WithersRavenel
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PHASE 4
DRAINAGE INFRASTRUCTURE IMPROVEMENTS
CONCEPTUAL DESIGN FINAL REPORT
Sites 4, 5, 6, 7, 8, 9, 10, 12 and 13
Nags Head, NC

Prepared For:
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August 2019
WR No. 02160539.30

Hunter C. Freeman, PE
Brandon J. Miller, EI

EXCERPTS

COVERING SITES 10, 12 AND 13

EXECUTIVE SUMMARY

The Town of Nags Head selected WithersRavenel as their consultant for further analysis and implementation of the Town's 2006 Stormwater Management Plan – Capital Improvement Plan. This memorandum summarizes the additional analyses and conceptual designs completed for project areas 4, 5, 6, 7, 8, 9, 10, 12 and 13.

Project Area 4 – Wrightsville Avenue
The Town requested additional hydrologic modeling of a groundwater pumping system to reduce flooding along Wrightsville Avenue. This work was completed by Moffat & Nichol, a sub-consultant to WithersRavenel on this project.

Project Area 5 – North Ridge
WithersRavenel completed cost-benefit analyses of potential design alternatives at the request of the Town Board.

Project Area 6 – Old Nags Head Place
Project Area 7 – Southridge
Project Area 8 – Soundside Road
Project Area 9 – Carolinian Circle / Nags Head Pond
Project Area 10 – Kipper Court
Project Area 12 – Old Oregon Inlet Road (Juncos St)
Project Area 13 – Old Oregon Inlet Road (E. Hardgrove St. to Fire Station)
WithersRavenel developed design alternatives and cost benefit analyses for each of these sites.

After discussing each project area with Town staff, WithersRavenel presented our findings to the Board of Commissioners. The Board used the results of this phase of work to determine next steps for implementation and construction projects intended to commence in the winter of 2019/2020.

No construction work was completed as part of this phase of the project.

PROJECT APPROACH

For project area 4, Moffat & Nichol completed detailed hydrologic and groundwater modeling to evaluate the benefits of various groundwater pumping and discharge scenarios. The overall intent was to more accurately predict the flood reduction benefits of proposed pipe systems, and also to determine the maximum rate and volume of pumped groundwater that the soils under the Bonnet Street beach access parking lot could accept without exacerbating existing flooding concerns on S. Virginia Dare Trail (NC-12).

The project report from Moffat & Nichol includes more detailed information on their approach, methods, and results. The report is included in the appendices of this report.

For Site 5, WithersRavenel expanded on previous preliminary design work in an effort to find alternatives which might reduce flooding along Lookout Road and Buccaneer Drive. This work focused on additional coordination with NCDOT and work within their right of way, including potential improvements NCDOT drainage infrastructure.

For the additional sites, WithersRavenel's approach was to develop simple models to represent complex and unique hydrologic challenges. Each conceptual design is intended to improve the quality of life of Nags Head residents by reducing the detrimental impacts of persistent standing water present after moderate rainfall events.

The study of all sites relies on the development of hydrologic models. The models were developed to help understand the hydrologic components existing in the present conditions, and also understand how the physical site conditions were affected by rainfall events. Once the existing conditions models were

calibrated to more closely match field observations from Town staff and citizens, we began developing proposed conditions models and retrofit options.

WithersRavenel modeled the six new project areas (6, 7, 8, 9, 10, 12, and 13) using PondPack software. Both physical (i.e., upgrade infrastructure) and mechanical (i.e., lowering groundwater through pumping) options were considered. Metrics presented for each project area include the depth of roadway flooding and time for floodwaters to recede. Projected performance of the proposed design alternatives was compared to existing conditions using these metrics to gauge their effectiveness in addressing the concerns noted by the stakeholders.

For the proposed groundwater lowering scenarios, WithersRavenel looked at the net result of the pumping to assess the effect on floodwater levels during small storm events. This approach removed the need to design and model specific pumping options for the time being. This level of detail will be added in the final design if the Board of Commissioners earmarks the project area for construction. The hydrologic models simulate the change in soil properties due to elevated and lowered water tables within each drainage area. Existing conditions (e.g., no groundwater pumping operation) were considered to be saturated, resulting in the loss of infiltration capacity as a starting boundary condition. To simulate the effect of the groundwater lowering operation, the soil type within the project area was revised to reflect the available absorptive capacity of the dewatered soil to infiltrate a portion of rainfall. This reflects WithersRavenel's assumption that prior to a rainfall event the soil would be functioning sandy, high infiltration-capacity soils that exist in most portions of the Town.

This approach was intended to address the primary impacts to quality of life voiced during community meetings. It should be noted that we are not attempting to quantify the results using traditional engineering metrics (peak flow, inches of runoff, level of service based on XX-year storm), but rather evaluating these scenarios within a framework that quantifies how each option will improve day-to-day quality of life. This approach is similar to the method in which previous project areas were evaluated.

PRELIMINARY RESULTS & COST ESTIMATES

*Note: the cost estimates below do not include potential costs of easements or land acquisition.

Project Area #4 – Wrightsville Avenue – Additional Study

Problem Statement

Insufficient drainage infrastructure, along with low-lying properties and elevated groundwater, are causing flooding along Wrightsville Avenue from Bonnett Street to Bainbridge Street.

Existing Constraints and Design Considerations

The detailed modeling is aimed at determining the ability for the pumped groundwater to infiltrate through the dune system and reach the Atlantic Ocean. There is no available open space where pumped groundwater could be discharged and expected to infiltrate (other than environmentally sensitive areas), therefore the area under the parking lot at the Bonnett Street beach access was the most viable location.

Project Area 4 Conceptual Design

Previous studies of the project area investigated the potential benefits of installing a french drain as well as potentially improving the culvert upstream of the Curlew St outfall. Both alternatives showed limited cost/benefit returns, therefore this pumping alternative was investigated.

Project Area #10 – Kipper Court

Problem Statement

Kipper Court is located at the low point of a 6.8-acre drainage area which includes many homes on W. Baracuda Rd. runoff from upland areas floods the cul de sac and the roadway, including portions of Baracuda Road.

