although it was a good question). McClure responded that there was a specific scope of services that they were tasked with and provided to the town, however, if there are additional items that the town would like W&S to work on, they would be glad to work on these additional items as well.

The committee continued their discussion on optimizing fire flow in the area north of Exit 33, and the equalization of storage:



Jeff McClure discussed a model where there is no added water storage, but rather upsizing the 8" mains to 12" mains which would essentially improve the fire flow up to the Route 3 area, however, this would be a long stretch of water mains (up to the Indian Head). McClure felt that by adding the storage tank to this area to provide the additional fire flow, the upsizing of the water mains would not be a critical need.

Jeff Provost noted that it is important at this juncture to understand that the town has communicated that they feel like they are studying a study (and do not want any more studies), and looking to come up with alternatives which was beyond W&S initial scope of services. Provost explained that he wanted the committee to understand that there were many added value discussion points discussed today, however, they were not part of their original Scope of Services agreement, as W&S was tasked with providing a recommendation on *what the problem was* (where to put a storage tank, and, is there a storage deficiency).

There was a brief discussion about ISO (Insurance Services Organization) and fire protection and whether or not there currently are any real-life safety issues. Provost commented that as engineers, they do not make life safety determinations which would fall under the purview of the Fire Department.

Chairman Robinson questioned if they should add on to the Loon Village tank, or replace the tank with a larger tank? Provost responded that their intent was to add a second suitably sized tank at the same elevation so that the two tanks would work in conjunction with each other.

Jay Scambio commented on the broad requirements that are being put on the three (3) new hotels in town to fund adequate on-site water for fire suppression, yet according to the stats the town does have water. Scambio understands the elevated services that the town is also trying to address, but questioned if there is not a better way to use these funds, and focus more on the water storage aspect instead. Chief Beard responded that recent fire flow assessments from another engineering firm had determined that the town did not have adequate fire flow availability in the main pressure zone.

Town Manager Burbank commented that he spoke with Dave Edson of Hoyle Tanner a short while ago and he had a chance to review W&S's report and disagreed on the improvement list, although he did concur with their numbers which were relatively close. Burbank also noted that Town Engineer Ray Korber has also review W&S report and has submitted a written response to the same which Burbank said he would forward to the committee.

Chairman Robinson recommended that the committee determine their priorities, review the reports and discuss further at a later date. Robinson thanked Weston and Sampson for their presentation.

V. ADJOURNMENT

With no further business to attend to, the Committee made the following motion.

MOTION: "To adjourn."
Motion: OJ Robinson **Second: Paul Beaudin** **Motion Carries.**

The meeting adjourned at 4:30 p.m.

Respectfully Submitted,
Jane Leslie

Approval Date _1__/_7_/_2021_

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Chairman OJ Robinson

Weston & Sampson SM

transform your environment

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Town of Lincoln
Storage Assessment & Model Update

Board of Selectmen Presentation
October 1, 2020

Weston & Sampson

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Project Goals

- Assess Storage Capacity within the Main Pressure Zone (MPZ)
- Update Hydraulic Model
- Examine 3 primary pressure zones & distribution system flow patterns

Weston & Sampson

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Storage Types

Equalization

- Provides Domestic Pressure (35 psi min)
- Buffer for Peak Demands

Fire

- Determined by ISO
- Provides Fire flow (20 psi min)

Emergency

- Water Main Breaks, Equipment Failure, Raw Water Contamination

Based on Elevation

Weston & Sampson

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Storage Volume by Pressure Zone

Equalization	✓ MPZ ✓ LV ✓ IH
Fire	✓ MPZ × LV × IH
Emergency	× MPZ × LV × IH

Weston & Sampson

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Storage Assessment Results

Pressure Zone	Main (MG)	Loon Village (MG)	Indian Head (MG)
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Weston & Sampson

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Storage Assessment Conclusions

- Town has a storage deficit in all three major pressure zones
- Direct solution = add more storage
  - High capital cost, land availability, & water quality
- Short-term alternatives?

Weston & Sampson

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Hydraulic Model Update

Verify infrastructure & equipment

Confirm Calibration

Set modeling scenarios and parameters

Run EPS to examine impacts of modeling scenarios over time

Weston & Sampson

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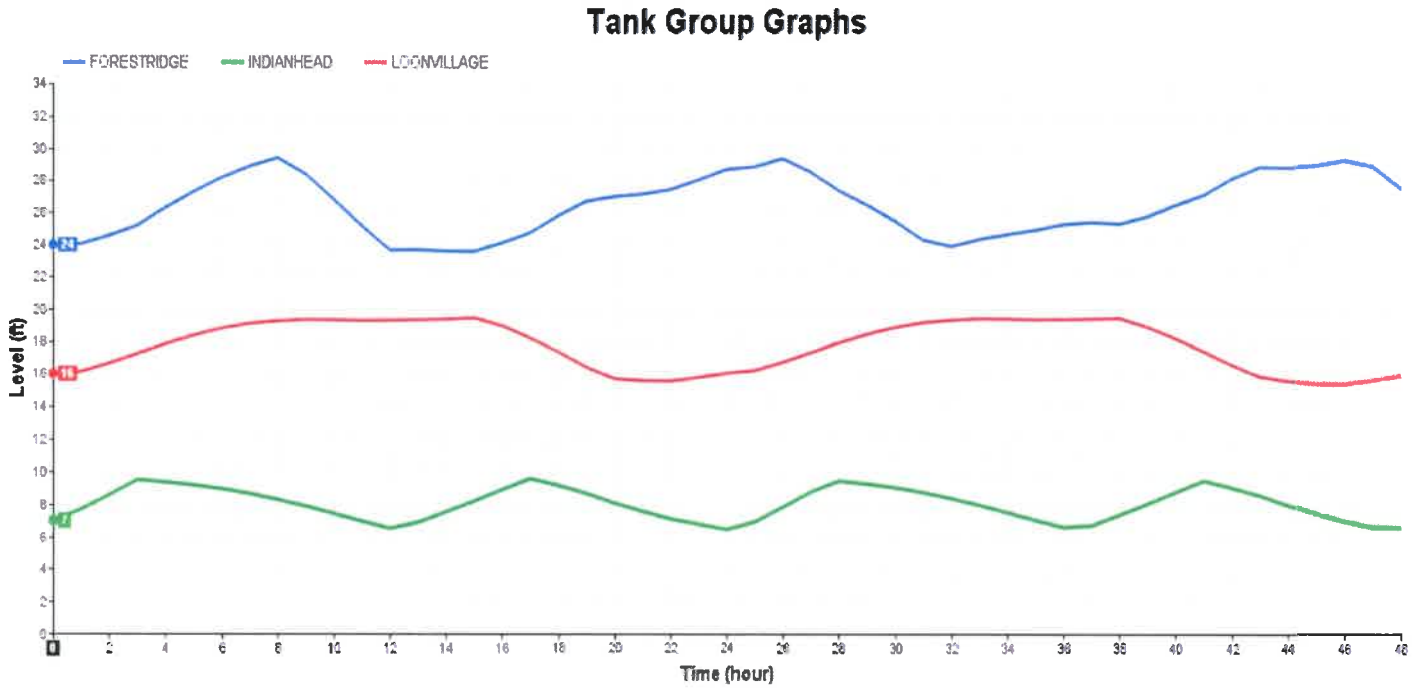
Modeled Improvements & Alternatives

- PRV from Loon Village to MPZ
- Remove Crooked Mountain Road from MPZ
- Prioritize & Sequence Storage Installation
- Optimize flow on Route 3/Indian Head

