Lake Panorama Watershed Analysis, Sedimentation Assessment, and Water Quality Review

For:

Lake Panorama
Rural Improvement Zone (RIZ)
Panora, Iowa

PROJECT # 415592-0
DATE: January 30, 2017

I hereby certify that the portion of this technical submission described below was prepared by me or under my direct personal supervision. I am a duly licensed Professional Engineer under the laws of the State of Iowa.
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My license renewal date is December 31, 2018.
Pages, sheets, or divisions covered by this certification: ________
All ____________________

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Project # 415592-0

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1. Executive Summary

The Lake Panorama watershed analysis, sedimentation assessment, and water quality review was developed to document the conditions of Lake Panorama and the need for improvements. This document was reviewed with and coordinated with the Lake Panorama Rural Improvement Zone (RIZ).

Watershed Characteristics

The Lake Panorama watershed is approximately 425 square miles and encompasses portions of Guthrie, Greene, and Carroll Counties. This section provides general information about the watershed including topography, land use, soils, hydrology, tributary streams and communities within the watershed. The Middle Raccoon River splits the watershed into two primary landforms. Northeast of the river is the Wisconsin glacial till known as the Des Moines Lobe characterized by flat slopes. Southwest of the river is the Southern Iowa Till Plain with steep slopes and broad valleys.

Lake Sedimentation

Sediment is delivered to Lake Panorama from several sources throughout its large watershed. Recent studies estimate sediment has been deposited in the lake at a rate of approximately 476,000 cubic yards per year. This volume varies from year to year and is highly dependent upon rainfall intensities and river flow. The quantity of sediment currently accumulated in the lake is estimated at 9.3 million cubic yards, which is approximately 30% of the original water volume. The “Lake Sedimentation” section includes discussion of historical, current, and future sediment accumulation within the lake, as well as sediment removal efforts.

Sediment Storage

Since its construction, approximately 12.6 million cubic yards of material has been dredged from the lake and is stored in sediment storage basins around the lake. Currently, there are approximately 8.5 million cubic yards of available storage for dredged sediment. The “Sediment Storage” section discusses current storage infrastructure and the need for additional storage to continue sediment removal operations. In addition, preventative structures that catch sediment before it enters the lake are reviewed and discussed in this section.

Water Quality

Several factors currently influence the overall water quality of Lake Panorama. These include physical water characteristics, nutrient concentrations, pathogen counts, and more. The “Water Quality” section contains recent water testing results and discussion of the current water quality of the lake. Similar to other lakes in Iowa, the water quality of Lake Panorama fluctuates dramatically throughout the course of the year and is highly dependent upon rainfall. The major pollutants impacting water quality at the lake are sediment, nitrogen, phosphorus, and waterborne pathogens.

Estimate of Costs

Estimated costs to effectively address erosion control and water quality over the next 20 years have been based upon the RIZ district’s historical data, as well as market costs from third-party dredging vendors. Estimates for various activities are imperfect due to the extended timeline, but have been generated to detail the magnitude of work the Rural Improvement Zone must undertake to preserve the current useable state of Lake Panorama.

The Lake Panorama Rural Improvement Zone is currently pursuing a diverse approach to protecting Lake Panorama. Efforts include the removal of sediment through hydraulic and mechanical dredging, the creation and maintenance of preventative sediment forebays, and the development of wetlands that improve water quality. This diverse approach currently serves Lake Panorama effectively by addressing short-term needs while seeking to improve long-term conditions. Furthermore, leveraging of state and federal dollars on wetland construction has allowed the Lake Panorama Rural Improvement Zone to multiply the impact of local dollars spent.

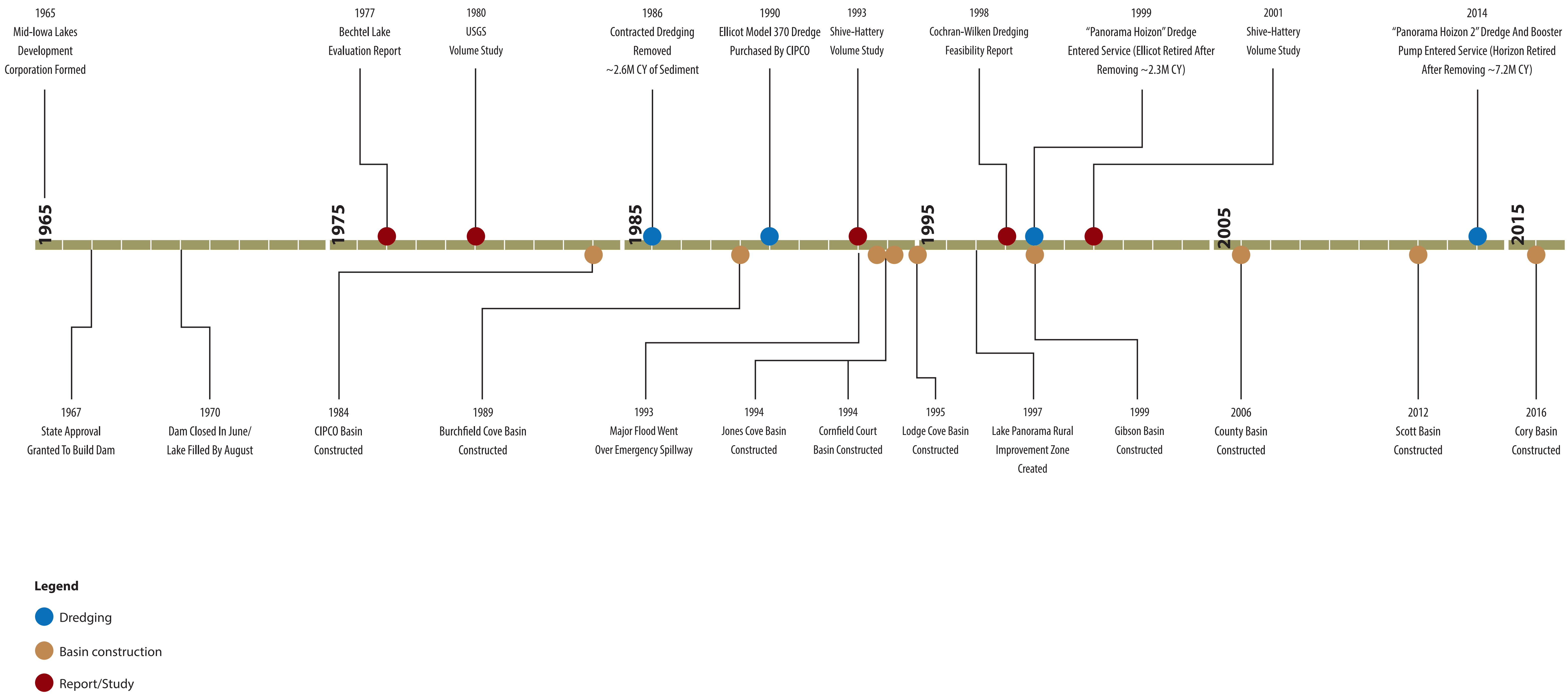
The Rural Improvement Zone believes it can effectively address erosion control and water quality over the next 20 year period for approximately $50 million. Current estimates to remove approximately 12 million cubic yards of material over the next 20 years are around $40 million. In addition, over $10 million should be directed toward conservation and water quality initiatives in the Lake Panorama watershed to reduce pollutant loading and improve water quality. The “Estimate of Costs” section includes discussion on how these costs were established.

2. Project Background and Goals

The Lake Panorama Rural Improvement Zone has undertaken this report to meet the requirements of IA Code 357H, as amended by HF 615 in the 2015 legislative session. This report will be provided to the Guthrie County Board of Supervisors as requested in their letter of January 14, 2016 regarding the Lake Panorama Rural Improvement Zone's preceding request for extension.

To assist with understanding the history of Lake Panorama and its efforts to address sedimentation issues, a timeline has been constructed. This timeline provides information on previously completed studies/reports, dredging, and storage basin construction. The timeline is presented on the following page.

LAKE PANORAMA TIMELINE



3. Watershed Characteristics

3.1 Watershed Data

Lake Panorama is a privately-owned lake formed by an earthfill dam on the Middle Raccoon River in central Iowa. It is situated about one mile northwest of the city of Panora. A 2016 analysis by Shive-Hattery estimates the lake surface area to be approximately 1,160 acres at its normal pool elevation of 1045.5 feet.

The Lake Panorama watershed lies mainly within Carroll, Greene, and Guthrie Counties, with a small portion extending into Sac County. A listing of all municipalities that lie partially or completely within the Lake Panorama watershed is provided in Table 1. The watershed is approximately 49 miles long with a width of roughly 10 miles. It has an approximate area of 425 square miles, or just over 271,900 acres. This results in a drainage area to lake surface area ratio of 234:1.

Table 1: Municipalities Located in Lake Panorama Watershed

Town	Population (2010)
Carroll	10103
Coon Rapids	1305
Glidden	1146
Arcadia	484
Breda	483
Bayard	471
Lidderdale	180
Willey	88

A map of the Lake Panorama watershed area is provided in Figure 1. The map includes HUC 12 watersheds and the names of the major streams and rivers within the Lake Panorama watershed. The major streams also are listed in Table 2.

Table 2: Streams Located in Lake Panorama Watershed

Stream
Battle Run
Calamus Creek
Cottonwood Creek
Kings Creek
Middle Raccoon River
Spring Branch
Springbrook Creek
Storm Creek
Willey Branch
Willow Creek

The Lake Panorama watershed consists of a portion of one HUC 8 watershed, 07100007, which is the South Raccoon subbasin of the Des Moines subregion and the Upper Mississippi Region. The lake's watershed boundary contains two full HUC 10 watersheds – the Upper Middle Raccoon River watershed and the Willow Creek watershed—and a portion of the Lower Middle Raccoon River HUC 10 watershed. Within those, eleven HUC 12 watersheds make up the watershed for Lake Panorama.

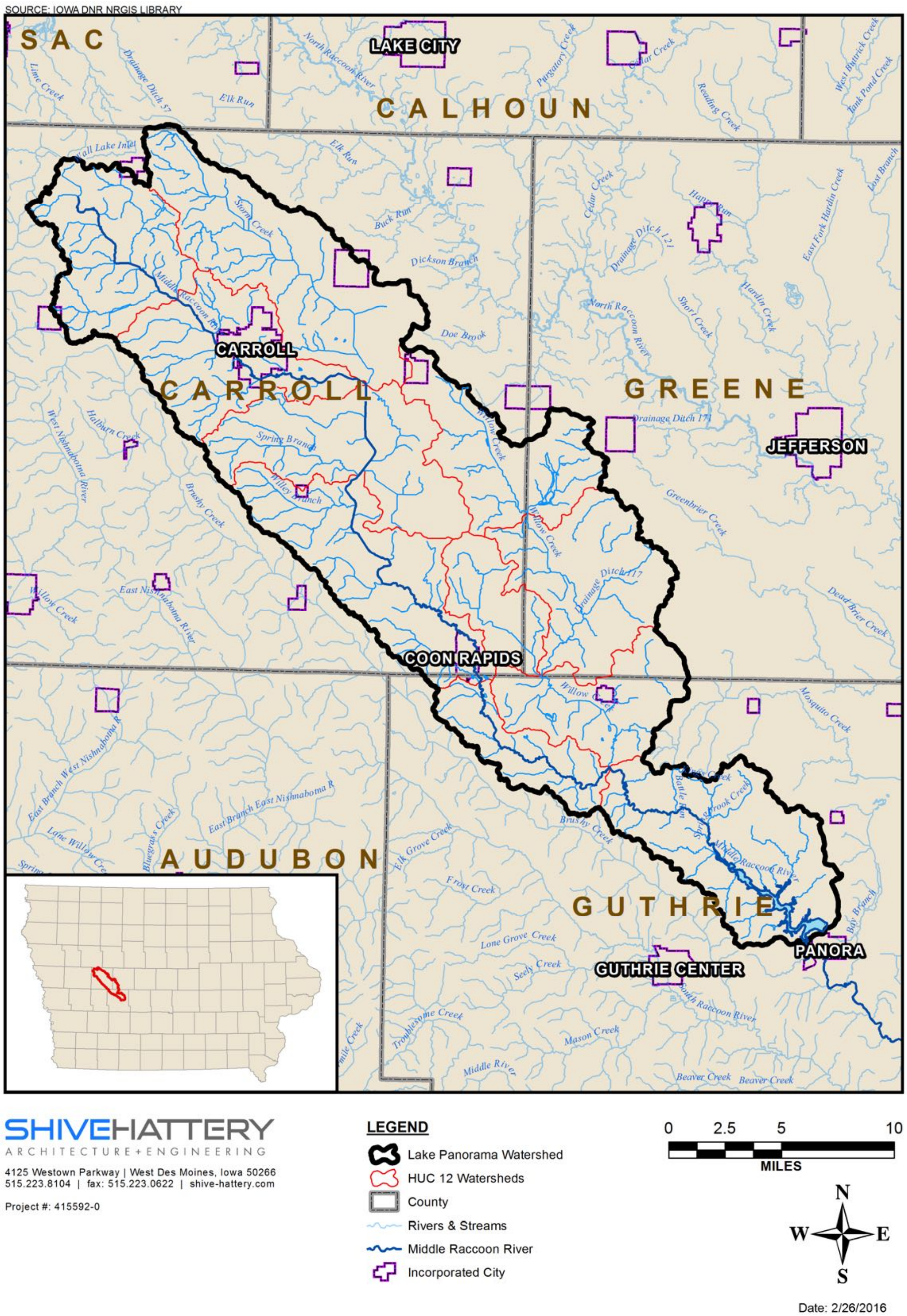


Figure 1: Lake Panorama Watershed Area

3.2 Topography

The topography and varying slopes of the Lake Panorama watershed are depicted in Figure 2. As illustrated by the figure, the slopes of the watershed are steeper southwest of the Middle Raccoon River and at downstream end of the watershed, while the areas northeast of the Middle Raccoon River and near the top of the watershed are generally flatter. This dramatic change in topography is due to the glacial boundary, which corresponds with the location of Lake Panorama. Figure 2 was created using LiDAR data obtained from the Iowa Department of Natural Resources. LiDAR technology uses aircraft-mounted lasers to scan the land surface and generate elevations. Elevation points are generated on a 1.4 meter by 1.4 meter grid and are vertically accurate to within 18 centimeters. Iowa DNR LiDAR data was collected between 2007 and 2010. Table 3 displays the sums of the areas for various ranges of land slopes within the lake's watershed. It also provides the percentage of the watershed area that has slopes falling within each of the ranges. As the figure and table show, most of the Lake Panorama watershed is relatively flat, with nearly two-thirds of the land area having a slope of 1% or less. The total difference in elevation from the lake surface of 1045.50 to the highest point in the watershed is approximately 430.5 feet. The highest point in the Lake Panorama watershed is located close to its northwest end, near the intersection of 150th Street and Delta Avenue in Carroll County. The elevation of the point is about 1476 feet.

