EXHIBIT tabbies 18-17 A

The Town of Elsmere

11 Poplar Avenue, Elsmere, Delaware 19805
Phone (302) 998-2215 Fax (302) 998-9920

Application for Hearing

☐ **Board of Adjustment**
☒ **Planning Commission**

Petition # 18-17 Filing Fee: $300 Date Received 6/14/18 Received by: Cp

Subject Property: 504 Kirkwood Highway

Property is: ☐ Residential ☒ Commercial

Tax Parcel # 1900500104 Zoning District: CC

Applicant name: RT Properties of PA, LLC

Address: 1487 Dunwoody Drive Telephone # _____

City: West Chester State: PA Zip Code: 19380

Application for Zoning Variance Related to: _____

- ☐ Front yard setback
- ☐ Rear yard setback
- ☐ Side yard setback
- ☐ Lot Area
- ☐ Lot Coverage
- ☐ Fencing
- ☐ Parking requirements
- ☐ Signage

Application for Special Exception Use Permit for the following use: N/A

Application for Appeal of an Administrative decision: N/A

By: _____ Date: _____

For the following reasons: _____

EXHIBIT
tabbies
18-17 B

Application for relief other than above: N/A

State reasons for this request: New Business - Domino's Pizza w/ Planning Commission Review Required Drive Thru

Has a previous application for this property been filed with the Town? Yes (No)

If yes, Petition # _____

If the applicant is not the Legal Owner of the property:

Legal owner information:

Name: Green Bunny, LLC

Address: 219 W. 9th Street Telephone # _____

City: Wilmington State: DE Zip Code: 19801

Please submit the following with this petition:

- A copy of a plot plan showing the following: location of the property; a diagram showing the layout, size, and location of existing structures on the property.
- A copy of any deed restrictions on the property.
  NOTE: THE BOARD OF ADJUSTMENT OR PLANNING COMMISSION CANNOT APPROVE ANY APPLICATION PROHIBITED BY DEED RESTRICTIONS.
- Filing fee, payable to the Town of Elsmere.

The undersigned hereby certifies that the legal owner of the subject property is aware of, and agrees to the filing of this application, that the information submitted herein is correct, and agrees to be bound by any decision of the Town of Elsmere Board of Adjustment with respect to the subject property.

NOTE: The legal owner and his/her authorized representative must sign this form.

Applicant's Signature: M A. Connor* Date: 6/14/2018

Legal Owner's Signature: _____ Date: 10/16/2018

* Counsel for RT Properties, signed on its behalf

EXHIBIT
tabbies
18-17 C

Name of person representing applicant (if applicable):

Todd A. Coomes

Address: One Rodney Square, 920 N. King St Telephone # (302) 651-7500

City: Wilmington State: DE Zip Code: 19801

I, Robert Taylor, as owner of the property listed on this application, authorize the above named representative to act on my behalf during any proceedings pertaining to this application.

Legal Owner Signature — Date: 6/14/18

Subscribed and sworn to before me on the following date:

Notary Public Signature

6/14/18
Date

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Cynthia Thompson, Notary Public
West Chester Boro, Chester County
My Commission Expires Nov. 17, 2019
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

In addition to the persons listed above please send copies of all correspondence to:

Name: Ronald H Sutton, Jr, P.E.

Address: 55 W. Main St Telephone # 302-547-2494

City: Middletown State: DE Zip Code: 19709

EXHIBIT
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18-17 D

Site Analysis
Petition 18-17

Property Owner:	Green Bunny LLC
Zoning District:	CC – Community Commercial
Address:	504 Kirkwood Hwy, Elsmere, DE 19805
Primary Use:	Commercial
Parcel No.:	19-00500-104

LOT COVERAGE CALCULATIONS

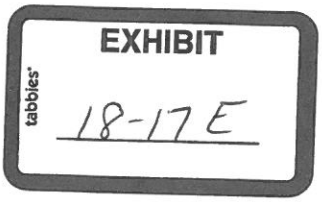
Lot Area in Sq. Ft.:	20,446	Sq. Ft.
Allowable Lot Coverage:	2,325	Sq. Ft. (or 15 %)
Total Coverage:	11,222	Sq. Ft. (55 %)
❖ Building =	1,380	Sq. Ft.
❖ Impervious Pave =	9,842	Sq. Ft.
Proposed Addition:	- 2,662	Sq. Ft. (reduction)
Proposed Total:	8,560	Sq. Ft. (42 %)

Conclusion: The applicant seeks to reduce the existing impervious lot coverage by 2,662 square feet or 13%.

Required Setbacks: Front: 20' Rear: 20'
Side: 0' Both Sides: 20'

Proposed Setbacks: Front: 35' Rear: 52'
Side: 13.75' Both Sides: 53.75'

Conclusion: The proposed setbacks comply with Chapter 225 Attachment 3 of the Code of the Town of Elsmere.



STATEMENT OF FACT

The subject parcel is legal non-conforming with regard to lot coverage. The existing lot coverage is 11,222 or 55%. Chapter 225 Attachment 3 of the Code of the Town of Elsmere requires a maximum lot coverage of 15%.

REQUEST BY THE APPLICANT

The applicant seeks to construct and open a Domino's Pizza with a drive-thru. The applicant seeks to reduce the non-conformity of the subject parcel by reducing impervious lot coverage by 13%.

ISSUE(S)

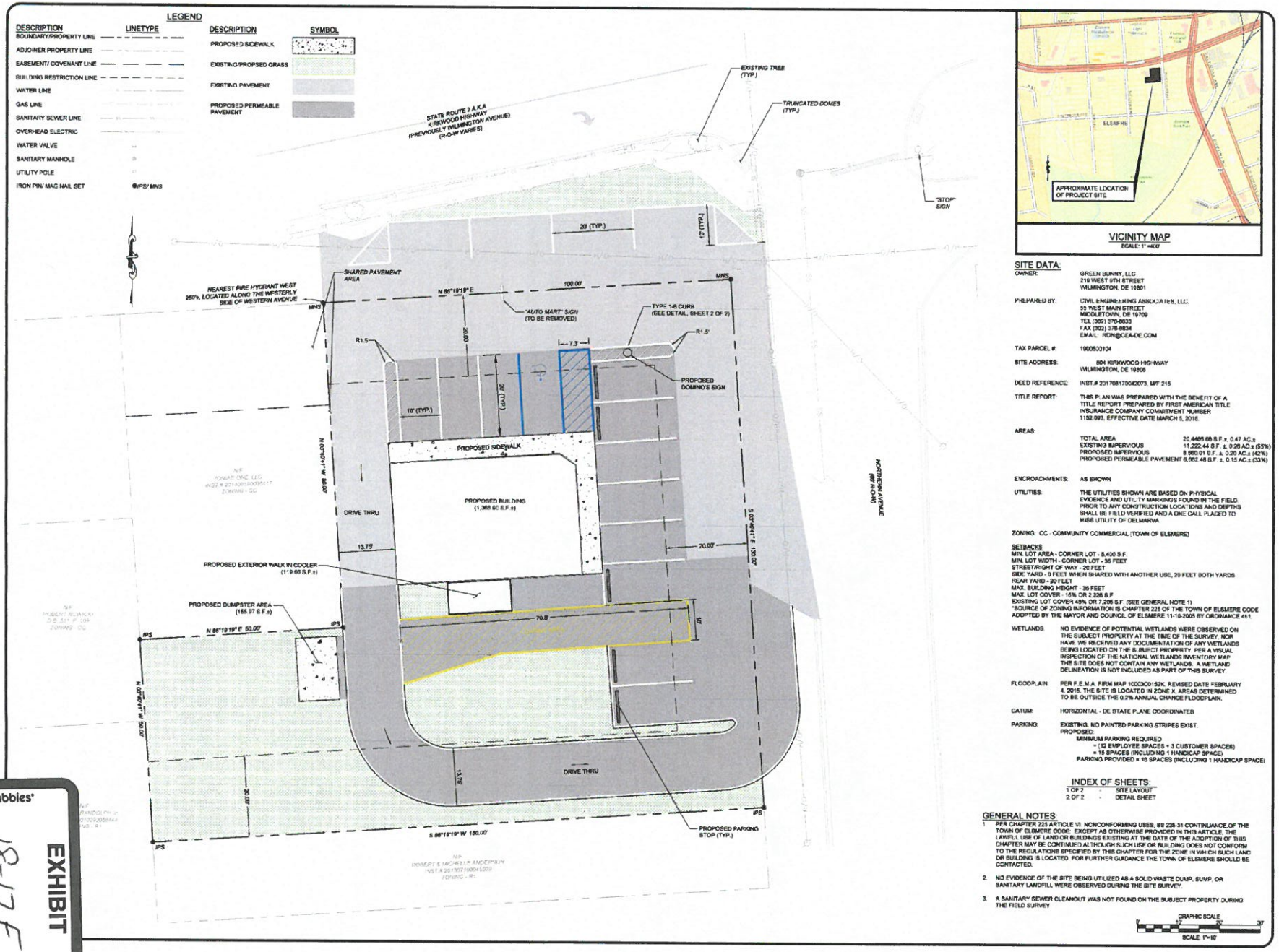
Section 225-9 of the Code of the Town of Elsmere requires that the construction be reviewed by the town's Planning Commission to ensure harmonious development.

GRANTING OF THE PETITION

Should the Planning Commission of the Town of Elsmere grant Petition 18-17, the following must occur:

1. The Planning Commission of the Town of Elsmere shall determine that the proposed development meets the harmonious development intent of Section 225-9 of the Code of the Town of Elsmere.

2. The Planning Commission of the Town of Elsmere shall require the applicant to obtain permits from the Code Enforcement Office and the Office of the State Fire Marshal within one year of this approval.



VICINITY MAP
SCALE: 1" =400'

SITE DATA:

OWNER: GREEN BUNNY, LLC
219 WEST 9TH STREET
WILMINGTON, DE 19801

PREPARED BY: CIVIL ENGINEERING ASSOCIATES, LLC
55 WEST MAIN STREET
MIDDLETOWN, DE 19709
TEL (302) 376-8833
FAX (302) 378-8834
EMAIL: RDN@CEA-DE.COM

TAX PARCEL #: 1900530104

SITE ADDRESS: 504 KIRKWOOD HIGHWAY
WILMINGTON, DE 19808

DEED REFERENCE: INST.# 20170817 0042073, M/F 215

TITLE REPORT: THIS PLAN WAS PREPARED WITH THE BENEFIT OF A TITLE REPORT PREPARED BY FIRST AMERICAN TITLE INSURANCE COMPANY COMMITMENT NUMBER 1152.093, EFFECTIVE DATE MARCH 5, 2018.

