Jenness Beach Drainage Study
Rye, New Hampshire

DRAINAGE STUDY

December 10, 2021

Prepared for:
Town of Rye, NH
10 Central Road
Rye, NH 03870

Prepared by:
CMA Engineers, Inc.
35 Bow Street
Portsmouth, NH 03801

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December 10, 2021

Mr. Dennis McCarthy, Director of Public Works
Town of Rye
10 Central Road
Rye, NH 03870

Re: Jenness Beach Drainage Study, Town of Rye
CMA #1220

Dear Mr. McCarthy:

The purpose of this letter is to transmit our report dated December 2021 regarding the Jenness Beach Drainage Study for the Town of Rye. This transmittal letter presents an executive summary of our report.

The study area for this report consisted of the low-lying residential area bounded by Ocean Boulevard and Old Beach Road, including East Atlantic Avenue, Kenphil Avenue, and Jenness Avenue in the Jenness Beach neighborhood of Rye. This area has been subject to periodic flooding following significant rainfall events, after which several days of tidal cycles are required for floodwaters in the streets and swales to subside. The Town is planning on repaving the streets and wished to make whatever near term drainage improvements are needed prior to repaving.

CMA Engineers' services included field survey of key features, physical external inspection of the Town's stormwater pipes and catch basins in the project area with the assistance of Public Works Department staff, evaluation of the hydrology and hydraulics of the Town's stormwater system, inspection by drone photography of downstream drainage pathways, and the preparation of conceptual designs for needed drainage improvements.

The New Hampshire Department of Transportation (NHDOT) is planning the following two projects:

- Replace NHDOT's existing drain line on the west side of Ocean Boulevard, as well as the cross pipes under Ocean Boulevard that connect to the Town's drainage system in the project area;
- Remove an abandoned set of driveway culverts downstream of an active driveway (at 2125 Ocean Boulevard);
- Replace the active driveway culverts (2125 Ocean Boulevard) and lower inlet by six inches. The lowering of these culverts is highly advisable and will provide benefit to reduce the time required to evacuate flood waters from the project area following major rainstorms.

Our investigations on this project, revealed that the driveway culverts are not the only constraint to evacuating floodwaters from the project area. (We also used information from another project completed earlier in 2021 on the downstream tidal channel which CMA Engineers managed on behalf of NHDOT and NHDES). When Ocean Boulevard was reconstructed in the mid-1950's, a clear open channel

existed between the marshes at Rye Harbor and the Jenness Beach neighborhood, allowing salt water and ponded stormwater to flow freely to Rye Harbor at low tide. Since that time, the tidal channel has filled in with stands of phragmites and the channel has silted in, resulting in a significant constraint (like a dam) for water to flow out to the ocean at low tide. While the downstream tide range is typically about four feet between high and low tide, the tide range near Jenness Beach is only about two feet. It is our opinion that the absence of a clear drainage channel through the saltmarsh is also a contributor, in addition to the driveway culverts, to the slow drainage from the project area after significant rain events.

CMA Engineers considered the potential benefits of re-establishing the previously existing saltmarsh channel to improve drainage after rainstorms. However, we determined that the constriction also limits the elevation of peak tides in the Jenness Beach neighborhood. Eliminating the constriction would result in regular astronomic high tides rising into the neighborhood, resulting in substantially more frequent flooding in the Jenness Beach project area, from this "sunny day flooding" as well as storm surges. The roadside swales and drainage structures at Jenness Ave and East Atlantic Avenue would regularly fill at higher astronomic tides, and the roads would flood at the highest of tides on a regular basis. Future sea level rise would exacerbate those impacts. As a result, we do not recommend re-establishment of an open drainage channel through the downstream saltmarsh.

It is recommended that the Town replace at least one run of drain pipe in Jenness Avenue to resolve current permanent inundation of upstream pipes and catch basins. It has also been recommended that the Town might consider replacing the existing storm drains in East Atlantic and Kenphil Avenues with marginally larger diameter pipes, although this would result in limited improvement to existing flooding conditions.

We would note that the project area is underlain by significant peat layers. When the Town's sewers were constructed in the 1980's, pipes in adjacent Old Beach Road needed to be constructed on pilings. Subsurface settlement can be expected, particularly if additional loads are added above existing road elevations.

The roadways at Jenness, East Atlantic and Kenphil Avenues are very low, with the lowest pavement elevations at about elevation 6. These will be among the first public roads in the NH seacoast to be impacted by sea level rise and associated groundwater rise. We are not aware of a reasonably feasible engineering solution to lessen those flooding impacts over time.

We have appreciated the opportunity to assist the Town of Rye in this capacity. If you have any questions or comments, please don't hesitate to contact us.

Very truly yours,
CMA ENGINEERS, INC.

Nick Messina, EIT
Project Engineer

William Straub, PE
Principal

Introduction

The East Atlantic Avenue and Jenness Avenue neighborhood east of Route 1A (see Appendix A for project location) experiences severe flooding regularly, at least annually. Roadway flooding has been over a foot in depth and is sustained for what is considered a long period in an urban setting. Several residents have installed pumps in their basements in response to the flooding. Long-term residents have anecdotally stated that flooding has increased in frequency and severity in recent years.

The drainage systems from these neighborhoods flow under Route 1A (Ocean Boulevard) and into the drainage system maintained by the New Hampshire Department of Transportation (NHDOT). This system discharges into a channel west of Ocean Boulevard and then north into a saltmarsh. This saltmarsh is connected to the ocean through a meandering channel and is tidally influenced. The NHDOT Ocean Boulevard drainage system was installed in the 1950's.

