Monitoring Protocol for Two New Jersey Ponds with Littoral Zone Vegetative Restoration

Michael Wilson

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ABSTRACT

Restoration projects are becoming more frequent and commonplace because of increased regulations on development to replace lost ecosystems. Many of these projects have marginal success and rarely achieve the desired results. The mistakes and oversights are sometimes in the planning stages, but more often are made during the installation, primarily due to improper horticultural technique, poor monitoring, education, or lack of follow-up maintenance. Wetland restoration is even more difficult, due to the variable hydrologic patterns and reliance on environmental conditions. The most difficult type of wetland plant to establish is the emergent aquatic that typically grows in water up to a depth of 61 cm. This thesis reviews the establishment of emergent aquatic plants on two comparable ponds with similar species, and supports the hypothesis that proper maintenance and monitoring of a restoration project can determine the success of plant establishment. It outlines the necessary steps for a successful restoration project. With a proper monitoring protocol and maintenance there is a greater chance of success.
MONTCALIR STATE UNIVERSITY

MONITORING PROTOCOL FOR TWO NEW JERSEY PONDS WITH
LITTORAL ZONE VEGETATIVE RESTORATION

by

Michael Wilson

A Master's Thesis Submitted to the Faculty of
Montclair State University
In Partial Fulfillment of the Requirements
For the Degree of
Master of Arts in Environmental Studies

May 2009

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A THESIS

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Montclair, NJ

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TABLE OF CONTENTS

ABSTRACT 1

CHAPTER 1: INTRODUCTION TO THE RESTORATION CASE STUDIES 2

Introduction to Case Study #1; Kameron Pond Restoration 7

Introduction to Case Study #2; Catch and Release Pond Restoration 11

CHAPTER 2: ECOLOGY OF THE OBSERVED PLANTS 16

CHAPTER 3: METHODS 22

CHAPTER 4: ANALYSIS OF THE CASE STUDIES 23

CHAPTER 5: ENVIRONMENTAL MANAGEMENT OF RESTORATION PROJECTS 26

Environmental Management of Case Study #1; Kameron Pond Restoration 28

Environmental Management of Case Study #2; Catch and Release Pond Restoration 33

CHAPTER 6: ROLE OF MONITORING, MANAGEMENT, AND MAINTENANCE 36

CONCLUSION 41

REFERENCES 44

Appendix A: Kameron Pond Landscape Plan; Installation and Maintenance Recommendations 46

Appendix B: Kameron Pond Landscape Plan Assessment 47
CHAPTER 1: INTRODUCTION TO THE CASE STUDIES

Restoration of aquatic plants in the littoral zone of a fresh water lake or pond can be the most difficult of wetland creation and mitigation projects. Most of the reforestation and wetland creation projects require mitigation due to loss of habitat. There are certain criteria for all projects that should be followed. Involvement from the project designer and/or manager should be throughout the entire project including the monitoring period. Often projects are designed, prepared, and planted without proper follow-up.

Monitoring is often required for mitigation and can be critical to the success of a habitat restoration project. Monitoring of New Jersey Department of Environmental Protection (NJDEP) projects requires the submission of monitoring reports for a period of three to five years. Federal agencies and other state agencies have similar requirements. The monitoring process is conducted by environmental consultants and/or governing agencies. The effectiveness of monitoring is dependant upon the recommendations of the report and if proper action is taken as a response to the reporting process. Often follow-up on the report does not occur and the filing of the report fulfills regulatory requirements and thus the connection between the monitoring process and the success of a habitat restoration breaks down.

In New Jersey, mitigation for wetland creation or enhancement is regulated by the Freshwater Wetlands Protection Act Rules (N.J.A.C.7:7A, 2008), which provides guidance for monitoring protocol. According to these rules, all mitigation sites must be monitored from the first full growing season after planting and for three to five full growing seasons. The monitoring information must be submitted twice a year; in the spring and fall (NJDEP, 2008). There is specific mitigation guidance for vegetation that
applies to mitigation wetlands. The monitoring period is for five full growing seasons and reports must include documentation that the goals of the project are met. The requirement is 85% plant survival and 85% area coverage. The site must also be free of invasive species or noxious plants by 10% or less. If the mitigation project fails, a revised plan to rectify the mitigation site must be submitted (Kusler, 2006).

Monitoring may report problems and success; however, follow-up maintenance may not occur in response to the report. Monitoring is often conducted by an outside agency to the property owner and the monitor can only make recommendations due to lack of involvement as a decision maker. If a consultant is directly involved with a project and has greater control in directing project installation and after-care, there is a better chance of success. The first year after installation of a habitat restoration project is the most important, however, a project should be monitored for as long a period as possible, with a minimum of 10 years. Monitoring protocol must include an adaptive management plan to correct problems as they occur and allow for a better chance of success (Niedowski, 2000).

A good monitoring protocol is critical for plant survival in freshwater littoral zones, due to difficulties with establishment from changing hydraulics and erosion. The following work presents two case studies of aquatic plant establishment in littoral zones in two New Jersey ponds, with different monitoring protocols. This work is relevant because it shows that with good monitoring practices there is a better chance of success and completion of restoration projects in a timely fashion.

The two ponds that received aquatic planting are (1) Kameron Pond located on the Ramapo College campus in Mahwah, New Jersey, and the (2) Catch and Release
Pond on the property of Mahlon Dickerson Reservation (MDR), which is in Jefferson Township and part of the Morris County Park Commission (MCPC). Both of the ponds were planted with the same emergent aquatics, *Acorus americanus* (Sweetflag), *Alisma plantago-aquatica* (Water-plantain), *Iris versicolor* (Blueflag Iris), *Peltandra virginica* (Arrow Arum), *Pontederia cordata* (Pickerelweed), and *Sagittaria latifolia* (Duck Potato), on the littoral edge to provide habitat and to help prevent goose intrusion as an environmental tool. As with most lake and pond restoration, the reason for the restoration was to provide a convenience for human activity (National Research Council, 1992). The two ponds had a created planting shelf which is an area made for planting seedlings at the pond edge. The two planting shelves are different. The shelf for Kameron Pond was created out of the native soils as part of the dredging process, while the Catch and Release Pond created a shelf with the use of coir logs, which are 12” x 20’ tubes of coconut fiber that are used to stabilize eroding shorelines or streambanks. This shelf was backfilled with a mixture of compost and topsoil. The recommendations for plant material, technique, and maintenance are similar. The Kameron Pond emergent aquatic plants have failed, with marginal success on a second planting, and the Catch and Release Pond appears to be successful to date.

The Kameron Landscape Plan was a mitigation plan that was developed as part of a dredging project, which was included with the construction plans for The Overlook Student Housing. Part of the requirements from NJDEP was the treatment of storm water. Since the location of the new construction was a nine story building adjacent to the pond, it was decided to utilize the pond to accept the storm water run-off. This necessitated the dredging of the pond to allow extra storage of water. As part of the project Paulus,
Sokoloski, and Sartor, LLC (PS&S), the engineering firm hired by Ramapo College, recommended the planting of three grass-like species, *Glyceria melicaria* (Mannagrass), *Juncus Canadensis* (Canada Rush), and *Carex lacustris* (Hairy Sedge), on ¾ of the pond edge to prevent geese from entering the pond, as the population was beyond the carrying capacity. These plants were to be placed on a 183 cm planting shelf that extended to a 45.75 cm depth under the water and a few feet beyond the pond’s edge into hydric soils that were not submerged, except during storm water events. The plants recommended by PS&S were (1) species that could handle inundation of water, (2) aggressive plants providing quick coverage to prevent goose intrusion, and (3) grow to a height of 122 cm. The overall planting plan lacked diversity according to the researcher.

The Catch and Release Pond planting was the result of a request from the recreation department for MCPC. Help from the horticultural division for plant selection and planting procedures was needed. The pond is used extensively for fishing. MCPC in collaboration with the Knee Deep Fishing Club was interested in creating spawning habitat for fish as part of a dedication project in memory of William Clark; an avid fisherman who dedicated part of his life to educating children in fishing skills. A plan was developed that sited the preferred locations for a partial planting, allowing access for fishing and recommended the use of six plant species. The six chosen plants are *Acorus americanus* (Sweetflag), *Alissma plantago-aquatica* (Water-plantain), *Iris versicolor* (Blueflag Iris), *Peltandra virginica* (Arrow Arum), *Pontederia cordata* (Pickerelweed), and *Sagittaria latifolia* (Duck Potato). The pond also does not have the goose problem that Kameron Pond has, so therefore complete coverage was not necessary. This pond was not a dredging project and planting would have to be made with the existing
topography of the pond. Creation of planting shelves with the use of coir logs was recommended due to the steepness of the grade under water and to allow a wider planting shelf.

