Investing below the surface: Financial viability and unrecovered investment frameworks for tenant-installed subsurface drainage on rented farmland

by

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ABSTRACT

Subsurface drainage installation represents one of the most significant capital investments available to tenant operators on rented farmland, yet no established framework exists to quantify and protect unrecovered investment in the event a lease relationship ends before the investment has fully paid out. This thesis evaluates the economic viability of subsurface drainage investment from the tenant's perspective and develops a model-based compensation framework to address early lease termination risk. Using net present value and payback analysis on a representative 155-acre Upper Midwest field with a corn-soybean rotation, the study evaluates 20 sensitivity scenarios across installation cost, yield improvement, field productivity, crop prices, and discount rate variables. All analysis is conducted over the 15-year asset life established by the Internal Revenue Service Modified Accelerated Cost Recovery System (MACRS).

Under base case assumptions with an investment cost of $1,050 per acre, 15 percent corn and 6 percent soybean yield improvement, $4.65 per bushel corn and $11.50 per bushel soybean prices, a 6 percent discount rate, and a 22 percent federal income tax rate applied to a Section 179 first-year deduction, the investment achieves a marginally positive net present value of $1,514 at Year 15. The undiscounted cash-flow recovered occurs at Year 10, but discounted economic break-even does not occur until Year 15, creating a five-year zone of unrecovered capital that is not visible from cash-flow analysis alone. Across all scenarios, 13 of 20 produce a positive NPV at Year 15 with the two most sensitive variables being installation cost and yield response producing the widest outcome ranges at $110,623 and $107,882 respectively. Building on the results, the thesis develops an applied

lease exhibit framework that translates model-derived unrecovered investment values into a year-specific, pre-agreed compensation schedule for use in a tenant-landlord lease negotiations including a template in Appendix A that tenant operators can populate with their own investment values. The framework developed represents an original contribution to the applied agribusiness literature on tenant-financed drainage investment on rented farmland.

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CHAPTER I: INTRODUCTION

Subsurface drainage, also known as “drain tile” or “tile” has been a land practice used by farmers and landowners since as early as 1835 when introduced by J. Johnston, known as the “Father of American Tile Drainage”. Over the decades, drain tile has been produced with different components including cement and sand, clay, bituminous-fiber (Robinson & Luthin, 1968), smooth wall plastic pipes to corrugated PVC pipe that was introduced around the late 1960s (Valipour, et al., 2020) and are commonly used today. This type of tile including the advancement of GPS, pull-type and self-propelled tile plows, made tile installation quicker and more reliably at a whole-field scale (Wright & Sands, 2001). Over the years as tile has gained in popularity, researchers have tried to provide data to back an expected yield increase or decrease that may occur through the installation of drain tile. A long-standing research location from 1962 through 1980 at the University of Ohio is one of the few studies but suffers from the scalability of tile in fields. Some of the latest research finds increases of 12 to 17 percent increase in yield for corn (Rui, Goller, & Kladivko, 2024) and smaller increases of 4 to 8 percent for soybeans (Mourtzinis, et al., 2021). Yield increases provide the return for the investment on the cost of drain tile installation, which once paid back, provides the farmer with greater income. The other major crop grown in the United States includes wheat, however very limited research, with multiple years of data collected, has been done to provide any valuable confidence to use; along with that, wheat is grown in areas that don’t have as much rainfall or have heavier soils.

Every five years, the USDA conducts a census of agriculture and in 2012 began recording the number of acres that had tile installed. It is estimated as of the 2022 census that there is over 53.1 million acres of cropland with subsurface drain tile installed. Three of the top ten cropland area states are also in the top three with the highest percentage of farmland with tile installed representing over 56% of the total acres reported. The top three states are Iowa, Illinois, and Minnesota (Table 1.1).

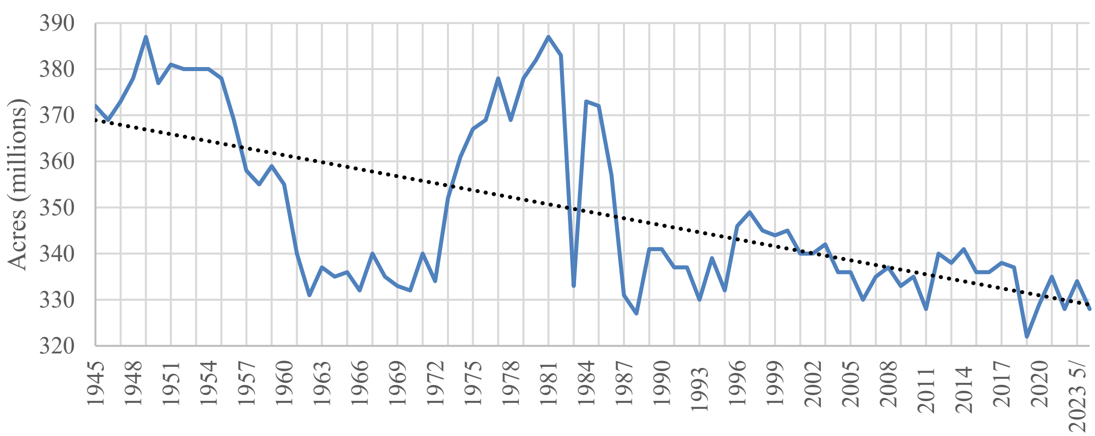
Table 1.1 Top 10 states with subsurface tile installed

Rank	State	Acres (in 1,000)	% of Total
1	Iowa	13,017	24.48%
2	Illinois	8,836	16.61%
3	Minnesota	8,247	15.51%
4	Indiana	5,841	10.98%
5	Ohio	5,092	9.57%
6	Michigan	2,921	5.49%
7	Missouri	1,053	1.98%
8	Wisconsin	1,012	1.90%
9	New York	863	1.62%
10	California	798	1.50%

Source: USDA, 2024

Total cropland acres available for cropland, since 1945 has been on a steady decline (Figure 1.1).

Figure 1.1 Total cropland acres per year in the United States 1945-2022

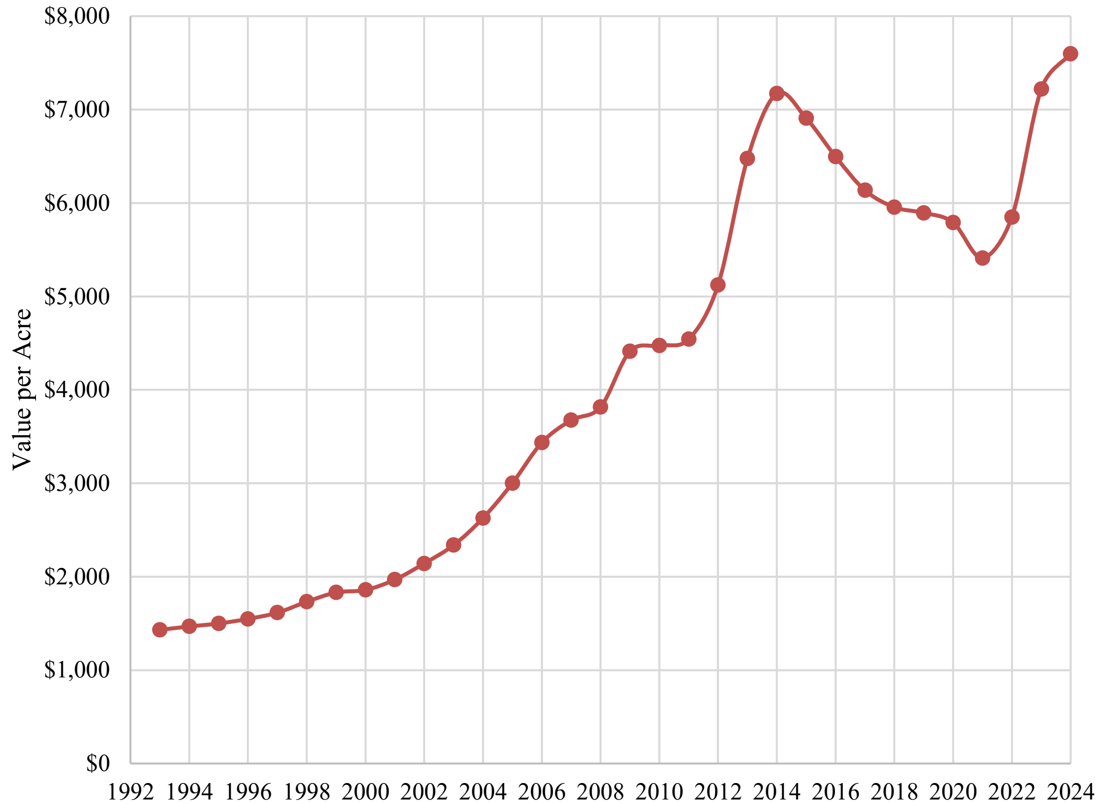


Source: USDA Economic Research Service (ERS), 2026

Data from 1993 to 2024 shows the average value of cropland suitable for raising crops in Minnesota has risen 531% from 1993 at $1,431 per acre to $7,597 per acre in

2024. Values have been adjusted for inflation to 2024 dollars (Figure 1.2) (University of Minnesota, 2026).

Figure 1.2 Farmland values in Minnesota from 1993-2024 (adjusted for inflation)



Source: University of Minnesota, 2026

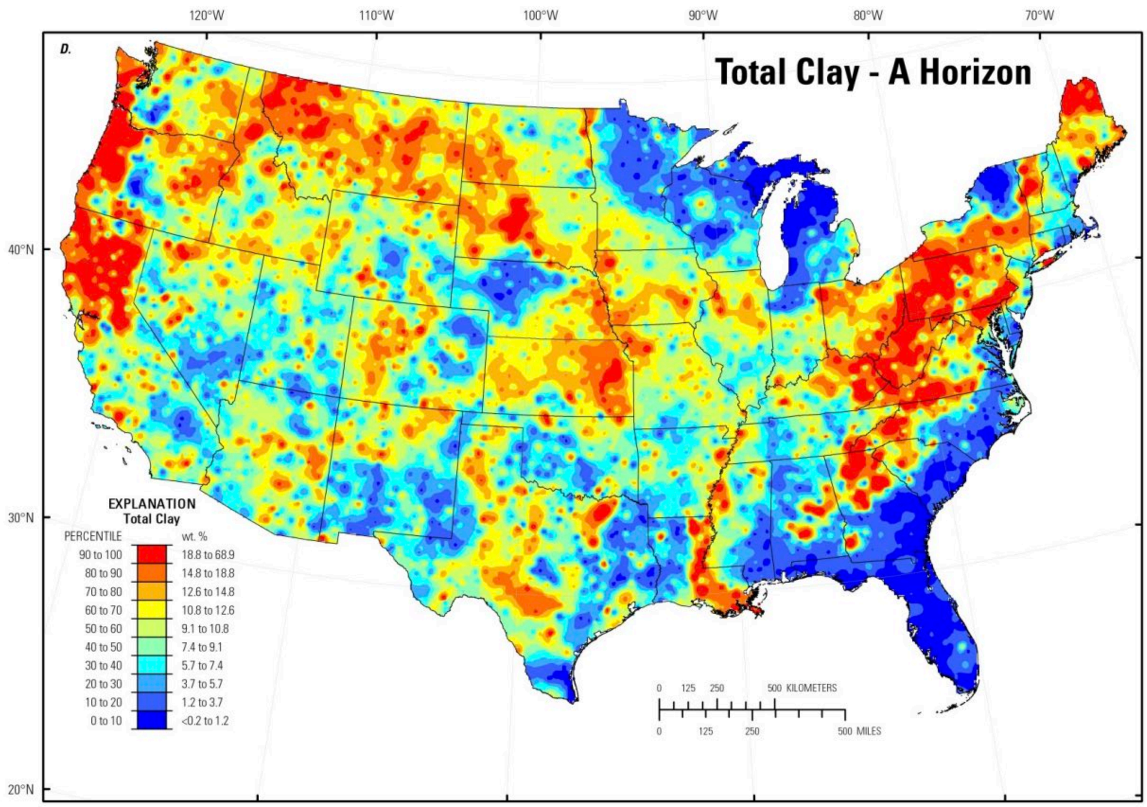
Rising land values have reduced ownership opportunities and increased reliance on rented land for many farm operators. For tenants already committed to farming ground they don't own, shifting capital toward land improvements, rather than land acquisition, can provide faster and more accessible returns. Subsurface drainage is one of the few improvements a tenant can make that directly increases the productivity of rented acres, yet the financial risk of investing in land you don't own is a problem the existing literature has not fully addressed.

This thesis has the following objectives:

1) Evaluate the net present value (NPV) of the investment of tile on leased land
2) A break-even analysis on investing in tile on rented land
3) A buy-back model to be incorporated into leases when the tenant-landlord relationship is terminated prior to the tenant receiving the full payback from the tile investment.
4) Conduct various investment returns with different sensitivity points including drain-tile cost, grain prices, interest rates and yield improvements.

The preceding discussion establishes the economic and functional context of subsurface drainage investments on rented farmland, covering the scale of adoption along with the financial constraints faced by farm operators in increasingly capital-intensive land markets. While tile is widely recognized as a productivity-enhancing land management tool, the financial outcomes of such investments depend on a combination of agronomic conditions, installation costs, commodity prices, financing assumptions and lease arrangements. To inform the theory and methods used in this study, Chapter II reviews the existing literature related to subsurface drainage, focusing on documented yield responses on corn and soybean production, drainage system costs, and prior economic analyses. Particular attention is given to articles studying the Upper Midwest which includes states like Minnesota, eastern North Dakota, eastern South Dakota, Iowa, and Illinois given the higher levels of clay located in their soil profiles comparative to other states (Smith, Cannon, Woodruff, Solano, & Ellefsen, 2014) (Figure 1.3).

Figure 1.3 Total estimated clay in the A horizon in the United States



Source: Smith, Cannon, Woodruff, Solano, & Ellefsen, 2014

While subsurface drainage has been studied from an agronomic perspective, relatively few studies evaluate the economic implications of drainage investments under short- or medium-term land rent agreements. For tenant operators, the benefits of subsurface drainage are uncertain due to year-to-year yield variability, dependence on precipitation pattern, and the potential for lease termination prior to full recovery of investment costs. These factors introduce additional financial risk that is not fully captured by yield response alone and underscore the importance of evaluating drainage investments using financial metrics that account for time, uncertainty, and lease duration.

CHAPTER II: LITERATURE REVIEW

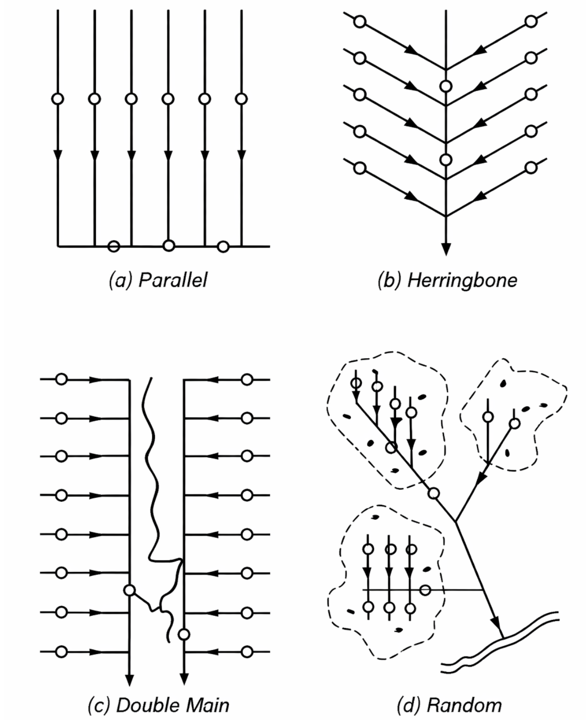
2.1 Overview of Subsurface Drainage

The amount of replicated research quantifying the yield impacts of subsurface drainage installation remains limited, particularly for long-term, whole-field systems evaluated under commercial production conditions. Available studies consistently indicate that observed yield responses are highly variable and strongly dependent on annual precipitation patterns. Subsurface drainage has long been used to improve poorly drained soils (Valipour, et al., 2020) and is generally regarded as an effective land improvement for increasing areas that have limited or no production at all to being actually productive.

