FIELD ENGINEERING CO., INC.
CONSULTING ENGINEERS

11D Industrial Drive, P.O. Box 1178
Mattapoisett, Massachusetts 02739
Telephone: (508) 758-2749
Facsimile: (508) 758-2849

February 3, 2022
Project No. 2443

Mr. Richard Swenson, Chairman
Town of Wareham Planning Board
Memorial Town Hall
54 Marion Road
Wareham, MA 02571

Subject: **WAREHAM - Response to Peer Review Report #1 Comments**
Shell Point Place Definitive Subdivision Plan
Great Neck Road, Wareham, MA

Dear Mr. Swenson:

Field Engineering Co., Inc. has received the initial Peer Review Report prepared by Charles L. Rowley, PE, PLS for the Town of Wareham Planning Board dated 12/6/2021 and has prepared the following responses to comments for consideration by the Planning Board.

General

1. The project is located in the R-30 zoning district requiring a minimum lot size of 30,000 square feet and a minimum frontage dimension of 150 feet.

FEC Response: Statement of fact. No response needed.

2. Section 615, Lot Shape Factor of the Zoning By-Law requires a circle of diameter equal to the minimum frontage be shown for each lot. Lots 2 and 3 of the six lots shown appear to meet this requirement. The other four lots do not.

FEC Response: The side lines of Lots 4, 5, and 6 have been adjusted to accommodate the 150-foot diameter Lot Shape Circle on the Exhibit Plan dated 12/14/2021. The applicant is seeking a waiver to allow a 140-foot Lot Shape Circle on Lot 1. Refer to the Amended Request for Waivers letter revision dated 12/14/2021 and submitted to the Planning Board on 12/14/2021. A copy of the Amended Request for Waivers letter is submitted in the Appendix of this Report.

3. The proposed road layout width of 40 feet is compliant with Section 5, Design Standards of the Rules and Regulations for minor residential streets. Pavement with is shown as 22 feet including 12" Cape Cod berms on both sides of the pavement. Travel surface is 20 feet.

FEC Response: Statement of fact. No response needed.

4. Since the project makes a connection with Great Neck Road, a town way, a curb cut permit will be required from Municipal Maintenance.

FEC Response: The applicant will apply for a Curb Cut Permit from Municipal Maintenance prior to the commencement of construction.

5. The plan did not evolve from a preliminary plan. Therefore, the Board has 135 days to vote to approve, approve with modification, or disapprove the plan from the date of filing.

FEC Response: Statement of fact. No response needed.

Plans
Sheet 3 of 8, EC-1

1. This sheet shows existing conditions which includes an existing dwelling, garage and shed. It is assumed that these structures would be removed if a subdivision plan is approved.

FEC Response: These structures will be removed as noted on Sheet GD-1 Grading & Drainage Plan.

2. The subject property adjacent to Great Neck Road is in a mapped flood zone AE-14. A wetlands line has been shown on the opposite side of Great Neck Road from the property. This line has not been field checked according to note 7 on Sheet 4 of 8, L-1.

FEC Response: The wetland line shown on Lot 1004.A Map 18 N/F Perched, Inc. was derived from MassGIS mapping data and is not the result of an actual on the ground wetland delineation. The applicant does not own Lot 1004.A and therefore does not have right of entry on the property. We acknowledge a portion of the proposed roadway and stormwater management basin on Lot 1 lies within the 100-foot buffer zone to this wetland system on the adjacent property. A Notice of Intent application has been filed with the Conservation Commission concurrently with the Form C submission to the Planning Board.

3. Prior to any work commencing within the mapped flood zone or within 100 feet of a wetlands, a filing will be required for submission to the Wareham Conservation Commission.

FEC Response: A Notice of Intent application has been filed with the Conservation Commission concurrently with the Form C submission to the Planning Board.

Sheet 4 of 8 Lotting Plan, L-1

1. Lots, 1, 4, 5, and 6 do not comply with Section 615 of the Zoning By-Law for lot shape but Section 615 gives the Board latitude to adjust the minimum dimension if it so chooses.

FEC Response: The side lines of Lots 4, 5, and 6 have been adjusted to accommodate the 150-foot diameter Lot Shape Circle on the Exhibit Plan dated 12/14/2021. The applicant is seeking a waiver to allow a 140-foot Lot Shape Circle on Lot 1. Refer to the Amended Request for Waivers letter revision dated 12/14/2021 and submitted to the Planning Board on 12/14/2021. A copy of the Amended Request for Waivers letter is submitted in the Appendix of this Report.

2. The length of the proposed street meets the requirements of Section 5, C,5 of the Rules and Regulations. The cul-de-sac diameter also meets the requirements of a minimum of 120 feet.

FEC Response: Statement of fact. No response needed.

3. Note 2 on the plan needs clarification as no easements can be conveyed without town meeting action to accept the proposed street as a town way.

FEC Response: Note 2 has been reworded as follows:

Lots 1 and 2 are subject to Utility / Access easements to be conveyed to the Town of Wareham upon Town Meeting acceptance of the proposed roadway and stormwater infrastructure.

Sheet 5 of 8, Grading and Drainage, GD-1

1. The plan shows that there is a substantial grade change from Great Neck Road upward toward the rear of the property.

FEC Response: Refer to FEC Response to Comment 3 on Sheet 6 of 8, Plan and Profile, P-1 on Page 5 of this Report.

2. Drainage of the proposed road surface has been divided into two sections;
   a. Cul-de-sac and 200 feet of road surface along with abutting ground and roofs from potentially 4 dwellings,
   b. Approximately 280 feet of road surface and potentially 2 dwellings.

FEC Response: Statement of fact. No response needed.

3. Runoff calculations appear to show that roof areas have been included in the impervious surfaces of each sub-catchment area but that there are no potential paved driveways shown. This should be clarified to indicate what portion of the total impervious surfaces of the calculations are dedicated to roofs and driveways. It would also be helpful to know how much of the remaining lot areas are dedicated to lawns or areas of moderate runoff potential.

FEC Response: We have reviewed and revised the Post Development Hydrologic Calculations to clarify the breakdown of impervious surfaces in each subcatchment are and these revised calculations are presented in the attached Stormwater Management System Report Addendum 1. We have also added the linework and notation designated the approximate limits of clearing on each lot that were assumed to be lawn areas in the hydrologic model to the revised Post Development Watershed Plan. It should also be noted that we have assumed that the roof drains from each proposed dwelling will be handled be appropriately sized infiltration systems on each lot such that they will not be contributing runoff to the roadway drainage system. We trust that the information provided in the Stormwater Management Report Addendum 1 will adequately address this comment.

4. The upper drainage system consists of leaching chambers and stone. The system is at capacity at the 25-year storm and overflows most runoff to the infiltration basin at the street intersection. It is recommended that the system be re-sized to contain the runoff from the 25-year storm without overflow.

FEC Response: We have reviewed and revised the sizing of the upper drainage system to capture additional runoff and minimize the overflow in the 25-year storm without the need for an excessive number of leaching pits. We have increased the number of leaching pits from 7 to 12 in the revised model calculations. As the revised Post Development Hydrologic Calculations show, over 75% of the runoff volume from the upper drainage system will now be retained and infiltrate into the ground with the leaching pit system (Only 34% of the runoff volume was retained in the original analysis for the 25-year storm).

5. The drainage basin shown at the intersection of the proposed road and Great Neck Road collects runoff from possibly two dwelling roofs, driveways, lawn and grass areas, 280 feet of road surface and other natural cover including the infiltration basin itself. It also receives overflow runoff from the upper drainage area. It appears to contain up to and including the 25-year storm event. However, it is overtopped for the 100-year storm event and discharges to Great Neck Road and two adjacent catch basins.

FEC Response: As previously mentioned, we have reviewed and revised the design of the upper drainage system to retain and infiltrate significantly more runoff than the original submittal. The drainage basin will contain and infiltrate up to the 25-year storm event and will have minimal flow through the overflow spillway in the 100-year storm event while maintaining over one foot of freeboard within the basin. As noted in Table 1.5 of the attached Stormwater Management System Report Addendum 1, there is an anticipated reduction of 73.1% in the rate of runoff and 61.4% in the volume of runoff to the Greak Neck Road drainage system.

6. The stormwater regulations require that impacts from the 100-year storm event will not adversely affect abutting properties. No evidence has been presented to show that allowing overflow to Great Neck Road will not adversely impact public safety or the capacity of the catch basins to adequately handle the runoff. Input from the Municipal Maintenance Department is recommended.

FEC Response: As previously mentioned, we are achieving a significant reduction in the rate and volume of runoff towards Great Neck Road and the underlying drainage system in the 100-year storm event. Given the significant reduction, we feel confident that allowing the minimal overflow from the drainage basin will not adversely impact public safety or the capacity of the existing catch basins.

A complete hard copy of this submittal has been submitted to the Highway Department for review and comment on 2/3/22. A representative from Field Engineering will follow up with the Director of Municipal Maintenance prior to the next scheduled public hearing with the Planning Board.

7. Structures and pipe should be labeled on the plan view of the drainage system.

FEC Response: Structure numbers and pipe diameters have been labeled on Sheet GD-1.

Sheet 6 of 8 Plan and Profile, P-1

1. A water quality inlet is shown for the infiltration area near the street intersection but none is shown for the system involving the subsurface infiltration system at Station 3+ 0. Please explain.