Weston & Sampson

Existing Conditions



Storage Tank Levels under 48-hour EPS at Maximum Day Demand

Weston & Sampson

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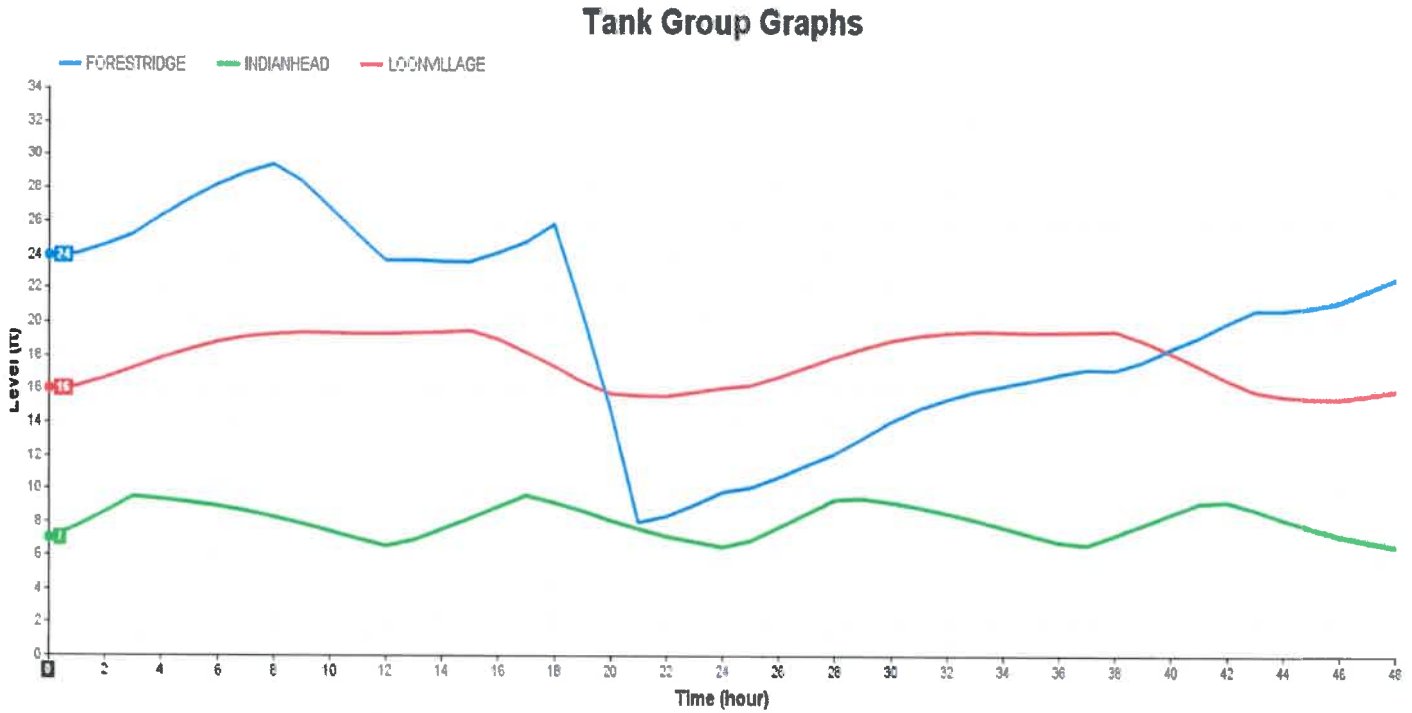
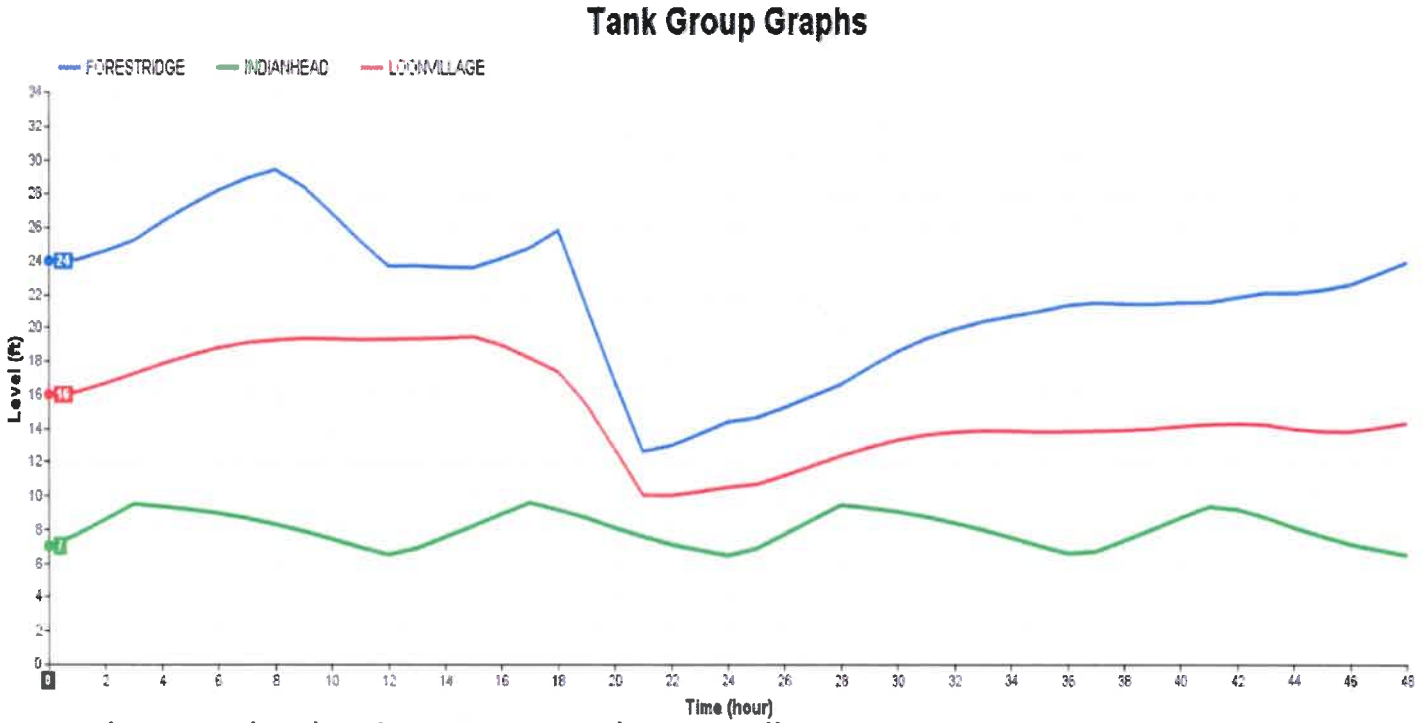
Existing Conditions – MPZ Fire Flow



Fire Flow at School St & Main St – Existing Conditions

Weston & Sampson

Improvement 1:
PRV from Loon Village to MPZ



Fire Flow at School St & Main St – with Loon Village PRV

Weston & Sampson

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Improvement 2:
Remove Crooked Mountain Road from MPZ

- 4 homes
- Domestic water service from South Peak
- Fire flow from MPZ (maintain 12" main on MPZ)
- Entire tank volume classified as equalization storage in MPZ

Weston & Sampson

Improvement 3:
Prioritize Storage Improvements

- Loon Village
  - Largest deficit
  - Additional PRV to MPZ
  - Geographic location to water system
- Indian Head
  - Strengthen the system extremities
  - PRV to MPZ
- Main
  - WTP Clearwell
  - Supplement from LV & IH

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Improvement 4: Optimize Fire Flow North of Exit 33

1. Increase storage in IH
2. Upsize remaining 8" water main on Route 3
3. Optimize pumping capacity

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Next Steps

- Storage increase vs. no storage increase
- Align report findings with Town's goals
- Finalize improvement alternatives
- CIP & Maximize NBRC Funding

Weston & Sampson

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thank you

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Weston & Sampson

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Weston & Sampson

100 International Drive, Suite 152, Portsmouth, NH 03801
Tel: 603.431.3937

September 18, 2020

Mr. Butch Burbank
Town Manager
Town Hall
148 Main Street
Lincoln, NH 03251

Re: **Water Storage Tank Storage Assessment & Model Update**

Dear Mr. Burbank:

The Town of Lincoln has engaged Weston & Sampson to provide engineering services to evaluate the town's water storage tank capacity and to provide a storage assessment for a future water storage tank, if warranted. We are pleased to provide guidance in management of the storage tanks while addressing hydraulic restrictions and storage availability throughout the distribution system within this report.