AREAS:

TOTAL AREA	20,4495.68 S.F.± 0.47 AC.±
EXISTING IMPERVIOUS	11,222.44 S.F. ± 0.26 AC.± (55%)
PROPOSED IMPERVIOUS	8,960.01 S.F. ± 0.20 AC.± (42%)
PROPOSED PERMEABLE PAVEMENT	8,662.48 S.F. ± 0.15 AC.± (33%)

ENCROACHMENTS: AS SHOWN

UTILITIES: THE UTILITIES SHOWN ARE BASED ON PHYSICAL EVIDENCE AND UTILITY MARKINGS FOUND IN THE FIELD PRIOR TO ANY CONSTRUCTION LOCATIONS AND DEPTHS SHALL BE FIELD VERIFIED AND A DIG CALL PLACED TO MISS UTILITY OF DELMARVA.

ZONING: CC - COMMUNITY COMMERCIAL (TOWN OF ELSMERE)

SETBACKS
MIN. LOT AREA - CORNER LOT - 5,400 S.F.
MIN. LOT WIDTH - CORNER LOT - 36 FEET
STREET/RIGHT OF WAY - 20 FEET
SIDE YARD - 0 FEET WHEN SHARED WITH ANOTHER USE, 20 FEET BOTH YARDS
REAR YARD - 20 FEET
MAX. BUILDING HEIGHT - 35 FEET
MAX. LOT COVER - 16% OR 2,335 S.F.
EXISTING LOT COVER 48% OR 7,205 S.F. (SEE GENERAL NOTE 1)
*SOURCE OF ZONING INFORMATION IS CHAPTER 225 OF THE TOWN OF ELSMERE CODE ADOPTED BY THE MAYOR AND COUNCIL OF ELSMERE 11-15-2005 BY ORDINANCE 451.

WETLANDS: NO EVIDENCE OF POTENTIAL WETLANDS WERE OBSERVED ON THE SUBJECT PROPERTY AT THE TIME OF THE SURVEY. NOR HAVE WE RECEIVED ANY DOCUMENTATION OF ANY WETLANDS BEING LOCATED ON THE SUBJECT PROPERTY. PER A VISUAL INSPECTION OF THE NATIONAL WETLANDS INVENTORY MAP, THE SITE DOES NOT CONTAIN ANY WETLANDS. A WETLAND DELINEATION IS NOT INCLUDED AS PART OF THIS SURVEY.

FLOODPLAIN: PER F.E.M.A. FIRM MAP 10003C0152K, REVISED DATE FEBRUARY 4, 2015, THE SITE IS LOCATED IN ZONE X, AREAS DETERMINED TO BE OUTSIDE THE 0.2% ANNUAL CHANCE FLOODPLAIN.

DATUM: HORIZONTAL - DE STATE PLANE COORDINATES

PARKING: EXISTING: NO PAINTED PARKING STRIPES EXIST.
PROPOSED:
MINIMUM PARKING REQUIRED
= (12 EMPLOYEE SPACES + 3 CUSTOMER SPACES)
= 15 SPACES (INCLUDING 1 HANDICAP SPACE)
PARKING PROVIDED = 15 SPACES (INCLUDING 1 HANDICAP SPACE)

INDEX OF SHEETS:

1 OF 2	-	SITE LAYOUT
2 OF 2	-	DETAIL SHEET

GENERAL NOTES

1. PER CHAPTER 225 ARTICLE VI NONCONFORMING USES, §§ 225-31 CONTINUANCE,OF THE TOWN OF ELSMERE CODE: EXCEPT AS OTHERWISE PROVIDED IN THIS ARTICLE, THE LAWFUL USE OF LAND OR BUILDINGS EXISTING AT THE DATE OF THE ADOPTION OF THIS CHAPTER MAY BE CONTINUED ALTHOUGH SUCH USE OR BUILDING DOES NOT CONFORM TO THE REGULATIONS SPECIFIED BY THIS CHAPTER FOR THE ZONE IN WHICH SUCH LAND OR BUILDING IS LOCATED. FOR FURTHER GUIDANCE THE TOWN OF ELSMERE SHOULD BE CONTACTED.
2. NO EVIDENCE OF THE SITE BEING UTILIZED AS A SOLID WASTE DUMP, SUMP, OR SANITARY LANDFILL WERE OBSERVED DURING THE SITE SURVEY.
3. A SANITARY SEWER CLEANOUT WAS NOT FOUND ON THE SUBJECT PROPERTY DURING THE FIELD SURVEY.

GRAPHIC SCALE
0 15' 30' 60'
SCALE: 1"=30'

REVISIONS

REVISION	DATE	DESCRIPTION

DATE: 5/31/18

CIVIL ENGINEERING ASSOCIATES, LLC
• ENGINEERING • SURVEYING • CONSTRUCTION SERVICES
55 WEST MAIN STREET
MIDDLETOWN, DE 19709
PHONE (302) 376-8833
FAX (302) 376-8834
WEB WWW.CEA-DE.COM

SITE LAYOUT
PREPARED FOR
GREEN BUNNY, LLC & RT PROPERTIES OF PENNSYLVANIA, LLC
504 KIRKWOOD HIGHWAY
T.P.# 19-005.00-104
TOWN OF ELSMERE
NEW CASTLE COUNTY, DELAWARE

DATE: MAY 31, 2018
DESIGNED BY: RT
APPROVED BY: RHB
FILE: P18012-DOMINOSLAYOUT.DWG
SHEET NO.: **1 OF 2**

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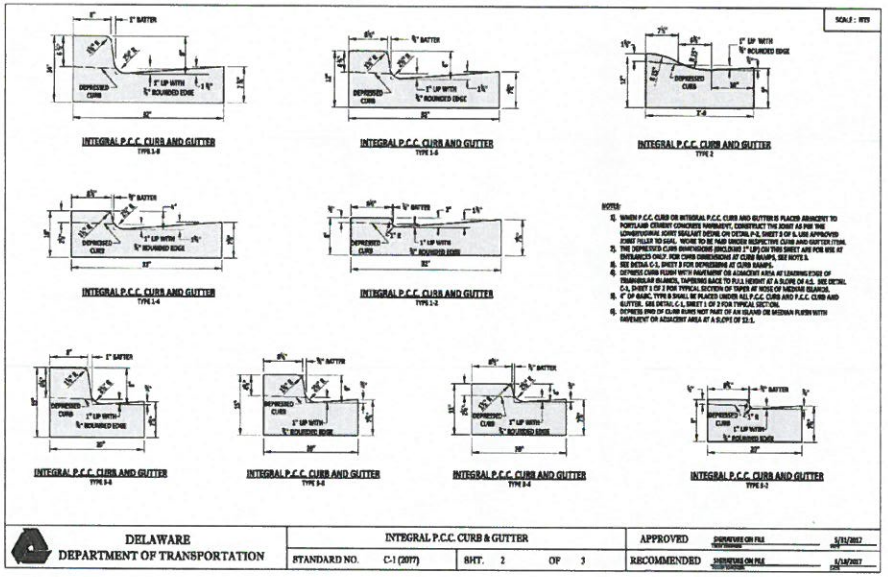
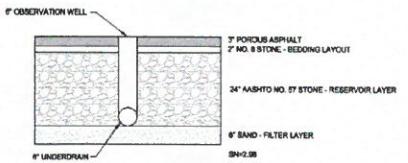
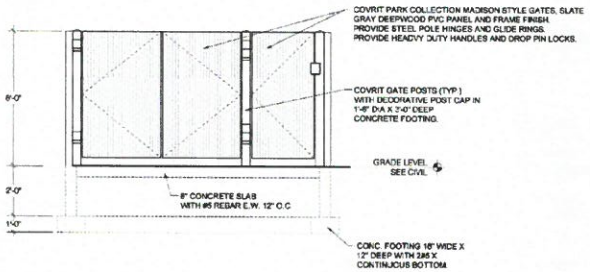
EXHIBIT
8-17-18



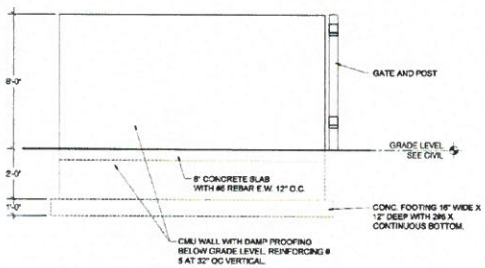


TYPICAL PERMEABLE PAVEMENT SECTION
NTS

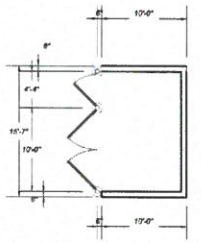
NOTE:
FOR PERMEABLE PAVEMENT DETAILS, SEE DNREC'S POST CONSTRUCTION STORMWATER BMP STANDARDS AND SPECIFICATIONS, SECTION 3.06.2.3.



GARBAGE ENCLOSURE EAST
NTS



GARBAGE ENCLOSURE SOUTH
NTS



GARBAGE AND RECYCLING ENCLOSURE PLAN
NTS

NOTE:
SIZE AND CONFIGURATION TO BE VERIFIED AND FINALIZED BY OWNERS TRASH AND RECYCLING DUMPSTER SIZES

REVISIONS

REVISION	DATE	DESCRIPTION

DATE

CIVIL ENGINEERING ASSOCIATES, LLC
• ENGINEERING • SURVEYING • CONSTRUCTION SERVICES
35 WEST MAIN STREET
MIDDLETOWN, DE 19709
PHONE (302) 376-8833
FAX (302) 376-8834
WEB WWW.CEA-DE.COM

DETAIL SHEET
PREPARED FOR
GREEN BUNNY, LLC & RT PROPERTIES OF PENNSYLVANIA, LLC
504 KIRKWOOD HIGHWAY
T.P.# 19-005.00-104
TOWN OF ELSMERE
NEW CASTLE COUNTY, DELAWARE

DATE: MAY 31, 2018
DESIGNED BY: RT
APPROVED BY: RHS
FILE: P18012-DOMINOSLAYOUT.DWG
SHEET NO.: **2 OF 2**

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EXHIBIT
18-176

504 Kirkwood Hwy

Author: CLP

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EXHIBIT
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Date: 6/14/2018

New Castle County Delaware GIS: http://gis.nccde.org

Disclaimer: For informational purposes only - not to be used as official documentation.

