and Tiger Cat Flowage. The maximum flow through these three culverts could be approximated by assuming that the flood level at McClaine Road was up to the road overflow (but not overtopping the road). Assuming a 3-foot head at these three culverts, the cumulative flow would be about 15-20 cubic feet per second. This flow is based on approximate data and does not take into account partially collapsed culverts.

When Sawyer County created Tiger Cat Flowage and constructed diversion channels to connect it to Lake Placid, the water levels in Lake Placid were increased by around 10 feet. This increase in the Lake Placid water levels increases the frequency and duration of overflows through adjacent wetlands near Lake Placid which increases the inflows into Round Lake. These overflows contain water from the adjacent Tiger Cat Flowage watershed which were not tributary to Round Lake prior to Sawyer County's drainage system modifications.

B. Outflows from Round Lake

The primary outflows from Round Lake include natural overflows and flows through the constructed outlet. Evaporation and infiltration into the groundwater have a minor contribution to outflows.

1. Natural Overflows

Prior to development in the area and installation of the Little Round Lake Dam, there appears to have been three natural outlets for Round Lake that directed flow to Osprey Lake or Osprey Creek. All three natural overflows have either been completely or partially blocked. Figure 6b shows the locations of these natural overflows.

- **Wetlands to the east of Little Round Lake**: A natural overflow channel is adjacent to Thunderbird Road at the channel's narrowest point and directs flows into Osprey Lake. The approximate elevation of the overflow channel is currently about 76 to 76.5; observations during the field visit indicate that the channel has not been recently changed. Some documents indicate that there may have been some dredging of this channel in the past. Aerial photographs from 1938 indicate that the channel alignment has not changed since that time. Historic documents indicate that outflows through this channel occurred continuously for about seven years from 1941 to 1948 (SC 2032); based on recorded levels during this time the overflow channel would have been about the same as the current elevation. This channel was blocked with a road crossing. The road crossing is currently equipped with a 15-inch corrugated metal culvert that prevents outflow below elevation 77.7. The current capacity through the 15-inch culvert is limited to about 4 cubic feet per second at a Round Lake level of 79. Prior to the installation of this culvert, the natural outflows at Round Lake elevations above 80.5 would have been several hundred cubic feet per second. However, when this overflow channel was blocked, flows below elevation 77.7 were eliminated and the capacity of the natural overflow was reduced.

- **Low area on the southwest end of Little Round Lake**: This natural overflow can be seen on the quadrangle maps and would direct flows into Osprey Creek downstream of Osprey Lake. The elevation of this natural overflow cannot be determined because construction of

Frogg Road appears to have altered the overflow and raised the overflow elevation, preventing overflows into this channel.

- **Wetlands near the Little Round Lake Dam:** Historic documents indicate that there were wetlands both upstream and downstream of the dam. According to these documents, the natural overflow between these wetlands appears to have been at elevation 77.7 (DNR 0559). The construction of Carlson Road and the construction of the Little Round Lake Dam blocked this natural overflow.

2. Constructed Outlet

The outflows from Round Lake currently flow into Little Round Lake to the Little Round Lake Dam structure and into a manmade channel that directs flows into Osprey Lake. Outflows from Osprey Lake flow into Osprey Creek. There are three primary restrictions along this drainage path:

- The Little Round Lake Dam is a timber bridge structure with two 5-foot-wide openings. The sill of the dam is at about elevation 75.7. The structure is equipped with a channel for stoplogs that can be placed to temporarily raise the elevation of the dam. This structure has capacity for about 30 cubic feet per second when Round Lake is at elevation 76.75 (the state-designated maximum Round Lake water level adjusted per the datum convention). Increasing the capacity of the dam would require lowering the sill and/or widening the opening.

- The constructed channel between the dam and Osprey Lake is about 315 feet long and has a bottom width that varies between 9 and 10 feet. The slope of the channel bottom is very flat. The current channel capacity is about 15 cubic feet per second when Round Lake is at elevation 76.75. The channel capacity is currently restricted by high downstream tailwater elevations and the channel configuration. Widening the channel would increase the capacity.

  Some of the banks in this channel downstream of the Little Round Lake Dam are very steep, with side slopes at about 2 horizontal to 1 vertical. These steep banks with sandy soils will erode over time; higher water levels will increase the bank erosion. Probing of the channel bottom indicates soft sediment to depths of about 1 to 2 feet, which suggests that the channel has filled in with sediment since construction of the channel. This is likely due to bank erosion from the steep channel banks and high water levels. This is a repetitive cycle, where slope instability due to high water causes erosion which fills in the channel and in turn increases the high water.

- The water from Osprey Lake flows into Osprey Creek. Osprey Creek periodically collects debris and beaver dams can temporarily block portions of the channel. The Osprey Creek crossing under Highway NN is very restrictive, with a capacity of about 60 cubic feet per second when the Osprey Creek level is at elevation 76.75. Two 48-inch corrugated metal culverts are currently in-place at this crossing; the culverts have inverts about 2 feet above the surrounding channel bottom. Increasing the flow capacity at this crossing would require increasing the number or size of the culverts and lowering the invert elevations.