For economic evaluations, particularly from the perspective of a tenant operator, full-pattern drainage data is more relevant because it reflects a whole-field investment decision rather than targeted installation of tile in isolated problem areas. Targeted installations may generate rapid payback under extreme drainage limitations; however, such outcomes are not representative of the financial risk and return profile associated with whole-field drainage systems (Schwab, Fausey, & Weaver, 1975).

The cost of whole pattern subsurface drainage systems is influenced by a variety of design and site-specific factors, including tile spacing, layout configuration, need for artificial outlets, utilities, and the system's ability to move water through the soil profile. These factors include total acres drained, soil composition, long-term average precipitation, rainfall intensity during rainfall events, and field topography (Wright and Sands, 2001). Figure 2.1 provides a simplified illustration of various styles of subsurface drainage designs that are used when planning and installing drain tile. In a field, any number and combinations of these patterns can be used in a single project to best aid in the movement of rainfall through the soil profile quickly and efficiently.

Figure 2.1 Various types of subsurface drain tile designs used on cropland



Source: Leibold, Johanns, & Hofstrand, 2023

2.2 Yield Impacts of Tile

Targeted areas of improvement may achieve faster returns on investment when yields are consistently poor and respond dramatically to subsurface drainage installation. For example, multi-year research conducted in Ohio reported soybean yields as low as 3.8 bushels per acre in non-drained plots, which increased to 49.8 bushels per acre following subsurface drainage installation (Schwab, Fausey, & Weaver, 1975). While this represents an extreme, localized response rather than a whole-field average, it illustrates the potential magnitude for crop yield recovery in severely waterlogged areas of cropland.

Research has consistently shown the installation of subsurface drainage enables for earlier field operations and reduces delays caused by excess soil moisture, even in studies not explicitly focused on yield outcomes (Leibold, Johanns, & Hofstrand, 2023; Mourtzinis, et al., 2021; Wright & Sands, 2001). Earlier corn planting has been associated with yield advantages ranging from approximately 5 to more than 30 bushels per acre compared to delayed planting. The magnitude of this yield response varies by region and by the relative maturity of corn hybrids. Observed data consistently indicates that planting in the latter half of May is associated with significant reductions in corn yield (Tsimba, Edmeades, Millner, & Kemp, 2013). The benefits indirectly increase yield potential but do not guarantee yield increases in any given year.

Long-term data from Purdue University, spanning more than 37 years (Rui, Goller, & Kladivko, 2024) and Ohio research sites with over 30 years of observations (Schwab, Fausey, & Weaver, 1975) (Schwab, Fausey, Desmond, & Holman, 1985) report corn yield responses ranging from the minimal increases of approximately 5% to yield gains exceeding 50% relative to non-drained areas. On average, these studies report corn yield increases in the range of 12-17% following the installation of subsurface drainage systems.

Soybean yield research responses to subsurface drainage have generally been smaller and more variable than those observed for corn (Mourtzinis, et al., 2021; Rui, Goller, & Kladivko, 2024). Long-term data for soybeans remains limited; however, a study combining research trials with farmer-reported survey data estimated average soybean yield increases ranging from 4% reported by farmers surveyed to 8% yield increase in replicated smaller trials following the installation of subsurface drainage (Mourtzinis, et al., 2021).

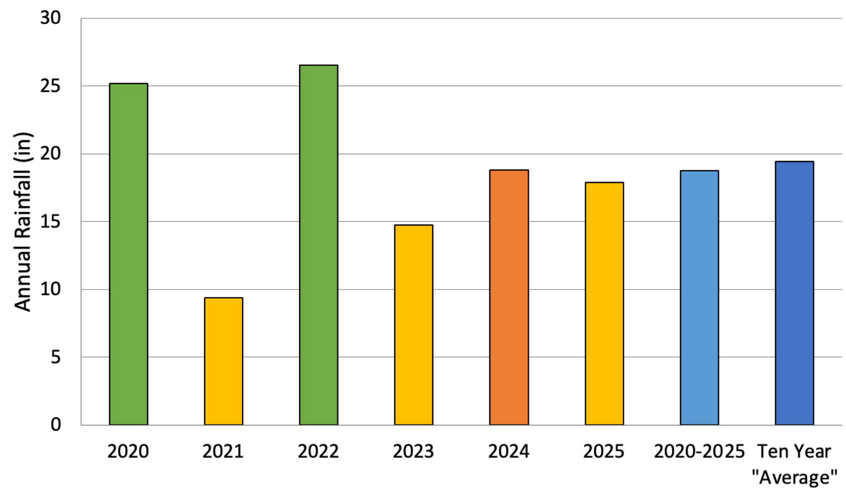
Annual rainfall amount and the timing of precipitation events represent the most influential factors explaining yield differences between tiled and non-drained areas. A more recent study conducted at the University of Minnesota Crookston in the Red River Valley observed yield responses consistent with precipitation variability, as illustrated in Figures 2.2 and 2.3.

Figure 2.2 Yield from UMN Crookston tile project

	2020	2021	2022	2023	2024		2025
	Soybean	Wheat	Soybean	Wheat	Sugarbeet		Wheat
	---------------- Yield (bu/ac) ---------------				Yield (t/ac)	Recov. Sucrose (%)	Yield (bu/ac)
Drained	40 **A**	54 **B**	39	86	33.5	17.4% **A**	94
Undrained	34 **B**	58 **A**	40	88	34.6	17.0% **B**	92

Source: Pease, 2026

Figure 2.3 Total annual rainfall at UMN Crookston tile project



Source: Pease, 2026

The study shows the wetter years of 2020 and 2022 produced differing yield responses to subsurface drainage. In 2020, yield differences were large enough to be statistically significant, whereas in 2022 the observed yield increase was smaller and not statistically significant. In contrast, the drier years of 2021 and 2023 resulted in yield responses that were negative to neutral, with one year exhibiting a statistically significant difference and the other showing only minimal differences. Those two years led to a net yield loss from subsurface drainage (Pease, 2026).

Ohio drainage studies used controlled irrigation to reduce the variability and tried to isolate drainage effects by applying uniform water applications during early and late growth stages (Schwab, Fausey, & Weaver, 1975) (Schwab, Fausey, Desmond, & Holman, 1985). This methodology allowed researchers to quantify the rate at which water was absorbed into the soil profile, commonly referred to as the drainage coefficient, across different drainage treatments.

The Ohio studies evaluated five different drainage treatment setups:

1) No drainage done at all (surface or subsurface)
2) Surface drainage done exclusively
3) Sub-surface drainage done exclusively (at average 3ft depth)
4) Sub-surface drainage and surface drainage
5) Shallow depth of tile (at 1.5-1.6ft deep) completed in in 1976 versus the deeper (3ft – more traditional depth) installed in 1960

By partially controlling rainfall, one of the largest variables that the farmer has no control over, the Ohio study was better able to clearly identify the agronomic benefits attributed to subsurface drainage. Across years, drainage treatments demonstrate more stable yields and lower coefficients of variation compared to non-drained systems, indicating reduced production risk in addition to potential yield gains.

2.3 Economics of Tile Installation

While agronomic research documents the impacts on yield from subsurface drainage, economic literature evaluating drainage as a capital investment is more limited, particularly for tenant-operated farmland. Economic evaluations of drainage installations have generally focused on the question of optimal system design rather than investment recovery under lease constraints. Langemeier, Kladivko, and Farris (2023) used long-term Purdue University trial data to evaluate drainage spacing economics using NPV analysis and stochastic dominance criteria, finding that 66-foot lateral spacing represented the economically optimal configuration across varying risk aversion levels. Their analysis demonstrates that the tile investment decisions are sensitive not only to yield response but to installation cost, discount rate, and the useful life assumed for the system, variables that become especially consequential when evaluated from a tenant's shorter planning horizon.

Hofstrand (2023) identifies three distinct investment strategies for tile drainage: landowner investment with adjusted cash rental rate, tenant investment with returns accruing to the tenant, and a shared investment arrangement under a crop-share lease. In the tenant investment scenario, Hofstrand notes directly that a major concern is whether the tenant will have access to the land long enough to justify the capital outlay and identified a pro-rate buyout arrangement structured as an ancillary contract to the standard lease. This arrangement was presented as the mechanism to protect unrecovered investment value; however, no model-based framework was provided for calculating that value on a discounted, year-specific basis, and the buyout schedule illustrated used a simple straight-line declining value rather than a cash-flow based recovery approach.

The financial performance of drainage investments depends not only on average yield increases, but on the timing and consistency of those gains relative to installation costs, crop prices, and financing conditions. Studies have shown that yield responses to drainage area to be highly variable across years, driven largely by precipitation patterns, which introduces uncertainty into the cash flows generated by subsurface drainage investment. As a result, the economic viability of subsurface drainage cannot rely on agronomic outcomes alone but must also account for the variability and risk inherent in agriculture production.

For tenant operators, this economic evaluation carries additional complexities not addressed in the existing literature. Unlike landowners, tenants face uncertainty regarding lease continuation and future access to the improved land, increasing the risk that the investment may not be fully recovered before the tenant–landlord relationship ends. Even when long-term average yield benefits are positive, the timing of those benefits is critical, as delayed or intermittent gains can substantially reduce the economic value of the investment when evaluated over a shorter planning horizon. This risk is further compounded by fluctuations in commodity prices and interest rates, which affect both the value of incremental production and the opportunity cost of invested capital. These factors highlight the need for tenant-focused financial evaluation frameworks and lease arrangements that explicitly account for time and risk, including provisions that address unrecovered investment value in the event a lease ends before the tenant has fully recovered the yield-based returns from a drainage installation.

CHAPTER III: DATA

This chapter describes the data inputs used to parametrize the financial model. Each input is drawn from published agronomic research, market data, commercial cost quotes, or federal tax and lending sources relevant to Upper Midwest production conditions. The data described here feed directly into the analytical methods in Chapter IV, which converts these inputs into NPV, payback, sensitivity, and unrecovered investment results.

3.1 Data Sources

Multiple data sources are used to parametrize the economic analysis, combining agronomic research findings with market and cost information relevant to the Upper Midwest production regions.

3.1.1 Yield Response Assumptions

Expected yield responses to subsurface drainage are based on published agronomic research. Rather than relying on individual site-specific results, this study adopts representative average yield improvements from long-term, replicated studies representing as close as possible to the Upper Midwest. This approach reflects typical whole-field drainage outcomes and avoids overstating potential benefits observed under extreme or isolated conditions.

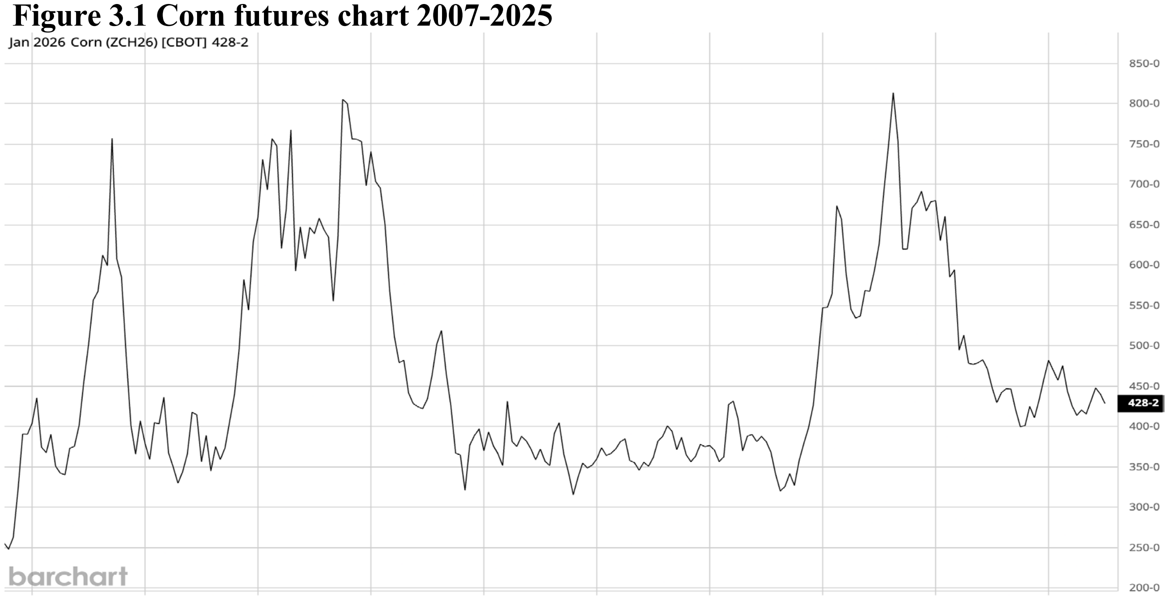
Separate yield assumptions are used for corn and soybeans to reflect crop-specific differences documented in the literature. These yield gains are treated as incremental increases relative to non-tiled conditions and are assumed to occur over time, consistent with the observed dependence of drainage benefits on annual precipitation patterns.

Corn yield increase is assumed at an average of 15%; soybean average yield increase is assumed at 6%. Other crops are not considered in the modeling.

