element
WATER MANAGEMENT + DESIGN

PROFITPLAN

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Atlanta 15

THE BENEFITS OF DRAINAGE WATER MANAGEMENT

Water management plays a crucial role in long-term yield performance and soil health. The positive effects of proper water management have been studied and observed both practically and academically and research consistently reports a significant long-term yield increase across nearly all crop types, on farms with a proper water management system in place.

In addition to long-term yield increases, below are the other agronomic benefits of drainage:

Better Soil Aeration

A good drainage water management system permits deeper and more extensive root development and a more favorable environment for beneficial soil microorganisms and earth worms.

Better Soil Moisture Conditions

A properly drained field permits timely operation of tillage, planting and harvesting equipment as well as decreased the chance of destroying soil tilth due to working soil when it's too wet.

Longer Growing Season

A longer growing season can be achieved with a good drainage water management system due to the possibility of being able to plant earlier. Planting delays typically result in a one to two percent decrease in yield for each day of delay. Well drained fields allow you to begin planting 7 to 15 days earlier and allows you to complete fall tillage programs later in the year.

Increased Nitrogen Supply

An increased supply of nitrogen can be obtained from the soil where water tables are lowered by drainage systems, resulting in reduced nitrogen fertilizer application.

Soils Warm Quickly

Soils will warm more quickly in the spring when free water is removed by a drainage water management system. This reduces the likelihood of planting delays or seeds rotting before germination.

Reduced Soil Erosion

Soil erosion can be reduced on well-drained soil by increasing its capacity to hold rainfall, resulting in less runoff.

Deeper Root Development

Deeper root development enables plants to better withstand summer droughts. Roots usually penetrate to within 15 inches of the water table. High water tables in the spring due to poor drainage can cause shallow root development and a smaller soil volume from which plants can obtain moisture and nutrients.

Livestock Water Supplies

Valuable livestock water supplies can be obtained by draining hillside seeps and piping the water into stock water tanks.

Sources: Ohio State University and the U.S.D.A

PROFITPLAN: TERMS DEFINED

Find key subsurface water management terms used throughout the assessment defined and explained further below:

Drainage Coefficient: The design capacity of a drainage system expressed as a depth of water removed in 24 hours (inches/day). For example, a ½ drainage coefficient means the system can remove ½ of an inch of water in a day. A drainage coefficient should be chosen that will economically remove excess water from the top part of the root zone within 24 to 48 hours.

Crop Productivity Index (CPI): A 1-100 rating comes from the Natural Resources Conservation Service to provide a relative ranking of soils based on their potential for intensive crop production. This productivity index can be used to rate the potential yield of one soil against that of another over a period of time.

Weather Susceptibility Index (WSI): Our 1-100, drainage specific, index that rates the amount of risk your field assumes based on the crop rotation, crop water tolerance levels, crop productivity, and field specific historical weather patterns.

Element Index (EI): Our 1-100 index that quantifies each field's potential drainage benefit based off its soil properties, yield potential, and other agronomic factors.

Yield Response: The increased productivity of your land due to tile drainage. Yield response will vary based the selected drainage coefficient in combination with the weather events on your farm and crop value.

Spacing: The distance between lateral drain tiles. Drain spacing is determined based on the following factors: soil type, soil permeability and stratification, crop rotation, the desired drainage coefficient, and the degree of surface drainage.

K SAT: Hydraulic conductivity (K) or saturated hydraulic conductivity is a measurement of the soil's ability to transmit water, or how easily the water is permitted to move through the pores of saturated soil.

Yield Impacting Event: A weather event that causes a crop to become saturated long enough to cause harm and forfeit yield potential. While agriculture in the United States continues to achieve enhanced productivity, it is also experiencing greater variability in crop yields and associated farm income in recent decades. This increased yield variability is, in part, directly related to increases in extreme weather events during critical growth phases of crop development.

% Yield Increase: Yield gains accumulated from proper drainage. Yield can be increased by proper drainage enabling timely planting in a wet spring, or by factors like less yield-loss potential during wet periods in the growing season, fewer plant diseases and less soil compaction.

ROI: A guiding principle in any business, Return on Investment is the major reason for installing drain tile. Improvements in productivity of the farmland mean higher yields, and that translates into more returns. A drainage ROI decision is based on whether the higher crop returns will justify the investment in drain tile. All factors should be considered while calculating ROI. For example, a field that is able to dry out quicker, may afford the ability to plant and harvest earlier in the spring and fall; longer plant and harvest window allows efficiencies to a farmer that can translate to real time and money – particularly for farmers who have large acreages to cover.