The roadside channel on Ocean Boulevard is crossed by two separate driveway locations at the 2125 Ocean Boulevard property. The newest driveway was constructed in October 2008 with dual 24" HDPE (high density polyethylene) pipes. The older driveway was consequently abandoned, but dual 21" PVC (polyvinyl chloride) pipes remain.

Figure 1. Dual 21" PVC Culverts under abandoned driveway at 2125 Ocean Boulevard.

NHDOT has applied for and obtained a New Hampshire Department of Environmental Services (NHDES) Standard Dredge and Fill Wetlands Permit to remove the abandoned driveway and restore the channel and replace the active driveway with culverts of the same size but at lower elevations.

The purpose of this drainage study is to evaluate the impacts of this project to the East Atlantic/Jenness Ave neighborhood and to determine additional actions that are needed by the Town to mitigate flooding.

Data Collection

CMA Engineers obtained NHDOT's DES Standard Dredge and Fill Permit Application. The permit plans indicate the abandoned driveway and its dual 21" PVC culverts will be completely removed, and the ditch will be reshaped to match inlet and outlet ditch conditions. The plans also indicate the newer, southern driveway culverts will be replaced by dual 24" HDPE culverts with the inlets set 0.5' below the existing inlets. This will reduce the pipe slope from 2.5% to 0%. The permit indicates the project will increase hydrologic connectivity upstream and downstream of the driveway, reduce channel erosion, decrease flooding in the area, and improve aquatic organism passage.

James Verra & Associates, Inc. of Newington, NH was retained by CMA Engineers to provide surveying services. The survey provided elevations on drainage structure rims, driveway culvert inverts, and the pipe invert where the DOT drainage system discharges into the channel.

A site visit was conducted by CMA Engineers on September 2, 2021 to observe flooding. Flooding occurred following 2.35 inches of rain on the morning of September 2 (Precipitation was measured at the nearest available weather station, Pease International Airport). A storm event of 2.35" of precipitation over 12 hours is a storm with a return interval between one and two years for this area. Flooding was observed to be over a foot on East Atlantic Ave and Jenness Ave, and flooding had not dissipated within twelve hours of precipitation ending. It was noted that Jenness Ave experienced more severe flooding than East Atlantic Ave. See Figure 2 below and Appendix B for project photographs.

Figure 2. Flooding observed at Jenness Avenue during site visit on September 2, 2021.

A site visit was also conducted by CMA Engineers on November 2, 2021 to perform pipe inspections. Rye Public Works personnel pumped water from the drainage structures such that pipe inverts were visible. Pipes were not videoed for complete inspection. Pipe invert measurements were also recorded. Information from the survey and inspections were used to produce a drainage system map, provided in Appendix D. All drainage structures and pipes referenced going forward will refer to the labeling convention from this map.

Evaluations

Jenness and Eastern Atlantic Ave Drainage Analysis

The pipe crossing Jenness Ave (Pipe-402) was in good condition and appeared newer than other pipes inspected, however the drainage system layout restrains flow due to a fault in invert elevations. Pipe-403 has a lower invert than Pipe-402 in CB-402, even though the direction of flow is from Pipe-403 to Pipe-402. The water surface elevation (WSEL) in CB-402 was observed to be above

the rim elevation during pumping, indicating flow out of the structure fails to overcome the jump in the succeeding catch basin and that CB-402 never drains freely.

The pipes in the East Atlantic Avenue neighborhood are in serviceable condition. The network comprises almost entirely 8" CMP (corrugated metal pipe) pipes. Slopes vary from ~0% -0.25%. The standard minimum slope of drainage pipes is 0.5%, however these pipes are constrained by the road's low elevation and relatively flat grade. CB-306 remained completely full during pumping, indicating Pipe-306 is either obstructed or has a negative slope. It was also noted Pipe-305 had warped into an ovular shape due to crushing (see Figure 3 below).

Figure 3. Pipe-305 at Kenphil Avenue observed on November 2, 2021.

The Old Beach Road elevation is higher than either of Jenness Ave or East Atlantic Ave. Consequently, Old Beach Road did not experience flooding as the rest of the neighborhood

experienced during the September 2 site visit. This includes the Old Beach Road/Ocean Boulevard intersection. It was noted that the catch basin southeast southof the intersection (CB-501) was shrouded in dense vegetation and is likely operating at less-than-optimal capacity.

DOT Drainage Analysis

The following is prefaced with the understanding that DOT intends on replacing the Route 1A drainage system in-kind in 2022.

Two pipes in the NHDOT drainage system were observed to have rusted and collapsed: Pipe-401 and Pipe-103. The flow in Pipe-103 was not impeded as the debris from collapse appears to have washed away (see Figure 4b). Soil and material from Pipe-401's collapse was observed to be impeding flow through the pipe (see Figure 4a). This obstruction likely accounts for Jenness Ave's more severe flooding than East Atlantic Ave.

The NHDOT drainage network discharges into the channel upstream of the southern driveway at elevation 2.8'. The existing invert of the driveway culverts is 4.5'. The outlet pipe is 18", with the resulting elevation of the top of the NHDOT pipe at 4.3'. Therefore, this outlet pipe is continuously submerged, and water does not freely discharge. This pipe has collapsed where it terminates into the channel, rendering it in poor condition (see Figure 4c).

a.

b.

c.

Figure 4. Photographs of failed pipes on NHDOT drainage network from site visit on November 2, 2021.

