4.14. Lake Lulu

Background

Physical and chemical characteristics specific to Lake Lulu are presented here in the context of relevant regulatory criteria and requirements (Table 4-28). Lake Lulu (WBID 1521), the terminal lake in the WHCL Southern Chain, is hydrologically connected to lakes Shipp, Roy and Eloise via constructed navigable canals (Photo 4-17, Figure 4-55). In 2005, Lake Lulu was declared verified impaired based on elevated TSI values (>60). A TMDL was adopted for the Southern Chain of the WHCL, including Lake Lulu (FDEP 2007), and Lake Lulu was subsequently delisted from impairment by FDEP in 2010. Based on the modeled external TP load to Lake Lulu, a 55 percent reduction in TP load (84 kg TP/year) is required to comply with the TSI criteria of 60 (FDEP 2007). The TP, TN, and chlorophyll *a* geometric mean for Lake Lulu for the period of 1997 to 2007 and corresponding EPA NNC water quality targets are listed in Table 4-28. To comply with the NNC, concentration reductions of 39 percent for TP, 19 percent for TN, and 48 percent for chlorophyll *a* are required.

A summary of water quality statistics for Lake Lulu is presented in Table 4-29. Lake Lulu historically received point source discharges from four WWTF (City of Winter Haven, Bordo's citrus processing plant, Snively, and Swift Fertilizer). While the effluent discharges have been eliminated, the discharges resulted in nutrient and sediment accumulation in the lake bottom. An inverse relationship between lake levels and TP concentrations may suggest sediment resuspension resulting in a decline in water quality. In response to the TMDL, the City of Winter Haven and SWFWMD implemented a stormwater alum injection project (Figure 4-56). Based on TP load reduction estimates for projects constructed on Lake Lulu (193 kg/year), the TMDL required TP load reductions (84 kg/year) have been accomplished. After the implementation of the stormwater retrofit project in 2005, the chlorophyll *a* values continue to exceed 20 µg/liter, indicating that TSI_{CHLA} values less than or equal to 60 (which would require chlorophyll *a* levels to be below 20 µg/L) were not reached. Since 1996, *Hydrilla* eradication projects have been completed annually, treating over 40 percent of the lake surface area in some years. The median chlorophyll *a*, TN and TP concentrations continue to exceed the NNC targets provided by EPA for Lake Lulu. A statistically significant trend in chlorophyll *a* concentrations from 1983 to 2007 was not observed (seasonal Kendall-Tau, $p > 0.10$). Lake Lulu is a terminal lake, therefore, improvements in water quality of the lake would result in no benefit farther downstream.

The Lake Lulu watershed is 547 acres in size and includes 303 acres (55 percent) of developed lands compared to 244 acres (45 percent) of undeveloped lands (Table 4-28). The 2000-2007 median color value (20 PCU) was below 40 PCU indicating the lake is a clear (non-colored) lake and specific conductivity data indicate the lake is alkaline. The lake area, perimeter, water depth, and volume statistics are based on a water level elevation of 129 feet in June 2007 (Table 4-28). Bathymetry data are available for Lake Lulu for the June 2007 water level elevation (Figure 4-57). A water level of 130 feet was reported in August 2010, reflecting a 1.0 foot increase in water elevation when compared to 2007. The subsequent changes in overall surface area, water depth, and volume of the lake should be considered during the development and implementation of water quality restoration projects.

Water Quality Restoration Project Selection and Priorities

Based on Lake Lulu water quality and the surrounding watershed characteristics, five potential water quality restoration projects were identified using the WHCL WQMP decision key (Figure 4-58). The decision key presents the factors on which yes/no decisions were based and used to identify and select water quality improvement projects. Projects to address water quality, nutrient and sediment loading, and reduced lake levels are proposed. The projects are listed in order of priority, based on expected water quality improvements. A detailed discussion of the potential water quality restoration implications for each project can be found in Section 3.0.

