APPENDIX 2D. WATER DISTRIBUTION SYSTEM COMPUTER MODEL & HYDRAULIC ANALYSIS

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Hon. Joseph Gross, Mayor, and Board of Trustees
Village of Cornwall-on-Hudson
325 Hudson Street
Cornwall-on-Hudson, NY 12520

Reference: Water Distribution System Computer Model & Hydraulic Analysis

Dear Hon. Mayor and Village Trustees:

In accordance with our Agreement, we have completed the development of a computer model of the Cornwall-on-Hudson Water Department's water distribution system. The model has been completed and calibrated and was used to evaluate the impacts of the Winding Creek and Cornwall Commons developments. The model can also be used for evaluating impacts to the distribution system by other new developments, determining available fire flows throughout the system, sizing of booster pumps that may be needed, locating new storage tanks, water quality modeling, etc. In addition to the computer model, we also updated the Distribution System Map including the boundaries of the various service zones, storage tanks, booster pump stations and supply facilities.

Model Description

The model was created in WaterCAD Version 8.0 and incorporated to distribution water mains, raw water mains, storage facilities, pumping systems, operational parameters, system demands and service area boundaries. Where appropriate, pump data including head-discharge curves and pump discharge pressures as appropriate. System demand was allocated by means of spatially applying the village's billing records of the top ten water users and evenly distributing the remaining system usage. Eight (8) hydrant flow tests were performed on May 2, 2007 in conjunction with the Cornwall-on-Hudson Water Department and used to calibrate the model. Available operating parameters were recorded during the flow tests to accurately input the data into the model. The model was calibrated to an accuracy so that no greater than 10% differential between simulated and field measured hydrant flows and residual pressures under a steady-state simulation.

Winding Creek and Cornwall Commons Hydraulic Analysis

As requested, we have performed an evaluation of the water distribution system for the proposed Winding Creek and Cornwall Commons developments. Each development was analyzed under the different distribution system improvements requested by Lanc & Tully Engineers in their letter dated May 17, 2007.

Reference: Reference: Water Distribution System Computer Model

Recognizing that the present system can't provide the extent of fire protection required by each project, this modeling was performed to evaluate what improvements would be necessary to improve fire flow deliveries to each project site.

Winding Creek

The Winding Creek development is comprised of 52 residential townhouse dwellings located between Mailler Avenue and U.S. Route 9W in the Town of Cornwall. The plans reviewed for this evaluation were prepared by Lanc & Tully Engineering and Surveying, P.C. dated August 4, 2004 and most recently revised on January 3, 2007.

The proposed project ranges in topography from approximate elevations of 180 ft. to 218 ft. There is currently municipal water service east of the proposed development on Mailler Avenue (6-inch main) and south of the proposed development on Ferguson Street (8-inch main). Presently, as proposed by the developer, the proposed development is to be connected at both Mailler Avenue and Ferguson Street. Under this scenario, the Winding Creek development would be included in the existing 460 service zone (his service zone has an approximate hydraulic grade line of 460 feet). This would be accomplished by relocating the existing pressure reducing valve (PRV) station on Mailler Avenue to a point downstream of the project entrance.

In order to evaluate the impacts of the proposed subdivision, the distribution system model was updated to include the new water mains proposed within this development (approximately 3,200 feet of 8-inch water main).

There are currently 2 alternatives proposed for providing water service to the Winding Creek project. These options are shown on Figure 1, and described as follows:

> **Alternative 1**: Install a new 12-inch water main (2,100± LF) on Mailler Avenue, from Willow Avenue to the project entrance.
>
> **Alternative 2**: Install a new 12-inch main (4,000± LF) along Maple Avenue, from the intersection of Laurel Avenue to Willow Avenue, then along Willow Avenue to Mailler Avenue and along Mailler Avenue to the proposed Cornwall Commons development.