Pertinent observations in developing this project were made by the researcher since he was the horticultural consultant and landscape designer for both projects. Furthermore, having expertise as a horticulturist for MCPC, observational control on the Catch and Release project with the owning agency was required. On this project he had control of the project from conception to decide on technique and maintenance, and monitoring was part of the work requirements. With the Ramapo College project, the researcher could observe and make recommendations, but had no authority to direct the planting crews to assure the project was installed to horticultural standards. Maintenance was the responsibility of Ramapo College, and the researcher did monitor the progress of the plantings on his own. He was able to observe and make recommendations, providing an assessment report after the job completion outlining the mistakes made by the contractor. The plant list on both projects varies, with Kameron Pond having a larger selection of species, but the technique, plant suppliers, maintenance, and monitoring recommendations were the same. However, the six species chosen for study were planted on both projects and include *Acorus americanus* (Sweetflag), *Alisma plantago-aquatica* (Water-plantain), *Iris versicolor* (Blueflag Iris), *Peltandra virginica* (Arrow Arum), *Pontederia cordata* (Pickerelweed), and *Sagittaria latifolia* (Duck Potato).
Introduction to Case Study #1: Kameron Pond Restoration

Kameron Pond is a man-made pond that was built in the late 1800’s for the Mayer estate, one of the private owners of the property prior to the purchase by the State of New Jersey for the Ramapo College campus. It was initially 488 cm deep, and more than likely was landscaped according to designs that were current in that era, utilizing both native and exotic species. Currently the terrestrial edge of the pond is heavily wooded, particularly on the western shore.

Kameron Pond had been plagued by sedimentation, a problem that has increased since the building of Interstate 287. According to Paulus, Sokoloski, & Sartor (PS&S), with a sedimentation rate of 20 cubic yards per year, it is estimated that in fifteen years the pond will be completely filled in. The pond was only 183 cm deep and was also inundated with *Lemna minor* (Duckweed), an exotic invasive aquatic plant that thrives under eutrophic conditions and often is an indicator of polluted water (Crow, 2000). The Duckweed and Milfoil, also present in the pond, was competing for resources with other pond life and further degrading the pond. There was also a presence of exotic invasive species such as *Lythrum salicifolia* (Purple Loosestrife) and resident Canada Geese.

The plans presented by PS&S on March 19, 2003 were for a 244 cm dredge utilizing a dry dredge method. This meant that the pond would have to be drained and while it was empty a new spillway would be created that would allow the pond to accommodate storm water. The dredged material would be trucked to Potter’s Field on campus and spread out into a 152.5 cm high layer to dry. According to PS&S, the wooded side of Kameron Pond would remain intact, with no impact to the vegetation on the pond’s edge. It was decided at the consultation hearing, that a 366 cm deep dredge
would be preferred, as it would have a greater thermal stratification within the pond. The
plan called for a 183 cm wide, 30.5 cm deep ledge on the pond edge as a safety
precaution. This ledge was to be mitigated on three forth of the ponds edge by
landscaping with *Glyceria melicaria* (Melic Mannagrass), *Juncus Canadensis* (Canada
Rush), and *Carex lacustris* (Hairy Sedge) in an effort to prevent geese from entering the
pond. The other edge on the north side, the location of the dam, will have a stone edge
with no plants. The mitigation plan lacked bio-diversity and would not solve the Canada
Geese problem, due to the fact that they were nesting on the edge that was to be
unplanted.

The Kameron Pond Landscape Plan that was developed represented a reasonable
addition to the design suggested by PS&S. The new plan presented an additional 11
species of shrubs, 8 species of emergent aquatic plants, and 3 species of ferns that were
regionally native and meet the criteria of adding bio-diversity. The goose problem, cost,
and maintenance concerns were considered. An educational component was added to the
Kameron Pond Landscape Plan by providing native plants for botanical study and
restoration ecology. The plan also called for all four sides of the pond to be heavily
planted to combat the goose problem. Due to the intense planting scheme, access to the
pond for students was suggested by building a belvedere, 45' x 40' deck-like structure,
which would cantilever over the waters edge and be large enough for use as an outdoor
classroom. The Kameron Pond Landscape Plan was a conceptual plan given to Ramapo
College and PS&S as an addition to the proposed landscape plans. The recommended
planting and maintenance procedures were given in a written consultation with a 24" x
36" conceptual design (See Appendices A & F).
The Kameron Pond Landscape Plan was presented to Ramapo College and PS&S on June 23, 2003. The plan was approved by both the college and PS&S, with copies given to the landscape architect from PS&S to amend the dredging plans. This new plan was endorsed by the Environmental Studies and Science Departments at Ramapo College.

The dredging process began in Oct. 2003 with a fish harvest. The pond was partially drained to concentrate the fish. Students were allowed to participate and assist Great Blue Lake Management, the company contracted for this service. Several species of fish were harvested through a low-voltage shock treatment that brought the fish to the waters' surface. These were netted, put into aerated tanks, and released at Sally’s Pond in the Ramapo Reservation; a Bergen county park located across the street from the college. Fortunately, no exotic species, such as carp were found, as these would have to have been euthanized before removal from the property.

By November the pond had drained enough to begin work. An access road that went into the pond was constructed to accommodate the dump trucks that would transport the dredged material to Potters Field. It was stated at the initial consultation for the dredging that the watershed for Kameron Pond was full of active springs and it would refill in a short period of time. The hydraulic flow was stronger than thought. To begin the dredging process the crew had to dig a trench to channel the incoming water and had to extend the access road to get the trucks filled. A small area was sectioned off near the spillway to hold this incoming water. This water had to be pumped 24 hrs a day to keep the water level low. With winter rains and snow the hydraulic activity increased and a stronger pump had to be used while the crew was working.
Because of the strong hydraulics, the job took longer than planned. The pond bottom had become souppier during the course of the winter, and it was getting harder to accumulate and haul the dredged material away. As the dredging process got deeper, this situation increased and the job was taking much longer than expected. The crew was able to dredge to 10 feet before stopping in the spring. The safety ledge was created prior to filling the pond, and this was proving difficult with the soupy conditions. The ledge in some areas was altered from what was on the plans.

The planting of the shrub border and aquatic plants began on May 12, 2004 and was completed in 3 days, with the work being performed by a contracted landscape firm. Several mistakes were made in the planting process that included inferior plants, improper planting technique, plants not sited well, and lack of correct protection from herbivory. The combination of all these factors created a failed project. If monitoring had occurred, some of these problems could have been corrected immediately and the project may have been more successful. No one with authority from Ramapo College was checking on the work performed by the landscape firm. However, the researcher was present and did take notes to report back to the college. (See Appendix B)

The most critical mistake was not putting the plants in the correct locations as indicated on the plans. Another problem was the replacement of certain species due to unavailability from landscaper’s supplier. Some of the mistakes were corrected immediately, such as the protective netting, but the damage had already occurred. In combination with the inferior planting, the hydraulic flow from the storm water system for The Overlook Housing was proving to be too strong, and the inundation levels had increased by about 30.5 cm more than planned. With an unusual rainy season in late
spring and early summer, the water levels in the pond never settled at their normal height and the young, dormant plants were at depths they could not handle until maturity. The plants never grew and the aquatic vegetative mitigation part of the restoration failed.

*Introduction to Case Study #2: Catch and Release Pond Restoration*

The request for a planting scheme and design was made in August 2006 by Aric Gordon, Superintendent of Recreation for MCPC. This request was a result of discussions from a committee that was formed to dedicate the pond to William Clark; due to his devotion to teaching youth how to fish. The committee was interested in creating habitat for fish and at the same time hoping to enhance the landscape of the pond. This committee had a few species in mind which included *Nymphaea* species (Waterlily), *Iris versicolor* (Blueflag Iris), and *Pontederia cordata* (Pickerelweed) but were looking for advice on additional species and planting technique. The design process began in December 2006 with a plant selection of six species *Acorus americanus* (Sweetflag), *Alisma plantago-aquatica* (Water-plantain), *Iris versicolor* (Blueflag Iris), *Peltandra virginica* (Arrow Arum), *Pontederia cordata* (Pickerelweed), and *Sagittaria latifolia* (Duck Potato) that were emergent aquatics, which fulfilled the criteria of being aggressive for easy establishment, grow into the water at a depth of 30.5 cm providing habitat, and also having aesthetic appeal with interesting flowers. *Nymphaea* (Waterlily) species were not recommended due to a concern with invasiveness and possible loss of open water, which is preferred by fisherman.

The immediate recommendation was to consider planting only one third of the pond and continuing the rest of the planting in phases because of the difficulty with
planting and establishment in a littoral zone. Site investigations revealed the preferred locations for the first planting phase, which was in two locations. One was on the south side where there is shallow water which will be conducive to good plant growth and also provide a large habitat for spawning. The other area chosen was not as large and is on the north side of the pond (See Appendix F). It was also noted that there was a sharp drop-off on the pond's edge in several areas that were chosen for this initial planting. This resulted in a narrow littoral zone that would accept emergent plants. It was suggested that this littoral zone be increased with the use of coir logs to make a wider planting bed. This required additional soil. Because dredging was not a part of this project and the hydrology of the pond remains stable due to a consistent supply of water from a nearby stream, it was decided that there may be difficulty with planting under water into the native soils. The water level would have to be lowered to install the coir logs and plant.

The design, plant and material ordering, and overall process for planning were completed in February 2007. It was decided that the actual work was to be completed by volunteers that included a local Cub Scout troop and members of the Knee Deep Fishing Club. Discussions about the water level being drawn down to facilitate the planting resulted in a suggestion to use of the fire department to pump out a portion of the pond. A commitment from the Jefferson Fire Department to test out one of their new pump trucks was also secured, with a test date prior to the actual planting to determine the time needed for pumping and recharge of the pond to the existing water level.