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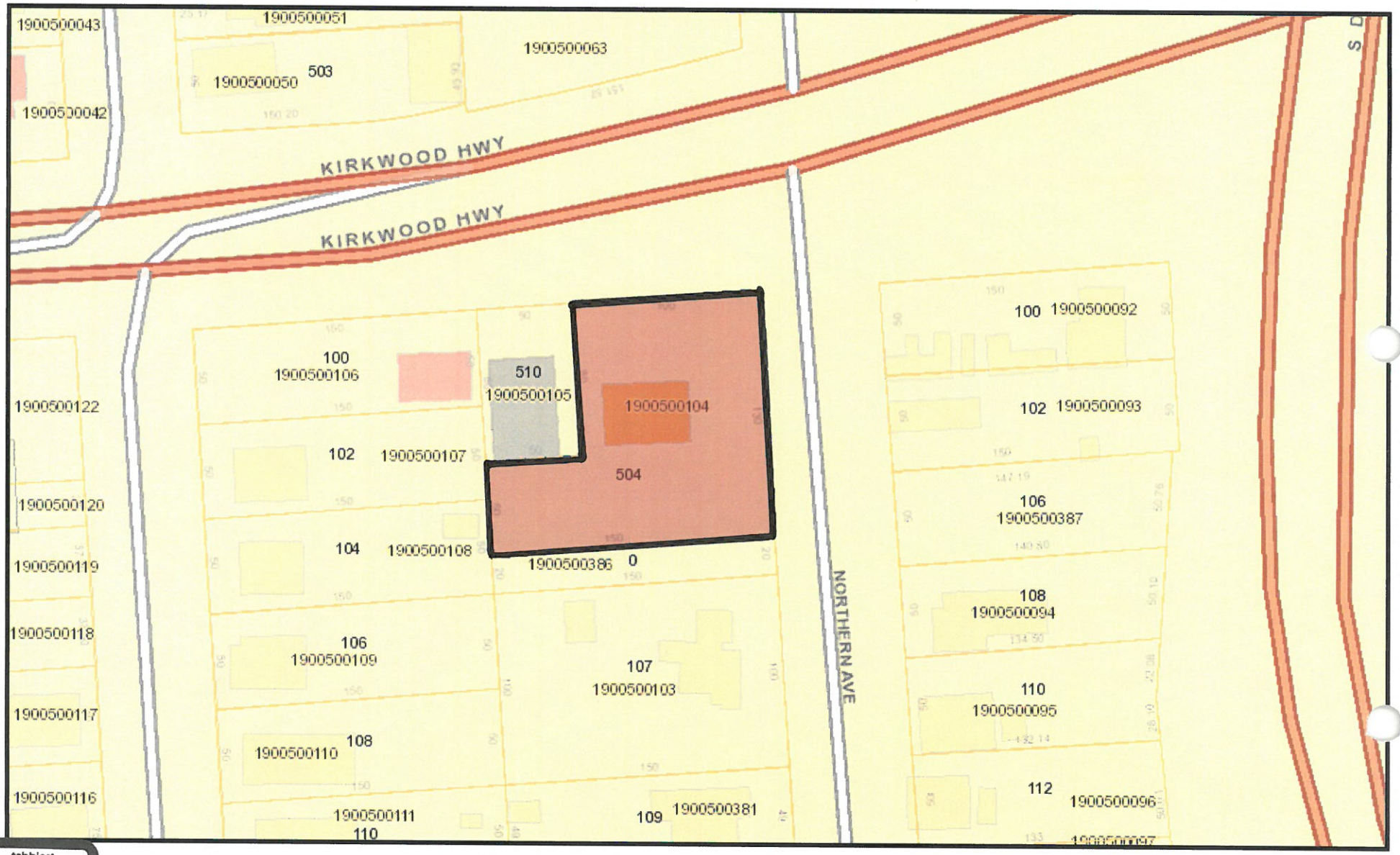

504 Kirkwood Hwy

Author: CLP

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Date: 6/14/2018

New Castle County Delaware GIS: http://gis.nccde.org

Disclaimer: For informational purposes only - not to be used as official documentation.

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18-17 I

EXHIBIT
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18-17 K

20170817-0042073
Pages 2 F $65 00
08/17/17 11 54 49 AM
T20170028458
Michael E Kozikowski
New Castle Recorder DEE

Tax Parcel No 19-005 00-104
PREPARED BY AND RETURN TO
Cooch and Taylor, P A (DMH)
P O Box 1680
Wilmington, DE 19899-1680

THIS DEED is made this 16th day of August, 2017, between

DRLBLS, LLC, a Delaware limited liability company, party of the first part,

AND

GREEN BUNNY LLC, a Delaware limited liability company, party of the second part

WITNESSETH, that the said party of the first part, for and in consideration of the sum of TEN DOLLARS ($10 00) lawful money of the United States of America, the receipt of which is hereby acknowledged, hereby grants and conveys unto the said party of the second part, its successors and/or assigns, in fee,

ALL that certain lot, piece or parcel of land with the building thereon erected, situate in the Town of Elsmere, Christiana Hundred, New Castle County and State of Delaware, known as 504 Kirkwood Highway, and being parts of Lots Nos 124, 125 and 126 as shown on the plan of ELSMERE of record in the Office of the Recorder of Deeds in and for New Castle County, Delaware in Microfilm No 215, and being more particularly bounded and described as follows

BEGINNING at a corner formed by the intersection of the Southerly side of Wilmington Avenue, at sixty feet wide, with the Westerly side of Northern Avenue, at sixty feet wide, (Wilmington Avenue being parallel with New Road and distant four hundred feet Southerly therefrom and Northern Avenue, running at right angles to New Road and being distant three hundred feet Westerly from the Westerly side of DuPont Road), thence Southerly along the said Westerly side of Northern Avenue, one hundred thirty feet to a point, thence Westerly and through Lot No 124 and parallel with Wilmington Avenue, one hundred and fifty feet to a point, thence Northerly and along the division line between Lot Nos 124, 125, 128 and 129, fifty feet to a point in line of land conveyed to Henry J DiDonato and Gloria C DiDonato, his wife (Deed Record C, Volume 64, Page 539), thence thereby the following two courses and distances (1) Easterly and parallel with Wilmington Avenue, fifty feet to a point, (2) Northerly and parallel with Northern Avenue, eighty feet to a point in the said Southerly side of Wilmington Avenue, thence thereby one hundred feet to the point and place of Beginning

SUBJECT to the regulations and restrictions that (1) no building shall be erected on said lot of land at a less distance than twenty feet Southerly from the said Southerly side of Wilmington Avenue or Westerly from the said Westerly side of Northern Avenue, (2) the whole front on said Avenues, twenty feet wide, shall be kept an open ornamental space for the free passage of air and

NCC 257748 08/17/17 11 52 00
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light forever (3) no malt or spirituous liquors shall be sold on the land and premises hereby conveyed forever

BEING the same lands and premises which Casale Holding Company, a Delaware corporation, by Deed dated May 18, 2010 and recorded May 24, 2010 in the Office of the Recorder of Deeds in and for New Castle County, Delaware, in Instrument Number 20100524-0025454, did grant and convey unto DRLBLS, LLC, a Delaware limited liability company, in fee

SUBJECT to all easements, restrictions, reservations, agreements and covenants of record, if any, affecting the property or the title thereto, together with the benefits of the same

IN WITNESS WHEREOF, the said party of the first part has hereunto set its hand and seal, the day and year aforesaid

SEALED AND DELIVERED IN THE PRESENCE OF

DRLBLS, LLC, a Delaware limited company

Witness

By Silvia Joswick (SEAL)
Silvia M Joswick, Manager

STATE OF DELAWARE)
) SS
COUNTY OF NEW CASTLE)

BE IT REMEMBERED, that on this 16th day of August, 2017, personally came before me, the Subscriber, a Notarial Officer for the State and County aforesaid, Silvia M Joswick, Manager of DRLBLS, LLC, a Delaware limited liability company, party to this Indenture, known to me personally to be such, and acknowledged this Indenture to be her act and deed and the act and deed of the said company

GIVEN under my Hand and Seal of Office, the day and year aforesaid

Notary Public
Printed Name R GRANT DICK ESQ
My Commission Expires DELAWARE LAWYER
NOTARIAL OFFICER
29 Del C §4323(a)(3)

GRANTEE'S ADDRESS
219 West Ninth Street, Suite 200
Wilmington, DE 19801

00323759

THE TOWN OF ELSMERE DELAWARE INCORPORATED FEB 9TH 1909

No 17-111
Amount $ 3,825.00
Date 8-17-17
Kent County Tax Collector

EXHIBIT
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18-17 M

Parcel # 1900500104

Property Address: 504 KIRKWOOD HWY
WILMINGTON, DE 19805-
Subdivision: ELSMERE
Owner: GREEN BUNNY LLC
219 W 9TH ST
Owner Address: SUITE 200
WILMINGTON, DE 19801
Municipal Info: Incorporated in ELSMERE PROPERTY TAX AREA

Lot #: P124-26
Location:
Map Grid: 09403560
Block:
Census Tract: 124.00
Street Type:
Water:
Microfilm #: 000215

Property Class: COMMERCIAL
Lot Size: 0.36
Lot Depth: 150
Lot Frontage: 130
Street Finish:

District & Zoning Info

Districts

- **FIRE/RESCUE - ELSMERE**
- **RED CLAY SCHOOL DIST-TRES**
- TRAFFIC ZONE T083 (YR2000)
- NORTH OF C&D CANAL
- COUNCIL 1 - KENNETH R WOODS
- ADD REQ PER SEC 10.3.4.4 DSSR
- SEWER DISTRICT NORTHERN-ASMT
- PLANNING 8 - LOWER CHRISTINA
- DE SEN 07-ANTHONY DELCOLLO
- DE REP 13-JOHN L MITCHELL JR

Zoning

- 19CC - COMMUNITY COMMERCIAL

Deed History

Grantee(s)	Deed	Multi?	Sale Date	Sale Amount
CASALE DONATA	WR067946	Y	6/1/1976	$0.00
CASALE HOLDING COMPANY	1449 160	N	12/9/1992	$10.00
DRLBLS LLC	20100524 0025454	N	5/18/2010	$10.00
GREEN BUNNY LLC	20170817 0042073	N	8/16/2017	$10.00

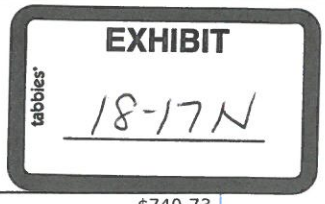
Tax/Assessment Info

Assessment

Land: 78400
Structure: 16700
Homesite: 0
Total: 95100
County Taxable: 95100
School Taxable: 95100

Tax Bills as of 6/14/2018 3:00:04 AM

	County			School		
Tax Year	Principal Due	Penalty Due	Amt Paid	Principal Due	Penalty Due	Amt Paid
1998A	$0.00	$0.00	$275.11	$0.00	$0.00	$1,512.90
1999A	$0.00	$0.00	$249.07	$0.00	$0.00	$1,902.33
2000A	$0.00	$0.00	$216.55	$0.00	$0.00	$1,796.11
2001A	$0.00	$0.00	$353.23	$0.00	$0.00	$1,862.06
2002A	$0.00	$0.00	$327.19	$0.00	$0.00	$1,836.20
2003A	$0.00	$0.00	$301.15	$0.00	$0.00	$1,795.91
2004A	$0.00	$0.00	$278.17	$0.00	$0.00	$1,803.18
2005A	$0.00	$0.00	$244.97	$0.00	$0.00	$1,912.25
2006A	$0.00	$0.00	$239.22	$0.00	$0.00	$1,921.99
2007A	$0.00	$0.00	$271.15	$0.00	$0.00	$2,058.98
2008A	$0.00	$0.00	$283.30	$0.00	$0.00	$2,235.07
2009A	$0.00	$0.00	$323.63	$0.00	$0.00	$2,231.65
2010A	$0.00	$0.00	$380.47	$0.00	$0.00	$2,081.46
2011A	$0.00	$0.00	$352.07	$0.00	$0.00	$1,851.83
2012A	$0.00	$0.00	$326.90	$0.00	$0.00	$1,694.68
2013A	$0.00	$0.00	$325.03	$0.00	$0.00	$1,798.34
2014A	$0.00	$0.00	$326.26	$0.00	$0.00	$1,830.01
2015A	$0.00	$0.00	$325.10	$0.00	$0.00	$2,115.74
2016A	$0.00	$0.00	$324.31	$0.00	$0.00	$2,310.56
2017A	$0.00	$0.00	$326.00	$0.00	$0.00	$2,353.06