Estimated Water Demands

Anticipated water demands for the 52 unit townhouse complex were provided by Lanc & Tully Engineers. The anticipated demands are as follows:

Average Day Demand = 13,520 gpd
Maximum Day Demand = 20,280 gpd
Peak Hour Demand = 75 gpm

Reference: Reference: Water Distribution System Computer Model

Hydraulic Analysis

For the purposes of this analysis, the water distribution system was modeled with one Taylor Road Well on-line, the Maple Road Booster Station on-line, the Holloran Road (Catskill Aqueduct) Water Treatment Plant off-line, the Black Rock Treatment Plant off-line, and the Maple Road Water Storage Tank at 3 feet below overflow (Elev.=523.5 ft). Health department guidelines specify that source capacity be evaluated with the largest supply out of service, recognizing that water supplies can be disrupted in numerous situations. Therefore, simulating static pressures and fire flows with these sources off-line is a conservative approach and appropriate for this type of analysis.

The proposed development was analyzed at several proposed hydrant locations throughout the development under the two distribution system improvement alternatives. The following static pressure ranges between average demands and peak hour demands could be expected in the Winding Creek development:

Hydrant Location	*Alternative 1*	*Alternative 2*
Road C Sta 8+00	110 psi – 117 psi	111 psi – 117 psi
Road B Sta 8+25	108 psi – 115 psi	111 psi – 117 psi
Road A Sta 9+75	96 psi – 103 psi	97 psi – 103 psi
Road A Sta 0+30	96 psi – 102 psi	96 psi – 102 psi

A fire flow at 20 psi residual pressure was simulated at each of the four hydrant locations during maximum day demand conditions. The results of the fire protection simulation are as follows:

Hydrant Location	*Alternative 1*	*Alternative 2*
Road C Sta 8+00	2,350 gpm	2,700 gpm
Road B Sta 8+25	2,550 gpm	3,100 gpm
Road A Sta 9+75	2,300 gpm	2,650 gpm
Road A Sta 0+30	2,600 gpm	2,600 gpm

Fire Flow Requirements for Winding Creek have not been provided by the developer's engineer. Typically, the required fire flow for a residential area consisting of single family and duplex homes, based on ISO insurance guidelines, is between 750 gpm and 1000 gpm at a 20 psi residual pressure.

Additionally, the recommended minimum system pressure for domestic water use is 35 psi per American Water Works Association (AWWA) standards. The recommended maximum pressure per AWWA standards is 110 psi. Furthermore, the recommended maximum pressure per the Orange County Department of Health, and "Ten State Standards", is 100 psi.

Reference: Reference: Water Distribution System Computer Model

Winding Creek Conclusions & Recommendations

The proposed Winding Creek development will create a new demand on the water system of approximately 13,520 gallons per day (average day) and 20,280 gallons per day (maximum day). The results of the hydraulic analysis indicate that under the proposed connection to the existing distribution system, the operating pressures within the lower elevations of the development will be above recommended pressures. Additionally, with the relocation of the Mailler Avenue PRV, several side streets off of Mailler Avenue would undergo significant increases in static pressure in excess of AWWA recommended pressures.

We have determined that the preferred hydraulic grade line for the Winding Creek development is 378 feet and recommend the development connect to the existing 388 service zone (approximate hydraulic grade line = 388 feet). This would involve leaving the existing Mailler Avenue PRV in its current location and providing a Service Zone boundary (PRV, closed valve, etc.) at the development connection on Ferguson Street. A simulation at the highest elevation in the development (Elev = 218) was performed with the Mailler Avenue PRV at its current location. The results were as follows:

Hydrant Location	*Improvement*	*Static Pressure*	*Fire Flow @ 20 psi*
Road A Sta 9+75	Alternative 1	73 – 74 psi	1,500 gpm
	Alternative 2	73 – 74 psi	1,700 gpm

Connection to the 388 Service Zone would provide more acceptable pressures throughout the development and existing side streets off of Mailler Avenue while maintaining typical minimum ISO fire flow requirements for residential dwellings.