CMA Engineers agrees with NHDOT's assertion that their project will improve hydrologic/hydraulic connectivity. Lowering the remaining driveway culvert inverts 0.5' will likely decrease flooding upstream and decrease the time required for flooding to subside.

It is understood that the system would be replaced in-kind, and that the outlet pipe discharging into the roadside channel will remain at elevation 2.8'. With the top of this pipe at an elevation of 4.3' and the proposed driveway culvert at 4.0', water will be able to discharge from this pipe more freely, though not entirely. The proposed driveway culvert has a slope of 0%, which will increase aquatic organism passage and restore natural hydrologic flow conditions to the channel by allowing tidal influences to pass through the flat culvert.

Removing the abandoned driveway culverts will also be beneficial. The old driveway pipes' inlet inverts are higher than the new driveway pipes' outlet inverts, indicating flow is restricted by this increase in elevation as it flows out. Replacing dual 21" culverts with the natural ~10' wide, 2' deep channel will increase hydraulic capacity.

Salt Marsh Drainage Analysis

The roadside channel on the west side of Route 1A discharges into a tidal salt marsh to the north. The channel flows into open water before flowing into a dense phragmites stand. Phragmites are an invasive species found in freshwater and saltwater wetlands, seen in Figure 5. The water is visually obscured in the stand of phragmites, and there is no discernible channel. The channel is redefined after the dense vegetation, and water flows freely towards Locke Road. Appendix C shows a historical aerial photo of the salt marsh, highlighting the absence of dense vegetation and the presence of a clear open channel prior to the construction of Route 1A in the 1950's.

Figure 5. Aerial photo looking east over salt marsh taken with drone on November 3, 2021.

A prior CMA Engineers' project provided information on tidal flows through this salt marsh. The project modeled freshwater and saltwater influences on a Route 1A culvert north of the project site. The hydrologic and hydraulic modeling and field data collection were performed by Streamworks, PLLC of Madbury NH, and DES, NHDOT, and The Nature Conservancy also contributed to this project. Transducers were installed at the Locke Road culvert and the culverts passing under Route 1A, where the roadside channel discharges into the salt marsh (see Figure 6 below). The transducers measured continuous WSELs from September 25 to November 27, 2020. This data set gives insight into the tidal influences experienced at both locations, as well as freshwater storms' effect on WSELs in the marsh.

Figure 6. Location of transducers from nearby project, prepared by Streamworks, PLLC. The referenced project was located at R2 and R3.

The R4 transducer recorded maximum and minimum WSEL elevations of 6.0' and 1.3', respectively, yielding a range of 4.7' The R5 Transducer recorded a maximum and minimum WSEL of 5.4' and 3.2', respectively, yielding a tidal range of 2.2'. The data indicates R5 does not experience the full tidal range that downstream R4 does, and the water upstream of the phragmite stand does not fully drain out at low tide.

The WSEL at R5 due to tidal influences directly impacts the Route 1A roadside channel, DOT drainage system, and Jenness and East Atlantic Ave's drainage systems' ability to drain freshwater storm events. Both the existing and proposed driveway culverts have an elevation of 4.0' on the downstream side. The water is impeded from freely flowing out of the channel when freshwater flows from the drainage systems reach this driveway pipe during high tide (WSEL ~5.4'). It may take several tidal cycles for the freshwater from this system to drain out due to the location at R5 not experiencing full tidal ranges because of the phragmite stand impeding flow draining out towards the ocean.

Future Drainage Analysis

Coastal environments are predicted to experience sea level rise, groundwater rise, increases in storm surge, and increases in both storm intensity and frequency over the coming years and decades. The previously mentioned nearby project resulted in modeling forecasts from these phenomena that are relevant to this project. As described below, increasing sea levels will significantly affect stormwater discharges from the project area.

NHDES sea level rise projections for Rye predict an increase of 0.7-1.1' by 2030, 1.3-2.3' by 2050, and 2.9-6.2' by 2100. Information from the US Army Corps of Engineers' North Atlantic Coast Comprehensive Study (NACCS) Report present day extreme tidal elevations (assuming no freshwater influences) of 6.23' for the 2-year event, 7.28' for the 10-year event, and 8.23' for the 100-year event. These extreme tidal elevations will increase as sea level rises. Increases in the WSEL where the Route 1A roadside channel terminates into the salt marsh will further impede freshwater discharges from the NHDOT and Rye drainage systems and increase flooding in the subject neighborhood.

Increases in sea level rise will cause increases in groundwater level elevations. Rising groundwater will increase overland flooding due to decreases in the absorptive capacity of soils and increase road failure instances when groundwater levels rise into the roadway subbase materials and pavements.

Present day FEMA flood maps indicate the entire project area is sited in the 100-year floodplain, with a base flood elevation of 8.0' from freshwater flows. This WSEL elevation is several feet above the existing East Atlantic, Jenness, and Kenphil Ave roadway elevations, which are at approximately elevation 6.

The University of New Hampshire's New Hampshire Coastal Flood Risk Summary was used in the previous modeling study as a source for predictions in precipitation increases. The study used a 15% increase in precipitation depths by 2100. Increases in overland precipitation will contribute to increases in flooding in the project neighborhood due to increases in storm frequency and increases in storm magnitudes at a given return interval.