The inlet to the pond was plugged May 17, 2007 in the afternoon to prevent water from entering the pond. That evening the Jefferson Fire Department arrived with two pump trucks that were running at a capacity of 568,500 liters per minute. The
recommended draw down was 61 cm and it took one hour to bring the water level to the
desired depth. This was a total of 1,137,000 liters of water, which was pumped into a
storm drain that emptied into an adjacent stream and also was dispersed into a wetland
that was located downstream from the pond. This drawdown allowed sufficient area for
the creation of an aquatic shelf at various depths and a wider planting area.

On May 19, 2007 the entire project was planted and completed in less than 5
hours. There were 3 members from the Knee Deep Fishing Club, 14 cub scouts and their
parents, 3 members of the Clark family and their children, and 3 employees from the
Morris County Park Commission. The project began at 7:30 in the morning with the
installation of the coir logs performed by the fisherman and Aric Gordon, because they
were able to utilize waders allowing them to comfortably stand waist deep in water.

The cub scouts arrived at 9:00 and at this time some of the coir logs were in the
process of being backfilled with a mixture of topsoil and compost to create a friable
planting bed, which was easy to dig into. As the cub scouts and their parents organized
themselves, the plants were laid out into the desired locations. Then a short planting
demonstration and instructions were given to guide the scouts on how to perform their
task.

By the time that the coir logs were installed, the scouts had completed
approximately 50% of the planting. At this time, the fisherman began to install the
fencing to protect the plants from herbivory and damage from water fowl. It was also
recommended to prevent vandalism and discourage fishing in these locations. The
fencing would be removed after one year which should be a long enough period to allow
plant establishment. The planting phase of the project, including cleaning up and loading
left over plants and equipment onto the truck, was completed by 12:15. It began to rain after completion of the planting phase and the severity of the storm was a concern.

Monitoring was the more critical stage of the project to ensure success. The plantings were checked the following morning particularly to see if the pond had recharged enough to allow for sufficient water and for erosion damage. Most of the plants were covered with approximately 2 to 5 cm of water which meant that additional irrigation was not necessary. Contingent plans were in place if the pond did not recharge sufficiently. All of the planting beds were at different elevations since the coir logs were placed by eye and not with the use of a transient. One of the last coir logs installed was considerably higher than the rest, and this planting bed was partially out of the water. This area was used for the planting of *Alisma plantago-aquatica* (Water-plantain) and it was determined that some mortality could occur if the root systems do not receive water. Most of this area did survive during the 2007 growing season; however, a number of plants died before establishment due to drought. It is possible that if irrigation on a regular basis was given here the plants may have grown enough to push their roots into the hydric soils. Although the amount of plants that succumbed to drought were minimal and most of the *Alisma* had thrived in 2007, a minimal amount survived the winter and most of the plants were not present in 2008. This zone received supplemental planting on June 10, 2008 with *Iris versicolor* (Blueflag Iris) and *Juncus effuses* (Soft Rush) as a replacement, since these plants can also thrive with less inundation.

The project was monitored into the fall when the plants began to go into dormancy. This included site visitation and weekly communication with the maintenance staff at MDR. On June 4, 2007, during a site visit it was noted that a section of the fence
in the water had come down after a storm with high winds. Calls were made to MDR to
make arrangements for repair as soon as possible, with the project manager requesting
help from the staff and a need for waiters. The response from the park foreman was that
he had repaired it after receiving the message that the fence was down. This shows that
monitoring and communication can help to solve problems in a timely fashion.
CHAPTER 2: ECOLOGY OF OBSERVED PLANTS

The six species chosen for study and restoration were selected because they are readily available from restorative nursery suppliers. Although a reference wetland was not chosen for either of the projects, these plants were utilized because their native range includes New Jersey and they are commonly found throughout the state. They were also used for their flowering qualities and their aggressive growing characteristic. Every plant was cross referenced to make sure that it would be able to handle inundation to meet the hydraulic conditions (See Table A) and is found in obligate wetlands. The references utilized are *Hortus III* (Bailey, 1976), *Wetland Planting Guide for the Northeastern United States* (Thunhorst, 1993), and *An Illustrated Flora of the Northern United States and Canada* (Britton and Brown, 1970).

*Acorus americanus* (Sweet Flag) is an emergent, herbaceous perennial that grows to a height of 30.5 cm to 61 cm and is capable of being permanently inundated. One of the habitats that it is found in is shallow water and it can have up to 15.25 cm of water over its crown. It has an insignificant flower that is yellow and blooms from May to August. It is also found in fresh to brackish tidal marshes, non tidal marshes, and wet meadows. The rhizomes of *Acorus* provide food for many species of waterfowl and muskrats, and the plant also provides cover for wildlife. It has a moderate rate of growth and can spread up to 0.5 feet per year in unconsolidated sediment. This plant also can tolerate partial shade, is a soil stabilizer, and tolerates acidic conditions. The native range of *Acorus* is from Nova Scotia and Quebec to Montana, Oregon, and Alberta, south to Florida, Texas, and Colorado.
Alisma plantago-aquatica (Water Plantain) is an emergent, herbaceous perennial that grows to a height of 106.75 cm, flowers white in June to September. It is found on the edges of lakes, ponds and streams, and is also found in fresh tidal marshes, nontidal marshes, ditches and seeps. The plant has a moderate rate of growth that can be irregular, and it is recommended that it is planted in clusters at irregular intervals with other species which provide cover. *Alisma* will accept permanent inundation of up 30.5 cm of water over its crown. It has a wildlife benefit of providing food (nutlets) for waterfowl and pheasant. This plant is found from Nova Scotia and Quebec to British Columbia south to Florida, Texas, and Mexico.
*Iris versicolor* (Blue Flag) is an emergent, herbaceous perennial with a height up to 122 cm that flowers blue or violet in May through July. The plant can be permanently inundated with up to 15.25 cm of water. It is found in fresh to moderately brackish tidal marches, wet meadows and shores, swamps, and occasionally forested wetlands. The rate of growth is slow with less than 6 cm per year in unconsolidated sediment; however *Iris versicolor* forms clumps that keep spreading outward. The plant will tolerate shade but requires full sun to flower, prefers acidic soil and remains in clumps. The plant’s natural distribution is from Newfoundland to Manitoba, south to Virginia and Minnesota.

*Iris versicolor* distribution

![Iris versicolor distribution map](image)

(Purdue, NRCS, 2009)

*Peltandra virginica* (Arrow Arum) is an emergent, herbaceous perennial with a height up to 61 cm with a green, inconspicuous flower color from May to July. It can be permanently inundated in up to 30.5 cm of water, or grow in saturated soils 25 to 100 % of the growing season. It is found in shallow waters on the edges of ponds and lakes, in swamps, nontidal marches, and fresh to moderately brackish tidal marshes. *Peltandra virginica* has shown some allelopathic characteristics and will tolerate shade. The rate of growth is slow, being less than 61 cm per year in unconsolidated sediment. The natural distribution range is from Southern Maine to Michigan and south to Florida and Texas.
The wildlife benefit is that the seeds provide food for wood duck, and other marsh and shorebirds. The foliage and rootstocks are not eaten by geese or muskrat.

*Peltandra virginica* distribution

(USDA, NRCS, 2009)

*Pontederia cordata* (Pickerelweed) is an emergent, herbaceous perennial with a height of 106.75 cm and violet blue spike flower in June to November. It has a moderate rate of spread and growth of approximately 15.25 cm per year in unconsolidated sediment. This plant can also tolerate permanent inundation of water, or grow in saturated soils 25 to 100% of the growing season. It will also tolerate partial shade. *Pontederia* can be found in shallow water around ponds and lakes, in nontidal marshes, and fresh to moderately brackish tidal marshes. The distribution range for *P. c.* is from Nova Scotia to Ontario and Minnesota and south to northern Florida and Texas. The wildlife benefit is the seed provides food for mottled duck and other water fowl. Canada geese and muskrat will eat the foliage. The plant also provides cover for fish.
*Pontederia cordata* distribution

![Map of North America showing distribution of *Pontederia cordata*](image)

(USDA, NRCS, 2009)

*Sagittaria latifolia* (Arrowhead) is an emergent, herbaceous perennial that grows to a height of 122 cm. It’s flower color is white with a yellow center. It flowers from July through September, and has a ball shaped, green nutlet for fruit distribution. Its rate of growth is rapid, with a spread of over 1 foot per year in unconsolidated sediment. It can be permanently inundated up to 61 cm of water, but also can grow in saturated soils 25 to 100% of the growing season. This plant will tolerate partial shade and is found on the borders of swamps, lakes and ponds, in forested seeps, swamps, nontidal marshes, and fresh tidal marshes. The natural distribution range for *S.l.* is from New Brunswick to southern British Columbia and south to Florida, California, and Mexico. It has wildlife benefits of providing food from seeds, tubers and plants for numerous birds, water fowl and mammals that include beaver, muskrat, ducks, and swans. It has been noted that mallard ducks and muskrat rapidly consume tubers in a planted area.
**Sagittaria latifolia** distribution

(USDA, NRCS, 2009)

Table A: The selected plants and their inundation tolerance levels

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Common Name</th>
<th>Inundation Tolerance in Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acorus americanus</td>
<td>Sweet Flag</td>
<td>0-1 ft.</td>
</tr>
<tr>
<td>Alisma plantago-aquatica</td>
<td>Water Plantain</td>
<td>0-1 ft.</td>
</tr>
<tr>
<td>Iris versicolor</td>
<td>Blue Flag</td>
<td>0-.5 ft.</td>
</tr>
<tr>
<td>Peltandra virginica</td>
<td>Arrowhead</td>
<td>0-1 ft.</td>
</tr>
<tr>
<td>Pontederia cordata</td>
<td>Pickerelweed</td>
<td>0-1 ft.</td>
</tr>
<tr>
<td>Sagittaria latifolia</td>
<td>Duck Potato</td>
<td>0-2 ft.</td>
</tr>
</tbody>
</table>
CHAPTER 3: METHODS

A comparative chart of all the important criteria for a successful restoration project was made using the Kameron Pond Restoration project and the Catch and Release Restoration project. The criteria were developed by using recommendations from The National Research Foundation *Restoration of Aquatic Ecosystems* (National Research Council, 1992), from Environmental Concern *The Do’s and Don’ts of Wetland Construction: Creation, Restoration and Enhancement* (Garbish, 2002), and from the author’s personal experience in public horticulture. Three planting projects were compared (See Table B) with the recommended criteria with the two plantings for Kameron Pond and the one planting for Catch and Release Pond. Numbers 1 and 2 were assigned to answers yes or criteria applied and no or criteria not applied, with yes being #1 and no being #2.