3.1.2 Crop Price Data

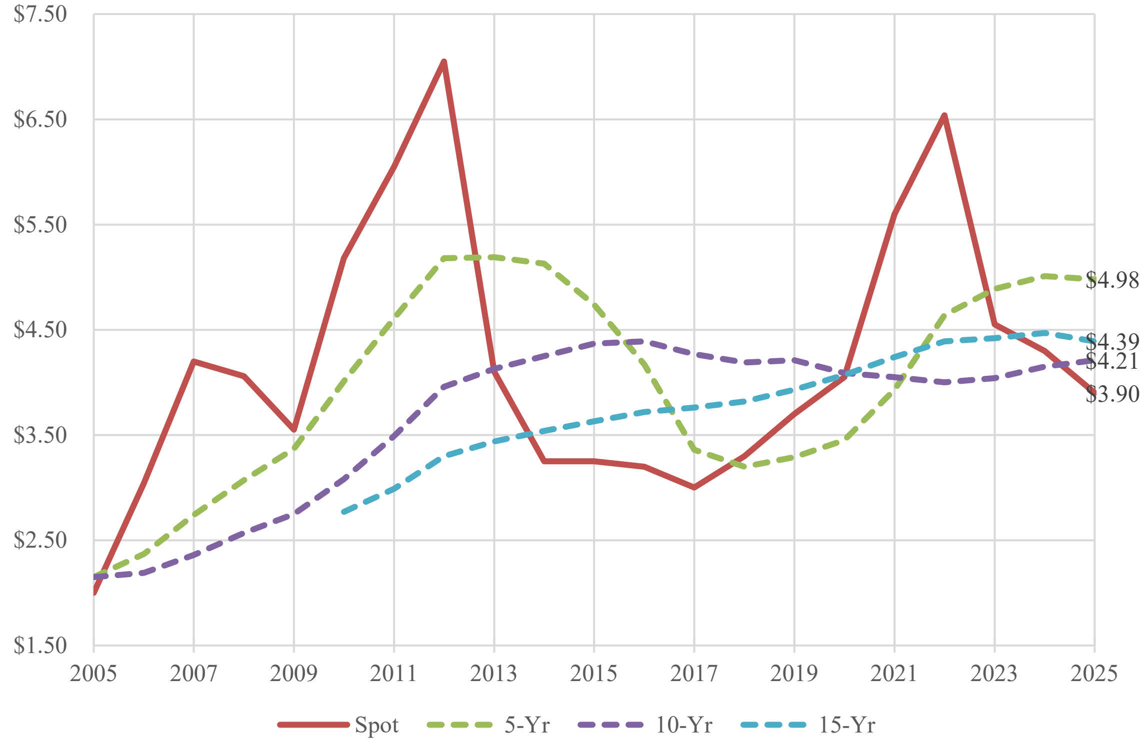
Crop prices for corn and soybeans are based on historical averages to reflect realistic market conditions faced by farmers. To capture price variability and reduce sensitivity to short-term market fluctuations, average prices received by farmers are calculated using the 10 and 15-year trailing average. Figure 3.1 shows corn futures from 2007 to 2025, and Figure 3.2 shows the annual average price received by farmers per bushel by year with 5, 10 and 15 year trailing average prices as graphed as well. Figure 3.3 provides the soybean market from 2007 to 2025 with Figure 3.4 providing grower average cash price paid per bushel of soybeans from 2005 to 2025 with the trailing 5, 10 and 15 year averages.

Figure 3.1 Corn futures chart 2007-2025



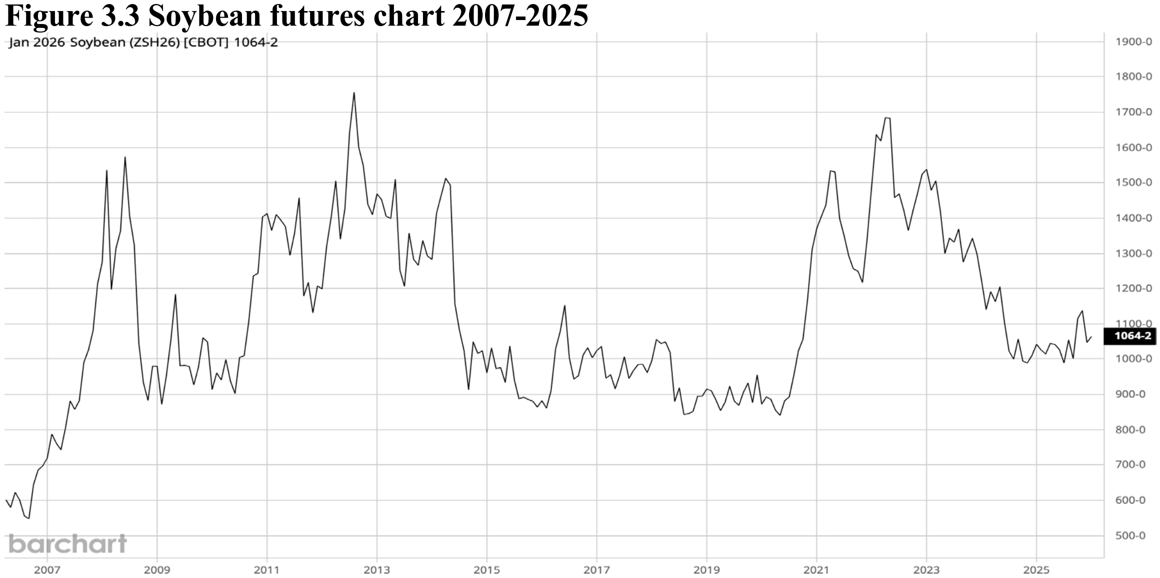
Source: Barchart, 2026

Figure 3.2 Corn cash price received by farmers 2005-2025



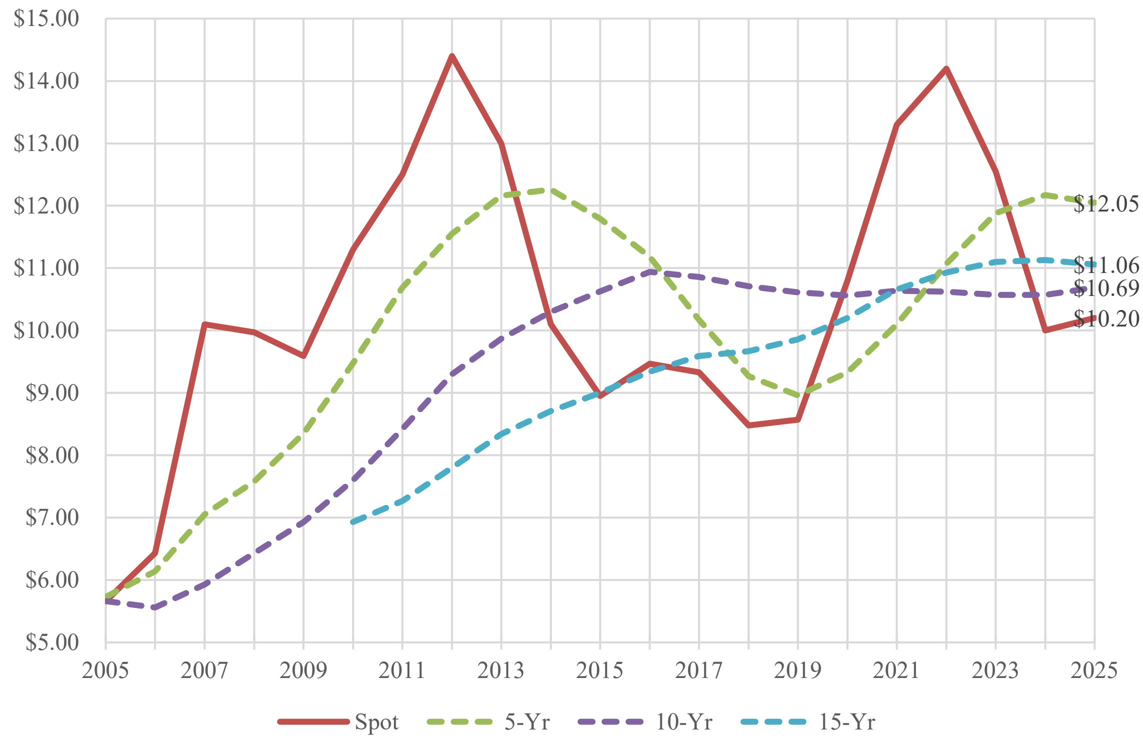
Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2026

Figure 3.3 Soybean futures chart 2007-2025



Source: Barchart, 2026

Figure 3.4 Soybean cash price received by farmers 2005-2025



Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2026

These alternative price horizons are used as scenarios in financial analysis rather than as forecasts. This approach allows the analysis to examine how investment outcomes change under different price environments while avoiding assumptions about future price trends. The low price used is the market reference price from USDA updated in The One Big Beautiful Bill (OBBB) which is $4.10 for corn and $10.00 for soybeans (Schnitkey, Paulson, & Coppess, 2025). These reference prices represent the floor below which federal commodity support payments would be triggered, making them a defensible lower bound for this analysis.

3.1.3 Drainage Installation Costs

Quotes from three different commercial companies were used to inform estimates for per-acre installation costs and the average of all three was used. A quote from a tile materials retailer was also used to represent the cost of raw materials in the case of self-installation. For consistency, all quotes were requested based on the same pre-designed system layout, with specified totals of each tile size and type required for project completion.

Cost assumptions account for tile material, installation labor and system design. Actual costs vary based on soil conditions, tile spacing, field size, topography, and the potential need for utilities to run a lift station pump. Installation costs are treated being an upfront capital investment incurred on Year 0 of the analysis period. No residual value is assumed at the end of the planning horizon, which results in a conservative assessment of investment performance.

To maintain uniformity in quotes between commercial companies, a pre-designed system setup on 60-foot wide lateral spacing was used for the drain tile investment in the model. The 60-foot spacing was selected based on research done by Langemeier, Kladivko and Farris (2023), which identified this spacing as the most cost-effective configuration relative to yield return. Quotes for the same design were also requested for 90-foot spacing requiring 33% less tile, as well as 30-foot spacing, doubling the amount of tile. Subsurface drain tile design is an art that doesn't necessarily mean one design is wrong over the other, just that it can vary the number of lateral lines, connections, and time needed to install the system fully.

The average cost of quotes received for the 60-foot spacing came in at $1,050 per acre; the 30-foot spacing had an average cost of $1,600 per acre and the average of the 90-foot spacing was at $890 per acre. A quote for the cost of raw materials was obtained from a retailer of tile materials of the same designed system with total length of tile along with other materials needed. This quote provided a raw material cost of $475 per acre investment required. The tenant would be responsible for installing the tile themselves, however due to modern advances with technology and ability to use machinery already owned by farmers, this is an option that a tenant may consider purchasing to help provide a faster return on investment. The costs widely varied, but for this model a cost of $300 per acre is used to factor the cost of capital, labor, fuel and repairs bringing the total cost of this option to $775 per acre (NDSU, 2024).

The three tile cost scenarios used in this model then consisted of a low-cost option of $775 per acre, a medium cost of $1,050 per acre and a high cost of $1,690 per acre.

3.1.4 Lease Duration and Planning Horizon

The duration of land control is critical factor influencing the economic viability of subsurface drainage investments made by tenant operators. While subsurface drainage systems are long-lived assets, tenants typically face shorter and uncertain lease terms that can limit their ability to recover investment costs through realized yield benefits. This study adopts a 15-year planning horizon as the primary evaluation period since for tax purposes, subsurface drainage improvement is classified as a 15-year property under the Modified Accelerated Cost Recovery System (MACRS). Although tax depreciation schedules do not determine the economic life of the asset, the 15-year classification provides a practical intuitional benchmark for capital recovery expectations.

Lease duration is treated as an endogenous component of the analysis by examining cumulative net returns over time and identifying the point at which the investment reaches a break-even lease length. This break-even length represents the minimum period of continuous land access necessary for the tenant to fully recover installation costs, given assumed yield responses, crop prices, financing conditions, and production variability.

Both undiscounted (cash-flow) and discounted (Net Present Value-based) break-even measured are reported. The discounted break-even measure serves as the primary economic indicator, as it accounts for the time value of money and reflects the opportunity cost of the invested capital.

By structuring the evaluation around a 15-year planning horizon, the analysis directly addresses the central research question: how long a tenant must reasonably expect to control the land to justify subsurface drainage installation.

3.1.5 Tax Treatment of Drainage Investment

For tax purposes, subsurface drainage systems are classified as 15-year property under the Modified Accelerated Cost Recovery System (MACRS). Under current federal tax provisions, qualifying drainage investments may be expensed in the year of installation through Section 179, subject to eligibility limits (The Ohio State University, 2012).

In this analysis, Section 179 deduction is incorporated as a one-time tax benefit realized in Year 0. A marginal tax rate of 22% is assumed, resulting in an immediate reduction of the net initial investment equal to 22% of total installation cost. This tax benefit is treated as a reduction in the initial cash outlay rather than as a recurring annual depreciation deduction.

The net initial investment after the Section 179 tax benefit is applied is calculated as:

$$C_0 = (A \times IC) - (\tau \times A \times IC)$$

Where A is field size in acres, IC is installation cost per acre, and τ is the marginal federal tax rate. The tax benefit is treated as a one-time reduction in the initial cash outlay at Year 0.

There are no additional depreciation deductions beyond the Section 179 expense modeled. The assumed tax rate is held constant across all scenarios, and the tax treatment is applied consistently in the base scenario and all sensitivity analyses.

While actual tax strategies vary across individual operations, this simplified approach captures the primary tax effect of drainage investment without introducing specific tax complexity that may actually arise.

The 22 percent rate corresponds to the federal marginal tax bracket for taxable income between $94,301 and $201,050, which is consistent with the income profile of a tenant operator making an investment of this size. Tenants with different income levels or operating in states with additional income tax obligations may face different effective rates, which would alter the net initial outlay accordingly. A tenant could alternatively elect straight-line depreciation rather than Section 179 expensing, which would reduce the Year 0 benefit but generate annual depreciation deductions in Years 1 through 14. This analysis uses Section 179 expensing exclusively, reducing the net initial outlay from $162,750 to $126,945 — a one-time tax benefit of $35,805 applied at Year 0.

3.1.6 Discount Rate

The discount rate used in this analysis is 6 percent and applied as the base case across all NPV calculations. The discount rate represents the opportunity cost of capital which is the rate at which the investment must return for a rate to justify committing capital in subsurface drain tile rather than using them elsewhere or pay down existing debt.

For a tenant operator, the most direct way to think about the opportunity cost of capital is the rate at which they can borrow money. A drainage investment financed through an intermediate-term agricultural loan needs to generate returns that at a minimum cover the cost of that borrowing. A tenant using working capital instead of borrowed funds faces the same logic, those dollars have an alternative use and the rate at which they could borrow reflects the market's assessment of what the capital is worth.

The 6 percent rate is consistent with agricultural lending conditions during the period this analysis was conducted. It is also the same rate used by Langemeier, Kladivko, and Farris (2023) in their NPV analysis of drainage spacing economics at Purdue University's long-term drainage research site. The discount rate is held constant across all scenarios except in the discount rate sensitivity analysis in Section 4.5, which tests the model at 4 and 10 percent. The 4 percent rate reflects the lower end of USDA direct lending programs (Atkinson, 2026), while the 10 percent rate reflects conditions a tenant might face borrowing through commercial guaranteed loan during a period of elevated market rates.

All of the discount rates above reflect the net initial outlay after the Section 179 tax benefit was applied at Year 0. Had the tenant not received that tax benefit and instead carried the full gross investment of $162,750, the equivalent effect discount rates, calculated by dividing each stated rate by one minus the 22 percent tax rate, would be 5.1 percent, 7.7 percent, and 12.8 percent for the low, medium, and high scenarios respectively. These higher effective rates illustrate the degree to which the Section 179 deduction reduces the real cost of capital for the tenant investor.