Existing Constraints and Design Considerations

There is no storm drainage system on Baracuda or Kipper other than small shallow swales. The nearest storm drainage system is on Danube St, and the system eventually discharges into a manmade canal adjacent to Old Cove Road. The receiving waters are classified as SA waters.

Project Area 10 Conceptual Design

Study of the GIS survey of the storm drainage network indicates that gravity connection to the existing network may be feasible but would require acquisition of easements on private property. A gravity flow option was studied that utilizes subsurface drainage. A second gravity flow design that included a trapezoidal swale has been excluded per Town comments. A third option of pumping water west along Baracuda Dr. to an outfall on Shiner Ct. was not studied in detail, but could be investigated if easements on private property cannot be obtained.

Conceptual Design – Install storm drainage system to connect to the existing system on Danube St.

Goal: Provide a french drain and outfall from Kipper Court to allow the area to drain more easily.

Assumptions: Two tailwater conditions were assumed based on field observations of the existing outfall. One option, with a tailwater of 0.0 represents normal dry weather low tide conditions, the other, with a tailwater of 3.21 represents observed storm conditions where the outfall pipe is ½ submerged.

Design: Catch Basin on 207 W. Kipper Ct and installation of a new storm drainage system and cross pipe under Danube St, tying into the existing system at a catch basin on the south side of Danube St.

Preliminary Engineer's Cost Opinion: $45,000 - $60,000 (including french drain)

"The reports for project areas #10, 12, and 13 were prepared by Withers Ravenel under the direction of the Town of Nags Head under grant award # NA15NOS4190066 to the Department of Environmental Quality, Division of Coastal Management from the Office for Coastal Management, National Oceanic and Atmospheric Administration. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of DEQ, OCM or NOAA."

Project Area 10 Preliminary Results

We estimate that Kipper Ct floods approximately 3 times every five year, but localized flooding on private property is more frequent (multiple times per year). The pipe option improves the flooding conditions during larger storms event, and Kipper Ct would reduce to flooding once in five years. Road flooding duration is reduced by 89% across the road in the 5-year 24-hour storm.

Table 10. Projected depth of roadway flooding and time to recede for Project Area 10

Existing Staging						
Event	WSEL	Start	Finish	Time (hrs)		
2-YEAR	5.52	12.50	13.50	1.00		
5-YEAR	5.57	12.25	14.50	2.25		
1.5-YEAR	5.50	12.75	13.25	0.50		
Proposed Design (Tailwater EL. 0.0)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.40	-	-	-	-	-
5-YEAR	5.53	12.5	12.75	0.25	-1%	-89%
1.5-YEAR	5.35	-	-	-	-	-
Proposed Design (Tailwater EL. 3.21)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.40	-	-	-	-	-
5-YEAR	5.53	12.5	12.75	0.25	-1%	-89%
1.5-YEAR	5.35	-	-	-	-	-

*Road flooding benchmark assumed to be EL. 5.5

Discussion and Next Steps

The Town preferred the design option which included a french drain system near Kipper Court. The underdrain from the french drain would flow into a new storm drainage pipe which would flow east before turning south and connecting to the existing system on the south side of Danube St. This keeps the new alignment in Town owned property, minimizing the need for easements or property acquisition.

The Town requested that WithersRavenel obtain field survey information along the project corridor, and the Town would lead the design and construction effort.

Project Area #12 – Old Oregon Inlet Road @ Juncos St

Problem Statement

The area between Olympic St and Juncos St remains flooded for prolonged periods of time after rainfall events. S Old Oregon Road is often restricted to one lane of travel due to standing water. Saturated soils and damage to driveways was noted during the site visit.

Existing Constraints and Design Considerations

This southern portion of the Town has little relief and high groundwater elevation are evident by the water elevation in the existing swale west of Old Oregon Road. The volume of groundwater, ocean influence, and the proximity of this flooding to the existing ditch results in the assumption that localized groundwater lowering is not a feasible option.

Project Area 12 Conceptual Designs

Conceptual Design Alternative #1 – Install french drains and perforated pipe system.

Goal: Improve effective storage below the existing ground level and provide a high infiltration area to relieve standing water concerns as quickly as possible.

Assumptions: Effective depth of the french drain is limited to 1' – 2' below the existing edge of pavement, any depth below that elevation is expected to be continually saturated with groundwater.

Design: Add 2,100 lf of shallow french drain (5' wide, 1'-2' deep) and perforated pipe along east side of Old Oregon Inlet Rd. Repair and elevate driveways where possible, adding driveway culverts.

Preliminary Engineer's Cost Opinion: **$100,000 – $125,000**

Conceptual Design Alternative #2 – Add pump system to Alt 1.

Goal: Pump water from the french drain to a new infiltration area to be incorporated into the design of new beach access parking north of Juncos St.

Assumptions: Higher elevations in the parking area, especially closer to the ocean, provide separation from the groundwater table and suitable soils for infiltration.

Design: Install Alternative 1, and include submersible pumps and a force main to the discharge location. The system could be designed as a continuous low flow pump operation or an emergency pump connection.

Preliminary Engineer's Cost Opinion: Groundwater lowering option - **$250,000 – $300,000**
Emergency pump option - **$200,000 - $250,000**

Project Area 12 Preliminary Results

Under existing conditions, roadway flooding through the project area is expected multiple times per year. The proposed alternatives eliminate flooding for small storm events expected to occur 3 times per year (+/- 2" of rainfall). There is insufficient storage area and volume to prevent flooding from any larger storms. Flood ponding times are expected to be improved for very small storms.

In Alternative 2, the frequency of roadway flooding is expected to be slightly better than Alternative 1, however it is difficult to quantify this improvement as the effect of low flow pumping (2 cfs average flow rate) is insignificant compared to the rate of inflow from rain events. Both low flow and emergency pumping could reduce the long-term flood durations to less than 1 day after larger rainfall events.

