POND ASSESSMENT AND ENHANCEMENT OPPORTUNITIES
THE MEADOWS AT MELODY RANCH
TETON COUNTY, WYOMING

Prepared For

The Meadows at Melody Ranch HOA

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POND ASSESSMENT AND ENHANCEMENT PLAN
THE MEADOWS AT MELODY RANCH
TETON COUNTY, WYOMING

INTRODUCTION AND BACKGROUND

Biota Research and Consulting, Inc. (Biota) has been retained by the Meadows at Melody Ranch Homeowners Association to complete an assessment and provide enhancement recommendations for 8 water features located in the Melody Ranch Subdivision in Teton County, Wyoming (Appendix 1-Exhibit 1). Study objectives included investigation of physical pond parameters and water quality, and development of a list of cost-effective management strategies and improvement opportunities that could be employed to enhance the water quality, ecological health, recreational and fishery amenities, and aesthetics of the ponds.

POND ASSESSMENT

Field investigations, performed in early July and late August 2015, involved the documentation of physical attributes such as water sources and hydrologic regimes; pond productivity; pond depth and form; and proximate and submerged vegetative cover. In addition to the assessment of physical attributes, water quality samples were collected during the July field visit. Water samples were packaged in laboratory containers and sent to the Wyoming Department of Agriculture Analytical Services Lab in Laramie, Wyoming for analysis. Water quality analysis included quantification of the parameters identified below.

- Calcium
- Magnesium
- Sodium
- Potassium
- Total Dissolved Solids
- Total Suspended Solids
- pH
- Conductivity
- Turbidity
- Chemical Oxygen Demand
- Total Organic Carbon
- Carbonate
- Bicarbonate
- Fluoride
- Chloride
- Nitrate
- Nitrite
- Ortho Phosphate
- Sulfate
- Total Phosphate
- Ammonia
- Hardness
- Total Alkalinity

PHYSICAL ASSESSMENT

It appears that all 8 ponds were designed and constructed to operate as flow-through systems supported by irrigation water diverted from Flat Creek north of the Melody Ranch Subdivision. Two main supply ditches convey water from Flat Creek to a collection ditch immediately north of the Melody Ranch Subdivision. According to Bob Forsyth of Grand Teton Property Management, the eastern ditch provides approximately 70% of the water supply for the ponds and the western ditch provides the remaining 30% of the water supply. Water in the collection ditch feeds several laterals, which convey water to the ponds. The easternmost lateral feeds Ponds 1, 2, and 3, and the central and western laterals supply water to Ponds 4 through 8. Based upon field observations and anecdotal information, Pond 5 is the only water feature that has continuous inflow and outflow throughout most of the growing season. The other ponds receive only intermittent flows as needed to keep them at full pool. It appears that all ponds are lined and all have a gravel/silt substrate. None of the feeder ditches appear to be lined.

Pond water levels are managed by Grand Teton Property Management and Mountain Town Management. Mountain Town Management treats all ponds except Pond 5 with a microbe treatment (Bio-Zyme) in an attempt to help reduce nutrient levels. In addition, Ponds 1 and 2 receive periodic copper sulfate treatments in response to severe algae blooms or accumulations.

Pond 1

Pond 1 is a small, shallow pond with a surface area of approximately 0.17 acres. Inlet and outlet structures are fixed, and no aeration system is installed. Signs of muskrat activity were observed during the assessment effort. The pond liner was exposed in several areas around the pond, indicating that the pond is lined. A narrow emergent wetland fringe (1 to 6-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by cattails (*Typha latifolia*), reed canarygrass (*Phalaris arundinacea*), and several species of sedges (*Carex spp.*) and rushes (*Juncus spp.*). Water flows south from the collection ditch north of Melody Ranch Subdivision through Pond 3, Pond 2, and finally to Pond 1. The outflow from Pond 1 flows east into a collection channel that eventually conveys water back into Flat Creek.

During multiple pond assessment visits conducted in the summer and fall of 2015, the water in Pond 1 was stagnant, and both inflow and outflow channels were dry. Pond water clarity was poor due to a planktonic algae bloom (Appendix 2-Photo 2). Pond 1 is in poor ecological health and is currently providing only marginal habitat for aquatic and semi-aquatic organisms, such as macroinvertebrates, amphibians, muskrats, and waterfowl. Photos of Pond 1 are presented in Appendix 2 (Photos P1-P6).

Pond 2

Pond 2 is a small, shallow pond with a surface area of approximately 0.18 acres. Water depths range from 1 to 3 feet throughout the pond, and no aeration system is installed. A narrow emergent wetland fringe (1 to 6-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by cattails (*Typha latifolia*), reed canarygrass (*Phalaris arundinacea*), and several species of sedges (*Carex spp.*) and rushes (*Juncus spp.*). Water flows south from the collection ditch north of Melody Ranch Subdivision through Pond 3 to Pond 2. Outflow from Pond 2 flows south into Pond 1.

During multiple pond assessment visits conducted in the summer and fall of 2015, the water in Pond 2 was stagnant, and both inflow and outflow channels were dry. Pond water clarity was good, but some floating mats of filamentous algae were present around the perimeter of the pond (Appendix 2-Photo P8) as well as some on the bottom of the pond (Appendix 2-Photo P12). Pond liner was exposed in several areas around the pond, indicating that the pond is lined. Photos of Pond 2 from the field investigation are presented in Appendix 2 (Photos P7-P12).

Pond 3

Pond 3 is a small, shallow pond with a surface area of approximately 0.23 acres. Water depths in the pond range from 1 to 4 feet, and no aeration system is installed. A narrow emergent wetland fringe (1 to 3-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by reed canarygrass (*Phalaris arundinacea*) and several species of sedges (*Carex spp.*) and rushes (*Juncus spp.*). Water flows south from the collection ditch north of Melody Ranch Subdivision into Pond 3, and outflow from Pond 3 flows south into Pond 2.