Drainage Classes: Natural drainage class refers to the frequency and duration of wet periods under conditions similar to those under which the soil developed. Alteration of the water regime by man, either through drainage or irrigation, is not a consideration unless the alterations have significantly changed the morphology of the soil. The classes follow:

i. Excessively Drained – Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have very high hydraulic conductivity or are very shallow.

ii. Somewhat Excessively Drained – Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have high saturated hydraulic conductivity or are very shallow.

iii. Well Drained – Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness. Sometimes well drained soils can be subject to a high-water table in the Spring and Early Summer and may still require tile drainage.

iv. Moderately Well Drained – Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 m, periodically receive high rainfall, or both.

v. Somewhat Poorly Drained – Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: low or very low saturated hydraulic conductivity, a high-water table, additional water from seepage, or nearly continuous rainfall.

vi. Poorly Drained – Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of low or very low saturated hydraulic conductivity of nearly continuous rainfall, or of a combination of these.

vii. Very Poorly Drained – Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater.

Undrained Scenario: A scenario in which soil drains naturally without the aid of installed drainage practices.

PROFITPLAN: REPORT OVERVIEW

Understanding the purpose and value of your full subsurface Element Water Management assessment.

Water management plays a crucial role in long-term yield performance and the positive effects of proper water management have been studied and observed for decades. Drainage has shown to significantly improve the consistency of yields from year-to-year, proving that investing in subsurface water management systems pays dividends in the long-term. Just like other investments in an operation, subsurface water management is a key factor that will address the drainage issues that are damaging to yield.

The purpose of this document is to aid you in making your investment decisions in subsurface water management. Numerous data sources were analyzed to prepare the following customized Element assessment for each field included with the single goal of maximizing yields and managing risk, in relation to water.

PROFITPLAN: METHODOLOGY

Our H_2Onomy approach and analysis, applied to your fields.

For each field included in this assessment, we've analyzed soil and agronomic risk factors from a subsurface water management perspective to predict yields and return on investment (ROI). The payback analysis and total annual return calculations are based on the specific data collected from your farm, combined with nearly 50-years of subsurface water management experience and expertise. Our calculations and indexes are used to rank your fields in order of the highest return for your subsurface water management investment.

PROFITPLAN: SUMMARY TABLE

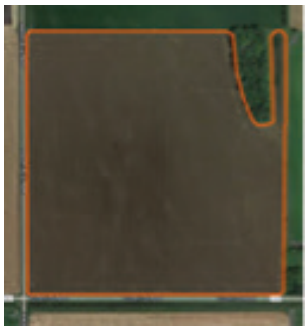
Your full Element assessment snapshot.

The table below outlines key information on all fields/farms selected for this assessment. Fields have been ranked by their projected Return on Investment (ROI), providing you with a recommendation of which fields to tile first. Element ROI values are derived from proprietary calculations using factors such as: preliminary project costs, soil properties, weather history, crop value and rotation, and each crop's projected yield response to tile drainage.

ProfitPlan Summary							
Field Rank	Field Name	Location	Total Area (Acres)	Investment Range	Annual ROI	Image	Recommended Drainage Coefficient
#1	Atlanta 15	Minnesota, Eagleton County, T193N R19W 15	146.62	$124,000-$168,000	22.8%		1/2"
#2	Macon 22SE	Minnesota, Eagleton County, T192N R18W 22	156.8	$133,000-$165,000	20.9%		3/8"
#3	Perry 11NW	Minnesota, Eagleton County, T205N R16W 11	156.27	$94,000-$122,000	17.5%		1/2"
#4	Lincoln 08SW	Minnesota, Eagleton County, T201N R17W 08	156.83	$91,000-$125,000	16.4%		3/8"
#5	Jackson 17	Minnesota, Eagleton County, T192N R18W 17	147.6	$131,000-$173,000	15.3%		1/2"

FIELD-LEVEL SUMMARY

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15



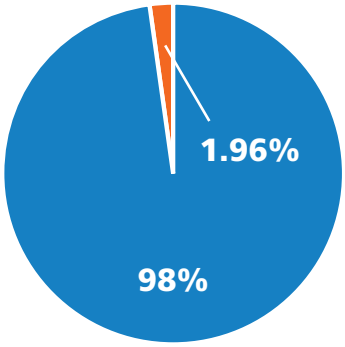
Current Crop Rotation			
Crops	Rotation %	Base Yield*	Unit
Soybean	20%	41.0	Bu/Ac
Wheat	40%	58.0	Bu/Ac
Sugar Beet	20%	27.0	Ton/Ac
Edible Bean	20%	2140.0	Lbs/Ac