Table 11. Projected depth of roadway flooding and time to recede for Project Area 12

Event	Existing WSEL	Alt-1 WSEL	Alt-2 WSEL
4-MONTH	1.53	1.35	0.89

Discussion and Next Steps

The Town directed WithersRavenel to proceed with field survey and design documents for installation of Alternate #1 (french drain). All design drawings will need to be reviewed by NCDOT prior to bidding.

Project Area #13 – Old Oregon Inlet Road – East Hardgrove St to Fire Station

Problem Statement

Flooding along the east side of Old Oregon Inlet Road for prolonged periods after small and large rainfall events. Saturated soils and high groundwater were noted during the site visit.

Existing Constraints and Design Considerations

High groundwater elevation and sensitive natural areas near the project site limit the design options and the ability to release concentrated stormwater or construct new stormwater outfalls west of the roadway. There are no significant swales or ditches in the project area.

Project Area 13 Conceptual Designs

Conceptual Design Alternative #1 – Install french drains in the project area and pump groundwater to an area near the fire station.

Goal: Improve local infiltration and dewater area using low flow groundwater pumps

Assumptions: Existing utilities would not pose significant conflicts and permits could be obtained to allow for the discharge of the pump system.

Design: 2,050 lf of shallow french drain (5' wide, 1'-2' deep) and perforated pipe, new catch basins and wells, 3,100 lf of force main

Preliminary Engineer's Cost Opinion: $225,000 – 275,000

Conceptual Design Alternative #2 – Expand scope of Alternative 1 to include additional french drain

Preliminary Engineer's Cost Opinion: TBD based on extent of additional french drain

Project Area 13 Preliminary Results

Under existing conditions localized standing water is to be anticipated after all measurable rainfall events. Installation of the system would improve dewatering times (often reduced to less than 1 day following rainfall) and sufficient storage could be installed to eliminate roadway flooding for storms less than 1.5" of total rainfall.

Table 12. Projected depth of roadway flooding and time to recede for Project Area 13

Event	Existing WSEL	Alt-1 WSEL
4-MONTH	1.55	0.67

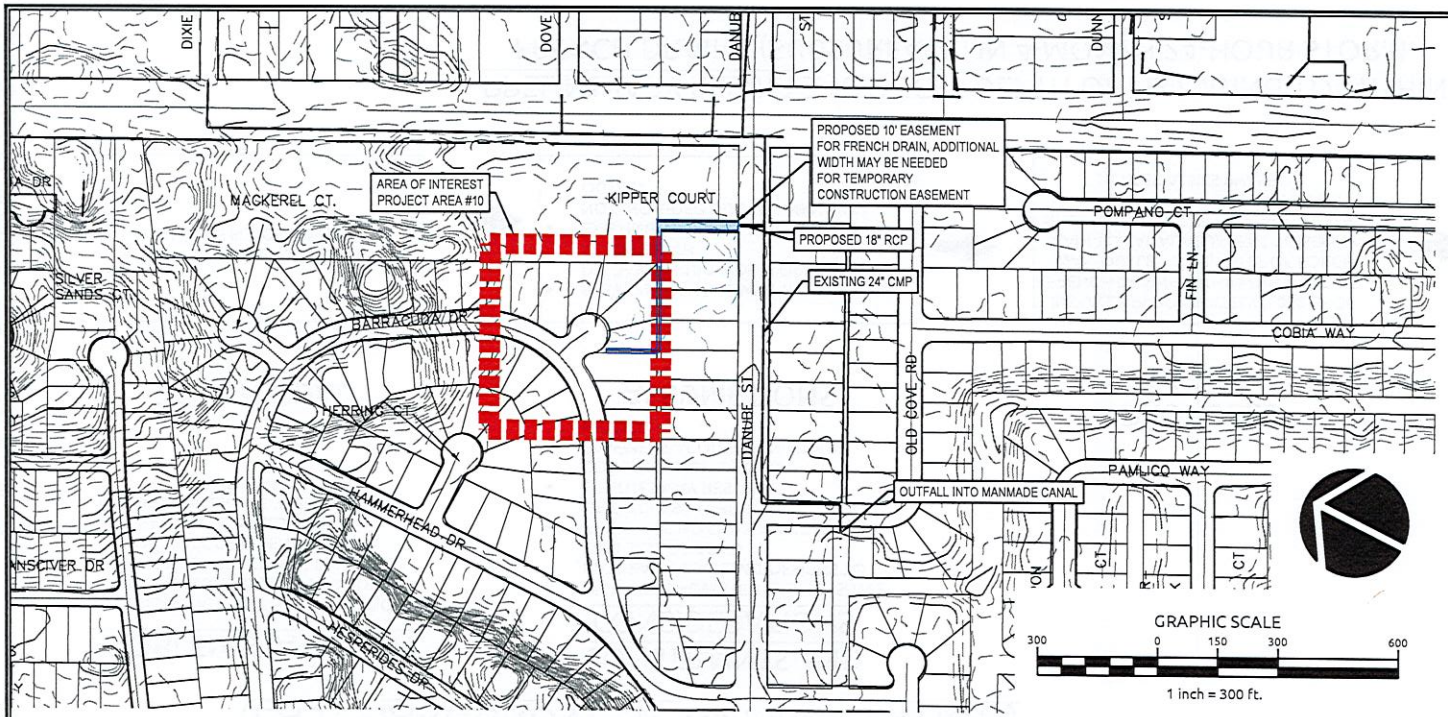
Discussion and Next Steps

The Town directed WithersRavenel to proceed with field survey and design documents for installation of Alternate #1. The design will also include construction of an infiltration area north of the fire station on the west side of the road. All design drawings will need to be reviewed by NCDOT prior to bidding.

This report concludes Phase 4 of this project. Additional work described above will be conducted in Phase 5.

APPENDIX A:
EXHIBITS OF SELECTED DESIGNS FOR PROJECT AREAS 10, 12 AND 13

"This exhibit was prepared by Wither Ravenel under direction of The Town of Nags Head under grant award # NA15NOS4190066 to the Department of Environmental Quality, Division of Coastal Management from the Office for Coastal Management, National Oceanic and Atmospheric Administration. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of DEQ, OCM or NOAA."