During the July site visit, pond liner material was exposed in several areas around the pond, indicating that the pond is lined. At that time the water in Pond 3 was stagnant. A small amount of water (5-10 gpm) was entering the pond but the pond water level was a foot low and the outflow channel was dry, suggesting the presence of leaks in the pond liner. Both the inflow and outflow channels were dry during the August site visit, but water clarity was improved.

A layer of white foam was observed in the southern portion of the pond during the July visit (Appendix 2-Photo P16). The foam was apparently the result of a recent enzyme treatment performed by Mountain Town Management. Photos of Pond 3 from the field investigations are presented in Appendix 2 (Photos P13-P18).

Pond 4

Pond 4 is a small, shallow pond with a surface area of approximately 0.21 acres. Water depths range from 1 to 5 feet throughout the pond, and no aeration system is installed. A robust, diverse, emergent wetland fringe (2 to 12-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by numerous native hydrophytic plant species. Water flows south from the collection ditch north of Melody Ranch Subdivision into Pond 4. When sufficient water is available, outflow from Pond 4 flows south into Pond 6.

During the July pond assessment visit, approximately 1.5 cubic feet per second (cfs) was flowing into the pond, but the pond water level was low and the outflow channel was dry. There is a steep channel between the concrete apron and the pond, which oxygenates the water flowing into the pond. Both inflow and outflow channels were dry during the August site visit, and pond water was tea colored and clarity was moderate. Some submerged aquatic macrophytes and filamentous algae were observed. Photos of Pond 4 from the field investigations are presented in Appendix 2 (Photos P19-24).

Pond 5

With a surface area of approximately 0.86 acres, Pond 5 is the largest and healthiest pond. Although the pond is large, it is still relatively shallow. Water depths range from 4 to 6 feet throughout most of the pond, and no aeration system is installed. A robust, emergent wetland fringe (2 to 15-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by reed canarygrass (*Phalaris arundinacea*) and several species of sedges (*Carex spp.*) and rushes (*Juncus spp.*). Water flows south from the collection ditch north of the subdivision into Pond 5. Unlike the outlets of the other ponds that are comprised of fixed concrete aprons, the outlet of Pond 5 is controlled by an AgriDrain water level control structure (Appendix 2-Photo 29). Outflow from Pond 5 flows south to the southern boundary of the Melody Ranch Subdivision.

During the July site visit, an estimated 0.5 to 1.0 cfs was flowing into the pond and an equal or slightly greater volume was exiting the pond. Pond water clarity was good, but some floating mats of filamentous algae were present around the perimeter of the pond and on the bottom of the pond. Some submerged aquatic macrophytes were also observed. During the August site visit, only a trickle (approximately 1 gpm) was flowing into the pond, and there was no outflow. Submerged aquatic vegetation and floating mats of filamentous algae were prevalent. Photos of Pond 5 from the field investigations are presented in Appendix 2 (Photos P25-P30).

Pond 6

Pond 6 is the smallest pond, with a surface area of only 0.05 acres. Water depths range from 1 to 5 feet throughout the pond, and no aeration system is installed. Concentric bands of emergent wetland vegetation exist around the perimeter of the pond (Appendix 2-Photo 33). A 2- to 12-foot wide band of cattails is surrounded by a 2- to 6-foot wide band of diverse native hydrophytes such as *Mentha arvensis, Epilobium ciliatum, Agrostis exarata,* and several species of *Carex*. Hydrologic support for Pond 6 is provided by irrigation water, but according to Bob Forsyth, he has trouble getting water all the way down to Pond 6 because of seepage from the supply ditches and very little gradient in the delivery system. As such, the water level in Pond 6 is rarely at full pool. During the early-July site visit, both the inflow and the outflow channels were dry. Pond water was tea colored and clarity was moderate. Some submerged aquatic macrophytes and filamentous algae were observed. Photos of Pond 6 from the field investigations are presented in Appendix 2 (Photos P31-36).

Pond 7

Pond 7 is a shallow pond that has been overrun by cattails. The current surface area of the pond (open water) is approximately 0.13 acres, with 0.37 acres of cattails surrounding the open water area. Water depths in the pond range from 1 to 4 feet. Because of the cattail encroachment, a robust, emergent wetland fringe (as much as 45 feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by cattails (*Typha latifolia*), with a small band of sedges (*Carex spp.*) and rushes (*Juncus spp.*) between the cattails and adjacent uplands. Hydrologic support for Pond 7 is provided by irrigation water that flows out of Pond 8.

During the July site visit, both the inflow and the outflow channels were dry, and the water level was 5 to 6 feet below full pool. It appears that the water level in Pond 7 is rarely, if ever, at full pool. Pond water was tea colored and clarity was moderate. Some submerged and floating-leaved aquatic macrophytes and filamentous algae were observed. During the August site visit, the water level had dropped further, and most of the open water in the pond was covered with duckweed (Lemna sp.), a free-floating aquatic plant. Because of the extensive emergent wetlands, shallow water depth, and submerged/floating aquatic vegetation, Pond 7 provides quality habitat for dabbling ducks. Photos of Pond 7 from the field investigations are presented in Appendix 2 (Photos P37-42).