PROFITPLAN – SOIL EVALUATION

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

Drainage Class Breakdown

Drainage Class Map



Total Acres: 146.6

- Poorly Drained
- Somewhat Poorly Drained

Soil Map

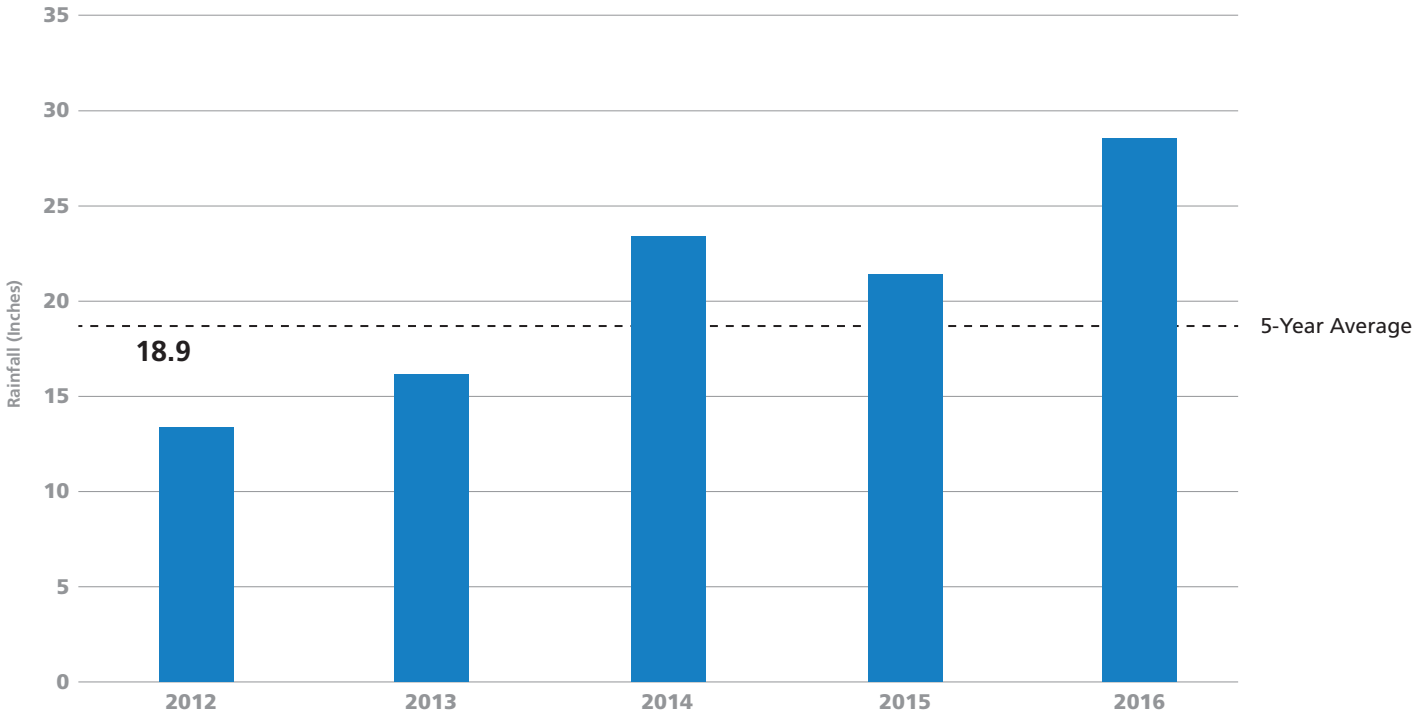
Code	Soil Description	Area	Drainage Class	Sand/Silt/Clay % Relative	Ksat_r	Prod Index	Element Index
I123A	Bearden-Colvin silty clay loams, 0-2% slopes	131.47	Somewhat poorly drained	7/65/28	0.92	70	89
I467A	Bearden silt loam, 0-2% slopes	12.37	Somewhat poorly drained	7/67/26	9.17	95	91
I666A	Colvin-Perella silty clay loams, 0-1% slopes	2.88	Poorly drained	7/65/28	0.92	70	89
Total		**146.72**					
Weighted Average						**72**	**89**

*The Element Index is a value that shows the potential your field has, to benefit a drainage system based off of your soils.