Existing Water Storage Facilities

The town currently maintains three water storage facilities within the existing water distribution system. The distribution system contains three primary pressure zones, with each tank located within a different pressure zone. The Pollard tank is located in the town's Main Pressure Zone adjacent to Main Street, the Loon tank is located in the northeast adjacent to Loon Mountain and the Kancamagus Highway in the Loon Village Pressure Zone, while the Indian Head tank is located at the northwest extent of the distribution system adjacent to Route 3 in the Indian Head Pressure Zone. The town also maintains small localized pressure zones including the South Peak pressure zone and the Landing pressure zone; however, these areas are geographically small and do not contain water storage facilities. The primary focus of this report is to address concerns regarding the availability of fire flow in the main pressure zone. A summary of the existing water storage facilities including their dimensions and storage volumes are listed in the table below.

Table 1: Existing Water Storage Facilities

Facility Name	Pollard	Loon	Indian Head
Pressure Zone	Main	Loon Village	Indian Head
Diameter (feet)	75	65	65 x 30*
Height (feet)	30	20	10
Nominal Storage Volume (gallons)	1,000,000	500,000	146,000
Approx. Storage Volume/Foot	33,050	24,840	14,600
Base Elevation (feet)	1058	1246	1256
Overflow Elevation (feet)	1088	1266	1266

*Indian Head Tank is rectangular in shape

Water System Demand

Based on prior water demand data and discussions with town staff, the average day demand (ADD) is approximately 0.75 million gallons per day (MGD) and the maximum day demand (MDD) is approximately 1.3 MGD. The town believes water demands have been relatively stable over the past several years. The total water system demand is split at an approximately 58/32/10% distribution between the Main/Loon Village/Indian Head pressure zones, respectively, as determined in past water system reports and confirmed by water personnel.

The 2019 water system usage data received from the town indicates that the average day demand is 0.67 MGD with a maximum day demand of 1.1 MGD. The distribution of this demand between pressure zones is indicated in the table below. Demand for the Main Pressure Zone was determined by subtracting the volume pumped into the Loon Village and Indian Head pressure zones from the total water production records for the distribution system.

Table 2: 2019 Water System Demands

Pressure Zone	Average Day Demand (mgd)	Maximum Day Demand (mgd)	% of Total Distribution System ADD
Main	0.390	0.649*	58.2%
Loon Village	0.211	0.347	31.5%
Indian Head	0.069	0.158	10.3%
Total (2019)	**0.670**	**1.116***	**100%**

*Maximum day demand of water system occurred in July 2019. Main Pressure Zone MDD calculated based on 58.2% of system MDD

An observed peaking factor of 1.7 was observed in the 2019 demand data (calculated as the ratio of MDD divided by ADD). However, prior reports have indicated a peaking factor as high as 1.9 for the town's water system. To provide contingency in the storage assessment a peaking factor of 1.9 MGD was used in the calculations provided in the evaluation. Additionally, a water system ADD of approximately 0.75 MGD and a MDD of 1.3 MGD were used for the storage calculations within this report as these values are reflected within an analysis of distribution system usage between 2011 – 2017 conducted by Hoyle, Tanner & Associates and provide a more conservative calculation than using lower ADD and MDD values.

Water System Storage Requirements

The DES Drinking Water and Groundwater Bureau promulgates New Hampshire state regulations regarding water distribution system and source requirements as specified in the Drinking Water Protection Program published rules in sections Env-Dw 300 (source water rules), 400 (public water system classification and design), 500 (operation and maintenance) and 700 (water quality). DES also specifies general water distribution and supply design criteria and considerations in the Standards of the Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers (Ten States' Standards).

Ten States' Standards - Recommended Standards for Water Works, states that "The system shall be designed to maintain a minimum pressure of 20 pounds per square inch (psi) at ground level at all points in the distribution system". This pressure is equivalent to 46 feet in elevation and will permit water to overcome the frictional resistance of house plumbing and rise to a height equivalent of about a three-story building. Under all conditions of flow, the normal working pressure in the distribution system should be approximately 60 to 80 psi and not less than 35 psi.

Typically, average day and maximum day water demands are satisfied by the pumping capacity of the water supply facilities and peak hour and fire flow requirements are satisfied by distribution system storage. Equalization, fire, and emergency storage are typically allocated at specific levels within a storage facility to ensure the storage volume will be available at a hydraulic gradient adequate for the intended purpose. Equalization storage is provided within the top portion of the tank with fire storage positioned immediately below. Emergency storage is located in the lowest portion of the tank.

The quantity of system storage has been calculated using the methodologies outlined in the American Water Works Association (AWWA) M32 Manual for Water Supply Practices - Distribution Network Analysis for Water Utilities. Calculation of the available storage was determined by the elevation of the highest house in the town's distribution system and the storage tanks' ability to provide minimum pressures as described below to that house.

Equalization Storage

AWWA Manual M32 states that equalization storage makes up 20 to 25 percent of the average day demand, although these percentages are guidelines and are not recommended as design criteria. While equalization storage of 25 percent of the average day demand is acceptable for communities with large total water use and significant commercial and industrial demands, Weston & Sampson recommends a that a small, primarily residential community such as the town's distribution system provide an additional equalization storage buffer of at least 25-percent of the maximum day demand for the area served by the tank. This will provide additional storage for the peak demands that arise from uses such as lawn irrigation, pool filling, influx of the ski population on weekends, etc.

The maximum day demand for the town's system is approximately 1.3 MGD under current demand conditions. The town has three different pressure zones that have individual storage requirements based on hydraulic restrictions within each zone. When a factor of 25-percent is applied, the current volume required for equalization storage at the Pollard tank within the Main Pressure Zone is 0.214 MG, the Loon tank in the Loon Village pressure zone is approximately 0.119 MG and the Indian Head tank is approximately 0.036 MG. According to Ten States' Standards, a minimum pressure of 35 psi (81 feet) should be provided to customers under normal demand conditions. Therefore, only the volume of water within each tank that will provide a pressure of 35 psi to the highest house elevation within its service area can be considered usable as equalization storage. Please see the tables below for more detail and a tabular view of this information.

Fire Storage

The Insurance Services Office (ISO) recommends that municipalities maintain a minimum pressure of 20 psi in the distribution system at all times during a fire flow event. The ISO has also established recommended time duration requirements during which the needed fire flow should be maintained. In general fire flows up to 2,500 gpm should be available for two hours, while fire flows greater than 2,500 gpm should be maintained for three hours or more depending on the flow. Any fire flow requirement above 3,500 gpm is the responsibility of the property owner of the establishment although a municipality could decide to provide additional fire flow capacity beyond 3,500 gpm to attract more business development, for instance.

