Sapsucker Woods Outfall Replacement and Beaver Control Retrofit Plan

CEE 5022/6025: Restoration of Streams and Wetlands

May 11, 2020

Photo Credit: Jessie Powell

CEE 5022/6025 Team

Eirini Sarri - Project Manager

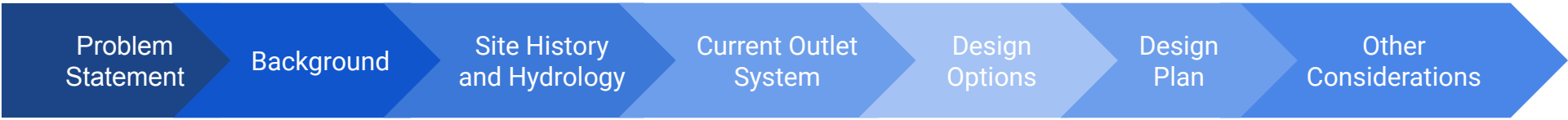
Haowen Jin

Jessie Powell

Ke Xu

Ari Wetzel

Presentation Outline



Problem Statement

- Beaver population recovering
- Beaver plugged current outlet system
  - Localized flooding
  - Dam safety
    - Bank Den tunneling
    - Reduced freeboard in storm events - overtopping failure
  - Increased tree mortality
  - Increased maintenance demands
- Current outlet pipe conditions

The American Beaver

Photo credit: Castro, 2017

Maintenance

- Increased frequency of debris removal
- Staff time and cost
- Corrugated metal pipe (CMP) at end of design life
- Seepage around outlet into rusted pipe

Outlet Structure

CMP at Sapsucker Woods

Photo credit: CEE 5021/6025 Fall 2019

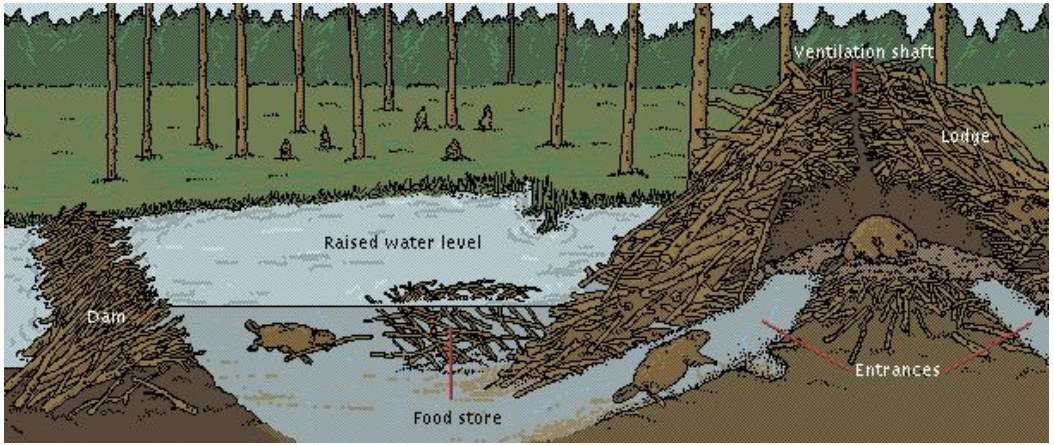
Client Needs

- Lab of Ornithology - conservation organization
- Coexist peacefully with beavers

Photo credit: Cornell University and WCS

Beaver Needs

- Safe shelter
  - Deep water - protection from predators
- Food source
- Beaver motivation
  - Stop the noise of running water

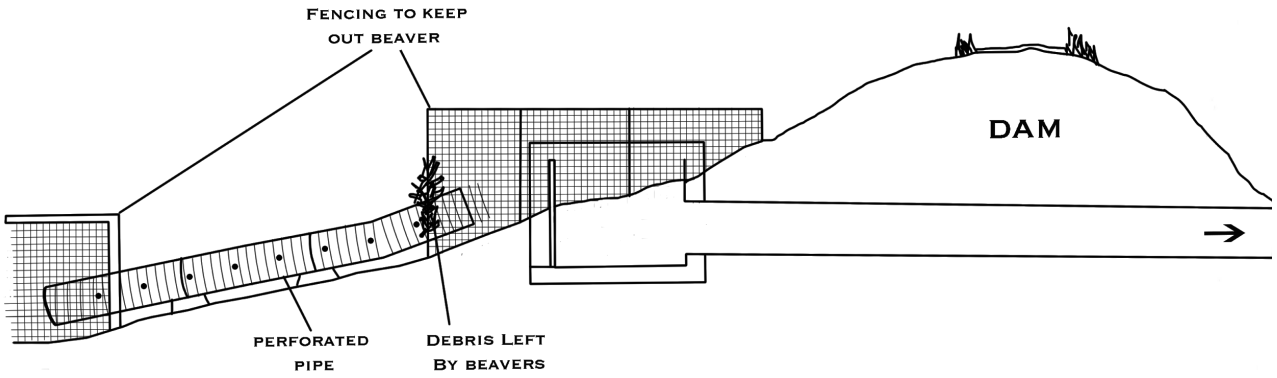


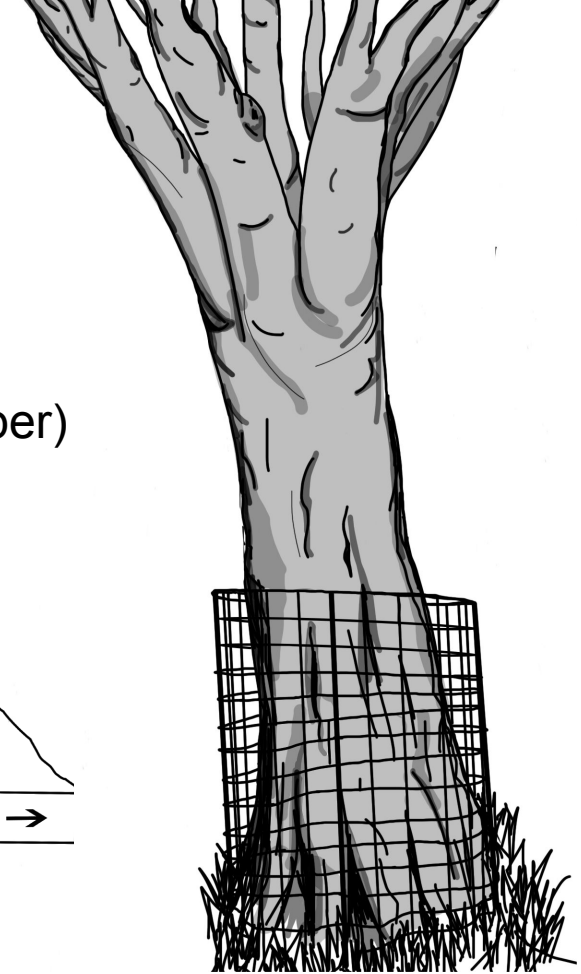
Construction of beaver dam and lodge

Photo credit: Strong, 1997

Beaver Impact Minimization

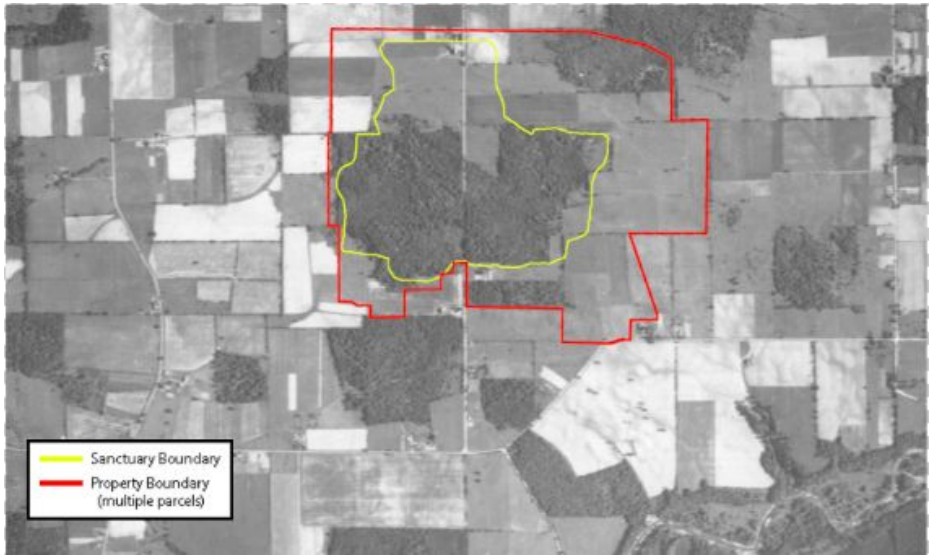
- Sound reduction
- Barriers around food source
- Increasing difficulty of damming (bigger, longer, deeper)

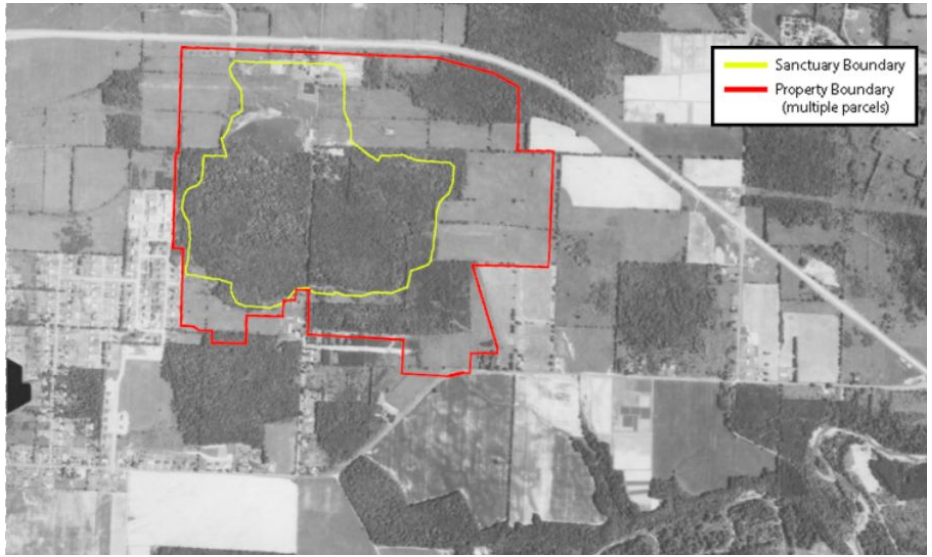




Drawing credit: N. Gill

Site History

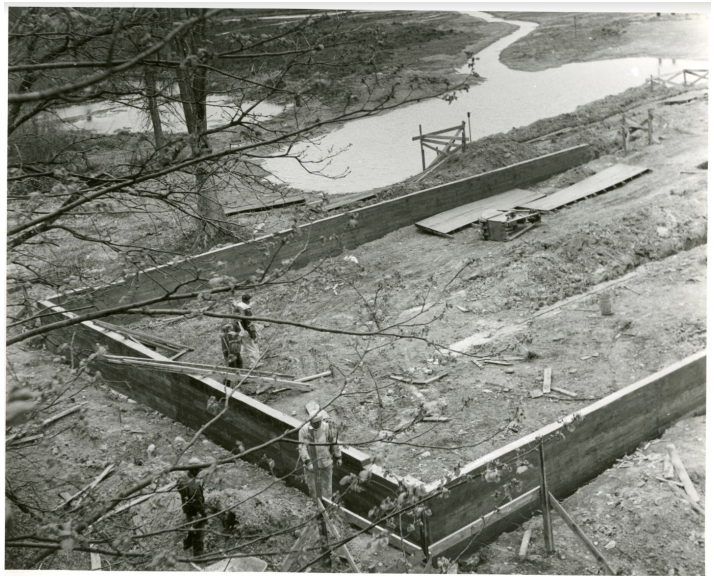




Aerial photographs from 1938 and 1965.

Source: Cornell University Library

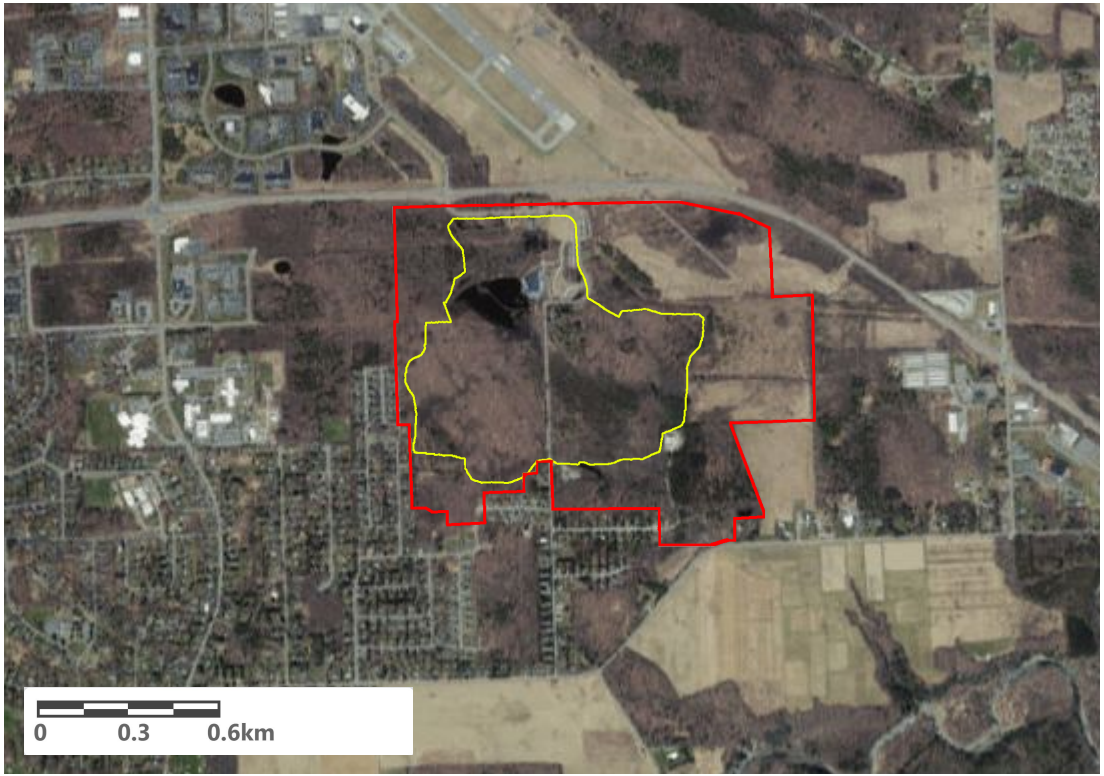
Site History



The first lab construction in 1956.

Source: Cornell University Library

Recent Aerial Photograph

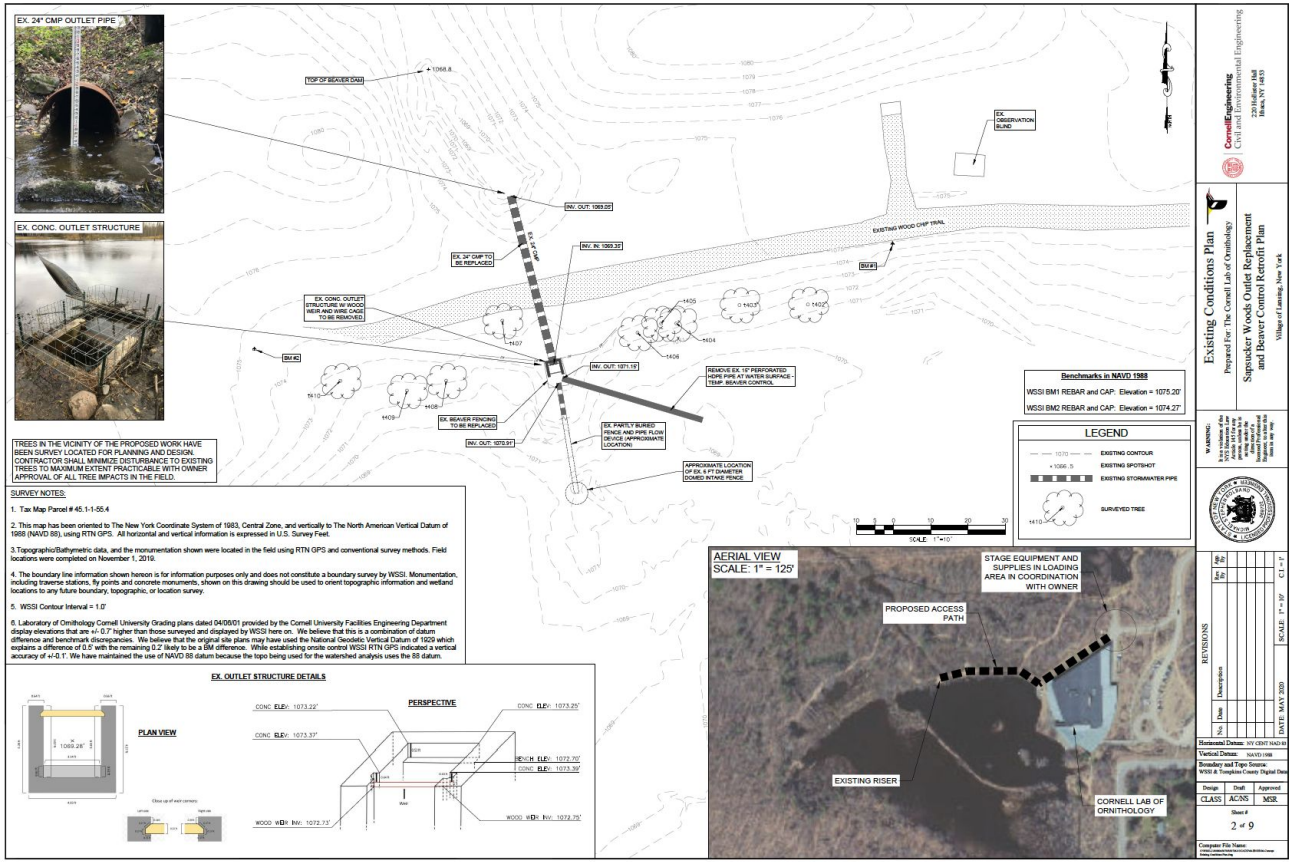


Source: Tompkins County GIS

Team Site Survey

Photo credit: CEE 5021/6025 Fall 2019

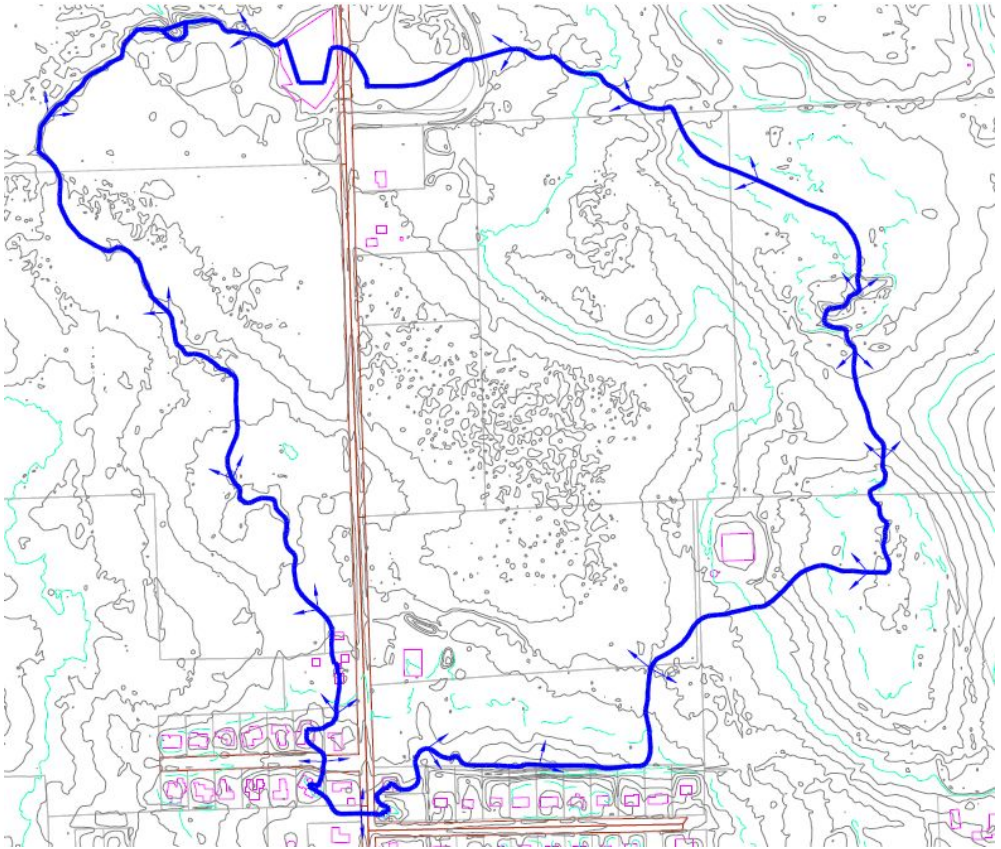
Survey Results



Watershed

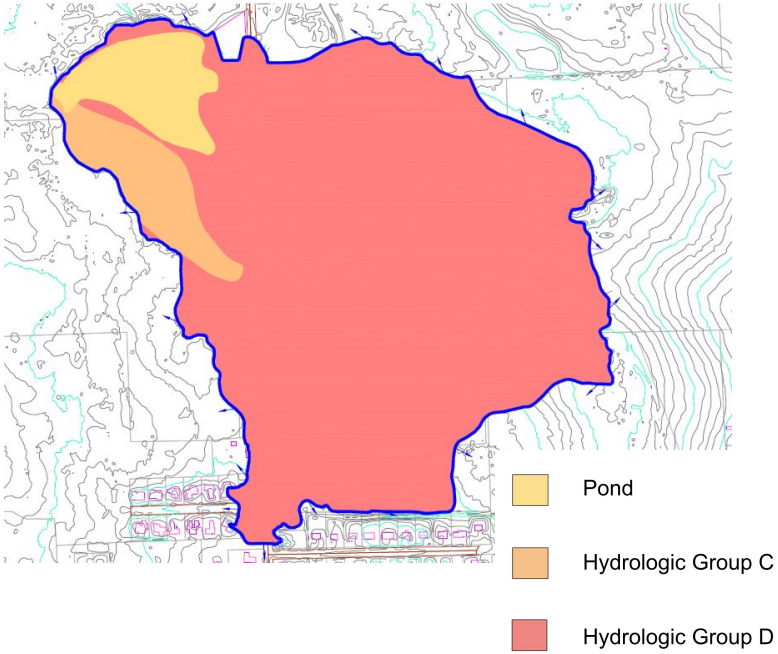
Area: 128 acres

- Flat
- Indistinct drainage divides in some locations
  - Detailed survey watershed cost ~ $40,000 (not worth it)
  - Roof and parking lot area delineated with design plans