PROBLEM STATEMENT

KIPPER COURT IS LOCATED AT THE LOW POINT OF A 6.80 ACRE DRAINAGE AREA, WHICH INCLUDES MANY HOMES ON W. BARACUDA ROAD. THE CUL-DE-SAC FLOODS THE ROADWAY, INCLUDING PORTIONS OF BARACUDA ROAD.

CONSTRAINTS AND CONSIDERATIONS

- THERE IS NO STORM DRAINAGE SYSTEM ON KIPPER OTHER THAN SMALL SHALLOW SWALES
- THE DANUBE STREET STORM SYSTEM DISCHARGES INTO A MANMADE CANAL ADJACENT TO OLD COVE ROAD
- THE RECEIVING WATERS FROM THE CANAL AREA SA WATERS
- EASEMENTS REQUIRED

PROJECT AREA #10 - NAGS HEAD COVE (KIPPER COURT)

DESIGN GOAL

PROVIDE FRENCH DRAIN AND PIPE SOUTH OF KIPPER COURT PROPERTIES, AND OUTFALL TO DANUBE STREET 24" CMP.

ASSUMPTIONS

- OVERFLOW OUT OF PROJECT AREA SET AS ROAD CREST ACTING AS WEIR AT ELEVATION 5.5
- SURFACE AREA OF ELEVATION 5.0 ESTIMATED FROM FIELD OBSERVATIONS AND GIS LIDAR DATA
- THE DANUBE STREET OUTFALL WAS OBSERVED WITH FREE OUTFALL, MODELS ALSO INCLUDED A HALF FULL SCENARIO WITH A TAILWATER ELEVATION OF 3.21

PROPOSED DESIGN

INSTALL 330 LF OF FRENCH DRAIN WITH 12" PERFORATED PIPE BEHIND KIPPER COURT LOTS IN EXISTING EASEMENT, OUTLET VIA CROSS PIPE UNDER DANUBE STREET AND TIE INTO THE EXISTING 24" CMP.

ENGINEER'S COST OPINION*

- SPOIL/HAUL: $10,000
- FRENCH DRAIN: $8,500
- CROSS PIPE: $20,000
- MOBILIZATION: $2,000

TOTAL ESTIMATE: $40,000 - $45,000

PRELIMINARY RESULTS: FLOODING EVENTS REDUCED TO ONCE PER FIVE YEARS. DURATION OF PONDING REDUCED BY 85% IN THE 5-YEAR 24-HOUR STORM.

*THIS ESTIMATE OF PROBABLE COST IS APPROXIMATE. ACTUAL CONSTRUCTION BIDS MAY VARY SIGNIFICANTLY FROM THIS STATEMENT OF PROBABLE COSTS.

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Sheet No. 10

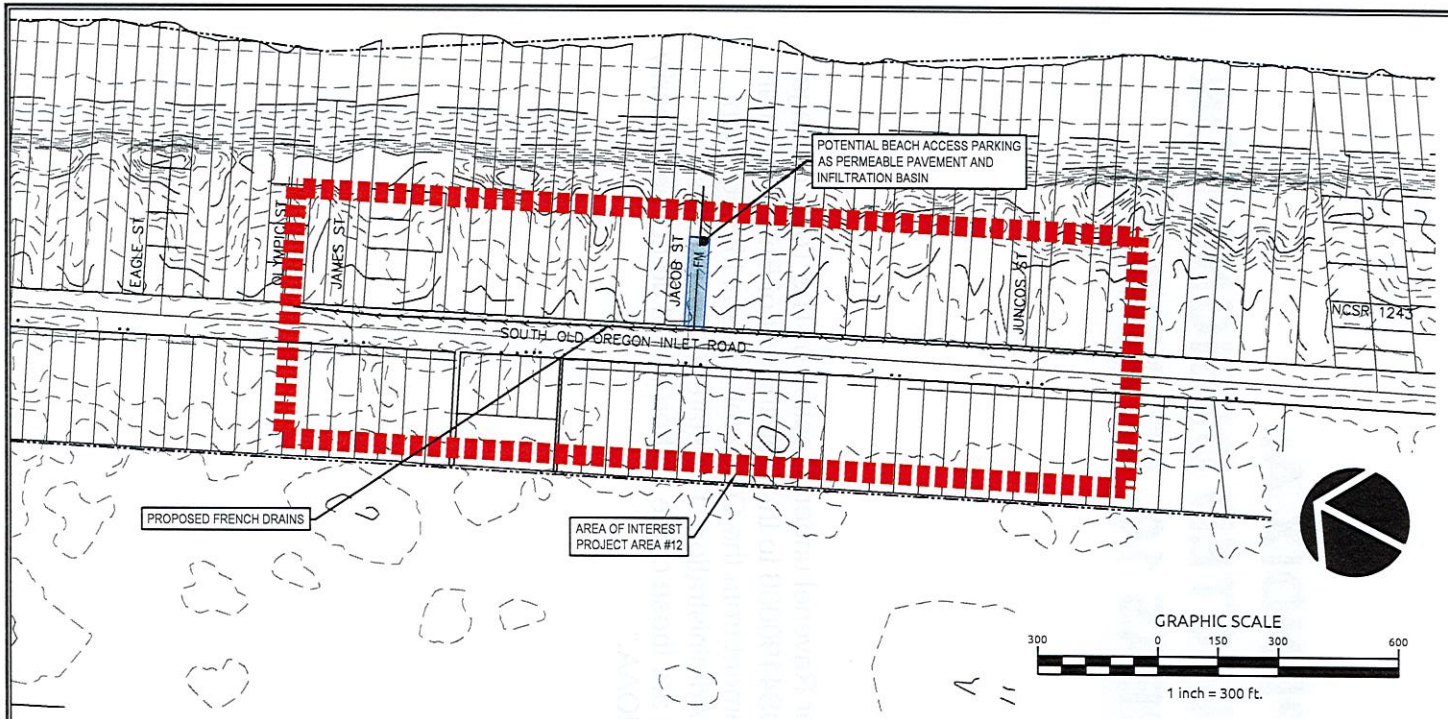
PROJECT AREA #10

NAGS HEAD PHASE 4 NC

NAGS HEAD

Designer: WS Scale: AS NOTED
Drawn By: WS Date: 3/7/19
Checked By: Job No. 02160503.30

No.	Revision	Date	By



PROBLEM STATEMENT

THE AREA BETWEEN OLYMPIC STREET AND JUNCOS STREET REMAINS FLOODED FOR PROLONGED PERIODS OF TIME AFTER RAINFALL EVENTS. SOUTH OLD OREGON INLET ROAD IS OFTEN RESTRICTED TO ONE LANE OF TRAVEL DUE TO STANDING WATER. SATURATED SOILS AND DAMAGE TO DRIVEWAYS HAS BEEN OBSERVED IN THE AREA.