Usable fire storage is defined as the amount of water within a storage tank that will provide a pressure of 20 psi (46 feet) to the highest house elevation in each service area system. The town's most recent ISO report from 2007 determined the following ISO maximum fire flow requirements within each service area. The list below outlines these requirements as well as the required fire storage within each service area:

- Main Pressure Zone: 3,500 gpm at a duration of 3 hours, minimum volume of 0.63 MG
- Loon Village Pressure Zone: 3,000 gpm at a duration of 3 hours, minimum volume of 0.54 MG
- Indian Head Pressure Zone: 2,500 gpm at a duration of 2 hours, minimum volume of 0.30 MG

Emergency Storage

Any storage provided within a tank below the elevation required to maintain the 20-psi pressure for fire storage is considered emergency storage, and would be used to supply water during water main breaks, equipment failures, or raw water contamination events. The water volume required is a function of risk and the desired system dependability with respect to an interruption of supply. Typically, up to 2 days of average day demand may be recommended for a system without emergency power generation at their wells or water treatment plant and no additional supply via an interconnection with a surrounding community. As backup power is available at the town's water treatment plant and primary booster pumping facilities, one day of average day demand will be used for calculating the emergency storage requirement within each service area for the purposes of this report. The town may choose to reduce or increase this assumption based on desired water system level of service and costs.

Within the main pressure zone, a volume of 0.45 MG is required at the Pollard tank for emergency storage, Loon tank within Loon Village requires a volume of 0.25 MG for emergency storage, and the Indian Head tank in the Indian Head pressure zone requires 0.075 MG of emergency storage.

Storage Assessment

According to the storage volume requirements discussed above, the town's distribution system is shown to have a storage deficit within all three pressure zones under the current water system demands. The table below shows the results of the evaluation based on the individual water system demands within each pressure zone. Each pressure zone is further analyzed on the following pages.

Table 3: Current Water Distribution System Storage Requirements

Pressure Zone	Main (MG)	Loon Village (MG)	Indian Head (MG)
Equalization Requirement (25% of MDD)	0.214	0.119	0.036
Fire Flow Requirement*	0.63	0.54	0.30
Emergency Storage (Volume Equal to ADD)	0.45	0.25	0.075
Total Required Storage	1.29	0.909	0.411
Total Storage Available	1.00	0.500	0.146
Available Storage	0.294 deficit	0.409 deficit	0.265 deficit

*as required by ISO

Individual assessments are performed within this report for the three primary pressure zones within the water system. Information provided from the town, Google Earth imagery, and an examination of node elevations within the existing hydraulic model determined the high house elevation of each pressure zone. The high house elevation determines the location within each pressure zone that has the lowest anticipated pressure and identify where pressure deficiencies will first be observed under the requirements of the Ten States' Standards. The high house elevations found within each pressure zone are as follows:

- Pollard Tank: 1000 feet (Crooked Mountain Road adjacent to Hemlock Drive)
- Loon Tank: 1165 feet (multiple locations)
- Indian Head Tank: 1180 feet (adjacent to NH Route 3/Parker's Motel)

Main Pressure Zone Assessment

As discussed above, the highest water service elevation served by Pollard Tank within the Main Pressure Zone is at 1000 feet on Crooked Mountain Road. The table below shows the results of the evaluation based on the demands within the Main Pressure Zone.

Table 4: Available Storage (MPZ)

Tank	Ground Elevation (feet)	Volume (MG)	Equalization Storage (>35 psi) (MG)	Fire Storage (>20 psi) (MG)	Emergency Storage (<20psi) (MG)
Pollard Tank	1058	1.0	0.231	0.769	0
Volume Required			0.214	0.630	0.45
Surplus/(Deficit)			0.017	0.139	(0.45)

The volume required for equalization storage is 0.214 MG, a condition which is met when calculating the equalization storage of the Pollard Tank. Usable fire storage is defined as the amount of water within a storage tank that will provide a pressure of 20 psi (46 feet) to the highest house elevation in the system. For a high service elevation of 1000 feet, the volume of water required for fire storage would need to be provided above an elevation of 1046 feet (1000 feet + 46 feet) to be considered usable. As the base elevation of the Pollard Tank is at 1058 feet, all remaining storage within the tank meets the criteria for useable fire storage and contributes to the 0.63 MG requirement.

Since the base tank elevation is above the elevation used to calculate emergency storage, there is no volume within the tank that is solely calculated for emergency alone. However, the remaining portion of the tank volume after excluding the volumes allocated for equalization and fire storage can be considered as emergency storage. In this case, there is 0.156 MG available for emergency flow storage as calculated by the excess equalization storage (0.017) plus the excess fire storage (0.139). Due to this, the actual deficiency of emergency storage is 0.294 MG as calculated by volume required (0.45) less the volume available (0.156).

Loon Village Pressure Zone Assessment

While the highest elevation found within the Loon Village pressure zone is 1220 feet located adjacent to Beechnut Drive, the town has indicated these homes are served by individual booster pumps to alleviate pressure concerns. The ground elevation of this area, coupled with the overflow elevation of 1226 feet at the Loon tank, result in a maximum water pressure of approximately 20 psi that can be provided to Beechnut Drive. These low pressures required the use of the individual booster systems to these properties to comply with Ten States' Standards.

The hydraulic model indicates that only two of the approximately 50 nodes that comprise this pressure zone are located on Beechnut Drive at an elevation of 1220 feet and that these locations have individual booster systems to provide adequate pressures. However, the town serves multiple other customers within this pressure zone at an elevation of approximately 1165 feet (three locations) which was utilized as the highest elevation of the pressure zone. Using this elevation and the ground elevation of the tank, the table below shows the results of the evaluation based on the available storage.

Table 5: Available Storage (LVPZ)

Tank	Ground Elevation (feet)	Volume (MG)	Equalization Storage (>35 psi) (MG)	Fire Storage (>20 psi) (MG)	Emergency Storage (<20psi) (MG)
Loon Tank	1246	0.50	0.5	0	0
Volume Required			0.119	0.54	0.25
Surplus/(Deficit)			0.381	(0.54)	(0.25)

The volume required for equalization storage is 0.119 MG, a condition which is met when calculating the equalization storage of the Loon Tank. All storage within the Loon Tank meets this threshold as the elevation required to deliver 35 psi (81 feet) to a high water service elevation of 1165 feet matches the base elevation of the tank (1246 feet). Usable fire storage is defined as the amount of water within a storage tank that will provide a pressure of 20 psi (46 feet) to the highest water service elevation in the system. For a high service elevation of 1165 feet, the volume of water required for fire storage would need to be provided above an elevation of 1211 feet (1165 feet + 46 feet) to be considered usable. As the base elevation of the Loon Tank is at 1246 feet, all remaining storage within the tank meets the criteria for useable fire storage and contributes to the 0.54 MG requirement. However, only 0.381 MG is available in the tank after removing the equalization storage (0.5 – 0.119) leaving a fire storage deficit of 0.159 MG (0.54 – 0.381).

Since the base tank elevation is above the elevation used to calculate emergency storage, there is no volume within the tank that is solely calculated for emergency alone. Since there is a fire flow deficiency, there is no storage available for emergency storage and represents a deficiency of 0.25 MG, resulting in a total storage deficit of 0.409 MG within the Loon Tank (0.381 – 0.54 – 0.25).

Indian Head Pressure Zone Assessment

The Indian Head Tank is able to serve a high water service elevation at 1180 feet located adjacent to NH Route 3 and Parker's Motel. The table below shows the results of the evaluation based on the demands within the Indian Head pressure zone.