Freshwater flows will increase, and the drainage potential for discharge into the tidal marsh system will decrease accordingly. Improvements to the stormwater piping system in the project area will improve performance, but those improvements will decrease over time and likely be reversed due to sea level rise and increased severity of precipitation events. The slow draining of ponded stormwater in the Jenness and Eastern Atlantic Ave area is partly due to the existing driveway culverts, and also partly due to the absence of a clear drainage channel into the saltmarsh downstream due to the phragmite growths.

Recommendations

Jenness and Eastern Atlantic Ave Drainage Improvements

CMA Engineers recommends that the Jenness Ave drainage system be reconstructed following NHDOT's drainage improvements. The pipes upstream of Pipe-103 should be reconstructed such that a positive slope is maintained across both pipes.

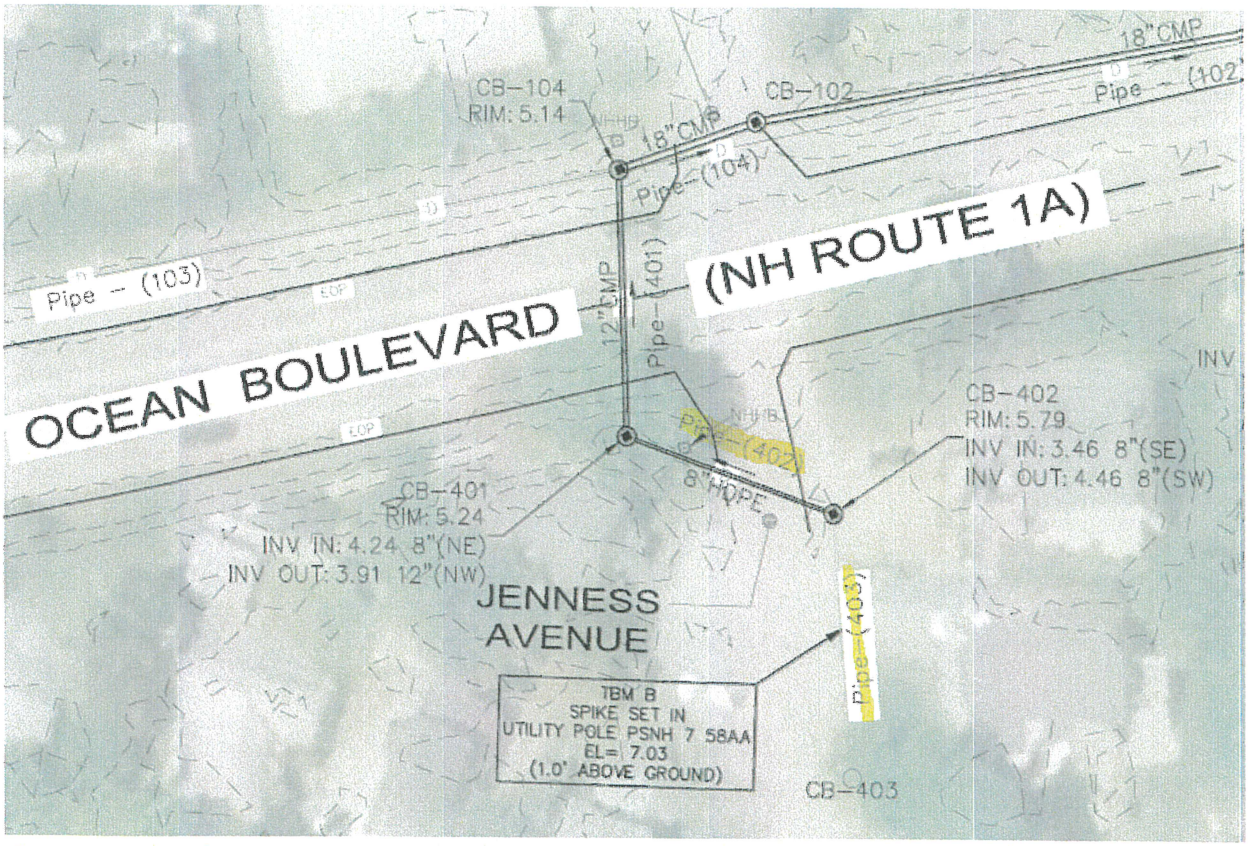


Figure 7. Overview of pipes recommended to be replaced (highlighted; see Appendix D for complete Drainage System Map).

Improvements to the Eastern Atlantic Ave drainage network are limited by the site's flat grade, and existing pipes are observed to be in serviceable shape. The system could see marginal improvements in replacing the system of 8" CMP pipes with 12" HDPE pipes. The system would still be constrained by the DOT drainage system outlet conditions. Pipe-306 on Kenphil Ave should be investigated for an obstruction in the pipe or be reconstructed if the pipe has a negative slope.

It is recommended that routine maintenance be performed for the catch basin southeast of the Old Beach Road/Ocean Boulevard intersection and be cleared of vegetation to allow for greater inlet capacity into the system.

CMA Engineers notes that the project area is underlain by significant peat layers. When the Town's sewers were constructed in the 1980's, pipes in adjacent Old Beach Road needed to be constructed

on pilings. Subsurface settlement can be expected, particularly if additional loads are added above existing road elevations.

NHDOT Drainage Improvements

It is understood the DOT drainage network will be replaced in 2022, and this is the bare minimum improvement that should be done to improve flooding in the project site. The following pipes are anticipated to be replaced by NHDOT:

- Pipe – (501)
- Pipe – (103)
- Pipe – (401)
- Pipe – (104)
- Pipe – (102)
- Pipe – (201)
- Pipe – (101)
- Dual 24" HDPE culverts at 2125 Ocean Boulevard
- Dual 21" PVC culverts at 2125 Ocean Boulevard (to be removed)

Replacing the rusted and collapsed pipe crossing from Jenness Ave under Route 1A with a new pipe in-kind will immediately improve the flow coming out of the neighborhood.