Pond 8

Pond 8 is a small shallow pond with a surface area of approximately 0.15 acres. Most of the pond is between 3 and 5 feet deep. A robust, emergent wetland fringe (2 to 14-feet wide) exists around the perimeter of the pond. The wetland fringe is dominated by cattails (*Typha latifolia*), with a small band of sedges (*Carex spp.*) and rushes (*Juncus spp.*) between the cattails and adjacent uplands. Water is supplied to Pond 8 by a feeder ditch that splits off from the main lateral above Pond 4 and flows south to Pond 8. When sufficient water is available, outflow from Pond 8 flows south into Pond 7, but this doesn’t appear to occur frequently.

During the July site visit, approximately 0.5 cfs was flowing over the concrete inlet structure and into the pond. Outflow from the pond was minimal. There is a steep channel between the concrete apron and the pond, which oxygenates the water flowing into the pond. Both inflow and outflow channels were dry during the August site visit. Pond water was tea colored, and clarity was moderate. Submerged aquatic macrophytes and filamentous algae were observed, as well as floating mats of filamentous algae. Photos of Pond 8 from the field investigations are presented in Appendix 2 (Photos P43-48).

WATER QUALITY ASSESSMENT

Water samples were collected from 8 locations throughout the Melody Ranch pond and ditch system in July 2015. Water quality sampling procedures followed protocols specified by the Wyoming Department of Agriculture Analytical Services Lab. Water quality results are presented in Table 1, and a discussion of the results for several key water quality parameters (Nitrogen, Phosphorous, pH, and Alkalinity) is presented below. These parameters are important indicators of overall water quality and provide insight into possible causes of algal blooms and excessive aquatic vegetation growth. A range of concentrations for each parameter has been identified as ideal in order to facilitate optimum pond function. It should be noted that the chemical treatments applied to select ponds during 2015 by Mountain Town Management may have resulted in quantification of current water quality parameters that could deviate from background levels.

Table 1. Pond water quality analysis results, The Meadows at Melody Ranch HOA Project Area.

Parameter	Suitable Condition	Pond 1	Pond 2	Pond 3 Inlet	Pond 4 Inlet	Pond 5 Outlet	Pond 6	Pond 8 Inlet	Pond 8 Outlet
Chemical Oxygen Demand (mg/L)		39	17	5.9	<5.0	<5.0	20	<5.0	5.8
Alkalinity (mg/L)	50-200 mg/L	140	160	150	160	170	210	160	170
Bicarbonate (mg/L)	<165 mg/L	160	200	180	190	210	260	190	200
Carbonate (mg/L)	<165 mg/L	4.6	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Conductivity(µS/cm)	150 - 500 µS/cm	330	370	330	340	360	460	340	360
pH units	6.5 - 8.5	8.5	7.7	8.2	8.1	7.9	7.8	8.1	7.9
Calcium (mg/L)	4 - 160	32.8	49	48.5	46	51.1	64	45.6	49.9
Magnesium (mg/L)		23.5	17.2	14.8	13.7	15.4	21.1	13.7	15
Potassium (mg/L)		5.82	1.2	0.876	0.9	1.12	3.01	0.884	1.09
Sodium (mg/L)	<20 mg/L	6.37	4.17	4.1	3.81	4.11	5.29	3.71	3.86
Turbidity (NTU's)	<10 NTU's	9.72	1.59	1.23	1.06	0.836	3.82	0.783	0.741
Total Hardness (mg/L)		180	190	180	170	190	250	170	190
Total Disolved Solids (mg/L)		192	220	172	192	204	272	188	200
Total Suspended Solids (mg/L)	<500 mg/L	20	7.4	<4.0	3.9	9.7	10	<4.0	<4.0
Chloride (mg/L)	<250 mg/L	7.1	2.3	1.4	1.5	1.9	3.6	1.5	1.8
Fluoride (mg/L)	0.7 to 1.2 mg/L	0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.3
Nitrate:N (mg/L)	<5 mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrite:N (mg/L)	<0.6 mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Ortho Phosphate (P) (mg/L)	<0.03	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate (mg/L)	<75	26	32	27	24	26	30	25	27
Ammonia: N (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus (P) (mg/L)	<0.08, <0.03 ideal	0.03	0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02
Total Organic Carbon (mg/L)		16	5.9	4.1	3.8	3.9	8.8	3.8	3.9

Nitrogen

The concentration of ammonia (NH_3) in all samples was below 1 mg/L, which is the identified threshold level above which eutrophication (severe nutrient loading and algae proliferation) is often a problem. Nitrate (NO_3) was effectively absent from all water samples, which is ideal. Nitrite (NO_2) was absent from all samples except for the sample taken from the Pond 8 outlet, which had a NO_2 concentration that was still within the optimum range and significantly below hazardous levels. In light of such low concentrations of nitrate in the water, it appears that the presence of nitrogen is not currently a problematic factor contributing to undesirable algal activity. The relative concentrations of these 3 common forms of nitrogen indicate that the bacteria community in the ponds (supplemented with Bio-Zyme bacteria) are properly utilizing nitrogen. Bacteria facilitate the conversion of more toxic and unusable forms of nitrogen (ammonia and nitrite) into a more accessible form (nitrate) that can then be utilized by plants. Additionally, some specialized bacteria perform the process of denitrification, during which nitrate in the pond is consumed and converted back to nitrogen gas. This cycle (the nitrogen cycle) is desirable because it limits nitrogen availability to aquatic flora, which effectively reduces the severity and occurrences of undesirable algal blooms.

Phosphorous

Phosphorus is often *the* limiting factor (more so than nitrogen) for plant and algal growth in ponds. It is rare to find pure, elemental phosphorus (P) in the environment. In nature, phosphorus typically exists as part of a phosphate (PO_4) molecule. Studies have demonstrated that plants growing in the absence (or presence of only very small amounts) of phosphate are slow-growing or stunted. For this reason, it is important to ensure that phosphate levels in the ponds remain low. The control of phosphate concentration in the ponds and ditches that feed the ponds can be influenced through a reduction in the use of fertilizers in the immediate area of the ditches and ponds, but the HOA has no control of land management practices that may affect phosphorous concentrations in the source ditches upstream of the subdivision.

