2003 SUMMARY REPORT
of
DUGDALE LAKE

Lake County, Illinois

Prepared by the

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January 2004

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EXECUTIVE SUMMARY

Dugdale Lake, located in the Greenbelt Forest Preserve in Waukegan Township, was built in 1984-1985. It is currently owned and maintained by the LCFPD District (LCFPD). The lake has a surface area of 4.6 acres, a maximum depth of 17.0 feet and an estimated mean depth of 8.5 feet. It is located entirely within LCFPD property and is used by the public for fishing, hiking and aesthetics. A walking path surrounds the lake.

Water quality parameters, such as nutrients, suspended solids, oxygen, temperature and water clarity were measured and the plant community was assessed each month from May-September 2003. Dugdale Lake had very good water quality due in part to its origin (borrow pit) and the surrounding land use with no development around the shoreline and limited impact from non-point sources. Dugdale Lake was thermally stratified from May-September. A pelagic algae bloom occurred in June and August, which resulted in increased dissolved oxygen concentrations at 12 feet, below the depth of the initial anoxic boundary. Phosphorus, nitrogen and total suspended solids concentrations were low throughout the summer. Dugdale Lake had a TSIp value of 51.9 and ranked 24th out of 130 lakes studied in Lake County since 1999. As a result of the low nutrients and low total suspended solids, water clarity was high all summer and reached a maximum of 11.78 feet in August. Dugdale Lake had conductivity levels higher than the Lake County median, as it receives stormwater runoff from 10th Street, 14th Street and Green Bay Road.

Eurasian watermilfoil (EWM) and coontail dominated the plant community in 2003. A total of eight aquatic plant species were identified in the lake. The milfoil weevil was found in 2003 and had caused moderate damage to the EWM in the shallow areas. Qualitative surveys suggest that weevil density may not be high enough to have a huge impact on the EWM at this time. However, because there are no other plant management techniques being employed in Dugdale Lake and it is a relatively undisturbed system with a high amount of native shoreline, it is possible that in the future, the weevil population may increase to the point of severely reducing the EWM population.

The shoreline of Dugdale Lake is completely undeveloped and surrounded entirely by emergent wetland species. No area of the shoreline was eroding. Exotic species (buckthorn, purple loosestrife, reed canary grass and common reed) were present along 100% of the shoreline. These are exotic plant species that out-compete native vegetation and provide poor habitat for wildlife. A plant of interest was bulb-bearing hemlock, a very poisonous species that grew scattered along the shoreline. A good mix of waterfowl and songbird species were observed on and around the lake throughout the summer.

LAKE IDENTIFICATION AND LOCATION

Lake Name: Dugdale Lake

County: Lake

Nearest Municipality: North Chicago, Illinois

Location: T45N, R12E, Section 31

Watershed: Lake Michigan

Sub-basin: Waukegan River

Major Tributaries: None

Receiving Body of Water: Waukegan River

Surface Area: 4.6 acres

Shoreline Length: 0.46 miles

Maximum Depth: 17 feet

Mean Depth (estimated): 8.5 feet

Volume (estimated): 39.1 acre-feet

Lake Type: Manmade 1984-1985

Dugdale Lake is located within the City of Waukegan in the Greenbelt Forest Preserve. The lake was built in 1984-1985. Because of its location near Waukegan and North Chicago, the area is heavily used by hikers and anglers. No boating (i.e., canoes, etc.) is permitted and only bank fishing is allowed on this lake.