Lowering the remaining driveway culverts inlet inverts will increase the flow discharged from the system's outlet pipe that terminates in the channel upstream of the driveway. Removing the abandoned driveway culverts will remove a hydraulic constraint and increase the channel's capacity.

Salt Marsh Drainage Improvements

CMA Engineers evaluated the feasibility of further decreasing neighborhood flooding by making improvements to the salt marsh channel. Reestablishment of the channel from the driveway culvert just upstream of the Locke Road culvert to the Route 1A roadside channel would allow water levels to decrease at low tides. The transducer data graph, Figure 8, indicates that while the tide goes out to low levels at sites R1 through R4 at each low tide, the low tide level at R5, adjacent to Ocean Boulevard just north of Atlantic Avenue, does not decrease below about Elevation 4 at low tide on the days graphed. If the historic channel were reestablished at elevation 2 or 3, flood waters would evacuate better at each low tide, and the duration of flooding after freshwater storms would decrease.

Channel reestablishment would require removal of the invasive phragmite species and channel regrading. Removal of the dense vegetation would eliminate water impounding experienced under existing conditions. With reestablishment of the historical marsh channel, NHDOT might also consider lowering the remaining driveway culvert and balance of the roadside swale to ~3.0' if this improvement project were pursued.

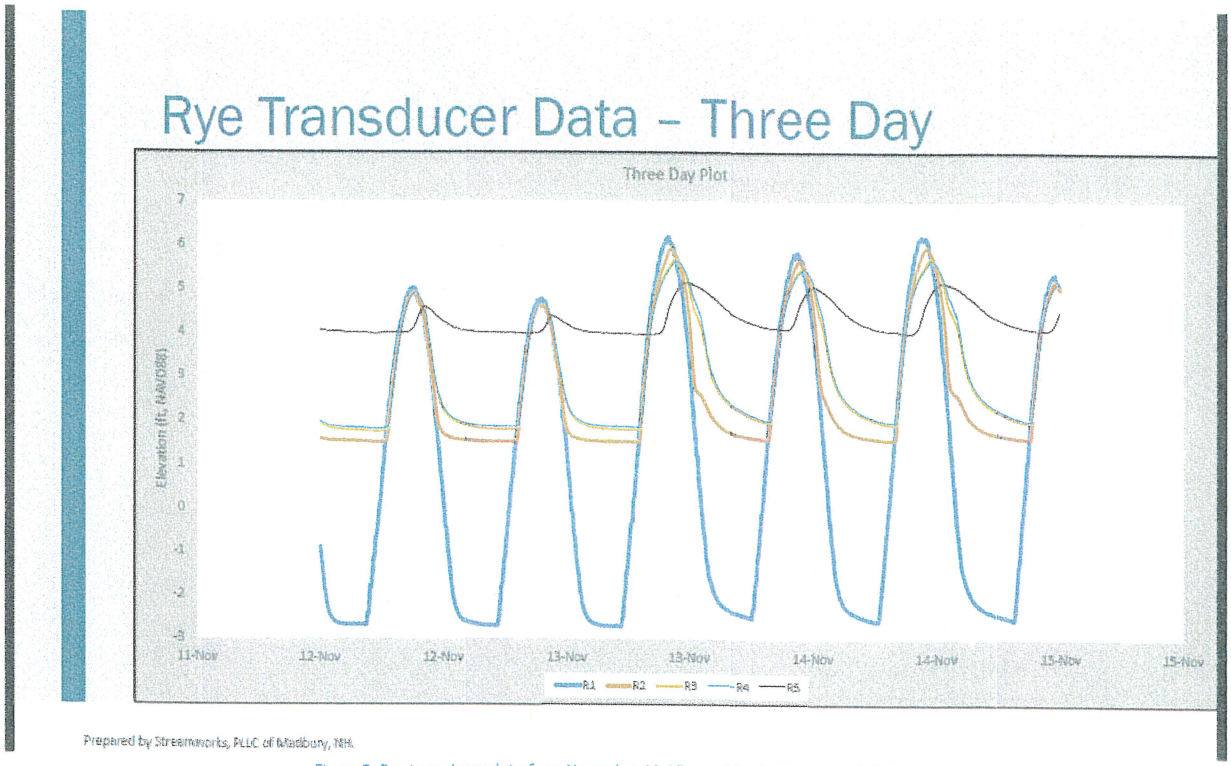


Figure 8. Rye transducer data from November 12-15, provided by Streamworks PLLC

However, making the saltmarsh drainage improvements described above would increase flooding into the neighborhood from astronomical high tides and ocean storm surges. Referring again to Figure 8, note that there is a significant difference in the high tide elevation between R5 and R4. The marsh channel improvements described above would result in both high and low tides at R4 and R5 at essentially equivalent levels, and resultant water surface levels at Jenness and East Atlantic Avenues would be slightly higher. CMA Engineers' detailed review of the transducer dataset indicated that, under current sea level conditions, for the period between September 25 and November 29, 2020, higher tide levels from the channel improvements would result in flooding of the lowest rim elevations in the neighborhood at 16 tides on 13 different dates to depths of 1 to 10 inches, for periods of time each high tide from 1 to 4 hours. Since current sea level rise rates are roughly 1 inch every 3 years, the frequency, depth, and time of these "sunny day" road flooding events would increase over time. Under current conditions none of the tides during that period of record would have flooded Jenness and East Atlantic Avenue. Making saltmarsh drainage improvements to improve the outflow of ponded stormwater after significant rain events would result in more frequent and deeper flooding in the project area from the other direction – from astronomical high tides and storm surges.