FEC Response: pursuant to the current DEP Stormwater Management Policy, a minimum TSS removal rate 44% is the recommended pre-treatment for any discharges to an infiltration system. Applying the 25% TSS removal credit to the deep sump catch basins and the oil water separator manholes at station 3+00

results in a 44% TSS removal prior to discharge into the leaching pits. A water quality inlet with a higher degree of pollutant removal was the selected pre-treatment device to capture and treat the lower portion of the proposed roadway and any potential stormwater bypass from the upper catch basins at station 3+00.

The overflow from the leaching pit system will achieve an 89% TSS removal through the treatment train to the outfall at the lower infiltration basin. The discharge out of the water quality inlet will achieve an 85% TSS Removal at the lower infiltration basin. The overflow to the existing catch basin on Great Neck Road will achieve a 97% TSS Removal Rate under any condition.

2. Confirm with the Wareham Fire Dept. that three hydrants are needed for the project. Hydrant layout is typically 500 foot spacing. Where is the nearest existing hydrant on Great Neck Road?

FEC Response: The proposed extension of the water main off Great Neck Road and number of hydrants have been approved by the Wareham Fire District. Refer to Wareham Water Department letter dated 1/25/2022 and Wareham Fire Department letter dated 1/26/22. Copies of these letters are submitted in the Appendix of this report.

3. It is recommended that the road profile be reviewed to see if it is possible to lower the centerline grade to 2% approaching Great Neck Road rather than 4% as proposed. This would increase the grade slightly from station 0 + 40 to station 3 + 50.

FEC Response: Our office has reviewed the roadway profile in this area and note the following:

1. ***The elevation of the roadway in the vicinity of CB 1&2 has been established by the bottom elevation of the Infiltration Basin which has been set at 3-feet above the observed maximum groundwater elevation in Test Pit #1. A one-foot safety factor to the minimum 2-foot separation requirement has been incorporated into the design to ensure proper drainage within the basin.***
2. ***In order to capture as much of the roadway runoff as possible into the Infiltration Basin and to ensure a proper fit and pipe cover at CB 1&2, the specified road grade at these structures should be maintained.***
3. ***The specified profile grade is well within the operational limits of the recommended ground clearance geometry in the National Cooperative Highway Research Program (NCHRP) Report 659 Guide for the Design of Driveways. Using a Passenger Design Vehicle, the maximum profile grade change is limited to 9.0% per Exhibit 5-68 of the NCGRP Report. The proposed profile grade change is 4.8 % which is the sum of the existing transverse slope on Great Neck Road at the centerline intersection measured in the field at 0.80% and the proposed profile grade. Excerpts of the NCGRP are submitted in the Appendix of this report.***
4. ***Field measurements and pavement observations were obtained from a similar subdivision roadway designed by our office and constructed in 2007 to assess the functionality of the roadway grading. Godfrey Circle is a 7-lot subdivision located off Plymouth Street in Carver. Profile measurements on Godfrey Circle at the intersection with Plymouth Street varied between 3.5 % and 4.5%. The profile at the centerline intersection was measured at 4.0% The transverse slope measurements on Plymouth Street at the centerline intersection was measured at 1.1%. The maximum profile change at the centerline was measured at 5.1% which is reasonably close to the proposed condition on Shell Point Place. There was no evidence of vehicular chafing or plow damage observed on the pavement***

of either street. The As-Built Plan Godfrey Circle and photos of the intersection grade measurements and pavement are submitted in the Appendix of this report.

4. The Datum Elevation at the beginning of the profile stationing should be Elevation 0 rather than Elevation 2.

FEC Response: The Datum Elevation has been corrected as noted.

5. It is recommended that the electric system boxes shown on the plan not be located so as to interfere with the proposed sidewalk. Small easement areas behind the sidewalk at the lot corners would be preferable.

FEC Response: The electric boxes have been relocated outside of the right-of-way as noted.

6. Maximum stone size in road base gravel should be 3 inches for a 6" thick layer of material. The 2" stone size for the upper layer is satisfactory.

FEC Response: The gravel specification has been changed to Type B Gravel Borrow (3-inch maximum stone size) on the Typical Cross Section as noted.

Sheet 7 of 8 Detail Sheet, D-1

1. Show all structures with a 12" thick by 12" wide cement concrete ring that surrounds the casting and riser. Bring the surface of concrete level with the top of the binder course of pavement.

FEC Response: Cement concrete rings are specified on the manhole, catch basin, double catch basin, oil water separator manhole and leaching pit details on Sheets D-1 and D-2 as noted

2. All pipe in and out of structures should be mortared in place inside and outside the structure.

FEC Response: Non-shrink grout on the inside and outside of the structures are specified on the manhole, catch basin, oil water separator manhole and leaching pit details on Sheets D-1 and D-2 as noted.

3. The Catch Basin Detail should show the gas/oil trap as extending a minimum of 12" below the flow line of the outlet pipe.

FEC Response: The Catch Basin Detail has been edited to show an HDPE tee on the outlet pipe extending 12-inches below the flow line as noted.

4. The Flared End Detail should show stone extending under and in back of the flared end a distance of 2 feet to prevent scouring. The splash block would not be required. Identify the stone size as referenced by the MDOT spec. Maximum size should be half the depth of the stone layer. Filter fabric is recommended under the stone.

FEC Response: The Flared End Detail has been edited as noted.

Sheet 8 of 8 Detail Sheet, D-2

1. Specify dry wells to be H-20 design.

FEC Response: The Stormwater Recharge System Detail has been edited as noted.

2. Castings on dry wells (leaching pits) should be secured with cement concrete in a similar manner to those for catch basins.

FEC Response: Cement concrete rings are specified on the manhole, catch basin, double catch basin, oil water separator manhole and leaching pit details on Sheets D-1 and D-2 as noted

3. All piping between dry wells should be mortared in.

FEC Response: Non-shrink grout on the inside and outside of the structures are specified on the manhole, catch basin, oil water separator manhole and leaching pit details on Sheets D-1 and D-2 as noted.

4. A notation should be placed with the detail for Infiltration Basin #1 that the sand at the bottom should connect directly with the sand identified in Test Pits #1 and #2. Excavation of the top layers of material may be required.

FEC Response: Agreed. Construction quality control notes for the verification of soil conditions and backfill requirements within the leaching pit area has been added to the leaching pit detail.

Stormwater Report

The stormwater report contains the Long-term Maintenance plan for the project after completion. There is no reference to an Operation and Maintenance plan for the construction phase of the project. This should be incorporated into the project as a condition of approval.

FEC Response: A Notice of Intent for coverage under the Massachusetts PGP will be filed with the EPA. A complete Stormwater Pollution Prevention Plan (SWPPP) will be prepared prior to construction.

Calculations presented conform with accepted practice except where noted above for additional information to confirm conditions.

FEC Response: Statement of fact. No response needed.

Other Comments

The plan indicates that a covenant will be provided as security for the road construction. The covenant should be presented to the Board for review and signature. The plan, if approved, can be signed after the expiration of the 20- day appeal period. Copies of the recorded plan and covenant should be submitted to the Planning Board for the file.

FEC Response: A Covenant will be submitted to the Planning Board prior to the recording of the Definitive Plan.

If you have any questions or need additional information, please contact me at our Mattapoisett Office at (508) 758-2749.

Very truly yours,
Field Engineering Co., Inc.

Kenneth J. Motta
Senior Project Manager

Reviewed by:

COMMONWEALTH OF MASSACHUSETTS
RICHARD R. RICCIO III
CIVIL
No. 45898
REGISTERED PROFESSIONAL ENGINEER
2/3/2022

Richard R. Riccio, P.E.

cc: David Andrade, Applicant
Dave Pichette, Wareham Conservation Commission
Dave Menard, Director Municipal Maintenance

Appendix Documents

1. Amended Request for Waivers letter dated 12/14/21
2. Wareham Fire District letter dated 1/25/22
3. NCHRP Report 659 – Guide for the design of Driveways (Excerpt pages)
4. Godfrey Circle Pavement Assessment Photographs
5. Godfrey Circle As-Constructed Plan & Profile Drawing dated 10/30/07