HISTORICAL RAINFALL INFORMATION

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

5-Year Annual Rainfall*



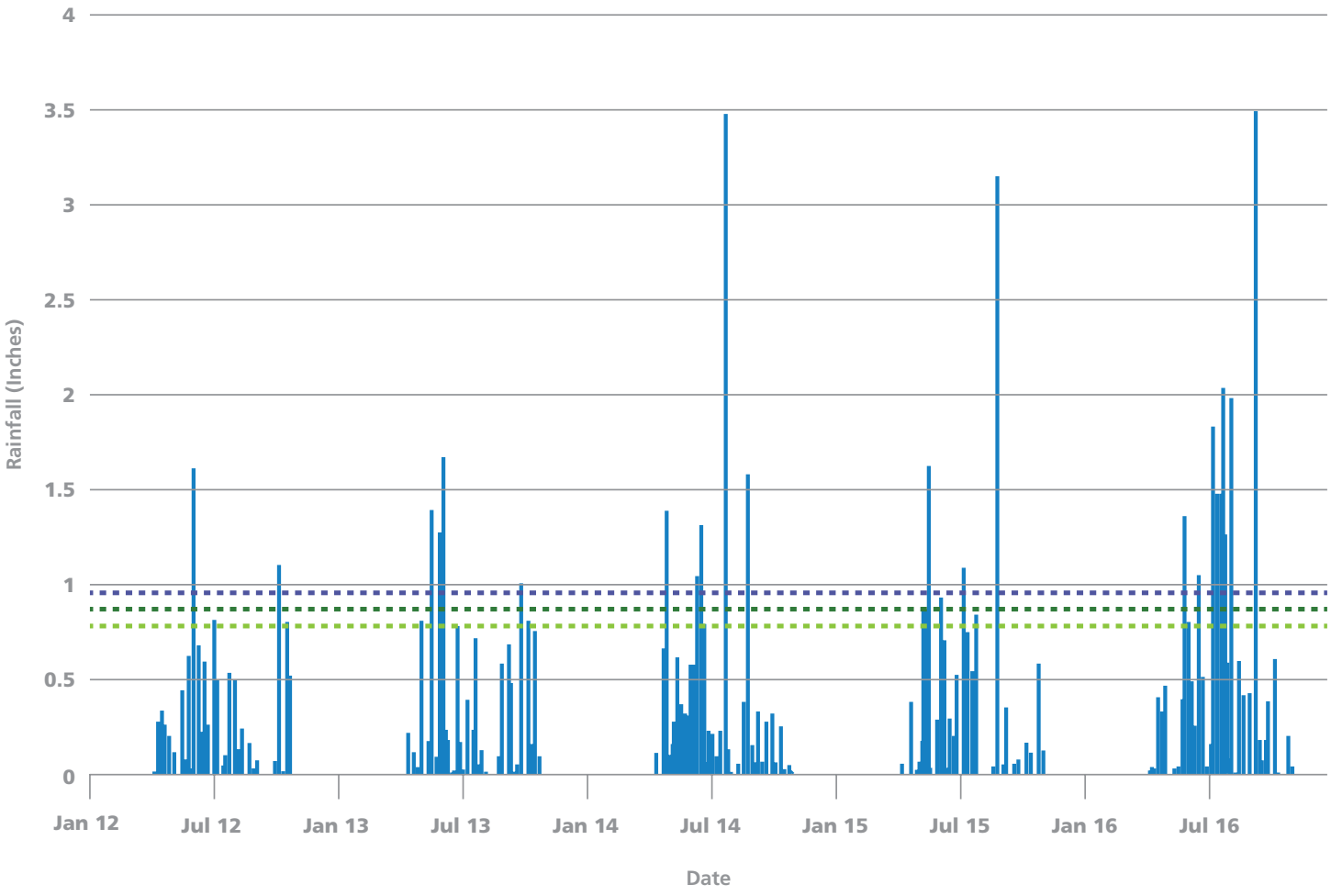
Historical rainfall data provided by DTN

*Annual cumulative rainfall over the last 5 years. The horizontal dashed line represents the 5-year average annual cumulative rainfall.

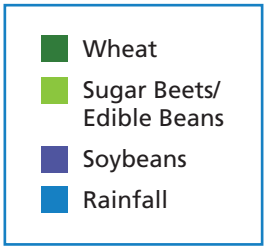
PROFITPLAN—W. LUMBERGH

Farm/Field name: Atlanta 15
Acres: 146.6 AC in Eagleton County, MN
Location: T193N R19W Sec: 15