Table 6: Available Storage (IHPZ)

Tank	Ground Elevation (feet)	Volume (MG)	Equalization Storage (>35 psi) (MG)	Fire Storage (>20 psi) (MG)	Emergency Storage (<20psi) (MG)
Indian Head Tank	1256	0.146	0.073	0.073	0
Volume Required			0.036	0.3	0.075
Surplus/(Deficit)			0.037	(0.227)	(0.075)

The volume required for equalization storage is 0.036 MG, which is available when calculating the equalization storage of the Indian Head Tank. Usable fire storage is defined as the amount of water within a storage tank that will provide a pressure of 20 psi (46 feet) to the highest service elevation in the system. For a high service elevation of 1180 feet, the volume of water required for fire storage would need to be provided above an elevation of 1226 feet (1180 feet + 46 feet) to be considered usable. As the base elevation of the Indian Head Tank is at 1256 feet, all remaining storage within the tank meets the criteria for useable fire storage and contributes to the 0.30 MG requirement as determined by ISO. However, only 0.110 MG (0.073 + 0.037) is available in the tank after removing the equalization storage leaving a fire storage deficit of 0.190 MG (0.073 + 0.037 – 0.300).

Since the base tank elevation is above the elevation used to calculate emergency storage, there is no volume within the tank that is solely calculated for emergency alone as it can be classified as equalization and/or fire flow storage. Since there is a fire flow deficiency, there is no storage available to be earmarked as emergency storage and represents a deficiency of 0.075 MG, resulting in a total storage deficit of 0.265 MG within the Indian Head Tank (0.037 – 0.227 – 0.075).

Future Service Connections

If special considerations are not currently in existence for high-elevation homes wishing to connect to the water system, the town should consider modifying the bylaws to deny future connections to the water system for connections above pre-determined elevations without written acknowledgement by the developer that not all water pressure requirements will be met under all demand conditions. For each pressure zone the maximum ground elevation capable of meeting all pressure requirements is as follows:

- Main: 1000 feet
- Loon Village: 1180 feet
- Indian Head: 1180 feet

These elevations are based on the existing equalization storage requirements in the town's tanks. As equalization storage is calculated as a percentage of each pressure zone's maximum day demand the required equalization storage increases as more connections are added to the water system (i.e. the town requires an incrementally larger tank with each new service connection).

This is especially noteworthy for the Main pressure zone as only 17,000 gallons of surplus equalization storage is available in the 1.0 MG Pollard Tank based on the inclusion of Crooked Mountain Road on the Main pressure zone. Future water service connections to the Main pressure zone will reduce the available surplus equalization and/or lower the highest service elevation capable of being served by the tank. Removing a portion of Crooked Mountain Road immediately adjacent to the intersection of Hemlock Drive (the current high service elevation in the Main pressure zone) from this pressure zone would significantly increase the available equalization storage in the Pollard Tank. The next highest service elevation within this pressure zone is approximately 976 feet located adjacent to the tank. With a high service elevation of 976 feet, a 35-psi minimum pressure requirement can be met at an elevation of 1057 feet (one foot below the base of the Pollard Tank), allowing the entire tank volume to be available as equalization storage. Removing a portion of Crooked Mountain Road from the Main pressure zone to the South Peak zone is further discussed within the Modeling Results section of this report. While this approach will significantly increase the available equalization storage within the Main pressure zone, it does not alleviate the emergency storage deficiency as described above. Potential modifications to the water system to alleviate this deficiency are discussed within the Modeling Results section of this report.

Storage Tank Water Age

The American Water Works Association (AWWA) recommends that maximum water age in a storage tank should average between three and five days. Low water turn-over rates within a tank prohibit effective standalone mixing and leads to excessive water age and thermal stratification which may contribute to low chlorine residuals and unsafe levels of disinfection by-products (TTHMs and HAA5s), high rates of sediment accumulation, ice build-up, and undesirable taste and odor. Turnover times for each tank was analyzed using water level data provided by the town for each water storage tank during January and July 2020. The town has relatively high winter demands due to the annual snowmaking and tourism while the periods of lowest water usage typically occur in the early spring and late fall.

Analysis of the data showed that the Pollard tank displays an approximate three-foot band during the winter months and cycles approximately every 6 hours. Similar band elevations and tank cycle times are observed within the summer months with the tank sometimes being unable to fill to the high tank level shut off elevation due to elevated demands. The Loon tank displayed an approximate three-foot operational band between the low and high SCADA settings and cycling approximately every 12 hours under both winter and summer scenarios. The Indian Head tank also displayed a narrow operating band at around three feet in January while cycling every 24-hours, and a three-foot band during July 2020 operating on a 12-hour cycle. Turnover within each tank is within the AWWA recommendation, as seen below:

- Pollard tank turnover between 2.5 (winter) to 2.5 days or less (summer)
- Loon Village tank turnover at approximately 3.2 days (winter and summer)
- Indian Head turnover at 3.3 days (winter) and 1.7 days (summer).

Tank mixers are also capable of providing on-site mixing and reduction of water age within tanks if water age and/or quality are consistent issues within the distribution system. Instituting mixers eliminates plug-flow operation of the tanks (either first water in is first water out or last water in is first water out). Mixers can also assist with reducing ice formation in tanks by maintaining a consistent water temperature while reducing thermal stratification. The town has installed a mixer within the Pollard Tank to address disinfection byproduct formation concerns and could pursue this option for the other tanks if warranted. Tank mixers can carry a capital cost of approximately $40,000 or less and carry an operational cost of $120 - $200 per month for electrical costs.

Storage Assessment Conclusion

The town has a calculated storage deficit in all three primary pressure zones (Main, Loon Village, Indian Head). The town currently meets the equalization storage requirements (minimum 35 psi to all connections under normal demand conditions) in all three pressure zones. However, the Main pressure zone has nearly reached its equalization storage requirement with only a 17,000-gallon surplus remaining. Additional service connections within the Main pressure zone will stress the existing equalization storage availability and warrant additional storage. The Loon Village and Indian Head pressure zones have a fire storage deficit as detailed above. All three pressure zones have an emergency storage deficit.

The most effective solution for the town's storage deficit is to construct new storage tanks in all three pressure zones to eliminate this condition and provide a storage surplus to the individual service areas for the foreseeable future. To meet today's storage deficits, this would result in new storage of at least 0.294 MG in the Main pressure zone, 0.409 MG in Loon Village and 0.265 MG in Indian Head. Please note new storage tanks would be sized for anticipated water demands 25 to 35 years from now (year 2045) so the actual volumes would be larger than identified herein.

Construction of three new storage tanks carries a high capital cost and may not be feasible for the town. Other challenges include the availability of land for siting the new tanks and an increased water residence time due to the increased storage. The modeling results presented below present multiple system improvements that can be explored to increase the effectiveness of the water system without the need to construct three new storage tanks.

Water System Hydraulic Model Update

The storage assessment was conducted in tandem with an effort to update the town's hydraulic model which represents the town's water distribution system. Previous discussions with the town have indicated that the distribution system was primarily built out in the 1960s and 1970s and largely contains cement-lined pipes such as ductile iron and asbestos cement. Earlier portions of the system constructed in the 1930s and 1940s with cast iron pipe have largely been replaced at this time and have been intentionally targeted for replacement as part of improvement projects. The model was initially developed in 2000, significantly updated in 2008, and received its latest update in 2018 as part of Hoyle, Tanner & Associates, Inc. (HTA) Fire Flow Assessment report effort. The model was previously run in the EPANET modeling program, with all recent modeling work being performed as steady-state conditions. As part of this effort, the hydraulic model was converted to the InfoWater v.12.3 software platform.