Godfrey Circle View North from Plymouth Street

Godfrey Circle Approach Grade
at Centerline View West

Godfrey Circle/Plymouth Street View East

Plymouth Street Transverse Slope View West

Plymouth Street Pavement View South

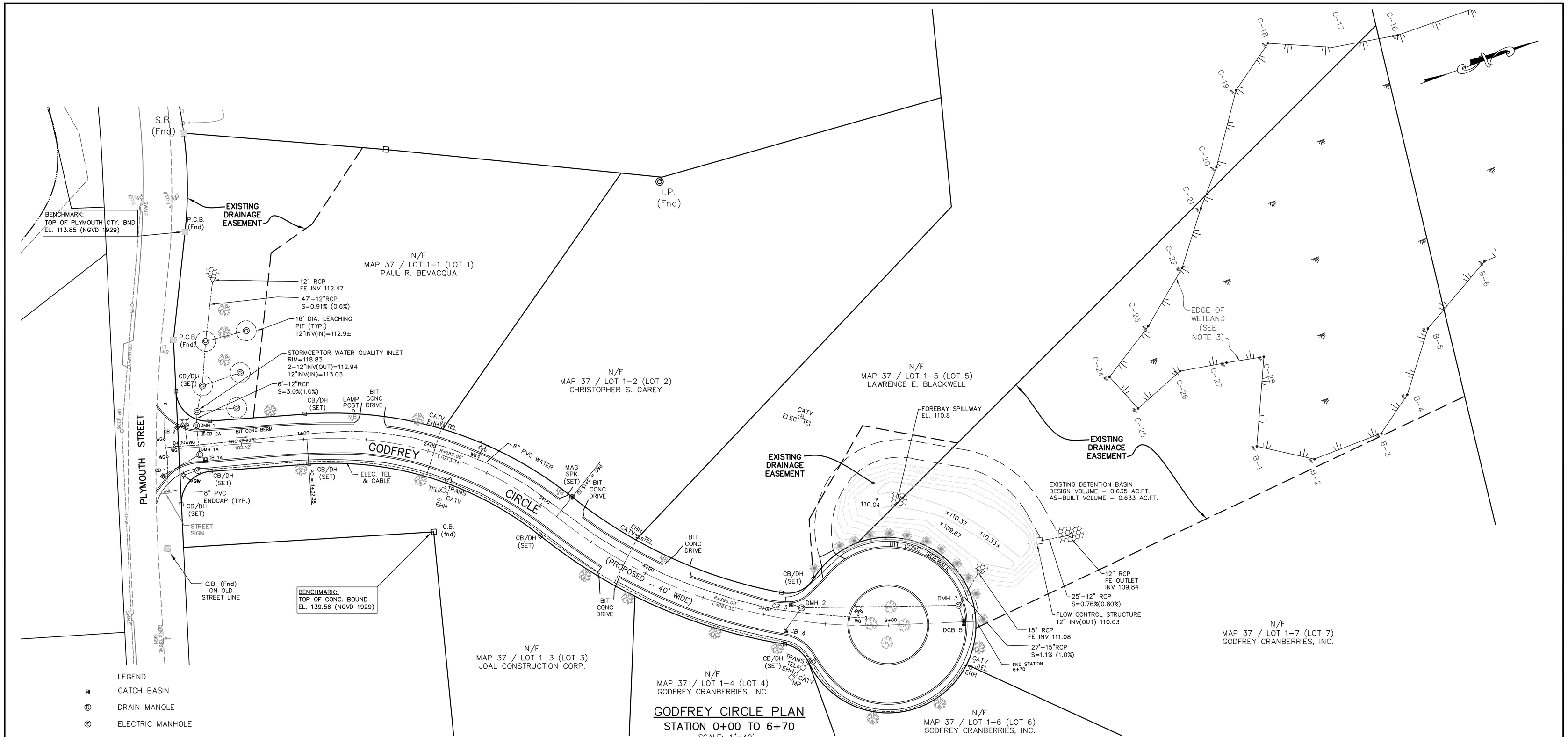
Plymouth Street Pavement View South

Godfrey Circle Approach Grade View East

Godfrey Circle Pavement West Side View North

Plymouth Street Transverse Slope at Centerline View East

Great Neck Road Transverse Slope at Centerline View East



LEGEND

- CATCH BASIN
- DRAIN MANOLE
- ELECTRIC MANHOLE
- WATER
- U.G. ELEC/TEL/CATV
- STREET TREE
- ROADWAY MONUMENT FOUND
- CONCRETE BOUND W/ DH SET
- EHH, MP, CATV,TEL — ELEC. HANDHOLE, ELEC. METER PEDESTAL, CABLE TV PEDESTAL, TELEPHONE PEDESTAL

I CERTIFY THAT THE LINE AND GRADE OF THE ROADWAY UTILITIES AND SURFICIAL ROADWAY IMPROVEMENTS SHOWN ARE IN SUBSTANTIAL COMPLIANCE WITH THE GODFREY WOODS DEFINITIVE SUBDIVISION PLAN DATED 12/12/02 AND APPROVED BY THE CARVER PLANNING BOARD ON 12/17/02 TO THE EXTENT SHOWN ON SAID PLANS.

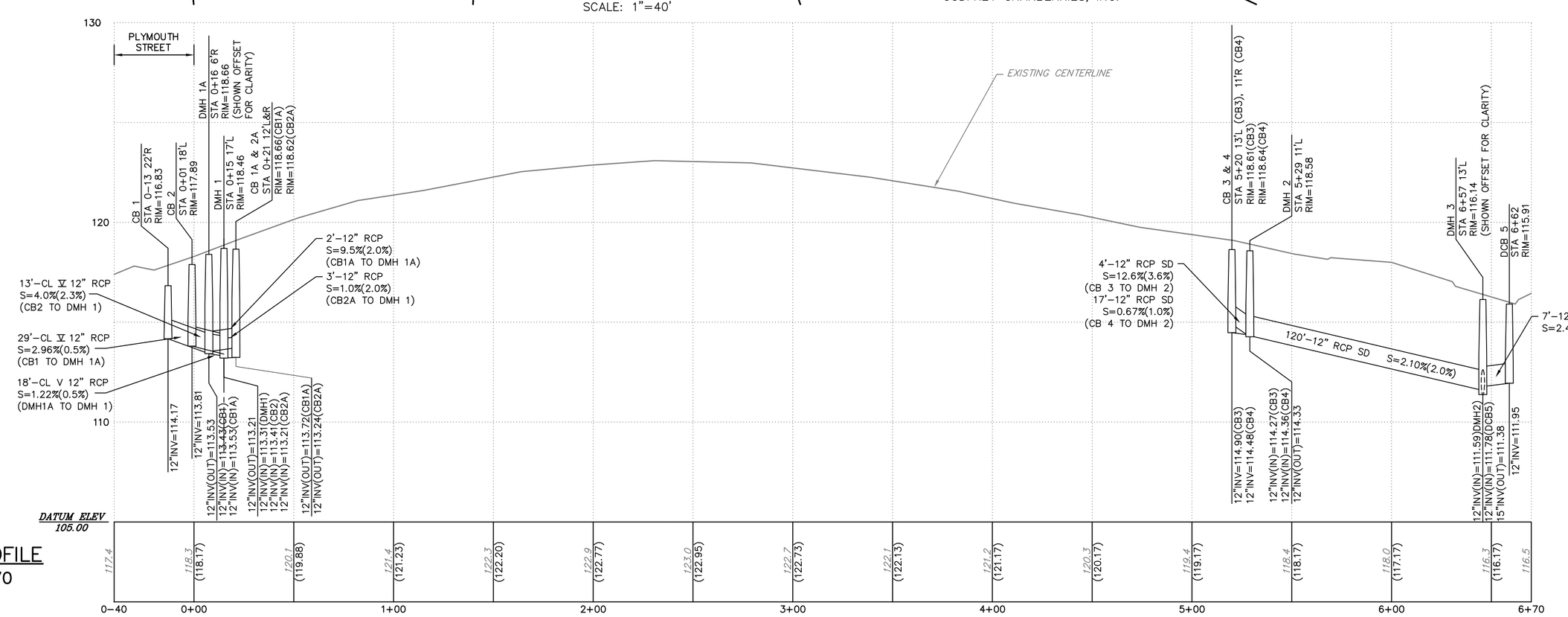
DATE REGISTERED PROFESSIONAL ENGINEER

I CERTIFY TO THE BEST OF MY PROFESIONAL KNOWLEDGE, INFORMATION AND BELIEF THAT THESE PLANS ARE A TRUE AND ACCURATE REPRESENTATION OF THE ROADWAY INFRASTRUCTURE AND TOPOGRAPHY INCLUDING INVERTS, ELEVATIONS AND LOCATIONS.

DATE REGISTERED PROFESSIONAL LAND SURVEYOR

907-ASBUILT

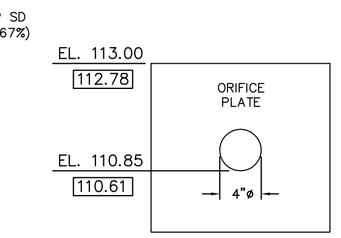
GODFREY CIRCLE PLAN
STATION 0+00 TO 6+70
SCALE: 1"=40'



GODFREY CIRCLE PROFILE
STATION 0+00 TO 6+70
SCALE: 1"=40' HORIZONTAL
1"=4' VERTICAL

NOTES:

1. TOPOGRAPHIC AND AS-BUILT INFORMATION WERE OBTAINED BY AN ACTUAL ON THE GROUND SURVEY BY CULLINAN ENGINEERING CO. INC. ON AUGUST 27, 2004 AND OCTOBER 20, 2007.
2. THE BOUNDARY OF THE WETLAND RESOURCE AREAS SHOWN ON LOTS 1-7 HAS BEEN FIELD DETERMINED BY RENE DROUIN OF WETLAND CONSULTING SERVICES INC ON 9/01 AND FIELD LOCATED BY EARTH TECH, INC. THE BOUNDARIES OF THE WETLAND RESOURCE AREAS ON LOTS 1-7 HAVE BEEN VERIFIED TO BE ACCURATE BY THE CARVER CONSERVATION COMMISSION ON NOVEMBER 1, 2002.
3. DRAINAGE EASEMENTS SHOWN ON LOTS 1, 5 AND 7 ARE TO BE CONVEYED TO THE TOWN OF CARVER UPON ACCEPTANCE OF THE GODFREY CIRCLE ROADWAY.



