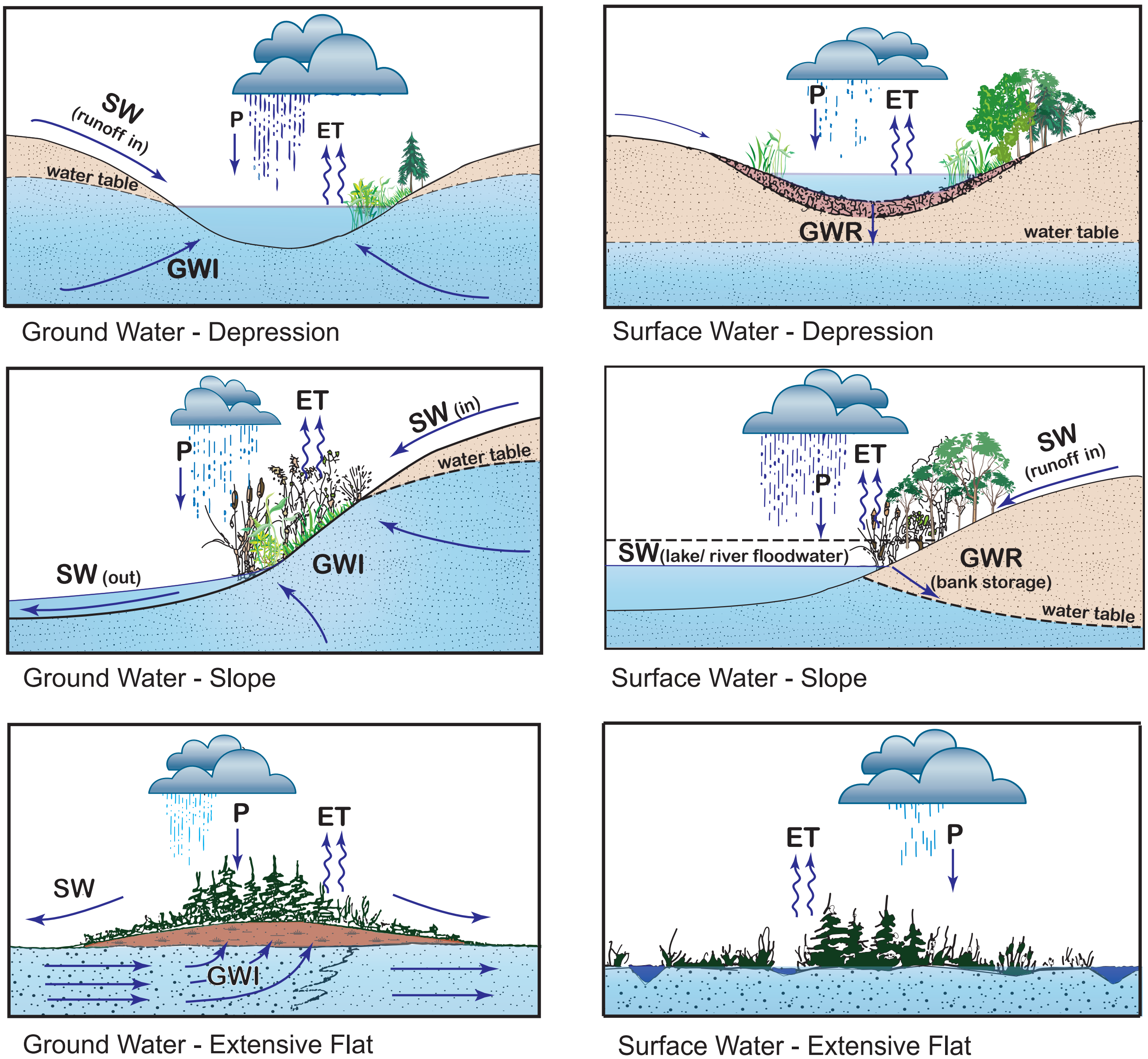
3A Wetland Hydrology Classification

A wetland's hydrology is governed by water source (precipitation, runoff, ground water), water movement (seepage, overland flow), and geomorphic setting (landscape position, soils, geologic setting). Hydrology will directly affect a project's wetland type, functions, and ability to achieve established goals. Evaluating and designing a successful restoration project requires some understanding of the wetland's hydrologic setting and processes.