Weather Events



Daily rainfall events data provided by DTN

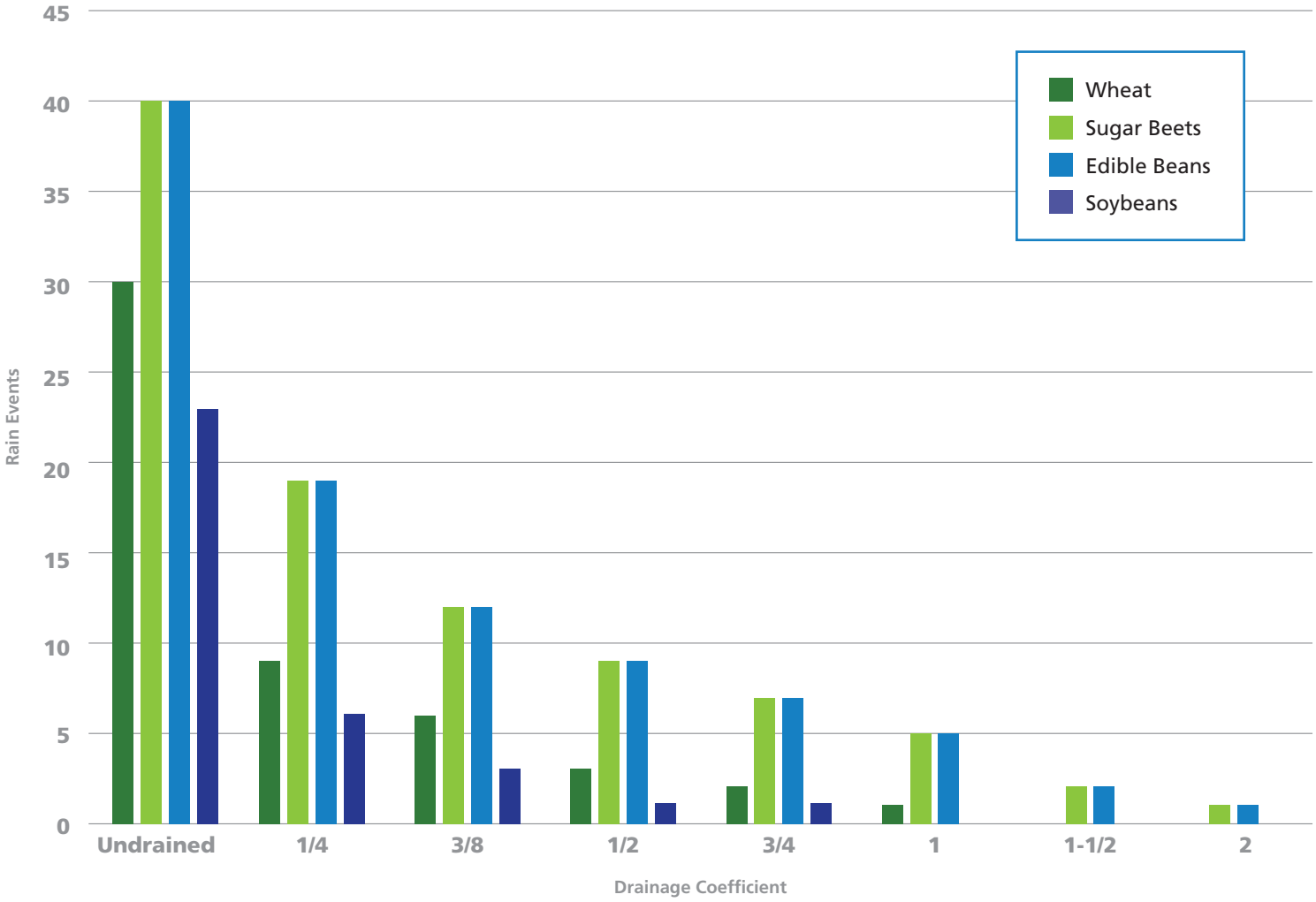


*Daily rainfall events over the last 5 years in your area. The horizontal dashed lines represent the rainfall amount that a crop can handle without drainage before the crop is damaged or drown out – resulting in impacted yields or complete losses.

YIELD IMPACTING EVENTS

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

The number of significant, negative yield-impacting rainfall events over the five-years on this field and the difference in impact if the field were to remain undrained as well as if tiled with different drainage coefficients.