The model was delivered to Weston & Sampson as part of the water storage tank assessment effort. However, there were initial concerns with making final recommendations on the sizing and siting of a water storage tank or other major infrastructure improvements without being able to readily duplicate past modeling efforts. The town observed an occurrence in 2017 where a withdrawal event caused depleted water availability issues in the system. The model had not been previously set up to evaluate the extended period simulation (EPS) scenario which would display system deficiencies that occur over time because of water demands and system operations (tank fluctuation, WTP run times, etc.). Updating the model become a focal point to best determine how water moved through each individual pressure zone and identify potential improvements for the entirety of the water system.

Town staff assisted with examining the hydraulic model and assessing the connectivity and pipe diameters of the water mains shown in the model. The town also field verified valve sizes at numerous locations within the distribution system to assess the overall baseline model accuracy and provided the existing pump curves to confirm the modeled parameters of the pumps. More than a dozen modifications were made to the model following this review process. While most modifications were minor, a few significant items were found including an approximately 1,500 linear foot section on Main Street between Maple Street and the Nordic Inn that was shown in the model as 12-inch diameter pipe but found to be 6-inch pipe upon field inspection. Other modifications included sizing of the Indian Head Tank and the Loon pump flow rate.

Table 7: Significant Hydraulic Model Feature Updates

Updated Feature	Previously Modeled	Model Update
Water main on Main Street from Maple Street to Nordic Inn	12" main	6" main
Indian Head Tank	36,650 gallons	146,000 gallons
Pollard Tank Level (beginning water level)	18 feet	24 feet
Loon Village Pump Flow Rate	500 gpm	360 gpm
Loon Village PS, WTP Finish Water Pumps, Boyce Brook PS	Old pump curves	Current pump curves
Typical AWWA Diurnal curve and Extended Period Simulation	Steady State	Extended Period Simulation

Additonal field flow testing was not performed as part of the model update. A series of flow tests were conducted in 2018 by HTA which were used to confirm calibration of the model. Not conducting flow tests allowed additional time to be allocated to updating the model to increase the accuracy of the EPS.

Potential Water System Improvements

Following the update of the model the items below emerged as potential items the town can pursue to increase the available fire flows and pressures within the water system instead of increasing storage within each individual pressure zone:

1. Installation of a Pressure Reducing Valve (PRV) between the Loon Village and Main pressure zones
2. Remove a portion of Crooked Mountain Road from the Main pressure zone
3. Optimize available fire flow in Route 3 east of Route 93 and in the Indian Head pressure zone
4. Prioritize an increase in available storage within the primary pressure zones

Improvement 1: Install a PRV between Loon Village and Main Pressure Zones

The town could explore supplementing the Main pressure zone by installing a piped connection and pressure reducing valve (PRV) between the Loon Village and Main pressure zones. These pressure zones are not currently connected in this manner and there is no mechanism for water stored within Loon Village to supplement the Main pressure zone during a fire flow event. A 48-hour EPS was run using the model to show the normal fluctuation within the towns tank under a maximum day demand scenario of 1.3 MGD. The EPS results are shown in Figure 1 below:

Figure 1: Storage Tank Levels under 48-hour Maximum Day Demand EPS

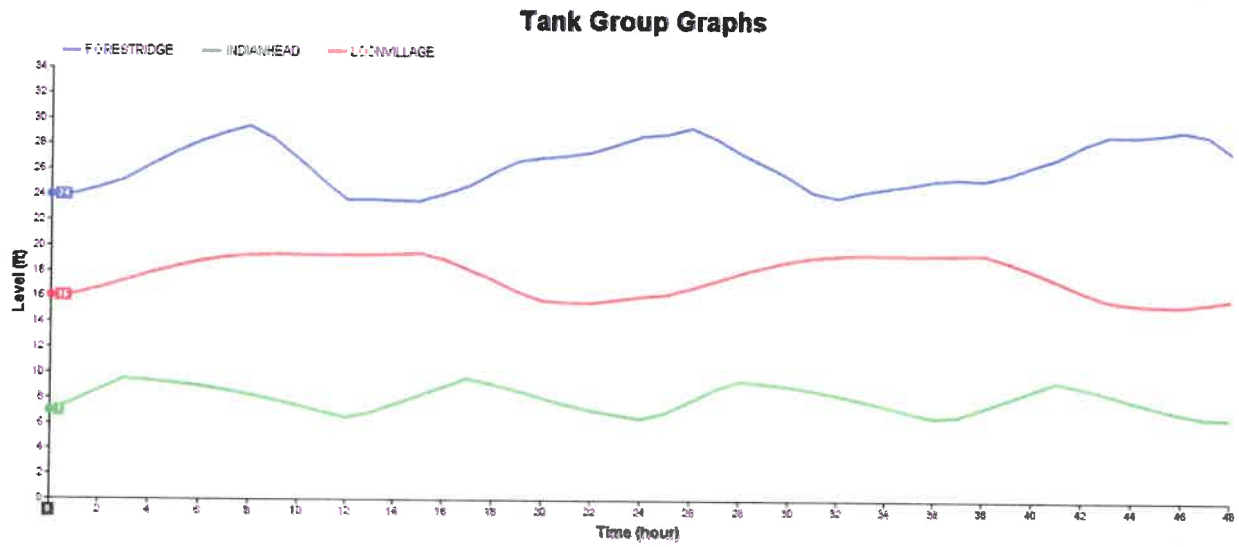
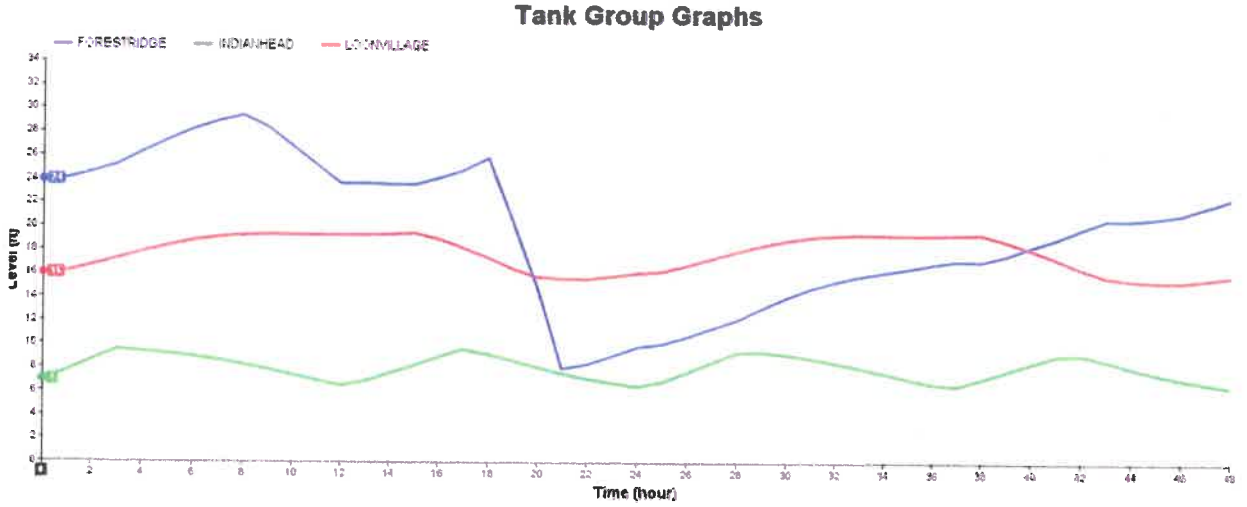


Figure 2 shows the storage tank levels when a fire flow demand of 3,500 gpm at a 3-hour duration is simulated at the intersection of Main Street and School Street under maximum day demand conditions.