P = Precipitation
ET = Evapotranspiration
SW = Surface Water
GWI = Ground Water Inflow
GWR = Recharge to Ground Water

Figure 3A-1 *Basic Wetland Hydrology Classes for Minnesota's Wetlands (Novitzki 1982 and 1998)*

Wetlands can be classified in terms of hydrology based on **landscape position** and **water source**. In Minnesota, wetlands commonly occur in depressions, on slopes, or on extensive flats. They are supported by surface water, ground water, or a combination of both. A wetland's interaction with surface water and ground water together with its landscape position accounts for its unique hydrologic functions. A classification based on this principle uses six wetland hydrology classes (Novitzki 1982, 1989). The classification is simplified; wetlands may exhibit properties of more than one class (**Figure 3A-1**).

Following is a description, list of characteristics, and information sources used to define the characteristics of these six wetland classes, as well as strategies used to restore these wetlands when drained and altered. Further information on restoration strategies occurs in *Section 4-3, Drainage Systems Modifications* and in the associated *Technical Guidance Documents*.

Depressional Wetlands

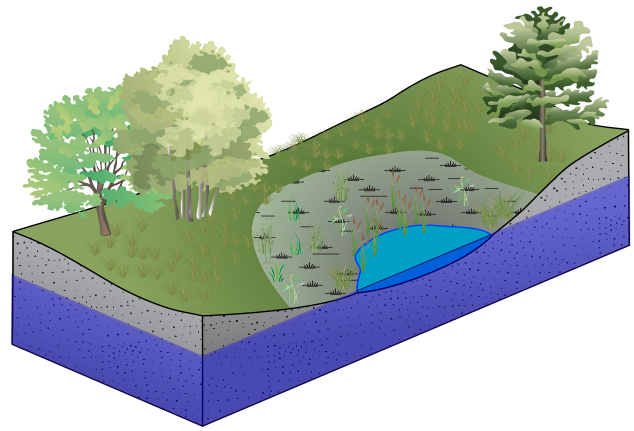
Depressional wetlands occur in land-surface depressions that result from various geomorphic processes, such as glacial erosion and deposition, fluvial processes, and subsidence. The processes of glacial erosion and till deposition left behind large land areas with irregular surfaces containing many depressions. Depressions formed where buried ice blocks melted and also behind glacial deposits that dammed pre-glacial valleys. Fluvial processes may create depressions in river valleys. Shifting river channels carve and abandon small channel segments. Sinkholes are depressions caused by the collapse of land surface into openings produced by the dissolving of underlying carbonate bedrock. Depressional wetlands may or may not have surface water inlets or outlets.

Depressional wetlands with no surface inlets or outlets are often supported by rainfall and evapotranspiration; in some cases, ground water plays a role. This isolated setting is typical for prairie pothole wetlands. These wetlands experience significant hydroperiod variability, such as being wet in spring and fall and dry in summer.

Depressional wetlands with inlets and outlets often have hydrologic and hydraulic function similar to that of open water systems such as reservoirs, ponds, or lakes. The hydrology of each of these wetlands is unique and may vary significantly from one setting to another.

The functions provided by depressional wetlands depend on their location, landscape setting, hydroperiod, size, and inlet or outlet condition.

Ground Water Depression Wetlands



These occur where a depression wetland intercepts the water table and receives ground water inflow as well as some precipitation and overland flow (**Figure 3A-2**). The distinguishing characteristics of these wetlands are interaction with ground water and lack of significant surface drainage away from the site.

Ground water inflow may not be a large portion of the wetland's total water budget, but because it is continuous rather than seasonal or sporadic, it is a very important factor in vegetation type, soil development, and water availability during dry periods. Water usually leaves these wetlands by evapotranspiration (ET), but they may also lose water to ground water recharge or occasional surface water outflow. If the water table slopes toward the wetland, it functions most of the time as a ground water discharge area. Wetland water levels may briefly rise above the local water table, resulting in recharge to ground water (Novitzki, 1989).