Additionally, we recommend that the Village's Mailler Avenue PRV Station be modified to accommodate the increased demand in the area. Increasing the existing 6-inch PRV size would provide a reduction in headlosses during peak or fire flow demands. A parallel PRV system similar to the PRV Stations along Quaker Street would provide service for average domestic flow with minimum maintenance, while reserving the capacity for peak and fire flow demands at minimum headlosses.

Cornwall Commons

The Cornwall Commons development is comprised of 490 residential dwelling units, retail, restaurant and office space, a 104 room hotel, and a 70 bed Congregate Care facility. The proposed development is located between U.S. Route 9W and the former New York Ontario & Western Railroad line, north of Frost Lane, in the towns of New Windsor and Cornwall. The plans reviewed for this evaluation were prepared by Lanc & Tully Engineering and Surveying, P.C. dated May 14, 2007.

Reference: Reference: Water Distribution System Computer Model

The proposed project ranges in topography from approximate elevations of 138 ft. to 238 ft. There is currently municipal water service south of the proposed development on Frost Lane (6-inch main) and Howard Street (6-inch main). There is also municipal water service on Mailler Avenue (6-inch main) to southeast of U.S. Route 9W. There are currently 3 alternatives proposed for providing water service to the Cornwall Commons project. These options are shown on Figure 2, and described as follows:

Alternative 1: Install a new 12-inch main (5,000± LF) along Maple Avenue, from the intersection of Laurel Avenue to Willow Avenue, then along Willow Avenue to Mailler Avenue and along Mailler Avenue to the proposed Cornwall Commons development. Under this connection to the existing system, the Cornwall Commons development would be included in the 388 Service Zone. For modeling purposes, this was studied as two discrete elements, as follows:

- **Alternative 1A** – new 12" main in Maple Avenue
- **Alternative 1B** – new 12" main in Mailler Avenue

Alternative 2: Install an new 12-inch main (3,300± LF) starting at the intersection of Hudson Street and Second Street, running down Second Street and Academy Avenue, along Mailler Avenue, up Halverson Street and then across U.S. Route 9W into the project site. Under this connection to the existing system, the Cornwall Commons development would be included in the 388 Service Zone.

Alternative 3: Install a new 12-inch main (3,200± LF) on Mill Street starting at the existing 12-inch main near Old Mill Street, then up Howard Street into the Cornwall Commons project. Under this connection to the existing system, the Winding Creek development would be included in the 460 Service Zone.

In order to evaluate the impacts of the proposed subdivision, the distribution system model was updated to include the new water main proposed for this development (approximately 15,000 feet of 8-inch water main and 6,800 feet of 12-inch water main).

Estimated Water Demands

Anticipated average daily water demands for the development were provided by Lanc & Tully Engineers. To factor this up to peak demand figures required for modeling purposes, typical multiplying factors were used to establish Maximum Day Demand and Peak Hour Demand. The anticipated demands are as follows:

Average Day Demand = 157,250 gpd
Maximum Day Demand = 2 x Average Day Demand = **314,500 gpd**
Peak Hour Demand = 4 x Average Day Demand x = **440 gpm**

Hydraulic Analysis

For the purposes of this analysis, the water distribution system was modeled with one Taylor Road Well on-line, the Maple Road Booster Station on-line, the Holloran Road (Catskill Aqueduct) Water Treatment Plant off-line, the Black Rock Treatment Plant off-line, and the

Reference: Reference: Water Distribution System Computer Model

Maple Road Water Storage Tank at 3 feet below overflow (Elev.=523.5 ft). Health department guidelines specify that source capacity be evaluated with the largest supply out of service, recognizing that water supplies can be disrupted in numerous situations. Therefore, simulating the pressures and fire flows with these sources off-line is a conservative approach and appropriate for this type of analysis.