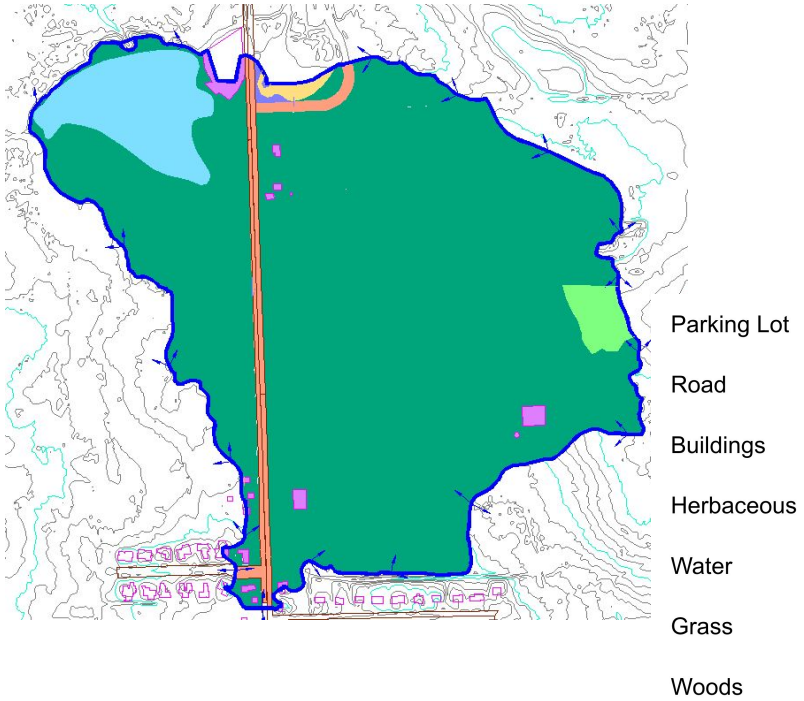


Curve Number

Hydrologic Soil Group (HSG)



Land Cover



CN - Sample calculation

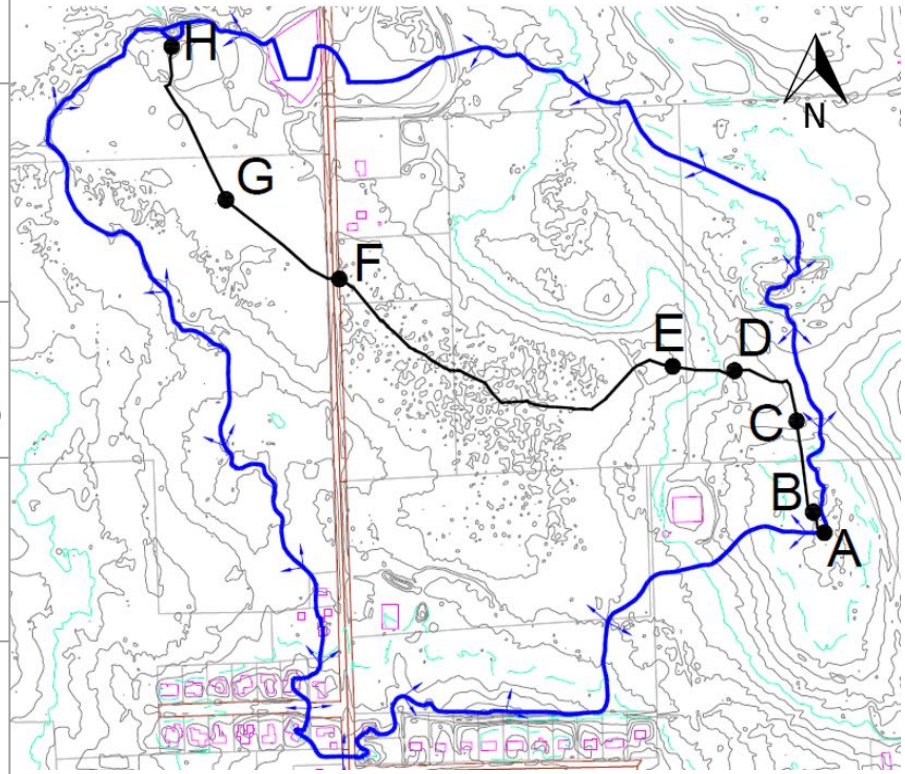
Soil series	Associated area (acres)	Cover type	Hydrologic condition	Hydrologic soil group	Associated CN	Fraction of total area	Associated CN * Fraction of area
ErA	77.3	Woods	Good	D	77	0.61	46.66
ErA	3.5	Road	-	D	98	0.03	2.72
ErA	0.5	Buildings	-	D	98	0.00	0.40
ErA	0.6	Parking lot	-	D	98	0.00	0.44
ErA	0.3	Herbaceous	Good	D	85	0.00	0.18
BgC	8.2	Woods	Good	C	70	0.06	4.52

⋮

Total watershed area (acres)	128	Total watershed curve number	79

Time of Concentration

	Category	Tc Calculation	V Calculation
A → B	Sheet Flow	$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5} S^{0.4}}$	*n comes from Manning's roughness coefficients for sheet flow*
B → F	Shallow Concentration	$T_t = \frac{\ell}{3{,}600V}$	$V = 2.516(S)^{0.5}(forest)$ $V = 6.962(S)^{0.5}(pasture)$
F → G	Channel Flow	$T_t = \frac{\ell}{3{,}600V}$	$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n}$
G → H	Pond Flow	$T_t = \frac{\ell}{3{,}600V}$	$V_w = \sqrt{gD_m}$



Time of Concentration

Path	Land Cover	Flow Type	Length (ft)	Time (mins)
A-B	Woods	Sheet flow	250	84.6
B-C	Woods	Shallow Concentrated Flow	226	12.4
C-D	Grass	Shallow Concentrated Flow	388	9.8
D-E	Woods	Shallow Concentrated Flow	257	10.7
E-F	Forested Wetland	Shallow Concentrated Flow	1616	304
F-G	Woods	Channel Flow	565	14.1
G-H	Pond	Pond Travel	683	1.2
Total	**-**	**-**	**3985**	**437 (7.3 hr)**

Design Storm Calculations

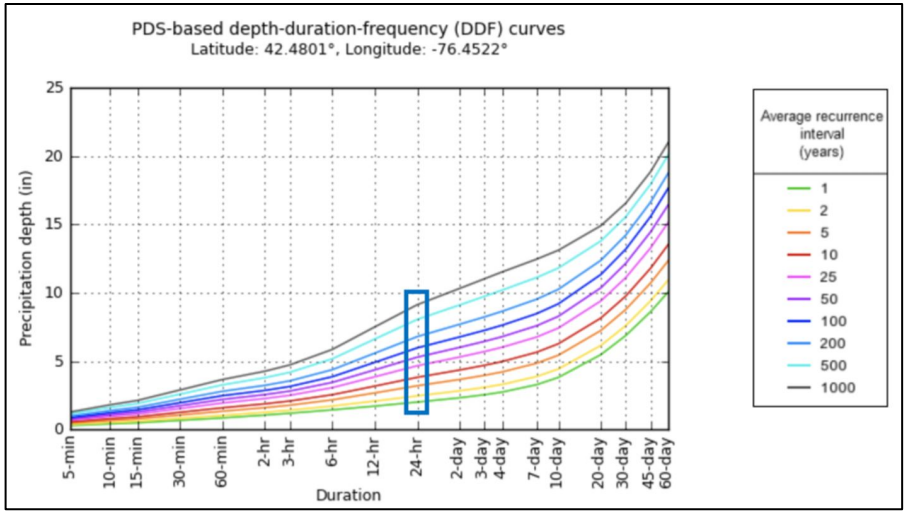
Small storms (< 1 year) from **Ranking Method**

- 30 years of historic data ranked in descending order
- Rank calculated by recurrence interval

$$\#\ Events = \frac{\#\ Years\ on\ Record}{Recurrence\ Interval}$$

Large storms (> 1 year) from **NOAA 14-point Precipitation Analysis**

- Based on NOAA precipitation data



Design Storm Flow Rate (TR-55)

When:

CN = 79

t_c = 437 min

S = 2.66 in

- USDA *"Urban Hydrology for Small Watershed" (1986)*
- Estimate the runoff for each return period

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

- Estimate the peak discharge for each return period

$$q_p = \frac{2Q}{1.1t_c + 1.1 * 1.67t_c}$$

Design Storm Results

Return Period	PRCP [in]	q [cfs]
1 mo	0.75	**0.20**
2 mo	1.01	**0.88**
3 mo	1.18	**1.53**
4 mo	1.32	**2.18**
5 mo	1.46	**2.90**
6 mo	1.51	**3.18**
1 yr	2.01	**6.38**
2 yr	2.34	**9.78**
10 yr	3.43	**21.94**
100 yr	5.92	**44.19**

When:

t_c = 437 min

A = 128 ac

Baseflow ~ 0.2 cfs

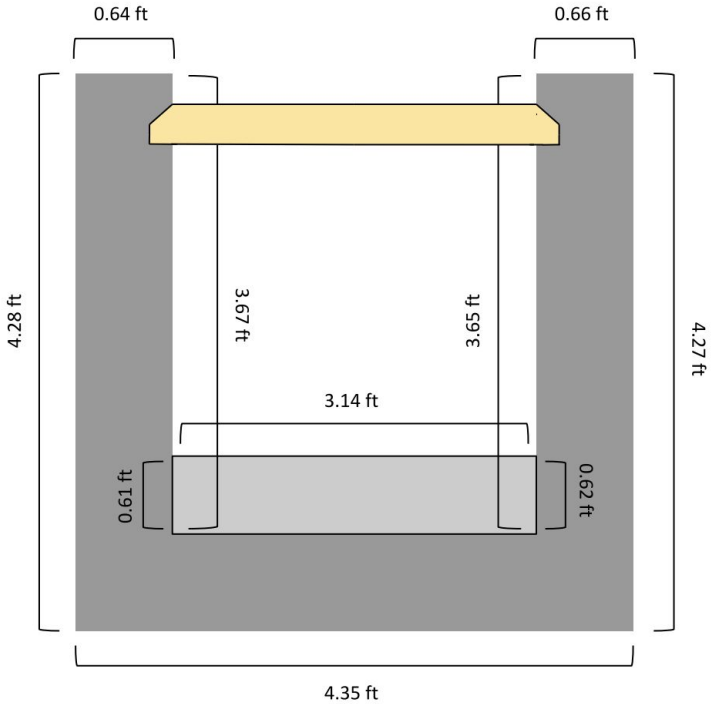
Current Outlet System - Outlet Structure

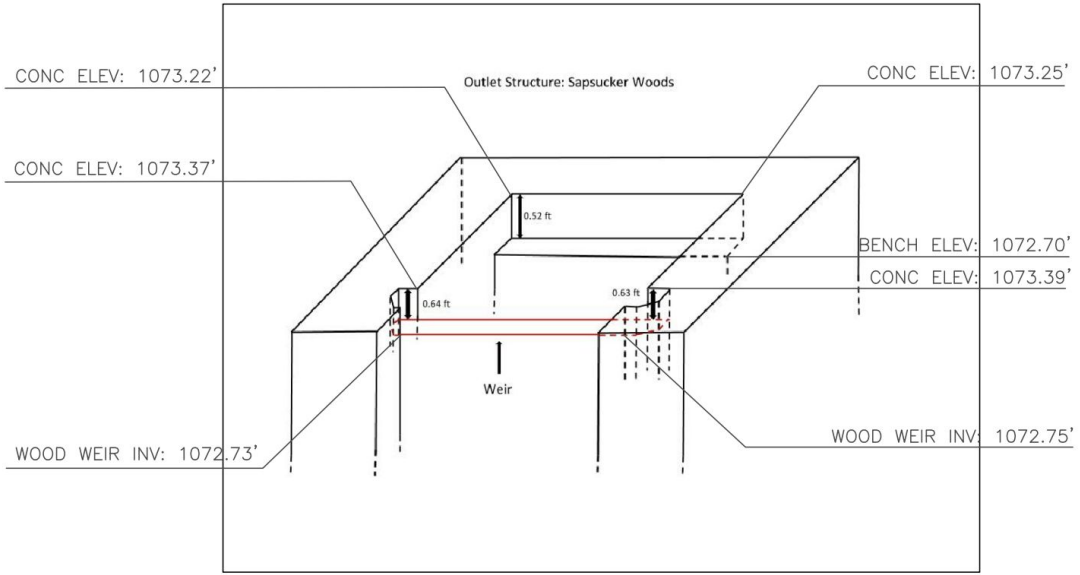
Concrete outlet with wood weir

CMP outlet pipe

Photo credit: CEE 5021/6025 Fall 2019

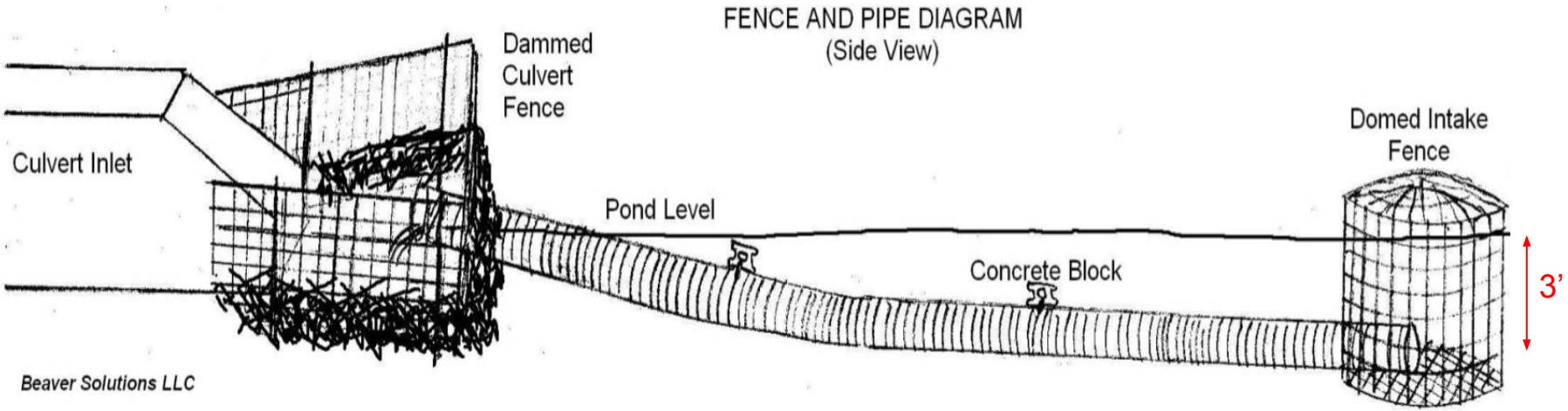
Current Outlet System - Outlet Structure





Source: CEE 5021/6025 Fall 2019

Original Design - Flexible Pond Leveler



Fence Design

Source: J. Payne, Photo credit: CEE 5021/6025 Fall 2019

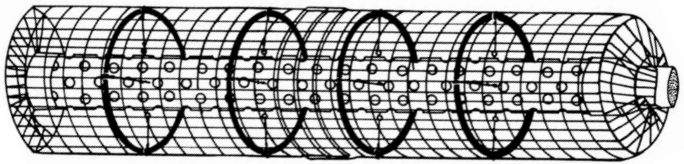
Current Outlet System - Temporary Pond Leveler

Floating high density polyethylene (HDPE) perforated pipe.

Regular maintenance of beaver debris removal around weir structure.

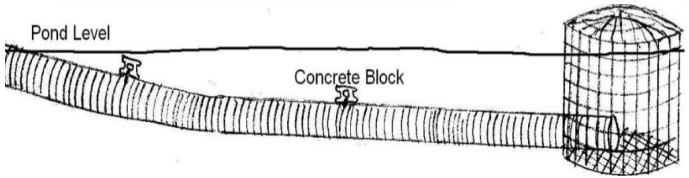
Designs for Sound Reduction

Clemson Beaver Pond Leveler



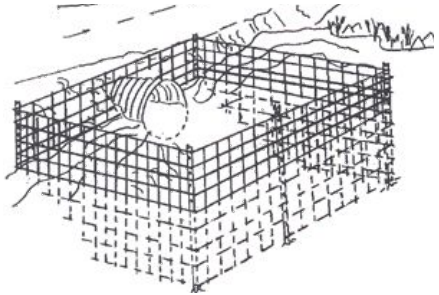
- Size of holes limit noise
- Gabion cage increases distance

Flexible Pond Levelers



- Eliminate vortex
- Domed intake cage increases distance

Outlet Structures



- Fence and other structures to increase distance

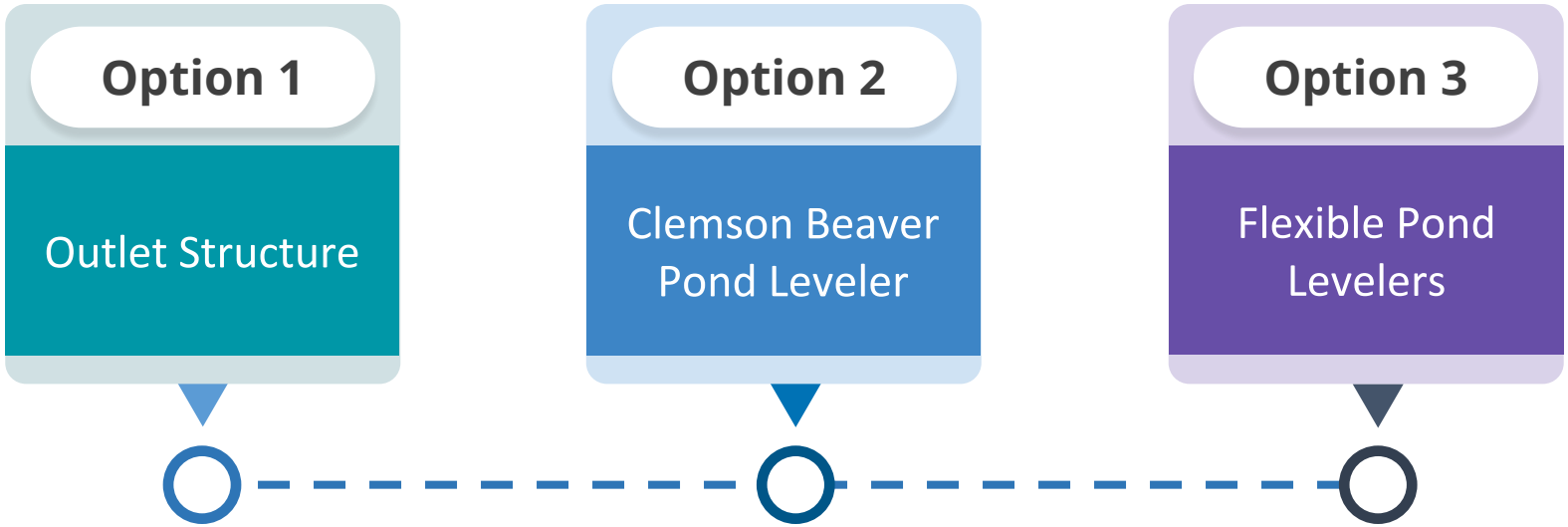
Sources: J. Payne, M. Rolband

Design Constraints/Assumptions

- Limit work so it is considered “maintenance”
  - Total outlet structure replacement can trigger dam safety standards
    - Free board requirements
    - No trees on dam or toe area
  - Risk is low because:
    - Low height: less than 6 feet
    - Overland relief around building and to northwest
    - No habitable structures immediately downstream
- Match existing hydraulic capacity
  - Consistent with “maintenance”
  - Minimize change in user experience