Table 3: Slopes within Lake Panorama Watershed

Slope Range	Area (Square Miles)	Percentage
0%-0.5%	190.5	44.8%
0.5%-1%	90.7	21.3%
1%-2%	84.8	20.0%
2%-5%	50.6	11.9%
>5%	8.3	2.0%
TOTAL	**424.9**	**100.0%**

Source: Iowa DNR NRGIS Library

The following research from the Lake Panorama Association provides further description of the glacial boundary and the landforms in the Lake Panorama watershed.

The south/west side of the lake is found in the Southern Iowa till plain landform region. [West] of Panora, the valleys are much deeper and steeper than those north and east of the city. The hills are the eroded remnants of what was left behind by the ancient glaciers that covered this area (and on to Kansas) some 500,000 years ago. This deposit, known as till, is made up of the materials pushed by the glacier, including everything from giant rock blocks down to fine sand and clay ground up by the slow moving mass of ice. Half a million years of rain, snow, and vegetation changes have shaped this material into long series of broad rolling hills, wide valleys and complex drainage patterns. This ground has been exposed to erosion for many thousands of years and was particularly impacted when the "Des Moines Lobe" of the Wisconsin glacier traveled up to about where the river is today and then began melting away some 14,000 years ago. That latest (Wisconsin) glacier rode over the older deposited materials to the north and deposited a fresh layer of newer glacial till here. As the 300-400-foot thick ice retreated from melting, the current channel of the Middle Raccoon River developed generally along the path of the edge of the glacier's furthest travel.

The landforms from the river north and east are distinctly different and are characterized by the hummocks, knobs, ridges, and pothole ponds of the newer Wisconsin glacial till. … This is the relatively new ground that has not had years of erosion to develop the drainage. A visitor here over 150 years ago would have found a vast region of ponds and wet marshes along with sandy knobs and hills covered with tallgrass prairie species.

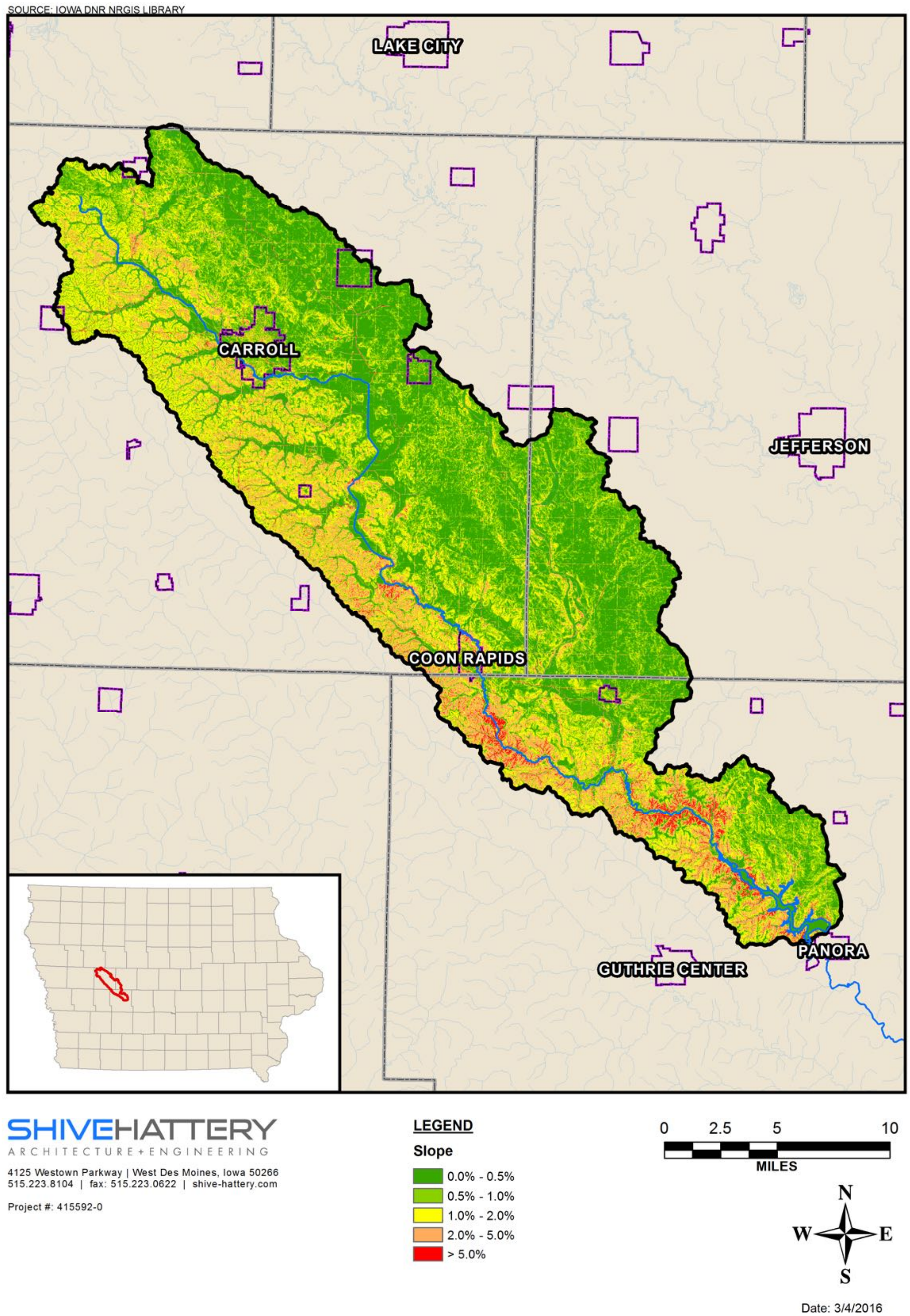


Figure 2: Slopes within Lake Panorama Watershed

3.3 Land Use

Land use and land cover are fairly consistent throughout the Lake Panorama watershed. A summary of the land cover types and associated areas is displayed in Table 4. Most of the watershed of Lake Panorama is covered by row crops, with over 72% of the land area used for growing corn or soybeans. In addition to the row crops, small areas of pasture and forest are included in the watershed, as well as the urban areas of Carroll and Coon Rapids and several other small communities.

Table 4: Land Cover (2009) of Lake Panorama Watershed

Land Cover	Area (Square Miles)	Percentage
Water	4.2	1.0%
Wetland	3.5	0.8%
Coniferous Forest	1.6	0.4%
Deciduous Short	4.9	1.2%
Deciduous Medium	8.0	1.9%
Deciduous Tall	8.9	2.1%
Grass 1	41.1	9.7%
Grass 2	27.0	6.3%
Cut Hay	2.0	0.5%
Corn	161.4	38.0%
Soybeans	147.5	34.7%
Barren / Fallow	2.7	0.6%
Structures	1.5	0.4%
Roads / Impervious	9.9	2.3%
Shadow / No Data	0.7	0.1%
TOTAL	**424.9**	**100.0%**

Source: Iowa DNR NRGIS Library

Figure 3 provides an illustration of the land cover types included in the Lake Panorama watershed. The highest concentrations of row crop land cover are found in the northern and eastern portions of the watershed, which is also where the land slopes are the flattest. Near the Middle Raccoon River at the southern end of the watershed, where the slopes are steeper, there are higher densities of forest and grassland land covers. Figure 4 shows land use within the Lake Panorama watershed.

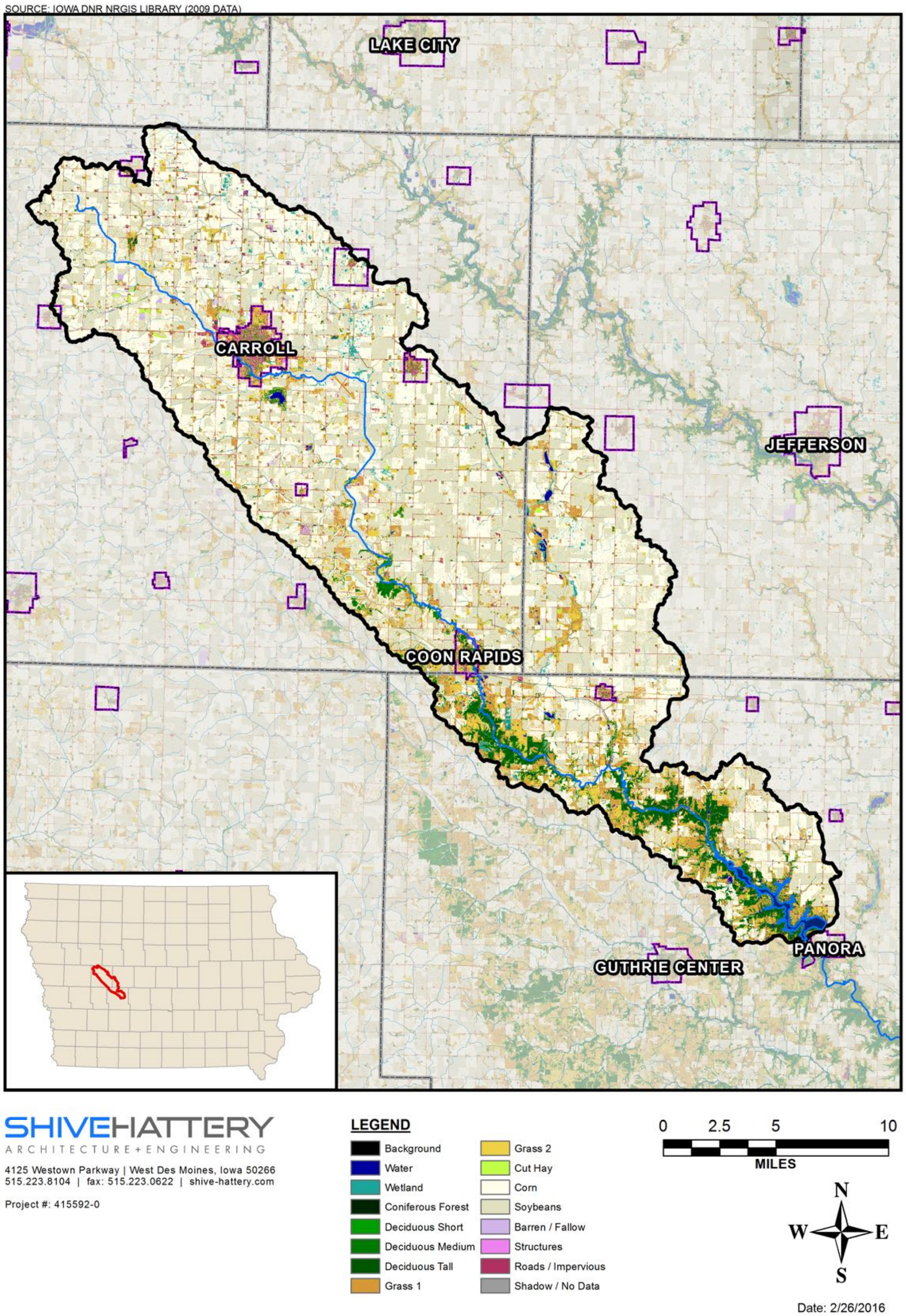


Figure 3: Land Cover (2009) of Lake Panorama Watershed

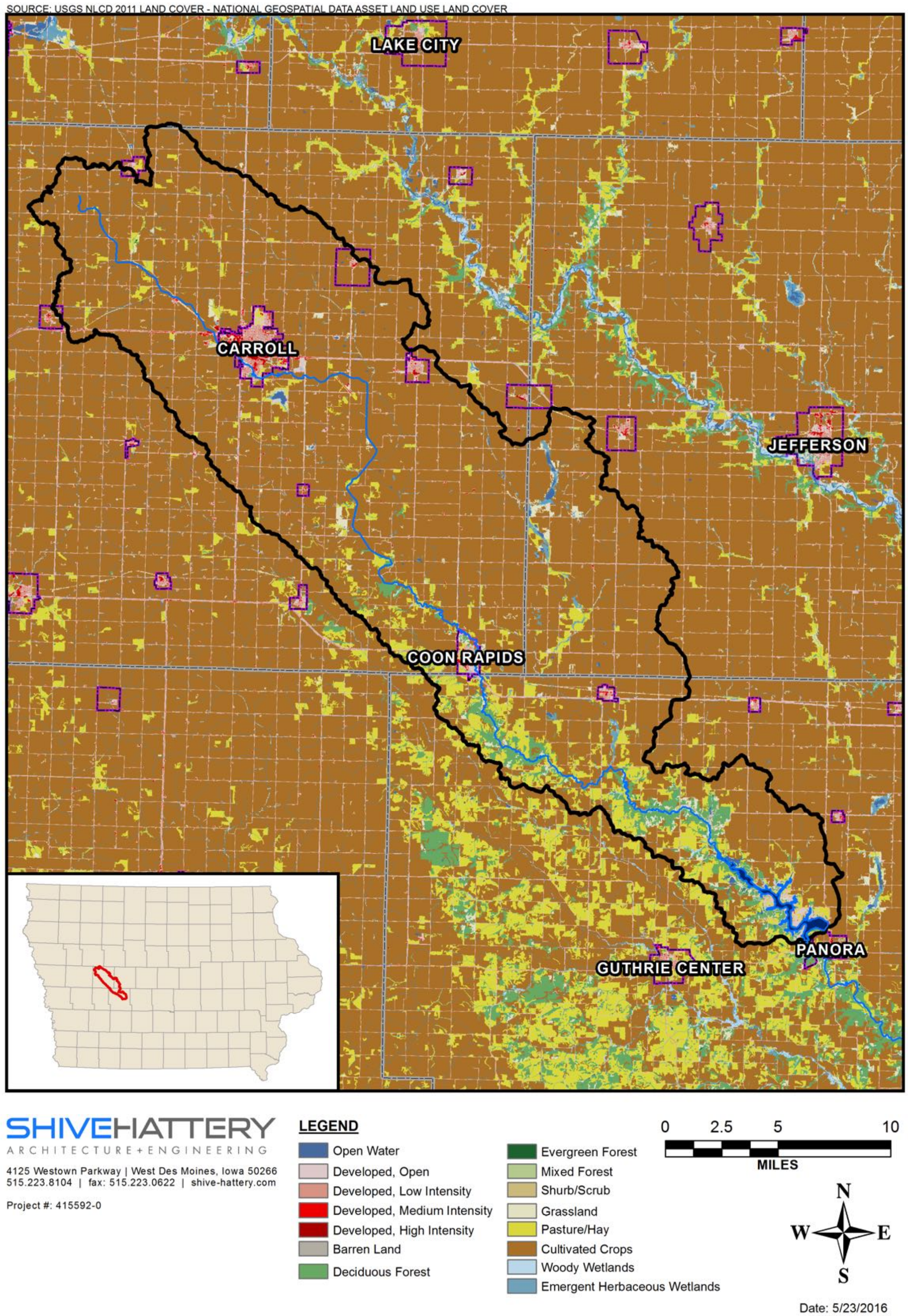


Figure 4: Land Use (2011) of Lake Panorama Watershed

The space dedicated to growing corn has generally increased in the Lake Panorama watershed area over the past several years. Figure 5 shows the number of acres of corn planted in Carroll, Greene, and Guthrie counties for each year since 1970. In 2007, there were about 66,000 more acres of corn planted than in 2006. This coincides with an increase in corn prices largely due to expansion of the ethanol industry. As the number of acres planted with corn increased, the number of acres enrolled in the Conservation Reserve Program (CRP) has decreased. Figure 6 presents the number of acres in Carroll, Greene, and Guthrie counties enrolled in CRP for the years 1986 to 2014. In 2007, when the acres of corn began to increase significantly, the acres in CRP began a downward trend. From this information, it can be inferred that as a result of higher corn prices, farmers began to put more acres into production and reduce the area set aside for conservation. The increase in acres dedicated to growing corn is significant because sediment and nutrient runoff rates are significantly higher from land used for row crop cultivation than from land used for conservation purposes. It is worth noting that, at the time of this report, crop prices have declined from recent highs. However, enrollment in CRP also has become more challenging for many landowners. The short-term drop in prices is not expected to dramatically reduce sediment forecasts for Lake Panorama in the long term. The bulk of existing row crop acres is expected to remain in production despite current low prices.

