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Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Paula Winchell, AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 1.c. – Facilities Preliminary Design** **Final Technical Memorandum on Collection System Technologies (GS, LPS, STEG, STEP, and VS)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	05/21/16

1. Background

The purpose of this Collection System Technology and Evaluation Technical Memorandum is to identify the types of collection system technologies and to evaluate each of the technologies in order to develop a cost-effective alternative for the proposed Downtown Area and Meetinghouse Pond Area wastewater collection areas of Orleans. The Collection System Technologies include: (a) Gravity Sewers (GS); (b) Low Pressure Sewers (LPS); (c) Septic Tank Effluent Gravity (STEG); (d) Septic Tank Effluent Pumping (STEP); and (e) Vacuum Sewers (VS).

2. Introduction

a. General

The Orleans Water Quality Advisory Panel (OWQAP) was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town of Orleans. The panel consisted of stakeholder representatives (Orleans Selectmen and representatives of engaged citizen constituencies), and liaisons from key town boards and commissions, organizations, neighboring towns, and regional, state, and federal partners. The OWQAP met for twelve half-day meetings starting in July 2014, all of which were open to public attendance and comment. The Project is necessary in order to reduce excessive nitrogen discharges to the Town's ponds, estuaries and embayments. The Project represents the first to implement a "Hybrid" approach under the Cape Cod 208 Water Quality Plan, recently approved by both USEPA and MassDEP. The Project consists of conceptual and preliminary design to update the Comprehensive Wastewater Management Plan (CWMP) completed by the Town in 2011 to reflect the Consensus Plan (Water Quality Management Plan) developed by the Town in 2015. The Project goal is to minimize the proposed sewered footprint (area of Town and number of properties to be sewered) to the greatest extent possible by maximizing the use of several the non-traditional technologies (Coastal Habitat Restoration, Aquaculture, Floating Constructed Wetlands, and Permeable Reactive Barriers).

The Project includes two areas proposed for sewering: (1) about 350 parcels encompassing Downtown Orleans (250,000 gpd) to be treated at a new wastewater treatment facility and groundwater effluent disposal area; and (2) about 375 parcels within the Meetinghouse Pond sub-watershed (100,000 GPD), to be treated at a new satellite treatment facility and groundwater effluent disposal area. The resulting map (Figure. 1), entitled Conceptual Approach to Meet Orleans Water Quality Goals (March 2015) shows the agreed upon water quality management plan and indicates the two proposed areas to be sewered. This map also indicates the number of lots and associated wastewater flows associated with the respective Downtown Area and Meetinghouse Pond Area wastewater collection systems.

b. Definitions

1) Gravity Sewers (GS) – A Gravity Sewer system two major components: (a) collection system; and (b) a conveyance system. Gravity Sewers have historically been the most popular method used for the collection and conveyance of wastewater in the United States. The pipes are installed on a slope to enable the wastewater to flow by gravity from each property through a series of gravity collector pipes, often to a pumping station, for conveyance to a wastewater treatment facility for treatment and disposal. Pipes are generally 8 inches and larger and they typically are installed at a minimum depth with 5 feet of cover and a maximum depth of about 25 feet. Manholes are located a maximum of 400 feet apart and/or at changes of direction or slope.

a) Design Considerations

- Most cost effective for areas with topographic relief. Size and slope of pipes are determined by minimum scouring velocity requirements;
- Installation can require deep excavations with large open cut trenches to maintain grade and require dewatering;
- Require allowance for infiltration/inflow;
- Operation and maintenance costs and requirements are well known; and
- Typically requires pumping stations in areas of variable topography.

b) Advantages

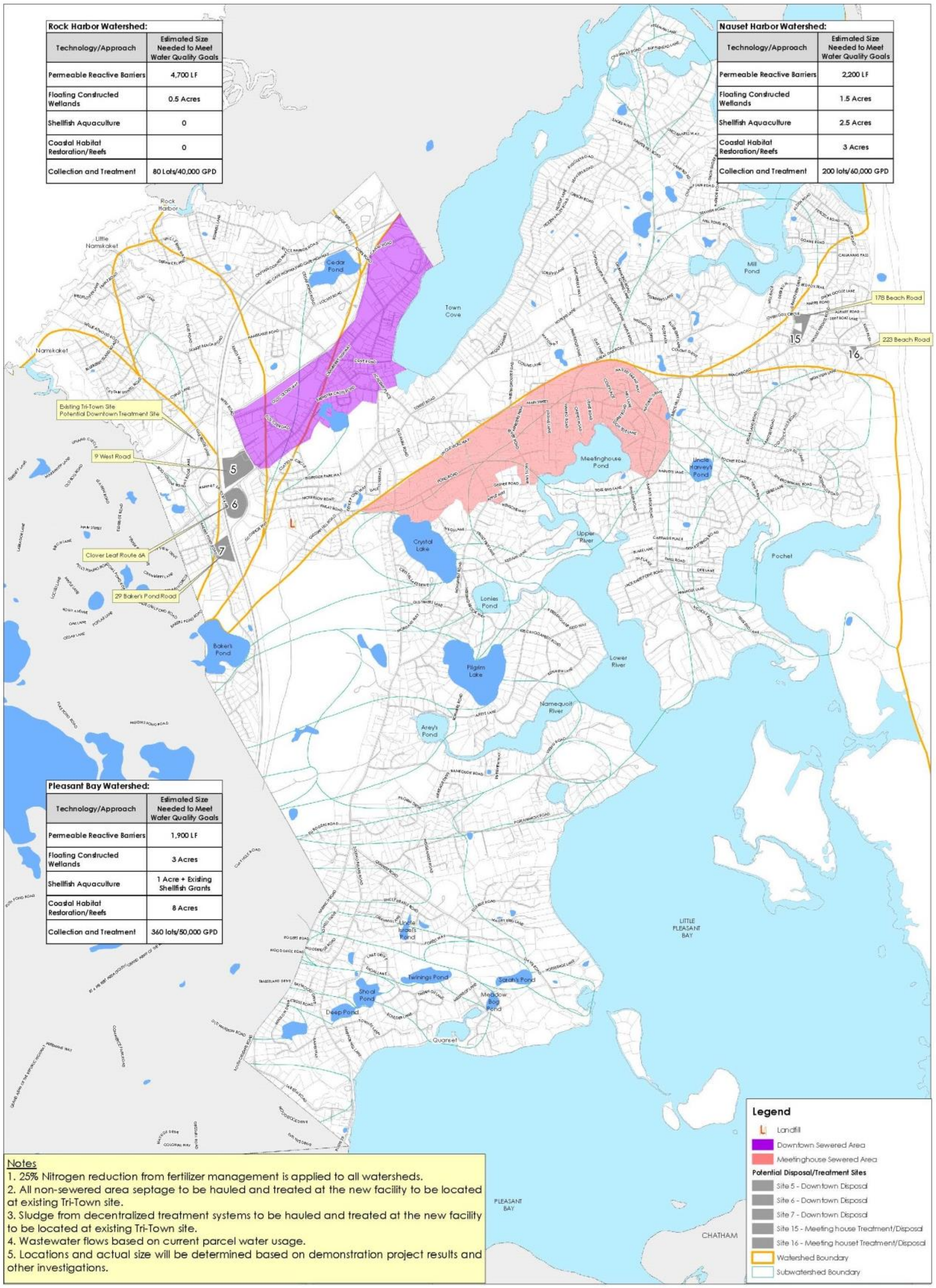
- Familiarity with the operation and maintenance of the systems;
- Gravity sewer systems typically have large amounts of storage volume;
- Gravity sewers generally can accommodate to future flow;
- Absence of mechanical components reduces the routine operation and maintenance required;
- Operation and maintenance limited to pumping stations;
- Detention times and the ability to adjust/control pumping operations can shave peak flows at downstream components including wastewater treatment facilities.

Stantec

CONCEPTUAL APPROACH TO MEET ORLEANS WATER QUALITY GOALS

TOWN OF ORLEANS
MASSACHUSETTS

MARCH, 2015



Rock Harbor Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	4,700 LF
Floating Constructed Wetlands	0.5 Acres
Shellfish Aquaculture	0
Coastal Habitat Restoration/Reefs	0
Collection and Treatment	80 Lots/40,000 GPD

Nauset Harbor Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	2,200 LF
Floating Constructed Wetlands	1.5 Acres
Shellfish Aquaculture	2.5 Acres
Coastal Habitat Restoration/Reefs	3 Acres
Collection and Treatment	200 lots/60,000 GPD

Pleasant Bay Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	1,900 LF
Floating Constructed Wetlands	3 Acres
Shellfish Aquaculture	1 Acre + Existing Shellfish Grants
Coastal Habitat Restoration/Reefs	8 Acres
Collection and Treatment	360 lots/50,000 GPD

Notes
1. 25% Nitrogen reduction from fertilizer management is applied to all watersheds.
2. All non-sewered area septage to be hauled and treated at the new facility to be located at existing Tri-Town site.
3. Sludge from decentralized treatment systems to be hauled and treated at the new facility to be located at existing Tri-Town site.
4. Wastewater flows based on current parcel water usage.
5. Locations and actual size will be determined based on demonstration project results and other investigations.

c) Disadvantages

- Construction costs are dependent on the depth of construction, and amount of dewatering;
- Deep installation can lead to wide trenches and have a greater impact to the environment and increased restoration cost;
- Reconstructing of entire roadway is typically required;
- May require several pumping stations;
- Ownership of the land and/or easements would be required to site pumping stations and/or to minimize the number of pumping stations;
- Increased potential infiltration based on the depth, the groundwater table and the system configuration (ie. number of manholes, size of pipes, etc.).

2) Low Pressure Sewers (LPS) – A Low Pressure Sewer system has two major components: (a) private property facilities; and (b) a collection system. Depending upon the distance to the termination point a conveyance system may also be required. Private property facilities consist of a pump chamber, and control panel at each property. The pumps are small and are equipped with a grinding mechanism that macerates the solids. Wastewater from the property flows by gravity to the pump chamber. The pumps automatically operate based on water level and discharge into a pressurized pipe system (1-1/2-inch increasing to 4-inches in diameter) terminating at a gravity collection sewer for gravity flow to a wastewater treatment facility for treatment and disposal. In some areas, a pumping station may be required for conveyance to a wastewater treatment facility.

a) Design Considerations

- Used with difficult site conditions including topography, poor soils, high groundwater and narrow roadways;
- Small diameter piping system typically between 1-1/2-inch to 4-inches; and
- Incorporates isolation and cleanout manholes.

b) Advantages

- The depth and width of the trenches are reduced due to small diameter piping;
- Trenchless technologies can be utilized in areas of favorable soils conditions and geography;
- Smaller pipe size with narrower and shallower trenches reduce impacts to the environment, reduce construction restoration, and overall construction costs;
- Routine servicing at private grinder pump chamber can be done without exposure to sewage;
- Collection system operation and maintenance requires minimal access to manholes.

- Infiltration is eliminated by the closed system design throughout the system, thereby reducing the operating and maintenance costs at downstream pumping stations and at the wastewater treatment facility.

c) Disadvantages

- Added operation and maintenance costs for the private property components;
- Property owner responsible for maintenance of system components. Storage is only in the gravity line and/or pump chamber, and typically provides 24-hour capacity during a power outage.
- Risk of overflow during extended pump shutdown/failure; and
- Shifting operation and maintenance costs to the property owner may not be acceptable and/or increase the number of complaints.

3) Septic Tank Effluent Gravity (STEG) – A Septic Tank Effluent Gravity system has three major components: (a) private property facilities; (b) a collection system; and (c) a conveyance system. Gravity Sewers have historically been the most popular method used for the collection and conveyance of wastewater in the United States. The private property facilities consist of a chamber (existing or new septic tank) at each property. The collection sewers are installed on a slope to enable the wastewater to flow by gravity from each property to a pumping station for conveyance to a wastewater treatment facility for treatment and disposal. Pipes are generally 8 inches and larger and they typically are installed at a minimum depth with 5 feet of cover and a maximum depth of about 25 feet. Manholes are located a maximum of 400 feet apart and at all changes of direction or slope.

a) Design Considerations

- Most cost effective for areas with topographic relief. Size and slope of pipes determined by minimum scouring velocity requirements;
- Installation can require deep excavations with large open cut trenches to maintain grade and require dewatering;
- Uses the existing or a new on-site septic tank;
- Require allowance for infiltration/inflow;
- Operation and maintenance costs and requirements are well known; and
- Typically requires pumping stations.

b) Advantages

- Familiarity with the operation and maintenance of the systems;
- Gravity sewer systems typically have large amounts of storage volume;
- Gravity sewers generally can be designed to accommodate future flow;

- Absence of mechanical components reduces the routine operation and maintenance required;

- Mechanical operation and maintenance limited to pumping stations;

- Detention times and the ability to adjust/control pumping operations can shave peak flows at downstream components including wastewater treatment facilities.

c) Disadvantages

- Private property owner responsible for septic tank inspections and pump outs.

- Septage pump-outs require trucking and processing at septage receiving facility;

- Odors may result from improperly maintained septic tanks; and

- Ownership of the land and/or easements would be required to site pumping stations and/or to minimize the number of pumping stations.

4) Septic Tank Effluent Pumping (STEP) – A Septic Tank Effluent Pumping system has two major components: (a) private property facilities; and (b) a collection system. Depending upon the distance to the termination point a conveyance system may also be required. Private property facilities consist of a pump, pump chamber (existing or new septic tank) and control panel at each property. The pumps are small and are designed to pump septic tank effluent, but will not pump raw sewage solids. Wastewater from the property flows by gravity to the pump chamber. The pumps automatically operate based on water level and discharge into a pressurized pipe system (1-1/2-inch increasing to 4-inches in diameter) discharging to the gravity collection sewer, a pumping station for conveyance to a wastewater treatment facility, or directly at a wastewater treatment facility for treatment and disposal.

a) Design Considerations

- Difficult site conditions including varying topography, poor soils, high groundwater and narrow roadways;

- Septic tank utilized to retain solids from effluent;

- Small diameter piping system typically between 1-1/2-inch to 4-inches;

- Can be utilized in low pressure sewer arrangement for small communities, and

- Effluent pump design requires dual system (primary/back-up) per TR-16.

b) Advantages

- The septic tank serves as pre-treatment allowing less solids in pumped effluent and smaller diameter piping;

- Pump chamber in new septic tanks is designed to provide 24-hours emergency storage volume.

- Trenchless technologies can be utilized assuming favorable soils conditions and physical geographic area;

- Smaller pipe size with narrower and shallower trenches reduce impacts to the environment as well as reduced construction restoration; and

- Collection system costs are reduced due to smaller pipe size, narrower and shallower trenches;

- Infiltration is reduced by the closed system effluent piping, thereby reducing the operating and maintenance costs at downstream pumping stations and at the wastewater treatment facility.

c) Disadvantages

- Property owner responsible for maintenance costs of system components (pump, controls and septic tank pump-outs);'

- Septage pump-outs require trucking and processing at septage receiving facility;

- Added operation and maintenance costs for the private property components;

- Requires monitoring of the septic tank on a regular basis in order to avoid plugging of the pump with solids;

- Storage in the system is only in the gravity line and/or pump chamber;

- Power outages shuts down the system and may cause overflow; and

- Shifting operation and maintenance costs to the property owner may not be acceptable and/or increase the number of complaints.

5) Vacuum Sewers (VS) – A Vacuum Sewer system has four major components: (a) gravity property connection to valve pit; (b) a vacuum collector main; (c) a vacuum collection station; and (d) a sewage pump and force main conveyance system. Wastewater from the property flows by gravity to an on-site vacuum interface valve pit/ holding tank. When a specific level has been reached, the vacuum interface valve, which operates automatically using pneumatic controls, opens for a few seconds allowing the wastewater and a volume of air to be sucked through the service pipe and into the vacuum sewer collection system. Vacuum pumps at the central collection station cycle as needed to maintain a constant level of vacuum throughout the service area. When the wastewater in the collection tanks reach a certain level, conventional sewage pumps transmit the wastewater by force main to the wastewater treatment facility for treatment.

a) Design Considerations

- Used with difficult site conditions including; flat or minimal slope topography, poor soils, high groundwater and narrow roadways;

- Vacuum collection chambers include sump and valve pit that must be vented to introduce air for vacuum;

- Vacuum collection chambers can serve multiple properties by gravity connections and be located near street for municipal access;

- Minimum slope of 0.2 percent between lifts and pipeline is installed in a saw tooth profile for lifting flow up an incline and to maintain vacuum level at end of each line;

- Two sets of pumps are required – collection (vacuum) and conveyance (sewage) – with careful selection of pumps required for proper facility operation; and

- One vacuum pumping station can typically pull vacuum in the collection system at a distance of up to 10,000 linear feet;

b) Advantages

- Collection chambers are serviced without exposure to sewage;

- A local power outage is not a factor in service at the property since no power is required at each collection chamber;

- Collection pipe diameters typically range from 4-inches to 10-inches;

- Construction costs, restoration, and environmental impacts are reduced due to smaller pipe size, narrower and shallower trenches;

- The system from private property collection chambers to the vacuum station can be monitored from a control panel located at the vacuum pumping station;

- Emergency power back-up is only needed at the combined vacuum pumps/collection tank and sewage pumping station; and

- Infiltration is reduced or eliminated by the closed system, thereby reducing the operating and maintenance costs at pumping stations and at the wastewater treatment facility.

c) Disadvantages

- Added operation and maintenance costs for the private property components;

- Requires timely response to low vacuum alarms.

- May require several vacuum stations to serve a large service area;

- Ownership of the land and/or easements would be required to site system vacuum/pumping station and/or to minimize the number of vacuum/pumping stations;

- Limited flexibility regarding future expansion, new vacuum station typical for each added service area;

- Limited storage in the collection system;

- Unsteady flows conveyed to WWTF if the majority of the service area is on vacuum stations that typically run in a batch cycle; and

- Vacuum station requires larger building to house two sets of pumps; vacuum and sewage, which will increases operation and maintenance costs.

c. Design Criteria – Present the design criteria (i.e. minimum pipe sizes and slopes. materials of construction, trench depth and width, private property scope of work, restoration, typical production rates) that will be used as part of the basis of the technologies evaluations.

(1) Gravity Sewers (GS)

- Gravity Sewer Main Layout – Layout the system to allow gravity connections from all properties to be serviced. Pipes shall laid with a uniform slope between manholes and be installed at a minimum of 6 feet below grade in order to prevent freezing and minimize conflicts with other utilities.

- Pipe Size and Material – Pipe diameter sized to provide a cleansing velocity of 2 feet/second when flowing full based on Manning's formula using an "n" value of 0.013 but shall not be less than 8-inches in diameter. Pipe Material to be SDR 35 PVC piping or greater.

- Manholes – Installed at the end of each sewer reach; at all changes in grade, size, or alignment; and at all pipe intersections with a nominal distance of 300 to 400 linear feet. Manhole material to be precast concrete.

(2) Low Pressure Sewers (LPS)

- Pressure Sewer Main Layout – Layout the system to allow connections to all properties to be services. Pipe routing shall include long radius sweeps but not looped. Pipes shall be installed at a minimum of 5 feet below grade in order to prevent freezing and minimize conflicts with other utilities.

- Pipe Size and Material – Pipe Size diameter sized to provide a cleansing velocity based on the system's average daily flow but not less than 1-1/2-inches in diameter. Sizing shall also consider the retention times of each line segment to provide sufficient wastewater changes to reduce the potential for odor generation. Pipe Material to be Class 200, SDR 21 PVC piping or greater or HDPE SDR 11 to provide the necessary working pressure rating for the system, and to provide durability during installation.

- Isolation Valves and Check Valves – Provide Isolation Valves and Check Valves to allow isolation of individual STEP units, at points where system expansion is projected and at key locations such as property lines. Provide a valve box with a redundant check valve at property lines to protect properties from back-ups and/or flooding.

- Air Release and Vacuum Valves – Provide Automatic Air Release and Vacuum Valves to release air trapped in pressure lines and to prevent system siphoning or vacuum conditions. Provide Air Release and Vacuum Valves at all high points in a system and at least 14 pipe diameters downstream of locations where hydraulic jumps occur. Air Release/Vacuum Valves should be located in a manhole or structure to allow access for repair and maintenance.

- Cleanout Connections – Provide Cleanout Connections as a means for cleaning out pressure mains. Provide Cleanout Connections and valves to conduct required maintenance at terminal ends of branches or zones, intersections, sharp bends, and low and high points. Provide Cleanout Connections at least every 1,500 to 2,000 linear feet in all lines.

- Pump Chamber - Construct each pump chamber of concrete, high density polyethylene, or custom-molded, fiberglass-reinforced polyester resin using a filament wound process, layup and spray technique, or other approved process that will ensure a smooth and resin-rich interior surface designed for structural integrity. Lockable access opening at the ground surface with a minimum inside diameter of 24 inches. Equipped with PVC closet flange or flexible inlet flange suitable for connection to the structure's gravity sewer line. The pump chamber shall be sized to prevent accumulation of solids and designed to promote mixing during pumping actions.

- Pump System

  - Pump Removal - Pump shall be able to be removed without the need for manual disconnection of piping.

  - Grinder - The grinder should be positioned immediately below the pumping elements, securely fastened to the pump motor shaft, and driven directly by the same motor.

  - Pump Opening - The grinder should be capable of reducing all components in normal domestic sewage, including a reasonable number of foreign objects (e.g., paper, wood, plastic, glass, and rubber). Objects should be reduced to finely divided particles that will pass through the passages of the pump and a minimum 1.25 inch diameter discharging pipe.

  - Intake - The grinder should be positioned so solids are fed into it from the bottom in an upward flow, reducing the possibility of overloading or jamming. Sufficient turbulence should be created to keep the tank bottom free of permanent deposits or sludge banks.

  - Check Valve and Anti-Siphon Valve – Provide each pump system with a check valve that is installed in a horizontal position on the discharge pipe. Provide each pump system with a gravity-operated, and integral anti-siphon valve.

  - Ventilation - Provide adequate ventilation as required by State and Local regulations.

  - Controls and Alarms - Provide non-fouling level sensing devices to detect wastewater levels for initiating pump operation and to detect high water levels. Level sensing devices will not be placed near flows entering the well. Alarm indicators should include an audible alarm and a visual light.

  - Electrical Equipment – Provide wiring and electrical connections that are NEMA-rated for the environment in which they are to be placed.

(3) Septic Tank Effluent Gravity (STEG)

- Gravity Sewer Main Layout – Layout the system to allow gravity connections to all properties to be serviced. Pipes shall be installed at a minimum of 5 feet below grade in order to prevent freezing and minimize conflicts with other utilities.

- Pipe Size and Material – Service pipe from septic tank to street collector shall be minimum 6-inches in diameter. Collector pipe in street sized to provide a cleansing velocity of 2 feet/second when flowing full based on Manning's formula using an "n" value of 0.013 but shall not be less than 8-inches in diameter. Sizing shall also consider the retention times of each line segment to provide sufficient wastewater flushing to reduce the potential for odor generation. All pipe material to be SDR 35 PVC piping or greater.

- Manholes – Installed at the end of each line; at all changes in grade, size, or alignment; and at all pipe intersections with a distance not to exceed 400 linear feet. Manhole material to be precast concrete.

- Septic Tanks – Existing Septic Tanks shall meet current Title 5 Standards. Existing Septic Tanks shall be pumped out, cleaned and pressure tested. Existing Septic Tanks which do not meet current Title 5 Standards or fail the pressure test shall be replaced.

(4) Septic Tank Effluent Pumping (STEP)

- Pressure Sewer Main Layout – Layout the system to allow connections to all properties to be serviced. Pipe routing shall include long radius sweeps but not be looped. Pipes shall be installed at a minimum of 5 feet below grade in order to prevent freezing and minimize conflicts with other utilities.

- Pipe Size and Material – Pipe diameter sized to provide a cleansing velocity based on the system's average daily flow but not less than 1-1/2-inches in diameter. Sizing shall also consider the retention times of each line segment to provide sufficient wastewater flow-through to reduce the potential for odor generation. Pipe Material to be Class 200, SDR 21 PVC piping or greater or HDPE SDR 11 to provide the necessary working pressure rating for the system, and to provide durability during installation.

- Isolation Valves and Check Valves – Provide Isolation Valves and Check Valves to allow isolation of individual STEP units, at points where system expansion is projected, and at key locations such as property lines. Provide a valve box with a redundant check valve at property lines to protect properties from flooding.

- Air Release and Vacuum Valves – Provide Automatic Air Release and Vacuum Valves to release air trapped in pressure lines and to prevent system siphoning or vacuum conditions. Provide Air Release and Vacuum Valves at all high points in a system and at least 14 pipe diameters downstream of locations where hydraulic jumps occur. Provide Air Release/Vacuum Valves should be located in a manhole or structure to allow access for repair and maintenance.

- Cleanout Connections – Provide Cleanout Connections as a means for cleaning out pressure mains including valves, to conduct required maintenance at terminal ends of branches or zones, intersections, sharp bends, and low and high points. Provide Cleanout Connections at least every 1,500 to 2,000 linear feet in all lines.

- Septic Tanks – Existing Septic Tanks shall meet current Title 5 Standards. Existing Septic Tanks shall be pumped out, cleaned and pressure tested. Existing Septic Tanks which do not meet current Title 5 Standards or fail the pressure test shall be replaced.

- Pumps

  - Dual pump design (lead/stand-by) required per TR-16.

  - Pump design – Provide pump capable of pumping septic tank effluent through the passages of the pump and a minimum 1.25 inch diameter discharging pipe at pressure conditions required for the collection system.

  - Check Valve and Anti-Siphon Valve – Provide each pump system with a check valve that is installed in a horizontal position on the discharge pipe. Provide each pump system with a gravity-operated, and integral anti-siphon valve.

  - Ventilation - Provide adequate ventilation as required by State and Local regulations.

  - Controls and Alarms - Provide non-fouling level sensing devices to detect wastewater levels for initiating pump operation and to detect high water levels. Level sensing devices will not be placed near flows entering the wet well. Alarm indicators should include an audible alarm and a visual light.

  - Electrical Equipment – Provide Wiring and electrical connections that are NEMA-rated for the environment in which they are to be placed.

(5) Vacuum Sewers (VS)

- Vacuum Sewer Main Layout – The system layout allow gravity service connections to valve chambervacuum connections to all properties to be serviced. Pipe routing shall include long radius sweeps in a saw tooth pattern but not looped. Pipes range from 4-inches to 10-inches and shall be installed at a minimum of 5 feet below grade in order to prevent freezing and minimize conflicts with other utilities. Pipe line lengths shall be sized based on static lift and losses with a maximum total head loss of 13 feet.

- Pipe Size and Material – Pipe diameter sized to provide a cleansing velocity using the Hazen-Williams formula for full-bore flow but not less than 1-1/2-inches in diameter. Use a C-factor of 150 for PVC pipe material and a flow that consists of 2 parts of air to 1 part of liquid. Sizing shall also consider the retention times of each line segment to provide sufficient wastewater flow-through to reduce the potential for odor generation. Pipe Material – Pipe Material to be Class 200, SDR 21 PVC piping or greater or HDPE SDR 11 to provide the necessary working pressure rating for the system, and to provide durability during installation.

- Vacuum pumps –Designed as duplex (lead/back-up) to cycle and maintain constant level of vacuum on the entire collection system.

- Collection tank – The total volume of the collection tank shall be 3 times the operating volume with a minimum size of 400 gallons. The operating volume is the sewage accumulation required to restart the discharge pump. Operating volume should be sized so that at minimum design flow, the pump will operate once every 15 minutes.

- Sewage Transfer Pumps

  - Discharge pump capacity shall be 20 percent greater than the peak design flow.

  - Motors are sized using the procedure for force mains plus 25 feet of additional head to pump against the vacuum in a collection tank.

  - Pumps shall be duplex (lead/back-up) design alternating, non-clog type.

- Standby Power - Provide 100 percent standby power at vacuum collection/transmission stations for use during normal power failure.

3. Enumerate Site Evaluation and Screening Criteria

a. Identify and define technology evaluation and screening criteria for the proposed Collection Systems (GS, LPS, VS, STEP, and STEG), such as:

(1) Site Suitability

- Land Ownership - Recognizes that project implementation is likely the most feasible when there is a minimal requirement to negotiate with and obtain access from private property owners, with tendency for risk to increase as the property owners increases. Favorable scores (+1) are given to those technologies which can be achieved via construction predominantly in public roads and/or public rights-of-way. Less favorable scores (-1) are given to those technologies which will require construction within or through a substantial number of private roads and/or private properties. Neutral (0) scores are given to those technologies that contain elements of both public and private construction access, but the number of private properties affected is less than the lowest ranking technology(s).

- Constructability (Method of Installation) - Considers the likely method of installation for the technology, recognizing that conventional construction methods, at nominal depths, typically have lower risks. Favorable scores (+1) are given to those technologies expected to be constructed with typical cut-and-cover trenching. Less favorable scores (-1) are given to those technologies which require substantial lengths of pipe to be installed by non-conventional means (e.g. horizontal directional drilling) and/or require substantial lengths of pipe to be installed in conventional open cut trenches exceeding 15 feet in depth. Neutral scores (0) are given to those technologies that contain elements of both favorable (shallow, conventional trenches) and less favorable (deep trenches and/or non-conventional installation technologies), but the length of less favorable segments is less than the lowest ranking technology(s).

(2) Environmental Considerations

- Permittability - Considers the potential impacts to natural resources that would occur as a result of constructing the collection system by the given technology, recognizing that the greater the potential adverse effect on natural resources regulated by federal, state, or local agencies, typically corresponds to increasing complexity, and potential uncertainty, in obtaining permits and approvals. Favorable scores (+1) are given to those technologies anticipated to require the fewest number of permits and have the least adverse impact on natural resources; for example technologies whose alignments allow them to follow almost exclusively previously disturbed corridors (such as roads or rights-of-way). Less favorable scores (-1) are given to those technologies whose alignments require crossing of environmentally sensitive areas (such as wetlands or woodlands) for which mitigation would likely need to be incorporated into the project in order to obtain regulatory approval. Neutral scores (0) are given to those technologies that contain elements of both favorable (predominantly constructed through previously developed corridors) but include some construction within natural areas, that require some permitting, but not to the extent of the lowest ranking technology(s).

- Extent of Dewatering - Recognizes that construction in areas where the groundwater table is shallow frequently requires dewatering of the trench/pit in order to safely and efficiently install the collection system. However, as the extent of dewatering increases, there is an increase in the environmental concerns with respect to collecting, storing, treating, and discharging the construction dewatering. Favorable scores (+1) are given to those technologies likely to generate the lowest volume of construction dewatering effluent, either because of the shallow nature of the trenches or because of the installation technology chosen (e.g. trenchless technologies often generate less construction dewatering because of the smaller excavation areas). Less favorable scores (-1) are given to those technologies likely to generate the greatest volume of construction dewatering effluent, either because of the deep nature of the trenches or the locations through which trenches must be constructed (e.g. wetlands, areas of shallow groundwater). Neutral scores (0) are given to those technologies whose construction contains elements of favorable and less favorable considerations with respect to construction dewatering, but do not approach the quantity of the lowest ranking technology(s).

- Sustainability - Considers the extent to which natural resources and/or non-renewable resources would be required to support the construction and operation of the technology. Since the use of non-renewable resources (e.g. fossil fuels) is likely to be similar for construction of any of the technologies, this parameter focuses primarily on the long term demands on non-renewable resources. Favorable scores (+1) are given to those technologies that require little electricity (presumed to be generated primarily from non-renewable resources) for operation, consume little/no natural resources, and generate little/no solid waste (other than solid waste which can be repurposed for beneficial reuse). Less favorable scores (-1) are given to those technologies that have high electrical demands for operation, require frequent use/disposal of ‘consumables’, and/or generate substantial non-recyclable waste materials. Neutral scores (0) are given to those technologies having characteristics of both sustainable-favorable and sustainable-unfavorable categories, but not to the extremes of the highest or lowest ranking technology(s).

(3) Financial Considerations

- Construction Costs - Considers the financial burden of constructing the technology. For this criterion, the overall cost of constructing the technology is considered; this evaluation does not attempt to make a distinction between costs borne by the Town versus costs borne by individual property owners but rather looks at the overall financial investment that must be made by the Town and the people of the Town. Favorable scores (+1) are given to those technologies having the lowest construction costs. Less favorable scores (-1) are given to those technologies having the highest construction costs. For the purpose of this estimate, technologies having a construction cost within 5 percent of each other are ranked the same. Neutral scores (0) are assigned to those technologies that fall neither among the highest nor the lowest construction costs.

- Operation and Maintenance Costs - Considers the financial burden of operating the technology. For this criterion, the overall cost of operating the technology (e.g., over a 20 year span) is considered; this evaluation does not attempt to make a distinction between costs borne by the Town versus costs borne by individual property owners but rather looks at the overall financial investment that must be made by the Town and the people of the Town. Favorable scores (+1) are given to those technologies having the lowest operating costs. Less favorable scores (-1) are given to those technologies having the highest operating costs. For the purpose of this estimate, technologies having an operating cost within 10 percent of each other are ranked the same. Neutral scores (0) are assigned to those technologies that fall neither among the highest nor the lowest operation and maintenance costs.

(4) Maintenance Considerations

- Level of Maintenance, Homeowner - Considers the anticipated (recommended) amount of maintenance that must be performed by the homeowner (or property owner) for the collection technology; measured by time, convenience, and costs. Favorable scores (+1) are given to those technologies anticipated to require little to no homeowner intervention on an annual basis. Less favorable scores (-1) are given to those technologies that have a reasonable probability of requiring service calls (e.g. pump out tanks, reset pumps, replace floats or valves). Neutral scores (0) are assigned to those technologies that fall neither among the highest nor the lowest with respect to the level of homeowner responsibility for maintaining a fully functioning system.

- Level of Maintenance, Town - Considers the ability of the Town to perform maintenance and the type (routine vs non-routine, frequent vs infrequent) of maintenance required by the collection technology. Favorable scores (+1) are given to those technologies that are considered reasonably easy for the Town to implement and do not require a substantial investment in equipment or personnel. Less favorable scores (-1) are given to those technologies that may require a substantial investment in equipment or personnel, or have a greater tendency to require emergency (rather than planned) maintenance. Neutral scores (0) are assigned to those technologies that fall neither among the highest nor the lowest with respect to demands on the Town for ensuring a fully functioning system.

(5) Other Considerations

- Reliability - Considers the track record of the technology in similar locations, including factors such as frequency of unplanned shutdowns and performance in adverse weather conditions, and/or hydraulic conditions. Favorable scores (+1) are given to those technologies that are considered the most fail-safe (generally those having the least complexity and/or reliance on powered equipment). Less favorable scores (-1) are given to those technologies that have a record of higher than average malfunctions and/or have a higher risk for backups in the event of a malfunction or weather event (e.g. a power outage). Neutral scores (0) are assigned to those technologies that fall neither among the most or least reliable.

- Ability to Accommodate Expansion - Recognizes that homes, schools, and businesses adjacent to the study area may be added to the collection system at some point in the future in response to evolving planning and zoning, or environmental challenges. Favorable scores (+1) are given to those technologies that have the greatest flexibility to accommodate additional flows without substantial additional capital investment and/or without making previously capital investments obsolete. Less favorable (-1) scores are given to those technologies that have the least flexibility to accommodate additional flows without the investment of substantial capital (e.g. laying new/parallel piping; resizing wet wells or pumps, etc.). Neutral scores (0) are assigned to those technologies that have no strong advantages, nor any strong disadvantages, with respect to their ability to accommodate additional sewage flows in the future.

- Area of Disturbance - Recognizes that construction within a densely developed area has the potential to adversely impact, in the short-term, abutting homes, businesses, and institutions. To the extent that the disturbance can be minimized by the technology selection, the construction anticipated to result in fewer disruptions and thus fewer complaints is desirable. Favorable scores (+1) are given to those technologies that require the smallest construction footprint to install the collection system. Less favorable scores (-1) are given to those technologies that require the largest construction footprint (wide, deep trenches that occupy more than 40 percent of a roadway width). Neutral scores (0) are assigned to those technologies that have an average area of disturbance, and are characterized as having neither the smallest nor the largest construction footprint.

- Duration/Schedule - Recognizes that the public is willing to accept short-term impact for the realization of long-term benefit, but also recognizes that the longer the duration of construction disruption, the greater the potential for impact to the community. Favorable scores (+1) are given to those technologies anticipated to require the shortest time to install, thereby minimizing disruptions to the community and achieving the public benefit most quickly. Less favorable scores (-1) are given to those technologies anticipated to require the longest construction schedule. Neutral scores (0) are assigned to those technologies whose anticipated construction duration falls in between the shortest and longest alternatives.

- Aesthetics - Considers the extent to which the collection technology, after installation, will alter the aesthetic charm of the Town. Favorable scores (+1) are given to those technologies having little/no aboveground structures larger than a utility box. Less favorable scores (-1) are given to those technologies that require either a considerable number (>3) of aboveground structures larger than a utility box (e.g. pump station) or that require a large aboveground structure in a prominent location where its presence would not easily blend with the surroundings. Neutral scores (0) are assigned to those technologies that are not distinctly above the most favorable, nor the least favorable, with respect to potential aesthetic impact.

b. A technology evaluation matrix for the proposed Collection Systems (GS, LPS, VS, STEP, and STEG) in the proposed Downtown Area and Meetinghouse Pond Area was developed and is presented in Table 3-1 and Table 3-2, respectively.

4. Analysis: Evaluate and Rate Each Technology based on Criteria

a. The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows:

1) Good = 1 point

2) Neutral = 0 points

3) Poor = -1 point

b. An overall rating for each technology was completed based on the criteria and weights assigned to each of the individual criteria. The technologies were ranked using both the weighted and un-weighted criteria.

c. Table 4-1 and Table 4-2 present the results of each technology ranking (weighted and un-weighted) for the Downtown Area and Meetinghouse Pond Area, respectively.