- Project 1: Sediment Removal/Inactivation
- Project 2: Stormwater Infiltration Areas (SIAs)
- Project 3: Forested Wetland Rehydration
- Project 4: SAV Planting/Management or FTWs
- Project 5: EAV Planting/Management

Table 4-28. Physical, chemical, and regulatory characteristics of Lake Lulu.

Physical			
Location in chain	Southern	**High infiltration soils (acres)**	292 (53 percent)
Relation to other lakes	Terminal	**Developed land (acres)**	303 (55 percent)
Watershed area (acres)	547	**Undeveloped land (acres)**	244 (45 percent)
Lake area (acres)*	318	**Median water depth (feet)***	5.0
Perimeter (feet)*	24,471	**Maximum water depth (feet)***	13.7
Surface area: lake volume ratio*	0.21	**Volume (acre-feet)***	1,514
Watershed to surface area ratio*	1.72		
Water Chemistry			
Locally-derived: acidic or alkaline	Alkaline	**Clear or colored**	Clear
Geometric mean chlorophyll *a* (µg/L)	39	**NNC chlorophyll *a* target (µg/L)**	20
Geometric mean TN (mg/L)	1.24	**NNC TN target (mg/L)**	1.00
Geometric mean TP (mg/L)	0.049	**NNC TP target (mg/L)**	0.030
Regulatory Data			
Impaired	Yes	**TMDL status**	Required†
Chlorophyll *a* trend	No trend**	**TP concentration reduction required**	39 percent

*at a water level elevation of 129 feet †TMDL adopted
**presented in section 5.0

Photo 4-17. Southern view of Lake Lulu.

Table 4-29. Lake Lulu water quality summary for 1997 to 2007.

Parameter	N	Minimum	Median	Maximum
Chlorophyll *a* (µg/L)	223	1	42	66
Color (PCU)	27	5	20	25
Conductivity (µmhos/cm)	28	185	247	326
Dissolved oxygen (mg/L)	28	7	8.72	10.26
pH	28	6.83	8.04	9.07
Secchi depth (feet)	226	1.2	1.8	3.7
Total nitrogen (mg/L)	225	0.0	1.22	1.89
Total phosphorus (mg/L)	218	0.00	0.050	0.080

Figure 4-55. Lake Lulu and associated watershed.