The proposed development was analyzed at several proposed hydrant locations requested by Lanc & Tully throughout the development under the three connection alternatives and a combination of Alternatives 1 & 2. As stated previously, the recommended system pressure range for domestic water use is 35 psi - 110 psi per American Water Works Association (AWWA) standards and maximum recommended system pressure per Orange County, NY standards and Ten State Standards is 100 psi. The following static pressures between average demands and peak hour demands could be expected in the Cornwall Commons development:

Hydrant Location	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternatives 1 & 2*
Road A Sta 16+00	104 – 105 psi	99 – 104 psi	128 – 135 psi	104 – 105 psi
Road L	91 – 92 psi	86 – 91 psi	115 – 121 psi	91 – 92 psi
Road A Sta 28+50	83 – 84 psi	78 – 83 psi	107 – 113 psi	83 – 84 psi
Road A Sta 43+50	83 – 84 psi	77 – 84 psi	106 – 113 psi	82 – 83 psi
Road K	77 – 78 psi	72 – 77 psi	101 – 107 psi	77 – 78 psi
Road G @ Road B	72 – 73 psi	66 – 72 psi	96 – 102 psi	71 – 72 psi
Road T	66 – 67 psi	60 – 66 psi	89 – 96 psi	65 – 66 psi
Road G	66 – 67 psi	60 – 66 psi	90 – 96 psi	65 – 66 psi
Road D @ Road O	74 – 75 psi	68 – 74 psi	99 – 104 psi	73 – 74 psi
Frost Lane Connection	57 – 58 psi	52 – 57 psi	82 – 88 psi	57 – 58 psi

A fire flow at 20 psi residual pressure was simulated at each of the hydrant locations during maximum day demand conditions. Fire Flow Requirements for Cornwall Commons have not been provided by the developer's engineer. As stated previously, the typical required fire flow for a residential area consisting of single family and duplex homes, based on ISO insurance guidelines, is between 750 gpm and 1000 gpm at a 20 psi residual pressure. Further, it must also be recognized that, as Cornwall Commons project proposes a combination of residential and commercial development, required fire flows for average commercial occupancies can typically range to 1500 gpm and above.

The results of the fire protection simulation are as follows:

Reference: Reference: Water Distribution System Computer Model

Hydrant Location	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternatives 1 & 2*
Road A Sta 16+00	1,700 gpm	1,875 gpm	2,400 gpm	2,725 gpm
Road L	1,700 gpm	1,875 gpm	2,425 gpm	2,700 gpm
Road A Sta 28+50	1,725 gpm	1,900 gpm	2,400 gpm	2,750 gpm
Road A Sta 43+50	1,850 gpm	2,000 gpm	2,400 gpm	3,125 gpm
Road K	1,700 gpm	1,850 gpm	2,400 gpm	2,650 gpm
Road G @ Road B	1,650 gpm	1,825 gpm	2,400 gpm	2,550 gpm
Road T	1,700 gpm	1,850 gpm	2,400 gpm	2,650 gpm
Road G	1,650 gpm	1,825 gpm	2,300 gpm	2,500 gpm
Road D @ Road O	1,625 gpm	1,800 gpm	2,500 gpm	2,400 gpm
Frost Lane Connection	1,600 gpm	1,750 gpm	2,950 gpm	2,350 gpm

Additionally, a fire simulation with respect to fire sprinkler deliveries was performed at the highest elevation (Elev = 238, End of Road S). Actual fire sprinkler requirements would be determined by the building engineer. This simulation can be used to assess the system's ability to provide fire sprinkler service to the intended development. The results, calculated to a residual pressure of 50 psi, are presented below. This simulation can be used to assess the system's ability to provide fire sprinkler service.

Hydrant Location	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternatives 1 & 2*
Road S	1,150 gpm	1,050 gpm	2,325 gpm	1,450 gpm

Cornwall Commons Conclusions & Recommendations

The proposed Cornwall Commons development will create new demands on the water system of approximately 157,250 gallons per day (average day) and 314,500 gallons per day (maximum day).