LIMNOLOGICAL DATA - WATER QUALITY

Water samples were analyzed for a variety of water quality parameters (See Appendix B for methodology). Samples were collected at 3-foot and approximately 14-foot depths from the deep hole location in the lake (Figure 1). Thermal stratification occurs when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically becomes anoxic (dissolved oxygen= 0 mg/l) by mid-summer. Aquatic organisms such as fish experience stress if the dissolved oxygen (DO) concentrations drop below 5.0 mg/L. Dugdale Lake was thermally stratified in the deepest area of the lake from May-September. Although still weakly stratified in September, the lake was beginning to turn over. The least amount of DO occurred in June and August, when concentrations were under 5.0 mg/l below a depth of 6 feet. During these months, the lake experienced anoxia (<1 mg/L) at about 8 feet in June and at about 9 feet deep in August. A sharp increase in the DO concentrations occurred at 12 feet in both months: 2.39 mg/l in June, and 6.77 mg/L in August. This is an unusual phenomenon and is indicative of a deep-water algae bloom. In September, the epilimnion had begun to mix, causing DO concentrations to fluctuate. Concentrations ranged from 5.58 mg/L to 4.87 mg/L from the surface down to 12 feet deep, below which anoxia occurred. Because there is no recent, accurate bathymetric map with volume calculations for Dugdale Lake, it is not possible to determine the percentage of the lake volume that had adequate DO concentrations for the summer months. Of note, though, is that the lake does not have frequent reports of fish kills due to low oxygen concentrations, which indicates that this may not be a problem in Dugdale Lake.

High total phosphorus (TP) in the water column is often the reason for nuisance planktonic algal blooms. In Dugdale Lake, TP concentrations were low, with a seasonal average of 0.027 in the epilimnion, which is two times lower than the Lake County median. Although TP was low, filamentous algae was noted growing attached to plants at the beginning of June. By August, not as much filamentous algae was present in Dugdale Lake. This type of algae is able to obtain its phosphorus from the sediment before rising to the surface later in the season.

The other nutrient critical for algae growth is nitrogen. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal cells. TKN was very low in Dugdale Lake. The epilimnetic and hypolimnetic samples averaged 0.71 mg/L and 1.52 mg/L, respectively. The Lake County TKN medians are 1.22 mg/L in epilimnetic samples and 2.25 mg/L in hypolimnetic samples.

The ratio of total nitrogen (TN) to total phosphorus (TP) indicates if the lake is in shorter supply of nitrogen or phosphorus. Lakes with TN:TP ratios greater than 15:1 are limited by phosphorus. Those with ratios less than 10:1 are limited by nitrogen. In 2003, the TN:TP ratio of Dugdale Lake was 26:1, which means it is limited by phosphorus. Lakes with low TP concentrations such as this one can be very sensitive to small increases in TP. Most lakes throughout Lake County are phosphorus limited. TP also can be used to

INSERT FIGURE 1

determine the trophic state index (TSI), which classifies lakes according to the overall level of nutrient enrichment. Using the TP concentration in the epilimnion, the TSIp score can be calculated. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those that have excessive nutrients, with nuisance algae growth reminiscent of "pea soup" and have a TSIp score greater than 70. Lakes with a TSIp score of 50 or greater are classified as eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae and fish. Mesotrophic and oligotrophic lakes are those with lower nutrient levels. These are very clear lakes, with little or no plant and/or algae growth. Lakes with low TP concentrations are not as common in Lake County. Most lakes in the area are rich in TP, resulting in a eutrophic condition. The trophic state of Dugdale Lake in terms of its phosphorus concentration during 2003 was mesotrophic, with a TSIp of 48.5. Dugdale Lake ranked 24th out of 130 Lake County lakes based on average total phosphorus concentrations of lakes studied since 1999 (See Table 2 in Appendix A).

The water clarity is usually the first thing people notice about a lake, and typifies the overall water quality. The water clarity in Dugdale Lake during 2003 averaged 9.22 feet deep, nearly three times higher than the Lake County median. The good water clarity is due to the low concentrations of total suspended solids (TSS) in the water column and the fact that aquatic plants dominated Dugdale Lake rather than planktonic algae. The filamentous algae noted in Dugdale Lake may not impair water clarity as much, since they are not free-floating within the water column like the planktonic species. The planktonic species are a portion of the TSS results. The seasonal average TSS in this lake was 2.2 mg/L, which is approximately three times less than the Lake County median of 7.5 mg/L.