Tax Payments as of 6/14/2018 3:00:04 AM

Date Paid	Amt Paid
7/26/2000	$740.73
12/5/2000	$400.00
2/21/2001	$400.00
4/17/2001	$400.00
6/30/2006	$1,000.00
8/2/2006	$1,000.00
9/6/2006	$170.00
10/2/2006	$180.00
11/1/2006	$2,700.00
12/5/2006	$750.00
1/24/2007	$500.00
5/2/2007	$500.00
9/12/2007	$200.00
2/26/2008	$128.85
2/26/2008	$71.15
3/31/2008	$3,600.00
5/5/2008	$800.00
7/11/2008	$500.00
8/22/2008	$500.00
9/26/2008	$500.00
10/24/2008	$250.00
12/1/2008	$500.00
12/29/2008	$500.00
2/3/2009	$500.00
3/3/2009	$500.00
3/31/2009	$500.00
5/1/2009	$500.00
6/2/2009	$450.00
7/1/2009	$400.00
8/3/2009	$342.05
9/8/2009	$400.00
10/29/2009	$300.00
1/4/2010	$500.00
2/2/2010	$500.00
3/8/2010	$255.78
4/5/2010	$450.00
1/5/2011	$1,200.00
2/2/2011	$500.00
3/4/2011	$500.00
4/6/2011	$250.00
5/6/2011	$250.00
6/6/2011	$250.00
8/10/2011	$250.00
10/14/2011	$250.00
12/27/2011	$482.54
12/27/2011	$5,076.10
10/2/2012	$2,021.58
10/1/2013	$2,123.37
10/1/2014	$2,156.27
10/1/2015	$1,000.00
10/22/2015	$1,440.84
9/26/2016	$1,000.00
10/19/2016	$1,634.87
8/22/2017	$2,353.06
8/22/2017	$326.00

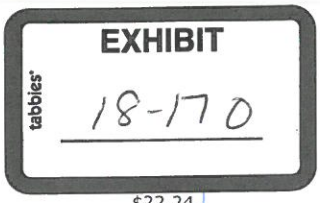
County Balance Due: $0.00

School Balance Due: $0.00

These amounts are valid through the last day of the month. For accounts with delinquent balances, statutory penalty will accrue on the first day of next month.

Sewer History as of 6/14/2018 3:00:04 AM

Tax Year	Principal Due	Penalty Due	Date Paid	Amount Paid
1993S3	$0.00	$0.00	12/6/2000	$7.38
1993S4	$0.00	$0.00	12/6/2000	$43.94
1994S1	$0.00	$0.00	12/6/2000	$24.93
1994S2	$0.00	$0.00	12/6/2000	$24.51
1994S3	$0.00	$0.00	12/6/2000	$24.01
1994S4	$0.00	$0.00	12/6/2000	$23.59
1995S1	$0.00	$0.00	12/6/2000	$34.07
1995S2	$0.00	$0.00	12/6/2000	$33.47
1995S3	$0.00	$0.00	12/6/2000	$32.90
1995S4	$0.00	$0.00	12/6/2000	$32.30
1996S1	$0.00	$0.00	12/6/2000	$26.61
1996S2	$0.00	$0.00	12/6/2000	$26.10
1996S3	$0.00	$0.00	12/6/2000	$25.60
1996S4	$0.00	$0.00	12/6/2000	$25.09
1997S1	$0.00	$0.00	12/6/2000	$24.58
1997S2	$0.00	$0.00	12/6/2000	$24.07
1997S3	$0.00	$0.00	12/6/2000	$23.60



1997S4	$0.00	$0.00	12/6/2000	
1998S1	$0.00	$0.00	12/6/2000	
1998S2	$0.00	$0.00	12/6/2000	$22.24
1998S3	$0.00	$0.00	12/6/2000	$22.43
1998S4	$0.00	$0.00	12/6/2000	$21.92
1999S1	$0.00	$0.00	12/6/2000	$25.61
1999S2	$0.00	$0.00	12/6/2000	$25.01
1999S3	$0.00	$0.00	12/6/2000	$24.50
1999S4	$0.00	$0.00	12/6/2000	$23.90
2000S1	$0.00	$0.00	12/6/2000	$11.65
2000S2	$0.00	$0.00	12/6/2000	$11.35
2000S3	$0.00	$0.00	12/6/2000	$11.07
2000S4	$0.00	$0.00	12/6/2000	$10.26
2001S1	$0.00	$0.00	6/2/2006	$25.27
2001S2	$0.00	$0.00	6/2/2006	$28.14
2001S3	$0.00	$0.00	6/2/2006	$27.60
2001S4	$0.00	$0.00	6/2/2006	$27.09
2002S1	$0.00	$0.00	6/2/2006	$21.47
2002S2	$0.00	$0.00	6/2/2006	$21.05
2002S3	$0.00	$0.00	6/2/2006	$20.69
2002S4	$0.00	$0.00	6/2/2006	$20.27
2003S1	$0.00	$0.00	6/2/2006	$14.68
2003S2	$0.00	$0.00	6/2/2006	$14.38
2003S3	$0.00	$0.00	6/2/2006	$14.17
2003S4	$0.00	$0.00	6/2/2006	$13.87
2004S1	$0.00	$0.00	6/2/2006	$13.57
2004S2	$0.00	$0.00	6/2/2006	$13.27
2004S3	$0.00	$0.00	6/2/2006	$12.93
2004S4	$0.00	$0.00	6/2/2006	$12.63
2005S1	$0.00	$0.00	6/2/2006	$12.33
2005S2	$0.00	$0.00	6/2/2006	$12.03
2005S3	$0.00	$0.00	6/2/2006	$16.28
2005S4	$0.00	$0.00	8/24/2006	$15.95
2006S1	$0.00	$0.00	8/24/2006	$15.86
2006S2	$0.00	$0.00	8/24/2006	$15.44
2006S3	$0.00	$0.00	8/24/2006	$14.77
2006S4	$0.00	$0.00	11/30/2006	$14.77
2007S1	$0.00	$0.00	2/28/2007	$12.50
2007S2	$0.00	$0.00	6/1/2007	$12.50
2007S3	$0.00	$0.00	9/5/2007	$12.50
2007S4	$0.00	$0.00	12/3/2007	$12.50
2008S1	$0.00	$0.00	2/29/2008	$64.01
2008S2	$0.00	$0.00	6/6/2008	$64.01
2008S3	$0.00	$0.00	9/3/2008	$64.01
2008S4	$0.00	$0.00	12/12/2008	$64.01
2009S1	$0.00	$0.00	3/4/2009	$54.16
2009S2	$0.00	$0.00	8/4/2009	$57.95
2009S3	$0.00	$0.00	3/10/2010	$66.51
2009S4	$0.00	$0.00	3/10/2010	$64.74
2010S1	$0.00	$0.00	3/10/2010	$62.97
2010S2	$0.00	$0.00	1/5/2011	$66.51
2010S3	$0.00	$0.00	1/5/2011	$67.60
2010S4	$0.00	$0.00	1/5/2011	$65.74
2011S1	$0.00	$0.00	12/27/2011	$116.65
2011S2	$0.00	$0.00	12/27/2011	$113.62
2011S3	$0.00	$0.00	12/27/2011	$114.91
2011S4	$0.00	$0.00	12/27/2011	$111.76
2012S1	$0.00	$0.00	3/5/2012	$12.50
2012S2	$0.00	$0.00	5/22/2012	$12.50
2012S3	$0.00	$0.00	7/18/2012	$12.50
2012S4	$0.00	$0.00	11/14/2012	$12.50
2013S1	$0.00	$0.00	2/11/2013	$23.43
2013S2	$0.00	$0.00	5/29/2013	$23.43
2013S3	$0.00	$0.00	12/27/2013	$25.83
2013S4	$0.00	$0.00	4/14/2014	$25.84
2014S1	$0.00	$0.00	6/30/2014	$71.05
2014S2	$0.00	$0.00	8/22/2017	$72.49
2014S3	$0.00	$0.00	8/22/2017	$94.42
2014S4	$0.00	$0.00	8/22/2017	$92.41
2015S1	$0.00	$0.00	8/22/2017	$205.36
2015S2	$0.00	$0.00	8/22/2017	$200.80
2015S3	$0.00	$0.00	8/22/2017	$196.24
2015S4	$0.00	$0.00	8/22/2017	$191.68
2016S1	$0.00	$0.00	8/22/2017	$74.88
2016S2	$0.00	$0.00	8/22/2017	$73.05
2016S3	$0.00	$0.00	8/22/2017	$71.22
2016S4	$0.00	$0.00	8/22/2017	$69.39
2017S1	$0.00	$0.00	8/22/2017	$67.56
2017S2	$0.00	$0.00	8/22/2017	$65.73
2017S3	$0.00	$0.00	8/22/2017	$60.86
2017S4	$0.00	$0.00	11/30/2017	$60.86
2018S1	$0.00	$0.00	2/13/2018	$24.34

2018S2 |	$0.00 |	$0.00 |	5/10/2018 |	$24.34

Balance Due: $0.00

These amounts are valid through the last day of the month. Statutory penalty will accrue on the first day of next month.

Commercial Structure Characteristics

Building #: 01

Occupancy: 251	# of Stories: 1	Year Built: 1955	
Struct Class: C	Quality: C	Condition: AV	
Floor Level: F	Grnd Flr Area: 1380	Total Flr Area: 1380	
Ext Wall Type: 11	Wall Height: 14	Perimeter: 152	
AC %: 0	Heat %: 90	Rentable Units: 1	
Bsmt: 0	Bsmt Util: 0		
Year Renov: 0	Renov Rtng: 0	Eff. Yr Built: 1958	

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3.0 Permeable Pavement Systems

Definition: Paving surfaces that capture and temporarily store stormwater by filtering runoff through voids in the pavement surface into an underlying reservoir. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil.

Design variants include:

- 3-A Porous Asphalt (PA)
- 3-B Pervious Concrete (PC)
- 3-C Permeable interlocking concrete Pavers (PP) or Concrete grid Pavers (CP)
- 3-D Plastic Grid Pavers (GP)

Other variations of permeable pavement that are DNREC approved permeable pavement surface materials are also encompassed in this section.

Permeable pavement systems may be designed to provide stormwater detention for all design storm events. Permeable pavement practices that are unable to infiltrate all design storms are often combined with a separate facilities to provide controls for larger runoff events.

Regardless of which design variant is chosen, the runoff reduction credit applied to the practice is the volume of runoff that is being stored in the reservoir layer underneath the permeable pavement and infiltrated over a period of 48-hours. It is recommended that an underdrain and control structure be constructed within the reservoir for long term maintenance and facility inspections.