DRAINAGE COEFFICIENT—RAIN EVENT AND REMOVAL DURATION

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

Days to Remove Water, by Drainage Coefficient

TABLE A

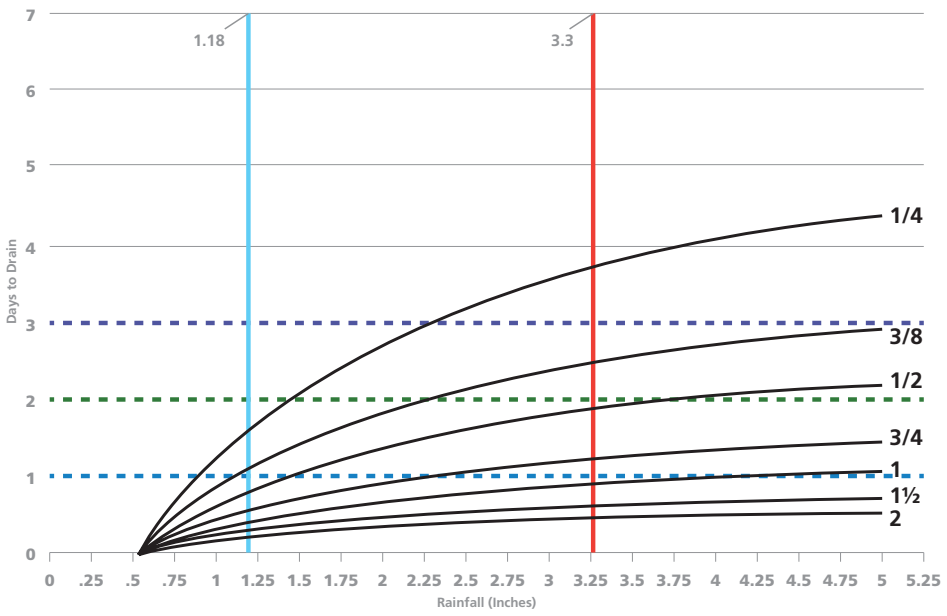
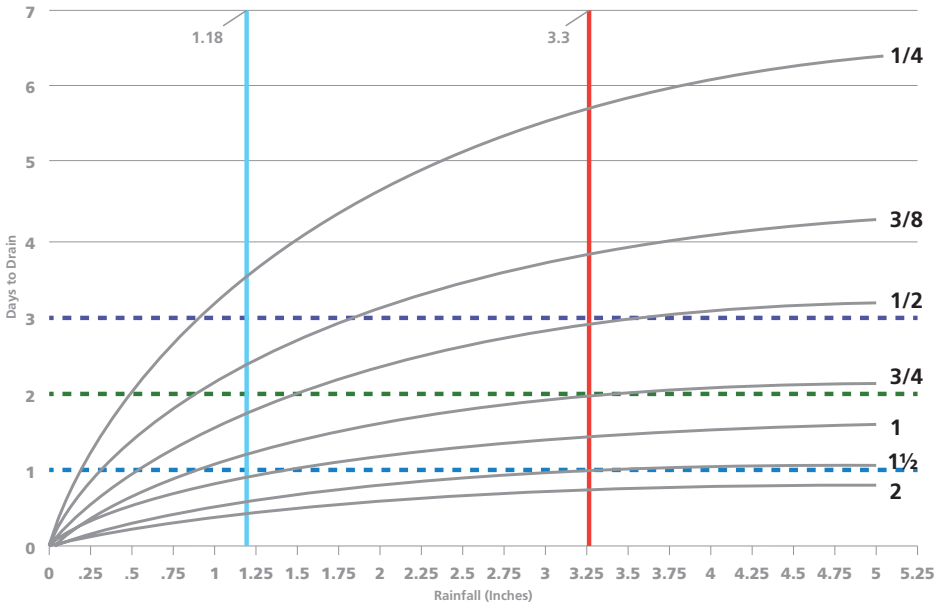


TABLE B



These graphs show how long it takes for each drainage coefficient to drain your field after the various rain events.