The Illinois Environmental Protection Agency has assessment indices to classify Illinois lakes for their ability to support aquatic life, swimming, or recreational uses. The guidelines consider several aspects, such as water clarity, phosphorus concentrations and aquatic plant coverage. Dugdale Lake fully supports aquatic life and swimming uses according to these guidelines. Recreational uses are partially impaired due to the heavy amount of plant growth in the lake. The overall use support category for Dugdale Lake is that of full support.

Conductivity is a measurement of water's ability to conduct electricity via total dissolved solids (TDS) made up of minerals and salts in the water column. Lakes with residential and/or urban land uses in their watersheds often have higher conductivity readings and higher TDS concentrations than lakes that are not surrounded by development because of the use of road salts. Stormwater runoff from impervious surfaces such as roads and parking lots can deliver high concentrations of these salts to nearby lakes and ponds. The average conductivity reading in the epilimnion is 0.7909 milliSiemens/cm (mS/cm) for Lake County lakes. During 2003, the conductivity readings in Dugdale Lake were higher than the Lake County average, at 1.0628 mS/cm in the epilimnion. TDS concentrations in Dugdale Lake were also higher than the Lake County median of 451 mg/L during 2003, with a seasonal average of 566 mg/L in the epilimnion. The lake receives stormwater runoff from 10th Street, 14th Street and Green Bay Road, which would be the

source of road salts. In comparison, Pulaski Lake, just on the other side of Green Bay Road within Greenbelt Forest Preserve has low conductivity and low TDS concentrations. This lake does not receive as much stormwater runoff from streets treated with road salt as Dugdale Lake.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

We randomly sampled locations in Dugdale Lake each month for aquatic plants, and identified seven species (Table 3). We also identified one macroalgae, (*Chara*) and recorded plants present along the shoreline. Table 4 in Appendix A lists the plant species and the frequency with which they were found. Aquatic plants will not photosynthesize at water depths with less than 1% of the available sunlight at the surface. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. During 2003, the depth of the 1% light level was the least in June, (approximately 10 feet deep). The maximum depth to which plants were found was 14 feet. The plants did not reach the surface across the entire lake, but we could see plants growing below the surface over most of the lake bottom. The only place at which we did not find plant growth was at the deep hole, which was a very small area. Based on these observations, it is probable that nearly 100% of the lake area could have supported plant growth. To maintain a healthy bluegill/bass fishery, the optimal plant coverage ranges from 30% to 40% of the lake. The most common plant over the season was coontail, which was found at 74% of all sample locations in 2003. Eurasian water milfoil (EWM), an exotic, aggressive plant species, was found at 67% of all sample locations. All plant species found in Dugdale Lake except for the EWM are beneficial, native plants. However, coontail, a native species, can grow to nuisance populations.

Of note was the discovery of the milfoil weevil (*Euhrychiopsis leconteii*) in the lake this year. This very tiny insect serves as a biological control for EWM, and when present in large enough numbers, can cause significant damage to milfoil beds. In 2003, the weevil had caused moderate damage to the EWM in shallow areas of Dugdale Lake. Adult weevils were observed in June. The reasons for weevil success or failure in controlling EWM are still being researched and there are no definite answers at this time. Research has shown that approximately 1-2 weevils per stem are needed in order to see significant damage and decline of a EWM bed. Weevil density in Dugdale Lake has not been quantitatively analyzed, but qualitative surveys suggest that weevil density may not be at this level. However, because there are no other plant management techniques being employed in this lake and it is a relatively undisturbed system with mostly native plants along the shoreline, it is possible that in the future the weevil population may increase to the point of severely reducing the EWM population.

Table 3. Aquatic and shoreline plants on Dugdale Lake, May – September, 2003.