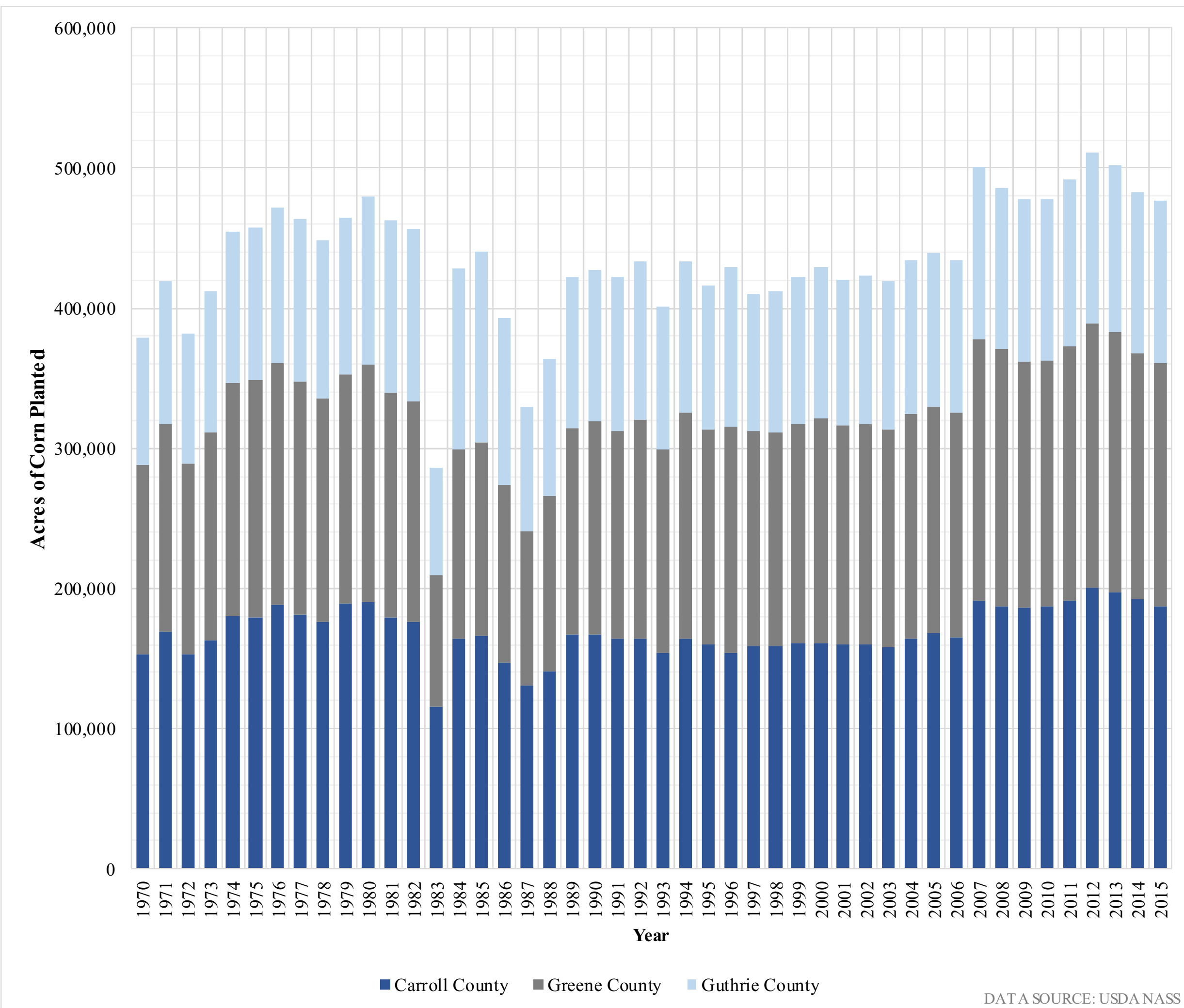


Figure 5: Acres of Corn Planted

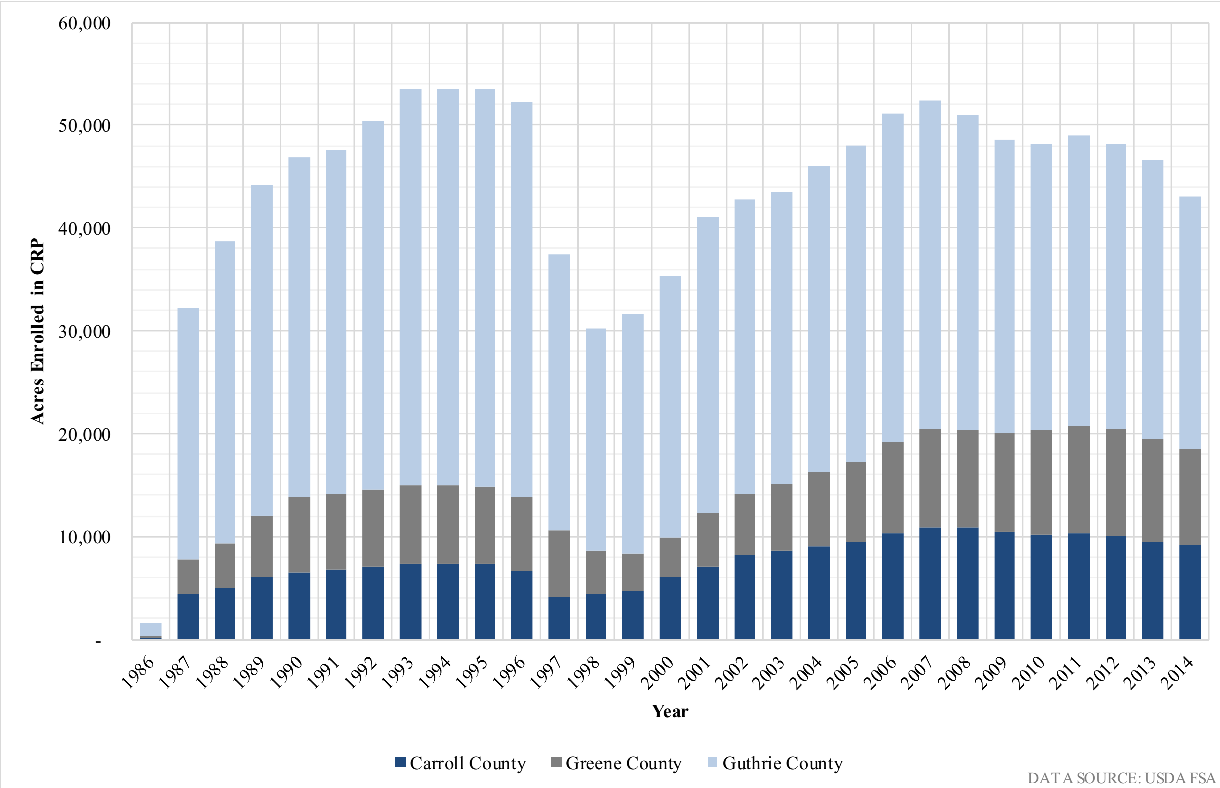


Figure 6: Acres Enrolled in Conservation Reserve Program (CRP)

3.4 Soils Classification

The Lake Panorama watershed consists of two primary soil groups. These groups are divided by the Middle Raccoon River. Southwest of the river, the soil is mainly Kansan glacial till, which is a highly erodible loess soil. To the northeast of the river is Wisconsin glacial drift. In the Wisconsin till area, the Clarion-Nicolet-Webster Soil Association is present, while the Marshall Soil Association is present in the northern portion of the Kansan till area with the Shelby-Sharpsburg-Macksburg Soil Association in the southern half.

The USDA Natural Resource Conservation Service classifies soils into four hydrologic soil groups based on the soil's runoff potential. Group D soils, consisting primarily of clays, generally have the greatest runoff potential, while group A soils, consisting primarily of sands, would have the smallest potential for runoff. Group A soils have a much higher infiltration rate, at 1.42 inches per hour, than Group D soils, which have an infiltration rate of 0.06 inches per hour. Dual hydrologic soil groups are given to certain wet soils that could be adequately drained if not for a shallow water table. Soils are assigned to dual groups when the sole reason for assigning them to hydrologic group D is the depth to a permanent water table. The areas of each of the hydrologic soil groups within the Lake Panorama watershed are shown in Table 5. Soil groups B and B/D are the primary hydrologic soil groups represented, making up over 94% of the total watershed area. These soils have a moderate potential for runoff. The B/D designated soils are mainly found in the very flat areas of the watershed, such as low-lying floodplains and prairie pothole regions, where the water table is shallow. The largest concentration of Group C soils within the watershed, which have moderately high runoff potential, are mainly located in the Kansan glacial till area southwest of the Middle Raccoon River.

Table 5: Hydrologic Soil Classifications of Lake Panorama Watershed

Hydrologic Group	Area (Square Miles)	Percentage
A	1.5	0.4%
B	275.1	64.7%
B/D	125.4	29.5%
C	19.2	4.5%
C/D	3.4	0.8%
D	0.3	0.1%
TOTAL	**424.9**	**100.0%**

Source: Iowa DNR NRGIS Library

Hydrologic Soil Groups

GROUP A
Group A soils have high infiltration rates and low potential for runoff. These have a high rate of water transmission and consist mainly of well-drained sands or gravels. These are sand, loamy sand, or sandy loam.

GROUP B
Group B soils have a moderate infiltration rate and have moderately fine to moderately coarse textures. These consist mainly of moderately well- to well-drained soils and are a silt loam or loam.

GROUP C
Group C soils have low infiltration rates and generally have a layer that impedes downward movement of water. These are sandy clay loam.

GROUP D
Group D soils have very low infiltration rates and the highest runoff potential. These consist mainly of clay soils.

SOURCE: USDA NRCS

The Lake Panorama watershed would have less runoff than a similarly sized watershed with predominantly hydrologic group C and D soils, and it would have more runoff than one comprised of A and B group soils. Figure 7 depicts the locations of each of the hydrologic soil types in the Lake Panorama watershed.

In addition to the soil classification, the presence of drainage tile also impacts runoff in the watershed. Drainage tile has progressively become more prominent in the Lake Panorama watershed since the closing of the dam in 1970. Subsurface drainage generally decreases peak surface runoff from fields where it is installed. It can, however, cause increased flows in streams or channels where it outlets, which can contribute to prolonged saturation of streambanks, leaving them more susceptible to erosion during storm events. Studies have been conducted to attempt to determine the effects of drainage tile on sediment delivery, but most are at the scale of individual fields. Watershed-scale studies are relatively few in number. Due to the limited availability and variability of the study results, it is difficult to suggest that net sediment delivery rates are impacted by drainage tile.