The particular design configuration to be implemented on a site is typically dependent on specific site conditions and the characteristics of the native soils.

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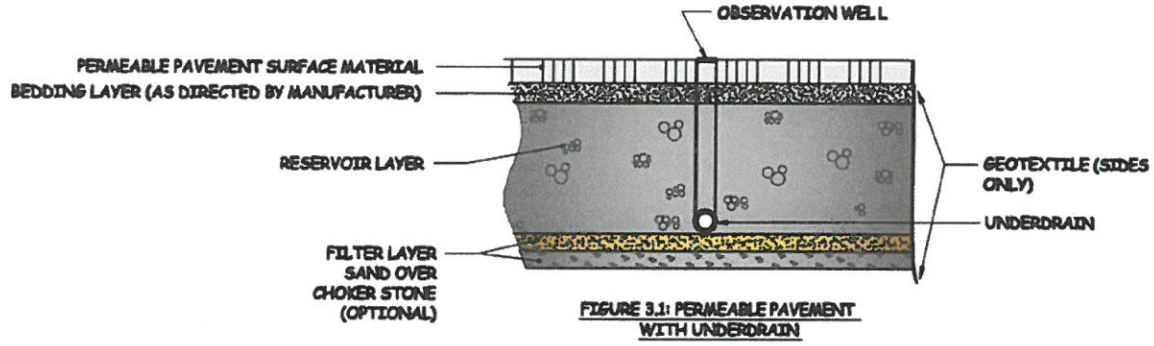

FIGURE 3.1: PERMEABLE PAVEMENT WITH UNDERDRAIN

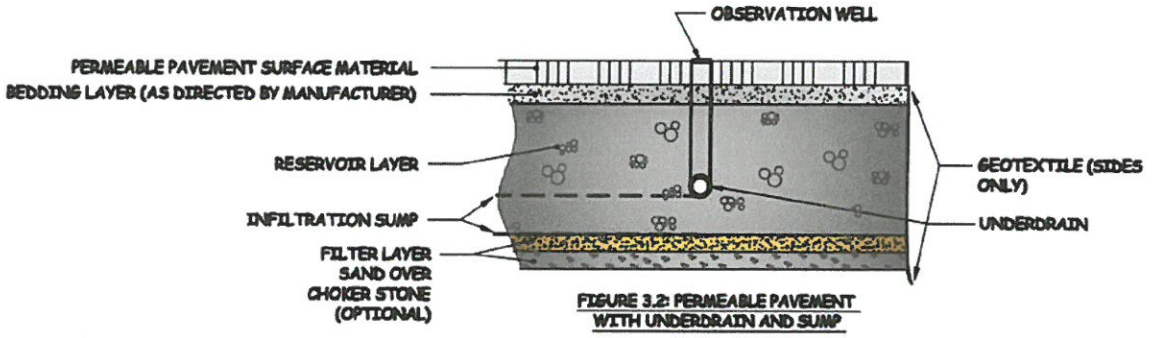

FIGURE 3.2: PERMEABLE PAVEMENT WITH UNDERDRAIN AND SUMP

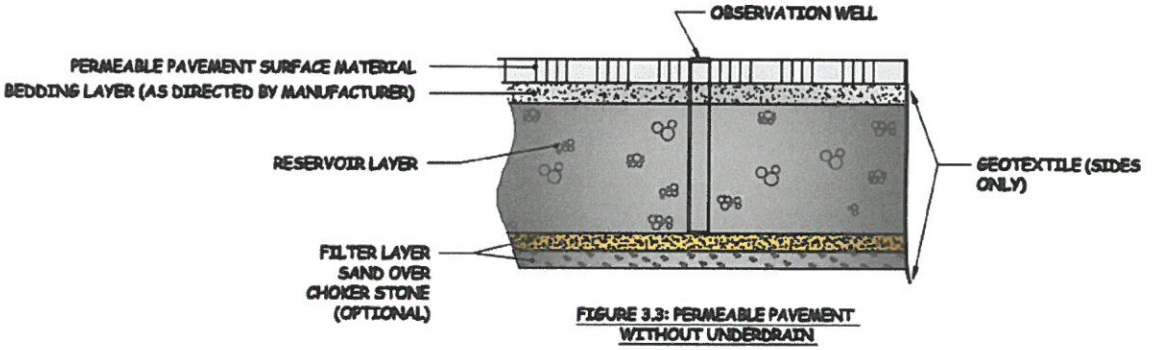

FIGURE 3.3: PERMEABLE PAVEMENT WITHOUT UNDERDRAIN

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3.1 Permeable Pavement Stormwater Credit Calculations

The retention volume credit for permeable pavement depends on the volume of runoff that is infiltrated from this practice (Table 3.1).

3.1 Permeable Pavement Performance Credits

Runoff Reduction	
Retention Allowance	100%
RPv -A/B Soil	100% of Retention Storage
RPv - C/D Soil	100% of Retention Storage
Cv	100% of Retention Storage
Fv	100% of Retention Storage
Pollutant Reduction	
TN Reduction	100% of Load Reduction
TP Reduction	100% of Load Reduction
TSS Reduction	100% of Load Reduction

The practice must be sized using the guidance detailed in ***Section 3.6. Permeable Pavement Design Criteria.***

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3.2 Permeable Pavement Design Summary

Table 3.2 summarizes design criteria for permeable pavement, and Tables 3.3 and 3.4 summarize the materials specifications for this practice. For more detail, consult Sections 3.3 through 3.7. Sections 3.8 and 3.9 describes practice construction and maintenance criteria.

Table 3.2 Permeable Pavement Design Summary

Feasibility (Section 3.3)	• Minimum soil infiltration of 1"/hr, unless an underdrain is used • External drainage close to 100% impervious • Pavement surface < 3% slope • Minimum 2' separation to seasonal high groundwater, unless an underdrain is used. If an underdrain is used the seasonal high groundwater shall not enter into the reservoir • Cannot treat hotspots or areas with high pollutant loads • Cannot treat high speed roads • Setbacks from wells, buildings and utilities (Table 3.5)
Conveyance (Section 3.4)	• Safely convey Cv and Fv design storms
Pretreatment (Section 3.5)	• Not needed
Sizing (Reservoir Layer Depth) (Section 3.6)	$d_p = \frac{\{(d_c \times R) + P - (\frac{1}{2} i \times t_f)\}}{\eta_r}$
Variables:	d_p = Depth of the reservoir layer (ft.) d_c = Depth of runoff from the contributing drainage area (not including the permeable pavement surface) for the design storm (ft.) R = A_c/A_p = The ratio of the contributing drainage area (A_c) (not including the permeable pavement surface) to the permeable pavement surface area (A_p) P = The rainfall depth for the design storm (ft.) i = The field-verified infiltration rate for the native soils (ft./day). If an impermeable liner is used in the design then $i = 0$. t_f = The time to fill the reservoir layer (day) – assume 1 day η_r = The effective porosity for the reservoir layer (0.4)
Landscaping (Section 3.7)	Not applicable

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Material Specifications: Permeable pavement material specifications vary according to the specific pavement product selected. A general comparison of different permeable pavements is provided in **Table 3.3**, but designers should consult manufacturer's technical specifications for specific criteria and guidance.

Table 3.3. Different Permeable Pavement Specifications

Material	Specification	Notes
Permeable Interlocking Concrete Pavers (PP)	Surface open area: 5% to 15%. Thickness: 3.125 inches for vehicles. Compressive strength: 55 Mpa. Open void fill media: aggregate	Must conform to ASTM C936 specifications. Reservoir layer required to support the structural load.
Concrete Grid Pavers (CP)	Open void content: 20% to 50%. Thickness: 3.5 inches. Compressive strength: 35 Mpa. Open void fill media: aggregate, topsoil and grass, coarse sand.	Must conform to ASTM C 1319 specifications. Reservoir layer required to support the structural load.
Plastic Reinforced Grid Pavers (GP)	Void content: depends on fill material. Compressive strength: varies, depending on fill material. Open void fill media: aggregate, topsoil and grass, coarse sand.	Reservoir layer required to support the structural load.
Pervious Concrete (PC)	Void content: 15% to 25 %. Thickness: typically 4 to 8 inches. Compressive strength: 2.8 to 28 Mpa. Open void fill media: None	May not require a reservoir layer to support the structural load.
Porous Asphalt (PA)	Void content: 15% to 20 %. Thickness: typically 3 to 7 in. (depending on traffic load). Open void fill media: None.	Reservoir layer required to support the structural load.

Table 3.4 describes general material specifications for the component structures installed beneath the permeable pavement. Note that the size of stone materials used in the reservoir and filter layers may differ depending on the type of surface material.

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Table 3.4. Material Specifications for Underneath the Pavement Surface

Material	Specification	Notes
Bedding Layer	PP: 2 in. depth of No. 8 stone over 3 to 4 inches of No. 57 stone PC: None PA: 2 in. depth of No. 8 stone	ASTM D448 size No. 8 stone (e.g., 3/8 to 3/16 inch in size). Should be double-washed and free of all fines.
Reservoir Layer	PP: No. 57 stone PC: No. 57 stone PA: No. 2 stone	ASTM D448 size No. 57 stone (e.g. 1 1/2 to 1/2 inch in size); No. 2 Stone (e.g. 3 inch to 3/4 inch in size). Depth is based on the pavement structural and hydraulic requirements. Should be double-washed and clean and free of all fines. The reservoir layer shall be at least 6" deep.
Underdrain	Use 4 to 6 inch diameter perforated PVC pipe (or equivalent corrugated HDPE may be used for smaller load-bearing applications), with 3/8-inch perforations at 6 inches on center. Perforated pipe installed for the full length of the permeable pavement cell, and non-perforated pipe, as needed, is used to connect with the storm drain system. T's and Y's installed as needed, depending on the underdrain configuration. Extend cleanout pipes to the surface with vented caps at the Ts and Ys.	
Infiltration Sump	An aggregate storage layer below the underdrain invert. The depth of the reservoir layer above the invert of the underdrain must be at least 12 inches. The material specifications are the same as Reservoir Layer.	
Filter Layer (optional)	The underlying native soils may require separation from the stone reservoir by a thin layer of choker stone as determined by geotechnical investigation.	The choker stone layer should be a minimum of 1" thick, and a minimum of 1" per foot of reservoir depth.
Non-woven Geotextile (optional)	Use a needled, non-woven, polypropylene geotextile with a Flow Rate greater than 125 gpm/sq. ft. (ASTM D4491), and an Apparent Opening Size (AOS) equivalent to a US # 70 or # 80 sieve (ASTM D4751).	
Observation Well	Use a perforated 4 to 6 inch vertical PVC pipe (AASHTO M 252) with a lockable cap, installed flush with the surface or just beneath PP.	

3.3 Permeable Pavement Feasibility Criteria

Since permeable pavement has a very high runoff reduction capability, it should always be considered as an alternative to conventional pavement. Permeable pavement is subject to the same feasibility constraints as most infiltration practices, as described below.