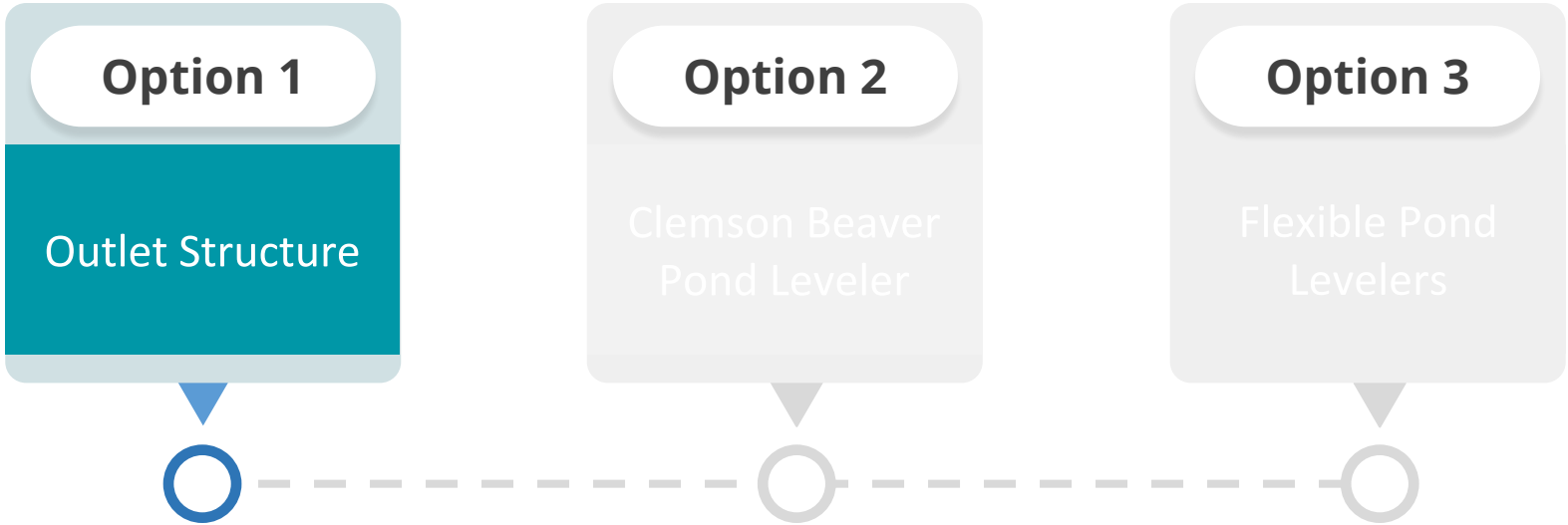
Photo credit: C. Wetzel

Design Options



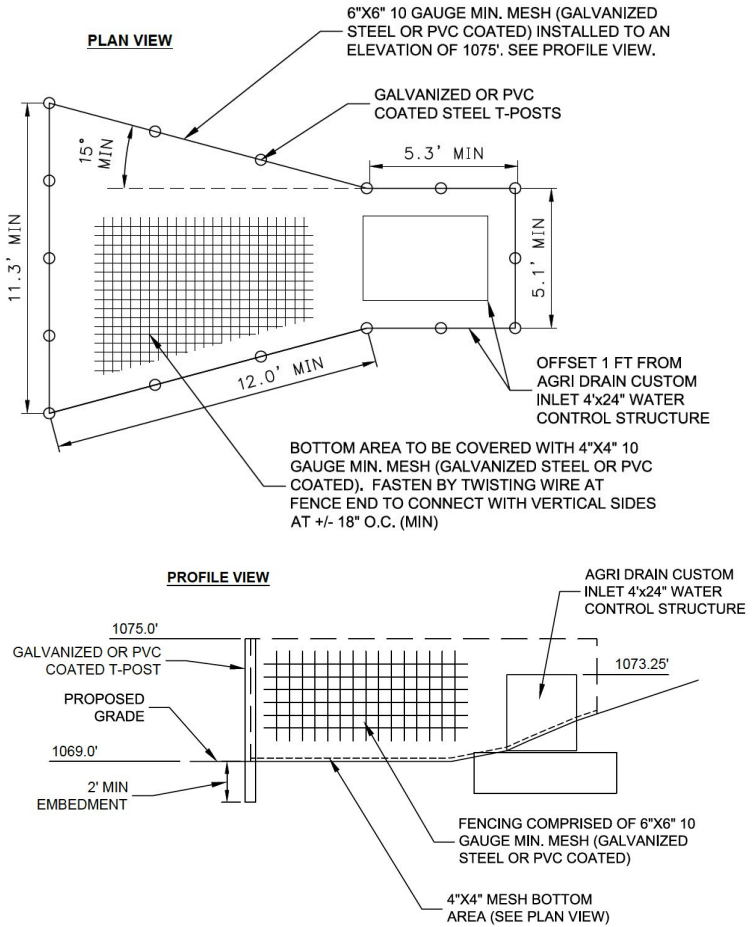
A combination of options

Design Options



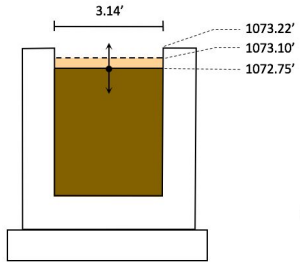
Trapezoidal Fencing

- Trapezoidal design
  - Unnatural angle
  - Deeper
  - Longer dam
  - Sound separation



Weir Design Options

1. Replace Wood Weir



2. Retrofit Existing Structure

3. Replace Existing Structure

Design criterion: mimic existing hydraulic conditions

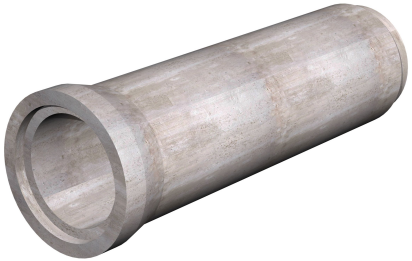
Photo credit: Agri Drain Corporation

Outlet Pipe Replacement

- Replace with HDPE or concrete
  - HDPE: Cheaper, easier to install, installation deformation
  - Concrete: More expensive, longer life
- Add rodent guard

Current pipe
(Corrugated metal pipe)

HDPE pipe



Reinforced
concrete pipe

Rodent guard

Sources: Tractor Supply Co., Oldcastle Infrastructure, Agri Drain Corporation

Seepage Control

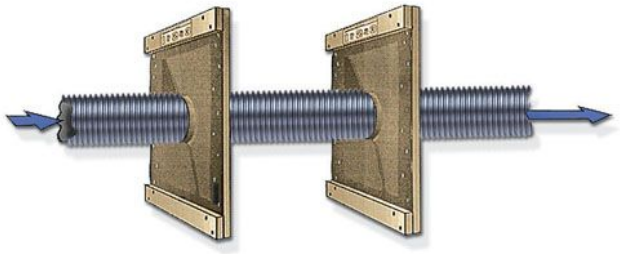
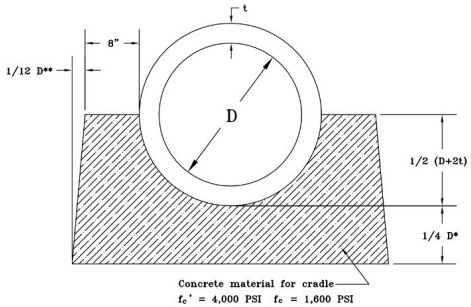
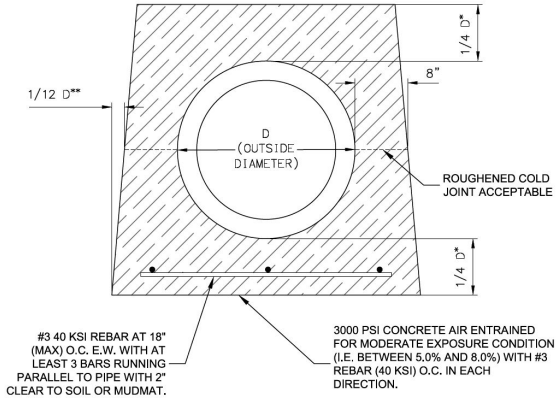


Plate Collars



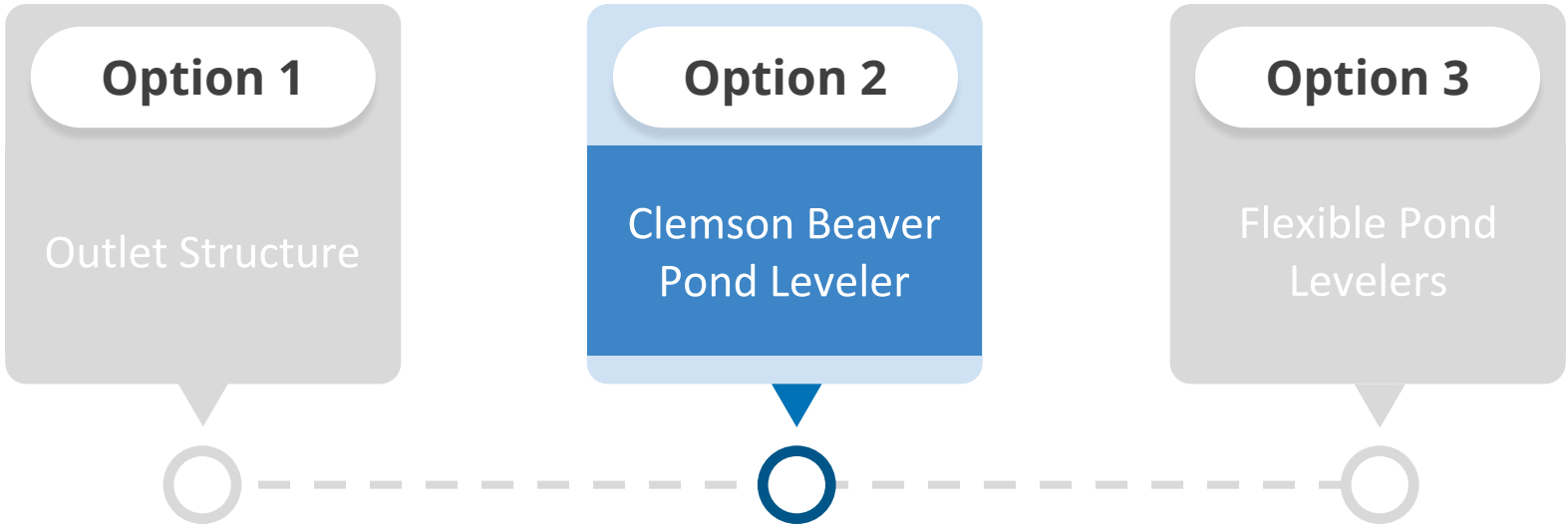
Concrete Cradle



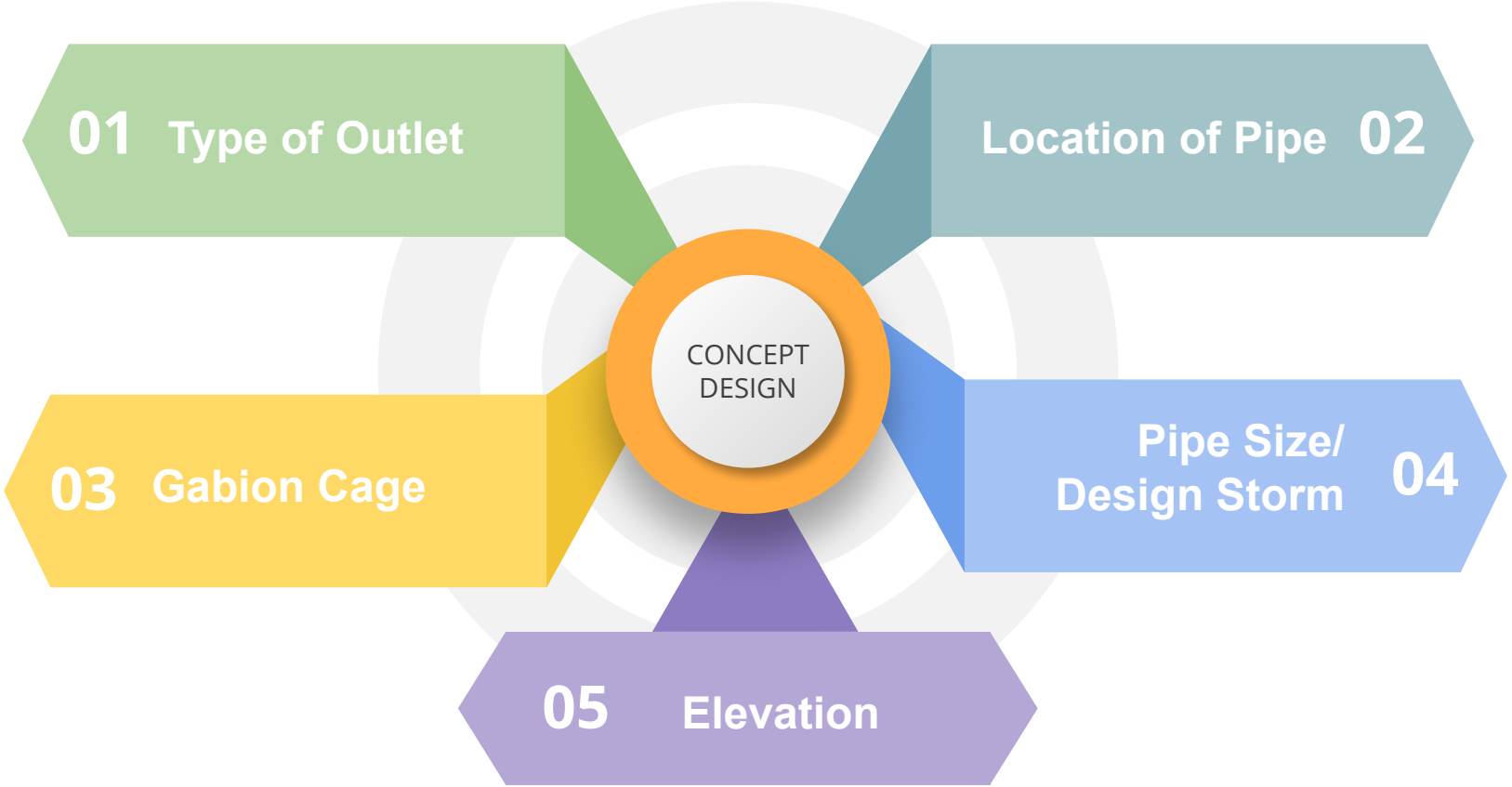
Concrete Collar Encasement

Sources: Agri Drain Corporation, Fairfax County Public Facilities Manual

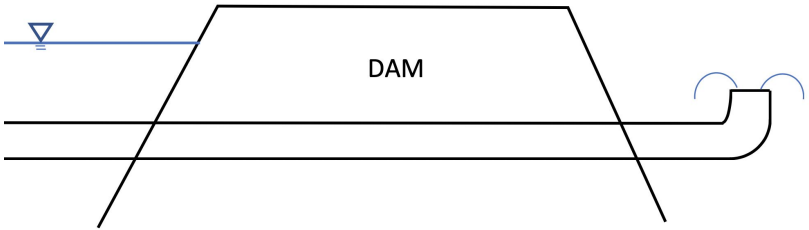
Design Options



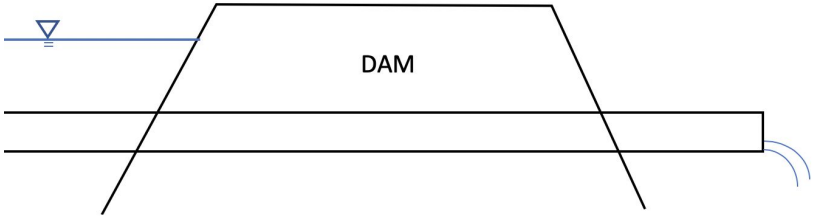
Clemson Beaver Pond Leveler - Design Iterations



Design Iterations - Type of Outlet

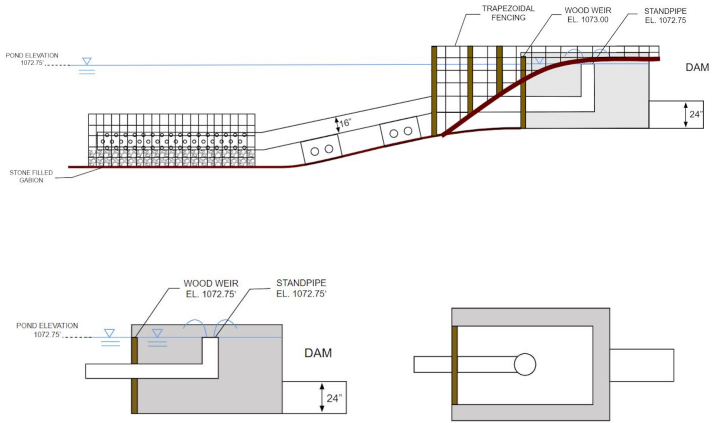


Standpipe

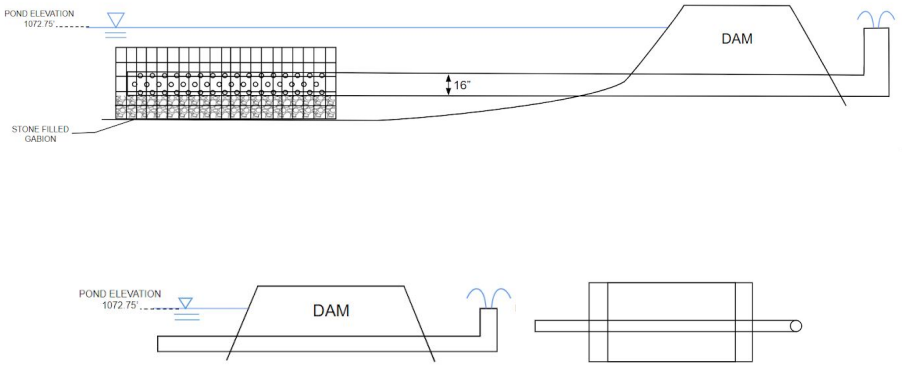


Straight Pipe

Design Iterations - Location of Pipe

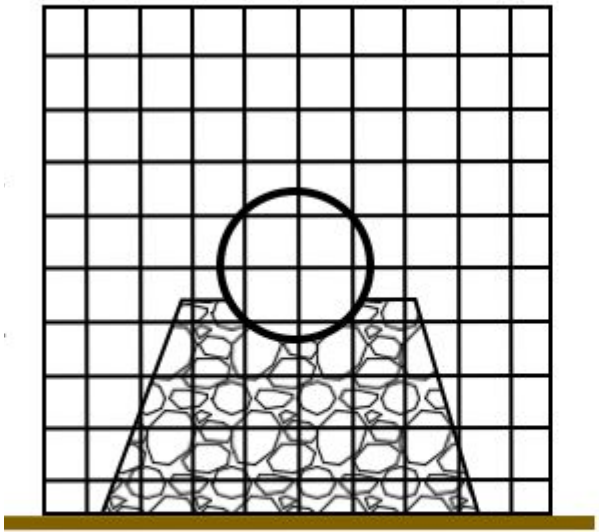


Pipe through wood weir

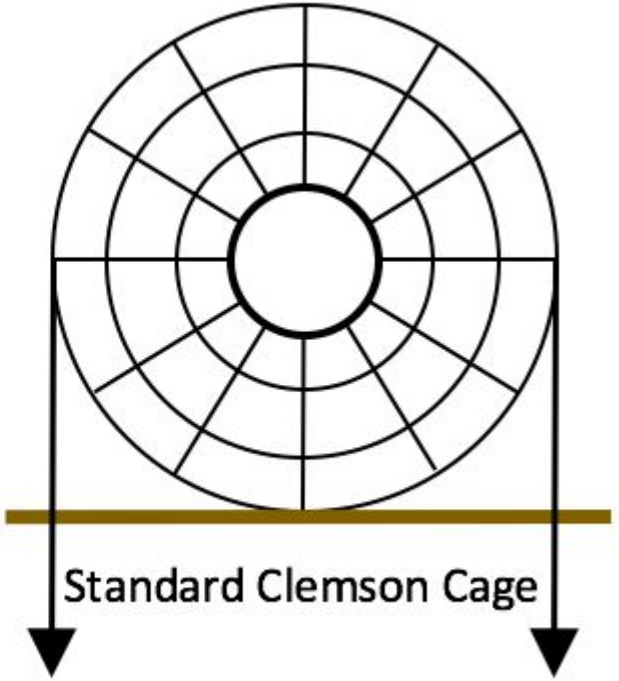


Pipe through dam

Design Iterations - Gabion Cage



Gabion Cage

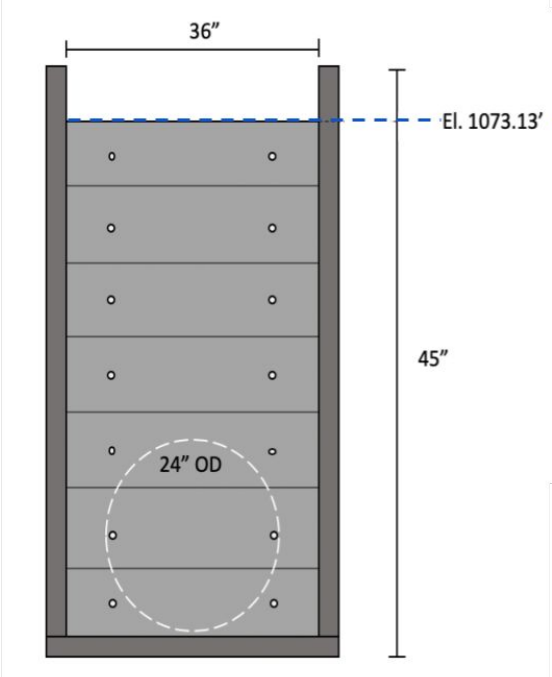


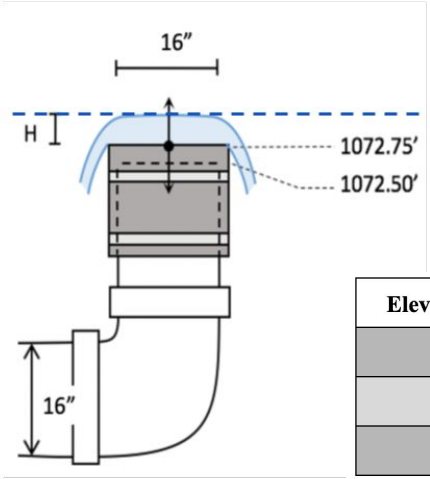
Standard Clemson Cage

Design Iterations - Pipe Size

Pipe Diameter (in)	Flow Capacity (cfs)	Return Period (months)
10	0.96	2
12	1.50	3
16	2.65	4

Design Iterations - Elevation





Elevation Difference (ft)	Flow Capacity (cfs)	Return Period (months)
0.55	3.19	6
0.38	2.65	4
0.25	1.62	3

Flow capacity for a 16” diameter PVC pipe

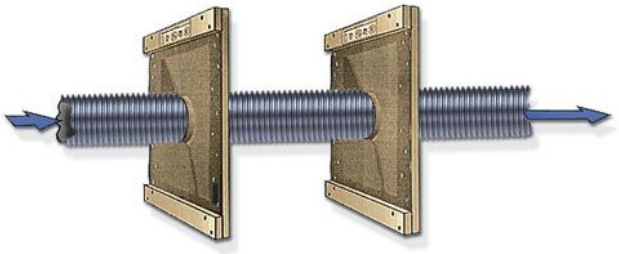
Maintenance Valve

Agri Drain Inline Water Level Control Structure™

Agri Drain Gate Valve

Source: Agri Drain Corporation

Seepage Control



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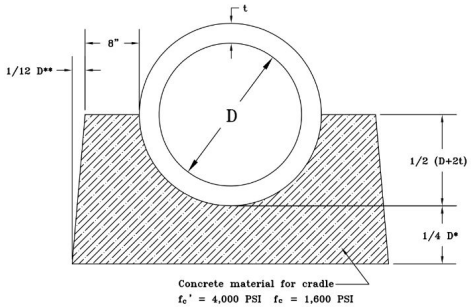