Ground water depression wetlands include marshes, sedge meadows, wet meadows, and fens, depending on the depression depth, water table configuration, and ground water flow.

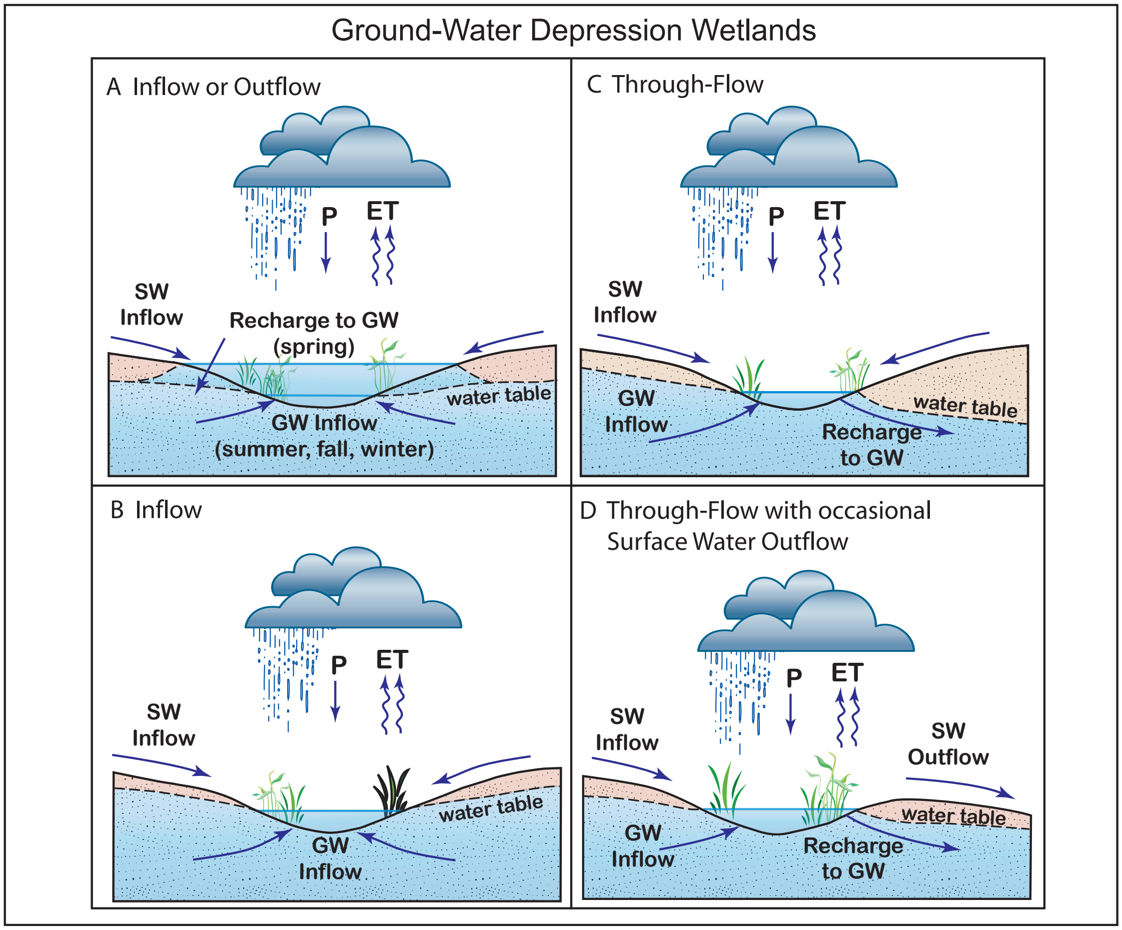


Figure 3A-2 *Water budget components of ground-water depression wetlands. SW = surface water. GW= ground water. P = precipitation. ET = evapotranspiration. Modified from Novitzki, 1982.*

Characteristics (*and information resources*)

- Topographic depression intercepts the regional water table. Usually indicated if the water table in adjacent uplands is at or near the same elevation as the water level in the wetland (*geologic maps, hydrologic atlases, topographic maps, observation well data, piezometer data, water well records, field investigation*).
- Lack of surface drainage away from site (*topographic maps, field observation*).
- Smaller (~8:1 or less) watershed-to-wetland area ratio (*topographic maps*).
- Relatively constant water quality—conductance, alkalinity, pH vary substantially less with time than in surface water depression wetlands (*water quality analysis*).
- Often drained by more complex and extensive drainage systems – pattern tile, deep ditches, lift stations (*drainage information, maps*).