Ortho-phosphate was effectively absent from all samples, and total phosphorous was absent from all samples except for the samples from Pond 1 and Pond 2, which were 0.03 and 0.02 mg/L respectively. The suitable condition for total phosphorous is less than 0.08 mg/L, with an ideal or optimal level of less than 0.03 mg/L. As such, the results indicate that all samples are within the suitable condition for total phosphorous, and all are in the optimal range except for Pond 1. Pond 1 had the poorest water clarity of all ponds and experienced a phytoplankton bloom during the assessment period. As such, high levels of total phosphorus were expected. Ponds 1, 2, and 3 are flow-through ponds that share the same water source. According to Mountain Town Management, Pond 3 had been treated with enzymes shortly before the water quality sampling was conducted. This likely affected nutrient concentrations (including total phosphorous) detected in the water sample for Pond 3.

pH

pH is a measure of acidity and is equal to the negative log of the number of free hydrogen ions. A high concentration of hydrogen ions equates to a low pH and an acidic solution, while a low concentration of hydrogen ions results in a high pH and a basic solution. pH is an important water quality indicator because, the pH of water determines the solubility and biological availability of nutrients such as phosphorus, nitrogen, and carbon that are present in the water. pH also directly affects the ability of plants and animals to survive in a given environment, as few plants or animals can tolerate acidic conditions. The acidity of waterbodies naturally fluctuates in conjunction with photosynthetic activity. Photosynthesis reduces carbon dioxide (a gas that acts as an acid when it is dissolved) levels in the pond, which results in a more basic environment with a higher pH. This is another reason to minimize available nutrients in order to avoid severe algal blooms, as such blooms can result in pH fluctuations beyond the conditions tolerated by aquatic organisms. On the upper end of the pH spectrum, many of the worst algae species including the toxic blue-greens prefer high pH and stagnant water.

All pH values were within the suitable range of 6.5 – 8.5, although the pH in Pond 1 was at the upper limit of the range (Figure 1). A factor that contributes to explaining the high pH value in Pond 1 is that algae concentrations were high and the water sample was collected mid-day during the peak of photosynthetic activity.

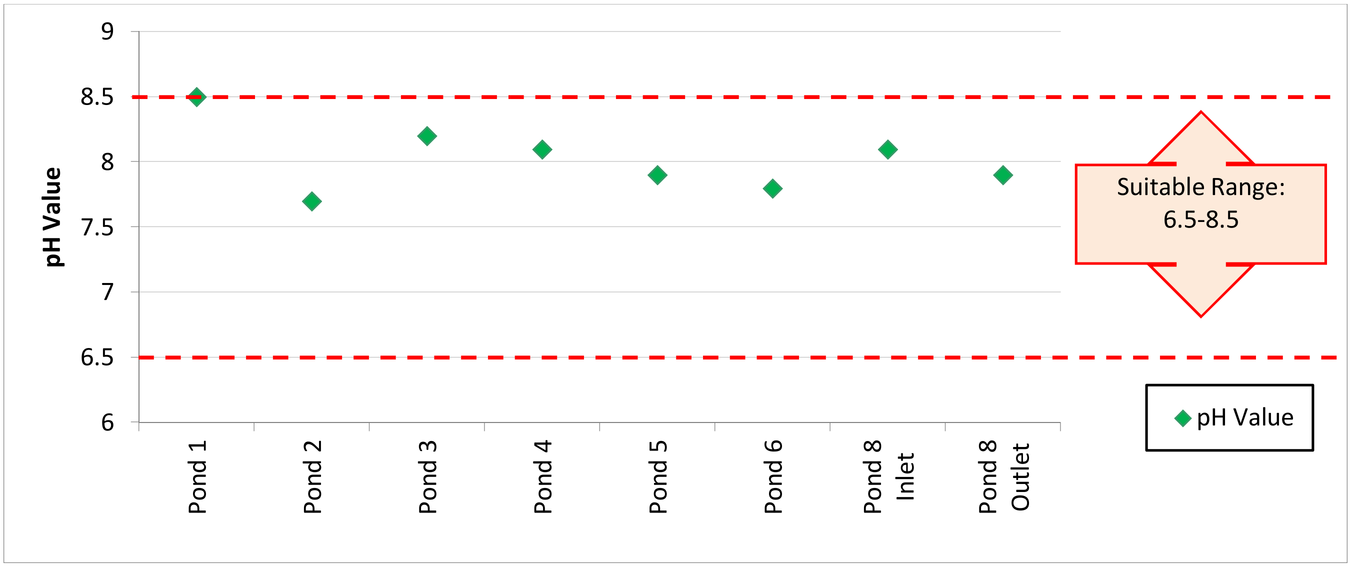

Figure 1. pH values for pond water quality samples, The Meadows at Melody Ranch HOA property.

Alkalinity

Alkalinity, or buffering capacity, is a measure of the ability of a waterbody to maintain relatively constant pH despite receiving inputs with varying pH (either acidic or basic). Alkalinity is measured in milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$). Alkalinity is affected by the type of minerals in the adjacent soil and bedrock, and by the extent with which the pond water or source water comes into contact with such minerals. If a pond receives water from a source that originates in limestone or other carbonate compounds, hardness (and alkalinity) measures are inevitably high. Conversely, if carbonate compounds are not prevalent in the area, then alkalinity and hardness values are often low.