FLOW CONTROL STRUCTURE AS-BUILT DETAIL

1. FIGURES SHOWN AS 110.61 DENOTE AS-BUILT ELEVATIONS

40 0 20 40 80
SCALE: 1 INCH = 40 FEET

FIELD ENGINEERING CO., INC.
CONSULTING ENGINEERS

11D INDUSTRIAL DRIVE
P.O. BOX 1178
MATTAPOISETT, MA 02739
TEL: (508) 758-2749
FAX: (508) 758-2849

THE CROCKER BUILDING
4 COURT STREET SUITE 104
TAUNTON, MA 02780
TEL.: (508) 824-9279
FAX: (508) 824-9276

Revisions

No.	Description	Date	Appvd.

Date: 10/30/07

Scale: AS SHOWN

Drawn By	Designed By	Checked By

Issued For: CERTIFICATE OF COMPLETION

AS-CONSTRUCTED ROADWAY PLAN
GODFREY CIRCLE
CARVER, MASSACHUSETTS

PREPARED FOR: GODFREY CRANBERRIES, INC.

Drawing Title: PLAN & PROFILE

Project No.	Sheet
907	1 OF 1

Sheet No. 1

FIELD ENGINEERING CO., INC.
CONSULTING ENGINEERS

11D Industrial Drive, P.O. Box 1178
Mattapoisett, Massachusetts 02739
Telephone: (508) 758-2749
Facsimile: (508) 758-2849

December 13, 2021
(Revised December 14, 2021)
Project No. 2443

Mr. Kenneth Buckland, Town Planner
Town of Wareham Planning Board
54 Marion Road
Wareham, MA 02571

RE: **WAREHAM - Amended Request for Waivers Letter**
Shell Point Place Definitive Subdivision of Land
69 Great Neck Road, Wareham, MA

Dear Members of the Board:

On behalf of the owner/applicant of record, David Andrade, we hereby request the following waivers from the current Planning Board Rules & Regulations Governing the Subdivision of Land and Zoning Bylaws of the Town of Wareham.

Planning Board Rules & Regulations Governing the Subdivision of Land

1. **Section IV.B.26. – Waiver to not require the preparation of a Street Light & Tree Plan.**

The applicant will work with the public utility provider to install an LED street light mast arm on the existing UP 24/52 on Great Neck Road to provide lighting at the intersection in accordance with of Section IV.D. For the remaining portion of Roadway A, the applicant is proposing to install two (2) driveway lanterns at each Lot under a Covenant to be recorded with the Subdivision Plan. The driveway lanterns will be wired to the electric service to each home and will be maintained by the individual homeowners.

With respect to Street Trees within the 40-wide right-of-way, the location of the underground utilities such as gas, electric, telephone and CATV, as well as the required 5-foot sidewalk on one side, does not leave sufficient area to locate trees. On the sidewalk side, the proposed gas service is within the 3-foot grass strip between the front of the sidewalk and the back of the asphalt berm. Most public utility companies do not allow trees or sidewalks over their utilities. There is no room on the sidewalk side of Roadway A to plant trees.

The electric, telephone, and CATV duct bank along with the utility pedestals and manholes will occupy most of the opposite shoulder. The location of the duct bank was governed by the location of the hydrants which share the same side of the road.

Zoning Bylaws of the Town of Wareham.

1. **Article 6 – Density and Dimensional Regulations**

Pursuant to Article 6 - Section 615, the Planning Board has the authority to waive certain elements of the Lot Shape Factor criteria if it is found that granting such relief would not be detrimental to the intent of the Shape Factor regulation.

The applicant is seeking a waiver to allow a 10 foot reduction in the required 150 foot diameter shape circle to 140 feet on Lot 1 as shown on the submitted Definitive Subdivision Plan. In support of the waiver request, we respectfully ask the Board to consider the following site specific circumstances.

1. It is our understanding the intent of Shape Factor criteria is to discourage gerrymandered or "pork chop" lots as well as marginal lots encumbered by excessive bordering vegetated wetland resource areas. Lot 1 as proposed, satisfies both the minimum area and frontage requirements of the Bylaw and is generally rectangular in nature. Direct vital access to the building envelope is available from the proposed subdivision roadway so it could not be considered a "pork chop" lot.

   Furthermore, there are no bordering vegetated wetlands on the lot or within the proposed building envelope. While, the southerly portion of the lot lies within a FEMA mapped coastal flood zone (Zone AE – Elevation 14.00), the average existing grade within the building envelope (Elev. 17.0 +/-) is well above the established base flood elevation. There is sufficient buildable upland area to allow the location of a 3-bedroom single family dwelling and septic system outside of the mapped Zone AE.

2. The location of the proposed subdivision roadway intersection at Great Neck Road has been established by the location of the existing shared driveway entrance to 71 Great Neck Road, N/F St. Jacques and the required 30 foot property line radius from the southwesterly corner of 67 Great Neck Road, N/F LeBlanc. Access to Lot 1 will be provided off of the subdivision roadway, so the existing shared driveway will no longer be needed. The portion of the existing shared driveway to 71 Great Neck Road will remain in service. We have maintained the maximum horizontal separation between the subdivision roadway intersection and the existing driveway to 71 Great Neck Road to offset any potential impacts to this adjacent property. A horizontal separation distance of about 128 feet has been provided between the centerlines of the existing driveway and the subdivision road.

   A conscious effort has been made to preserve an existing vegetated buffer strip between the easterly sideline of the roadway layout and the adjacent sideline to 67 Great Neck Road. The existing house at 67 Great Neck Road is about 25 feet off the common sideline so maintaining the vegetative screening was also a primary consideration in determining the location of the roadway. The geometry of the subject parcel is unique in that it is simply not wide enough to maintain a 150 feet depth on Lot 1 without sacrificing the vegetative buffer to 67 Great Neck Road.

In closing, we would note that an extensive effort has been put forth in the initial planning and design of this subdivision given the unique character of the subject parcel and the surrounding neighborhood. Primary consideration has been given to the minimization of impacts to the surrounding properties. The resultant design is one which best fits the existing site conditions in keeping with requirements of the Rules and Regulations and the Bylaws. The granting of the requested waivers would not be detrimental to the adjacent properties and would be consistent with the intent of the current Rules and Regulations and the Zoning Bylaws of the Town.

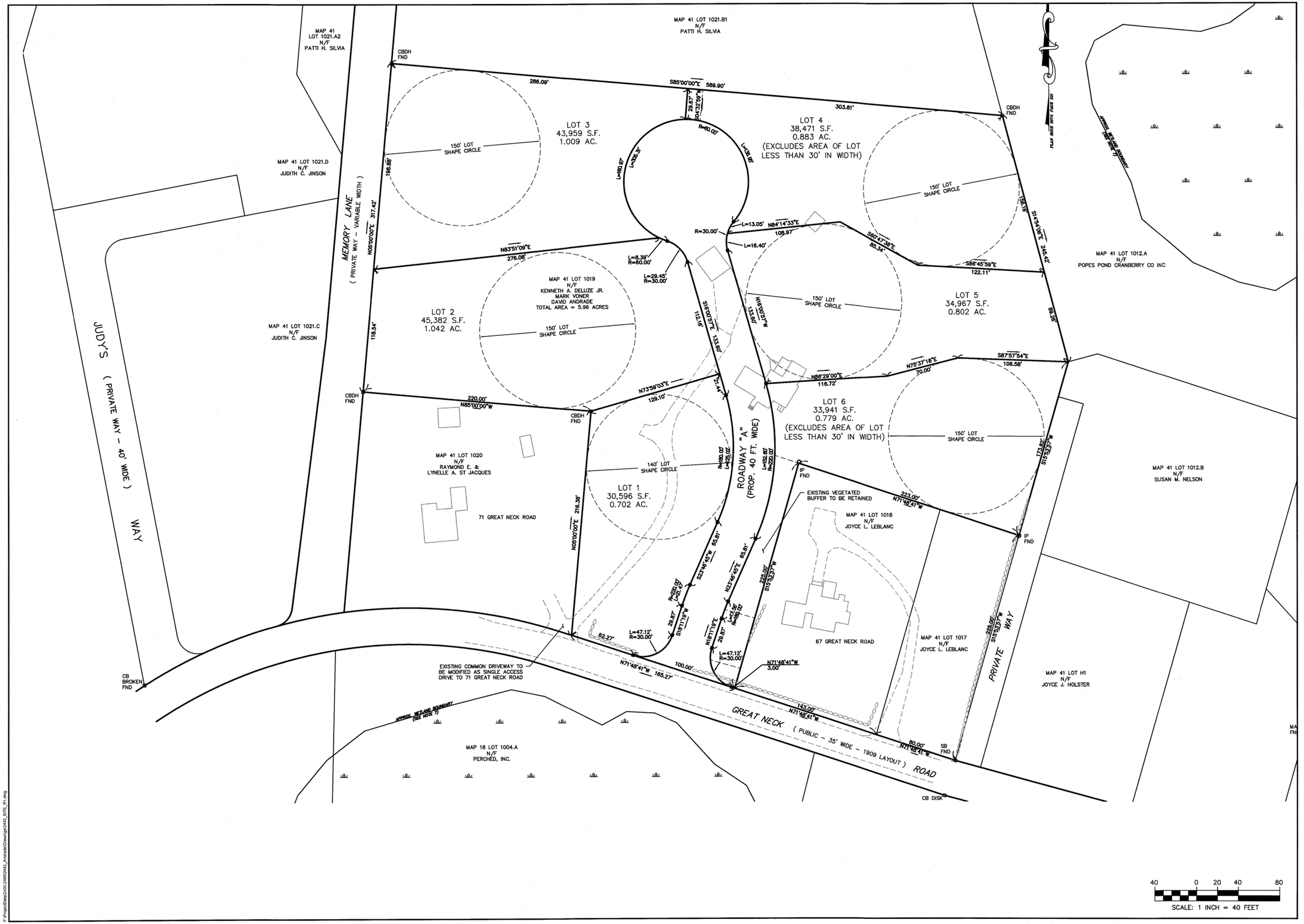
If you have any questions or require additional information, please contact me at (508) 758-2749.