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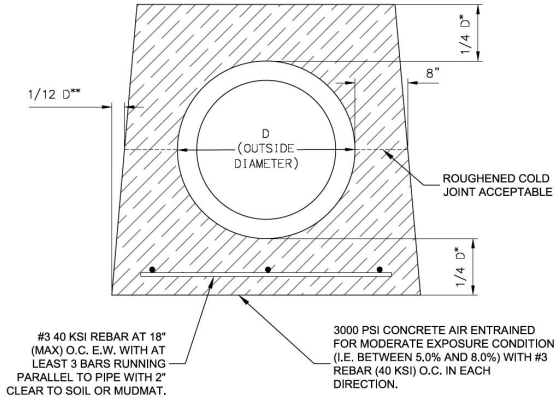
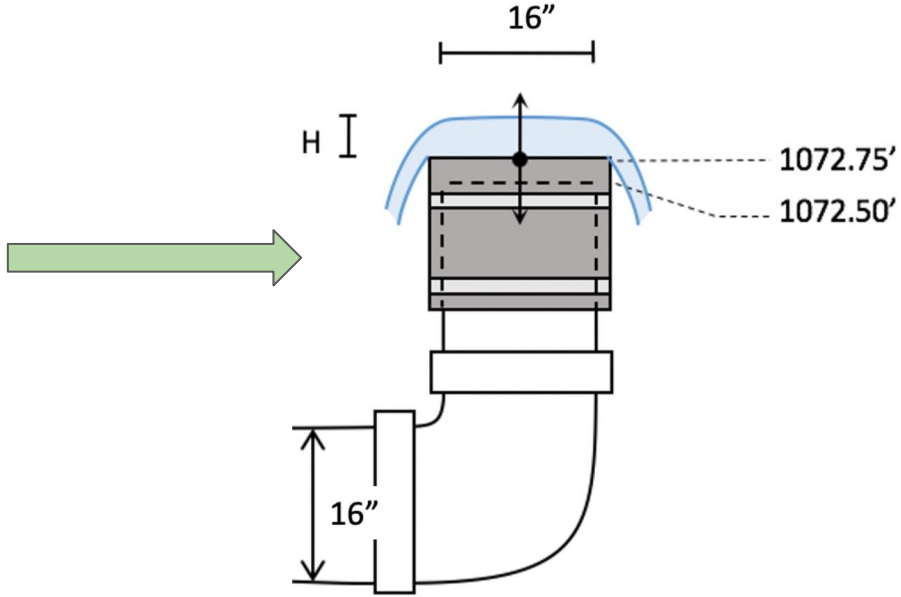


Concrete Collar Encasement

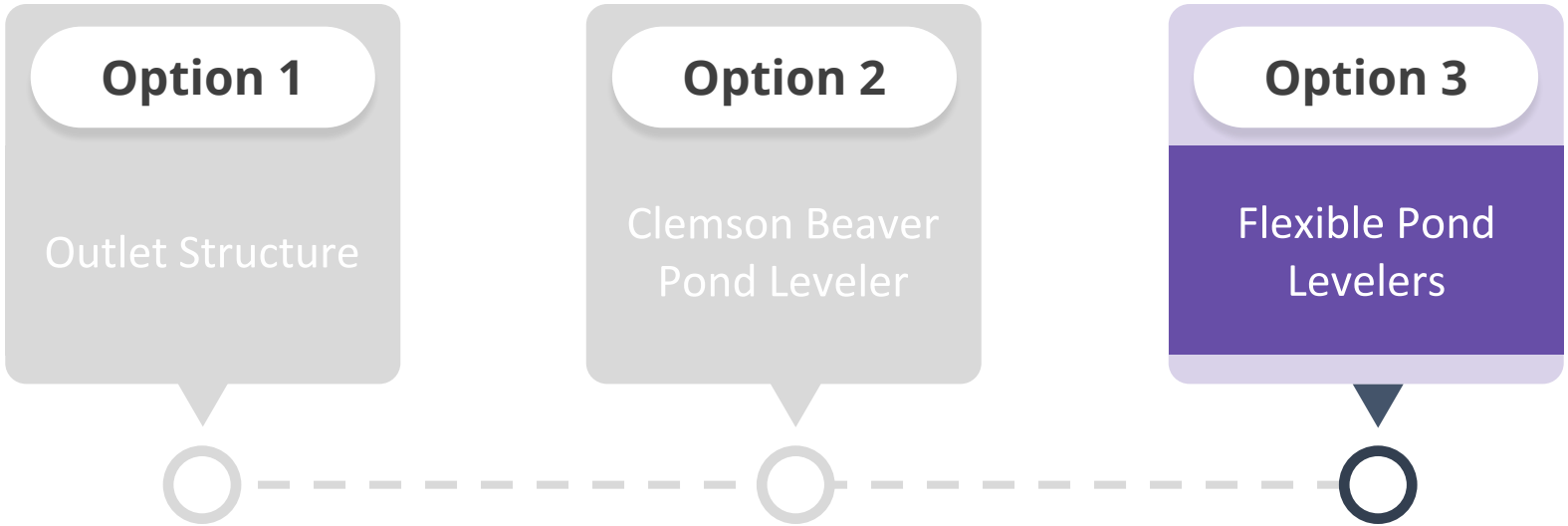
Source: Agri Drain and Fairfax County Public Facilities Manual

Neoprene Sleeve



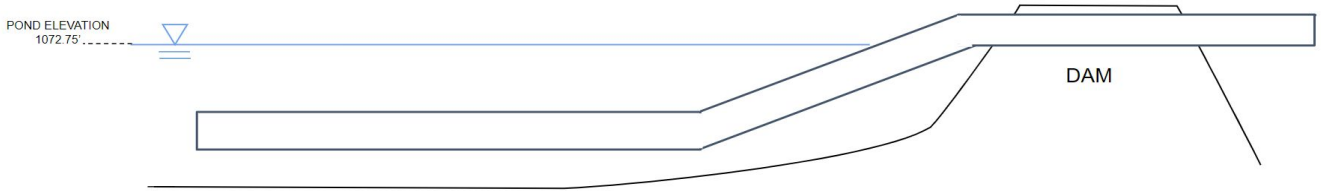
Sources: Fernco, CEE 5021/22

Design Options



Flexible Pond Leveler Location

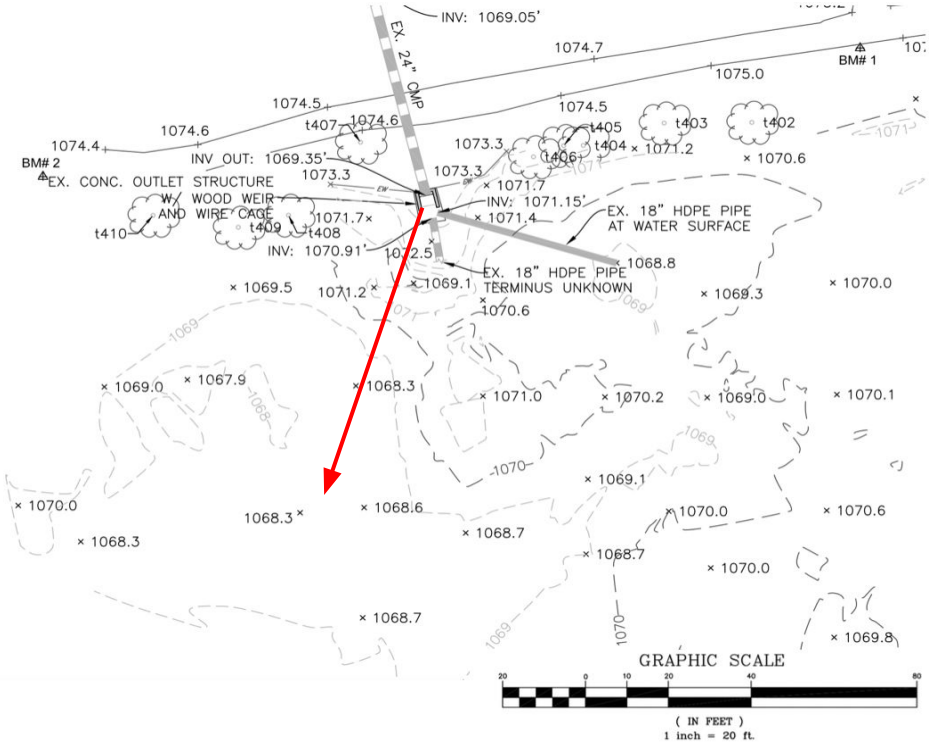
Flexible Pond Leveler through fence



Flexible Pond Leveler through dam

Reuse of Existing Pond Leveler

- Redundant feature for pond level control
- Recovery of initial investment
- Clean, extend, reposition

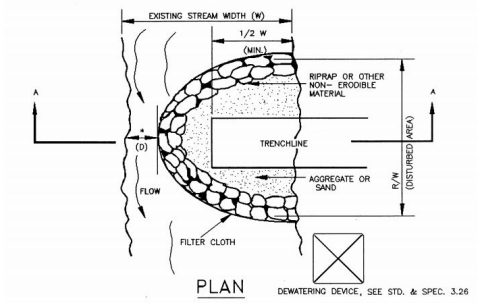


Constructability

- Drain pond through weir
  - Low cost but impacts all organisms living/using the ponded area
  - Pump used for low spots
- Pump water out through a filter bag
  - Bag protects downstream areas from turbidity but more expensive than #1
  - Can be combined with #1 for ponded areas
- Temporary dam - CofferDam
  - Set dam then drain by lowering the wood weirs and/or using a pump/bag system (can be used for low spots)
  - Minimizes impacts to aquatic system
  - More costly than #1 or #2.
- Small-scale CofferDam (sandbags)
  - If only the outlet structure is replaced per value engineering

PortaDam

AquaDam



Sandbag Cofferdam

Source: AquaDam, Portadam, Virginia E&S Control Manual

Dam Safety

Existing Tree Concerns

Water Lowering During Construction

Photo credit: CEE 5021/22

Facility Manager’s Input

Team Meeting with Jeff Payne

- Clemson Beaver Pond Leveler
- Reinstallation of the Flexible Pond Leveler™
- Clemson pipe diameter increased to 16 inches
- Rectangular gabion cage
- Leaking issues = custom Agri Drain structure
- Concrete encasement for seepage control
- Prefers to drain pond through outlet

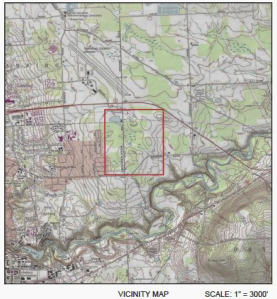
Meeting with J. Payne on January 25, 2020

Final Design - Construction Plan Set

SAPSUCKER WOODS OUTFALL REPLACEMENT AND BEAVER CONTROL RETROFIT PLAN

CEE 5022 AND CEE 6025: WETLANDS AND STREAM RESTORATION

INDEX



VICINITY MAP SCALE: 1" = 3000'

CornellEngineering
Civil and Environmental Engineering

220 HOLLISTER HALL
ITHACA, NY 14853

CornellEngineering
Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853

Cover Sheet

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

WARNING: It is a violation of the NYS Education Law Article 145 for any person, unless acting under the direction of a licensed Professional Engineer, to alter this item in any way.

REVISIONS

No.	Date	Description	By	Appr.	By	Appr.

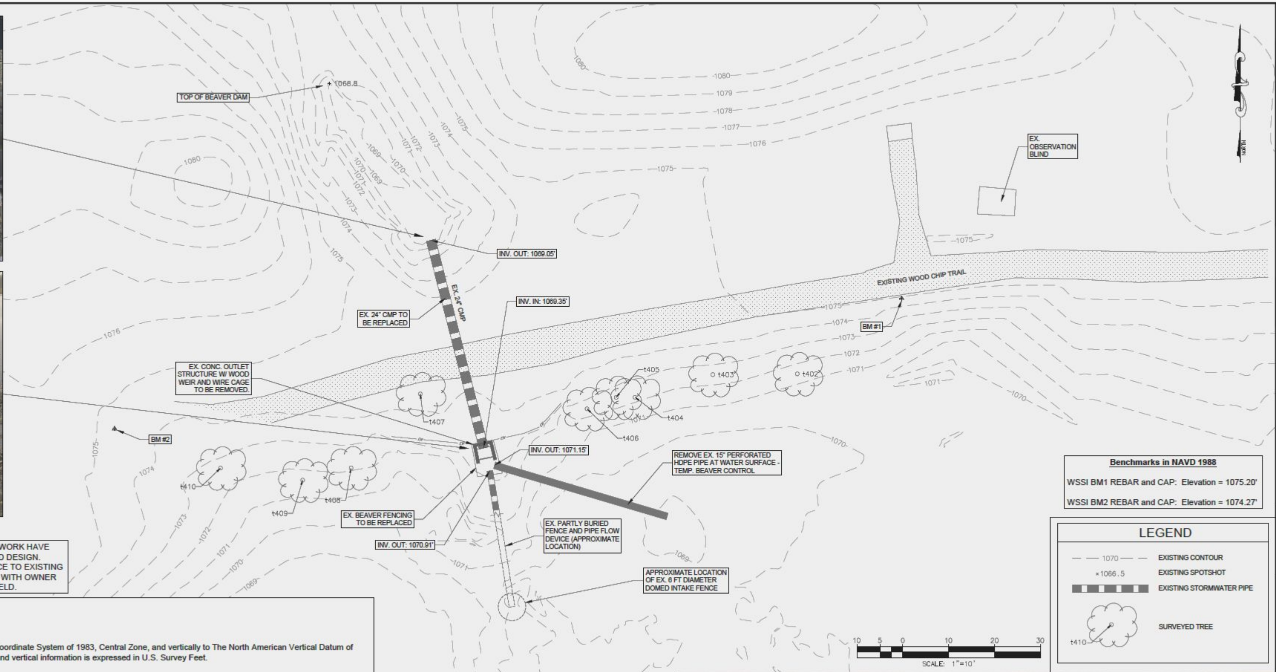
DATE: MAY 2020 SCALE: N/A CL = N/A

Horizontal Datum: NY CENT NAD 83
Vertical Datum: NAVD 1988
Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Draft	Approved
CLASS	AC/NS	MSR

Sheet #
1 of 9

Computer File Name:



TREES IN THE VICINITY OF THE PROPOSED WORK HAVE BEEN SURVEY LOCATED FOR PLANNING AND DESIGN. CONTRACTOR SHALL MINIMIZE DISTURBANCE TO EXISTING TREES TO MAXIMUM EXTENT PRACTICABLE WITH OWNER APPROVAL OF ALL TREE IMPACTS IN THE FIELD.

Benchmarks in NAVD 1988

WSSI BM1 REBAR and CAP: Elevation = 1075.20'

WSSI BM2 REBAR and CAP: Elevation = 1074.27'

LEGEND

1070	EXISTING CONTOUR
×1066.5	EXISTING SPOTSHOT
	EXISTING STORMWATER PIPE
t410	SURVEYED TREE

SURVEY NOTES:

1. Tax Map Parcel # 45.1-1-55.4

2. This map has been oriented to The New York Coordinate System of 1983, Central Zone, and vertically to The North American Vertical Datum of 1988 (NAVD 88), using RTN GPS. All horizontal and vertical information is expressed in U.S. Survey Feet.

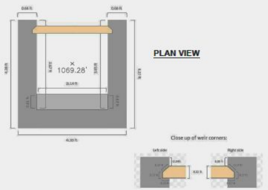
3. Topographic/Bathymetric data, and the monumentation shown were located in the field using RTN GPS and conventional survey methods. Field locations were completed on November 1, 2019.

4. The boundary line information shown hereon is for information purposes only and does not constitute a boundary survey by WSSI. Monumentation, including traverse stations, fly points and concrete monuments, shown on this drawing should be used to orient topographic information and wetland locations to any future boundary, topographic, or location survey.

5. WSSI Contour Interval = 1.0'

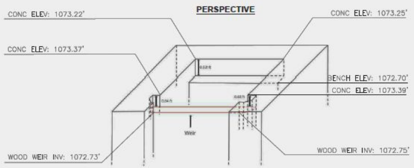
6. Laboratory of Ornithology Cornell University Grading plans dated 04/06/01 provided by the Cornell University Facilities Engineering Department display elevations that are +/- 0.7' higher than those surveyed and displayed by WSSI here on. We believe that this is a combination of datum difference and benchmark discrepancies. We believe that the original site plans may have used the National Geodetic Vertical Datum of 1929 which explains a difference of 0.5' with the remaining 0.2' likely to be a BM difference. While establishing onsite control WSSI RTN GPS indicated a vertical accuracy of +/-0.1'. We have maintained the use of NAVD 88 datum because the topo being used for the watershed analysis uses the 88 datum.

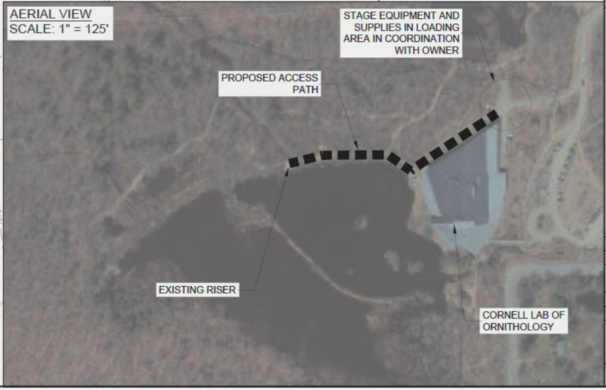
EX. OUTLET STRUCTURE DETAILS



PLAN VIEW

PERSPECTIVE





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Existing Conditions Plan

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

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No.	Date	Description	Rev. By	App. By

REVISIONS

DATE: MAY 2020 — SCALE: 1" = 10' — CI = 1'

Horizontal Datum: NY CENT NAD 83

Vertical Datum: NAVD 1988

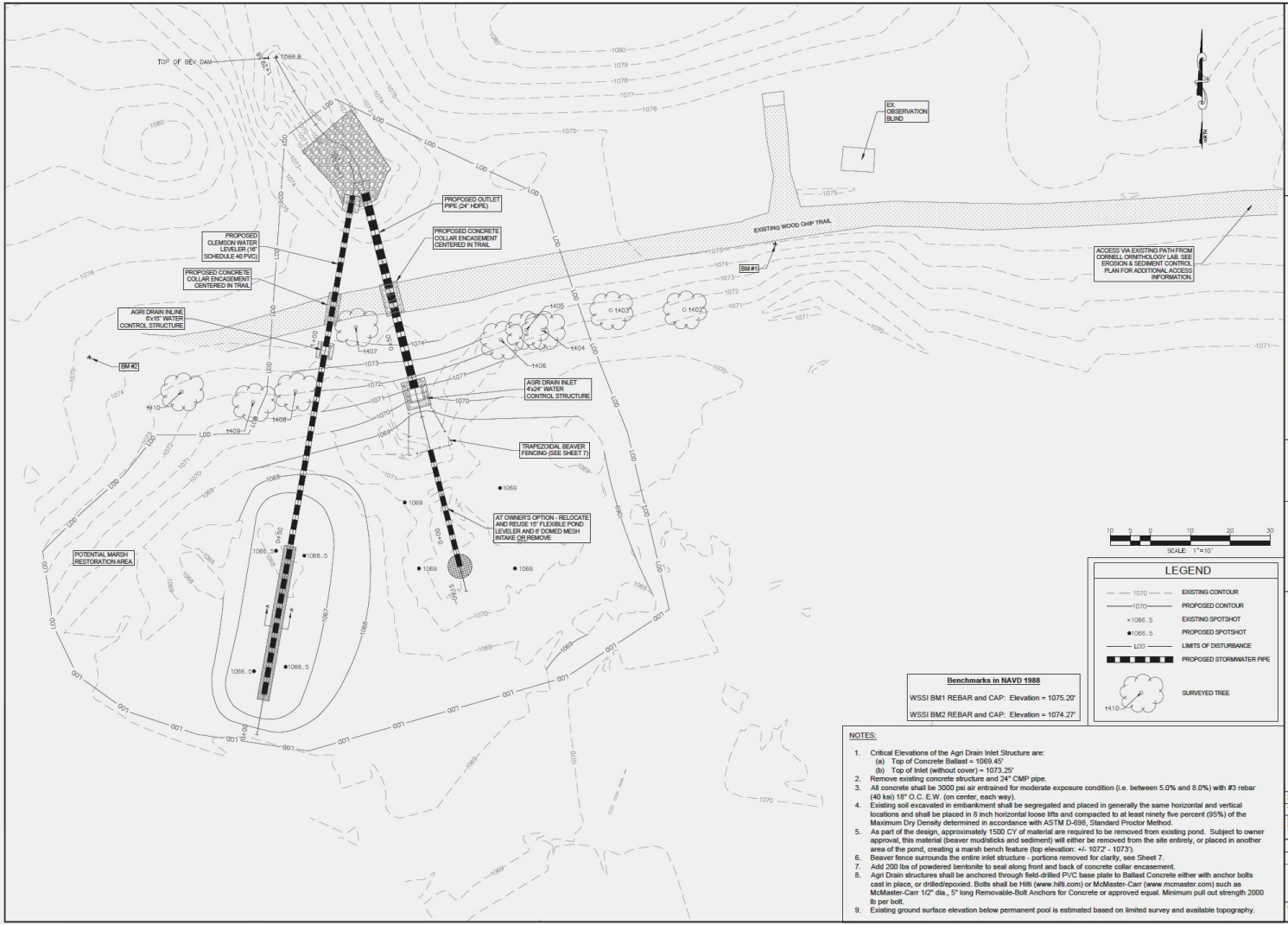
Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Draft	Approved
CLASS	AC/NS	MSR

Sheet #

2 of 9

Computer File Name:



Benchmarks in NAVD 1988

WSSI BM1 REBAR and CAP: Elevation = 1075.20'

WSSI BM2 REBAR and CAP: Elevation = 1074.27'

NOTES:

1. Critical Elevations of the Agri Drain Inlet Structure are:
   (a) Top of Concrete Ballast = 1069.45'
   (b) Top of Inlet (without cover) = 1073.25'
2. Remove existing concrete structure and 24" CMP pipe.
3. All concrete shall be 3000 psi air entrained for moderate exposure condition (i.e. between 5.0% and 8.0%) with #3 rebar (40 ksi) 18" O.C. E.W. (on center, each way).
4. Existing soil excavated in embankment shall be segregated and placed in generally the same horizontal and vertical locations and shall be placed in 8 inch horizontal loose lifts and compacted to at least ninety five percent (95%) of the Maximum Dry Density determined in accordance with ASTM D-698, Standard Proctor Method.
5. As part of the design, approximately 1500 CY of material are required to be removed from existing pond. Subject to owner approval, this material (beaver mud/sticks and sediment) will either be removed from the site entirely, or placed in another area of the pond, creating a marsh bench feature (top elevation: +/- 1072' - 1073').
6. Beaver fence surrounds the entire inlet structure - portions removed for clarity, see Sheet 7.
7. Add 200 lbs of powdered bentonite to seal along front and back of concrete collar encasement.
8. Agri Drain structures shall be anchored through field-drilled PVC base plate to Ballast Concrete either with anchor bolts cast in place, or drilled/epoxied. Bolts shall be Hilti (www.hilti.com) or McMaster-Carr (www.mcmaster.com) such as McMaster-Carr 1/2" dia., 5" long Removable-Bolt Anchors for Concrete or approved equal. Minimum pull out strength 2000 lb per bolt.
9. Existing ground surface elevation below permanent pool is estimated based on limited survey and available topography.