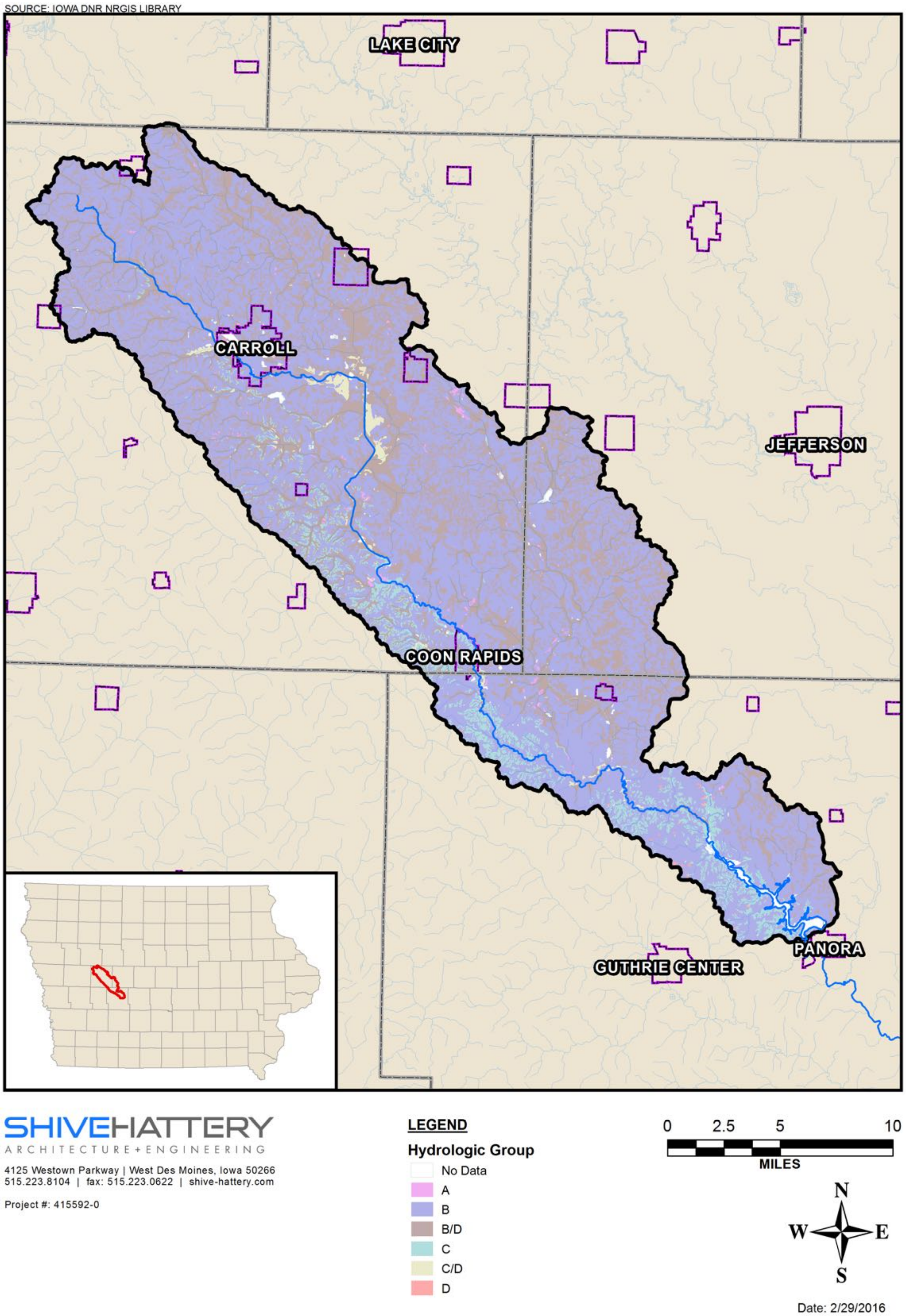


Figure 7: Hydrologic Soil Classifications of Lake Panorama Watershed

4. Lake Sedimentation

Sediment is delivered to streams, rivers, and lakes from several sources, including runoff and streambank erosion. For most natural lakes, sediment accumulation is not a major issue due to small watershed size and low levels of topographic relief. In many man-made lakes, however, sedimentation is a major problem. Sediment is delivered by the stream or river that feeds the lake, and the incoming water is slowed by the lake pool. As the speed of the incoming water is reduced, sediment settles out and accumulates on the bottom of the lake. When lakes have high drainage area to lake surface area ratios, as Lake Panorama does, sedimentation becomes an even larger concern. The larger drainage area results in a larger area of runoff, so there is a potential for more sediment to be carried with that runoff into the watershed's streams and rivers and eventually to the lake. The long-term viability of Lake Panorama depends on maintaining a lake depth and size suitable for boating and other recreational activities.

4.1 Historical Sediment Accumulation

Since Lake Panorama was constructed in 1970, several efforts have been made to estimate the rate at which sediment has accumulated in the lake. In 1977, a report by Bechtel concluded that, based on multiple testing methods, their best estimate of sedimentation rate was 461,000 cubic yards per year. A study conducted by Iowa State University in 1981 estimated the average silt accumulation was around 860,000 cubic yards per year. After completing a volume study in 1993, Shive-Hattery calculated that, based on the change in lake volume from 1980 to 1993, the sedimentation rate was approximately 629,000 cubic yards per year. Shive-Hattery produced an updated volume study in 2001, which once again used the change in lake volume to calculate the siltation rate. The results of that study estimate sediment accumulated between 1993 and 2001 at a rate of 403,000 cubic yards per year. To better estimate the historical sediment delivery to the lake, a new survey was completed by Shive-Hattery in 2016. The results of this most recent survey indicate sediment has been deposited in Lake Panorama at an average rate of approximately 476,000 cubic yards per year since the lake was built in 1970.

4.2 Sediment Removal

The impacts of excessive sediment delivery rates on Lake Panorama became apparent less than a decade after the lake was constructed. The first dredging work took place in 1986, when a contractor removed about 2.6 million cubic yards of sediment from the upper reaches of the lake. Dredging feasibility studies were conducted in the late 1980s, and the local dredging program began in 1990 when the Ellicot Model 370 dredge entered service. This dredge was retired in 1999 after removing approximately 2.3 million cubic yards of sediment from the lake for an average of about 250,000 cubic yards per year. In the same year, the Panorama Horizon dredge entered service. Upon its retirement in 2014, it had removed roughly 7.2 million cubic yards of sediment, resulting in an average of 480,000 cubic yards per year. The Panorama Horizon 2 dredge is currently in operation, and it has dredged approximately 478,000 cubic yards of sediment since 2014.

4.3 Current Sediment Accumulation

According to the construction documents for the lake and dam, the original storage capacity of Lake Panorama at pool elevation 1045 was 31.8 million cubic yards. Later studies estimated the lake volume had decreased to 23.3 million cubic yards in 1980 and 20.3 million cubic yards in

1993, both with the lake pool at elevation 1045. In the mid-1990s, the lake's normal pool elevation was increased from 1045.0 to 1045.5, which would increase each of the previously reported lake volumes by about 900,000 cubic yards. A comprehensive lake volume study was completed in 2001 by Shive-Hattery and concluded the lake volume at that time was approximately 20.5 million cubic yards.

To generate a more accurate estimate of the current quantity of sediment in the lake, new survey work was completed in 2016. A bathymetric survey was conducted to map the current depth, or top of sediment. This work was done using sounding equipment to collect more than 300,000 data points along 450 cross sections. A model was generated from this data to show the current (2016) top of accumulated sediment. This model also can be compared to the 1045.5 pool elevation, which results in an estimated current lake volume of 21.3 million cubic yards.

Also in 2016, depth probes through existing sediment to the original bottom were taken in 945 locations along 88 cross sections, and these data points were used to generate an estimated original hard bottom surface model. Comparing this model to the current pool elevation of 1045.5 feet shows an estimated original lake volume of 30.6 million cubic yards. There could be multiple reasons for the difference between the volume reported here and the 31.8 million cubic yards reported on the lake's original construction plans. The topographic survey information used in 1970 could have been of poor quality. Additionally, the 2016 survey uses the 180th Trail Bridge over the Middle Raccoon as the northernmost point of the lake, while the 1970 documents show the lake extending further upstream.

Comparison of the original depth and current depth models indicates the current (2016) estimated quantity of sediment accumulated in Lake Panorama is about 9.3 million cubic yards. A lake map showing estimated sediment thicknesses is included as Figure 8. In this figure, darker colors indicate areas in which the estimated sediment deposits are thicker. Some areas in the lake have as much as 15-20 feet of sediment deposition. The current volume of sediment, compared to the modeled original lake volume estimate of 30.6 million cubic yards, shows that approximately 30.4 percent of the lake has been filled in.

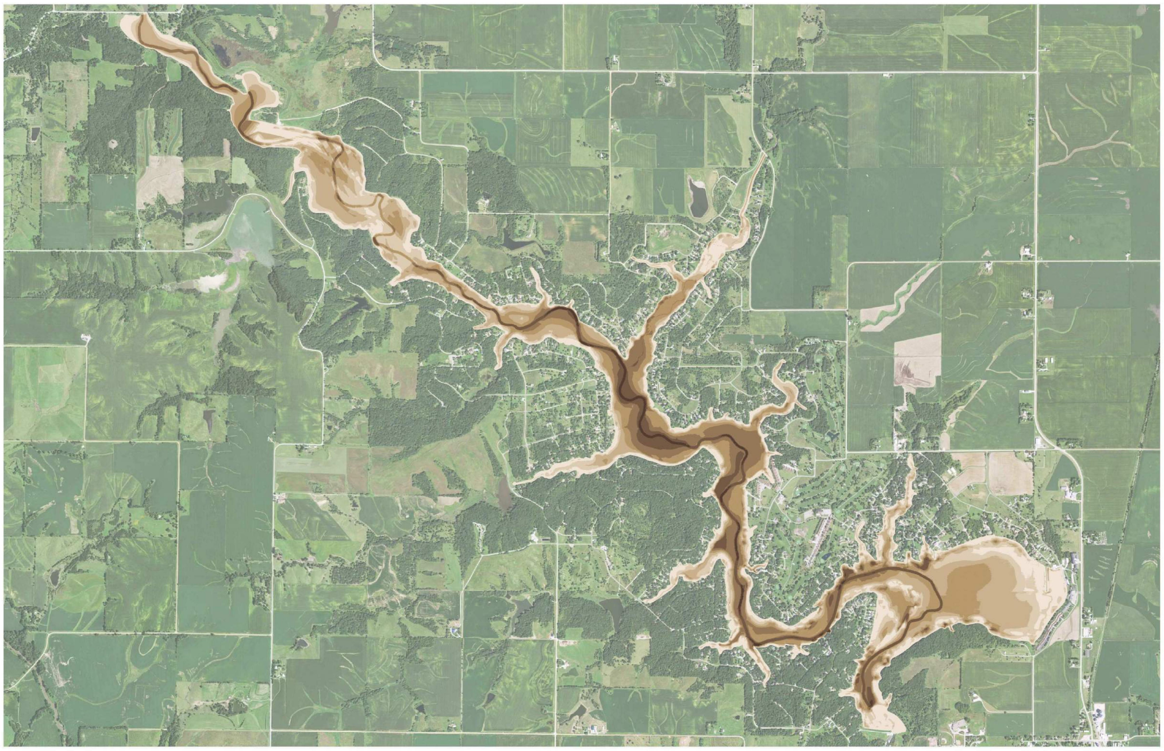


Figure 8: Lake Panorama 2016 Sediment Thickness

4.4 Future Sediment Accumulation

Over the years, multiple studies have been completed to attempt to estimate the accumulation rate of sediment in Lake Panorama. Advancements in soil conservation practices throughout the watershed, such as no-till or reduced tillage farming and the construction of protective structures upstream from the lake's coves, have contributed to a decrease in the annual rate of sedimentation. However, as described in section 3.3 above, this progress is threatened by the continued increases in acres of corn planted and decreases in acres enrolled in CRP. It is estimated that during the 20-year period following the publication of this report, silt will continue to accumulate at a rate of approximately 476,000 cubic yards per year. It is important to note the lake sedimentation rate is heavily dependent upon rainfall across the Lake Panorama watershed. Given the high drainage-area to lake-surface area ratio for Lake Panorama, intense rainfall events can have massive effects on the amount of sediment that enters the lake. Anecdotally, operators of the RIZ hydraulic dredge reported eight feet of sand accumulation in the river channel after only one weekend of extremely high river flows. Overall, annual rainfall amounts have remained steady since the lake was constructed in 1970. Figure 9 shows the total precipitation recorded in each year from 1970 to 2014 at the National Weather Service station in Carroll, Iowa. The average total precipitation is shown by the horizontal line on the graph and is just over 33 inches per year. Although there is no significant upward or downward trend in total annual precipitation since the lake was filled, the graph does illustrate the variability in precipitation totals from year to year. The varying precipitation totals are likely indicative of highly variable sedimentation rates from year to year, with substantial inflow of sediment being correlated with extreme rainfall events.