Table 4-1 - Downtown Area Collection System

	Weighted		Un-Weighted	
Technology	**Number of Evaluation Points**	**Rank**	**Number of Evaluation Points**	**Rank**
Gravity Sewers	-4	3	-2	3
Low Pressure Sewers	6	1	3	1
Septic Tank Effluent Gravity	-13	4	-6	4
Septic Tank Effluent Pumping	3	2	2	2
Vacuum Sewers	-15	5	-6	4

Table 3-1 – Downtown Area Collection System Technology Evaluation Matrix

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Collection System Evaluation - Downtown

Criteria	Criteria Weight	Technology A		Technology B		Technology C		Technology D		Technology E	
		Gravity Sewer		STEG		LPS		Vacuum Sewer		STEP	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability											
Land Ownership	2	-1	-2	-1	-2	0	0	-1	-2	0	0
Constructability (Method of Installation)	1	0	0	0	0	1	1	1	1	1	1
Environmental Considerations											
Permitability	1	0	0	0	0	0	0	0	0	0	0
Extent of Dewatering	2	0	0	0	0	1	2	1	2	1	2
Sustainability	1	-1	-1	-1	-1	1	1	-1	-1	1	1
Financial Considerations											
Construction Costs	3	-1	-3	-1	-3	1	3	-1	-3	1	3
Operation and Maintenance Costs	3	-1	-3	-1	-3	1	3	-1	-3	1	3
Maintenance Considerations											
Level of Maintenance - Homeowner	2	1	2	0	0	-1	-2	0	0	-1	-2
Level of Maintenance - Town	2	-1	-2	-1	-2	0	0	-1	-2	-1	-2
Impact to WWTF Operations	2	1	2	-1	-2	0	0	0	0	-1	-2
Other Considerations											
Reliability	3	1	3	0	0	0	0	-1	-3	0	0
Ability to Accommodate Expansion	3	1	3	1	3	-1	-3	-1	-3	-1	-3
Area of Disturbance	2	-1	-2	-1	-2	1	2	0	0	1	2
Duration/Schedule	2	-1	-2	-1	-2	0	0	0	0	0	0
Aesthetics	1	1	1	1	1	-1	-1	-1	-1	0	0
Total Criteria Points			**(4)**		**(13)**		**6**		**(15)**		**3**
Rank			**3**		**4**		**1**		**5**		**2**

Notes:
High Criteria Weight = Greater Importance
Higher Rating = Better Conditions

Table 3-2 – Meetinghouse Pond Area Collection System Technology Evaluation Matrix

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Collection System Evaluation - Meetinghouse Pond

Criteria	Criteria Weight	Technology A Gravity Sewer		Technology B STEG		Technology C LPS		Technology D Vacuum Sewer		Technology E STEP	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability											
Land Ownership	2	-1	-2	-1	-2	1	2	-1	-2	1	2
Constructability (Method of Installation)	1	0	0	0	0	1	1	1	1	1	1
Environmental Considerations											
Permitability	1	0	0	0	0	0	0	0	0	0	0
Extent of Dewatering	2	0	0	0	0	1	2	1	2	1	2
Sustainability	1	-1	-1	-1	-1	0	0	-1	-1	0	0
Financial Considerations											
Construction Costs	3	-1	-3	-1	-3	1	3	-1	-3	1	3
Operation and Maintenance Costs	3	-1	-3	-1	-3	1	3	-1	-3	1	3
Maintenance Considerations											
Level of Maintenance - Homeowner	2	1	2	0	0	-1	-2	0	0	-1	-2
Level of Maintenance - Town	2	-1	-2	-1	-2	0	0	-1	-2	-1	-2
Impact to WWTF Operations	2	1	2	-1	-2	0	0	0	0	-1	-2
Other Considerations											
Reliability	3	1	3	1	3	0	0	-1	-3	0	0
Ability to Accommodate Expansion	3	1	3	1	3	-1	-3	-1	-3	-1	-3
Area of Disturbance	2	-1	-2	-1	-2	1	2	0	0	1	2
Duration/Schedule	2	0	0	0	0	0	0	0	0	0	0
Aesthetics	1	1	1	1	1	-1	-1	-1	-1	0	0
Total Criteria Points		**-2**		**-8**		**7**		**-15**		**4**	
Rank			**3**		**4**		**1**		**5**		**2**

Notes:
High Criteria Weight = Greater Importance
Higher Rating = Better Conditions

Table 4-2 - Meetinghouse Pond Area Collection System

	Weighted		Un-Weighted	
Technology	**Number of Evaluation Points**	**Rank**	**Number of Evaluation Points**	**Rank**
Gravity Sewers	-2	3	-1	3
Low Pressure Sewers	7	1	3	1
Septic Tank Effluent Gravity	-8	4	-4	4
Septic Tank Effluent Pumping	4	2	2	2
Vacuum Sewers	-15	5	-6	5

5. Findings/Recommendations: Summarize Technology Selection Matrix/Screening Results

As can be seen in the ranking results, the overall ranking of the individual technologies is not differentiated much between weighted and un-weighted rank for each system. It is noted that septic tank effluent pumping (STEP) and low pressure sewer (LPS) are ranked the most favorable with very close criteria points and thus considered essentially equivalent in this analysis. Vacuum sewers were ranked the least favorable for both areas mainly because they are most beneficial in flat terrain. Gravity sewers were ranked at 3 of 5, and septic tank effluent gravity (STEG) systems ranked at 4 of 5. However, the criteria points for gravity were more significantly favorable in the Downtown area due to the emphasis on reliability and minimal maintenance required by the owner at the property level. For both collection system areas, Low Pressure Sewers (LPS) and Septic Tank Effluent Pumping (STEP) systems are ranked essentially equivalent with one point difference in total criteria points.

In this analysis, key differentiators were construction impacts related to cost, environmental considerations and restoration. This focus highlights the benefits of utilizing smaller pipes from LPS and STEP systems to collect and transmit sewage flows at a lower cost of construction per service connection. However, these systems are most suitable to small communities with an established service area and are less able to provide future expansion capacity within the same collection area. For this reason, a hybrid system is recommended that takes advantage of the newer collection system design strategies to provide services to the individual properties, with a limited traditional gravity sewer system that can collect the flows and provide the capacity for long-term expansion. In this manner, additional phases, or neighborhoods can be added to the system without impacting the existing infrastructure. The gravity sewer would be installed in the public right of ways and designed to eliminate deep excavations and the need for pumping stations as much as possible, by relying on pressure service connections where practical.

While LPS and STEP collection systems were comparable in this analysis, the LPS is determined most favorable for use in the hybrid plan mainly due to the additional cost and maintenance burden on the homeowner related to the septage management requirements of the STEP system. Additional factors include the higher potential for corrosion and odors from the septic conditions of the STEP system at the property as well as increase in difficulty in the biological process of the septic effluent at a wastewater treatment facility. Both systems require nominal cost to the homeowner related to operation and maintenance of the effluent service pumps.

6. System Layout and Cost Estimates

a. Figure 1 shows the map developed as part of the Conceptual Approach to Meet Orleans Water Quality Goals (March 2015) and shows the agreed upon water quality management plan and indicates the two proposed areas to be sewered. The map has been updated to reflect the activities which have occurred over the past year (see Figure 2). This map includes the following summary of the proposed plan:

- Downtown Area – Number of Connection; Estimate Wastewater Generation at Buildout with Infiltration/Inflow; and System Configuration;
- Overland Way WWTF – Capacity; and Process;
- Meetinghouse Pond Area – Number of Connection; Estimate Wastewater Generation at Buildout with Infiltration/Inflow; and System Configuration;
- Meetinghouse Pond WWTF – Capacity; and Process;
- Potential Effluent Disposal Sites – Location and Estimated Capacity;
- Permeable Reactive Barriers and Shellfish/Aquaculture – Demonstration Sites.

b. A preliminary system layout (plan and profiles) was developed for both the Downtown Area and Meetinghouse Pond Area. Refer to Appendix A. The development of the plan and profiles for each area system was based on existing information as follows:

1) Town of Orleans Assessors Records;

2) Town of Orleans topography survey from the stormwater project for part of the Downtown Area; and

3) USGS topographic survey.

The preliminary system layouts were developed in accordance with the New England Interstate Water Pollution Control Commission - TR-16, Guides for the Design of Wastewater Treatment Works, 2011 Edition.

It is anticipated that the final system layouts will be further developed based on various site factors as defined by obtaining detailed topographic survey; preforming subsurface investigations (ie. soil types, and depth to groundwater); ability to obtain land and/or easements; and investigation of existing utilities.

Figure 3 and Figure 4 present a flow schematic for the Downtown Area and Meetinghouse Pond Area, respectively.

c. Preliminary cost estimates were developed based on the preliminary system layouts and included Project Costs; Annual Operation and Maintenance Costs; Replacement Costs; and Annual Monitoring Cost and is included in the following sections.

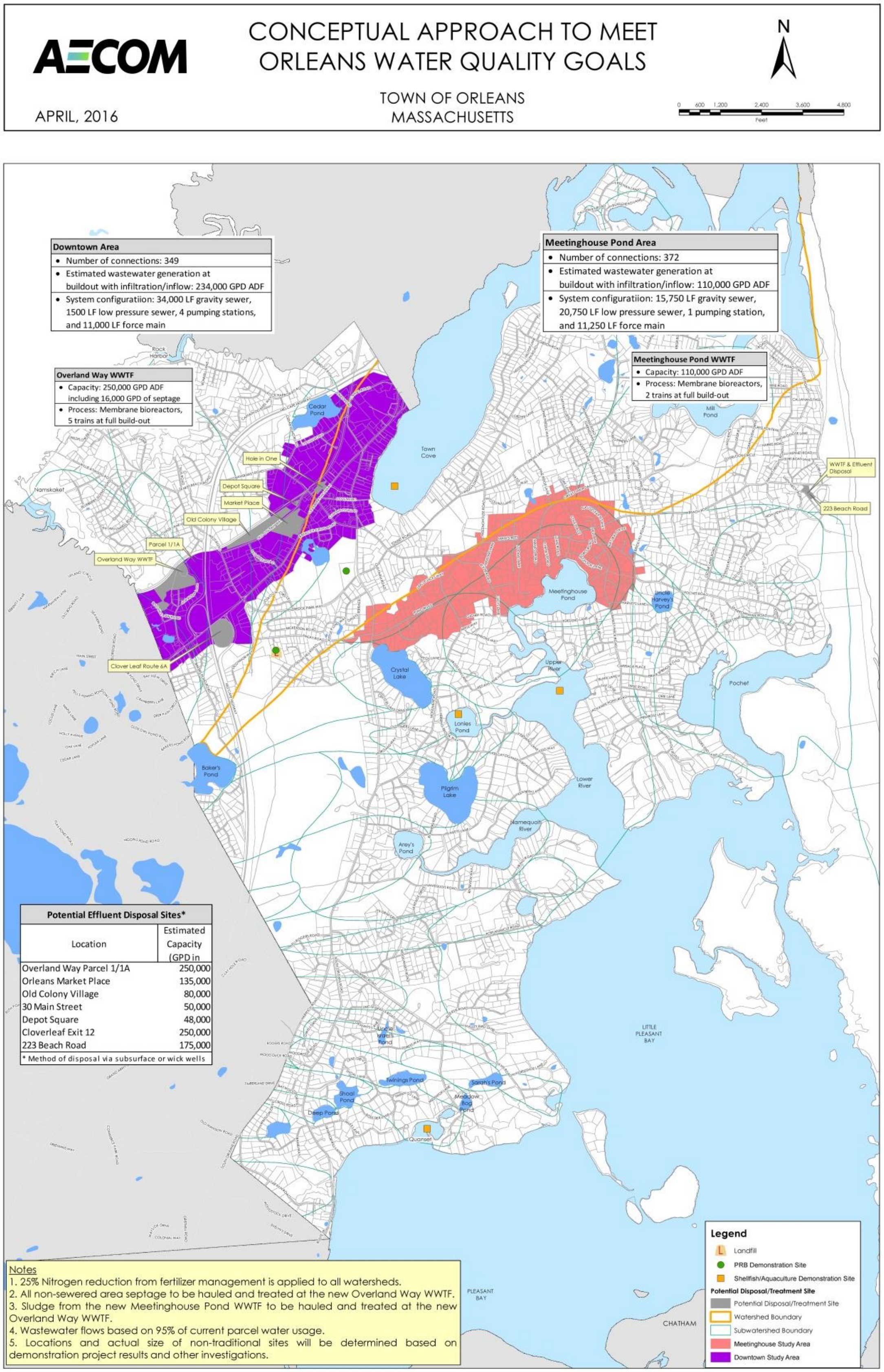

AECOM
CONCEPTUAL APPROACH TO MEET
ORLEANS WATER QUALITY GOALS
TOWN OF ORLEANS
MASSACHUSETTS
APRIL, 2016
N
0 600 1,200 2,400 3,600 4,800
Feet
Downtown Area
• Number of connections: 349
• Estimated wastewater generation at buildout with infiltration/inflow: 234,000 GPD ADF
• System configuratiion: 34,000 LF gravity sewer, 1500 LF low pressure sewer, 4 pumping stations, and 11,000 LF force main
Meetinghouse Pond Area
• Number of connections: 372
• Estimated wastewater generation at buildout with infiltration/inflow: 110,000 GPD ADF
• System configuratiion: 15,750 LF gravity sewer, 20,750 LF low pressure sewer, 1 pumping station, and 11,250 LF force main
Overland Way WWTF
• Capacity: 250,000 GPD ADF including 16,000 GPD of septage
• Process: Membrane bioreactors, 5 trains at full build-out
Meetinghouse Pond WWTF
• Capacity: 110,000 GPD ADF
• Process: Membrane bioreactors, 2 trains at full build-out
Hole in One
Depot Square
Market Place
Old Colony Village
Parcel 1/1A
Overland Way WWTF
Clover Leaf Route 6A
WWTF & Effluent Disposal
223 Beach Road
Cedar Pond
Town Cove
Meetinghouse Pond
Uncle Harvey's Pond
Mill Pond
Crystal Lake
Upper River
Lonies Pond
Baker's Pond
Pilgrim Lake
Lower River
Namequoit River
Arey's Pond
Pochet
Namskaket
Rock Harbor
Twinings Pond
Sarah's Pond
Shoal Pond
Deep Pond
Meadow Bog Pond
Quanset
LITTLE PLEASANT BAY
PLEASANT BAY
CHATHAM
Potential Effluent Disposal Sites*
Location | Estimated Capacity (GPD in
Overland Way Parcel 1/1A 250,000
Orleans Market Place 135,000
Old Colony Village 80,000
30 Main Street 50,000
Depot Square 48,000
Cloverleaf Exit 12 250,000
223 Beach Road 175,000
* Method of disposal via subsurface or wick wells
Notes
1. 25% Nitrogen reduction from fertilizer management is applied to all watersheds.
2. All non-sewered area septage to be hauled and treated at the new Overland Way WWTF.
3. Sludge from the new Meetinghouse Pond WWTF to be hauled and treated at the new Overland Way WWTF.
4. Wastewater flows based on 95% of current parcel water usage.
5. Locations and actual size of non-traditional sites will be determined based on demonstration project results and other investigations.
Legend
Landfill
PRB Demonstration Site
Shellfish/Aquaculture Demonstration Site
Potential Disposal/Treatment Site
Potential Disposal/Treatment Site
Watershed Boundary
Subwatershed Boundary
Meetinghouse Study Area
Downtown Study Area

Figure 3 - Downtown Area Flow Schematic

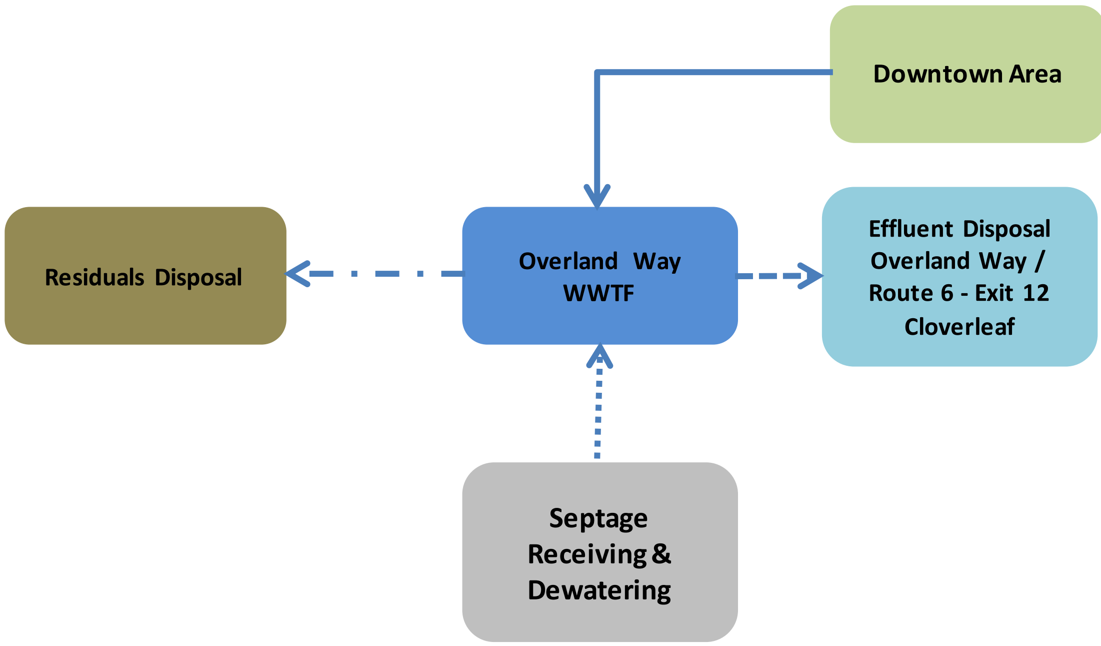
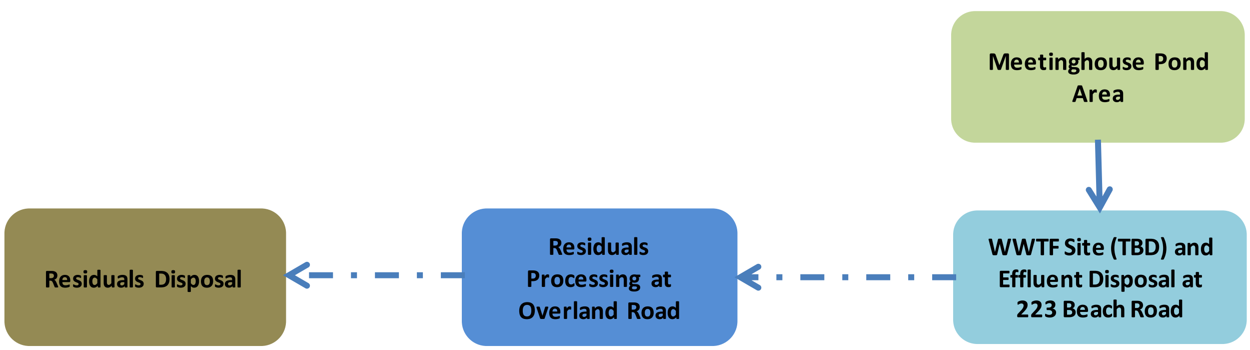
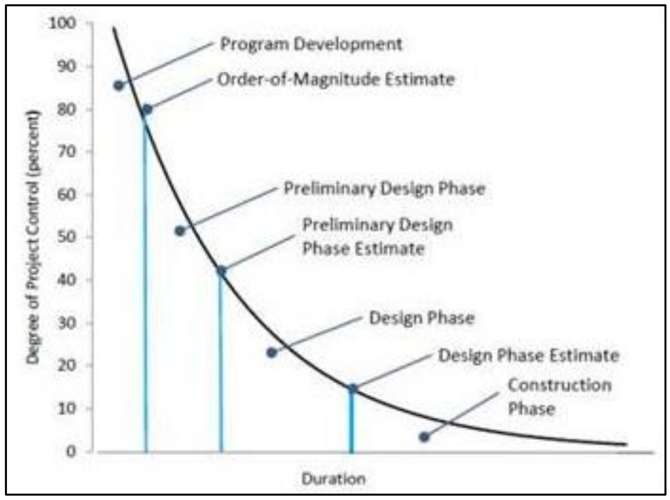


Figure 4 – Meetinghouse Pond Area Flow Schematic



7. Development of Program Costs



Cost estimating is a critical component of a project evaluation in the early stages of planning and concept design, before selection of a definitive plan and commitment of any funds. As part of the development of this document, order-of-magnitude Program Cost estimates were developed for the collection system technologies:

- Gravity Sewers;
- Low Pressure Sewers;
- Septic Tank Effluent Gravity;
- Septic Tank Effluent Pumping; and
- Vacuum Sewers.

The Program Costs were developed with our in-house specialists who prepare cost estimates for construction and operation using industry standards for materials and labor as well as actual bid tabs from a library of projects. Supplemented with information obtained from the Project's interactive workshops and a collaborative process to fully understand the cost implications of the various alternatives, these comprehensive costs allow for informed decision making.

The Program Costs include Capital Costs, Annual Operation and Maintenance Costs, Replacement Costs and Monitoring Costs. These costs obviously vary with the specific design considerations and layout configuration ultimately selected for each collection system technology. Nonetheless, it is possible to put together an estimate that can be used for Life-Cycle Cost Analysis to determine of the most cost effective technology or combination of technologies.

The Program Costs presented are planning level costs and should be refined as additional informational details are identified and/or determined. This refinement to the project scope includes topographic survey, subsurface exploration, types of equipment, redundancy, and types of control systems. In addition, project constraints, project schedule, and overall project complexity will impact Program Costs. It is recommended that planning level Program Costs be updated just prior to appropriation of funding for design and construction.

The Program Costs are preliminary in nature and contain construction cost, construction contingencies, administrative, legal, construction engineering, environmental and regulatory permitting related costs. The Class 3 opinion of probable construction costs were developed in accordance with "AACE International Recommended Practice No. 18R-97 - Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries" as prepared by the Association for the Advancement of Cost Estimating (AACE) International (www.aacei.org) dated February 2, 2005. Refer to Table 7-1 for the AACE International Cost Estimating classification system.

AECOM has no control over costs of labor, materials, competitive bidding environments and procedures, unidentified field conditions, financial and/or market conditions or other factors likely to affect the opinion of probable project costs all of which are and will unavoidably remain in a state of change. It is further understood that the probable project costs are a “snapshot in time” and that the reliability of this opinion of probable project costs will inherently degrade over time. The probable project costs need to be indexed on a common “baseline”. The construction industry uses the Engineering News Record (ENR) Construction Cost Index (www.enr.com) that is based on construction and materials costs throughout the United States. Therefore, the probable project costs contained herein are based on an ENR Construction Cost Index of 10182 for February 2016.

a. Capital Costs

Capital Costs are those to construct any type of wastewater treatment system including non-traditional and traditional technologies. Capital Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Capital Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources. Included in the Capital Costs were land purchases, at $200,000 per acre, required for locations of pumping stations that are not proposed on existing municipally owned land.

b. Operation and Maintenance Costs

Operations and Maintenance (O&M) Costs relate to the day-to-day running and upkeep of the non-traditional and traditional technologies. O&M Costs include items such as labor, utilities, chemicals, etc. In order to achieve maximum asset life and reduce O&M costs, the establishment of standardized O&M procedures is critical. Standardized procedures helps personnel operate all assets within acceptable operational levels and ensures that each person is following the same routines. Lack of regular maintenance may result in the deterioration of the system components and result in rapid failure and reduced nitrogen removal from the environment as well as the ability to meet operating permits. O&M Costs are an annual cost generally paid through fee or tax revenues as costs accrue. O&M Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

c. Replacement Costs

In addition to O&M Costs, system components will malfunction or fail and therefore Replacement Costs, including Repair Costs, become a necessary part of the overall costs of the wastewater collection system. Replacement Costs are used to replace components and/or equipment that have failed or malfunctioned such as; failed ejector pumps from LPS or STEP sewer systems, or pump bearings, mixers or control valves installed at conveyance pumping stations. As part of an Asset Management Program, a schedule of assets with their useful life should be developed since understanding the costs for partial replacement and full replacement of an asset will become necessary for sound financial planning. If more funding is spent on a repair to an asset, there will be a decreased need for the replacement of the asset. However, if greater funding is spent to replace the asset, there will be a decreased need for repairs to an asset. Overall there is a balance between how much to fund in each category in order to achieve the most efficient system. Like Capital Costs, Replacement Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Replacement Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources.

Table 7-1 - AACE International Cost Estimating Classification System

Estimate Class	Primary Classification	Secondary Classification			
	Level of Project Definition[1]	End Usage[2]	Methodology[3]	Expected Accuracy Range[4]	Preparation Effort[5]
5	0 to 2 percent	Concept Screening	Capacity Factored, Parametric Models, Judgment or Analogy	L: -20 to -50 percent H: +30 to +100 percent	1
4	1 to 15 percent	Study or Feasibility	Equipment Factored or Parametric Models	L: -15 to -30 percent H: +20 to +50 percent	2 to 4
3	10 to 40 percent	Budget Authorization or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10 to -20 percent H: +10 to +30 percent	3 to 10
2	30 to 70 percent	Control or Bid Tender	Detailed Unit Cost with Forced Detailed Take-off	L: -5 to -15 percent H: +50 to +20 percent	4 to 20
1	50 to 100 percent	Check Estimate or Bid Tender	Detailed Unit Cost with Detailed Take-off	L: -3 to -10 percent H: +3 to +5 percent	5 to 100

Notes:

1 Expressed as percent of Complete Definition

2 Typical Purpose of Estimate

3 Typical Estimating Method

4 Variation of Low and High Ranges. The state of process technology and availability of applicable reference costs data affect the range market. The +/- value represents percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope.

5 Typical Degree of Effort Relative to Least Cost Index of 1. If the range index value of "1" represents 0.005 percent of project costs, then an index value of "100" represents 0.5 percent. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

d. Monitoring Costs

Monitoring of the non-traditional and traditional technologies is an essential component of adaptive management. Monitoring will assess the effectiveness of implementing the different collection system technologies. The results of monitoring will indicate which technologies are preferred based on long-term performance and which are less successful. This allows adjustments in the phased approach to improve overall performance of the solution. Like O&M Costs, Monitoring Costs are an annual cost generally paid through fee or tax revenues as costs accrue. Monitoring Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

8. Development and Assumptions of Program Costs

a. Capital Costs

Capital Costs for wastewater collection systems for both public property and private property installation were estimated by compiling typical unit costs for gravity sewers, vacuum sewers, low pressure sewers, septic tank effluent pumping/gravity and septic tank effluent pumping and, as applicable, pumping stations and force mains. Table 8-1 presents a Menu of Collection System Construction Unit Costs. Table 8-2 presents a Menu of Other Collection System Unit Costs required as part of the Project Costs. The Unit Costs are based on a municipal design-bid-construct process and include the costs for paying minimum wage rates per Massachusetts Prevailing Wage Law for public works projects G.L. c. 149, §§ 26 - 27 ("The Prevailing Wage Law") which establishes minimum wage rates for workers on public construction projects. In addition, review of actual construction costs for other similar projects was reviewed, adjusted for local bidding costs, and utilized to develop these unit costs.

Table 8-1 - Menu of Collection System Construction Unit Costs

Description	Unit	Unit Cost
Custom Pump Station	Each	$585,000
Force Main	L.F.	$120
Gravity Sewer	L.F.	$125
Gravity Sewer - Private Property	Each	$7,800
Low Pressure Sewer	L.F.	$100
Low Pressure Sewer - Private Property	Each	$12,000
STEG - Private Property	Each	$7,800
STEG Sewer	L.F.	$125
STEP - Private Property	Each	$10,750
STEP Force Main	L.F.	$100
Submersible Pump Station	Each	$275,000
Vacuum Collection/Transmission Station	Each	$860,000
Vacuum Sewer	L.F.	$110
Vacuum Sewer - Private Property	Each	$10,250
Wet Pit /Dry Pit Pump Station	Each	$470,000

Table 8-2 - Menu of Other Collection System Costs

Description	Unit	Unit Cost
Overhead and Profit	Percent	22.00
Contingency	Percent	25.00
Project Services	Percent	35.00
Planning/Consultation	Percent	5.00
Design Engineering	Percent	10.00
Construction Engineering	Percent	15.00
Town Administrative	Percent	5.00

b. Operation and Maintenance Costs

- 1 full time employee for administration, operation and maintenance of each type of technology (Gravity Sewers; Low Pressure Sewers; Septic Tank Effluent Gravity; Septic Tank Effluent Pumping; and Vacuum Sewers) including Private Property Components such as pumps, valves, and vaults/tanks;

- A minimum of 260 hours per year for each type of Pump Station (Custom Pump Station; Submersible Pump Station; Vacuum Pump Station; and Wet Pit /Dry Pit Pump Station);

- Utilities, chemicals, etc. per each type of Pump Station (Custom Pump Station; Submersible Pump Station; Vacuum Pump Station; and Wet Pit /Dry Pit Pump Station) based on 25 horsepower pumps each running an average of 15 minutes per day at $0.15 per kWh; miscellaneous supplies (i.e. fuses, lamps, filters, grease, etc.); and chemicals for odor control.

- Clean and TV 25 percent of sewers per year for Gravity Sewer and STEG technologies;

- Clean 25 percent of pressure/vacuum pipes per year for Low Pressure Sewer, STEP and Vacuum Sewer technologies as well as force mains; and

- Pump-out Septic Tanks Every 3 Years for STEP and STEG technologies in order to avoid septic conditions and plugging of pumps.

- Power costs for private pumps for LPS, or STEP systems based on 0.5-1 HP and 250 hours per year (350 gal/home/45 gal) x (8 pump outs x 5 min = 0.67 hours/day) x 356 d = 250 hours/yr.).

c. Replacement Costs

- Equipment (i.e. pumps or pump parts - impellers and bearings) for each type of Pump Station (Custom Pump Station; Submersible Pump Station; Vacuum Pump Station; and Wet Pit /Dry Pit Pump Station) at 1 percent of original Capital Cost of the Pump Station per year; and

- Equipment (ie. pumps and valves) located on Private Property for Low Pressure Sewer, STEP and Vacuum Sewer technologies at 5 percent of total number connections per year.

d. Monitoring Costs

- Calibration of monitoring equipment at each type of Pump Station (Custom Pump Station; Submersible Pump Station; Vacuum Pump Station; and Wet Pit /Dry Pit Pump Station) at $2,500 per year; and

- Monitoring of Private Property Components (i.e. pumps, valves, and vaults/tanks) to verify system integrity estimated at 8 hours per connection per year.

9. Life-Cycle Cost Analysis

A Life-Cycle Costs evaluation of the various collection system alternatives was performed to compare the Program Costs (Project Costs, Annual Operation and Maintenance Costs, Replacement Costs and Monitoring Costs). The assumptions used in the Life-Cycle Cost Analysis are as follows:

- Evaluation Period of 20 Years.

- Rate of Return of 3.00 percent.

- Inflation Rate of 3.00 percent annually based on the average ENR Construction Cost Index from January 2005 through February 2016.

- The proposed service areas consist of only one type of collection system alternative even though it may not be technical feasible in all cases.

- The Program Costs include Capital Costs, Annual Operation and Maintenance Costs, Replacement Costs and Monitoring Costs will vary with the specific design considerations and will change the Life-Cycle Cost Analysis.

- A hybrid system is typically the most cost effective alternative. For comparison, a hybrid system consisting of Gravity Sewer and Low Pressure Sewer was also evaluated for both the Downtown Area and Meetinghouse Pond Area.

Based on the estimated quantities developed from the preliminary system layouts, estimated Program Costs and Life-Cycle Cost Analysis Assumptions a Life-Cycle Cost was developed for each of the technologies (Gravity Sewers; Low Pressure Sewers; Septic Tank Effluent Gravity; Septic Tank Effluent Pumping; and Vacuum Sewers). The results of the Life-Cycle Cost Analysis are presented in Table 9-1 and Table 9-2 for the Downtown Area and Meetinghouse Pond Area, respectively.

Table 9-1 - Downtown Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Capital	$26.82	$28.52	$18.71	$28.30	$19.46	$24.18
O&M, Replacement and Monitoring	$0.77	$0.80	$0.55	$0.86	$0.60	$0.58
Present Value	$38.22	$40.43	$26.96	$41.08	$28.23	$32.81

Note: Costs in Millions of Dollars

Table 9-2 - Meetinghouse Pond Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Capital	$32.35	$34.16	$21.92	$38.06	$22.73	$21.20
O&M, Replacement and Monitoring	$1.25	$1.29	$0.59	$1.25	$0.63	$0.45
Present Value	$51.01	$53.37	$30.72	$56.73	$32.08	$27.93

Note: Costs in Millions of Dollars

The "Life-Cycle Cost Analysis" are very cost sensitive to revisions to the system layout, components utilized, changes in unit prices, etc. To understand this sensitivity by the changing system layout the following example is utilized. In the Downtown Area Hybrid (GS and LPS) alternative, once the detailed topographic survey and subsurface investigations are complete, the preliminary system layout will be reviewed and adjusted. If the revised layout results in 3 pump stations, the capital cost, associated O&M, Replacement and Monitoring Costs for a Hybrid System will be reduced and would result in a Present Value of $29.38 million or 10.4 percent reduction over the Present Value shown in Table 9-1.

10. Recommendations

a. Based on the technical evaluation and economic evaluation (Life-Cycle Cost Analyses) it is recommended that a “hybrid” wastewater collection system be constructed in both the Downtown Area and Meetinghouse Pond Area. The “hybrid” configuration is recommended because of its ability to accommodate changes in wastewater flows particularly with the Downtown Area caused by zoning changes and business dynamics; ability to phase the design, construction and operations; proven long term reliability; generally a higher public acceptance; and ease of permitting. It is also recommended that to utilize similar collection system alternatives in each of the proposed services areas and standardize design details/configurations since this reduces overall project costs.

b. Develop 20 to 25 percent planning documents for the Downtown Area and Meetinghouse Pond Area Collection Systems consisting of the following:

   1) Conduct Topographical Survey (combination of aerial mapping and on the ground field survey). Aerial mapping will be based on photography previously flown to capture imagery at a photo scale of 1:500 which will produce 1-inch = 40-feet mapping with 2-foot contours. All work will be conducted on the Massachusetts State Plane Coordinate System of NAD 1983 and vertically on NAVD 1988;

   2) Conduct a Subsurface Investigation that will consist of performing Drilling and Sampling used to identify soils types and depth to groundwater;

   3) Perform a Cultural Resource Evaluation consisting of a review of local geography, ecology, soils, and Native American Groups to develop cultural contexts and predictive statements for archaeological resources that may be present;

   4) Update the preliminary system layout (plan and profiles) for developed for the Downtown Area and Meetinghouse Pond Area based on the detailed topographic survey and subsurface investigations;

   5) Update the proposed system phasing;

   6) Confirm/modify the recommended collection system configuration; and

   7) Update the Preliminary cost estimates (Project Costs; Annual Operation and Maintenance Costs; Replacement Costs; and Annual Monitoring Costs) based on the updated preliminary system layouts.

c. Determine the preferred method of implementation – design-bid-construction; design-build, etc.

d. Utilize the updated information to engage in Public-Private-Partnerships negotiations.

e. Utilize the updated information to prepare funding applications in order to obtain grants and loans.

f. In addition, as part of the inputs to the Financial Model, the Program Costs need to be inflated to the year anticipated for implementation. The ENR’s Cost Index History Tables can be used for estimating inflation on future cost projections that are then used for development of Capital Improvement Plans and Financing Plans.