The results of the hydraulic analysis indicate that, from the standpoint of satisfying minimum system hydraulics in order to serve the project, the Cornwall Commons development could utilize connection Alternative 2, tying into the 388 service zone, in addition to Alternative 1A (installation of a new 12-inch main installation on Mailler Avenue, as was also recommended for the proposed Winding Creek development). However, from a system reliability standpoint, a second connection to the Village's water system is necessary, given the overall project's size, and so it is recommended that Alternative 3 be provided in lieu of Alternative 2. Further, as Alternative 3 proposes a connection to the 488 service zone, a new Pressure Reducing Valve (PRV) Station will be required so as to avoid creation of pressures within the proposed development above AWWA recommended pressures.

Reference: Reference: Water Distribution System Computer Model

A simulation at the highest elevation in the development (Elev = 238) was performed under the recommended connection configuration. The results were as follows:

Hydrant Location	*Static Pressure*	*Fire Flow @ 20 psi*	*Fire Flow @ 50 psi*
Road S	60 – 65 psi	2,600 gpm	1,400 gpm

Additionally, as we also recommended for the Willow Creek project, the Village's Mailler Avenue PRV Station should be modified to accommodate the increased demand in the area of Cornwall Commons and Winding Creek. Increasing the existing 6-inch PRV size would provide a reduction in headlosses during peak or fire flow demands. A parallel PRV system similar to the PRV Stations along Quaker Street would provide service for average domestic flow with minimum maintenance, while reserving the capacity for peak and fire flow demands at minimum headlosses.

Summary of Recommended Improvements

The recommended system improvements needed to properly service each project is summarized below:

Winding Creek

- Connect development to 388 Service Zone
- Leave Mailler Avenue PRV in current location.
- Install new 12-inch water main on Mailler Avenue.
- Modify Mailler Avenue PRV Station by installing parallel 8-inch and 4-inch PRVs.
- Provide Service Zone boundary at development connection on Ferguson Street

Cornwall Commons

- Requires the following improvements also needed for the Willow Creek project (connecting to the 388 Service Zone):
  a. Install new 12-inch water main on Mailler Avenue. (Also recommended for Winding Creek)
  b. Extend the 12-inch main from Mailler Avenue up Halverson Street and then across U.S. Route 9W into the project site.
  c. Modify Mailler Avenue PRV Station by installing parallel 8-inch and 4-inch PRVs.
- Install a new 12-inch main on Mill Street starting at the existing 12-inch main near Old Mill Street, then up Howard Street into the Cornwall Commons project (Alternative 3).
- Installation of a new PRV along Howard Street, to create a 388 service zone boundary to avoid excessive pressures within the development

Reference: Reference: Water Distribution System Computer Model

Distribution Storage

Through the development of the model and the fire flow simulations performed, a deficiency in distribution storage has been observed. For example, with one of the Taylor Road wells on-line, a 2,500 gpm fire flow event during maximum day demands on the west side of the system would drain the 0.5 mg Maple Road Storage Tank at approximately 3,500 gpm. This would quickly create unfavorably low pressures in the higher elevations in the water system and effectively empty the tank. In addition, a similar event with the Black Rock Reservoir on-line would draw from the two storage facilities unequally (Maple Road = 70%, Black Rock = 30%). This again would cause unfavorably low pressures and tank levels. We recommend that the Village include in their long-range Water System planning a component to investigate distribution storage improvement alternatives with respect to both volume and location.

We thank you for the opportunity to serve the Village of Cornwall-on-Hudson on this evaluation. If you have any questions please do not hesitate to call me.