The total alkalinity levels in all samples were within the suitable range of 50-200 mg/L, except for the Pond 6 sample, which was 210 mg/L (Figure 2). Levels greater than 120 mg/L are ideal in order to sustain a healthy system and promote microbial consumption of organics in the water column. When alkalinity levels are below 100 mg/L, microbial production is inhibited and pH is susceptible to fluctuation. Several conditions can then influence pH, including the presence of highly productive aquatic plant communities, large die-offs in the plant community, and the presence of decaying material. Given that the alkalinity measurements were 140 mg/L or greater, the current alkalinity of the pond is not likely a serious matter.

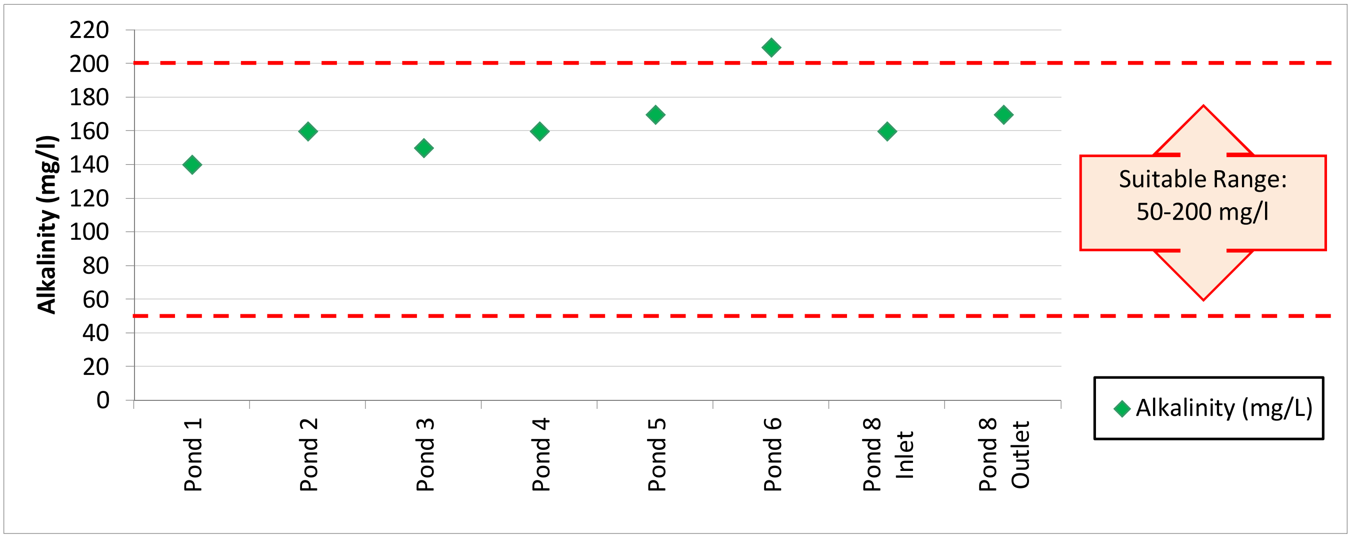

Figure 2. Alkalinity values for pond water quality samples, The Meadows at Melody Ranch HOA property.

SUMMARY

An assessment of the 8 water features located in the Melody Ranch Subdivision was conducted in July and August 2015. Water samples were collected from 8 locations throughout the pond and ditch system in July 2015 and sent to the Wyoming Department of Agriculture Analytical Services Lab for analysis. In general, water quality conditions are suitable to support high quality ponds. However, elevated phosphorous concentrations in Pond 1 and 2 should be addressed in order to minimize availability of the nutrient to undesirable algae growth. The summary of water quality conditions obtained through this assessment will provide a quantitative benchmark of conditions that can be used to assess the influences and results of improvements made to the pond network in the future. The physical assessment of the pond system and interviews with individuals responsible for pond management provided informative information from which to develop recommendations for improving the water quality, ecological health, and aesthetics of the ponds.

MANAGEMENT STRATEGIES AND IMPROVEMENT OPPORTUNITIES

Based on site investigations and assessment results, a suite of specific management practices and physical system alterations have been developed in order to improve pond conditions, ecological health, and aesthetics of the Melody Ranch ponds.

Flow Regime

One of the most detrimental management practices associated with the ponds is limiting the amount and duration of hydrologic support for the ponds. Limited flows result in prolonged pond turnover (the amount of time it takes for the full volume of the pond to be replaced) and can result in stagnant, warm water with high nutrient concentrations that provide ideal conditions for excessive growth of algae and aquatic plants. This process is exacerbated by the shallow depths of the Melody Ranch ponds the depths of the pond are not protected from solar inputs, which can penetrate and warm the entire water column. In optimized pond systems, the water supply is sufficient to result in turnover rates of 24 to 48 hours throughout the summer growing season. Any management activities that could be employed to increase the volume and consistency of supply flows to the Melody Ranch ponds should be pursued.

Beneficial Bacteria (Microbes)

The treatment of ponds through the addition of beneficial microbes is an integral part of pond maintenance. It is recommended that bacterial treatments be conducted in all of the Melody Ranch ponds on a regular basis due to the flow-through nature of the pond network and the impaired conditions of all water features. Beneficial microbes break down organic material and reduce excess nutrients in the water column.

Maintaining relatively low concentrations of phosphorous and nitrogen in the aquatic systems is vital because the availability of these crucial elements is almost always the limiting factor restricting the growth and production of undesirable algae species. When nitrogen and phosphorous are not present in excessive concentrations, algal blooms are less frequent and are less severe. Phosphorus is often *the* limiting factor (even more so than nitrogen) for plant and algal growth in ponds. Studies have demonstrated that plants growing in the absence (or presence of only very small amounts) of phosphorous are slow-growing or stunted. For this reason it is important to ensure that nutrient levels remain low in the pond. Since the control of nutrient concentrations in the surface water that provides hydrologic support for the ponds is not a viable option, treating the ponds with microbes that remove nutrients from the water column is important.