Figure 2: Fire Flow at School Street & Main Street – Existing Conditions

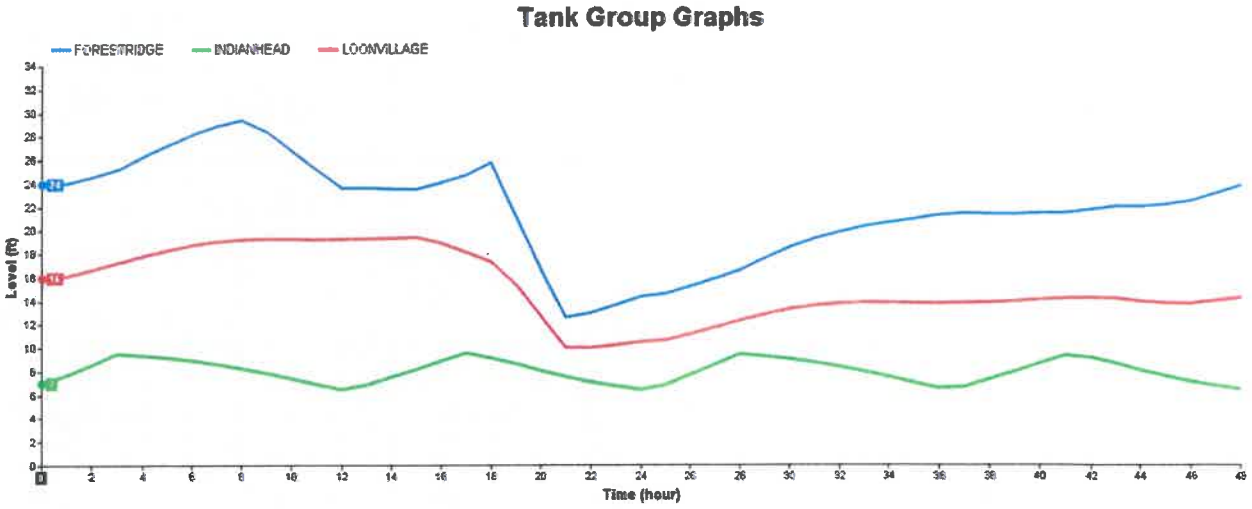


The water level within the Pollard Tank drops as to an elevation of 8 feet during the fire flow event before returning to normal water levels. The levels within the Loon Village and Indian Head tanks are not impacted by this event as the Loon pumps and Boyce Brook pump station maintain their typical operations during the event. The town should implement a SCADA setting based on a low water elevation in the Pollard Tank that signals the Loon Village and Boyce Brook pumps stations to shut off. This will allow more water to be maintained within the Main pressure zone during a fire flow event. The core of the Main pressure zone water system (defined as available water mains in the system and their size) appears strong during the modeling exercise and is capable of meeting the ISO requirement for fire flow. It should be noted that the WTP finished water pumps are pumping approximately 1.5 MGD and Cold

Spring Pump Station is pumping approximately 120 to 130 gpm during the simulated fire event and immediately afterwards to refill Pollard Tank.

Figure 3 shows the same fire flow demand scenario of 3,500 gpm at a 3-hour duration at the intersection of Main Street and School Street under maximum day demand conditions. However, before running this modeling scenario a PRV was added to the model to allow water to flow out of the Loon Village pressure zone and into the Main pressure zone. The PRV was modeled adjacent to the WTP where water mains in both service areas are in close proximity. Depending on pipe configuration, the original Loon Village pump station may be able to accommodate a PRV at this location and provide the town with a convenient, pre-existing access point to install the valve. The exact location for the PRV would need further investigation to ensure that hydraulic restrictions are not created while attempting to improve flow into the Main pressure zone.

Figure 3: Fire Flow at School Street & Main Street – with Loon Village PRV



The water level within the Pollard Tank drops to an elevation of 13 feet during the fire flow event, showing an overall improvement of 5-feet in elevation drop. The level within the Loon tank shows a corresponding drop to a water level of 10 feet during the event as water flows out of the Loon Village pressure zone to supplement the Main pressure zone. The level within the Indian Head tank is not impacted by this event as the Boyce Brook pump station maintains its typical operations during the event.

The emergency storage deficit within the Main and Loon Village pressure zones can also be supplemented by the WTP clearwell. The clearwell volume is 250,000 gallons however, not all of this volume is available in emergency situations. Reducing the water level within the clearwell during an emergency pumping event will reduce the disinfection contact time and can cause the town to no longer maintain proper 4-log inactivation of bacteria and viruses during the event. Flow out of the clearwell is also restricted by the finished water pumps (operated between 750 - 1000 gpm currently to match WTP capacity) which allow flow to the Main pressure zone. Flow into the Loon Village pressure zone is limited by the Loon pumps (500 gpm), which are further discussed within the section detailing increased storage in Loon Village.

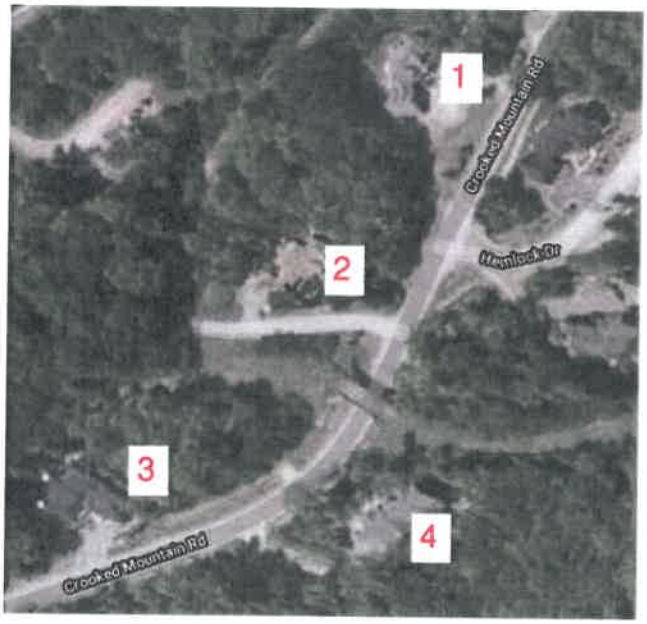
Installation of a PRV to connect these pressure zones allows the Loon tank to serve as additional storage for the Main pressure zone during fire flow and emergency events. This improvement option presents a relatively low-cost mechanism to increase storage availability within the Main pressure zone and should also be considered in conjunction with Improvements 2 and 4 discussed below.

Improvement 2: Remove a Portion of Crooked Mountain Road from Main Pressure Zone

As mentioned in the storage assessment of the Main pressure zone, the 1000-foot high service elevation within the pressure zone occurs at approximately four homes located on Crooked Mountain Road adjacent to the intersection of Hemlock Drive. Hemlock Drive is currently the only location served by the South Peak pump station at a hydraulic gradeline of approximately 1098.5 feet (966.5-foot pump station floor elevation plus 132-foot head of the pumps). The pump station has two 150-gpm pumps and a 40-gpm jockey pump that provide only domestic service.

Removing the four homes closest to this intersection allows the high service elevation of the Main pressure zone to be reduced to approximately 976 feet (located adjacent to the Pollard Tank and the Pemi Base Camp). At a hydraulic gradeline of 1098.5 feet the static pressure at these homes would be approximately 43 psi satisfying Ten States' Standards for minimum domestic pressure. Moving these homes to the South Peak pressure zone can be accomplished in two ways:

- The town could re-instate the PRVs in Crooked Mountain Road. Two vaults were previously installed for this purpose, however the PRVs have been removed and a section of straight-line pipe is currently installed connecting all Crooked Mountain Road to the Main pressure zone. The gate valve to Hemlock Drive is currently closed, isolating the street as the only location served by the South Peak pressure zone.