Aquatic Plants	
Coontail	*Ceratophyllum demersum*
Chara	*Chara* sp.
Duckweed	*Lemna minor*
Eurasian Water Milfoil	*Myriophyllum spicatum*
American Pondweed	*Potamogeton americanus*
White Water Crowfoot	*Ranunculus longirostris*
Sago Pondweed	*Stuckenia pectinatus*
Watermeal	*Wolffia* sp.
Shoreline Plants	
Swamp Milkweed	*Asclepias incarnata*
Bulb-bearing Water Hemlock	*Cicuta bulbifera*
Purple Loosestrife^	*Lythrum salicaria*
Reed Canary Grass^	*Phalaris arundinacea*
Common Reed^	*Phragmites australis*
Pickerelweed	*Pontederia cordata L.*
Broad –leaved Arrowhead	*Sagittaria latifolia*
Softstem bulrush	*Scirpus validus*
Cattail	*Typha* spp.
Trees/Shrubs	
Green Ash	*Fraxinus pennsylvanica*
Locust	*Gelditsia* sp.
Cottonwood	*Populus deltoides*
Oak	*Quercus* sp.
Bur Oak	*Quercus macrocarpa*
Buckthorn^	*Rhamnus* sp.
Staghorn Sumac	*Rhus typhina*
Willow	*Salix* spp.
Common Elderberry	*Sambucus canadensis*

^ Exotic plant or tree species

Floristic quality index is a rapid assessment tool designed to evaluate the closeness of the flora (plants species) of an area to that with undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long term floristic trends, and 4) monitor habitat restoration efforts. Each floating and submersed aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). These numbers are then used to calculate the floristic quality index (FQI). A high FQI number indicates that there are a large number of sensitive, high quality plant species

present in the lake, and better plant diversity. Nonnative species are included in the FQI calculations for Lake County lakes. The FQI of 118 lakes measured between 2000 and 2003 ranges from 0 to 37.2, with an average of 14. Dugdale Lake has a FQI of 14, indicative of average plant diversity.

Of the 16 emergent plant and trees species observed along the shoreline of Dugdale Lake, four (purple loosestrife, reed canary grass, common reed and buckthorn) are invasive species that do not provide ideal wildlife habitat.

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted at Dugdale Lake on July 31, 2003. The shoreline was assessed for a variety of criteria (See Appendix B for methods), and based on these assessments, several important generalizations could be made. The entire shoreline is undeveloped, and ringed with wetland emergent plants, mostly cattails. A plant of interest was bulb-bearing hemlock, a very poisonous species that grew scattered along the shoreline. Wetland is one of the most desirable shoreline types, providing wildlife habitat and, typically, protecting the shore from excessive erosion. As a result, the shoreline exhibited no erosion.

Dramatic water level fluctuation can increase shoreline erosion, especially if the fluctuations occur over short periods of time. The water level in Dugdale Lake had a net decrease of about 10 inches from May to September. Erosion occurs when water levels drop and newly exposed soil, which may not support emergent plant growth, is subjected to wave action. However, the wetland plants along the shore helped to reduce the likelihood of shoreline erosion, as evidenced by the lack of erosion around the lake.

Invasive plant species, including reed canary grass, buckthorn, common reed and purple loosestrife were scattered along the shoreline. These plants can exclude native plants from the areas they inhabit. Buckthorn provides very poor shoreline stabilization and may lead to increasing erosion problems in the future. Reed canary grass, common reed and purple loosestrife inhabit mostly wet areas and can easily outcompete native plants. Additionally, they do not provide the quality wildlife habitat that native plants provide. Steps to eliminate these plants should be carried out as soon as possible in order to prevent further spread of these species and to preserve the quality of the lake and its surrounding shoreline.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

The Illinois Department of Natural Resources (IDNR) has assessed the fishery in Dugdale Lake during 1990, 1992, 1993, 1994 and 1999. The 1990 results indicated that the bluegill population was at the carrying capacity of the lake, but the largemouth bass population was still in good condition. It was recommended that the LCFPD stock largemouth bass and channel catfish annually to increase predation on the bluegill.