A final assessment, using the monitoring reports developed by Ralph Tiner from the *Wetland Monitoring Guidelines* (Tiner, 1999) for the US Fish and Wildlife Service, was made for each project to determine success. The one year vegetative monitoring report, Form V I, was used for each pond. The annual wetland monitoring report form was filled out in reference to vegetative analysis, with any other data that was available. The main use of this form was for vegetative purposes. In addition, form V4 – Planted or Seeded Data, from the *Wetland Monitoring Guidelines* were also completed. These forms were utilized to determine the success of the two projects. The plantings at Kameron Pond and the Catch and Release Pond were assessed in August of 2008 (See Appendix C).
CHAPTER 4: ANALYSIS OF THE CASE STUDIES

The results from using the assessment forms from the *Wetland Monitoring Guidelines* showed the first planting of Kameron Pond was a failure, and the second planting of Kameron Pond had very little success. The planting of the Catch and Release Pond after one year is successful and continues to show promise. The form V4- Planted or Seeded Site Data shows that on Kameron Pond, only 3 species are still present, with a low percentage of success. The *Acorus americanus* (Sweetflag) and *Iris versicolor* (Blueflag Iris) only show about 10% cover of their original planted location on the pond, with the *Pontederia cordata* (Pickerelweed) only showing about a 5% cover of its planted location. With the Catch and Release Pond there is a 90% cover of each of the species planted in there intended locations, except for *Alisma plantago-aquatica* (Water-plantain) which did not succeed. On the Catch and Release Pond 5 of the 6 species planted survived, and all are exhibiting growth beyond the original planting beds. *Pontederia cordata* (Pickerelweed) has reseeded on the Catch and Release Pond, and one population has become established in an area away from the bulk of the plantings. It is predicted that this will become a larger mass in time as this population is well established.

*Alisma plantago-aquatica* (Water-plantain) did not survive in any of the plantings at both sites. It is recommended that this plant should be installed with other plants as a mixture and not as a solitary planting (Thunhorst, 1993). This was done with the second Kameron Pond planting, and it has not survived. This leaves a question as to the suitability of *Alisma* as a restoration species for quick establishment. It obviously needs the protection of other species to help it survive. A true determination could have been made if the rest of the Kameron Pond plantings had also done well, since this species was
used in a mixture on that project. On the Catch and Release Pond, *Alissma plantago-aquatica* (Water-plantain) was used as a solitary species and planted as a group of 200-2 inch landscape plugs.

Table B: Criteria for a Successful Restoration Project

<table>
<thead>
<tr>
<th>Criteria</th>
<th>KP1</th>
<th>KP2</th>
<th>C&amp;RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horticulturist consulted in design process</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Use of bio-logs</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Plant shelf created</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Amend existing soil</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Same emergent plants</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Recommended supplier used</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Followed recommended installation procedure</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Project designer involved in decision process</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Landscape designer consulted over plant changes</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Design followed correctly</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subcontracted installation</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Agency installed</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Monitoring process followed</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance corrections performed</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Adaptive management plan in place</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Key:  
KP1 = Kameron Pond first planting
KP2 = Kameron Pond second planting
C&RP = Catch and Release Pond

1 = Yes
2 = No

A review of Table B shows the criteria necessary for a successful restoration. This is a listing of the similarities between the projects along with important criteria that was either followed or not. The least successful project, KP1, has the greatest number of 2, which is equivalent to the answer no, or criteria not applied and the least number of 1, which is yes to the criteria applied. There are only 4 times that 1 is represented. The next successful project, KP2, has an increase in the amount of 1 and a decrease of 2. Here the
number 1 is represented 9 times out of 15. Five more of the important criteria for success were considered, and the second planting did have a better amount of plants established, although the percent coverage of plant material was not enough to consider the restoration a success. The most successful project of the three, C&RP, has only one 2, which is a non subcontracted planting. This shows that as much of a project can be controlled by the stakeholders concerned with the restoration, the better the chance of success provided all the other criteria are met. A project can still be successful through subcontracting, especially when the pursuing agency or stakeholders are not experienced in restoration. For success, it is necessary for full involvement of consultants and experts in habitat restoration. In all the categories, except for subcontracting, a score of 1 is more desirable than a score of 2. The results show why the Catch and Release Pond was more successful than the Kameron Pond project.

The first planting of Kameron Pond only met 4 of 15 of the criteria needed for a successful project: a horticulturist was consulted in the design process, a plant shelf was created, emergent plants were utilized, and planting was subcontracted. This planting was a complete failure. The second planting occurred the following year after a meeting with contracted landscape firm to discuss the details of the mistakes that were made. The second planting of Kameron Pond included 9 of 15 criteria, and included the use of coir logs and the use of recommended supplier. Following recommended installation procedure and consulting the designer about plant changes, the design was followed correctly. This planting had minimal success in one location. The Catch and Release Pond met all of the desired criteria and this project has succeeded.
CHAPTER 5: ENVIRONMENTAL MANAGEMENT OF RESTORATION PROJECTS

The environmental management of restoration projects is critical to success. The outcome of a restoration can have political, economic, and social consequences that are strengthened through positive results. Politically, success is important because if the project is part of mitigation for a development, there is already negative criticism that can be subdued by providing a newly created ecosystem. Political success is still important if the project was only an enhancement made in a local park or corporate site, because positive results will help to provide continued support for such projects. Public participation process can bring community support and become an aid to restoration projects (Tiner, 2002). Economically, it is needed to make sure that the available funding is allocated in a proper fashion both during the restoration and afterwards. Economic viability in a project will also help to gain financial aid in the future for restoration. Positive social consequence brings support from the community, and proof of a successful project in the past will create confidence for future project work.

Proper management is needed from the beginning stages such as the design process until the project is deemed successful. Monitoring is a major part of environmental management, because without observation, it is impossible to know what is needed to keep a project viable. With proper monitoring protocols, corrections to the maintenance schedule can be made in a timely manner. These corrections are also dependant upon the communication process of all the stakeholders involved. Adaptive management is also a critical part of this monitoring process. Alternative plans need to be developed so maintenance protocols can be flexible to allow for different approaches, depending upon the success of the plantings. In order to avoid inappropriate expenditures
of effort and money, a restoration schedule needs to be set with a monitoring period that is long enough for resource managers to confirm that the restoration can withstand unusual environmental events, such as floods, droughts, and frosts (National Research Council, 1992).

Along with proper monitoring protocol, a maintenance plan needs to be established prior to planting the project, and adaptive management planning can provide the needed flexibility in maintenance protocols. This plan should also include contingencies in case of drought or severe weather. Excessive run-off during a thunderstorm or wake activity can cause poorly established plants to uproot themselves; they can be found floating in the water. Checking the project after major storm events is a recommended addition to a monitoring protocol. This is also true in times of drought, as the plantings need to be checked regularly to see if they are wilting and stressed. A stressed plant is unable to produce new growth; compromising establishment.

Proper maintenance is critical to success, but rarely is proper maintenance performed on a restoration project. Often a project is installed by an engineering firm, landscape contractor, or by a group of volunteers, and all looks well when completed. But follow up maintenance usually does not occur, unless it is a contracted job with maintenance stipulations in the agreement. Watering, invasive plant removal and general weeding are the most critical tasks within the first few years until the plants reach a certain level of maturity and establishment, when they can self regulate as part of the ecological process of natural succession (Clewell, Reiger and Munro, 2005). The use of plant material that lends itself to natural succession is beneficial to expediting this goal of self regulation (Sauer, 1998). Monitoring is still needed at this point to make sure that the
restoration remains viable and still follows a healthy ecological process, changing in a positive direction.