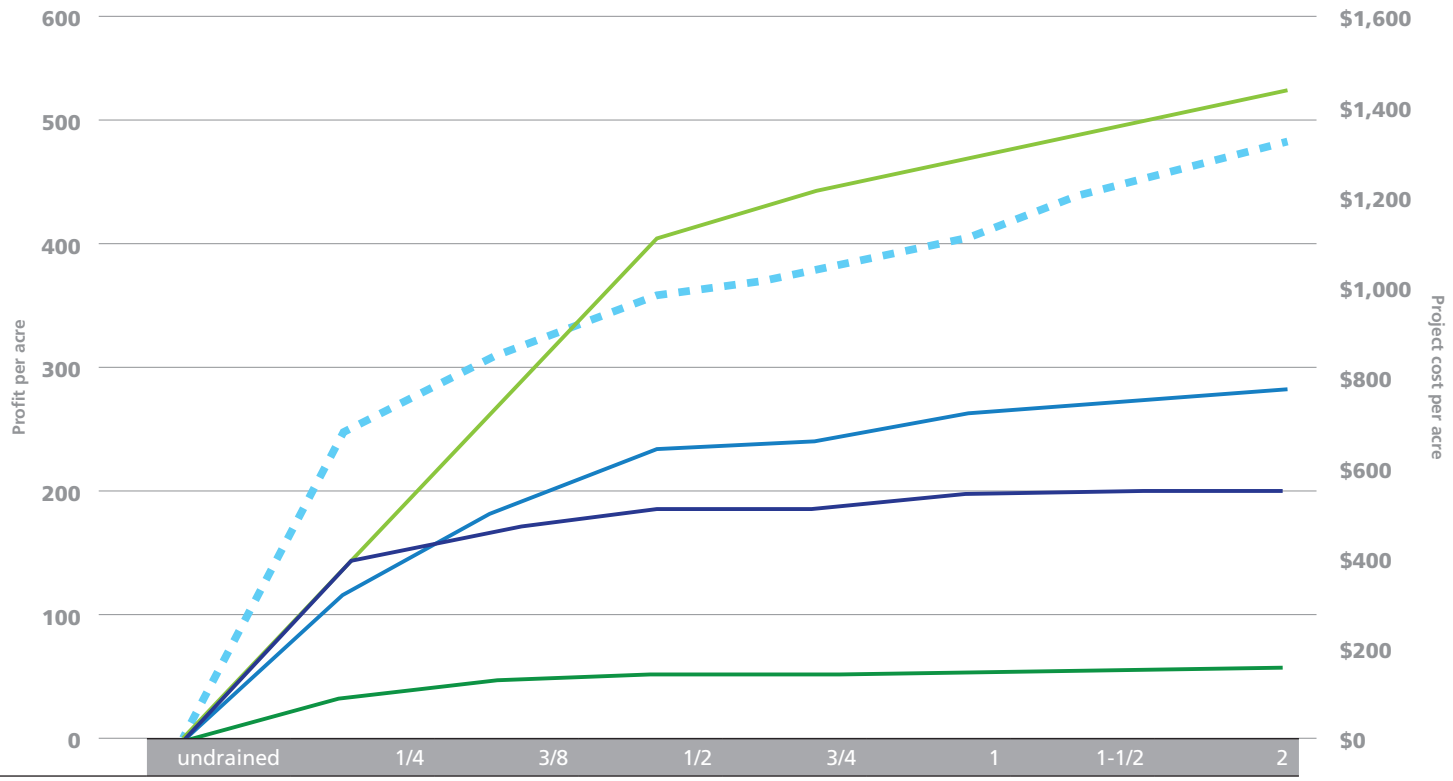
- The black series of lines (A) represents a rain event under unsaturated conditions (which means the soil has capacity to absorb some of the rainfall).
- The light grey series (B) of lines represents a scenario with back to back rain events and a saturated soil condition.
- The horizontal dashed lines represent the number of days a crop can withstand waterlogging before yield is impacted.
- The vertical lines show the average yield impacting rain event and the maximum rain event for the 5-year period.

- Wheat
- Soybeans
- Edible Beans/Sugar Beets
- 5 yr average rainfall of yield impacting events
- 5 Year Max Rainfall Event

PROFIT ANALYSIS

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

Profit Analysis Chart



	undrained	1/4	3/8	1/2	3/4	1	1-1/2	2
Edible Bean	$0.00	$120.66	$192.58	$243.47	$249.78	$270.99	$281.67	$291.51
Soybean	$0.00	$145.82	$175.02	$191.36	$194.73	$204.80	$209.18	$209.18
Sugar Beet	$0.00	$148.42	$285.87	$419.41	$462.45	$490.10	$517.74	$543.82
Wheat	$0.00	$87.95	$126.04	$139.67	$140.24	$148.84	$151.83	$154.38
Project Cost	**$0.00**	**$685.91**	**$858.45**	**$994.38**	**$1,049.87**	**$1,132.43**	**$1,247.80**	**$1,339.45**

The chart above reflects the additional profit for each crop as it pertains to the various drainage coefficients. The blue dashed line represents the cost per acre for the subsurface water management system for each drainage coefficient.

DRAINAGE COEFFICIENT INVESTMENT ANALYSIS

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

1/2

Your recommended drainage coefficient for Atlanta 15

Return on Investment (ROI) Table

Return on Investment (ROI)							
Drainage Coefficient	1/4	3/8	1/2	3/4	1	1-1/2	2
Soybeans	21.3%	20.4%	19.2%	18.5%	18.1%	16.8%	15.6%
Wheat	12.8%	14.7%	14.0%	13.4%	13.1%	12.2%	11.5%
Sugar Beet	21.6%	33.3%	42.2%	44.0%	43.3%	41.5%	40.6%
Edible Beans	17.6%	22.4%	24.5%	23.8%	23.9%	22.6%	21.8%
ROI	**17.2%**	**21.1%**	**22.8%**	**22.6%**	**22.3%**	**21.0%**	**20.2%**

The table above shows a return on investment for each drainage coefficient. Numbers are **weighted** based the crop rotation specified. Your best returns are highlighted in Dark Blue.