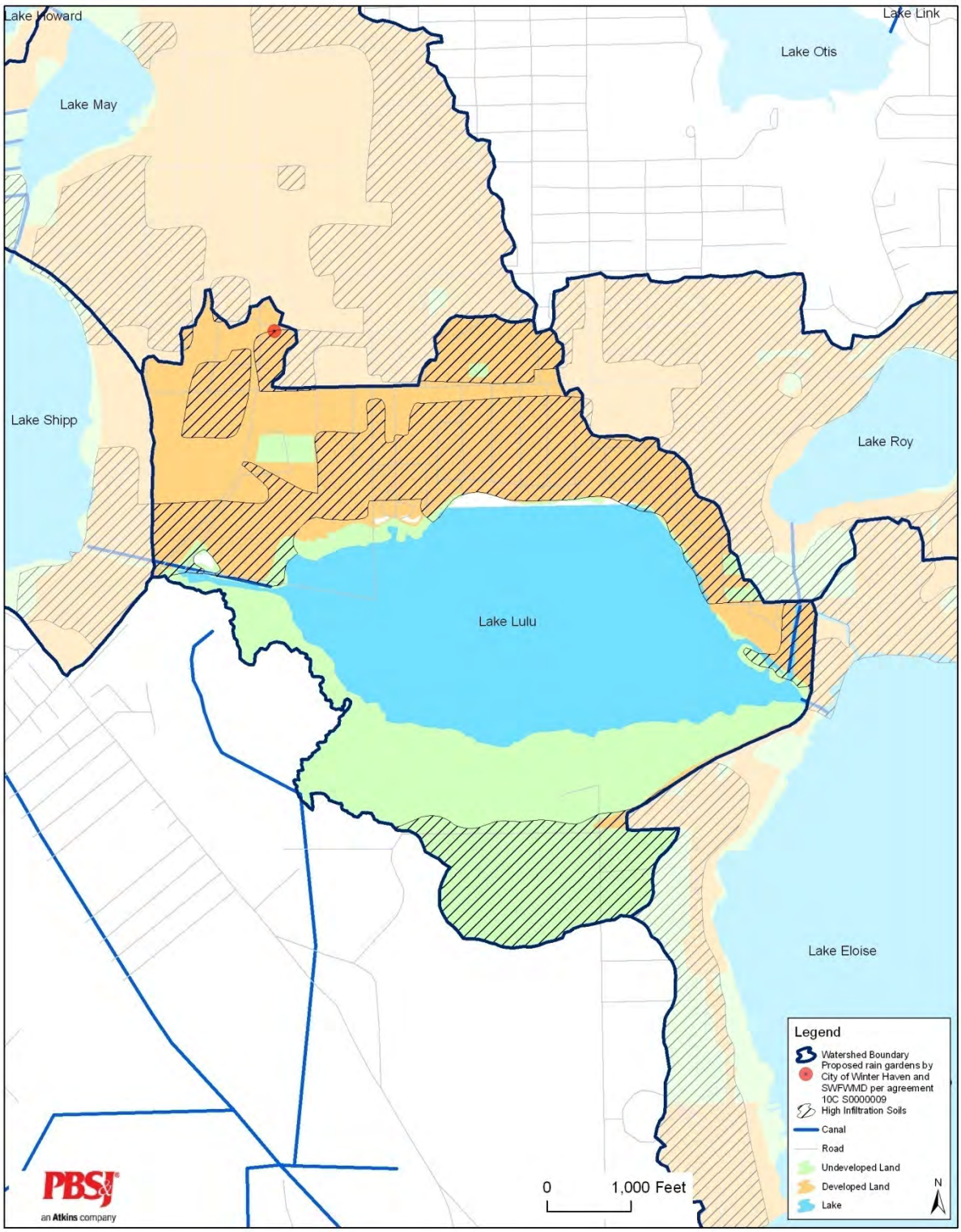


Figure 4-56. Lake Lulu chlorophyll *a* concentrations and *Hydrilla* treatment history using available data from 1983 to 2007.