Supplemental watering is most important if rain fall is not reliable, and is needed to keep the plant material alive until the roots systems have been able to grow and establish themselves into the native soils. This should not be an issue if the proper plants are selected for the conditions expected when they are established. Due to the shock of transplanting, newly installed plant material requires water to recover. It is most important that recently installed aquatic plants receive proper irrigation during dry periods due to their natural requirements and to aid in establishment. This reduces plant loss and provides the new plant material a chance to develop root growth, as an aid to future survival (Blick, et al, 2004). Once established, wetland plants can withstand dry periods because as water is slowly withdrawn from the ecosystem, the plants will acclimate themselves by either going dormant or reducing growth.

*Environmental Management of Case Study # 1: Kameron Pond Restoration*

The lack of a maintenance plan and monitoring protocol was the demise of the Kameron Pond project. The project started off with compromised plant material, lack of watering, placement in the wrong locations, and no follow up on the job performance. The second planting at Kameron Pond did have some supervision; however a maintenance plan was never established. The second planting of the project was fenced at the time of planting; however it quickly fell into disrepair and never was corrected.

The first mistake made in the first Kameron Pond planting, in terms of monitoring, was that the firm hired did not follow recommendations that were stated with
the original design of the project. The landscape contractor claimed that they had never received them. There was no follow up to make sure that the engineering firm, PS&S gave the written instructions to the contractor and had only forwarded the design itself (See Appendix A). There was an assumption that the landscape firm would use an acceptable supplier. Due to this, the plants were shipped from Swift Creek Nurseries from St. Louis, MO in a dormant state. It is possible they may have been sitting around the landscape firm’s facility for a period of time prior to planting. The plants were not suitable and in a stressed condition. While observing the planting that day, the researcher had noted that the boxes were being opened for the first time and therefore the plants were not watered upon arrival, watered prior to planting, or after being planted. All plant material should be watered and in a viable state prior to planting, to help the root system uptake addition water when irrigation or natural rainfall occurs (Blick, et al, 2004).

The plants were not placed in the correct locations and the design was not correctly read. Monitoring and proper environmental management could have corrected this problem with a stop order on the work. The first plant installed was *Cephalanthus occidentalis* (Buttonbush). If the plant material had survived, there would have been twenty foot tall shrubs of *Cephalanthus occidentalis* (Buttonbush) growing in front of the dam which would have blocked the view shed, which was placed in the design. The design had considered light and soil requirements for the plant material, but placing them in the wrong locations compromised their establishment. The Buttonbush would have performed better if the root systems were allowed to grow into natural soils as opposed to the back fill and rocks that had been placed on the dam edge as part of the dredging reconstruction. This is true regarding the whole first planting, as the Buttonbush was the
first group of plants installed. The rest of the planting was off by approximately 30.5 meters from their desired locations. Environmental management may have been able to correct this situation by removing the buttonbush to a desired location and by helping to improve the plants that now needed additional light with some tree pruning to open up the shade canopy. *Cephalanthus occidentalis* (Buttonbush) was planted in the correct location for the second planting and a number of those have survived and are currently growing.

The first planting of the Kameron Pond project occurred when the pond was beginning to fill up again after the dredging. There was no indication as to how fast the pond would recharge. The lack of environmental management and monitoring did not allow for a contingency plan if the plants were to wilt due to lack of irrigation. The pond construction took longer than expected, and most of the plants died from lack of irrigation before the water level reached the plants. If the plant material was watered directly after installation and again in the next consecutive days, the mortality rate would have been lower because the plants would not have been stressed out and ready for their new hydrological inundation.

Proper environmental management procedures would have guaranteed that the first planting was fenced in at the end of each planting day. Again, this is lack of communication and failure to provide written instructions along with the design. Monitoring could have corrected this by pointing out to the contractor that fencing was vital to success. One of the reasons for the dense littoral edge planting was to mitigate the goose problem in the pond by denying access, as new plantings are susceptible to browse by waterfowl. Instead the project was fenced in at the completion of planting that
occurred over a 3 day period. By then the resident geese had already browsed the plants, pulling most of them from the ground. This exposed the roots to the sun and air, which caused them to dry out. When the water level finally did reach the plants, they started to float and were never able to establish roots into the soil.

The most critical mistake, in terms of monitoring and management for establishment of the plants that survived the normal water levels in Kameron Pond, was a lack of observation for inundation of the plants. Newly planted emergent aquatics should have a percentage of their leaves extending out of the water to help them photosynthesize to aid in establishment. The following weeks after the planting, the project site was plagued with heavy rain, and the hydrologic flow was greater than expected. Many of the plants were flooded. This water level could have been controlled with the new valve that was installed on the dam spillway as part of the dredging project. Again, monitoring and management could have observed this and corrected the hydrologic flow, until the plants were able to survive on their own.

A second planting along with a corrected design (See Appendix F) was made the following year, but again a management plan was not put in place. Some monitoring was conducted during the actual planting stage. Although the monitoring in the planting stage was an improvement, there was still a lack of communication, as some decisions were made without consultation of the designer. It was decided during an assessment meeting (See Appendix B) to discuss the installation of the second planting for Kameron Pond, that coir logs will be utilized along the dam to help with plant establishment. A coir log is a netted tube filled with organic material that is used often for erosion control. It can have plugs of rooted plants placed into the log to aid in plant establishment on eroded sites. Dr.
Eric Karlin from the Environmental Science program at Ramapo College was present during the planting and has occasionally checked the plantings afterwards. Formal care of the plantings or follow up on the part of the college never occurred, and a lack of maintenance contributed to failure of the second planting.

Decisions were made during the day of the planting to increase the amount of coir logs that were to be utilized, and to change the fencing procedure. Some additional coir logs were purchased, to extend the coir logs for aesthetics. This beneficial decision resulted with one of the areas having partial success. In terms of the fencing, it was decided to leave gaps or aisles in the fencing to allow access to the pond for the geese. If the designer had been contacted, the recommendation would have been to close the pond off completely to avoid any access to the pond by waterfowl, as the primary goal of the project was to mitigate for the goose population.

Dr. Karlin did monitor the success of the plantings, although he did it more out of interest after observing the planting rather than as a formal monitoring protocol. Personal conversation has revealed that he did transplant some of the plants to a better location, and those plants have survived and currently are growing. This is an example of how monitoring along with proper action can help to make a project a success. Unfortunately, with Kameron Pond it was too little of an effort. Proper monitoring, along with an adaptive management plan, could have made contingencies for plant establishment. A more concise plan from the college would have produced a more successful project.
Environmental management and monitoring did occur at the Catch and Release Pond at Mahlon Dickerson Reservation (MDR), although it was loosely structured. There was an agreement from the administration of the Morris County Park Commission that the project manager/designer was going to survey the plants on a regular basis as part of his job duties. The Catch and Release Pond had a regular maintenance staff that was not horticulturally minded, but performed maintenance tasks on a regular basis and recognized if anything major was wrong with the project. They repaired the fence several times, but were not able to recognize invasive plants which were removed when monitoring the project. Because of the required field checks after the initial planting stage, which included frequent monitoring site visits and communication with the staff, problems have been avoided.

Maintenance procedures have been historically performed by the staff at MDR because this pond is frequently used by the public. It is part of the weekly procedure for park maintenance. Along with turf management and trash removal, goose management is part of the maintenance protocol. This is done through egg addling programs and harassment of nesting geese. It has been successful, with little visitation from Canada geese. It was noted by the staff that once the fencing was installed for the littoral edge restoration, goose visitation diminished. This control of the goose population remains in effect, and is part of an environmental management plan that can include adaptive management for changes in goose visitation or population size. For example, due to diminished goose visitation, the protective fencing was removed after one year of growth because of the successful establishment of the plants.
This pond is located in the middle of a field that is mowed on a weekly schedule like any other turf in a park. The crew used to cut up to the waters edge but a new management recommendation was made to leave a couple of feet un-mowed on the ponds edge to improve water quality. The newly planted area could not be cut due to the protective fence and when that was removed, it remained a no mow zone. The staff at MDR also requested that another part of the pond is planted with a left over coir log because that section was eroding and a Toro Groundsmaster lawn mower almost slipped into the water.

The staff at MDR has shown interest in the project. The additional area was planted with an extra coir log, with plants that were being held in the nursery at Frelinghuysen Arboretum, to be used as replacements if needed. This planting was conducted in late August, 2007. The plants did not establish as well as those planted in the spring and there was about a 50% loss. This area was given some additional plants in the spring, 2008 with *Iris versicolor* (Blueflag Iris), *Acorus americanus* (Sweetflag) and *Juncus effusus* (Soft Rush) that were in the Frelinghuysen Arboretum nursery. To date all of these plants have become established and are growing.

The spring planting in 2008 also incorporated the zone where the *Alissma plantago-aquatica* (Water-plantain) did not survive and the same mixture of plants was used in this location. The new plants that were installed in the spring are a better choice as the inundation is not as great as the rest of the planting on the Catch and Release Pond. This section of coir log was placed higher than the others and created an area that was not submerged under water and had a hydric soil zone that is typical in a terrestrial zone on a ponds edge. The *Iris versicolor* (Blueflag Iris), *Juncus effusus* (Soft Rush), and *Acorus*
*Americanus* (Sweetflag) are commonly found in these ecosystems, and will grow into the water as the plants spread with maturity. Environmental management along with adaptive procedures was able to accomplish this additional planting, because extra plants were held in the Frelinghuysen Arboretum nursery as a backup for plant mortality, or to be utilized elsewhere in the park system.
A highly recommended restoration strategy is adaptive management, which is an important component of environmental management. It is important to have contingency plans in place and to be flexible in applying them. What happens in one phase of a project can alter what was planned for the next phase of the project. A built-in flexibility to accommodate alternative action that addresses underperformance, lack of plant survival, and changes in hydrology must be contained in any restoration plan (Clewell, Reiger and Munro, 2005).