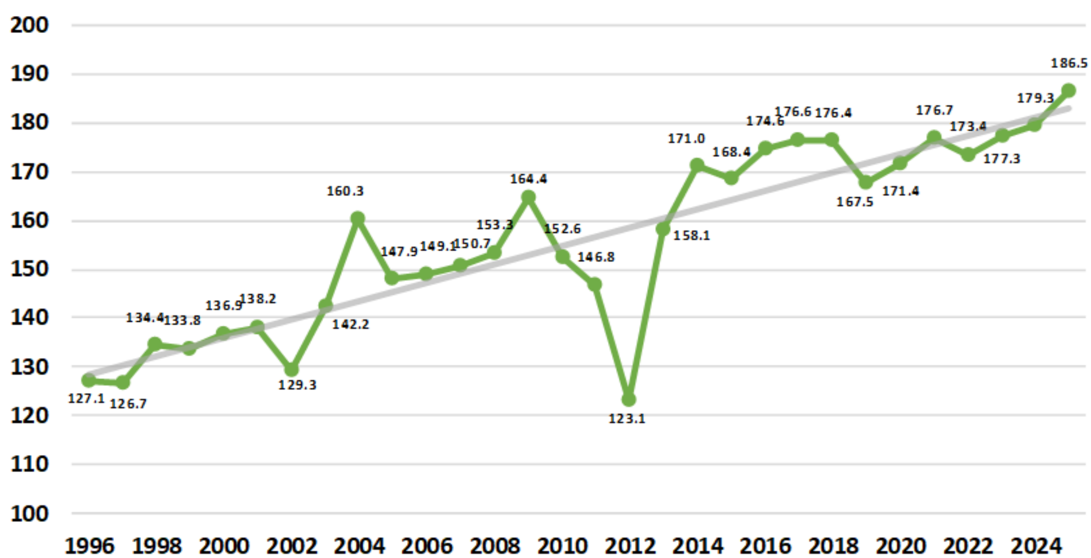
3.1.7 Yield Trend Data

Historical data from the U.S. Department of Agriculture National Agricultural Statistics Service indicate that national average corn and soybean yields have increased steadily over multiple decades, driven by improvements in seed genetics, management practices, fertilizer efficiency, and precision agriculture technologies (U.S. Department of Agriculture, National Agricultural Statistics Service, 2026). These trends are used in

Section 4.5 to construct yield trend scenarios that test whether rising baseline productivity alters the timing and magnitude of drainage investment recovery.

Long-run corn yield trends have been estimated at approximately 1.5 to 2.0 bushels per acre per year over extended historical periods, with recent growth rates showing modest deceleration relative to earlier decades. As shown in Figure 3.5, the yield change from 1996 of 127.1 bushels per acre to 2025 of 186.5 bushels per acre averages 1.9 bushels per acre per year. On a 10-year average from 2015 to 2025, that trend has slowed to 1.55 bushels per acre per year.

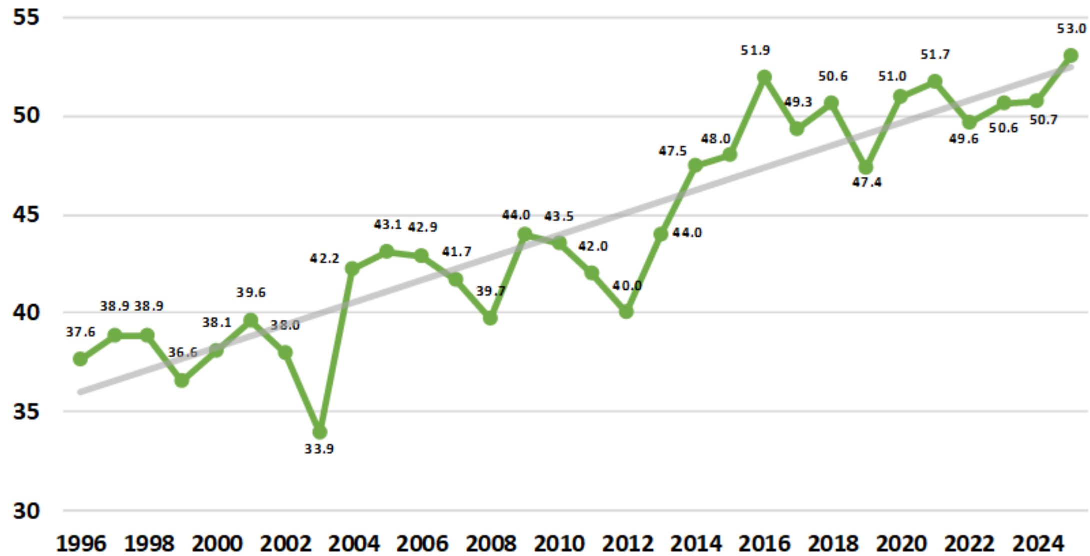
Figure 3.5 United States corn yield (bushels per acre)



Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2026

Soybean yield trends have historically grown at a slower rate than corn but exhibit a positive trajectory over time. As shown in Figure 3.6 the yield change from 1996 at 37.6 to 2025 at 53.0 is an average of 0.81 bushels per acre per year. The shorter term yield gain has only been 0.11 bushels per acre per year.

Figure 3.6 United States soybean yield (bushels per acre)



Source: U.S. Department of Agriculture, National Agricultural Statistics Service, 2026

These trends are widely documented in extension and applied agriculture economics literature, including work from Purdue University and the University of Illinois which regularly publish analyses of national yield trend estimates.

The data inputs described in this chapter — yield response assumptions, crop prices, installation costs, lease duration, tax treatment, discount rate, and yield trend observations — form the complete parameter set used in the financial model. Chapter IV describes how these inputs are structured analytically, including the specific methods used to calculate net present value, payback period, sensitivity outcomes, and unrecovered investment value at each year of the planning horizon.

CHAPTER IV: METHODS

This chapter describes the analytical approach used to evaluate the economic viability of subsurface drainage investment from the tenant's perspective. A partial budgeting framework is used to isolate the incremental costs and benefits associated with drainage installation. Incremental benefits come from the yield improvements described in Chapter III, and costs reflect the installation expenses adjusted for the Section 179 tax benefit. Financial performance is then evaluated using discounted cash flow analysis and break-even metrics that account for the time value of money across a range of economic conditions.

The base case model evaluates a single 155-acre Upper Midwest field under a corn-soybean rotation, with an installation cost of $1,050 per acre, a 15 percent corn yield improvement, a 6 percent soybean yield improvement, crop prices of $4.65 per bushel for corn and $11.50 per bushel for soybeans, and a 6 percent discount rate. A 22 percent federal income tax rate is applied to a Section 179 first-year deduction, reducing the net initial outlay in Year 0. All cash flows are evaluated over a 15-year horizon consistent with the IRS MACRS asset classification for subsurface drainage systems. Building from the base case, 20 sensitivity scenarios are tested by varying one parameter at a time across installation cost, yield improvement, field productivity zone, discount rate, and crop price. Two combined scenarios and two yield trend scenarios are also evaluated. The full set of base case parameters is summarized in Table 5.1.

The model is built around a 155-acre field, representative of a typical Upper Midwest field-scale tile project, large enough to absorb fixed costs such as lift station installation, electrical hookup, and contractor mobilization fees, without being so large as to be atypical. The analysis uses an explicit corn-soybean rotation, with corn cash flows generated in odd years and soybean cash flows in even years. In corn years, the yield improvement from subsurface drainage generates an estimated $19,785 in additional gross revenue per year. In soybean years the corresponding value is $5,668. These gains are held constant in all scenarios except the yield trend analysis described in Section 4.5.

4.1 Net Present Value (NPV)

Net Present Value (NPV) is used as a primary metric to evaluate the economic viability of subsurface drainage investment. NPV measures the difference between the present value of expected future benefits and upfront investment cost, discounted to reflect the time value of money.

The NPV formula used in this analysis is:

$$NPV = -C_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}$$

Where C_0 is the net initial investment cost incurred at Year 0 after the Section 179 tax benefit is applied, CF_t is the net incremental cash flow in year t attributable to subsurface drainage, r is the discount rate, and n is the 15-year planning horizon. Because the investment occurs at Year 0, it is not discounted. A positive NPV indicates that discounted cumulative returns exceed the net cost of investment within the planning horizon.

In this thesis, NPV is calculated over a 15-year planning horizon consistent with the lease duration framework described in Section 3.1.4. The initial investment includes total drainage installation cost adjusted for the Section 179 tax benefit, which is incorporated as a one-time positive cash flow in Year 0. Annual net returns reflect incremental yield gains attributable to drainage, valued at assumed crop prices.

Annual net incremental cash flow in each year is calculated as:

$$CF_t = A \times \Delta Y_c \times P_c \text{(corn years)}$$

$$CF_t = A \times \Delta Y_s \times P_s \text{(soybean years)}$$

where A is the field size in acres, ΔY_c and ΔY_s are the per-acre yield gains attributable to drainage for corn and soybeans respectively, and P_c and P_s are the assumed crop prices per bushel. No additional variable costs attributable to drainage are modeled, consistent with the partial budgeting approach described above.

A positive NPV at Year 15 indicates that the discounted cumulative returns are sufficient to fully recover the net initial investment within the assumed 15-year period. A negative NPV at Year 15 indicates incomplete economic recovery within that timeframe.

Discount rates are selected to reflect the opportunity cost of capital faced by tenant operators and are evaluated across levels in a sensitivity analysis. By focusing on NPV for a 15-year horizon, the analysis provides a consistent and economically grounded measure of investment performance within a realistic tenant planning window.

4.2 Payback Period and Break-Even Lease Length Analysis

In addition to NPV, payback period analysis is used to evaluate the timing of cost recovery associates with subsurface drainage investments from a tenant perspective. While NPV captures overall investment performance within a defined horizon, payback analysis focuses on the number of years required for cumulative incremental returns to offset the net initial outlay cost (after tax benefit).

The undiscounted payback period is calculated as:

$$\text{Payback Year} = \min\left\{t: \sum_{t=1}^{n} C\,F_t \geq C_0\right\}$$

The discounted break-even lease length is calculated equivalently using discounted cash flows:

$$\text{Discounted Break-Even} = \min\left\{t: \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \geq C_0\right\}$$

Both measures are reported for each scenario. The discounted break-even serves as the primary economic indicator, as it reflects the time value of money and the opportunity cost of invested capital.

In this study, the payback period is defined as the point in time at which cumulative net cash flows generated by subsurface drainage equal the initial investment cost. This payback point is interpretated as the minimum lease length required for a tenant to break even on the drainage investment under a given set of assumptions. If cumulative returns do not reach the investment cost within the evaluated period, the investment is considered unrecovered for that lease scenario.

Payback and break-even lease length are evaluated under multiple scenarios reflecting variation in yield response, commodity prices, installation costs, and discount rates. By examining the shifting payback horizon across scenarios, the analysis identifies conditions under which subsurface drainage investments may be economically feasible for tenant operators and conditions under which lease duration constraints represent a binding limitation.

4.3 Sensitivity Analysis

Given the uncertainty surrounding yield responses, commodity prices, installation costs, interest rates, and lease duration, sensitivity analysis is conducted to evaluate the robustness of investment outcomes. Key parameters are varied individually to assess their influence on NPV and payback period results. Sensitivity scenarios include:

1. Alternative yield improvement assumptions
2. Historical price averages across different time horizons
3. Variation in subsurface drainage installation costs
4. Changes in discount rates

The analysis highlights which factor most strongly influence investment viability and identifies conditions under which subsurface drainage investments may or may not be financially justifiable for tenant operators.

4.4 Buy-Back and Unrecovered Investment Framework

To address the risk of lease termination prior to the full investment recovery from the drainage system installation, a buy-back framework is incorporated into the analysis. This framework estimates the unrecovered portion of the drainage investment at different points in time based on cumulative realized returns.

The unrecovered investment value at any year $t$is defined as:

$$UV_t = C_0 - \sum_{k=1}^{t} \frac{CF_k}{(1+r)^k}$$

where UV_t is the unrecovered discounted investment value remaining at year t, C_0 is the net initial outlay, and the summation represents cumulative discounted cash flows through year t. When UV_t is positive, the investment has not yet been fully recovered on a discounted basis. When UV_t reaches zero or below, the discounted break-even has been achieved. The buy-back compensation schedule presented in Chapter VI is derived directly from UV_t values at each year of the planning horizon

The calculated unrecovered value represents the amount that would be required to compensate the tenant for foregone future benefits if the lease is terminated early. This framework is intended as an analytical tool to quantify financial exposure rather than as a policy recommendation.

4.5 Yield Trend Scenario Specification

Building on the historical yield trend data described in Section 3.1.6, two yield-trend scenarios are incorporated into the model to evaluate whether rising baseline productivity alters the timing and magnitude of drainage investment recovery. In addition to the base scenario in which crop yields are held constant over the 15-year planning horizon, the following trend rates are modeled:

- Trend-Low: corn yields increase at 0.5% annually; soybean yields increase at 0.3% annually.
- Trend-High: corn yield increase at 1.0% annually; soybean yields increase at 0.7% annually.

These rates are intentionally conservative relative to long-run historical averages and are designed to reflect the slower recent pace of yield growth observed in national data. Yield growth is applied as a compounded annual percentage increase to the baseline yield levels used in the model:

$$Y_t = Y_0(1 + g)^{t-1}$$

where Y_0 represents the baseline yield in Year 1, and g is the assumed annual yield growth rate. Importantly, the percentage yield gains attributable to subsurface drainage (15% for corn and 6% for soybeans in the base scenario) remain constant. As a result, the incremental bushels attributable to drainage increase proportionally as baseline yields rise over time.

This approach does not attribute general technological progress to drainage installation rather it evaluates whether rising baseline productivity alters the timing and magnitude of drainage investment recovery. The yield-trend scenarios are interpreted as robustness tests, illustrating how broader agricultural productivity growth may influence tenant-level capital budgeting outcomes under otherwise unchanged economic conditions.

Results are presented beginning with the base case, which uses all medium values for installation cost, yield improvement, crop prices, and discount rate. Single-variable sensitivity scenarios follow, testing each input individually across low and high values while holding all others at the base. Combined scenarios are then evaluated by adjusting multiple variables simultaneously to represent adverse and optimistic conditions. A yield trend analysis follows, and the chapter concludes with the unrecovered investment analysis, which provides the foundation for the lease framework developed in Chapter VI.

CHAPTER V: RESULTS

This chapter presents the financial results of the subsurface drain tile investment model on a 155-acre field from the perspective of a tenant operator making the full investment in land that is owned by another party in Minnesota. All results are evaluated from the tenant's perspective, treating the installation cost as capital outlay that has no contribution or compensation from the landlord. The investment is evaluated primarily using Net Present Value (NPV) at the end of the 15-year planning horizon. The reason for the 15-year value of choice is to coincide with treatment from the United States Internal Revenue Service (IRS) MACRS classification on this type of asset investment for a business.

For scenarios in which NPV remains negative at Year 15, the first year that the cumulative discounted cash flow becomes positive is reported. If the discount cumulative cash flow does not converge to a positive value within the modeled horizon, the scenario is classified as having no discounted break-even within the life of the model. Results are organized by base model first with all median values of investment, yield increase, price, and discount rate. A sensitivity analysis follows by changing a single variable individually, then changing multiple variables together and then in summary a buy-back table for tenants to consider into their long-term lease agreement. This would ensure that the capital invested is not lost due to an early departure of contract or other event that would prevent the tenant from receiving enough gains from the yield improvement to cover the cost of the project.