In recent years, Biota has worked with our supplier to refine a specific blend of beneficial bacteria that works in this region and local climate. The product, Teton BioPond, is available through Biota and is completely organic and safe for children, pets, fish, and wildlife. The bacterial mixture reduces the availability of both nitrogen and phosphorous to nuisance aquatic vegetation, while breaking down sludge and organic waste in the treated water feature. Teton BioPond converts phosphorous to an organic form that is not available to algal species for absorption. Teton BioPond also converts Ammonia and Nitrite into Nitrate, effectively reducing the availability of various nitrogen compounds to algal and undesirable aquatic plant species. We have had great success with Teton BioPond in this region and numerous private land owners and large scale developments (Teton Springs Golf and Casting Club, for example) have expressed success with the product and observed dramatic improvements in pond health as result of implementing a maintenance treatment program.

Application of 3 to 6 lbs of Teton BioPond per surface acre of water feature are recommended during the initial treatment. Continued bi-monthly application of BioPond is recommended at a rate of 2 to 3 lbs per surface acre throughout the growing season (May – October) in order to maintain a population of microbes large enough to metabolize pollutants and nutrients. Viable populations of microbes will reduce the availability of nutrients to nuisance algal species and will decompose organic material in the water column and on the pond bottom. These activities inevitably combine to result in clear water and reduced algal activity. The total water feature acreage at Melody Ranch is approximately 2 acres, and could be treated twice a month for a growing season using a total of 4 buckets (25 lbs each) of Teton BioPond. The treatment materials would cost about $800-$1,000 and applications could be completed by property managers at Melody Ranch.

Pond Aeration

Aeration is an essential part of maintaining a high quality pond because it effectively adds oxygen to all levels of the water feature. The physical movement of air bubbles from the pond bottom up through the water column creates vertical currents that eliminate stratification. The direct delivery of oxygen to all levels of the pond increases dissolved oxygen concentrations to meet the Biological Oxygen Demand (BOD). The BOD of a pond is determined by the number, type, and oxygen requirements of all organisms (bacteria, vegetation, and other aquatic organisms) present in the system. When required BOD levels are not met, eutrophication occurs causing the accumulation of sludge and organic debris on the pond bottom.

If left untreated, this accumulation of organic matter can produce foul odors, noxious gases, and greatly diminished water feature quality and aesthetics.

Aquatic vegetation, aquatic organisms, and ground and surface water supply sources all contribute to the effects of nutrient loading in ponds. Nutrients of primary concern are nitrogen and phosphorous because they both stimulate the growth of algae and other aquatic vegetation that detract from the aesthetics of the water feature and reduce the amount of dissolved oxygen available to other organisms. Aeration minimizes the accumulation of organic material and nutrients in a pond. The distribution of oxygen throughout the pond horizontally and vertically stimulates natural (or supplemented) microbial consumption of organic matter and utilization of excess nutrients.

The occurrence of algal blooms in ponds often facilitates further deterioration of pond and water quality through what can easily become a negative feedback loop. Blooms near the surface of water bodies serve to shade out deeper levels and prevent vascular plant growth. Algal blooms produce oxygen during the day and consume oxygen at night. The result is often an upper layer in the pond that is supersaturated with oxygen while the deeper layers are devoid of the vital element. Such oxygen stratification encourages further algal activity near the surface while supporting only anaerobic (undesirable bacteria) activity in oxygen-deprived depths. Aeration helps to solve this problem by adding oxygen to all depths of the pond, facilitating the persistence of insect, snail, and aerobic bacterial life on the pond bottom.

A standard aeration system pulls ambient air and disperses it throughout the pond by supplying it to diffusers located on the pond bottom. These systems supply oxygen to all levels of the pond, eliminate stratification, and therefore help maintain water quality. Biota is a dealer for Vertex Water Features, a manufacturer of high quality pond aeration systems, and we recommend this manufacturer over others that we have experienced due to the high quality components, utilization of piston compressors instead of carbon vein compressors, low pressure and low temperature operating conditions, self-cleaning membrane diffusers, hardware warranties, and reasonable pricing. Various sizes of standard Vertex aeration systems are available and could be specified for each of the Melody Ranch ponds based upon water feature size (surface area) and availability of electrical supply. Alternately, the Vertex BriteStar Solar Aeration systems could be utilized in instances where providing an electrical supply might be problematic. It is recommended that aeration be considered for all of the Melody Ranch ponds, and individual systems could be installed sequentially or simultaneously. Each of the Melody Ranch ponds could be equipped with a standard Vertex aeration system for approximately $2,500-$5,000 based upon water feature size. Biota is available to specify system specifics, configurations, and exact pricing based upon the desires of the Melody Ranch HOA.

Ditch Lining/Piping

The supply ditches that convey water to, and between, ponds are not lined. Seepage and related loss through ditches results in inefficiencies and reduced hydrologic support for the water features. Lining the primary ditches in Melody Ranch or converting some ditches to pipes would increase the quantity of water delivered to the ponds and would also prevent seepage of water from ditches into undesirable locations (e.g., residential crawl spaces or basements). Ditch lining or sealing would require a financial investment to improve infrastructure of the pond system. However, lining activities could be implemented in multiple phases over several years. Lining the water delivery network at Melody Ranch, from upstream to downstream through the series of ponds, would enable property managers to increase the magnitude and duration of hydrologic support for the water features. This approach to system infrastructure improvement would enhance water feature health using the existing water supply, and would not be impacted by implementation of other infrastructure improvement treatments (pond deepening, aeration, etc.).