Improving downstream channel conditions to improve the flow of floodwaters out to the ocean at low tide would exacerbate storm surge and sunny day flooding in the neighborhood and is therefore not recommended. As a result, slow drainage of ponded stormwater after significant rain events is likely to continue, although at a lesser level, after the NHDOT improvements are completed.

Future Drainage Improvements

A previous modeling study near this project location indicates the East Atlantic, Jenness, and Kenphil Ave neighborhood will experience increases in flooding, likely regardless of the implementation of drainage improvements. Increases in precipitation intensities, and thus peak runoff flow rates, will increase the frequency and magnitude of flooding events.

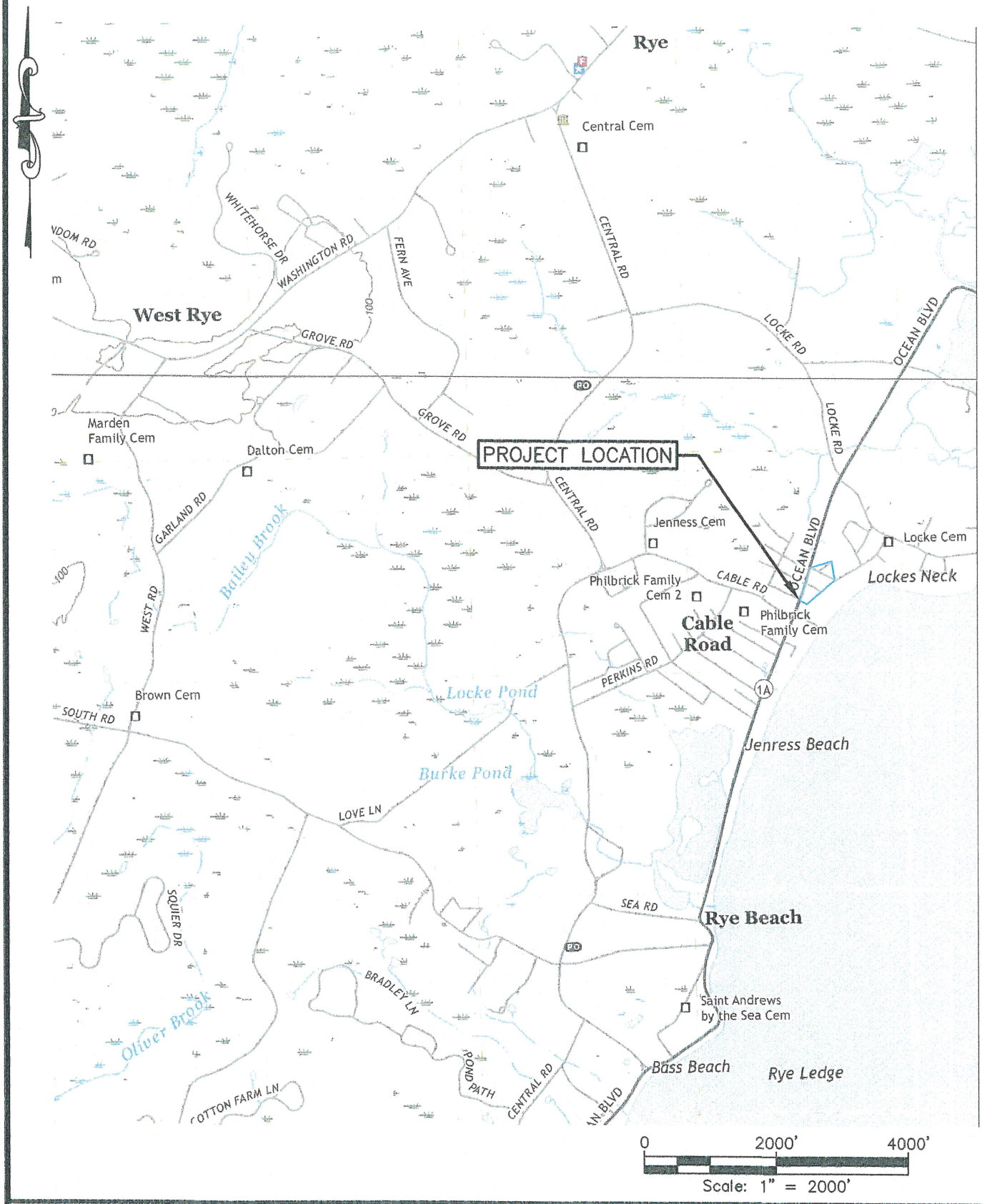
Increases in sea level rise, and corresponding increases in the WSEL in the project area's salt marsh, will increase instances of flooding in the neighborhood by impeding freshwater flows from flowing out of the drainage systems. These impacts will likely continue to be experienced in the neighborhood.

Groundwater levels beneath roads and in swales will rise as sea level rises, increasing the potential for pavement damage from freeze/thaw.

It is likely that additional infrastructure improvements such as the raising of roadways and house sill elevations will be required in the next several decades to adapt to climate change if long term residential land use is to continue in these and other low-lying areas. Improvements to the drainage systems, and consideration of salt marsh improvements, will need to be considered with this in mind.