5.1 Base Model Assumptions

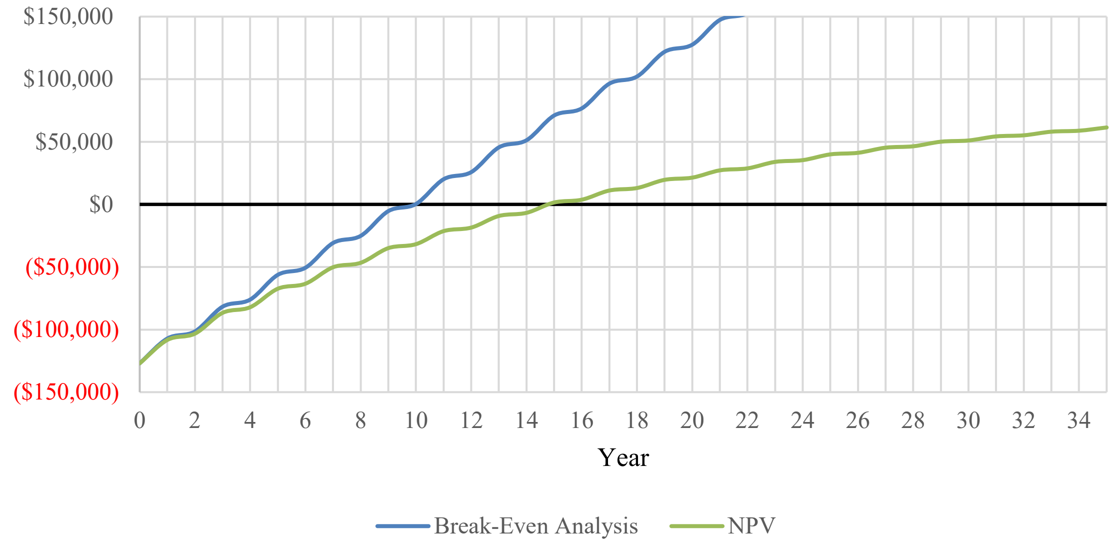
The base model results presented in this chapter use all medium values for each input as summarized in Table 5.1. All sensitivity analyses hold non-tested variables at those same base values unless otherwise noted. Results are reported at Year 15 as the primary evaluation point, consistent with the IRS MACRS planning horizon described in Chapter IV.

Table 5.1 Base model input assumptions

Parameter	Value	Source / Note
Farm & Investment		
Farm Size	155 acres	Modeled unit; representative Upper Midwest field scale
Investment Cost (medium)	$1,050/acre	Average of three commercial contractor quotes, 60-ft spacing
Total Investment	$162,750	155 acres × $1,050/acre
Federal Tax Rate (Section 179)	22%	IRS 2024 marginal bracket; Schedule F operator profile
Tax Benefit (Year 0)	$35,805	22% × $162,750; one-time Year 0 credit
Net Initial Outlay	$126,945	Total investment less Section 179 benefit
Yield Assumptions		
Base Corn Yield	183 bu/acre	Medium productivity zone; MN state average reference
Base Soybean Yield	53 bu/acre	Medium productivity zone; MN state average reference
Corn Yield Gain (medium)	15%	Rui, Goller & Kladivko (2024); mid-range of 12–17% literature range
Soybean Yield Gain (medium)	6%	Mourtzinis et al. (2021); mid-range of 4–8% literature range
Crop Rotation	Annual corn–soybean	Alternating years; odd years = corn cash flow, even years = soybean
Prices & Discount Rate		
Corn Price (medium)	$4.65/bu	Average of the 10 and 15-year trailing average; USDA NASS prices received
Soybean Price (medium)	$11.50/bu	Average of the 10 and 15-year trailing average; USDA NASS prices received
Discount Rate (medium)	6%	Reflects opportunity cost of capital for tenant operators
Annual Incremental Returns		
Corn Year Annual Gain	$19,785	155 ac × 27.45 bu/ac gain × $4.65/bu
Soybean Year Annual Gain	$5,668	155 ac × 3.18 bu/ac gain × $11.50/bu
Planning Horizon	15 years	IRS MACRS 15-year property classification for drainage systems

Note: All sensitivity analyses holds non-tested variables at the medium values shown above. Tax benefit calculated as 22% × total installation cost, applied as a one-time Year 0 Section 179 deduction. Corn-soybean rotation assumed throughout; corn years and soybean years alternate annually beginning with corn in Year 1.

Figure 5.1 Cumulative undiscounted cashflow vs. cumulative NPV



On an undiscounted basis, the cumulative cash flows from the investment turns positive at Year 10, when the running total reaches $320. This is the accounting break-even point in the year in which the tenant has nominally recovered the net capital outlay. However, when cash flows are discounted at the base rate of 6% to reflect the time value of money, the investment does not achieve a positive cumulative NPV until Year 15, where NPV stands at $1,514. The gap between the undiscounted and discounted cash flow is an important practical distinction: a tenant who evaluates the investment only on a cash-flow basis may conclude the investment has paid off at Year 10, while the economic cost of capital remains unrecovered for an additional five years. The implications of this difference are discussed in Section 5.10.

The base result with a positive NPV at year 15 supports the IRS defined 15-year life of the asset as being financially viable under expected conditions. The margin on this model is narrow and highly sensitive to the changes in the individual inputs examined in the following sections. Table 5.2 presents the complete year-by-year cash flow, undiscounted cumulative balance, and discounted cumulative NPV for the base case model.

Table 5.2 Base case year-by-year results – base model

Year	Cumulative Undiscounted CF	Unrecovered (UD)	Cumulative NPV	Unrecovered (Disc.)
0	−$126,945	$126,945	−$126,945	$126,945
1	−$107,160	$107,160	−$108,280	$108,280
2	−$101,492	$101,492	−$103,235	$103,235
3	−$81,707	$81,707	−$86,624	$86,624
4	−$76,039	$76,039	−$82,134	$82,134
5	−$56,255	$56,255	−$67,350	$67,350
6	−$50,586	$50,586	−$63,354	$63,354
7	−$30,802	$30,802	−$50,196	$50,196
8	−$25,133	$25,133	−$46,640	$46,640
9	−$5,349	$5,349	−$34,929	$34,929
10	+$320	Recovered	−$31,764	$31,764
11	+$20,104	Recovered	−$21,342	$21,342
12	+$25,773	Recovered	−$18,525	$18,525
13	+$45,557	Recovered	−$9,249	$9,249
14	+$51,226	Recovered	−$6,742	$6,742
15	+$71,010	Recovered	+$1,514	Recovered

CF = Cash Flow   UD = Undiscounted

5.2 Investment Cost Sensitivity

Of all the variables that were examined in this analysis, the installation cost is the one most directly within the tenant's ability to control prior to making the investment. Other factors like soil composition, commodity prices, and yield responses to drainage are largely determined outside of anyone's ability to control. The results of the installation cost sensitivity analysis reflect the impact of this controllable variable.

The low installation cost of $775 per acre, with a net outlay after tax of $93,698 the investment achieves an undiscounted break-even at Year 7 and a discounted break even at Year 10, with a 15-year NPV of $34,761. This outcome represents a favorable investment with recovery well within a lease term that parties may feel more comfortable entering into. The median cost of $1,050 per acre, the results have already been discussed in Section 5.1. The higher cost installation scenario of $1,690 per acre, with a net outlay after tax of $204,321, the undiscounted break-even does not occur until Year 17 and the discounted NPV remains negative throughout the modeled 35-year horizon, reaching -$75,862 at year

15. With high-cost conditions, the investment fails to generate sufficient drainage attributable revenue to recover the capital used within any realistic lease duration.

The difference between the low and high cost NPV outcomes at Year 15 is $110,623 which is the largest range of any single variable examined in this analysis. Knowing this information reinforces that the installation bid and design received at the outset of the project is not something to be taken lightly; it is the primary determinant of whether the investment is financially viable. Tenants should treat the per-acre installation cost of the project as a decision threshold, obtaining multiple competitive bids and designs before committing capital towards a project.

Table 5.3 Investment cost sensitivity — NPV and break-even results at Year 15

Scenario	$/Acre	Total Investment	Net Outlay (After Tax)	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
Low	$775	$120,125	$93,698	+$34,761	Year 7	Year 10
Medium	$1,050	$162,750	$126,945	+$1,514	Year 10	Year 15
High	$1,690	$261,950	$204,321	−$75,862	Year 17	None in 35 yrs

5.3 Yield Impact Sensitivity

The yield improvements that can be attributed to subsurface drainage is the most agronomically uncertain variable in this analysis. Unlike the installation cost, which is a fixed and known value before the work begins, the actual yield response to sub surface drainage cannot be directly observed until after installation. Even after the installation of subsurface drainage, results can vary due to factors that are not controlled including soil types, weather events including timing of such weather events, commodity prices, and field characteristics. The yield impact sensitivity analysis tests the consequence of this uncertainty by comparing low, medium and high drainage responses while keeping all other variables at base case levels.

Under low yield response assumptions with a 10% yield increase in corn and a 4% increase to soybean yields, annual cash flows in corn years fall to $13,190 and soybeans to $3,779. With these levels of cashflow improvement from subsurface drainage, the cumulative undiscounted cash flow recovers the net investment at Year 15 ($5,025), and the discounted NPV remains negative at -$41,306, with no discounted break-even in the 35-year model horizon. This is indicative that a subsurface drainage tile investment made under base case cost assumptions will fail to recover its investment cost if the agronomic yield response is below expectations. Under high yield response assumptions with a 22% yield increase in corn and a 10% increase to soybean yields, annual cash flows increase substantially, generating a NPV of $66,576 at Year 15 and a discounted break even at Year 9.

The NPV range across the yield impact sensitivity of $107,882 is the second largest variable examined, closely comparable to the installation cost range. Together, these two variables, cost and yield response, represent the dominant sources of financial risk and upside for the tenant drainage investor. Notably, yield impact sensitivity interacts directly with the installation cost sensitivity for an operator who can secure a low installation cost but achieves only modest yield gains, may still face marginal or negative returns. Whereas an operator who pays mid-range or a higher design plan but has a higher and more consistent yield gain, may be able to recover the capital cost at an accelerated rate and before the end of the contract. Having an agronomic assessment of subsurface field drainage response before the field is tiled, is just as important as a competitive bid in evaluating the ability to proceed with a project.

Table 5.4 Yield impact sensitivity results – NPV and break-even results at Year 15

Scenario (Corn/Soybean gain)	Annual CF (Corn Yr)	Annual CF (Soybean Yr)	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
Low (10% / 4%)	$13,190	$3,779	−$41,306	Year 15	None
Medium (15% / 6%)	$19,785	$5,668	+$1,514	Year 10	Year 15
High (22% / 10%)	$29,017	$9,447	+$66,576	Year 7	Year 9

5.4 Yield Zone Sensitivity

The yield zone sensitivity analysis examines how the base productivity level of a field affects investment returns. Yield zone in this context refers to the inherent productivity of the land as an example through the state of Minnesota. The northern half of the state has a lower yield expectation of grain yield for corn and soybeans compared to the southern part of the state which would have a significantly higher yield expectation for grain. Because the drainage benefit is modeled as a fixed percentage improvement over the base yield, higher-productivity fields generate greater gains from the same proportional yield response.

At the low yield zone with an estimated 165 bushels per acre of corn and 48 bushels per acre of soybeans, annual cash flows that are attributed from the subsurface drainage are lower in absolute terms, producing an NPV of -$11,332 at Year 15 and pushing the discounted break-even to Year 19. On lower-productivity ground, the investment is marginal at best under the base case cost and price assumptions. At the high yield zone with 210 bushels per acre of corn and 61 bushels per acre of soybeans, the annual cash flows are correspondingly higher, which in turn produces a discounted break-even at Year 13 and an overall NPV of $20,782 at Year 15.

The results from this sensitivity variable provide a practical implication for tenants to consider when looking at several fields they may want to prioritize capital towards a subsurface drainage investment. The economic case for drainage investment is stronger on higher-productivity fields where the absolute dollar per additional bushel is greatest, and weaker on lower-productivity ground where the same installation cost must be recovered from a smaller revenue base.

Table 5.5 Yield zone sensitivity results – NPV and break-even results at Year 15

Yield Zone (Corn/Soybean Yield)	Annual CF (Corn Yr)	Annual CF (Soybean Yr)	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
Low (165/48)	$17,806	$5,102	−$11,332	Year 11	Year 19
Medium (183/53)	$19,785	$5,668	+$1,514	Year 10	Year 15
High (210/61)	$22,752	$6,519	+$20,782	Year 9	Year 13

5.5 Discount Rate Sensitivity

The discount rate used in the analysis represents the tenant operator's opportunity cost of capital – essentially the return that could be earned by investing the same funds in the next-best available alternative. For farm operators, this is influenced by factors including operating credit, returns available on other investments, land purchase opportunities and the cost of debt. The discount rate sensitivity analysis holds all cash flows constant while varying only the rate at which those cash flows are discounted to present value, putting the effect of time-value assumptions on investment viability.

Since all cash flows are identical across the three different discount rate scenarios, the undiscounted break even at Year 10 is the same in all cases. The discount rate affects only the discounted NPV timeframe. The low discount rate of 4 percent, the penalty for waiting diminishes and the NPV at Year 15 comes to $19,934 with a discounted break-even at Year 13. At the base case rate of 6 percent, the results correspond to the base case scenario which is a NPV at Year 15 of $1,514 which coincides with the year that the discounted break-even occurs as well. At a high discount rate of 10 percent, the NPV at

Year 15 is -$25,981, with no discounted break-even occurring within the 35-year model horizon.

The discount rate finding has practical dimensions that is not captured in the sensitivity table alone. Tenant operators who have access to no other high-return investments, effectively face a low discount rate, making the drainage investment relatively more attractive. Equally however, farm operators facing competitive opportunities such as land or equipment purchases, inputs, or expansion of other capital needs, may apply a higher inherent hurdle rate to the subsurface drainage investment, making the marginal nature of the base case result more significant.

Table 5.6 Discount rate sensitivity results – NPV and break-even results at Year 15

Discount Rate	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
4%	$19,934	Year 10	Year 13
6%	$1,514	Year 10	Year 15
10%	-$25,981	Year 10	None

5.6 Crop Price Sensitivity

Commodity prices represent the input variable with low controllability. While installation costs can be managed through competitive bidding or design changes, and yield response can be partially anticipated through design and field selection, the price received for corn and soybean production is determined by domestic and global supply and demand conditions, currency dynamics, and policy decisions that are external to the individual farm operator. The only ability the farm operator may have with crop prices is the ability to sell, or hedge, grain up to three years in the future. The crop price sensitivity analysis tests the consequence of price variation by applying low, medium and high price assumptions to the base case model.

The low-price scenario uses the One Big Beautiful Bill (OBBB) reference price established by the USDA Farm Service Agency with $4.10 per bushel for corn and $10.00 per bushel for soybeans. The values represent a set floor price used for commodity program evaluation purposes and are not intended as long-run market price forecasts. Under the conditions of low prices, annual cash flows from corn fall to $17,444 and in the years, soybeans are grown are reduced to $4,929, producing a 15-year NPV of -$13,991 and extending the discounted break-even to Year 19.

At the high price assumption of $5.65 per bushel for corn and $13.75 per bushel for soybeans, annual cash flows from corn rise to $24,039 and from soybeans rise to $6,777. These higher commodity prices result in a 15-year NPV of $28,643 with a discounted break-even occurring at Year 11. The sustained periods of depressed commodity prices observed for producers in the United States especially in the years of 2009 to 2010, 2014 to 2020 and more recently in late 2023 through the end of 2025 illustrate that the low-price scenario is not a statistical abstraction. It reflects conditions that farmer tenants have navigated during the period in which many drainage investments were made. A farmer tenant who commits to a drainage investment at the medium cost assumption and then encountered a sustained low-price environment would face the possibility of the lease terminating before the investment had fully recovered as discussed in more detail in Section 5.10.