For example, a change in the plant list is possible due to lack of availability from nurseries, and proper environmental management should also have an adaptive plan in place to seek alternative plant material. An adaptive plan for plant material can begin in the design phase, by finding three suppliers for plant selection and for cost analysis of a restoration project. The designer of the project will become familiar with the plant material from those nurseries, and can develop an alternative plant list in the design phase to allow for crop failures or unavailability of the selected species. An adaptive management plan for plant selection could be documented and given to the installer of the project. This allows for easy coordination with the designer in case of changes during the planting phase. The designer of a restoration project should be consulted if substitutions in plant material are made due to lack of availability (Garbish, 2002).

A good environmental management plan for restoration projects should also include adaptive management plans for every period of the monitoring protocol. Once the project is planted, there is still a chance of mortality that would have to be corrected to make a project successful. An adaptive plan can provide funding, or have guarantee
clauses in the contract for sub-contracted work, for replanting as needed. This can be accomplished with coordination of an adaptive plan for plant material. Hydrology can also affect plant growth and if hydraulic conditions rapidly change, there is also a possibility of plant mortality. An adaptive plan can allow for changes with contingencies to adjust water levels until plants are established or to replant with alternatives to compensate for the new conditions. The designer of a wetland restoration should never rely on the current hydrologic regime and must be aware that changes to hydrology can occur (Garbish, 2002). Damage from wildlife can affect plant growth and be a cause of plant mortality that can be addressed in an adaptive management plan that contains wildlife management alternatives. An adaptive management plan, in coordination with proper monitoring protocols, gives an environmental management plan that will provide success in plant development at restoration sites (Clewell, 2000).

The mistakes to avoid were made in the Kameron Pond Restoration, and are some of the oversights that are commonly made in restoration projects. Despite the fact that there was good communication during the planning process and a good plan had been developed, in the end the landscape plan was never monitored correctly. In order to avoid inappropriate expenditures of effort and money, a restoration schedule needs to be set with a monitoring period that is long enough for resource managers to confirm that the restoration can withstand unusual environmental events, such as floods, droughts, and frosts (National Research Council, 1992).

Several mistakes were made with the Kameron Pond Restoration regarding landscaping, and the contractor was not communicating some of the concerns to the school. Some plants that were on the plan were never planted. Plant substitutions were
made by the contractor’s discretion, and he had never checked with the school or the designer. The plants utilized for replacement were not the most desirable for the conditions, with a replacement in the shrub border that had a questionable nativity in NJ. It is important for the contractor to remain in communication with the designer and reflect any changes that may have to be made (Garbish, 2002).

Some of the plants used by the contractor were not of the highest quality and were not supplied by a restorative plant nursery or the recommended supplier. Cultivars of some of the shrub species were utilized. In the case of Kameron Pond, this was not as critical as it would have been if the restoration location was in a natural setting. Species were specified in the landscape plan, as opposed to cultivars, to allow students to learn plant identification of our native species. Cultivars are often morphologically different and since some are sterile there is no addition to the gene pool; resulting in a lack of diversity (Segal, 2004).

The aquatic plants were also put in the wrong locations and therefore the inundation levels were different than planned. Many of the plants were placed too deep in the water. The aquatic plants were not planted according to the planting details on the plans from PS&S. (See Appendix F) The recommended supplier, Pinelands Nursery, was not utilized in the first planting and instead a non-regional supplier, Swift Creek Nurseries from Missouri was used for the aquatic plants. A commercial nursery, Shemin Nurseries, that has a national distribution range, supplied the shrubs and ferns. The plant numbers and spacing were not as specified. A greater density allows for coverage within one year after establishment. The plants were also still in a dormant state, and mid-May is late in the year to be working with dormant material. The crew neglected to install netting
to protect the plants from the herbivory at the end of each planting day, as suggested in the Kameron Pond Landscape Plan. Instead they installed it when the whole job was completed and did not do it properly. This was corrected at another date, but was too late because herbivore damage had already occurred.

The hydrologic flow was greater than planned. Those involved in restoration know never to count on the hydrology to remain the same as before restoration when the job is completed (Garbish, 2002). This may have been corrected with a good monitoring protocol that includes adaptive management. The new spillway had a new gate valve on the outlet pipe of the dam for draining the pond. This valve could have been utilized to control the water levels until the plants had become established, provided they broke dormancy. In order to react promptly to contingency plans and schedule maintenance, a restorative specialist should inspect the project site frequently. A restoration should contain flexibility, and alternative interventions should be attempted if monitoring reveals that objectives are not being met (Clewell 2000).

The Catch and Release Pond Restoration seems to have been more successful than the Kameron Pond Restoration for several reasons. There was direct involvement throughout the whole process from the landscape designer who also monitored all of the activities and pursued the follow up maintenance. The planning process was monitored to assure proper planting, fence erection, and the quality of materials. The recommended supplier was utilized with a higher quality of fence and plant materials. The monitoring process after planting was greater with more frequent site visitations and dedicated personnel to fulfill monitoring goals. The monitoring protocol that included frequent site visitation and flexibility to make immediate adjustments as needed. Without a monitor
present during the installation, on site problems could delay the project due to time lost consulting with the project managers and designers. This could have a negative effect on the success (Garbish, 2002).
CONCLUSION

A recommended monitoring protocol for a restoration project should begin at conception of the project and continue until the project is deemed successful or the goals of the restoration have been met. The monitoring protocol can include adaptive management practices and a maintenance schedule. Preferably, the monitoring is conducted by the same person or group of stakeholders from the design stage, installation, and recommended monitoring period. The monitoring requirements need to be specific and include plant growth goals, desired species, official wetland classification, and size (Tiner, 1999). A restoration needs to have qualified personnel to conduct the monitoring, and if the situation warrants, it is recommended to obtain professional advice from consultants in restoration ecology (Sauer, 1998).

The following are monitoring recommendations for the three most critical stages of a restoration project:

- **Design Phase** – During this phase of a project it is important that an adaptive management policy is developed. An alternative plant list needs to be developed with possible sources. If time allows, contract growing may be an alternative (Garbish, 2002). During this phase it is important to set up a time-line for installation that is flexible enough to allow for weather complications and changes in hydrology. Planning in this phase must include installation procedures and how implementation will occur, with immediate after care and a maintenance schedule. If volunteers are to be utilized, this is the time to solicit public support.
- **Installation Phase** – In this phase, proper planting and horticultural technique are critical. A specialist needs to be on site during the entire installation process. The
recommended time for planting is in the spring to allow for a whole season of growth, for better establishment and less chance of mortality during the dormant season. Plants must be evaluated for vigor and in acceptable condition. It is recommended that the plants are watered upon arrival and protected from herbivores if stored on the site overnight. Soils need to be amended to allow for a friable planting bed to allow for quicker establishment. The plants must be placed at the correct depth, because if the plants are too shallow there is a greater chance of frost heaving in the spring. All plantings are to be watered in at the end of the day and protected from herbivores. Alternative installation plans need to be implemented immediately if problems arise.

- Monitoring Phase – The Monitoring phase should continue until the project is successful and start immediately after installation. The project needs to be checked in 24 hours, 72 hours, and weekly or bi-weekly after planting, depending on how well the plants have recovered from transplant shock and weather conditions, which can affect hydrology and erosion. Usually, the monitoring phase is only as long as requirements dictate, but this period needs to be extended. A five year period may be long enough to determine plant establishment, but is not long enough for the evaluation and impact of invasive species. Weather conditions and hydrology can change after the required monitoring period. The monitoring period needs to be extended if there are signs of project failure early in the monitoring (Tiner, 1999). Adaptive management is important with the monitoring phase, and the purpose of periodic review is to recognized changes that can be addressed in a timely manner. The monitor must be able to identify
actions to take to correct damage and be able initiate repair or implement alternatives (Sauer, 1998).

Both the Kameron Pond Restoration and The Catch and Release Restoration had the same recommendations that included plant diversity, suppliers, maintenance and monitoring. The process of installation had different approaches, as the Kameron Pond project did not follow all of the recommendations. This is partly due to the hiring of a landscape contractor for the installation and minimal monitoring during and after the installation. With the Catch and Release Pond project, monitoring was performed by the project manager/designer. He was present during the planting phase, with the authority to make sure the installation followed recommendations. Monitoring also occurred on a regular basis to locate any problems. It is probable that if some of the problems at Kameron Pond were noticed through a better monitoring protocol, that the project would have been more successful. A complete monitoring protocol for littoral zone restoration must be well designed from conception of a project, and followed through the design phase, planting, and maintenance to determine success.
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USDA, NRCS. 2009 The Plants Database National Plant Data Center, Baton Rouge, LA 70874-4490 USA http://plants.usda.gov
Appendix A:

Kameron Landscape Plan;
Installation and Maintenance Criteria

Ramapo College has a limited and overextended grounds maintenance staff. This is why a landscape is more appropriate than a garden. The aquatic plants are self-sustaining and require no care once established. The shrubs are all slow growing and will require little pruning. In approximately 5 years some of the species chosen may require limited pruning if branches are growing into the roadway on the eastern border. \textit{Cornus amomum} should be monitored yearly for canker and damaged branches should be removed yearly in the spring. This is common with newly planted shrub specimens of \textit{Cornus} and usually once the plants are established this problem seems to diminish. There are installation criteria that must be met for a successful landscape, which includes goose netting and no fertilizer. A suggested list of contractor specifications to include with the American Association Landscape Standards and plant notes is listed below. Monitoring a project of this magnitude is recommended for the first year and a management program that includes input from marine biologists will have to be developed for long term care of Kameron Pond.