Very truly yours,
Field Engineering Co., Inc.

Kenneth J. Motta
Senior Project Manager

cc: David Andrade, Applicant

Attachments: Exhibit Plan – Shell Point Place dated 12/13/2021 & revised 12/14/21



FIELD ENGINEERING CO., INC.
CONSULTING ENGINEERS

11D INDUSTRIAL DRIVE
P.O. BOX 1178
MATTAPOISETT, MA 02739
TEL: (508) 758-2749
FAX: (508) 758-2849

Revisions			
1	REVISED PER PUBLIC HEARING	12/14/21	KJM
No.	Description	Date	Appvd

Date: 12/13/2021

Scale: 1"=40'

Drawn By	Designed By	Checked By
PGT	KJM	RMF

Issued For: PERMITTING

EXHIBIT PLAN
SHELL POINT PLACE
DAVID ANDRADE

69 GREAT NECK ROAD
WAREHAM, MASSACHUSETTS

Drawing Title: EXHIBIT PLAN

Project No.	Sheet
2443	1 OF 1

Sheet No.: EX-1

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January 26, 2022

Town of Wareham Planning Board
C/O Kenneth Buckland
54 Marion Road
Wareham MA 02571

RE: Shell Point Place

Dear Planning Board Members,

The Wareham Fire Department has reviewed the proposed subdivision plan for Shell Point Place and have the following comments:

1. The number of fire hydrants and spacing is more than sufficient for the proposed subdivision.
2. The proposed road width with cape cod berm on both sides will be wide enough for responding fire department apparatus to navigate this neighborhood.

If you have any additional questions regarding this project, feel free to contact our office.

Respectfully,

Captain Christopher Smith
Fire Prevention

Captain James Brandolini
Fire Prevention

WAREHAM FIRE DISTRICT

WATER DEPARTMENT

2550 CRANBERRY HIGHWAY, WAREHAM, MA 02571

Phone (508) 295-0450 Fax (508) 291-2737

January 25, 2022

Field Engineering Co.
Attn: Ken Motta
11D Industrial Drive
PO Box 1178
Mattapoisett, MA 02739

RE: Plan Review – ***Proposed definitive subdivision plan for proposed Shell Point Place (located at 69 Great Neck Rd)***

1. Comments per Site Development Plan date 10/7/21. By Field Engineering Co.
2. The project is off an existing 12-inch Ductile Iron water main within Great Neck Rd
3. Plan shows the proposed development as: ***Approximately 565 feet of additional 8" water main to service the 6 new residential homes. Three (3) additional hydrants are shown at acceptable spacing. The existing 1" domestic service for 69 Great Neck Rd must be abandoned at the water main. This can be done the same time as the new 8" tap.***
4. Developer will confirm the need for any additional on-site fire hydrants from the Wareham Fire District Fire Department.
5. Property will be served only by Domestic water and hydrants. No Irrigation service is assumed proposed at this time.
6. A dual spring check valve backflow device is required on each residential domestic service.
7. If applicable a testable Dual Check Valve Assembly (DCVA) or Reduced Back Pressure-Zone (RPZ) backflow protection device is required on each commercial/business building, type required device installed will be dependent upon the potential hazards at each location.
8. If applicable all RPZ device installations must include the means to catch water and properly divert that water to a floor drain or other designated location from the bottom of the device. This is required for routine testing procedures and for control of water within the facility.
9. All new water infrastructure installations shall comply with the ***Wareham Fire District (WFD) Rules & Regulations*** *adopted February 11, 2002, Updated December 2021.* Document can be found at ***http://www.warehamfiredistrict.org/***
10. **Please note the following section of the *WFD Rules and Regulations*: Section 4.0 - WATER MAIN MATERIALS**

    All water main materials used within the WFD system shall conform to ANSI/AWWA standards, and where applicable, have National Sanitary Foundation approval. All material must be installed as to have no leakage under 150 pounds hydrostatic pressure. In general, the WFD has standardized on lead-free materials and ductile iron for pipe and fittings. Cast iron fittings shall not be accepted.

PIPE: All water main pipe shall be buried at a depth of no less than 4.5 feet and not more than 6 feet deep and conform to one of the following standards:

a) **District owned water mains**: Class 52 (or better) or pressure class 350 North American made cement lined ductile iron pipe. Pipes will be manufactured by McWane Ductile, US Pipe, American Pipe, or approved equal. ii. Pipe shall meet the latest revision of the following standards:

ANSI/AWWA C104/A21.4 Cement - Mortar Linings ANSI/AWWA C105-A21.5 Polyethylene Encasement for Ductile Iron Pipe ANSI/AWWA C110/ A21.10 Ductile-Iron and Grey-Iron Fittings, 3 Inch Through 48 Inch for Water ANSI/AWWA C111/A21.11 Rubber - Gasket Joints ANSI/AWWA C115/A21.15 Flanged Pipe ANSI/AWWA C150/A21.50 Design ANSI/AWWA C151/A21.51 Water Pipe ANSI/AWWA C153/A21.53 Fittings - Ductile Iron ANSI/AWWA C600 Installation

iii. All products shall be constructed of ductile iron. Cast iron products are only acceptable if written permission is provided by the WFD. iv. Exterior of pipe shall be provided with zinc coating as follows: i. Consists of a layer of arc applied or paint applied, 99.99% pure zinc coating having a mass of 200g/m^2. ii. Has a finish layer of standard shop applied bituminous paint in accordance with AWWA C-104. iii. Pipe markings shall include the word "Zinc" in the pipe markings or label required by AWWA C-151 and/or other markings as deemed appropriate by the manufacturer. iv. Shall comply with all applicable parts of ISO 8179 for zinc coatings. v. Minor scratches in the zinc coating will not need to be repaired due to the self-healing nature of zinc coatings but larger areas shall be repaired by field application of a zinc rich paint in accordance with ISO 8179.

b) **Private owned mains - Beyond District owned gate valves**: Material listed in paragraph a) above or ii. C-900 DR-14 PVC (Permitted only beyond District owned gate valves) i. Where organic contaminants exist (e.g. petroleum) in the soil that are not compatible providing safe water with PVC pipe, PVC pipe shall not be used. In such situations only ductile iron pipe shall be acceptable. iii. Fittings shall be ductile iron.

c) **Pipe Laying Conditions**: Pipe laying conditions shall be Type 5 (Table 1).

g) **Restraining System**: All pipes shall be restrained. Restraints shall be provided by Sure Stop 350 gaskets (Gripper) for sizes 3 inch to 24 inches in diameter and TR Flex over 24 inches in diameter or equal by approved manufacturers (Field Lok 350, Fast grip). Where soil is believed to provide the necessary friction for restraint, permission shall be obtained by the WFD in writing and calculations by certified by a professional engineer in the state of Massachusetts shall be provided. Thrust blocks or mechanical joint restraints can be provided as described below are acceptable alternatives where appropriate

11. In conjunction with the ***Wareham Fire Department,*** we request hydrant spacing meet no greater than 300-foot spacing for "high hazard" occupancies and 500-foot spacing otherwise. Final determination on the need for additional hydrants and their location will be determined by the Wareham Fire Department.
12. Plan shows the proposed hydrants approximately 450-500 feet away from the existing hydrants east and west of the property.
13. All hydrants shall be Mueller Super Centurion traffic model hydrants. Hydrants shall have a gate valve attached to an anchoring tee. All hydrants and all gate valves shall be Open Left.
14. If needed the developer shall provide WFDWD with fixture count calculation per 248 CMR 10.14(4), and AWWA-M22 to validate service line and sizing of the domestic service water meter shall be adequate.
15. The cost of the first initial installed water meter for any ***Non-Residential*** service will be paid by the applicant. Selection of type/brand of the meter shall be determined by the Wareham Water Department. **** This meter cost is not shown in the estimated fees below.***
16. Plan shows landscaping improvements but no proposed irrigation system.
17. The property owner or their designee shall complete a "Water Service Application Card". Application cards are available at the Water Department office. All application and service fees shall be paid in accordance with the rate tariff in effect at the time of application. No work will begin until application fees are paid.