Restoration Strategies

To address additional hydrologic inputs from ground water, ground water depression wetlands were often drained by more complex and extensive drainage systems – pattern tile, deep ditches, and lift stations.

In restoring hydrology to these wetlands, the goal should be for abandonment of the site's drainage, generally at the edge or rim of the depressional basin. Restoration strategies include ditch plugs, tile blocks, and lift station removal.

A wetland receiving significant ground water inflow will also require assessment for potential surface outlets to accommodate regular surface discharges. An outlet will need to handle regular, continuing ground water inflow (base flow) as well as sporadic flow from large surface runoff events. Consider using trickle drains along with other, higher-capacity outlets.

Surface Water – Depression Wetlands

A surface-water depression wetland occurs where precipitation and overland flow collect in a depression; water leaves primarily by surface outlets, evapotranspiration, and infiltration (**Figure 3A-3**). The bottom of the depression is above the water table most of the time. The water table may temporarily rise to wetland level but ground water inflow is minor compared to surface water inflow. A confining layer or relatively impermeable layer often exists and limits downward water movement. The confining layer may maintain the wetland water level above the regional water table, resulting in a "perched" wetland.

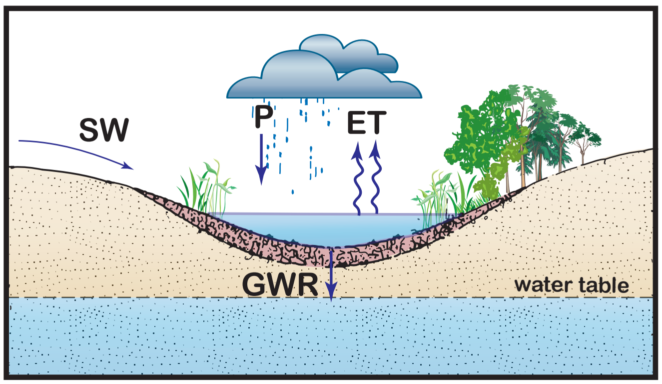


Figure 3A-3 *Water budget components of surface water depression wetlands. SW= surface water. GWR= recharge to ground water. P= precipitation. ET= evapotranspiration. Modified from Novitzki, 1982*

Surface-water depression wetlands may vary from small seasonal or temporary wetlands to open water marshes. Seasonal wetlands may have little organic soil present. Permanent wetlands will appear markedly different from the adjacent uplands because water is constantly present and gives rise to organic soils such as muck or peat (Novitzki, 1989). Typical surface-water depression wetlands are marshes, bogs, sedge meadows, wet meadows, and wet prairies.

Characteristics (*and information resources*)

- Occur where precipitation and overland flow collect in a depression (*air photos, topographic maps, field observation*).
- Receive precipitation and overland flow and loses water by evapotranspiration and ground water recharge (*water budget analysis*).
- Bottom of depression is usually above local water table, or wetland water level is consistently above local water table (*geologic maps, hydrologic atlases, topographic maps, observation well data, piezometer data, water well records, field investigation*).
- Water levels are high in spring and decline throughout the rest of the year, with smaller scale fluctuations due to single rainfall events (*air photos, water level records, field investigation*).
- Water quality varies between spring high water and fall low water. Conductance, hardness, and alkalinity lower in the spring and higher in the fall (*water quality analysis*).
- Larger (~8:1 or more) watershed-to-wetland area ratio (*topographic maps*).
- Depending on size of wetland, drainage is by a single tile main with surface inlets or an open ditch. Smaller basins are often filled in to remove them from the landscape (*drainage information, maps, and historic photos*).