CONSTRAINTS AND CONSIDERATIONS

- AREA HAS LITTLE RELIEF
- EXISTING SWALES HAVE BEEN OBSERVED WITH STANDING WATER, INDICATING HIGH GROUNDWATER
- LOCALIZED GROUNDWATER LOWERING NOT FEASIBLE

PROJECT AREA #12 - SOUTH NAGS HEAD (MILEPOST 19.5)

DESIGN GOAL

INCREASE SOIL STORAGE CAPACITY TO REDUCE STANDING WATER AND INCREASE INFILTRATION.

ASSUMPTIONS

- EASTERN RIGHT OF WAY ACTS AS V-SHAPED DITCH WITH 10:1 SIDE SLOPES, AND 12" OF DEPTH

PROPOSED DESIGN

INSTALL APPROXIMATELY 2,100 LF OF FRENCH DRAINS IN RIGHT OF WAY. DEMOLISH AND RAISE ELEVATION OF ASSOCIATED DRIVEWAYS.

ENGINEER'S COST OPINION*

- SPOIL/HAUL: $25,000
- FRENCH DRAIN: $75,000
- MOBILIZATION: $5,000

TOTAL ESTIMATE: $100,000 - $125,000

PRELIMINARY RESULTS**: REDUCES DEPTH OF FLOODING BY 2-INCHES IN 4-MONTH 24-HOUR STORM. DRIVEWAY FLOODING TO BE REDUCED.

**IMPROVED BEACH ACCESS MAY PROVIDE RECHARGE BASIN AS PUMP OUTFALL. PUMPING OF FRENCH DRAINS RESULTS IN REDUCING DEPTH OF FLOODING TO WITHIN FRENCH DRAINS (SUBSURFACE) IN 4-MONTH 24-HOUR STORM.

*THIS ESTIMATE OF PROBABLE COST IS APPROXIMATE. ACTUAL CONSTRUCTION BIDS MAY VARY SIGNIFICANTLY FROM THIS STATEMENT OF PROBABLE COSTS. DOES NOT INCLUDE COST OF BEACH ACCESS DESIGN AND CONSTRUCTION.

Sheet No. 12

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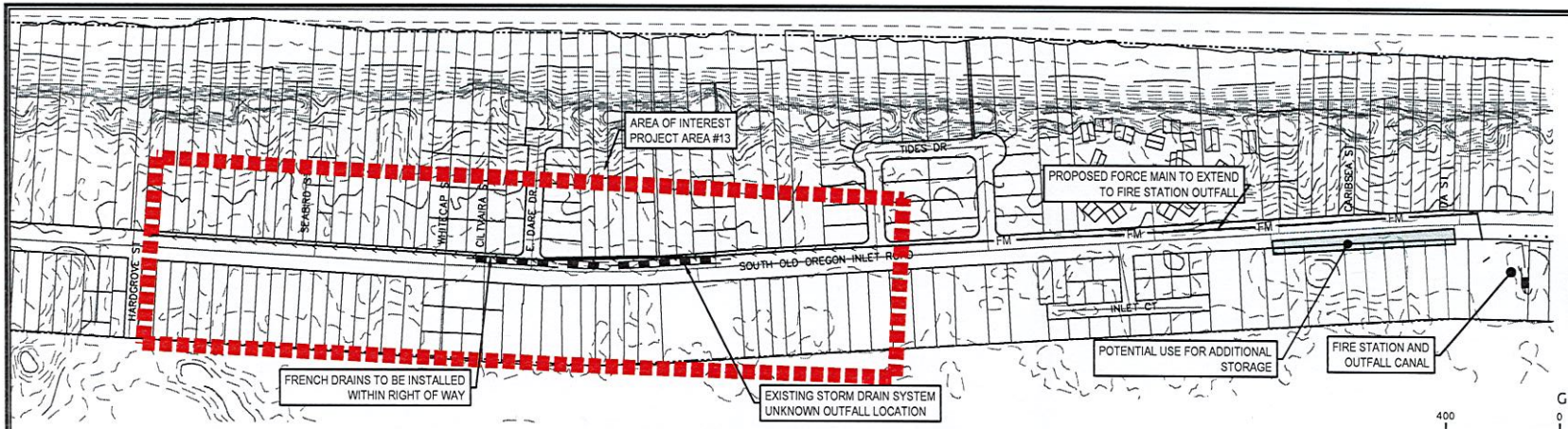
PROJECT AREA #12

NAGS HEAD PHASE 2 NC

NAGS HEAD

Designer: WS | Scale: AS NOTED
Drawn By: | Date: 3/11/19
Checked By: DB/NS
WR: 0216059.30

No	Revision	Date	By



PROJECT AREA #13 - OLD OREGON INLET ROAD (EAST HARDGROVE ST TO FIRE STATION)

PROBLEM STATEMENT

FLOODING ALONG THE EAST SIDE OF OLD OREGON INLET ROAD FOR PROLONGED PERIODS AFTER SMALL AND LARGE RAINFALL EVENTS. SATURATED SOILS AND HIGH GROUNDWATER HAS BEEN OBSERVED IN THE AREA.