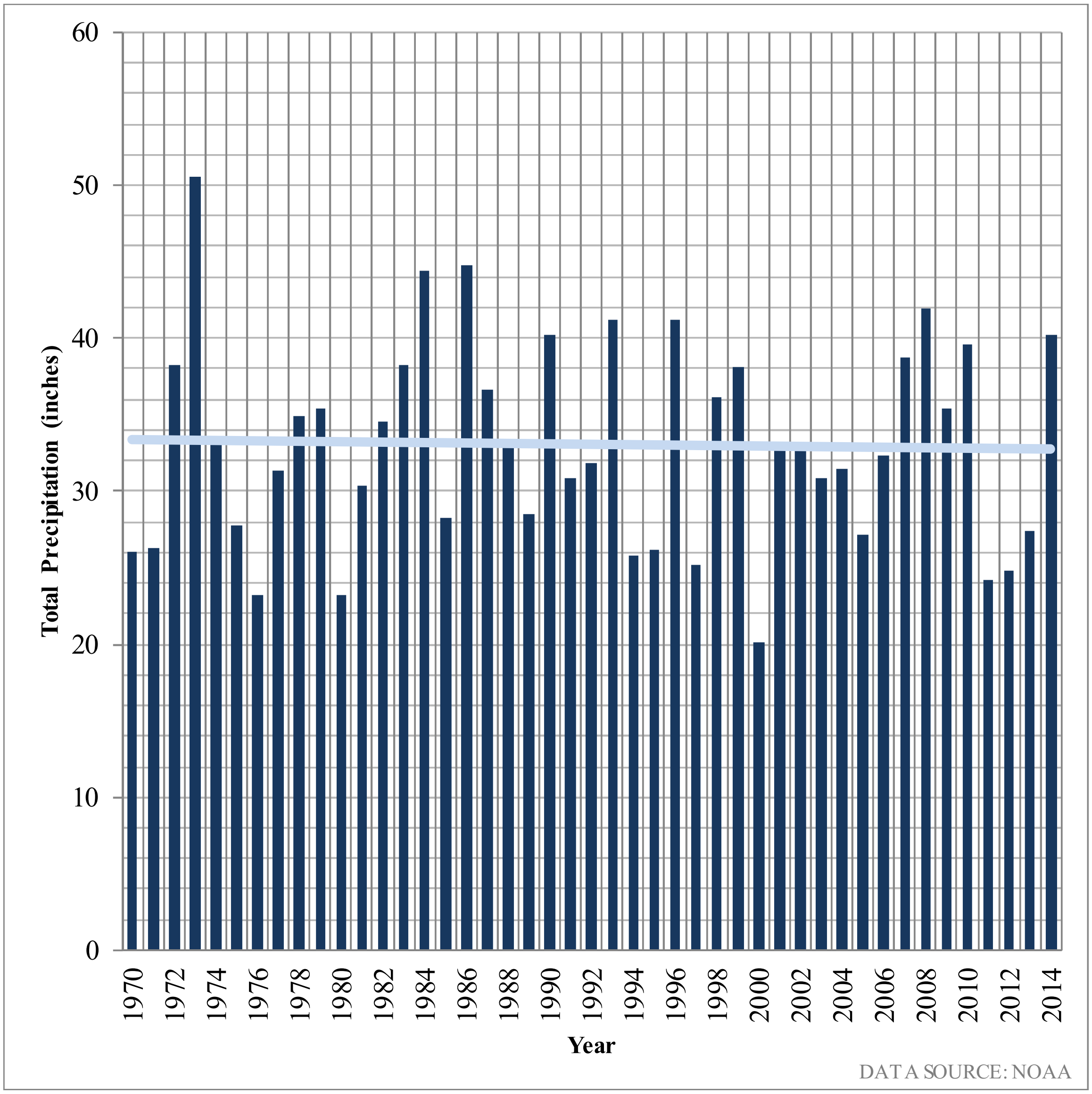


Figure 9: Total Annual Precipitation at Carroll, Iowa

5. Sediment Storage

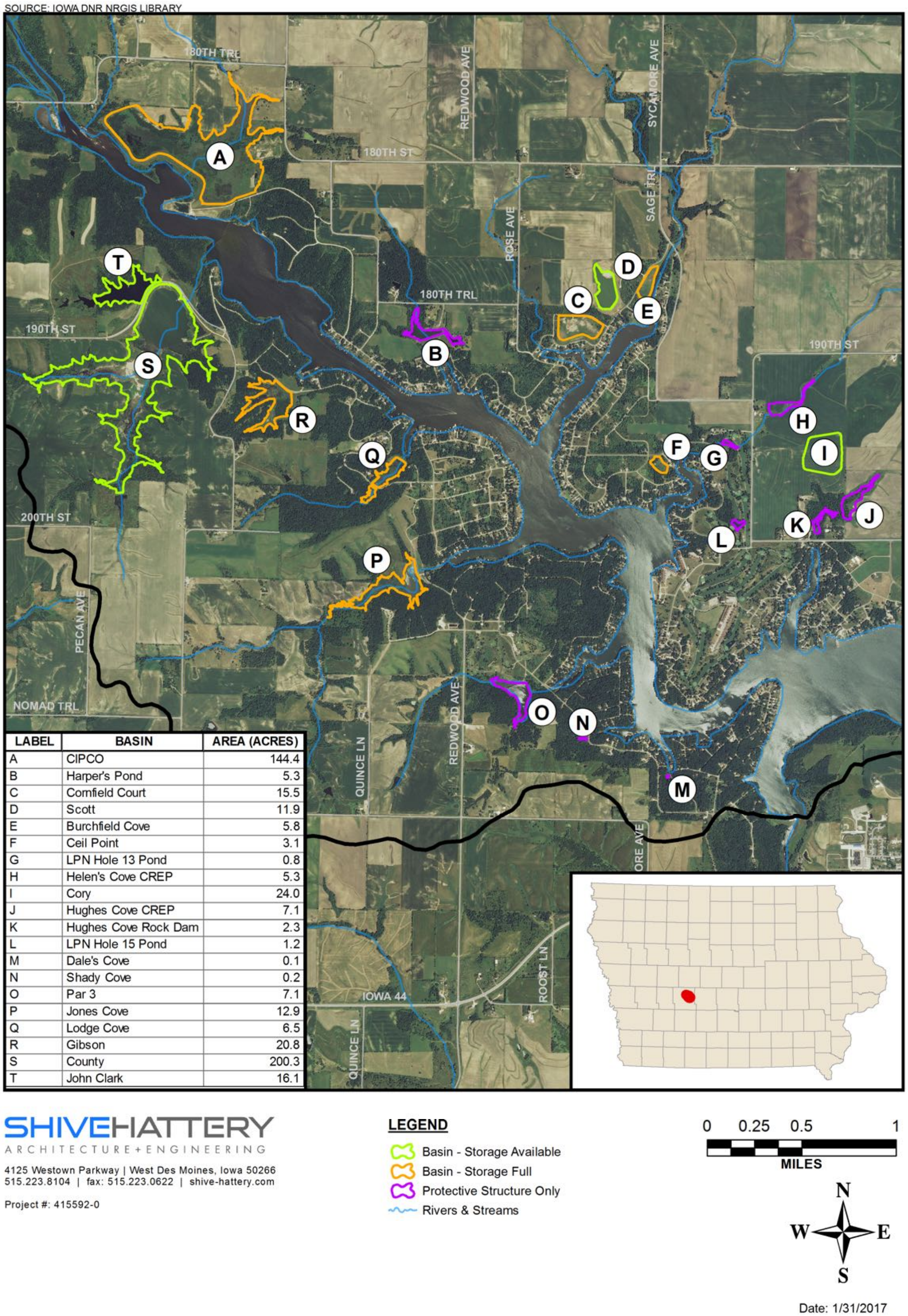
5.1 Current Sediment Storage

Lake Panorama currently has multiple active storage basins for the disposal of sediment dredged from the lake. In addition, there are many other basins that have been filled and have no additional storage remaining. It is estimated there are about 8.5 million cubic yards of storage space available to accept silt dredged from Lake Panorama in the active storage basins. A listing of the sediment storage basins at Lake Panorama is shown in Table 6. The table includes the original and estimated remaining storage capacities for each of the basins, as well as totals for all basins combined. The remaining storage capacities listed are not necessarily the total amount of volume remaining in the basin. Instead, these represent the storage volume available for the storage of sediment. Some basins are not full, but are unavailable for further storage for various reasons. Of the unavailable basins, most are used as buffers to prevent sediment from entering the lake. Filling them with dredged sediment would greatly reduce the buffering capacity. Additionally, Harper's Pond is unavailable for sediment storage because it is privately owned.

Table 6: Lake Panorama Storage Basins and Protective Structures

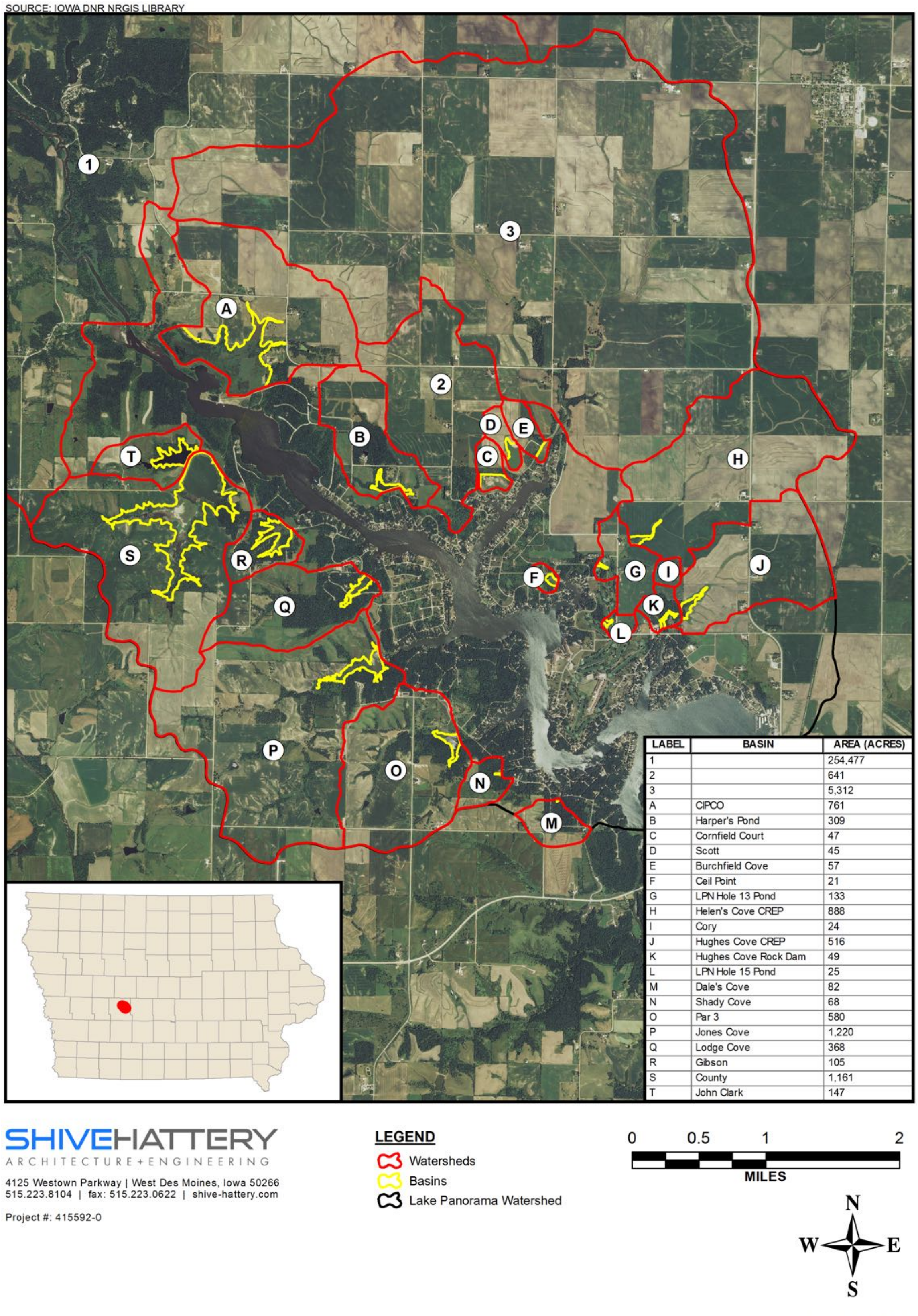
	Map Label	Basin	Year Constructed/ Modified	Original Capacity (CY)	Remaining Capacity (CY)	Surface Size (acres)	Area Drained (acres)
ACTIVE STORAGE BASINS	S	County	2006	8,933,000	6,383,000	200.3	1161
	T	John Clark	2006	604,000	604,000	16.1	147
	D	Scott	2012	386,100	233,200	11.9	45
	I	Cory	2016	1,303,300	1,299,800	24.0	24
INACTIVE STORAGE BASINS	A	CIPCO	1984, 2001, 2002	10,840,900	0	144.4	761
	E	Burchfield Cove	1989	65,800	0	5.8	57
	O	Par 3	1980's	92,900	71,300	7.1	580
	F	Ceil Point	1991	43,200	0	3.1	21
	C	Cornfield Court	1994	185,000	0	15.5	47
	P	Jones Cove	1994	128,600	30,000	12.9	1220
	Q	Lodge Cove	1995	80,700	0	6.5	368
	R	Gibson	1999	1,144,500	0	20.8	105
STRUCTURES FOR PROTECTION ONLY	G	LPN Hole 13 Pond	1970's	-	-	0.8	133
	L	LPN Hole 15 Pond	1970's	-	-	1.2	25
	B	Harper's Pond	1986	70,300	-	8.2	309
	K	Hughes Cove Rock Dam	1980's	-	-	0.4	49
	M	Dale's Cove	1980's	-	-	0.1	82
	N	Shady Cove	1980's	-	-	0.2	68
	H	Helen's Cove CREP	2016	15,400	-	5.3	888
	J	Hughes Cove CREP	FUTURE	-	-	7.1	516
		TOTAL		**23,893,700**	**8,621,300**		

A depiction of the locations and sizes of each of the sediment basins and protective structures is provided in Figure 10. Following that, Figure 11 shows the individual basins with the subdivided watersheds that drain to each basin.



LABEL	BASIN	AREA (ACRES)
A	CIPCO	144.4
B	Harper's Pond	5.3
C	Cornfield Court	15.5
D	Scott	11.9
E	Burchfield Cove	5.8
F	Ceil Point	3.1
G	LPN Hole 13 Pond	0.8
H	Helen's Cove CREP	5.3
I	Cory	24.0
J	Hughes Cove CREP	7.1
K	Hughes Cove Rock Dam	2.3
L	LPN Hole 15 Pond	1.2
M	Dale's Cove	0.1
N	Shady Cove	0.2
O	Par 3	7.1
P	Jones Cove	12.9
Q	Lodge Cove	6.5
R	Gibson	20.8
S	County	200.3
T	John Clark	16.1

Figure 10: Lake Panorama Storage Basins



LABEL	BASIN	AREA (ACRES)
1		254,477
2		641
3		5,312
A	CIPCO	761
B	Harper's Pond	309
C	Cornfield Court	47
D	Scott	45
E	Burchfield Cove	57
F	Ceil Point	21
G	LPN Hole 13 Pond	133
H	Helen's Cove CREP	888
I	Cory	24
J	Hughes Cove CREP	516
K	Hughes Cove Rock Dam	49
L	LPN Hole 15 Pond	25
M	Dale's Cove	82
N	Shady Cove	68
O	Par 3	580
P	Jones Cove	1,220
Q	Lodge Cove	368
R	Gibson	105
S	County	1,161
T	John Clark	147

Figure 11: Lake Panorama Storage Basin Watersheds

5.2 Future Sediment Storage

Storage for sediment removed from Lake Panorama will continue to be necessary well into the future. As previously stated in this report, sediment is expected to continue to accumulate at an approximate rate of 476,000 cubic yards per year. In the next 20 years, that calculates to a total of 9.5 million cubic yards of sediment. In order to store the sediment received over the next 20 years, it is estimated 9.5 million cubic yards of storage space will be required. Lake Panorama currently has approximately 8.5 million cubic yards of storage space available, which excludes basins and wetlands designated for conservation or preventative use. Thus, Lake Panorama would require additional storage of roughly 1 million cubic yards to impound all sediment forecasted over the next 20-year period.

If the sediment removal program was accelerated so it would not only remove all sediment that enters the lake in the next 20 years, but also all sediment currently deposited in the lake, significantly more storage space would be needed. To return the lake to its original 1970 volume in the next 20 years, and to maintain that volume over the same time span, would require approximately 18.8 million cubic yards of storage space. This volume is much greater than the amount of storage space currently available to Lake Panorama. However, returning the lake to its original 1970 volume over the next 20 years would require about 935,000 cubic yards of sediment to be removed each year, a number which is likely not feasible to reach without substantial investment in more equipment and staffing.

A realistic goal for Lake Panorama would be to remove all sediment that enters the lake over the next 20 years plus 25% of the sediment that is currently accumulated in the lake. Much of the 25% of additional removal should be concentrated at the upper end of the lake. This area has traditionally provided Lake Panorama with the best economy of scale for both operations and sediment storage. In addition, this strategy will allow the Rural Improvement Zone to maintain depth in the upper basin and upper river channel, which causes silt to drop out before it reaches the developed portions of the lake. Removing this quantity of sediment would require roughly 12 million cubic yards of storage, which is about 3.5 million cubic yards more than the quantity of storage currently available at Lake Panorama. To achieve the 25% reduction in accumulated sediment would require about 600,000 cubic yards to be removed each year for the next 20 years, which is an attainable rate. Additionally, the construction of an additional 3.5 million cubic yards of storage also would be feasible.