Restoration Strategies

Surface water depression wetlands were drained by an open ditch or single tile main with surface inlets, depending on the size of wetland. Larger basins included additional drainage via laterals or branches off the main system. Smaller basins were filled in to remove them from the landscape.

In restoring hydrology to drained surface water depression wetlands, the goal should be to abandon any drainage out of the wetland and seal off breaches through the wetland's substrate. This may include completely filling in drainage ditches that penetrate the confining layer at the base of the wetland. During investigation and assessment of drained surface water depression wetlands, pay attention to possible impacts during excavations. Those areas should be noted for sealing in the restoration.

A surface water depression wetland will require assessment for potential surface outlets, as periodic surface outflow may occur, especially where surface water inflow exists. An outlet will need to handle any ongoing surface water inflow, if it exists, as well as flow from large surface runoff events.

Slope Wetlands

Slope wetlands occur in a variety of landscapes including areas with steeply or mildly sloping topography as well as riverine or fringe areas to lakes and other larger water bodies. Slope wetlands can be supported by ground water or surface water. With the exception of certain riverine settings, flooding of these areas rarely occurs, providing for unique and diverse vegetation communities.

Ground Water Slope Wetlands

Ground water slope wetlands occur where ground water discharges as springs or seeps at the land surface (**Figure 3A-4**). They often occur at the bottoms of hills, breaks in slope, or on hillsides, and are often associated with changes in subsurface materials. The amount of ground water inflow to the wetland may range from a relatively small percentage to a major portion of the total water budget, resulting in a wide range of plant communities and soil development (Novitzki, 1989). The distinguishing characteristic of these wetlands is a constant ground water discharge and an opportunity for surplus water to flow down slope away from the site, eliminating ponding. This is most obvious where a wetland is the headwaters of a stream but it may be difficult to recognize if discharge is by diffuse leakage along a stream bank or lakeshore. The size of the wetland depends on how large an area is kept wet by the ground water discharge.

Typical ground water slope wetlands are fens, sedge meadows, and wet meadows.

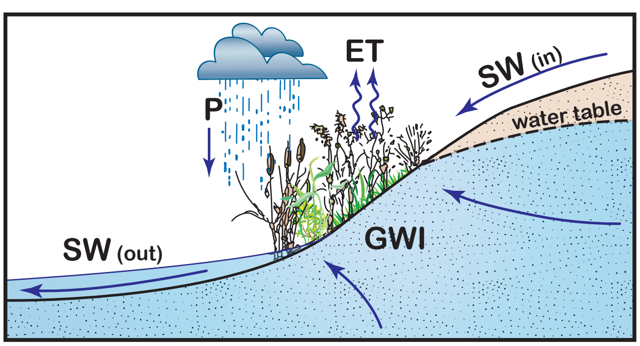


Figure 3A-4 *Water budget components of ground water slope wetlands.SW = surface water. GWI= ground water inflow. P= precipitation. ET= evapotranspiration. Modified from Novitzki, 1982.*

Characteristics (*and information resources*)

- Ground water discharges as springs or seeps at the land surface temporarily or continuously (*observations*).
- Drainage away from the site eliminates permanent ponding.
- Occur at the bottoms of slopes, breaks in slopes, or on hillsides where ground water discharges to the land surface.
- Increasing hydraulic head with depth (*piezometer data*).
- Water quality reflects local ground water quality—relatively stable. pH~7-9, conductance ~150-500 µmhos, alkalinity ~ 100 -200 mg/l (*water quality analysis*).
- Drained by single tile line running up slope. Pattern tiling may occur in some hillside settings (*drainage information, maps*)

Restoration Strategies

These types of wetlands were often drained by a single tile line running up a slope or draw. In settings with more gentle sloping topography, shallow ditches and pattern tiling have been used.

In restoring hydrology to drained ground water slope wetlands, the goal should be to completely remove and abandon artificial drainage. When abandoning a drainage system in a sloped setting, there are some special considerations. Give extra thought to the potential impacts of grade. Steeper grades require more attention to erosion and sediment control measures. These considerations are particularly important in this setting as surface flows from ground water discharge may be present during and after construction. Constructed outlets are rarely needed when restoring these wetlands unless required to convey surface outflow from the wetland to a ditch, stream, or other surface water body.