System Development Fee per 8-inch Connection	$ 21,419.69
System Development Fee per 1-inch Domestic Connection (5) at $809.93 Each – One credited for existing connection to #69 Great Neck Rd.	$ 4,519.45
System Development Fee per new Fire Hydrant (3) at $2954.44 each	$ 8,863.32
New Main Acceptance Testing Fee (Estimate Only – Invoiced later)	$ 1,500.00
Town of Wareham Excavation Permit per Trench Cut (Invoiced later)	$ 250.00
Refundable Warranty Deposit (Minimum)	$ NA

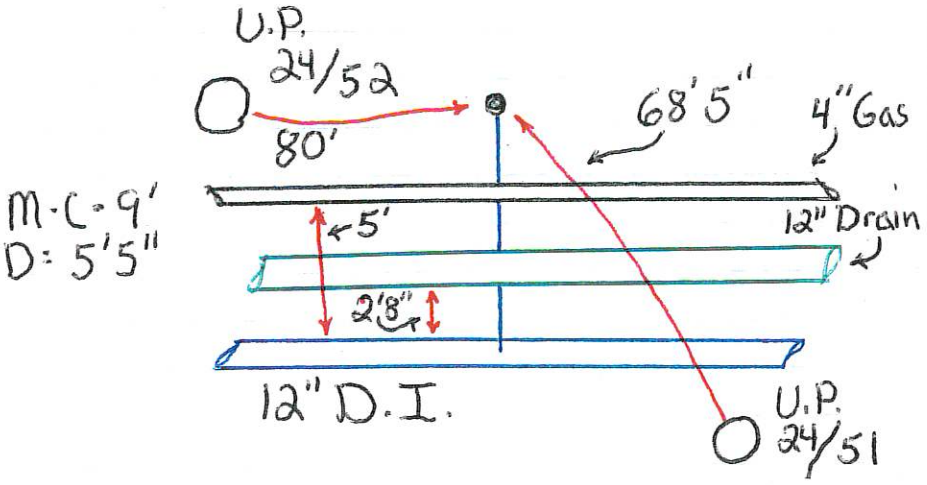
Total Estimated Fees: $ 36,552.46

Total Estimated Fees Due at the time of Application: $ 34,802.46

Andrew Cunningham
Water Superintendent
Wareham Fire District Water Department

cc: Town of Wareham Zoning
Town of Wareham Planning Board
Wareham Fire District Fire Department
Board of Water Commissioners (3)

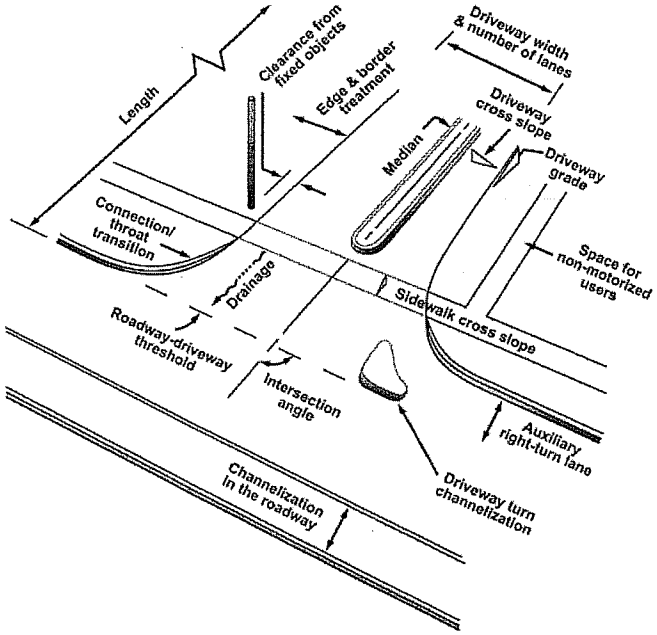
69 Great Neck Rd. 7-31-18 Acc 13-21210



NCHRP
REPORT 659

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Guide for the Geometric Design of Driveways



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

smaller radius than indicated in the turning dimensions and the turning templates provided in the current AASHTO Green Book (*3-2*, pp.16–43).

Underclearance or ground clearance is the distance from the bottom of the vehicle body to the ground (*3-7*). Ground clearance and wheelbase are critical dimensions at a crest situation. The ground clearance, in combination with either the front or rear overhang, is critical at sag situations. For example, rear-load garbage trucks may drag in the rear; therefore, rear overhang is the critical parameter. Car carrier trailers can drag in the rear or hang up between the wheels; therefore, either wheelbase or rear overhang may be critical. When the designer does not take these dimensions into account, the result can be vehicles dragging, scraping, and even becoming lodged on the vertical profile grade changes.

Although a designer can consult the AASHTO design policy for lengths, widths, overall heights, turning radii, and swept path templates for a menu of vehicle types, the policy does not include vehicle ground clearance or underclearance data. Exhibit 3-5 presents vehicle ground clearance dimensions. Note that dashes (—) in cells in the table indicate that hang-up problems are not expected on this part of the vehicle.

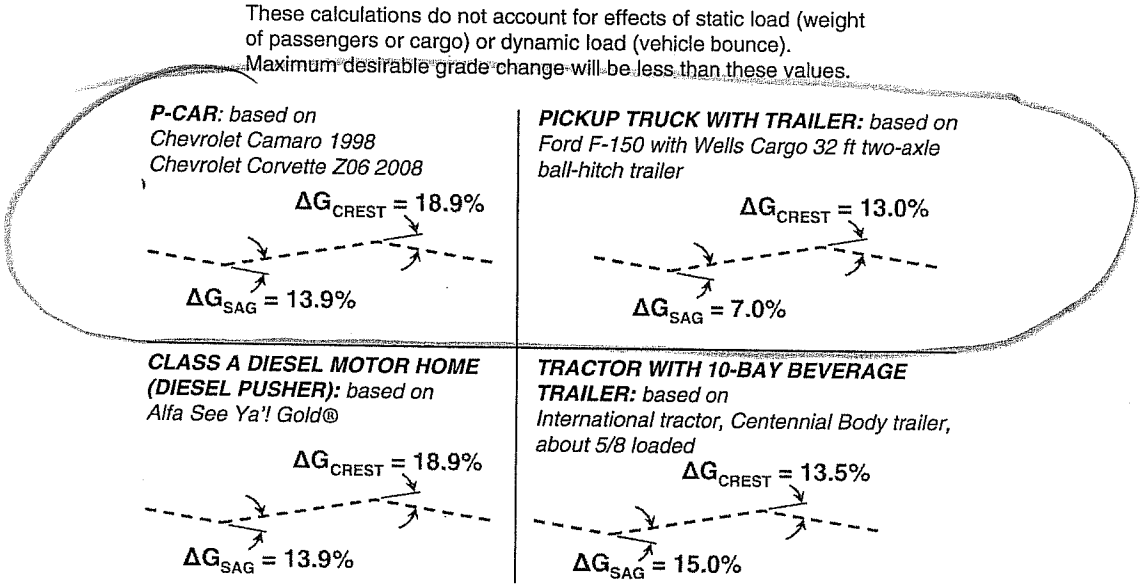
Exhibit 3-6 shows the findings from a recent study in which the underside dimensions of a select group of vehicles were measured. From this, the crest and sag angles at which underside dragging would occur were calculated. These values reflect the physical limits of the vehicles.

Exhibit 3-5. Vehicle ground clearance dimensions.

Design Vehicle	Rear Overhang (ft)	Wheelbase (ft)	Front Overhang (ft)	Ground Clearance for Rear Overhang (in)	Ground Clearance for Wheelbase (in)	Ground Clearance for Front Overhang (in)
Rear-Load Garbage Truck	10.5	20	--	14	12	--
Aerial Fire Truck	12	20	7	10	9	11
Pumper Fire Truck	10	22	8	10	7	8
Single-Unit Beverage Truck	10	24	--	8	6	--
Articulated Beverage Truck	--	30	--	--	10	--
Low-Boy Trailer <53 feet	--	38	--	--	5	--
Double-Drop Trailer	--	40	--	--	6	--
Car Carrier Trailer	14	40	--	6	4	--
Belly Dump Trailer	--	40	--	--	11	--
Mini-Bus	16	15	--	8	10	--
School Bus	13	23	--	11	7	--
Single-Unit Transit Bus	--	25	18	--	8	6
Motorcoach	10	27	7.6	8	7	10
Articulated Transit Bus	10	--	--	9	--	--
Passenger Vehicle and Trailer - Private Use	13	20*	--	5	5	--
Passenger Vehicle and Trailer - Commercial Use	13	24*	--	7	7	--
Recreational Vehicle (RV)	16	27	7.8	8	7	6

NOTES: * indicates distance from rear wheels to hitch
-- indicates hang-up problems not expected on this part of the vehicle
These dimensions reflect only the physical limits of vehicles. They do not account for the effects on vehicles in operation (e.g., dynamic load—vehicle bounce). The desirable maximum grade changes will be less than those reflected in these values.

Exhibit 3-6. Ground clearance geometry for specific models.



Pick-up with trailer and beverage truck calculations by R. Eck.
Passenger car and motor home calculations by J. Gattis.

Angles used for design, reflecting attributes of vehicles under actual operation conditions, should be less than these.

Selecting a Design Vehicle

The activities served and the location of a driveway will affect the types of vehicles using the driveway. Typical vehicles include passenger cars, service vehicles, and bicycles. Large trucks, with their wide offtracking, use many commercial driveways—although usually few in number, larger trucks must be able to negotiate curves and grades. They should be the design vehicle for driveways serving industrial areas.

Design vehicle selection involves two conflicting mandates: (1) select a vehicle with sufficiently large dimensions so that all users can negotiate the driveway in the future and (2) confine the dimensions so that the driveway is not overdesigned. Designers can easily believe that they lack information needed to select a design vehicle. Designers may not know how frequently certain larger vehicles will use a site; regardless, the word "considerable" in the phrase "use . . . with considerable frequency" is undefined. Designers are left to their judgment to assess to what extent it is acceptable for offtracking turning vehicles to encroach into other lanes. Not only is the frequency of vehicle use a consideration, but the volume and speeds on the main roadway are also factors.

Exhibit 3-7 lists suggested design vehicles for various types of driveways. Exhibit 3-8 shows an example from a state transportation agency.