11. References

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- Lacey, Washington – 20-Year Life Cycle Analysis of Effluent Sewer (STEP) System, 2013
- New England Interstate Water Pollution Control Commission - The Northeast Guide for Estimating Staffing at Publicly and Privately Owned Wastewater Treatment Plants, 2008
- New England Interstate Water Pollution Control Commission - TR-16, Guides for the Design of Wastewater Treatment Works, 2011 Edition
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- United States Environmental Protection Agency - Decentralized Systems Technology Fact Sheet Low Pressure Pipe Systems, September 1999
- US EPA – Alternative Wastewater Collection System Manual, 1991
- Water Environment Research Foundation (2010)

Appendix A

Downtown Area Collection System Preliminary Plan and Profiles

Meetinghouse Pond Area Collection System Preliminary Plan and Profiles

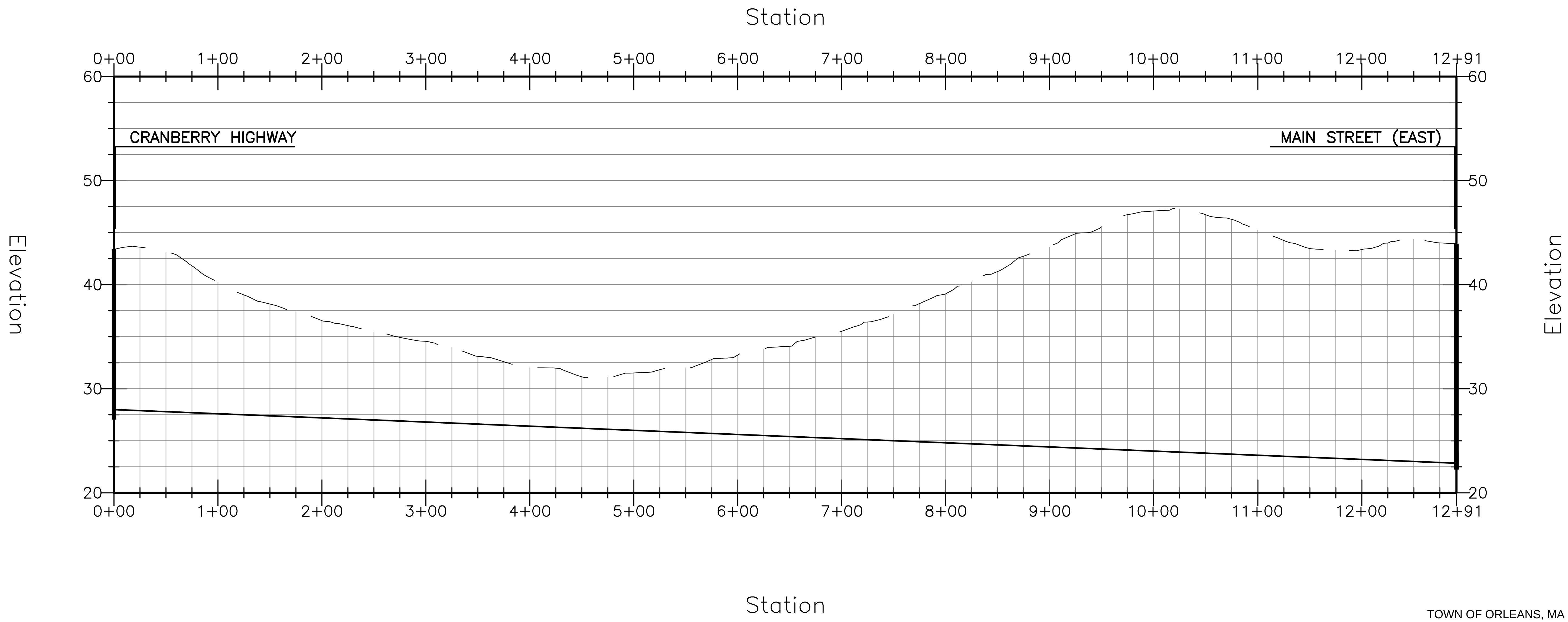

Town of Orleans, MA
Water Quality and Wastewater Planning Services
Downtown
Proposed Collection System Layout
Legend
Downtown Sewer Area
Proposed Gravity Sewer/STEP
Proposed Low Pressure Sewer/STEG
Proposed Force Main
Potential WTP Sites
45
Spot Elevation
N
0
300
600
Feet
AECOM
January 2016
Vicinity of Proposed Pump Station
Vicinity of Proposed Pump Station
Vicinity of Proposed Pump Station
Vicinity of Proposed Pump Station

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF DOWNTOWN AREA SEWERS

AECOM
January 2016

Brewster Crossroad



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DOWNTOWN AREA SEWERS

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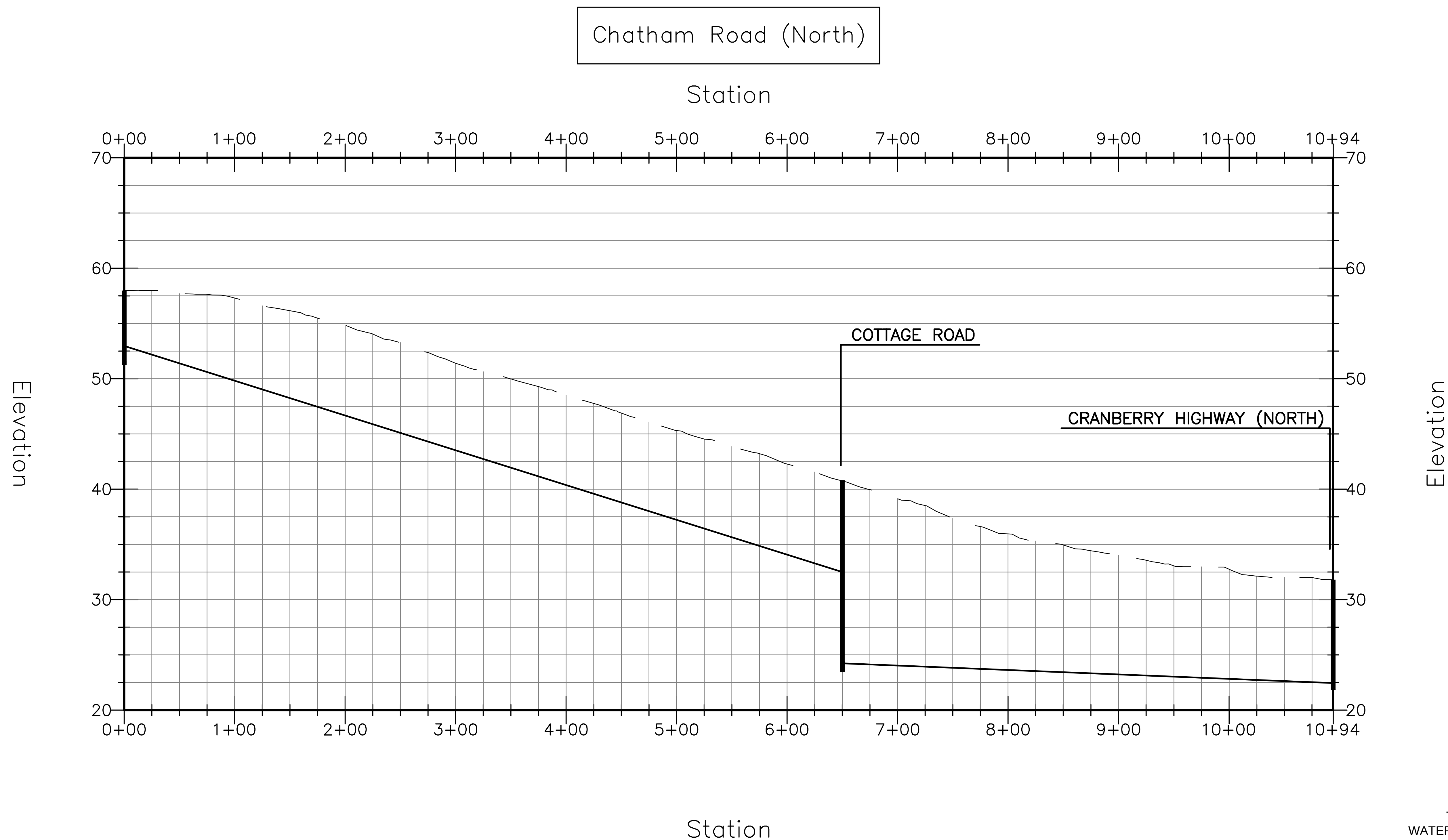
January 2016



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DOWNTOWN AREA SEWERS

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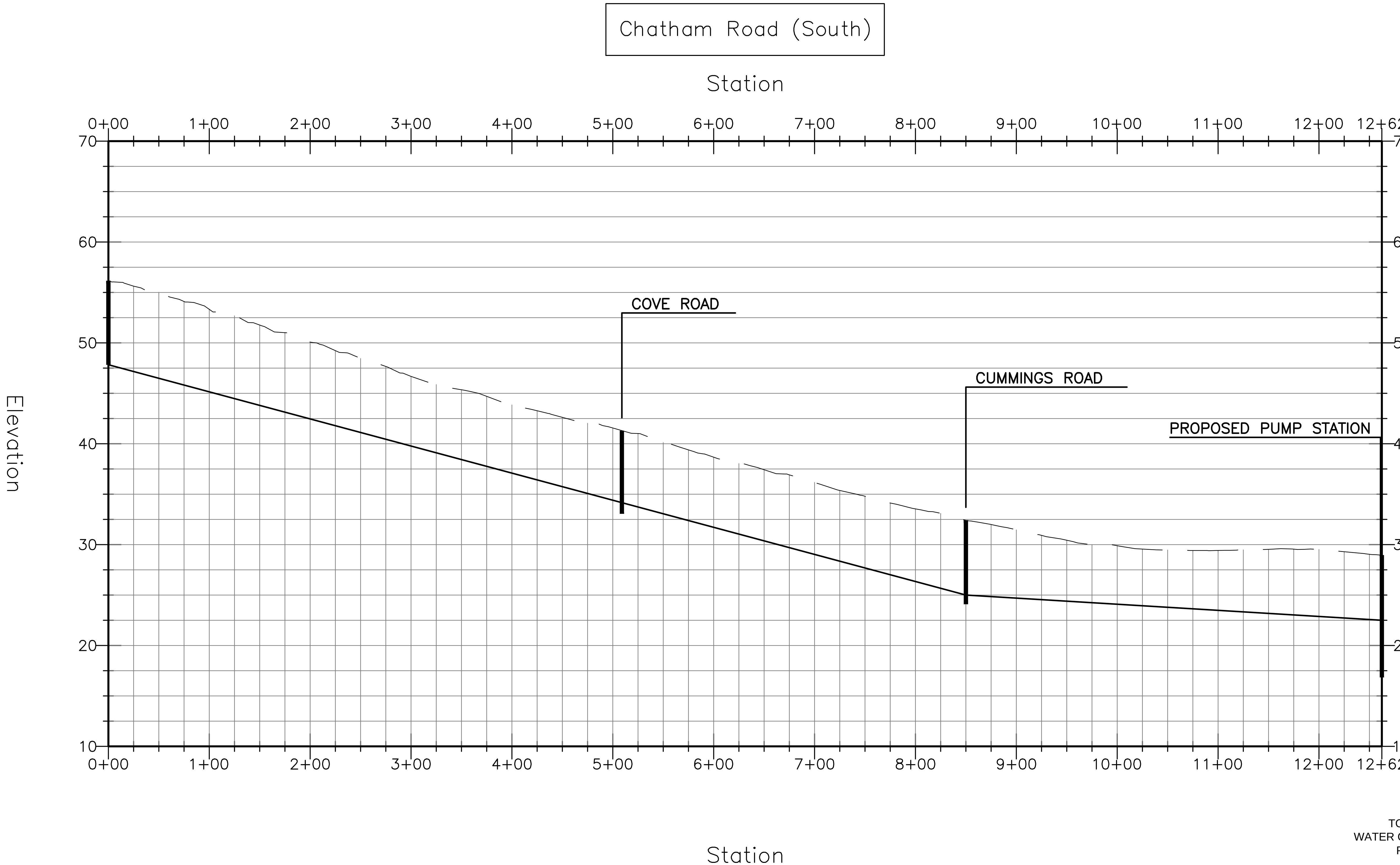

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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DOWNTOWN AREA SEWERS

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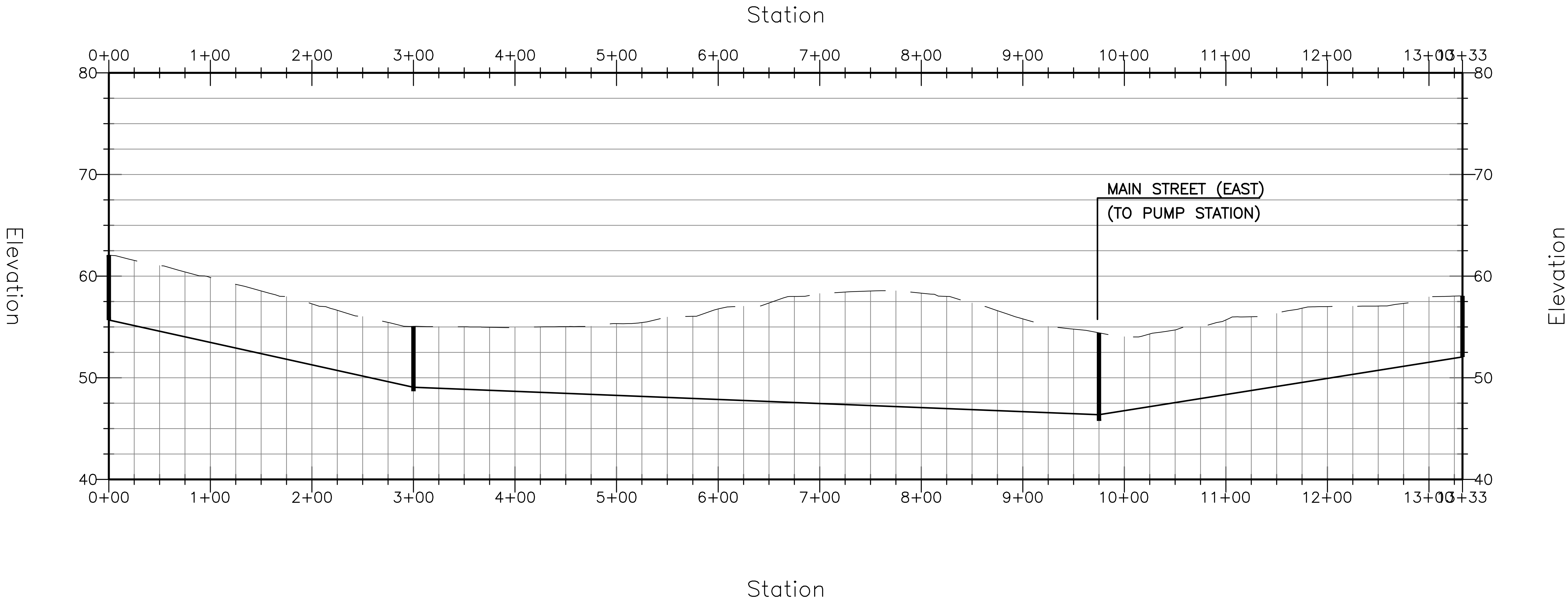
January 2016

Cranberry Highway – Middle 2



TOWN OF ORLEANS, MA
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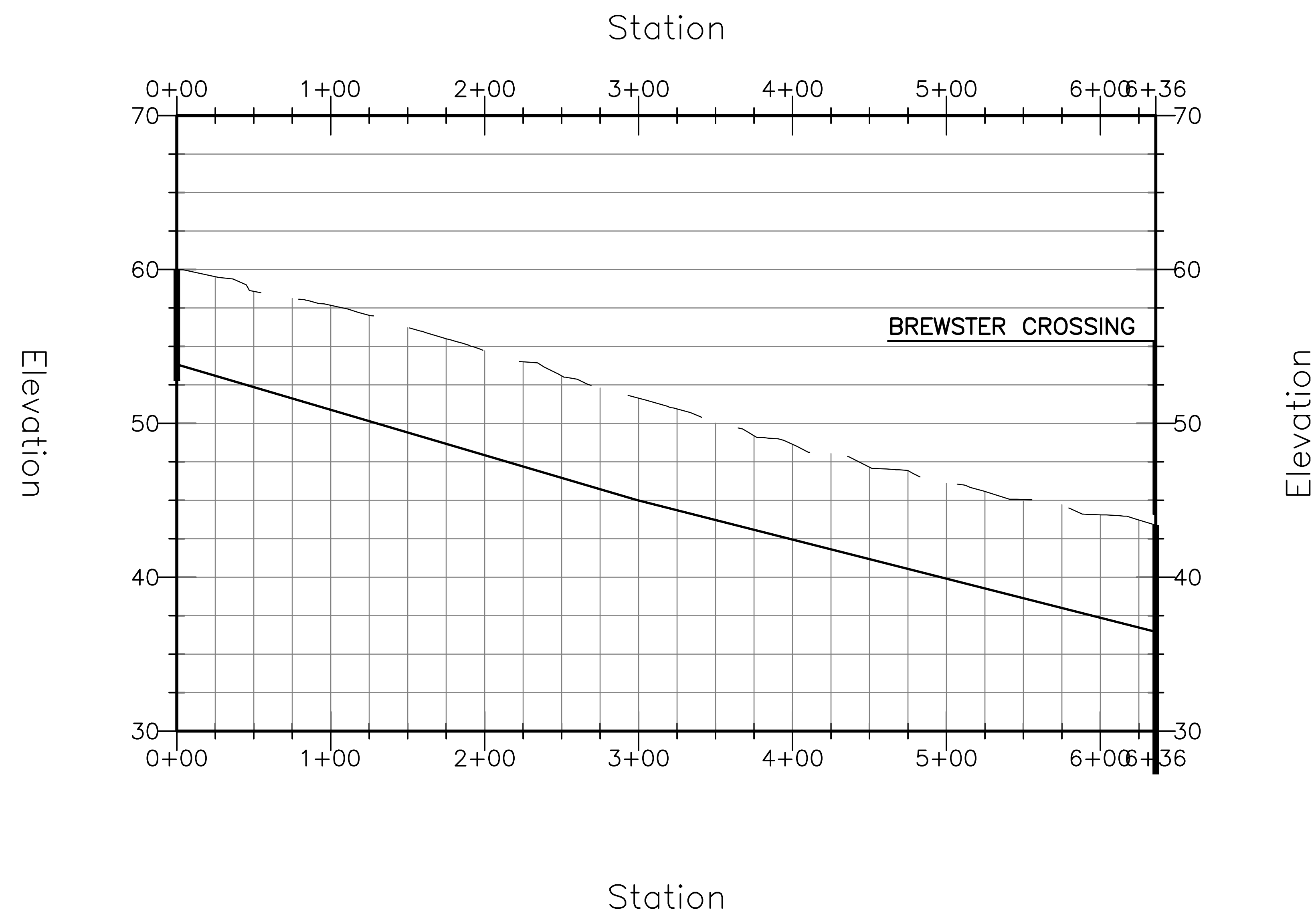
January 2016

Cranberry Highway – Middle 1



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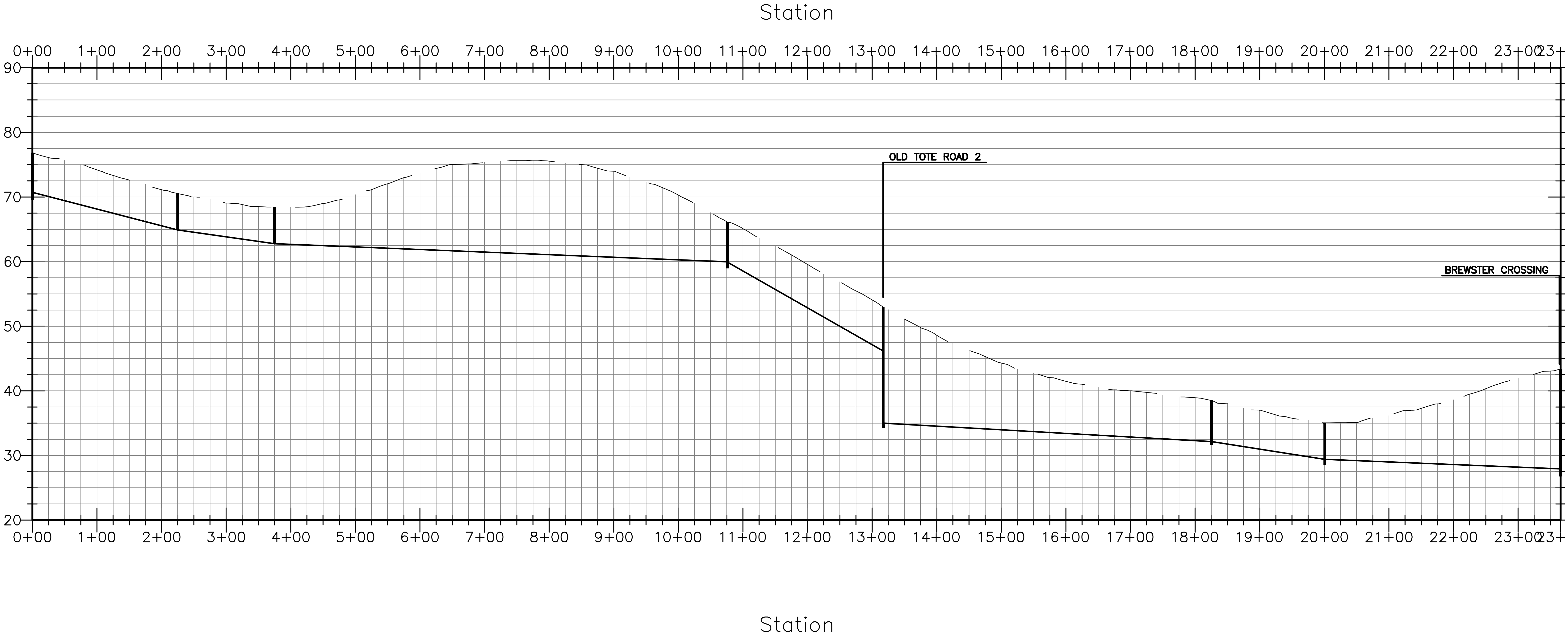
January 2016

Cranberry Highway – South



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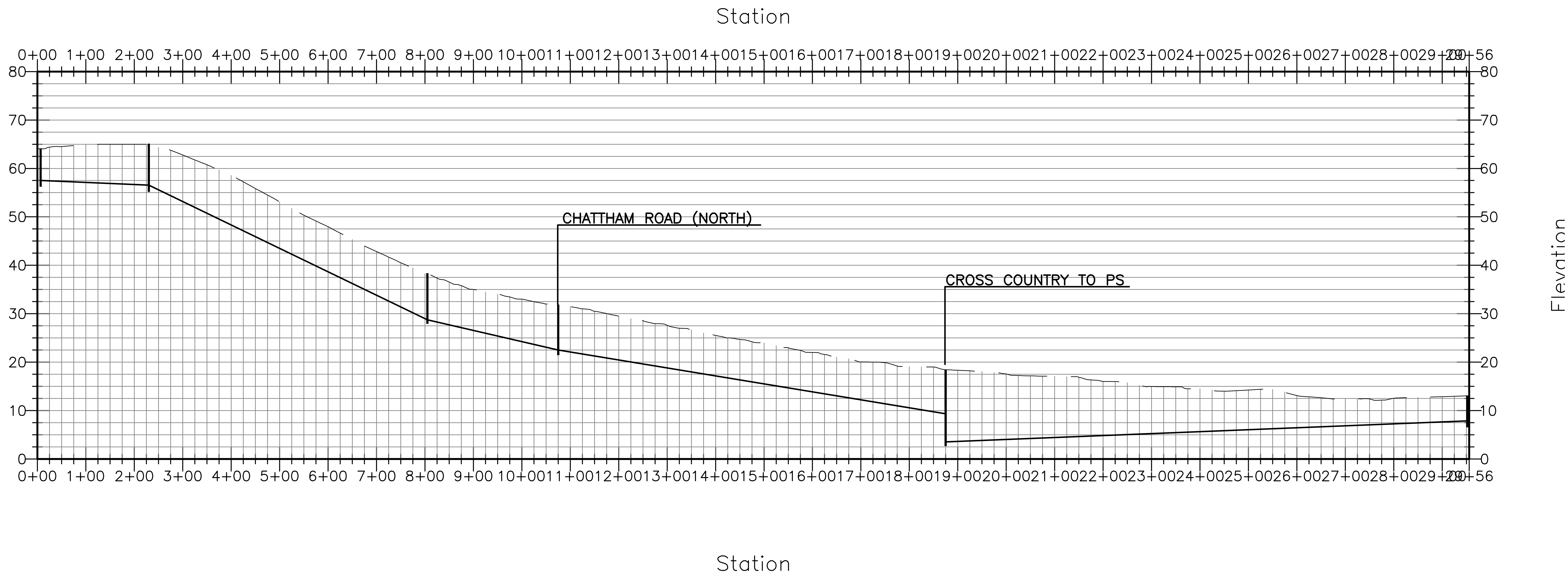
Cranberry Highway North



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CONCEPTUAL LAYOUT OF
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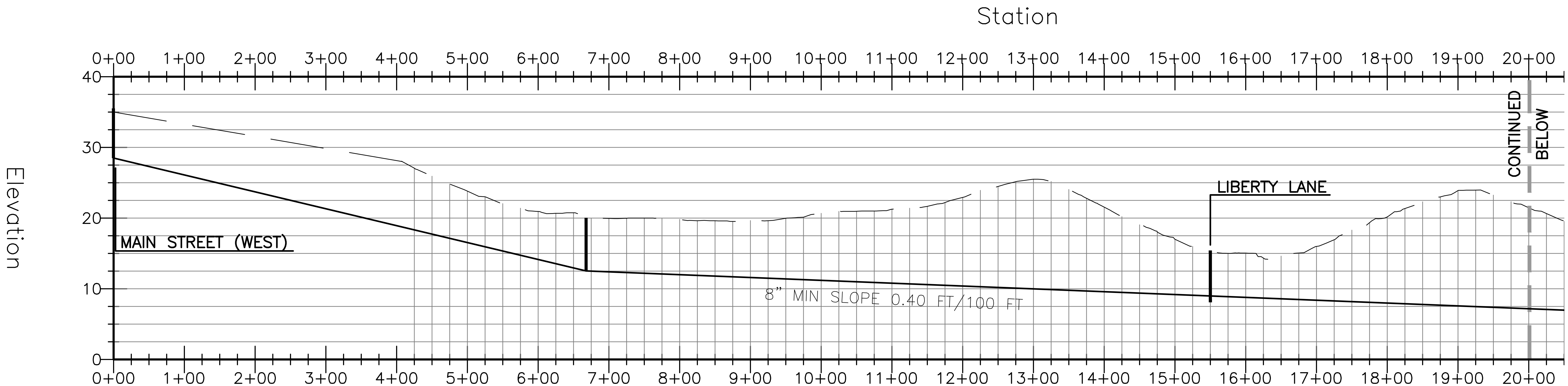
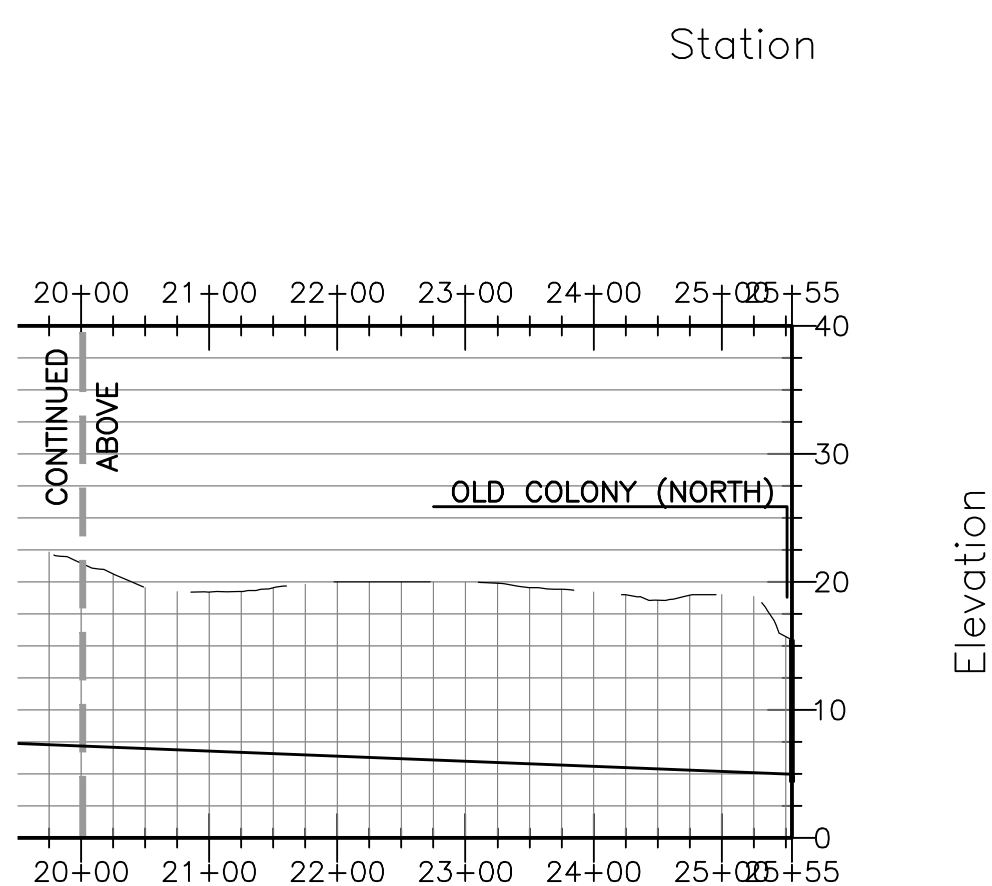
January 2016

Locust Road





TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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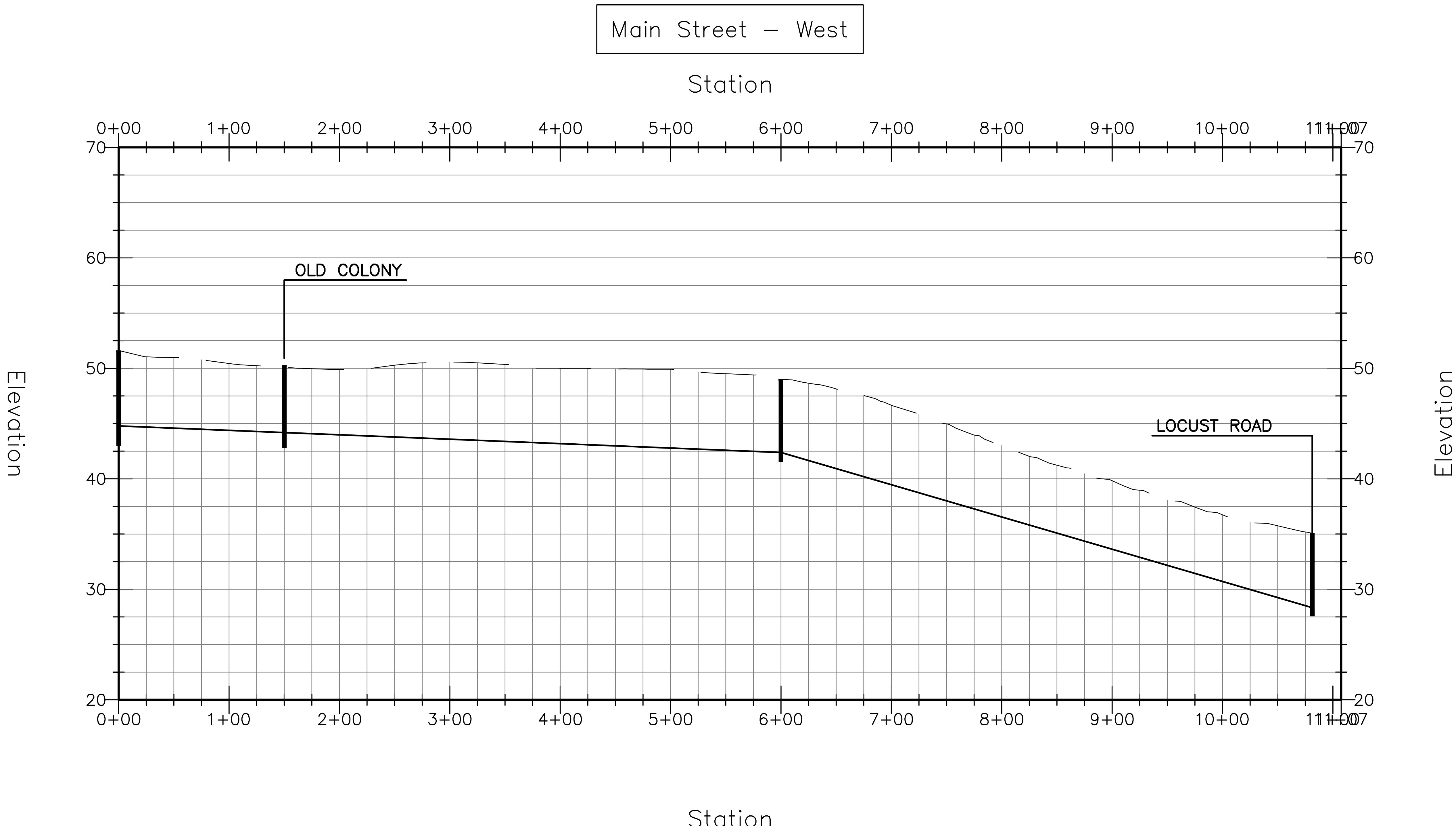
January 2016



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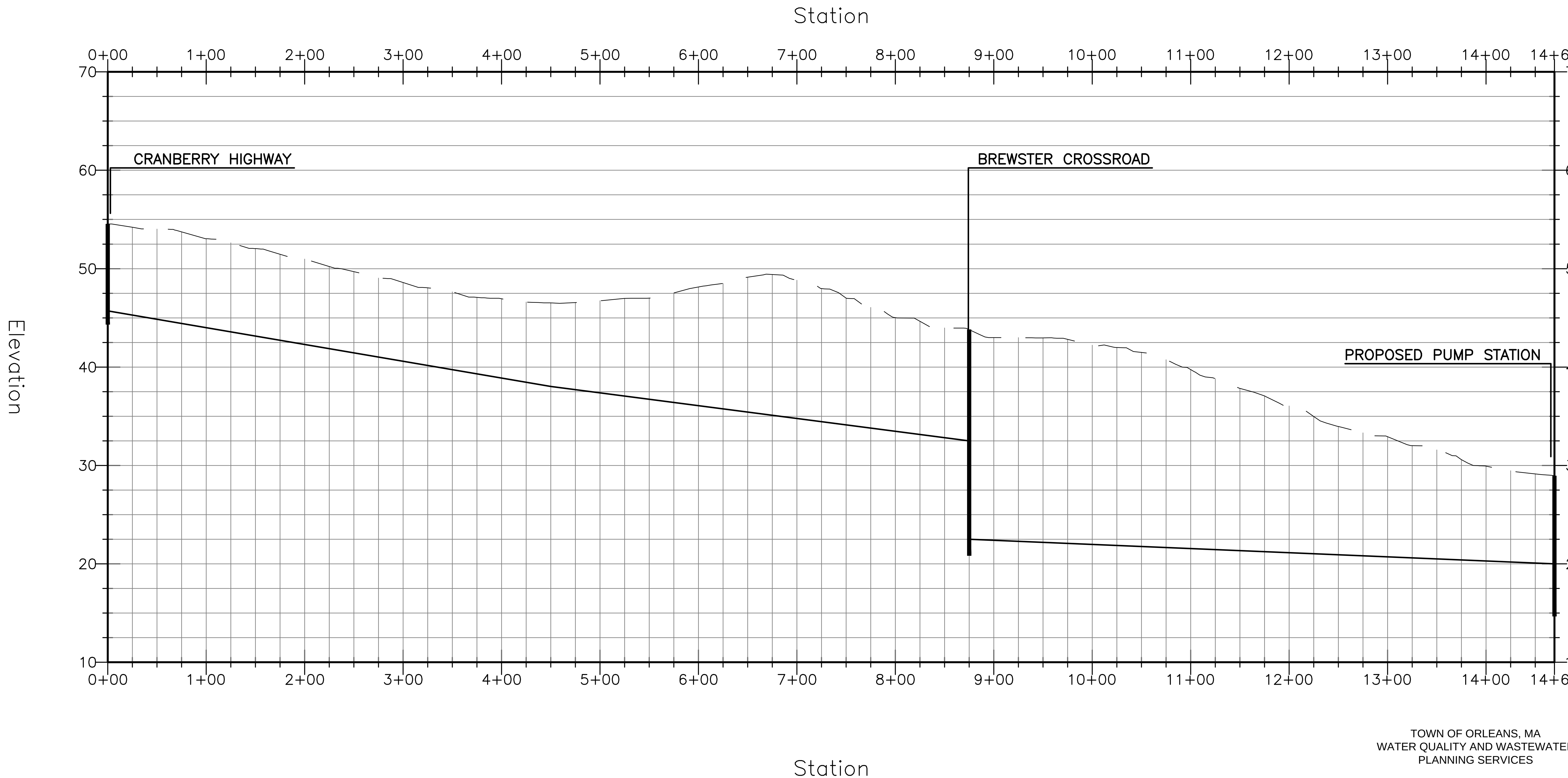
Main Street – East



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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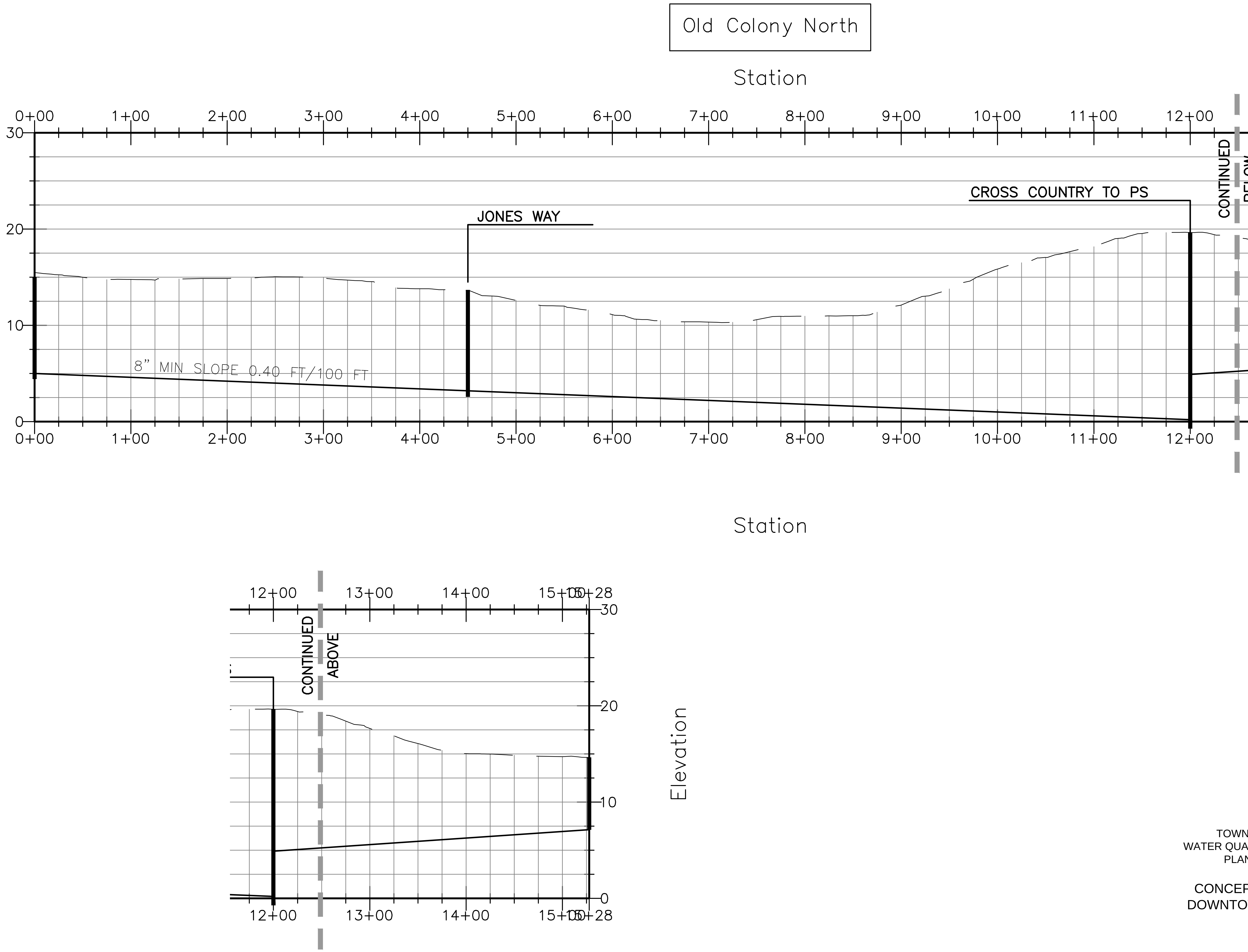
January 2016



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
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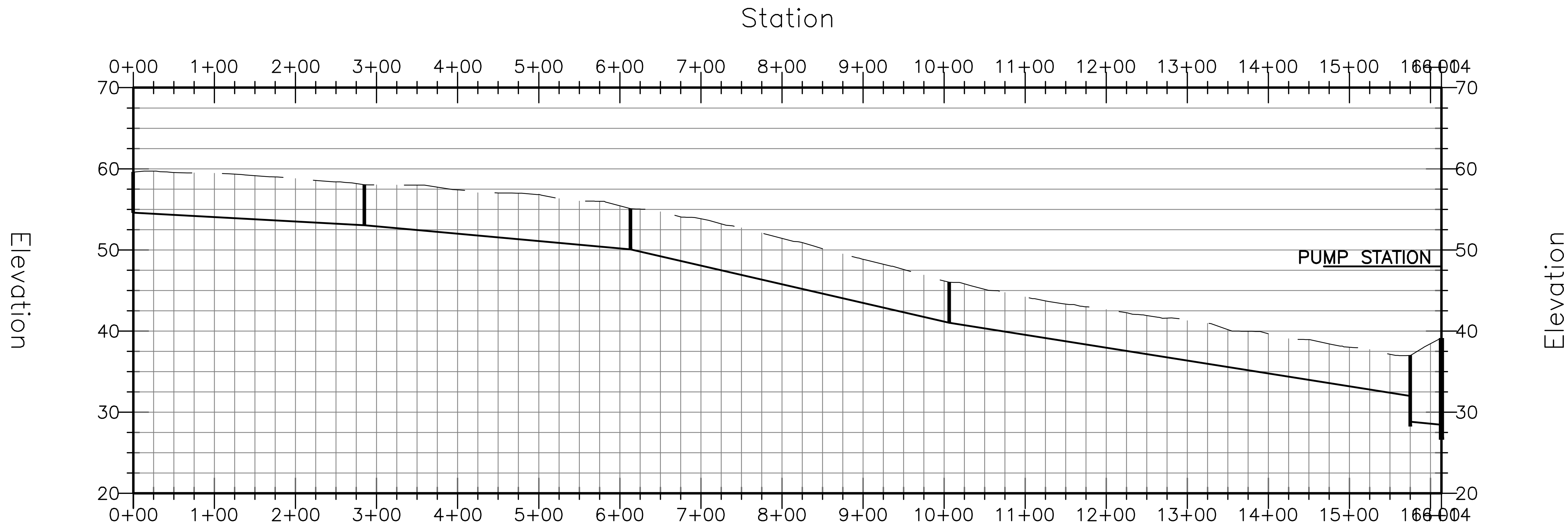
January 2016