Although this recommendation was followed, the largemouth bass population in subsequent years declined in number and in health. During the 1999 survey, only 5 largemouth bass were caught, with an average length of just 11.8 inches. The bluegill population was stunted, with an average length of 3.8 inches. The IDNR staff commented that the poor fishery was probably due to inadequate law enforcement to prevent illegal harvesting – this lake is near a densely populated area and is under heavy fishing pressure. Also, the Lake County LCFPD had not placed signage with the more stringent creel limit rules that had been established. At this time, signs have been posted stating the limits as one largemouth bass per day (15" minimum) and 2 channel catfish per day.

The LCFPD has continued stocking the lake over the years. Stocking records are listed in Table 5. The IDNR recommendations from the 1990 survey suggest stocking Dugdale Lake with 550 3-inch largemouth bass fingerlings and 275 non-vulnerable channel catfish annually. However, the stocking records show that about half as many largemouth bass were stocked only in 1992 and 1993. The next time they were stocked was in 2000 when 525 1.3-inch bass were placed in the lake. The channel catfish were stocked according to recommendations from 1991 to 1996. They were still stocked yearly from that time to the present, but in numbers less than the recommendation, ranging from 123 fish to 242 fish. In order to counter the heavy fishing pressure in Dugdale Lake, the LCFPD may want to follow the IDNR recommendations more closely as well as to step up enforcing the creel limits.

Table 5. Fish Stocking Records For Dugdale Lake

Year	*Species*	*Number*
1985	Bluegill	45
1985	Largemouth Bass	70
1990	Largemouth Bass	Unknown
1991	Channel Catfish	275
1992	Largemouth Bass	269
1993	Channel Catfish	275
1993	Largemouth Bass	220
1994	Channel Catfish	275
1995	Channel Catfish	275
1996	Channel Catfish	275
1997	Channel Catfish	184
1998	Channel Catfish	242
1999	Channel Catfish	160
2000	Channel Catfish	123
2000	Largemouth Bass	525
2001	Channel Catfish	179

Wildlife observations were made on a monthly basis in 2003 during water quality and plant sampling activities (See Appendix B for methodology). As a result of the trees and wetland areas adjacent to Dugdale Lake, a good mix of wetland birds and waterfowl, as well as several species of songbirds were observed (Table 6). It is important that the shoreline around the lake be maintained as is (minus the invasive shoreline plant species) in order to provide the appropriate habitat for birds and other animals that can be enjoyed by lake users for many years to come.

Table 6. Wildlife species observed on Dugdale Lake, May – September 2003.

Birds	
Mallard	*Anas platyrhnchos*
Green Heron	*Butorides striatus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Canada Goose	*Branta canadensis*
Ring-billed Gull	*Larus delawarensis*
Common Flicker	*Colaptes auratus*

Table 6. Wildlife species observed on Dugdale Lake, May – September 2003, con't.

Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
Chimney Swift	*Chaetura pelagica*
American Crow	*Corvus brachyrhynchos*
Catbird	*Dumetella carolinensis*
Mourning Dove	*Zenaida macroura*
American Robin	*Turdus migratorius*
Northern Cardinal	*Cardinalis cardinalis*
Cedar Waxwing	*Bombycilla cedrorum*
Red-eyed Vireo	*Vireo olivaceus*
Red-winged Blackbird	*Agelaius phoeniceus*
Common Grackle	*Quiscalus quiscula*
Northern Oriole	*Icterus galbula*
Northern Cardinal	*Cardinalis cardinalis*
American Goldfinch	*Carduelis tristis*
Song Sparrow	*Melospiza melodia*
Mammals and Reptiles	
Eastern Chipmunk	*Tamias striatus*
Reptiles	
Painted Turtle	*Chrysemys picta*
Insects	
Cicadas	
Dragonfly	
Damselfly	
Locusts	

