Recovery Potential Metrics Summary Form

Indicator Name: WATERSHED PERCENT TILE-DRAINED CROPLAND

Type: Stressor Exposure

Rationale/Relevance to Recovery Potential: Tiles efficiently drain water from the soil saturated zones to streams, thereby reducing residence time in areas conducive to denitrification and increasing nitrogen export. Tile draining also has created concern for the delivery of sediment, sources of bacteria, contaminants, and suspended solids. Tile drains can selectively transport fine-grained sediment from soils to receiving freshwater, and increase the size of the contributing area, by hydraulically connecting remote areas of the catchment to the stream system, and (ii) circumvent management strategies such as buffer strips. Subsurface drain tiling that accompanied wetland drainage can lead to flashy hydrology that can decimate the stream biota. Most of the above effects are exacerbated by the way tiles extend the total area producing these negative impacts farther out into the watershed.

How Measured: Based on verifying the association of tile drain usage with specific soil types (generally hydric soils) that are being cropped. Basic information needs include three elements: locally gathered monitoring data on agricultural practices associated with specific soil types and agricultural uses (e.g., NASS, NRI surveys by USDA), soil type mapping, and agricultural land cover mapping. Locally appropriate measure is developed, then applied to total area within the watershed where selected soil types co-occur with cropland as determined by overlaying

Data Source: Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php), as well as various state sources. The USGS lists cropland by county since 1850 (See: http://landcover.usgs.gov/cropland/index.php). If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx). Direct mapping of tile drained lands is unlikely to be available but can be inferred if data on agricultural practices is available. Data on agricultural practices is available through the USDA Census on Agriculture (See: http://www.agcensus.usda.gov/). Approximate watershed boundaries can be constructed by aggregating small-scale catchments from the NHDplus datasets (See: http://www.horizon-systems.com/nhdplus/).

Indicator Status (check one or more)

___x__ Developmental concept.
___x__ Plausible relationship to recovery.
______ Single documentation in literature or practice.
___x__ Multiple documentation in literature or practice.
______ Quantification.

Comments: May be best used by first verifying how closely specific hydric soil types, croplands and tile drain presence are associated, at the state or sub-state scale. May be patchy in its degree of relevance but regionally can be very important.

Supporting Literature (abbrev. citations and points made):

- (Freeman et al., 2007) Over 20 million hectares of farmland in Ohio, Indiana, Illinois, Iowa, southern Wisconsin, and southern Minnesota was tile-drained from 1870-1920 and 1945-1980 for row-crop agriculture (Zucker and Brown, 1998; Goolsby et al., 2001;

Mitsch et al., 2001). Tiles efficiently drain water from the soil saturated zones to streams, thereby reducing residence time in areas conducive to denitrification (saturated sediments of headwater streams and wetlands). In association with chemical fertilizer inputs, tile drainage increases nitrogen export from midwestern croplands (Baker and Johnson, 1981; Fenelon and Moore, 1998; David and Gentry, 2000; McIsaac and Hu, 2004). Nitrate nitrogen loads from the Mississippi River basin to the Gulf of Mexico approximately tripled between 1970 and 2000, with most of the increase occurring before 1983 (Goolsby et al., 2001) (9).