Appendix A

USGS Map



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Town of Rye
Rye, New Hampshire
Jenness Beach
Drainage Study

USGS Map

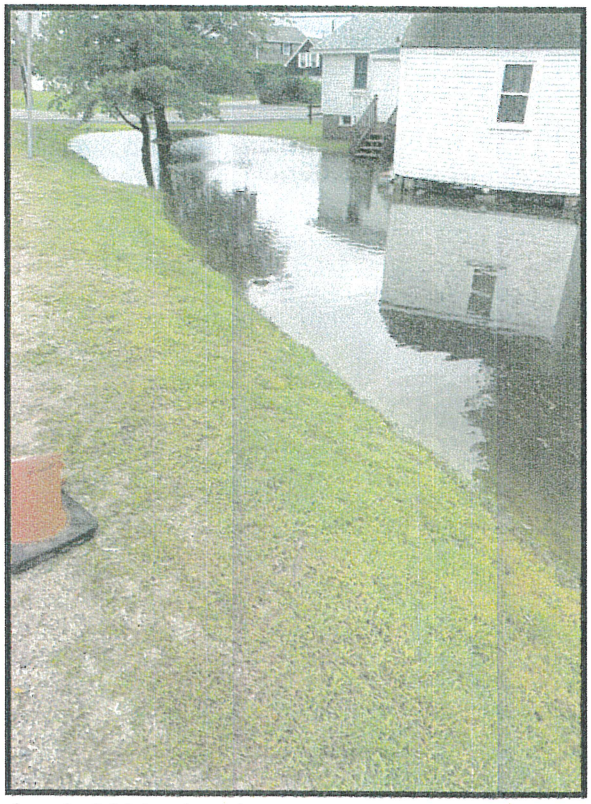
Appendix A

Appendix B

Project Photos

Photograph #1 – September 2, 2021 – East Atlantic Ave (looking east)

Photograph #2 – September 2, 2021 – corner of Jenness Ave and Route 1A (looking south)



Photograph #3 – September 2, 2021 – looking at Jenness Ave, east of Route 1A (looking north)

Photograph #4 – September 2, 2021 – down stream of southern driveway culvert (looking south)

Photograph #5 – September 2, 2021 – upstream of northern driveway culverts (looking north)

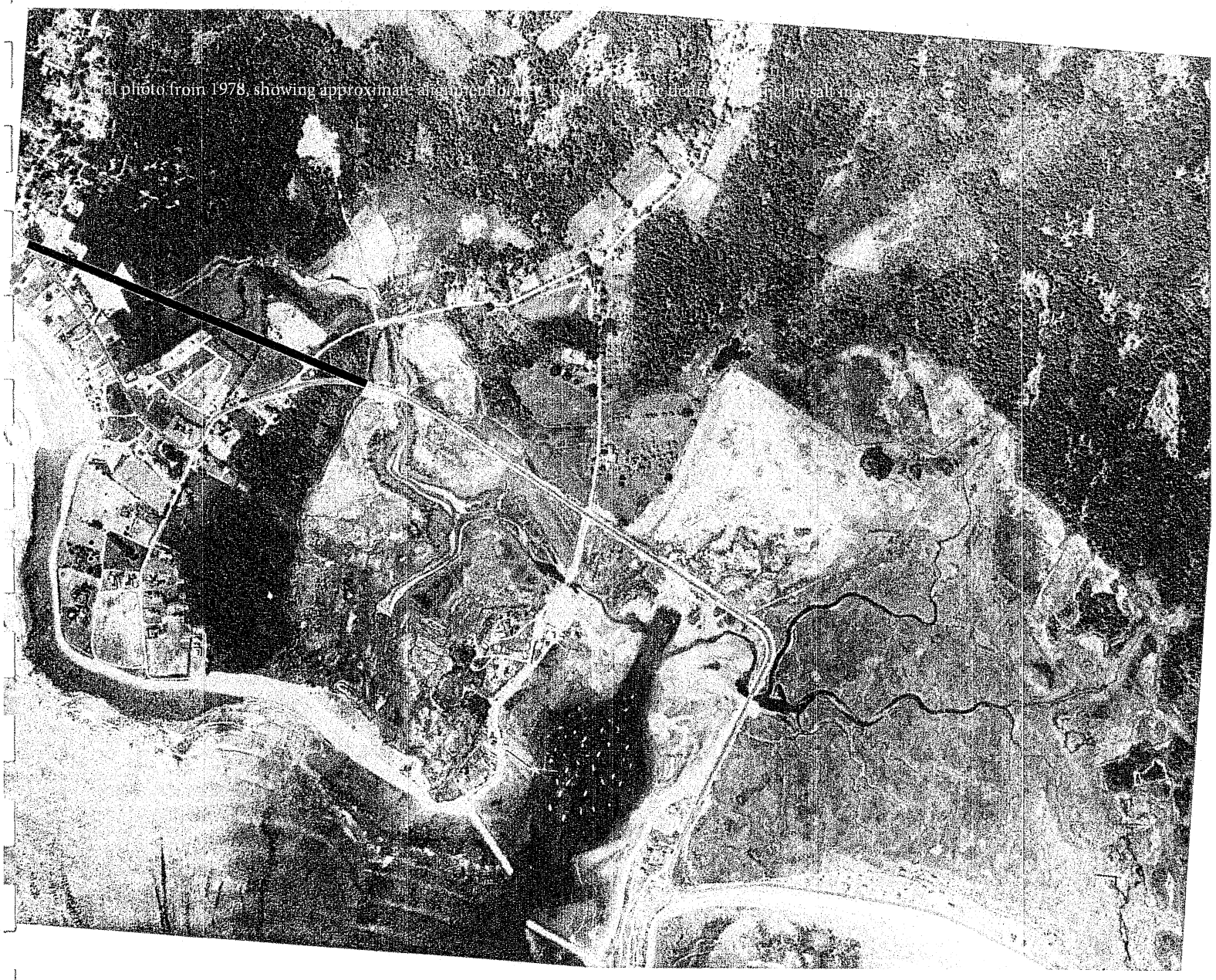
Photograph #6 – September 2, 2021 – downstream from north driveway culverts (looking south)