Old Colony Way



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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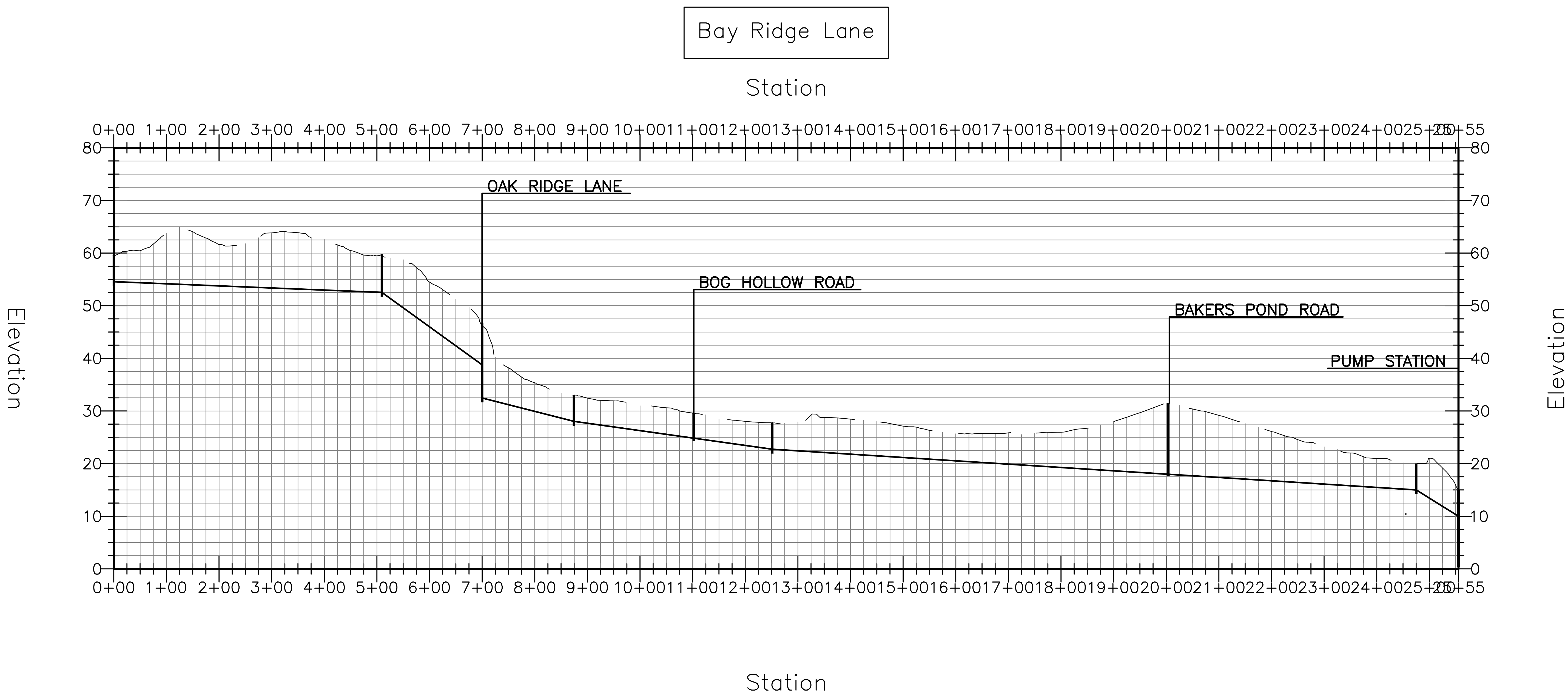
CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

AECOM
January 2016



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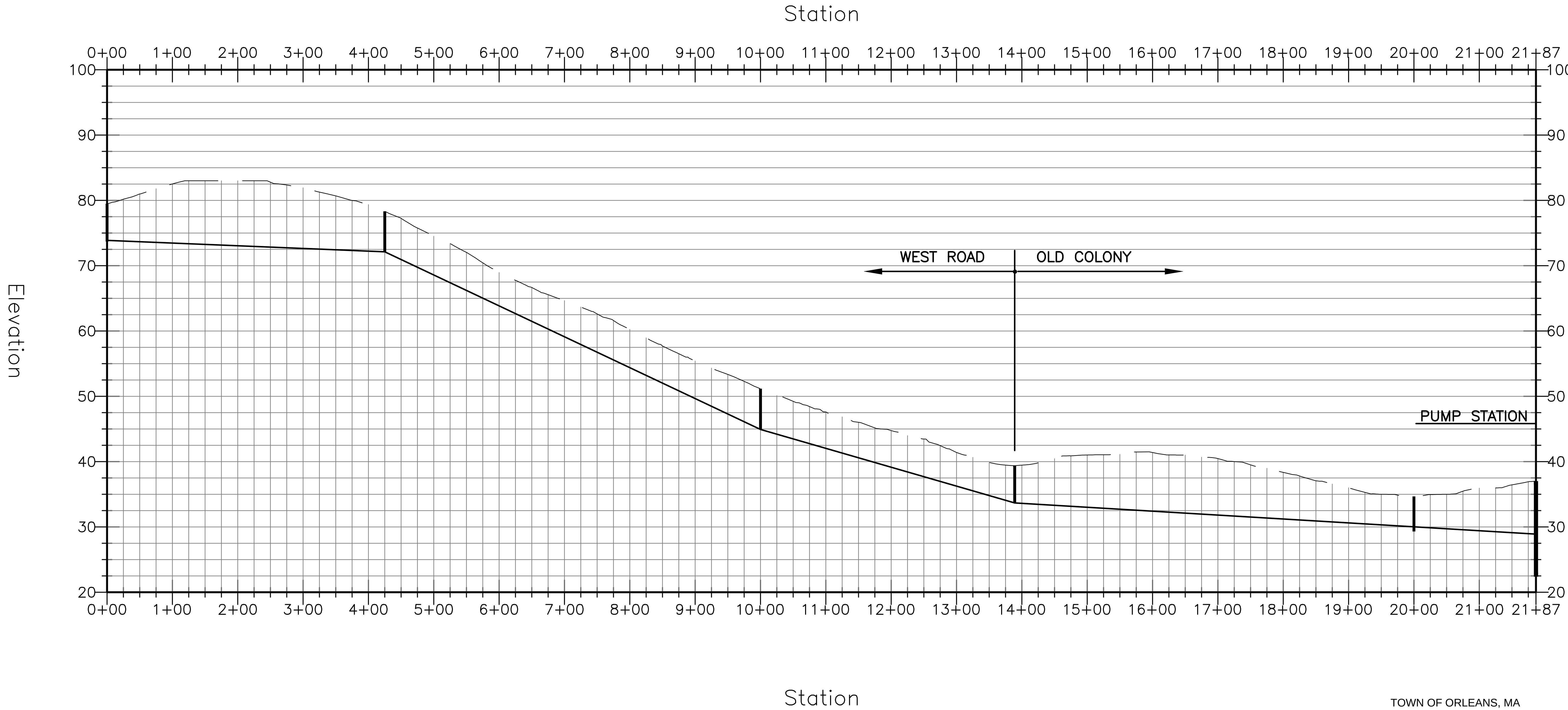
January 2016

West Road to Old Colony



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WATER QUALITY AND WASTEWATER
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CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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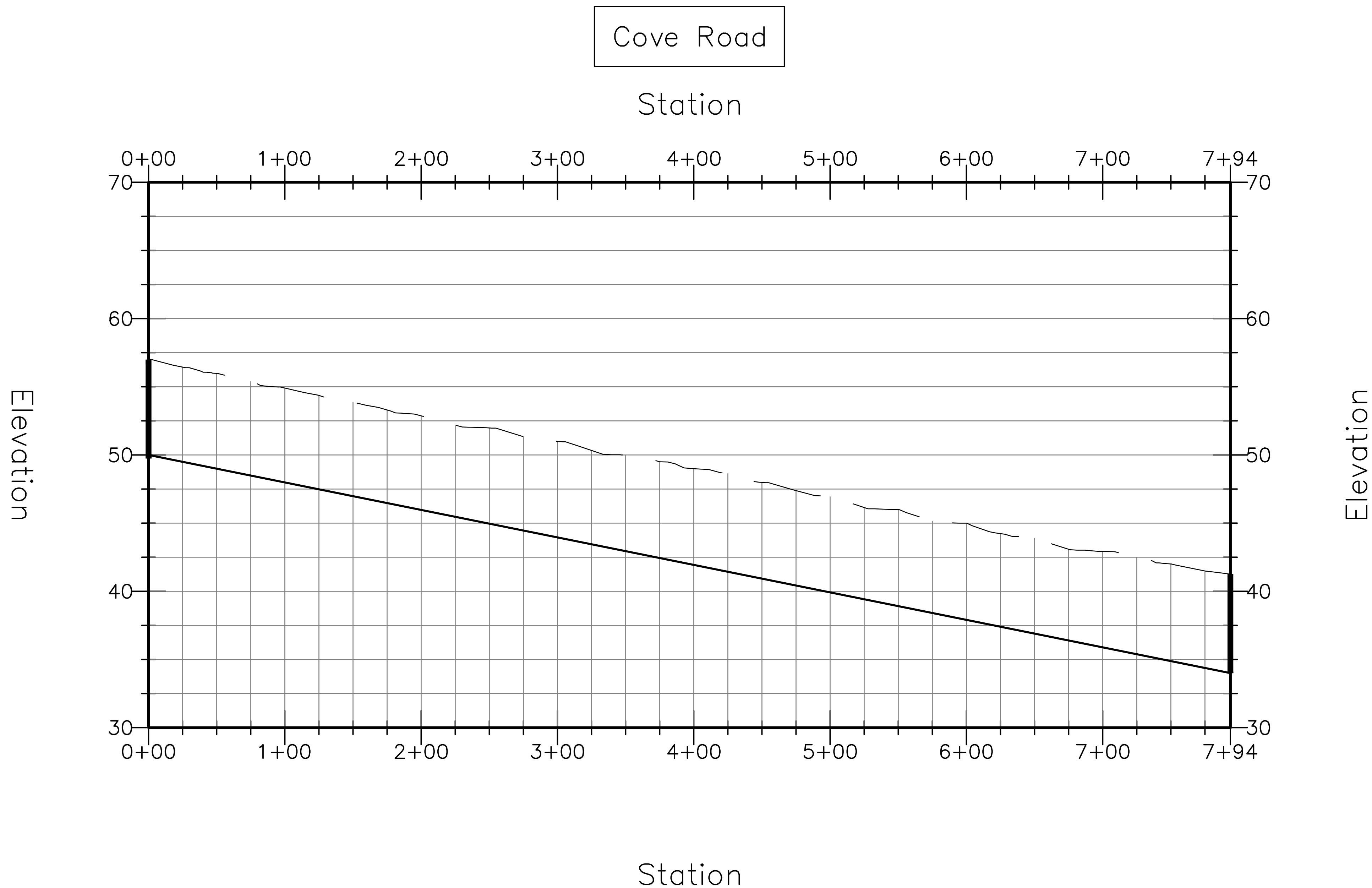
January 2016



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WATER QUALITY AND WASTEWATER
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CONCEPTUAL LAYOUT OF
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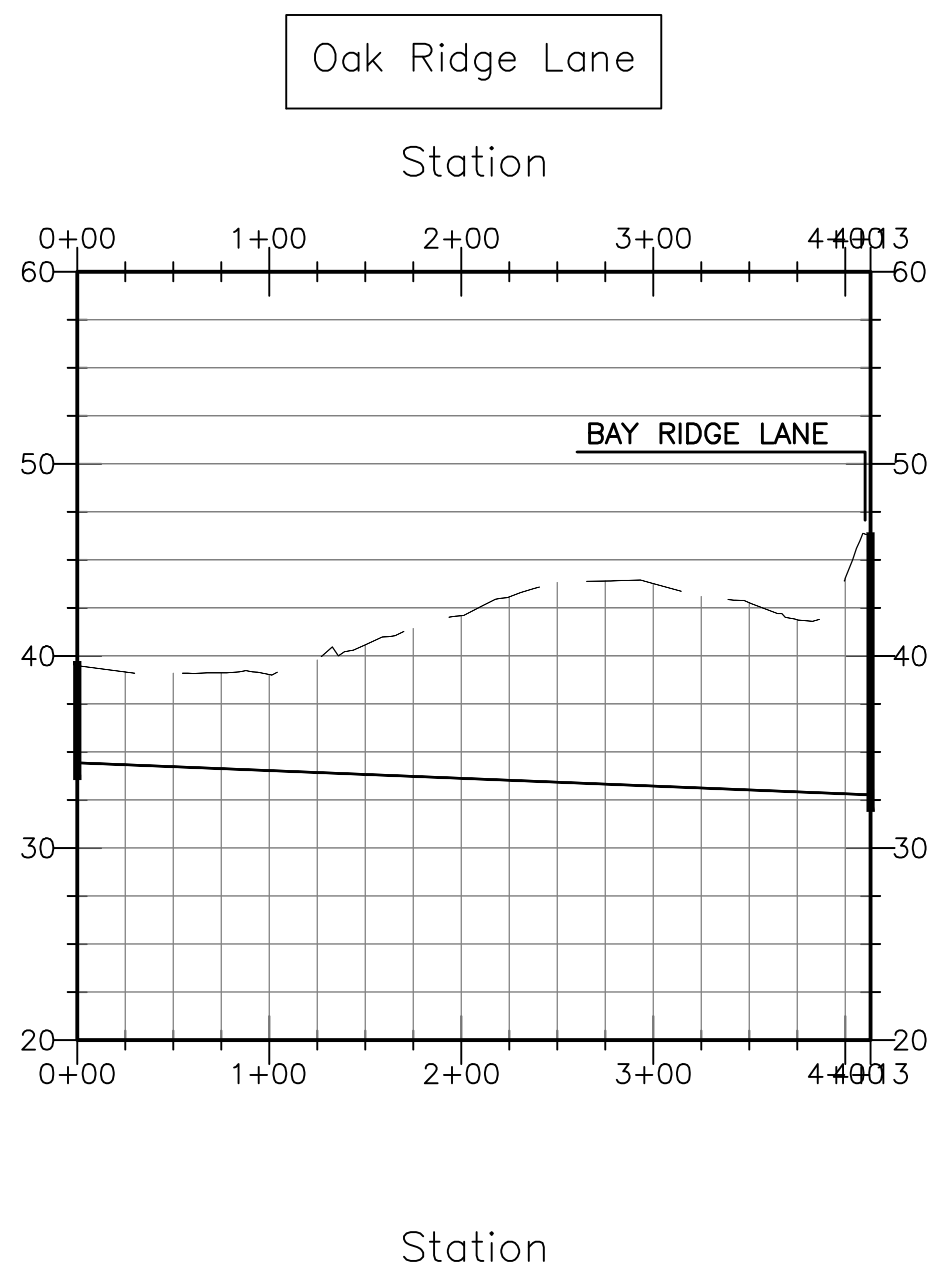
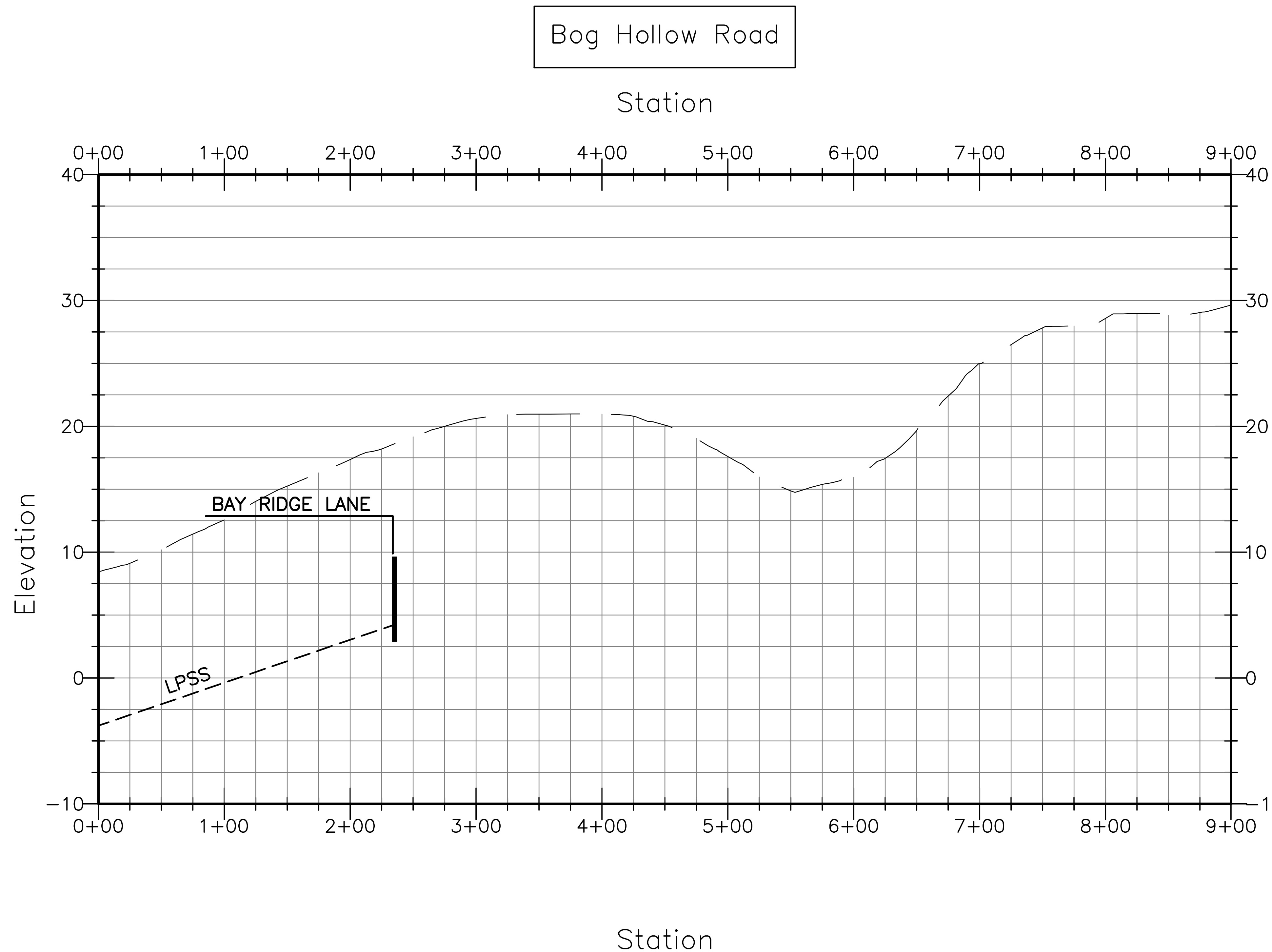
January 2016





TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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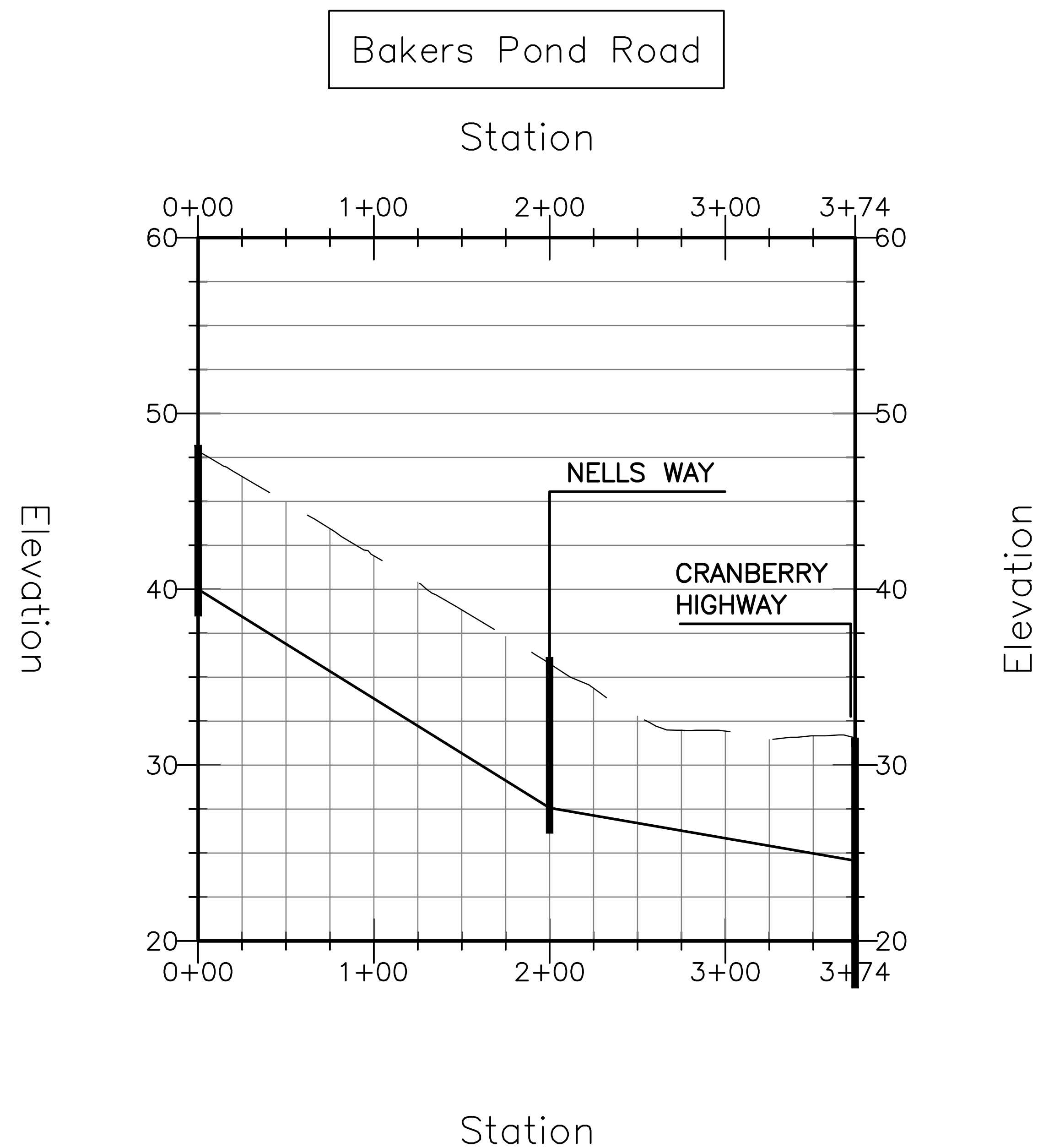
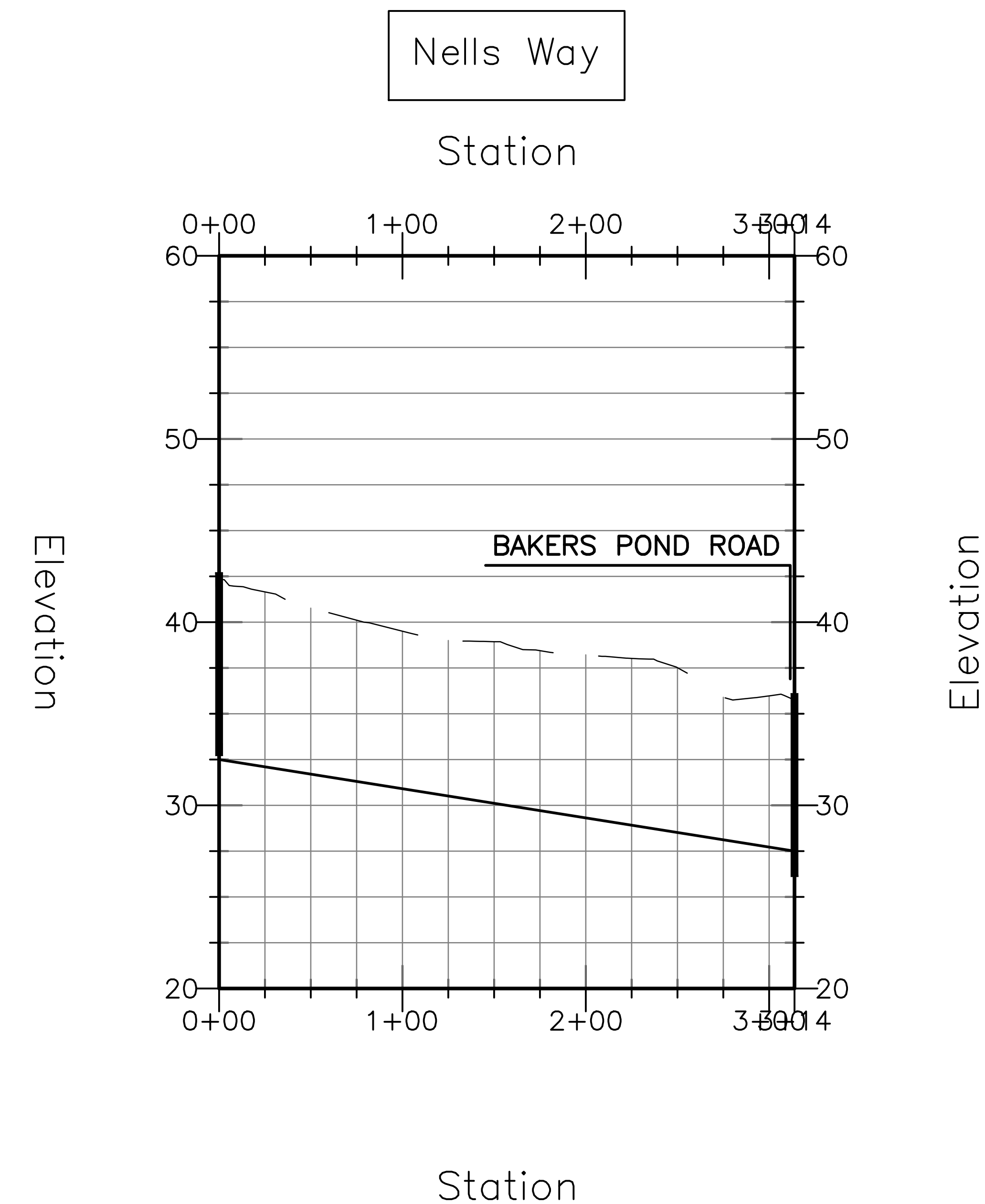
January 2016





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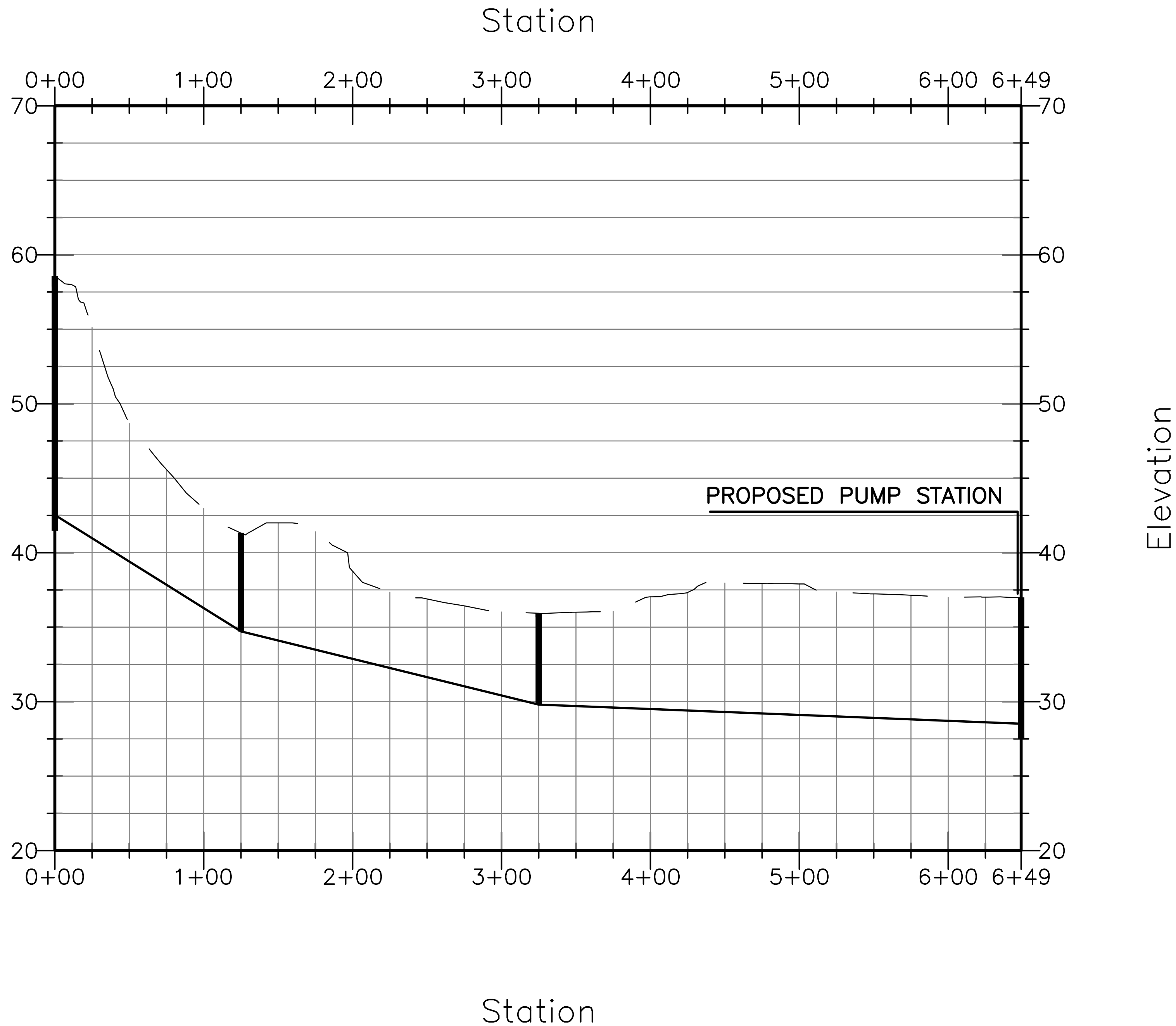
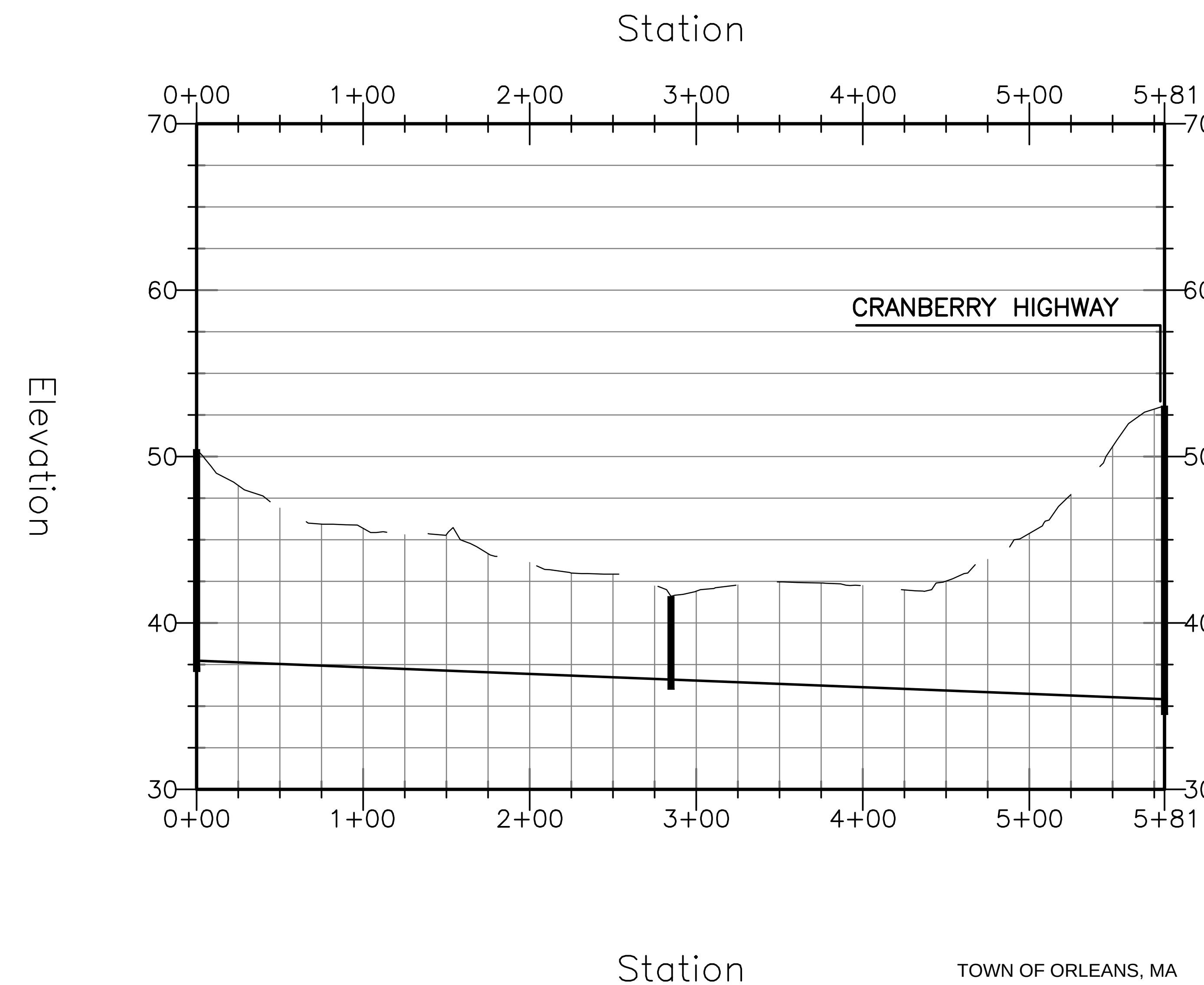
January 2016

Old Tote Road



Old Tote Road 2



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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CONCEPTUAL LAYOUT OF
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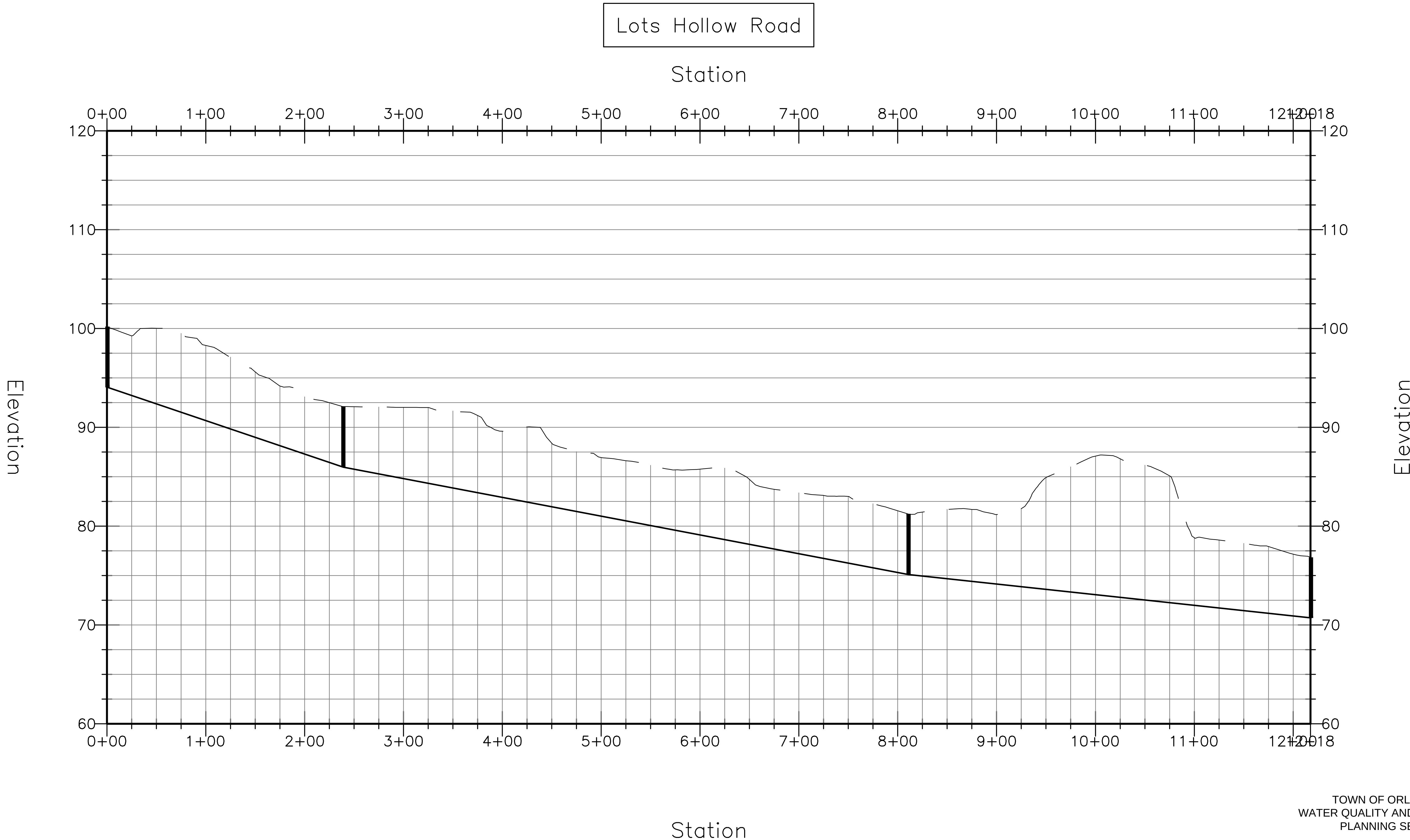
January 2016