- However, as the South Peak pressure zone has no fire storage capability the town could extend a 2-inch domestic water main from Hemlock Drive heading east and west on Crooked Mountain Road. This would extend the higher available water pressure from the South Peak pressure zone to these homes while leaving the water main in Crooked Mountain Road on the Main pressure zone for fire fighting purposes. This option would reduce the tank's lack of available of surplus equalization storage in the Main pressure zone (as discussed in the storage assessment) and allow fire flow to be available at Crooked Mountain Road. If the town wants to extend this domestic service further west from South Peak to include the Pemi Base Camp a 4-inch water main may be required.

Improvement 3: Optimize available fire flow in Route 3 east of Route 93 and in the Indian Head pressure zone

The Indian Head pressure zone has adequate equalization storage and adequate fire storage for a residential area (approximately 1,800 gpm @ 1 hour is available). However, the presence of the Indian Head Resort (and other commercial properties) increases the fire flow requirement of the pressure zone. The resort does not have any on-site fire storage and relies on the Indian Head tank to provide fire flow. The Boyce Brook pump station can supplement the pressure zone during a fire event at a flow rate of approximately 300 gpm. However, this flow is not able to offset the fire flow storage deficiency within the pressure zone.

In addition to Indian Head Resort, two locations along Route 3; at the intersection of Woodward's Lane and at the intersection of Drummer Lane have existing ISO defined fireflow requirements of 3,500 and 3,000 gpm, respectively, for three hour durations each. Currently, the available fire flow to each site is 500 gpm. Satisfying these fire flow requirements should be explored in further detail to identify an optimal approach to improving available fire flow capacity. The town may consider increasing the available fire storage volume in this area of the

system, should assess how to satisfy available fire flow through properly located pumping facilities and/or assess a combination of each option. The town could also explore creative methods in which the fire flow deficit for Indian Head Resort can be satisfied in concert with solutions for satisfying the Woodward's Lane and Drummer Lane fire flow deficiencies.

The town could also examine replacement of the remaining sections of 8-inch water main on NH Route 3 with 12-inch main. Some of these sections are complex such as the crossing of I-93 and could be supported by the installation of a parallel 8-inch main if a true replacement of the pipe is not feasible. Two 8-inch mains have the flow capacity of a single 12-inch main and can effectively supply the same volume without removing the existing infrastructure.

Improvement 4: Prioritize an Increase in Available Storage within the Primary Pressure Zones
As discussed in the storage assessment conclusion the most effective solution for the town to alleviate the storage deficit within all three of the primary pressure zones is to construct new storage within these areas. However, this approach carries a high capital cost for the town and may not be feasible at this time. As an alternative method, the town could prioritize and sequence the construction of new storage tanks in the following pressure zones 1) Loon Village, 2) Indian Head, 3) Main.

The Loon Village pressure zone is prioritized for new storage due to the following factors:

1. The pressure zone has the largest storage deficit of all three major pressure zones within the distribution system (909,000-gallon requirement vs. 500,000-gallon tank volume)
2. When combined with Improvement 1 described above, a PRV allows flow to leave this pressure zone and supplement the Main pressure zone during a fire flow event
3. The pressure zone is less geographically isolated (as compared to Indian Head pressure zone which is fed by a single water main corridor (NH Route 3)) and would therefore provide more benefit to more of the distribution system. Additionally, the potential modifications to the NH Route 3 water mains discussed in Improvement 3 are more costly than Improvement 1.

If more storage is constructed within the Loon Village pressure zone the existing Loon booster pumps will likely require replacement with larger pumps to effectively fill the tanks.

The Indian Head pressure zone would be prioritized next for an increase in available storage. The town may face complexity with the existing tank located on Department of Natural and Cultural Resources (formally DRED) land. Increasing the storage volume by a minimum of 0.265 MG within this pressure zone would eliminate the existing fire and emergency storage deficit. A PRV could connect the Indian Head and Main pressure zones (similar to the description provided for Improvement 1). Increasing storage within this service area and utilizing a PRV would expand the water system's capability to provide fire flow to the pressure zone and further supplement the Main pressure zone during a fire flow event. Although an existing PRV is present near the Boyce Brook station, the town has indicated the PRV is not in operation. It should be noted the Indian Head tank is small in volume and would not provide a significant improvement to the Main pressure zone if the existing PRV was operational. Further assessment is needed to determine an optimal location for a PRV between Indian Head and Main pressure zones.

The Main pressure zone would be prioritized last for construction of a new tank after the extremities of the water system in the adjacent pressure zones are strengthened. Increased fire flow/emergency storage are available due to the connections with the Loon Village and Indian Head pressure zones. The WTP clearwell is also capable of supplementing the pressure zone during an emergency. Further modification to the SCADA system to shut off the Loon Village and Boyce Brook pump stations once the Pollard Tank reaches a pre-determined low water level setting will also increase availability of water within the pressure zone during a fire.

Report Conclusions
The town has a storage deficit within all three primary pressure zones according to the AWWA M32 methodology described above. The most effective solution to eliminate the storage deficit is to construct new storage in all three

pressure zones. As this may not be feasible for the town, additional water system improvements were identified using the model. These improvements are summarized in the table below:

Table 8: Summary of Storage Improvement Options

Water System Improvement	Advantages	Disadvantages
Construct new storage in all 3 primary pressure zones	• Alleviates calculated storage deficit in all pressure zones • Increases available fire flow in all pressure zones	• High capital cost • Availability of land/siting for tanks • Increased water residence time in tanks
Install a PRV between Loon Village and Main pressure zones	• Increases available storage to the Main pressure zone during a fire flow event • Reduces the water level drop in Pollard Tank during fire flow event • Low capital cost (depending on location)	• Does not address storage deficit in Loon Village or Indian Head
Remove a portion of Crooked Mountain Road from the Main pressure zone	• Significantly increases equalization storage within the Main pressure zone • Low capital cost	• Does not alleviate overall storage deficit in any pressure zone
Optimize available fire flow in Route 3 east of Route 93 and in the Indian Head pressure zone	• Increases available fire flow to Indian Head and MPZ along Route 3 east of Route 93	• High capital cost • Construction complexity to upsize sections of 8-inch water main on NH Route 3
Prioritize/Sequence construction of new storage in the 3 primary pressure zones	• Lower capital cost than constructing new tanks in all pressure zones • Directly addresses storage deficiency • Strengthens extremities of water system first and allows them to supplement Main pressure zone	• High capital cost • Requires other system improvements to maximize benefit

While all the improvements above will improve the town's water system and the flow between pressure zones, not all the options directly address the calculated storage deficit. The effectiveness of each improvement for addressing the town's needs can be further investigated and discussed with the town. In addition to the improvements above, the town could also consider adopting a bylaw to address the maximum water service elevations in each pressure zone and a modification to the SCADA system to prevent water from flowing out of the Main pressure zone and into the Loon Village and Indian Head pressure zones during a fire flow event.

Thank you and Nate Hadaway, Director of Public Works, for your assistance, time, and consideration during this study. Jeffrey C. Provost, P.E. and Samuel H. Kenney, P.E. both assisted with the development of this report.

Sincerely,

WESTON & SAMPSON ENGINEERS, INC.

Jeffrey W. McClure, P.E.
Senior Associate