Tile Water Recycling

WS-01

Figure 1. Water storage reservoir near Gnadenthal, MB (JKW Construction).

What can tile water recycling accomplish?

The objectives of tile water recycling are ***Conserving Water*** and ***Improving Water Quality***. Tile drainage water is captured and stored in a retention structure (e.g. Figure 1), primarily for crop irrigation but may also reused for other purposes such as livestock watering.

Making use of tile drainage water to reduce crop water deficits can increase yields. Recycling tile water for crop irrigation allows the crop to reuse most of the nutrients present in the captured drainage water. Recycling tile water improves water quality by reducing the discharge of nutrients, as well as salts, to downstream water bodies.

Drainage water recycling captures excess water drained from fields, stores the water in a pond or reservoir, and uses the stored water to irrigate crops when there is a water deficit. Relative to conventional tile drainage, drainage water recycling can: (1) increase crop yield, and (2) improve downstream water quality.

Source: Adapted from TransformingDrainage.org

Overview of tile water recycling

Tile water recycling involves several components (Figure 2):

- A constructed water storage reservoir or pond;
- A pump to move the tile water from the tile outlet to the storage;
- A distribution system to use the water which could include irrigation of a crop, water for livestock or other farm needs;
- A water treatment system, if necessary, depending on the proposed use.

When used for irrigation, recycled tile water needs to be stored for several months, because soil moisture deficits generally occur in July and August while most tile flow tends to occur in the spring and late-fall. Similarly, if used to water livestock, storage is required to meet year-round livestock demands.

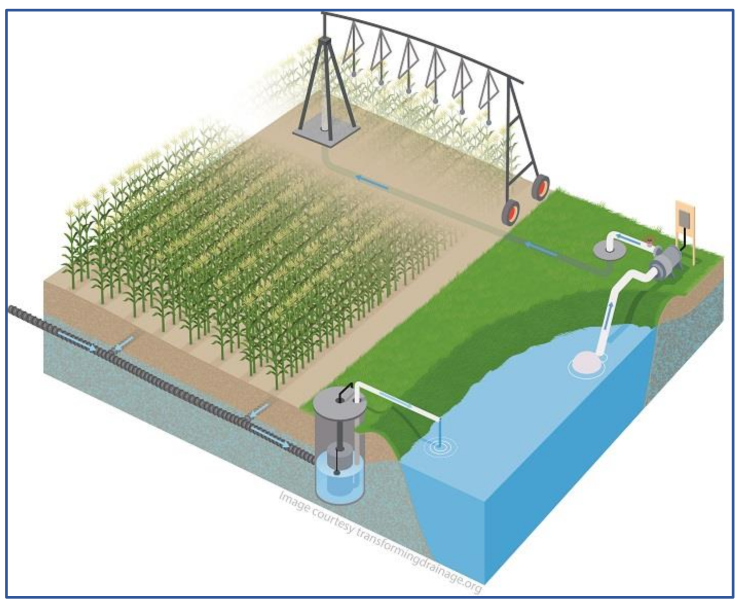

Figure 2. Capture and recycling of tile drainage water typically involves pumping, storage, and reuse (TransformingDrainage.org).

Applicability of tile water recycling in Manitoba

Tile drainage recycling is broadly applicable across agri-Manitoba. Site-specific consideration is required to determine its suitability to a given agricultural operation. For a successful recycling water project there must be: (1) existing water shortage (i.e. demand for recycled water), and (2) sufficient flow from the tiles to meet all or part of the shortage.

Manitoba crops often experience water deficit in the summer. The benefits of irrigating with recycled tile drainage water has been shown through research and practical experience. Research in Ontario showed that sub-irrigating with tile water conserves water and nutrients, and improves crop yields (Tan et al., 2007). Research in Ohio (Purdue Extension, 2017) also showed that recycling water can increase net corn and soybean yields between 12% and 29% (depending on the moisture deficit) versus conventional (free) tile drainage.

In some areas, dugout water is necessary to meet livestock water needs. In Manitoba, some producers use tile water for a portion of their farm water needs. To date there has been minimal data/analysis published for the Manitoba sites.

What are the design considerations?

Due to the complexity associated with tile water recycling, *Professional Services* (see *BMP EA-01*) are recommended for project planning and design, especially for the following aspects.