6. Water Quality

6.1 Current Water Quality

Water quality refers to the chemical, physical, and biological characteristics of water. Water quality is a measure of the condition of the water relative to the requirements of one or more species and/or to any human need or purpose. The designated uses for Lake Panorama include primary contact recreation and aquatic life. There are several elements that influence the overall water quality of a lake. Physical water characteristics, nutrient concentrations, pathogen counts, and lake retention time all are contributing factors.

Generally speaking, the water quality of Lake Panorama fluctuates dramatically throughout the course of the year and is highly dependent upon rainfall. The major pollutants impacting water quality at the lake are sediment, nitrogen, phosphorus, and waterborne pathogens.

6.1.1 Chemical/Physical Water Quality Testing

Water quality testing was performed at Lake Panorama in the summers of 2006 and 2007 as part of the Iowa Lakes Survey report compiled by the Iowa State University Limnology Laboratory for the Iowa Department of Natural Resources. Additional testing for the same parameters was conducted in the summer of 2016 by the State Hygienic Laboratory to assist with the development of this report. The results of these tests are presented in Table 7. It is important to note tests on samples are snapshots that often are influenced by weather events in the hours and days prior to the tests being taken.

Table 7: Water Quality Testing Results

Parameter	6/1/06	6/28/06	8/3/06	5/31/07	6/27/07	7/30/07	5/31/16	6/29/16	8/11/16	Limit	Limit Source
Lake Depth (m)	8.3	8.0	7.8	8.0	7.9	10.0	8.3	7.9	8.0	N\A	
Thermocline Depth (m)	5.0	7.0	6.2	2.8	2.6	6.4	3.5	5.5	2.0	N\A	
Secchi Disk Depth (m)	4.0	2.5	1.7	0.7	1.4	1.2	1.4	1.2	1.2	N\A	
Temperature (°C)	22.5	24.9	27.8	20.7	26.8	27.5	22.4	27.3	26.7	<32	IAC 567.61, p.10 (as Class B)
Dissolved Oxygen (mg/L)	9.0	8.9	7.4	9.4	9.1	8.9	8.5	11.1	10.8	>5	IAC 567.61, p.19 (as Class B)
Dissolved Oxygen Saturation (%)	104	107	94	105	114	113	98	140	135	N\A	
Specific Conductivity (µS/cm)	591.1	629.6	528.1	557.9	594.7	547.1	620	560	560	[a]	
Turbidity (NTU)	3.3	7.1	5.6	19.9	7.0	7.2	5.9	5.8	6.5	[a]	
Chlorophyll a (µg/L)	5	8.9	23.7	8.1	10.7	40.9	5	24	35	[a]	
Total Phosphorus as P (µg/L)	17	16	32	257	118	42	130	60	60	[a]	
SRP as P (µg/L)	1	-	-	176	-	1	90	-	-	[a]	
Total Nitrogen as N (mg/L)	8.72	8.18	4	13.65	13.86	<0.28	12.9	12.1	8.6	[a]	
Total Kjeldahl Nitrogen as N (mg/L)							0.9	1.1	1.0	[a]	
Nitrate + Nitrite (NO3 + NO2) as N (mg/L)	8	7.46	3.42	12.5	13.86	<0.12	12	11	7.6	10[b]	IAC 567.61, p.16 (as Class C)
TN:TP ratio	513	511	125	53	117	-	99	202	143	[a]	
pH	8.3	8.5	8.4	8.2	8.5	8.2	8.1	7.9	8.1	6.5≤pH≤9.0	IAC 567.61, p.9 (as Class A, B, & C)
Alkalinity as CaCO3 (mg/L)	197	205	183	202	259	176				[a]	
Dissolved Organic Carbon (mg/L)	3.9	-	3.62	4	2.32	3.49	3.3	3.4	3.7	[a]	
Inorganic Suspended Solids (mg/L)	3	1	2	30	3	4				[a]	
Volatile Suspended Solids (mg/L)	<1	3	4	<1	2	6	3	5	5	[a]	
Total Suspended Solids (mg/L)	3	5	6	13	4	10	4	9	9	[a]	
Carlson Trophic State Index (Secchi)	40	47	53	66	55	58	55	57	57	65	
Carlson Trophic State Index (Chl a)	46	52	62	51	54	67	46	62	65	65	
Carlson Trophic State Index (TP)	45	44	54	84	73	58	74	63	63	[a]	

[a]No numeric criteria exists in the Iowa Water Quality Standards

[b]No numeric criteria exists for recreation or aquatic life in the Iowa Water Quality Standards; limit provided is for drinking water

Dissolved Oxygen (DO)

Dissolved oxygen is an important parameter in assessing water quality. In freshwater systems such as lakes, rivers and streams, dissolved oxygen concentrations will vary by season, location and water depth. Rapidly moving water tends to contain a lot of dissolved oxygen, whereas stagnant water contains less. The amount of dissolved oxygen present in a particular body of water can greatly influence the organisms living within that body of water. DO is necessary to many forms of aquatic life such as fish, invertebrates, bacteria, and plants. The amount of dissolved oxygen needed varies for each organism.

Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material within the body of water. When favorable water temperatures and nutrients/fertilizers are present, algae and other aquatic plants can flourish. When these aquatic plants die, certain bacteria and fungi can use up this oxygen and cause a depleted concentration in the water body. This depleted condition can cause adverse conditions such as fish, amphibian, and invertebrate kills.

Dissolved oxygen levels from samples taken from Lake Panorama in 2006-2007 varied from 7.4 mg/L to 9.4 mg/L. Data from the most recent sampling in 2016 produced dissolved oxygen ranges from 8.5 mg/L to 11.1 mg/L. This most recent data indicates dissolved oxygen levels have been relatively consistent and are above the recommended minimum. According to IAC 567.61, the minimum allowable DO level for Iowa waters to be protected for wildlife is 5.0 mg/L, which is the approximate minimum level that can support a large population of fish. Historically, DO concentrations have not been an issue for Lake Panorama, but conditions can rapidly change from year to year and season to season depending on environmental and human impacts.

Turbidity

Turbidity is simply the measure of clarity of a liquid and is a key component in determining water quality. Its unit of measurement is the Neophelometric Turbidity Unit (NTU) and is an expression of the amount of light scattered by material in the water when a light is shined through the water sample. The more particles present in the water, the more light that will be scattered. Therefore, the higher the intensity of scattered light, the higher the turbidity. According to the Methodology for Iowa's 2014 water quality assessment, listing, and reporting, turbidity refers to non-algal materials suspended in the water column, especially soil particles, that give the water a brown, cloudy appearance. Therefore, turbidity values can be a good indication of the level of erosion for a particular watershed.

Knowing the turbidity of a water body is important because suspended particles diffuse sunlight and also absorb heat. High concentrations of particulate matter affect light penetration and plant productivity, recreational values, habitat quality, and increase water temperatures because suspended particles absorb heat. In lakes and streams, increased sedimentation and siltation can occur when these particles settle, which can result in harm to habitat areas for fish and other aquatic life. Particles also provide attachment places for other pollutants, notably metals and bacteria. For this reason, turbidity readings can be used as an indicator of potential pollution in a water body.

Turbidity values from samples taken from Lake Panorama in 2006 and 2007 varied from 3.3 NTU to 19.9 NTU. Data from the most recent testing in 2016 showed samples ranging from 5.8 NTU to 6.5 NTU. Although there is no defined numeric criteria for turbidity for the state of Iowa, the lowest value obtainable is desired. Overall, the turbidity values at the sample times were similar to previously collected data. Note that turbidity values can fluctuate as a result of rainfall events. Figure 12 shows the appearance of different turbidity values for reference.

Figure 12: Typical Appearance of Turbidity Values

Total Nitrogen

In water, nitrogen can be present in several forms or oxidation states such as ammonia, nitrate, nitrite, and total Kjeldahl nitrogen. Total Nitrogen is defined as the sum of these oxidation states and is the measure most often proposed as an indicator of nutrient enrichment in surface waters. Total Nitrogen also is the form proposed for inclusion into state water quality standards as a nutrient criterion.

Common sources of nitrogen in surface and groundwater are fertilizers, livestock waste, and human waste associated with septic and municipal wastewater systems. In addition to fertilizer, nitrogen occurs naturally in the soil in organic forms from decaying plant and animal residues.

In Iowa waters, nitrate is the largest contributor of nitrogen in water bodies. In the soil, certain bacteria convert various forms of nitrogen to nitrate (NO_3^-). This is desirable as the majority of the nitrogen used by plants is absorbed in the nitrate form, however, nitrate is highly leachable and readily moves with water through the soil profile. When excess amounts of fertilizer are applied or if fertilizer is applied when no plants are present to use the fertilizer, rainfall can cause nitrate to be leached to groundwater, which ultimately reaches surface water. This occurs most often in areas when agricultural tiling provides a direct path for the nitrates to reach the surface water.

Total Nitrogen values from samples taken from Lake Panorama in 2006 and 2007 varied from <0.28 mg/L to 13.85 mg/L. Data from the most recent testing in 2016 shows Total Nitrogen values ranging from 8.6 mg/L to 12.9 mg/L. As previously mentioned, nitrates make up the vast majority of the total nitrogen. Comparing the Nitrate + Nitrite as N values of the same years, the values are only slightly lower than the Total Nitrogen values. Currently there is no limit outlined in the Iowa Water Quality Standards for Total Nitrogen, however, there is a limit of 10 mg/L of Nitrate + Nitrate as N.

The United States Geological Survey operates a monitoring site on the Middle Raccoon River approximately one mile downstream from the lake near the city of Panora. This site measures discharge, gage height, water temperature, and nitrate plus nitrite in water. Since 2010, the monitoring site has collected nitrate data seasonally, with no readings taken during the winter months. A graph showing this nitrate concentration data is shown in Figure 13.

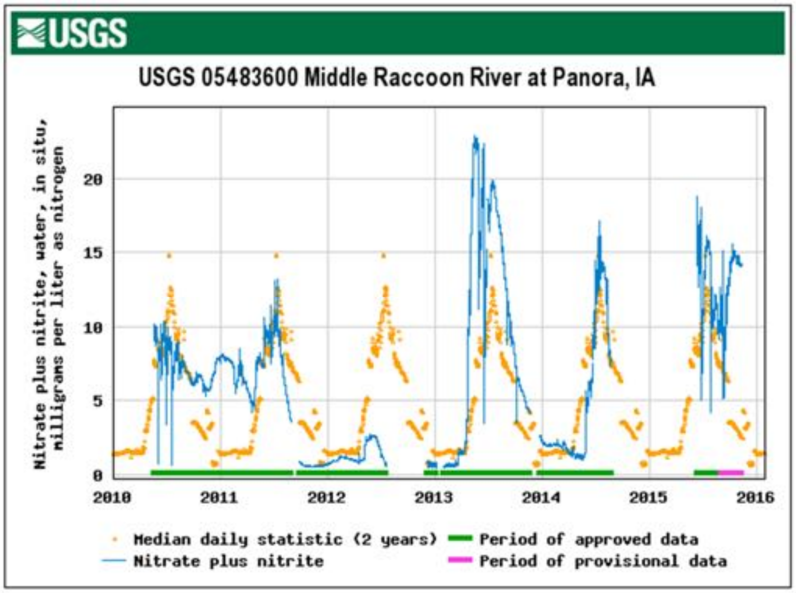


Figure 13: USGS Nitrate Data for Middle Raccoon River at Panora

According to the EPA, the maximum nitrate level present in safe drinking water is 10 mg/L. As Figure 13 shows, the nitrate level in the river discharging from Lake Panorama regularly exceeds this level during the summer months, and is sometimes measured at nearly double the safe limit. These elevated nitrate levels are indicative of high levels of runoff from agricultural land that makes up the lake watershed. While Lake Panorama is not a drinking water source, nitrate still can be an issue. The city of Panora, directly downstream from the lake, draws its drinking water from the Middle Raccoon River. Further downstream, other municipalities also utilize the Raccoon River as a drinking water source. Additionally, elevated nitrate levels can contribute to excessive growth of algae and aquatic plants, and the effects also can lead to fish kills.

Total Phosphorus

Phosphorus is one of the key elements necessary for the growth of plants and animals, and, in lake ecosystems, it tends to be a limiting nutrient. The presence of phosphorus often is scarce in well-oxygenated lake waters, and the low levels of phosphorus limit the production of freshwater systems. Unlike nitrogen, phosphorus is retained in the soil particles and usually is transferred to the water body from erosion in the watershed. Therefore, in watersheds that have high erosion rates, phosphorus values tend to be high. Although not toxic at levels found in the aquatic environment, high levels of phosphorus in water can stimulate excessive production of plant biomass. This high level of plant biomass can eventually have adverse effects as previously outlined in the discussion of dissolved oxygen (DO).

The Iowa Water Quality Standards do not contain water quality criteria for Total Phosphorus, but other nutrient criteria groups have recommended standards of 50 ppb (µg/L) for lakes and 100 ppb (µg/L) for rivers. The median level of Total Phosphorus in approximately 9,500 samples collected from 2000 to 2009 as part of Iowa DNR's ambient stream/river water quality monitoring network is 200 parts per billion, which is well above the recommended 100 ppb. It should be noted, however, that the time of year and proximity to rainfall events can have significant effects on sampling results.

Total Phosphorus values from samples taken from Lake Panorama in 2006 and 2007 varied from 16 µg/L to 257 µg/L, which range from well-below to well-above the recommended 100 ppb for lakes. Data from the most recent testing in 2016 shows Total Phosphorus values ranging from 60 µg/L to 130 µg/L, which shows the total phosphorus levels in the lake are higher than desired.

PH

The pH of a water body is an important parameter of water quality and is a measure of how acidic or basic water is. The range goes from 0 - 14, with 7 being neutral. A pH of less than 7 indicates acidity, whereas a pH of greater than 7 indicates a base. pH is a measure of the relative amount of free hydrogen (H^+) and hydroxyl ions (OH^-) in the water. Excessively high and low pH can be detrimental for the use of water.

Within a pH range of 6.5-9.0, direct impact to aquatic life is minimal. pH levels outside of this range also can impact swimmers by causing eye irritation. Because of the potential impacts to both aquatic life and primary contact recreation uses, the Iowa Water Quality Standards specify an acceptable pH range of 6.5-9.0 to protect aquatic life as well as recreational swimmers. Levels of pH in Iowa tend to be more basic than acidic, largely due to the limestone bedrock found abundantly throughout the state.

pH values from samples taken from Lake Panorama in 2006 and 2007 varied from 8.2-8.5. Data from the most recent testing in 2016 shows pH values ranging from 7.9-8.1, which is within the acceptable range of 6.5-9.0. This data suggests pH has remained relatively stable and within the acceptable range.

