In-field Management Practices

Drainage Water Management: Controlled Drainage or shallow drainage

The process of managing water discharges from surface and/or subsurface agricultural drainage systems with artificial drainage structures; the purpose of these systems is to actively manage the water table. Drainage water management is applicable to agricultural lands with surface or subsurface agricultural drainage systems that are adapted to allow management of drainage discharges.

As described in Frankenberger (2014) **controlled drainage** involves placing simple water control structures at various locations in a tiled system to raise the water elevation at certain points in a growing season (see figure 1 below, table 1). This effectively raises the water table and decreases the drained depth of the field. Reductions in nitrate losses from fields may occur primarily due to reductions in the volume of water drained and by enhancing the anaerobic conditions for denitrification in the soil; published research has noted reductions in annual nitrate load in drain flow has ranged from about 15% to 75% (Frankenberger 2014; though it has been argued that nitrate reductions are associated more with shallow ground water and less so with tile outflow). In certain situations, it has been noted that controlled drainage has the potential to improve crop yields by making more water available to plants at critical points in the growing season. Controlled drainage systems (including shallow drainage; see below) require relatively flat fields with 0.5%-1% grades. Such systems can be installed on new tile or retro-fitted to existing tile systems.

Shallow drainage systems reduce drainage flow volume by raising tiles to a depth of 2.5 to 3 feet (typical subsurface drainage depth in the Midwest is ~ 4 to 4.5 feet). Adjusting tile depth, reduces the drainable soil volume by 25 percent. As such, the water table is higher throughout the year resulting in a larger anaerobic zone that promotes the conditions for denitrification. Shallow drainage systems may lead to similar outcomes (in terms of nitrate reduction in shallow ground water and crop yields) yet they do not provide the same flexibility as controlled drainage does and tend to be more expensive due to the need for expanded tile coverage.

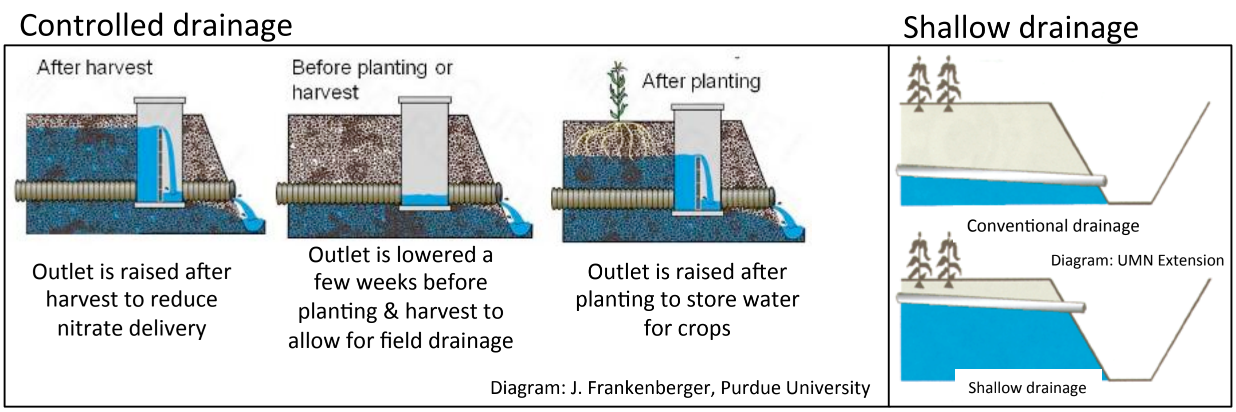

Figure 1. Generalized diagram showing general processes involved with both controlled drainage and shallow drainage practices. Controlled drainage diagram (left had side): J. Frankenberger, Purdue University, 2014; Shallow drainage diagram (right hand side): Bushman and Sands, 2012.

Table 1. General practice characteristics for drainage water management as used in Iowa and basic cost parameters. This practice can be cost shared with the NRCS via the EQIP drainage water management program.

Best Management Practice (NRCS practice standard code)	General use of the BMP: For the most part this information comes directly from NRCS practice standard information.	Basic Cost Parameters: Varies considerably from site to site and depends on initial conditions, hydrology, soil, crop, practice design, and management characteristics.
Drainage water Management (Practice code 554) [1]	Reduce nutrient, pathogen, and/or pesticide loading from drainage systems into downstream receiving waters Improve productivity, health, and vigor of plants Reduce oxidation of organic matter in soils Reduce wind erosion or particulate matter (dust) emissions Provide seasonal wildlife habitat	Site planning, design, and contractor fees; control and supporting structures; stop log/ gate replacement.