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Proposed Site Plan

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

REVISIONS

No.	Date:	Description:	By:	App'd By:

DATE: MAY 2020

SCALE: 1" = 10'

C.I. = 1'

Horizontal Datum: NY CENT NAD 83

Vertical Datum: NAVD 1988

Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Draft	Approved
CLASS	AC/NS	MSR

Sheet #
3 of 9

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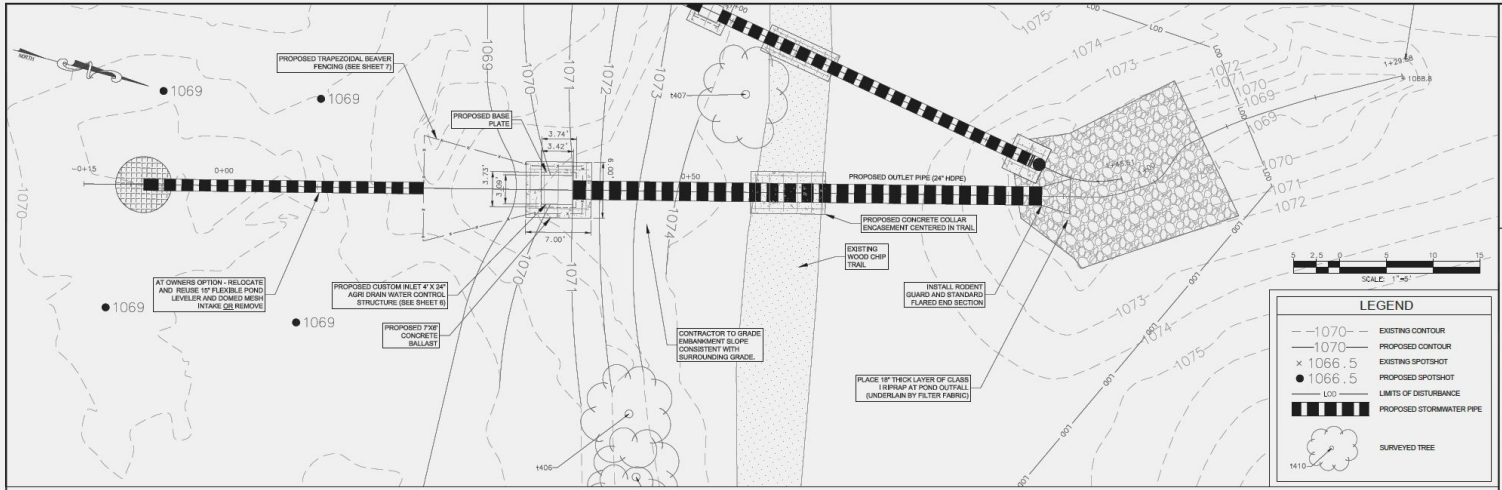

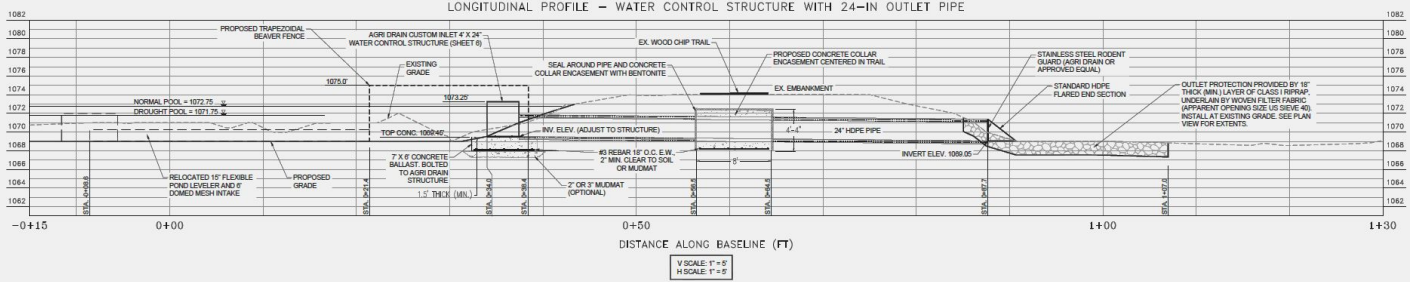

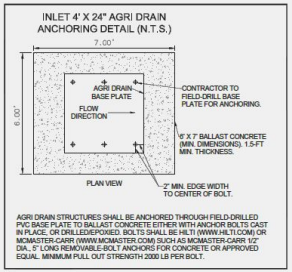

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Outlet Pipe Planview and Profile

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

REVISIONS

No.	Date	Discription	Rev. By	App. By

SCALE: 1" = 5' C.I. = 1'

DATE: MAY 2020

Horizontal Datum: NY CENT NAD 83
Vertical Datum: NAVD 1988
Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Draft	Approved
CLASS	AC/NS	MSR

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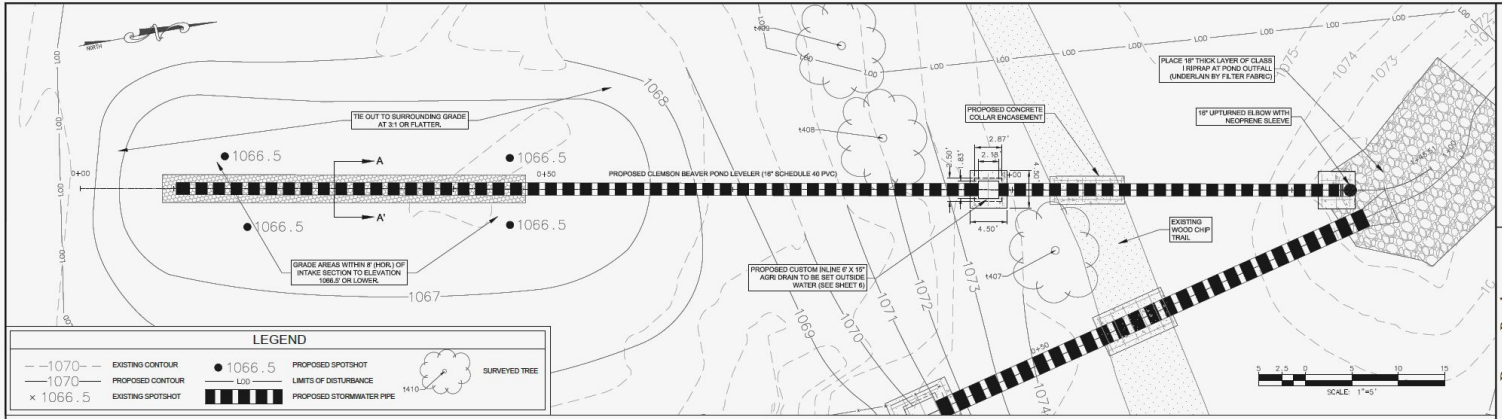
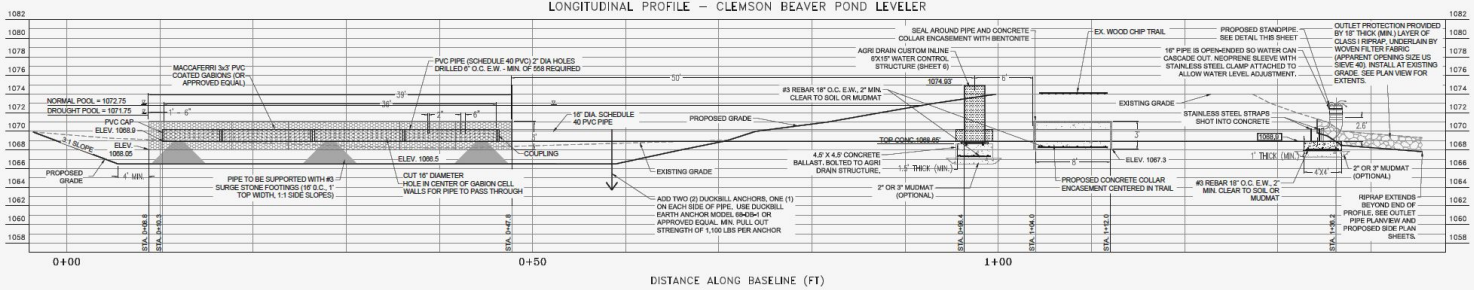
4 of 9

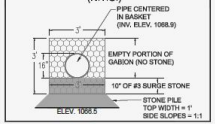
Computer File Name:



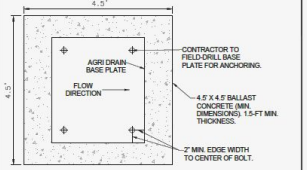
LONGITUDINAL PROFILE – CLEMSON BEAVER POND LEVELER



SECTION A-A'
GABION / PIPE SINGLE-PIPE
(N.T.S.)

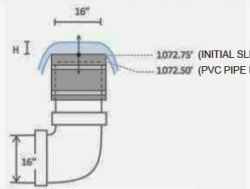


INLINE 6' X 15" AGRI DRAIN
ANCHORING DETAIL (N.T.S.)



AGRI DRAIN STRUCTURES SHALL BE ANCHORED THROUGH FIELD-DRILLED PVC BASE PLATE TO BALLAST CONCRETE EITHER WITH ANCHOR BOLTS CAST IN PLACE, OR DRILLED/EPOXIED. BOLTS SHALL BE HILTI (WWW.HILTI.COM) OR MCMASTER-CARR (WWW.MCMASTER.COM) SUCH AS MCMASTER-CARR 1/2" DIA., 5" LONG REMOVABLE-BOLT ANCHORS FOR CONCRETE OR APPROVED EQUAL. MINIMUM PULL OUT STRENGTH 2000 LB PER BOLT.

STANDPIPE AND NEOPRENE SLEEVE DETAIL



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Clemson Beaver Pond Leveler Planview and Profile

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

No.	Date	Description	Rev. By	App. By
		REVISIONS		

SCALE: 1" = 5'
C.I. = 1'
DATE: MAY 2020

Horizontal Datum: NY CENT NAD 83
Vertical Datum: NAVD 1988
Boundary and Topo Source: WSSI & Tompkins County Digital Data

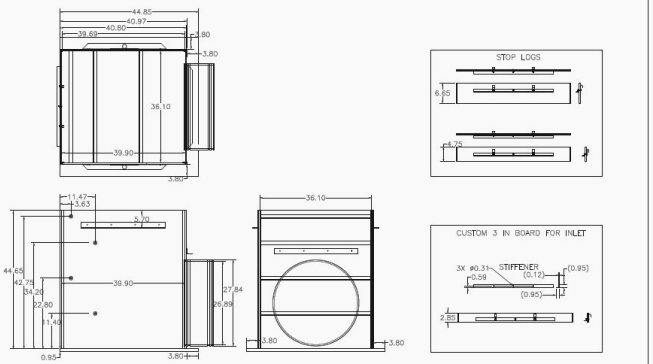
Design	Draft	Approved
CLASS	AC/NS	MSR

Sheet #
5 of 9

Computer File Name:

PART NO.	REV.	CO. AGRI DRAIN CORP	MATERIAL:

REVISIONS			
REV	DESCRIPTION	DATE	BY



DRAWN WITH 1056–2727 COUPLER

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES.
X ±.06
.XX ±.03
.XXX ±.010
ANGLES ±2°
BREAK ALL SHARP CORNERS.

ALL INFORMATION CONTAINED IN THIS DOCUMENT IS PROPRIETARY TO AGRI DRAIN CORP. DUPLICATION OR TRANSMITTAL OF THIS DOCUMENT IS STRICTLY PROHIBITED WITHOUT THE WRITTEN CONSENT OF AGRI DRAIN CORP.

ITEM	QTY	ITEM DESCRIPTION	PART NO.

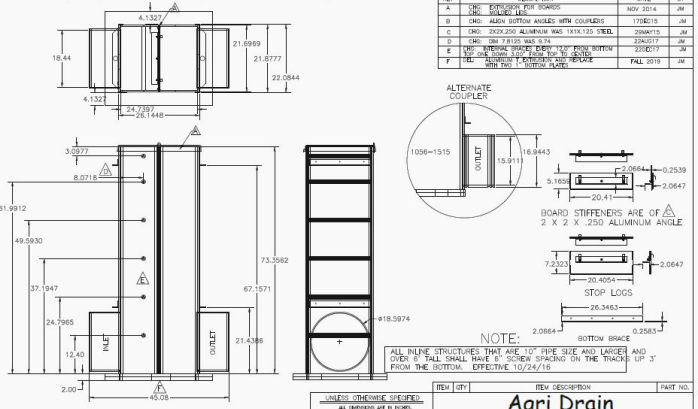
Agri Drain CORPORATION
America's Most Complete Supplier of Water Management Products
P.O. Box 458 ~ 1462 340th St. ~ Adel, IA 50003 ~ Ph: 1-800-232-4742 ~ Fax: 1-800-282-0353 ~ www.agridrain.com

TITLE
CUSTOM INLET 4' X 24" WCS

DATE: 26FEB20	DRAWN BY: J. MOORE	PART NO.	REV.

PART NO.	REV.	CO. AGRI DRAIN CORP	MATERIAL:

REVISIONS			
REV	DESCRIPTION	DATE	BY
A	CHG: EXTENSION FOR BOARDS CHG: WELDED LEG	NOV 2014	JM
B	CHG: ALIGN BOTTOM ANGLES WITH COUPLERS	17DEC15	JM
C	CHG: 2X2X.250 ALUMINUM WAS 1X1X.125 STEEL	29MAY15	JM
D	CHG: DIM 7.8125 WAS 9.74	22AUG17	JM
E	CHG: INTERNAL BRACES EVERY 11x5" FROM BOTTOM TOP ONE DOWN 3.00" FROM TOP TO WELDED	22DEC17	JM
F	DEL: ALUMINUM EXTRUSIONS AND REPLACE WITH TWO 1" BOTTOM PLATES	FALL 2019	JM



DRAWN WITH 1001–1515 COUPLER

SHOWN WITH BASE EXTENDED 4" ON ALL SIDES

NOTE:
ALL INLINE STRUCTURES THAT ARE 10" PIPE SIZE AND LARGER AND OVER 6' TALL SHALL HAVE 6" SCREW SPACING ON THE TRACKS UP 3' FROM THE BOTTOM. EFFECTIVE 10/24/16

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES.
X ±.06
.XX ±.03
.XXX ±.010
ANGLES ±2°
BREAK ALL SHARP CORNERS.

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America's Most Complete Supplier of Water Management Products
P.O. Box 458 ~ 1462 340th St. ~ Adel, IA 50003 ~ Ph: 1-800-232-4742 ~ Fax: 1-800-282-0353 ~ www.agridrain.com

TITLE
INLINE 6' X 15" WCS

DATE: 15APR10	DRAWN BY: J. MOORE	PART NO.	REV. F

NOTE: DO NOT INSTALL TOP ON 4'X24" INLET. STORMS NEED TO FLOW OVER ALL FOUR SIDES OF THIS STRUCTURE.

Page: 1

Agri Drain CORPORATION
1462 340th Street - P.O. Box 458 - Adel, IA 50003
Ph: 800-232-4742 Fax: 800-282-0353
www.agridrain.com

Quote

Sold To	Ship To
Cornell University Engineering 315 Hollister Hall Ithaca, NY 14853	Lab of Ornithology 159 Sapsucker Woods Rd Cornell University Engineering Att: Mike Rolband Ithaca, NY 14850
Phone: (703) 307-6415	Phone: 703-679-5802 Ext.:
Cell Phone:	Cell Phone:

Customer No.	Quote No.	Quote Date	Terms	FRT	Shipping Order
L017991	032620Dking	2/27/2020	Net 30 Days	QF	0514028

Qty.	Item No.	Description	Unit Price	Tax	Amount
		Allow 1-2 week manufacture lead time.			
1	99-404	Custom Inlet WCS Inlet WCS 4' tall x 24" FT (coupler 99-2727). Inside box dimensions 39" wide x 45" deep. Structure will have a 4" base extension on all three panel sides to allow for anchoring into concrete. Structures are not pressure rated. Structures are intended for gravity flow. Low pressure and some seepage will occur.	$1,827.3100	TX	$1,827.31
1	APP-POND	WLCS Application-Pond	$0.0000	NT	$0.00
4	99-404	33" 3/4" wide x 3" tall Stoplog Stoplog will have 1"x1" powder coated angle iron. Customer has been made aware that non-standard, custom built item(s) have no warranty, are nonreturnable, and Agri Drain will not be liable for issues that occur during use. Customer has acknowledged and agrees to the above statement and has given Agri Drain authorization to release this product(s) into production and bill their account in full for the item(s) ordered. Quote valid for 30 days from quote date. Lift gate needed: No Restricted: No Estimated freight not to exceed: $ 480.51 via FedEx. kk Sending quote to Mike- mrolband@cwilands.com	$168.7200	TX	$168.72
					Continued

Page: 2

Agri Drain CORPORATION
1462 340th Street - P.O. Box 458 - Adel, IA 50003
Ph: 800-232-4742 Fax: 800-282-0353
www.agridrain.com

Quote

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Phone: (703) 307-6415	Phone: 703-679-5802 Ext.:
Cell Phone:	Cell Phone:

Customer No.	Quote No.	Quote Date	Terms	FRT	Shipping Order
L017991	032620Dking	2/27/2020	Net 30 Days	QF	0514028

Qty.	Item No.	Description	Unit Price	Tax	Amount
		Will not need until May/ June 2020.			

Thank you for the opportunity to quote. If actual order is more or less than original quote quantity, items will need re-quoted. Taxes and shipping charges may not be included unless otherwise stated. In the event of errors or omissions, this offer is void and will be corrected on request.

Tax:	0.00
Discount:	0.00
Freight:	480.51
TOTAL:	$2,494.54

SIGN AND RETURN A COPY WHEN ORDERING

Katie Gettler — Agri Drain Sales Rep | Customer | Date Accepted

Page: 1

Agri Drain CORPORATION
1462 340th Street - P.O. Box 458 - Adel, IA 50003
Ph: 800-232-4742 Fax: 800-282-0353
www.agridrain.com

Quote

Sold To	Ship To
Cornell University Engineering 315 Hollister Hall Ithaca, NY 14853	Lab of Ornithology 159 Sapsucker Woods Rd Cornell University Engineering Att: Mike Rolband Ithaca, NY 14850
Phone: (703) 307-6415	Phone: 703-679-5802 Ext.:
Cell Phone:	Cell Phone:

Customer No.	Quote No.	Quote Date	Terms	FRT	Shipping Order
L017991	031620Dking	3/16/2020	Net 30 Days	QF	0515584

Qty.	Item No.	Description	Unit Price	Tax	Amount
1	99-404	Inline WCS 6' x 15" PVC w/ Ears Inline WCS 6' tall x 15" PVC couplers (will stretch for 16" OD PVC). Box size 20" wide x 24" deep. Structure will have a 4" base extension all the way around to allow for anchoring to concrete.	$1,402.1000	TX	$1,402.10
1	APP-MISC	WLCS Application-Misc. The above items are custom or nonstandard items. Custom or nonstandard items built by Agri Drain according to your specifications carry a one (1) year warranty (from date of invoice) on material and manufacturing defects only and are nonreturnable. Quote valid for 30 days from quote date. Lift gate needed: No Restricted: No Estimated freight not to exceed: $ 332.63 via Sala. kh Sending quote to Mike- mrolband@cwilands.com	$0.0000	NT	$0.00

Thank you for the opportunity to quote. If actual order is more or less than original quote quantity, items will need re-quoted. Taxes and shipping charges may not be included unless otherwise stated. In the event of errors or omissions, this offer is void and will be corrected on request.

Tax:	0.00
Discount:	0.00
Freight:	332.63
TOTAL:	$1,794.73

SIGN AND RETURN A COPY WHEN ORDERING

Katie Gettler — Agri Drain Sales Rep | Customer | Date Accepted

CornellEngineering
Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853

Agri Drain Details

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York.

No.	Date	Description	Rev. By	App. By

REVISIONS

C.I. = N/A
SCALE: NTS
DATE: MAY 2020

Horizontal Datum: NY CENT NAD 83
Vertical Datum: NAVD 1988
Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Drawn	Approved
CLASS	AC/NS	MSR

Sheet #
6 of 9

Computer File Name:

ADS, Inc. Drainage Handbook — Specifications ♦ 3-3E

ADS FLARED END SECTION SPECIFICATION

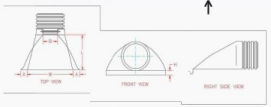
Scope
This specification describes 12- through 36-inch (300 to 900mm) ADS Flared End Sections for use in culvert and drainage outlet applications.

Requirements
The ADS Flared End Section shall be high density polyethylene meeting ASTM D3350 minimum cell classification 213320C; contact manufacturer for additional cell classification information. When provided, the metal threaded fastening rod shall be stainless steel.

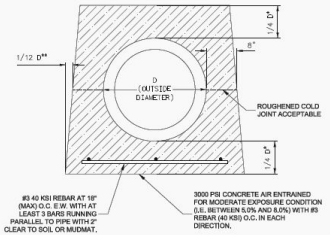
Installation
Installation shall be in accordance with ADS installation instructions and with those issued by state or local authorities. Contact your local ADS representative or visit www.ads-pipe.com for the latest installation instructions.