Trophic State Index

Many of the sampled parameters do not have numeric criteria established by the State of Iowa for determining water quality. In the absence of numeric criteria for these parameters, Iowa uses the trophic state index, abbreviated as TSI, values for chlorophyll and Secchi depth to assess lake water quality. The trophic state index is a numeric indicator that is reflective of a lake's nutrient condition and water transparency. The TSI value for chlorophyll is an estimate of the amount of plant biomass in the water. Turbidity-related impacts, mainly due to suspended algae, can be conveniently measured using the TSI. The Iowa DNR designates lakes as impaired when the TSI value for either chlorophyll-a or Secchi depth is greater than or equal to 65. Sediment or nutrient-related water quality problems are likely in lakes with these high TSI values. These are likely to have excessive turbidity, which can impair either the primary contact recreation use, aquatic life use, or both. For several reasons, TSI values for total phosphorus do not accurately measure the trophic state in Iowa lakes, so the Iowa DNR does not use them in determining whether a waterbody supports its primary contact recreation or aquatic life uses.

6.1.2 Biological Testing

In addition to the chemical and physical water quality testing, phytoplankton and zooplankton also were sampled in 2006 and 2007 as part of the ISU Iowa Lakes Survey report. For comparison purposes, plankton sampling was included with the State Hygienic Laboratory's 2016 water quality testing. The results of this sampling, as well as the previous test results, are presented in Table 8 and Table 9. Phytoplankton and zooplankton are important components to a freshwater ecosystem. These represent the bottom end of the food chain. Phytoplankton are microscopic plant organisms while zooplankton are small animal organisms.

Table 8: Phytoplankton Sampling Results

Division	Wet Mass (mg/L)								
	6/1/06	6/28/06	8/3/06	5/31/07	6/27/07	7/30/07	5/31/16	6/29/16	8/11/16
Cyanobacteria	1.356	15.422	14.203	14.726	37.347	7.065	0.027	0.140	10.826
Chlorophyta	0.200	1.155	0.272	0.014	2.149	2.155	0.241	8.183	5.376
Bacillariophyceae	0.246	0.000	0.815	0.000	0.494	3.255	0.276	0.622	8.991
Dinophyceae	*	*	*	*	*	*	0.006	0.000	0.000
Protozoa	*	*	*	*	*	*	0.102	0.547	0.055
Chrysosphaerella	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
Euglenophyta	0.000	0.000	0.000	0.486	0.000	0.320	0.000	0.000	0.000
Cryptophyta	0.504	0.084	0.257	1.432	0.705	0.000	2.645	1.218	1.541
TOTAL WET MASS	**2.306**	**16.661**	**15.561**	**16.658**	**40.695**	**12.795**	**3.297**	**10.710**	**26.789**
*No test results available									

Table 9: Zooplankton Sampling Results

Subclass	Order	Total Biomass (µg/L)								
		6/1/2006	6/28/2006	8/3/2006	5/31/2007	6/27/2007	7/30/2007	5/31/2016	6/29/2016	8/11/2016
Cladoceran	Bosmina	33.002	0	0	58.936	9.879	0	70.33891		
	Ceriodaphnia	4.705	0	0	0	0	0			
	Chydorus							0.300959		
	Daphnia	14.638	62.511	0	15.698	38.773	33.982	63.76835	47.4	
	Diaphanosoma								30.9	6.6
Copepoda	Calanoid	19.11	16.995	10.681	20.298	47.455	15.562		126	86.6
	Cyclopoid	30.708	15.183	7.983	23.219	6.849	5.912	53.70841	193.4	
	Nauplii	10.656	1.068	3.589	9.798	6.378	1.536	16.82362	30.4	17.6
Rotifera	Anuraeopsis							0.000593		
	Ascomorpha	0	0	0.013	0	0	0			0.5
	Asplanchna	0	0	1.242	0	0	0			
	Brachionus	0	0	0.07	0	0.418	0.082		0.9	
	Cephalodella								0	
	Conochilus	0.012	0	0	0	0	0			
	Epiphanes								0.1	
	Filinia				0	0.051	0			
	Hexarthra									2.2
	Kellicottia	0	0.009	0	0	0	0			
	Keratella cochlearis	0.016	0.165	0.083	0.011	0.044	0.441	0.013074	0.1	1
	Keratella quadrata				0.489	0	0			
	Lecane	0	0.045	0	0	0	0			
	Polyarthra	1.121	0	0.259	2.369	0.767	0.182	4.752288	4.3	2.7
	Pompholyx	0	0	0.044	0	0	0.081			4
	Synchaeta							1.097851		0.5
	Trichocera	0	0	0.032	0	0	0			1.4

6.1.3 Indicator Bacteria Testing

In addition to the other water quality parameters, pathogen counts also are an important factor in water quality for recreational lakes. Samples of lake water from each of the beaches have been tested for the indicator bacteria *E. coli* on a regular basis starting in 2000. While most

E. coli are harmless to humans, the presence of indicator bacteria generally indicates that other pathogens are also present. For primary contact recreational use, the State of Iowa maximum for each sample is 235 *E. coli* organisms per 100 milliliters of water. Since 2000, there have been 790 samples taken from Lake Panorama at various locations. Of those, 68.2% were at or below the state maximum sample limit. In 2015 and 2016, 33 tests were taken. Due to high levels of indicator bacteria, swimming was not advised at one or more of the Lake Panorama Association's beaches 29 out of those 33 tests. Ten of those test results were five times the standard and seven of those test results were 10 times the standard. Three different tests had results at or exceeding 20,000 organisms per 100 milliliters of water.

Similarly to sediment delivery, *E. coli* counts are highly variable throughout the year and generally spike with each rainfall event. Because of this, a cumulative average also is used when describing indicator bacteria counts. Iowa water quality standards limit the maximum geometric mean for five samples in a 30-day period to 126 *E. coli* organisms per 100 milliliters of water. The geometric mean bacteria counts for 2000 through 2015 are presented in Figure 14. The maximum acceptable value of 126 is shown by the red horizontal line on the chart. Due to the amount of data available, these figures have been calculated on a yearly basis, rather than the 30-day time period used by the Iowa DNR. Additionally, to make calculation of the geometric mean possible, bacteria counts of "0" were changed to "1" for use in the calculation procedure.

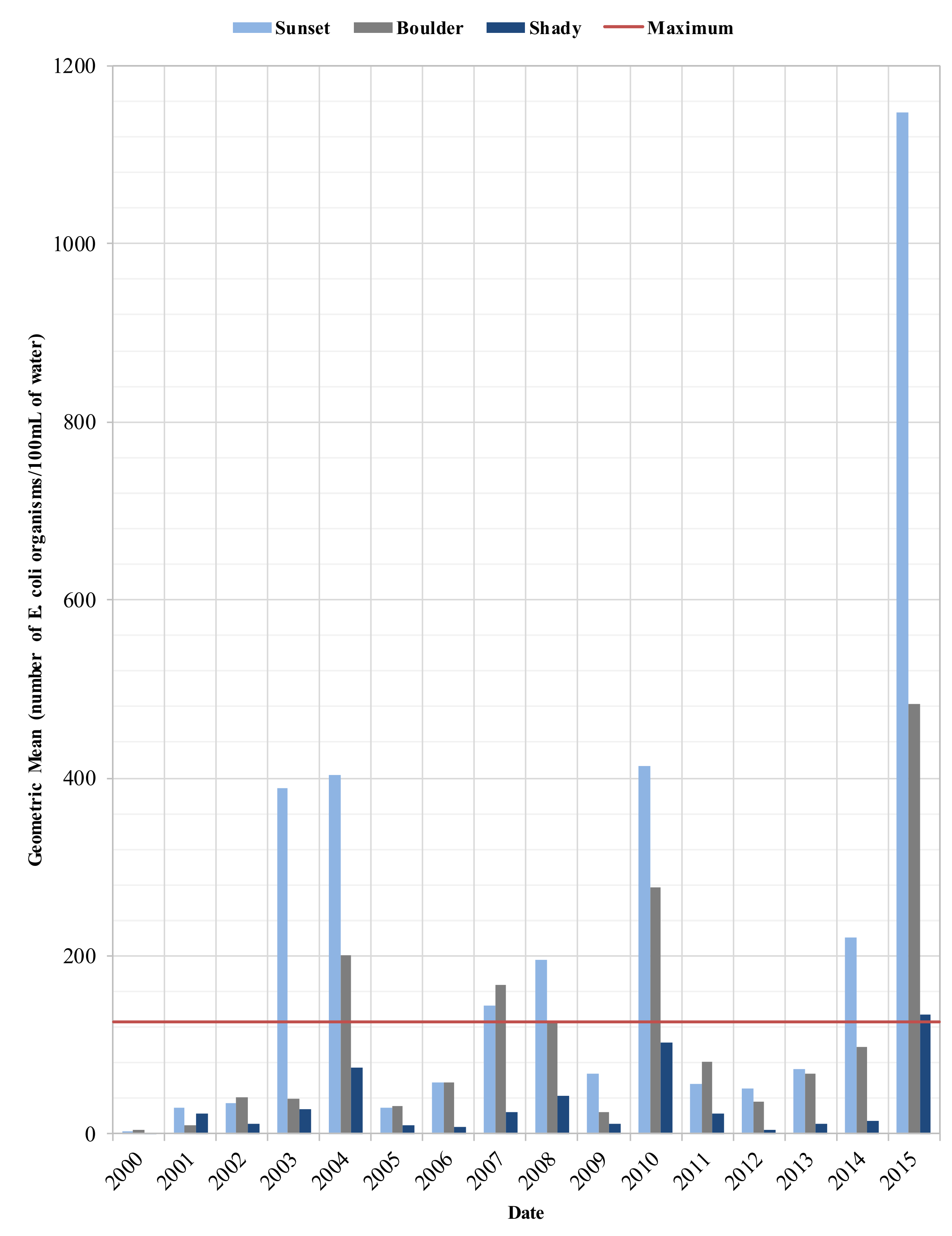


Figure 14: Lake Panorama Indicator Bacteria Testing Results

6.1.4 Nearby Impaired Waters

The Iowa Department of Natural Resources publishes a report on its progress in meeting water quality goals every two years. The report includes a list of impaired waterbodies within the state. A body of water is considered impaired when its water quality does not fully support its designated uses for human contact, aquatic life, or drinking water. A map showing the 2014 impaired waterbodies is included as Figure 15. The 2014 list is reflective of water quality data collected between 2010 and 2012. Within the Lake Panorama watershed, the impaired waterbodies include Springbrook Lake in Guthrie County and Swan Lake in Carroll County. Springbrook Lake is classified as having Category 5 Impairment, which means it is impaired and is in need of a water quality improvement plan. Swan Lake is classified as having Category 4 Impairment, meaning it is impaired, but it either already has or does not need a water quality improvement plan. The Middle Raccoon River immediately upstream of Lake Panorama is classified as Category 2. This means some of its designated uses are met, but there are insufficient data to determine if the remaining uses are met. The designated uses for this section are aquatic life, fish consumption, and primary contact (recreation). The Middle Raccoon River immediately downstream of Lake Panorama, however, has been designated as one of just five protected water areas in the State of Iowa due to its high natural and scenic value. It is likely past sediment and water quality efforts by Lake Panorama have contributed to this designation.

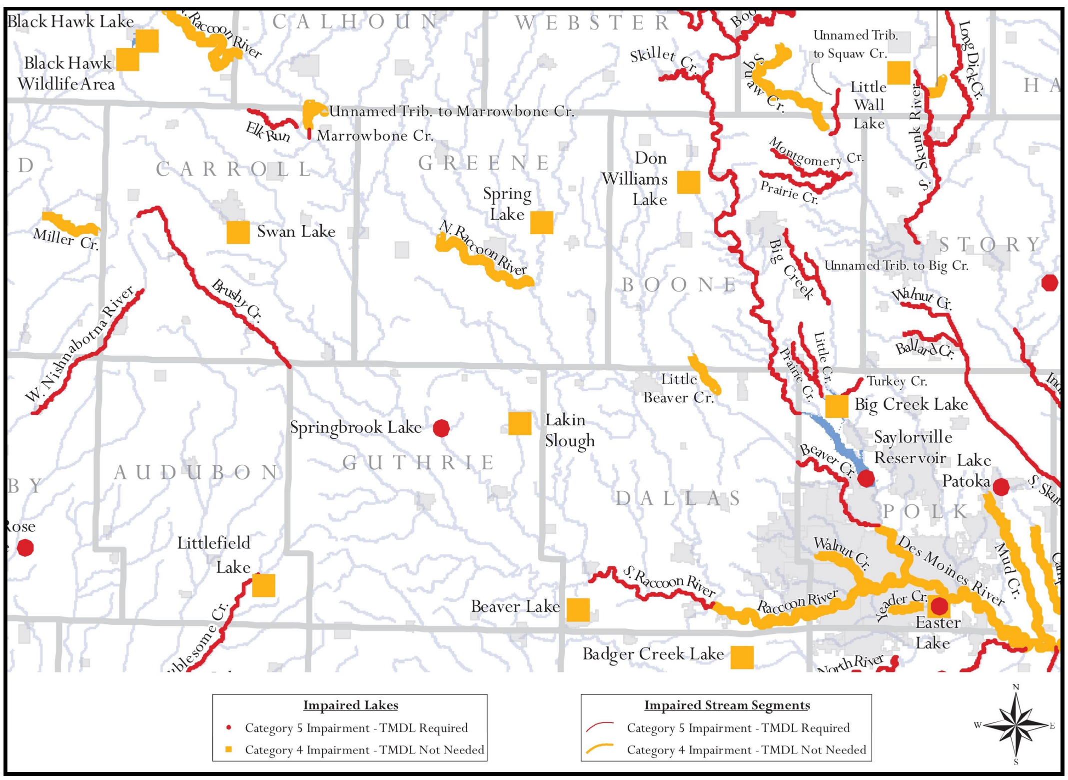


Figure 15: 2014 Iowa Impaired Waterbodies

6.1.5 Lake Retention Time

Lake retention time, also known as flushing rate, is the average amount of time that water entering the lake stays in the lake before flowing out of the lake, and it is calculated by dividing the average volume of the lake by the annual flow that enters the lake. Retention times vary depending on lake types, sizes, watershed areas, and other factors. These times can range from a few days to hundreds of years. Lake Panorama has an estimated average retention time of just under 35 days. This equates to a flushing rate of approximately 10.5 times per year. These rates are calculated by first finding the annual volume of flow that enters the lake. According to the Hydrologic Assessment of the Middle Raccoon River Watershed, a report published in October 2014 by the Iowa Flood Center, the Middle Raccoon River watershed receives an average of 35 inches per year of precipitation. The report further states that of the 35 inches, 73.6% evaporates, and 26.4%, or 9.24 inches, makes its way to the lake by either surface flow or base flow. Taking this multiplied by the Lake Panorama watershed area of nearly 272,000 acres results in an annual average volume flow to the lake of 208,388 acre-feet of water. Dividing the volume of the lake, estimated at approximately 20,000 acre-feet, by the annual average volume flow to the lake, gives the retention time of about 35 days. Because this calculation depends upon the annual precipitation over the watershed, the retention time could vary greatly from one year to the next depending on the relationship between the average precipitation and the actual precipitation received. Lake Panorama has a relatively short retention time, which can be good for lake water quality, as pollutants can be quickly flushed from the lake. However, the benefits of the lake's short retention time are somewhat decreased by the fact the water entering the lake often brings in additional pollutants, such as sediments and nutrients. If improvements were made throughout the watershed to reduce sediment and nutrient runoff, the high flushing rate could work to greatly improve the water quality in Lake Panorama.