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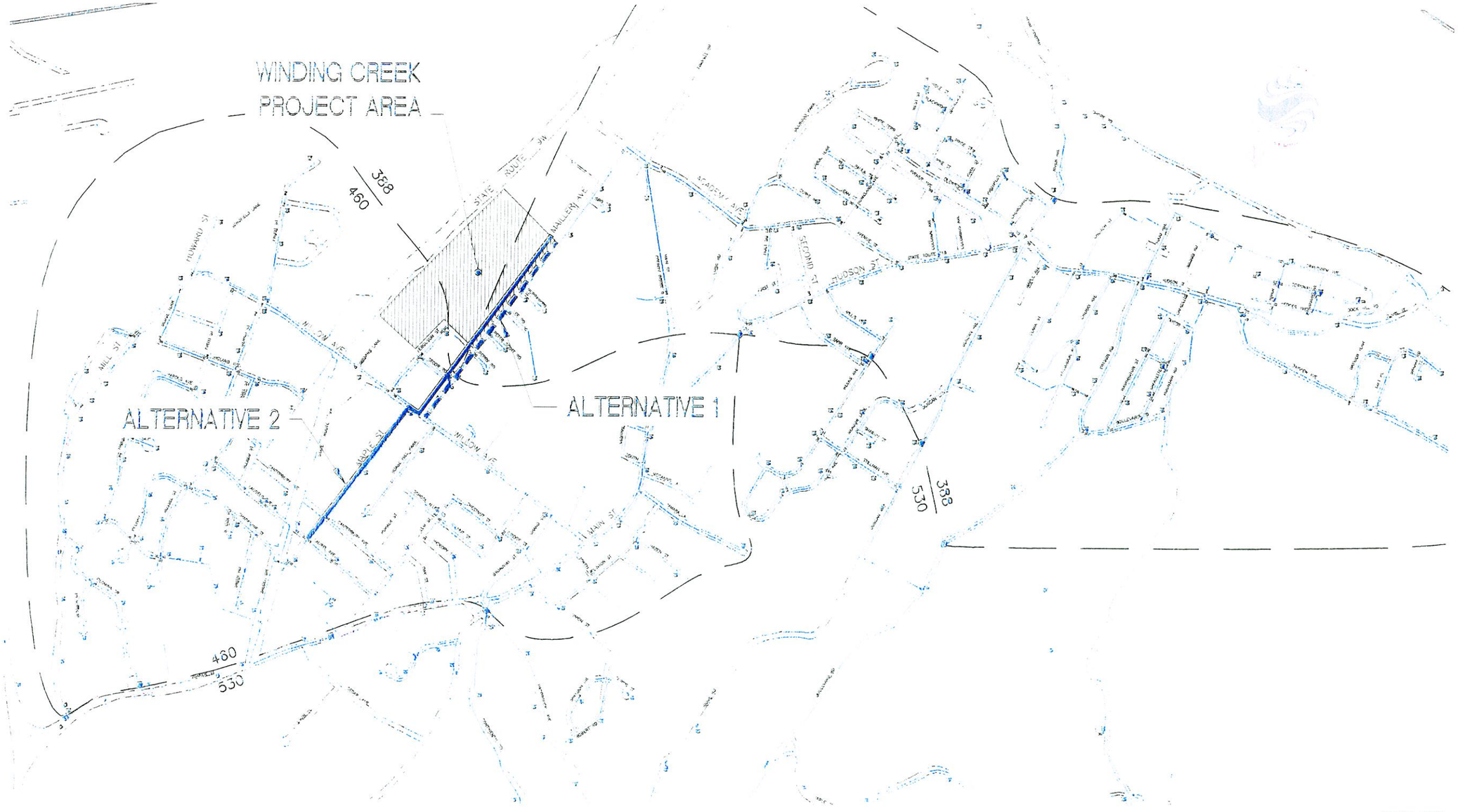

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Legend

Notes

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SCALE 1" = 1000'