Vehicles for Farm/Ranch and Field Entrance Design

Design vehicle information for farm vehicles is not generally available. The County Engineer for Delaware County, Iowa, Mark J. Nahra, P.E., observed that large equipment will be found using both the field entrances and driveways to farm residences. Also, P-vehicles use field entrances, so the designer should use both the standard driver eye height for a P-vehicle and the eye height for a heavy vehicle.

Despite their size, large combines and other pieces of farm equipment are very maneuverable. Large combines are usually less than 16 feet wide. Based on this, farm driveways and

Exhibit 3-7. Suggested design vehicles for common driveway types.

Category	Description of Common Applications	Design Vehicles
STANDARD DRIVEWAYS		
Very high intensity	Urban activity center, with almost constant driveway use during hours of operation.	Large truck, buses (May be P-vehicle if have separate truck entrances.)
Higher intensity	Medium-size office or retail (e.g., a community shopping center) with frequent driveway use during hours of operation.	Large truck, buses (May be P-vehicle if have separate truck entrances.)
Medium intensity	Smaller office or retail, some apartment complexes, with occasional driveway use during hours of operation.	P-vehicle, single-unit truck
Lower intensity	Single-family or duplex residential, other types with low use. May not apply to rural residential.	P-vehicle
SPECIAL SITUATION DRIVEWAYS		
Central business district	Parking lot or garage for automobiles only	P-vehicle
	Other than exclusive automobile facility	Single-unit truck
Farm or ranch	Mix of residential and industrial characteristics	Single-unit truck, farm equipment
Field	Seldom used, very low volume	Single-unit truck, farm equipment
Industrial	Driveways are often used by large vehicles	Large truck
Other	Bus terminal	Bus
	Fire or Ambulance station	Emergency vehicle

Notes: P-vehicle is the AASHTO passenger car design vehicle.
Large truck may be WB-50, WB-62, or WB-65.
These descriptions are intended to help the designer from a mental image of some of the more common examples of the category.

field entrances should be at least 16 feet wide, although 20 feet is recommended. A 30-foot top-width over the driveway culvert is recommended to allow large combines and tractor-semitrailer combinations to pull into farm driveways. A radius of at least 20 feet is recommended to allow service vehicles (e.g., propane or fuel oil trucks) (single-unit vehicles) to be able to turn safely into a rural residential driveway. A site review is recommended to assess ground clearance issues.

Exhibit 3-8. Example design vehicles for driveway types.

Design Vehicle by Land Use	
Land Use(s) Served by Access	**Design Vehicle**
Residential	Passenger Car/Pickup
Residential on Bus Route	Single Unit Truck
Office with Separate Truck Access	Passenger Car/Pickup
Office without Truck Access	Single Unit Truck
Commercial/Retail with Separate Truck Access	Passenger Car/Pickup
Commercial/Retail without Truck Access	WB-50 Truck
Industrial with Separate Truck Access	Passenger Car/Pickup
Industrial without Separate Truck Access	WB-50 Truck
Recreational without Water or Camping	Passenger Car/Pickup
Recreational with Water or Camping	Motor Home/Boat
Agricultural Field Access	Single Unit Truck
Municipal and County Roads	WB-50 Truck

- "with Separate Truck Access" indicates truck prohibition from primary access.
- "without Water" indicates no recreational watercraft.

Source: New Mexico DOT, *State Acc. Mgmt. Manual*, Ch. 8, Sec. 18, p. 86, Sept. 2001

Driveway-sidewalk crossing transitions call for special attention. Of particular concern are the multi-dimensional tapers that arise from dust-pan and similar flared treatments. The 2004 AASHTO pedestrian design guide points out that "side flares and cross slopes at driveway aprons may cause a drive wheel, caster, or leg tip to lose contact with the surface" (5-2, p. 61–62). Therefore, such flares should not be used unless there is another suitable PAR, such as might be provided by a wide sidewalk.

Driveway Grade (Sidewalk Cross Slope), Change of Grade, and Vertical Alignment

Three types of control for the design of the driveway profile are physical, operational, and drainage:

- Physical controls call for a design that maintains enough clearance so the underside of a vehicle does not drag on the roadway or driveway surface. This control is necessary for all driveways, even one connecting to an alley. Because of the changes in vertical profile grade often found at driveway entrances, these locations are among the more vulnerable to hang ups when the undercarriage of the vehicle comes into contact with or drags the pavement surface.
- Operational controls dictate a vertical alignment for the driveway that allows a convenient and safe entry with minimal conflicts. To achieve this, the changes of gradient must not be too abrupt. This is especially important on driveways that intersect higher volume or higher speed roadways. Operational problems may arise from certain combinations of vertical profiles and vehicles. One problem is vehicle-occupant discomfort due to poor vertical alignment such as bumps, steep grades, and abrupt changes in grade. In extreme cases, there may be restricted sight distance, which affect safety adversely. In addition, excessive differences in speed between through vehicles and vehicles turning into or out of the driveway, because of the vertical profile, can also increase vehicles' exposure to crashes.
- Drainage, requires a profile that does not create undesirable drainage patterns. It may be unacceptable for surface runoff in the gutter to flow into the driveway opening and onto private property.

Physical Vehicle Ground Clearance Control

As Exhibit 5-65 shows, the underside of a vehicle entering or exiting a driveway can drag on either a crest or a sag alignment with an abrupt change of grade. Any excessive grade change between the cross slope of the roadway and the driveway grade, between the driveway grade and an intersecting sidewalk, or between successive driveway grades can cause a vehicle to drag (see Exhibit 5-66). Vehicles with low ground clearance and a long wheelbase or overhang can even become lodged (also referred to as "hung up" or "high-centered") on alignments with sharp grade changes. At best, hang-ups result in some vehicular delay and minor damage to the undercarriage of the vehicle and to the pavement surface. At worst, a crash can occur.

Exhibit 5-65. Geometry of ground clearance dragging.

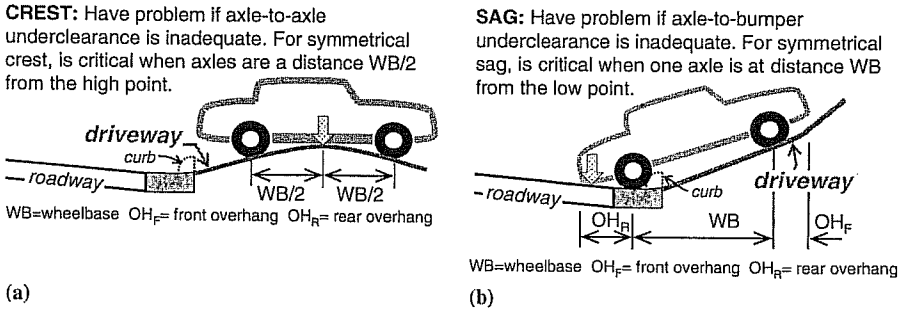
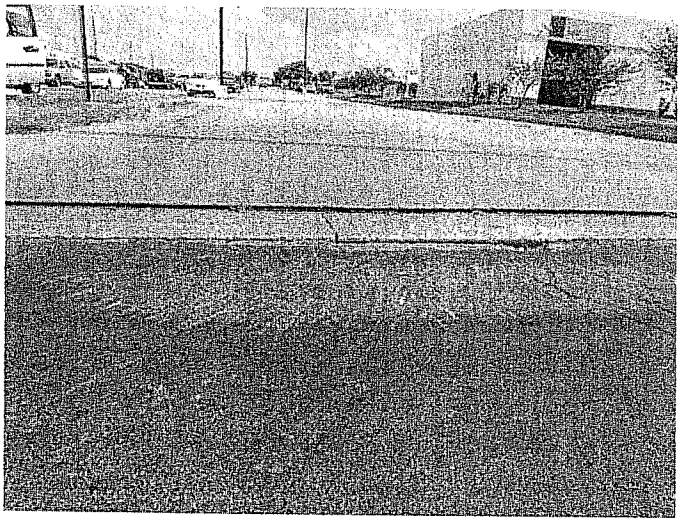


Exhibit 5-66. Driveway with multiple scrapes from underside dragging.



To design the vertical alignment elements, the designer needs to determine an appropriate design vehicle. As previously discussed, several types of long-wheelbase, low-ground-clearance vehicles can be expected to use some driveways, including articulated beverage trucks, car carriers, and passenger car-trailer combinations. The design vehicle for vertical alignment may be different from the design vehicle used to design the horizontal alignment (e.g., turning radii). The designer also needs to have a general understanding of the shape of the vertical profile to be negotiated by the design vehicle. This includes, for example, the roadway cross slope, the driveway grade line, and other controls (e.g., locations and elevations of intersecting sidewalks).

Using reasonable care in selecting a design vehicle and designing the vertical elements to accommodate that vehicle will not completely preclude hang-ups, dragging, or other operational problems from occurring. A vehicle longer and/or lower than the design vehicle may enter a driveway and encounter problems. To meet the needs of shippers, commercial vehicle manufacturers continue to introduce longer and/or lower vehicles and new vehicle configurations that will require periodic updating of the list of design vehicles. Similarly, as property changes hands or as redevelopment occurs, the nature of the land use served by the driveway may change over time. A different class of vehicle than originally intended may use the driveway. Although this is beyond the control of the designer, it offers an explanation of why hang-ups may happen at locations where they formerly did not occur and represents an issue to be addressed in the permitting process.