Surface Water Slope Wetlands

Surface water slope wetlands occur along the sloping margins of lakes, streams, rivers, streams, and ditches (**Figure 3A-5**). They extend from the shallow but permanently flooded part of the lake, stream, or river upslope to a point that is flooded only occasionally. They receive lake or river floodwaters or stream or creek storm flows in addition to runoff and direct precipitation. Water leaves primarily by surface drainage as the stage of the lake or river declines, as well as by infiltration and evapotranspiration. Water levels are controlled by lake or river stage and are typically high in spring and decline through the rest of the year (Novitzki, 1989). The distinguishing characteristic of this wetland condition is that the water received from flooding can readily drain back to the lake, river, or stream as levels fall. Riparian settings naturally function to attenuate flood flows and trap sediments.

Typical surface water slope wetlands are marshes along the edges of lakes and floodplain forests.

Characteristics (*and information resources*)

- Occur at margins of lakes, streams, valleys, or drainageways.
- Include shallow part of lake or river and extend up slope to periodically-flooded areas.
- Water source predominantly lake or river water; drain as river or lake stages fall.
- Water level above local water table (*observation well data, piezometer data*).
- Drained or altered by simple surface ditches or tile systems where adequate outlets exist. Occasionally drained and altered by more complex and extensive drainage systems including levees and lift stations (*drainage information, maps*).

Restoration Strategies

Drainage of surface water slope wetlands is not as prevalent as with other types. When drained, it was often via subsurface drainage tile and, in limited circumstances, open ditches.

In restoring hydrology to drained surface water slope wetlands, the goal should be to completely remove and abandon artificial drainage. When abandoning a drainage system in a sloped setting, there are some special considerations. Extra thought should be given to the potential impacts of grade when evaluating the effectiveness of removal strategies. Steeper grades require more attention to erosion and sediment control measures. Constructed outlets are rarely needed when restoring these wetlands unless required to convey surface outflow from the wetland to a ditch, stream, or other surface water body.

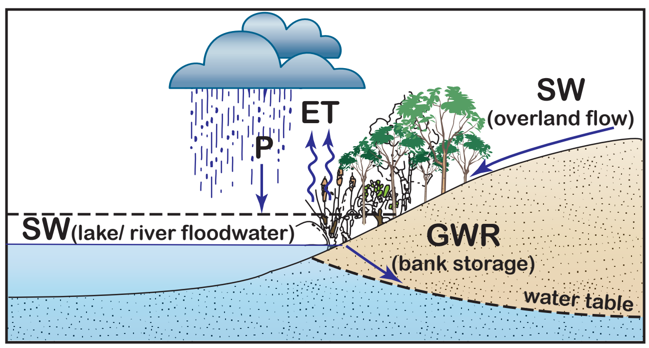
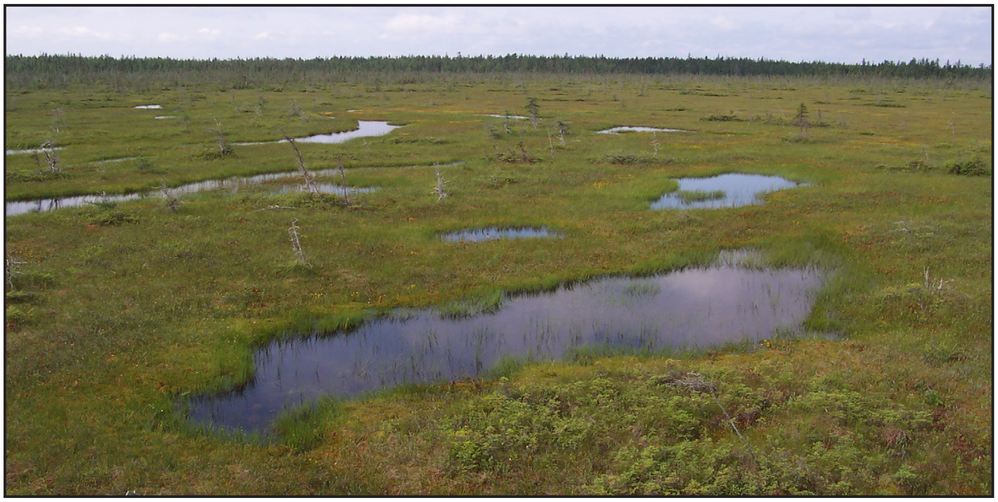