- (Stone and Krishnappan 1997) The use of tile drains for subsurface drainage in agricultural watersheds has created concern for the delivery of sediment to receiving waters and potential undesirable effects on surface and subsurface water quality (89).
- (Stone and Krishnappan 1997) The extent of agricultural drainage has created concern for its potential undesirable effects on surface and subsurface water quality. Tile drainage and agricultural runoff are sources of bacteria (Panti et al. 1984; Palmateer et al. 1993), contaminants (Kladviko et al. 1991; Mostaghimi et al. 1992; Richards and Baker, 1993), and suspended solids (Culley et al. 1983) (89).
- (Stone and Krishnappan 1997) Tile drains can selectively transport fine-grained sediment from soils to receiving freshwater fluvial systems (Grass et al. 1979) (89).
- (Stone and Krishnappan 1997) The mineralogy and major element composition of tile drain and river sediment collected downstream of the tile outlet varies from that of the surface soils and river sediment collected upstream of the tile outlet (Table 1) (97).
- (Stone and Krishnappan 1997) Compared to river sediments collected above the tile drain, increased levels of anorthite (CaAl2Si2O8) and albite (NaAlSi3O8) are present in surface soils, tile sediments, and stream sediment connected to the tile drain. This suggests that fine-grained surface materials are selectively transported through macropores into the tile drains. During subsequent irrigation or rainfall events, these fine-grained feldspar minerals will be resuspended and transported through the tiles to the stream (97).
- (Stone and Krishnappan 1997) If bed shear stress in the stream is less than the critical shear stress for deposition (0.056 Nm-2), then all of the tile sediment entering the stream will be deposited on the stream bed. But, if the bed shear stress in the stream is greater than the critical shear stress for deposition, then only a portion of the sediment entering the stream is transported in suspension. Thus, suspended tile sediments will be carried long distances within the stream depending on variations in shear stress along the length of the stream and the textural composition of the stream bed (98-100).
- (Dils and Heathwaite 1999) Whereas the installation of artificial drains significantly improves the structural stability of the soil, water quality in recipient streams may be adversely affected by the accelerated rate of nutrient transport, and the circumvention of critical storage areas such as buffer zones (55).
- (Dils and Heathwaite 1999) Phosphorus concentrations in drain discharge were low (<100 micrograms Total P 1-1) and stable during base flow periods (<0.5 1 min-1), and generally lower than in the receiving stream. In contrast, temporary (hours) elevated P peaks exceeding 1 mg Total P 1-1 were measured in drain-flow during high discharge periods (>10 1min-1). Large sediment-associated particulate P losses were measured during the first major drain-flow events of the autumn. Field drains are evidently effective conduits for P export from agricultural catchments.
- (Dils and Heathwaite 1999) Although drainage improvements are beneficial from an agronomic perspective, they are frequently accompanied by detrimental environmental impacts as natural hydrological pathways and hydrochemical processes are modified. For example, increases in peak runoff rates and sediment losses have been reported (Skaggs et al., 1994) (56).
- (Dils and Heathwaite 1999) Field drains also (i) increase the size of the contributing area, by hydraulically connecting remote areas of the catchment to the stream system, and (ii) circumvent management strategies such as buffer strips (56).

- (Dils and Heathwaite 1999) It is widely reported that a large proportion of the annual P load exported through tile drains occurs during a few isolated storm events (e.g. Ulen, 1995). Few studies report P losses at different flow stages despite concentrations and loads changing by orders of magnitude within hours (58).
- (Dils and Heathwaite 1999) In response to storm events in the Pistern Hill catchment, temporary (hours) elevated TP peaks (maximum: 966 micrograms TP 1-1) were observed in drain discharge, followed by a gradual decrease in TP concentrations as P sources became depleted and/or drain-flow was diluted by P-poor ‘new water’ (58).
- (Dils and Heathwaite 1999) Despite the traditional view that P losses in subsurface drainage are minimal, we recorded loads exceeding 0.3 g TP hr-1 in water draining from a grassland site which is managed in accordance with Ministry of Agriculture, Fisheries and Food (MAFF) fertilizer recommendations and codes of good agricultural practice. Similarly, for a grassland site in Devon, UK, Haygarth and Jarvis (1996) reported elevated P loss in drain-flow at 85cm (1.77kg TP ha-1 yr-1) relative to 0.38kg TP ha-1yr-1 transported in surface runoff (0-30cm depth). Further, Withers (1996) estimated that a single tile drain delivered 60% of the TP load in a 150 ha mixed arable catchment in Herts, UK. In the Pistern Hill study, TP concentrations ranging from 30 micrograms P1-1 (base flow) to 966 micrograms P1-1 (storm-flow) were determined. Jordan and Smith (1985) reported similar values for a small (6 ha) intensively managed grassland catchment in Northern Ireland, with flow-weighted mean concentrations of 95, 81, and 295 micrograms TP1-1 for 1977, 1981, and 1982, respectively (59).
- (Dils and Heathwaite 1999) This study as demonstrated that field drains are an effective conduit for the export of P from agricultural land. Although such losses represent a small proportion of the total amount of P applied annually in the form of fertilizers and manures, the efficiency of drainage, combined with the extension of the grazing season and the circumvention of buffer zones, means that these losses may be detrimental to the environment (61).
- (Dils and Heathwaite 1999) Buffer strips are not as effective in areas with tile drained fields (61).
- (Poole and Downing 2004) Multiple regression analysis, done on the watershed-averaged changes in richness showed that changes in richness were most closely associated with agricultural land use, presence of alluvial deposits, and prevalence of the Mississippian geologic formation (Table 3). Intensive agriculture can adversely influence water quality, so the negative partial effect on change in species richness is not surprising. A bivariate plot of this partial effect (Fig. 4B) shows that species richness increased or was unchanged in watersheds where agricultural practices accounted for 25% of land use. Both alluvial deposits and the Mississippian formation enhance groundwater quantity and quality (Anderson 1998) and were associated with lowest rates of decline probably because they stabilize the hydrologic regime. The alteration of drainage in this agricultural area through channelization and subsurface drain tiling that accompanied wetland drainage has led to flashy hydrology that can decimate the stream biota (121).