Also, a vehicle for which the vertical elements have been appropriately designed may encounter problems at a particular driveway. This could be due to vehicle loading condition (e.g., an overloaded vehicle) that reduces actual ground clearance to something below the design value. The vertical profile is subject to changes over time. For example, the roadway may be milled or resurfaced such that its elevations and cross slopes change. In addition, the roadway and/or driveway (and associated features such as sidewalks) may deform over time due to applied loads, the effects of weather, or construction deficiencies. As mentioned above, the vertical profile(s) used in design should be that reasonably expected to be used by the design vehicle. The possibility always exists that a design vehicle will follow an unusual or out-of-the-ordinary path in negotiating the driveway such that hang-up or dragging could result.

Exhibit 5-67 shows maximum uphill and downhill grades, as reported by transportation agencies in a survey.

Exhibit 5-67. Reported steepest allowed driveway grades.

	Normally, Use This in Most Situations			Commercial			Residential		
	Smallest reported	Average	Largest reported	Smallest reported	Average	Largest reported	Smallest reported	Average	Largest reported
Grade: maximum (+) uphill from road allowed 	2.6	9.7	15	5	7.5	10	6	11	15
Grade: maximum (-) downhill from road allowed 	-5	-9.4	-15	-5	-7.8	-10	-6	-11.0	-15

NOTE: These values reflect survey responses from 1 local and 16 state transportation agencies.

Maximum allowable grade, by itself, is not a sufficient control. What matters is the difference between successive grades, or the change of grade. The change of grade is what creates the crests and sags that cause the underside of a vehicle to drag. Although perhaps not widely recognized, guidance on vertical geometry applicable to driveways has been available for some time. The section on railroad-highway grade crossing design in AASHTO's policy on geometric design (*5-1*) provides recommendations on designing the vertical profile at grade crossings. AASHTO recommends that the crossing surface be in the same plane as the top of rails for a distance of 2 feet outside of the rails, and that the surface of the roadway be not more than 3 inches higher or lower than the top of the nearest rail at a point 30 feet from the rail, unless track superelevation dictates otherwise.

Similarly, a 1987 ITE guideline for driveway design discussed vertical alignment. Eck and Kang (*5-24*) used a vehicle with a 36-ft wheelbase and 5 inches of ground clearance to analyze a maximum grade change of 3 percent (for low-volume driveways on major or collector streets). This "design vehicle" had problems with the aforementioned geometry, suggesting that the ITE driveway design recommendations did not accommodate low-clearance vehicles. A similar statement can be made about the AASHTO standard railroad-highway grade crossing since French, Clawson, and Eck (*5-25*) found that car carrier trailers would hang-up on this crossing. Thus, additional research was conducted to develop driveway vertical alignment guidelines to accommodate selected design vehicles.

Operational Control

A research team made measurements at 31 driveways with visible scrapes from the undersides of vehicles, and then measured speeds and elapsed travel times for over 1500 vehicles observed turning right or left into a number of driveways. The speed and elapsed time studies were conducted at commercial driveways on built-up suburban (but not CBD) arterial multilane roadways with posted speeds of 40 and 45 mph. All of the roadways had either a raised median or a TWLTL. These data were collected at driveways with right-turn entry radii ranging from 13 to 19.5 feet, and an entry lane width of about 13 feet.

Very few vehicles about to enter a driveway exceeded 20 mph at the locations at which speeds were measured. After crossing the driveway threshold, average speeds for vehicles turning left into the driveway were around 10 mph. Vehicles that had turned right into the driveways were slightly slower, with average speeds around 7 mph. The speeds of vehicles entering driveways with breakover sag grades up to 10.5% were close to the speeds of vehicles entering flatter driveways. Scrapes on the pavement surface, presumably from the undersides of vehicles, began to be common with a sag breakover of around 10 percent, and a crest breakover of about 11 percent.

The study led to the suggestions following in Exhibit 5-68. Except where noted, these guidelines are based on observations of passenger vehicles (P-vehicle).

Where low-clearance vehicles are expected to traverse crest curves, refer to Exhibit 5-69 developed by Eck and Kang (*5-26*) that suggests vertical curve lengths for various breakover angles (i.e., algebraic difference in grades).

Drainage Control

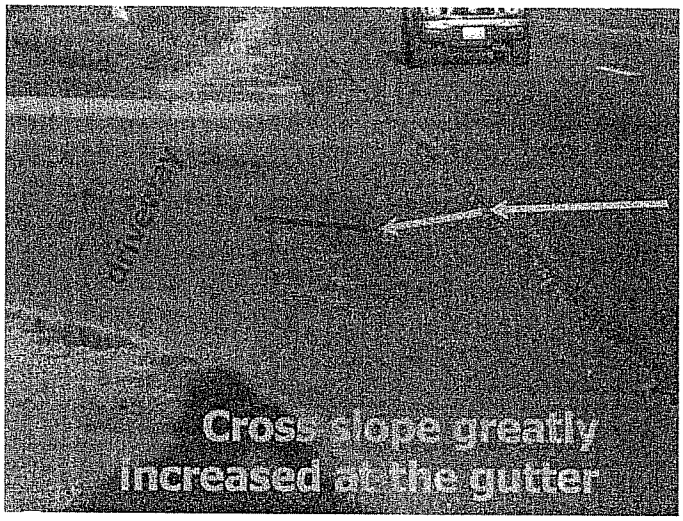
Surface runoff from the roadway should not inundate the sidewalk or spill over onto private property. It is also undesirable for the depth of flow to cover the driveway, making it difficult for motorists to determine were the edges of the driveway are.

Exhibit 5-68. Driveway vertical profile guidelines.

Category	Description of Common Applications*	Vertical Profile Guidelines	
		Suggestion	Rationale
STANDARD DRIVEWAYS			
Very high intensity	Urban activity center, with almost constant driveway use during hours of operation.	Refer to roadway design guidelines.	These driveways are often built to the standards of and resemble public roads and streets.
FOR BOTH Higher intensity *AND*	Medium-size office or retail, such as community shopping center, with frequent driveway use during hours of operation.	• Limit the maximum driveway grade to +8% (except where a lesser grade is required, such as when crossing a sidewalk), and the maximum sag breakover without a vertical curve between the roadway cross slope and an uphill driveway grade to 9%.	From observations of vehicles entering driveways with radii up to 20 ft and comparisons of Flatter (1.5-5%) and Moderate (6-9%) grades revealed (1) little difference between speeds and travel times of vehicles turning right; and (2) only slight differences between speeds and travel times of vehicles turning left.
Medium intensity	Smaller office, retail, or other sites with occasional driveway use during hours of operation.	• Limit the driveway profile maximum grade change without a vertical curve for: a crest to 10% and a sag to 9%.	From measurements of 31 driveways with scrape marks, underside dragging became a problem at a crest of about 11%, and at a sag of about 10%.
	Apartment complexes	• May limit the sag to 7%.	Due to trailers.
Lower intensity	Single family or duplex residential, other types with very low use. May not apply to rural residential.	• Limit the driveway profile maximum grade change without a vertical curve for: a crest to 10% and a sag to 9%.	From measurements of 31 driveways with scrape marks, underside dragging became a problem at a crest of about 11%, and at a sag of about 10%.
SPECIAL SITUATION DRIVEWAYS			
CBD	Building faces are close to the street.	Refer to the guidelines above for "Higher intensity" and "Medium intensity."	
Farm or ranch; Field	A mix of design vehicles; some may be very low volume.	• Limit the driveway profile maximum grade change without a vertical curve for: a crest to 10% and a sag to 7%.	These driveways should accommodate trailers.
Industrial	Driveways are often used by large vehicles.	• Varies, depending on types of vehicles. If low-boy trailers are expected, then limit crest breakover grades without a vertical curve to 3.5%.	
Other	Motels	• Limit the driveway profile maximum grade change without a vertical curve for: a crest to 10% and a sag to 7%.	Travelers pulling a trailer may stay at a motel; therefore, motel driveways should accommodate trailers.

NOTES: Additional information on which to assess ground clearance is in Chp 3.
The sag clearance for trailers is based on Eck's evaluation; truck+trailer clearances will vary.
* These descriptions are intended to help the designer form a mental image of some of the more common examples of the category.

Exhibit 5-73. Increased gutter cross slope.



exiting the driveway have to negotiate. Many scrape marks on the driveway surface from the dragging of vehicles bumpers are clearly visible. More study should be done on this type of design to weigh any drainage benefits against impediments to traffic flow.

Vertical Alignment Examples

The following examples apply some of the guidelines for designing the vertical alignment of driveways. Exhibit 5-74 shows the driveway profile rising from the gutter line up to the sidewalk, then flattening at the sidewalk before falling as the driveway continues onto the private property. This type of design will confine normal depths of water in the gutter and not allow water to flow on to private property and down the driveway.

Exhibit 5-75 shows the suggested values for driveways at which the P-vehicle is the design control. If the near edge of the sidewalk is 5.5 feet from the face-of-curb or gutter line, and the driveway is on a +7.0% grade, then the near edge of the sidewalk is 0.39 feet above the elevation of

Exhibit 5-74. Schematic showing driveway vertical alignment concepts.

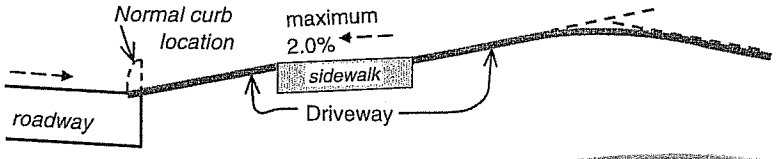


Exhibit 5-75. Example of a driveway vertical profile design.