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WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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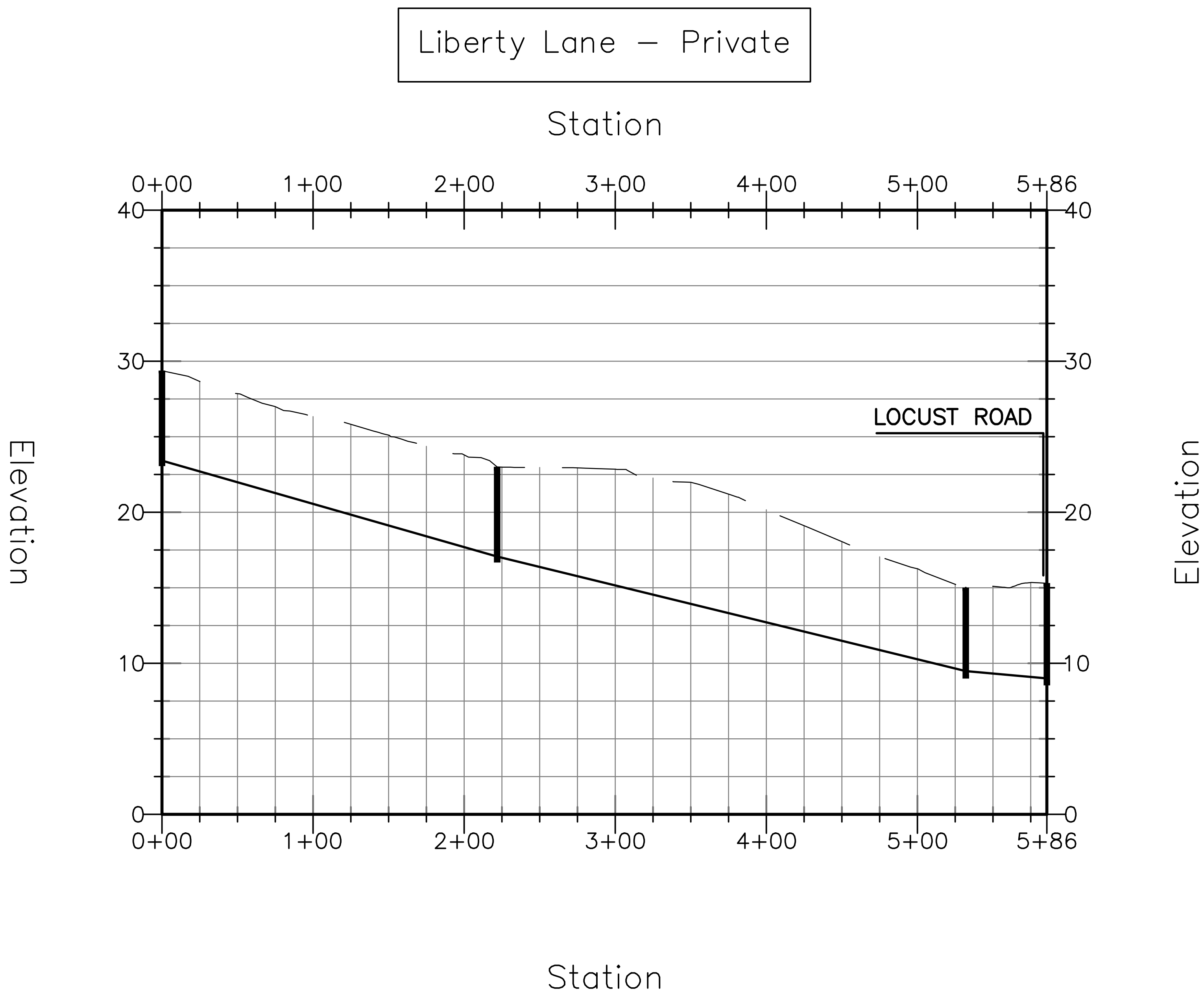
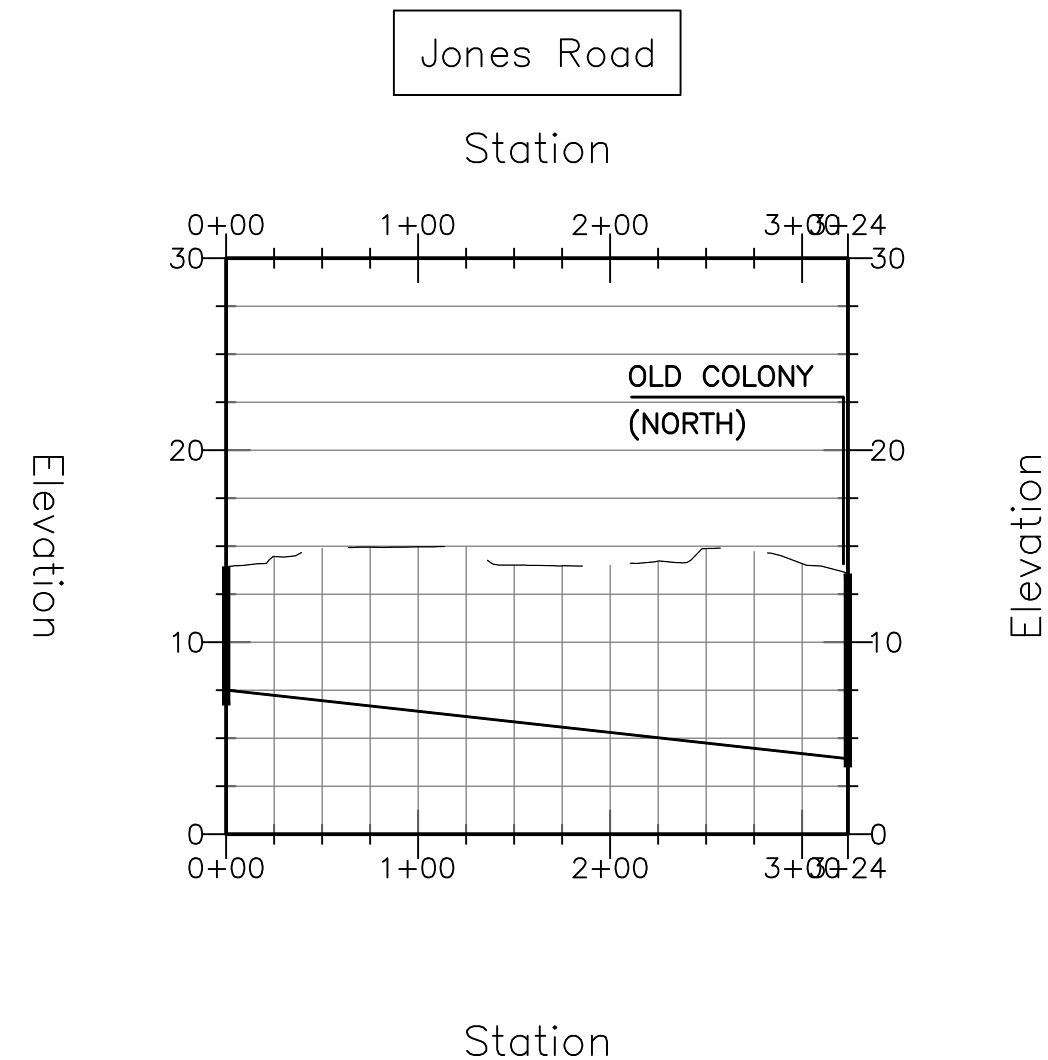
January 2016





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WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
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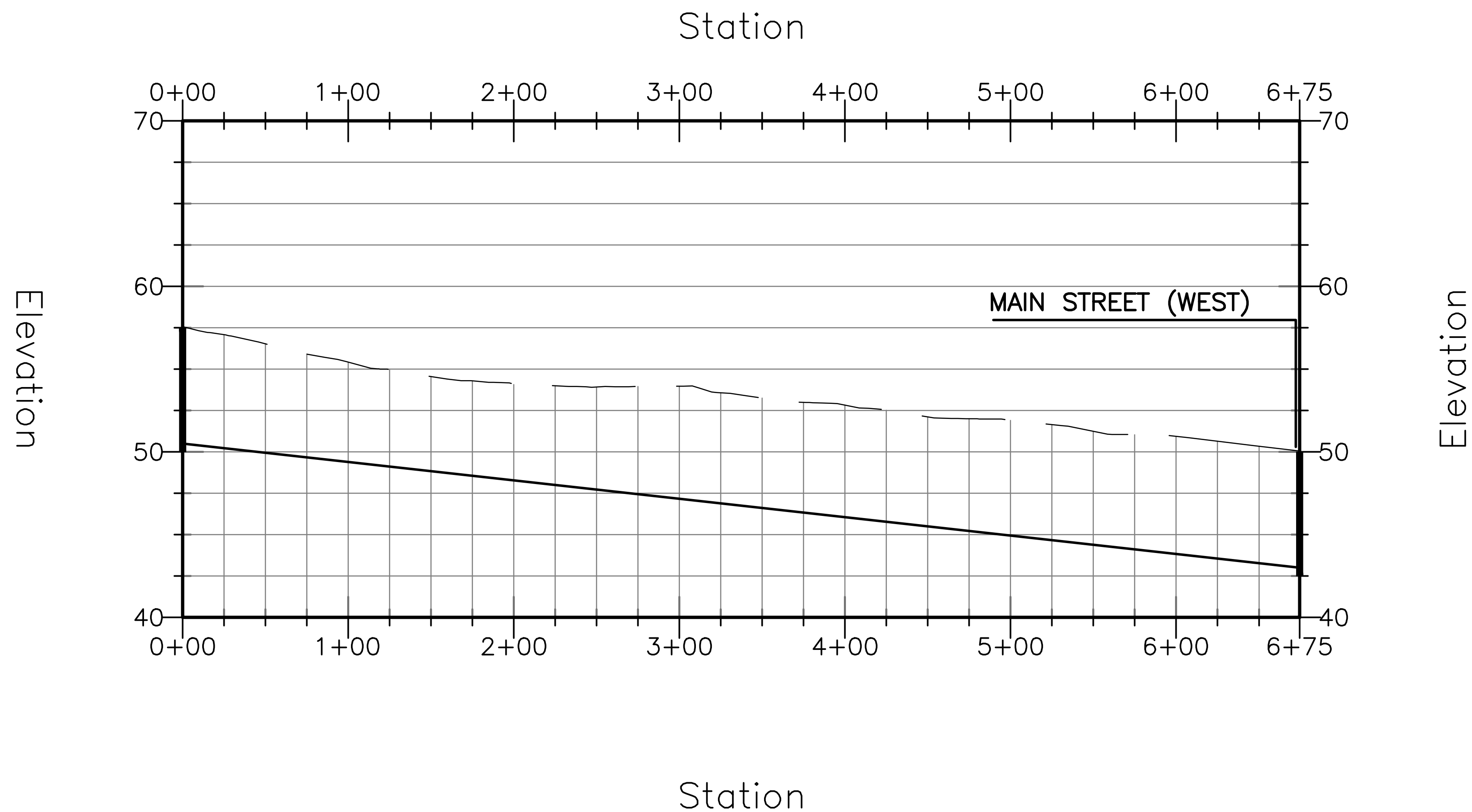
January 2016

Old Colony Way – Mid



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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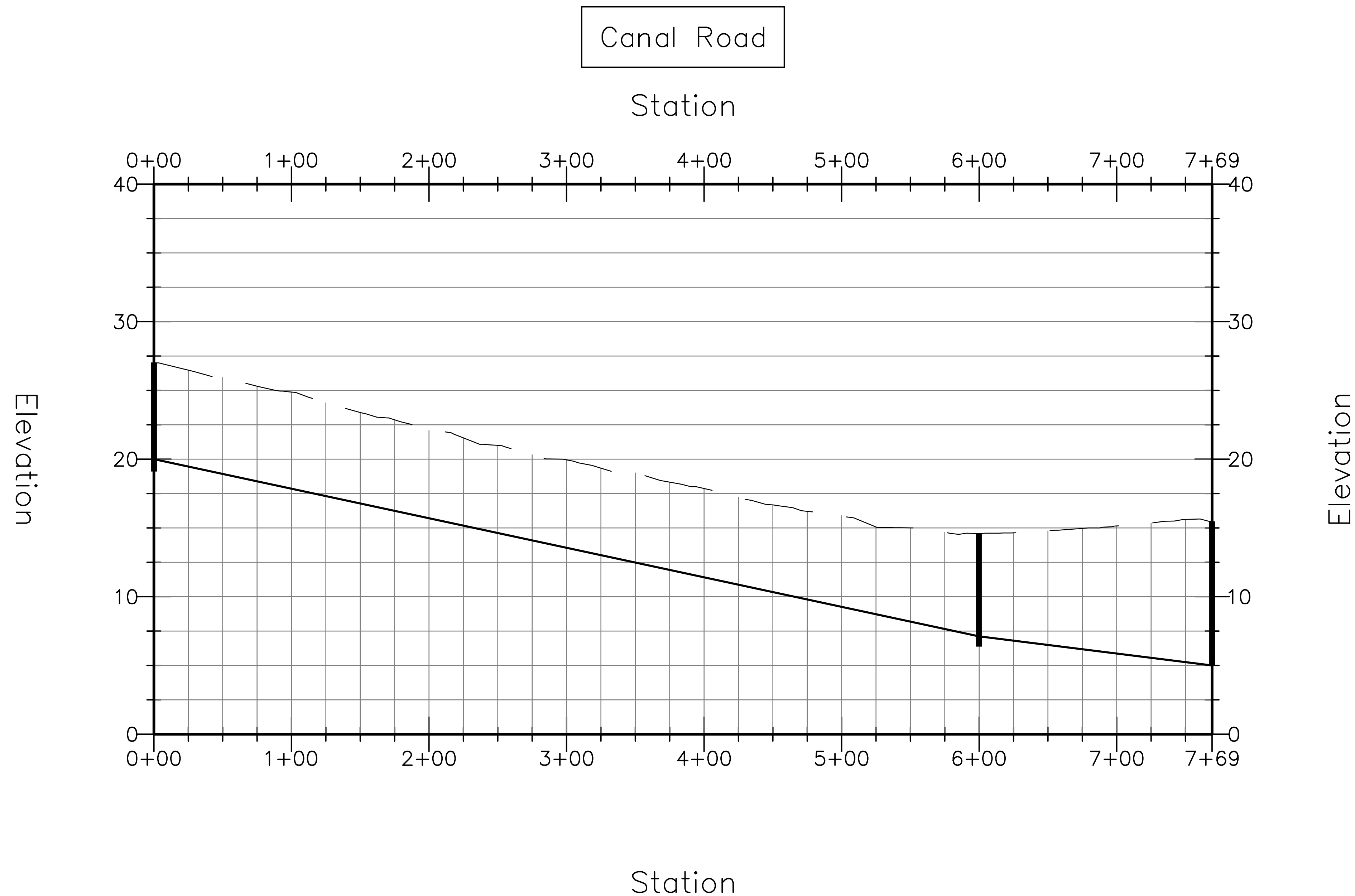
January 2016



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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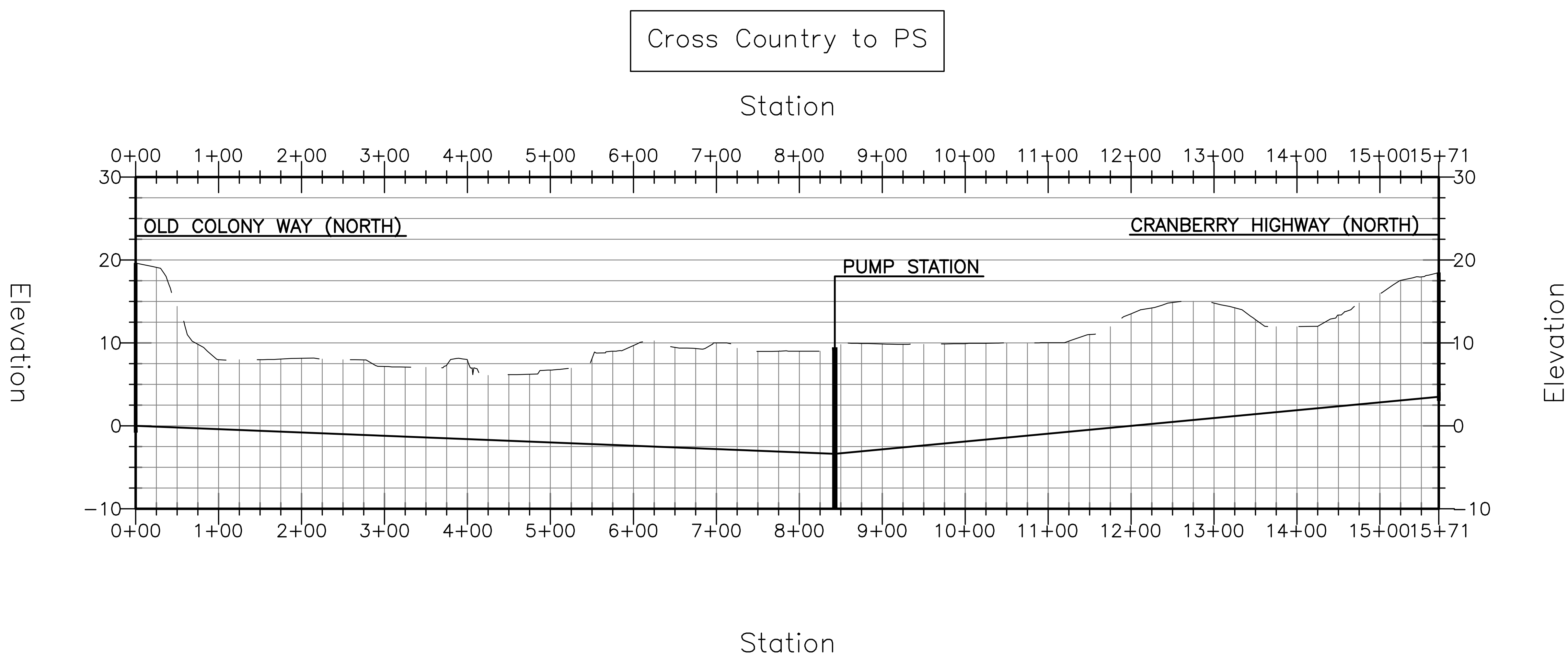
January 2016



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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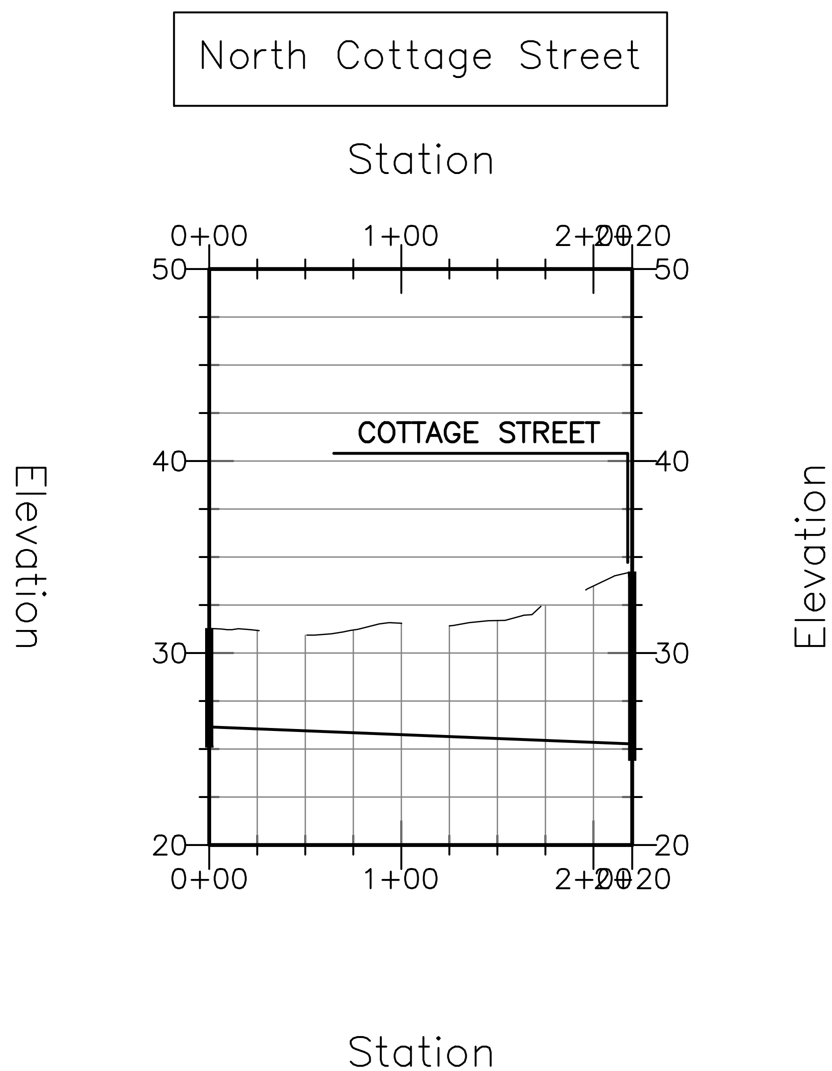
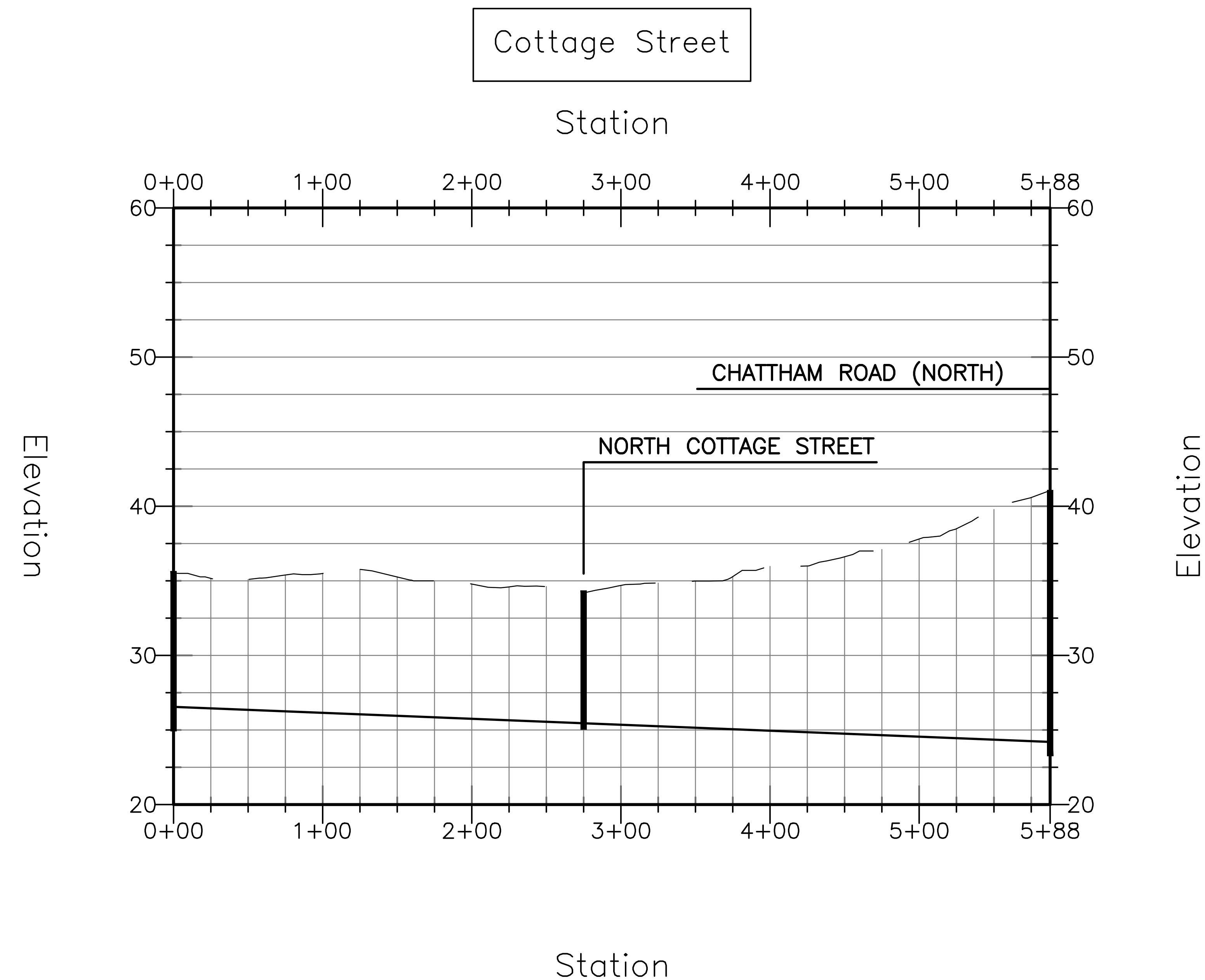
January 2016





TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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CONCEPTUAL LAYOUT OF
DOWNTOWN AREA SEWERS

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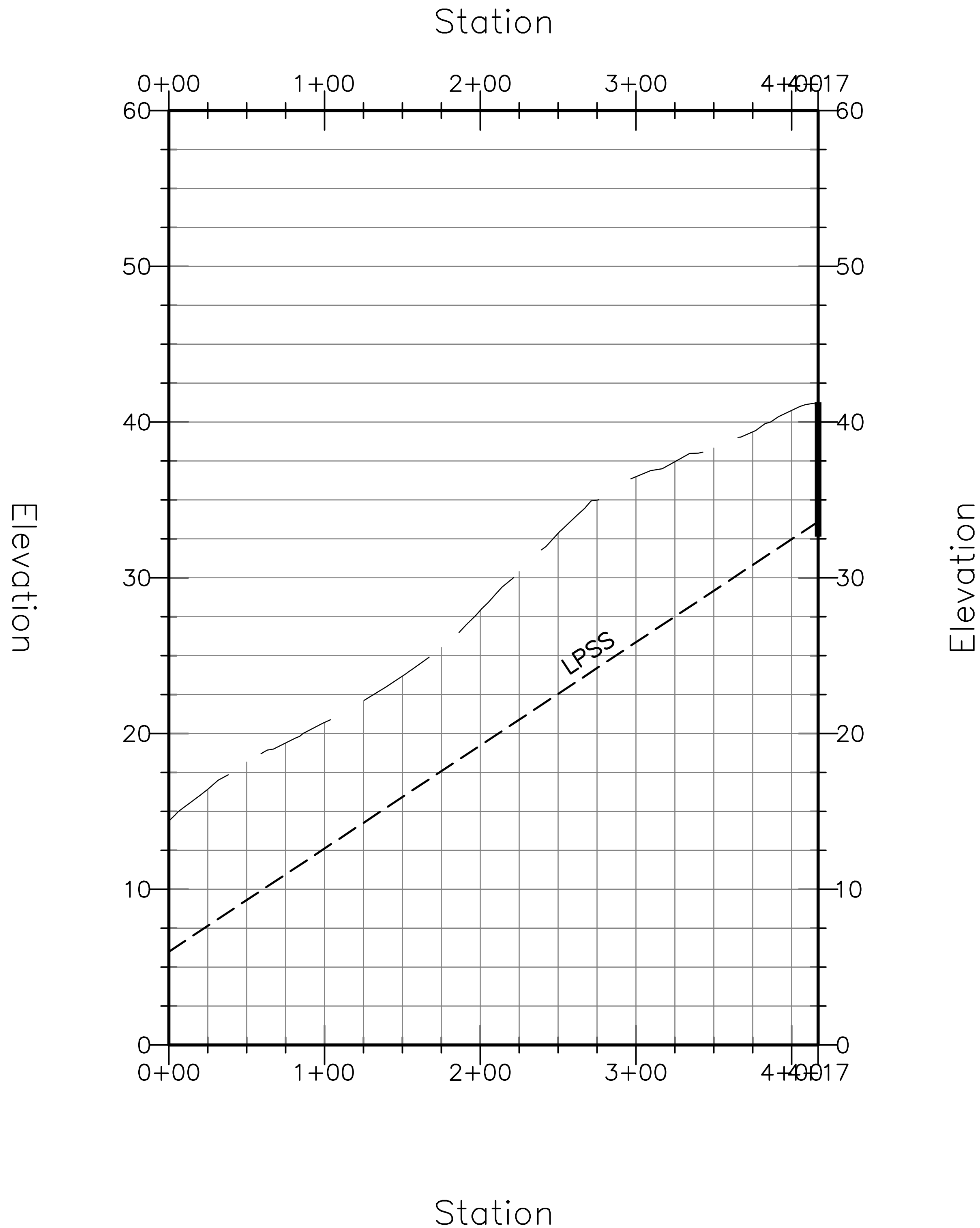
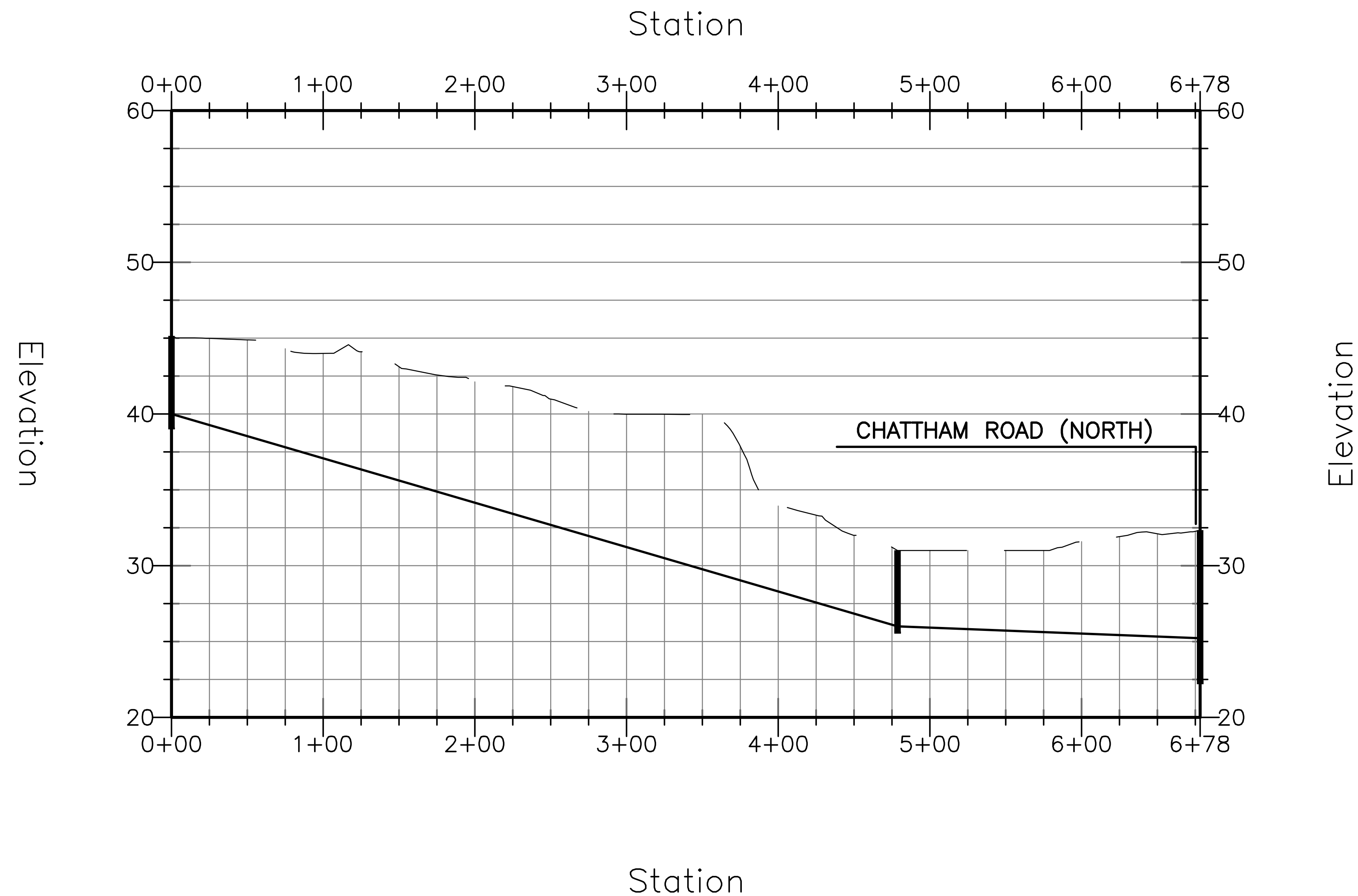
January 2016

Cove Road – East



Cummings Road



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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January 2016

Town of Orleans, MA
Water Quality and Wastewater Planning Services
Meetinghouse
Proposed Collection System Layout
Legend
Meetinghouse Sewer Area
Proposed Gravity Sewer/STEP
Proposed Low Pressure Sewer/STEG
Proposed Force Main
Potential WTP Sites
45 Spot Elevation
N
0 300 600
Feet
AECOM
January 2016
Sewer Forcemain to 178 Beach Road
Vicinity of Proposed Pump Station
MAIN STREET
BREWSTER CROSS ROAD

TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
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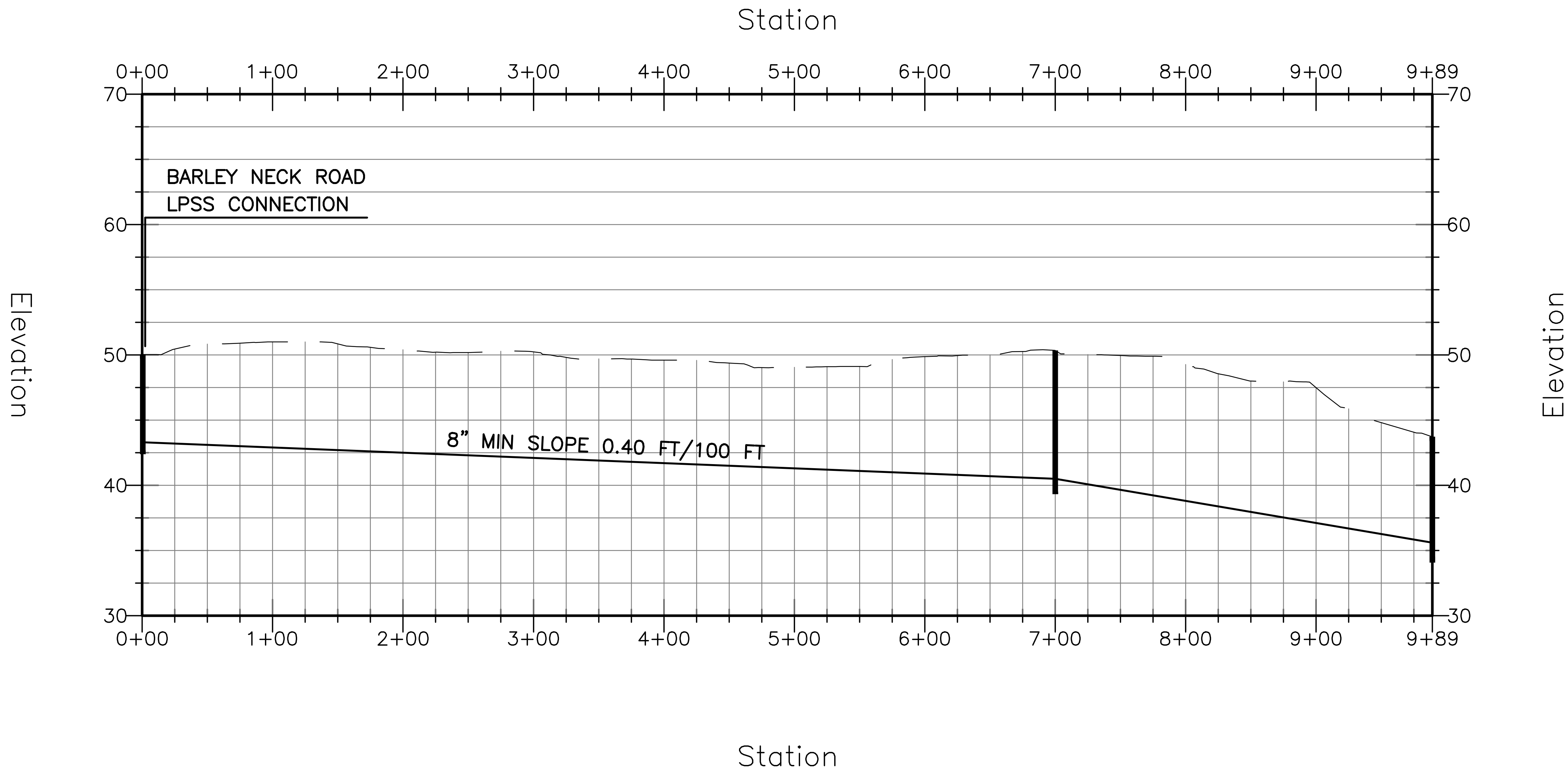
CONCEPTUAL LAYOUT OF
MEETINGHOUSE AREA SEWERS