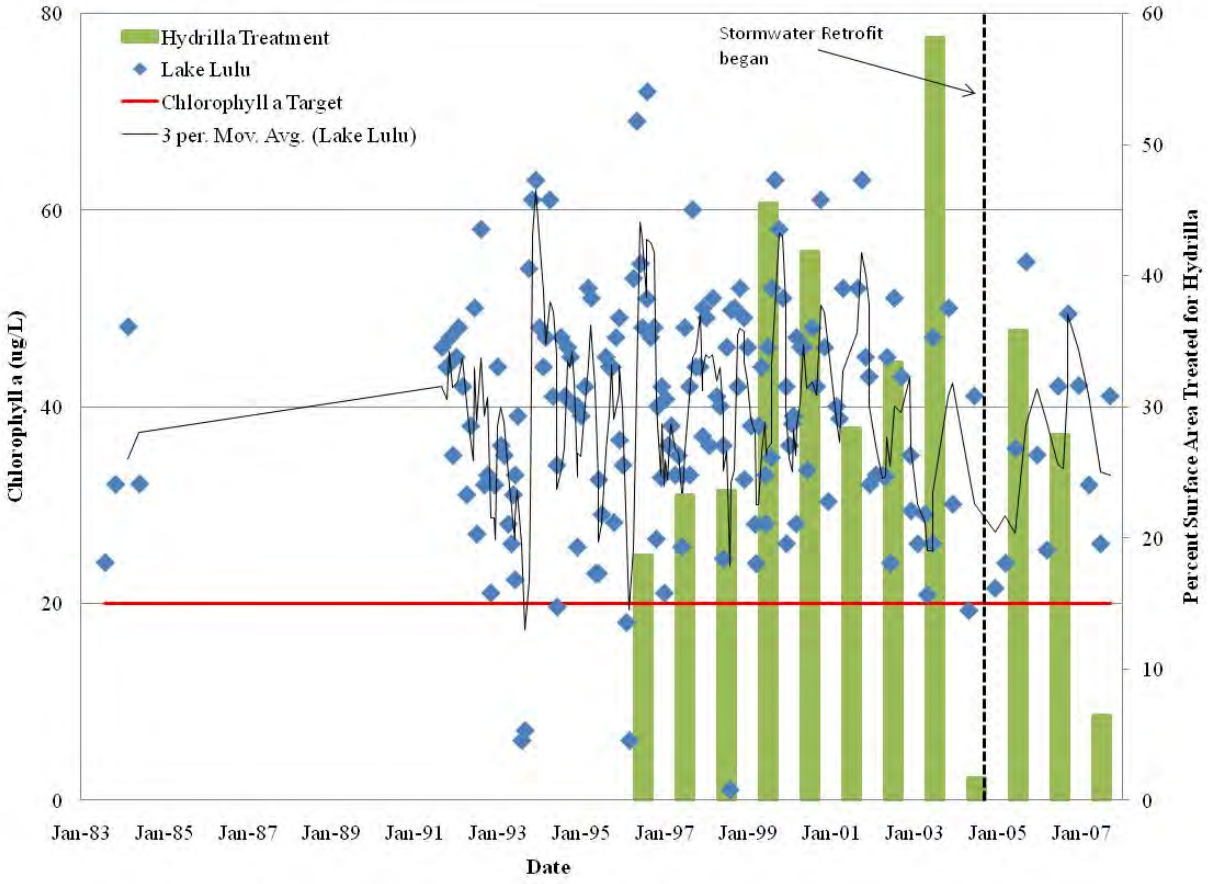
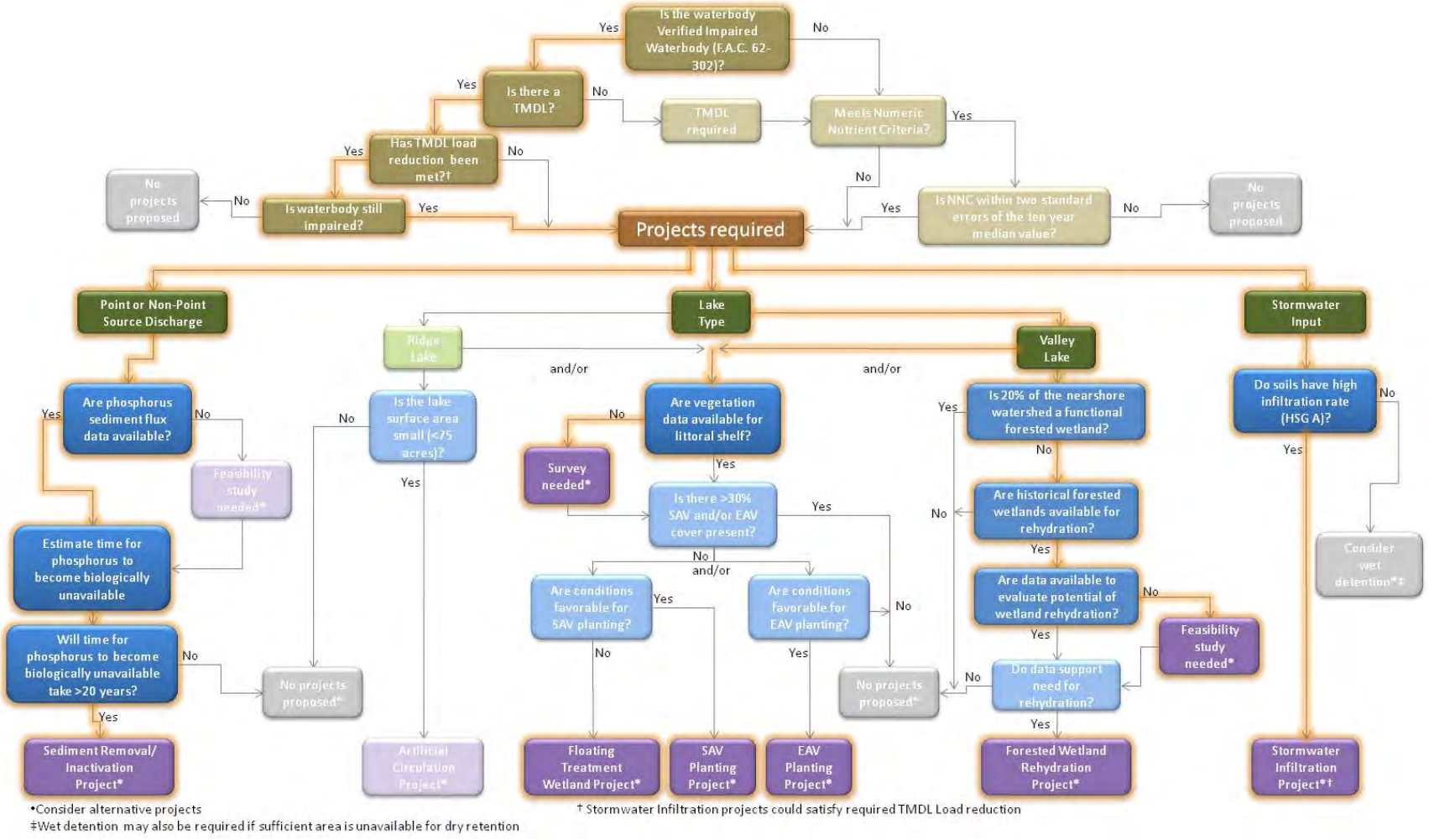