Required Space. A prime advantage of permeable pavement is that it does not normally require additional space at a new development or redevelopment site, which can be important for tight sites or areas where land prices are high.

Soils. Soil conditions do not typically constrain the use of permeable pavement, although they do determine whether an underdrain is needed. Underdrains are required if the measured permeability of the native soils is less than 1.0 in/hr, per the on-site soil investigation methods provided in ***Appendix 1***.

External Drainage Area. Any external drainage area contributing runoff to permeable

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pavement should never exceed five times the surface area of the permeable pavement (two times is recommended), and it should be as close to 100% impervious as possible.

Pavement Surface Slope. Steep pavement surface slopes can reduce the stormwater storage capability of permeable pavement and may cause shifting of the pavement surface and base materials. Designers should use a terraced design for permeable pavement when the local slope is 3 percent or greater.

Pavement Bottom Slope. The bottom slope of a permeable pavement installation should be as flat as possible (i.e., 0% longitudinal and lateral slopes) to enable even distribution and infiltration of stormwater. On sloped sites, internal check dams or terraces can be incorporated into the subsurface to encourage infiltration. If an underdrain is used, low-grade longitudinal slopes are permissible on a case-by-case basis.

Minimum Hydraulic Head. The elevation difference needed for permeable pavement to function properly is generally nominal.

Minimum Depth to Water Table. A minimum vertical distance of 2 feet must be provided between the bottom of the permeable pavement installation (i.e., the bottom invert of the reservoir layer) and the seasonal high water table if an underdrain system is not used. If an underdrain is used, the seasonal high groundwater may not encroach into the reservoir layer.

Setbacks. To avoid the risk of seepage, permeable pavement practices should not be hydraulically connected to structure foundations. Setbacks to structures vary based on the size of the permeable pavement installation (Table 3.5)

Table 3.5. Setbacks for Permeable Pavement

Pavement Area	Buildings		Wells/ Utilities
	Up-Gradient	Down-Gradient	
250 to 1,000 sf	5'	25'	100' from wells 5' down-gradient from utility lines
1,000 to 10,000 sf	10'	50'	
>10,000 sf	25'	100'	
*Note: In some cases, the use of an impermeable liner along the sides of the permeable pavement practice (extending from the surface to the bottom of the reservoir layer) may be used as an added precaution against seepage, and the setback requirements may be removed or relaxed on a case-by-case basis.			

Hotspot Land Uses. Permeable pavements should not be used to treat hotspot runoff. For a list of potential stormwater hotspot operations, consult ***Appendix 4***.

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High Pollutant Loading Situations. Permeable pavement is not intended to treat sites with sediment or trash/debris loads, since such loads will cause the practice to clog and fail. Sites with significant pervious area (newly established turf and landscaping) are considered high loading sites and the pervious areas should be diverted from the permeable pavement area. If unavoidable, an increased maintenance schedule to check for clogging may be required on a case-by-case basis.

High Speed Roads. Permeable pavement is recommended for sidewalks, driveways, residential streets, parking areas, shoulders, and gutter sections. Permeable pavement should not be used for high speed roads with prior approval from DelDOT or other applicable roadway agency.

3.4 Permeable Pavement Conveyance Criteria

Permeable pavement designs should include methods to convey larger storms (e.g., Cv, Fv) to other stormwater management facilities. The following is a list of methods that can be used to accomplish this:

- Place an underdrain in the bottom of the reservoir layer and attached to a control structure, designed to pass excess flows after water has filled the reservoir layer.
- Place an over flow pipe; a perforated pipe horizontally near the top of the reservoir layer, to pass excess flows after stormwater has filled the reservoir layer.
- Increase the thickness of the reservoir layer to increase storage (i.e., create freeboard) to accommodate the Cv and Fv events.
- Create additional underground detention within the reservoir layer of the permeable pavement system using structural void space. Reservoir storage may be augmented by plastic or concrete arch structures, etc.
- Route excess flows to another detention or conveyance system that is designed for the management of greater event flows.
- Set the storm drain inlets flush with the elevation of the permeable pavement surface to effectively convey excess stormwater runoff past the system. The design should also make allowances for relief of unacceptable ponding depths during larger rainfall events.

3.5 Permeable Pavement Pretreatment Criteria

Pretreatment for most permeable pavement applications is not necessary, since the surface acts as pretreatment to the reservoir layer below. Pretreatment is necessary if the pavement receives run-on from adjacent pervious areas. For example, a gravel or grass buffer strip can be placed adjacent to pervious (landscaped) areas to trap coarse sediment particles before they reach the pavement surface, in order to minimize clogging.

3.6 Permeable Pavement Design Criteria

Type of Surface Pavement: The type of pavement should be selected based on a review of the

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pavement specifications and properties, and designed according to the product manufacturer's recommendations.

Internal Geometry and Drawdowns:

- **Rapid Drawdown.** Permeable pavement should be designed so that the target storage volume is detained in the reservoir for as long as possible – up to 48 hours - before completely discharging through infiltration. An underdrain attached to a control structure with a minimum orifice size of 0.5" (recommended regardless of the calculated drawdown time) may also be employed. Runoff Reduction retention volumes will only be based off of runoff infiltrated.
- **Infiltration Sump.** To promote greater runoff reduction for permeable pavement located on marginal soils, an infiltration sump can be installed to create a storage layer below the underdrain invert.
- **Conservative Infiltration Rates.** Designers should always decrease the measured infiltration rate by a factor of 2 during design, to approximate long term infiltration rates.

Reservoir layer: The reservoir layer consists of the stone underneath the pavement section and above the bottom filter layer or underlying soils. The total thickness of the reservoir layer is determined by runoff storage needs, the infiltration rate of native soils, structural requirements of the pavement sub-base, depth to the seasonal high water table and bedrock, and frost depth conditions. A geotechnical engineer should be consulted regarding the suitability of the soil subgrade.

- The reservoir layer should be composed of clean, double-washed stone aggregate and sized for both the storm event to be treated and the structural requirements of the expected traffic loading.
- The reservoir layer should consist of clean double-washed Delaware No. 3 stone, unless a specific site constraint or structural concern requires different stone sizing.
- The bottom of the reservoir layer should be completely flat so that runoff will be able to infiltrate evenly through the entire surface. For sites with native slope that do not allow for a flat bottom, the bottom should either be terraced or check dams should be installed.

Underdrains: Most permeable pavement designs will require an underdrain (see **Section 3.3**). Underdrains can also be used to keep detained stormwater from flooding permeable pavement during extreme events. Flat terrain may affect proper drainage of permeable pavement designs, so underdrains should have a minimum 0.5% slope. Underdrains should be located 20 feet or less from the next pipe. The underdrain should be perforated schedule 40 PVC pipe, with 3/8-inch perforations at 6 inches on center, or corrugated HDPE depending on load-bearing application. The underdrain should be encased in a layer of clean, washed No.57 stone with a minimum of 2" of stone below the underdrain pipe. The underdrain system should include a flow control to ensure that the reservoir layer drains slowly; however it should completely drain within 48 hours.

- The underdrain outlet can be fitted with a flow-reduction orifice within a weir or other easily inspected and maintained configuration in the downstream manhole as a means of regulating the stormwater detention time. The minimum diameter of any orifice should be 0.5 inch. The designer will verify that the volume will draw down completely within 48 hours

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- For infiltration designs, an underdrain(s) can be installed into a control structure that has an outlet higher than the underdrain inlet in order to promote the full infiltration volume, while still allowing for overflow within the system. In this scenario, a lower capped drain should also be installed for future maintenance.
- Alternatively, an underdrain(s) can be installed and capped at the downstream structure for future use if maintenance observations indicate a reduction in the soil permeability.

All permeable pavement practices should include observation wells. The observation well is used to observe the rate of drawdown within the reservoir layer following a storm event and to facilitate periodic inspection and maintenance. The observation wells should consist of a well-anchored, perforated 4 to 6 inch (diameter) PVC pipe that is tied into the underdrain system. The well should extend vertically to the bottom of the reservoir layer and extend upwards to be flush with the surface (or just under pavers) with a lockable cap. In addition, cleanout pipes should be provided if the pavement surface area exceeds 1,000 sq. ft.

Infiltration Sump (optional): An optional upturned elbow, elevated underdrain, or other control structure configuration can be used to promote greater runoff reduction for permeable pavement located on marginal soils (see Figure 3.2). The Infiltration Sump allows for the design of infiltration reservoirs even in marginal soils. The depth of the reservoir layer above the invert of the underdrain must be at least 12 inches. The depth of th infiltration sump is sized so that the design storm can infiltrate into the native soil within a 48 hour period. If no underdrain is employed, the bottom of infiltration sump must be at least 2 feet above the seasonal high water table. The inclusion of an infiltration sump is not permitted for designs with an impermeable liner.

Filter Layer (optional): To protect the bottom of the reservoir layer from intrusion by underlying soils, a filter layer is required in marginal soils. The native soils should be separated from the stone reservoir by a thin, (minimum 1", or 1"/foot of reservoir) layer of choker stone (No. 8 or approved equal).

Non-woven Geotextile (optional): Non-woven filter fabric is not recommended for the bottom of the reservoir layer as filter fabric can become a future plane of clogging within the system. Permeable non-woven filter fabric is still recommended to protect the excavated sides of the reservoir layer, in order to prevent soil piping. A needled, non-woven, polypropylene geotextile with a Flow Rate greater than 125 gpm/sq. ft. (ASTM D4491), and an Apparent Opening Size (AOS) equivalent to a US # 70 or # 80 sieve (ASTM D4751). The geotextile AOS selection is based on the percent passing the No. 200 sieve in "A" soil subgrade, using FHWA or AASHTO selection criteria.

Impermeable Liner (optional): This material should be used only for appropriate fill applications where deemed necessary by a geotechnical investigation. Use a thirty mil (minimum) PVC Geomembrane liner covered by 8 to 12 oz./sq. yd. non-woven geotextile. The usage of an impermeable liner precludes any runoff reduction from the permeable pavement. However, the system may still be employed as a stormwater capturing and routing facility

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particularly in densely urban areas.

Permeable Pavement Sizing: The thickness of the reservoir layer is determined by both a structural and hydraulic design analysis. The reservoir layer serves to retain stormwater and also supports the design traffic loads for the pavement. Permeable pavement structural and hydraulic sizing criteria are discussed below:

Structural Design. The pavement surface must be able to support the maximum anticipated traffic load. The structural design process will vary according to the type of pavement selected, and the manufacturer's specific recommendations. The thickness of the permeable pavement and reservoir layer must be sized to support structural loads and to temporarily store and then infiltrate the design storm volume (e.g., the water quality, channel protection, and/or flood control volumes). On most new development and redevelopment sites, the structural support requirements will dictate the depth of the underlying stone reservoir.

The structural design of permeable pavements involves consideration of four main site elements:

- Total traffic;
- Native soil strength;
- Environmental elements; and
- Bedding and Reservoir layer design.