AECOM
January 2016

Barley Neck Road

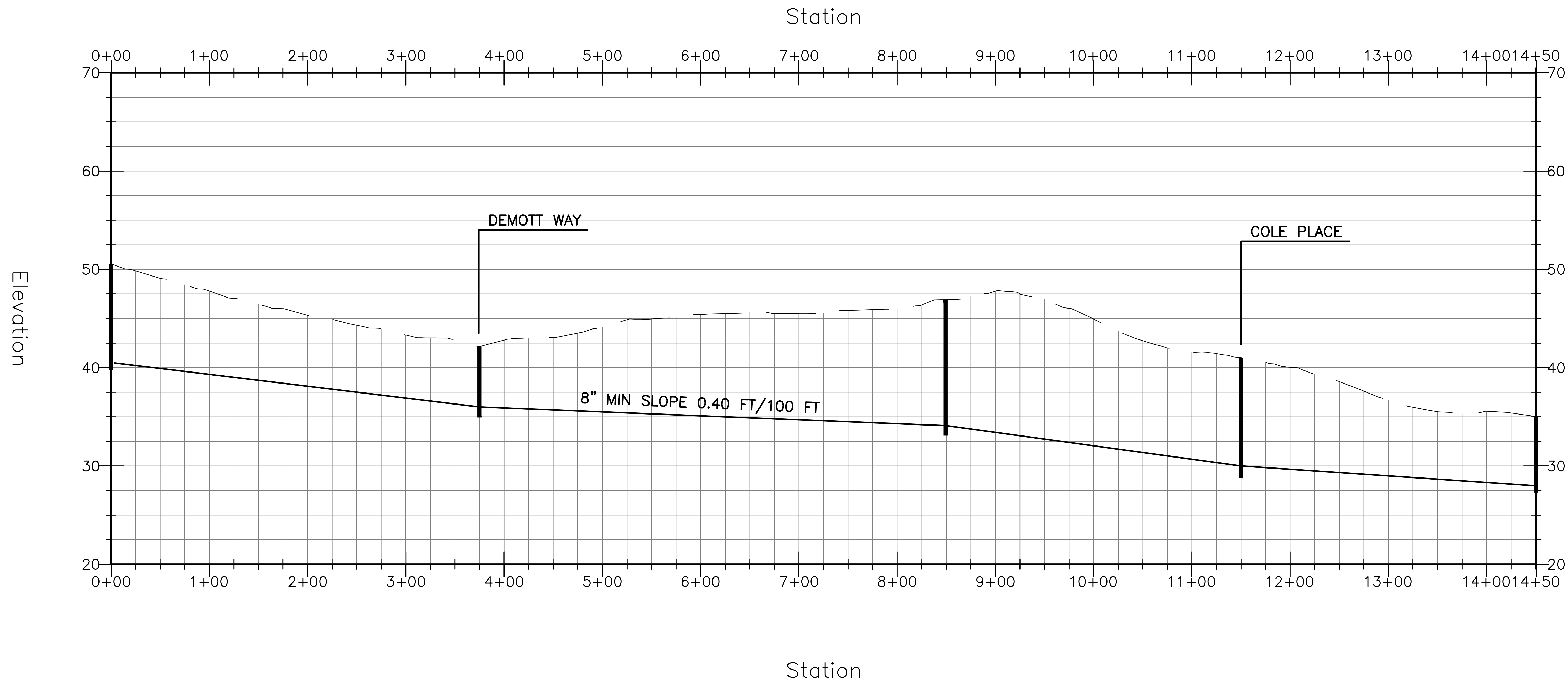


TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
MEETINGHOUSE AREA SEWERS

AECOM
January 2016

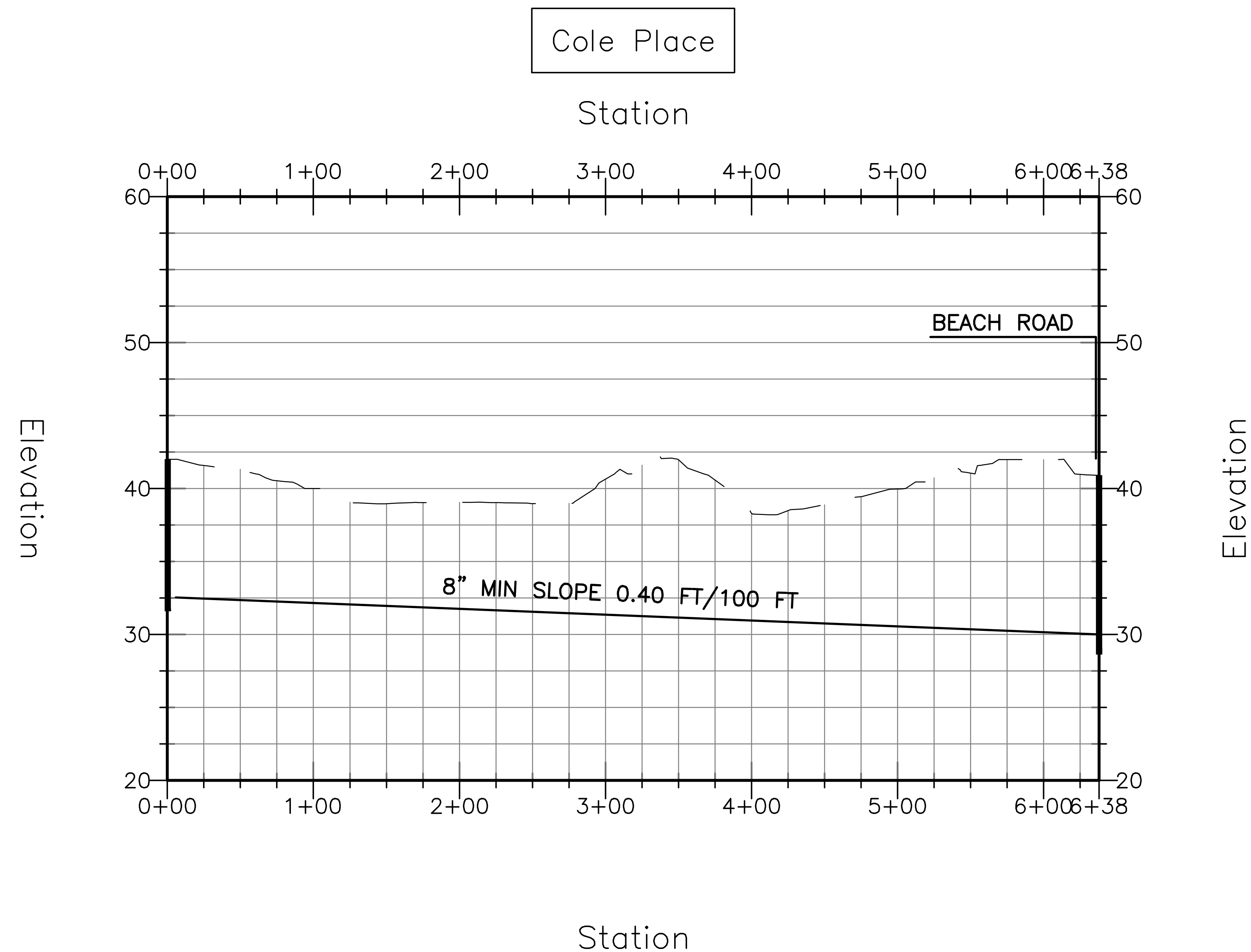
Beach Road



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
MEETINGHOUSE AREA SEWERS

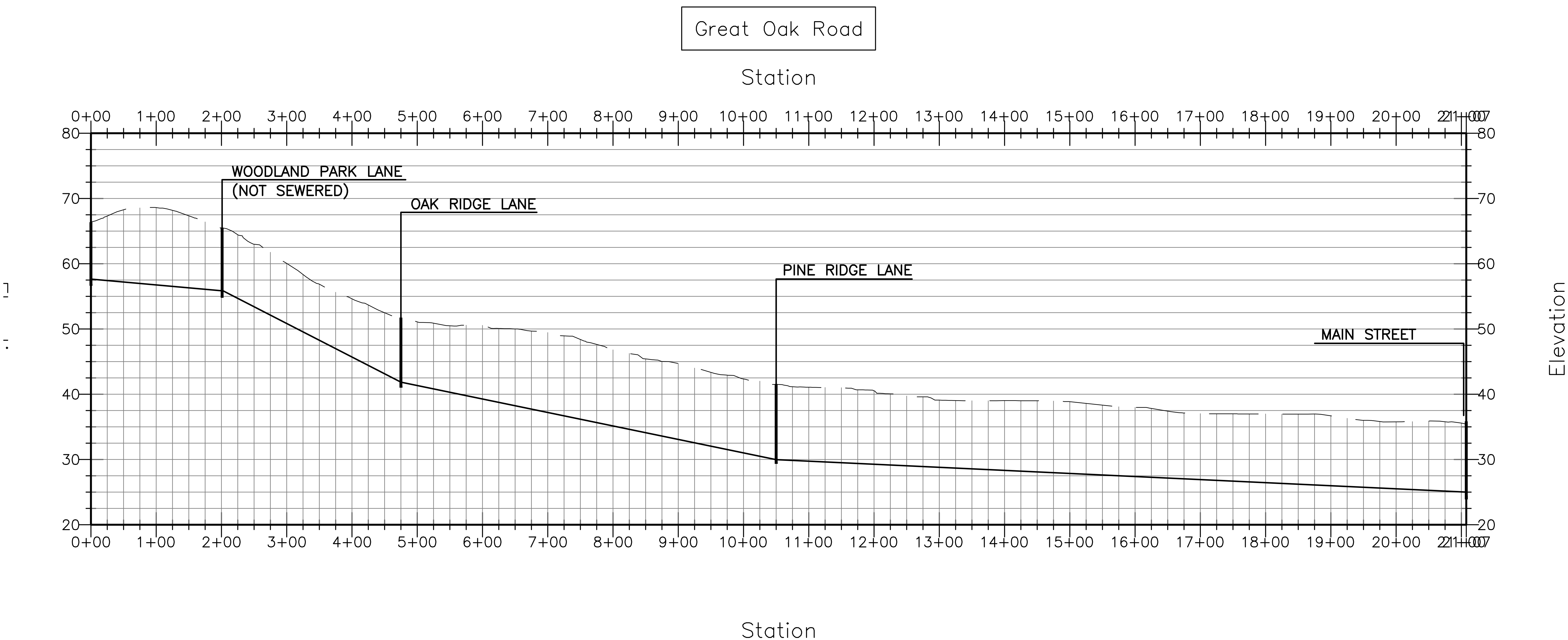
AECOM
January 2016



TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
MEETINGHOUSE AREA SEWERS

AECOM
January 2016

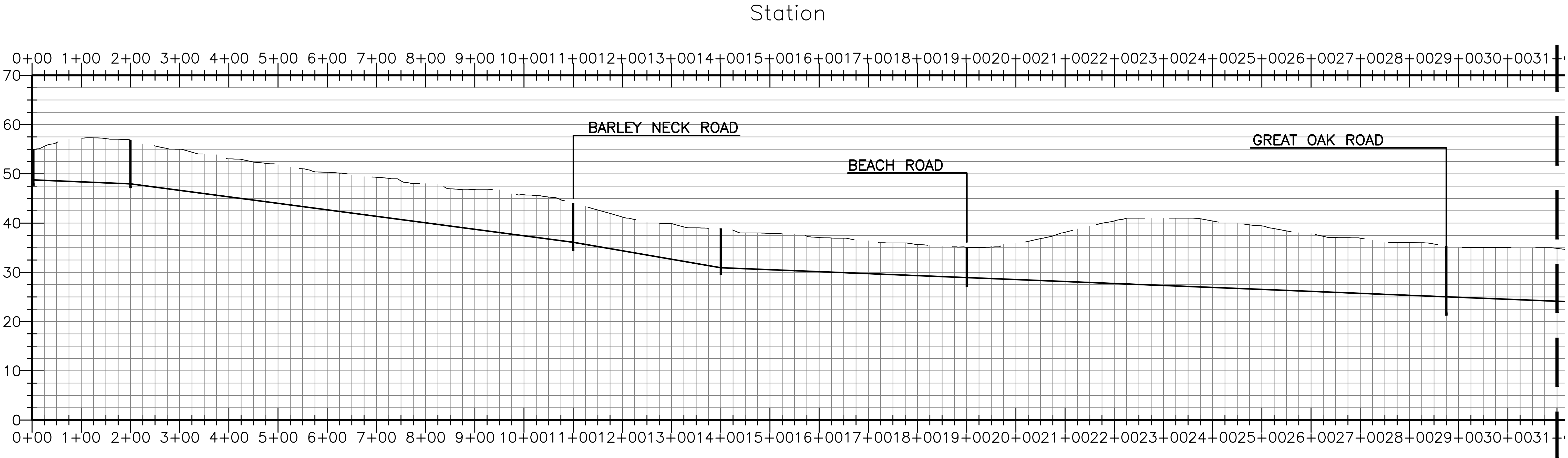


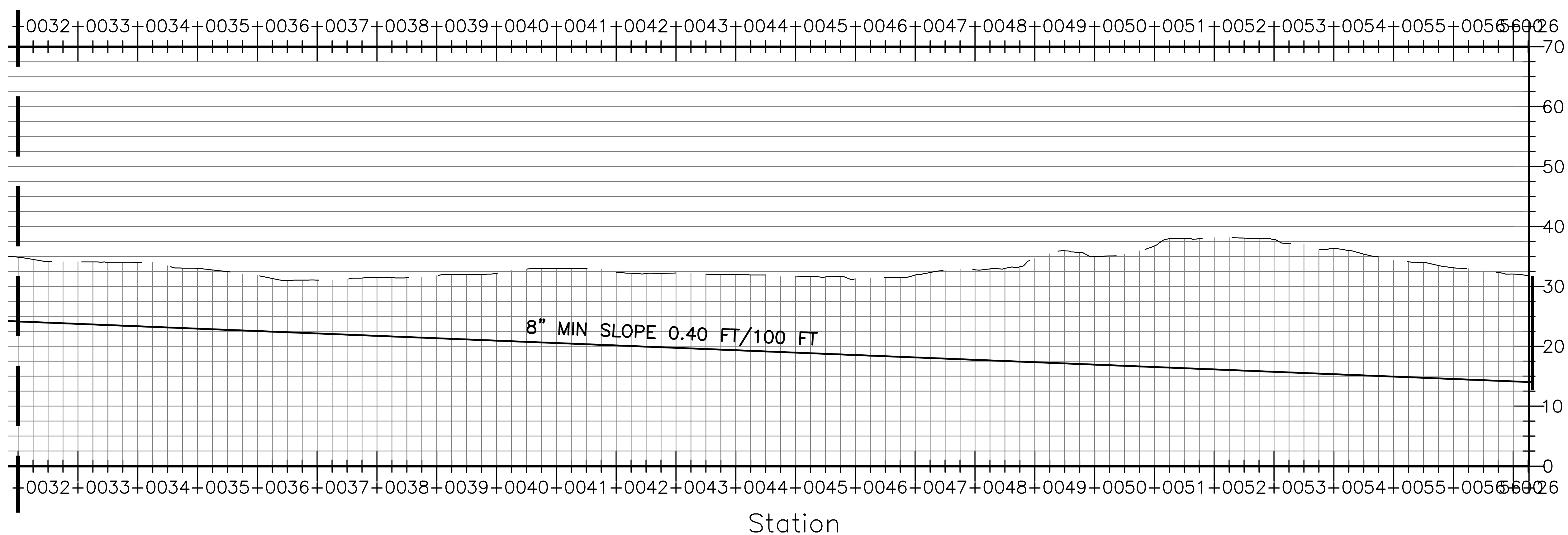
TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER
PLANNING SERVICES

CONCEPTUAL LAYOUT OF
MEETINGHOUSE AREA SEWERS

AECOM
January 2016

Main Street





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WATER QUALITY AND WASTEWATER
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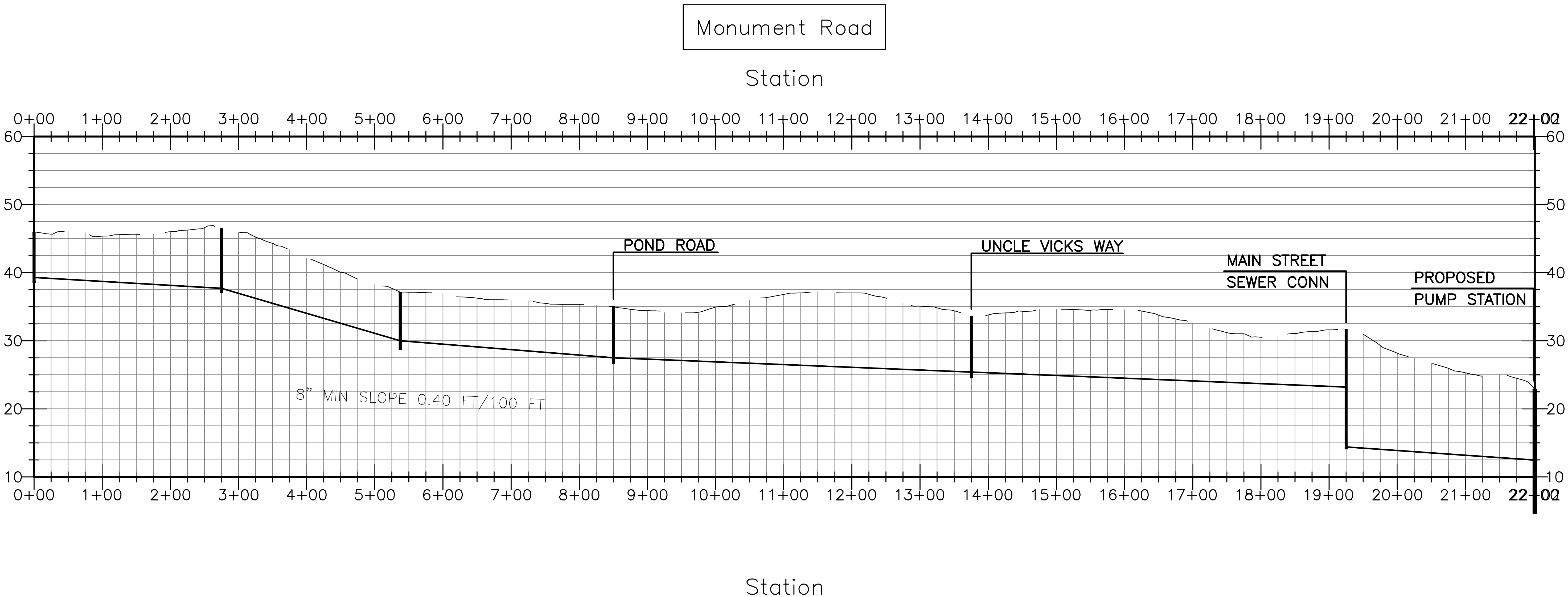

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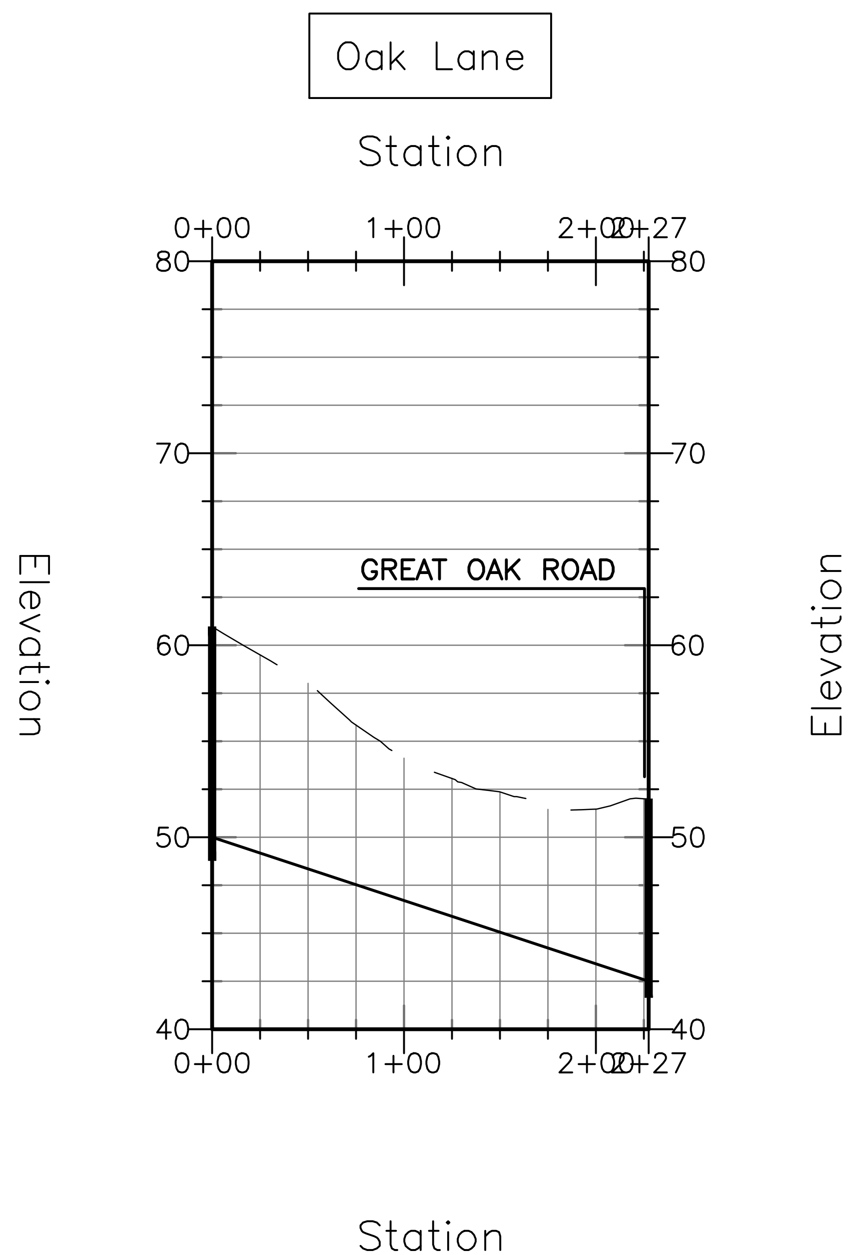

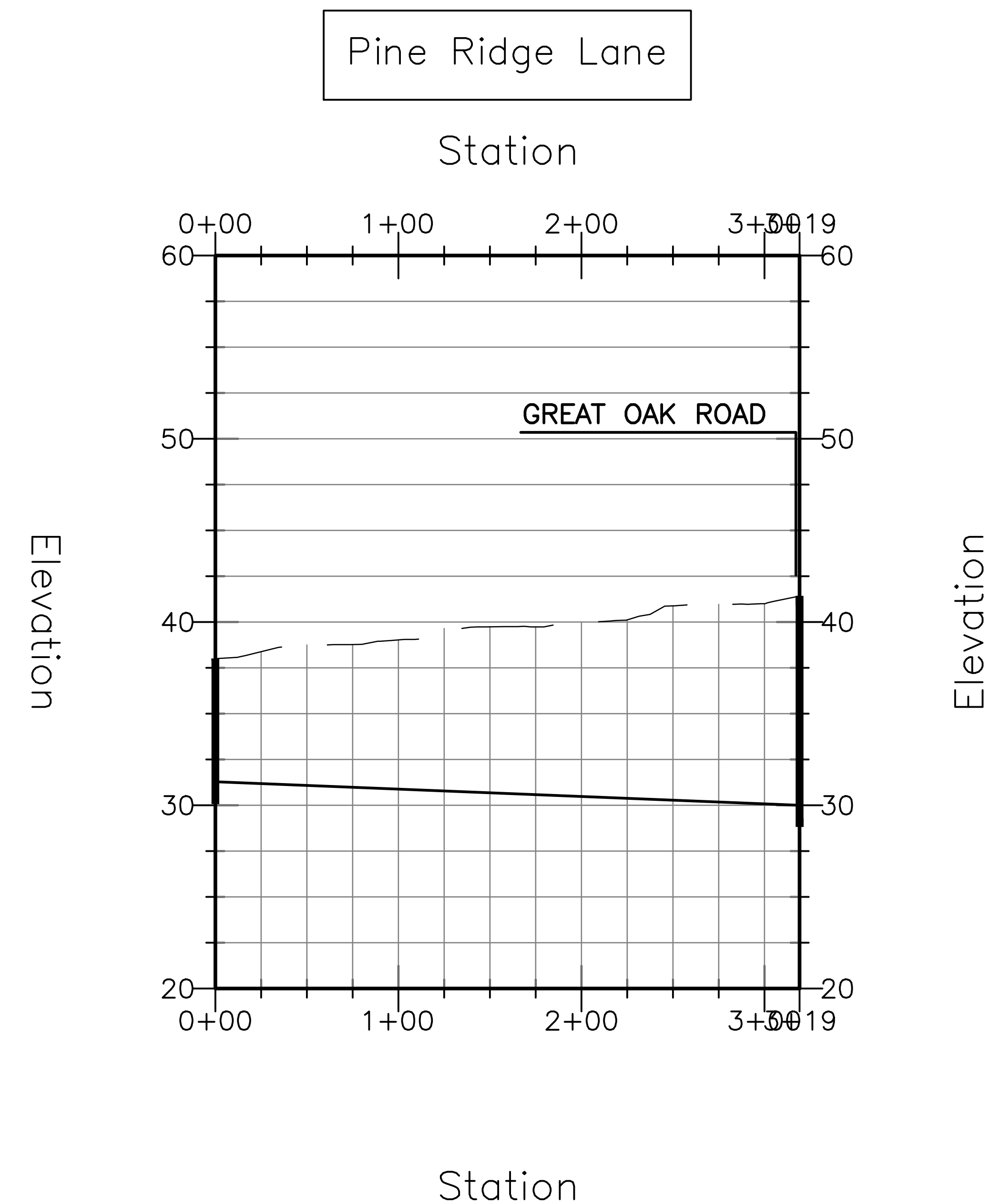

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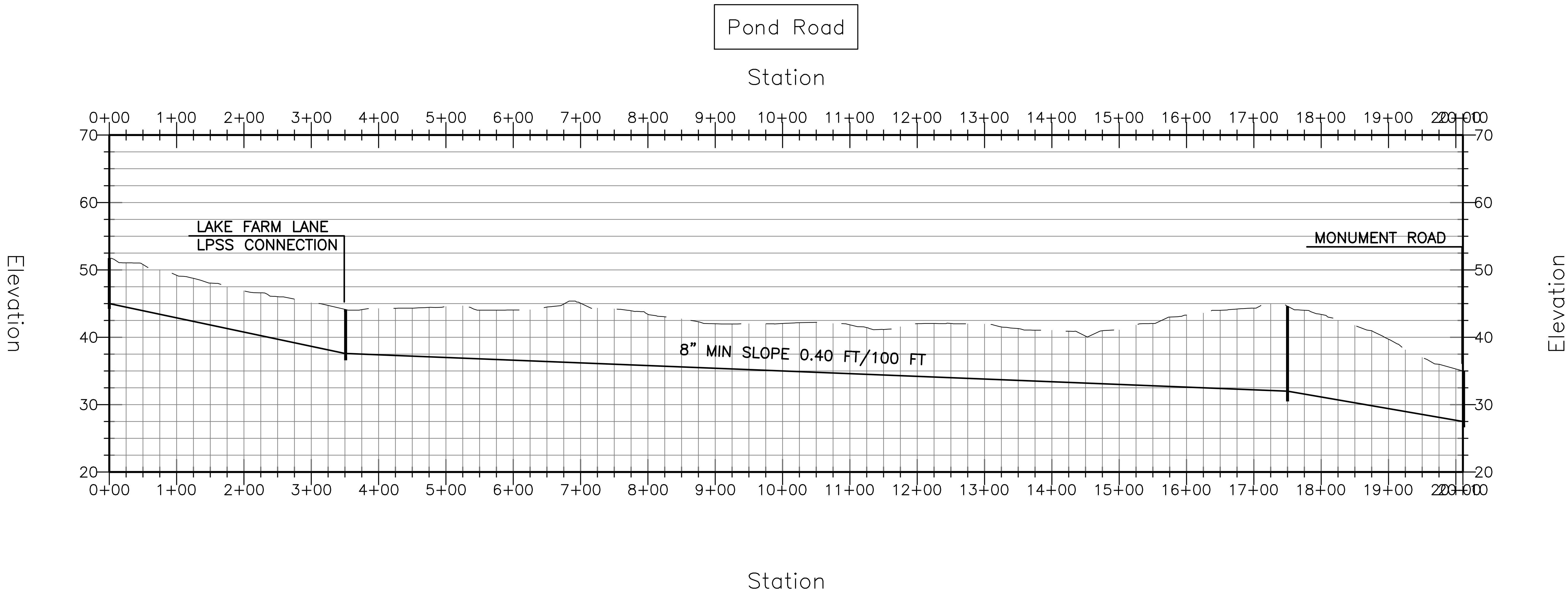

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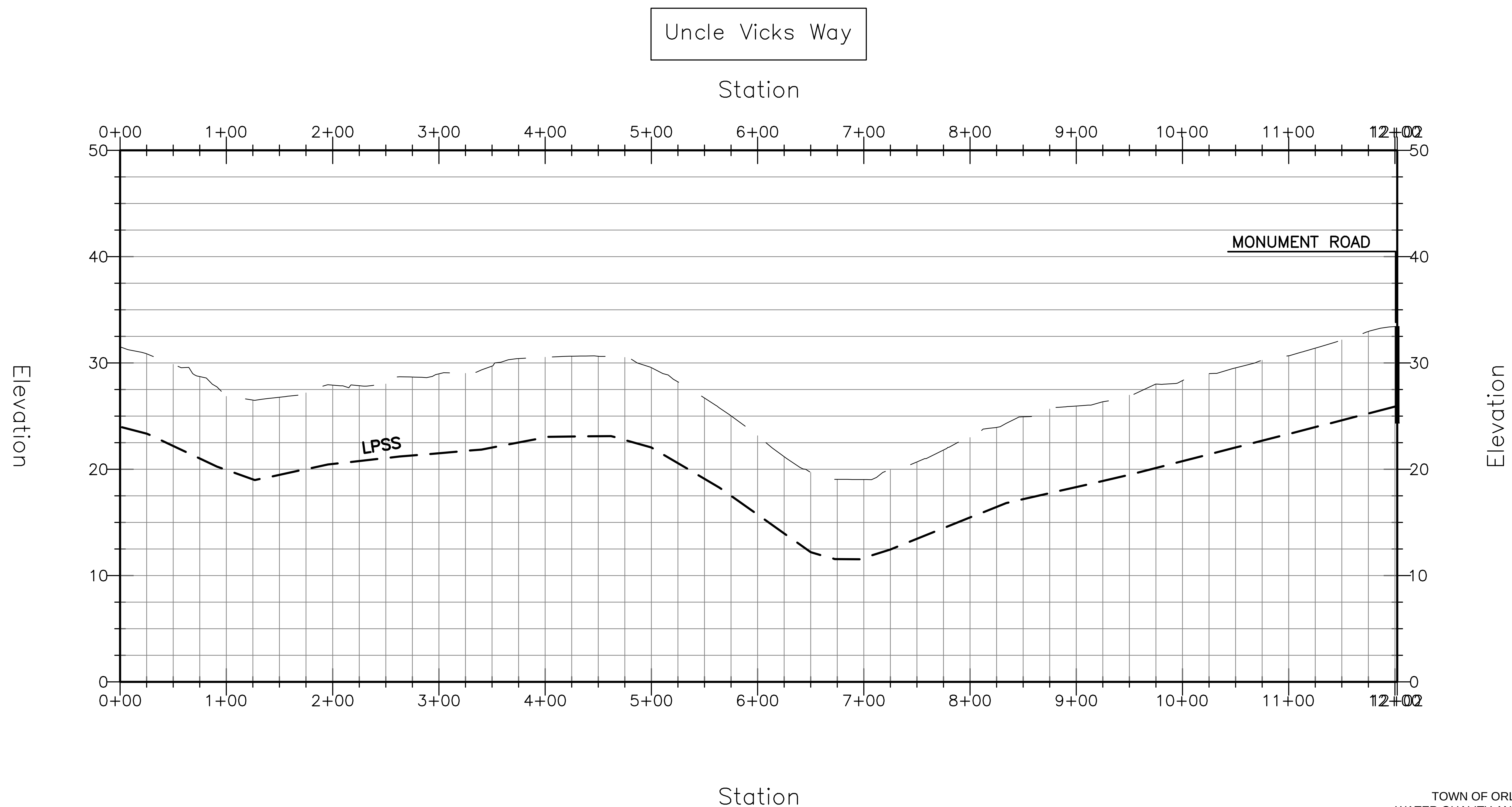

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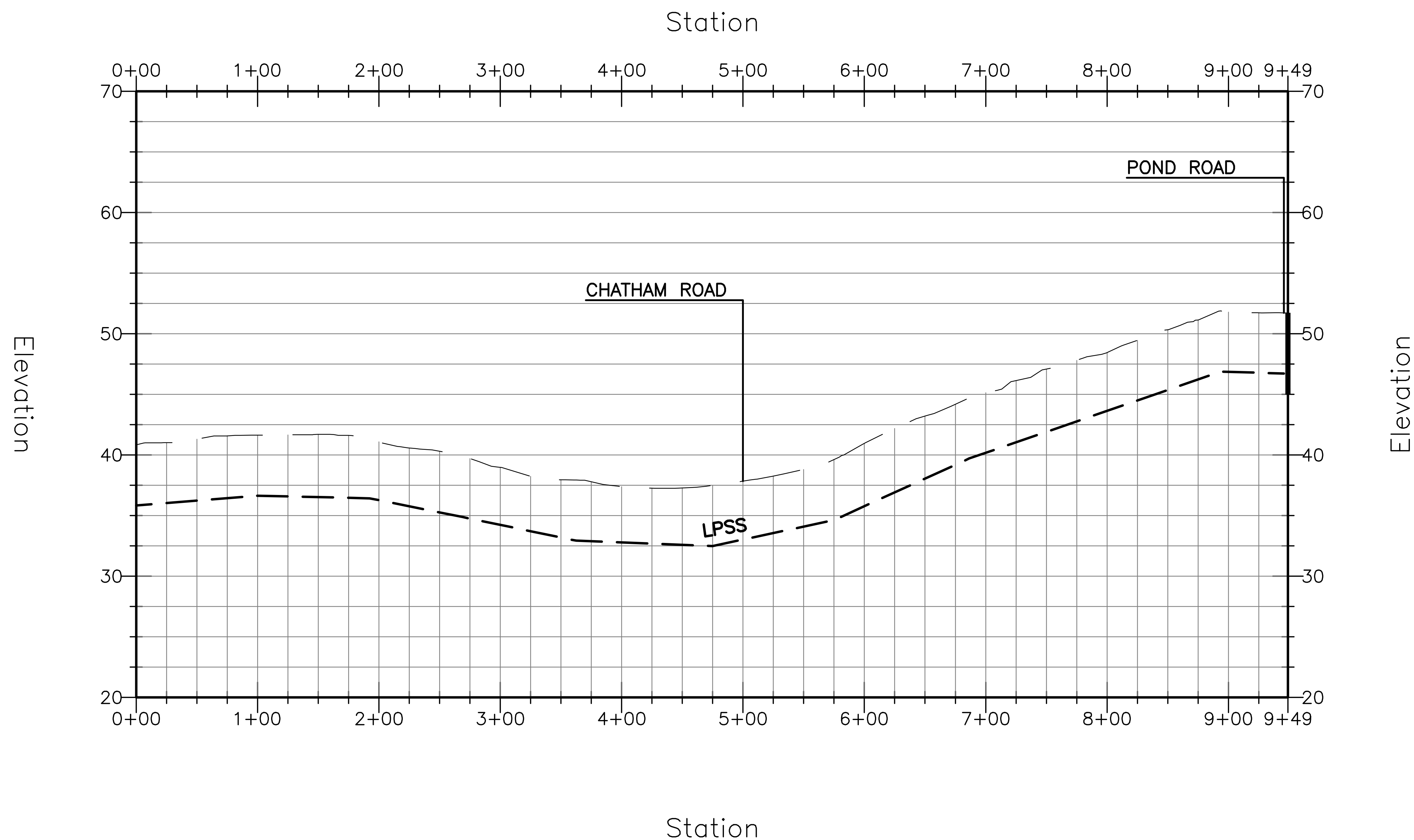
Finlay Road



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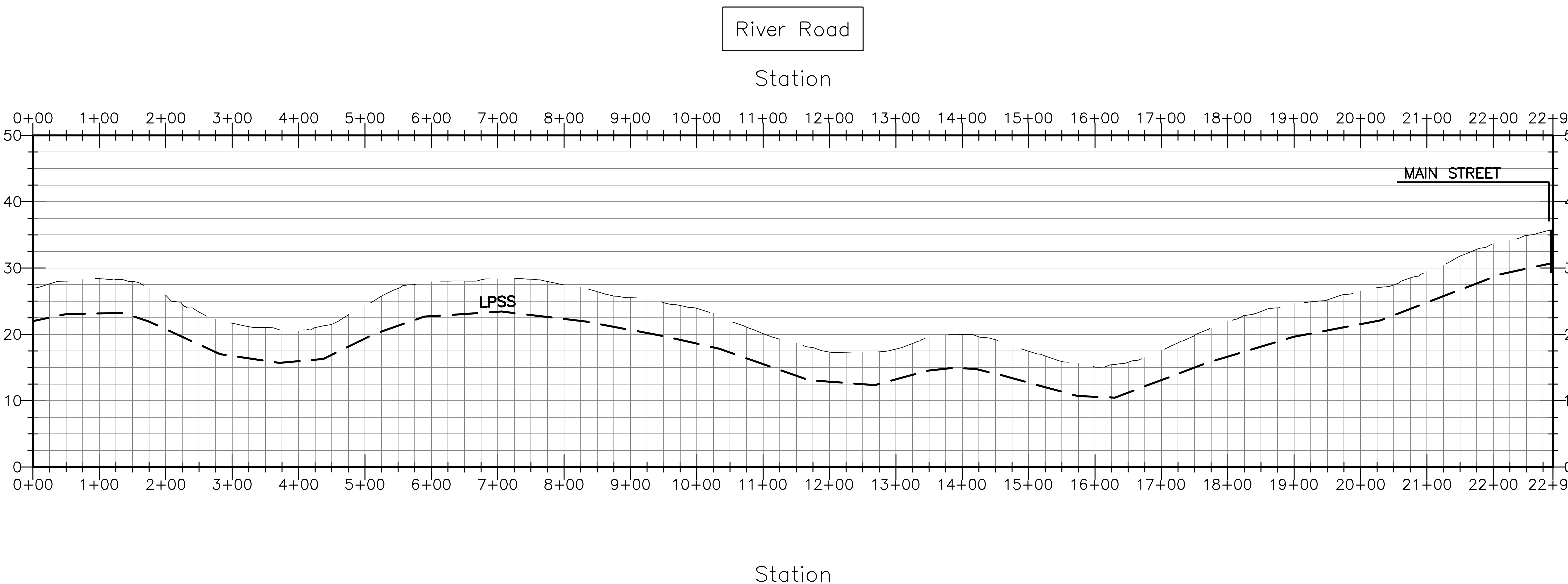

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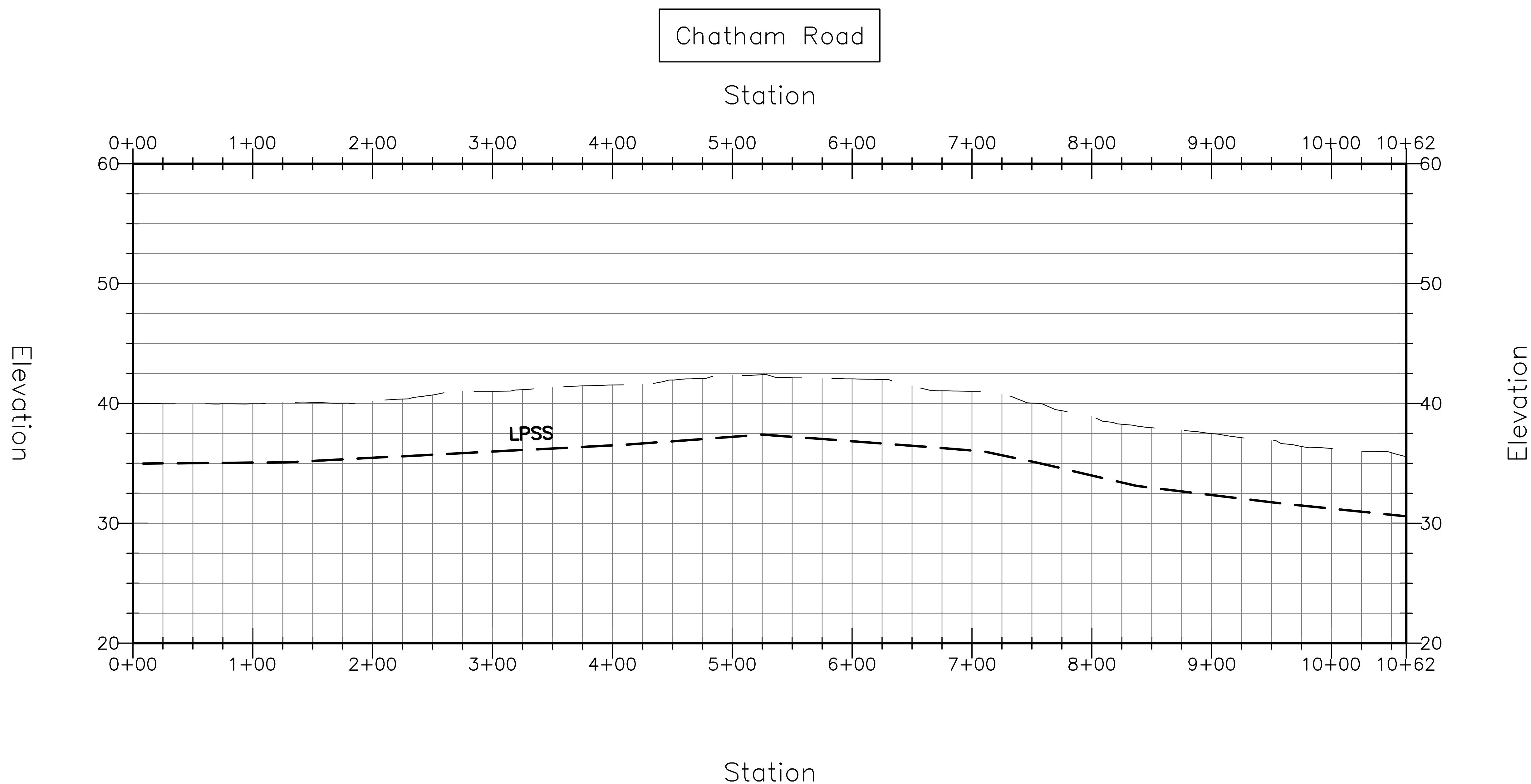