EXISTING LAKE QUALITY PROBLEMS AND MANAGEMENT SUGGESTIONS

Highpoints of the lake:

A. Low phosphorus, nitrogen and total suspended solids concentrations
B. High water clarity
C. Milfoil weevil present in the lake
D. Wetland plants surround the shoreline
E. No erosion present along the shoreline

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- *Lack of a Quality Bathymetric Map*

  A bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features of the lake, such as depth, surface area, volume, etc. The knowledge of this morphometric information would be necessary if lake management practices such as aquatic herbicide use or fish stocking were part of the overall lake management plan. Since stocking has been done frequently, this information could assist in planning this management strategy. Dugdale Lake does not have a current bathymetric map with volume calculations. Maps can be created by the Lake County Health Department – Lakes Management Unit or other agencies for costs that vary from $3,000-$10,000, depending on lake size.

- *Invasive Shoreline Plant Species*

  We observed purple loosestrife, buckthorn common reed and reed canary grass around Dugdale Lake, all of which are exotic, invasive species. Recently, two beetles (*Galerucella pusilla* and *G. calmariensis*) and two weevils (*Hylobius transversovittatus* and *Nanophyes marmoratus*) have offered some hope to control purple loosestrife by natural means. The LCFPD has introduced a total of 7,200 bio-control beetles within the Greenbelt Forest Preserve since 1997, but not directly in the vicinity of Dugdale Lake. There was no observed damage to the loosestrife plants along the Dugdale Lake shoreline. However, the possibility exists that the beetles could reach this area and begin feeding on the loosestrife plants at this location.

- *Exotic Aquatic Vegetation*

  One key to a healthy lake is a healthy aquatic plant community. Eurasian watermilfoil (EWM) is the second most common plant in Dugdale Lake. The presence of the milfoil weevil (*Euhrychiopsis leconteii*) may keep the EWM in check. However, the density of EWM should be monitored closely in order to

determine if intervention is necessary to reduce the plant's density. The LCFPD District may want to consider supplementing the existing weevil population with additional weevils. However, it may be worthwhile to wait and see if the population increases on its own before adding more.

Weevils are stocked in known quantities to achieve a density of 1-4 weevils per stem. As weevil populations expand, EWM populations may decline. After EWM declines, weevil populations decline and do not feed on any other aquatic plants. When EWM starts to grow again in the spring, the weevil populations respond by keeping the increasing milfoil under control before it becomes a problem. Once the weevil is established, EWM should no longer reach nuisance proportions and begins to become less dense. Best results are achieved in lakes that have shallow EWM infestations in areas where it is undisturbed by recreational and management actives. Weevils need proper overwintering habitat such as leaf litter and mud, which are typically found on naturalized shorelines or shores with good buffer strips such as those found surrounding Dugdale Lake. Additionally, water temperatures need to be 68-70^{o}F for maximum weevil activity. For this reason, weevils are typically stocked in late spring/early summer. Currently only one company, EnviroScience Inc., has a stocking program (called the MiddFoil® process). The program includes evaluation of EWM densities, of current weevil populations (if any), stocking, monitoring, and restocking as needed. One prohibitive aspect to weevil use is price. Typically weevils are stocked to achieve a density of 1-4 weevils per stem. This translates to 500-3000 weevils per acre of EWM. At a cost of $1 per weevil plus labor, a EWM management program using weevils can be expensive. The cost of the weevils does not include the labor involved in initial surveys, stocking, and monitoring, which typically run an additionally $3,500-$4,500. Additionally, there is no guarantee that weevils will provide long term control or even produce any results at all.

The weevils can be obtained from:

EnviroScience, Inc.
3781 Darrow Road
Stow, Ohio 44224
1(800) 940-4025