The resulting structural requirements may include, but are not limited to, the thickness of the pavement, filter, and reservoir layer. Designers should note that if the native soils have a California Bearing Ratio (CBR) less than 4%, they may need to be compacted to at least 95% of the Standard Proctor Density, which generally rules out their use for infiltration. As such, if the underlying soils are found to be sub-standard an additional amount of subsoil may need to be excavated and replaced to increase the structural capacity of the system.

Designers should determine structural design requirements by consulting transportation design guidance sources, such as the following:

- AASHTO Guide for Design of Pavement Structures (1993); and,
- AASHTO Supplement to the Guide for Design of Pavement Structures (1998).

Hydraulic Design. Permeable pavement is typically sized to store stormwater runoff in the reservoir layer. The storage volume in the permeable pavement system must account for the underlying infiltration rate and flow through any underdrain or overflow structure. The design storm is routed through the pavement to accurately determine the required reservoir depth.

The depth of the reservoir layer or infiltration sump needed to store the design storm can be determined by using **Equation 3.1**.

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Equation 3.1

$$d_p = \frac{\{(d_c \times R) + P - (\frac{1}{2} i \times t_f)\}}{\eta_r}$$

Where:

d_p = Depth of the reservoir layer (ft.)

d_c = Depth of runoff from the contributing drainage area (not including the permeable pavement surface) for the design storm (ft.)

R = A_c/A_p = The ratio of the contributing drainage area (A_c) (not including the permeable pavement surface) to the permeable pavement surface area (A_p)

P = The rainfall depth for the design storm (ft.)

i = The field-verified infiltration rate for the native soils (ft./day). If an impermeable liner is used in the design then $i = 0$.

t_f = The time to fill the reservoir layer (day) – assume 24 hours or 1 day

η_r = The effective porosity for the reservoir layer (0.4)

This equation makes the following design assumptions:

- The contributing drainage area (A_c) does not contain pervious areas.
- For design purposes, the field-tested subgrade soil infiltration rate (i) is divided by 2 as a factor of safety to account for potential compaction during construction. If the native soil will be compacted to meet structural design requirements of the pavement section, the design infiltration rate of the subgrade soil shall be based on measurement of the infiltration rate of the subgrade soil subjected to the compaction requirements.

For design with underdrains, calculate the drawdown times using the hydrological routing or modeling procedures used for detention systems with the depth and head adjusted for the porosity of the aggregate to ensure that the practice will draw down within 48 hours.

The depth of the reservoir layer cannot be less than the depth required to meet the pavement structural requirement. The depth of the reservoir layer may need to be increased to meet structural or larger storage requirements, and shall always be a minimum of 6" deep.

For crediting purposes (see ***Section 3.1 Permeable Pavement Stormwater Credit Calculations***), the total storage volume provided by the practice, *Sv*, should be determined using **Equation 3.2.**

Equation 3.2.

$$Sv = d_p \times \eta_r \times A_p$$

Depending on the design option, all or a portion of the design volume will be designed to infiltrate, as calculated using Equation 3.3. This equation also ensures that the volume credited with infiltration will draw down within 48 hours. This equation also assumes that the measured soil infiltration rate is divided by 2 due to compaction during construction.

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Equation 3.3.

$$Sv_{\text{inf iltration}} = \min(d_s \times \eta_r, i) \times A_p$$

Where:

$Sv_{infiltration}$ = Volume designed to infiltrate through the porous pavement section.

d_s = depth of the sump or, for designs without an underdrain, depth of the reservoir

Some of the volume stored in the infiltration practice is not designed to infiltrate, but is contained within the reservoir, during which time a portion of the volume is evaporated, or detained for a long period. Although the volume calculated as filtering can be equal to the entire storage volume minus the amount infiltrated, no more than 1" of storage within this reservoir can be considered in crediting this practice. This volume is calculated using equation 3.4.

Equation 3.4.

$$Sv_{filtering} = \min\left(Sv - Sv_{\text{inf iltration}}, A_p \times 3{,}630\right)$$

Detention Storage Design: Permeable pavement can also be designed to address, in whole or in part, the detention storage needed to comply with Cv and/or Fv requirements. Various approaches can be modeled by factoring in storage within the stone aggregate layer, expected infiltration, and any outlet structures used as part of the design. Routing calculations can also be used to provide a more accurate solution of the peak discharge and required storage volume.

Once runoff passes through the surface of the permeable pavement system, designers should calculate outflow pathways to handle subsurface flows. Subsurface flows can be regulated using underdrains, the volume of storage in the reservoir layer, the bed slope of the reservoir layer, and/or a control structure at the outlet (see ***Section 3.4 Permeable Pavement Conveyance Criteria***).

3.7 Permeable Pavement Landscaping Criteria

Permeable pavement does not have any landscaping needs associated with it. However, large-scale permeable pavement applications should be carefully planned to integrate the typical landscaping features of a parking lot (such as trees and islands) in a manner that maximizes runoff treatment and minimizes the risk that sediment, mulch, grass clippings, leaves, nuts, and fruits will inadvertently clog the paving surface.

3.8 Permeable Pavement Construction Sequence

Experience has shown that proper installation is absolutely critical to the effective operation of a permeable pavement system.

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Erosion and Sediment Controls. The following erosion and sediment control guidelines must be followed during construction:

- All permeable pavement areas should be fully protected from sediment intrusion by silt fence or construction fencing to prevent construction traffic tracking.
- Permeable pavement areas should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. Permeable pavement areas should be clearly marked on all construction documents and grading plans. To prevent soil compaction, heavy vehicular and foot traffic should be kept out of permeable pavement areas during and immediately after construction. If compaction occurs, an additional geotechnical investigation may be required to determine that the native soils are still capable of infiltrating. All stormwater calculations will need to be revised to match the revised compacted native soil infiltration capacity.
- During construction, care must be taken to avoid tracking sediments onto any permeable pavement surface to avoid clogging.
- Areas intended to be permeable pavement shall not be used as a temporary sediment basin. When locating a sediment basin on an area intended for permeable pavement is unavoidable, the invert of the sediment basin must be a minimum of 1 foot above the final design elevation of the bottom of the reservoir course. All sediment deposits in the excavated area shall be carefully removed prior to installing the subbase.

Permeable Pavement Installation. The installation of permeable pavement systems should follow the manufacturers recommended guidelines. The following is a typical construction sequence, which will be modified per manufacturer's recommendations:

Step 1. Construction of the permeable pavement shall only begin after the entire contributing drainage area has been stabilized. The proposed site should be checked for existing utilities prior to any excavation. Do not install the system in rain or snow, and do not install frozen bedding materials.

Step 2. As noted above, temporary erosion and sediment controls are needed during installation to divert stormwater away from the permeable pavement area until it is completed. Additional protective measures such as erosion control fabrics may be needed to protect vulnerable side slopes from erosion during the excavation process. The proposed permeable pavement area must be kept free from sediment during the entire construction process. Construction materials contaminated by sediments must be removed and replaced with clean materials.

Step 3. Heavy equipment should work from the sides to excavate the reservoir layer to its appropriate design depth and dimensions to minimize compaction of the subsoil. For small pavement applications, excavating equipment should have arms with adequate extension so they do not have to work inside the footprint of the permeable pavement area. For larger pavement applications, contractors can utilize a cell construction approach, whereby the proposed permeable pavement area is split into 500 to 1000 sq. ft. temporary cells with a 10 to 15 foot earth bridge in between, so cells can be excavated from the side. Excavated material should be

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placed away from the open excavation so as to not jeopardize the stability of the side walls.

Step 4. The native soils along the bottom of the permeable pavement system should be scarified or tilled to a depth of 3 to 4 inches.

Step 5. Provide a minimum of 2 inches of aggregate above and below the underdrain. The underdrain should slope towards the outlet at a grade of 0.5% or steeper. The up-gradient ends of the underdrain should be capped. Where an underdrain pipe is connected to a structure, there shall be no perforations within 1 foot of the structure. There are to be no perforations in the clean-outs and observation wells within 1 foot of the surface.

Step 6. Spread 6-inch lifts of the appropriate washed stone aggregate (Delaware No. 3 or approved equal). Place at least 2 inches of additional aggregate cover above the underdrain, and then compact until there is no visible movement of the aggregate, but do not crush the aggregate with the compaction equipment.

Step 7. Install the bedding layer, per manufacturer's recommendations.

Step 8. Paving materials shall be installed in accordance with manufacturer, industry, or engineer's specifications for the particular type of pavement. Examples as shown below:

- **Installation of Porous Asphalt.** The following has been excerpted from various documents, most notably Jackson (2007).
  - Install porous asphalt pavement similarly to regular asphalt pavement. The pavement should be laid in a single lift over the bedding course. The laying temperature should be between 230°F and 260°F, with a minimum air temperature of 50°F.
  - Complete compaction of the surface course when the surface is cool enough to resist a 10-ton roller. One or two passes of the roller are required for proper compaction. More rolling could cause a reduction in the porosity of the pavement.
  - The mixing plant must provide certification of the aggregate mix, abrasion loss factor, and asphalt content in the mix. Test the asphalt mix for its resistance to stripping by water using ASTM 1664.
  - Transport the mix to the site in a clean vehicle with smooth dump beds sprayed with a non-petroleum release agent. The mix shall be covered during transportation to control cooling.
  - Test the permeability of the pavement surface by application of clean water at a rate of at least five gallons per minute over the entire surface. All water must infiltrate directly, without puddle formation or surface runoff.
  - Inspect the facility 18 to 30 hours after a rainfall greater than 1/2 inch, to determine if the facility is draining properly.

- **Installation of Pervious Concrete.** The basic installation sequence for pervious concrete is outlined by the American Concrete Institute (2008). It is strongly recommended that concrete installers successfully complete a recognized pervious concrete installers training program,

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such as the Pervious Concrete Contractor Certification Program offered by the NRMCA. The basic installation procedure is as follows:

- Drive the concrete truck as close to the project site as possible.
- Water the underlying aggregate (reservoir layer) before the concrete is placed, so the aggregate does not draw moisture from the freshly laid pervious concrete.
- After the concrete is placed, approximately 3/8 to 1/2 inch is struck off, using a vibratory screed to allow for compaction.
- Compact the pavement with a steel pipe roller per manufacturer's recommendation.
- Cut joints for the concrete to a depth of 1/4 inch.
- The curing process is very important for pervious concrete. Cover the pavement with plastic sheeting within 20 minutes of the strike-off, and keep it covered for at least seven (7) days. Do not allow traffic on the pavement during this time period.
- Remove the plastic sheeting only after the proper curing time. Inspect the facility 18 to 30 hours after a rainfall greater than 1/2 inch, to determine if the facility is draining properly.