Table 5.7 Crop price sensitivity results – NPV and break-even results at Year 15

Crop Prices (corn/soybean)	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
Low ($4.10 / $10.00)	-$13,991	Year 11	Year 19
Medium ($4.65 / $11.50)	$1,514	Year 10	Year 15
High ($5.65 / $13.75)	$28,643	Year 9	Year 11

5.7 Combined Scenarios

The combined scenario analysis departs from the single-variable sensitivity approach from the prior sections to examine the implications of simultaneous variation in all major input variables. Three scenarios are constructed: an adverse scenario in which all variables take their least profitable values simultaneously, an expected scenario reflecting medium vales on all variables (this is the same as the base case scenario), and an optimistic scenario where all variables take their most favorable values. These scenarios are not intended as a probabilistic forecast of likely outcomes, instead they establish the boundaries of financially plausible results and illustrates the results of variable interaction.

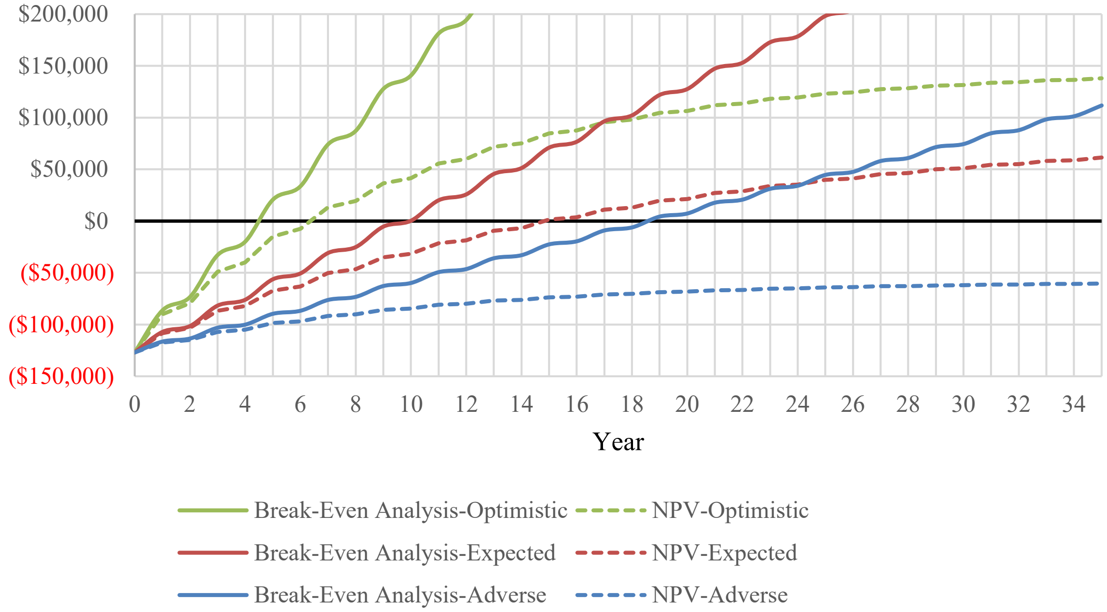
The adverse scenario uses a low base yield zone of 165 bushels per acre for corn and 48 bushels per acre for soybeans, a low drainage yield gain on 10 and 4 percent, a high discount rate of 10 percent, and low crop prices of $4.10 per bushel for corn and $10.00 per bushel for soybeans. The annual cash flows in corn years fall to $10,467 and $2,957 for soybeans. The cumulative undiscounted cash flows do not recover the net investment until Year 19, and the discounted NPV remains negative through the entire 35-year model horizon, reaching -$73,677 at Year 15. A farmer tenant who invests under these conditions for a long duration of the lease would carry substantial unrecovered capital throughout any typical lease term. Under the optimistic scenario which has high yields, strong yield increases, low discount rate and favorable prices, the investment recovers on an undiscounted basis by Year 5 and on a discounted basis by Year 7, with a 15-year NPV of $84,787.

The range between the adverse and optimistic NPV is $158,464 total or $1,022 per acre. This reflects the degree to which the drainage investment decision is outcome-sensitive to conditions that cannot be fully known during the duration of the lease and payback of the capital investment. The expected scenario produces a NPV of $1,514, which sits near the lower end of positive outcomes and confirms that the margin for error under the base conditions is narrow. Looking at it from a risk management perspective, the adverse scenario is particularly instructive with the combination of both below-average drainage yield response and sustained commodity price weakness is not a statistically remote outcome. These two combinations have been documented in the agronomic and applied literature (Schwab, et al., 1975, 1985; Rui, et al., 2024) and observed in the Upper Midwest production area (Pease, 2026). Tenants who invested in drainage improvements during periods of elevated commodity prices have in some cases encountered precisely the conditions in this scenario finding themselves with unrecovered capital in a weakened revenue environment.

Table 5.8 Combined scenario results

Scenario	Key Conditions	Annual CF (Corn Yr)	Annual CF (Soybean Yr)	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
Adverse	Low zone, low gain, 10% disc., $4.10/$10.00	$10,467	$2,957	−$73,677	Year 19	None
Expected	All medium, 6% discount	$19,785	$5,668	+$1,514	Year 10	Year 15
Optimistic	High zone, high gain, 4% disc., $5.65/$13.75	$40,546	$12,990	+$84,787	Year 5	Year 7

Figure 5.2 Cumulative NPV and un-discounted trajectories combined scenarios



5.8 Yield Trend Analysis

Historical yield data for corn and soybeans in the United States reflect a long-run upward productivity trend which occurs from genetic improvement, agronomic practices and input technology. The yield trend analysis incorporates this pattern by applying compounding annual growth rates to the base yield scenario, simulating the additional benefit that accumulates throughout a 15-year period. Two trend rates are tested: a low trend of 0.5 percent per year for corn and 0.3 percent for soybeans, and a high trend of 1.0 percent per year for corn and 0.7 percent for soybeans.

The results indicate that yield trend growth improved investment returns modestly relative to the flat-yield base case though the effect was smaller than other sensitivity variables examined. Both trend scenarios achieve positive NPV at Year 15 with $5,028 under the low trend and $8,846 under the high trend. This in comparison to the base scenario having a 15-year NPV of $1,514 in the flat-yield case. The discounted break-even remains at Year 15 in both cases of high and low yield trend increase. The compounding nature of yield trend benefits means that their effect is more pronounced in later years of the analysis period with the NPV advantage over the base scenario which grows the benefit slowly and building gradually versus appearing immediately. This has a practical implication for lease structure; tenants who maintain long-term lease relationships over 15 or more years, are better positioned to capture the benefit of underlying yield and productivity growth that those in the short-term annual or cash-rent agreement.

Table 5.9 Yield trend sensitivity results

Scenario	Annual Yield Growth	NPV @ Yr 15	UD Break-Even	Disc. Break-Even
No trend (base case)	0% corn / 0% soy	+$1,514	Year 10	Year 15
Trend-Low	+0.5% corn / +0.3% soy	+$5,028	Year 10	Year 15
Trend-High	+1.0% corn / +0.7% soy	+$8,846	Year 10	Year 15

5.9 Summary of Sensitivity Results

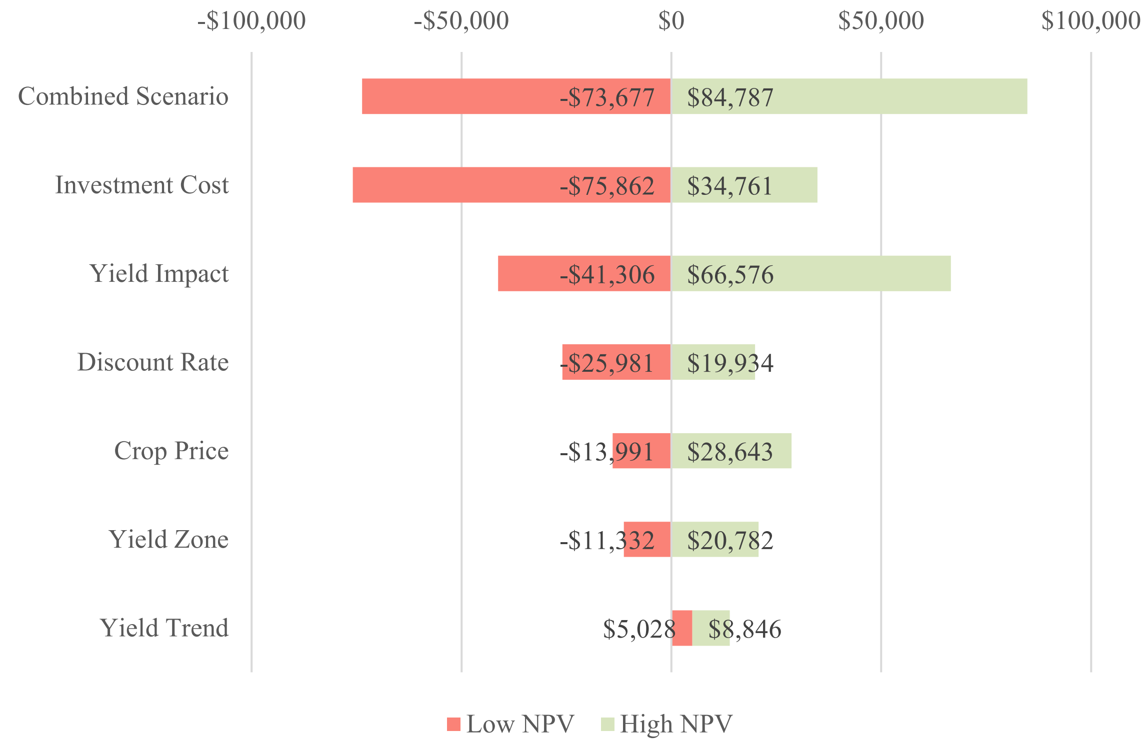
After evaluating the 20 individual sensitivity scenarios in this analysis, 13 produce a positive NPV at Year 15 and 7 produced a negative NPV. The investment is then considered as viable under most scenarios examined, including both expected and optimistic combined scenarios as well as both yield trend scenarios. The negative NPV outcomes are not limited to extreme or implausible conditions; they do include medium installation costs with low yield response, medium installation costs and low commodity prices and medium all-variable conditions with a 10 percent discount rate. The narrow margin of the base case result of $1,514 still implies that a modest adverse deviation in any single variable is sufficient to shift the outcome to negative.

Across all sensitivity scenarios evaluated, the two variables that produced the widest NPV ranges were the installation cost with a range of $110,623 between the low and high scenario, as well as the yield impact with a range of $107,882. These two variables are also the ones most amenable to pre-investment assessment. The former being through competitive bidding and design planning, and the latter through soil survey review, field drainage class evaluation, and a consultation of agronomic research on the expected yield increase that could happen across a field plan. The findings suggest that laborious pre-investment analysis focused on these two variables offer the greatest potential to reduce financial uncertainty for the tenant drainage investor. Table 5.10 provides a consolidated summary of all sensitivity results. Figure 5.3 graphs the low and high NPV of each scenario variable. The only one that produces a positive NPV in both low and high variables was the trend yield scenario since the median variable which the base case scenario was already a positive NPV of $1,514.

Table 5.10 Summary of all sensitivity results at Year 15

Category	Scenario	NPV @ Yr 15	Viable at Yr 15?	Disc. Break-Even
Investment Cost	Low ($775/ac)	+$34,761	Yes	Year 10
	Medium ($1,050/ac)	+$1,514	Yes	Year 15
	High ($1,690/ac)	−$75,862	No	None
Yield Impact	Low (10%/4%)	−$41,306	No	None
	Medium (15%/6%)	+$1,514	Yes	Year 15
	High (22%/10%)	+$66,576	Yes	Year 9
Yield Zone	Low (165/48 bu)	−$11,332	No	Year 19
	Medium (183/53 bu)	+$1,514	Yes	Year 15
	High (210/61 bu)	+$20,782	Yes	Year 13
Discount Rate	Low (4%)	+$19,934	Yes	Year 13
	Medium (6%)	+$1,514	Yes	Year 15
	High (10%)	−$25,981	No	None
Crop Price	Low ($4.10/$10.00)	−$13,991	No	Year 19
	Medium ($4.65/$11.50)	+$1,514	Yes	Year 15
	High ($5.65/$13.75)	+$28,643	Yes	Year 11
Combined	Adverse	−$73,677	No	None
	Expected	+$1,514	Yes	Year 15
	Optimistic	+$84,787	Yes	Year 7
Yield Trend	Trend-Low (0.5%/0.3%)	+$5,028	Yes	Year 15
	Trend-High (1.0%/0.7%)	+$8,846	Yes	Year 15

Figure 5.3 Sensitivity analysis – NPV at Year 15 by variable ($)



5.10 Buy-Back and Unrecovered Investment Analysis

One of the distinctive features of subsurface drainage investment made by tenant operators on rented farmland is the unbalanced exposure to lease termination risk. When a tenant invests capital in a permanent improvement to leased land, the asset becomes physically attached to the real property and cannot be recovered or relocated if the lease is terminated. If termination occurs before the investment has been financially recovered, whether this is through non-renewal, sale of property or dispute, the tenant sustains a capital loss that is not compensated in any other way. Quantifying this unrecovered value by year of potential termination provides the empirical foundation for evaluating contractual mechanisms used to reduce this exposure.

Table 5.11 presents the unrecovered investment at each year of potential lease termination under the expected scenario. Two values are reported with one being the undiscounted unrecovered balance, which represents the nominal net investment not yet offset by cumulative cash flows, and the second is the discounted unrecovered balance which is the cumulative NPV deficit. This NPV deficit is the amount by which the present value of cash flows received to date falls short of the net investment outlay. At Year 6, a potential point for renegotiation of the lease, for example, calculates the undiscounted unrecovered balance of $50,586 and the discounted balance is $63,354. The discounted figure is higher in early years because the discounting process reduces the present value of future cash flows that have been foregone, making the economic cost of early termination greater than its nominal cost.

The values in Table 5.11 were derived by applying the unrecovered investment formula described in Section 4.4 to the base case cash flow stream. At each year, the discounted unrecovered balance represents the net initial outlay less the sum of all discounted cash flows received through that year. The undiscounted balance is calculated identically using nominal rather than discounted cash flows.