Criteria for Planting

- All plants are not to be fertilized
- All perennials and shrubs are to be planted with a liberal amount of compost or leaf mold comprising of approximately 40\% of the back-fill soil
- All woody specimens are to be planted no more than 1" above grade or below grade
- All terrestrial plants are to be mulched with a high grade, double ground wood mulch; preferably cedar, at a depth of 2" to 3"
- All root balls must be scarified and burlap removed from the top of the ball and plant crown; all synthetic burlap must be removed completely
- Goose fencing must be installed on both sides of the planting immediately at the time of completion of the planting
Appendix B

Kameron Pond Landscape Assessment
Michael Wilson
Sept. 1, 2004

Background:

At the first meeting with Paulus, Sokolowski and Sartor (PS&S) on 3/19/2003 to discuss the dredging of Kameron Pond, it was discovered that only three species of plants with grass-like characteristics were suggested for bank stabilization and landscaping. The spillway side of the pond was to be left unplanted. The Kameron Pond Landscape Plan (KPLP) was developed as an alternative to add bio-diversity, aesthetics, and educational value. This plan retained the suggested grass border by PS&S and added plants where none were located, including additions to the grass border. This resulted in an additional eleven species of shrubs, eight species of aquatic plants, and three species of ferns. The plant species chosen for the KPLP were matched to specific site conditions for aesthetics, water quality, and growth habit, with a review of inundation rates (Appendix I). The plan was drawn after a review of the Ramapo Campus Pond Dredging plans, dated 4/4/03 from PS&S (Appendix II). Dick Roberts and Bruce Hawkins, CLA, Associate Principal for PS&S approved the KPLP on 6/23/03. The final plan for the landscape contractor, which is a duplicate of the conceptual plan presented on 6/23/04 by Michael Wilson, was plotted by PS&S.

Draw down of the water in the pond began in September 2003 and there was a successful fish harvest in early October 2003. Several different species were taken to Sally’s Pond at the Ramapo Reservation. The actual excavation of Kameron Pond began in late October. Due to strong hydrological conditions, dredging took longer than projected to complete. The planting of the shrub border and aquatic plants began on 5/12/04 with the work being performed by Let it Grow Landscape, Inc.

Review of Landscape Installation:

On 5/12/04, I noticed that Potentillia fruticosa, which was not in the landscape plan, was planted in the shrub border. An employee from Let it Grow that was holding the plans explained that it was a substitute for Comptonia peregrina, which he said was unavailable. He said that no other substitutions were being made. The employee said the plant supplier was Shemin Nurseries and the aquatic supplier was Swift Creek Nurseries. His copy of the plan was checked to see if the plant schedule was the same and it was.

A call to Matthew L. DelPreore, Project Manager for Let it Grow was made on 5/13 to request a copy of the plan, plant list for cultivar names, and a list of substitutions. He agreed to send the information. The requested information arrived on 8/27/04, after a few follow up calls in August.

Another inspection of the job on 5/16 revealed that all of the aquatic plants and some of the shrubs were planted in the wrong locations. A call was made to PS&S on 5/20 to verify that their landscape architect did not make location changes. A copy of the plan arrived at my house from PS&S on 5/22. The design from PS&S is the same as the
conceptual plan with slight changes in the number of plants needed for the job. The location changes were made by Let it Grow.

The pond was inspected on several occasions after the initial planting (Appendix III). The shrub border has marginal success, but the aquatic plantings have failed. This includes the plants selected initially by PS&S and the additional aquatic plants in the KPLP. Details of the assessment are listed below:

**Aquatic Planting:**

1. All of the plants were put in the wrong locations. For example, *Carex lacustris* was planted in the aquatic section near the spillway where deep-water aquatics like *Sagittaria latifolia* (Duck Potato) were specified. *Carex lacustris* grows best on the waters edge and creeps into the deeper water. This plant was intended for the other sides of the pond. This is one of the reasons why the aquatic plants failed to grow. It is critical to put the plants in the correct locations to match inundation tolerances.

2. The aquatic plugs from Swift Creek Nurseries were not fully leafed out and many did not have foliage at all. May 12th is late in the year to be working with dormant material. In addition, it is suspected that the plants were not watered upon arrival to Let it Grow. The recommended supplier was Pinelands Nursery in Columbus, NJ.

3. The aquatic plants were not planted according to the Planting Details shown on page C2 from the Ramapo Campus Pond Dredging (Appendix II). The spacing on the plants installed was not as dense as specified on the plan. A greater density is preferred for coverage within one year.

4. The netting was not installed at the right time. Netting should be installed at the end of each planting day for protection from waterfowl damage. Initially, netting was not installed correctly and this was corrected on approximately 5/19.

5. There was a sudden change in hydrology, due to the fact that Kameron Pond receives storm water from Phase VIII. All of the plants chosen are capable of receiving periodic flooding and are recommended for bio-retention ponds for storm water management. However, the plants must be established prior to receiving excessive inundation. Therefore, the water level of the pond should have been monitored and managed more carefully.

**Shrub Border:**

1. The planting holes for the shrubs were not prepared well and the root mass on the plants were not scarified prior to planting. Some of the shrubs were not planted at the right height.

2. Some of the shrubs are also not in the right locations, however this is not critical overall.

3. Two important shrubs were not included in the planting. These are *Comptonia peregrina*, which was replaced with *Potentillia fruticosa*, and *Spiraea latifolia* that was replaced with *Spiraea tomentosa*. These two shrub species were included in the original landscape design for their suckering characteristic as an aid for discouraging goose habitation and the replacement shrubs do not have the same characteristics. These replacements were made by Let it Grow, Inc.
4. Another shrub that was not planted is *Rhododendron viscosum*. The shrubs that were not planted may have been unavailable from Let it Grow’s supplier, Shemin Nurseries. Again, the recommended supplier was not utilized.

Ferns:
1. The fern border was also planted incorrectly. The fern planting was designed to go to the waters edge and be much larger.
2. There is two species of ferns planted and not with the correct number of plants. The landscape plan specified three species of ferns.

Recommendations:

The shrub border can be left alone, due to the marginal success. The *Comptonia peregrina* and *Spiraea latifolia* should be added where some shrubs have died and in some of the gaps in the shrub border. There is a large planting of *Spiraea tomentosa* that was intended to be *S. latifolia*. Because *S. tomentosa* does not grow densely, this is a good area for additional perennials, like *Solidago rugosa* or *Aster novi-belgii* for fall color. Milkweed (*Asclepias syriaca*) has already established itself in the shrub border and it could be left as an attractive part of the landscape.

The aquatic shelf needs to be replanted. The change in hydrology and grade of the shelf should be considered with the replanting. The plants should come from a nursery that specializes in restoration and should be in good health. The planting should start at the waters edge and go inward until a depth of one foot is realized. They should be placed in their intended location for optimum performance. It is critical that the plants are put in the right locations to match their inundation tolerances. It is equally critical that a monitoring and maintenance plan is implemented immediately after replanting.

There are three options to consider for replanting the aquatic shelf:
1. Check the landscaping contract with Let it Grow and see if they are obligated through job guarantees or contract criteria to replant.
2. Hire a landscaping company that specializes in restoration and wetland enhancement to plant the aquatics. See appendix IV.
3. Replant the aquatic shelf as a student project similar to the Ramapo Reservation project at Sally’s Pond.

It is critical that during and after replanting the pond that the project is monitored. This is to assure that the planting is done correctly and to follow up in case problems arise after the planting. This monitoring is to make sure that no damage occurs to the netting, check the performance of the planting, and to report problems to the appropriate personnel.

Conclusion:

Although the aquatic plants have failed, it is still repairable. Three options have been given to accomplish this task. Option one is the preferred option due to possible contract obligations. Monitoring is the most important aspect for a project of this magnitude. The recommended supplier should be consulted to review plans and if given enough lead-time, can provide all of the plants. If substitutions must be made, Pinelands Nursery will give advance notice with reasonable suggestions for substitute plants.
Planting details need to be followed closely with the plants in the proper locations. Adjustments should be made to address the current hydrology. Other than the loss of the aquatic plants, the KPLP has been a benefit to Ramapo College. Kameron Pond is in the core area of the campus and has now received attention. It still provides an area for students to do project work on invasive plants, wetland restoration, and study aquatic ecology. The shrub border is an addition that otherwise would have not been added and provides a variety of indigenous shrubs. Part of the educational component has been fulfilled because students may now study both the successes and the failures of the Kameron Pond Dredging Project.