Figure 3A-5 *Water budget components of surface water slope wetlands.SW= surface water (overland flow or lake/ river floodwater). GWR= recharge to ground water (bank storage). P = precipitation. ET= evapotranspiration. Modified from Novitzki, 1982.*

Photo by Randy C. Bunney, Great Circle PhotoGraphics

Extensive Flat Wetlands



The preceding four classes cover most situations. An exception is the type of extensive wetland systems that occupy large, flat areas and do not fit readily into any of the above four categories (Novitzki, 1989).

Ground Water Extensive Flat Wetlands

Extensive ground water-supported wetland systems occur on large, relatively flat plains such as the Glacial Lake Agassiz region. Their origins may be subsurface stratigraphy or where other physical phenomena cause ground water to flow to the surface. These wetlands probably have spread outward from original wetland areas, which were dependent upon ground water discharge. As the wetlands enlarged, the available ground water discharge was spread over a larger area.

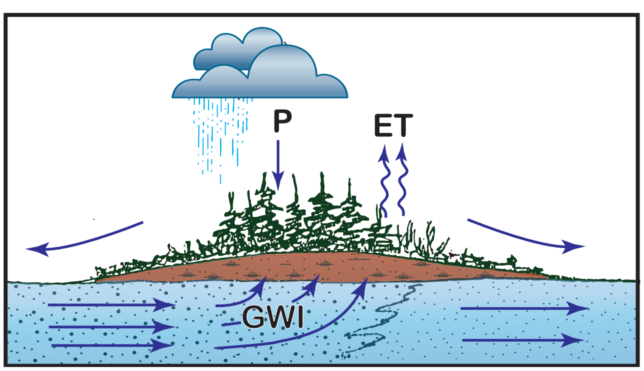


Figure 3A-6 *Water budget components of ground water extensive flat wetlands.GWI= ground water inflow. P= precipitation. ET= evapotranspiration. Modified from Novitzki, 1998.*

Eventually the wetland areas stabilized at the size where the water needed by the plant community balanced the available water supply (ground water discharge plus direct precipitation). As organic soils accumulated, favored by continuous wetness, they separated the plant community from the ground water source, changing the water balance from predominantly ground water to predominantly precipitation, and the plant community changed as a result. Because the wetlands are flat and can drain from their edges, they are rarely flooded by more than a few inches, yet remain at or near saturation throughout most of the year.

Typical ground water extensive flat wetlands are bogs, fens, and coniferous swamps, but many other communities, including alder thickets, shrub carrs, wet meadows, and sedge meadows can occur in this setting.

Characteristics (*and information resources*)

- Occur on large, relatively flat plains (*topographic maps, field observation*).
- Origins due to subsurface stratigraphy or where other physical phenomenon cause ground water to flow to the surface (*geologic maps, hydrologic atlases, topographic maps, observation well data, piezometer data, water well records, field investigation*).
- Accumulation of organic soils sufficient to constitute peat deposits (*geologic maps, soils maps, field investigation*). Continuing peat accumulation can separate the plant community from the ground water source,

changing the water balance from predominantly ground water to predominantly precipitation, as well as changing the plant community.

- Probably have spread outward from an original ground-water-supported wetland area. As the wetland enlarged, the available ground water discharge was spread over a larger area that eventually stabilized at the size where the water needed by the plant community balanced the water supplied by ground water discharge and direct precipitation.
- Relatively flat and can drain from edges. Rarely flooded by more than a few inches. Remain at or near saturation throughout most of the year (*air photos, water level records, field investigation*).
- During prolonged periods of deficient precipitation, the surface may become dry, and during extreme drought, the peat may become so dry as to support fires.
- Likely wettest at the center; plant community zones may radiate out from the center.
- More likely to show relatively long-term responses caused by drought cycles (*air photos, water level records, field investigation*).
- Drained by drainage ditches. There are many examples of failed attempts to drain these extensive wetland systems, especially in northern Minnesota.