CONSTRAINTS AND CONSIDERATIONS

- HIGH GROUNDWATER AND SENSITIVE NATURAL AREAS LIMIT DESIGNS TO EAST SIDE OF ROAD
- THERE ARE NO SIGNIFICANT SWALES OR DITCHES IN THE PROJECT AREA
- UTILITIES MAY RESTRICT CONSTRUCTION OPTIONS
- EASEMENT ACQUISITION MAY BE NEEDED

DESIGN GOAL

PUMP STANDING WATER TO REDUCE FLOOD TIMES.

ASSUMPTIONS

- EASTERN RIGHT OF WAY MODELED AS DITCH WITH 10:1 SIDE SLOPES, AND 12" OF DEPTH
- EXISTING STORM DRAIN CAPACITY NOT INCLUDED DUE TO UNKNOWN OUTLET

PROPOSED DESIGN

INSTALL APPROXIMATELY 2,050 LF OF FRENCH DRAINS WITHIN THE RIGHT OF WAY. OUTLET VIA 3,100 LF OF FORCE MAIN TO CANAL ADJACENT TO SOUTH NAGS HEAD FIRE STATION. ADDITIONAL STORAGE MAY BE ADDED AT SOUTH CREEK ACRES PHASE 2.

ENGINEER'S COST OPINION*

- GROUNDWATER PUMPS: $30,000
- SPOIL/HAUL: $10,000
- FRENCH DRAIN: $75,000
- FORCE MAIN: $125,000
- MOBILIZATION: $10,000

TOTAL ESTIMATE: $225,000 - $275,000

PRELIMINARY RESULTS: REDUCES DEPTH OF FLOODING TO WITHIN FRENCH DRAINS (SUBSURFACE) IN 4-MONTH 24-HOUR STORM.

*THIS ESTIMATE OF PROBABLE COST IS APPROXIMATE. ACTUAL CONSTRUCTION BIDS MAY VARY SIGNIFICANTLY FROM THIS STATEMENT OF PROBABLE COSTS.

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Sheet No. 13

PROJECT AREA #13

NAGS HEAD PHASE 4

NAGS HEAD NC

Designer WB | Date AS NOTED | Drawn By WB | Date 3/7/19 | Checked By WB | Job No. 02160539.0

No	Revision	Date	By

ADDENDUM

1) Stakeholder Input
2) Conceptual Design Alternatives – 3/15/2019

Appendix A – Stakeholder Input

Project Area #10

January 28, 2019 – Meeting with Town Staff, site visits, discussion of flooding problems, discussion of flooding frequency, and discussion and observation of site constraints -
Hunter Freeman & Brandon Miller (WR) toured project area 10 with David Ryan. David described the general problem and pointed out areas where flooding occurred. They discussed the existing infrastructure and local constraints (property boundaries, vegetation, utilities, and other utility or infrastructure improvement projects planned for the vicinity of the project area). They also discussed performance goals and possible solutions/strategies worth investigating.

April 23, 2019, Board of Commissioners Budget Workshop – Presentation of Preliminary Concepts - Hunter Freeman (WR) presented the preliminary concept for project area 10, the addition of storm drainage alignment on Danube Street. No comments were received from the Public or Board of Commissioners.

June 5, 2019, Town Board Meeting – Project area 10 was approved for Engineering contract to proceed.

Project Area #12

January 28, 2019 – Meeting with Town Staff, site visits, discussion of flooding problems, discussion of flooding frequency, and discussion and observation of site constraints - Hunter Freeman & Brandon Miller (WR) toured project area 12 with David Ryan. At the site, David described the general problem and pointed out areas where flooding occurred. They discussed the existing infrastructure and local constraints (property boundaries, vegetation, utilities, and other utility or infrastructure improvement projects planned for the vicinity of the project area). They also discussed performance goals and possible solutions/strategies worth investigating.

April 16, 2019 - Town Board Meeting & Committee Meeting - The Town and Withers Ravenel met with NCDOT Division Staff to review the initial concept designs for Project Area 12. The preliminary design includes a french drain on the east side of S. Old Oregon Inlet Road connected to stormwater pumping systems. They acknowledged that there was frequent localized flooding in the area which restricted traffic flow. Maintenance work had been done on the existing swale within the past few years, this maintenance had helped, but not fully resolved the issues. NCDOT was unsure about the availability of funds, but indicated that the Division would need to review and approve the construction documents and bid documents prior to greenlighting the project for possible fund assistance.

April 23, 2019 – Board of Commissioners Budget Workshop -
Hunter Freeman (WR) presented the preliminary concepts for project area 12, in addition to other concept areas. The board had questions, but none related to project area 12.

June 5, 2019, Town Board Meeting – Project area 12 was approved for Engineering contract to proceed.

Project Area #13

January 28, 2019 – Meeting with Town Staff, site visits, discussion of flooding problems, discussion of flooding frequency, and discussion and observation of site constraints - Hunter Freeman & Brandon Miller (WR) toured project area 13 with David Ryan. At each site David described the general problem and pointed out areas where flooding occurred. They discussed the existing infrastructure and local constraints (property boundaries, vegetation, utilities, and other utility or infrastructure improvement projects planned for the vicinity of the project area). They also discussed performance goals and possible solutions/strategies worth investigating.

April 16, 2019 - Town Board Meeting & Committee Meeting - The Town and WithersRavenel met with NCDOT Division Staff to review the initial concept designs for Project Area 13. The preliminary design included french drains on the east side of S. Old Oregon Inlet Road connected to stormwater pumping systems. Project area 13 includes an infiltration area north of the Fire Station on the west side of S. Old Oregon Inlet Road. NCDOT had few initial concerns regarding the french drain systems. They acknowledged that there was frequent localized flooding in the area which restricted traffic flow. Maintenance work had been done on the existing swale within the past few years, this maintenance had helped, but not fully resolved the issues. NCDOT was open to allowing the wet well on project area 13 within the right of way and agreed that impact to private property should be minimized. NCDOT was unsure about the availability of funds, but indicated that the Division would need to review and approve the construction documents and bid documents prior to greenlighting the project for possible fund assistance.