Photograph #7 – November 4, 2021 – downstream of phragmites (looking south)

Photograph #8 – November 4, 2021 – Phragmite vegetation (looking east)

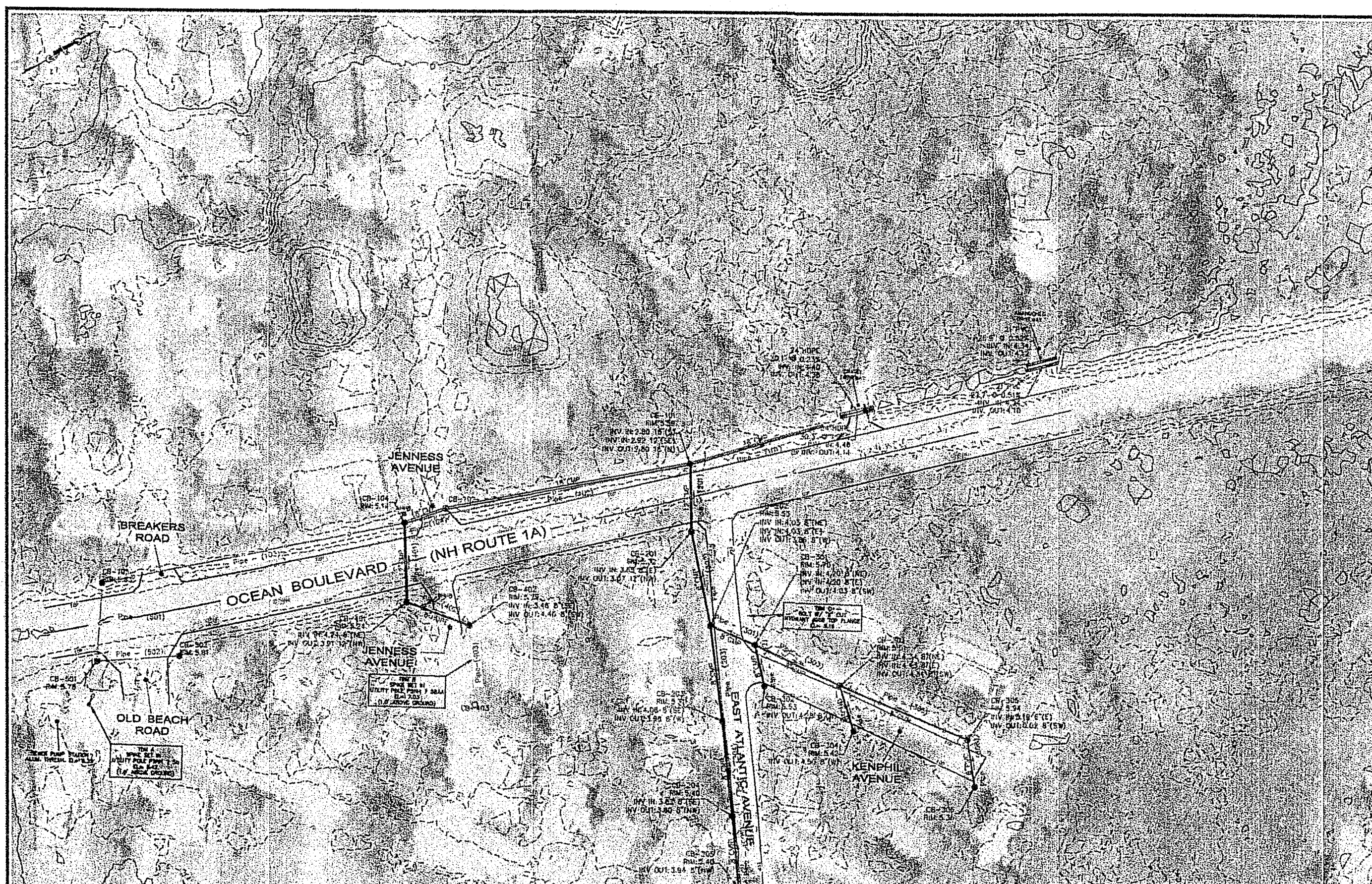
Appendix C

Historical Aerial Photo



Appendix D

Drainage System Map



Notes:

1) The topographic information was generated from 2018 NOAA LIDAR.
2) Survey was completed by James Verra & Associates, Inc. on 10/6/2021. Survey included catch basin rims and driveway culvert inverts.
3) Pipe inverts were generated from field measurements on 12/2/21 and are noted as approximate.
4) Structures shown in grey were not inspected.

Town of Rye
Rye, New Hampshire

Jenness Beach
Drainage Study

Drainage System
Map

date:	designed by:
Dec 2021	NJM
project no:	drawn by:
1220	NJM
checked by:	approved by:
CMM	WGS

scale: 1" = 40'

drawing no. 1

sheet: 1 of 1

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no.	revision	date	by