Restoration Strategies

To address inputs from ground water, these wetlands were often drained by more complex and extensive drainage systems – pattern tile, deep ditches, and lift stations. In restoring hydrology to drained ground water extensive flat wetlands, the goal should be to completely remove and abandon artificial drainage at strategic locations in the wetland. Restoration strategies include ditch plugs, tile blocks, and lift station removal.

A wetland receiving significant ground water inflow will also require assessment for potential surface outlets, as regular surface discharges may occur. An outlet will need to handle continuing, regular ground water inflow (base flow) as well as flow from large surface runoff events. Consider using trickle drains along with other, higher-capacity outlets.

Surface Water Extensive Flat Wetlands

Extensive surface water-supported wetlands occur on large, poorly-drained flat areas. Streams that pass through such areas have very low gradient and do not effectively drain the area. During snowmelt and early spring rains, the entire area may be flooded; in early summer, water may slowly drain back into streams. The soils beneath the wetland may be saturated for much of the year, as water movement through the soil is slow, inhibited by the low gradients and lack of drainage.

It is difficult to differentiate surface water supported flats from ground water supported flats. In each, the soils are likely saturated to the surface during much of the year. However, the continuous wetness associated with the ground water supported systems causes the accumulation of organic soils sufficient to constitute peat deposits, whereas the organic soils associated with surface water supported systems do not, suggesting a difference in the function of the two systems.

The ground water supported system is wettest at the center and plant community zones may radiate out from the center. The surface water supported system is wettest near streams and plant community zones parallel the stream network. Surface water supported systems are more likely to show relatively short-term responses caused by variations in annual precipitation whereas ground water supported systems are more likely to show relatively long term responses caused by drought cycles.

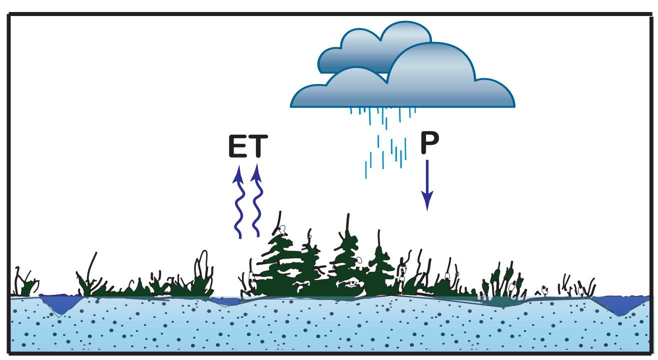


Figure 3A-6 *Water budget components of surface water extensive flat wetlands. P= precipitation. ET= evapotranspiration. Modified from Novitzki, 1998.*

Typical surface water extensive flat wetlands are coniferous swamps and bogs, but many other communities, including hardwood swamps, alder thickets, shrub carrs, wet meadows, wet prairies, and sedge meadows can occur in this setting.

Characteristics (*and information resources*)

- Occur on large, poorly drained flat areas (*topographic maps, field observation*).
- Any streams that pass through such areas are very low gradient and do not effectively drain the area (*topographic maps, field observation*).
- During snowmelt and early spring rains, may be flooded. In early summer, water may slowly drain from wetland storage back into streams.
- Soils beneath the wetland saturated for much of the year. Water movement through the soil is slow, inhibited by the low gradients and lack of drainage (*air photos, water level records, field investigation*).
- Accumulation of organic soils may not be sufficient to constitute "peat deposits" (*geologic maps, soils maps, field investigation*).
- Likely wettest near streams; plant community zones may parallel the stream network.
- More likely to show relatively short term responses caused by variations in annual precipitation (*air photos, water level records, field investigation*).
- Drained by drainage ditches. There are many examples of failed attempts to drain these extensive wetland systems, especially in northern Minnesota.

Restoration Strategies

In restoring hydrology to drained surface water extensive flat wetlands, the goal should be to completely remove and abandon artificial drainage at strategic locations in the wetland. Restoration strategies include ditch plugs and tile blocks.

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