	PIPE DIAMETER, in (mm)						
Diameter*	12	15	18	24	30	36	
inch(es)	(300)	(375)	(450)	(600)	(750)	(900)	
A	12.0	15.0	18.0	24.0	30.0	36.0	
inch(es)	(305)	(381)	(457)	(610)	(762)	(914)	
B (Ref.)	19.8	19.8	19.8	19.8	59.0	59.0	
inch(es)	(503)	(503)	(503)	(503)	(1499)	(1499)	
C	12.0	15.0	18.0	24.0	30.0	36.0	
inch(es)	(305)	(381)	(457)	(610)	(762)	(914)	
L	39.8	39.8	39.8	39.8	98.0	98.0	
inch(es)	(1011)	(1011)	(1011)	(1011)	(2489)	(2489)	
W	39.5	39.5	39.5	39.5	93.5	93.5	
inch(es)	(1003)	(1003)	(1003)	(1003)	(2375)	(2375)	

*Product detail may differ slightly from actual product appearance



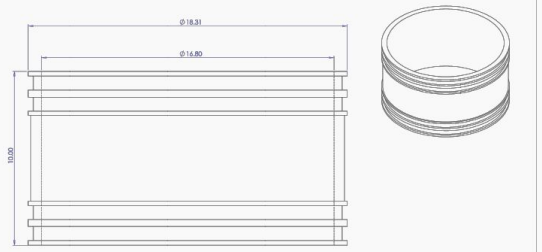
CONCRETE ANTI-SEEP COLLAR ENCASEMENT



* BUT NOT LESS THAN 6"
** IF THE PIPE IS LAID IN AN EXCAVATED TRENCH, THEN THE SIDE WALLS MAY CONFORM TO THE TRENCH SHAPE (I.E. THE TRENCH MAY BECOME THE CRADLE FORM)
*** SOIL BELOW COLLAR MUST BE IN-SITU OR UNDISTURBED SOIL OR PLACED ON SOIL COMPACTED TO 95% MODIFIED PROCTOR IN MAXIMUM OF 8" LIFTS.

NEOPRENE SLEEVE TO BE FERNCO OR APPROVED EQUAL

Fernco — 300 S. DAYTON ST. DAYSON, MI 48423 PH: 810-653-9426 FAX:810-654-2816 — 1072-1515 — DESCRIPTION: Coupling 1.5" ETI/DI x 1.5" ETI/DI



TOLERANCES:	Part Weight	13.62 lbs.	Installation torque	40" lbs.	UNITS	SIZE	DRAWN	SCALE:
X= Fractional ±	Min/Area Temp.	35/140 Degrees F	Conforms to ASTM	D3915, C1173	INCHES	A	D. Brady	not to scale
XX= ± .06	Pressure Tested	4.3 PSI	Clamps used	300 Series SS Hi-Torq	3RD ANGLE PROJECTION		DATE: 7/31/2012	SHEET 1 OF 1
ANG= ± 3° UNLESS OTHERWISE SPECIFIED	Material	Flexible PVC SS Ends Style 1	Box Quantity		DO NOT SCALE DRAWING			

24" AGRI DRAIN STAINLESS STEEL RAT GUARD OR APPROVED EQUAL

Manufactured by: Agri Drain Corporation
PO Box 458 · 1462 340th Street · Adair, Iowa 50002
Phone: 1-800-232-4742 · Fax: 1-800-262-3353
www.agridrain.com · email: info@agridrain.com

Rat Guards™

Avoid irritating and costly plugged drainage systems with stainless steel Rat Guards and zinc dichromate-plated mild steel Rat Guards.

Rat Guard, Stainless Steel
- Stainless steel material and hardware provides extended life.
- Resists rust and corrosion.
- Easy to install.
- 18" and 24" Rat Guards are held in place with a steel rod (included) which extends through the frame and then through the pipe. The rod extends approximately 1" on either side of frame.

Discount available when purchased in case quantity. Cases available on 4"-10" per case, 8"-100 per case, 8"-50 per case, 10"-50 per case, 12"-25 per case, and 12"-15 per case.

All bars are MIG welded on both sides.

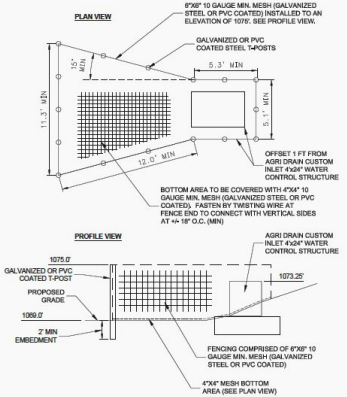
Rat Guard, Mild Steel
- Zinc dichromate plating resists corrosion.
- Easy to install. Position far enough in the pipe to allow it to swivel up and let trash pass without exposing the Rat Guard beyond the pipe.
- 18" through 60" Rat Guards are held in place with a steel rod (included) which extends through the frame and then through the pipe. Rod extends approximately 1" on either side of frame.

Discount available when purchased in case quantity. Cases available on 4"-100 per case, 8"-100 per case, 8"-50 per case, 10"-50 per case, 12"-25 per case, and 12"-15 per case.

Size	Diameter of Steel Frame & Center Bars	Approx. Bar Spacing	Steel Strap Size	Bolt Size
4"	5/16"	2"	1/8" x 3/4"	1/4" x 1 1/4"
6"	1/4"	1.34"	1/8" x 3/4"	1/4" x 1 1/2"
8"	1/4"	1.06"	1/8" x 3/4"	1/4" x 1 1/2"
10"	5/16"	1.17"	1/8" x 1"	5/16" x 1 1/2"
12"	5/16"	1"	1/8" x 1"	5/16" x 1 1/2"
15"	5/16"	1.38"	1/8" x 1"	5/16" x 1 1/2"

Size	Diameter of Center Bars	Approx. Bar Spacing	Square Steel Frame	Steel Rod Size
18"	5/16"	1.19"	3/4"	3/8"
21"	5/16"	1.19"	3/4"	3/8"
24"	5/16"	1.19"	1"	3/8"
30"	5/16"	1.19"	1"	3/8"
36"	5/16"	1.19"	1"	3/8"
42"	1/2"	1"	3/4" / 1"	3/8"
48"	1/2"	1"	3/4" / 1"	3/8"
54"	1/2"	1.5"	1 1/4" / 1 1/2"	3/8"
60"	1/2"	1.5"	1 1/4" / 1 1/2"	3/8"

TRAPEZOIDAL BEAVER FENCING



CONTRACTOR TO BRACE T-POSTS AS NEEDED

CornellEngineering
Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853

Construction Details

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

REVISIONS

No.	Date	Description	Rev. By	App. By

SCALE: NTS — C.I. = N/A

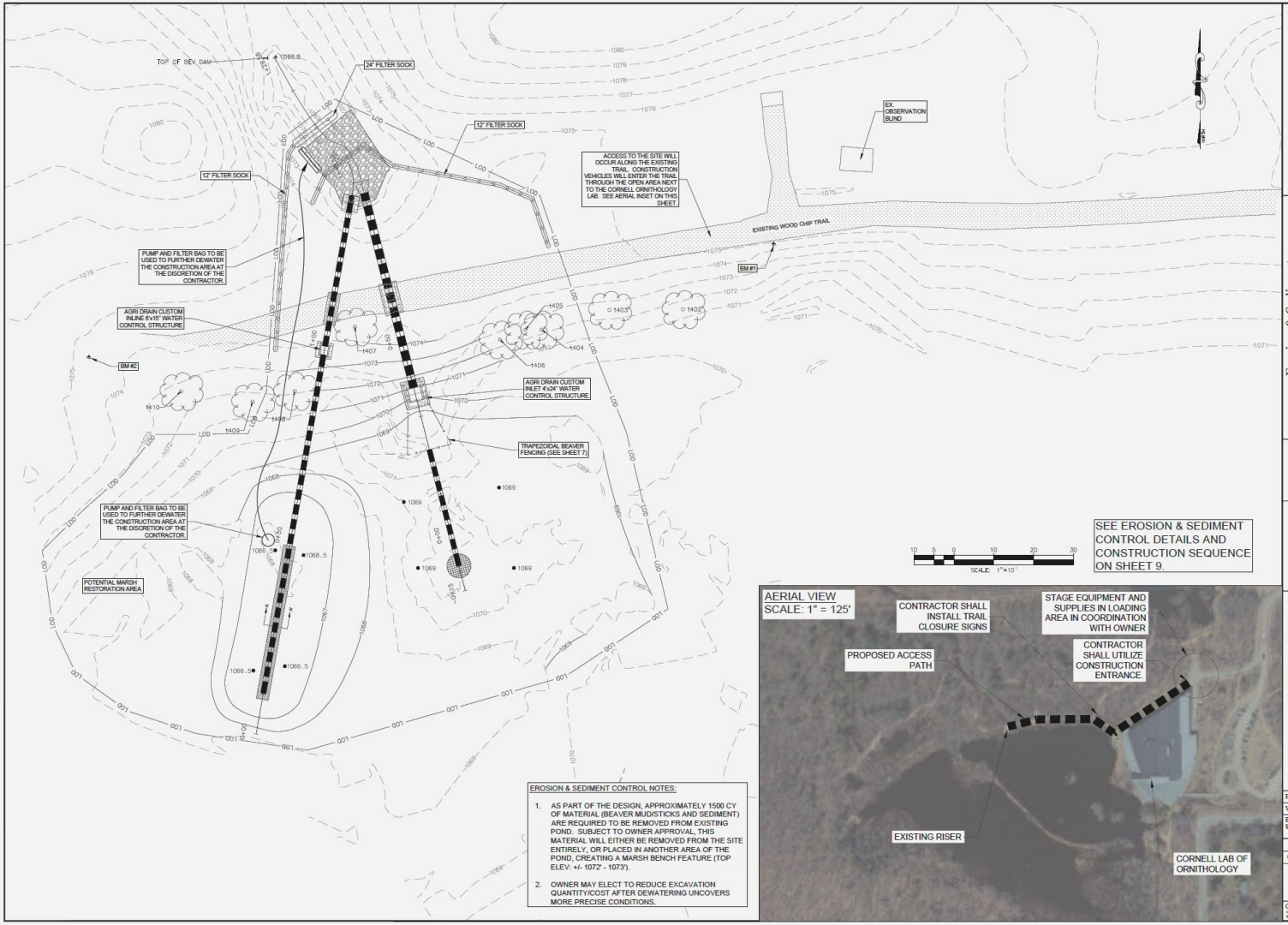
DATE: MAY 2020

Horizontal Datum: NY CENT NAD 83
Vertical Datum: NAVD 1988
Boundary and Topo Source: WSSI & Tompkins County Digital Data

Design	Draft	Approved
CLASS	AC/NS	MSR

Sheet #
7 of 9

Computer File Name:



EROSION & SEDIMENT CONTROL NOTES:

1. AS PART OF THE DESIGN, APPROXIMATELY 1500 CY OF MATERIAL (BEAVER MUDSTICKS AND SEDIMENT) ARE REQUIRED TO BE REMOVED FROM EXISTING POND. SUBJECT TO OWNER APPROVAL, THIS MATERIAL WILL EITHER BE REMOVED FROM THE SITE ENTIRELY, OR PLACED IN ANOTHER AREA OF THE POND, CREATING A MARSH BENCH FEATURE (TOP ELEV: +/- 1072' - 1073').
2. OWNER MAY ELECT TO REDUCE EXCAVATION QUANTITY/COST AFTER DEWATERING UNCOVERS MORE PRECISE CONDITIONS.

CornellEngineering
Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853

Erosion & Sediment Control Plan

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

REVISIONS

No.	Date	Description	Rev. By	App. By

SCALE: 1" = 10' C.I. = 1'

DATE: MAY 2020

Horizontal Datum: NY CENT NAD 83

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Design	Draft	Approved
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Sheet #

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Computer File Name:

STANDARD AND SPECIFICATIONS FOR GEOTEXTILE FILTER BAG

Materials and Installation

1. The geotextile material will have the following attributes:

Minimum Grab Tensile Strength	200 lbs.
Minimum Grab Tensile Elongation	50 %
Minimum Trapezoid Tear Strength	80 lbs.
Mullen Burst Strength	360 psi
Minimum Puncture Strength	130 lbs
Apparent Opening Size	40 - 80 US sieve
Minimum UV Resistance	70%
Minimum Flow Thru Rate	70 gpm/sq ft

2. The bag shall be sewn with a double needle machine using high strength thread, double stitched "Joe" type capable of minimum roll strength of 100 lbs/inch (ASTM D4884).
3. The geotextile filter bag shall have an opening large enough to accommodate a 4 inch diameter discharge hose with an attached strap to tie off the bag to the hose to prevent back flow.
4. The geotextile shall be placed on a gravel bed 2 inches thick, a stone mat 4 inches thick, or a vegetated filter strip to allow water to flow out of the bag in all directions.

Definition & Scope

A **temporary** portable device through which sediment laden water is pumped to trap and retain sediment prior to its discharge to drainageways or off-site.

Condition Where Practice Applies

On sites where space is limited such as urban construction or linear projects (e.g. roads and utility work) where rights-of-way are limited and larger de-silting practices are impractical.

Design Criteria

1. Location - The portable filter bag should be located to minimize interference with construction activities and pedestrian traffic. It should also be placed in a location that is vegetated, relatively level, and provides for ease of access by heavy equipment, clearout, disposal of trapped sediment, and proper release of filtered water.

   The filter bag shall also be placed at least 50 feet from all wetlands, streams or other surface waters.
2. Size - Geotextile filter bag shall be sized in accordance with the manufacturers recommendations based on the pump discharge rate.

Maintenance

1. The geotextile filter bag is considered full when retaining bag flow area has been reduced by 75%. At this point, it should be replaced with a new bag.
2. Disposal may be accomplished by removing the bag to an appropriate designated upland area, cut open, remove the geotextile for disposal, and spread sediment contents and seeded and mulched according to the vegetative plan.

Figure 5.2
Compost Filter Sock

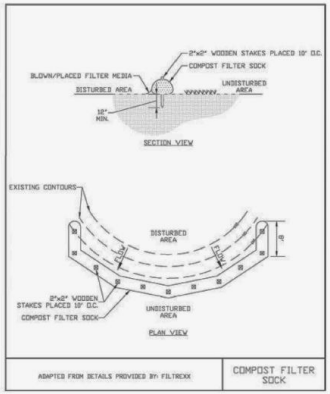
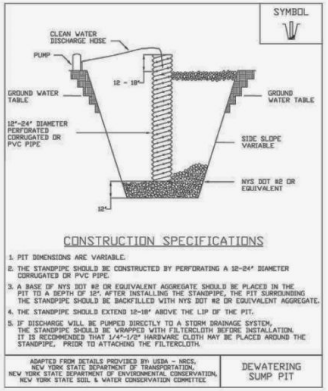
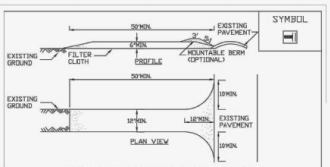


Figure 3.3
Dewatering Sump Pit Detail



(IF REQUIRED BY LOCAL INSPECTORS. DUE TO LIMITED VEHICULAR USE, THIS REQUIREMENT IS AT THE DISCRETION OF THE LOCAL INSPECTOR)

Figure 2.1
Stabilized Construction Access



CONSTRUCTION SEQUENCE

Contractor is solely responsible for selecting the methods and means to implement the project design. The Construction Sequence is solely provided as non-binding advice by the engineer to the contractor. Many other methods may be utilized and achieve the same results.

Owner may elect to have the contractor perform only certain portions of the steps below and may choose to complete parts of the sequence with facility resources. Refer to Contract with owner for Scope of Work Exclusions.

1. Install Construction Entrance and perimeter Erosion and Sediment control.

2. Drain pond area
   - 2.1. Install E&S controls downstream of outlet pipe and perimeter of disturbed areas.
   - 2.2. Drain pond water level (max of 6"per day to prevent dam slope failure) by removing wood weir. Additional ponded water removed by optional Pump and Filter bag.
   - 2.3. Remove beaver mud and woody materials from the ponded area per grading plan and place in designated disposal area on site and stabilize with hand cast seed and mulch.

3. Outlet replacement
   - 3.1. Remove soil from 24" corrugated metal outlet pipe and stockpile soil (segregate topsoil).
   - 3.2. Remove 24" corrugated metal pipe, existing concrete outlet and wood weir, and dispose off-site.
   - 3.3. Install 24" HDPE pipe.
   - 3.4. Insert form and place concrete cradle encasement and concrete ballast.
   - 3.5. Place bentonite seal.
   - 3.6. Replace and compact subsoil, then cover and track in 6" layer of topsoil.
   - 3.7. Install Agri Drain *Inline* Water Level Control Structure™ and bolt to the concrete ballast- do not install weir until completion of project. Make sure that the three fixed sides of the Agri Drain structure have an invert of 1073.25 and do not install cover.
   - 3.8. Place fabric and riprap at outlet.
   - 3.9. Install trapezoidal beaver fencing.
   - 3.10. Place topsoil, rake, seed and mulch.

4. Clemson Beaver Pond Leveler
   - 4.1. Remove soil for pipe installation and stockpile soil (segregate topsoil).
   - 4.2. Install 18" PVC pipe through the dam.
   - 4.3. Form and place concrete cradle encasement and concrete ballast.
   - 4.4. Place bentonite seal.
   - 4.5. Replace and compact subsoil, then cover and track in 6" layer of topsoil.
   - 4.6. Install Agri Drain *Inline* Water Level Control Structure™ and bolt to concrete ballast (keep weir open at bottom - use as valve).
   - 4.7. Place 18" PVC (with section of perforations) and gabions with #3 stone in the specified pond area, connect to Agri Drain *Inline* Water Level Control Structure™.
   - 4.8. Insert duckbill anchors, one on each side of the pipe.
   - 4.9. Place fabric and riprap at the standpipe.
   - 4.10. Place topsoil, rake, seed and mulch.

5. Flexible Pond Leveler
   - 5.1. Remove existing Beaver Solutions™ Flexible Pond Leveler™ and debris from outlet structure.
   - 5.2. Re-install domed intake fence from Flexible Pond Leveler™ in a new location with 15' HDPE pipe extension, if desired by Owner.

6. Clean-Up
   - 6.1. Remove all debris from site.
   - 6.2. Remove all Erosion and Sediment controls, after vegetative coverage exceeds 80%.
   - 6.3. Place wood chips over the trail path.
   - 6.4. Install weir in Agri Drain *Inline* Water Level Control Structure™ to elevation 1073.13' (initial setting) or slightly lower because PVC stoplogs can only be adjusted within 1" increments (unless customized by Owner).
   - 6.5. Keep the weir of the Agri Drain *Inline* Water Level Control Structure™ open at the bottom - use as a valve. Confirm weir is at least 16" above pipe invert in Clemson Agri Drain *Inline* Water Level Control Structure™ for free pipe flow.

SEEDING SCHEDULE FOR DISTURBED AREAS OUTSIDE POND

	Species or Mix	Rate	Area*	Quantity
Cover Crop	Annual or Grain Rye (if planted in Spring, Summer, or Fall)	40 lbs/ac	0.1 ac	4 lb
	Winter Rye (if planted in Late Fall or Early Winter)	100 lbs/ac		10 lb
Floodplain Mix	Floodplain Mix (ERNMX-154)	20 lbs/ac		2 lb
Meadow	Deer Resistant Meadow Mix (ERNMX-155)	20 lbs/ac		2 lb

*Planting Area = Area within LOD, above elevation 1073, and outside of the wood chip trail.
Source: www.ernstseed.com or approved equal

CornellEngineering
Civil and Environmental Engineering
220 Hollister Hall
Ithaca, NY 14853

Erosion & Sediment Control Details

Prepared For: The Cornell Lab of Ornithology

Sapsucker Woods Outlet Replacement and Beaver Control Retrofit Plan

Village of Lansing, New York

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   - 2.3. Remove beaver mud and woody materials from the ponded area per grading plan and place in designated disposal area on site and stabilize with hand cast seed and mulch.

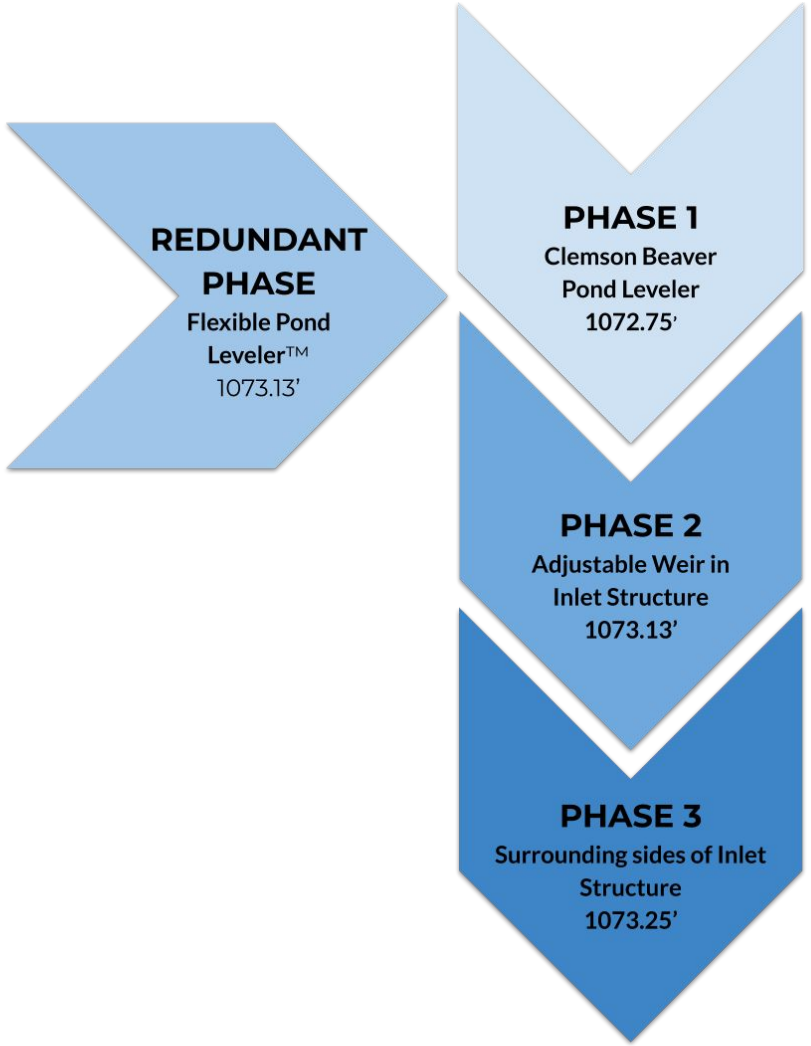
3. Outlet replacement
   - 3.1. Remove soil from 24" corrugated metal outlet pipe and stockpile soil (segregate topsoil).
   - 3.2. Remove 24" corrugated metal pipe, existing concrete outlet and wood weir, and dispose off-site.
   - 3.3. Install 24" HDPE pipe.
   - 3.4. Insert form and place concrete collar encasement and concrete ballast.
   - 3.5. Place bentonite seal.
   - 3.6. Replace and compact subsoil, then cover and track in 6" layer of topsoil.
   - 3.7. Install Agri Drain ***Inlet*** Water Level Control Structure™ and bolt to the concrete ballast- do not install weir until completion of project. Make sure that the three fixed sides of the Agri Drain structure have an invert of 1073.25 and do not install cover.
   - 3.8. Place fabric and riprap at outlet.
   - 3.9. Install trapezoidal beaver fencing.
   - 3.10. Place topsoil, rake, seed and mulch.