April 23, 2019 – Board of Commissioners Budget Workshop –
Hunter Freeman (WR) presented the preliminary concept for project area 13, in addition to the other areas. Responses to board questions were presented to the board by David Ryan at the June 5, 2019 board meeting. There were no questions related to project area 13.

June 5, 2019, Town Board Meeting – Project area 13 was approved for Engineering contract to proceed.

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MEMORANDUM

To:	David Ryan, PE, Town of Nags Head
From:	Hunter Freeman, PE, WithersRavenel
Date:	March 15, 2019
Project:	Nags Head Stormwater Master Planning
Subject:	Phase 4 Conceptual Design Alternatives Summary – Sites 10, 12, and 13

Executive Summary and Overall Approach

This memorandum summarizes the preliminary conceptual design and results for an additional 3 drainage projects located in the Town of Nags Head.

In this fourth phase of our contract, 7 additional sites that were previously identified by staff will be studied. Grant funding was obtained by the Town to study sites 10, 12, and 13, and therefore these designs are separated from sites 6, 7, 8, and 9 for reporting purposes.

The study of all sites relies on the development of hydrologic models. The models were developed to help understand the hydrologic components existing in the present conditions, and also understand how the physical site conditions were affected by rainfall events. Once the existing conditions models were calibrated to more closely match field observations from Town staff and citizens, we began developing proposed conditions models and retrofit options.

WithersRavenel modeled the three project areas using PondPack software. Both physical (i.e., upgrade infrastructure) and mechanical (i.e., lowering groundwater through pumping) options were considered. Metrics presented for each project area include the depth of roadway flooding and time for floodwaters to recede. Projected performance of the proposed design alternatives was compared to existing conditions using these metrics to gauge their effectiveness in addressing the concerns noted by the stakeholders.

For the proposed groundwater lowering scenarios, WithersRavenel looked at the net result of the pumping to assess the effect on floodwater levels during small storm events. This approach removed the need to design and model specific pumping options for the time being. This level of detail will be added in the final design if the scenario reaches that stage. The hydrologic models simulate the change in soil properties due to elevated and lowered water tables within each drainage area. Existing conditions (e.g., no groundwater pumping operation) were considered to be saturated, resulting in the loss of infiltration capacity as a starting boundary condition. To simulate the effect of the groundwater lowering operation, the soil type within the project area was revised to reflect the available absorptive capacity of the dewatered soil to infiltrate a portion of rainfall. This reflects WithersRavenel's assumption that prior to a rainfall event the soil would be functioning sandy, high infiltration-capacity soils that exist in most areas of the Town.

This approach was intended to address the primary impacts to quality of life voiced during community meetings. It should be noted that we are not attempting to quantify the results using traditional engineering metrics (peak flow, inches of runoff, level of service based on XX-year storm), but rather evaluating these scenarios within a framework that quantifies how each option will improve day-to-day quality of life. If a more traditional engineering reporting is requested, we can add this type of analysis to the report.

Preliminary Results & Cost Estimates

*Note: the cost estimates below do not include potential costs of easements or land acquisition.

Project Area #10 – Kipper Court

Problem Statement

Kipper Court is located at the low point of a 6.8 acre drainage area which includes many homes on W. Baracuda Rd. The cul de sac floods the roadway, including portions of Baracuda Road.

Existing Constraints and Design Considerations

There is no storm drainage system on Baracuda or Kipper other than small shallow swales. The nearest storm drainage system is on Danube St, and the system eventually discharges into a manmade canal adjacent to Old Cove Road. The receiving waters are classified as SA waters.

Project Area 10 Conceptual Design

Study of the GIS survey of the storm drainage network indicates that gravity connection to the existing network may be feasible but would require acquisition of easements on private property. Two gravity flow options were studied. A third option of pumping water west along Baracuda Dr. to an outfall on Shiner Ct. was not studied in detail, but could be investigated if easements on private property cannot be obtained.

Conceptual Design Alternative #1 – Install a swale and storm drainage system to connect to the existing system on Danube St.

Goal: Provide an outfall from Kipper Court to allow the area to drain more easily.

Assumptions: Two tailwater conditions were assumed based on field observations of the existing outfall. One option, with a tailwater of 0.0 represents normal dry weather low tide conditions, the other, with a tailwater of 3.21 represents observed storm conditions where the outfall pipe is ½ submerged.

Design: Vegetated swale across 207 W. Kipper Ct and 0 W. Danube St to a cross pipe under Danube St, tying into the existing system at a catch basin on the south side of Danube St.

Preliminary Engineer's Cost Opinion: $30,000 - $40,000

Conceptual Design Alternative #2 – Install storm drainage system to connect to the existing system on Danube St.

Goal: Provide an outfall from Kipper Court to allow the area to drain more easily.

Assumptions: Two tailwater conditions were assumed based on field observations of the existing outfall. One option, with a tailwater of 0.0 represents normal dry weather low tide conditions, the other, with a tailwater of 3.21 represents observed storm conditions where the outfall pipe is ½ submerged.

Design: Catch Basin on 207 W. Kipper Ct and installation of a new storm drainage system and cross pipe under Danube St, tying into the existing system at a catch basin on the south side of Danube St.

Preliminary Engineer's Cost Opinion: $45,000 - $60,000 (including french drain)

Project Area 10 Preliminary Results

We estimate that Kipper Ct floods approximately 3 times every five year, but localized flooding on private property is more frequent (multiple times per year). The swale option allows for additional flood storage on 207 W Kipper Ct, reducing the frequency of road flooding to once per five years, and also reducing property flooding to once per year, with the exception of the swale itself, which would be saturated frequently and may be suitable for wetland planting. The duration of flooding is reduced from 50% to 67% depending on downstream tailwater conditions and the time it takes for the canal to recede to normal low water levels.

The pipe option does not improve the flooding conditions during larger storms event, and Kipper Ct would still be expected to flood 3 times per five years, however flooding duration is reduced by 50% (depending

on the water level in the canal) and property flooding from small events would be expected to be less frequent if some portions of private property were also graded to drain to the swale. A french drain and perforated pipe design alteration would further reduce localized flooding on private property and should be considered.