Table 5.11 Unrecovered investment by year of lease termination – base case scenario

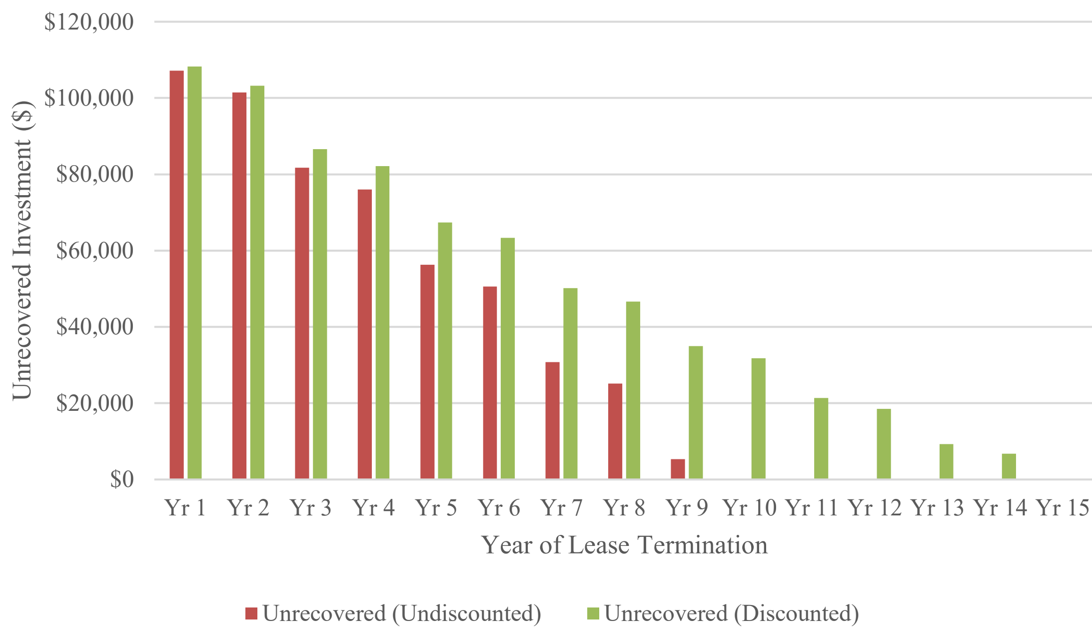
Year	Cumul. Undiscounted CF	Unrecovered (UD)	Cumulative NPV	Unrecovered (Disc.)
0	−$126,945	$126,945	−$126,945	$126,945
1	−$107,160	$107,160	−$108,280	$108,280
2	−$101,492	$101,492	−$103,235	$103,235
3	−$81,707	$81,707	−$86,624	$86,624
4	−$76,039	$76,039	−$82,134	$82,134
5	−$56,255	$56,255	−$67,350	$67,350
6	−$50,586	$50,586	−$63,354	$63,354
7	−$30,802	$30,802	−$50,196	$50,196
8	−$25,133	$25,133	−$46,640	$46,640
9	−$5,349	$5,349	−$34,929	$34,929
10	+$320	Recovered	−$31,764	$31,764
11	+$20,104	Recovered	−$21,342	$21,342
12	+$25,773	Recovered	−$18,525	$18,525
13	+$45,557	Recovered	−$9,249	$9,249
14	+$51,226	Recovered	−$6,742	$6,742
15	+$71,010	Recovered	+$1,514	Recovered

The undiscounted break-even at Year 10 and the discounted break even at Year 15 define two distinct thresholds of financial risk and exposure. Between Year 0 and Year 9, the tenant has not recovered either the nominal or economic investment, and any lease termination represents a full or substantial capital loss. Between Year 10 and Year 14, the nominal investment has been recovered but the present value of capital invested has not and termination of the lease in this window produces a net economic loss even though the tenant has nominally received more in cash flows than was originally invested. Only at Year 15 and beyond has the investment fully recovered on both measures under expected conditions.

The discounted unrecovered balance is the more appropriate measure for compensation purposes in most contexts, because it reflects the actual economic cost to the tenant of the foregone investment opportunity. A buy-back clause constructed around the undiscounted balance would undercompensate the tenant in early termination years by failing to account for the time value of the capital invested and not recovered. Equally, the discounted column provides a defensible, year-specific figure that both parties can verify using model inputs disclosed in advance. The practical structure and enforceability of such clauses is discussed later in Chapter VI. A tenant and landowner should still consult legal advice to structure a lease agreement that protects both interested parties.

The compensation values in Table 5.11 provide a measurable basis for the practical lease instrument designed to protect tenant capital during the investment recovery period. The discounted unrecovered balance is the recommended measure for compensation purposes, as it accounts for the time value of capital invested. There is a case that a tenant and landowner may want to look at the undiscounted balance which is also presented and ultimately the decision between both parties to decide on which to use. The discounted unrecovered balance also better reflects the necessary amount of money needed if in the event the tenant was looking at financing the project instead of using working capital to fund the project. After Year 15, the subsurface drainage investment has fully recovered its economic cost under expected conditions, and no compensation obligation exists, the subsurface infrastructure at that point transfers fully to the benefit of the landowner with no remaining financial claim by the tenant. The structure and language of a model-based lease is laid out with these values is developed in Chapter VI.

Figure 5.4 Unrecovered investment by year of lease termination – base case scenario



CHAPTER VI: APPLIED LEASE FRAMEWORK

The results of the NPV analysis presented in Chapter V establish that subsurface drainage investment by tenant operators on rented cropland in financially viable under expected conditions, but it is done with narrow margins by Year 15 with significant sensitivity to variables that cannot be fully known at the time of the investment is made. Of just as much importance to the viability question is the distribution of financial risk across the lease relationship. In this entire framework, the tenant bears the full capital cost of a permanent improvement to land they do not own, and no portion of that investment is recoverable if the lease is terminated before the investment has paid out. This chapter will look at developing a practical lease framework, a model-based compensation exhibit, that quantifies the tenant's unrecovered investment at each year of potential termination and establishes a pre-agreed basis for compensation should early termination occur.

The framework is intended as a tool a tenant operator can use and introduce at lease negotiations and attach as a signed exhibit to the cash rent lease agreement. Its purpose is not to make drainage investment risk-free, but to eliminate the specific risk that arises from the lapse of any agreed-to compensation mechanism. The framework developed is derived directly from the NPV model presented in this thesis. The compensation exhibit created in this chapter follows taking the quantitative results of Chapter V into a format that is usable by practitioners without requiring them to replicate the underlying model; it is presented as an economic tool. Tenants and landlords seeking to execute an agreement of this type should involve legal counsel familiar with their own states lease laws to ensure the exhibit is enforceable as intended.

6.1 Lease Structure Assumptions

The 15-year horizon is grounded in the IRS MACRS (Modified Accelerated Cost Recovery System) classification of the subsurface drainage as a 15-year depreciable asset and is consistent with the NPV analysis horizon used throughout this thesis. As demonstrated in Chapter IV, the capital investment into subsurface drainage achieves a positive net present value at the end of Year 15 under expected conditions. This makes both the analytical and contractual endpoint of 15-years tie out well from a compensation obligation for the tenant investor.

In practicality, cash rent lease agreements are rarely structured as a 15-year fixed term contract unless doing some sort of contract for deed situation. The more common pattern is shorter-term agreements that can be as few as annually or more commonly three- or four-year agreements with renegotiations at the end of these agreements to allow for review of the farm economy conditions (Leibold & Stoneberg, 2024). This thesis assumes a structure that accommodates that reality while preserving the integrity of the compensation schedule. The proposed framework assumes a base lease relationship with an intended 15-year duration, within which cash rent terms are reviewed and renegotiated at 3-year intervals. These 3-year updates may result in rent increases, decreases or no change, depending on commodity prices, land values and the tenant and landowner's assessment of current and forecasted market conditions. The compensation schedule established at the time of installation remains in effect across all such renegotiation updates and run continuously from the start of the contract. A lease renewal at Year 6 for example, does not restart the compensation clock and the schedule would continue with Year 7 values as if the relationship had been uninterrupted.

This continuity provision is one of the framework's most important structural features and guarantees a large portion of the investment made by the tenant is not lost during one of these times. By specifying that the compensation obligation survives lease renewal and attaches to the land rather than to any individual lease term, the framework protects the tenant's investment across the full recovery period regardless of how many lease agreements are executed during that time.

6.2 Triggering Conditions

The compensation schedule established by this framework is triggered by two categories of events, each reflecting a situation in which the tenant's lease is ended by events outside the tenant's control or choice. The first triggered condition is the sale of the property by the landlord to another party who does not, as a condition of purchase, formally assume the compensation exhibit in writing. Agriculture land sales occur regularly in the United States, and a tenant who has invested capital in subsurface drainage improvements should not bear the cost of the landowner's liquidity event. If the incoming owner assumes the exhibit and continues to rent the ground to the tenant, no compensation is due at the time of sale and the arrangement continues with the new owner. If the incoming owner does not assume the exhibit, the compensation obligation falls to the selling landlord at the time of closing.

A second triggering condition is the failure of the parties to reach agreement on lease extension or renewal, resulting in the termination of the relationship the tenant and landowner share. This condition is intentionally defined broadly to capture the range of the situations in which a tenant is forced to exit the lease agreement. This may include cases where the landlord sets cash rent terms at levels the tenant cannot economically accept, or where the landlord elects to farm the ground personally, or finally where the relationship between the parties deteriorates to the point that the continuation is not feasible. It does not apply when the tenant voluntarily elects to not renew at the expiration of an agreed term and the landlord was willing to continue the arrangement. The distinction between a landlord-driven and a tenant-driven exit is one the parties should address explicitly in the exhibit language and have legal counsel involved in drafting verbiage ensuring triggering conditions are enforceable under the proper state law.

6.3 The Compensation Schedule as a Lease Exhibit

The compensation schedule is constructed by entering the tenant's actual installation cost into the base case of the NPV model and recording the discounted unrecovered investment at each lease year from Year 1 through Year 15. The tenant will make model assumptions which include yield increase, base crop prices, discount rate and the tax treatment which will all be documented within the exhibit and acknowledged by both parties at signing. By documenting all of this, it serves as two purposes: it provides transparency about how the compensation values were derived and it creates a shared factual basis against which any future dispute about the appropriateness of the schedule can be evaluated.

The exhibit presents both the undiscounted and discounted unrecovered investment value at each year. The discounted measure has been the recommended compensation basis throughout this thesis because it reflects the actual economic cost to the tenant of the unrecovered capital, accounting for the time value of money over the investment period. Although the undiscounted measure has been discussed as an alternative and a simpler way to calculate in the model, it underestimates the tenant's economic loss in early years of the schedule when the discounting penalty is the greatest. The choice of compensation basis is a matter for negotiation between the tenant and landlord, but the framework is designed to support either approach. Both the undiscounted and discounted unrecovered investment values presented in this framework are stated on a post-tax basis, reflecting the net initial outlay after the Section 179 deduction has been applied.

At Year 15, the compensation obligation extinguishes entirely. The drainage infrastructure, having hopefully generated sufficient cumulative cash flow to recover the tenant's net investment, transfers fully to the benefit of the land. The landowner assumes complete ownership of the improvement with no remaining financial obligation to the tenant. Having a clean endpoint is an important feature of the framework for landlord acceptance. It is not meant to be a perpetual encumbrance on the property but a time-limited annual declining obligation that decreases to zero across the 15-year recovery period. Table 6.1 presents the sample compensation exhibit structures for attachment to a cash rent lease agreement, calculated with the base case values derived from the Chapter IV analysis.

Table 6.1 Sample lease Exhibit A — tenant drainage investment compensation schedule

Lease year	Unrecovered (undiscounted)	Unrecovered (discounted)	Recommended compensation
Year 1	$107,160	$108,280	$108,280
Year 2	$101,492	$103,235	$103,235
Year 3	$81,707	$86,624	$86,624
Year 4	$76,039	$82,134	$82,134
Year 5	$56,255	$67,350	$67,350
Year 6	$50,586	$63,354	$63,354
Year 7	$30,802	$50,196	$50,196
Year 8	$25,133	$46,640	$46,640
Year 9	$5,349	$34,929	$34,929
Year 10	Recovered	$31,764	$31,764
Year 11	Recovered	$21,342	$21,342
Year 12	Recovered	$18,525	$18,525
Year 13	Recovered	$9,249	$9,249
Year 14	Recovered	$6,742	$6,742
Year 15	Recovered	Recovered	None owed

Note: All values based on base case model assumptions. Tenants with different installation costs, yield assumptions, or discount rates should substitute their own values using the model provided in Appendix. Recommended compensation column reflects discounted unrecovered investment. Both parties should confirm the appropriate compensation column in Exhibit language at signing.

6.4 Practical Considerations for Implementation

The practical viability of this framework depends substantially on the landlord relationship and the willingness and understanding to sign a compensation exhibit at lease execution. In the current environment of cash rent leasing as well as some distance of landowners to the farmland investment they hold, meaning two or three generations of having a farmer in their family, some landlords may initially resist a framework that imposes a financial obligation in the event of early termination. The most effective argument for landlord acceptance is one grounded in mutual benefit where the tenant has contractual protection for the drainage investment which is paid back through time of improved yields and productivity. In turn, this will provide the landowner an increase in land value and history of higher productivity throughout the 15-year compensation schedule which ends at Year 15 with that investment owned fully by the landlord. With this framework, the exhibit is not a restriction on the landlord but an incentive structure that encourages permanent capital investment in the land.

The 3-year rent update provision addressed a related concern that landlords, and tenants, view a 15-year fixed type arrangement as too restrictive given the time at when the lease and compensation schedule are agreed to. If done in either a higher or lower cycle of commodity prices and world economy, could greatly benefit or hurt either party one way or the other. The compensation schedule operates independently of the rent negotiation – it does not set rent, constrain rent, or in any way prevent the landlord from seeking market returns on the land. Its only effect is to establish a pre-agreed basis for compensation in the specific event of early termination. Separating these two components clearly in the exhibit language is important for landlord acceptance and for the practical function of the framework.

From the tenant who is willing to make the investment on leased ground, the framework provides meaningful protection only if the lease relationship has a realistic prospect of continuity through the investment recovery period. A tenant who installs drainage on land leased from an owner who may be known to actively considering a sale or the relationship between the landlord and tenant is fragile, faces a different risk scenario than one investing under a long-standing, stable relationship. The compensation schedule reduces but does not eliminate exit risk. Tenants should assess the stability of the landlord relationship as part of the investment decision itself, recognizing and realizing that the framework's protection is only as valuable as the landlord's willingness and financial ability to honor the compensation obligation if triggered. Finally, and most importantly, this framework is grounded in rigorous financial analysis, it is presented as an economic instrument rather than a legal document. The tenant and landlord should both involve qualified legal counsel familiar with their state's lease law before executing an exhibit of this type as part of a binding agreement. Appendix A provides a blank exhibit template that any tenant can populate with their own investment values.

6.5 Installment-Based Compensation as an Alternative Structure

The lump-sum schedule presented in Section 6.3 addresses the tenant's unrecovered investment through a single payment made at the point the triggering condition is met. A second structural option is to amortize that same discounted balance as a series of equal annual installment payments spread across the years remaining in the 15-year lease period. Rather than requiring the landowner or successor tenant to produce the full unrecovered balance at one time, the installment approach spreads the obligation over the remaining lease term. This reduces the immediate financial burden at the point of triggering while still ensuring the tenant is compensated for the full economic value of the unrecovered capital.

This structure also addresses a risk that exists in any single-payment buyout arrangements. When a tenant knows a defined lump sum is available upon exit, there is a financial incentive to trigger the compensation rather than continue farming through the recovery period. The installment approach removes that incentive and puts compensation tied to ongoing payment stream that runs through the remainder of the lease, so the tenant only receives full recovery if the payments run their course. There is no accelerated payout available at any single trigger point, which aligns the tenant's financial interest with continued occupancy rather than early exit. For the landowner or successor tenant responsible for the payments, annual installments are also more practically manageable than a large lump sum at closing, particularly in a property sale scenario where a new owner may be absorbing significant acquisition costs at the same time.