4. Clemson Beaver Pond Leveler
   - 4.1. Remove soil for pipe installation and stockpile soil (segregate topsoil).
   - 4.2. Install 16" PVC pipe through the dam.
   - 4.3. Form and place concrete collar encasement and concrete ballast.
   - 4.4. Place bentonite seal.
   - 4.5. Replace and compact subsoil, then cover and track in 6" layer of topsoil.
   - 4.6. Install Agri Drain ***Inline*** Water Level Control Structure™ and bolt to concrete ballast (keep weir open at bottom - use as valve).
   - 4.7. Place 16" PVC (with section of perforations) and gabions with #3 stone in the specified pond area, connect to Agri Drain ***Inline*** Water Level Control Structure™.
   - 4.8. Insert duckbill anchors, one on each side of the pipe.
   - 4.9. Place fabric and #3 surge stone at the standpipe.
   - 4.10. Place topsoil, rake, seed and mulch.

5. Flexible Pond Leveler
   - 5.1. Remove existing Beaver Solutions™ Flexible Pond Leveler™ and debris from outlet structure.
   - 5.2. Re-install domed intake fence from Flexible Pond Leveler™ in a new location with 18" HDPE pipe extension, if desired by Owner.

6. Clean-Up
   - 6.1. Remove all debris from site.
   - 6.2. Remove all Erosion and Sediment controls, after vegetative coverage exceeds 80%.
   - 6.3. Place wood chips over the trail path.
   - 6.4. Install weir in Agri Drain ***Inlet*** Water Level Control Structure™ to elevation 1073.13' (initial setting) or slightly lower because PVC stoplogs can only be adjusted within 1" increments (unless customized by Owner).
   - 6.5. Keep the weir of the Agri Drain ***Inline*** Water Level Control Structure™ open at the bottom - use as a valve. Confirm weir is at least 16" above pipe invert in Clemson Agri Drain ***Inline*** Water Level Control Structure™ for free pipe flow.

Flow Phases of Final Design



Adjustments

- Allow “fine tuning” by facilities manager
- Easy maintenance
  - Neoprene sleeve to adjust standpipe elevation
  - Agri Drain Inline control structure
    - Substitute for valve
    - Allows additional water elevation adjustment
  - Agri Drain Inlet control structure

Neoprene Sleeve

Agri Drain Inlet and Inline Water Level Control Structures™

Source: Supply.com and Agri Drain Corporation

Cost Estimate

Project costs were divided into five sections:

Shared Costs	**$9,500**
Trapezoidal Beaver Fencing	**$1,650**
Clemson Beaver Pond Leveler	**$30,300**
Existing Outlet Structure Improvement	**$12,700**
Existing Flexible Pond Leveler Improvement	**$1,600**
10% Contingency	**$5,600**
Total	***$62,350***

Buoyancy Calculations

- Concrete ballast
  - SF of 1.4
- Bolt strength
  - SF of 3.0

OUTLET REPLACEMENT BALLAST CONCRETE	***A*** ***VOLUME OF STRUCTURE*** *(CF)*
Ballast Concrete Dimensions: 6'x7'x2'	84.0
Inlet Agri Drain Dimensions: 41"x36"x45"	38.4
Total	**-**
Safety Factor for Buoyancy	-

F = E/C ***SAFETY FACTOR***	***COMMENTS***
	3000 PSI concrete
	Dimensions and weight from manufacturer
1.70	**SF exceeds 1.4 requirement ✓**

Example calculation for concrete ballast

OUTLET STRUCTURE ANCHOR BOLT DESIGN	***A*** ***AGRI DRAIN BUOYANCY*** *(LBS)*
	2398.5
Safety Factor for Bolts*	

G = (F*D)/(A-B) ***SAFETY FACTOR***	***COMMENTS***
	Recommended Bolt: 1/2" Dia., 5" L. Removable-Bolt Anchors for Concrete: https://www.mcmaster.com/removable-bolt-anchors/
6.00	**SF exceed 3.0 requirement ✓**

Example calculation for bolt strength

Flow Calculations

Outlet Pipe

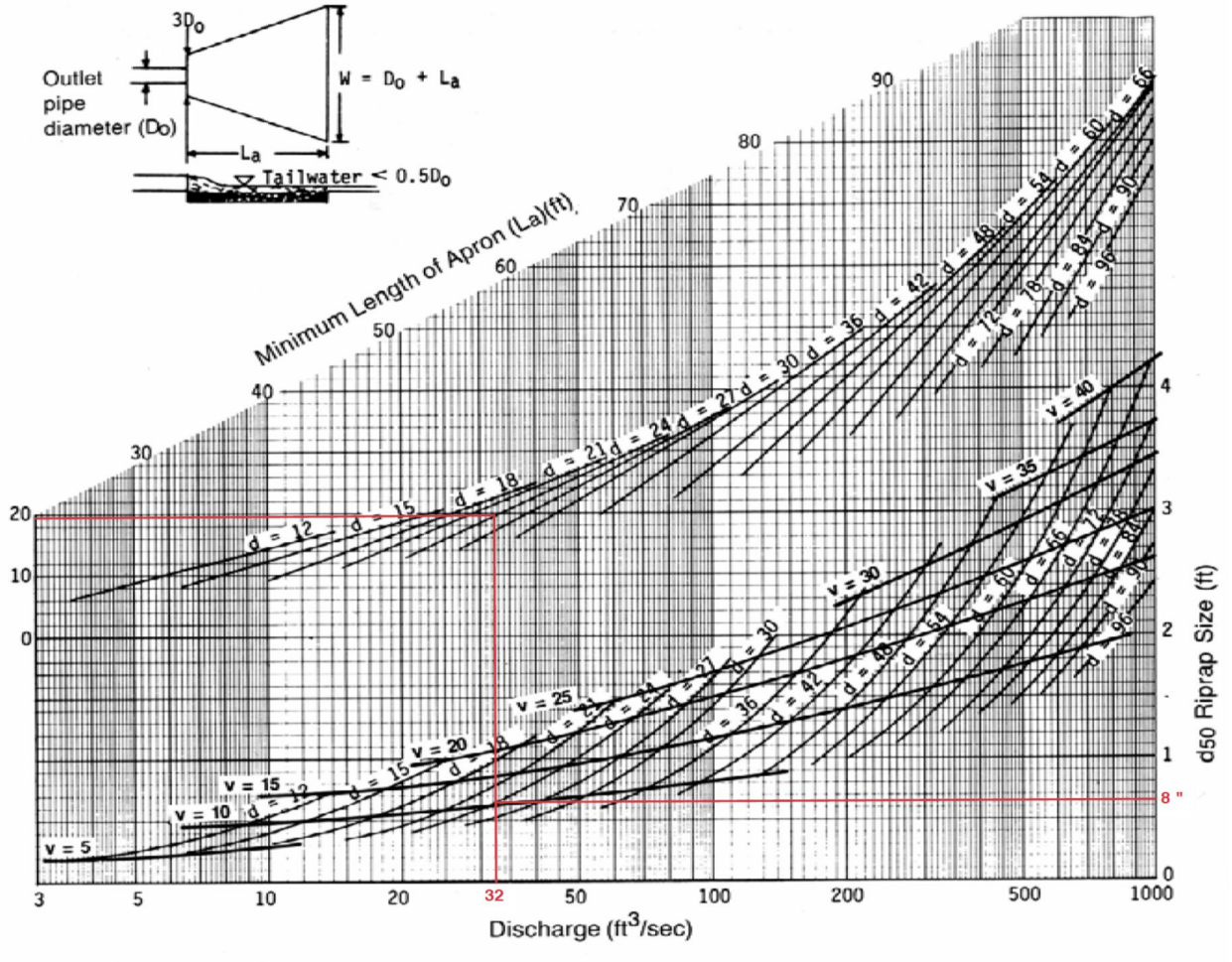
- Equation $\boxed{Q = C_d A\sqrt{2gh}}$
- Flow Capacity $\boxed{\mathrm{Q} = 31.85\ \mathrm{cfs}}$

Clemson Beaver Pond Leveler

- Flow Capacity $\boxed{\mathrm{Q} = 2.65\ \mathrm{cfs}}$
- Return Period $\boxed{\mathrm{Return\ Period} = 4\ \mathrm{months}}$

Riprap Sizing

$$Q = 31.85 \text{ cfs}$$



Value Engineering

Implement design in stages

1) Replace the outlet structure and install trapezoidal beaver fencing
    a) Potentially re-using the temporary HDPE pipe
2) Clean and reposition Flexible Pond Leveler™
3) Install the Clemson Beaver Pond Leveler

Clemson Beaver Pond Leveler size reduction

Eliminate dredging and abandon Flexible Pond Leveler™

Permitting

US Army Corps of Engineers ®

Clean Water Act,
Section 404

NEW YORK STATE OF OPPORTUNITY Department of Environmental Conservation

Clean Water Act,
Section 401

Village of Lansing CODE

Village of Lansing EST. 1974

Notice of Ground Disturbance

Considerations after COVID-19

- We were able to:
  - Complete concept design plans drawn by hand
  - Work extensively on design calculations used to size the components of the proposed system
- Due to COVID-19:
  - Limited the scope of work
  - Ask for assistance from engineers outside the class to aid us with the construction plans
- Focused on:
  - Compiling report and associated calculations and design specifications
  - Reviewing and commenting on the construction plans
  - Permitting requirements

Future Ideas for Student Projects

- Design Changes
- Water Budget
- Watershed Measurements and Modeling
- Constructed Wetlands North of the Cornell Lab of Ornithology Building

Thank you!

Lab of Ornithology

- Jeff Payne
- John Fitzpatrick

Cornell CEE & Libraries

- Charissa King-O'Brien

WSSI Team

- Chad Laskaris & Jim Quirin
- John Cooke & Margaret McMenamin
- Alex Chapla & Nate Staley

Army Corps of Engineers

- Judy Robinson

CEE 5021 Team

- Hannah, Mary, Nick & Wenduo

Photo credit: Mike Rolband

Questions?

Spreadsheets Included

SHARED COSTS

ITEM/DESCRIPTION	QTY	LABOR + MATERIALS UNIT	LABOR + MATERIALS UNIT PRICE	LABOR UNIT	LABOR UNIT PRICE	MATERIALS UNIT	MATERIALS UNIT PRICE	COST*		UNIT PRICE SOURCE	COMMENTS
Mobilization	1	EA	2000	N/A	N/A	N/A	N/A	2000		Engineer's Estimate	---
Dewatering	1	EA	1000	N/A	N/A	N/A	N/A	1000		Engineer's Estimate	---
6" Pump and Filter Bag	2	WKS	1050	N/A	N/A	N/A	N/A	2100		Sunbelt Rentals, Inc.	http://bit.ly/36DfOz4
Excavation, Fill, and Compaction	16	HR	200	N/A	N/A	N/A	N/A	3200		Engineer's Estimate	---
Erosion Control	1	EA	500	N/A	N/A	N/A	N/A	500		Engineer's Estimate	---
Temporary Seeding and Mulch	4	N/A	N/A	N/A	N/A	LB	14	55		Ernst Conservation Seeds, Inc.	Annual or Grain Rye (if planted in Spring, Summer, or Fall), or Winter Rype (if planted in Late Fall or Early Winter). https://bit.ly/3cZuRXB
Permanent Seeding and Mulch	4	N/A	N/A	N/A	N/A	LB	161	642		Ernst Conservation Seeds, Inc.	ERNMX-154: Floodplain Mix - (https://bit.ly/3bEwN7t) and ERNMX-155: Deer Resistant Meadow Mix - (https://bit.ly/2VBbGDl)
SUBTOTAL									**$9,457**		

TRAPEZOIDAL BEAVER FENCING

ITEM/DESCRIPTION	QTY	LABOR + MATERIALS UNIT	LABOR + MATERIALS UNIT PRICE	LABOR UNIT	LABOR UNIT PRICE	MATERIALS UNIT	MATERIALS UNIT PRICE	COST*		UNIT PRICE SOURCE	COMMENTS
10-Gauge Welded Wire Fence - 4"x4" Mesh	5	N/A	N/A	N/A	N/A	SHEET (4'x10')	86	432		Edward J Darby & Son, Inc.	For bottom; galvanized steel or PVC coated, fastened by twisting wire at fence end and connect to vertical sides. Approximately 206 square ft. https://bit.ly/3eZe6gE
10-Gauge Welded Wire Fence - 6"x6" Mesh	1	N/A	N/A	N/A	N/A	ROLL (5'x150')	133	133		Fastenal Company	For sides; galvanized steel or PVC coated. Approximately 300 square ft. https://www.fastenal.com/products/details/0953331
Steel Fence T-Post - 10"	8	N/A	N/A	N/A	N/A	EA	12	95		Tractor Supply Co.	https://bit.ly/2VHjZYB
Steel Fence T-Post - 6"	2	N/A	N/A	N/A	N/A	EA	4	9		The Home Depot	https://thd.co/31gP9Hb
Galvanized T-Post Clips	48	N/A	N/A	N/A	N/A	EA	0.54	26		The Home Depot	https://thd.co/2UcwOcZ
Labor to Remove Previous Fencing and Debris	8	N/A	N/A	HR	60	N/A	N/A	480		Engineer's Estimate	---
Labor to Install	8	N/A	N/A	HR	60	N/A	N/A	480		Engineer's Estimate	---
SUBTOTAL									**$1,654**		

CLEMSON BEAVER POND LEVELER

ITEM/DESCRIPTION	QTY	LABOR + MATERIALS UNIT	LABOR + MATERIALS UNIT PRICE	LABOR UNIT	LABOR UNIT PRICE	MATERIALS UNIT	MATERIALS UNIT PRICE	COST*		UNIT PRICE SOURCE	COMMENTS
16" Diameter, 20' L, Sch 40 PVC	6	N/A	N/A	N/A	N/A	EA	756	4536		PVC Pipe Supplies	http://bit.ly/37Bilv2
16" Diameter, 10' L, Sch 40 PVC	1	N/A	N/A	N/A	N/A	EA	336	336		PVC Pipe Supplies	https://pvcpipesupplies.com/16-x-10-schedule-40-pvc-pipe-n0401600pw1000.html
Hole Drilling - 2" Diameter	558	N/A	N/A	EA	3.33	N/A	N/A	1858		Engineer's Estimate	2 min/hole and $100/hr
PVC End Cap - 16" Diameter	1	N/A	N/A	N/A	N/A	EA	216	216		PVC Fittings Online	https://www.pvcfittingsonline.com/16-pvc-duct-cap-1034-ca-16.html
PVC Coupling - 16" Diameter	5	N/A	N/A	N/A	N/A	EA	184	918		PVC Fittings Online	https://www.pvcfittingsonline.com/16-sch-40-pvc-coupling-soc-429-160f.html
PVC 90° Elbow - 16" Diameter	1	N/A	N/A	N/A	N/A	EA	972	972		PVC Fittings Online	https://www.pvcfittingsonline.com/16-sch-40-pvc-90-elbow-soc-406-160f.html
PVC Glue	1	N/A	N/A	N/A	N/A	GAL	72	72		Platt Electric Supply	https://bit.ly/3eSxzje
Neoprene Sleeve - 16" Diameter	1	N/A	N/A	N/A	N/A	EA	76	76		Fernco	https://www.fernco.com/dimensional-drawings/1072-1515
Gabion - 3' x 3' x 39' PVC coated	1	N/A	N/A	N/A	N/A	EA	594	594		Gabion Supply	https://gabionsupply.com/
#3 Stone - Leveler Ballast	4	N/A	N/A	N/A	N/A	TON	72	287		Cayuga Compost	http://cayugacompost.com/products/stone/
Duckbill Earth Anchors	2	N/A	N/A	N/A	N/A	EA	10	20		Forestry Suppliers	https://www.forestry-suppliers.com/product_pages/products.php?mi=53503&itemnum=79131
Custom Agri Drain Inline Water Level Control Structures™ - 6'x15" WCS	1	N/A	N/A	N/A	N/A	EA	1795	1795		Agri Drain Corporation	Custom design: Inline WCS 6' tall x 15" PT (coupler 1001-1515). Box size 20" wide x 24" deep. Structure will have a 4" base extention all the way around to allow for anchoring to concrete.Custom quote has tax already included.
Anchor Bolts	0.4	N/A	N/A	N/A	N/A	PK**	39	16		McMaster-Carr	Anchor bolts cast in place, or drilled/epoxied. Bolts shall be Hilti (www.hilti.com) or mcmaster-carr (www.mcmaster.com) such as mcmaster-carr 1/2" dia. 5" long removable bolt anchors for concrete or approved equal minimum pull out strength 2000 lb per bolt. Package of 10. https://www.mcmaster.com/concrete-anchors

Concrete Ballast - 4.5'x4.5'x1.5'	1.1	N/A	N/A	N/A	N/A	CY	735	831		Fairfax County	Class B concrete for unsuitable foundation material A4; placed at base of Custom Agri Drain Inline Water Level Control Structures™. http://bit.ly/38LYb1x
Mudmat - 2"-3" Thick (Optional)	0.2	N/A	N/A	N/A	N/A	CY	735	118		Fairfax County	Class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
#3 Rebar	3	N/A	N/A	N/A	N/A	EA	6	17		The Home Depot	18" O.C. E.W. 2" min clear to soil or mudmat; sold in 20ft increments.https://thd.co/3aFrRho
Concrete Collar Encasement	2.3	N/A	N/A	N/A	N/A	CY	735	1655		Fairfax County	Class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
Class 1 Riprap - Outlet Apron	2	N/A	N/A	N/A	N/A	TON	137	274		Cayuga Compost	http://cayugacompost.com/products/stone/
Filter Fabric	1	N/A	N/A	N/A	N/A	ROLL (3'x50')	60	60		The Home Depot	https://thd.co/313kPzl
Concrete Ballast - 4'x4'x1' at Pipe Exit (Optional)	0.6	N/A	N/A	N/A	N/A	CY	735	434		Fairfax County	Class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
Mudmat - 2'-3" Thick - at Pipe Exit (Optional)	0.1	N/A	N/A	N/A	N/A	CY	735	88		Fairfax County	Class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
Bentonite Seal	200	N/A	N/A	N/A	N/A	LB	2.16	432		Walmart	http://bit.ly/2S8J4sh
Re-Grading	1500	CY	5	N/A	N/A	N/A	N/A	7500		Engineer's Estimate	---
Labor to Install CWL	72	N/A	N/A	HR	100	N/A	N/A	7200		Engineer's Estimate	---
SUBTOTAL									**$30,305**		

EXISTING OUTLET STRUCTURE IMPROVEMENT

		LABOR + MATERIALS		LABOR		MATERIALS					
ITEM/DESCRIPTION	*QTY*	*UNIT*	*UNIT PRICE*	*UNIT*	*UNIT PRICE*	*UNIT*	*UNIT PRICE*	*COST***		*UNIT PRICE SOURCE*	*COMMENTS*
Custom Agri Drain Inlet Water Level Control Structures™ - 4'x24" WCS	1	N/A	N/A	N/A	N/A	EA	2495	2495		Agri Drain Corporation	Custom design: Inlet WCS 4' tall x 24" PT (coupler 56-2727). Inside box dimensions 38" wide x 42" deep. Structure will have a 4" base extension on all three panel sides to allow for anchoring into concrete. Custom quote has tax already included.
Labor to Remove Concrete Structure	1	N/A	N/A	DY	1000	N/A	N/A	1000		Engineer's Estimate	---
Concrete Structure Disposal	1	EA	500	N/A	N/A	N/A	N/A	500		Engineer's Estimate	---
Concrete Ballast - 6'x7'x1.5'	2.3	N/A	N/A	N/A	N/A	CY	735	1714		Fairfax County	Class B concrete for unsuitable foundation material A4; placed at base of Custom Agri Drain Inlet Water Level Control Structures™. http://bit.ly/38LYb1x
#3 Rebar	5	N/A	N/A	N/A	N/A	BAR (20')	6	29		The Home Depot	18" O.C. E.W. 2" min clear to soil or mudmat; sold in 20ft increments. https://thd.co/3aFrRho
Mudmat - 2"-3" (optional)	0.3	N/A	N/A	N/A	N/A	CY	735	235		Fairfax County	Optional placement beneath concrete ballast; class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
Anchor Bolts	0.6	N/A	N/A	N/A	N/A	PK**	39	23		McMaster-Carr	Anchor bolts cast in place, or drilled/epoxied. Bolts shall be Hilti (www.hilti.com) or mcmaster-carr (www.mcmaster.com) such as mcmaster-carr 1/2" dia. 5' long removable bolt anchors for concrete or approved equal minimum pull out strength 2000 lb per bolt. Package of 10. https://www.mcmaster.com/concrete-anchors
Existing 24" CMP Removal	1	HR	200	N/A	N/A	N/A	N/A	200		Engineer's Estimate	---
HDPE Pipe - 24" Diameter	1	N/A	N/A	N/A	N/A	EA	0	0		--	50' section already purchased by client
HDPE Pipe - 24" Installation	4	HR	200	N/A	N/A	N/A	N/A	800		Engineer's Estimate	---
Rodent Guard	1	N/A	N/A	N/A	N/A	EA	168	168		Agri Drain Corporation	http://bit.ly/2GyI6RJ
Flared End Section	1	N/A	N/A	N/A	N/A	EA	244	244		PlumbersStock	http://bit.ly/395XdgQ
Concrete Collar Encasement	4.6	N/A	N/A	N/A	N/A	CY	735	3405		Fairfax County	Class B concrete for unsuitable foundation material A4. http://bit.ly/38LYb1x
Bentonite Seal	200	N/A	N/A	N/A	N/A	LB	2.2	432		Walmart	http://bit.ly/2S8J4sh
Class 1 Riprap - Outlet Apron	32	N/A	N/A	N/A	N/A	TON	43	1376		Cayuga Compost	http://cayugacompost.com/products/stone/
Filter Fabric	1	N/A	N/A	N/A	N/A	ROLL (3'x50')	60	60		The Home Depot	https://thd.co/313kPzl
SUBTOTAL									**$12,683**		