Table 10. Projected depth of roadway flooding and time to recede for Project Area 10

Existing Staging						
Event	WSEL	Start	Finish	Time (hrs)		
2-YEAR	5.52	12.50	13.50	1.00		
5-YEAR	5.57	12.25	14.50	2.25		
1.5-YEAR	5.50	12.75	13.25	0.50		
Proposed Alternative #1 (Tailwater EL. 0.0)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.49	-	-	-	-1%	-
5-YEAR	5.58	22.00	22.75	0.75	0%	-67%
1.5-YEAR	5.42	-	-	-	-1%	-
Proposed Alternative #1 (Tailwater EL. 3.21)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.49	-	-	-	-1%	-
5-YEAR	5.58	12.00	13.00	1.00	0%	-56%
1.5-YEAR	5.42	-	-	-	-1%	-
Proposed Alternative #2 (Tailwater EL. 0.0)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.53	12.25	12.75	0.50	0%	-50%
5-YEAR	5.57	12.25	12.75	0.50	0%	-78%
1.5-YEAR	5.50	12.50	12.75	0.25	0%	-50%
Proposed Alternative #2 (Tailwater EL. 3.21)						
Event	WSEL	Start	Finish	Time (hrs)	WSEL Δ%	Time Δ%
2-YEAR	5.53	12.50	12.75	0.25	0%	-75%
5-YEAR	5.57	12.25	12.75	0.50	0%	-78%
1.5-YEAR	5.50	12.50	12.75	0.25	0%	-50%

Project Area #12 – Old Oregon Inlet Road @ Juncos St

Problem Statement

The area between Olympic St and Juncos St remains flooded for prolonged periods of time after rainfall events. S Old Oregon Road is often restricted to one lane of travel due to standing water. Saturated soils and damage to driveways was noted during the site visit.

Existing Constraints and Design Considerations

This southern portion of the Town has little relief and high groundwater elevation are evident by the water elevation in the existing swale west of Old Oregon Road. The volume of groundwater, ocean influence, and the proximity of this flooding to the existing ditch results in the assumption that localized groundwater lowering is not a feasible option.

Project Area 12 Conceptual Designs

Conceptual Design Alternative #1 – Install french drains and perforated pipe system.

Goal: Improve effective storage below the existing ground level and provide a high infiltration area to relieve standing water concerns as quickly as possible.

Assumptions: Effective depth of the french drain is limited to 1' – 2' below the existing edge of pavement, any depth below that elevation is expected to be continually saturated with groundwater.

Design: Add 2,100 lf of shallow french drain (5' wide, 1'-2' deep) and perforated pipe along east side of Old Oregon Inlet Rd. Repair and elevate driveways where possible, adding driveway culverts.

Preliminary Engineer's Cost Opinion: **$100,000 – 125,000**

Conceptual Design Alternative #2 – Add pump system to Alt 1.

Goal: Pump water from the french drain to a new infiltration area to be incorporated into the design of new beach access parking north of Juncos St.

Assumptions: Higher elevations in the parking area, especially closer to the ocean, provide separation from the groundwater table and suitable soils for infiltration.

Design: Install Alternative 1, and include submersible pumps and a force main to the discharge location. The system could be designed as a continuous low flow pump operation or an emergency pump connection.

Preliminary Engineer's Cost Opinion: Groundwater lowering option - **$250,000 – 300,000**
Emergency pump option - **$200,000 - $250,000**

Project Area 12 Preliminary Results

Under existing conditions, roadway flooding through the project area is expected multiple times per year. The proposed alternatives eliminate flooding for small storm events expected to occur 3 times per year (+/- 2" of rainfall). There is insufficient storage area and volume to prevent flooding from any larger storms. Flood ponding times are expected to be improved for very small storms.

In Alternative 2, the frequency of roadway flooding is expected to be slightly better than Alternative 1, however it is difficult to quantify this improvement as the effect of low flow pumping (2 cfs average flow rate) is insignificant compared to the rate of inflow from rain events. Both low flow and emergency pumping could reduce the long-term flood durations to less than 1 day after larger rainfall events.

Table 11. Projected depth of roadway flooding and time to recede for Project Area 12

Event	Existing WSEL	Alt-1 WSEL	Alt-2 WSEL
4-MONTH	1.53	1.35	0.89

Project Area #13 – Old Oregon Inlet Road – East Hardgrove St to Fire Station

Problem Statement

Flooding along the east side of Old Oregon Inlet Road for prolonged periods after small and large rainfall events. Saturated soils and high groundwater was noted during the site visit.

Existing Constraints and Design Considerations

High groundwater elevation and sensitive natural areas near the project site limit the design options and the ability to release concentrated stormwater or construct new stormwater outfalls west of the roadway. There are no significant swales or ditches in the project area.

Project Area 13 Conceptual Designs

Conceptual Design Alternative #1 – Install french drains in the project area and pump groundwater to an area near the fire station.

Goal: Improve local infiltration and dewater area using low flow groundwater pumps

Assumptions: Existing utilities would not pose significant conflicts and permits could be obtained to allow for the discharge of the pump system.

Design: 2,050 lf of shallow french drain (5' wide, 1'-2' deep) and perforated pipe, new catch basins and wells, 3,100 lf of forcemain

Preliminary Engineer's Cost Opinion: **$225,000 – 275,000**

Conceptual Design Alternative #2 – Expand scope of Alternative 1 to include additional french drain

Preliminary Engineer's Cost Opinion: **TBD based on extent of additional french drain**

Project Area 13 Preliminary Results

Under existing conditions localized standing water is to be anticipated after all measurable rainfall events. Installation of the system would improve dewatering times (often reduced to less than 1 day following rainfall) and sufficient storage could be installed to eliminate roadway flooding for storms less than 1.5" of total rainfall.

Table 12. Projected depth of roadway flooding and time to recede for Project Area 13

Event	Existing WSEL	Alt-1 WSEL
4-MONTH	1.55	0.67

Upcoming Work

WithersRavenel intends to compile conceptual design alternatives into 1-page exhibits for each project area to graphically represent design goals and results.