Increasing Pond Depths

Increasing the depth of the Melody Ranch ponds through excavation is highly recommended, but would represent a significant financial expenditure, especially when compared to the cost of other presented management actions or site improvements. However, the existing minimal depth of the Melody Ranch ponds poses significant difficulty to efforts to maintain clean, healthy, functional, and aesthetic water features. Solar inputs typically penetrate 4 to 5 feet of the water column in this region during the growing season. Penetrating sun light supports aquatic plant and algae growth and provides thermal inputs that result in elevated water temperatures. The minimal depth of the Melody Ranch ponds enables solar inputs to penetrate all, or most of, the water column and results in algal growth and water warming throughout the water features. Increased pond depths would allow more of each pond to remain cool and sheltered from sun light, which would result in less area within each pond that is suitable for nuisance algae growth and anaerobic conditions. The relative system benefits achieved from microbe treatments and aeration would also be dramatically increased if pond depths were increased because aeration would enable mixing of cool deep water with warmer shallow water and microbes would function at all pond depths (including deeper areas that do not support algal growth) to remove nutrients from the water column and break down organic waste and sludge.

Increasing pond depths would represent a significant effort, but would dramatically improve pond conditions and would provide an opportunity to repair leaking pond liners and address areas where pond liners are exposed. The effort would require excavation of material currently covering pond liners, removal of existing liners (which may or may not be salvageable), excavation of additional material to achieve desired water feature depth (of approximately 10-12 feet), installation of suitable pond liner with appropriate alluvium cover, and reclamation of construction access routes and disturbed areas. Biota is available to assist the Melody Ranch HOA in obtaining construction cost estimates for this type of work from qualified contractors, but the cost of these pursuits might warrant exploration of other recommended management strategies and infrastructure improvements first. Implementation of other recommended system improvements prior to pond deepening would not represent a waste; improved flow regimes and beneficial microbe treatments could continue after pond deepening, aeration systems could be re-installed and re-used after pond deepening, and lined delivery ditches could remain intact through the pond deepening process.

APPENDIX 1 – EXHIBITS

Exhibit 1 Aerial photograph depicting the location and site characteristics of The Meadows at Melody Ranch HOA pond project area, Teton County, Wyoming.

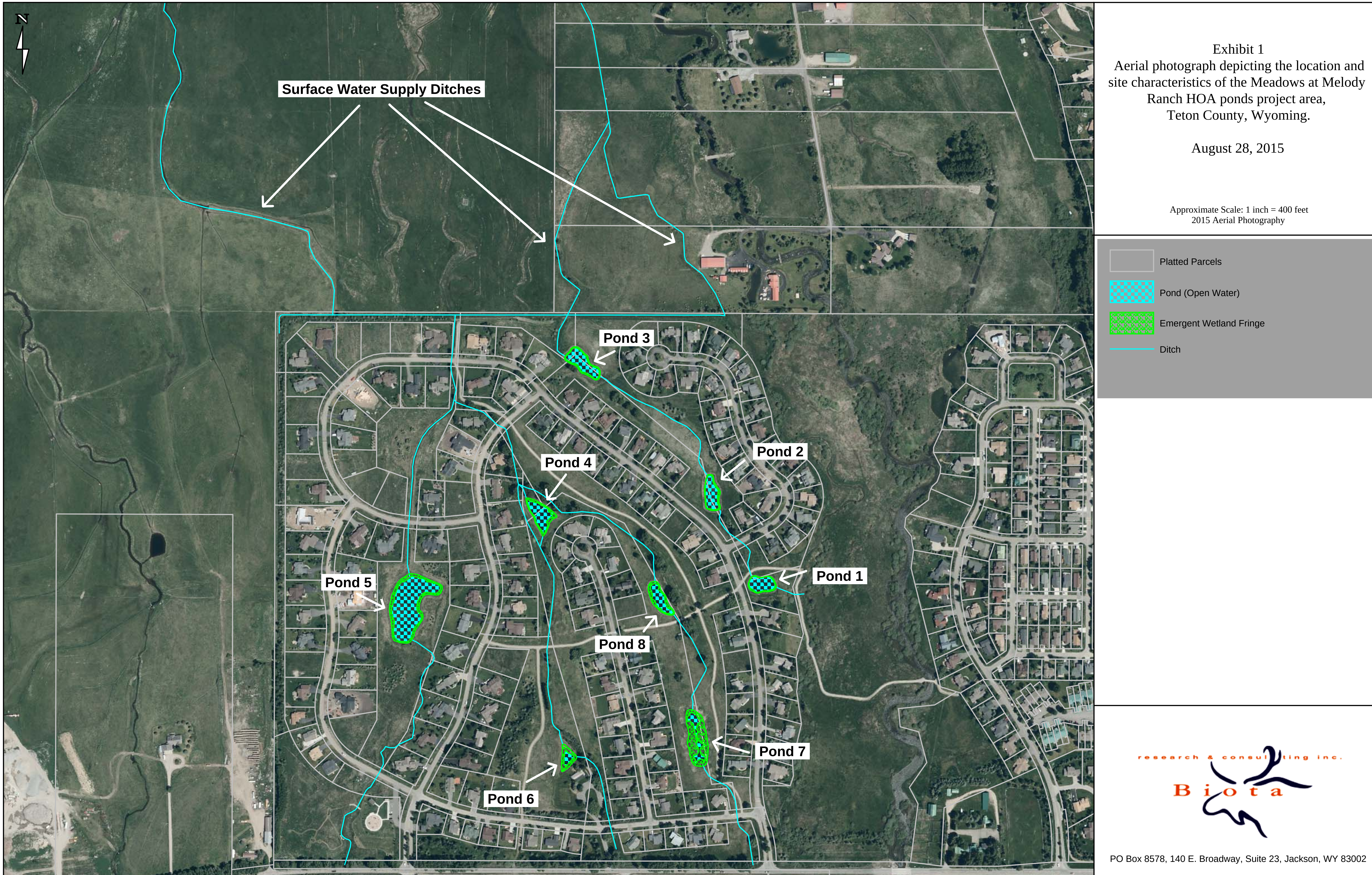

Exhibit 1
Aerial photograph depicting the location and site characteristics of the Meadows at Melody Ranch HOA ponds project area, Teton County, Wyoming.