The annual installment payment is calculated using a standard loan amortization formula. At the trigger year, the remaining discounted NPV balance, which is identical to the Recommended Compensation column in Table 6.1, is treated as the principal balance. That balance is amortized over the number of lease years remaining using the 6 percent discount rate applied throughout this thesis, keeping the installment schedule internally consistent with the same financial logic used to derive the unrecovered balances in Chapter V. Table 6.2 presents the resulting annual payment per acre and total annual field payment for each trigger year under base case assumptions.

The annual payment per acre does not decline uniformly from year to year. This reflects the alternating corn-soybean cash flow structure of the underlying model, where corn years retire a greater portion of the unrecovered balance than soybean years, producing an uneven step-down in the principal at each trigger point. The values are internally consistent with the NPV model and directly traceable to the cumulative discounted cash flows reported in Table 5.2.

Table 6.2 Installment-based annual compensation payment by trigger year

Lease Year	Remaining Lease Years	Discounted Balance	Balance ($/acre)	Annual Payment ($/acre)	Annual Field Payment
Year 1	14	$108,280	$698.58	$75.16	$11,649
Year 2	13	$103,235	$666.04	$75.24	$11,661
Year 3	12	$86,624	$558.86	$66.66	$10,332
Year 4	11	$82,134	$529.90	$67.19	$10,414
Year 5	10	$67,350	$434.52	$59.04	$9,151
Year 6	9	$63,354	$408.74	$60.09	$9,314
Year 7	8	$50,196	$323.85	$52.15	$8,083
Year 8	7	$46,640	$300.90	$53.90	$8,355
Year 9	6	$34,929	$225.35	$45.83	$7,103
Year 10	5	$31,764	$204.93	$48.65	$7,541
Year 11	4	$21,342	$137.69	$39.74	$6,159
Year 12	3	$18,525	$119.51	$44.71	$6,930
Year 13	2	$9,249	$59.67	$32.55	$5,045
Year 14	1	$6,742	$43.50	$46.11	$7,146
Year 15	0	—	—	—	None owed — infrastructure transfers to land

Note: Discounted balance is drawn from the Recommended Compensation column in Table 6.1. Annual payment is calculated using a standard amortization formula at 6% interest applied to the remaining discounted NPV balance over the remaining lease years. No compensation obligation exists at or after Year 15.

The lump-sum and installment structures are not mutually exclusive. Parties may choose to include both options within the exhibit language, with the selection made at the time of the triggering event based on the financial position of both parties. A tenant who needs immediate capital recovery may prefer the lump sum. A landowner or successor tenant managing cash flow may prefer the installment arrangement. Including both as named options in the exhibit at signing preserves flexibility without requiring renegotiation at the time of termination, which is often an adversarial environment. As with all the components of this framework, any installment payment obligation should be reviewed by qualified legal counsel to confirm enforceability under the applicable state's lease law before the exhibit is executed.

CHAPTER VII: CONCLUSIONS & LIMITATIONS

This thesis addressed the four objectives stated in Chapter I: evaluating the net present value of subsurface drainage investment on rented farmland from the tenant's perspective, conducting a break-even analysis to identify the minimum lease duration required for cost recovery, developing a buy-back model to address unrecovered investment value in the event of an early lease termination, and conduct sensitivity analysis across key agronomical and financial variables.

Using NPV, the base case model produces a marginally positive NPV of $1,514 at the end of the year 15-year MACRS planning horizon. This characterizes the investment as economically viable under expected conditions, while simultaneously confirming that the margin is narrow and sensitive to changes in the individual inputs. The break-even analysis identified two distinct recovery thresholds. For an undiscounted cumulative cash flow, the investment has a recovery at Year 10, while the discounted NPV-based break-even does not occur until Year 15. The five-year gap between these measures is a practical finding; a tenant who evaluates the investment only on a cash-flow basis may conclude the investment has paid off at Year 10. Whereas with the discounted cash flow, the economic cost of capital remains unrecovered for an additional five years which has a direct implication for lease termination risk.

The sensitivity analysis demonstrates that the investment outcome is the most responsive to installation cost and yield response, which together produce the widest NPV ranges of any of the variables tested. Thirteen of the twenty scenarios produce a positive NPV at Year 15, including both the expected and optimistic combined scenarios and both yield trend scenarios. Seven produced a negative NPV, including the high installation cost scenario, the low yield response scenario and the adverse combined scenario. The adverse combination which included low base yields, low drainage response, high discount rate and low commodity prices produced a 15-year NPV of -$73,677 with no discounted break-even within the model horizon. This demonstrated the severity of the downside risk when multiple unfavorable conditions occur simultaneously.

The buy-back and unrecovered investment analysis of Chapter V and the applied lease framework of Chapter VI together establish the original applied contribution of this thesis. By using model-derived NPV values into a year-specific compensation schedule designed for attachment to a cash lease agreement, this thesis provides a practical decision tool that directly addressed the principal financial risk facing a tenant considering making a drainage investment of this size laid out in the base case scenario with the possibility of capital loss due to an early lease termination. The framework establishes a 15-year compensation period with 3-year rent review intervals, triggered by landlord-initiated termination or property sale without exhibit assumption, and removing the compensation completely at Year 15 with the drainage investment transferring permanently to the benefit of the land.

7.1 Connection to Literature

The conclusions of this thesis are largely consistent with the existing literature on drainage investment economics while extending it into areas not previously addressed. Prior analyses including the Iowa State Extension work of Leibold, Johanns, and Hofstrand (2023) and the related University of Minnesota Extension guidance, have generally evaluated drainage investment from a landowner perspective without isolating the tenant-specific exposure that arises from farm lease rental agreements. This thesis addresses that gap directly, indicating that the tenant context introduces a materially different risk profile, particularly with respect to lease duration, early termination risk, and the absence of contractual protections in a standard cash rent agreement.

The agronomic assumptions underlying the financial model are consistent with the peer reviewed literature. The base case corn yield gain of 15 percent falls within the 12 to 17 percent range documented from Purdue University, as well as the 6 percent yield gain from soybeans reported by Mourtzinis et al. (2021) which indicated a gain between 4 to 8 percent. The precipitation-dependent variability documented in numerous articles including from The Ohio State University (Schwab,et al., 1975, 1985), University of Minnesota (Pease, 2026), and Purdue University (Rui, Goller, & Kladivko, 2024) reinforce the model's use of a constant average yield gain as a long-run simplification rather than a precise annual forecast. The compensation framework of Chapter VI represents the most novel contribution relative to the literature. No prior published work identified in the review develops a model-derived, year-specific compensation schedule intended for direct use as a lease exhibit in a tenant-landlord negotiation over sub surface drainage investment.

7.2 Limitations

There are several limitations of this analysis that should be acknowledged. First, the model assumes a constant grain price received as well as a constant annual yield gain from subsurface drainage across all 15 years of the planning horizon. In all the articles reviewed, the drainage benefits are highly dependent on the annual precipitation as documented by UMN Crookston research (Pease, 2026) and the long-term Ohio drainage studies (Schwab, Fausey, Desmond, & Holman, 1985). In dry years the amount of benefit received from sub surface drainage may be minimal or negative as found by a three-year study on spring wheat and soybeans by Wiersma, et al., (2010); in wet years, they tend to be the largest and even towards the higher end of yield gain reported. The model's fixed average yield gain reflects expected long-run performance but does not capture the sequence risk of dry years occurring early in the investment period when unrecovered capital is at its highest. As well as shown in Figure 3.2 and Figure 3.4, the constant price received by the tenant farmer is not at all reality that occurs. This is why a 15-year rolling price average was used for both corn and soybeans for this framework.

Secondly, all results are calculated from a single 155-acre field modeled with medium-productivity Minnesota soils. Results may not generalize to smaller fields where per-acre fixed costs (like electricity needed for a lift station, flat-rate contract fees for setup/installation, etc) are proportionally higher, to large-scale operations where economies of scale may differ or to fields in productivity zones other than those captured in the yield zone sensitivity analysis. Third, the analysis relies entirely on published cost estimates and market data rather than primary farm observations. Tenants applying this framework to their own decisions should substitute their actual installation quotes, yield expectations, and current market conditions for the base case parameters. Fourth, the lease framework of Chapter VI is an economic instrument. Its enforceability under each individual's state laws has not been tested and both parties should involve qualified legal counsel before executing any exhibit based on this framework. Finally, while the $775 per acre low-cost scenario partially reflects self-installation economics through a raw material plus labor cost construction, a complete analysis of tenant-owned tile installation equipment, including the capital cost, multi-field utilization, and operational expenses was beyond the scope of this study (NDSU, 2024).

7.3 Directions for Future Research

There are several directions for future research that are suggested by the findings and limitations of this thesis. The most significant methodological extension would be incorporating stochastic modeling to replace the constant yield gain and commodity price assumptions with probability distributions, enabling Monte Carlo simulation to produce a full distribution of NPV outcomes and quantify the probability of investment recovery within specified lease durations. This would directly address the primary limitation of the current model and its inability to capture year-to-year variability in drainage benefits and commodity prices. From a policy and legal perspective, future research could evaluate the enforceability of the compensation exhibit developed in Chapter VI under various state's agriculture lease law, assessing whether current statutory frameworks support such provisions or whether changes would be needed to facilitate adoption. Another consideration that may want to be examined is the additional financial cost of an early-termination and the capital gains tax that would be due from the tenant to the IRS. This tax could be calculated back into the cumulative NPV of the model with an increase of the agreed upon capital gains tax rate. Finally, the compensation framework developed here could be extended to other categories of tenant-financed permanent improvements like irrigation infrastructure where capital recovery timeliness and lease termination exposure present similar financial risks for tenant operators.

7.4 Concluding Statement

Subsurface drainage investment represents one of the most significant capital decisions, aside from purchasing farmland directly, available to tenant operators seeking to improve the productivity of rented farmland. As discussed in Chapter I, rising land values across Minnesota and the broader Upper Midwest have reduced ownership opportunities for farm operators, concentrating the incentive to invest in land improvements among those who farm ground they do not own. This thesis has evaluated whether that investment is financially justified and, critically, what mechanisms exist to protect the investor when the lease ends before the investment has paid out fully.

The main finding is that subsurface drainage investment on rented cropland is economically viable under expected conditions, achieving marginal positive net present value at the end of the IRS-defined 15-year asset life. The margin of error is narrow and sensitive to variables that are least predictable at the time of the investment is made. Installation cost and yield response are the two factors that most determine the outcome, and both are substantially knowable before the first tile is placed into the ground. Tenants who invest in agronomic pre-assessment and competitive bid solicitation before committing capital are reducing the financial uncertainty of the investment, not just the physical drainage risk.

The buy-back and lease exhibit framework developed in Chapters V and VI, and operationalized in Appendix A, extends the analysis to be used in practicality. By translating model-derived NPV values into a year-specific, pre-agreed compensation schedule that both parties can review and sign at lease execution, this thesis provides a practical tool that reduces the financial risk inherent in tenant drainage investment. The tenant who understands the discounted break-even at Year 15, recognizes the economic exposure that remains in Year 10 through 14 after nominal recovery, and has secured a compensation provision before installation is in a fundamentally more defensible position than the tenant who invests without any contractual protection. The difference between knowing the risk and having a framework to address it is the applied contribution of this work.

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APPENDIX A

A.1 Purpose

This appendix provides two resources derived from the financial model described in Chapter III and IV. Section A.2 presents the base case model input parameters in a consolidated reference format. Section A.3 presents a compensation schedule template populated with the base case values from Table 6.1, formatted for use as an exhibit attachment to a cash rent lease agreement. Section 6.5 introduces an installment-based alternative to the lump-sum schedule; the exhibit template in A.3 may be adapted to reflect whichever structure the parties elect. Tenants whose installation costs, yield assumptions, or discount rates differ from the base case should recalculate the compensation values using the model structure described in Chapter III and IV before completing Section A.3.

A.2 Base Case Model Parameter Reference

Table A.1. Base case input parameters — all values used to generate results in Chapters V and VI

PARAMETER	BASE CASE VALUE	SOURCE / NOTE
Farm and Investment		
Farm size	**155 acres**	Modeled unit; representative Upper Midwest field scale
Investment cost per acre	**$1,050**	Average of three commercial quotes, 60-ft lateral spacing
Total investment	**$162,750**	155 acres × $1,050/acre
Federal tax rate (Sec. 179)	**22%**	IRS 2024 marginal bracket; Schedule F operator profile
Tax benefit — Year 0	**$35,805**	22% × $162,750; one-time Section 179 deduction
Net initial outlay	**$126,945**	Total investment less tax benefit
Yield Assumptions		
Base corn yield	**183 bu/acre**	Medium productivity zone; MN state average reference
Base soybean yield	**53 bu/acre**	Medium productivity zone; MN state average reference
Corn yield gain from drainage	**15%**	Rui, Goller & Kladivko (2024); mid-range of 12–17%
Soybean yield gain from drainage	**6%**	Mourtzinis et al. (2021); mid-range of 4–8%
Crop rotation	**Corn–soybean**	Annual alternating; odd years = corn, even = soybean
Prices, Discount Rate, and Planning Horizon		
Corn price	**$4.65/bu**	Average 10 and 15-year trailing average; USDA NASS prices received
Soybean price	**$11.50/bu**	Average 10 and 15-year trailing average; USDA NASS prices received
Discount rate	**6%**	Opportunity cost of capital for tenant operators
Planning horizon	**15 years**	IRS MACRS 15-year property classification for subsurface drainage
Annual Incremental Cash Flows		
Corn year annual gain	**$19,785**	155 ac × (183 bu × 15%) × $4.65/bu
Soybean year annual gain	**$5,668**	155 ac × (53 bu × 6%) × $11.50/bu

Note. All sensitivity analyses in Chapter V hold non-tested variables at the base case values shown above. Tax benefit calculated as 22% × total installation cost, applied as a one-time Year 0 Section 179 deduction.

A.3 Compensation Schedule Template

Exhibit A — Subsurface Drainage Investment Compensation Schedule
Attachment to Cash Rent Lease Agreement

Property and Parties

Tenant (installing party)		**Landlord**	
Property / legal description		**County, state**	
Date of installation		**Lease start date**	

Investment Summary

Total acres (N)		**Cost per acre (I)**		**Gross investment**	
Tax rate — Sec. 179		**Tax benefit — Year 0**		**Net outlay after tax**	
Corn yield gain assumed		**Soybean yield gain assumed**		**Discount rate applied**	

Annual Compensation Schedule

Table A.2. Unrecovered investment by year of lease termination — blank table

LEASE YEAR	CROP RAISED	CUMUL. UNDISCOUNTED CF	UNRECOVERED UNDISCOUNTED	UNRECOVERED DISCOUNTED	AGREED COMPENSATION
Year 1					$______________
Year 2					$______________
Year 3					$______________
Year 4					$______________
Year 5					$______________
Year 6					$______________
Year 7					$______________
Year 8					$______________
Year 9					$______________
Year 10					$______________
Year 11					$______________
Year 12					$______________
Year 13					$______________
Year 14					$______________
Year 15					

Compensation basis selected: ☐ Discounted lump-sum (recommended) ☐ Undiscounted lump-sum ☐ Installment payments (see Table 6.2)

After Year 15, no compensation is owed. The subsurface drainage infrastructure transfers fully to the benefit of the land.

Signatures

Tenant: ______________________________ **Date:** ______________________________

Signature

Landlord: ______________________________ **Date:** ______________________________

Signature

This document is Exhibit A to the Cash Rent Lease Agreement dated _____________ between the parties named above.