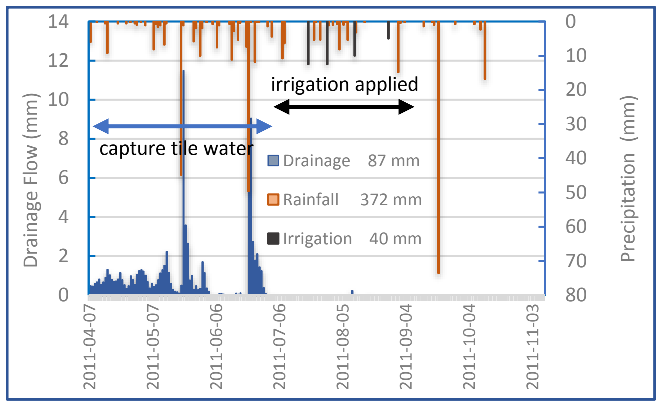

Figure 3. Drainage water flow vs. irrigation and precipitation – Hespler Farms (Cordeiro, 2013).

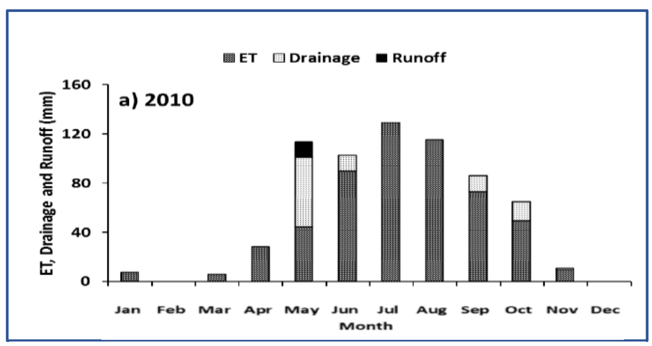

Figure 4. Monthly drainage water flow, surface runoff and evapotranspiration modelled with DRAINMOD for Hespler Farms (Satchithanantham, 2013).

Sizing

Understanding the water balance is the first step in sizing a tile water recycling system. The size of the reservoir should be based on irrigation and/or another farm water demand. Generally, tile water alone can only be expected to meet a portion of the irrigation requirements in Manitoba. Other sources of water are likely necessary to fill the reservoir. Local or estimated tile flow data, mathematical modelling, land availability and economics should be considered in sizing the system.

Local data (Figure 3) showing tile drainage flow in relation to precipitation and irrigation provide insight into the water balance in Manitoba. Cordeiro (2013) measured a total tile drainage volume of 87 mm (3.4 in) in April, May and June 2011. The volume of tile drainage water could have replaced the irrigation water (40 mm or 1.6 in) applied that year in July and August.

Irrigation reservoirs in the Winkler area are typically sized to hold 6 inches (150 mm) a portion of irrigation water volume DRAINMOD (Skaggs et al., 2012) is a mathematical model that can simulate tile drainage flows using multi-year climate data. Based on results from DRAINMOD (Sands, 2013; Satchithanantham, 2013 – Figure 4) and Cordeiro (2013), a reasonable estimate for how much tile water could be captured in Manitoba is about 2.5 to 3.5 inches (64 to 89 mm). In some years (e.g. 2012), however, tile flows may be much less than this (Satchithanantham, 2013).

Drainage flow, irrigation demand and storage requirements will vary significantly across southern Manitoba, especially where shallow groundwater provides a significant portion of the crop water demand (University of California, 2015). As an example, irrigation reservoirs in the Winkler area are typically sized to hold 6 inches (150 mm) of water volume.

Engineering

The storage reservoir should be engineered using investigation, design and construction standards that provide assurance of embankment safety and seepage prevention (e.g. Figure 5). OMAFRA (2016) provides guidance in this area.

Figure 5. Construction of an engineered seepage cut-off trench on a water storage reservoir (PBS Water Engineering Ltd.).

Regulatory requirements

The construction of a reservoir or pond and the installation of a tile drainage system requires provincial and municipal approvals.

Water quality

Tile drainage water will likely contain dissolved nitrates and phosphorus. Recycling this water eliminates the direct discharge of these nutrients from tiles to receiving water bodies. The nutrients in the tile water will benefit crop production when the water is reused for irrigation.