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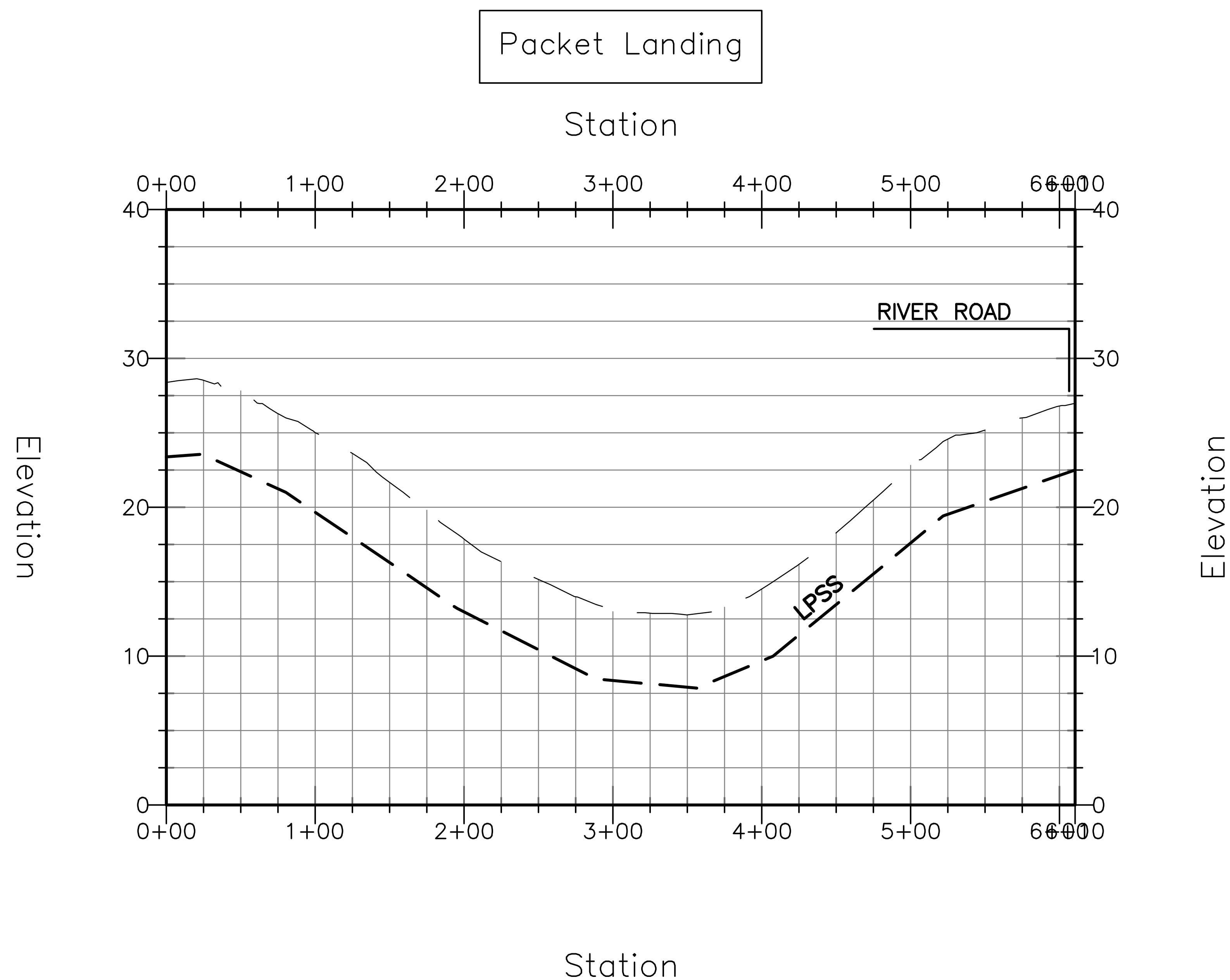

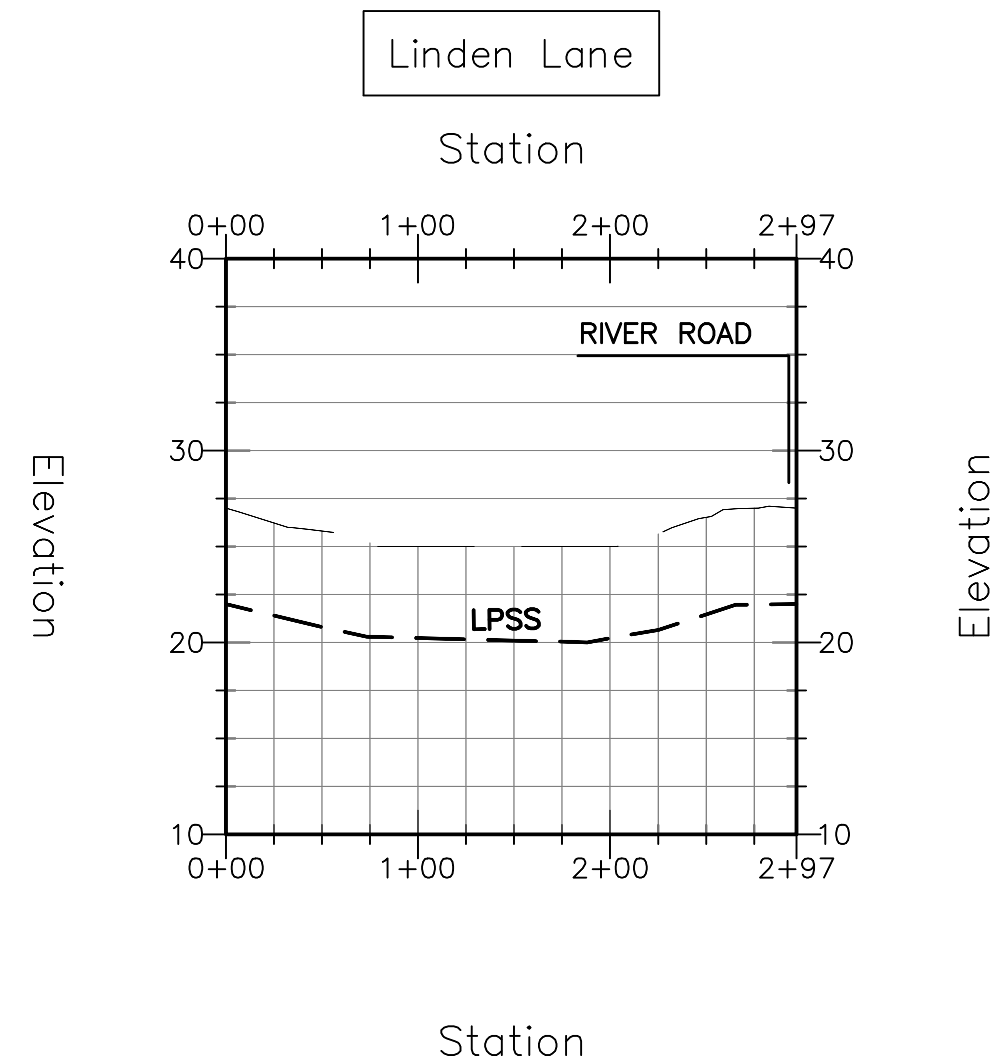

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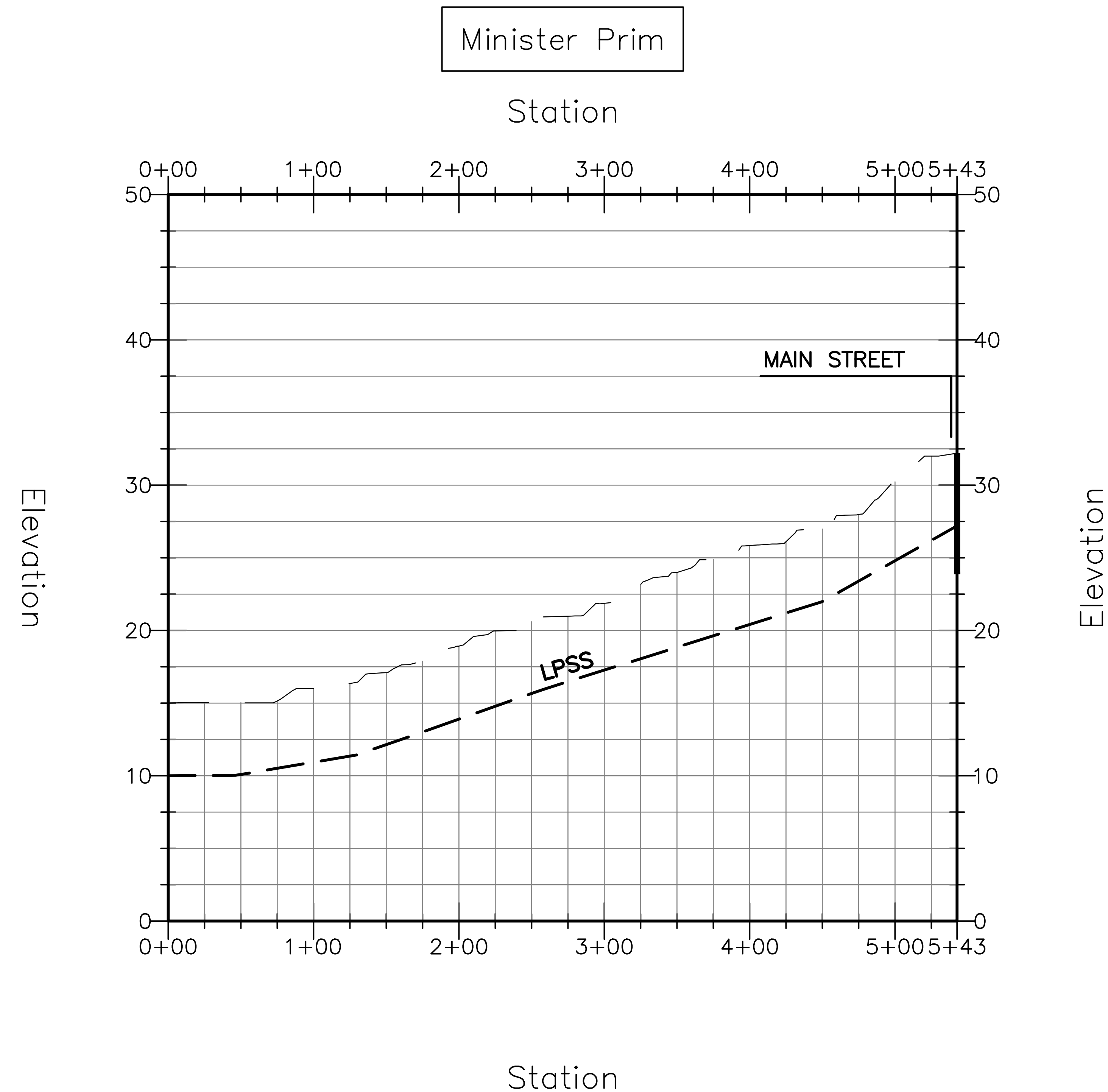

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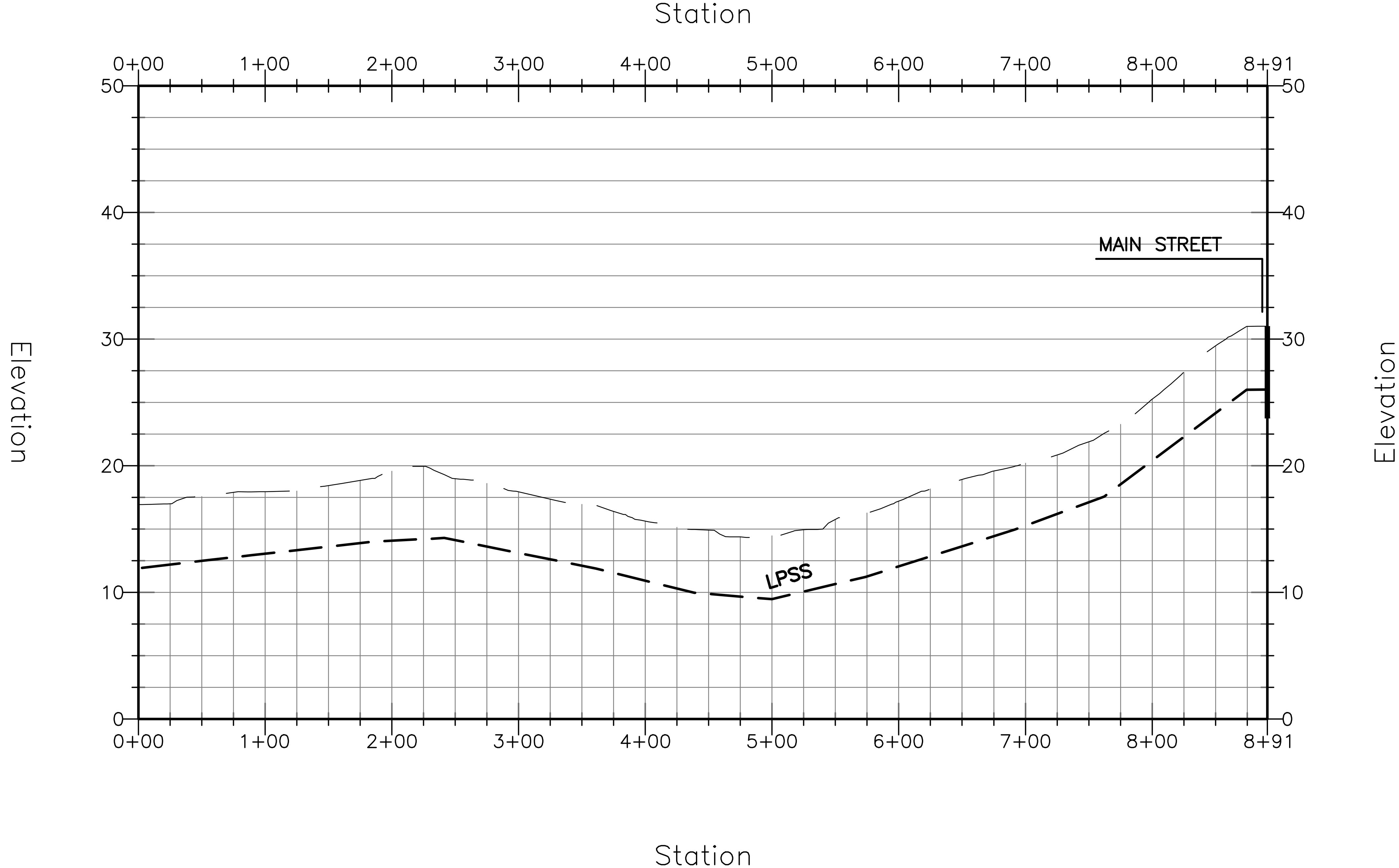
Deerwood Park



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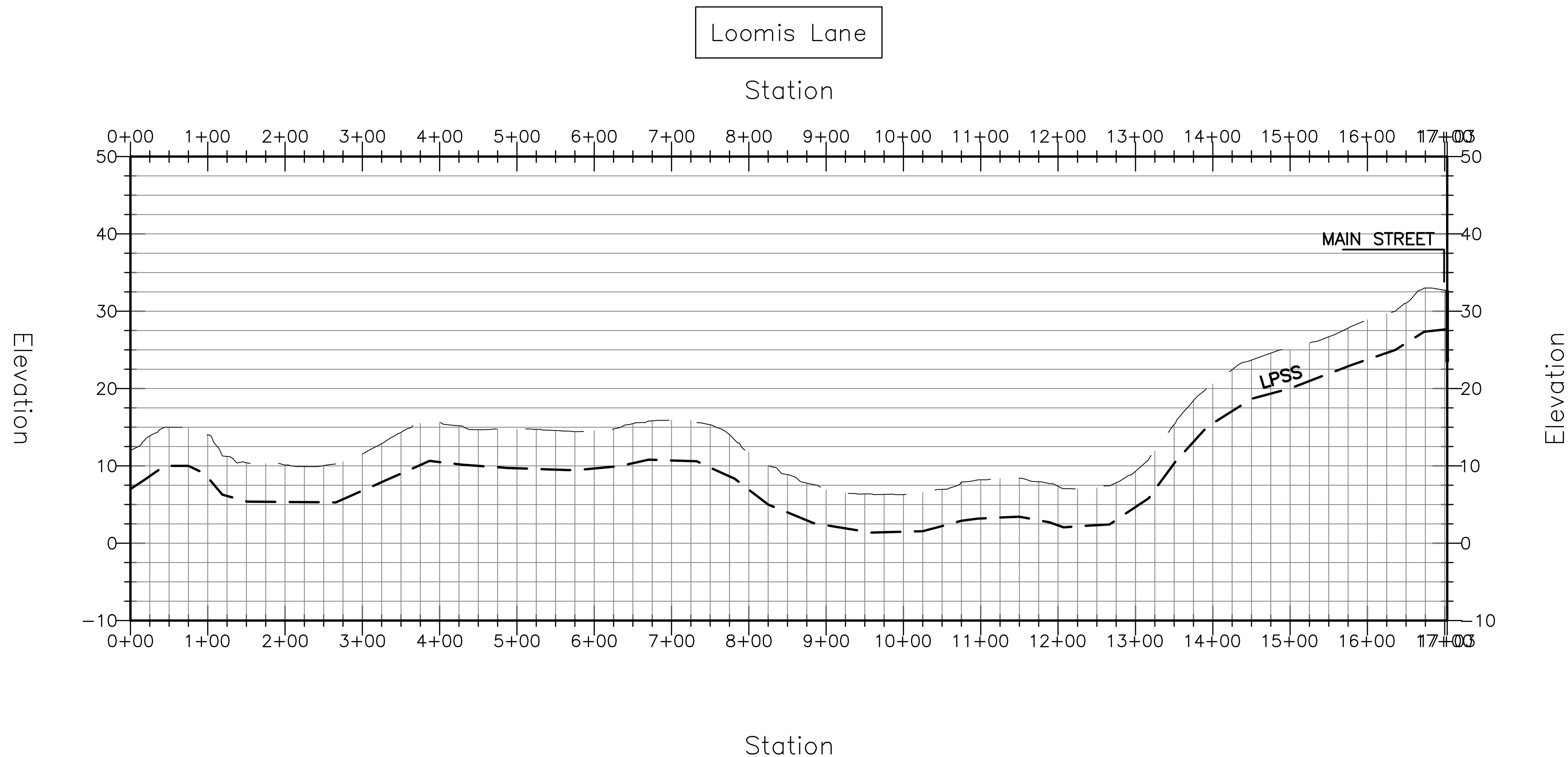

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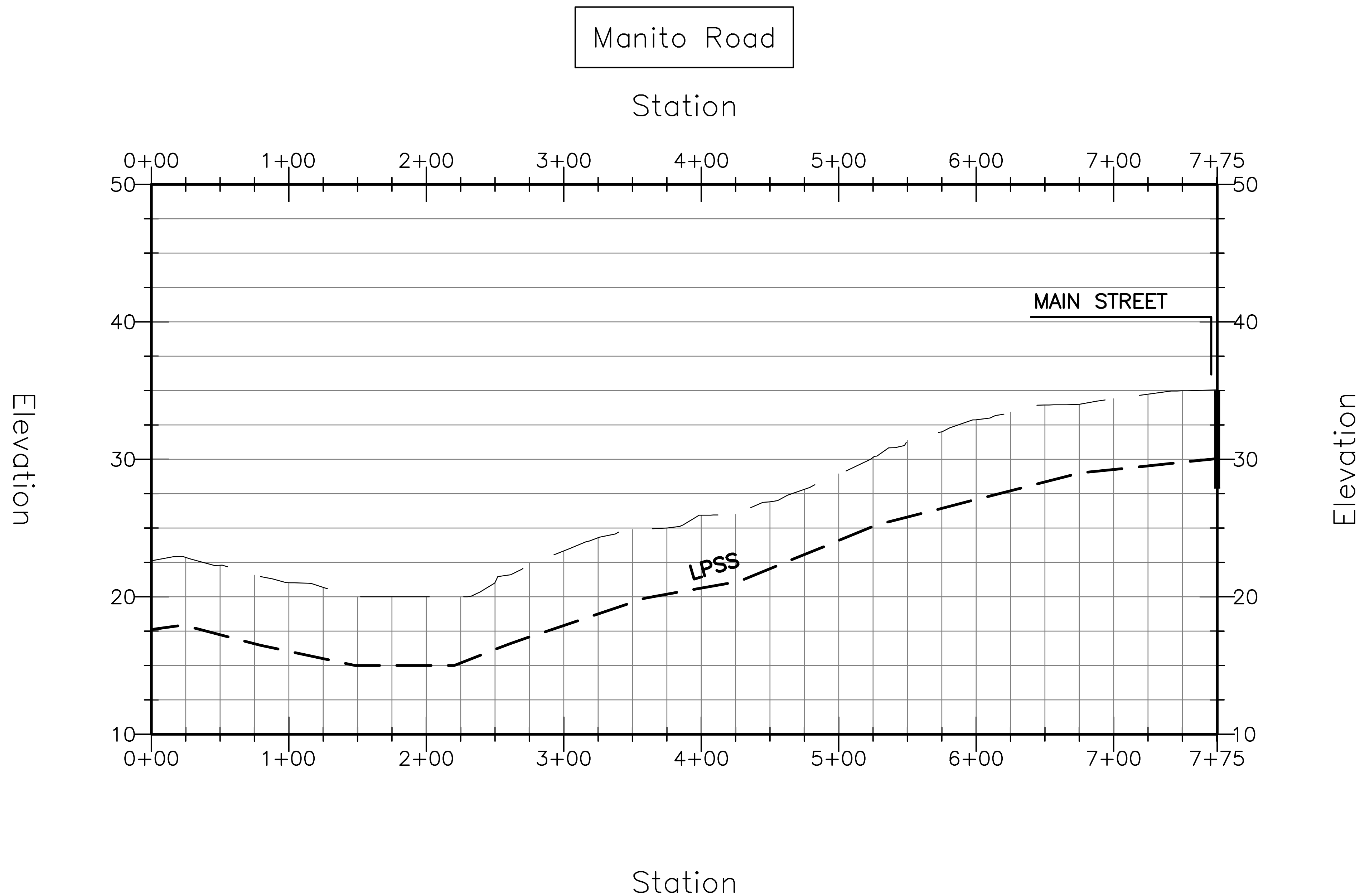

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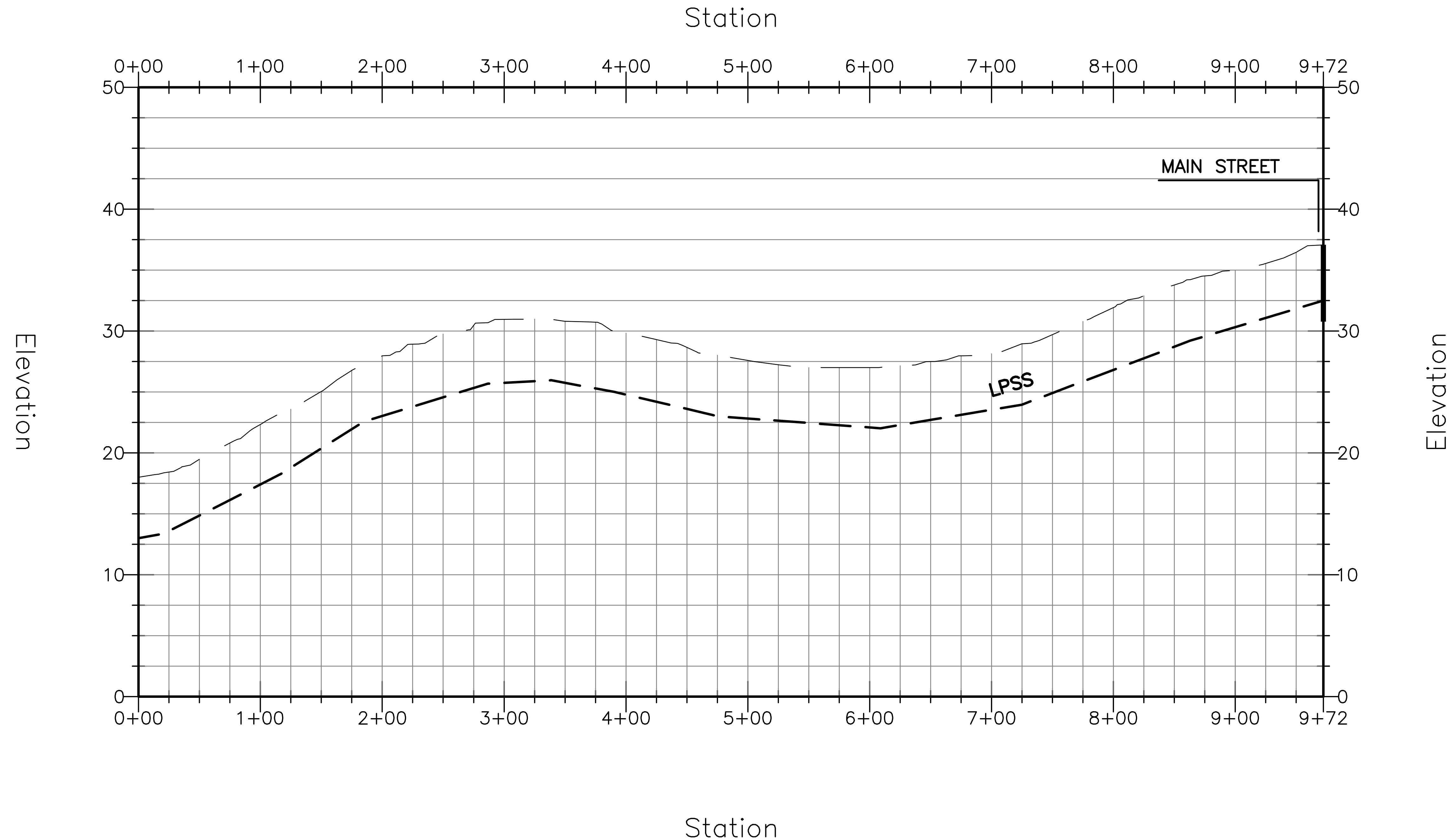
Cheney Road



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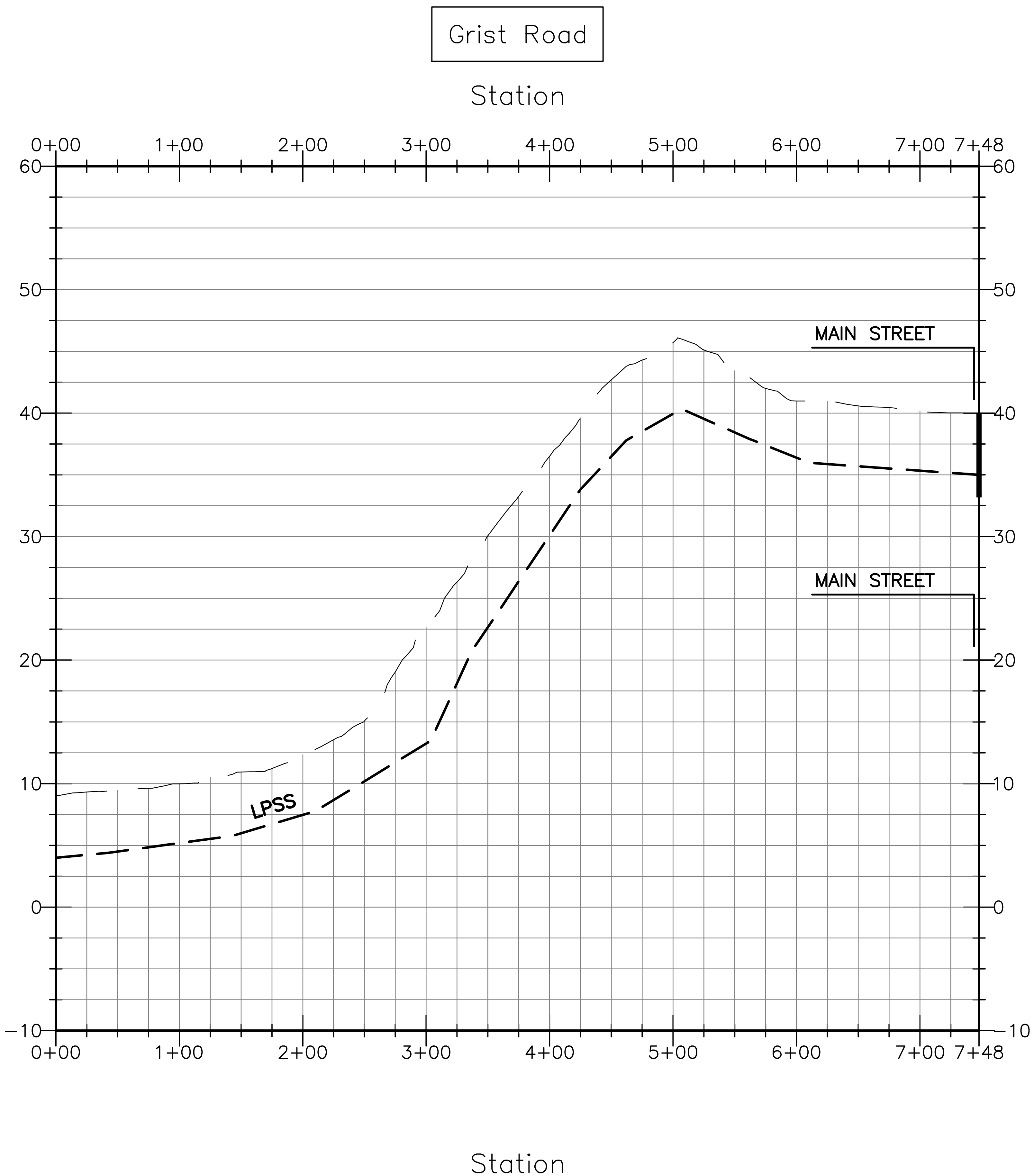

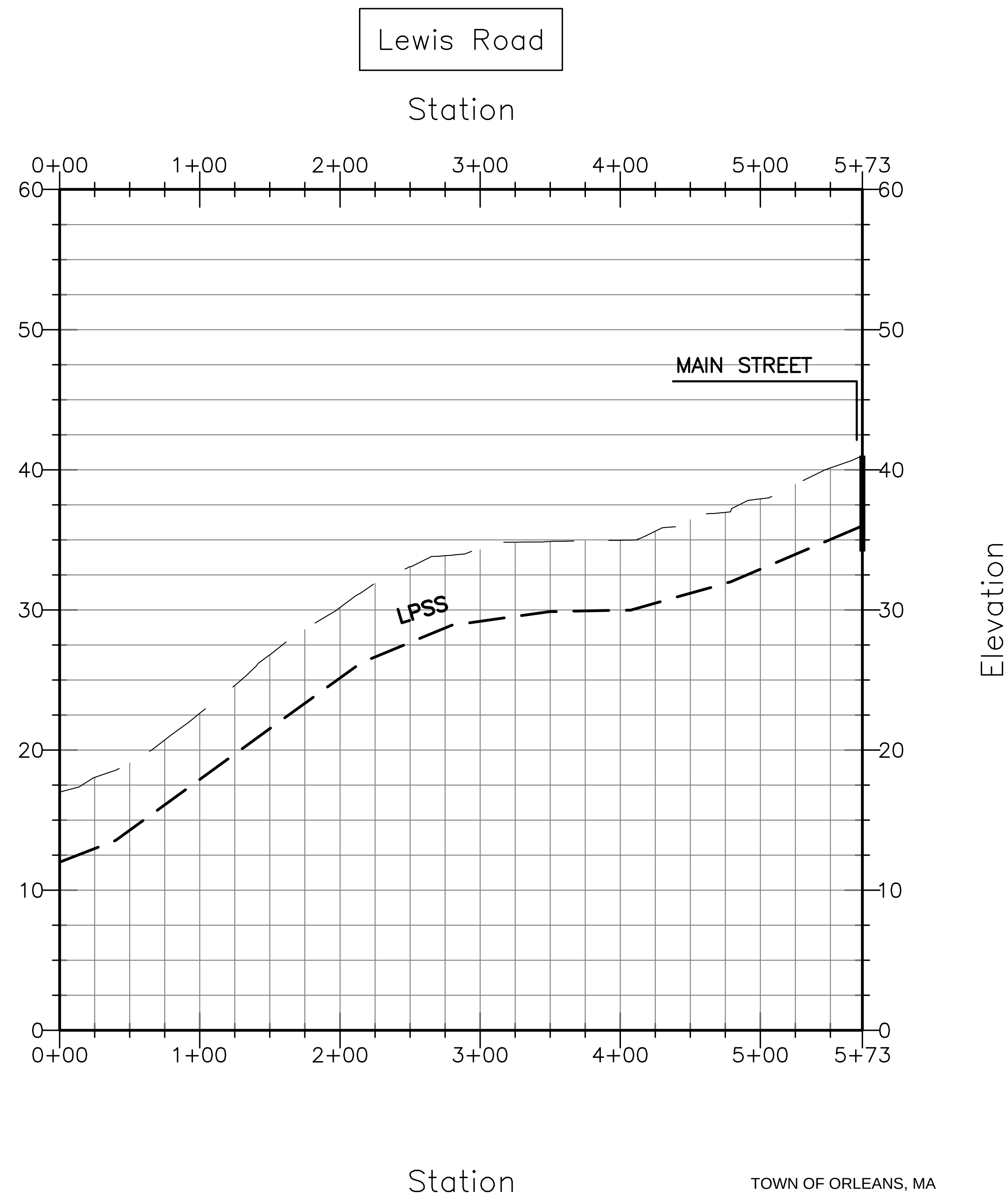

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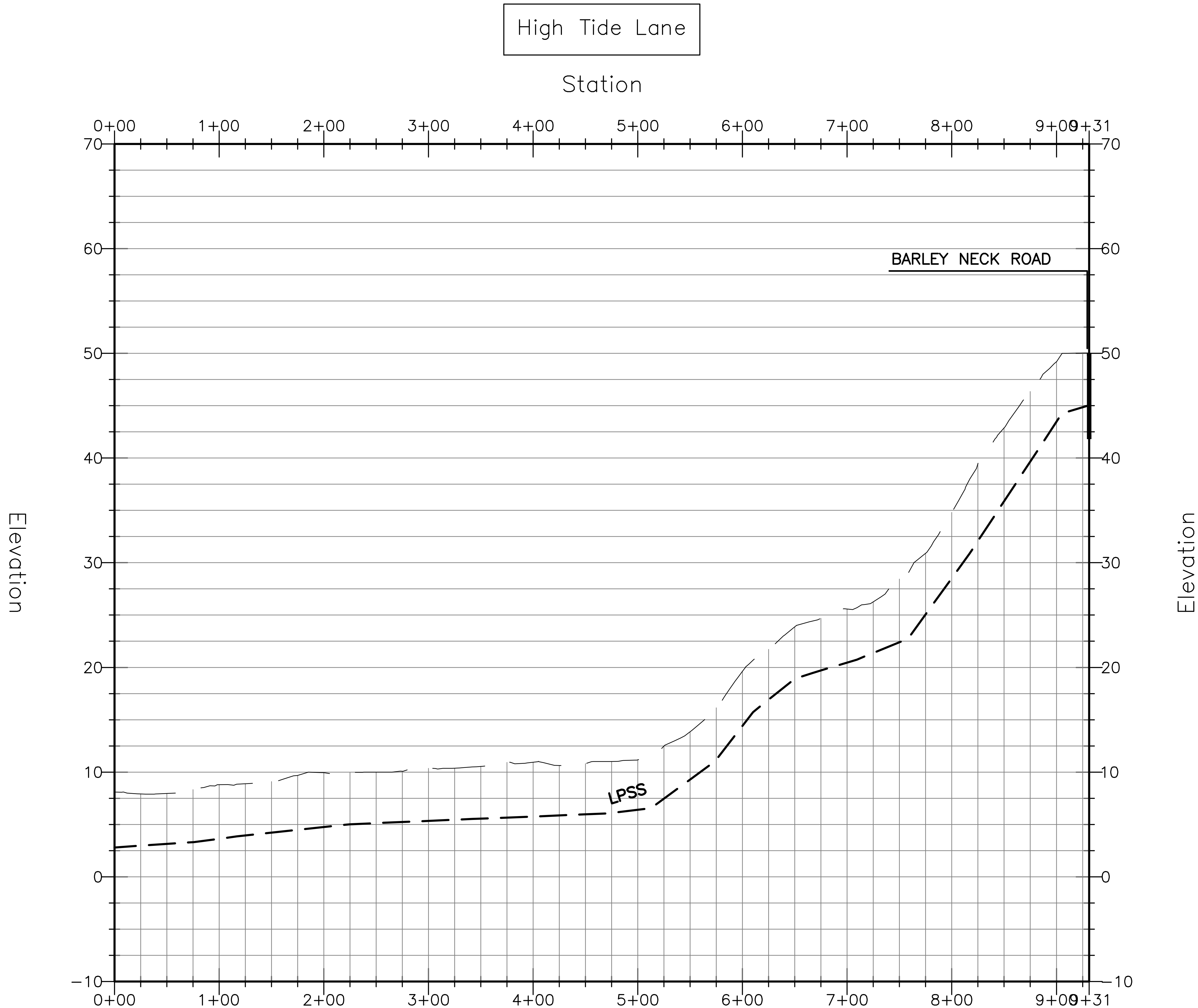