Figure 4-57. Lake Lulu bathymetry (June 2007) at water level elevation = 129 feet (Polk County Water Atlas).

Figure 4-58. Lake Lulu decision key: highlighted path shows decision process.



Project 1: Sediment Removal/inactivation

Historical point source discharges to Lake Lulu from WWTFs require further evaluation of the potential internal phosphorus load from the lake bottom sediments. The City of Winter Haven funded a Sediment Removal Feasibility Study performed by ERD to evaluate the sediment characteristics, phosphorus flux, and volume (ERD 2010). An estimate of the length of time until the pool of available phosphorus within the bottom sediments returns to background conditions was calculated using TP concentration in the sediments, the percent of available phosphorus and bulk density. Approximately 142 years are required for phosphorus concentrations to return to background conditions. Therefore, sediment removal/inactivation is recommended to address internal phosphorus loads. A cost estimate for sediment removal/inactivation has been completed by ERD (2010).

Sediment Removal: Costs associated with hydraulic dredging can be highly variable depending upon a variety of factors such as dredge capacity, availability of disposal areas, and distance to disposal areas, sludge dewatering requirements, booster pump requirements, and final sediment disposal. Since none of these factors have been fully evaluated at this time, a general sediment dredging cost of approximately $10.00 per cubic yard is assumed for this analysis. This value assumes that a shoreline dewatering facility would be used. A summary of estimated costs for hydraulic dredging in Lake Lulu, based on the previously determined organic sediment volumes, is $13,665,000. An estimated 847 ac-ft (1,366,493 cubic yards) of organic material would be removed.

Sediment Inactivation: A summary of estimated application costs for sediment inactivation in Lake Lulu is given based on an application of 10:1 Al:P ratio. This estimate assumes an alum volume of 728,023 gallons and a sodium aluminate volume of 128,006 gallons would be applied over two applications within a 6-12 month time period. It is assumed that the alum and sodium aluminate are purchased at a government contract price. Planning and mobilization costs are estimated to be approximately $5000 per application, which includes initial planning, mobilization of equipment to the site, demobilization at the completion of the application process, and clean-up. A labor rate of $125/hour is assumed which includes labor costs, water quality monitoring, expenses, equipment rental, insurance, mileage, and application equipment fees. The estimated cost for sediment inactivation in Lake Lulu is $1,412,239 or approximately $706,119 per application.