It is important to note ongoing dredging operations have a positive impact on water quality in Lake Panorama. A larger lake volume, made possible by removing deposited sediment, provides a greater quantity of water to dilute any pollutants that enter the lake. In addition, dredging removes sediment to which some of the nutrients and *E. coli* bacteria discussed earlier can attach themselves, thus reducing nutrients in the lake.

6.2 Need for Preventative Practices

The elevated levels of nutrients in the water of Lake Panorama show the need for practices to reduce nutrient runoff. Within the lake, high levels of nitrogen and phosphorus can contribute to excessive growth of algae blooms and bacteria, which can suffocate fish and other aquatic life or produce toxins harmful to humans and other animals. Additionally, nutrient-rich water that flows out of the lake eventually reaches the Gulf of Mexico, where it can contribute to the hypoxic zone at the mouth of the Mississippi River.

Due to the high rate at which sediment accumulates within the lake, protective structures are needed to trap sediment before it can enter the lake. The lake evaluation report completed in 1977 by Bechtel recommended the construction of sediment traps on all of the streams that enter the lake. Since then, five protective basins have been installed on the lake's coves, and one more is scheduled for construction in 2017. In addition, several sediment storage basins have been constructed on the lake's coves and also act as buffers to trap silt before it enters Lake Panorama.

6.3 Impact of Preventative Practices

Since its inception in 1997, the Lake Panorama RIZ has worked to effectively address sediment accumulated since the lake was formed in 1970. This strategy reflected the immediate needs of the lake, as well as legislative language that limited endeavors into water quality improvements. 2015 legislative changes provided RIZ the opportunity to invest in water quality improvements.

RIZ has pursued this goal through the ongoing development of two Conservation Reserve Enhancement Program (CREP) wetland structures. Iowa State University research has shown that CREP wetlands can remove 40-90% of nitrates and over 90% of herbicides from cropland drainage waters.

A map from the Iowa Department of Agriculture and Land Stewardship (IDALS) showing the completed sites and sites under development in the area of the Lake Panorama watershed is provided as Figure 16. The solid red line marks the boundary of the Lake Panorama watershed.

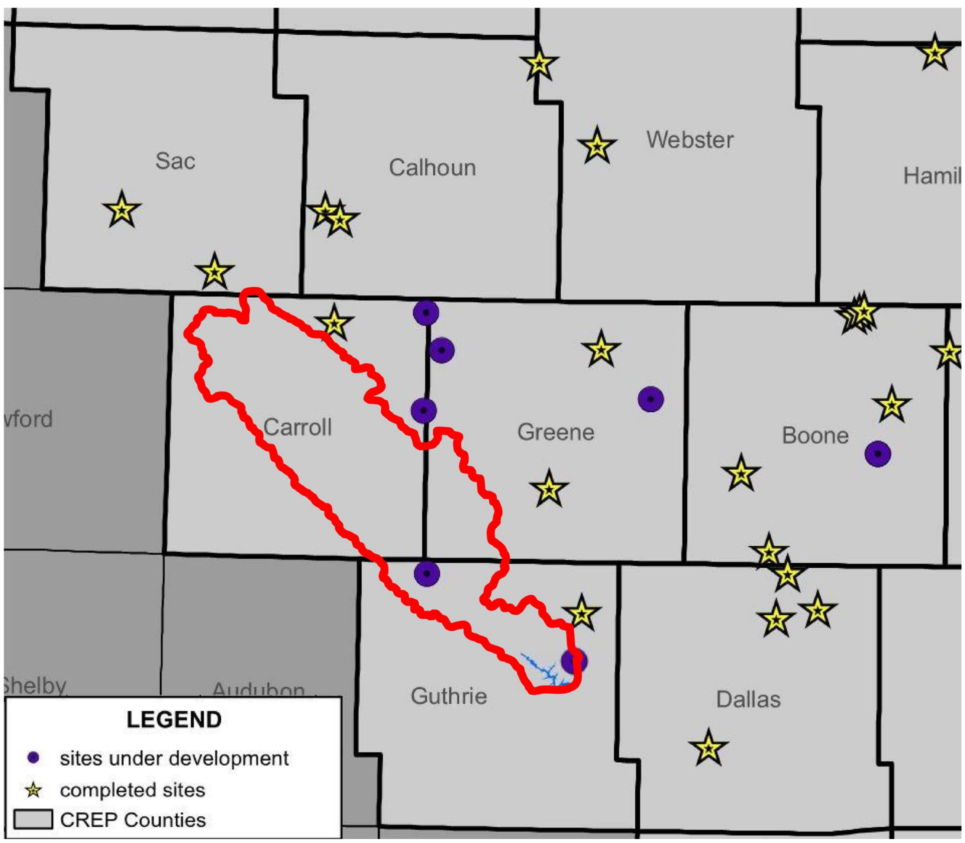


Figure 16: Iowa CREP Sites near Lake Panorama Watershed (2015)

Two CREP wetland projects are currently in progress near Lake Panorama: one was constructed in late 2016, and another is scheduled for completion in 2017. These CREP projects were led by the Lake Panorama RIZ, but couldn't have been completed without willing landowners at locations where optimum performance could be obtained or other partners including Guthrie County Soil and Water Conservation District, Natural Resources Conservation Service, IDALS, and Farm Service Agency.

These projects leveraged local money to access state and federal cost-share, and represent a good model for future efforts. In the next 20 years, the Lake Panorama RIZ will directly work to improve water quality through continued projects of this nature within the Lake Panorama watershed. Leveraging of state and federal incentives will be a top priority. The RIZ also will work to impact water quality throughout the watershed by actively supporting conservation activities.

The Iowa Nutrient Reduction Strategy was prepared by the Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, and the Iowa State University College of Agriculture and Life Sciences to assess and reduce nutrient transfer to Iowa waters and the Gulf of Mexico. The following tables, Table 10 and Table 11, are a part of the strategy document and outline potential preventative practices for reduction of nitrate-N and phosphorus.

Table 10: Example Statewide Nitrate-N Reduction

Example Statewide Results for Individual Practices at Estimated Maximum Potential Acres, Nitrate-N Reduction and Farm-Level Costs

Notes: Research indicates large variation in reductions not reflected in this table. Some practices interact such that the reductions are not additive.

Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

A positive $/lb N reduction, total cost or EAC is a cost. A negative $/lb N reduction, total cost or EAC is a benefit.

	Name	Practice/Scenario	Nitrate-N Reduction % (from baseline)	Potential Area Impacted for practice * (million acres)	Total Load (1,000 short ton)	Cost of N Reduction $/lb (from baseline)	Total Equal Annualized Cost (million $/year)	State Average EAC ** ($/acre)
	BS	Baseline ***			307			
Nitrogen Management	CCb	Cover crops (rye) on ALL CS and CC acres	28	21.0	221	5.96	1,025	49
Nitrogen Management	RR	Reducing nitrogen application rate from background to the MRTN 133 lb N/ac on CB and to 190 lb N/ac on CC (in MLRAs where rates are higher than this)	9	18.9	279	-0.58	-32	-2
Nitrogen Management	CCa	Cover crops (rye) on all no-till acres	6	5.1	288	5.97	227	45
Nitrogen Management	SN	Sidedress all spring applied N	4	13.5	295	0.00	0	0
Nitrogen Management	NI	Using a nitrification inhibitor with all fall applied fertilizer	1	2.2	305	-1.53	-6	-3
Nitrogen Management	FNb	Move all liquid swine manure and anhydrous to spring preplant	0.3	7.3	306	-74.36	-149	-20
Nitrogen Management	FNa	Moving fall anhydrous fertilizer application to spring preplant	0.1	5.7	307	-283.27	-113	-20
Edge-of-Field *****	W	Installing wetlands to treat 45% of the ag acres	22	12.8	238	1.38	191	15
Edge-of-Field *****	BR	Installing denitrification bioreactors on all tile drained acres	18	9.9	252	0.92	101	10
Edge-of-Field *****	BF	Installing Buffers on all applicable lands ****	7	0.4	284	1.91	88	231
Edge-of-Field *****	CD	Installing Controlled Drainage on all applicable acres	2	1.8	300	1.29	18	10
Land Use Changes	EC	Perennial crops (Energy crops) equal to pasture/hay acreage from 1987. Take acres proportionally from all row crop. This is in addition to current pasture.	18	5.9	253	21.46	2,318	390
Land Use Changes	P/LR	Pasture and Land Retirement to equal acreage from 1987 (in MLRAs where 1987 was higher than now). Take acres from row crops proportionally.	7	1.9	287	9.12	365	192
Land Use Changes	EXT	Doubling the amount of extended rotation acreage (removing from CS and CC proportionally).	3	1.8	297	2.70	54	30

*Acres impacted include soybean acres in corn-soybean rotation as the practice has a benefit to water quality from the rotation.

**EAC stands for Equal Annualized Cost (50 year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing the practice. Average cost based on 21.009 million acres, costs differ by region, farm, field.

***Baseline load includes both point and nonpoint source.

****Acres impacted for buffers are acres of buffers implemented and EAC are per acre of buffer.

*****These practices include substantial initial investment costs.

Table 11: Example Statewide Phosphorus Reduction

Example Statewide Results for Individual Practices at Estimated Maximum Potential Acres, Phosphorus Reduction and Farm-Level Costs

Notes: Research indicates large variation in reductions. Some practices interact such that the reductions are not additive. Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

A positive $/lb P reduction, total cost or EAC is a cost. A negative $/lb P reduction, total cost or EAC is a benefit.

	Name	Practice/Scenario	P Reduction % (from baseline)	Potential Area Impacted for practice* (million ac)	Total Load (1,000 short ton)	Cost of P Reduction $/lb (from baseline)	Total EAC** (million $/year)	State Average EAC** ($/ac)
	BS	Baseline			16.8			
Phosphorus Management	CCa	Cover crops (rye) on all CS and CC acres	50	21.0	8.3	60	1,022.9	49
	Tnt	Convert all tillage to no-till	39	16.1	10.3	14	186.4	12
	Tct	Convert all intensive tillage to conservation tillage	11	8.6	14.9	-2	-7.2	-1
	RR	P rate reduction in MLRAs that have high to very high soil test P	7	25.8	15.6	-110	-263.5	-11
	CCnt	Cover crops (rye) on all no-till acres	4	4.8	16.1	150	216.3	45
	IN	Injection/band within no-till acres	0.3	4.8	16.8	707	70.4	15
Edge-of-Field****	BF	Establish streamside buffers (35 ft) on all crop land***	18	0.4	13.7	14	88.0	231
Land Use Changes	EC	Perennial crops (Energy crops) equal to pasture/hay acreage from 1987. Take acres proportionally from all row crop. This is in addition to current pasture.	29	5.9	11.9	238	2,318	390
	P/LR	Pasture and Land Retirement to equal acreage of Pasture/Hay and CRP from 1987 (in MLRAs where 1987 was higher than now). Take acres from row crops proportionally.	9	1.9	15.3	120	365	192
	EXT	Doubling the amount of extended rotation acreage (removing from CS and CC proportionally)	3	1.8	16.3	53	54	30

* Acres impacted include soybean acres in corn-soybean rotation as the practice has a benefit to water quality from the rotation.
** EAC stands for Equal Annualized Cost (50 year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing the practice. Average cost based on 21.009 million acres, costs will differ by region, farm and field.
*** Acres impacted for buffers are acres of buffers implemented and EAC are per acre of buffer.
**** This practice includes substantial initial investment costs.

7. Cost Estimate

It is difficult to estimate costs to effectively address erosion control and water quality over the next 20 years, but estimates for various activities have been generated to detail the magnitude of work the Lake Panorama Rural Improvement Zone could undertake.

To dredge approximately 2.5 million cubic yards of sediment currently in the lake plus the additional 9.5 million cubic yards expected to come in over the next 20 years would cost approximately $40 million. These costs include equipment, fuel, labor, insurance, and storage basin construction and are broken out in Table 12:

Table 12: Dredging Cost Estimate (12 million CY)

ITEM	COST
Equipment	$5,800,000
Fuel	$7,200,000
Labor & Insurance	$16,200,000
Maintenance	$1,800,000
Storage Basin Construction	$8,750,000
TOTAL	**$39,750,000**

In addition, water quality improvements could entail construction of nutrient reduction wetlands, preventative structures, stream stabilization, soil conservation practices, and watershed protection. The Iowa Nutrient Reduction Strategy update released in 2016 estimates an annual cost to achieve the nutrient reduction goals by example scenarios with costs annualized over a 50-year period. Annual costs for the entire state range from $77 million to $1.2 billion. While these are not recommendations of the science team for the Nutrient Reduction Strategy, these do give context to the challenges Iowa and its water bodies face with non-point source nutrients. By ratio of areas, the cost for Lake Panorama to effectively pursue watershed improvements would exceed $500,000 annually, which would equate to $10 million over 20 years. The impact of RIZ efforts could be multiplied by leveraging local dollars to access state and federal funding opportunities.

With limited funding, the Lake Panorama Rural Improvement Zone should adopt a strategy of diversity in its efforts to reduce and remove sediment in the lake as well as improve the lake's water quality. The Lake Panorama RIZ proposes to remove all sediment entering the lake over the next 20-year period, plus remove approximately 25% of the sediment currently in the lake. This would leave approximately 7 million cubic yards remaining in the lake, and costs would be an estimated $40 million. Assuming an investment of $10 million to water quality over the next two decades, the cost to effectively address erosion and water quality for the next 20 years is estimated at $50 million.