References:


Appendix C

Site Evaluation Forms
August 2008
YEAR I VEGETATION OBSERVATION DATA FORM (Form VI)

Name: Kamakura Pond Date: ___________________ 

Location: Rt. 202 BERCER Morichai N.J. 
Street County Town State 

Investigator: M. Wilson Affiliation: ________________________ 

Vegetation Observations*

What is the percent cover of vegetation to bare ground and open water at the site? 
5% Vegetated/5% Bare Ground 50% Water 

List all species observed in project wetland and indicate common species (with > 20% areal cover): 
Sweet Flag - Grows emergences 
Blue Flag Iris - List species. 
Button Rush. 
Rostadum Spadix - 

How many different plant communities are present? Briefly describe each. 
Wetland front on 1/2 of pond porition of rigid bark 

Was project wetland seeded or planted? Yes No If yes, complete Form V4 and attach. 
Additional comments Kamakura Pond was planted 9 times. Snow-lily 

Note: Be sure to attach photographs of site showing vegetation patterns.
PLANTED OR SEEDED SITE DATA FORM (Form V4)

Site Name: Kamaree Pond
Site Location: Rt. 202, Bergen, New Jersey
Investigator: M. Wilson
Affiliation:
Monitoring Year: 1 2 3 4 5 6 7 8 9 10

Observations

1. What type of site is this? _Planted ___Seeded (Note: If woody plants are seeded, their growth should be measured as if they were planted.)

2. List species that were planted and/or seeded

3. For seeding projects, is seeding successful? _Yes __No. Briefly explain

4. What is the percent cover of each seeded species? (List species and % cover)

5. For planted sites, what is the estimated survival of each species? (List species and % survival)

6. Is there any evidence of reproductive success (e.g., flowers or fruits present)? _Yes _No. If yes, identify species and observed features.
7. Is there any evidence of growth in woody plants (e.g., changes in dbh and height from last observation*)? __Yes ___No. If yes, explain. __________________________________________

________________________________________

*This information is derived from plot sampling results.

8. List species present that were not seeded or planted and estimate their percent cover. __________
   __________
   _Ailanthus altissima_ – less than 1% __________

9. Is project successful to date? __Yes ___No (Compare with last report). Briefly explain. ________
   __________
   __________

10. If the project is not successful, what mid-course correction is needed to achieve success?
    __________
    The soil needs to be replanted with a better adaptive maintenance plan & protection.
YEAR 1 VEGETATION OBSERVATION DATA FORM (Form V1)

Name: Catch & Release Pond  Date: 

Investigator: M. Wilson  Affiliation: 

Vegetation Observations*

What is the percent cover of vegetation to bare ground and open water at the site?

% Vegetated  % Bare Ground  % Water

List all species observed in project wetland and indicate common species (with > 20% areal cover):

Piedonal Weed
Sweet Flag
Blue Flag
Snow Reeds
Duck Potato

How many different plant communities are present? Briefly describe each.

Wetland forest with mix of shrub species. There is a ground cover of ferns & woodland vegetation. Understory of shrubs that primarily consists of Willows. Directly surrounding the pond is marshy tidal

Was project wetland seeded or planted?  Yes  No  If yes, complete Form V4 and attach.

Additional comments

Note: Be sure to attach photographs of site showing vegetation patterns.
PLANTED OR SEEDED SITE DATA FORM (Form V4)

Site Name: Catch & Release Pond

Date: ________________________

Site Location: Weldon Rd. Morris Jefferson N.J.

Street County Town State

Investigator: M. Wilson

Affiliation: ___________________________________________________________

Observations

1. What type of site is this? Planted ___Seeded (Note: If woody plants are seeded, their growth should be measured as if they were planted.)

2. List species that were planted and/or seeded

3. For seeding projects, is seeding successful? Yes No. Briefly explain

4. What is the percent cover of each seeded species? (List species and % cover)

5. For planted sites, what is the estimated survival of each species? (List species and % survival)

6. Is there any evidence of reproductive success (e.g., flowers or fruits present)? Yes No. If yes, identify species and observed features.
7. Is there any evidence of growth in woody plants (e.g., changes in dbh and height from last observation*)? Yes [_] No. If yes, explain. ____________________________________________________________

*This information is derived from plot sampling results.

8. List species present that were not seeded or planted and estimate their percent cover. ____________________________________________________________

9. Is project successful to date? Yes [_] No (Compare with last report). Briefly explain. ____________________________________________________________

10. If the project is not successful, what mid-course correction is needed to achieve success?

_________________________________________________________________
Appendix D

Plant Records for Kameron Pond
And Catch and Release Pond

Kameron Pond
The plants for Kameron Pond were purchased by Let it Grow, Inc. The chart below is taken from the plant order with Sweet Creek Nursery, St. Louis, MO.

*Note: *Acorus americanus* (Sweetflag) is not on this list. This plant was added to the second planting of Kameron Pond. Plant records for the second planting were unavailable.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Plant</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>680</td>
<td><em>Alisma plantago-aquatica</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>283</td>
<td><em>Iris versicolor</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>354</td>
<td><em>Peltandra virginica</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>2140</td>
<td><em>Pontederia cordata</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>180</td>
<td><em>Sagittaria latifolia</em></td>
<td>2&quot; plug</td>
</tr>
</tbody>
</table>

Catch and Release Pond
The plants for the Catch and Release Pond were purchased by the Morris County Park Commission from Pinelands Nursery in Columbus, NJ.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Plant</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td><em>Acorus americanus</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>125</td>
<td><em>Alisma plantago-aquatica</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>284</td>
<td><em>Iris versicolor</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>167</td>
<td><em>Peltandra virginica</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>203</td>
<td><em>Pontederia cordata</em></td>
<td>2&quot; plug</td>
</tr>
<tr>
<td>357</td>
<td><em>Sagittaria latifolia</em></td>
<td>2&quot; plug</td>
</tr>
</tbody>
</table>
Appendix E

Photographs of Kameron Pond and Catch and Release Pond

Kameron Pond prior to dredging

Fish harvest by Blue Meadow Lake Management
The dredging project included the construction of a shelf around the edge of the pond to allow for the establishment of emergent plants.

Created planting shelf at Kameron Pond

Coir log installation from the second planting of Kameron pond
Catch and Release Pond prior to drawdown for planting

Jefferson Fire department testing new equipment and drawing down water level at Catch and Release Pond
Catch and Release Pond bank after drawdown

Volunteers planting on the catch and Release Pond after installation of coir logs and planting beds prepared with compost/soil mixture
Members of the Knee Deep Fishing Club installing fencing

Completed restoration planting on Catch and release Pond
Completed planting at Catch and Release Pond after total recharge of pond

*Pontederia cordata* (Pickerelweed) and *Sagittaria latifolia* (Duck Potato)
At Catch and Release Pond after one season of growth (Sept. 2007)
Appendix E

Photographs of Kameron Pond and Catch and Release Pond

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Fish harvest by Blue Meadow Lake Management
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*Pontederia cordata* (Pickerelweed) and *Sagittaria latifolia* (Duck Potato)
At Catch and Release Pond after one season of growth (Sept. 2007)
Appendix F

Landscape and Engineering Plans for Kameron Pond
And Catch and Release Pond

The landscape and engineering plans are reduced copies of 24" x 36" plans and are not to scale. The north arrow on the original set of plans from PS&S for the pond dredging and on the Kameron Pond Landscape Plan (Conceptual) is incorrect. This mistake was discovered on June 23, 2003 when the Kameron Pond Landscape Plan was submitted. These plans were used either for the design of the projects or for the installation.

The landscape and engineering plans contain the following:
- Ramapo Campus Pond Dredging – Dredging plan for 12’ depth
- Ramapo Campus Pond Dredging – Pond cross section and planting details
- Kameron Pond Landscape Plan – Conceptual Plan
- Ramapo Campus Pond Dredging – Landscape Plan
- Kameron Pond Landscape Plan – Revised planting
- Catch and Release Pond Landscape Plan
All plantings are to be protected with plastic fencing completely on all sides to prevent browse from both herbivores and waterfowl for one year until the plantings are established.

Recommended time for planting is in the spring to allow for a complete growing season for plant establishment.

The use of barrier stabilization material, such as Geoweb® or Bio-logs is recommended for plant establishment.

All plantings are to be watered at the end of each planting day until the water level is brought back to its normal level.

Pond should be brought back to the normal water level immediately upon completion of planting.

---

**Notes:**

- All plantings are to be protected with plastic fencing completely on all sides to prevent browse from both herbivores and waterfowl for one year until the plantings are established.
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- Pond should be brought back to the normal water level immediately upon completion of planting.

---

**Legend:**

- **AA**: Acorns
- **AP**: Arrowhead
- **PL**: Pickerelweed
- **SLO**: Duck Potato
- **S**:
- **TV**:
- **L**:
- **P**:
- **C**:
- **PC**:
- **SL**:
- **PV**:
- **TV**:
- **SL**:
- **PV**:
- **AA**:
- **AP**:
- **PL**:
- **SLO**:
- **Duck Potato**
- **Acorns aim ricanus**
- **Sweet Flag**
- **Water Plantain**
- **Blue Flag Iris**
- **Arrow Arum**
- **Pickerelweed**
- **Duck Potato**
- **Acorns aim ricanus**
- **Sweet Flag**
- **Water Plantain**
- **Blue Flag Iris**
- **Arrow Arum**
- **Pickerelweed**
- **Duck Potato**

---

**Scale:** 1" = 20'

---

**Notes:**

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