The outflow from Round Lake is restricted by the cumulative effects of these three controls, with a combined capacity of about 15 cubic feet per second when Round Lake is at the state-designated maximum elevation of 76.75. Figure 7 shows the capacity of the existing drainage system at various water levels. To achieve a capacity of 150 cubic feet per second, the existing Round Lake water level would be at about elevation 79.7. The 100-year flood level of Round Lake is estimated to be at elevation 79.2, with about 125 cubic feet per second outflow (County Highway NN Flood Analysis, Barr Engineering, 2004). Therefore, to achieve a capacity of 150 cubic feet per second with the existing controls, the level on Round Lake would have to exceed the 100-year flood level.

3. Evaporation

Evaporation rates from open water surfaces in this area are estimated to be about 23 inches per year. Evaporation rates impact the long-term water levels in the lake, however they do not have significant impact on reduction of water level during specific storm events.

4. Infiltration into Groundwater

As discussed above in Section A.2, the rate of groundwater outflow from Round Lake would be about 1 cubic foot per second less than the groundwater inflow because of the minimal hydraulic gradient to Osprey Lake compared to the hydraulic head from Tiger Cat Flowage. Precise groundwater flow rates were not evaluated and would require collection of measured data over time.

Tiger Cat Flowage levels are high due to the overtopping of the Lake Placid Dam and natural overflows through wetlands.

B. Major Outflows

The outflows from Round Lake were also modified by Sawyer County in the late 1930s. The two primary outflows and modifications are described below and illustrated on Figure 6b.

1. Current topography shows three natural low points that were likely outlets for Round Lake that directed flow to Osprey Lake or Osprey Creek prior to development in the area and installation of the Little Round Lake Dam. All three natural overflows have either been completely or partially blocked, reducing the outflow capacity at high levels on Round Lake.

    - The overflow through the wetlands to the east of Little Round Lake into Osprey Lake appears to have been raised by around 1.2 to 1.7 feet with a road crossing and restricted by a 15-inch-diameter culvert. This natural overflow is illustrated by a blue line on Figure 6b. The current overflow elevation is about 1 foot above Round Lake's state-designated maximum lake level. The outflow capacity of Round Lake has been reduced by blocking this overflow.

    - The low area on the southwest end of Little Round Lake was blocked by construction of Frogg Road, preventing overflows, illustrated with a black line on Figure 6b. This natural overflow would have directed flows into Osprey Creek downstream of Osprey Lake.

    - Historic documents indicate that there were wetlands both upstream and downstream of the Little Round Lake Dam, with a natural overflow at about 1 foot above the state-designated maximum lake level (elevation 76.7[7] adjusted local datum). This natural overflow is illustrated by a red line on Figure 6b. The construction of Carlson Road and the construction of the Little Round Lake Dam blocked this natural overflow.

2. The outflows from Round Lake currently flow through Little Round Lake to the Little Round Lake Dam structure and into a manmade channel that directs flows into Osprey Lake and eventually into Osprey Creek. There are three primary restrictions along this drainage path: the Little Round Lake Dam, the channel between the dam and Osprey Lake, and the culvert at County Highway NN. All of these restrictions were constructed by Sawyer County. None of these structures has the capacity to discharge the state-designated outflow capacity (150 cubic feet per second) at the state-designated maximum level, and when combined restrict the outflows to about 15 cubic feet per second at the state-designated maximum level.

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[7] The datum used for this study was determined using survey data from a Global Positioning System (GPS). In regards to historic documents, conversions to the local datum were developed for each benchmark as discussed in Appendix B. Using this conversion and adjusting for the high staff gage reading at Kaisers Resort, the state-designated normal water level on Round Lake in this adjusted local datum is 76.5 and the state-designated maximum water level is 76.75. The largest difference between the historic and adjusted datums used in this report would be about 6 inches.

Figure 7 shows the Round Lake outflow capacity under the existing drainage system at various water levels. To achieve a capacity of 150 cubic feet per second, the existing Round Lake water level would be at about elevation 79.7 (3 feet above the state designated maximum level). The 100-year flood level of Round Lake is estimated to be at elevation 79.2, with about 125 cubic feet per second outflow (Preliminary Version, County Highway NN Flood Analysis, Barr Engineering, 2004). Therefore, to achieve a capacity of 150 cubic feet per second with the existing controls, the level on Round Lake would have to exceed the 100-year flood level.

Other outflows from Round Lake include evaporation and groundwater. Evaporation rates impact the long-term water levels in the lake, however they do not have significant impact on reduction of water levels during specific storm events. The rate of groundwater outflow from Round Lake would be about 1 cubic foot per second less than the groundwater inflow because of the minimal hydraulic gradient to Osprey Lake compared to the hydraulic head from Tiger Cat Flowage.