Project 2: Stormwater Infiltration Areas (SIAs)

The Lake Lulu watershed has approximately 292 acres (53 percent of the watershed) classified as high infiltration soils. A TMDL has been established for Lake Lulu, and as such, the SIA design should be focused on satisfying the TMDL requirements. SIA projects would need to encompass approximately 7 percent (38 acres) of the watershed in order to accomplish an annual 84 kg reduction in TP loads to Lake Lulu. Acres of SIA estimated to meet the TP NNC was 32 (6 percent of the watershed) for a 39 percent phosphorus reduction in Lake Lulu to meet its NNC. Fifty-three percent of the watershed is characterized by high infiltration soils; therefore, it may be feasible to satisfy the TMDL load reductions through SIA implementation.

Presently, the City of Winter Haven has preliminarily identified one rain garden project within the contributing drainage basin for Lake Lulu as part of SWFWMD funded agreement (Figure 4-59). The rain garden is 500 feet^2 providing treatment to 4,000 feet^2. A brief description of the project is identified below as provided by the City of Winter Haven.

Site 29: South side of Post Ave. SW east of Third Street SW at the WH Water Plant:

Type of Project:	Rain Garden along Post Ave. SW.
Objective:	To capture and percolate the runoff coming down the south side of Post Ave. SW. The runoff can be easily directed into the depressional area/rain garden at this location as the area is lower than the adjacent edge of pavement.
Drainage Area:	4,000 SF
Rain Garden:	500 SF
Treatment Volume:	360 CF (provided)
Cost Estimate:	$ 2,850

Project 3: Forested Wetland Rehydration

Approximately 45 percent of the land cover within the 500 foot buffer surrounding Lake Haines is classified as wetlands using the 2006 FLUCS data. Forested wetlands encompass 30 percent of the total wetland area, which is within the 10 to 20 percent recommended forested wetland cover required to maintain color levels above 50 PCU. While FLUCS classifies the land cover as forested wetland, the hydrologic connection between the lake and adjacent land might not be present as is observed along the southern rim of the Lake.

One proposed project area was identified adjacent to Lake Lulu along the southern rim and is expected to rehydrate approximately 167 acres (Figure 4-60). The feasibility study is recommended in order to evaluate the proposed project area for inundation.

Feasibility study cost estimate: $75,000.

Figure 4-59 . Proposed forested wetland rehydration project areas for Lake Lulu.

Project 4: SAV Planting or FTWs

SAV Planting

In Lake Lulu, *Hydrilla* eradication has been completed over as much as 58 percent of the lake surface area attributing to the continued degradation in water quality. A survey of existing SAV cover in Lake Lulu is recommended due to the lack of sufficient data to calculate percent lake cover. Based on the results of the SAV survey, conclusions regarding SAV planting can be determined. If SAV cover is less than 30 percent, lake conditions should be evaluated to assess if additional SAV is viable based on the soil condition, water clarity and water depth. *Hydrilla* harvesting may be required for successful establishment of selected SAV plants.

SAV plants should not be planted in water depths greater than 2 feet based on the median secchi depth values (1.8 feet). The maximum planting effort could result in vegetation cover of approximately 14 percent of the lake bottom (45 acres). Due to the extensive organic material located in Lake Lulu, it is recommended that SAV planting be performed after sediment removal/inactivation, if completed. If sediment removal is completed, the planting area would need to be recalculated using updated bathymetry data.

Cost Estimate: $220,000 (estimate based on previous purchase and installation cost of $0.90 per plant provided by EarthBalance®, additional funds included for maintenance).

FTWs

If the feasibility study indicates that more than 30 percent of Lake Lulu has SAV cover, FTW may be considered. The installation of floating mats with appropriate aquatic vegetation would be expected to assimilate nutrients from the water column.

Project 5: EAV Planting

A survey of existing shoreline vegetation surrounding Lake Lulu is recommended due to the lack of sufficient data at this time. Based on the results of the shoreline survey, conclusions and recommendations regarding emergent aquatic or woody vegetation planting can be determined. If limited shoreline vegetation is present, shoreline conditions should be evaluated to assess if vegetation planting is viable based on the soil conditions, slope, water level and inundation frequency and wave disturbance.