AUGUST, 2007
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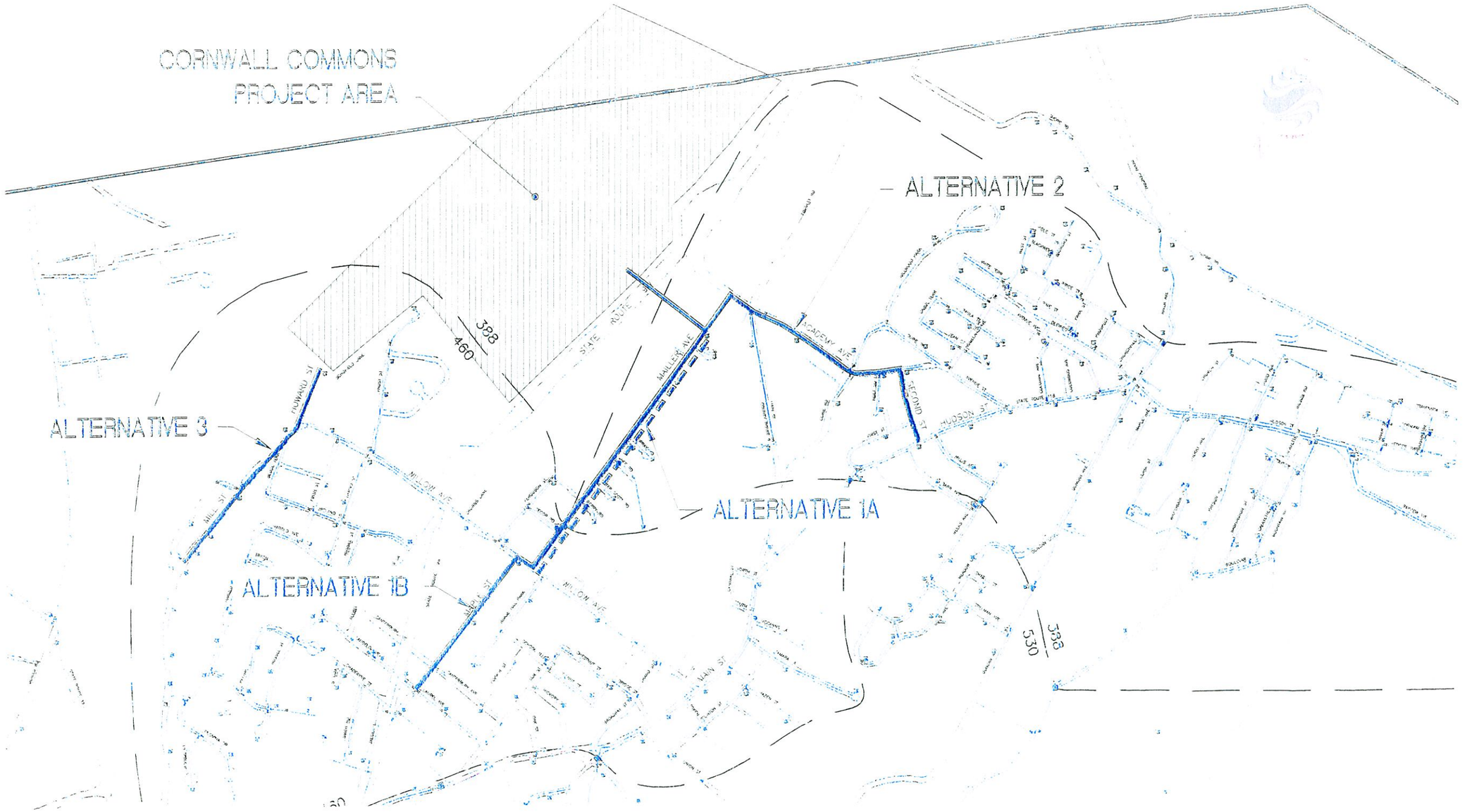
Client/Project
CORNWALL-ON-HUDSON, NY
WINDING CREEK ANALYSIS

Figure No.
1

Title
DISTRIBUTION SYSTEM IMPROVEMENT ALTERNATIVES



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Notes

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Client/Project
CORNWALL-ON-HUDSON, NY
CORNWALL COMMONS ANALYSIS

Figure No.
2

Title
DISTRIBUTION SYSTEM IMPROVEMENT ALTERNATIVES