1. NRCS Practice Standard for Bioreactors, Practice Code 554: http://efotg.sc.egov.usda.gov/references/public/IA/Drainage_Water_Management_554_STD_2010_07.pdf

Cost Assessment

The majority of the costs associated with drainage management are associated with site planning, design fees as well as the installation of various control structures. The major cost of controlled drainage is the capital expense of the structures and their installation. The practicable life span of the practice is assumed to be 40 years; at this time the structures themselves would likely need to be replaced. Regarding more long-term costs, the cost of maintenance for this practice includes landowner time to manipulate the control structures; this would vary based on the number of structures, distance between them, and the chosen management intensity.

Table. Average 2016 costs (first year costs and annual costs) for a 20 acre **controlled drainage** system. There is EQIP funding available in Iowa for controlled drainage[1].

First year costs (Design and installation)	$1,656 total or $83 per treated acre
Annualized costs over 20 year lifespan	~ $150 [2]
Annual maintenance costs	$20

1. For a drainage area > 10 acres, 2016 Iowa EQIP will pay at least $3.19 per managed drainage acre.

2. Costs were calculated and annualized using standard discounted cashflow procedures for structural water quality Best Management Practices. For more methodological detail see Tyndall and Roesch, 2014.

Average 2016 costs for **shallow drainage** for a 20 acre system (2.5 foot depth) would cost about $10,000 (or about 38%) more than a tile system working as a 4.5 foot depth due to the increase in total tile coverage.

Table 2. Custom rate costs associated with controlled drainage; a practice for reducing nitrate loads in drainage water in Iowa. Costs presented in 2016 dollars. All data updated from Christianson et al. 2013.

Cost Activities [1]/ items	Year(s) cost incurred	Range of costs (units)	Mean price (drainage ac)	Notes
Structure cost	0	$25.00 - $100.00 or $50.00 to $200.00 per drainage acre	$75 or $150	New drainage system: 1 structure per 20 acres at $500–$2000 per ea. Includes delivery to site. Existing drainage system: 1 structure per 10 acres at $500–$2000 per ea. As per the NRCS, a typical system would involve a 75 acre field with existing drainage tile lines and 5 installed water control structures.
Design costs[1]	0	$93 - $874/ drainage acre	$346	For new drainage systems but also included as design cost of existing
New tile	0	$0.50 to $3.00 per foot of tile. Plus ~ $50 per inlet	Highly Variable	Depending the type of tiling system and installation, tiling in Iowa can range from ~ $500 to $800 per acre.
Structure installation	0	$0.02 - $0.09 / ft^2 bioreactor area	$2.00	Structure installation: Back hoeing ranges from $35.00 per 125.00 per hour for 8h to treat 150 acres.
Time to raise/ lower gates	0	$0.10 to $0.44/ drainage acre	$0.24	Four hours two to four times a year; labor at $8–$20 per hour, 150 acre treatment area
Stop log/gate replacement	0-20	$0.01 to $0.09/ drainage acre	$0.05	Summation of single sum TPV every eight years for 5 gates per structure at original cost of $14.17–$15.32 per ea. for 15 cm structures, 1 structure per 4 (Existing) or 8.1 (New) ha
For Shallow Drainage	0	$0.50 to $3.00 per foot of tile.	Highly Variable	New tile installations, or when splitting lateral spacing. Depending the type of tiling system and installation, tiling in Iowa can range from ~ $500 to $800 per acre
Impacts on crop yield	0	Variable	--	The impact of controlled drainage or shallow drainage on corn and bean yields is assumed to be negligible.

1. Iowa EQIP Practice Code 130 will cover the cost of a written Drainage Water Management Plan (DWMP). This plan would be developed for relatively flat crop fields with patterned drainage systems, and where a map of the tile system is available. The DWMP will document soil, topographic, and drainage system maps of the site, and identify the number and location of water control structures that are needed to implement drainage water management according to Field Office Technical Guide standards (associated with Practice Code 554).

Important caveat: Please note that the direct and indirect cost of any Best Management Practice can vary considerably from site to site and are largely contingent on: initial conditions, hydrology, soils, crop, practice design, management characteristics and experienced opportunity costs (which can be highly variable). As with all of these types of financial assessments, the costs presented here are simply baseline numbers and are meant to be informative rather than prescriptive.

References

Bushman, L. and G. Sands (2012) Agricultural Drainage Publication Series: Issues and Answers. Available online at: http://www.extension.umn.edu/agriculture/water/agricultural-drainage-publication-series/index.html

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