August 28, 2015

Approximate Scale: 1 inch = 400 feet
2015 Aerial Photography

research & consulting inc.
Biota

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APPENDIX 2 – PHOTOGRAPHIC DOCUMENTATION

Photograph P1. Photograph depicting Pond 1, looking northwest from the southeastern portion of the pond.

Photograph P2. Photograph depicting the western portion of Pond 1 in early July, looking south from the northwestern portion of the pond.

Photograph P3. Photograph depicting the southwestern portion of Pond 1 in late August, looking south from the northwestern portion of the pond.

Photograph P4. Photograph depicting the inlet to Pond 1 and culvert under the pedestrian pathway of the north side of the pond.

Photograph P5. Photograph depicting the outlet of Pond 1 and a portion of exposed liner.

Photograph P6. Photograph depicting the channel that conveys water to Pond 1.

Photograph P7. Photograph depicting the eastern portion of Pond 2, looking northeast (July 2015).

Photograph P8. Photograph depicting the southern portion of Pond 2, looking east (July 2015).

Photograph P9. Photograph depicting the western portion of Pond 2, looking northeast (August 2015).

Photograph P10. Photograph depicting the Pond 2 outlet structure (July 2015).

Photograph P11. Photograph depicting the Pond 2 inlet structure and supplemental water pipe (July 2015).

Photograph P12. Photograph depicting the southern portion of Pond 2, looking southwest (July 2015).

Photograph P13. Photograph depicting the inlet and northern portion of Pond 3, looking northeast (July 2015).

Photograph P14. Photograph depicting the inlet structure and supplemental water pipe for Pond 3, looking south (July 2015).

Photograph P15. Photograph depicting the central portion of Pond 3, looking west (July 2015).

Photograph P16. Photograph depicting Pond 3 after treatment and agitation of Bio-Zyme, looking northeast (July 2015).

Photograph P17. Photograph depicting the inlet structure for Pond 3 (July 2015).

Photograph P18. Photograph depicting the southern portion of Pond 3, looking southeast (August 2015).

Photograph P19. Photograph depicting the inlet and northern portion of Pond 4, looking south (July 2015).

Photograph P20. Photograph depicting Pond 4, looking south (July 2015).

Photograph P21. Photograph depicting the inlet and northern portion of Pond 4, looking northeast (July 2015).

Photograph P22. Photograph depicting Pond 4, looking south (August 2015).

Photograph P23. Photograph depicting the inlet and northeastern portion of Pond 4, looking southwest (July 2015).

Photograph P24. Photograph depicting the outlet of Pond 4 (July 2015).

Photograph P25. Photograph depicting the inlet and northern portion of Pond 5, looking southwest (July 2015).

Photograph P26. Photograph depicting the eastern portion of Pond 5, looking south (July 2015).

Photograph P27. Photograph depicting the outlet pipe and southern portion of Pond 5, looking south (August 2015).

Photograph P28. Photograph depicting the northeastern portion of Pond 5 and an area where vegetation was mowed to the edge of water, looking west (July 2015).

Photograph P29. Photograph depicting the AgriDrain water level control box at the outlet of Pond 5 (July 2015).

Photograph P30. Photograph depicting the outflow channel below the water level control structure on Pond 5 (July 2015).

Photograph P31. Photograph depicting Pond 6, looking north (July 2015).

Photograph P32. Photograph depicting Pond 6, looking east (July 2015).

Photograph P33. Photograph depicting concentric bands of wetland vegetation surrounding Pond 6, looking northeast (July 2015).

Photograph P34. Photograph depicting the Pond 6 inlet channel, looking northeast (July 2015).

Photograph P35. Photograph depicting a portion of exposed pond liner at Pond 6 (July 2015).

Photograph P36. Photograph depicting Pond 6, looking north (August 2015).

Photograph P37. Photograph depicting the southern portion of Pond 7 in early summer, looking north (July 2015).

Photograph P38. Photograph depicting the southern portion of Pond 7 in late summer, looking north (August 2015).

Photograph P39. Photograph depicting the southern portion of Pond 7, looking north (July 2015).

Photograph P40. Photograph depicting the northern portion of Pond 7, concrete inlet structure, and supplemental water supply pipe, looking south (July 2015).

Photograph P41. Photograph depicting emergent and floating aquatic plants and filamentous algae in the northern portion of Pond 7 (July 2015).

Photograph P42. Photograph depicting the pond shoreline in the southern portion of Pond 7 (July 2015).

Photograph P43. Photograph depicting the concrete inlet structure for Pond 8 (July 2015).

Photograph P44. Photograph depicting Pond 8, looking south (July 2015).

Photograph P45. Photograph depicting the southern portion of Pond 8, looking southwest (July 2015).

Photograph P46. Photograph depicting Pond 8 in late summer, looking north (August 2015).

Photograph P47. Photograph depicting water clarity in Pond 8 in early summer (July 2015).

Photograph P48. Photograph depicting the outlet channel for Pond 8, looking north (July 2015).