Investment Variable Table

Investment Variable								
Drainage Coefficient			1/4	3/8	1/2	3/4	1	1-1/2	2
Investment		$/AC	685.91	858.45	994.38	1,049.87	1,132.43	1,247.80	1,339.45
Variance from Recommendation		$/AC	(308.47)	(135.92)		55.49	138.05	253.43	345.07
Amortized Variance		$/AC	(41.05)	(18.09)		7.38	18.37	33.72	45.92
Variance of Yield	Soybeans	BU/AC	(4.44)	(1.96)		0.8	2.0	3.6	5.0
	Wheat	BU/AC	(9.33)	(4.11)		1.7	4.2	7.7	10.4
	Sugar Beet	TON/AC	(0.85)	(0.37)		0.2	0.4	0.7	1.0
	Edible Beans	LBS/AC	(152.02)	(66.99)		27.3	68.0	124.9	170.1

The table above indicates the investment variance between the different levels of drainage coefficient and the amount of additional yield that is required to pay for the additional investment.

Variance of Yield

*Amortized variance assumes a 10-year loan duration at 7% interest

FINANCIAL SUMMARY

Atlanta 15
146.62 Ac in Eagleton County, MN
T193N R19W Sec 15

Total Acres:
146.6

ELEMENT
89
INDEX (EI)*

1/2
Your recommended drainage coefficient for Atlanta 15

Subsurface Water Management Investment Level

Investment – Total
$124,000 - $168,000

Investment – Per Acre
$850/AC - $1,100/AC

Yield Response to ½ Drainage Coefficient:

Current Crop Rotation					
Crop	Crop Rotation	Base Yield*	Unit	Yield Resp %	Projected Yield Unit
Soybean	20%	41.0	BU	51.5%	62
Wheat	40%	58.0	BU	54.5%	90
Sugar Beet	20%	27.0	TON	34.4%	36
Edible Bean	20%	2140.0	LBS	49.5%	3200

PROFITPLAN—W. LUMBERGH

Farm/Field name: Atlanta 15
Acres: 146.6 AC in Eagleton County, MN
Location: T193N R19W Sec: 15

Yield Response to ½ Drainage Coefficient

Current Crop Rotation									
Crop	Rotation	Market Price ($/unit)	Unit	Historical Ave Yield (Unit/AC)	Projected Yield Increase (Unit/AC)	Projected Yield (Unit/AC)	Current Revenue ($/AC)	Projected Revenue ($/AC)	Profit ($/AC)
Soybean	20%	9.25	BU	41	21	62	379.25	574.43	195.18
Wheat	40%	4.40	BU	58	32	90	255.20	394.24	139.04
Sugar Beet	20%	48.30	TON	27	9	36	1,304.10	1,753.29	449.19
Edible Bean	20%	0.23	LBS	2140	1060	3200	492.20	735.98	243.78
	100%							**770.43**	**233.24**

Investment Per Acre:
$994.38

Return on Investment:
22.8%

Profit per Acre:
$233.24

10-year Payback Analysis

			10 year Payback analysis									
			Years									
D/C	Initial Investment	Annual Profit	1	2	3	4	5	6	7	8	9	10
1/4	$100,636.31	17,336.74	$(83,299.57)	$ (65,962.83)	$(48,626.10)	$(31,289.36)	$(13,952.63)	$3,384.11	$20,720.84	$38,057.58	$55,394.31	$72,731.05
3/8	$125,952.25	$26,572.42	$(99,379.83)	$ (72,807.41)	$(46,234.99)	$(19,662.56)	$6,909.86	$33,482.28	$60,054.70	$86,627.13	$113,199.55	$139,771.97
1/2	$145,895.15	$33,263.65	$(112,631.50)	$ (79,367.86)	$(46,104.21)	$(12,840.57)	$20,423.08	$53,686.73	$86,950.37	$120,214.02	$153,477.66	$186,741.31
3/4	$154,036.67	$34,844.13	$(119,192.54)	$ (84,348.40)	$(49,504.27)	$(14,660.14)	$20,184.00	$55,028.13	$89,872.26	$124,716.40	$159,560.53	$194,404.66
1	$166,150.35	$37,078.12	$(129,072.22)	$(91,994.10)	$(54,915.98)	$(17,837.86)	$19,240.27	$56,318.39	$93,396.51	$130,474.63	$167,552.76	$204,630.88
1 1/2	$183,077.75	$38,506.47	$(144,571.28)	$(106,064.80)	$(67,558.33)	$(29,051.86)	$9,454.61	$47,961.08	$86,467.55	$124,974.02	$163,480.49	$201,986.96
2	$196,524.04	$39,710.46	$(156,813.59)	$(117,103.13)	$(77,392.68)	$(37,682.22)	$2,028.23	$41,738.69	$81,449.14	$121,159.60	$160,870.06	$200,580.51