EXISTING FLEXIBLE POND LEVELER IMPROVEMENT

		LABOR + MATERIALS		LABOR		MATERIALS					
ITEM/DESCRIPTION	*QTY*	*UNIT*	*UNIT PRICE*	*UNIT*	*UNIT PRICE*	*UNIT*	*UNIT PRICE*	*COST***		*UNIT PRICE SOURCE*	*COMMENTS*
Additional 15" HDPE Pipe	1	N/A	N/A	N/A	N/A	EA	0	0		--	Already purchased by client.
Labor to Install	8	HR	200	N/A	N/A	N/A	N/A	1600		Engineer's Estimate	---
SUBTOTAL									$1,600		

BUOYANCY CALCS

OUTLET REPLACEMENT BALLAST CONCRETE	A VOLUME OF STRUCTURE (CF)	B DENSITY OF WATER (LBS/CF)	C = A*B BUOYANCY (LBS)	D DENSITY OF MATERIAL (LBS/CF)	E = A*D WEIGHT OF STRUCTURE (LBS)	F = E/C SAFETY FACTOR	COMMENTS
Ballast Concrete Dimensions: 6'x7'x2'	84.0	62.4	5241.6	150.0	12600.0		3000 PSI concrete
Inlet Agri Drain Dimensions: 41"x36"x45"	38.4	62.4	2398.5	-	400.0		Dimensions and weight from manufacturer
Total	**-**	**-**	**7640.1**	**-**	**13000.0**		
Safety Factor for Buoyancy	-	-	-	-	-	**1.70**	**SF exceeds 1.4 requirement ✓**

CLEMSON POND LEVELER BALLAST CONCRETE	A VOLUME OF STRUCTURE (CF)	B DENSITY OF WATER (LBS/CF)	C = A*B BUOYANCY (LBS)	D DENSITY OF MATERIAL (LBS/CF)	E = A*D WEIGHT OF STRUCTURE (LBS)	F = E/C SAFETY FACTOR	COMMENTS
Ballast Concrete Dimensions: 4.5'x4.5'x1.5'	30.4	62.4	1895.4	150.0	4556.3		3000 PSI concrete
Inline Agri Drain Dimensions: 26"x22"x73"	24.2	62.4	1507.9	-	270.0		Dimensions and weight from manufacturer
Total	**-**	**-**	**3403.3**	**-**	**4826.3**		
Safety Factor for Buoyancy	-	-	-	-	-	**1.42**	**SF exceeds 1.4 requirement ✓**

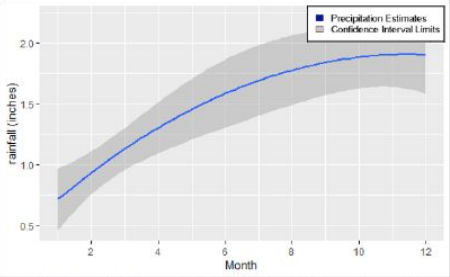
CLEMSON POND LEVELER PIPE	A VOLUME OF STRUCTURE (CF)	B DENSITY OF WATER (LBS/CF)	C = A*B BUOYANCY (LBS)	D DENSITY OF MATERIAL (LBS/CF)	E = A*D WEIGHT OF STRUCTURE (LBS)	F = E/C SAFETY FACTOR	COMMENTS
PVC Pipe Dimensions: 16" OD, 60' L	10.4	62.4	648.1	90.5	940.1		Pipe perforated with 558, 2" OD holes
Gabion Rock Dimensions: 3 piles, 21.5 cf each	38.7	62.4	2414.9	187.2	7244.6		Based on rock with 40% void and specific gravity of 3
Duckbill Anchors	-	-	-	-	2200.0		Weight based on anchor capacity, 1 on each side of pipe
Total	**-**	**-**	**3062.9**	**-**	**10384.8**		
Safety Factor for Buoyancy	-	-	-	-	-	**3.39**	**SF exceeds 1.4 requirement ✓**

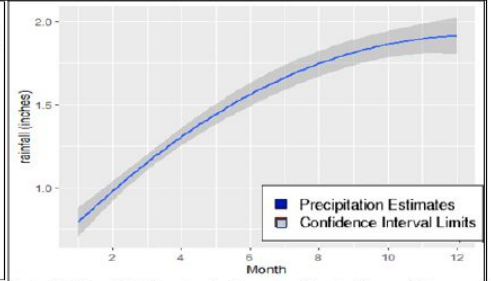
OUTLET STRUCTURE ANCHOR BOLT DESIGN	A AGRI DRAIN BUOYANCY (LBS)	B AGRI DRAIN WEIGHT (LBS)	C REQUIRED SAFETY FACTOR	D NUMBER OF BOLTS	E = [(A-B)*C]/D MIN. DESIGN LOAD PER BOLT (LBS)	F RECOMMENDED LOAD PER BOLT (LBS)	G = (F*D)/(A-B) SAFETY FACTOR	COMMENTS
	2398.5	400.0	3.0	6	999.3	2000		Recommended Bolt: 1/2" Dia., 5" L. Removable-Bolt Anchors for Concrete: https://www.mcmaster.com/removable-bolt-anchors/
Safety Factor for Bolts*							**6.00**	**SF exceed 3.0 requirement ✓**

CLEMSON POND LEVELER ANCHOR BOLT DESIGN	A AGRI DRAIN BUOYANCY (LBS)	B AGRI DRAIN WEIGHT (LBS)	C REQUIRED SAFETY FACTOR	D NUMBER OF BOLTS	E = [(A-B)*C]/D MIN. DESIGN LOAD PER BOLT (LBS)	F RECOMMENDED LOAD PER BOLT (LBS)	G = (F*D)/(A-B) SAFETY FACTOR	COMMENTS
	1507.9	270.0	3.0	4	928.4	2000		Recommended bolt for design simplicity: 1/2" Dia., 5" L (same as outlet stucture). Min. required bolt: 3/8" Dia., 4" L. Removable-Bolt Anchors for Concrete: https://www.mcmaster.com/removable-bolt-anchors/
Safety Factor for Bolts*							**6.46**	**SF exceed 3.0 requirement ✓**

DESIGN STORM

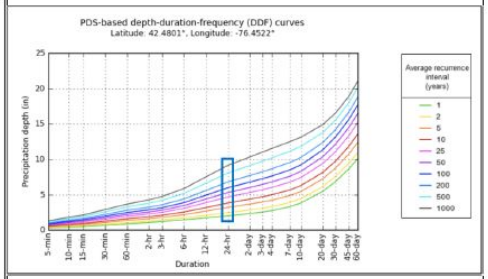
Small Storm	CN = 79, t_c = 437 min, S = 2.66 in, A = 128 ac				
RETURN PERIOD	***PRECIPITATION*** *(IN)*		***RUNOFF*** *(IN)*	***PEAK DISCHARGE*** *(CFS)*	***COMMENTS***
	Generalized Pareto Distribution (GPD) $PRCP(in) = u+(\sigma/\xi)(m(1-Pu)^{-\xi}-1) = u+(\sigma/\xi)((T\lambda)^{-\xi}-1)$ s.t.$P(x \leq u)$	Ranking Method # Events = # Years on Records/Recurrence Interval	$Q = (P-0.2S)^2/(P+0.8S)$	$q=2A*Q/(1.1t_c+1.1*1.67t_c)$	Choose precipatation obtained from Ranking Method in final calculation. Ranking Method is a more common and easy method to use. Choose month return period to adjust pipe size and flow rate.
1 mo	0.65	0.76	0.018	0.217	
2 mo	0.98	1.01	0.073	0.879	
3 mo	1.18	1.18	0.127	1.532	
4 mo	1.33	1.32	0.180	2.173	
5 mo	1.44	1.46	0.240	2.896	
6 mo	1.54	1.51	0.263	3.173	
1 yr	(1.91)	(1.92)	0.476	5.743	
REFERENCE GRAPH	GPD: Rainfall [in] vs. Month	*Ranking Method: Rainfall [in] vs. Month*			
SOURCE	Data: NRCS and NRCC center for Sapsucker Woods – Ithaca, NY Derivation and equation: Dr. Scott Steinschneider (2019)	Data: NRCS and NRCC center for Sapsucker Woods – Ithaca, NY Derivation and equation: Wetland Studies and Solutions, Inc (2019)	U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division. (1986). Urban hydrology for small watersheds. Washington, D.C.		





Large Storm	CN = 79, t_c = 437 min, S = 2.66 in, A = 128 ac				
RETURN PERIOD	***PRECIPATATION (IN)***		***RUNOFF (IN)***	***PEAK DISCHARGE (CFS)***	***COMMENTS***
	NRCC/NRCS	NOAA 14-point Precipitation Analysis	Q = (P-0.2S)^2/(P+0.8S)	q=2A*Q/(1.1t_c+1.1*1.67t_c)	Choose precipatation obtained from NOAA in final calculation.
1 yr	2.01	2.01	0.528	6.370	NOAA is a more common and conservative source to use.
2 yr	2.46	2.34	0.732	8.829	
10 yr	3.82	3.43	1.511	18.234	
100 yr	5.98	5.92	3.607	43.529	
REFERENCE GRAPH	Precipitation estimate from NRCC/NRCS	Precipitation estimate from NOAA			
SOURCE	NRCS and NRCC center for Sapsucker Woods – Ithaca, NY	NOAA Atlas 14 point precipitation frequency estimates for Sapsucker Woods in Ithaca, NY (2005)	U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division. (1986). Urban hydrology for small watersheds. Washington, D.C.		

Time (hours)	Estimate (inches)	Lower Limit (inches)	Upper Limit (inches)
1	0.75	0.68	0.81
2	0.95	0.81	1.01
3	1.08	0.95	1.16
4*	1.17	0.99	1.25
5*	1.25	1.02	1.34
6	1.34	1.06	1.43
7*	1.39	1.13	1.49
8*	1.44	1.21	1.54
9*	1.49	1.28	1.60
10*	1.54	1.36	1.65
11*	1.59	1.43	1.71
12	1.64	1.51	1.77
13*	1.67	1.54	1.79
14*	1.70	1.57	1.82
15*	1.73	1.60	1.85
16*	1.76	1.63	1.88
17*	1.79	1.67	1.91
18*	1.82	1.70	1.94
19*	1.85	1.73	1.97
20*	1.88	1.76	2.00
21*	1.91	1.79	2.03
22*	1.94	1.82	2.06
23*	1.97	1.86	2.09
24	2.01	1.89	2.12



REFERENCE

1.Extreme Precipitation in New York & New England. (n.d.). Retrieved from http://precip.eas.cornell.edu/
2. U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division. (1986). Urban hydrology for small watersheds. Washington, D.C.
3.US Department of Commerce, Noaa, Nws, & Office of Hydrologic Development. (2005, November 7). Retrieved from https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

CLEMSON PIPE FLOW CALCS

ASSUMPTION			UNITS	COMMENTS	CONVERSION FACTOR	
Nominal Pipe Diameter	=	16	in		in to ft	0.083
Inside Pipe Diameter	=	14.94	in			
Hole Diameter	=	2	in			
Holes per foot of pipe	=	16				
Normal Pool	=	1072.75	ft			
Inlet Agridrain Elevation	=	1073.13	ft			
Standpipe Diameter	=	16	in			
Standpipe Inside Diameter	=	14.94	in			
Hole Area to Pipe Area Ratio	=	10				
Pipe Length	=	120	ft			

1. HOLES TO ACHIEVE HOLE AREA TO PIPE AREA RATIO

$$N_{holes} = 10 * \frac{A_{pipe}}{A_{holes}}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Apipe	=	1.22	ft2		
Aholes	=	0.0218	ft2		
Nholes	=	558			
Length of Perforated Pipe	=	35	ft		

2. HOLE FLOW

$$Q = C_d A \sqrt{2gh}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Cd	=	0.62		Vena Contracta Coefficient	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 303
Ahole	=	0.0218	ft2		
g	=	32.2	ft/s2		
h	=	0.38	ft	Agridrain Weir to Standpipe	
Qinlet	=	0.067	cfs		

3. INLET CAPACITY

$$Q_{inlettotal} = N_{holes} * Q_{inlet}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Nholes	=	558			
Qinlet	=	0.067	cfs		
Qinlet_total	=	37.34	cfs		

4. PIPE FLOW (SUBMERGED INLET AND OUTLET)

$$Q = A\sqrt{\frac{2g\Delta h}{\frac{2gn^2L}{R^{\frac{4}{3}}} + k_e + 1}}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Apipe	=	1.22	ft2		
g	=	32.2	ft/s2		
Δh	=	0.38	ft		
n	=	0.01		Manning's n for PVC	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 281, Table 7.3
L	=	120	ft		
R	=	0.31	ft	Apipe/Perimeter	
ke	=	0.5		Squared-edge inlet	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 46, Figure 2.7
Q	=	2.65	cfs		

5. STANDPIPE (ASSUME SHARP-CRESTED WEIR)

$$Q = C_w b H^{\frac{3}{2}}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Cw	=	3.32	ft^0.5/s	Weir Coefficient (in English Units)	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 303, Equation 7.73
b	=	3.91	ft	Weir Circumference	
H	=	0.38	ft		
Qweir	=	3.04	cfs		

6. RETURN PERIOD

$$Q = C_w b H^{\frac{3}{2}}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Qlimiting	=	2.65	cfs	Limiting flow rate between Q and Qweir	
Return Period	=	4	month		

OUTLET PIPE FLOW CALCS

ASSUMPTION		VALUE	UNITS	COMMENTS	CONVERSION FACTOR	
Elevation to Emergency Spillway	=	1074.6	ft	Elevation to top of dam	ft to m	0.305
Nominal Pipe Diameter	=	2	ft		in to ft	0.083
Outside Pipe Diameter	=	28	in	Based on HDPE DR		
Inside Pipe Diameter (D)	=	2	ft	Based on HDPE DR		
Pipe Invert (Upstream)	=	1069.45	ft	3.83 ft below the top of the Inlet Agridrain based on specifications sheet by the company		
Pipe Invert (Downstream)	=	1069.05	ft			
Pipe Crown	=	1071.38	ft			
Pipe Length	=	50	ft			
Slope of Pipe (So)	=	0.008				

Step 1: CALCULATE FLOW RATE BASED ON TYPE 2 FLOW

$$Q = A\sqrt{\frac{2g\Delta h}{\frac{2gn^2L}{R^{\frac{4}{3}}} + k_e + 1}}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Area	=	0.29	m2		
g	=	9.81	m/s2		
Δh	=	0.98	m	For type 2 flow, Δh is the emergency spillway elevation - the crown of the culvert	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 273
n	=	0.012		Manning's n for HDPE	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 281, Table 7.3
L	=	15.24	m		
R	=	0.152	m	Area of Pipe / Perimeter	
ke	=	0.5		Squared-edge inlet	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 46, Figure 2.7
Q	=	0.899	m3/s	This equation uses metric units - convert to cfs in the end	

VARIABLE			UNITS	COMMENTS	SOURCE
Angle Equation	=	9.10		$\frac{(\theta - \sin\theta)^{\frac{5}{3}}}{\theta^{\frac{2}{3}}} = 20.16\frac{nQ}{D^{\frac{8}{3}}\sqrt{S_0}}$	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 268
θ	=	9.30	rad		
Angle Equation Match	=	9.09		Use a solver to determine the angle (F30) by matching F31 to F29 by changing F30	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 269
Normal Depth (y)	=	0.32	m	$y = \frac{D}{2}\left[1 - \cos\left(\frac{\theta}{2}\right)\right]$	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 269
Culvert Height	=	0.61	m	Since normal depth is less than the height of the culvert, the flow is probably Type 3	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 283

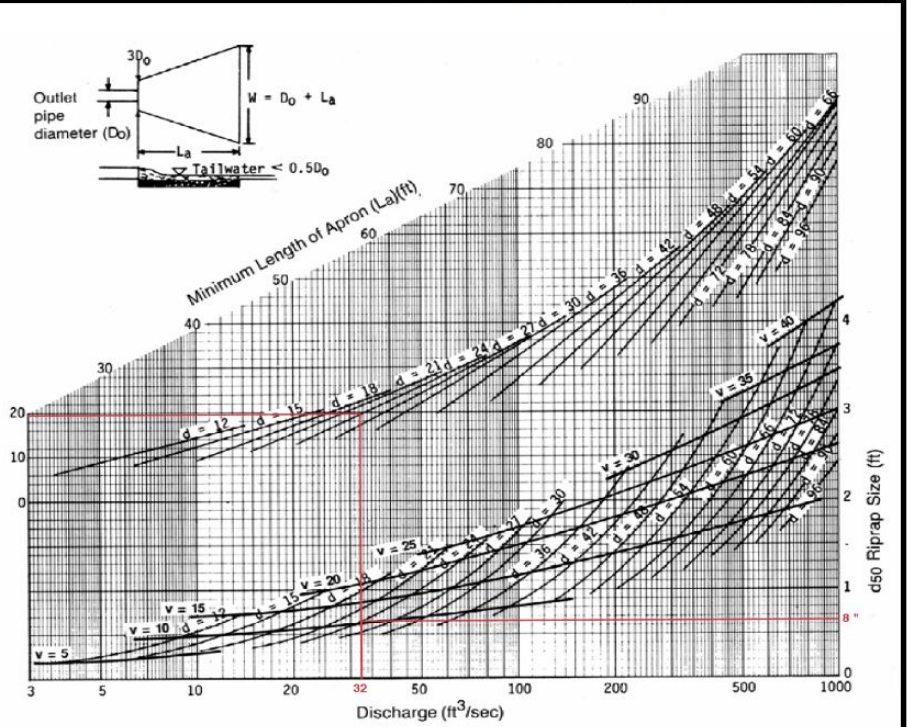
Step 2: CALCULATE FLOW RATE BASED ON TYPE 3

$$Q = C_d A \sqrt{2gh}$$

VARIABLE			UNITS	COMMENTS	SOURCE
Cd	=	0.62		Square edge entrance (vena contracta)	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 303
A	=	0.29	m2		
g	=	9.81	m/s2		
h	=	1.27	m	For type 3 flow, h is the distance from centroid of culvert at inlet to emergency spillway elevation	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 273
Q	=	0.902	m3/s	This equation uses metric units - convert to cfs in the end	
Angle Equation	=	9.13		$\frac{(\theta - \sin\theta)^{\frac{5}{3}}}{\theta^{\frac{2}{3}}} = 20.16\frac{nQ}{D^{\frac{8}{3}}\sqrt{S_0}}$	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 268
θ	=	9.31	rad		
Angle Equation Match	=	9.12		Use a solver to determine the angle (F48) by matching F49 to F47 by changing F48	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 269
Normal Depth (y)	=	0.322	m	$y = \frac{D}{2}\left[1 - \cos\left(\frac{\theta}{2}\right)\right]$	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 269
Culvert Height	=	0.61	m	Type 3 is confirmed because normal depth is less than the culvert height	Chin, D. A. (2013). Water-resources engineering. New Jersey: Pearson, pg. 283
Q	=	31.83	cfs		

Step 1: Determine stone size

VARIABLE			UNITS	COMMENTS	SOURCE
Q	=	31.83	cfs	flow through outlet	New York State Department of Environmental Conservation (2005).
d	=	24	inches	diameter of outlet	



Step 2: Calculate d50, La and W

VARIABLE			UNITS	COMMENTS	SOURCE
d50	=	8	in	from chart	New York State Department of Environmental Conservation (2005).
La	=	20	ft	from chart	
W	=	22	ft	from chart	
dmax	=	12	in	1.5x d50	
Blanket Thickness	=	18	in	1.5x dmax	

Class	Layer Thickness (in.)	Max. Velocity (ft/s)	Wave Height (ft.)		PERCENT FINER BY WEIGHT											
					D_{10}			D_{50}			D_{85}			D_{100}		
					Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)
I	18	8.5	-		5	5	4	50	10	8	100	13	10	150	15	12
II	18	10	-		17	7	6	170	15	12	340	19	15	500	22	18
III	24	12	2		46	10	8	460	21	17	920	26	21	1400	30	24
IV	36	14	3		150	15	12	1500	30	25	3000	39	32	4500	47	36
V	48	17	4.8		370	20	16	3700	42	34	7400	53	43	11,000	60	49

d_o = gravel material d□ = angular rock riprap
Wt = weight in pounds

Final Specifications

VARIABLE			UNITS	COMMENTS	SOURCE
d50	=	8	in		New York State Department of Environmental Conservation (2016). Rip rap volume based on 40% void and specific gravity of 3.
La	=	20	ft		
W	=	22	ft		
dmax	=	12	in		
Blanket Thickness	=	18	in		
Volume of rip rap	=	420	ft^3		
Weight of rip rap	=	23.6	tons		
Riprap Class	=	**Class 1**		selected from table	

Reference:
1. New York State Department of Environmental Conservation. (2016). New York State Standards and Specifications for Erosion and Sediment Control. Retrieved from https://www.dec.ny.gov/docs/water_pdf/2016nysstanec.pdf