- **Installation of Permeable Interlocking Concrete Pavers.** The basic installation process is described in greater detail by Smith (2006).
  - Place edge restraints for open-jointed pavement blocks before the bedding layer and pavement blocks are installed. Permeable interlocking concrete pavement (IP) systems require edge restraints to prevent vehicle loads from moving the paver blocks. Edge restraints may be standard curbs or gutter pans, or precast or cast-in-place reinforced concrete borders a minimum of 6 inches wide and 18 inches deep, constructed with Class A3 concrete. Edge restraints along the traffic side of a permeable pavement block system are recommended.
  - Place the No. 57 stone in a single lift. Level the filter course and compact it into the reservoir course beneath with at least four (4) passes of a 10-ton steel drum static roller until there is no visible movement. The first two (2) passes are in vibratory mode, with the final two (2) passes in static mode. The filter aggregate should be moist to facilitate movement into the reservoir course.
  - Place and screed the bedding course material (typically No. 8 stone).
  - Fill gaps at the edge of the paved areas with cut pavers or edge units. Cut pavers no smaller than one-third (1/3) of the full unit size.
  - Fill the joints and openings with stone. Joint openings must be filled with ASTM D 448 No. 8 stone, although No. 8P or No. 9 stone may be used where needed to fill narrower joints.
  - Compact and seat the pavers into the bedding course with a minimum low-amplitude 5,000-lbf, 75- to 95-Hz plate compactor.
  - Do not compact within 6 feet of the unrestrained edges of the pavers.
  - The system must be thoroughly swept by a mechanical sweeper or vacuumed immediately after construction to remove any sediment or excess aggregate.
  - Inspect the area for settlement. Any blocks that settle must be reset and re-inspected.
  - Inspect the facility 18 to 30 hours after a rainfall greater than 1/2 inch, to determine if the facility is draining properly.

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Construction Inspection. Inspections before, during and after construction are needed to ensure permeable pavement is built in accordance with these specifications. Use detailed inspection checklists that require sign-offs by qualified individuals at critical stages of construction, to ensure the contractor's interpretation of the plan is consistent with the designer's intent. An example construction phase inspection checklist for permeable pavement practices can be found in ***Article 4.***

Some common pitfalls can be avoided by careful construction supervision that focuses on the following key aspects of permeable pavement installation:

- Store materials in a protected area to keep them free from mud, dirt, and other foreign materials.
- The contributing drainage area should be stabilized prior to directing water to the permeable pavement area.
- Check the aggregate material to confirm it is double washed, meets specifications and is installed to the correct depth.
- Check elevations (e.g., the invert of the underdrain, inverts for the inflow and outflow points, etc.) and the surface slope.
- Make sure the permeable pavement surface is even and the storage bed drains within 48 hours.
- Ensure caps are placed on the upstream end of the underdrain.
- Inspect any pretreatment structures to make sure they are properly installed and working effectively.
- Once the final construction inspection has been completed, log the GPS coordinates for each facility and submit them for entry into the local BMP maintenance tracking database.

It is recommended to divert the runoff from the first few runoff-producing storms away from larger permeable pavement applications, particularly when up-gradient conventional asphalt areas drain to the permeable pavement. This can help reduce the input of fine particles often produced shortly after conventional asphalt is laid down.

3.9 Permeable Pavement Maintenance Criteria

Maintenance is a crucial element to ensure the long-term performance of permeable pavement. The most frequently cited maintenance problem is surface clogging caused by organic matter and sediment. Periodic street sweeping will remove accumulated sediment and help prevent clogging, however, it is also critical to ensure that surrounding land areas remain stabilized.

The following tasks must be avoided on ALL permeable pavements:

- sanding
- re-sealing
- re-surfacing
- power washing

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- storage of snow piles containing sand
- storage of mulch or soil materials
- construction staging

An Operation and Maintenance Plan for the project shall be approved by DNREC or the Delegated Agency prior to project closeout. The Operation and Maintenance Plan will specify the property owner's primary maintenance responsibilities and authorize DNREC or Delegated Agency staff to access the property for maintenance review or corrective action in the event that proper maintenance is not performed. Permeable Pavement practices that are, or will be, owned and maintained by a joint ownership such as a homeowner's association must be located in common areas, community open space, community-owned property, jointly owned property, or within a recorded easement dedicated to public use.

Maintenance of Permeable Pavement practices is driven by annual maintenance reviews that evaluate the condition and performance of the practice. Based on maintenance review results, specific maintenance tasks may be required.

Recommended maintenance tasks are outlined in **Table 3.6**.

Table 3.6. Recommended maintenance tasks for permeable pavement practices.

Maintenance Tasks	Frequency[1]
▪ For the first 6 months following construction, the practice and CDA should be inspected at least twice and after storm events that exceed 1/2 inch of rainfall. Conduct any needed repairs or stabilization.	After installation
▪ Mow grass in grid paver applications	As needed during the growing season
▪ Stabilize the contributing drainage area to prevent erosion ▪ Remove any soil or sediment deposited on pavement. ▪ Replace or repair any necessary pavement surface areas that are degenerating or spalling	As needed
▪ Vacuum pavement with a standard street sweeper to prevent clogging	2-4 times per year (depending on use)
▪ Conduct a maintenance inspection ▪ Spot weeding of grass applications	Annually
▪ Remove any accumulated sediment in pre-treatment cells and inflow points	Once every 2 to 3 years
▪ Conduct maintenance using a regenerative street sweeper ▪ Replace any necessary joint material	If clogged
[1] Required frequency of maintenance will depend on pavement use, traffic loads, and surrounding land use.	

Winter Maintenance Considerations: Winter maintenance on permeable pavements is similar to standard pavements, with a few additional considerations:

- Large snow storage piles should be located in adjacent grassy areas so that sediments and pollutants in snowmelt are deposited before they reach the permeable pavement.
- Sand or cinders should never be applied for winter traction over permeable pavement or areas of impervious pavement that drain toward permeable pavement.
- When plowing plastic reinforced grid pavements, snow plow blades should be lifted 1/2 inch to 1 inch above the pavement surface to prevent damage to the paving blocks or turf. Porous

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asphalt (PA), pervious concrete (PC) and permeable interlocking concrete pavers (PICP) can be plowed similar to traditional pavements, using similar equipment and settings.

- Owners should be judicious when using chloride products for deicing over all permeable pavements designed for infiltration, since the salts will most assuredly be transmitted into the groundwater. Salt can be applied but environmentally sensitive deicers are recommended. Permeable pavement applications will generally require less salt application than traditional pavements.

When permeable pavements are installed on private residential lots, homeowners will need to (1) be educated about their routine maintenance needs, (2) understand the long-term maintenance plan, and (3) be subject to a maintenance agreement as described above.

It is highly recommended that a spring maintenance inspection and cleanup be conducted at each permeable pavement site, particularly at large-scale applications. Example maintenance inspection checklists for permeable pavements can be found in ***Article 5.***

3.10 References

Hunt, W. and K. Collins. 2008. "Permeable Pavement: Research Update and Design Implications." *North Carolina Cooperative Extension Service Bulletin.* Urban Waterways Series.

Jackson, N. 2007. *Design, Construction and Maintenance Guide for Porous Asphalt Pavements.* National Asphalt Pavement Association. Information Series 131. Lanham, MD.

Smith, D. 2006. *Permeable Interlocking Concrete Pavement-selection design, construction and maintenance. Third Edition*. Interlocking Concrete Pavement Institute. Herndon, VA.

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EXISTING AERIAL VIEW
504 KIRKWOOD HIGHWAY

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EXISTING SITE - FRONT

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EXISTING SITE - REAR

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PROPOSED BUILDING RENDITIONS

JASON D GNICH ARCHITECT PIZZA THEATER EXTERIOR | PIZZA PROPERTIES, INC. | 504 KIRKWOOD HWY | WILMINGTON, DE

PERSPECTIVE LOOKING SOUTHWEST

MARCH 26, 2018

JASON D GNICH ARCHITECT PIZZA THEATER EXTERIOR | PIZZA PROPERTIES, INC. | 504 KIRKWOOD HWY | WILMINGTON, DE

NORTH ELEVATION

MARCH 26, 2018

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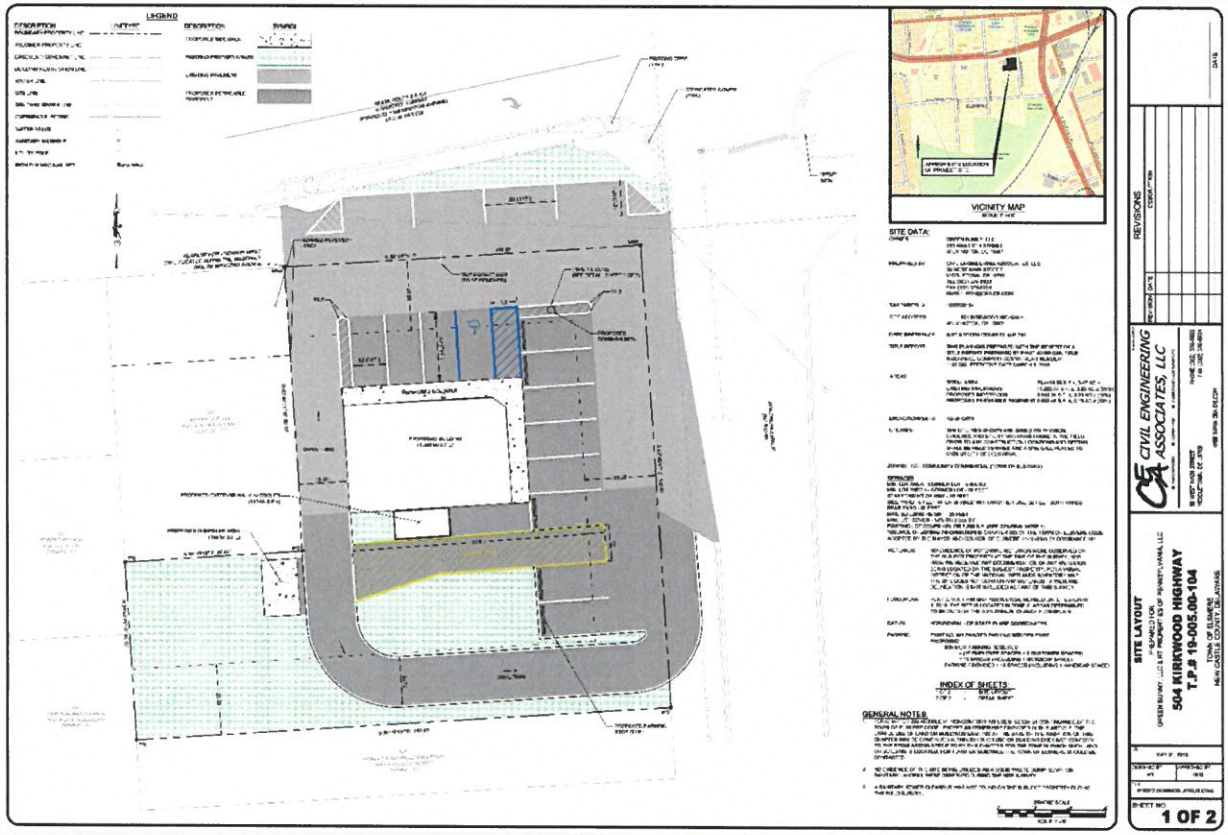
PROPOSED SITE LAYOUT



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QUESTIONS?