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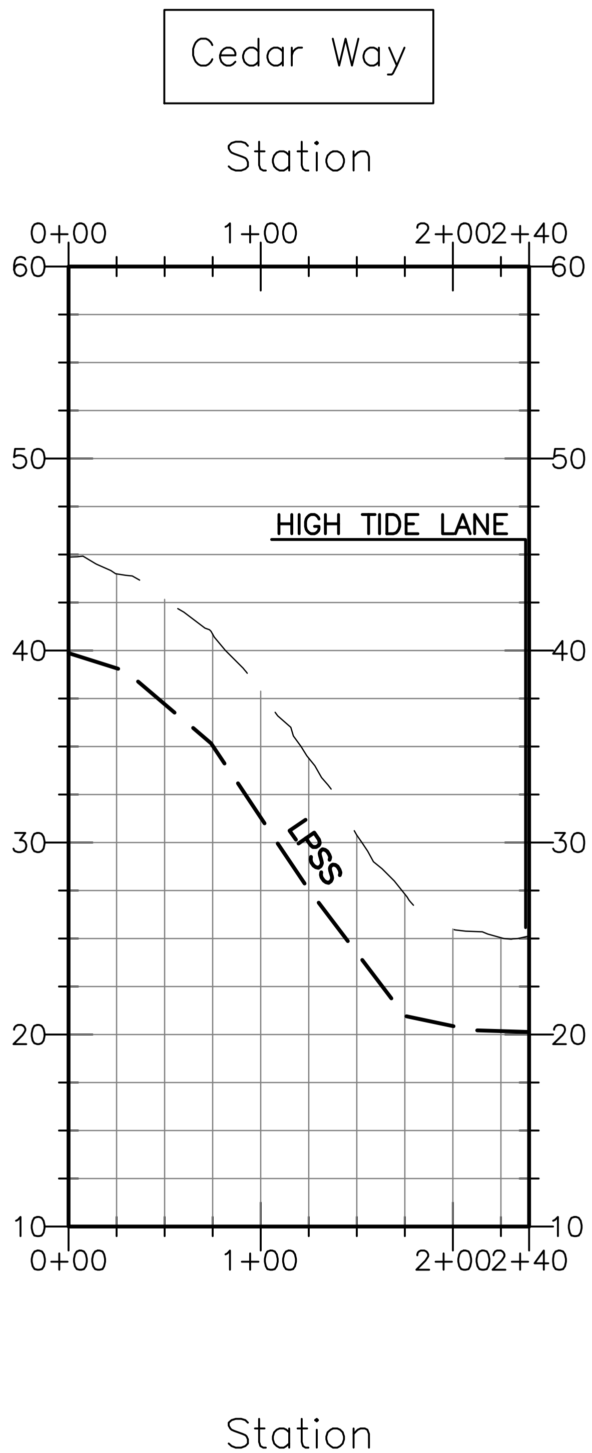

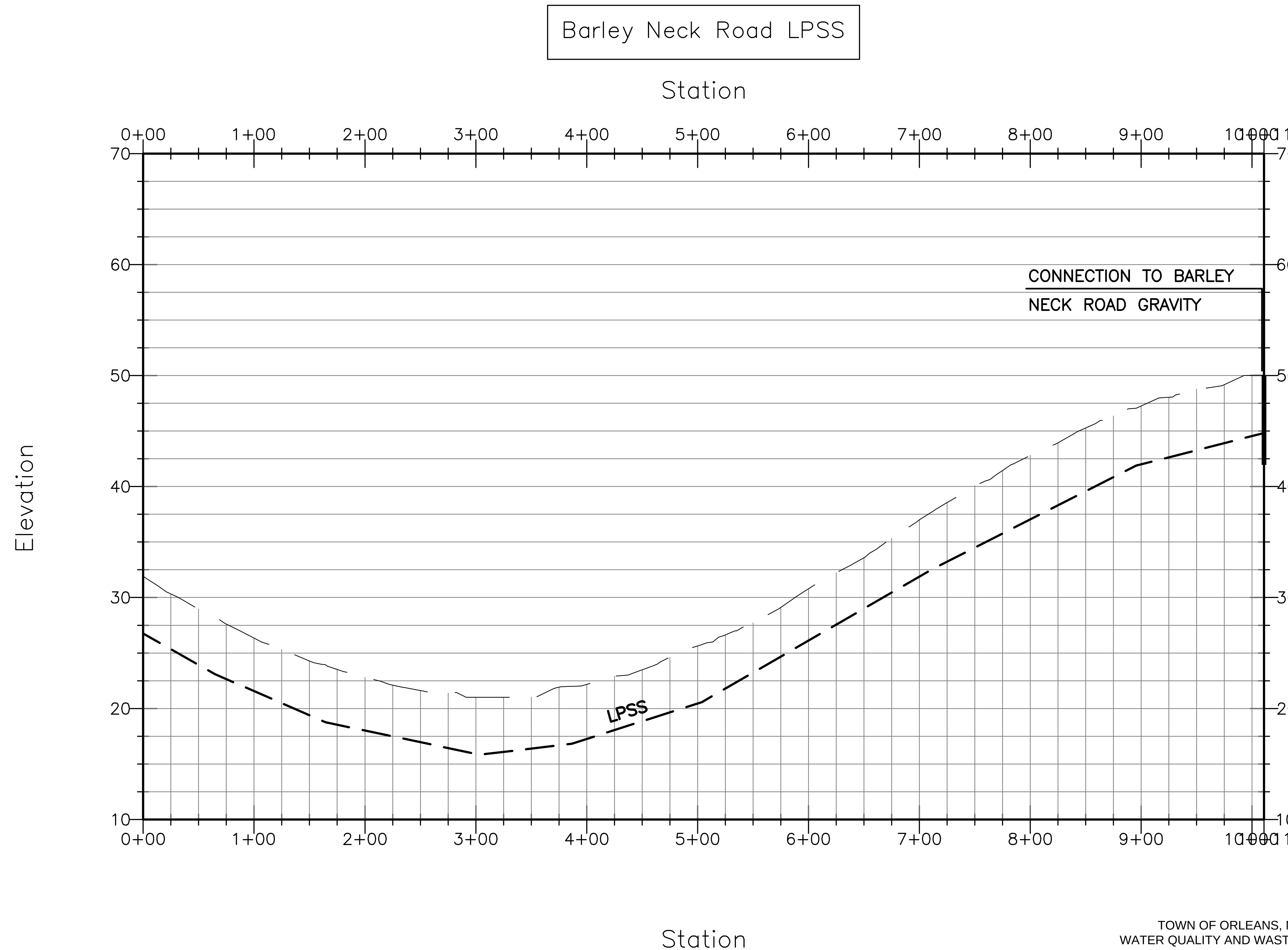

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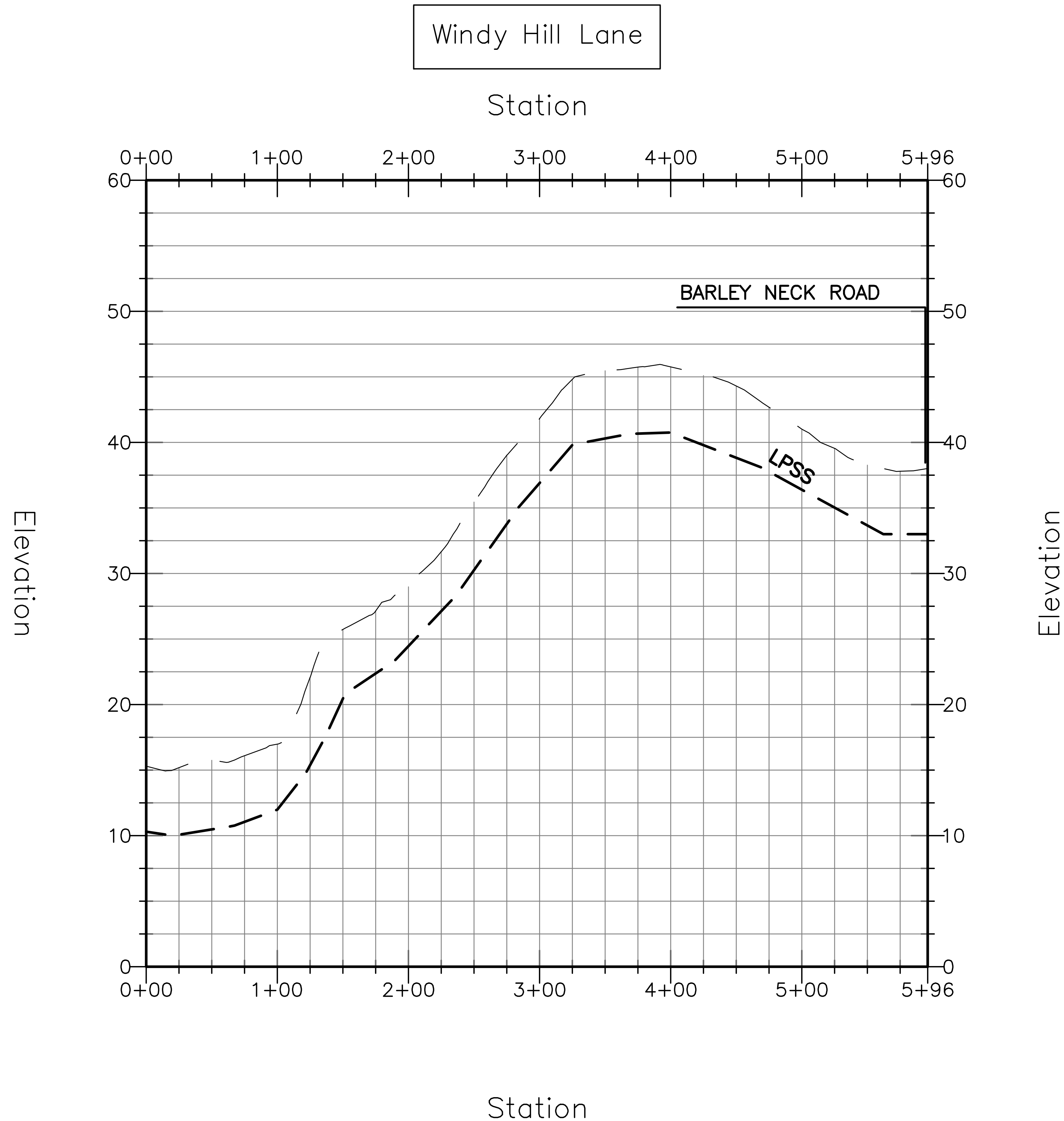

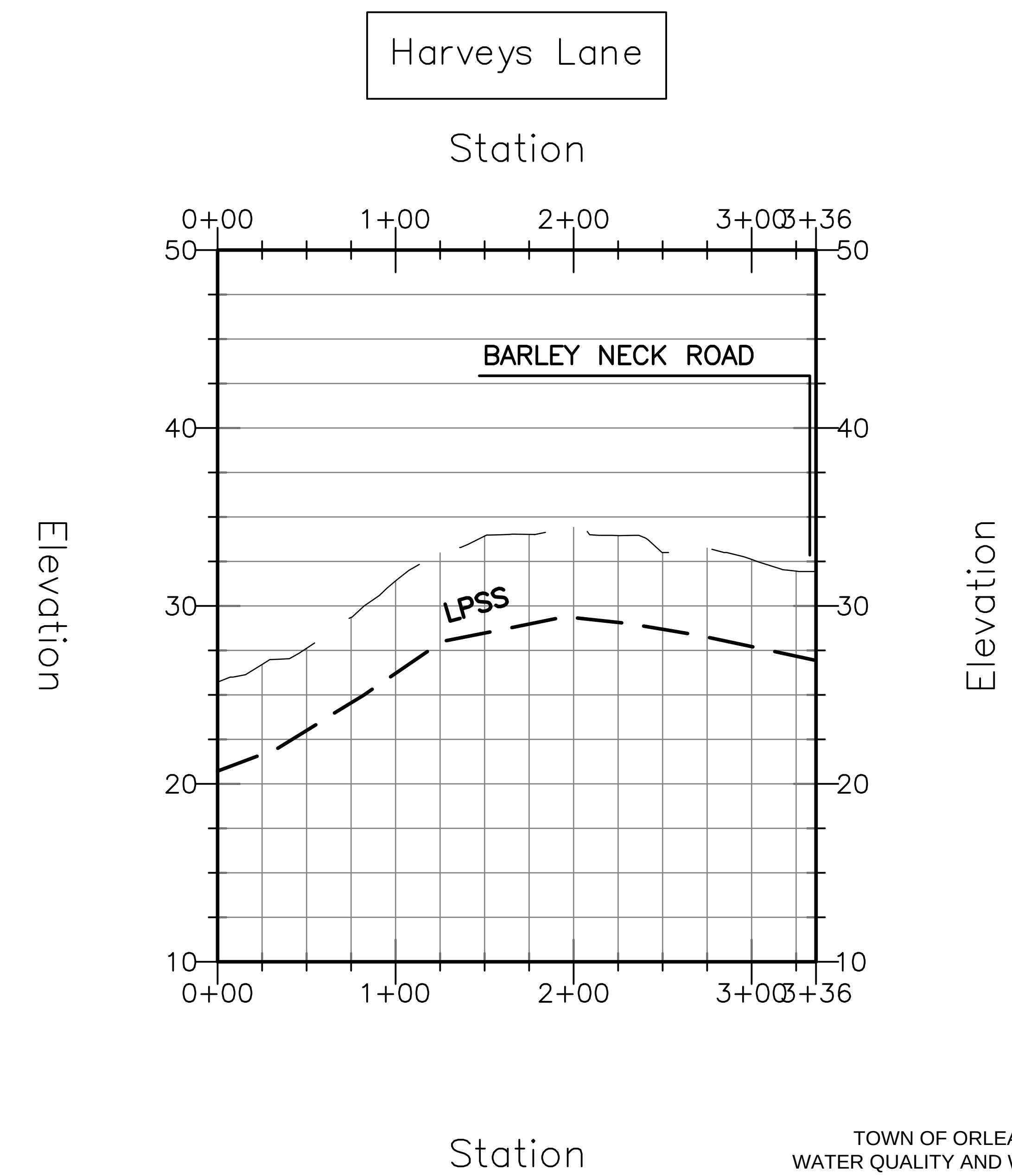

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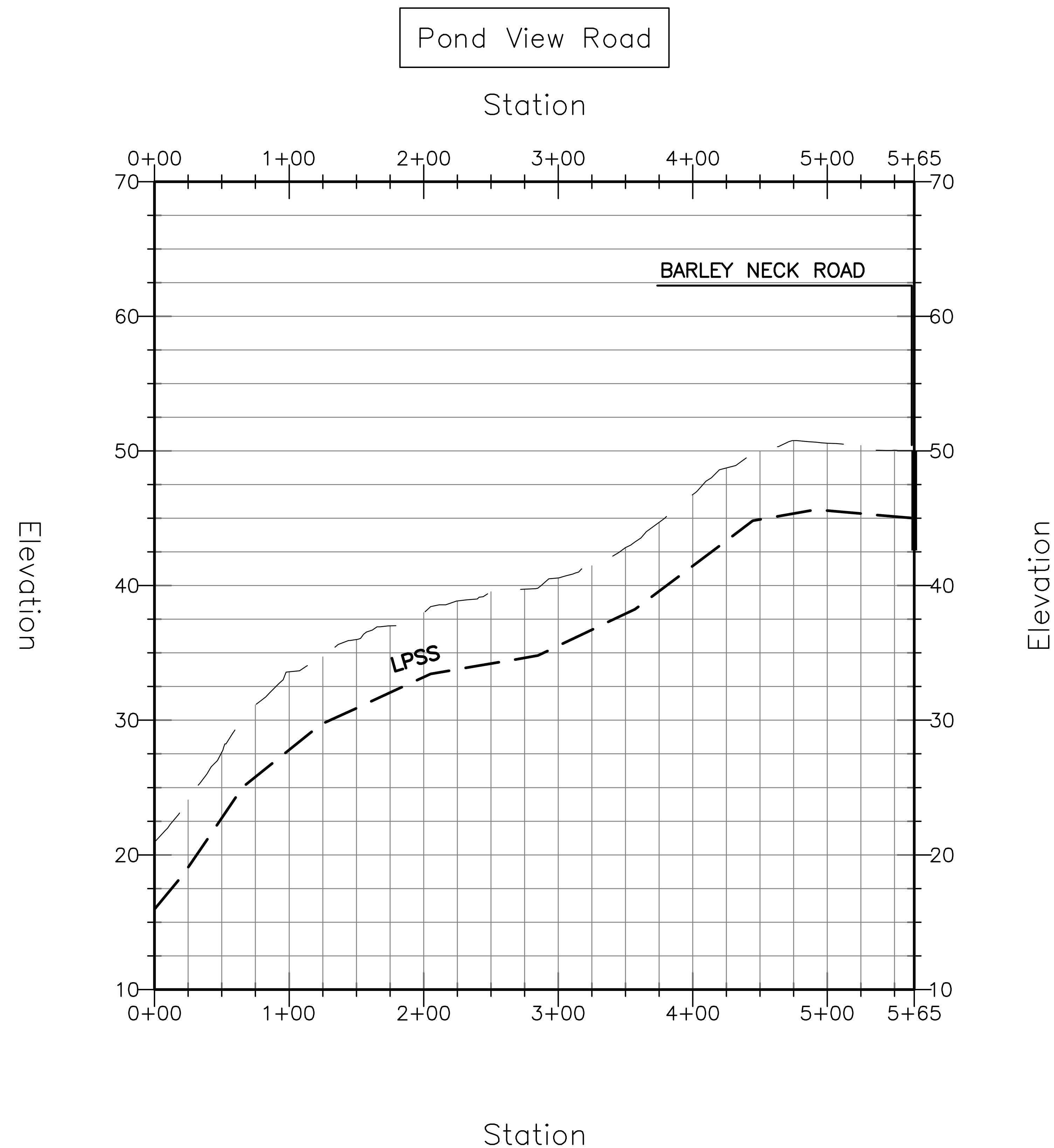

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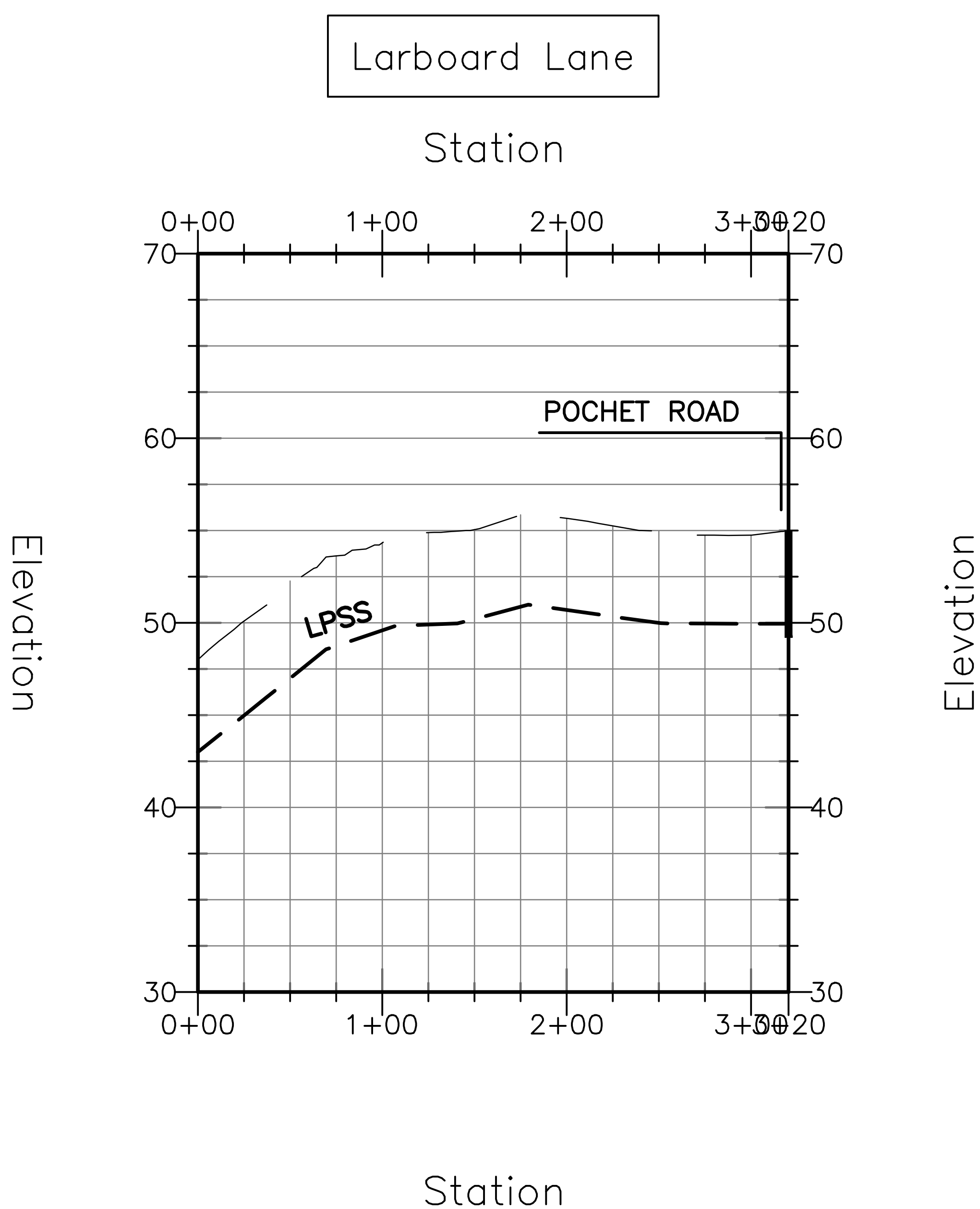

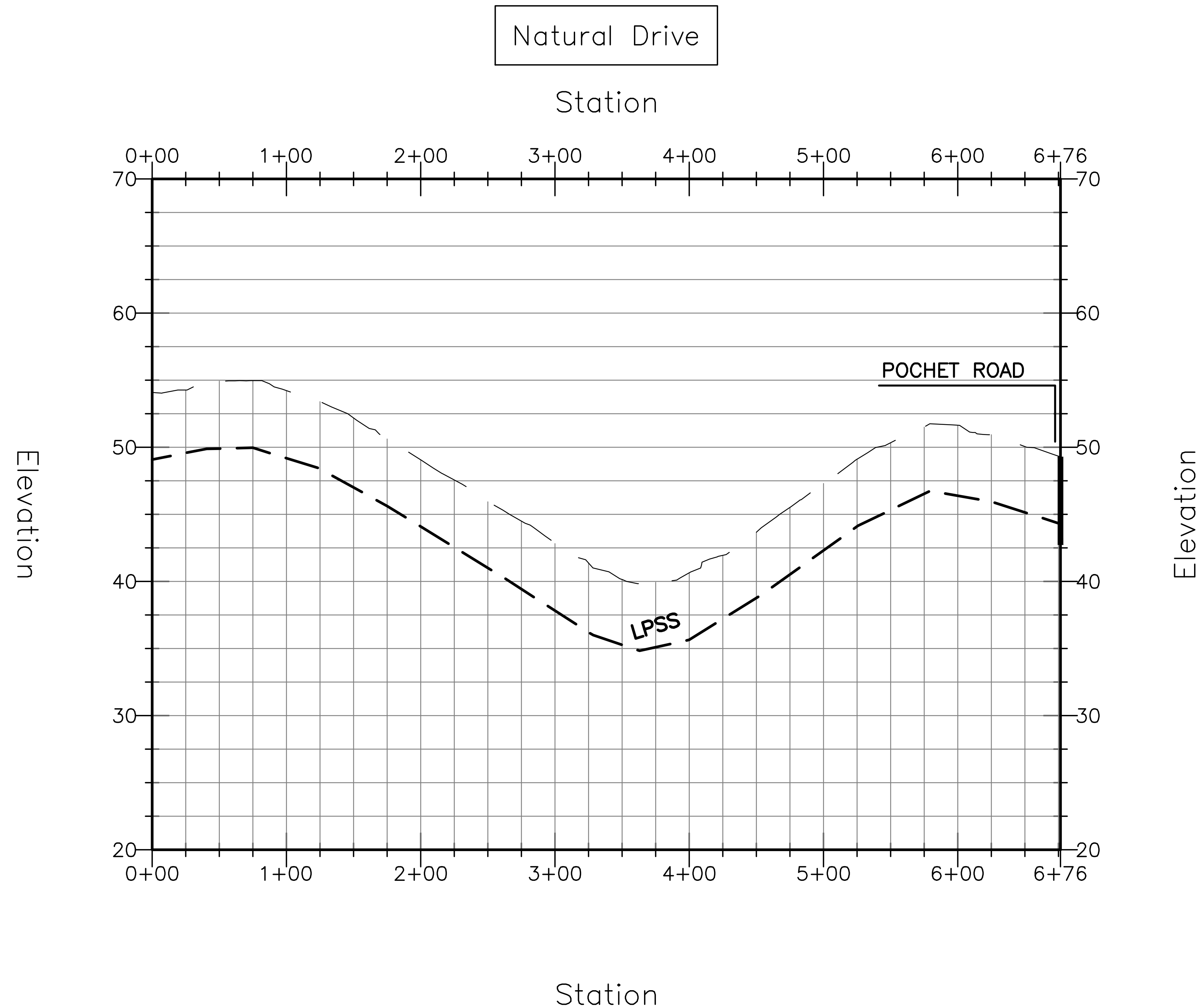

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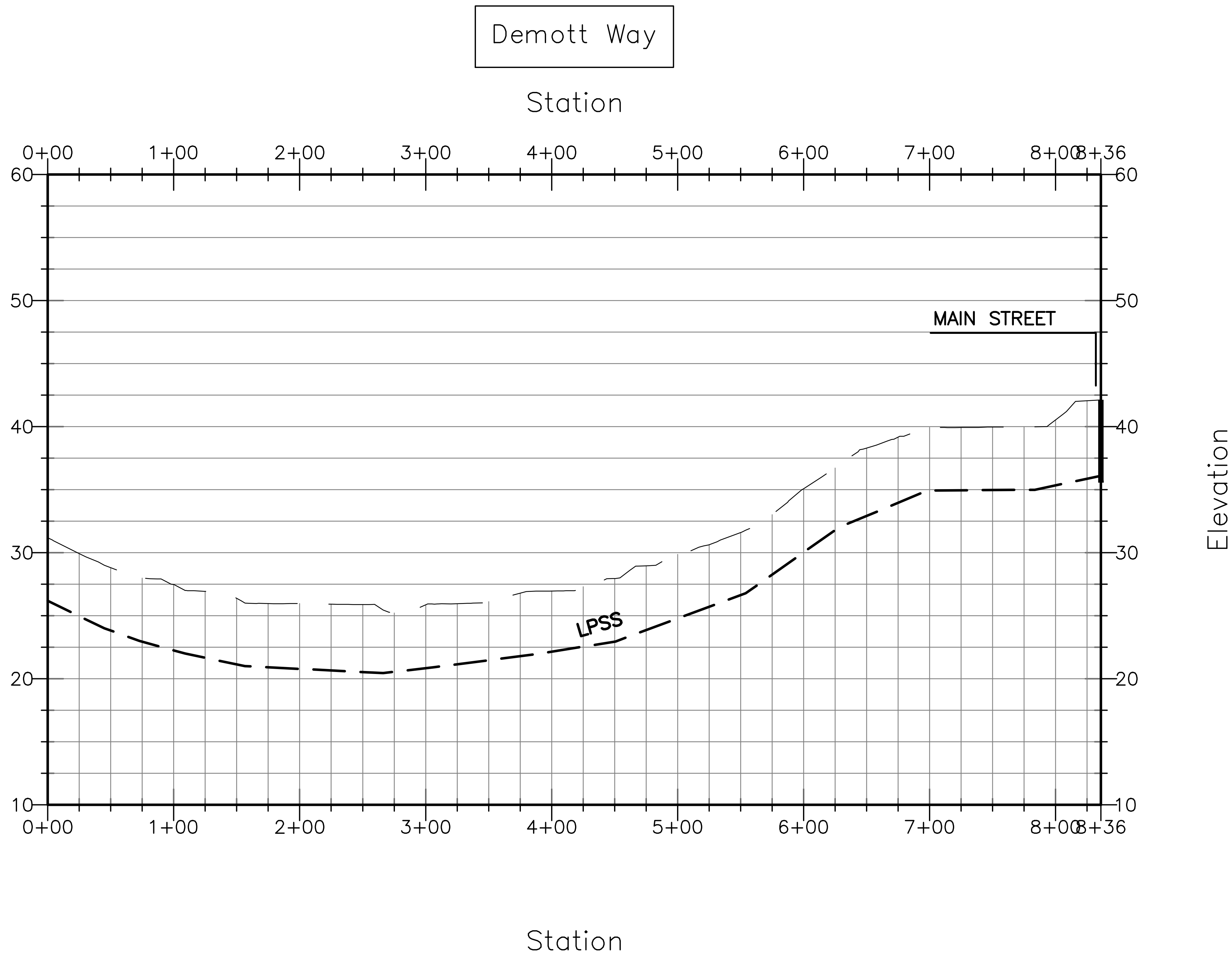

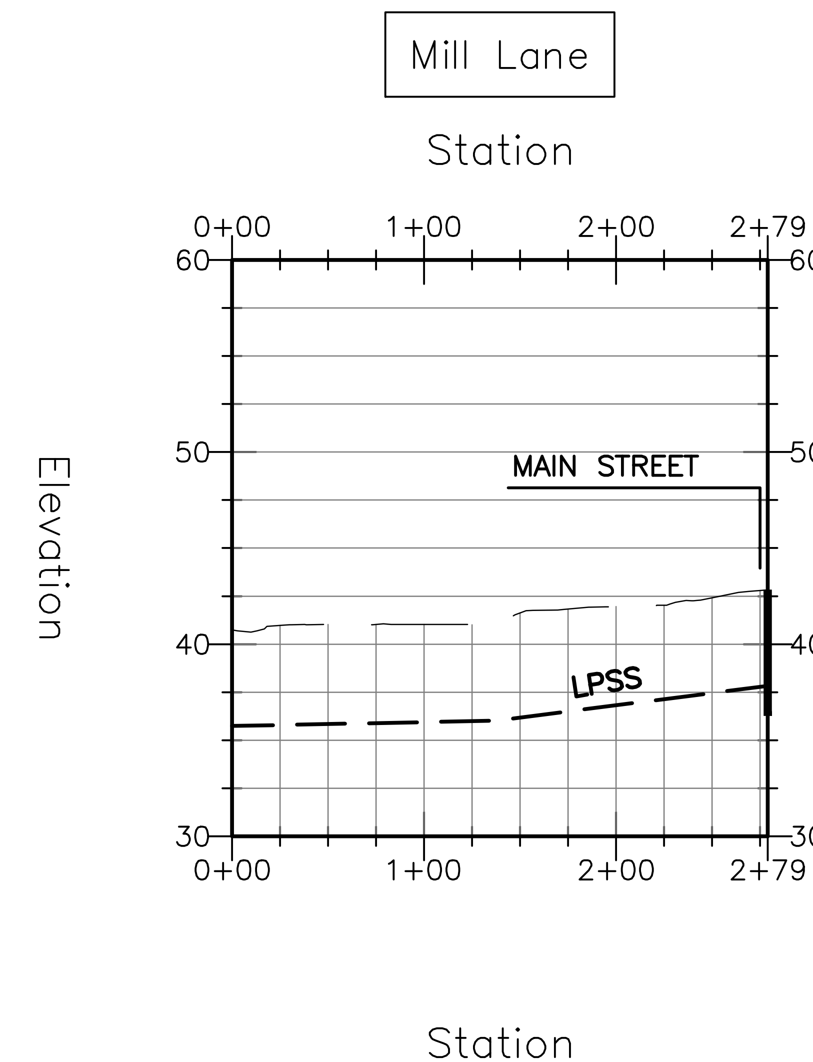

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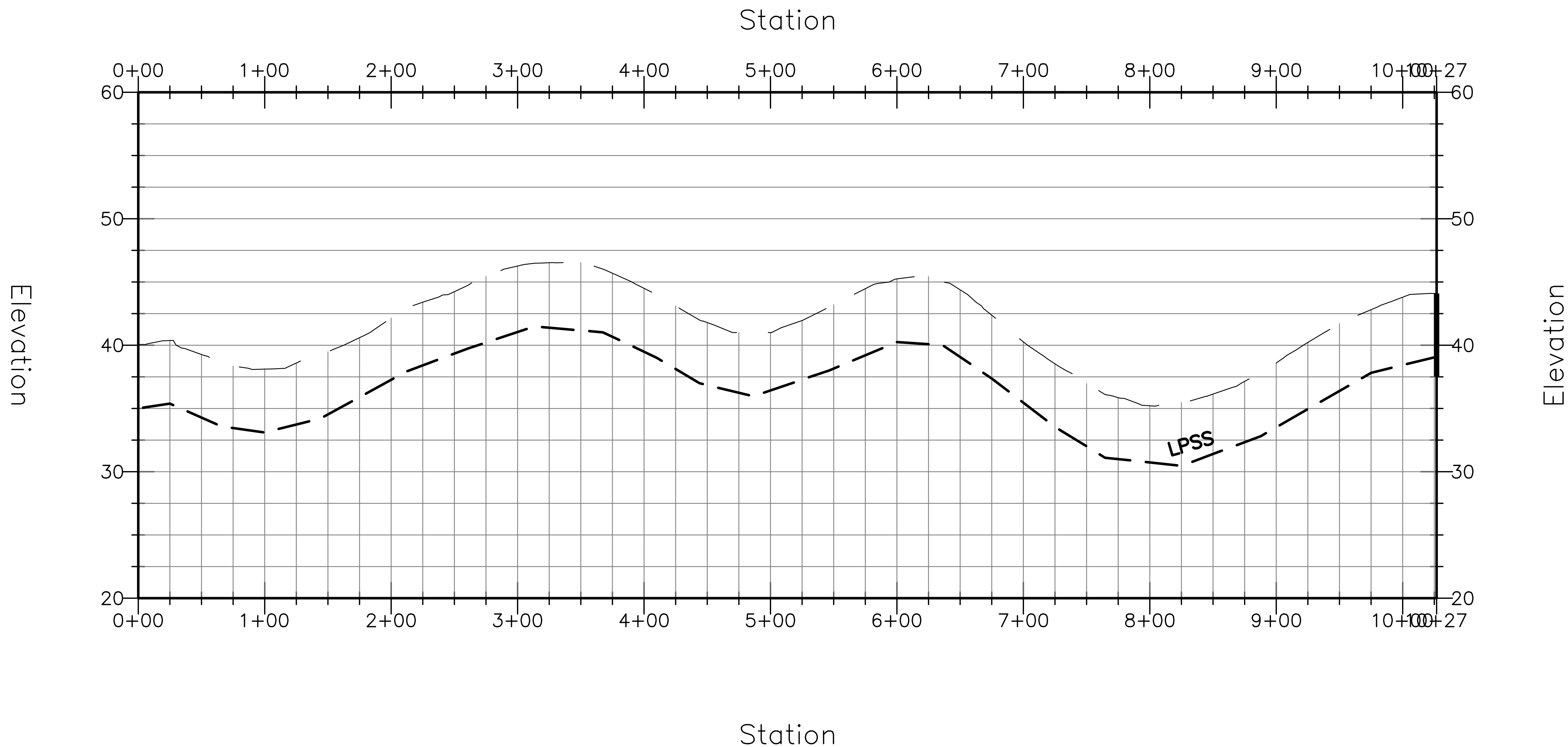
Lake Farm Lane



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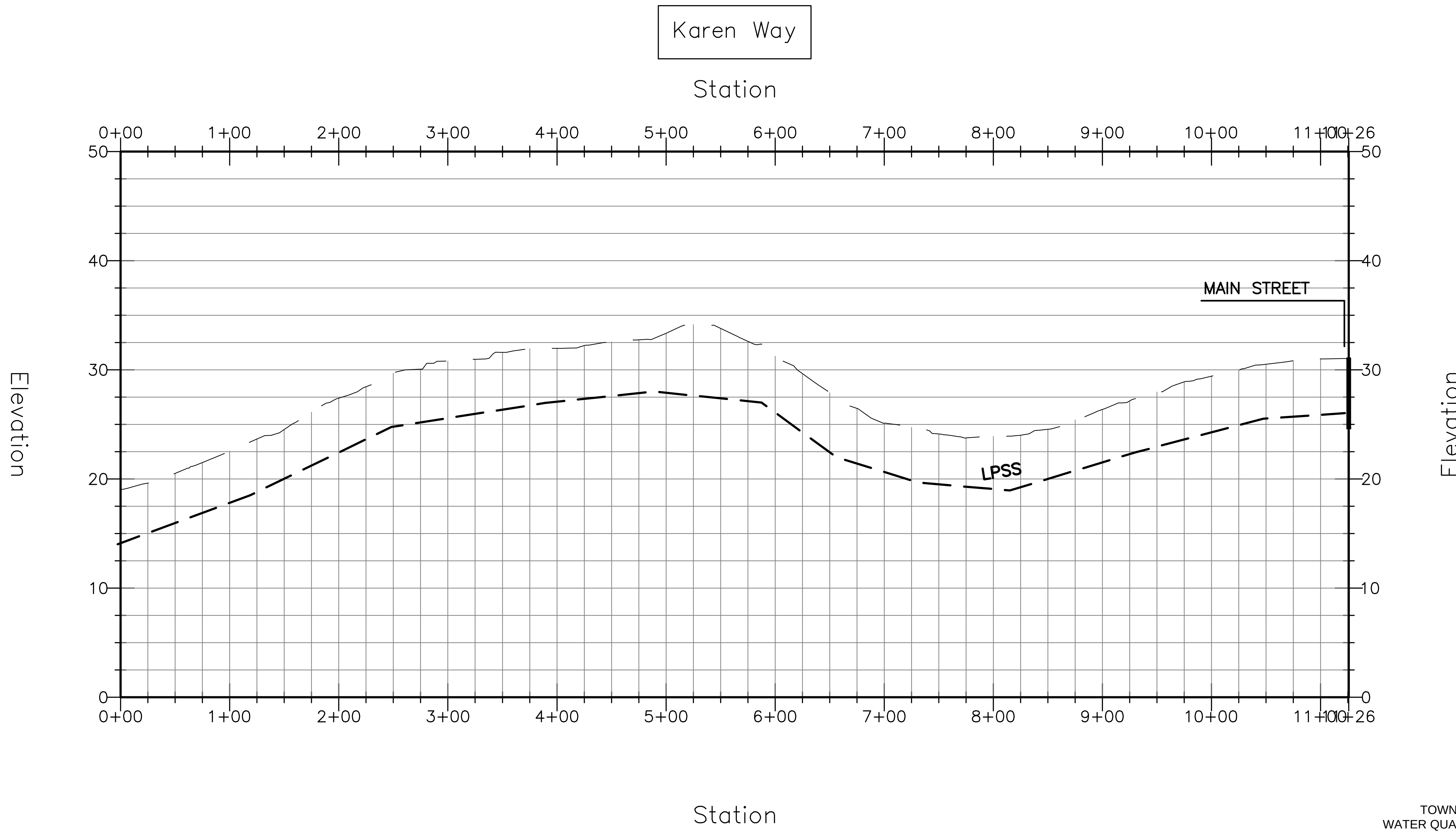

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