Irrigation water must meet all irrigation water quality standards including the amount of salt. Fields with a history of salinity prior to tile drainage will produce tile drainage water with elevated salt levels. Tile drainage with excessively-high salt levels can be diluted with spring runoff water to reach salt levels acceptable for irrigating crops (Sask. Ministry of Agriculture, 2008).

Pesticides from the tile water could be a cause for concern when the water is recycled. More research is needed in Manitoba to assess the risk of pesticides in recycled water.

Sediments and organics are a concern for sub-irrigation due to the potential to clog the tile lines.

Irrigation design

Drip irrigation and overhead irrigation have significantly better uniformity of water application than sub-irrigation; and hence crop uniformity. Higher-value crops (tomatoes, potatoes, etc.) may warrant a more uniform irrigation system design. Higher-value crops may provide better economic return on a tile water recycling investment.

Treatment

If sub-irrigation is used, water filtration to remove sediment and organics is recommended. Additional treatment may be needed for other farm water uses, such as livestock water.

Wetlands

Where possible, it is desirable to design wetland benefits as part of the reservoir (Purdue Extension, 2017).

Outstanding questions and potential future improvements

A better understanding of tile water recycling in Manitoba could involve:

- Hydrologic modelling of the water balance between precipitation and evaporation, snowmelt and rainfall runoff, tile drainage flows and irrigation demand, using software like DRAINMOD. Use of multi-year data sets to determine hydrologic risk and to optimize storage of surface and tile drainage water.
- Research on tile water quality with respect to impact on recycling to crops, including pesticides and salt loads.

- A means to correlate tile water salt levels to pre and post- tiling salt levels present in project specific soils.
- Cost-benefit analysis for Manitoba, including geographic differences in soils, hydrology, water quality, climate and crops.

Complementary practices

Drainage water recycling BMPs are complementary to other BMPs that reduce nutrients in tile outflow or drainage volume:

- *IF-01 – Nutrient Management and IF-02 – Cover Crops,* considering recycled nutrients;
- *IF-03 – Controlled Tile Drainage,* especially if sub-irrigation is being considered;
- *WS-01 – Constructed Wetlands,* reservoir design could provide some wetland benefits (Purdue Extension, 2017).

BMPs which would not be implemented if water recycling was put into practice include *EF-01 – Bioreactors* and *EF-02 – Saturated Buffers*.

News article

Corn and Soybean Digest. Farmers use reservoirs to collect water, use in irrigation pivots.

Additional BMP resources

Ontario Ministry of Agriculture, Food and Rural Affairs, 2016. Design, construction and maintenance of irrigation reservoirs in Ontario. Factsheet 16-009. AGDEX 753/562. May 2016.

Purdue University Extension, 2017. Questions and answers about drainage water recycling for the Midwest. Purdue Paper ABE-156-W. March 2017.

Transforming Drainage (.org). Website hosted by leading drainage researchers and extension specialists across the Midwest, as well as modeling experts and social scientists.

Guidelines

Saskatchewan Ministry of Agriculture, 2008. Irrigation certification guideline.

References

Cordeiro, M.R.C., 2013. Agronomic and environmental impacts of corn production under different water management strategies in the Canadian Prairies. Ph.D. thesis, Dept. of Biosystems Engineering, University of Manitoba.

Sands, G., 2013. Developing optimum drainage design guidelines for the Red River Basin. University of Minnesota.

Satchithanantham, S., 2013. Water management effects on potato production and the environment. Ph.D. thesis, Dept. of Biosystems Engineering, University of Manitoba.

Skaggs, R.W., M.A. Youssef and G.M. Chescheir, 2012. DRAINMOD: Model use, calibration, and validation. Trans. of the American Society of Agricultural and Biological Engineers: 55(4): 1509-1522.

Tan, C.S., T.Q. Zhang, C.F. Drury, W.D. Reynolds, T. Oloya and J.D. Gaynor, 2007. Water quality and crop production improvement using a wetland-reservoir and drainage/subsurface irrigation system. Canadian Water Resources Journal: 32(2): 129-138.

University of California, 2015. Use of shallow groundwater for crop production. Agriculture and Natural Resources Publication 8251. 2008. Irrigation certification guideline.